

**Athanasii Kircheri e Soc.
Jesu *Mundus*
Subterraneus, in XII
libros digestus**

(1665)

by Athanasius Kircher (1602–1680), Society of Jesus

Translation by Scott Weisman



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Translator Version 2

Upright reason dictates that the recipients of the good, of whatever type and level of beneficence it may be, must show gratitude and blessing to the beneficent person in every way possible, commensurate with the value of the beneficence. And one who has benefited all the people of the world — for example, one who invented a new instrument for the good of the world, or a good book — it is fitting for every discerning person, out of the obligation of love of fellow beings, to at least purchase it, so that the man will profit and his heart will be encouraged thereby to invent yet more good instruments in the world. And similarly, all other wise-hearted people will likewise strive and exert themselves to invent good things and instruments needed for the repair of the world and its perfection.

And therefore, whoever says: "What do I need this new instrument for?" — he does not act well towards the world. For if not for the man who invented it, where would you be? And what would your city do? And more than this, if the man did not exert himself, what would the world do?

— R. Pinchas Eliyahu Hurwitz, *Sefer HaBris HaShalem* (1797)

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A note on the work

A vast attempt to explain the whole hidden world beneath our feet. Drawing on a daring descent into the smoking crater of Vesuvius and a lifetime of reading, it describes a planet riddled with fiery channels and underground rivers, ranging across volcanoes, springs, tides, metals, minerals, fossils, poisons, subterranean creatures, and the secrets of alchemy. Famous for its dramatic engravings — above all the cross-section of an Earth burning at its core — it blends bold observation with Hermetic and biblical speculation. First published in 1665, it is the foundational synthesis of early modern earth science.

A note on the translation process

This translation was produced with the [translation-pipeline](#). See the linked repository for details on the process.

This text is the product of a highly refined automated translation process. It has undergone only cursory human review and should not be treated as an authoritative or scholarly rendering. It is offered solely as a reference and reading aid — a way to make an otherwise inaccessible work approachable — and any passage of real consequence should be checked against the original source.

Acknowledgements

Translated with the assistance of Claude. The translator thanks the [Anthropic](#) team for making this work possible.

Mundus Subterraneus — Front matter (binding and endleaves)

This opening consists entirely of the volume's binding and pre-textual leaves. No printed title page, dedication, privilege, or engraved plate appears yet; these pages carry only the limp-vellum cover and modern librarian's notes in pencil. The printed text begins in a later opening.

**** — Front cover (limp vellum).** ****** The outer board of the binding: a plain limp-vellum (parchment) cover with raised sewing-bands visible along the spine edge, surface staining and faint offset markings, but no printed or lettered title. No text content.

**** — Front pastedown / endleaf with library cataloguing notes (modern, in pencil).** ****** The leaf carries a modern librarian's hand in pencil. These are not part of Kircher's text; they are a 20th–21st-century cataloguer's collation and shelfmark notes. Transcribed as written:

[Margin: Shelfmark, upper left:]

Q 155 .K58 1865 JESUITANA

[Margin: Collation notes, center:]

I. Engr. title, (28), 346, [6][?] pp. Two portraits II. Engr. title, (10), 487, (9) pp.

19 engr. plates (12 fold. or double-page) 2 smaller plates (vol. II pp. 30, 384) 7 fold. tables slips with engr. volvelles (vol. I) at pp. 133, 154.

(one map at p. 71 (vol. I) a bit shaved)

[Margin: Lower edge:]

OCLC 52043805 RSR 4/1/03

These notes confirm the scan binds **both volumes together**: Tomus I (engraved title, 28 preliminary pages, 346 numbered pages, plus index leaves, with two portraits) and Tomus II (engraved title, 10 preliminary pages, 487 numbered pages, plus 9 leaves). The note "JESUITANA" indicates the copy belonged to a Jesuit collection.

**** — Free endleaf with faint pencil notes.** ****** Mostly blank laid paper. Faint modern pencil jottings at the upper corners only:

[Margin: Upper left, faint:] 5/93[?] [Margin: Upper right, faint:] Fst edition[?]
[Margin: Right, in pencil:]

4083V[?] aTzr/ex[?] w/TS[?]

No source text.

**** — Blank endleaf.**** Blank laid paper, no text or image. No content.

Diagram. Engraved allegorical title page (frontispiece title) of the work. The composition is dominated by a great radiant terrestrial globe at center, drawn as a sphere of fine engraved lines with landmasses sketched across its face, emitting rays in every direction. From a chain descending out of the clouds at the top hangs a winged emblem (an ouroboros-like serpent with outstretched wings). To the upper left a brilliant Sun blazes with long rays; to the upper right is a darkened, eclipsed orb (an eclipse of the Sun, or the Moon in shadow) also radiating lines. Banks of clouds fill the upper register, peopled by numerous putti (winged child-figures) and several venerable bearded figures (philosophers / personifications of the elements and natural forces) who gesture toward the globe. A hand emerges from the cloud at the very top, holding the chain. In the lower corners are two seated allegorical female figures: at lower left a woman in classical drapery holding an armillary or celestial globe (Astronomy / Urania); at lower right a seated woman holding a long instrument resembling a telescope or a torch, with a sword and other emblems at her feet. Across the center-bottom a large draped cartouche bears the title, and a scrolled banner at the very bottom carries the imprint.

A motto-banner unfurls across the middle register, beneath the winged emblem, in two scrolled halves:

- Left scroll: "Spiritus intus alit, totamque" [the spirit nourishes within, and the whole...]
- Right scroll: "infusa per artus Mens agitat molem" [...mind, infused through its limbs, sets the mass in motion]

(This is Virgil, *Aeneid* VI.726–727: "Spiritus intus alit, totamque infusa per artus / mens agitat molem" — "A spirit within sustains it, and a mind infused through its limbs stirs the whole mass.")

Title cartouche (center):

ATHANASII KIRCHERI E SOC. JESU **MUNDUS SUBTERRANEUS.**

[The *Mundus Subterraneus* of Athanasius Kircher, of the Society of Jesus.]

Imprint banner (bottom):

AMSTERODAMI, Typis Joannis Janssonii à Waesberge et Elizæi
Weyerstraet. 1665.

[At Amsterdam, from the press of Joannes Janssonius van Waesberge and Elizæus Weyerstraet. 1665.]

Engravers' signatures at the very foot, flanking the date:

- Lower left: "Jo. Paul. Schor delin. Romæ." [Johann Paul Schor drew (this) at Rome.]
- Lower right: "Theod. Matham sculpsit." [Theodor Matham engraved (it).]

[This confirms the edition: Amsterdam, Janssonius van Waesberge & Weyerstraet, 1665 — the first edition of *Mundus Subterraneus*.]

Diagram. Engraved portrait of the author. A bust-length oval portrait of Athanasius Kircher, shown half-turned to the viewer's right, wearing a Jesuit's biretta (clerical cap) and black cassock with a white collar. Behind him at right is a curtain drawn back to reveal a bookcase with volumes on shelves and a closed cabinet below; on a shelf rests an open book. The portrait is set within an oval frame bearing a circumferential inscription. Above the sitter's head, at the top of the oval, is the Jesuit emblem "IHS" surmounted by a cross. Below the oval is a scrolled cartouche with a verse legend and the author of the verse.

Oval-frame inscription (reading clockwise from top, around the oval):

P. ATHANASIUS KIRCHERUS FULDENSIS E SOCIETATE IESU ÆTATIS LXII
ANNO CIOICXLIV.

[Father Athanasius Kircher of Fulda, of the Society of Jesus, in the 62nd year of his age, in the year 1664.]

Cartouche verse (below the oval, in engraved italic script):

Frustrà vel Pictor, vel Vates dixerit, HIC EST: Et vultum, et nomen terra
scit Antipodum.

[In vain would either Painter or Poet have said "Here he is": for the land of the Antipodes knows both his face and his name.]

Attribution of the verse (lower right of cartouche):

Jacobus Albanus Ghibbesius, M.D. in Rom. Sapientiâ Eloq. Prof.

[Jacobus Albanus Ghibbesius (James Alban Gibbes), M.D., Professor of Eloquence in the Sapienza at Rome.]

Letterpress Title Page

ATHANASII KIRCHERI of the Society of Jesus

MUNDUS SUBTERRANEUS [*The Subterranean World*]

Arranged in XII Books;

in which

the divine workmanship of the subterranean world, the wondrous distribution of Nature's workshops [*Ergasteria*] within it — in a word, the all-shaping [Greek: *πάνταμορφον* (*pantamorphon*, "all-shaping," "of every form")] Realm of Proteus

and finally the whole Majesty and abundant riches of universal Nature are set forth in the fullest variety of things. The causes of hidden effects are demonstrated by keen investigation; and, once known through the union of Art and Nature, they are applied — by a varied apparatus of experiments, and also in a new manner and method — to the use necessary for human life.

TOMUS I. [Volume I]

To

ALEXANDER VII SUPREME PONTIFF

Diagram. An engraved allegorical vignette set within the title-page letterpress, below the dedication line to Alexander VII. At the center a female personification (Nature/Wisdom) is seated, draped, her right hand raised toward a radiance descending from the upper right; her head is encircled by a halo of stars. A short Latin motto is engraved in a band around her: "Sapientia Domina, sidere afflata sancto" [*Wisdom the Mistress, breathed upon by a holy star*] — the band-text is small and partly worn, read with some uncertainty [?]. To the upper left a radiant sun-face shines through smoke; below and around the seated figure are emblems of subterranean and natural philosophy: an alembic and furnace, glass vessels and flasks at left; a large terrestrial/sectioned globe at lower right; serpents, fish, and small creatures along the ground. In the right background, ships at sea and erupting/smoking volcanic mountains; a bare tree at far right.

- Center: seated female personification (Nature / Wisdom), haloed with stars
- Encircling band: "Sapientia Domina, sidere afflata sancto" [?] (Wisdom the Mistress, breathed upon by a holy star)
- Upper left: radiant sun-face amid smoke
- Left foreground: alembic, furnace, flasks, glass vessels
- Lower right: large sectioned globe / sphere
- Ground: serpents, fish, small creatures
- Right background: ships at sea; smoking volcanoes; bare tree

AMSTELODAMI [Amsterdam], By Joannes Janssonius & Elizeus Weyerstraten, In the year 1665 [cld lcc lxv]. *With privileges* [Cum Privilegiis].

Approbations

JOANNES PAULUS OLIVA [Gian Paolo Oliva] OF THE SOCIETY OF JESUS **VICAR GENERAL**

Since three theologians of our Society have examined the Twelve Books *On the Subterranean World* by Father Athanasius Kircher, a priest of our Society, and have approved that they may be published, we grant permission for them to be committed to print — if it shall so seem fit to those whom it concerns. In testimony of this we issue these letters, signed by our own hand and secured with our seal. Rome, 19 April 1662.

JOAN. PAULUS OLIVA.

Let it be printed, if it shall seem fit to the Most Reverend Father, Master of the Sacred Apostolic Palace. **OTTAVIANO** [Ottavianus], Bishop of Patras [Patracensis], Vicegerent.

Let it be printed, **F. RAYMUNDUS CAPISUCCUS** [Raimondo Capizucchi], Master of the Sacred Apostolic Palace.

Engraved Portrait of Pope Alexander VII

Diagram. A full-page engraved oval portrait of Pope Alexander VII (Fabio Chigi). The pope is shown half-length, facing slightly right, wearing the papal camauro (cap) and mozzetta with a buttoned cassock. The oval is framed by an inscribed border. At upper right, a putto (cherub) holds the papal tiara and crossed keys above clouds; in the right background, through an architectural opening, appears

a domed church with a smaller dome and lantern. At lower center, below the portrait, a cartouche bears the Chigi coat of arms (six mounds surmounted by a star, with an oak/tree element); two winged putti flank it holding garlands of fruit and flowers. A caduceus appears at left.

Inscriptions:

- Around the oval border (top): "IUSTITIA ET VERITATE" [*By Justice and Truth*]
- Border, upper left: "CREATUS APRILIS MDCLV." [*Created [Pope] April 1655*]
- Border, right side: "ALEXANDER VII PONTIFEX MAXIMUS" [*Alexander VII, Supreme Pontiff*]
- Lower cartouche: the Chigi armorial shield

Verse legend (engraved at the foot, in two columns of four lines):

Never did invincible Modesty clothe itself in mortal countenance, nor,
born of heaven, return to earth so [graced]; nor did kindly Wisdom more
fully unfold itself to the human mind, and offer itself to be cultivated; —
and seemly Justice, of its own accord lovely, the True: no beauty, unless
such as this, can please. While Peace, Counsel, and Right are demanded,
the World seeks in ALEXANDER the face of God.

[Reading of the verse legend is partly uncertain owing to the fine engraved script — several words read with low confidence [?]. Closing line abbreviated "PIE." [?].]

Dedicatory Epistle to Pope Alexander VII

**TO ALEXANDER VII, SUPREME PONTIFF, ATHANASIUS KIRCHER of the
Society of Jesus wishes happiness.**

MOST BLESSED FATHER,

While you, before the whole world, devote yourself to the majesty and august holiness of the City of Rome — while, with the most magnificent generosity, you both adorn and raise up from their foundations, at home and abroad, the churches of the most beneficent Mother of God and of your own Saint, Thomas of Villanova [Thomas of Villanova], that great bishop — while you inscribe the names of the pious in the new and happy register of eternity, duly bringing them to the altars with that authority which you alone on earth possess, first and supreme after God, and recording them in the sacred lists — you continue to deserve well of Rome, and best of all of the Heavenly City: that City whose

loftiness and solid wisdom we look up to in you, confirmed as it is by the laws and examples of ecclesiastical discipline. You let no single year slip away without commending it to memory by some heroic work, as though by a deed of living testimony.

I, meanwhile, am preparing a journey into the lower parts of the earth. There too I shall find some portion of your Apostolic kingdom, in that place where blessed souls, as if in exile, await your keys — the keys by which you may open to them the treasures of the Church, and supply them, as a kind of provision for the road, that they may reach their homeland the sooner. But that I may be allowed to set my foot fearlessly into the hidden recesses of that subterranean world, shut off from us and from the more secret Earth, I need your favoring star to bless the introductions I am planning. By its light I may describe those shadows clearly, lest the darkness trample me as I wander and labor in the labyrinth of the lower world — that is, as I turn a greater cask than Diogenes ever entered or turned. For since once the inner sanctuary of the temple, the hidden shrine, lay open to no one but the priest, I take you, the supreme Priest, as my guide. Under your auspices I shall enter that temple which God founded beneath this temple we inhabit, as a kind of shadowy basilica of his own marvelous nature and of his hidden works — and in it God placed the august darkness as his own hiding-place.

As I prepare to penetrate it, be present to me with your most blessed light, so that I may set these shadows of mine within the good light of your countenance. I shall search the bowels of the earth, and behold its dark gates, so that from what I glimpse within I may draw forth treasures of light. You once saw temples beneath temples in Germany, and now you see them in your Vatican. So, beneath the World a world lies hidden (as it were God's temple), and it holds no few mysteries — like the veins, as they call them, of hidden mineral ore and concealed gold. From this I must dig out the slight tribute of my talent, which I offer to that Genius and Wisdom of yours, so richly varied, as a token of the obligation by which you bind me too — since you love the least Society of Jesus as a father. And it will be the consolation of my return, when, brought back from the depths of the earth, I find again the Vatican square of Peter [Saint Peter], girded by your amphitheater; and the Chair of that same apostle, conspicuous at the head of the temple; and many other such things besides.

Deign therefore, MOST BLESSED FATHER, to look with the eye of your star upon this obscure gift; open your hand to receive the Book, and fill the Book's Author with your blessing. You who would not allow the statue decreed to you by the

Senate and People of Rome [S.P.Q.R.] — by this very act most worthy of the honors of the immortal and everlasting Capitol — admit these first shadows, or shades, of the Subterranean World; that in them the image of your most blessed Wisdom, and of your Piety useful for all things, may shine forth the more, and may make my shadows glow with the light of learning.

PRIVILEGE OF HIS IMPERIAL MAJESTY

Leopold, by the grace of divine clemency elected Emperor of the Romans, ever August, and King of Germany, Hungary, Bohemia, Dalmatia, Croatia, Slavonia, etc.; Archduke of Austria, Duke of Burgundy, Styria, Carinthia, Carniola, and Württemberg; Count of Tyrol, etc.

We acknowledge and make known to all by the present letters as follows. Our faithful and beloved Joannes Janssonius and Elizeus Weyerstraet [Janssonius van Waesberge & Weyerstraten], booksellers of Amsterdam, have most humbly represented to us that, for the public good of letters, they have committed to their press and undertaken to publish all the works of Father Athanasius Kircher of the Society of Jesus — both those already published, such as the *Ars Magnetica* [*Magnes, sive de Arte Magnetica*], the *Musurgia* [*Musurgia Universalis*], the *Ars Magna Lucis et Umbrae*, the *Obeliscus Pamphilius*, the *Oedipus Aegyptiacus*, the *Itinerarium Exstaticum Caeleste et Terrestre*, the *Scrutinium Physico-Medicum de Peste*, and other lesser pieces — and those still to be published hereafter, namely the *Mundus Subterraneus*, the *Ars Magna Sciendi* or *Ars Combinatoria*, the *Geographico-Physico-Politica Descriptio* of Etruria and Old Latium, the *China Illustrata*, the *Diatribes de Occultis Numerorum Mysteriis*, and the *Arca Noë et Turris Babel*. Fearing, however, that other printers, intent on their own profit, might by reprinting these same works in whole or in part deprive them — through fraudulent imitation and underhanded practices — of the fruit of their labors and expenses they hope for, they have humbly petitioned that we might graciously deign to provide for their indemnity in this matter by our Imperial privilege.

In keeping with our benevolent affection for assisting the cause of letters, we have been unwilling to refuse their most humble prayers. Accordingly, by the present letters we firmly forbid and prohibit each and every printer, bookseller, and any others who carry on the book trade, that none of them — within the bounds of the Holy Roman Empire and of our hereditary Kingdoms and Provinces, for the space of twenty years to be reckoned from the day of first publication — shall dare or presume to reprint the aforesaid works of Father

Athanasius Kircher, in whole or in part, by a similar or any other type or form or with the titles of the books altered; or to give them to another to reprint; or to bring in, sell, or distribute openly or secretly elsewhere any copy printed against the will of the said Father Kircher, the author, and of the aforesaid booksellers Janssonius and Weyerstraet and their heirs.

Should anyone, acting otherwise, attempt to scorn, violate, or transgress this our prohibition, we decree that he is irremissibly to be punished: not only by the forfeiture of such books — wrongfully reprinted and imported (which indeed the aforesaid booksellers, or with the aid of the local magistrate, may claim for themselves) — but also by a fine of ten marks of pure gold, to be paid in equal portions to our Imperial Treasury and to the use of the party or parties injured. This provided, however, that the said books contain nothing contrary to good morals or to the Constitutions of the Empire, and that they display the text of this our Imperial privilege printed at the front for public notice, and that the said booksellers transmit at least four copies, at their own expense and as soon as possible, to our Imperial Aulic Chancery.

We therefore command each and every one of our subjects and those of the Holy Roman Empire and of our hereditary Kingdoms and Provinces, of whatever station, rank, order, condition, or dignity they may be — ecclesiastical as well as secular, but especially those constituted in a magistracy, whether in their own name or in the name and place of their superiors administering law and justice — that they suffer no one rashly and with impunity to transgress or violate this our Imperial privilege; but rather that they take care to have any defiant persons whom they discover punished with the prescribed penalty and constrained by other suitable means, insofar as they themselves likewise wish to avoid the same fine. In testimony of these letters, which we issued furnished with the subscription of our hand and the impression of our Imperial seal, given in our Royal Castle of Pressburg [Pozsony / Bratislava], on the twenty-eighth day of the month of July, in the year of the Lord one thousand six hundred sixty-two, of our reigns the fifth of the Roman, the eighth of the Hungarian, and the sixth of the Bohemian.

LEOPOLD.

Wildericus, Baron of Walderdorff.

[Place of the seal.]

By the proper command of His Sacred Imperial Majesty,

J. Walderode.

PRIVILEGE OF CHARLES II

Charles II [Charles II of England], by the grace of God King of Great Britain, France, and Ireland, Defender of the Faith, etc. To all and singular who shall inspect these present Letters, greeting. Whereas Joannes Janssonius and Elizeus Weyerstraet, printers and booksellers of Amsterdam, have committed to their press and undertaken to publish a certain work of Athanasius Kircher entitled *Mundus Subterraneus*; and lest such an undertaking — which will be established at no small expense — should turn to their loss and detriment, were others permitted to print or imitate the same Book against their will: they have therefore most humbly petitioned that we might by our Royal privilege provide for their industry, by restraining at least our own subjects from the injurious appropriation of another's labor.

We indeed, in keeping with the affection with which we desire to embrace and promote Letters and the cause of Learning, have deigned to grant their just prayers. Accordingly, we forbid, and will that it be provided, that none of our subjects shall dare to print the aforesaid work of Kircher within our Kingdoms or Dominions, in a similar or other form, in whole or in part, for the term of the next ensuing decade, or to sell it printed elsewhere, without the knowledge and against the will of the aforesaid Joannes Janssonius and Elizeus Weyerstraet or their heirs. Whoever does otherwise shall not otherwise bear with impunity the contempt of our royal authority, but shall be fined with the confiscation of the books printed or imported contrary to the tenor of these presents — the same to be awarded to Janssonius and Weyerstraet or their heirs or agents toward the making good of the loss. Given at our Palace of Westminster on the fifteenth day of the month of August, in the year of the Lord 1664, and of our reign the sixteenth.

By command of His Sacred Royal Majesty,

Guil. Morice [William Morice].

[Privilege — Dutch]

Extract from the Privilege.

The States of Holland and West-Friesland have consented and granted to Joannes Janssonius and Elizee Weyerstraet, booksellers at Amsterdam, that for the term of fifteen successive years next to come, they alone in this country may print, have

printed, and publish all the works of Athanasius Kircher, whether in Latin, French, High German, or Low Dutch; forbidding all inhabitants of these countries to reprint, have reprinted, publish, or sell the aforesaid works in whole or in part, or to bring them, reprinted elsewhere, into the said countries, on penalty of [forfeiture of] the reprinted copies and of such a sum of money as appears from the Letters of Grant issued thereupon.

Done in the Assembly of the High and Mighty Lords the States of Holland, at The Hague, the 19th of January 1665.

Signed, Johan de Witt.

By Ordinance of the High and Mighty Lords the States of Holland.

Herbert van Beaumont.

PREFACE TO THE *MUNDUS SUBTERRANEUS*

Caput I.

On the occasion of this work, and on the author's travels.

The World plays as an organ vocal with its tenfold stops: as many measures sound in it as there are things that are. GOD is the harmost [master of harmony], in whom the Wisdom of the Father — which has ordered all things well — and Love, the πνεῦμα [Greek: pneuma, "breath" or "spirit"], make one. This love is harmony; by this love the World is bound together. Will you deny that this World is the ὄργανον [Greek: organon, "instrument" or "organ"] of the Divine?

So it is, kind Reader. This organ may, with the best right, be called the theme of this work, which we have entitled by the name of the Subterranean World. It is truly a harmonic organ, arranged and fitted by the workmanship of the most provident Triune Godhead in number, weight, and measure. For although it keeps the instruments of its operation hidden away in the innermost recesses and secret retreats of the Earth, yet through the dense subterranean tubes and pipes of an immense multitude it pours forth such modulations of sound, such a variety of the most diverse voices, that nothing within the compass of the sublunary World presents itself which is not steeped in a kind of sympathetic harmony — in its own number, its own weight, and at last its own measure. In twelve Books, then, as though furnished with so many stops, we comprehend this organ; and by them the whole Majesty and riches of Nature, with the greatest variety of things, are set forth.

In undertaking to expound this, I may well seem to commit a bold, indeed presumptuous deed, perhaps beyond a chest even of Hercules. For I am traveling in a far loftier chariot than that in which the mythologists tell of Proserpina once carried off by Pluto, into the hidden and unknown realms of the subterranean World, into the innermost sanctuaries and secret recesses of the Geocosmic Monarchy — by a road which, so far as I know, until now has been (I will not say attempted and trodden by [no one's] footsteps, but) not even penetrated by the conception of a human mind. To set out upon it less advisedly, I attempt. Yet I do not delay: I dare — I dare, I say, to enter upon and undertake the journey, undertaken not so much by my own will as persuaded by some impulse of the Divine Power I know not what, and extorted moreover by the prayers of illustrious men.

I know that, in the course of this enlightened age, there has been no lack of men distinguished by their cultivation of geographical study, who with truly outstanding effort — and with no less praise and the immortality of their name — have toiled tirelessly and at the greatest expense to set forth the external face of the Geocosm. Yet of those who might supply the one thing that seemed to be lacking — who might reach the internal Economy of the Earth and the hidden mysteries of latent Nature (I will not say penetrate them, but even attain them in thought) — no one has been found. Hence it came about that I turned the eyes of my mind, as much as ever I could, to the admirable Organ of the Earth's interior and to its structure — neglected until now, whether on account of the inaccessible hiding-places of Nature, or generally despised because of the insuperable difficulties in penetrating it. I had long since conceived this theme to be as rare, unusual, and excellent as it was most worthy of every effort of human genius to toil over.

Much, I confess, I had read in most writers of Natural History concerning the hidden marvels of subterranean Nature; yet I believed these things had been recorded not so much rightly and sincerely explored — for want of the writers' own experiment — as by a simple report to which little trust could be given. I sought the αὐτοψίαν [Greek: autopsian, "eyewitness observation," seeing for oneself] of each thing; I demanded this one thing as, so to speak, utterly necessary for carrying out the project I had conceived. Tossed about by this vast surge of cogitations, it happened that at that very time, by command of my superiors, I undertook a journey to Sicily and Malta in the retinue of His Excellency the Prince Friedrich, Landgrave of Hesse [Friedrich of Hesse-Darmstadt] — now a most worthy Cardinal — whose confessor I was. I interpreted this occasion as

supplied to me, as it were, by the providence of the Divine Power, and as wonderfully opportune for at last carrying my undertakings into execution. Nor did my hope deceive me.

Having entered Sicily, I attained precisely that theater I had so long wished for with all my prayers — Nature explaining herself amid a wondrous variety of things. For whatever occurs in the whole Geocosm that is marvelous, rare, unusual, and worthy of admiration, I found gathered together here as in a kind of epitome of sagacious Nature's industry. And so, kindled with an immense desire to explore each thing, on a notable [galley] of the Maltese [i.e. *Melitensium* — of the Maltese galleys]

of those living there. With the Landgrave of Hesse, then Admiral of the fleet [Architalassus], ardently encouraging my undertaking out of the affection he bore toward me and my studies, I pursued my plan. Before all else, I climbed **Etna** [Ætna] — the thing I had most longed for — the source of all the prodigious effects that display themselves throughout Sicily, so that I might verify by my own experiment and αὐτοψία [Greek: αὐτοψία (autopsia), "eyewitness observation"] the marvels that historians of every age had written about it. Next I explored the **Aeolian** or **Hephaestian Islands** [Æoliae sive Hephaestiae Insulae, the Lipari Islands], and above all **Strongyle** [Strongylus, Stromboli] and the island they call **Vulcano** [Vulcanus]. I also explored — over a three-day investigation, with the utmost diligence — the **Mamertine Strait** [Fretum Mamertinum, the Strait of Messina], no less dangerous for its incredible reciprocations of tides than infamous for its shipwrecks. Moreover, at the famous Scylla and Charybdis, I examined the strange motions, the alternating cycles of boiling, and the causes of each individual symptom — wholly consonant, as it were, with my undertaking — with a great ferment of mind, perhaps no less violent than the surging of Scylla itself. Whatever astonishing things came up in each case, I committed to my notebook [palimpsesto], and once home again, I weighed them, measured against the exact balance of reason. The reader will find these described most fully, in the appropriate places, in the course of this work, as confirmation of the task I have undertaken.

When all these things had been duly observed, it pleased the Divine Goodness to open to me another theater — a fearful one, utterly filled with calamitous and tragic events — for no other purpose, so far as I can tell, than that, having seen the ineffable power of an angry Deity at work in Nature, I might enlarge my argument with an abundant harvest, not merely with the kind of things that would soothe the itch of an over-curious mind, but with things that would

implant the fear of GOD and the hidden abysses of His judgments in the innermost marrow of the heart. For while, having completed my observations by land and sea and being about to return to Rome, I was waiting for a suitable occasion to set out on my journey, I do not in fact know by what providence it came about that, detained at Messina against my own will for so long a time, and amid so many and so manifold opportunities to depart, I nonetheless — stripped of every opportunity — always held back. And just as we cannot sufficiently marvel at the hidden paths of Divine providence, by which He leads improvident mortals with more than fatherly care and solicitude, so too we are by no means permitted to investigate them, since they lie utterly beyond the limits of human understanding. Yet the light of truth first dawns upon us at that moment when, rescued from various

turns of events and from various perils of circumstance, we turn the inner eyes of our mind toward His immense goodness and mercy, by which alone we are sustained. This was made plainly evident by the delay I have mentioned in the port of Messina. It clearly appeared that GOD, the Best and Greatest [Deum Opt. Max.], had willed me to be not only an eyewitness of the evils that were soon to follow and were already all but imminent, but also — for the glory of His own name and as a trial of my faith — in some measure a sharer in them, so that those calamities, the like of which no past age has read to have befallen either Asia (when its twelve principal cities once collapsed) or Italy, I might not only relate in my writings but also, from my own experience, testify to — concerning the perils and the agonies of imminent death of those who find themselves in a like condition. For within a brief span of time nearly the whole portion of Hither Calabria [citerior Calabria] was reduced to desolation. And so this is how the matter stood.

CAPUT II.

On the dreadful earthquakes that arose in the year 1638 in Calabria, in the presence of which — over a span of fourteen days, and at great peril to his own life — the Author was present, and on whose occasion he learned great secrets of Nature.

In the year 1638, then, together with two religious of the Third Order of St. Francis [tertii Ordinis S. Francisci] and two other laymen, having hired a small boat, we set sail from Messina on the 24th day of March. That very day we reached the promontory of Pelorus in Sicily [Pelorum Siciliae promontorium], where, holding out for three days, we struggled with every kind of misfortune — so much so that all the assaults of the place and of the air seemed to have conspired against us. All these things were, as it were, the foreshadowing scenes

[proscenia] of the tragedy to come. Once and again we attempted to depart, but in vain; always driven back to the same place, partly by an unwilling sea and partly by the hidden hand of GOD (as later became clear) holding us back, we turned back. Had this not happened, all of us would have remained buried at S. Euphemia [Santa Eufemia], where we were hastening and where we had thought to stop a little while on business. From this wondrous disposition of Divine providence we learned how often a man does not know what he asks for, and how vain and fleeting are men's plans unless they are submitted to and sustained by the Divine will. And so, at daybreak on Palm Sunday, which was the 27th of March, weary of the long delay, we

set out on what was almost a forced departure. That very day the sea was surging beyond its custom, and it was driving huge whirlpools in a spiraling downward plunge, chiefly around the place of Scylla, so infamous for its many shipwrecks — so that the unusual sight struck terror not only into us but into most of the sailors as well. Since the sea's swell was thus against us, we steered our skiff [phaselum] toward Tyndaris or Mylae [the Tindari / Milazzo coast], so that from there, with the Euronotus [the south-southeast wind] driving us on, we might be carried by a shorter and straighter passage across the **Gulf of Cuja** [Sinus Cujacius] to the shores of Calabria. But when we reached that point of the sea which lies almost midway between Lipari, Mylae, and the **Vatican Promontory** [Promontorium Vaticanum, Capo Vaticano], I, gazing more attentively at Etna and Strongyle, noticed that they were belching forth, beyond their custom, those huge globes of smoke, like mountains. As these spread far and wide, the view not only of the Lipari Islands but of Sicily as well was entirely taken from our eyes. The horror was heightened by certain subterranean bellowings, as it were, which we perceived, and by crashes accompanied by a sulphurous odor — which, whispering I know not what fateful and deadly thing, seemed to have conspired by unanimous agreement toward the destruction of all Calabria and Sicily that they were preparing.

Terrified by these forerunners of impending calamities, I kept urging the sailors by every means and entreaty I could, that they should leave the Liparitan shore and make straight for the Vatican Promontory — adding that we were in great danger of being swept away by the sea's swell and of setting out on a journey from which there was no return. For though we were close to Strongyle, we nonetheless could not see it, veiled as it was in smoke; we only sensed the crashes, together with the heavy sulphurous stench it exhaled. Moreover, we all marveled that the sea itself was boiling and churning in the manner of boiling water, especially since the sky was silent and clear with serenity, and that it was

undergoing other unusual alterations of this kind. Anyone who has ever seen a lake in time of rain, seething with countless little bubbles, will be able to form a judgment from this of the boiling sea's fervor at that very moment. Furthermore, when we had now drawn near to the Vatican headland, and these same symptoms of the sea still persisting, I — as if sensing the calamities to come, out of an unaccustomed anguish of mind that gripped my spirit — openly foretold to my companions that a great earthquake would soon follow. Indeed I greatly feared that this whole tract of overhanging crags might be cast down and collapse, and therefore that we should not approach it too closely. The outcome proved my foreboding right: for after about two hours we heard that a great part of this Promontory, together with the neighboring

dwellings, had collapsed. Meanwhile, continuing our journey, we all came safe to **Tropea** [Tropaea], at last, and with the greatest joy — unaware of the perils we had just barely escaped a little earlier in the seething sea; only now, for the first time, were we beginning to be harried, and even though we were close to death we could not so much as suspect it, since the sky was clear and without the slightest cloud. But truly, scarcely had I crossed the threshold of our College when, behold, there came a subterranean sound and din — fearful, like that of chariots driven at top speed — and an earthquake so violent and horrible followed it that the College, together with the town and the mountain beneath it, seemed to be balanced as on a scale. The earth heaved with so violent a motion that I, no longer able to keep my feet, was suddenly dashed to the ground and thrown down on my face — running into the very thing I had earlier foreseen in my mind. Ceaselessly, with my life now given up for lost, I commended my soul to GOD. Oh, how in this point of anguish all the joys of the World grew worthless! How, in one blink of an eye, all honor, dignity, power, wisdom seemed to be nothing but smoke, a bubble, a stalk snatched away by the wind! — while, standing in the gateway of eternity, I was preparing to send forth my soul, freed from the bonds of the body, to take up the enjoyment of incorruptible life. And this would surely have happened that very moment, had it not seemed good to GOD, the Best and Greatest, to preserve me by His singular grace from the ruin of the walls, and to destine me to endure harder things for the honor and glory of His Name.

In this struggle of mind, both the crashes of the falling roof-tiles and the cracking of the splitting walls struck me with enormous dread, while I could not make out where to flee or on what side I might save myself, with ruin on every side now threatening me from the walls. Yet, having regained my courage, I escaped — though so dazed that, when I had come back to myself, I found myself without hat

or cloak. Once these had been recovered, I fled the town without delay and betook myself to our boat. Both our Fathers and all who accompanied me labored under this same consternation of mind, while each one, anxious for his own safety, busied himself as best he could in providing for the flight of his own life [vitae fuga] — like men struck dumb and deprived of all use of voice. On the following day, which was Palm Sunday, we continued our journey, and with the sea seething and swollen in a marvelous way we reached **Rochetta** [Rochetta]. But once we had disembarked, the earth's fever flared up again and shook it with so great a paroxysm that the boat, on account of the great danger which

the unbearable fury of the earth threatened us once more. Nearby stood a house suitable for receiving traveling guests, and we withdrew into it to gather a little rest. But as the earth's tremor flared up again, I—sensing the vast ruin that hung over us—declared openly: whoever wishes to secure his life, let him make for the shore with me. Moved by these words, my companions left the house at once and followed me. We had been allowed to linger on the shore scarcely half an hour when, behold, the earth raged again with even greater ferocity than usual. With a violent shock it struck many of the surrounding places, including the very lodging we had abandoned a moment before, and threw it down, leaving behind nothing but a heap of stones and lime. We therefore gave the greatest thanks we could to the Divine Majesty, who had snatched us from so imminent a danger through hidden promptings.

While we were searching for a place where we might keep ourselves safe and secure from the earth's great rage, we pressed on farther and reached Lopizium, the fortress that lies midway between Tropea and Saint Euphemia. There, while we waited for favorable winds with which we might cross the gulf, an indescribable terror was struck into us: on one side the sea boiled up in whirlpools, on the other lay an enormous wreckage of castles and villages, and we did not know which way to turn. While we were tossed about by these calamities, I, looking rather curiously at Strongylus [Stromboli], some sixty miles distant, noticed it raging in an unusual way: it appeared wholly filled with fires, in such abundance that it seemed to belch up whole mountains of flame—a spectacle dreadful to see, and one to be feared by even the most fearless spirit. Meanwhile a certain sound, like thunder, was heard—somewhat duller on account of the remote distance from which it arose—yet it took on an ever greater and greater increase within the subterranean passages, until it reached the underground spot on which we stood. There it shook the earth with such a roar and indignation that, unable to keep our feet any longer, each of us was

forced to grab whatever shrub or seaside bush was at hand and hold himself up, lest his limbs be wrenched apart by the excessive shaking.

In this same hour there occurred something worthy of eternal and immortal memory: the overthrow, namely, of the most famous town called Saint Euphemia. It was situated on the farthest shore of the gulf, under the jurisdiction of the Knights of Malta [the Knights of Malta]. And so, when at Lopizium we had been laid out flat upon the ground by the violent heaving of the earth, like men lifeless,

and finally, as Nature's paroxysm subsided, we cast our eyes upon the surrounding places and saw that the town just mentioned was enveloped in a huge cloud. This indeed seemed strange and unusual to us, especially since it was three hours past noon and the sky was clear. But as the cloud gradually dispersed, we looked for the town and did not find it—marvelous to tell—a most foul lake having sprung up in its place. We searched for men who might tell us something certain about the unheard-of event, but we found no one to report this dreadful disaster and so great a destruction. The sailors, as if thunderstruck at this spectacle and seized with incredible terror, threw down their oars, beat their breasts, and implored the Divine Mercy, expecting that any day they would meet either the same fate or the day of the Last Judgment. At last, comforted and cleansed by the sacrament of penance, with God as their guide they held their course amid the swelling waves of the sea to the opposite shore. There, having disembarked, we again searched for people, but apart from a boy sitting on the shore as though struck dumb with stupor, no one was found. When we asked him what had befallen Saint Euphemia, we extracted nothing from him, for he spoke not a word; so violent was his fear, and the event so frightful, that it had stunned both his tongue and his mind, so that we could not win over his spirit either with words full of compassion or with any act of charity. Overwhelmed by excessive grief and sorrow, he turned away entirely from all the food we offered him, and only by stretching out his fingers did he seem to point to the catastrophe of Saint Euphemia. Devoid therefore of all consolation, with a downcast face and like a man who had lost his mind, he withdrew from us and rushed off into the nearest wood, never to be seen again.

Continuing on our journey, we passed through Nicastrum [Nicastrol], Amantea, Paula [Paola], and Belvederium [Belvedere], and for two hundred miles we found nothing but the corpses of cities and the horrendous wreckage of castles, with people wandering scattered through the open fields and as if withered with fear—you would have said that the day of the Last Judgment was already, even now, at hand. Having seen these things to our great astonishment and grief, at last—

amid the enormous dangers of the seething sea, and by a truly unhappy voyage—we reached Naples [Neapolis]. What then happened to me, I shall set forth for the reader in a few words in what follows.

PRAEFATIO

CAPUT III.

On the exploration of Mount Vesuvius and of the other islands, made by the author.

After such great perils endured by sea and land, and after I had explored the incredible power of Nature working in her subterranean passages, a great desire came over my mind to learn whether Vesuvius too shared some commerce of hidden dealing with Strongylus [Stromboli] and Etna in so mighty a war of Nature. I went to Portici [Porticum], a town situated at the foot of the mountain. From there, with a faithful peasant guide who knew the roads—hired, to be sure, at a generous wage—I climbed the mountain in the middle of the night by difficult, rugged, and steep paths. When I had at last reached its crater, I saw—horrible to tell—the whole of it lit up with fire, together with an unbearable stench of burning sulphur and bitumen. Utterly astonished at this unaccustomed sight, I believed I was gazing upon the dwelling-place of the underworld, in which nothing seemed to be lacking except the horrible apparitions of demons. Dreadful bellowings and rumblings of the mountain were heard, an inexplicable stench, smoke mixed with darkish globes of fire, which both the floor and the sides of the mountain belched up continuously from eleven different places. Again and again they compelled me to utter that cry: *O the depth of the riches of the wisdom and the knowledge of God! How incomprehensible are thy ways!* If you display your power against the malice of the transgressing human race through such fearful portents of Nature, what will it be on that last day, when the earth, submerged in the wrath of your fury, the elements shall be dissolved with heat?

And so, as dawn was breaking, in order to explore the constitution of the whole interior of the mountain with all the diligence I could, I chose a safe spot, secure for planting my footsteps firmly: it was a huge rock with a flat surface, to which there was some access down the slope of the mountain. I let myself down there, and, taking out my pantometer [Pantometro], I began the measurement of the mountain. By geometric reasoning I found the circuit of the crater to contain nearly three hundred paces, and its depth eight hundred paces. The mountain was sheer on every side; with no incline given by which access to the interior

might lie open, it descended in its circuit in the form of a hollowed cylinder, πρὸς τὰς ὀρθάς [Greek: *prós tās orthás*, "at right angles"]. And although the floor seemed to our eyes to be enclosed within a narrower perimeter,

this nevertheless, according to the principles and laws of optics, came about only from the very great distance and depth measured from the innermost surface of the crater. At the center of the floor Nature seemed to have set up, as it were, her own hearth—truly the workshop of the Vulcanian kitchen, kept blazing by an everlasting outpouring of smoke and flames, busy with the boiling down of sulphur, bitumen, and the other kinds of minerals, with the melting and burning of them, and—by some hidden contrivance—soon to bring forth deadly destructions. For the vapors shut up within, since they cannot bear to be confined, with such force and violence, joined to dreadful crashes, shook off the burden imposed upon them, so that the mountain seemed to be agitated by an earthquake. Whenever this happened, the softer upper parts of the mountain—which were compacted out of ash, rain, and the other refuse of minerals—were shaken loose by the tremor and, collapsing like hills into the bottom of the abyss, set off, by the varied reflection of sound, such a crash as scarcely any man, however undaunted of heart, could endure.

The matter that was belched up continuously from the center of the mountain formed, as it were, a new mountain, endowed with a marvelous variety of striations. The varied bubbling-up of the liquefied minerals shaped these, by its flow into all the parts of the circumference, with Nature's ingenious brush, in colors now green from copper, now tawny from sulphur, arsenic, and sandarach [realgar], now red from cinnabar and minium [red lead], now black from vitriol mixed with water, or ashen-gray from the very ashes themselves. But the reader may consider all this in the figure provided. This little hill had grown so much after the last eruption of the mountain, which occurred in the year 1631, that one might conjecture from it that it would someday rise again to the same height it once held—unless it should be destroyed by another eruption supervening; which in fact happened in this very year in which I write this, 1660. For the mountain, raging with a new and dreadful eruption, so scattered the summit and crater of the mountain that today it appears much lower than as I described it a little while ago, and consequently it is found to be of greater circumference but of lesser depth.

When all these things had been duly examined, I returned to Naples. On the following day I betook myself to the island of Aenaria, which they also call Ischia, most famous in the renown of the ancient writers, and from there to the

Phlegraean fields of the Puteolan plain [the Campi Flegrei, near Pozzuoli] and the Forum of Vulcan [the Solfatara]. Whatever marvels both the ancients and the moderns have reported about those places,

I have found these accounts to be utterly reliable, but I will not waste space rehearsing them here; the reader will find each of them inserted at its proper place in the course of this work.

Once I had observed all the prodigies of Nature's works recounted above, together with the subterranean effects I have described, I began to turn over continually in my mind what force in the subterranean economy could be the author of such great and powerful things. And not infrequently, in my own heart, I would smile quietly at the opinion of those misled by a false persuasion — those who too simply suppose that the mass of the Geocosm was fashioned by God the World-shaper [Geoplasta] out of the slime of the Earth by a chance or random heaping-up of mud, rather than formed and compacted according to a fixed plan. They imagine it stripped of every interior arrangement of chambers, devoid of every use of Nature's storehouses, lacking every channel of its aqueducts — that it merely settled after the Flood, condensed out of slime and mud like some curdling of cheese, consolidated into a kind of useless, dead weight of the Earth, like an ἐτώσιον ἄχθος [Greek: etōsion achthos, "a useless burden" — a Homeric phrase], an idle mass. By I-know-not-what stubbornness of mind they wrongly persuade themselves of this.

But to those who recognize both the Majesty of the divine works and the providence in the sublime ends established by Nature — these will indeed admit that the inner fabric of the Geocosm has a constitution far different from the common conception of men. For in it the eternal Wisdom of GOD, when it laid the foundations of the globe of the Earth, sported with an ineffable ingenuity: working it out with that marvelous art, arranging it duly according to the architectonic measuring-line [amussis], and disposing the elements into innumerable receptacles for all the necessary uses of the whole of Nature. God labored to establish this fabric with no less care than that of the human body — distinguished by the workshops of so many vital members, equipped with the channels of so many veins, nerves, fibers, and muscles, and bored through with so many hidden siphons of its passages.

For this reason, spurred on by the usual ardor of a striving mind, I left no stone unturned, so that as far as possible I might penetrate more deeply into the constitution [syntaxis] of the things lying hidden in the subterranean realm of Vulcan — a thing so abstruse. Not at all content with what I had so far observed

myself, I drew out whatever bore upon the form of the terrestrial globe and the nature and properties of particular regions from the records of geographical reports. I gathered the ancient and modern Authors of Europe, Asia, Africa, and America — Historians, Natural Philosophers, Geographers — and the

undertaken endeavors of their oceanic expeditions around the whole globe of the Earth; and with equal care I weighed intimately whatever prodigies of nature had been discovered in finding new Regions and unknown seas. To these was added a most rich resource of reports made by our Fathers, arriving here at Rome from the Indies every three years: whatever things worthy of admiration they had seen and explored by land and sea, they set down in writing and, with a truly generous spirit, communicated to me, who was eager for such things. From contemplating these matters, it can scarcely be told how great an admiration seized my mind at the marvels — both those tested at my own peril and those received from others by reports not unworthy of my own — and how ardent a desire to inquire into their causes followed upon that admiration.

And so, when I had brought the particulars one by one to the anvil with the help of the Combinatorial Art [*combinatoria Ars*], and as I continually rose higher by the ferment of a studious mind, I at last undertook a subject perhaps until now untried — that is, the fabric of the Subterranean World. Having conceived it duly, so far as the weakness of my talent permitted, long since promised to the Republic of Letters and hindered by the manifold obstacle of delays, I have at last brought it forth into public light, to the glory of the Divine Majesty and the benefit of the common good.

In exploring all these things, my one purpose set before me has been the Glory of God: namely, that all things should be led back there, to GOD the Best and Greatest, whence, as from the origin of all good things, all things have flowed — to Him who is forever praised, blessed beyond measure, and loved for everlasting eternities by the affection of all possible Creatures. Farewell, Reader, and look kindly upon what I have begun.

PRAEFATIO SECUNDA

In which mention is made of those who, by their distinguished contribution of various observations, lent their labor to this Work.

When, at the prayers of many, I had taken up the care of this Work, and stood in need of resources for establishing — by legitimate authority — so many and such prodigious offspring of Nature (which present themselves to be seen, I will not say in the farthest shores of the Indies only, but in every single Province of Europe), I judged that I would be doing something worthwhile if I dispatched letters to the chief Provinces of Europe, and above all to the most expert men of our Society [the Jesuits]. In these letters, having explained the design of the Work I had undertaken, I asked that, if anything lay hidden in their regions — in waters, mountains, caves, rivers, mines, herbs, or animals — that was unknown elsewhere, or worthy of admiration for some exotic property of Nature, they would not find it burdensome to transmit it to me in writing, whether report or fact. And indeed, once the plan of the Work I was attempting had been perceived, each of them did not disdain to lend a helping hand, as it were as midwives to the birth, with all the care and diligence they could. So I too might not unjustly seem ungrateful if I were to pass over in silence the labor they bestowed for the benefit of the common good. For this reason it has pleased me to set down their names, here in the very forecourt of this first volume, to consecrate them to immortality.

FERDINAND III [Ferdinand III, Holy Roman Emperor], of glorious memory, ever-august Emperor of the Romans, who — by his wisdom and by that breadth of universal learning by which he shone before the World — was the first promoter of this Work, and did not cease to encourage me, however unworthy, toward the execution of the undertaken Work, both by his letters and by his monetary support. Following him, the imitator of a talent not unlike his own and of his father's virtues, and his successor in the Empire, **LEOPOLD I** [Leopold I, Holy Roman Emperor], Augustus — a wise Son — took up anew the web of the work left unfinished by the death of his most glorious Parent, and at last by his command and continued support brought it to completion, with the most serene Archduke **Leopold Wilhelm** [Leopold Wilhelm of Austria] acting as intermediary, who, out of his singular affection toward me and my

pursuits, devoted himself uniquely to this — that nothing should be lacking of those things that were necessary, both for the publication of my Works and,

above all, for preparing the Work of the *Subterranean World* for the press. To these, deservedly as the first and most munificent Patrons of my studies, if anything worthy of praise has come from me over the course of twenty years for the good of the Republic of Letters, I would wish a grateful posterity to credit it to their account.

To these was added His Eminence **Francis George** [Johann Philipp von Schönborn? — *recte* the text reads "Franciscus Georgius"], Elector of the Holy Roman Empire and Archbishop of Mainz; as well as **Charles Louis** [Karl Ludwig], the most serene Elector Palatine of the Holy Roman Empire, who did not cease to press forward the design of the work once begun with truly abundant resources. Following their example, the most serene and august Duke of Brunswick and Lüneburg, as well as the Primate of Hungary, **Ferenc Lippay** [Ferenc Lippay], Archbishop of Esztergom; then the most excellent **Bernard, Count of Martinitz** [Bernard Ignác Martinic], of the Holy Roman Empire, most deserving Burgrave and Viceroy of the Kingdom of Bohemia for the time being, together with his Brother **Maximilian**, who holds the second rank of dignity in the same Kingdom — with signal generosity they promoted and furthered this work at every season. When the most serene Archduke **Ferdinand Charles** [Ferdinand Charles of Austria, of Tyrol] had heard of these efforts of mine, he ordered that whatever was most intimate in Tyrol be collected and transmitted by his councilor.

Following these came the Fathers **Andreas Schaffer** and **Johannes Eiffert** of our Society. These transmitted whatever curious, rare, and unusual thing could be desired in the mineral mines of Hungary, sought out everywhere with incredible care and diligence in support of the work, and confirmed by the authentic attestation of the Prefects of the mines. By their labor not only this present Work, but also my Museum — enriched with the most diverse species of all minerals — will be able, together with the *Subterranean World*, deservedly to boast (as will appear in its proper place) as if of a most rich treasury. What support the Fathers N. N. — who came here to Rome from the Indies on business — contributed toward the perfection of the work, namely Father **Martin Martini** [Martino Martini], Father **Francis d'Orville** [François d'Orville], Father **Hyacinth de Magistris** [Giacinto de Magistris], Father **Philippe Marini** [Philippe Marini], and several others — Frenchmen, Spaniards, Portuguese — will be made manifest in the course of this work, where I shall bring forward the names of each. To all of these, as is fitting, we give the greatest and undying thanks.

But for myself — since I am so constituted by nature that, in the things handed down by Authors concerning the powers and prodigies of natural things,

[I am] so constituted that I do not readily give credence to the things handed down, unless either reports communicated to me by men of the highest trustworthiness, on indubitable testimony, or my own experience and the sensory inspection of the things themselves, render them entirely certain. To attain this certainty, it can scarcely be told how much time has had to be expended now over many years, how much expense incurred, and finally how many labors endured — while various journeys had to be undertaken to examine with my own eyes the prodigious works of nature themselves, while the hidden recesses of the mines had to be penetrated, the deep lurking-places of the subterranean bowels [of the earth] explored, the volcanic workshops [ergasteria] of Nature approached, and the quarries of stones and rocks examined. So nothing that seemed in any way conducive to the solidity of the work was left undone — lest there happen to me the same thing that happens to those authors who write about the differences of stones, gems, metals, and the other fossils, and about the most diverse species of plants — things not even known to them by name — and write, not to say describe, with futile and ill-considered labor.

I therefore took as my masters the men most expert in the said matters: the chemists themselves, I mean, the goldsmiths, the gem-cutters [gemmarii], and indeed the miners [fossores]; and those whom I could not have present with me, I undertook to consult by letter about the difficulties that arose. Made more learned and more refined by their instruction, I found by experience that I could philosophize about the hidden marvels of things on a somewhat more solid foundation. And so I would have you persuade yourself, reader, that nothing concerning hidden causes occurs in this work that has not been confirmed by experiments performed by me. For — moved by I know not what instinct — I firmly persuaded myself that I could then be said to have attained the innermost causes of natural things if, by art, I could produce in those matters the very prototype, true to life, of what nature does by the faculty implanted in her — in those things, that is, in which Nature suffers herself to be imitated. In this, unless my own φιλαυτία [Greek: philautia, "self-love"] deceives me, I have at least accomplished it according to my own small measure: so that, if I have not overcome the rock [scopulus] of the difficulties that arose by penetrating to its core, I may at least seem to others to have opened access to the proximate causes of things by paths now leveled and made smooth.

Perhaps there will be some other man, blessed with a happier portion of talent, who by the guidance of this Ariadnean thread [Ariadnei fili] will in due time open up the deeper sanctuaries of truth. As for me, what I could and ought to do

according to the weakness of my talent — in keeping with the talent entrusted to me by the Father of lights — I have accomplished.

And let no one persuade himself that I have written this with any end other than that single one which is the glory of God, who is wonderful in his works. But if from this work anything of praise, or of unfavorable censure, should arise against me, I am unconcerned; since I seek no other reward for my labors than Him who is "a reward exceeding great" [merces magna nimis] and the hope of all the ends of the earth. Farewell.

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LIBER PRIMUS — CENTROGRAPHICUS

which is also called CENTROSOPHIA.

Section I.

On the wonderful Nature of the Center and the supreme Workmanship of God.

PREFACE.

[Margin: De Natura Centri — On the Nature of the Center.]

As I set about bringing the wonders of the Subterranean World to light, it seemed right to begin the foundations of my discourse from the Center — since that is, not without reason, recognized to be the basis and foundation of all things. For just as in the whole fabric of the Corporeal World, infinite divine power shines forth in the order and arrangement of created things, so in the construction of the Center the wisdom of the Maker shines forth as most especially admirable and inexhaustible. Hidden within it is something — I know not what — utterly admirable, rivaling (so to speak) divinity itself, in which the greatest most closely coincides with the smallest: for it folds together all the bodies that shine throughout the whole vast extent of the World, draws them all into itself and compresses them, and unfolds them all outside itself again. It is truly an admirable work, the work of the right hand of the Most High, founded by no power save that of Almighty God. Just as He drew forth from the center all the offshoots of the world's framework, so into that same center He brings all things back; and He willed all things to be bound to it by a law so constant, by so great a binding-together of bodies, that it would be easier for the framework of the whole World to be dissolved than for bodies to be removed from this law, once it was established by the ineffable disposition of divine providence.

To this Center all the Systems of the heavenly globes look first of all, since by their perpetual revolution they point to nothing other than that without which they would seem to have been produced by God in the nature of things in vain — destined never to yield any effects of their influences. The System of the Elementary World has so necessary a dependence on the Center that without it the system could obtain neither any operation in the efficient action of things, nor

any energy in the propagation of generable things. And although this Center is — on the testimony of Proclus — ἀόρατον καὶ ἄτομον [Greek: *aoraton kai atomon*, "invisible and indivisible"], that is, the very smallest thing, inconspicuous and individual, yet it is so great in its power that it supports all things, preserves all things, animates all things, and strengthens all things. Without it there is no order of things, no efficacy of the elements; without it, in the subterranean World, no increase of mineral nature, no vegetative power, no operation of the sensitive faculty would attain its end. In a word, the World would be utterly compelled to pass into nothing. And lest we should seem to the Reader to be putting forward ἄπιστα καὶ παράδοξα [Greek: *apista kai paradoxa*, "incredible and paradoxical things"], we have resolved to demonstrate all that has been said thus far in the course of this Centrosophy. And so that we may proceed by a more solid method, we shall first set down the Definitions, Axioms, and other things necessary for forming a complete art.

DEFINITIONS.

[Margin: Definitiones — Definitions.]

1. The midpoint of the Universe is a point.
2. The midpoint of the Universe is immobile — it is what is called the Center of the World — and all things seek it.
3. The center of gravity of any heavy thing is the midpoint of that same heavy thing.
4. The center of magnitude is the midpoint of any figure whatsoever, through which the figure, however it be cut, is always divided into equal parts.
5. The center of Virtue [Centrum Virtutis] is the midpoint of a physical body, from which its virtue exerts itself most strongly.
6. The line of direction [Linea directionis] is that which directs the motion of heavy things, and is understood to be drawn from the Center up to the vertex, through the Center of the heavy thing.

CAPUT I.

Explanations of the Definitions.

[Margin: Quid sit Centrum — What the Center is.]

DEFINITION I.

The Center is the least and first point in space, simple, devoid of all composition and division, neither a whole, nor a quantity, nor great, nor commensurable with any quantity; yet it is that which all heavy things naturally seek, and toward which all light things are borne upward.

I demonstrate this whole matter κατὰ τὴν διάλυσιν καὶ σύνθεσιν [Greek: *kata tēn dialysin kai synthesin*, "by analysis and synthesis"] as follows.

If the central point is not the least in space, then something smaller than it can precede it in space; but this is impossible, since nothing smaller than a point can be assigned. It is therefore the least in space, and consequently the first; if first, then it will be simple; if simple, then devoid of all composition; if devoid of all composition, then indivisible; if indivisible, then it can be called neither a quantity nor a whole, since it lacks parts; if neither a quantity nor a whole, then neither great; and because not great, it will be neither greater, lesser, nor equal; and consequently it ought to be called neither a measure, nor a thing measured, nor commensurable with a quantity. Therefore, conversely, because it is commensurable with no quantity, it can be compared with no quantity; and since it is not comparable with a quantity, it cannot be a quantity; and since it is not a quantity, it is not divisible; and since it is not divisible, it is not partible; and because it is not partible, it is not a whole; and because it is not a whole, it has no parts; and because it has no parts, therefore it is simple; and because simple, therefore the least and first in space; and because it is first in space, therefore it has a situation in space; and because it has a situation, it also has a position in space, and consequently it asserts a relation to the points, lines, angles, surfaces, and bodies that are in space. From this arises that paradox.

The Center of the World, although it is a point, is nevertheless in a certain way commensurable with a periphery of any size whatever — so that the circumferences and surfaces even of any greatest Circle may seem to be contracted into a single, as it were, Central point, according to all their parts, and to be commensurable with it. For, on the testimony of Proclus, the circumference is joined on every side with the Center, and forces and contracts all its parts into the Central point. For if from some point an infinite number of concentric circles be described, and from the greatest of all the circles lines be drawn through all the intermediate ones to the Center from which they were described, it is certain that the smallest circle, than which no smaller can be drawn, coincides with the Center. So that from this very consideration you may recognize the necessary dependence of the Center upon the circumference — such that you can conceive

neither the Center without the circumference, nor the circumference without the Center. For since divine Wisdom unfolded the sphere out of the Center, take away the Center and there will be no unfolding of bodies; if no unfolding of bodies, there will be no amplitude of the World; if no amplitude, there will be no arrangement of worldly bodies in the world, no order, no influence, no motion. And since all these things are absurd, all things therefore are ordered toward the Center from which they were unfolded. The Center, then, is what all things seek; the Center is what all things encircle; the Center is what all things regard, inasmuch as it is utterly necessary for the conservation of the Universe and the union of bodies. By the virtue of the Center all the powers of natural and elemental motions emanate; without the virtue of the Center, no vegetable could take on increase, no bird could fly, no quadruped could walk, nor could man perform any bodily action — as will afterward be demonstrated. All things, therefore, are from the Center, and all things are ordered toward the Center. But that all these matters may become plainer, we have judged that we must first explain the difference between the Center of magnitude and the Center of gravity.

DEFINITION II.

[Margin: DEFINITIO II.]

The center of magnitude is the midpoint of any figure whatsoever, through which the figure is bisected.

[Margin: Quid sit Centrum Magnitudinis — What the Center of Magnitude is.]

A midpoint, taken according to its whole breadth, is called the midpoint of any given thing; and it is a point of continuous and finite quantity, marked out either in act or in potency — either in the quantity itself and its boundary, or outside it — with a definite relation, whether of extension, or of intervening distance, or of the disposition of the parts, to that thing of which it is said to be the Center. And in this respect it belongs not only to bodies, but also to surfaces and lines. But properly the Center of a figure is that midpoint in a circle and a Sphere from which all lines drawn to the periphery are equal to one another. In rectilinear figures, however, it is the point in which all the straight lines either joining opposite angles are bisected, or in which the lines drawn from the angles to the bisected sections of the opposite sides are divided in the same ratios. The center of magnitude is the point which is equally distant on every side, in respect of magnitude and extension, from the extremities. This [description] applies...

this applies, of course, to every finite quantity—that is, to lines, surfaces, and bodies—but not to all of them individually. For when a line is regular and

bounded at both ends, the Center is the point that bisects it. Among surfaces, only the circle among plane figures (and the sphere among solids) properly has a Center of Magnitude. In regular polygons and polyhedra it has its place only improperly, since in these the sides themselves and the area [ἔδρα, *hedra*, "seat" or "face"] are equally distant from this Center only when they are considered as wholes, not part by part. By this reasoning the Center of Magnitude can also be found *outside* the very quantity whose Center it is said to be—as happens with curved lines that return upon themselves, such as the circular and the elliptical, in the surfaces and bodies of zones, coronas, and annular figures. Among the Arab geometers I read that this is called the *point of magnitude*: the point that bisects straight lines, that divides a surface into two equal parts, and that in bodies is the point through which any plane whatever passing divides the body equally (just as was said of a surface), bisecting it so that the parts taken separately are equal. From all this it is clear that the Center of Magnitude and the Center of figure are exactly the same thing in lines and surfaces, and likewise in bodies.

DEFINITIO III

The Center of Gravity of any heavy body is the midpoint of that heavy body; and the midpoint of the Universe—that is, the point that all things seek—is called the Center of the World [Centrum Mundi].

[Margin: What the Center of Gravity is.]

This definition is taken from Aristotle [Aristotle], and we may confirm it in his own words and reasoning. For when he establishes that the Earth is spherical, among other very strong arguments he offers this one. *"It is not difficult,"* he says, *"for those who attend even a little and make the distinction, to see how we suppose that anything possessing magnitude, however great its weight, is carried toward the midpoint itself."* The Philosopher seems to require first an intent and focused effort of mind, with all confusion set aside, for this study of natural forces and motions; he then expressed in plain words that all heavy things are carried toward the midpoint. And he shows clearly that the midpoint is aptly called the Center in a sphere—or rather in the very definition of a sphere that Cicero [Cicero] used—for thus he speaks of the World: *"It was fashioned spherical"*—what the Greeks call σφαιροειδής [*sphairoeidēs*, "sphere-shaped"]—"such that its whole surface is touched by radii equal from the midpoint." So says Cicero. As for the Center of Gravity, Aristotle likewise says: *"For it is evident that it does not touch the extremity of the Center precisely, but rather the larger part must prevail until it has fully received the midpoint as its own midpoint."* This reasoning of

Aristotle's is indeed best suited for grasping the nature of the Center of Gravity, and I explain it as follows.

Suppose the Earth were removed from the midpoint, and imagine some heavy body let fall—say from the concave surface of the Moon. It will certainly move toward the Center, and it will not come to rest when it has touched the Center with its outermost part. For there is no force at the Center, as many suppose—no magnetic force that holds attracted bodies fast so that they do not move from there. Rather, in the heavy bodies themselves, and in each of their parts, there is a certain appetite that draws them toward the Center. Therefore, when that outermost part of the body which touches the Center—and which would come to rest if it were separated from the other heavier parts—is pressed by the other heavier parts standing above it, and cannot resist them as they bear down, it necessarily must give way: it is displaced from the Center and carried to the opposite side, until it has brought with it as many equally-weighting parts as remain on this upper side. Now all that I have said applies to one line only, the line along which that heavy body moved in a straight path; and this, which we have so far demonstrated of the motion along that line, will be shown in exactly the same way, by the same reasoning, for any other line of any other motion that might occur from the concave surface of the Moon to the Center of the World. From this it follows that the body cannot come to rest before its own midpoint reaches the midpoint of the World; for then the body will stand balanced, weighed down on every side by the equal weight of its parts pressing in all directions.

Plato [Plato] confirms all this in the *Phaedo* in these words: "*This, then, I have fixed firmly and unshakably in my mind: if the Earth is in the middle of the Universe, surrounded on every side by the heavens at equal distances, then it needs no support to keep it from falling—neither air nor any other necessary prop. To hold it in place, it is enough that the heaven is everywhere alike with respect to itself,*"—καὶ τῆς γῆς αὐτῆς ἰσορροπίαν [*kai tēs gēs autēs isorropian*, "and the equilibrium of the Earth itself"]—"and that the Earth itself is in equilibrium. For a thing in equilibrium, set in the midst of something uniform and uniformly disposed, will be unable to incline more or less in any direction, but, remaining in like condition, will lean to neither side, and will stay constant."

And thus the definition of the Center of Gravity handed down by Pappus of Alexandria [Pappus of Alexandria] also fits well. "*The Center of gravity of any body,*" he says, "*is a certain point set within it, such that, if one imagines the heavy body suspended from it, then while it is carried it rests and keeps the position it had*

at the beginning, and is not turned about during that motion." Frederico Commandino [Federico Commandino] sets this out a little more clearly in his book *On the Center of Gravity*: "*The Center of gravity of any solid figure,*" he says, "*is that point set within it, about which the parts of equal moments stand on every side.*" We ourselves explain it thus. Since in bodies both figure and weight can be assessed, and since in some bodies the weight and the figure agree with each other—as can be seen in the sphere and in similar figures—this does not, however, always hold. For in most bodies the ratio of figure and of weight is very different, and the midpoint of figure...

lies far from the midpoint of weight. Rightly, then, does Aristotle warn that account must be taken of the weight alone, not of the magnitude or bulk—and he hints at this when he says *the midpoint of the heavy body*. But when he says that, if a plane is drawn through such a Center, cutting the figure in any way whatever, it will always divide the figure into parts of equal weight, the words *cut* and *divide* are not to be taken as signifying a separation of the parts from one another. For it most often happens that a heavy body, divided into two equally-weighing parts by some plane passing through its Center of gravity, is not separated at all. The reason is that, once the parts of the heavy body have been divided, each of them has its own relation to its *own* Center, no longer to the prior Center, which was the Center of the whole. From this it follows that the same location most often takes on a different relation of weight with respect to one Center than the relation it had with respect to another. The chief reason for this can be given as follows: the parts, the more or less distant they are from the Center, weigh the more or the less, as will be shown below.

The sense of those words, then, will be this. If a plane is understood to pass in any way whatever through the Center of gravity, the parts of equal weight will stand about the said plane. As for the view of certain people that the Center of magnitude and of gravity are the same, on the grounds that the Center of gravity nowhere weighs—they are mistaken. For although the Center, of itself and by its own nature, does not weigh, it is nonetheless a foundation within the heavy body, in virtue of which the body, when a section is made through it into however many parts, always leaves the parts equal in weight—which never happens in the Center of magnitude. For suppose a sphere were given, one hemisphere of which was made of lead and the other of wood: it is certain that in this sphere the Center of magnitude differs from the Center of gravity—so much so that the Center of magnitude may be said rightly to occupy the middle of the sphere, as being the midpoint of the figure, while the Center of gravity recedes from the midpoint the farther, the lighter is the hemispherical portion out of which the

sphere is constituted: namely, to the point such that, if the sphere is cut at it, it leaves the parts *ισόρροπας* [*isorropas*, "of equal balance"], that is, of equal weight. It is nonetheless true that in a homogeneous sphere, composed without any admixture of differing material, the Center both of magnitude and of gravity coincide and are exactly the same.

It must be supposed that the same thing happens in the Terraqueous globe. For since water has a relation of differing weight to the structure of the earthy parts, it is certain that the Center of gravity in the earthen globe is distinct from the Center of magnitude—yet it always agrees with the Center of the World, inasmuch as it is borne toward it by an innate force, like all other things. But let me confirm the matter with this example. Let A B be the globe of the Earth, and let its Center of gravity C coincide with the Center of the World, the same C. Now let the segment D E be cut off by divine power—or any other segment whatever. Once this is removed, it is certain that the Center of gravity no longer remains at C, but is at F; and so, in order that it may again coincide with the Center of the World, it will at once accommodate itself to it, so as to stand balanced about the Center of gravity.

Diagram. A circle representing the globe of the Earth, with a chord D–E drawn across the upper portion (the segment to be removed).

- A (lower left of circumference): label of the globe
- B (lower right of circumference): label of the globe
- D (left end of upper chord): endpoint of the cut segment
- E (right end of upper chord): endpoint of the cut segment
- C (center of circle): the original Center of gravity, coinciding with the Center of the World
- F (just below C): the displaced Center of gravity after the segment D–E is removed

COROLLARIUM

From this it is clear that the Earth, if it were raised by divine power outside the Center of the World, would *not* stand still there (as some suppose), but, once released, would by its own proper power—like all heavy things—seek the Center of the World again. It is also clear that there is a great difference between the Center of gravity and the Center of magnitude. Therefore, just as it is proper to the sphere—solely because it has a point in the middle, surrounded on every side by equal parts—that the sphere is divided into two equal parts by a plane passing through that midpoint (for it can in no way be divided into two equal parts by a

plane not passing through the midpoint), so likewise, because every heavy body has its own midpoint of gravity, it will be cut into two equal parts by a plane passing through the Center, and it cannot be understood to be divided into two equal parts by a plane unless the said plane passes through that midpoint. The Canons follow.

Canones de Centro gravitatis & magnitudinis

(Canons concerning the Center of gravity and magnitude)

If the Center of gravity did not exist in things, then consequently there would be no motion. If there were no motion, all things would grow sluggish—indeed, it would necessarily follow that the whole of Nature reverted to its own Chaos. Therefore provident Nature implanted in heavy things an appetite for the Center, which all things seek. But since they could not descend to the Center by their own power, it seemed necessarily required that something direct their appetite for the Center of the Universe in their motion—which is nothing other than the Center of gravity proper to each heavy thing; for under this guidance all things attain their goal. But how this Center exists in individual bodies, and how it can be found, remains to be explained—since without knowledge of it, what we are going to say in the course of this work cannot be perfectly understood.

It must therefore be noted that the Center of gravity existing in solid bodies cannot be fully grasped unless it is first demonstrated in the surfaces of the sections of those bodies. For, as will be clear from what follows, since a Center of this kind, as being...

as being internal to solid bodies, is not open to the eyes, it certainly cannot be brought from the hidden into the open except through the surface, which is laid bare only by the sectioning of the said bodies. For the Center of gravity that is shown to exist in any body must also be reckoned to be a Center of gravity in that surface which passes through the midpoint of the cut body; and therefore let no one be surprised if he sees us inquiring after a Center of gravity in surfaces, which are entirely devoid of all weight. For this we arrange only with a view to finding the Center of gravity of the solid body—as will be clear when the reader has understood what follows.

But let us show the matter by example. In a globe and a cube of homogeneous material, the Center of gravity, since it is internal, is not visible. But if you cut the said bodies through the middle, in any part, into two halves, then at once, once the section is performed, two surfaces are left, whose midpoint of magnitude is

also the Center of gravity; and when these are joined together again into one body, the Center of gravity in the sphere or cube is the same as what it displayed in the surface—and you will judge the rest by like reasoning. With these preliminaries set down, let us now pursue the subject we have begun.

CANON I

In all regular figures the Center of magnitude and of gravity is the same.

Let there be, then, the regular figures: circle, square, pentagon, equilateral triangle. And since A is a circle, it is certain that the Center of the circle is the same as the Center of gravity—and this is clear from the second and third definitions. For just as in a circle a section made through the Center always divides the circle into two equal halves (that is, into two equal semicircles), so if a section were made through the Center of gravity, all the semicircles would be of equal weight. What is said of the circle can also be said of the square, whose Center of magnitude and of gravity is there where the diagonal lines C D and E F cut each other at the point S; for through this point, however the section is made, it always leaves parts equal both in quantity and in weight. The same must be said of any regular polygonal figure. For if you circumscribe the figure about a circle, the Center of the circle and of the circumscribed figure will be exactly the same; hence the figure, cut through it in any way, always leaves parts equal both in quantity and in weight. In an equilateral triangle the Center of magnitude and of gravity is there where the lines D L, I M, N O cut each other; hence a bisection made through this Center always leaves parts equal both in weight and in quantity.

Diagram. A circle with its center marked A.

- A (center of the circle): the Center, coinciding with the Center of gravity

Diagram. A square with both diagonals drawn, intersecting at the center.

- E (upper left corner): vertex
- D (upper right corner): vertex
- C (lower left corner): vertex
- F (lower right corner): vertex
- S (intersection of diagonals C–D and E–F at center): the Center of magnitude and of gravity

Diagram. An equilateral triangle with the three medians drawn from each vertex to the opposite side, meeting at the center.

- N (apex, top): vertex
- M (lower left): vertex
- L (lower right): vertex
- D (on left side, between N and M): bisection point / median endpoint
- I (on right side, between N and L): bisection point / median endpoint
- O (on base, midpoint between M and L): bisection point / median endpoint
- (the three lines D L, I M, N O intersect at the center, the Center of magnitude and gravity)

CANON II

In squares, parallelograms, rhombi, and rhomboids, the Center of gravity and of magnitude is properly that point where the diagonal lines, or diameters, of the said figures cut each other—as appears in figures S, B, C, D.

Diagram. Four quadrilaterals, each with both diagonals drawn intersecting at its center: a square (S), a rectangle/parallelogram (B), a rhombus (C), and a rhomboid (the figure labeled near its center).

- S (center of the square, lower left figure): Center of gravity and magnitude
- B (center of the rectangle, upper right figure): Center of gravity and magnitude
- C (center of the rhombus, right figure): Center of gravity and magnitude
- (lower middle rhomboid: center marked, label reads [?] — appears to be a fourth figure of the series)

CANON III

In regular polygons of any number of sides, the Center of the circle circumscribed about them is the Center of magnitude and of gravity. See figures E, F.

Diagram. Two regular polygons, each inscribed in a circle, with the center of each marked: a pentagon (E) and a hexagon or heptagon (F).

- E (center of the left polygon, inscribed in a circle): Center of magnitude and gravity
- F (center of the right polygon, inscribed in a circle): Center of magnitude and gravity

CANON IV

In rectilinear triangles of any kind, you will obtain the Center of gravity and of magnitude in this way.

Let A B C be an isosceles triangle, whose Center of perimeter is sought. Bisecting the three sides at the points D, E, F, and drawing the perpendicular A F, let E G be taken equal to F C; the line joining the points D, G will cut the perpendicular A F at I, which I say is the Center of gravity and of magnitude of the isosceles triangle A B C. I demonstrate this as follows. For when D F, F E, E D are joined, D E F E will be a parallelo...

Diagram. An isosceles triangle A B C (apex A at top, base B–C at bottom) with internal construction lines, midpoints, and the perpendicular from the apex.

- A (apex, top): vertex
- B (lower left, base): vertex
- C (lower right, base): vertex
- D (midpoint of left side A–B): bisection point
- E (midpoint of right side A–C): bisection point
- F (midpoint of base B–C, foot of the perpendicular A F): bisection point
- G (on right side, with E G equal to F C): construction point
- I (intersection of line D–G with the perpendicular A–F): the Center of gravity and of magnitude

gram, by [Elements] II.6; therefore, by [Elements] I.29, the angles D G E and F D G are equal. But the angle G D E at the base D G of the isosceles triangle D E G is equal to the same angle, by [Elements] I.5; therefore the angles F D G and G D E are also equal, and so the whole angle G D E is bisected by the straight line D G. But the angle D I E is also bisected by the straight line A F. Therefore the common point of section, I, is the sought Center of gravity of the isosceles triangle A B C; for when it is bisected through this point, it always leaves the parts equal in weight.

Next, let A B C be a scalene triangle, in which, if from D, the midpoint of the base A C, and from E, the midpoint of the hypotenuse C [?]
[recte: the midpoint of side C B / the hypotenuse]—you draw the lines from D B and from C E, the point of intersection of the lines B D and C E, at the point F, will be the sought Center of gravity. It is therefore clear that the Center of gravity of every triangle lies on the straight line drawn from an angle to the middle of the base—that is, where the straight lines drawn from the angles of the triangle to the midpoints of the sides

meet. It is also clear that the Center of gravity of every triangle is the point lying on the straight line drawn from an angle to the bisection of the base, which divides that line such that the segment toward the angle is double the remaining segment toward the base.

Diagram. A scalene triangle A B C (A at lower left, B at apex, C at lower right) with two cevians drawn from the vertices to the midpoints of opposite sides, intersecting at F.

- A (lower left): vertex
- B (apex, upper): vertex
- C (lower right): vertex
- D (midpoint of base A–C): bisection point
- E (midpoint of side C–B / hypotenuse): bisection point
- F (intersection of cevians B–D and C–E): the Center of gravity

In triangle A B C, let a section parallel to B C be made through the line D E, such that D A to D C, or A E to E B, are double; I say that the Center of gravity of that triangle is the point F, the midpoint in the line D E. You will also obtain this by an extremely easy method, if you divide one of the two legs, either A B or A C, into three equal parts; for a line drawn parallel through the [point of division] to the cathetus [base] B C, and bisected, will give the Center of gravity. But whoever desires demonstrations of all these, let him consult Archimedes [Archimedes], Commandino, Luca Valerio [Luca Valerio], and Guldin [Paul Guldin], where he will find everything demonstrated at length.

Diagram. A right triangle (vertex C at upper left, base B–A at bottom running from B at lower left to A at lower right) with a line D E drawn parallel to the base and the point F marked on it. The base is marked off in three equal divisions (3, 2, 1).

- C (upper left): vertex (right angle)
- B (lower left): vertex
- A (lower right): vertex
- D (on the left leg, upper): division point
- E (on the base, marking a division): division point
- F (on line D–E): the Center of gravity
- (the base B–A is graduated: 3, 2, 1 marking the three equal parts)

CANON V

To find the Center of gravity in a trapezium.

Let A B C D be a trapezium, whose Center of gravity is to be sought. On the bounding lines B C and A D, let the bisection points E, F be joined; divide that line [E F] into three equal parts, and through the points of division let lines I H and S T be drawn parallel to A D or B C; then from A and from [?] let two other lines be drawn to E and to C. With these set down, if through the points where E C and A E cut the lines I H and S T you draw the line L M, it will cut the line E F at the point G, which is the Center of gravity of the trapezium. For the demonstration, see Luca Valerio.

Diagram. A trapezium (quadrilateral) A B C D—A at lower left, B at upper left, C at upper right, D at lower right—with internal construction lines, the transversals I H and S T parallel to the sides, the median E F, and the diagonals, meeting at G and M.

- A (lower left): vertex
- B (upper left): vertex
- C (upper right): vertex
- D (lower right): vertex
- E (midpoint of side B–C, top): bisection point
- F (midpoint of side A–D, bottom): bisection point
- I (left end of transversal I–H): division point
- H (right end of transversal I–H): division point
- S (left end of transversal S–T, lower): division point
- T (right end of transversal S–T, lower): division point
- L (on transversal I–H, interior): construction point
- G (intersection on the median E–F): the Center of gravity of the trapezium
- M (interior construction point, lower): construction point

CANON VI

To find the Center of gravity in a semicircle.

In a semicircle you will obtain the Center of gravity if you describe the *tetragonizousa* [τετραγωνίζουσα, "squaring curve"], that is, the quadratrix, according to what we handed down in the *Ars Magna Lucis et Umbrae* [*The Great Art of Light and Shadow*], Book 3. Let A B C be a semicircle; let the *tetragonizousa*,

or quadratrix line, be described from the semidiameter A to D B, which is A E; I say that the point E, at which the *tetragonizousa* A E ends, is the sought point of gravity of the semicircle A B C. See the reasoning in the cited passage.

Diagram. A semicircle A B C standing on its diameter A–C, with the radius/vertical D B drawn from the midpoint D of the diameter up to B at the top of the arc, and the quadratrix curve drawn (as a dashed line) ending at the point E.

- A (left end of diameter): endpoint
- C (right end of diameter): endpoint
- B (top of the arc): apex
- D (midpoint of diameter A–C, foot of the vertical D–B): point
- E (where the quadratrix curve ends, on the vertical D–B): the Center of gravity of the semicircle

CANON VII

To find the Center of gravity in a parabola.

You will obtain the Center of gravity in a parabola if you divide the axis B G, which bisects the base A C, into five equal parts. For if you draw the straight line V T parallel to the base A C through the $\frac{2}{5}$ part [per $\frac{2}{5}$ partes] along the axis B G, it will give the point S of intersection, the sought Center of gravity in the parabola. Since all these things are demonstrated at length by the authors cited a little earlier, and are by now well-worn, we will not dwell on them.

Diagram. A parabolic segment standing on its base A–C, with the axis B–G running vertically from the apex B down to G at the midpoint of the base. The axis is graduated into five equal parts (5, 4, 3, 2, 1), and a horizontal line V–T is drawn across, meeting the axis at S.

- A (left end of base): endpoint
- C (right end of base): endpoint
- B (apex, top): apex
- G (midpoint of base A–C, foot of axis): point
- V (left end of the horizontal line): endpoint
- T (right end of the horizontal line): endpoint
- S (intersection of line V–T with the axis B–G, at the $\frac{2}{5}$ division): the Center of gravity of the parabola
- (the axis is graduated 5, 4, 3, 2, 1 from top to bottom)

CANON VIII

To find the Center of gravity in homogeneous solid bodies.

It remains for us to show briefly the method by which the Center of gravity may be found in any solid bodies whatever. This, being proper to our undertaking, we have judged should be treated somewhat more thoroughly, since many things to be produced in what follows depend upon this proposition. Let it be required, then, to find the Center of gravity in a globe or a cube made up of homogeneous material; one proceeds...

proceeds as follows: since the center of gravity of a globe coincides with its center of magnitude, I say that the center of the globe is the center of gravity sought. And since the cube too is a regular body, I say that the center of the cube—which lies at the midpoint of the cube's diagonal—is the center of gravity sought. The matter requires no demonstration, being self-evident, and it has already been fully demonstrated by Archimedes and by his commentators cited above.

CANON IX.

To find the centers of gravity in cylinders and prisms.

Since a column or cylinder is generated by carrying around a circle, the midpoint of the cylinder's axis P Q—the point B—will necessarily give the center of gravity sought. You will have the same result in a prism of any number of sides. Let there be, for example, a parallelepiped I R S formed by carrying around a square, having its axis drawn through the centers I S of the square sides; the midpoint of its axis, the point R, will give the center of gravity sought. The same is to be said of a prism of 5, 6, 7, 8, etc. sides, and so on to infinity.

Diagram. Two solid figures side by side, illustrating Canon IX. On the left, a rectangular prism (parallelepiped) shown in perspective with a vertical axis; on the right, an upright cylinder with its circular top and bottom and a vertical axis.

- L (top edge of prism): vertex label of the parallelepiped
- I (top edge of prism): adjacent vertex label
- R (interior, mid-height of prism): the midpoint of the axis = center of gravity
- S (bottom edge of prism): lower vertex label
- M (bottom edge of prism): lower vertex label
- P (top of cylinder): top of the cylinder's axis

- B (interior, mid-height of cylinder): midpoint of the cylinder's axis = center of gravity
- Q (bottom of cylinder): bottom of the cylinder's axis

CANON X.

To find the centers of gravity in a cone and a pyramid.

In cones and pyramids of any number of sides you will find the centers of gravity if you divide the axis of these bodies so that the part toward the vertex is double the remainder—that is, if you divide the axis into three equal parts, the center of gravity will be the point of division third from the vertex along the axis. For the center of the figure, through which the axis passes, is also the center of gravity—both of the base and of that parallel plane through which the section is made under the given proportion. See the adjoining figure M N O P, in which the center of gravity is the point T, and in the figure A B D of the pyramid, the point C.

Diagram. Two figures side by side. On the left, a cone with apex M and a circular base O N P, its axis M N marked off with division numbers 1, 2, 3; the center of gravity T is marked one-third of the way up from the base along the axis. On the right, a triangular pyramid (shown in perspective, one face shaded) with apex A and base B D, its axis likewise divided into segments 1, 2, 3, with the center of gravity C marked along the axis.

- M (apex of cone): vertex of the cone
- 1, 2, 3 (along the cone's axis from apex downward): the three equal divisions of the axis
- T (on the cone's axis, one-third up from base): center of gravity of the cone
- O (left end of cone's base): base-circle edge
- N (midpoint of cone's base): foot of the axis
- P (right end of cone's base): base-circle edge
- A (apex of pyramid): vertex of the pyramid
- 1, 2, 3 (along the pyramid's axis from apex downward): the three equal divisions of the axis
- C (on the pyramid's axis): center of gravity of the pyramid
- B (left base corner of pyramid): base vertex
- D (right base corner of pyramid): base vertex

CANON XI.

To find the center of gravity in a frustum of a pyramid. See the figure of Canon V.

If a pyramid is cut by a plane parallel to its base, the center of gravity of that frustum will be given by the center of the trapezium considered in the plane of the axis. Let the frustum of a cut pyramid be B C D A, its axis E F, and the trapezium in the plane of the axis be A B C D. If, following the preceding Canon V, you find the center of gravity of this trapezium—say G—then that G will also be the center of gravity of the proposed frustum of the pyramid.

CANON XII.

To find the centers of gravity of the five regular bodies.

The five regular bodies are the cube, the tetrahedron, the octahedron, the dodecahedron, and the icosahedron. If circles [spheres] are circumscribed about them, the center of the circle and of the five regular bodies will be one and the same—precisely the center of gravity sought. For the demonstration, see Stevin [Simon Stevin], Proposition 14.

CANON XIII.

To find the center of gravity in a hemisphere.

If you bisect a hemisphere, the plane of the section will necessarily be a semicircle. So if you find the center of gravity in this semicircular plane by Canon VI, that same point will also be the center of gravity sought on the axis of the hemisphere. Or otherwise, in this way: divide the axis of the hemisphere into eight equal parts; the point that marks off five parts downward from the vertex—or three upward from the base—is the center of gravity sought. The same is to be said of a paraboloid body. For the center of gravity that the parabolic plane yields through a section of the body taken along the axis will likewise give the center of gravity of the paraboloid body.

CANON XIV.

To determine mechanically, by means of a plumb-line, the center of gravity in any body.

Let a thread or plumb-line be dropped from the end of the body, and mark the line that the thread traces on the surface of the stone. Then apply the plumb-line at any other point of the stone, and again mark the line that the thread traces on the surface of the body. Where this line cuts the first, earlier line, there is the center of gravity on the surface of the stone. Now repeat both observations on the opposite side of the body, and in the same way mark the point where the lines

intersect. For if these two points—observed on the two surfaces—are imagined as joined by a line, the midpoint of that line will be the center of gravity sought. This is indeed true in regular bodies; but in irregular bodies more observations must be made to attain your aim.

COROLLARIES

from what has been said.

From this it follows that with all the bodies demonstrated up to now—spherical, cubical, cylindrical, prismatic, and the like—even if they are hollowed out so that the sphere leaves only a ring, the cube leaves only twelve solid struts connecting the cubic body, the cylinder turns into a tube, and the prism of any number of sides resembles a well—the center of gravity, conceived by the imagination in the empty space, will still be the same as it was in the solid bodies. Thus the center of a circular ring, of a hollow cube, and of the other figures will be the center of gravity in the imaginary middle, always supposing the homogeneous parts to be equal.

On the center of gravity that lies hidden in heterogeneous bodies.

CANON XV.

In a sphere made of uniformly heavy material, the center of gravity and the center of magnitude are the same, as we indicated above. But if it is composed of heterogeneous or dissimilar materials, the two can be either the same or different.

Three cases arise here. The first is when the whole globe is homogeneous, and then the center of gravity and the center of magnitude, as has been said, are always the same. The second case is this: suppose that in the following sphere—say, a leaden one—segments E F D and G C H are cut off from the axis A B at equal distances, and other equal segments are put in their place, but made of dissimilar material—say, of wood or wax. Let these named segments be E F D and G C H. If these segments are supposed to be of equal weight, then in the mutilated sphere they do not shift the center of gravity and magnitude; rather, they preserve the position the sphere first had when whole. The third case is this: if, the segment E D F having been removed, a segment of heterogeneous material is substituted in its place—of wood, wax, glass, metal, or gold—then once this is done the center of gravity will move from the axis A B toward C, coming nearer by as much as the substituted segment E F D is lighter; or toward F by as much as the substituted segment E D F is heavier than the material of the sphere. The center of

magnitude, however, always keeps its place, which is the center of the heterogeneous globe. These things are to be understood of all the regular bodies described above as well.

Diagram. A circle (representing the sphere in section) with a horizontal diameter A B drawn through its center. Near the top, a chord E D cuts off the upper segment, with F marked at the top of the circle above it; near the bottom, a chord G H cuts off the lower segment, with C marked at the bottom below it. The figure illustrates Canon XV's segments E F D and G C H.

- F (top of circle): apex of the upper cut-off segment
- E (upper left, end of upper chord): left end of the upper segment's chord
- D (upper right, end of upper chord): right end of the upper segment's chord
- A (left end of diameter): left endpoint of the axis
- B (right end of diameter): right endpoint of the axis
- G (lower left, end of lower chord): left end of the lower segment's chord
- H (lower right, end of lower chord): right end of the lower segment's chord
- C (bottom of circle): apex of the lower cut-off segment

CONSECTARIES

from what has been said.

From this it follows, first, that the center of gravity of any solid can be displaced from its place when something is added to it or taken from it, or when its parts are arranged in another way. Let the center of gravity of a cube A B made of uniform—that is, homogeneous—material be C. I say that it can be shifted in three ways. First, if a body E D B G is added to the given body: because if weight is added to the cube A B, a new center will necessarily recede from its place toward the added part. Second, what amounts to the same: if A E I R is taken away from A B, then since G B D E preponderates, the center of gravity C will likewise recede from its place toward B D. But if equal weights F R and E D are added to the intermediate body B F D A on either side, the center of gravity will remain unmoved at C, according to the laws of equilibrium [Greek: ἰσορροπίας (isorropias, "of equal balance," equilibrium)].

It follows, second, that a sphere—even if it is put together from segments of varied composition—still does not shift its center of gravity. Let there be a sphere A B C D, whose segments A E B and its opposite C H D are of wax, the other two A F C and B G D are of chalk, and A B C D, the innermost body of the sphere, is of lead. I say that even though the sphere is made up of segments of heterogeneous

material, it still shifts neither its center of gravity nor its center of magnitude. For since the segments A E B and C H D, equal and made of the same material—say wax—are of equal weight on both sides by hypothesis, the center of gravity C will not recede from its place, according to what Archimedes demonstrates concerning bodies in equilibrium. And the gypsum [chalk] segments A F C and B G D are likewise of equal weight. Therefore, since the globe is composed of opposite segments—even though of different weights—the center C will nevertheless not shift. Therefore, if the sphere, etc.—which was to be demonstrated. But if even one of the opposite segments were made of dissimilar material, then the center of gravity too would necessarily have to yield its place.

Diagram. A rectangular box (parallelepiped) drawn in perspective, illustrating the displacement of a cube's center of gravity. The center of gravity C is marked in the interior. Vertices are lettered around the front and back faces.

- E (top edge, upper left of front): vertex label
- B (top edge, front left): vertex label
- F (top edge, upper right): vertex label
- I (top edge, far right): vertex label
- C (interior center): center of gravity
- G (bottom edge, lower left rear): vertex label
- D (bottom edge, front left): vertex label
- A (bottom edge, front right): vertex label
- R (bottom edge, far right): vertex label

CAPUT II.

On the line of direction.

The line of direction is the line that directs the motion of heavy bodies, and it is conceived as drawn from the Center of the World to the top of the heavy body. For all heavy bodies are carried by their natural weight toward the middle, which is contained within the compass of the earth. And therefore, of all the things around us, some are moved while others are at rest; they are not moved because they are hindered and held back. But of those that are moved, some are hindered in their motion and others are unimpeded—just as is plain in water spread around the earth. For since water cannot descend straight down, it makes its way to the center by detours of descent, until, received into a suitable receptacle, it comes to rest; but if no obstacle stands in the way, it descends straight, joined to

its center. Now that line which directs such motion—or which would direct the motion if the obstacle were removed—is called the line of direction. This line must necessarily proceed from the Center, or tend toward the Center, which is the same thing; and it is nothing other than a line standing perpendicular to the horizon—or, what is the same, a line drawn from the pole of the horizon (that is, the zenith) through the Center of the World. The axis of the horizon, as astronomers call it, agrees with it exactly, and so the two are everywhere taken as the same. And if these lines are considered on the surface of the earthly globe, they are, as far as the senses can tell, parallel—as plainly appears in shadow-casting gnomons [gnomonibus sciothericis], which, however far apart in the day, are nonetheless reckoned parallel, with no harmful error in gnomonic work. This is also clear from the practice of architects, who lay out the walls of a building precisely parallel to the level [ad amussim], with no regard to the Center—although those walls, if drawn out to the Center, would no longer be parallel but would coincide in it. But on these matters see what we have written at length in Book 5 of the *Ars Magna Lucis et Umbrae* [Kircher].

PROPOSITION I.

All things that move necessarily move under the line of direction.

In every heavy body the center of gravity lies on the line of direction and moves along it, so that the center of gravity by its motion describes the very line of direction. For since all the parts of a heavy body, compared with respect to the center of gravity, are in equilibrium, the middle point of the heavy body will necessarily constitute the line of direction, while the remaining extreme parts of the body by their motion describe lines likewise parallel to the line of direction. Let there be a heavy spherical or cubic body A B, whose center of gravity is C. I say that the center of gravity C, by its motion to D, describes the line C D, which is the line of direction, while the points A B bounding the body describe lines A E and B F, parallel indeed to the line of direction C D on the surface of the earth, yet converging about the Center of the World, like all the parts of the heavy body, in the Center which they seek, nodding toward it. But if anyone denies that the motion takes place along the line of direction, let it then take place along A E or B F. But since those parts lie outside the middle line, and since no moment of equilibrium [Greek: ἰσορροπίας (isorropias, equilibrium)] can be established at B or A, it is impossible for the line of direction to be established at A or B. Therefore the line of direction is necessarily drawn through the middle point of the heavy body, which we have said is the center of gravity—which was to be proved.

Diagram. A circle with an inscribed square A B (top corners), center C marked inside, from which a long tapering vertical figure (like a pointed leaf or spindle) descends to a point D at the bottom; the lower corners E and F flank the descending lines. Illustrates Proposition I: the center of gravity C descending along the line of direction C D, with the bounding points describing A E and B F.

- A (upper left corner of inscribed square): bounding point of the body
- B (upper right corner of inscribed square): bounding point of the body
- C (center of circle): center of gravity
- E (lower left): point describing line A E
- F (lower right): point describing line B F
- D (bottom point): the point toward which C descends

PROPOSITION II.

The forward motion of a man must take place along the line of direction.

Let a man walk forward on the surface of the earth; I say that the forward motion takes place only under the line of direction. Let the surface of the earthly globe be A B C, its center D; let a man, or any other animal, be placed at the point F. I say that the man cannot walk by his natural gait except under the line F D, which is the line of direction. For along this path he would tend if he were to descend to the Center of the earth; therefore under this line he is truly and properly balanced and directed, to carry out his operations more conveniently. If anyone denies this, let him then go along the line F E; but since this lies outside the center of gravity and the line of direction, he will descend obliquely from the point I to K, and from K he will begin to ascend to E. Since these motions are not natural but violent—being outside the line of direction—it is impossible for anyone naturally to proceed except under the line of direction F D, which was to be shown.

Diagram. A large circle representing the earthly globe, with center D and several radii drawn from the center to the circumference like spokes. Tiny human figures stand on the upper rim at points I, K, and at the ends of the chord F...E; ships (or instruments) are shown at points C and G on the rim. A dotted radius D G descends vertically, and a dashed radius runs from D toward the upper right. Illustrates that men standing on the globe stand erect along radii (lines of direction) to the center D.

- B (top of circle): point on the rim
- I (upper rim, left of center-top): a man's position

- K (upper rim, center): point on the upper chord
- F (upper left rim): the man's starting position
- E (upper right rim): point toward which oblique ascent ends
- A (left of circle): point on the rim
- C (right of circle): point on the rim
- D (center): center of the world
- G (bottom of circle): point on the lower rim
- (additional small human and ship figures stand at the rim points, oriented radially)

CONSECTARY I.

From this it is clear why men or ships moving about the earth's surface are always erect, and on every side see all things above them—as at the points E, G, [F?]. Because, since they are heavy, they are necessarily carried downward, along the line of direction, to the Center, which all heavy bodies seek.

CONSECTARY II.

From this it is clear that every body resting on a point then stands, when the line of direction passing through the point on which it rests also passes through the body's own center of gravity; but it falls, if the line passes outside the center of gravity. Let the surface of the earthly globe be A D B, its center [D], the line of direction C D. Place, for example, a pyramid with its apex on the point D, so that the line of direction A C [?] passes precisely through the center of gravity of the pyramid at I. I say that the pyramid will remain erect; for since all its equally-weighting parts stand at an equal distance from the said line, and no parts can draw the rest toward either side, it cannot happen that, balanced in this way, the erect pyramid should fail to stand. But if the center of gravity declines from the line of direction C D even in the slightest, the pyramid must necessarily fall, since the parts on the side from which the center of gravity declines weigh more than the rest. But these matters will be further drawn out by examples in the following Proposition.

Diagram. A semicircle (dome) representing the earth's surface, with horizontal base A B and the base midpoint C; from the top of the dome a small triangle/pyramid F A G [with apex A above] stands balanced, its center of gravity I marked, and a vertical line of direction descends through D at the dome's summit to the center below. Illustrates Consectary II: a pyramid resting on point D, balanced when the line of direction passes through its center of gravity I.

- A (apex of the small pyramid at top): vertex of the balanced pyramid
- F (left base corner of the small pyramid): base vertex
- G (right base corner of the small pyramid): base vertex
- I (interior of small pyramid): center of gravity of the pyramid
- D (summit of the dome, foot of the pyramid's apex): the resting point on the line of direction
- A (left end of the dome's base): base endpoint [the base-line A B; the apex label A also appears at top]
- C (midpoint of the dome's base): base midpoint
- B (right end of the dome's base): base endpoint

CONSECTARY III.

From this it is also clear that a pike [sarissa] or huge spear, held balanced beneath the line of direction by the hand of a fencing-master [lanista], does not weigh down—except with the very lightest of all weights—nor does it fall: for since the length of the pike lies beneath the line of direction, all its equally-weighting parts will necessarily nod toward the Center, and consequently, with the skill of the fencer wielding the pike so as always to hold it straight beneath the said line, it will necessarily stand and will not weigh much. But if it declines even a little outside the line, it will at once acquire weight and the pike will fall; and the more it declines, the greater and ever greater the weight it acquires, until—parallel to the horizontal line—it can no longer bear any further weight. The reason for this is none other than that the pike O Y, held erect and resting freely on the palm of the fencing-master La[nista], has all its parts carried by natural motion toward the Center beneath the line of direction, and consequently acquires no weight. But if it is set outside the line of direction, as at A, then all the parts of the pike B C D E—being placed outside their natural position—must necessarily increase the weight, since each and every one of them weighs; and indeed by so much the more, the nearer it is to the horizontal, and by so much the less, the nearer to the vertical position.

Diagram. A woodcut showing a standing man in a hat and long coat balancing a long pike on the upturned palm of his raised hand. The pike rises diagonally from his hand at point O up to point I at its upper tip; along the inclined pike, points B, C, D, E [the latter near O] are marked, each dropping a vertical plumb-line of dots. Illustrates Consectary III: the pike held beneath the line of direction.

- A (upper left, start of the inclined pike) [recte: the inclined pike-line is labeled A at top-left where it leaves the page edge]

- B (along the inclined pike): division point
- C (along the inclined pike): division point
- D (along the inclined pike, lower): division point
- E (near the hand): division point
- O (at the man's palm): the point of support
- I (upper tip of the upright pike held vertically): top of the pike

CONSECTARY IV.

From this it is also clear why tightrope-walkers [funambulones] walking on a rope walk so steadily: because, balanced by the pole or transverse rod they carry in their hands, they walk continually beneath the line of direction. The result is that, with the ends of the rod or pole in equilibrium, the center of gravity—which lies on the line of direction—is also perfectly balanced, so that no fall need be feared.

PROPOSITION III.

Heavy bodies will then stand still, when the line of direction—drawn through the middle of the quantity on which the heavy body rests—passes through the center of gravity.

Let there be a heavy body A B C D, whose center of gravity is E, and let it rest on the quantity B C. So if the line of direction E F, passing through the point K, the middle of the quantity B C, also passes through the point E, then the heavy body will certainly stand still; for the parts of the heavy body that surround the point E are in equilibrium, and therefore they can neither draw those others nor be drawn by them. From which it comes about that the whole heavy body is at rest. But if the heavy body is increased on the other side by the quantity C D G, so that the center of gravity is H, and if the line of direction passing through the extremity C of the quantity B C, extended, passes through the point H, I say the body will likewise remain erect. The reason is that if the body rested on the point C only, by the second Consectary of the preceding Proposition it would stand. Nothing, therefore, can prevent it from standing, resting on the whole quantity B C. Again, if the line F C, extended, does not pass through the point H but advances it toward E, the heavy body, as before, will stand. For if the heavy body [on the point...]

Diagram. A solid figure drawn in perspective—a slab or wedge-shaped block A B C D with an added quantity C D G on one side—standing on a narrow base, with a long line of direction F descending below. Interior points H, E, K, Y and the base

points are lettered. Illustrates Proposition III: the body resting on quantity B C, with centers of gravity E and H and the line of direction through K.

- G (upper left, top of added quantity): vertex of the added block C D G
- S (upper right, top edge): vertex label
- D (upper front): vertex label
- A (right edge): vertex label
- I (left interior): point label
- H (interior): center of gravity in the augmented case
- E (interior, center): center of gravity
- Y (interior, right of E): point label
- F (lower, near base): foot of the line of direction
- K (base): midpoint of the quantity B C
- B (base, right): base vertex
- F (bottom, descending line): lower end of the line of direction

Liber I (Centrographicus), Sectio I

Caput II — De Linea directionis (continued)

[Continuation of the demonstration of Proposition III.] ...the point C can rest there, how much more, then, will it be able to stand resting on the line C K, on which the center of gravity necessarily lies? For it is impossible that a quantity A B C — whose center was E, now augmented on the side toward E — should draw the center of gravity back to the opposite side, namely toward E. Therefore the center will necessarily remain between the points H and E, the line of direction will pass between the points C and K, and so the body will stand.

From this it follows that if the center of gravity falls outside the space E E [recte: H E][?], for example at L or at V, and the line of direction is carried outside the line C K, the body will necessarily fall — since the quantity that is greater in weight will draw the lesser, and so it will fall on the side of G or of S, because the center of gravity is found in the heavier part, outside the line of direction F E [?]. Consequently the greater weight prevails, and so the body cannot keep standing.

Consectarium

From this it follows why one sometimes finds walls that seem on the verge of collapse, yet stand firm and unshaken forever. Of this kind is the leaning wall at

Rome, set into the walls outside the Porta Flaminia [Flaminian Gate], which everyone who passes shudders at, dreading at every moment that it is about to fall because of how steeply it leans. So, to let those unfamiliar with such matters understand more deeply the cause of the remarkable effect they marvel at, I have decided to give the explanation here.

Diagram. A rectangular block (the whole mass of the wall) seen in oblique view, A B C D F, with the upper face A L H B and a near vertical face that is "retorted" — leaning over — into a parallelogram, the inclined face E B C D. The line of direction G D runs down through the figure; G marks the center of gravity of the stone mass, set on that line of direction.

- A (upper left front corner): A
- L (top edge, left of center): L
- H (top edge, right of center): H
- B (upper right corner): B
- E [recte: P][?] (interior, just below H, top of the inclined face): label as printed
- I (left face, interior): I
- G (center of the figure): G — center of gravity of the whole mass
- C (lower right, foot of the inclined/leaning face): C
- K (bottom edge, left of center): K
- F (lower left corner): F
- D (lower right corner): D

Let the whole mass of the wall, then, be A B C D F, and let its leaning, inclined surface be E B C D, which deviates 20 degrees from the line of direction. Let the center of gravity of the whole stone mass be G, lying on that same line of direction G D. I say it is impossible for the wall E B C D to fall. For since the center of gravity of the whole mass is G, the part of the wall H B D C E will necessarily counterbalance the other part A H G D F. Consequently the wall, balanced beneath the line of direction, will stand — however much it is twisted and bent — since the part H B D C [recte; the leaning portion] cannot outweigh the rest, A H F D. But if the portion A L B K [?] were removed from the whole mass, then the portion H B C D E would necessarily fall, since the remaining part L H K D would be insufficient to resist the weight H B D C, the greater prevailing over the lesser. From all this it is plainly clear how the overhanging crags of mountains, and likewise towers, sometimes hold up under their own mass without falling. But on

these matters see our *Iter Hetruscum* [Etruscan Journey], on the Leaning Tower of Pisa.

Propositio IV

No motion or locomotive action can take place except under the line of central direction.

Divine providence, through its own art — that is, Nature — has so arranged the world that no locomotive action can occur without reference to the center. Everyday examples of this are not lacking in human movements. For what person could lean himself forward or backward, or to the sides, unless the line of direction — passing through the outermost part of the quantity he rests upon, on the side toward which he leans — also passes through the center of gravity of his body, or hangs over the quantity he rests upon? Otherwise he must necessarily fall. For this necessity Nature has provided, teaching a man, when he leans (as I said), to stretch his left foot backward, so that like the arm of a balance it counterweights the head. For, as I said, he cannot stand unless either the line of direction passes through the center of his face [?], or he extends [his foot] on the side opposite to the one toward which he leans.

For if someone joins both feet together and fits his whole body — back turned — against any upright wall, with his lower part kept against the wall, and then tries to lean forward, he will necessarily fall. From this he will learn that a man, guided by a kind of natural instinct, performs the things we have described whenever he leans. These same things happen to a man when seated; for there he has no need to direct his legs and the rest of his hanging body. But once he wishes to stand on his feet, it is necessary that the center of gravity of the whole body be as close as possible to the line of direction that passes through the feet he wants to stand on. And so he tucks his feet beneath his body and thrusts his head forward, so that he rises above his own feet, and, aided by his natural strength, raises himself up. Without this bending he cannot stand erect — especially if he rises too slowly, since the speed and impetus of the motion sometimes arises from these very movements, and brings it about that the others are not noticed by the senses.

The same must be said of people lying on the ground: if they want to get up, they first raise the head, then with hand or arm — as with a kind of lever — they raise themselves into a sitting position; then, drawing in the feet, and finally helped by both hands, they lift themselves into a standing posture. These actions are done for no other reason than that the body may fit itself to the line of direction and so

attain its end. As for the fact that tightrope-walkers [funambulones], stretched out flat like logs, seem to raise themselves in an instant with no advance preparation by any of the aforesaid methods — they appear to achieve this through long practice and speed of motion, which, just as it does not present the said actions to the senses, so too renders the spectators

deceived by the speed of the actions, and persuades them that these things are done without any adaptation of the body to the line of direction — although the said adaptation to the line of direction always intervenes, even if (as I said) it is imperceptible because of the speed of the action. I do not, however, deny that a practiced man can sometimes impart to himself such an impetus that he seems not at all bound by the laws of heavy bodies, indeed superior to them. But since this is a violent motion, we are not dealing with it here, but only with the natural motion of heavy bodies, which governs human actions that depend on local motion.

Propositio V

Four-footed animals cannot advance except under the perpetual support of the line of direction.

As in all other things, so in the progressive motion of animals the wonderful providence of Nature shines forth. For it has so constituted four-footed creatures that it is impossible for them to advance except by a diagonal progression of the feet. I explain the matter by the following figure.

Diagram. A tall rectangle representing the four feet of an animal seen from above (or in schematic plan): the two front feet A and B across the top, the two hind feet C and D across the bottom. Two diagonals cross from corner to corner, intersecting at the center G (the center of gravity). The horizontal line E F runs across near the top (the line of direction connecting the front feet); a corresponding line runs across near the bottom.

- A (top left): A — front foot
- B (top right): B — front foot
- E (top, on the upper crossbar): E
- F (bottom, on the lower crossbar): F [printed as Γ/F]
- G (center, intersection of the diagonals): G — center of gravity
- C (bottom left): C — hind foot
- D (bottom right): D — hind foot

Let the animal's four feet be A B C D: the two front ones A B, the two hind ones C D. I say that the animal cannot advance if the two feet on one side, B D or A C, are lifted at the same time. For in that case the line of direction E F does not coincide with the center of gravity of the said animal, which in a standing animal is found at the point G. Moreover, since the raised side E B F D would outweigh the other side A E C F, the animal would necessarily fall. Hence by Nature's marvelous shrewdness it comes about that two diagonally opposite feet always either rest on the ground or are raised — namely A D, or C B. For in this way the animal is perfectly balanced by the equipoise of the parts C B D and A B C about the center of gravity G and the line of direction E F, and so it advances without any fear of falling.

Here in the Roman Capitol there may be seen two huge horses of white marble, set at the top of the staircase, of which the one on the right as you ascend has its two lateral feet raised, the other two lateral feet resting on the pedestal [abacus] — which proves the great unskillfulness of the sculptor, since, by what has been said, it is impossible for a horse, or any other animal, to raise the two feet of the same side at one and the same moment without falling. Had he observed nature, he ought to have raised two diagonally opposite feet, with the rest resting on the pedestal — as was done in the bronze statue of the Emperor Antoninus mounted on horseback, in the square of the Capitol, an object of the highest admiration to all. In it the artist used better judgment, since he shaped the walking horse after the model of nature, so that only the two diagonally opposite feet are raised, the rest resting on the pedestal. This I thought worth adding here as the occasion arose, so that it may be apparent how much architects, sculptors, and similar craftsmen need judgment in representing nature.

Propositio VI

The motion of birds cannot take place except toward the line of central direction.

Nature too seems to have been by no means idle in providing the things necessary for the bird kind to carry out their actions properly. For whether they take food, or walk, or do anything else, it is always necessary that the rule of the line of direction, under which they keep their balance, be observed. As we know from daily observation, in order to take food on the ground they bend the feet forward while inclining the head toward the earth, so that in this way they may perform their actions more easily, well balanced.

Diagram. A small woodcut vignette in the margin: a long-necked, long-legged bird (a stork) in flight, neck stretched forward and legs trailing back, illustrating

how the bird balances its body about the center of gravity. No point-letters or labels.

When they fly, they are supported by their two wings as though by two props [fulcra], lest the whole body, preponderating toward the front or the rear, should tip over; rather, the body's weight is balanced evenly. This would not happen unless the line of direction passed through the prop and the center of gravity. And since different birds have different bodily constitutions, Nature did not fail to form them by such a method, and by such art to constitute the body, feet, tail, and wings, that they may carry out their operations unimpeded. For this reason Nature also gave longer legs to the longer-necked birds, as may be seen in storks: so that they may keep themselves perfectly balanced while flying, Nature taught them to stretch the neck forward and the legs backward by an equal interval, so that, accommodating the body to the center of gravity and the line of direction, they may continue their flight more conveniently.

Birds have been taught by Nature yet another way of balancing themselves. For when they wish to raise the front part upward and lower the rear, they extend the wings — that is, the props by which they are supported — toward the front; but when, on the contrary, they direct their flight downward, they draw the wings back toward the rear. By this means or that they easily bring it about that the center of gravity is shifted to another place in the flying body. By the same method, drawing back the wings on the side toward which the body inclines, birds are accustomed to balance themselves as if on a steelyard [trutina]. For they do what a man would do who removed a weight from the beam on which a balance rests, or removed the beam from the weight: in either way the weight would be brought into equipoise.

Propositio VII

Vegetable nature cannot grow except under the line of central direction.

Whoever considers with care the growth of plants will never be able sufficiently to marvel at the admirable wisdom of God, the supreme, best, and greatest, who has provided for them with so many and such great supports to preserve themselves, and has subjected them to the same laws of the line of direction, which they observe so earnestly that no violence can wrench them from this position. And so trees and plants alike raise themselves on high in a straight line by natural appetite — and this beneath the line of direction, since without it they would never attain their end. How persistent Nature is in preserving her own rights, the countless experiences made upon plants teach us. If you draw the

branches of a tree apart through the cracks of walls, as soon as they reach the open air, mindful again of their own right and seeking straightness from the horizontal position, they raise themselves on high.

Diagram. A woodcut: at the left, a tree or branching plant whose lower branches have been bent down and trained through and around a brick wall; a weight (a round ball) hangs from one branch. The upper shoots, marked G G, turn upward toward the light despite the constraint. The wall is the brick masonry at center; to the right of the wall stand two upright trees marked N and M, growing straight up from the slope/wall base.

- G, G (upper shoots of the trained tree, turning upward): G G
- A (on the tree, near the wall): A
- B (lower part of the trained tree): B
- I (at the foot, where the hanging weight is): I — the weight hung on the branch (cf. "in I" / "in L" in the text)
- N, M (the two upright trees right of the wall): N, M

as appears in the figure, at A G and B. But if someone hangs a weight on some branch, as at I [text: "L"], intending to twist it downward, the branch is still so tenacious of its own right that, as soon as the branch is bent, the topmost shoot G — not knowing how to tend downward — raises itself as much as it can and is allowed, so as to apply itself to its own line of direction. Here appears the persistence of nature in all trees and plants everywhere that emerge from the slope of mountains or the faces of cliffs, as is evident at N and M. Nature, then, willed them to grow according to the laws of the line of direction, without which they can never reach their end. For just as a man turned upside down cannot take food and drink, being set by nature in a contrary position, so plants cannot take, while inverted, the nourishment that is propagated upward from the deepest roots. Hence there is in them so great an appetite for turning upward that by no art can they be moved from it — sooner ready to die than to obey those who try to prescribe to them laws contrary to their nature. For a tree is the more stable the straighter it is; and since it cannot preserve itself without this straightness, it seeks the position agreeable to its preservation, which is along the line of direction.

To this is added that trees and plants, because they crave heat and life from the heaven and the stars, are carried up into the sky by a kind of natural instinct of motion, as experience abundantly teaches. For trees that are born in shady places rise higher than the rest, so that they may enjoy the kindly influx of the Sun's

heat. I have more than once marveled at the vehemence of this appetite. For trees and shrubs set among walls that face the North, as if weary of places uncongenial to their nature, if they find either a window or an open opening, send their branches by a kind of natural longing toward the Southern region — as being filled with more abundant heat — insinuating themselves through the said openings, so that warmed in this way by the kindly heat of the Sun they may attain their end. You would say they know, by a kind of instinct, how to discern what things are necessary for their own preservation.

It is remarkable what those curious about Indian voyages have observed concerning certain plants. The first of these (which they call *Sargassum*) is seen on the voyage of the Western Ocean, spread about like a meadow, and, agitated by the wind, it shows itself not fixed in one place but moved according to the storms, to be seen in various stretches. This plainly shows that it does not cling to the bottom by fixed roots, but, torn loose, lives in the midst of the water on the nourishment of the surrounding moisture, its roots detached from the bottom. Its stalk is of such size that it sometimes reaches 50 feet, with leaves two, three, or four palms in length raising themselves above the water — a marvelous prodigy of nature, with many broader leaves also unfolding to the surface of the water, struggling by a kind of hidden design of nature lest the root or the more extended stalk should press the leaves below the water by its weight.

The other is the rice [*Oryza*] of China, whose harvest is brought to completion not on land but in the very waters; whence it is first sown in pools of standing water, and, having conceived its fruit, sends its leaves up along a long stalk beyond the surface of the water, and, enjoying the free air, finally ripens into grain — to the great and sole benefit of the inhabitants. And this too is in this plant most worthy of admiration: that if the pools rise with the increase of the rains, then the plant itself also raises itself above the water in proportion to the increase of the waters. All of which I received from Fr. Martino Martini [Martino Martini], an eyewitness and most diligent investigator of Indian matters, who, while I write this, holds here at Rome the office of Procurator for China — things which are also described at length in his *Atlas Sinicus* [*Novus Atlas Sinensis*], which he published in print not long ago.

But you will object that some herbs depart from this law — such as wild thyme [*serpyllum*], ground ivy [*hedera terrestris*], and the like — which never seem to raise themselves perfectly, but, creeping along the earth's surface, while they never rise up, are held up by the foreign support of the ground. The same must be said of all the species of bindweed [*convolvulus*], of ivy, and of similar plants that

live by the support of trees or walls. I reply: there is no creeping thyme that does not crave to be raised upward; and since the leaves cannot do this, being without a stalk, the stalk

nevertheless — which bears the seed, flower, and fruit — always raises itself from the center of the plant, by whatever means it can, so that in this position it may preserve the propagation of its species, without which it would not attain its end. By the same reasoning, bindweed and hops [*lupulus*], since they cannot live without a stake [pedamentum], seek out foreign supports — shrubs, trees, and other stalks — that they may thence acquire both life and nourishment, seizing them by a kind of singular instinct. And bindweed indeed, by a marvelous industry of nature, when it cannot climb straight because impeded by the mass of its stalk or its flower-cluster [thyrsus], twists itself into spirals [helices] and forms a cone whose axis is the support [fulcrum]. For in this way, while in its oblique position, wound into spirals, it embraces the stake, it clings more tenaciously and more abundantly exerts its power in producing flowers and seeds. Ivy, however, by a kind of tyrannical force invades trees and the faces of walls, so that it may preserve, by the invasion of another's right, the life that it cannot obtain by its own weak stalk-constitution and feeble feet. From all this it plainly appears that nothing in the whole economy of vegetable nature lies hidden that does not direct itself to the line of direction, so as at last to attain the end prescribed to it by nature.

Propositio VIII

All natural operations of minerals in the subterranean world take place either toward the center or from the center.

In the Subterranean World, which is the matrix and receptacle of all minerals, besides water and fire — of which the latter tends from the center, the former toward the center — there are also juices, salts, mixtures of earthy faculties [facultates], metals, and stones of every kind, the origin of all of which depends on nothing but the center of the World. For the Subterranean World is like a kind of distilling furnace, in which fire and water joined together — by means of spirits, vapors, and exhalations, conveyed through innumerable channels into the hidden receptacles of the various mountains and subterranean caverns, which are like a kind of alembic — contrive all the workshops [officinae] of mineral nature. So it is that the moisture lurking in the bowels [of the earth] behaves after the manner of an active principle; from the reciprocal action and passion of these, the spirits latent in the earthy parts are roused, and, through vapors and exhalations, according to the nature and quality of each earthy portion, pour out

the essence of its mineral, the spermatic principle [ratio] of which that earthy portion contains.

Since all these things cannot take place except with reference to the center, it has been wisely provided by nature that light things should tend from the center to the circumference, while heavy things — such as moisture — should, on the contrary, tend from the circumference to the center. For from a marriage of this kind, with nature mediating as bridesmaid [paranympa], the generations of all subterranean things must necessarily flow forth. But since we shall be treating of these matters expressly in the whole third book, it has seemed superfluous to describe so large an argument more fully in this place. Therefore let it suffice to have demonstrated here that all actions of the subterranean world necessarily bespeak a reference to the center of the World. For if you take away the center, then, as we demonstrated above, all things will be at rest, all bodies will be devoid of motion; and with motion ceasing, the generations of all things must necessarily cease. Therefore the sole and single cause why light things tend upward and heavy ones downward, to bring about subterranean generations, is the center of the Earth.

Caput III — Paradoxa de Centro Terræ

Paradoxum I

How a wooden, circular, elliptical, square, or triangular bridge, hung in the air, can be built without any support.

I suppose first that the entire Earth, in the vicinity of the center, is hollow for many miles. This being granted, if around the center of the Earth a wooden or stone bridge, circular or elliptical, is built, I say that it will stand in the air without support.

Let there be around the center of the Earth I a wooden bridge A B C D, all of whose parts, since they incline toward the center, terminate at I. Being equally balanced, it will necessarily hang in the air, gravitating equally on every side. But if anyone should deny this — let it then rest at some one of the points A B C D. But since at none of the said points is the center of gravity of the whole mass (by Canons 1 and 2), it cannot rest there either.

Diagram. A ring-shaped bridge drawn as a double-walled circular masonry band (a circular bridge with crenellated/buttressed projections around the outer rim), with the center of the Earth marked I at its center. Four cardinal points are lettered around the ring: B at top, C at right, D at bottom, A at left.

- B (top of the ring): B
- C (right of the ring): C
- D (bottom of the ring): D
- A (left of the ring): A
- i (center of the ring): I — the center of the Earth

Rather, by the isorropic [equilibrium] laws, all the parts will accommodate themselves to the center of the middle — that is, the center of the world — which we have amply shown above to coincide with the center of gravity, so that they may there obtain a firm state;

Liber I (Centrographicus), Sectio I, Caput III — Paradoxa de Centro Terræ (continued)

since it is impossible for it to stand in any other way. A wooden bridge, then, built in a circle — or of any other material whatever — will necessarily stand in the air around the Earth's center without any support, which is what was to be shown. The same would happen if a ring or a huge wheel were thrown into the Earth's center. The same would happen with a bridge built in an elliptical form, with this one difference: only the four points A, B, C, D would have a level surface, while the remaining surface — from B and D toward C, or from B and D toward A — would slope upward and present something mountainous. So men at H and M, even though they are in opposite positions on the elliptical surface, would both be climbing uphill, until they reached one of the four named points A, B, C, D, where they would stand on a level surface.

Diagram. An elliptical ring-bridge, drawn with a serrated (brick-like) outer band, encircling the Earth's center. The center is at the meeting of several radial lines. Two small human figures stand on the inner rim of the right side, each leaning toward the center.

- B (top of ellipse): vertex label
- A (left of ellipse): vertex label
- C (right of ellipse): vertex label
- D (bottom of ellipse): vertex label
- H (upper-right inner rim): position of one man
- M (right inner rim, below H): position of the second man

CONSECTARIUM (Corollary)

[p. 53]

From this it is clear that if some bridge of square or prismatic form were built around the Earth's center, it too would hang suspended in the air. For since the center of gravity of a square and of an equilateral triangle is the same as the center of magnitude — as we demonstrated above (Canon 1) — a bridge built according to the laws of such bodies will necessarily hang in the air. For with each and every part of the mass leaning toward the center with equal force, the bridge will stand in equilibrium, since there is no reason why it should lean toward the center more on one side than on the other. But suppose, if it were possible, that the portion A B D M of the bridge N B H M leaned toward the center I more than the portion N H A D. In that case the equal would surpass the equal: those parts would counterbalance and yet not counterbalance — which, being absurd and contrary to the hypothesis, proves the opposite. Therefore, with the parts all around counterbalancing one another and tending toward the center with equal force, a bridge of square shape will remain suspended in the air, which is what was to be shown.

Diagram. A square with an inscribed circle. The square's corners are lettered, the center of the circle marked, and a diagonal is drawn from one corner toward the center.

- A (top side, center): label on the top edge
- N (top-left corner): corner label
- B (top-right corner): corner label
- E (left side, middle): label on the left edge
- C (right side, middle): label on the right edge
- I (center of the circle): the center
- H (bottom-left corner): corner label
- D (bottom side, center): label on the bottom edge
- M (bottom-right corner): corner label

The same must be said of a triangular bridge A B C D E F. The difference, however, between progressing across a square or a triangular one is this: a person walking across the square bridge would find a level surface only at the four points A, C, D, E [recte: at the four corners] — for going from A toward B he would climb steadily, and from B toward C he would descend steadily — and the same holds for the triangular bridge A B C D E F: at the points B, D, E [recte: B, D,

F] we must imagine a level surface, from which one would always climb or descend toward A, C, E. Thus the four corners of the square structure, or the three of the triangular one, behave like mountains, whose roots are at those points (or, in the triangular one, B, D, F), while their peaks are at the square's points B, H, N, M, and in the triangular one A, E, C [?] — since departing from the circular plane is nothing other than either climbing from the plane upward or descending from the height to the plane.

This same principle also appears on the surface of the terrestrial globe in the case of mountains: the steeper they are, the sharper the angle that the line of direction, along which we walk, makes with the slope of the mountain. Consequently a person must wrench his whole body violently toward the line of direction; and this wrenching, being violent, is contrary to nature. It is no wonder, then, that a person is so worn out in climbing steep mountains.

Now, what we have said about bridges to be set up immediately around the Earth's center must also be said of similar structures to be built in the air around the Earth's surface. But let us demonstrate the matter. Suppose that, by divine power, a triangular bridge A B E D F C [recte: A B C D E F] were built around the Earth's surface C B D, and that lines of direction were now drawn toward the outermost surface of the bridge. It is certain that a person advancing from B toward A would be climbing steadily as though up the highest mountain, and could nowhere stand upright except at the points E, B, D — namely, where the line of direction strikes the sides of the bridge at right angles. But as he advances, as the lines of direction between E and A show, he can no longer stand upright on the surface of the bridge, and the lines of direction no longer fall perpendicularly on the side of the bridge. Instead they make angles with the sides of the bridge that grow sharper the closer he comes to the apex A. Hence it follows that a person...

Diagram. A triangle with an inscribed circle, set over the Earth's curved surface. From the apex region a fan of "lines of direction" radiates outward to the bridge's surface, each topped by a tiny human figure standing perpendicular to its line; figures stand at various points up the sloping sides.

- A (apex, top): triangle vertex
- E (left base region, inner): point where the line of direction meets the side perpendicularly
- E (right side, inner) [?]: the text names points E, B, D as the perpendicular-incidence points; the right-side label appears to read E
- F (bottom-left corner): corner label

- D (bottom, center): base label / perpendicular-incidence point
- C (bottom-right corner): corner label

so that, to keep himself within the arrangement of the central line, he must bend his body toward the slope and stand on the very tips of his toes — since on a mountain slope it is impossible to stand upright without danger of falling.

CONSECTARIUM (Corollary)

[p. 54]

From this it is clear that at the Earth's center no structure fit for human use can exist except a circular one.

PARADOXUM II (Paradox II)

[p. 54]

Fire, water, sand, and other fluid bodies at the Earth's center will at once shape themselves into a sphere.

Suppose that, by divine power, a great quantity of water were conducted through a channel into the Earth's center. I say that at the Earth's center it would at once shape itself into a sphere. For since the center of gravity of any homogeneous sphere is the same as its center of magnitude — as we showed in the first Canon — it is certain that the water cannot stand in any other way than under the form of a watery globe. For suppose, if it were possible, that it stood under the form of a square or of any other figure whatever: then the water in this state would stand around the corners of the square against nature and by force. But this is absurd. Therefore it will necessarily shape itself into a globe. For in this position the individual parts, leaning toward the center with equal force, will support one another more perfectly and will stand counterbalanced on every side. The same must be said of fluid sand.

CONSECTARIUM EXPERIMENTI (Corollary by experiment)

[p. 54]

From this it follows that if someone were to put into a spherical flask four liquids of different kinds — representing the four elements by their weight and lightness, as we taught should be done in our *Ars Magnetica* — experience teaches that, at the Earth's surface, these liquids lie parallel to the horizon, one resting upon another, in such a way that: the heaviest, representing earth, holds the lowest

place; the second, of an airy color, representing water, holds the second place in the flask, above the earthy liquid; the third, airy, holds the third place above the watery one; and finally the fourth, fiery, occupies the fourth and topmost place in the flask above the airy one. And so they all stand distinct and unmixed on the Earth's surface, holding the position that flask A B exhibits.

Now let someone descend with this flask, by divine power, toward the Earth's center. I say that the more these liquids approach the Earth's center, the more they contract into less perceptible arcs. But when the flask reaches the Earth's center, then the individual liquids — according to the position they hold around the Earth — will compose themselves spherically: so that the earthy liquid contracts into a complete sphere, while the three remaining liquids, surrounding it, each compose themselves around the earthy one according to a certain analogy commonly conceived among the elements, as figure H here appended sufficiently demonstrates.

The reason is plain from what precedes. For since these liquids are unmixable, and one always heavier than another, the heaviest — earth — will necessarily accommodate itself in the manner of a sphere, its parts of the same kind leaning toward the middle. The watery liquid, resting on the heavier one, since it cannot be mixed with it, will form itself into a ring-shape around the earthy globe; the airy around the watery; and the fiery around the airy — by a certain wonderful artifice of nature. And this can happen nowhere except at the Earth's center, and perhaps in imaginary space outside this sensible world, if the said flask were carried there by divine power. See what we have treated more fully on these matters in the *Ars Magnetica*, Book 3.

Diagram. A spherical glass flask ("phiala") on a turned pedestal foot, shown at the Earth's surface, with a stopper at top (A) and the base joint at the foot (B). Its interior is divided into four horizontal bands, each engraved with a label and small naturalistic figures (flames at top, birds, a sailing ship in the watery band, plants at the bottom). The bands, top to bottom, are lettered C, D, E, F down the left edge.

- A (top, stopper): label of the flask's mouth
- B (foot, base joint): label of the flask's base
- C (top band, left edge): *Ignæus liquor* — "fiery liquid" (with flames)
- D (second band, left edge): *Aerius liquor* — "airy liquid" (with birds)
- E (third band, left edge): *Aqueus liquor* — "watery liquid" (with a sailing ship)

- F (bottom band, left edge): *Terreus liquor* — "earthy liquid" (with plants)

CONSECTARIUM II (Corollary II)

From this the empty and stupid boasting of certain alchemists is exposed — those who pride themselves that, by means of chemical liquids conglobated into spheres, they can represent in a glass sphere the whole artifice of nature (that is, the orbs of the sensible world), and so the entire fabric of the universe, outside the Earth's center. Since this exceeds the limits not only of human but even of angelic power — being reserved to the power of almighty God alone — I cannot sufficiently marvel at the crude ignorance of men of this sort, who are not ashamed to pour out such enormous nonsense upon the world. Either, when they think such things, they convince themselves they are not in error; or, when they see that they are in error, they more confidently imagine to themselves that their flagrant deceptions cannot be detected by true philosophy. Let there now cease, then, that empty preconceived opinion held among the common people about so insane a chemical work, and let them be firmly persuaded that it cannot be accomplished except at the Earth's center.

CONSECTARIUM III (Corollary III)

[Margin: *Infernus in Centro* — Hell at the Center.]

If it is true — as is handed down by the nearly unanimous consensus of all the holy Fathers — that Hell was established by God in the lowest place of the Earth, so that those who by the weight of their sins removed themselves as far as possible from God should deservedly occupy the last and most remote place in the sensible world; and since this place can be no other than that vast Abyss of a fiery crater set around the Center of the universe — then it is plainly clear from the premises that, after the universal resurrection of the flesh, the bodies of all the damned must be heaped together into a single globe, since no surface can there be conceived except a circular one. Therefore, just as herrings are packed in a cask, so they, conglobated, will endure punishments worthy of their sins — as long as God shall be God, that is, without any end — the harsher the closer they are to the Earth's center, throughout all eternity.

Let the Christian mind learn from this to draw back from sins and to pursue the good, lest, by the sentence of the most just Judge, it be cast headlong into this most horrible place of torments, into this dreadful pit of perpetual darkness — where, with all the bars of the earthly mass shut fast, no light ever shines, no day

breaks — and pay the penalty of everlasting horror. But let these things, said in passing, suffice.

PARADOXUM III (Paradox III)

[p. 55]

At the Earth's center no one will be able to stand on his feet or hold himself upright.

For since (as we showed in what precedes) all heavy bodies at the Earth's center arrange themselves according to the center of gravity, and since the center of gravity cannot lie in the feet — the extremities of the human body — it follows necessarily that a person will adhere to the Earth's center by the navel, or by the part near it, as appears in the figure. From this arises another paradox: that a person, stretched out in this position, will, with both halves of his body — feet on one side, head and chest on the other — tend upward at one and the same time.

But if, by divine power, a leaden globe of proportionate size — say six or seven feet in diameter — were set up at the Earth's center, I say that a person, since the globe would not resist by its weight, would stand on it in a natural posture and could walk around it, as appears in the figure.

Diagram. A circular globe seen in cross-section, with a man standing upright on top of it (his feet at the top, head above), poised on a horizontal bar spanning the top from A (left) to B (right). Arrows point outward in four directions (up, left, right, down), representing the lines of direction radiating from the center.

- A (left end of the top bar): endpoint of the horizontal line
- B (right end of the top bar): endpoint of the horizontal line
- N [?] (top center, near the bar): a small label appears at the top center; reading uncertain

CONSECTARIUM (Corollary)

[p. 55]

From this it follows also that if, upon the said leaden globe A B, a surface equal to its diameter were superimposed, a person could stand upright nowhere except at the middle point of that surface. Likewise a small globe N thrown onto that surface would come to rest nowhere except at that single point through which passes the line of direction drawn through the middle from the center — which is the shortest of all the lines drawn from the Earth's center to the surface. Again, this small globe would rest at any point of the leaden globe placed beneath it,

since it is everywhere equidistant from the center by an equal interval, and the line of direction is everywhere the same. All of which is clear from what has been said.

PARADOXUM IV (Paradox IV)

[p. 55]

A person placed at the Earth's center could neither eat nor drink.

Suppose that, by divine power, someone were placed at the Earth's center in such a way that his mouth coincided with the center's midpoint. I say that he could neither eat nor drink in this position. For since in this position his whole body, whichever way it is turned, is inverted, and his head always rests at the Earth's center, he will be able to pass neither food nor drink into his stomach — inasmuch as, being wholly inverted, he tends upward on every side by his feet. Yet as soon as his head emerges from the center, even by the distance of a foot, he will then indeed be able to swallow, but only up to the part that corresponds to the center, and no further; for he will always pass food the better, the further his mouth is from the center. But these things are clear.

PARADOXUM V (Paradox V)

[p. 55]

If the whole terrestrial globe were cut horizontally through the Earth's center — that is, diametrically — then in this cut plane, by mathematical position, only one person could stand upright in a natural posture; by physical position, several.

Suppose the surface of the terrestrial globe is cut horizontally, or in any manner whatever, as A B C D. I say that on the said surface only one person can stand upright in a natural posture by mathematical position — namely at the center E. For since all the lines of the said surface tend downward into the center, it is impossible for anyone to plant himself firmly at any point other than the center. For suppose someone tries to support himself on the line A E or C E: but since those lines...

Diagram. A disk-shaped slice of the terrestrial globe, seen in oblique perspective (its thickness shown as banded layers at the bottom edge), with a man standing upright at the center, arms outstretched. The rim is lettered at four points.

- B (top, far edge): rim label
- A (left edge): rim label

- C (right edge): rim label
- D (bottom, near edge): rim label
- E (center, at the man's feet): the center point

are lines of direction, he could plant himself firmly on them and yet not plant himself firmly — which is absurd and impossible. Therefore he will stand in a natural posture at the center of the said surface alone. With this qualification, however: if on the said surface he is given a perpendicular position, he could stand on his feet; but if he obtains a position parallel to the vertical plane, he will then adhere to the Earth's center in a natural posture not by his feet, but by his navel. The reason is that one standing perpendicularly on a plane has something beneath him to be supported by; but if he has a position parallel to the vertical plane, he will not then be able to stand on his feet, but his body will be fixed at the center according to its center of gravity — as appears in the second figure, where the plane L M N O is exhibited in a perpendicular position. There it clearly appears that a person can nowhere stand upright on the line L N, nor indeed stand on his feet even at the center S, but his body will first be fixed when the center of gravity of the heavy body corresponds to the Earth's center. All of which is clear from the figure.

Diagram. The slice of the terrestrial globe shown edge-on (a vertical plane), drawn as a disk seen from the side with banded layered thickness. A man lies/floats across it horizontally through the center, his body parallel to the plane. The plane's corners/axis are lettered L (top), M (left), N (right) [?], O, with the center marked S.

- L (top): label of the vertical plane L M N O
- M (left): plane label
- N (right) [?]: plane label; the text names the plane L M N O and the line L N
- O [?]: fourth corner label of the plane (not clearly visible)
- S (center): the center point

CONSECTARIUM (Corollary)

[p. 56]

From this it follows also that, in whatever way the terrestrial globe is cut — whether perpendicularly, horizontally, or at a sloping angle — the same result always follows. For a plane of this kind will always obtain a position perpendicular to the center. Hence we have called the plane A B C D "horizontal" only insofar as it appears such to our imagination, even though it is in no way

horizontal but is a perfectly perpendicular surface. For just as no one can naturally and freely stand on a wall or flat partition built up to him, so neither can he stand on the said surface, which behaves like some vast wall, perpendicular on every side; the middle of it is the Earth's center.

PARADOXUM VI (Paradox VI)

[p. 56]

At the Earth's center, any wheel set turning will be carried neither upward nor downward.

On the Earth's surface no wheel can be turned without one of its halves always ascending and the other descending. But at the Earth's center the said wheel, when turned around, will be carried neither upward nor downward, but will always keep the same position relative to the Earth's center, from which it is everywhere equidistant and which it everywhere counterbalances. Nor will there be any difference among its parts — right, left, oblique, upper, or lower. Moreover, into whatever direction it is turned, it always rests in that position, since it inclines no more to one side than to another, but is indifferent to every position in which it is placed.

CONSECTARIUM I (Corollary I)

[p. 56]

From this it follows that if the buckets of a mill-wheel, standing perpendicular, were filled with water, the wheel when turned would pour out none of the water it holds — since all the buckets press straight toward the center.

CONSECTARIUM II (Corollary II)

[p. 56]

From this it also follows how — something that many of the ancient Fathers could not conceive — the Antipodes move in a natural posture with their feet opposite to ours. Let A B C D be the watery-terrestrial globe; let the Antipodes be F G, E S [?], who walk with their feet turned toward us. I say that they walk in a natural posture, because each opposite part inclines toward the center D through the lines of direction F D and S G. The same must be understood of ships, since they all tend on every side toward the Earth's center along the lines of direction beneath which they are carried. Nor — as simpler folk falsely imagine to themselves — is the falling of men or ships on the parts opposite to us to be

feared. So if certain of the ancients had known the nature of the center, they would not have reasoned so unskillfully about some Abyss and whirlpool of the Earth, which they imagined to exist below the horizon.

PARADOXUM VII (Paradox VII)

[p. 56]

At the Earth's center, two men tending toward opposite parts will both ascend naturally.

Let A be at the Earth's center, with a ladder B C set against it. I say that from the center A two men — one of whom ascends from A toward B, and the other from A toward C, at one and the same time — both, although they ascend toward the opposite parts A and B [recte: B and C], nevertheless ascend naturally. The reason is clear of itself.

Diagram. A circle (the Earth's center region) with a vertical ladder running across it from B (top) to C (bottom), the center marked A on the ladder's midpoint. Two small human figures climb the ladder — one above the center, one below — each oriented to climb "upward" away from the center in opposite directions.

- B (top of the ladder): upper endpoint
- A (center of the ladder/circle): the Earth's center
- C (bottom of the ladder): lower endpoint

The ladder, too, moved into whatever direction, will there have its natural position.

PARADOXUM VIII.

The flight of any bird around the Center of the Earth will be easiest and most natural either along a circular path or along a helical line; every other motion will be violent.

A bird will move around the Center of the Earth with a natural and easy motion when it moves along a circle or a helical line. This is clear in the case of circle A, which the bird traces out in its flight, because in this way it sustains no violent motion. Violent motion is what happens to birds when they are carried upward. The same must be said of flight along a helical line: since that line is composed of the circular and the inclined, it will accelerate the flight most of all, and the bird cannot make for the Center of the Earth more easily than along this line. But if it were to move along the line A–B, I say that the bird would undergo nothing but

violent motion. From D it would be carried upward toward A or toward B along a straight line, which is most violent for birds; and the most violent of all is motion along a perpendicular line, so that there is scarcely a bird that could sustain it. Hence, by a certain instinct of nature, all birds in their flight prefer the helix, whether they are heading upward or downward. For this reason, a bird would remain fixed at the very Center of the Earth: since nothing is so contrary to birds as perpendicular upward motion, and at the Center of the Earth there is no ascent except along the perpendicular, the bird would stay put there — held back both by the difficulty of the ascent and by its own Center of Gravity.

Diagram. A bird's flight path drawn as a spiral (helix) winding inward toward the central point. A horizontal straight line runs across the top of the figure from A on the left through D at the center-top to B on the right. The spiral coils inward to a small central point marked I (the Center of the Earth). Two small birds are drawn on the spiral curve, illustrating the natural helical flight path.

- A (upper left): left endpoint of the horizontal straight line
- D (upper center): midpoint of the horizontal line, above the center
- B (upper right): right endpoint of the horizontal straight line
- I (center): the central point (Center of the Earth), toward which the spiral converges

PARADOXUM IX.

If the seed of some plant were thrown into the Center of the Earth, it would flower out in every direction into the shape of a radiating star.

If seeds of some plant, embedded in a mass of earth, were thrown into the Center of the Earth, I say that they could flower out only in the form of a radiating sphere. For since individual plants are naturally carried upward along the line of direction — as was also stated above — and at the Center of the Earth the lines of direction point upward in every direction, the seeds sprouting along them would raise their stalks spherically, since they cannot achieve their end under any other arrangement.

Diagram. A small woodcut showing a star-shaped or rosette arrangement: stalks radiating outward in every direction from a central point, like the petals of a flower or the rays of a star, illustrating how a seed planted at the Center would sprout outward in all directions to form a radiating sphere. No labels.

PARADOXUM X.

Fire kindled at the Center of the Earth is spherical.

For since fire by its nature is carried upward, and at the Center it would be conceived as moving upward in every direction, it would necessarily, being diffused in all directions, take on a radiating body.

PARADOXUM XI.

On establishing a perpetual motion at the Center of the Earth.

I cannot pass over at this point the empty contrivances and notable fallacies of certain people who suppose — indeed strive to demonstrate — that an artificial perpetual motion can be produced in a certain way at the Center of the Earth. They try to show it by the following argument.

First, let two supports G–K and H–I be set up, together with the axle G–H. Around this axle let a gnomon A–B–C, with a leaden globe C fixed to it, be applied in such a way that it can revolve about the axle by its pivot A. This being set up, they say it will come about that the gnomon A–B–C, once set in motion, will perpetually continue its motion about the axle G–H, driven in the circle B–D–E–F. They assign as the reason for this that the leaden globe fixed to the gnomon — since, being impeded, it cannot descend toward the Center A along the line of direction C–A — perpetually presses by its own weight toward D; and thus, since the motion, weighed down by the load, can come to rest nowhere as it passes from D toward E, and from F toward E, and from there toward B, it will repeat the circle again and again with an ever-new revolution, in a perennial motion. In this way, then, they falsely persuade themselves that a perpetual motion can be produced about the Center of the Earth.

Having very often observed this device — so impressive at first sight — I could not help laughing at the deceptive illusions of the human imagination. And so, since this is contrary to the propositions I have set down in this book, I decided it should be refuted, so that henceforth others may not wear themselves out in the useless labor of demonstrating it.

Diagram. A schematic of the proposed perpetual-motion machine. A large circle is drawn, at whose center is point A. Across and within the circle runs the gnomon (a rigid arm) with its parts labeled, carrying a leaden globe; the supports and axle frame the device. The circular path traced by the arm is marked by points B, D, E, F around the circle.

- A (center): the Center, the pivot point of the gnomon
- B (top of circle): top point of the circular path; upper end of the gnomon arm
- C / d (upper right): the leaden globe fixed to the gnomon (drawn as a small circle at upper right)
- I (between B and A, upper area): a point on the gnomon/arm near the axle
- E (left of circle): left point of the circular path
- D (right of circle): right point of the circular path
- d (left-center, on inner arm): a labeled point on an inner arm of the gnomon
- F (lower part of circle): lower point of the circular path
- G–H (center region): the axle, about which the gnomon revolves (H marked near the center-right)
- K (lower left): lower end of support G–K
- L (lower right): lower end of support H–I (marked at bottom right)

The supports G–K and H–I are drawn as two vertical bars descending below the circle to K (left) and L/I (right).

First, then, they set up two supports G–H [recte: G–K], H–I, together with the axle G–H, and they suppose that the axle and the supports have the same position about the Center of the Earth that they have on its surface — which is the mockery of a ridiculous and false imagination. For if the supports could be arranged about the Center of the Earth, they would certainly not be allotted a perpendicular position, as they have on the surface of the Earth, but the opposite: namely, an oblique position, sloping upward. In the same way, one half of the axle, G–A, and the other, H–A, would both tend upward alike. If, then, plumb lines fitted with leaden balls were attached at G and H, the extreme ends of the axle, it would clearly be seen that, given the position of the supports, these balls could by no means fall downward, since they lie outside the line of direction. They would therefore fall into the Center A, where they would come to rest. The supports, then, since they would tend upward against nature, cannot stand up.

Having shown this, let us now see whether a gnomon revolving about the axle G–H can produce a perpetual motion. Let it move, then, if it can, from C toward D through the arc C–D. But since this motion, being violent, lies outside the line of direction A–C, it is impossible for it to continue its motion without a fresh impulse. The gnomon will therefore come to a stand, together with the globe fixed to it, at whatever point of the circle B–D–E–F. This I show as follows. Since the

whole assembly of the gnomon A–B–C behaves as a single solid mass, by Definition III and Canon 4 its Center of Gravity will be at I; and consequently, wherever it is placed, it will come to rest, because the Center of Gravity I conforms perfectly to the line of direction. As was fully demonstrated in the first Section, a thing cannot move of its own accord into points [outside the line of direction], unless it is drawn into it.

Nor does it bear at all on the matter that the globe is falsely supposed to preponderate and always to strain forward. For preponderation of this kind does not come about by a natural motion forward, but toward the Center A, along the line of direction beneath it — as is also plainly established from the preceding paradoxes. For if a channel were made about the Center of the Earth, twisted into the circle B–D–F–E, and a globe were placed in it, it is certain that the globe, once set in motion, would not be moved perpetually, but would come to rest at some point of the channel. The same is to be understood of water poured into the channel: it would not flow, but would hold itself at rest along the lines of direction, without motion. Therefore what I assumed at the outset — that perpetual motion at the Center is, in the manner described, impossible — is what was to be demonstrated.

SECTIO II.

PHYSICO-MATHEMATICA.

AND IT IS

On the motion of heavy bodies toward the Center of the Universe.

PREFACE

Since all heavy bodies are carried toward the Center by a certain innate appetite, if there were no Center, all motion too would cease, since the heavy body would have nothing it sought. If there were no Center, the locomotive power would also cease, since — as we demonstrated above — no locomotive action can be produced without an essential reference to the Center. If there were no Center, light bodies would not tend upward, because there would be no motion from the Center to the circumference, just as there would be none from the circumference to the Center in heavy bodies. The Center, therefore, is the cause not only of local motion, but of all elementary motion. But what this motion properly is, and how it is accomplished, we have decided to set out in this Section.

CAPUT I.

Definition of the local motion of bodies, and of impetus.

We are not dealing here with intrinsic motions, which are those of the intellect, of the will, and of the various affections of the soul, but with the local motion of things, natural and violent, whether intrinsic or extrinsic: with rectilinear and circular motion, and finally with mixed motion — mixed both from the natural and the violent, and from the rectilinear and the circular — and with reflected motion; in short, with all motions that cannot be produced without reference to the Center.

The natural downward motion of heavy bodies is an intrinsic appetite toward the Center of the Earth, which all things seek. It is not, as some have persuaded themselves, due to an attractive force of the Earth, nor to some rarefied matter that solicits the heavy body to motion, nor to air set in motion and driving it back from behind (as Pererius [Benito Pereira] holds), nor to some gravity superadded to the stone during its very motion (as some Peripatetics hold). Rather, as I said, it is due to an innate appetite, whose whole force comes from impetus or impulse.

But before we proceed further, let me make clearer the nature of impetus or impulse. It should be known that impetus or impulse is nothing other than a certain quality that demands the motion of its subject. For since the motive potency and faculty is active, in order that it may produce something, it is necessary [that it produce something]; but it produces nothing other than impetus. Therefore, without impetus, a heavy body could not move naturally. Impetus or impulse is therefore necessarily connected and connatural to the motion of heavy bodies — even though it is something distinct from the substance of the moving body, since a moving body at rest can exist without impetus, whereas one actually in motion cannot be conceived without impetus.

From this I conclude that impetus produced from without is not produced by a quality, nor by a resisting power, nor by anything other than impetus, which is most of all the connatural cause of another impetus. Yet it acts upon what is external only insofar as it removes an impediment. Hence, according to the differing nature of the impeding object, it acts now more, now less — and most of all when the impediment is greatest.

From this it follows, secondly, that an intense impetus can produce a remitted impetus, if the impulse of a smaller moving body is carried into a larger one; and a remitted impetus can produce an intense one, if the impetus or impulse of a

larger moving body is carried into a smaller one. But if the moving bodies are equal, they will produce an equal impetus — which happens most of all when the Centers of Gravity of both moving bodies are connected by the line of direction, as will later be demonstrated.

Thirdly, since there is a natural downward motion of heavy bodies from an intrinsic source, it cannot exist except from an impulse — both because its acceleration cannot be explained without an impulse, and because a heavy body falling downward imprints an impulse on a body it meets, which would not happen if it were devoid of impulse from within. And so, that motion is naturally accelerated is plain even from this: since motion in a free medium is not impeded, and the impulse produced in the first instant is not preserved in the second instant by the cause that first produced it but by another — and since the cause is the necessary cause of the moving body's substance — certainly in the second instant it produces a new impulse; and the same is to be said of the third, fourth, and fifth instant. As the cause of motion thus grows, the motion itself also grows. Hence, in equal times, equal increments of velocity are acquired, because a necessary cause in equal times produces an equal effect.

§ I.

The true account is set out: why a heavy body in motion is faster at the end.

The motion of heavy bodies, like the motion of all things, has rightly tormented the minds of philosophers; and so it must also be explained with the greatest care, so that the most hidden cause of so plain an effect may be known.

I suppose, first, that the active principle of motion and the active principle of gravity are, as to the thing itself, identical; and I say that this principle is nothing other than a propensity, in first act, of tending toward something. Motion and gravity, on the other hand, are of second act, and are diversified as effects from that one principle — in much the same way as, on the Peripatetic view, light and heat produced by the Sun are different effects of one principle, namely the Sun. Indeed, motion is the effect of a natural propensity or inclination that is unimpeded, whereas gravity is the effect of the same propensity or inclination when it is impeded. For a body weighs precisely because it propends toward something and, in order that it may not be moved, is impeded; for if all propension were removed, certainly all gravity would necessarily cease.

I suppose, secondly, that every heavy body subsists in the same faculty and the same act, both when, released, it runs, and when, impeded, it weighs. For a bent bow, when relaxed, drives the arrow with as great a force as the impetus presses

upon the obstacle. Hence, with the impediment removed, the weight passes into motion, and with the obstacle imposed, the motion passes into weight — all of which is established by experience.

I suppose, thirdly, that every heavy body, as was also shown above, has received from the Author of nature a certain propensity of tendency toward the Center of the Earth, so that it perpetually seeks the Center of the World. This proneness is such that, together with the moving body or heavy body in which it exists, it is always [?] [continues below]

always [?] vigorous in act; and the moving body, to which it is always intimately present, it continually solicits — by a certain added stimulus — either to move or to weigh. Nothing is so opposed to this propensity as ever to turn it away from the affection innate to it — whether the moving body is composed in rest or is violently snatched away — since by that natural activity of its own it cannot necessarily be deprived of the effect that follows from it, even if it is assailed by a most violent and contrary seizure.

From this I conclude, first, that a body placed outside the Center either, when unimpeded, moves, or, when relatively impeded, weighs. I added "relatively" on account of the weak impediment that often occurs; for then the moving body partly weighs and partly moves. I conclude, secondly, that the velocity of motion is greater, and is discerned to be greater, in a moving body when the body itself traverses an equal space in a shorter time, or a greater space in an equal time. This too is manifest: that motion can be increased to infinity, if a motive power is present — so much so that, as far as the moving body is concerned, it could always traverse some designated space in a shorter and shorter time, according to the division of the parts of time to infinity.

These things being laid down, I demonstrate what I intended at the outset: that the velocity of a moving body must be greater at the end of its motion than at the beginning or in the middle. I suppose, however, that the medium is always full of a uniformly fluid body, and that it shows itself apt to be divided uniformly by the falling body; for whatever things occur in the medium, since they are extrinsic and help or retard only by accident, are to be disregarded in the demonstration.

Let the space A–B be traversed by a moving body in natural motion, and let the space itself be divided into equal spaces, which are C, D, E, F; and let the moving body be released from place A. It is certain that it must, by the natural propensity innate to it, first be carried through space C. In its first course, let us say that the degree of velocity of the moving body itself must be as one. But now, since at

point O the moving body, gliding without impediment, is not deprived of its natural propensity of tendency toward the Center, but preserves the motion once acquired — preserving the formation of that motion perpetually — it is therefore carried through space D by its innate propensity, agitated as if by a continual stimulus. For besides that adventitious motion from the first mover, which procures the formation of motion and what has been acquired once, that internal natural propensity toward the Center is vigorous: it continually stimulates and, as if by hand, drives, by the production of ever-new and new impulses. Therefore, since that stimulation claims its own effect for itself — just as one candle added to another candle increases and intensifies the light in a chamber — the moving body, thus formed by motion and stimulated by the natural impulse, will traverse space D in a shorter time than it would have traversed by the merely acquired violence at that point; and thus it will traverse the part of space D with a greater degree of velocity than it had completed the part of space C — let this degree of velocity be called, as I say, [a unit?]. In like manner, by the production of ever-new and new impulses, the moving body, set in motion, will traverse space E in a shorter span of time than it had completed in D, and in F in a still shorter span of time than in E, and so on to infinity. The moving body, therefore — both by that natural propensity of tendency toward the Center of the Universe, and by the production of ever-new and new impulses — will be driven faster and faster toward the end; which was to be demonstrated. But what the proportion of this motion is with respect to time must now be set forth.

Diagram. A vertical straight line representing the space A–B traversed by a falling body, with A at the top and B at the bottom. Along the line, division points mark the equal subdivisions of the fall (C, O, D, E, F, G, H), illustrating the successive spaces traversed with increasing velocity.

- A (top): the starting point of the fall, top of the vertical line
- C (below A): first division point
- O (below C): a marked point on the line (where the body glides without impediment)
- D (below O): division point
- E (below D): division point
- F (below E): division point
- G (below F): division point
- H (below G): division point
- B (bottom): the endpoint of the fall, bottom of the vertical line

CAPUT II.

On the accelerated natural and violent motion of heavy bodies, and its proportion to the time in which it covers the said space.

It cannot in the least be denied that the keenness of the lynx-eyed philosophers of our age, in scrutinizing the secrets of motion, has reached such a point that they seem to have left all the Ancients many leagues [parasangs] behind. For I find no one among the Ancients, so far as I know, who assigned the genuine proportion of accelerated motion; and yet, without that proportion being assigned, it does not seem possible to see how the account and property of motion (I am always speaking of the motion of heavy bodies, whether natural or violent) could be established. And since the matter is full of subtlety and ingenuity, I have decided to discuss it here somewhat more fully, following the doctrines and discoveries of the modern philosophers. In order to do this as well as possible, I must first set down a few things for the easier grasp of beginners.

It should be noted, then, first, that it is manifest to everyone that the motion of things falling from a height is faster at the end than in the middle, and faster in the middle than at the beginning. It should be noted, secondly, that the velocity of motion of heavy bodies multiplies its increments in such a way that, from the very first moment of the fall, when the moving body departs from rest, its motion is continually accelerated more and more — or, what is the same, ever more and more increments of velocity are uniformly added to those previously acquired. It should be noted, thirdly, that these increments can be compared [continues]

[these increments] can be compared either with parts of time or with parts of space. For one can first designate a certain interval of time — say, a first minute or a second of an hour — to which equal succeeding intervals can be assigned, so that the whole time that the falling body takes in descending is divided into many such parts of an hour. Or one can designate a certain length of space — say, of one foot or one cubit, or some similar measure — to which other equal lengths can be taken in the space that follows, so that the whole space traversed by the falling body is understood to be divided into many such parts. Or again, the motion can be compared to some first velocity, namely the one acquired at the end of that first interval of time, to which other equal velocities are added on by the succeeding motion — just as degrees are usually added to degrees in qualities capable of intensification. In this way the velocity acquired at the end of the

motion is the most intense, being constituted from all the velocities, or degrees, that were acquired while the motion continued, each of them equal to the others and to that first one.

With these preliminaries set down, let us first of all bring forward the definition of the accelerated motion of heavy bodies, so that once it is understood the rest may be grasped more easily. Galileo [Galileo Galilei] defines the accelerated motion of heavy bodies tending toward the Center as follows: *that which, departing from rest, acquires in equal times equal increments of speed and momentum [celeritatis momenta incrementaque].*

Some explain this definition wrongly. They suppose that the velocities behave like the spaces — that is, that just as many equal degrees of velocity are first acquired as there are equal parts of space traversed after the first degree has been passed. For example: if a certain space were divided into ten feet, and at the end of the first foot of space the body acquired one degree of velocity, in the second two, in the third three, in the fourth four, and so on for the rest, then in the tenth they suppose ten degrees of velocity to be acquired. But this, as experience refutes, can in no way be asserted. For it would follow that the last degree of velocity is equal to the first, which is contrary to our supposition, and plainly conflicts with the common axiom that *motion is faster at the end* [motui in fine velocior]. Others suppose that the time in which (for example) some body traverses AB is double the time in which it traverses BC — which likewise neither ought to be nor can be asserted. For it would necessarily follow that, given the time in which the part AD has once been traversed, another time equal to it could in no way be reached except after an infinite space had been passed. To make this plainly evident: let the line AB be understood as produced to infinity and divided into the equal parts AB, BC, CD, DE, EF, FG, and GH. If, then, the time in which AB is traversed were double the time in which BC is traversed, it would necessarily follow that the time in which BC is traversed is double the time in which CD is traversed; and this, double the time of DE; and that, double the time of [EF]; and the time in which EF is traversed [is double that in which FG is traversed], and so on. Nor is there any greater reason for the one than for the other. For since the time in which BC is traversed is half the time in which AB is traversed, it is necessarily concluded from this that the space traversed in CD is $\frac{1}{4}$ of the first time; and that of DE, $\frac{1}{8}$; and of EF, $\frac{1}{16}$; and of FG, $\frac{1}{32}$; and of GH, $\frac{1}{64}$ of the first time's portion. And so on, the diminution of the parts proceeding to infinity in a double proportion of the diminution corresponding to it. Yet all these taken together will never equal the first time AB, being parts of it — unless an infinite space, and within it infinite equal parts, be admitted, parts that would

correspond, by infinite analogous halvings of halves, to the things understood within the very time in which AB is traversed.

The definition, therefore, is by no means to be understood in this way, but in the way we shall now set out. It is certain that the increments of velocity bear a fixed proportion to the spaces — not, indeed, the proportion that uniform motion immediately exhibits, but the one that uniformly accelerated motion exhibits, whose velocity grows continuously and uniformly, so that there is no moment of the succeeding time in which the motion is not faster than in any preceding one, and in which the velocity is not increased by the same ratio.

[The figure that the text describes here — a right-triangle with side AC divided into five equal parts — is rendered at the foot of the page as a tall narrow schematic; see the diagram metadata at the foot of this page.]

Hence Galileo sets forth the increments of the said velocities by means of the following triangle ABC, whose side AC is divided into any number of equal parts — say, five: AD, DE, EF, FG, GC. From these are drawn just as many parallels to the base BC: HD, IE, KF, IG [recte: LG]. For in this way the parts of the side AC express equal times, while the parallels express the degrees of velocity, which grow equally and uniformly in equal times. Thus A represents the place of rest, from which the body falls; the parallel HD represents the velocity that the body acquires by falling through AD; the parallel IE marks the velocity that the body, falling from A, acquires through the space AE; and so on for the rest. But since this velocity grows continuously from moment to moment without any interruption, without any pause or leap, uniformly from a fixed time into a fixed time, it is certain that the degrees of velocity from A up to the acquisition of the degree HD — which happens in the time AD — are infinite, corresponding to the infinity of the instants of the time AD, or of the points of the line AD.

But let us set out the matter a little more clearly. It must be noted, then, that all the velocities BC are reckoned as composed of all the preceding ones, just as the line of times AC is reckoned as composed of all the other parts. But the surfaces of the triangles that the parallel lines form with the lines of times —

Diagram. A tall, narrow right-triangle drawn with a long near-vertical hypotenuse from the apex A down to the base point B at the lower left. The right side AC (here drawn as the right vertical edge) is divided into equal segments, with horizontal parallels carried across to the hypotenuse.

- A (apex, top): A — the place of rest, start of motion
- B (lower left, foot of hypotenuse): B

- The right (vertical) edge is divided at points D, E, F, G, C downward; the corresponding parallel chords meet the hypotenuse at H, I, K, L respectively.
- Parallel chords labelled (top to bottom): HD, IE, KF, LG — the degrees of velocity acquired through successive equal times AD, AE, AF, AG.

— that is, of the kind that the triangles AHD, AIE, AKF, AIG [recte: ALG], ABC are — increase in the ratio of the squares of the times, or, what is the same thing, in the doubled ratio of the times. In this way the triangle AIE exhibits the space traversed during the time of the motion from A to E, and it is quadruple the triangle AHD — namely the space traversed during the time of the motion from A to D; for this line AD is double the time AE [recte: AE is double the time AD], and consequently the surface of the triangle AKF is nine times greater than the surface of the triangle AHD, just as the space that the body covers in the time AF is nine times greater than the one it covers in the time AD. Hence, since the time AE and the velocity EI stand to the time AF and the velocity KF as 2 to 3, the spaces (or surfaces of the triangles) AIE and AKF will necessarily be as the squares 4 and 9. If, then, the whole space is distributed into the parts of the said times, the first part will contain 1, the second 3, the third 5, the fourth 7, the fifth 9, and so on, proceeding to infinity according to the progression of the odd numbers — just as the surfaces of the triangles exhibit:

Triangle	Value
AHD	1
HDIE	3
IEKF	5
KFLG	7
LGBC	9

But that you may grasp my meaning more clearly, I have judged it well to clarify what has been said by means of another diagram, which Gassendus [Pierre Gassendi] also uses in his letters. Let a triangle ABC be made, whose sides AB and AC are divided into any number of equal parts: the side AB into ADFHKMO, and so on, and the side AC into AEGIL, and so on, in successive order. Let the points where they meet on the two sides be joined by the lines DE, FG, HI, KL, and so on. Then from each of the points of the two sides let other lines, parallel to the sides, be drawn to the base BC of the triangle ABC — namely E α , G β , I γ — and parallels from the points of side AC to the points of the base, as well as parallels from the points of side AB, DFH, to the points I, θ , H of the base of the triangle, sufficiently

demonstrate it. For when these have been drawn, the whole triangle ABC is distributed into other smaller triangles, similar to one another and entirely equiangular in a continuous analogy with the larger one.

This being laid down, the point A in this triangle can be taken either for the beginning of time, or for the beginning of space, or for the beginning of velocity — the three things regarded here in motion, as was said above, which begin together with it. And the equal parts of each side, AE, EG, GI, IL, and so on, or AB [recte: AD], DF, FH, HK, into which it is divided, can be established as the equal moments of time flowing from the beginning, that is from the point A — so that AE marks the first moment, EG the second, GI the third, IL the fourth. The parallel lines within their own triangles — for example, in ADEHKMO [recte: in the triangles formed at A, D, E...], and so on — can be taken for the velocities by which the motions are accelerated, corresponding to and equal to the moments of the sides; and the triangles, for the parts of space that the body traverses in each of the said moments.

But let us apply each to each. Let there be a line PQ along which some body runs toward the Center with even and uniform motion, and let PQ be divided into 16 equal parts, which represent the parts of space through which the body slides from P to Q — say, through sixteen cubits. Surely the triangle, by its ingenious arrangement, beautifully shows that the body covers spaces in equal times. For the first triangle ADE shows, on the line PQ, the first space PR — of one cubit, say — which the body traverses in the first moment of time. The three next triangles show that the body, in the second moment, traverses three cubits, which on the line PQ they express as RS.

Diagram. A large equilateral triangle ABC with apex A at top and base BC at bottom, filled with a lattice of small similar triangles arranged in successive rows. Each small upward-pointing triangle is inscribed with the odd-number sequence (1, then 1·2·3, then 1·2·3·4·5, etc.) row by row, the rows increasing as the odd-number progression. To the left of the triangle, a dotted serpentine (S-shaped) curve runs alongside a vertical scale line marked P at top, then R, S, T, and B at bottom, graduated 1, 3, 5, 7 (and totalling 16 at B) — the line PQ of the text mapped against the cumulative fall distances.

- A (apex): A — origin of time, space, and velocity
- B (lower left base corner): B
- C (lower right base corner): C
- Left side, descending: D, F, H, K, M, O — division points of side AB

- Right side, descending: E, G, I, L, N (with further points) — division points of side AC; outer right margin also carries running tick-labels
- Left diagonal caption (along side AB, reading upward): *Tempora Quadrata* [the squared times]
- Right diagonal caption (along side AC, reading upward): *Momenta Temporis* [the moments of time]
- Base strip caption (hatched band along BC): [Latin band caption, abraded — [?]]
- Below the base, a row of Greek letters: $\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta, \theta, \iota$
- Vertical scale at left: P (top), R, S, T, B (bottom); tick values 1, 3, 5, 7 with cumulative total 16 at B

Five triangles, enclosed within the parts FG, HI in the triangle ABC, indicate that the body in the third moment GI traverses five cubits, which on the line PQ the space ST indicates. And seven triangles, enclosed between the parallels HI and KL, show that the body in the fourth moment IL traverses seven cubits, which on the line PQ the space TQ indicates. And so on for the rest, proceeding to infinity in the same way, it must be laid down.

From all this it clearly appears that the aggregates of the triangles behave like the squares of the times. For just as ADE is one triangle, so the space PR is also one, and the moment of time AE, in which the body traverses the said space, is likewise one (squared). But since within AG there are two spaces, these multiplied into themselves will give 4 — the square, namely, which just so many small triangles enclosed within the triangle AFG mark, and to which on the line PQ corresponds the aggregate of the parts enclosed between P and S. So you see that the aggregate AHI in the triangle ABC is 9, just as the —

— aggregate of the parts enclosed on the line PQ between Q [recte: P] and T, just as also the square of the line AI, divided into three parts, which marks three moments of time, is 9. Finally AKL, which on the line PQ corresponds to Q, is 16 — just as the square of AL, the line composed of four moments, is 16.

Furthermore, just as AL [recte: AE], the moment of the first time, can be divided to infinity, so from the infinite points of the line AE infinite parallels can be drawn from them up to D; so that, just as these lines grow continuously from the point A into the line DE, so the velocity grows continuously from the beginning of motion up to the last point of the first time, which E represents. And because the velocity, increasing thereafter, can again be represented by larger and larger lines drawn between the sides of the triangle, it follows from this that the line FG

represents the velocity acquired at the end of the second moment, the line HI the velocity acquired at the end of the third, and the line KL the velocity acquired at the end of the fourth. So that it is hence clearly evident that velocities behave as the times do; for as DE is to EA, so FG is to GA, and HI to HA [recte: IA], and KL to LA.

And from all this it is clear that the accelerated motion of heavy bodies tending toward the Center acquires the increments of its velocity continuously, equably, and uniformly according to the progression of the odd numbers from unity, as the definition set down above teaches; while the aggregates of the velocities turn out in the doubled ratio of the times. This is so true that there is no motion — whether natural or violent, whether straight or inclined, whether circular, or reflected in pendulums, or finally the lapse of water enclosed within channels — in which it is not verified; which I have judged fit to demonstrate in as many chapters.

CAPUT III.

De motu gravium supra plana inclinata.

[On the motion of heavy bodies upon inclined planes.]

Just as, in the preceding perpendicular motion of heavy bodies, the bodies are carried with accelerated motion, under a continuous and uniform increase of velocity, toward the Center, in just the same way they do this upon any planes inclined in any manner whatever — provided, however, that the inclined plane is supposed to be very smooth and highly polished, the body too exactly round, and its surface so disposed that it offers no impediment to the motion.

These things being laid down: let there be two inclined planes AC and AD, along which some body runs down to the horizontal point A; and let the line CB be perpendicular, along which a heavy body is moved by natural motion toward the Center. Then from DB [recte: from B] let perpendiculars BT and BI be drawn to each of the inclined lines CA and DA. Galileo therefore says that, at the same time and moment at which the body, falling from C, reaches the last terminus of motion, B, at that same time and moment the body, having slid down from C along the inclined plane CA and along the inclined plane DA, reaches its own terminus — the one from C at T, the other from D at I — namely the termini assigned by the perpendiculars BT and BI on the inclined planes AC and DA. The same is to be understood of any points whatever of the inclined lines that are assigned on CA and DA. And if the point A be determined as the last on the line

CA, he says that the body from C will descend to the terminus of its motion in the same time in which the body, falling from C to S, does so — which assigns two termini by means of the perpendicular line AS, defined on each line, both AC and CS produced.

From this it plainly follows that the time of the perpendicular fall stands to the oblique fall as the declined motion stands to the perpendicular. For example: the time of fall of some weight from C to D stands to the time of fall of the same weight from C to A, or from D to A, as CB to CA, or as DB to DA. But you will perceive the matter better in the second Figure.

Diagram. A fan of lines from a vertex A at the left, opening toward the right. Two inclined lines run up-and-out from A; a near-horizontal line AB runs to B; perpendiculars from B drop onto the inclined lines at the labelled points.

- A (left vertex): A — the horizontal point where the planes meet
- B (right): B — terminus of the perpendicular fall
- T (upper, on inclined plane CA): T — terminus of the slide along CA
- I (upper, near D): I — terminus of the slide along DA
- D (upper right): D
- S (lower right): S — terminus assigned by perpendicular AS

Diagram. A right triangle with apex A at top, a near-vertical right edge descending to D at bottom, and B at the left. A point C lies on the right edge between A and D, with B joined to C (BC, the half) and the angle at B marked.

- A (top): A
- B (left): B — angle B is 30 degrees
- C (right edge, between A and D): C — AC is the sine
- D (bottom): D

I say, then, that just as AC stands to BA, so the motion from A to C stands to the motion from A to B; and consequently the body will fall from A to D in the same time in which the body goes from A to B. This I demonstrate as follows. Since the angle B of the triangle ABC is 30 degrees, the line AC will be half of BA, which is the whole sine. Just as AC is the right sine of 30 degrees — such as the angle D of the triangle ABD also is — its sine AB is half of the radius AD, which is quadruple CA; and BA is the mean proportional between AC and AD, for it is double AC and half AD. And if we suppose AC to be a space of three feet, some weight will traverse it in the time of half of one second, and the other three parts, which run from C to D, in the time of another half of one second. This being laid down, we

say that the said weight is moved in the same time along the inclined plane AB as along the normal or vertical AD; from which it follows that the body, in the time of one second [unius secundi minuti], takes twice as much time as the body does in going from A to C. From which it again follows that the ratio of the time of the motion AB to the time of the motion AC is the same as that which the line BA of six feet has to the line AC of three feet — since the line AB is double AC, just as the time of fall AB is double the time of fall AC. Or, otherwise: Since —

— Since the times are in the sub-doubled ratio of the spaces, the ratio of the time in which the body falls through AC to the time in which it falls through AD will be as the root of the space AC, 1, to the root of the space AD, 2. The ratio of the line AC to BA, and of AB to DA, is also the same; for since AB is the mean proportional between AC and AD, it will stand to the said lines as the roots of the spaces AC and AD stand to one another.

SCHOLIUM.

[Scholium.]

Although Galileo has shown the motion upon inclined planes by ingenious arguments, no one who has weighed the matter on a finer balance will be able to deny that many falsehoods lie hidden beneath them, utterly contrary to experience.

The first thing, then, that can be objected to this is that a notable difference comes to light between straight or vertical motion and motion upon inclined planes. If anyone rightly compares these two motions with each other, he will see that it cannot be that a motion on an inclined plane, determined by the perpendicular, should exactly correspond to the one that takes place along a vertical line. For since in vertical descent the body has no other impediment besides the air, it will certainly cover its space far more quickly and freely than a body in descent along an inclined plane, where — at however many points some body touches it — just so many impediments and interruptions must be reckoned.

Secondly, there are experiments by which Mersennus [Marin Mersenne], in his *Harmonie universelle* [Mersenne, *Harmonie universelle*, bk. 2, fol. 113], and in a letter sent to me, sufficiently and more than sufficiently shows how far Galileo's conjectures stray from the truth. There he reviews the experiments he made, in these words:

In order, then, to examine more exactly the motion upon inclined planes described by Galileo, I first chose a height of 5 royal feet; then I had a plane made, as polished

as could be, so constructed that it could be directed at the operator's pleasure according to various inclinations. Finally I let two leaden globes of equal size and weight fall, the one along the inclined plane, the other along the vertical line, at the same time and from the same height of 5 [feet]. And we found that the globe running along the inclined plane of 5 degrees had completed only one foot on that plane, while meanwhile the other, falling along the vertical line, completed the 5 feet; whereas the globe on the inclined plane ought to have completed 16 inches on that plane, if Galileo's reasoning had been true, and not one foot.

Again we inclined the said plane to 25 degrees, and on the fall of the globes being repeated, we found that the globe along the inclined plane had completed only one foot and a half, whereas it ought to have completed two feet, one inch, and one third of an inch. In this way, on a plane inclined to 30 degrees, the globe completed only two feet, when from the prescribed rule it ought to have completed 2½ feet. Furthermore, upon a plane inclined to 40 degrees, the globe — which by the rule ought to have run three feet, two inches, and a half — on a most exact experiment being made, gave only two feet and 9 inches. Upon a plane of 45 degrees it ought to fall 3 feet and 1[?], but experience taught that it does not fall except three feet. Upon a plane inclined to 50 degrees, it ought to make three feet and ten inches, when nevertheless it made only two feet and 0 [?] inches.

All of which, with the utmost diligence, in the presence of many men skilled in the art, were carried out not merely once, but very often, from fear of an error which we suspected might perhaps have crept in somewhere, and were repeated. And this was seen as most wonderful and paradoxical: that the globe on a plane inclined to 50 degrees did not descend more quickly than on a plane inclined to 40 degrees, although the former was inclined by ten more degrees. And this too is to be noted: that the inclinations of planes of 50, 60, and 65 degrees obtain almost the same motion as that which takes place upon a plane inclined to 45 degrees — so that the motion on a plane inclined to 75 degrees does not differ from the earlier ones by more than half a foot. From all of which it appears how often speculations contradict experience. Thus far Mersennus.

If these things are true — as the diligence of so great a man persuades us they are most true — I for my part would not say that the cause of this great discrepancy is any other than the frequent interruption and interpolation of the motion on the said planes, by which the violent velocity of the motion is impeded. But as to why, on planes inclined beyond 45 degrees, the velocity of the motion is nearly the same as on planes before 45 degrees, I find no other cause for this than that on

the most steeply inclined planes the globe does not advance with so regular a motion as on the less inclined ones, but reaches its terminus by leaps upon leaps.

Hence it comes about that the globe, by frequent leaping and collision, is necessarily torn away from the straight line of its motion; and so it loses, by frequent leaping torn from the straight motion, that very time which, along the straight line on the most steeply sloping surface, it ought to have covered according to the calculated proportion of velocity. If, then, a globe could be rolled along some inclined plane on the condition that it touched the said plane as little as possible, but were carried only through the air, there is no doubt that Galileo's reasoning would have its plausibility — or perhaps even the flow of water within inclined channels would exhibit the said laws of motion more easily. But of these things in what follows.

The third thing that makes Galileo's reasoning doubtful is the very nature of the inclined plane. For he supposes, as most others also do, that the inclined planes one commonly meets with incline equally toward the horizon in all their parts and points — which is repugnant to mathematical reasoning. Let there be, for example, an inclined plane AD, a horizontal line BC, a vertical AC. I say, in strict mathematical rigor, that the point A on the inclined line AB inclines otherwise, the point E otherwise, the point B otherwise, and all the remaining intermediate points otherwise. And although, because of the smallness of the plane compared with the Center of the earth, this may not appear to us at all, nevertheless there could be given some plane in which the diversity of inclinations would be most [great] to us —

would be most perceptible; and so it could pose no slight obstacle to the truth of demonstrations that rest on what is indivisible. But let us prove what we have claimed.

So let EF be a horizontal line, touching the Earth's globe DNOP at D.

Diagram. A large circle (the Earth's globe) labelled D at the top, N on the right, O at the bottom, P on the left; its center is S. A horizontal line EF runs left-to-right tangent to the circle at the top point D, with E at the far left and F at the far right. Along EF, at successive points to the right of D, sit six small circles (drawn as little wheels, numbered 1 through 6 from left to right), each representing the globule placed at a different position. From the center S, straight lines are drawn up to the successive points on EF where the globules rest. The points of tangency along EF, from D rightward, are labelled D, X, H, L, V, Q. Letters I and S mark the tops of

the line of central directions through the first and last globules; M is near the sixth globule.

- D (top of circle): point of tangency, the natural resting point
- N (right of circle): cardinal point of the globe
- O (bottom of circle): cardinal point of the globe
- P (left of circle): cardinal point of the globe
- S (center): center of the Earth's globe
- E (far left of horizontal): left end of line EF
- F (far right of horizontal): right end of line EF
- X, H, L, V, Q (points along EF rightward of D): successive resting positions of the globule
- 1, 2, 3, 4, 5, 6 (small wheels on EF): the globule shown at each successive position
- I, M, S (above EF): endpoints/marks of the central direction-lines

Moreover, let there be a globule running along the line EF. Now since the globe first placed cuts the horizontal line EF at right angles by means of the vertical or central line I-S, at this position—where it stands upright on the horizon—it rests at no other point of the line EF except in this natural position, as we have already demonstrated elsewhere in what precedes. Now let the globe be placed at point X on the line EF. I say that it no longer has its natural position, since the central or direction-line SX no longer makes a right angle with EF, but one smaller than a right angle. As a result it begins gradually to incline toward the horizon. But if the globe is placed at H, the central line SH will now make a still greater inclination with the horizontal line EF; and so, always greater and greater at the remaining points L, V, Q, just as the figure itself shows. At all the points of EF, then, the globe will acquire a different inclination—which is what we wanted to indicate. From this it also follows that the moving body acquires different moments of velocity, by reason of the globe's center of gravity, at the various points of the said line EF.

You see, therefore, that this globe—placed as it is outside its natural position—can rest at no point of the said line EF except at point D. There, of course, the direction-line coincides exactly with the center of the globe, which it also bisects. For at any other point of the line EF the central line does not pass through the globe's center of gravity; instead the lines SX, SH, SL, SV, SQ, drawn through those points at which the globe touches the horizontal EF, always cut the globe into unequal portions. From this division it follows that the larger portion of the

globe, being heavier, outweighs the smaller, and consequently always acquires greater moments of velocity, until it comes to rest at D as its natural place.

The same thing happens—at least in mathematical rigor—on every inclined plane. Let AC be an inclined plane in triangle ABC; and let the surface of the Earth's globe be CBV, whose center is X.

Diagram. A circle representing the Earth's surface, with center X at the bottom. At the top is point A, from which two lines descend: AB (the vertical) reaching the circle's surface at B, and AC (the inclined plane) reaching the circle at C on the left. A chord CB is drawn across the circle from C to B. V marks a point on the circle at the right. The line AX (vertical) passes from A through B down to the center X.

- A (top, apex of triangle): release point of the globe
- B (on circle, below A): foot of the vertical AB
- C (left, on circle): foot of the inclined plane AC
- X (center of circle): center of the Earth's globe
- V (right of circle): point on the Earth's surface

Now suppose a globe falls from A along the inclined surface AC, and another from the same point and at the same time from A toward X. It is certain from what has been said that the globe gliding through the air from A to X—being, if you set aside the air, subject to no other impediment—covers the distance AX much more quickly than the globe from A reaches C. For the globe, just as it takes on a new configuration at every part of the inclined plane, so it acquires new and disparate moments of velocity. Hence its motion must be variously impeded, on account of the globe's varying section—made by the lines drawn from the center, which cut the globe unequally at the place where it rests on the plane. Since this section nowhere touches the globe's center along the plane, necessarily, because of the differing weight of the larger, outweighing portion of the globe, it induces a varying ratio of motion as well.

And so, since (as appeared in the preceding figure) the farther the globe is from point D, the more unequally it is divided by the central line, and the nearer to point D, the more equally—it follows that a larger portion of the globe at a greater distance from D, because of its greater weight, moves faster than where the portions cut by the central line are more nearly equal, being closer to rest, as is the case at point D, where the globe is bisected perfectly into the two hemispheres of the globe by the central line.

From this I conclude that the proportion of the motion can in no way be applied to it by means of numbers. For when, in the prior figure (for example), the globe placed at F begins to run, the globe is divided at that same place into an unequal measure—namely, into the smallest portion QIF and the largest QSF. It necessarily follows that the weight of the larger portion QSF is carried with a greater impetus, because of its inherent gravity, than at V, where the larger portion of the globe VTM is greater than the larger portion at QSF; and at the remaining points L, H, X, the larger portion of the globe is always smaller than at the preceding points, inasmuch as they tend ever more toward equality. And so, with gravity always diminishing and the globe drawing ever nearer to the place of rest that exists at D, it is plainly evident that the motion too, from A all the way to D, continually decreases through the intermediate parts of the plane.

But from Galileo's reasoning the opposite follows, since he says that the globe moves more slowly at the beginning, but faster at the end, on the said plane. It is true, however, that from the impetus acquired at the beginning the velocity is increased at the following points—but not in the ratio that the proportion of odd numbers prescribes for us. For the differing weight, by which the globe...

is moved through the inclined plane under an ever new and new diminution of weight, somewhat inhibits it; and so, beneath the plane, it must proceed under a certain disturbed proportion.

These, then, are the difficulties that seem to undermine Galileo's reasoning about motion carried out over different planes. Unless they are overcome, all the labor in assigning a definite proportion of motion over inclined planes, as compared to natural motion through the air, is rightly wasted in vain. Hence it is plainly evident from these considerations how many things are often bound up by geometrical laws which, nonetheless—when weighed in a more exact balance—are at last found false through constant experiment. I do say, however (as I also hinted above), that if some globe could be moved along a plane in such a way that it touched it at no part of itself—as happens with bodies carried straight downward by vertical motion—then Galileo's reasoning could be defended in some manner. But since motion of this kind seems to conflict with nature, no other account will be able to supply the deficiency of this motion except the one carried out by weights attached to pendulums—of which it now remains to speak.

CAPUT IV.

On the motion of pendulums.

[De motu pendulorum.]

It cannot happen that some globe should move freely along the convex surface of a sphere without, the moment that surface is abandoned, being carried downward in perpendicular motion by the appetite inherent in it toward the center. Hence it came about that the Lyncean philosophers of this age, in order to investigate the motion of weights more exactly, bound those motions to the laws of circular motion by the fastenings of cords and chains. So let LBK be a semicircle, in whose center A a cord is attached, weighted with a fixed globe so as to be raised up to L; and, the weight being let go, the pendulum necessarily descends from L to B, through the quadrant LB of circle LBK.

Diagram. A semicircle drawn on a horizontal diameter, opening downward. The diameter runs from K (far left) through A (center top) and on to I, N, L at the right; A is the center of the semicircle. From A a vertical line drops to B at the bottom; just to the left of B is C, and just to the right of B is D. M lies on the vertical line between A and B. From A a cord/radius runs out to the rim at the lower right, where O sits on the arc. The arc descends from L (upper right) through O down to B (bottom) and around to K (upper left).

- K (upper left, end of diameter): left end of the semicircle's diameter
- A (center top): center of the semicircle, the cord's pivot
- I, N (on diameter, right of A): division points of the line toward L
- L (upper right, end of diameter): the raised starting position of the pendulum
- O (on arc, lower right): intermediate point on the quadrant LB
- M (on vertical AB): point where line CD crosses AB
- C (lower center, left of B): point on the arc near the bottom
- B (bottom): lowest point, the natural resting point (representing the Earth's center)
- D (lower center, right of B): division point of the arc near the bottom

The cord, descending together with the weight, will obey differing laws of motion in the individual intermediate quadrantal parts—in such a way, namely, that the nearer it has come to point B, the faster it moves: it moves faster at O than at L, faster at D than at O, and faster at B than at D.

But before we compare the velocity of pendulums of this kind, agitated through the quadrant of a circle, with the velocity of weights tending naturally and perpendicularly downward, it must be noted that we here suppose the ratio of the spaces which the weights cover along two lines to be in the doubled ratio of the times—as when we compare the lines NO and ID, insofar as the arcs LO and LD correspond to them.

So I say, first, that the weight, while it descends through LDB, does not reach point B as quickly as while it descends along the vertical line AB from A to B; but if AB were prolonged so far that it equaled the quadrant-arc LB in its length, I say that in this case, in the same time, the weight will arrive both through the arc LB and through the line AB prolonged from A to its endpoint. For since AB the semidiameter is to the line of the quadrant LB as 7 is to 11, and the time in which the weight falls through the prolonged line is 30 thirds [tertia], it will, falling from A to B, take a time of only 23 thirds, and so will reach the endpoint B six thirds [tertia] sooner than the weight on the pendulum [reaches it] from L to B.

So let the cord AB be three feet long and divided into 500 parts; and let the arc LB likewise be divided into three equal parts—namely into LO, OD, and DB. It will then come about that, when the weight, falling from A along the line AB, has reached point M (namely the line AM equal to the sine of 30 degrees—now a space of 250 parts, of which AB is 500), it shall be reckoned to have completed [its first stretch]; and when it has touched that point at which the line CD cuts AB, it shall be reckoned to have completed a space of 433 parts. This space, indeed, is equal to the sine of 60 degrees; and if you subtract from it the prior 250 parts, there will remain 183, for the parts which the weight will cover by running through the arc OD. If, further, you subtract 433 from the radius of 500 parts, there will remain 67 parts, which the pendulum covers by its motion while it passes under the arc DE.

These things being laid down, in order that we may find the time which the pendulum takes for each individual space, proceed thus. Take the root of 500 parts, of which we have supposed the semidiameter AB to consist; and then take the root of 250, whose ratio is similar to the 30 thirds of a minute which the pendulum consumes in falling from L to O. You will have the two roots, $23 \frac{29}{141}$ and $12 \frac{6}{5}$, which stand to each other as $7 \frac{26}{141}$ to 5. Therefore, as $7 \frac{26}{141}$ stands to 5, so 30 thirds of a minute to another [number]; and there will come out $21 \frac{207}{397}$ thirds, the time which the pendulum takes in falling from L to O—that is, 250/500 parts. By this procedure you will find the time of the pendulum's fall from O to D to be $6'' 30'''$, and the time of the pendulum's fall from D to B to be $4''$

20^{'''}. From this it certainly follows that perpendicular motion attains its end faster than the motion of pendulums through an arc.

But here, above all, two things must be presupposed, as confirmed by infallible experience. The first is that a pendulum loaded with a weight, swung from L past B toward K, completes its vibration or "diadrome" [diadromus, single swing] in the time of one half-second; and although the diadromes from L to K are greater than those from O or D toward K, nonetheless even those smallest ones, between D and B, are nearly of equal duration with the greatest and with all the others. I said "nearly," because it has been ascertained that the largest diadrome exceeds the smallest by a span of time so imperceptible that, after 50 returns, the smallest returns lose no more than 1 [unit] relative to the largest return.

Second comes the consideration of the makeup of the cord. For the heavier the weight by which it is tensioned, the longer the time it lasts; on the contrary, when it is tensioned by a lighter weight, it completes its diadromes in proportionately less time. For example: a leaden globe, whose gravity contains twelve times the gravity of a wooden globe of the same size, lasts four times longer than the wooden one—where, however, each takes up its motion from an equal distance AB. For the wooden globe was found to make 40 diadromes while the leaden one in the meantime completes only 39, and so the wooden one [makes] one diadrome more than 40. But if the cord is six times thicker, it will gain one diadrome more than 260—in such a way, indeed, that the diadromes of the thicker cord are always diminished more than the diadromes of the finer cord; and the cords stand to one another as the weight attached to them stands to [its] weight.

So let us suppose, first, a cord AB of three feet, and a leaden globe attached to it of eight ounces, or half a pound. I say that this cord runs down from L to B all the faster the nearer it is to point B, which represents the center of the Earth. Second, I say that the velocity of the pendulum's motion through the quadrant of the circle follows the velocity of the whole weight falling through the vertical line. But from the comparison of the one with the other, I am confident the reader will more easily grasp my meaning.

We said above, in Caput 2, that the moments of velocity in the natural [motion] of weights downward occur according to the proportion of odd numbers—so that, if some weight covers the first part of the space in a given time (for example, in one moment), it covers three parts of the space in two moments, five parts of the space in the third moment, seven in the fourth moment, and finally, in the fifth, nine parts of the space; and so, in five moments—that is, in a duration of unequal

given [times]—the weight will exceed 25 parts of the space, as is clear from the figure set here.

The same must be said, in some manner, of the motion of pendulums agitated through a semicircle. I said "in some manner," because, since pendulums are carried by a twofold motion—the natural one, namely, in descending through the quadrant, and the violent one, in ascending through [the other quadrant]—the pendulums will follow the same ratio.

Diagram. A semicircle on a horizontal diameter, opening downward, divided by a vertical center-line and several horizontal parallel lines. Along the top diameter, from left to right: Q, P, O, N, M (left side) and A at the center top, then G, H, I, K, L descending the right side. The vertical center-line drops from A through points marked B, C, D, E to F at the bottom; numbers run alongside it (1, 3, 5, 7, 9 on the right of the center-line near B, C, D, E, F; and 2, 4, 6, 25 on the left). Horizontal parallel lines cross from the left arc to the right arc at the levels of B/H, C/I, D/K, E/L, etc.

- A (center top): apex / pivot, top of the diameter
- F (bottom): lowest point of the semicircle
- Q, P, O, N, M (left side of diameter/arc, top to bottom): left-hand endpoints of the parallels
- G, H, I, K, L (right side of diameter/arc, top to bottom): right-hand endpoints of the parallels — the lines BH, CI, DK, EL named in the text
- B, C, D, E (on the vertical center-line, descending): division points of the descent
- 1, 3, 5, 7, 9 and 2, 4, 6, 25 (alongside the center-line): the odd-number / cumulative-square progression of velocity moments

We said above, in Caput 2, that the moments of velocity in the natural [descent] of weights downward occur according to the ratio of projectiles [cast] upward, whose impetus is diminished upward in the same proportion as it grows in descending. In this way the pendulum AG, dropped from G, will increase the increments of its velocity according to the same proportion that the parallel lines BH, CI, DK, EL demonstrate in the semidiameter AF. In the same way the pendulum, swung by violent motion from F toward Q, diminishes its moments of velocity in the proportion in which, descending, it had increased them—as the parallels ME, ND, OC, PB sufficiently demonstrate above. So says Galileo.

But not even here is a place found where our intellect may rest, since the descent and ascent of the pendulum differ much from vertical motion downward—both

because of the resistance of the air and because of the resistance [renisus] of the cord. For since the cord, along its whole length, together with the globe attached to it, must overcome more air than if the globe alone were carried naturally from on high toward the center, it comes about that—as we said above—a globe descending freely and straight down always reaches its endpoint faster than a pendulum agitated in various ways through the windings of a circle. Yet since the difference is not so very perceptible, I would judge that the use of pendulums is not on that account to be rejected, especially since in physical matters the mathematical rigor is not always to be attended to. And although Galileo thinks he has found certainty in the matter by an infallible experiment repeated quite often, in the small three-foot pendulum which he himself used, I will readily grant it. But if the experiment were taken with a 30-foot pendulum, then without doubt a noticeable difference between the velocity of the pendulum and of the freely falling weight would be observed. For if we have found a difference of six thirds [tertia] of a minute, by which the weight in natural motion reaches its endpoint faster than the pendulum, then certainly this difference must grow in proportion to the length of the pendulum—there can be no doubt.

The same thing happens with two globes of equal [size] but composed of different material, if they are dropped from a height not so very great, [where] both, struck, strike against a horizontal plane: the eye judges them to arrive at the plane together and at one and the same time. But when the experiment has been made at a height of 600 palms, a very great and perceptible difference in the motion of each is constituted—the leaden globe always anticipating by some first minutes the globe composed of lighter material. And if this [were done] at a height of 600 feet...

what would happen at 1000? what at 10,000?

Next, I argue thus. Where the motive force is greater, there the motion is greater; but the motive force that [comes] from Q, [moving] in F, is greater than that by which it is moved from F to G; therefore this motion will be greater. I prove the minor [premise]: because the motion in the space QF is from its own gravity and from a continuously conceived impetus; but in truth, while it is moved through F G, the impetus alone moves it, and gravity does not conspire but resists; therefore the motion from Q to F is greater than from F to G. Which was to be proved.

CAPUT V.

On the parabolic motion of projectiles, and its marvelous effects.

[De motu projectilium parabolico, & miris ejus effectibus.]

From this admirable proportion of motion it was noted by the distinguished mathematicians of this time that heavy bodies, bound by no fastening, when thrown by the impulse of the one casting them, describe—out of the force of this declared proportion—a line which I-know-not-how affects a parabola. But let us look into the matter a little more deeply. For since two motions can be considered in any thrown heavy body—the natural and the violent—and since the natural seeks straight motion while the violent [seeks] motion toward that part toward which the heavy body was obliquely impelled, it comes about that in bodies obliquely thrown a certain mean motion is produced, by which the heavy body describes a line most closely resembling a parabola, according to the proportions of motion given in what precedes.

But let us show the matter in a piece of artillery. Let us suppose, then, that the line TO represents a cannon in a position parallel to the horizon (or in any other position), whose mouth is O. The globe, then, by the force of the ignited powder—if it had no gravity and met no resisting air—would without doubt finally be terminated in a straight line, by uniform motion, at Q, since it would find nothing to draw it back from the motion begun. But since, by its inherent gravity, it seeks the center along the normal line, it comes about that, displaced from the line TO begun by the force of gravity, it cuts a certain mean path.

Diagram. A rectangular grid (a parallelogram divided into cells by vertical and horizontal lines). Along the top edge, left to right: T, D, G, N, O, H, M, R, Q. Along the bottom edge, left to right: A, Δ [Delta], T, I, X, V, R, II, Y. From a cannon (a small barrel drawn at the lower left, with point T just above it) the line of fire rises to O at the top; a parabolic curve descends from O across the grid down to Y at the lower right. Point Q (cannon ball mark) sits above O. Inside the grid, descending along the second vertical from the left toward the curve, are intermediate points 5, B, F (top), then E, then 3, then L, then Z, then 5, then P, then 7, with K on the right limb of the curve and C near the lower right. The numbers 3, 5, 7 (and a 1 near the top) mark the odd-number progression of the vertical fall.

- O (top center): the cannon's mouth, start of the trajectory
- Q (above O): the point of pure uniform (gravity-free) motion

- T, D, G, N, M, R (top edge, left of/around O): division points along the horizontal of uniform motion
- H (top, right of O): division point
- A, Δ, T, I, X, V, R, Y (bottom edge): the foot-points OB, OL, OP, OX of the normal (vertical) fall — endpoints of the verticals
- B, L, P (descending the normal line from O): cumulative fall-points (the lengths OB, OL, OP, OX)
- E, F, Z, K, C (on/near the parabolic curve): points of the trajectory where it meets successive verticals
- 1, 3, 5, 7 (alongside the vertical): the odd-number progression of the fall increments

So let the time in which the globe would traverse TO be divided into four equal parts, and let this time be equivalent to a long note in music; and let the divided parts be OH, HM, MR, RQ. It is certain that the globe passes through each such part in one musical time, as appears in the margin. If, as I said, it were not heavy, and no resistance of the medium were given [it would continue straight]. But since gravity impels it toward the center, let us suppose that gravity, in the time in which the globe is moved through OH, displaces the globe from the line OQ by the space of the line OB, which is part of the line of normal motion OX.

In like manner let the line HV be drawn through point H parallel to OX; likewise also through the points M, R, Q let there be drawn MR, RΠ [?], QY, each and all parallel to one another and to OX. And let the displacement of the globe from the line OQ—as soon as it has touched the line MK—be as great as the portion OL of the normal line OX; and let the displacement of the globe from the line OQ, as soon as it has touched the line RΠ [?], be as great as OP; and let the displacement of the globe from the line OQ, as soon as it has touched the line QY, be as great as the normal line OX.

Then let there be drawn through the points O, B, L, P, X lines normal to OX and parallel to one another—SF, EK, ZC, AY—and others normal and parallel to TO: TA, ΔΔ [?], ΓΓ [Gamma], NI. These being laid down, the globe will be displaced from the line OQ, while it covers the space OH, by the quantity of the line OB or HF (which, being opposite sides in the parallelogram B F, are likewise equal); in the same way, while the globe is moved through HM, it will be displaced from OM in K, and through MR in C, and through RQ in Y. And since the displaced spaces of the globe of this kind are equal to the spaces OB, OL, OP, OX—that is, while they take their increment according to the quantity of the lines OB, BL, LP, PX—it

necessarily follows that these are increased according to the series of odd numbers continued from unity.

So if we set $OB = 1$, then $BL = 3$, $LP = 5$, $PX = 7$; or $OL = 4$, $OP = 9$, $OX = 16$. And in this same way the squares proceed: OH , OM , OR , OQ , or BF , LK , PC , XY , which are equal to the former, being opposite sides of the parallelograms. So since the square BF is 1, the square LK will be 4, and PC the square 9, and XY the square 16. And it will come about that as OX is to OP , so XY is to the square PC ; and as OP is to OL , so the square PC is to the square LK ...

and as LO is to OB , so is the square LK to the square BE . If, then, a semiparabola were described next to the points O , Y — or the whole parabola AOY (which would pass through point O and through the points A , Y) — the squares enclosed between OX and the parabola AOY would have the same proportion to one another that OX , OP , OL , OB have among themselves, as I showed at length in *Ars Magna Lucis et Umbrae* [*The Great Art of Light and Shadow*], in the chapter on conic sections [*De Conicis Sectionibus*]. The sides of these squares will therefore match the sides PC , LK , BF , and the sides PZ , LE , BS . The ball, then, at the points O , F , K , C , Y , will always lie on the parabola AOY . The same can be demonstrated for any other projection of a heavy body. Therefore a projected ball, by its rolling, will *approximate* a parabola — which was to be demonstrated.

I said it will *approximate* a parabola, because I do not believe that a line of this kind, produced by projectiles, is a perfect parabola — as most mathematicians of our day, following Galileo, suppose — but rather something resembling one. The ground of my doubt is this: it has no source from which it might be generated. Every parabola takes its origin from the section of a cone; but in projectiles no conic section can be conceived, as it can in matters of the sundial [in *Sciatherico negotio*], where light and shadow by their circuits found true cones, which are then cut by the plane of the horizon, acting as a cutting-plane [*Conotomo*], and produce conic sections of every kind. Where, therefore, the foundation of the conic sections is missing, there too the true properties of the sections can in no way be conceived. So too with a larger and heavier cord: if it is suspended from its two ends, it tends, on account of its weight, to sag downward somewhat in the middle and form a curved figure — which seems to approximate something parabolic, yet cannot properly be called a parabola, since it lacks the foundation from which one is generated, namely the cone. For if it were a true parabola, there would be no reason why it should not also produce a hyperbola, an ellipse, and similar curves — none of which, however, can be seen in effects of this kind, any more than in projectiles or in cords stretched by their own weight. As for the

fact that the proportions of the odd numbers fit this case exactly, that is an *a posteriori* matter. For since lines of this kind produced by projectiles are very like parabolas, they can easily be fitted to true parabolas. It is indeed the nature of geometrical and arithmetical objects that they are readily applied to physical things of every sort, even though no foundation of these properties exists in the physical things themselves.

COROLLARIUM. [COROLLARY]

From this it is also clear that the oscillations [diadromos] noted in the vibration of stretched cords do not describe mathematical parabolas, as some have claimed, but something approximating a parabola — for exactly the reason given concerning the cord.

Modern philosophers, instructed by experience drawn from the motion of projectiles, hold that a body shot obliquely and violently upward describes a true and perfect parabola, both in its ascent and in its descent. Its axis, they say, is the median normal line drawn from the vertex of the parabola down to the horizontal line lying beneath it — the line that writers on conics call the *ordinately applied* [ordinatim applicata]. Just as this ordinate stands at right angles [Greek: πρὸς ὀρθὰς γωνίας (pros orthas gōnias, "at right angles")], so it bisects the whole parabola; so that the ascent of the body, through one half of the parabola, has a violent motion, and through the other half, a natural motion — the whole motion being judged to be composed of the violent and the natural. They suppose, moreover, that the body takes just as much time in ascending, and just as much in descending, as a body would take in falling straight down, normally and naturally, along the axis of the parabola. So hold Galileo and his other followers — Gassendi, Torricelli, Cavalieri [Cavallerius] — and they think the matter can be demonstrated by the firing of cannon by the parabolic art, or by incendiary projectiles, as also by the motion of jets of water, all of which seem to describe a parabola. Others hold that this happens only with a mortar [pyrobolus] and with the leap of waters, when discharged with a sloping motion; but in a horizontal motion they judge that it produces not so much a parabola as a certain figure composed of a circle and straight lines. However that may be, the matter has not a few difficulties, which I have decided to untangle here, so that at last it may be known what is to be concluded. For it is certain — as we also hinted above — that geometrical principles, although they are readily applied to physical things, are nonetheless so constituted that they cannot in the least preserve the laws of mathematical rigor in their demonstrations, when these are noted only by sensible experience; and since this is fallacious, and the senses for

the most part deceive, it cannot be that infallible trust be placed in them. But before we carry the matter further, it seemed best first to bring forward here the demonstration that Cavalieri, following Galileo's principles, sets down, and then we will set out our own, so that it may be known what is to be concluded about each.

Cavalieri, like Torricelli, in setting out to demonstrate the parabolic motion of projectiles, reasoned thus. Since two motions can be considered in any projected heavy body — the natural and the violent — and since the natural seeks the center along the normal, while the violent tends upward toward that part toward which the heavy body was obliquely impelled, it comes about that in obliquely projected bodies a certain mean motion arises, by which the heavy body describes a parabolic line; and it describes it according to the given proportions of the odd numbers, through the several intervals of space that correspond to those proportions. And this they demonstrate in the case of a piece of artillery and of mortars. Let us therefore suppose that the line T represents the...

cannon, whose mouth-position relative to the horizon is parallel; or it is the same in an oblique position, whose mouth is T. The ball, then, by the force of the ignited powder, if it were subject to no gravity and met no resisting air, would doubtless at last be carried by uniform motion along the straight line TO and terminate at Q, since it would find no hindrance to draw it back from the motion once begun. But since, by its innate gravity, it seeks the center along the normal line, it comes about that the ball, displaced from the line OQ it had begun on by the force of gravity, cuts a certain mean path. Let the time, then, in which the ball would traverse OQ be divided into four equal parts, and let the several parts OH, HM, MR, RQ correspond to one second each. It is certain that the ball passes through each part of this kind in one second — if, as I said, it were not heavy, and no resistance of the medium were given. But because gravity drives it toward the center, let us suppose that, in the time in which the ball moves through OH along the line OQ, the ball is displaced by the space of the line OB, which is part of the normal line of natural motion OX. In like manner let the line HV, parallel to OX, pass through the point H. So too let MR, R π , QY be drawn through the points M, R — all of them equidistant from one another and from OX. And let the displacement of the ball from the line OQ, as soon as it reaches the line MR at K, be as great as the portion OL on the normal OX; and let the displacement of the ball from the line OQ, as soon as it reaches the line R π at C, be as great as the portion OP on the normal line OK; and let the displacement of the ball from the line OQ, as soon as it reaches the line QY at Y, be as great as the normal OX. Then let there be drawn through the points O, B, L, P, X the normals — parallel to one

another and to OX — SE, EK, ZC, AY, and others perpendicular to OT and parallel to one another: TA, OΔ, ΓΓ, NI, HV, MR, Rπ, QY.

With these laid down, let the ball be displaced from the line OQ. Meanwhile it accomplishes the space OH, of the magnitude of the line OB, or HF, which, being opposite sides in the parallelogram OF, are accordingly also equal. In like manner, while the ball moves through HM, it will be displaced by the impulse of gravity from OM to K, along the line FK; and from K to C, along KC; and from C to Y, by the normal lines MR, Rπ, QY. And since the spaces of the ball thus displaced, compared with their perpendiculars, are equal to the spaces OB, OL, OP, OX — that is, since the increments of velocity are taken according to the magnitude of the lines OB, BL, LP, OX — it necessarily follows that they increase according to the series of odd numbers continued from unity. If, then, we set the line OB to be one space, BL will be three spaces, LP five, PX seven; or, what is the same, OL will be as 4, OP as 9, and OX as 16. But in this same way proceed the lines OH, OM, OR, OQ, and BL, LK [recte: BF, LK?] [?], PC, XY, equal to them, because they are opposite sides in parallelograms. Therefore, since the square of the line BF is as 1, the square of the line LK will be as 4, the square of the line PC as 9, and the square of the line XY, finally, as 16; and it will come about that as OX is to OP, so XY is to PC; and as OP is to LO, so PC to LK; and as LO is to BO, so LK to BF. If, then, a semiparabola were described next to the points O, F, K, C, Y, or the whole parabola AOY, which would pass through point O and through the points A, Y, the sides of the squares too — that is, the lines OY, PC, LK, BF, or, from the opposite side, XA, PZ, LE, BS, equal to these — enclosed between OX and the parabola AOY, will have the same proportion to one another that the spaces OX, OP, OL, OB have among themselves. The ball, then, carried upward through the points A, Z, E, S, O, and likewise downward through the points F, K, C, Y, will describe a perfect [perfectam] parabola; and it will take just as much time, carried by natural motion from P to X, as, again, from Z to E, ascending from A to Z, and from there to E, and from E to S, and to O, as it takes from X to P, and from there to L, and so on from L to B, and to O, spread out violently and vertically. Again, descending by natural motion from O to E, and from there to K, C, and Y, it will take just as much time as in falling by natural motion from O to B, and from there to L, P, and X. Since, then, the ball, falling by natural motion along the line OX, accomplishes the spaces OB, BL, LP, PX according to the proportion of the odd numbers, it certainly must observe the law of the same proportion in the parabolic spaces OF [recte: OE?], FK, KC, CY — which was to be demonstrated.

And this is Cavalieri's demonstration, by which he thinks he proves that the motion of projectiles describes nothing other than a parabola. An ingenious

invention, I admit — if only the physical principle of the motion corresponded to it, or if experience held firmly consistent with itself. But since we showed above that the path of the moving body, according to the proportion of the odd numbers, has not yet been demonstrated mathematically, surely this demonstration, if it be taken as a geometrical one, will never satisfy the experts, since the mind always remains in doubt and suspense over the deceptiveness of the experiment. But let us examine the several parts of the demonstration.

Cavalieri assumes, indeed presupposes, that the motion of a ball from a cannon set in a horizontal position...

directed and discharged, begins at O, the vertex of the parabola — which experience teaches cannot at all be said, and which evidently convicts the whole discussion and that demonstration of resting on a false assumption. For the ball does not begin to describe a parabola as soon as it leaves the cannon, but rather seems to approximate straight lines for some distance in the impetus of its motion, and only then bends into the form of a parabola. Moreover, it does not seem consistent that the ball should accomplish equal parts of the horizontal line through equal spaces of time, as he himself supposes — since in every projectile the moving bodies seem to move ever more slowly, as is evident to the senses. It is also established that, just as in natural motions the velocity is always increased, so in violent motions it is always diminished. Let us therefore suppose that the mouth of the cannon is set at T. The ball will approximate a straight line for some distance, until, the impressed force flagging, it takes on the form of a parabola; nor can those spaces TD, DG, GN, NO be assumed equal, for the reason stated — since in the space TD the ball is carried with a swifter motion than in DG, and in this one swifter than in GN, and so on for the rest of the spaces. And therefore these spaces ought to stand exactly as the spaces OP, PL, LB, BO on the line OX, unequal among themselves. In no way, then, ought it to be said or supposed that the ball, in the several equal spaces of time, accomplishes equal parts on the horizontal line, compared to the arcs of the parabola. Furthermore, it is uncertain whether the parts of the parabola OF, FK, KC, CY — which correspond to the parts OB, BL, LE, EX on the vertical line XO — are traversed in exactly the same time in which some heavy body passes through the said parts of the line OX. For experience teaches that a ball or mortar-shell, as soon as the impressed force is extinguished, no longer keeps the parabolic path, but tends straight down and strikes the earth with perpendicular motion — which happens most of all in the last stage of its motion; whereas into a parabola nothing rectilinear can fall. From which it follows clearly that, in the last stage of its motion, the mortar-shell descends with a much swifter motion — being a natural one — than in the

remaining spaces CK, KF, FO. Since, then, the moving body in the parts of the line OX — being borne by natural appetite into the center — moves faster than in the parts of the parabola, which are composed of the violent and the natural, it necessarily follows that it makes a greater delay in the latter than in the former, since they both tend obliquely and sustain the resistance both of the air and of the violent motion. But if the character of these motions were established for us by experience, surely I myself would gladly subscribe to them; but since up to now there has been no one who has made an experiment in a matter exposed to so many tricks of the eyes, surely a certain demonstration about them cannot be handed down, and so the truth...

[the right column continues:]

would undergo a deflection from the line, so as soon to describe the parabola OB — since, as I said, in the first violence of its impulse it describes some rectilinear something or other, until, the force flagging, it at last conforms itself into E. But, to say what I feel, it seems more in keeping with experience that, if a cannon set in a horizontal position is fired, it will come about that, immediately upon leaving, the ball does not at once deflect from the straight line AB in proportion to the impulse, but is carried for some distance on a straight track on account of the force of the impetus, as appears in the line AC; until, the impetus flagging, its own weight urges the ball into a certain parabolic motion — and so the vertex of the parabola is to be set by no means at O, as Cavalieri set it in the preceding figure, but at V; from which then, according to the measure of the lasting impetus, it describes the other side of the parabola, OS [recte: VS?] [?]; but where, the impetus flagging, the impressed force is gradually extinguished, then it describes nothing further parabolic, but something wholly rectilinear, with natural motion — that is, perpendicular — striking the earth.

Let the mouth of the cannon be A, which when fired describes nothing parabolic from A as far as C,

Diagram. A trajectory figure illustrating Kircher's own account of cannon-shot. At upper left is a small drawing of a cannon (the mouth A) firing horizontally to the right. The trajectory runs as a nearly straight horizontal line from A across the top (passing through C) toward B at the far upper right; it then curves downward through V and continues down through T to S at the lower right, forming a quarter-turn that becomes a vertical straight descent near the bottom. A separate straight line (the tangent) runs from the curve obliquely down-left toward the lower-left of the figure.

- A (upper left, at the cannon's mouth): origin of the shot
- C (along the top, between A and B): point up to which the path is straight; "from A as far as C nothing parabolic is described"
- B (far upper right): end of the horizontal tangent line AB
- V (right side, where the horizontal path begins to curve down): the true vertex of the parabola (Kircher's correction of Cavalieri)
- T (right side, below V, on the descending curve): point on the descent
- S (lower right, foot of the vertical descent): end of the path; the segment TS is "under the ratio of a straight line"

inasmuch as the ball forms the part of the tangent AB of the parabola as far as C; then, however, it forms the arc of the supposed parabola [putaticiae parabolae] as far as V, its vertex, and from there the other arc of the parabola as far as T — where, the vigor of the impetus failing, it accomplishes the remaining space TS, under the ratio of a straight line, as a portion of the tangent BS of the parabola, or descends on a track parallel to it. And although to everyone the moving body seems to trace out something parabolic, yet it is not truly parabolic, since both at the beginning and at the end of the motion the ball moves along the tangents AB and BS of the parabola — which is absurd, since the tangents of a parabola cannot touch the parabola except at a point. Nor can it be said that the ball, immediately upon leaving the cannon, inclines into a perceptibly curved line; for experience teaches that a ball fired even to a distance of two hundred paces from the target [meta] describes, near the end, an arc scarcely perceptible; and that sometimes it tends wholly under a straight line — according to the ratio of velocity or impetus, along the path of the line of sight — toward the point of the target. But the ball ought, in order to...

describe a true parabola, to begin the description of the parabola at once, from the very first moment of its leaving, point by point — which is contrary to experience. So, just as the rectilinear is confounded with the curvilinear in the motion of projectiles, so too it is vain to seek any parabolic principles under them. There is the further point that a parabola of this kind, as was said a little before, has nothing from which it might be generated.

Every parabola takes its origin from the section of a cone; but in projectiles no section can be conceived, as it can in the theory of the sundial [in *Sciatherica theoria*], where light and shadow by their circuits found true cones, which then, according to the character of the sundial-plane, produce conic sections of every kind. Where, therefore, the foundation of the conic sections is lacking, there too the true properties of the sections can in no way be conceived. For if some heavy

body, whirled about by violent motion, described a true parabola, there would be no reason why it should not by the same reasoning describe also a circle, and a hyperbola or an ellipse — of which, however, no trace appears in projectiles. But, that the truth of the matter may stand out more clearly, I have decided to demonstrate it in this way.

Let the line AX in the present figure be the vertical line representing the natural motion, and the line AB the horizontal line, along which the moving body is led. Then let an arc be described from the point X,

Diagram. A geometric construction for Kircher's proof that the projectile path is none of the conic sections. The top edge is the horizontal line AB, with A at the upper left and B at the upper right; it is divided into equal segments by the points L, M, N, O, P. From A a quarter-arc AI is struck (centered, by the text, at X) curving down to I at the lower right. The left edge descends from A through V, K, C down to X at the lower left; AX is the vertical line. The bottom edge runs from X to I. Within the figure, perpendiculars dropped from L, M, N, O, P meet a row of points on the curve (E, F, and points labeled G, S, T near the curve), and the descending trajectory curve passes through these toward I, marked at one point H. Faint construction lines run from A to several of the lower points.

- A (top left corner): origin; the cannon's mouth / start of motion
- B (top right corner): end of the horizontal line AB
- L, M, N, O, P (along the top, A→B): equal foot-divisions of the horizontal AB
- V, K, C (down the left edge below A): points on the vertical AX marking the construction
- E (on the left, just below A; first curve-point under L): point on the line of motion
- F (below E; curve-point under M): point on the line of motion
- G, S, T (along the row of curve-points toward the right): successive points on the line of motion [?]
- H (on the descending curve, mid-figure): point on the curve
- X (bottom left corner): center of the arc AI; foot of the vertical
- I (bottom right corner): end of the arc AI and of the line of motion

and let it be AI; let the horizontal line AB also be divided into several equal feet, A, L, M, N, O, P, B; and when perpendicular lines have been drawn parallel to the horizontal line AB, there will be born six squares equal among themselves, AQ, LR, MG, etc. With these laid down, I assert, first, that in the line of motion of

projectiles there is neither a circle, nor a parabola, nor a hyperbola, nor an ellipse.

That it is not a circle, I demonstrate thus. Since the triangles APT, AEV are similar, EV will be to AV as AP is to TP. But TP is the fifth part of the line AP. Therefore AV too will be the fifth part of the line EV. And since the square of EV, or AL, is equal to the rectangle — that is, the parallelogram — contained under AV and the line AP, while EV is taken to be 10 parts of which AV is 2, its complement, namely the line AP, will be 50 parts, and the whole diameter 52 parts. Again, since CG is triple AC, and its square is equal to the rectangle contained by AC and its complement to the diameter of the circle — the square of CG being 900 parts and AC 10 parts — the remaining segment will therefore be 90 parts; but the whole diameter is 100 parts. Yet it is also 52 parts; therefore the line of motion AEFghi is not the circumference of a circle.

But neither can it be a parabola. For suppose, if it can be done, that it is the line of a parabola; then, as the straight line AC is to the straight line AV, so will be the square of the semi-ordinate CG to the square of the semi-ordinate VE. And since CG is triple, its square EV [recte: of EV] will be ninefold that square. But AC is to AV as 10 to 2 — that is, fivefold; therefore it is not as AC is to AV, so the square of CG to the square of VE; and consequently the line AEFg is not a parabola.

Now suppose, if it can be done, that it is a hyperbola. Let its diameter be taken as 8 parts, of which AC is 10 and AV is 2. Then the right-angled triangle [rectangle] contained under AV and the side composed of AV together with the diameter of the figure will be 20 points; but the rectangle contained under AC and the side composed of AC and the diameter of the same figure will be 180 points; and the ratio of the latter to the former is ninefold. But the square of the semi-ordinate CG is also to the square of the other semi-ordinate VE [in the same ratio], inasmuch as the side CG is triple the side VE. Since, then, the rectangles under the segments of the axis of the hyperbola have the same ratio to one another that the squares of the semi-ordinates have, there will be, by permutation, the same ratio of the rectangles under the segments of the axis of the hyperbola to the squares of their semi-ordinates; and consequently the points E, G lie on the same hyperbola. But again, since AOS, ARF are similar triangles, and AO is the square of [recte: AO to OS as] OS [?], so too AF will be [as] the square of AK; and AK is 8 parts, of which KF is 20. Therefore the right-angled rectangle contained under AK and the side composed of AK and the diameter of the figure will be 65 parts; but the rectangle contained under AV and the side composed of AV and the diameter of the same figure is 20 parts. Now the ratio of 65 to 20 is smaller than the ratio of the square

of KF to the square of VE. Therefore, by permutation, the ratio of the rectangles under the segments of the axis to the squares of the semi-ordinates is not the same; and consequently the points E, F are not contained on the line of a hyperbola.

Finally, that this line of motion is not an ellipse either, is proved thus. Let AX [recte: A] be produced to Z, which the perpendicular line IZ cuts. Since, then, at L the gravity becomes equal to the impulse, IZ will be greater than all the straight lines that fall perpendicularly from the line of motion to the diameter AZ; and consequently it will be the semi-diameter of the figure. But IZ is made equal to the semi-diameter AZ, whereas it ought to be unequal; therefore the points A, E, F, G, H, I are not contained on an ellipse.

It is therefore clear from what has been said that the line of motion in projectiles describes none of the conic sections.

to write. We must therefore conclude that the line of motion which any moving body traces does not proceed by a homogeneous motion, but by a heterogeneous one — that is, from rectilinear and circular motion imperceptibly mixed. For if the ratio between natural and violent motion held firm for us, certainly and geometrically, according to the proportion of the odd numbers, and if its true demonstration could be established, then certainly everything said up to this point would be correct. Nevertheless, since in my judgment no truer or closer proportion for demonstrating the principle of this motion can be assigned — nor has one been assigned up to now — we may legitimately use that proportion, as one does in any mechanical undertaking; and in what follows we shall in fact use it.

THE COSMOCENTRIC ART

SECTION III. PRACTICA [Practical]

or, The Uses That Can Be Derived from the Cosmocentric Art

CAPUT UNICUM [Single Chapter]

How the Velocity of the Motion of Heavy Bodies Toward the Center May Be Determined

Although in the preceding pages we showed clearly that the proportion of the motion of heavy bodies toward the center cannot be demonstrated geometrically according to the increment of the odd numbers from unity, nevertheless —

because no proportion more probable or nearer the truth has yet been assigned — most of the philosophers and mathematicians of our time assume this one as if it were true, and apply it in practical work without notable error, as will appear later. With the aid of this stated proportion, then, Galileo, Mersenne, and others believe they can determine how much time a stone takes in falling from the Moon, the Sun, and the stars down to the center of the Earth. Yet this matter rests on slender foundations, and so can never produce a solid certainty in the minds of judicious men. Therefore, before we develop the subject more fully, we must necessarily lay down certain assumptions, so that, once these are established, the reader may discern what to think.

I assume, first, that a stone or any other weight, in the natural descent of its motion, preserves in the increments of its velocity the same proportion that the odd numbers from unity preserve among themselves; from which it follows, consequently, that we must assume the velocity of the motion to be in the squared ratio of the times — or, what is the same, that it behaves as the square does to its roots.

I assume, second, that the medium through which any heavy body falls must be homogeneous, everywhere equally rarefied, and subject to no impediments of differing kind. For experience teaches that a heavy body descends more swiftly through a clear, still, and tranquil medium than through one that is dewy, foggy, or suffused with somewhat thick air.

I assume, third, that the constitution of the falling weight must above all be taken into account. For it is certain, and experience teaches, that a sphere or any spherical body descends more swiftly than a flat body, or one obstructed by various angles, even if they are equal in weight. Likewise a column dropped straight down along its length, perpendicularly, consumes less time in its descent than if it fell positioned along its horizontal length, because in this position it would meet greater resistance from the air than in the former. By the same token, porous and pumice-like bodies — such as cork and pumice, and countless others of this kind — when dropped from a height do not reach the end of their motion as quickly as less porous bodies of more solid composition, even if they are equal in weight or magnitude. Nor should we listen to those who say that a wooden ball and an iron or leaden one, released from any height, strike the ground in equal time; for in the Cochlea of St. Peter [the spiral staircase of St. Peter's], a place of notable height, repeated experience has taught me the exact contrary. It is true, however, that at a height of 100 or 200 feet the difference scarcely varies perceptibly; but from a notable height, the body that is heavier

strikes the ground sooner. For at a notable height, the compression of the air, owing to the violence of the pressing weight, is so tenacious that it can scarcely be cleft except by the gravity of the weight; whereas the lighter body does not descend straight, but wavers this way and that, variously agitated by the strength of the crowding air, which does not know how to yield. And if the air does this at a height of 400 feet, what will it not do at

[Margin: How much time a stone takes in falling from the Moon to the center of the Earth.]

a height of 1000, 2000, 3000, and so on feet? With these assumptions, then, let us now see whether some ball could fall from the globe of the Moon and from the peripheries of the other heavenly bodies, and, if it could, how much time it would take in falling. I am not unaware that various men have variously determined a time of this kind. [Scheiner?] thinks that some ball would take six days in falling from the Moon to the center of the Earth — but he is mistaken; for the Moon, carried about in its orbit by a wholly uniform motion, traverses that space [in that time]. A heavy body, by contrast, descending by natural motion, accelerates the increments of its velocity not by a uniform motion, but according to the proportion of the odd numbers. That proportion was not yet known at his time, and they perhaps held some other proportion of motion congruous to its acceleration. Galileo, wishing to correct Scheiner, comes nearer the truth, yet he too did not attain it; and so I have judged that I should disclose in this place what seems right to me.

PROBLEMA I. PROPOSITIO I.

To determine how much time a weight of one hundred pounds, falling from the heaven of the Moon, takes to reach the center of the Earth.

Assuming, then, that some heavy body acquires the degrees of its velocity according to the increments of the odd numbers, and that the spaces increase according to the squares of the times: let there be, for example, a certain ball — following Galileo, of 100 pounds — which in the time-span of five seconds falls from a height of one hundred cubits (and let this be confirmed by experiment by Galileo). He says that in a smaller time than 4 hours it [completes] its course — which is from the Moon to the center of the Earth — by its motion. For if you wish to know how much space it traverses in the time of one first minute, which is $\frac{1}{60}$ of an hour, you will have the desired time if you multiply 100 cubits (by which we said the ball falls in the span of five seconds) by the square of 12, that is, by 144 — because 5 seconds multiplied by 12 make 60 seconds; the square, therefore, of a

time of 5 seconds is 12, which, as I said, multiplied into itself give 144; and these again multiplied into 100 cubits give 14,400 cubits, for the time in which it falls to the earth in the space of one first minute.

[Note: "the square of 12 ... is 12" reflects the text's own loose phrasing: 12 is the multiplier ($5'' \times 12 = 60''$), and $12^2 = 144$. Transcribed as printed.]

But if you wish to know how much space the said ball traverses in falling over the course of one hour, multiply the square of 60 first minutes into the number just found, 14,400, and there will result cubits equivalent to 17,280 miles, the space sought. If, finally, you wish to know how much space it consumes in an interval of 4 hours, multiply the square of 4 hours, namely 16, into the 17,280 found just before as the space of one hour, and there will result 276,480 miles — which space is greater than the

semidiameter of the Moon's orbit. For according to the calculation of the astronomers, the semidiameter of the Moon's orbit is only 196,000 miles — or, what is the same, 56 semidiameters of the Earth; and the semidiameter of the Earth contains 3,500 miles, while one mile contains 3,660 cubits. If, then, the calculation is carried out exactly, we shall find that a ball falls from the concave [surface] of the Moon to the center of the Earth in less than 4 hours' time, namely — according to Galileo — three hours, 22', and 4". For since by supposition the ball falls from a height of 100 cubits in a time of 5'', it will necessarily, according to the rule of proportions, in a time of three hours, 22', and 4", traverse a space of 196,000 miles — or 588,000,000 cubits — which space is equivalent to 56 semidiameters of the Earth. And this calculation agrees very well with Galileo's experiment. But according to the experiment made by Mersenne, that ball would descend from the concave [surface] of the Moon to the center of the Earth in a time much smaller still. For when Mersenne brought Galileo's experiment to the anvil [tested it anew], he found that the ball — which Galileo found to traverse a space of 100 cubits in a time of 5 seconds — traversed a far greater space, namely 180 cubits, in a smaller time, namely 3'' 43''' 20''', and not in 5''; so that, according to Mersenne's observation, the said ball traversed an interval of 108 feet in precisely three seconds, and at last 300 feet — that is, 180 cubits — it traversed in a time of 5'', which differs not a little from Galileo's experiment. From this experiment it is concluded that a ball, falling from the Moon all the way to the center of the Earth, takes only a time of two hours, 29' 14".

PROBLEMA II. PROPOSITIO II.

To determine in how much time some ball, falling from the Moon to the center of the Earth, traverses the space lying between the surface and the center of the Earth — or, what is the same, the semidiameter of the Earth.

It must be noted, first, that the motion of a weight toward the center of the Earth can be considered under a twofold aspect: first, by way of *initiation*, as when someone, by divine power, should allow a ball to fall from the center of the Moon to the center of the Earth; second, by way of *continuation*, as if some ball, by divine power, fell from the surface of the Earth to the center of the Earth. For this latter motion, since it arises from a continual augmentation of the velocities, is much swifter; and so it also completes that space of the terrestrial semidiameter in a shorter time than if the ball slid from the very surface itself to the center of the Earth. We shall assign here the duration of each motion, so that the difference between the two motions may appear more clearly. Since, then, in the preceding Proposition we showed that a leaden ball, in falling from the Moon to the center of the Earth, [traverses] an interval of 196,000

miles in a time of 2 hours, 29' 14", while from the Moon to the surface of the Earth, according to Mersenne's calculation, it [traverses it] in a space of 2 hours, 17' 54", you will easily learn how much it traverses from the surface of the Earth to the center, by the motion continued from the Moon to the center. For if you subtract the motion from the Moon to the surface of the Earth from the motion from the Moon to the center of the Earth — namely, 2 hours, 17' 54" from 2 hours, 29' 14" — there will remain 11', 20", 18": the time, that is, which the motion continued from the surface of the Earth to the center takes. But if you wish to know how much time a leaden ball, released from the surface of the Earth all the way to the center, traverses, you must assume, first, that a stone in the time of one second traverses a space of 12 feet, and in a time of 5" traverses a height of 300 feet. This being granted, according to the aforementioned operations the stone or leaden ball will traverse the space of the terrestrial semidiameter in a time of 19' 56".

PROBLEMA III. PROPOSITIO III.

To determine how much time a leaden ball takes in falling from the surface of the Sun, and of the fixed stars, to the center of the Earth.

We suppose, first, by the common tradition of the astronomers, that the Sun is distant from the center of the Earth by 1,142 semidiameters. If you apply the rules of operation given above to these, you will find that the ball traverses the

whole space interposed between the center of the Earth and the disk of the Sun in eleven hours, 13' 50" 48'''; while the space interposed between the Sun and the Moon it traverses in ten hours, 57' 12" 54'''. These, subtracted from 11 hours, 13', leave 16' 43" from the Moon all the way to the center of the Earth. Again, the ball will traverse the space from the Sun all the way to the surface of the Earth in 11 hours, 13', 38", 57'''; and these, subtracted from 11 hours, 13', 56", 48''', leave 17', 51", for the time in which the said ball would traverse the remainder of its journey from the surface of the Earth to the center. Further, if anyone should more curiously wish to know how much time the said leaden ball takes from the Firmament all the way to the Sun, the Moon, and the center of the Earth, he must first assume that the Firmament is distant from the center of the Earth, according to the tradition of the astronomers, by 14,000 semidiameters of the Earth. If, then, you have operated according to the rules handed down above, you will find that the ball traverses that whole immense space from the Firmament all the way to the center in not more than 39 hours, 19' 41", 57", 54'''. The space, however, between the Sun and the Firmament it traverses in 37 hours, 4', 24", 37''', 21'''; and from the Sun to the center of the Earth, 1 hour, 39', 17", 20''', 33'''; from the Firmament all the way to the Moon, 39 hours, 14', 58", 50'''; and from the Moon, finally, to the center of the Earth, 4', 43", 23''', 4'''; and from the Sun all the way to the Moon, one hour, 53', 35", 52''', 39'''; from the Firmament, finally, all the way to the surface of the Earth, 39 hours, 19', 36", 54'''; and from there to the center of the Earth, 5", 4''', 15''''.

[Margin: We suppose first by the common tradition of the astronomers...]

Epilogismus temporis [Summary Reckoning of Time]

That a leaden ball, [falling] from the Earth, the Moon, the Sun, and the Firmament, takes all the way to the center.

A leaden ball traverses the space from the surface of the Earth all the way to the center — 1,145 leagues (each of which has 5,000 feet) — in a time of 19' 56".

From the Moon all the way to the center, a space of 196,000 miles, it traverses in a time of two hours, 29', 14".

From the Sun all the way to the center, a space of 3,997,000 miles, it traverses in a time of eleven hours, 13' 56".

From the Firmament all the way to the center of the Earth, a space of 49,000,000 miles, it traverses in a time of 39 hours, 19', 41".

From the Firmament all the way to the Sun, it accomplishes in a space [time] of 37 hours, 4', 24".

From the Sun all the way to the Moon, by the motion continued from the Firmament, a space [time] of 1 hour, 33', 33".

From the Sun all the way to the center of the Earth, by the motion continued from the Firmament, it accomplishes a space [time] of 39', 17".

From the Moon all the way to the center of the Earth, by the motion continued from the Firmament, it accomplishes in a space [time] of 4', 43".

From the surface of the Earth all the way to the center, by the motion continued from the Firmament, it traverses a space of 3,500 miles in a time of 5", 4".

And this is the reckoning of the time which any weight from the heavenly bodies takes in its fall to the center of the Earth, if it were to acquire the increments of its velocity according to the proportion of the odd numbers — a reckoning which we have arranged according to the experiments of Mersenne, as has been shown.

CONSECTARIUM I. [Corollary I]

From this it is clear how incomprehensible to the human mind is that velocity by which a ball, fallen from the Firmament, traverses the space of 3,500 miles from the surface of the Earth to the center in only 5" (which correspond to six regular pulse-beats of the vein). Hence many, compelled by the excess of such a velocity, openly denied a motion of this kind, lest they fall into absurdities. I say with certainty that, from so great a height, the velocity increases to such a degree that there is no body in the nature of things so solid that it could withstand the excessive impetus of such a motion; indeed, I do not doubt that a metallic body, melted by the violence of the heat kindled from the impetus, would soon be dissolved. Second, I say that nothing can be compared to the motion of this velocity — neither the casting of missiles and darts, nor the motion of birds, nor of the potter's wheel — except only the motion of the Firmament, which completes its period in a space of 24 hours; for a ball falling from the Firmament would reach its terminus 9 hours — that is, 15 hours — sooner, [its terminus] being the center of the Earth; and thus

from this motion of the Firmament its velocity may in some way be inferred.

CONSECTARIUM II. [Corollary II]

From this you will gather how unutterable is the velocity of spiritual substances, since they complete any space whatever, however far removed, as if in a

moment. But let this suffice concerning the fall of heavy bodies; and so let us pass on to other matters.

THE COSMOCENTRIC ART

SECTION IV. ARS COSMOCENTRICA [The Cosmocentric Art]

AND IT IS CENTROSOPHIA APPLICATA [Applied Centrosophy]

CAPUT I.

In the preceding Section we gave our judgment concerning the proportion of motion; in this Section we shall explain the use and application of the things that have been said. And although physical things applied to mathematical ones cannot — owing to the slipperiness of experiments and their hidden fallacies (the condition of matter being such) — exhibit true and geometrical demonstrations, nevertheless, abstracting from all resistance of the medium and from all the inconstancy of fallacious matter, we here bring forward some demonstrations by which the conditions of local motion may be demonstrated, so far as suffices for physical proofs — lest we should seem to have prejudged anything against the modern mathematicians. And that this may be done by the right method [εὐμεθόδως, eumethodōs, "in a well-methodical way"]:

I assume I: In every local motion, whether natural or violent, the moments of velocity behave as the increments of the odd numbers from unity.

II: The spaces, or lines, of the descent of heavy bodies are in the squared ratio of the durations or times; or, what is the same, the increments of velocity have the same ratio that the times have to the square.

PROPOSITIO I. THEOREMA I.

Motions along a vertical line and an inclined line, whose endpoints are joined by a straight line drawn perpendicular to the inclined line, are equal to one another.

When we say that the motions taken here are equal, we mean it not as to velocity, but as to duration. For it is certain that movable bodies are carried more slowly up [along] an inclined plane than by natural motion along the vertical. Let some movable body, then, descend from C to D, and another equal one from C to A — the former along the vertical line, the latter along the inclined line. Let any point be determined on the perpendicular line C E — for example, E — from which a normal drawn to the inclined line C A points out, at D, the terminus of the line C

D, upon which the movable body, rolled down, takes a time equal to that motion which occurs along the vertical line C E. For since the triangles A D E and A E C are equiangular and similar, the angles A D E and A E C will be equal — the straight line E A D being common. As, therefore, A C is to A E, so A E is to A D; whence the times along A D and C D are equal.

Diagram. A right triangle illustrating Theorema I, the equality (in duration) of motion along a vertical and an inclined line. The vertical leg runs from C (top) down to E (bottom left); the inclined hypotenuse runs from C down to A (bottom right); E and A are joined along the base. A circle (the rolling movable body) sits on the inclined line C A near the point D, which lies on the inclined line where the perpendicular from E meets it.

- C (top apex): vertex; origin of both the vertical line C E and the inclined line C A
- E (bottom left): foot of the vertical line C E
- A (bottom right): lower terminus of the inclined line C A
- D (on inclined line C A, near the rolling circle): point where the normal from E meets the inclined line C A

Marcus Marci [Jan Marek Marci of Kronland], by another argument, ingeniously demonstrates this same thing. For he says that the impulse of bodies rolled down an inclined plane is increased in proportion to the distance of the center [of gravity] of any heavy body from the fulcrum [hypomochlio, ὑπομόχλιον]. Let there be, in the figure, a ball rolled down from A to D; let the line of the fulcrum be E F, the center of gravity of the ball I, and its distance from the center

of gravity of the ball I, and its distance from the center [of gravity] and from the line of the fulcrum E F, let it be I Z. It will then be: as D I is the greater impulse to the lesser impulse D Z, so is the motion along A E to the motion along A D; for the triangles are similar to one another, and consequently the sides are analogous — the side I D to the side A C, and E Z to the side A E. Therefore, as C A is to E A, so is I D to I Z; and as A E is to A C, so is I D to Z D.

Diagram. A larger right triangle illustrating Marcus Marci's lever-based demonstration. The base runs horizontally from C (bottom left) to E (bottom right), with F marked on the base between them; a vertical rises from F to the apex region; the hypotenuse runs from C up to the apex at the upper right. A small circle (the rolling ball) is drawn near the top of the vertical, carrying the lever-and-center-of-gravity labels (H, e, I, Z, G, D) of the fulcrum construction.

- C (bottom left): lower terminus of the base / start of the inclined hypotenuse
- E (bottom right): right end of the base (also lettered as terminus of line E F / E Z construction)
- F (on base, between C and E): foot of the vertical; point on the fulcrum line E F
- A (apex, upper right): top terminus of the inclined line (the ball rolls down from A to D)
- H (at the small circle, upper left of circle): label on the rolling-ball / lever construction
- e (at the small circle, top): label on the rolling-ball construction
- I (within the small circle): center of gravity of the ball
- Z (within the small circle, near I): endpoint of the distance I Z from the fulcrum line
- G (below the small circle): point on the vertical near the circle
- D (at the small circle, right): point to which the ball rolls down

PROPOSITIO II. THEOREMA II.

Motion along a less inclined plane is faster than motion along a more inclined plane, in the ratio of the sines of the complements of those inclinations.

By a "less inclined" line or plane I mean here the one that departs less from the vertical or perpendicular line; a plane is "more inclined" when it departs further from the perpendicular. With this established, from the point A on the circle A L T R draw the lines A B, A C, A D, A E. Let A B be the horizontal line and A T the vertical — which is the same as the diameter of the circle. I claim that one and the same moving body — say the ball O — moves at unequal speeds along these lines: faster along the plane A E than along A D, and faster along A D than along A C, and so on for the rest. In each case the ball moves all the faster over a less inclined plane the closer that plane approaches the vertical or perpendicular line, and all the slower the closer it approaches the horizontal plane. Thus the velocity along the inclined line A E stands to the velocity along the line A D just as the sine of angle A T S stands to the sine of angle A T R.

From the points of contact of the ball — Q, R, S — draw the perpendiculars Q T, R T, S T to T. Then from those same points of contact Q, R, S draw further lines parallel to the diameter A T of the circle: Q G, S H, R I. Let these be called the lines of the fulcrum [lineae hypomochlii]. These lines touch [recte: cut — *secant*] the ball at the points K, N, V. Next, from the center of the moving ball draw the

perpendiculars αo , $o\beta$, $o\gamma$ to the lines of the fulcrum. Now since the external angle $T S L$ is greater than the angle $I R H$, the angle $\gamma \gamma o$ will consequently be greater than the angle $\beta \gamma o$; and the side γo will be greater than the side βo — these being the distances of the ball's center of gravity from the lines of the fulcrum. Therefore, since there is a greater impulse at the greater distance γo of the center of gravity from the line of the fulcrum than at the lesser distance βo , it follows that along the line $A S$ — that is, on the less inclined plane — the motion will be

faster than along the line $A R$, which is less inclined [recte: more inclined]. For the fulcrum-line $V S$ takes off the smaller portion $V X S$ from the ball, whereas the fulcrum-line $N R$ takes off a larger portion. Consequently, along $A S$ the ball moves faster, because of the preponderant larger portion of the ball $V Y S$, than along the line $A R$, where the fulcrum-line $R N$ leaves the larger part of the ball less preponderant.

That the velocity of the motion is in the ratio of the sines of the complements of the inclinations, I demonstrate as follows. As $S O$ stands to $o\beta$, so does the diameter $A T$ to the chord $A S$; and as $R O$ — equal to $S O$ — stands to $o\beta$, so does the diameter $A T$ to the chord $A R$. But as $A S$ and $A R$ stand to one another, so do their halves $A L$ and $A M$ — the sines of the angles $A P L$ and $A P M$, which are equal to the angles $A T S$ and $A T R$ respectively (because of the parallels $T S$ and $P L$, and $T R$ and $P M$), and which are the complements of the inclination of the planes $T A S$ and $T A R$. Therefore, as $o\gamma$ is to $o\beta$, so are the sines of the complements of the angles of inclination to one another — which was to be demonstrated.

Diagram. A large circle with horizontal diameter $region$, used for Theorem II on inclined-plane velocities. From the top point A several straight lines radiate downward to the right toward the circle and beyond. $A B$ is the horizontal line drawn to the right; $A T$ is the vertical (the diameter) descending to T at the bottom. The point L lies at the left extremity of the circle, and P lies on the horizontal at center. From A radiate the inclined lines $A C$, $A D$, $A E$ (with B , C , D , E lettered along the right margin from top to bottom). Several small circles (the rolling ball O in successive positions) are drawn along the inclined lines, with the contact-points and fulcrum constructions K , M , N , Q , R , S , V , X and the three small ball-circles labelled $K(\alpha)$, $R(\beta)$, $V(\gamma)$ with paired centre sub-letters (α/o , β/o , γ/o near the lowest), and the contact point S adjacent to the lowest. The diameter terminates at T ; index "III" appears near the foot at right.

- A (top of circle): apex from which all lines radiate

- B (upper right): end of horizontal line A B
- C (right margin, below B): end of inclined line A C
- D (right margin, below C): end of inclined line A D
- E (right margin, lowest): end of inclined line A E
- L (far left of circle): left extremity
- P (center, on horizontal): point on line A B
- T (bottom): foot of vertical diameter
- K, M, N (mid-figure): construction / contact points
- Q, R, S (mid-figure, near ball positions): points of contact of the ball
- V, X (lower interior): fulcrum-line / ball-portion points on the lowest ball-circle
- three small ball-circles K(α), R(β), V(γ): centre sub-letters α/o , β/o , γ/o (γ/o the lowest)
- G (foot, near T): noted with index "III"

PROPOSITIO III. THEOREMA III.

Bodies released from the same point and rolling down along the chords of a circle — which represent inclined planes — traverse the spaces of those chords in the same time in which bodies sliding down naturally along the diameter of the circle complete it.

Let there be a circle B C A G with diameter B A, and let chords be drawn from the point B to the periphery of the circle, representing inclined planes: B E, B F, B G, B H, B I. I claim that the time taken to traverse the chords B E, B F, B G, and so on, is equal to the time in which moving bodies finish their motion along the diameter B A of the same circle.

For if from the point A the straight lines A E, A F, A G, A K [recte: A H], A Y [recte: A I] are drawn, the angles A E B, A F B, A G B, and the rest, being inscribed in a semicircle, will be right angles. Consequently, by Theorem I, Proposition I of this [Sectio], the motion along B A is equal in duration to the motions along B E, B F, B G, B H, B I. The same will follow if, from the

arcs of the periphery B E, F G, H I, the motion is made to terminate at A through the chords E A, F A, G A, H A, I A — since the lines B E, B F, F G [recte: B G], B H, B I are perpendicular to those chords.

I therefore claim that the motion along the chord B E is equal to that along the chord E A; the motion along the chord B F is equal to that along the chord F A; the

motion along B G equals that along G A, just as those along B H and B I equal those along H A and I A. The reason is this: since the moving body — whether along the said chords B E, B F, B G, B H, B I, or conversely along I A, H A, G A, F A, E A — terminates in the circle, nature accordingly fixes, at the points E, F, G, H, I, at the extremities of the shortest lines through which it operates, the limits set to its motion by gravity, which it cannot overstep. For between these limits and the vertical line (the diameter A B of the circle) lies the smallest distance from the center of the Earth A. And since the angles A I B, A H B, A G B, A F B, A E B are right angles, having the same base A B, they will lie — by Euclid III.31 [Euclid, *Elements* III.31; printed "1 5. l. 4."] — in the same semicircle B E F G H I A, whose diameter B A is vertical: namely the distance between B and the Center of the World.

Suppose, then, that the lines — say B I — were to run beyond the circle to S or to T [?], and the line B H to N. They would then be moving against the Center, which is absurd. Therefore, at the points I, H, G, F, E — that is, by means of the shortest lines — nature fixes the limits of motion set by gravity, so that at these points, by means of the chords they bound, the moving body would attain its end and rest, in the same time in which the body that moves naturally along the vertical line B A attains its rest. Therefore the moving bodies, etc. — which was to be proved.

Diagram. A circle B C A G with vertical diameter B A (B at top, A at center-bottom of the inner circle). A horizontal line runs across the top through B, with points Y, Z, D marked to the right of B. From B several chords descend to the right toward the periphery and to outer points; from A several lines radiate to the right. The points E, F, H, I lie along the right side of the circle between B and A. Outer points U, M, N lie to the right, and S, T below A; P at the bottom; C and Q at the left.

- B (top): upper end of the vertical diameter; origin of the chords
- Y, Z, D (top, right of B): points along the top horizontal line
- A (center): lower end of inner diameter / Center of the World
- E, F (upper right, on circle): chord-endpoints
- H, I (mid-right, on circle): chord-endpoints
- K (right, near F): point on a chord
- U (right): outer point
- M (far right, on horizontal through A): outer endpoint
- N (lower right): outer point beyond the circle
- S (just right of A): point on the diameter line
- T (below A): point on the descending line

- P (bottom): foot of the vertical
- C, Q (left): points on the left of the circle

down [recte: along] the arcs of the periphery B E, F G, H I, let the motion be made to terminate at A through the chords E A, F A, G A, H A, I A, since the lines B E, B F, F G [recte: B G], B H, B I are perpendicular to those chords. I therefore claim that the motion along the chord B E is equal to that along the chord E A; the motion along B F is equal to that along F A; the motion along B G equals that along G A, just as those along B H and B I equal those along H A and I A.

The reason is that the moving body — whether along the said chords B E, B F, B G, B H, B I, or conversely along I A, H A, G A, F A, E A — terminates in the circle. So nature, at the points E, F, G, H, I, at the extremities of the shortest lines through which it operates, fixes the limits set to its motion by gravity, which it cannot overstep — since between these limits and the vertical line (the diameter A B of the circle) lies the smallest distance from the center of the Earth A.

And since the angles A I B, A H B, A G B, A F B, A E B are right angles, having the same base A B, they will lie — by Euclid III.31 [*Elements* III.31; printed "1 5. l. 4."] — in the same semicircle B E F G H I A, whose diameter B A is vertical: namely the distance between B and the Center of the World. Suppose, then, the lines — say B I — were to run beyond the circle to S, or to T, and the line B H to N: they would then be moving against the Center, which is absurd. Therefore at the points I, H, G, F, E — that is, by the shortest lines — nature fixes the limits of motion set by gravity, so that at these points, by means of the chords they bound, the moving body attains its end (which is rest), in the same time taken by the body that, moving naturally along the vertical line B A, attains it. Therefore the moving bodies, etc. — which was to be proved.

COROLLARY.

From this it follows that the perpendicular motion of a rectilinear figure stands to its inclined motion in the ratio of the semidiameter of the moving figure to the segment of it lying between the figure's center and the line of the fulcrum.

Let there be some plane O B declining from the perpendicular O Z, on which some body L moves — say a tetrahedron, a cube, or a pentahedron. Now, by what I taught in the first Sectio of this Book concerning the pyramid, the prism, and the tetrahedron, the center of gravity in a body cut through its center of gravity is P. Draw the line of the fulcrum from N in S, parallel to O Q; and from the center of gravity P draw P Q perpendicular to O Q — this is called the semidiameter of the figure.

I claim that the vertical motion along O Q stands to the motion along the inclined line O B as Q P, the semidiameter of the figure, stands to the segment intercepted between the center of gravity P and the line of the fulcrum N S — that is, to P R. For since the moving gravity is equal to the motion, and the whole or vertically-acting gravity stands to the gravity acting at P Q along O B as P Q to P R, it follows likewise that the vertical motion along O Q stands to the inclined motion along O B as P Q to P R — that is, as the semidiameter P Q to its segment between the figure's center P and the line of the fulcrum.

In the same way, the motion of a cube on the inclined plane [E L — *recte* uncertain] [?] will stand to its motion along the perpendicular O Q as the semidiameter of the cube K Z [recte: K L?] [?] stands to the segment K L between the center K of the cube and the line of the fulcrum N O. Likewise the motion of the pentahedron along the inclined line O B stands to its motion along the perpendicular O Q as the segment I X stands to the semidiameter T V of the pentahedron.

Here it should also be noted: the more the lines incline — that is, the more they recede by their inclination from the vertical O Q — the less the portion of the figures outside the line of the fulcrum weighs, and consequently the more slowly the body traverses the plane; but it rolls all the faster the more the portion of the figure outside the line of the fulcrum weighs — until the line of the fulcrum divides the figures in half. Once that has happened, the body rests perfectly, being situated, as it were, on a horizontal line.

It is therefore clear that from this foundation countless hidden principles may be brought in to enrich mechanics — and these few indications must suffice. Whoever wants more should consult the ingenious little book *On the Proportion of Motion* by Joannes Marcus Marci [Jan Marek Marci of Kronland].

Diagram. A construction for the Corollary, showing three rectilinear bodies on an inclined plane. A long inclined line runs from the upper left (near O, S) down to B at lower right, with several vertical dotted plumb-lines descending from the bodies to a horizontal base near Z. At top: a small triangle with vertices labelled O, S above and Q, R, P, M across, with N just below. In the middle: a pentagon (the pentahedron) with V and the cross-mark X, T at its center. Below it: a tilted square (the cube) with V at top, and z, L, K marking the fulcrum-line and center, with O at its lower corner.

- O, S (top left): top of the perpendicular / fulcrum points

- Q, R, P, M (upper triangle, left to right): center of gravity P, segment-points Q and R, outer vertex M
- N (below the triangle): fulcrum-line point
- V, X, T (pentagon, center): semidiameter construction of the pentahedron
- z, L, K (cube, center): fulcrum-line z, segment L, center K of the cube
- B (lower right): foot of the inclined line O B
- Z (lower left, base): foot of the perpendicular O Z

PRAGMATIA.

To make an instrument by which the equalities of motions with respect to duration may be exhibited.

Let a compass — the kind called a proportional compass — A B C be made, with its two legs divided into a hundred (or fewer) equal parts on each leg. Then let a cross-bar D be made, whose end D always rests at right angles against the side A C, the bar being movable along the side A C. Let the side A D represent the perpendicular line of the downward motion of some weight, while A C represents the inclined plane, which can be adjusted to fit any inclination once drawn out.

I claim that the bar, applied perpendicularly at D, marks the limit of motion on the inclined plane A C, and that the point at S marks the limit of the perpendicular motion that a perpendicularly falling weight reaches in the same time in which the weight at D is rolled down the inclined plane A C; and in the same time it reaches G as it reaches F, and I as it reaches H. For since the angle A [recte: A D S]

is a right angle, by Euclid III.31 the point will necessarily lie in the semicircle A D S, and the points F and H likewise in their own semicircles A F G and A H I.

Now since in Proposition 3 we showed that these are the shortest lines on inclined planes, by which nature reaches the limit of motion, and that the motions are equidiurnal [equal in duration] with the motions made along the perpendicular A I, it follows that the motion from A to D is equidiurnal with the motion from A to S; the motion from A to F stands to the motion from A to G [as equidiurnal]; and the motion from A to H is equidiurnal with the motion from A to I.

For if you imagine the cross-bar always standing perpendicularly on the side A C with one of its ends, running down the plane, and cutting the perpendicular line with its other end, it necessarily follows from what has been said that the body moving over the inclined plane A C describes a motion equidiurnal with that over

the perpendicular A S. The same follows if you spread the side A C of the compass into any inclination, great or small; for the equally divided parts in the legs indicate the spaces that the moving body covers in equal moments on the side A Y [recte: A C]. The sense of the proposition is therefore clear.

Diagram. The proportional-compass instrument for the Pragmatia. From the apex A a curved boundary descends to the right to D, with chords A S, A D, A F [?], A H drawn within. The compass leg A C runs from A down to C at the lower right; the leg A B descends to B at the lower left, with the index "I" near B. Cross-bars and the segments S, D, P, F, G, H mark the successive limits.

- A (apex): vertex of the compass
- S (upper, on inner arc): limit of perpendicular motion in semicircle A D S
- D (upper right): limit on the inclined plane
- P (left, mid): point on the leg A B [?]
- F (mid-right): limit-point in semicircle A F G
- G (lower left): foot-point of the semicircle A F G
- H (lower right): limit-point in semicircle A H I
- B (lower left): foot of leg A B (with index "I")
- C (lower right): foot of leg A C

CAPUT II.

De pendulorum motibus.

On the motions of pendulums.

Since the motions of pendulums along the arcs of a quadrant behave in exactly the same way as motions along inclined planes — which are nothing other than the chords subtending the arcs of a quadrant — and since infinitely many such chords can be considered in the arc of a quadrant, the pendulum too must be reckoned to traverse, in its vibrations, infinitely many planes that are now more, now less, inclined. The following Propositions concern these.

PROPOSITIO IV.

The motions of pendulums acquire many affections or properties. The first is that all single courses [diodromos], whether greater or smaller, traverse in equal time the space that lies between the beginning of the pendulum's motion and the line of direction (the line of the Center). The second is that all the outward swings and return swings are equidiurnal among themselves. The third is that all single

courses are mixed of natural and violent motion. The fourth is that all single courses — that is, both the outward and the return swings, though ever smaller and smaller — are nonetheless equidiurnal. The fifth is that different pendulums are in the doubled ratio of their times. Of all these, each in turn:

A pendulum from any point of the same circle returns in equal time to its station, that is, to the line of direction or of the Center; and its outward swings are equidiurnal with its return swings, in whatever arcs of the periphery.

For since the motions of pendulums behave as sines, and their intervals as the arcs intercepted by the sines, and since these intervals become continuously smaller, and at the last point of the semidiameter have no interval at all, while the motions continuously fall short of that point by an ever smaller interval — it follows necessarily that the motions of a pendulum, from whatever point of the periphery they begin, return in equal time to the last point of the semidiameter of the quadrant. Yet a pendulum set in motion at any point does not rest at the line of the Center, but swings beyond it, until — after the agitation of its repeated forward and return courses has been carried out — it finally comes to rest at the line of direction.

And since the pendulum swings out and back through ever smaller arcs, the impulse must necessarily be diminished in that ascent — because gravity and impulse are mixed together. In the descent along the same line, gravity and impulse move it (the impulse arising from gravity in a continuous flow); but from the line of direction (which we have established as the semidiameter of the quadrant), gravity continuously resists the impulse. For the contrary impulse, reborn from that same gravity, removes an equal part there, so that the remaining motion is equal to the excess of the greater. For just as the impulse continuously decreases by the same increments by which it had increased, so the velocity, from its maximum increment all the way to the end of the motion, becomes continuously smaller.

Let a pendulum be fixed at A; let it run down from E to N, and from N to F, and thence to M, and thence to G, and so on for the rest. I claim that the pendulum running down from E to N traverses this arc in the same time in which the pendulum running down from N to E does so, and thence to M in equal

Diagram. A semicircular fan of pendulum-radii hung from the apex A, illustrating the equidiurnal swings. From A a horizontal line runs left to O and right to B. The semicircular arc below carries, from upper left around to upper

right, the points N, M, L, V, I, K, H, G, F, E, with radial lines from A to each. The lowest points V, I, K lie near the bottom of the arc.

- A (apex, top center): point of suspension
- O (upper left, end of horizontal): left terminus of the line of direction
- B (upper right, end of horizontal): right terminus
- N (left, on arc): swing-point
- M (lower left, on arc): swing-point
- L (lower left, on arc): swing-point
- V (bottom, on arc): lowest left swing-point
- I (bottom): lowest point near the line of the Center
- K (bottom, right of I): swing-point
- H (lower right, on arc): swing-point
- G (lower right, on arc): swing-point
- F (right, on arc): swing-point
- E (upper right, on arc): starting swing-point

time as [it swings out] to G; for since the impulses at E and N increase, while at F and M they diminish the velocity of the motion in equal proportion, the momenta of the velocity will be equal to its decrement. Accordingly the velocity gathered in the motion, through equal decrements of its increment, terminates in rest. Thus what the impulse acquires in velocity from E to N in the greater arc, it loses from N to F in the smaller. For just as in the return swing the velocity continuously and unequally increases, so it does in the outward swing; and because the violent motion decreases proportionally, so that its decrements equal the increments of the other — the first matched to the last — because both arise from the same gravity, which from the beginning of the swing exerts its weight through the more inclined lines.

Therefore, since gravity alone diminishes the impulse — being situated at equal intervals from the line of the Center, and, on account of similar inclination, the circle and the arc weighing equally among themselves — so too the impulse of that same gravity. And since the contrary impulse removes a part equal to itself, the outward and return swings will be equal among themselves, the time being equalized on this basis: so that what the pendulum's outward swing acquired by natural impetus in the greater arc, the violent motion takes away in the ascent through the smaller arc. The proposition is therefore clear.

COROLLARY I.

From this it is clear that if a pendulum were to run from E to the last point O of the semicircle, the pendulum's motion would be perpetual; for there would be no greater reason for it to go from E to O than the reverse — and so it would not return to E, and again to O — since the impetus is altogether equal in both the forward and the return courses, and they always measure out an equal space.

Hence some, examining the cause why a pendulum running from E never reaches O, the terminus of the semicircle, and ascribing it to the resistance of the intervening air, supposed that if a pendulum were to move in a vacuum, it would have no resistance and so would move perpetually. Whether motion can occur in a vacuum, let them see to it. For my part, saving the judgment of others, I boldly declare: just as in nothingness — such as a vacuum is — no relation to the Center can be conceived, nor can a line of direction have any place, so too in that same nothingness, nothing can be moved. And the matter is clear from Definition III at the beginning of the canons on the center of gravity [De Centro gravitatis].

COROLLARY II.

From this it is again clear that the motions of pendulums along the arcs of the same circle have the ratio that the sines of the doubled angles have — namely, the angles that are the complements of the inclination of the chords or subtenses.

Let there be arcs B D C I and b D C [?]; the angles A B I and A B C will be the angles of inclination of the chords B I and B C, and their complements B A I and B A C, because of the right angles at I and C [recte: T and C]. Therefore let the lines I H [recte: T H] and C G touch the circle at the points I and C [recte: T and C]; and from the center K let the lines K T, K C be drawn to the tangents T H, C G. Since, then, K H T [recte: K T H] and K G C are the angles of inclination of the planes,

the angles H K I [recte: H K T] and G K C will be their complements, and B A I, B A C will be at the periphery of the doubled [arc]. Just as, then, the sine of angle B K T stands to the sine of angle B K C, so does the velocity of motion at I stand to the velocity of motion at C. For since the motion at any point of the circle takes place along the tangent line, the ratio of the velocity at I and C will be that which is the velocity of the tangents I H and C G; and the velocity along I H stands to the velocity along C G as the sine B L of angle B K I stands to the sine B M of angle B K C. Therefore the velocity along C B [recte: at C] is as the sine of angle B K I to the sine of angle B K C — namely, the sines of the doubled angles, which are the complements of the inclination of the chords B T, B C. Which was to be proved.

Diagram. A circle with apex A at the top, used for Corollary II on pendulum velocities and tangents. From A several chords descend to the right toward the circle and to outer points O, P, T. The center K is marked at mid-left of the circle, with L, M to its right and the inner construction lines. Below the circle the construction continues to B, E, and the long lines descend to G at the foot.

- A (top of circle): apex / starting point of the chords
- O (upper right, on circle): outer point
- P (right, on circle): chord-endpoint
- T (right, on circle, below P): tangent-point (printed I in places)
- K (center-left): center of the circle
- L (right of K): point on construction line
- M (below L): point on construction line
- C (lower right, on circle): tangent-point
- D (lower mid): chord-point
- B (bottom of circle): foot of the vertical
- E (just below B): point on the descending line
- G (lower, on the long line): tangent-line terminus

PROPOSITIO V.

That the motions along similar arcs of unequal circles have the ratio that the sines of those arcs have.

Let there be unequal circles B L and C M; let the arcs in the larger circle B D and B F, and in the smaller circle C E and C G, be similar to one another. Then the motions of the pendulums will stand to one another — the motion from F to B, the motion from G to C, and the motion from D to B to the motion from E to C — as the sines of those arcs.

Draw the tangent lines P K, A I, T B, G H from the points of contact F, D, G, E. The triangles A F K, A I D, A B T, A C [recte values uncertain] [?] will be similar; and because of the proportionality of their sides, the angles at K, I, B, C [?] will be equal, and the angle A common to all the triangles, while the angles at D, F [recte: D, E, C?] [?] are right angles. Just as, then, F is to D, so is G to E; and as F is to D, so is the sine of arc F B to [the sine of arc D B]; and as G is to E, so is the sine of arc G C to [...]

to the sine of arc E C; and by alternation, as the sine of arc F B is to the sine of arc G C, so is the motion in F to the motion in G; and the motion in D is to the motion

in E as the sine of arc D B is to the sine of arc E C. Therefore the motions along similar arcs of unequal circles, and so on, which is what was proposed.

Diagram. A figure of two concentric circles sharing the common center A. A vertical diameter runs from L at the top, through M, the center A, and down through B to I at the bottom. The outer (larger) circle carries the points L (top), B (lower part of the vertical line), and F (on the right); the inner (smaller) circle carries M (top), C (lower part of the vertical line, on the inner circle), and G (on the right). Below the center A, a cluster of straight chords and tangent lines connects the points V, G, C, E, F, H, T, B, and D, forming the similar triangles used in the proof. The construction compares the chords/sines B G and C V (of the two circles) and the motions along the corresponding arcs.

- L (top of outer circle, on the vertical diameter): vertex L
- M (top of inner circle, on the vertical diameter): vertex M
- A (common center of both circles): center A
- V (just below A, inside the inner circle): point V
- G (right side, on the inner circle): point G
- C (on the vertical line, on the inner circle below A): point C
- E (just right of C): point E
- F (right side, on the outer circle): point F
- H (below C, near the vertical line): point H
- T (between H and D): point T
- B (on the vertical diameter, on the outer circle): point B
- D (lower right, on the outer circle near B): point D
- I (bottom of the vertical diameter): point I

[continued at foot of the left column:] ...to the motion in G; and the motion in D is to the motion in E as the sine of arc D B is to the sine of arc E C. Therefore the motions along similar arcs of unequal circles, and so on, which is what was proposed.

Corollary I

From this it is clear that the motion in the smaller circle is faster than the motion in the larger circle. For since the motion in B F has to the motion in G C the same ratio that the sine B G has to the sine C V—and likewise A B is to A C as B G is to C V, on account of the analogy of the sides—and the line A B is greater than the line A C, the line B G will also be greater than the line C V. Therefore the motion in the line A B, over the greater interval A B, will be greater than the motion in A C. And

so the motion in the smaller circle will be faster; that is, it will take place in less time than in the larger circle.

Corollary II

From this it is further gathered that the motions of [bodies on] the circles stand in the ratio of their times, which the diameters have to one another doubled. For just as the sine B G is to the sine C V, so is the motion in F B to the motion in G C; and as B G is to C V, so is A B to A C—because the motion A B is equal to the motion B G, and the motion A C to the motion C V, by Theorem 2 preceding. But A B to the motion A C, and its double L B to M C, have the ratio that the times of the motions of the circles have. And consequently those times have the doubled ratio of the diameters to one another.

Caput III

On the use and benefit of the foregoing

Practical Problem I

To construct a table by which, given the time, you may know the height from which some weight has fallen from any place; and conversely, knowing the height, you may know the time it took in falling.

Let us assume, first, following the observation of Mersenne [Marin Mersenne], that a body in falling downward through a height of three feet takes a time of half a second. Let us assume, second, from what has been said, that the velocity of the falling weight is accelerated according to the proportion of the odd numbers. Let us assume, third, that the space through which the weight falls is [measured] in feet, of which one is divided into 12 inches; and that six such feet make one perch [*pertica*] or rod [*sexapeda*], that 15,000 such feet—or, what is the same, 250 decempedes [ten-foot measures]—make one French league [*leuca gallica*]. These things presupposed, let half-seconds be set down in order in the first column up to 60, so that the 60 half-seconds are equivalent to 30 seconds. This done, let a series of the odd numbers be set down in order in the second column, as appears in the table below. In the third column let the squares of the times be set down in natural order, as you see. In the fourth column [let there be] the feet, or the space, through which the weight falls in any given second, or half of one. Since, then, by the supposition the observed weight in the time of half a second covers a space of three feet, these three feet will hold the first place in the column; the rest you will continue in order in this manner.

Multiply these three feet by each of the odd numbers placed in order in the second column, and set the products in order opposite, in the fourth column. For example, the number 3, placed in the second position in column II, multiplied by itself produces 9, which are to be placed opposite in the second position of the fourth column. Again, let 3 be multiplied by the next following number, the five [i.e. 5], and let the product 15 be set down opposite in the fourth column. Then, finally, let 3 be multiplied by the number 7 placed in column II, and let the product 21 be set down opposite in the fourth column. And so you will be able to continue the table to infinity, always multiplying the number three [i.e. the ternary] into all the odd numbers placed in order in column II, and placing the products opposite them in the fourth column.

The fifth column is composed by this device. In the fourth column join the second number—namely 9—to the first in column V, namely 3, and you will have 12, which you set in the second place of column V of the table, opposite the 9. Again, add 15 in column IV to the number 12 just produced, and you will have 27, which are to be placed in column V after 12, opposite 15. Further, 21, which is the fourth number in column IV, let it be added to 27, the third in column V, and 48 will result, which set opposite 21 in column V. In this way you will proceed with the remaining numbers in order, always joining the numbers in column IV to the numbers just produced in column V; and you will have a table suited to your uses, as follows.

TABULA

From which it is known how much space any given weight covers.

[Header note over column VI: 1" pro 3 pedibus — "1 second for 3 feet"]

Half-seconds [<i>Minuta semisecunda</i>] (I)	Odd numbers of accelerated motion [<i>Numeri impares motus accelerati</i>] (II)	Squares of the times [<i>Quadrata Temporum</i>] (III)	Aggregate of numbers in feet [<i>Aggregata numerorum in pedibus</i>] (IV)	Aggregate of feet from column IV [<i>Aggregata pedum ex IV Columna</i>] (V)
½ 1"	1	1	3	3
2"	3	4	9	12
3"	5	9	15	27
4"	7	16	21	48

Half-seconds [<i>Minuta semisecunda</i>] (I)	Odd numbers of accelerated motion [<i>Numeri impares motus accelerati</i>] (II)	Squares of the times [<i>Quadrata Temporum</i>] (III)	Aggregate of numbers in feet [<i>Aggregata numerorum in pedibus</i>] (IV)	Aggregate of feet from column IV [<i>Aggregata pedum ex IV Columna</i>] (V)
5"	9	25	27	75
6"	11	36	33	108
7"	13	49	39	147
8"	15	64	45	192
9"	17	81	51	243
10"	19	100	57	300
11"	21	121	63	363
12"	23	144	69	432
13"	25	169	75	507
14"	27	196	81	588
15"	29	225	87	675
16"	31	256	93	768
17"	33	289	99	867
18"	35	324	105	972
19"	37	361	111	1082
20"	39	400	117	1200
21"	41	441	123	1323
22"	43	484	129	1452
23"	45	529	135	1587
24"	47	576	141	1728
25"	49	625	147	1875
26"	51	676	153	2028
27"	53	729	159	2187
28"	55	784	165	2352
29"	57	841	171	2523
30"	59	900	177	2700

Half-seconds [<i>Minuta semisecunda</i>] (I)	Odd numbers of accelerated motion [<i>Numeri impares motus accelerati</i>] (II)	Squares of the times [<i>Quadrata Temporum</i>] (III)	Aggregate of numbers in feet [<i>Aggregata numerorum in pedibus</i>] (IV)	Aggregate of feet from column IV [<i>Aggregata pedum ex IV Columna</i>] (V)
31"	61	961	183	2883
32"	63	1024	189	3072
33"	65	1089	195	3267
34"	67	1156	201	3468
35"	69	1225	207	3675
36"	71	1296	213	3888
37"	73	1369	219	4107
38"	75	1444	225	4332
39"	77	1521	231	4563
40"	79	1600	237	4800
41"	81	1681	243	5043
42"	83	1764	249	5292
43"	85	1849	255	5547
44"	87	1936	261	5808
45"	89	2025	267	6075
46"	91	2116	273	6348
47"	93	2209	279	6627
48"	95	2304	285	6912
49"	97	2401	291	7203
50"	99	2500	297	7500
51"	101	2601	303	7303 [recte: 7803]
52"	103	2704	309	8112
53"	105	2809	315	8427
54"	107	2916	321	8748
55"	109	3025	327	9078

Half-seconds [<i>Minuta semisecunda</i>] (I)	Odd numbers of accelerated motion [<i>Numeri impares motus accelerati</i>] (II)	Squares of the times [<i>Quadrata Temporum</i>] (III)	Aggregate of numbers in feet [<i>Aggregata numerorum in pedibus</i>] (IV)	Aggregate of feet from column IV [<i>Aggregata pedum ex IV Columna</i>] (V)
56"	111	3136	333	9418
57"	113	3249	339	9757
58"	115	3364	345	10102
59"	117	3481	351	10453
60"	119	3600	357	10810

Explanation of the Table

The first column of this table shows half-seconds, 120 of which make one first minute; hence any two consecutive numbers taken together make one second, and so the whole column, which contains 60 half-seconds, is reckoned to contain 30 seconds. And these are the times by which the spaces through which some weight falls are measured.

The second column contains the series of odd numbers from unity, which have been treated fully in the preceding pages, and which can be fitted to any measure once the time is given in the first column. Thus, if in one half-second the weight falls through a space of one foot, then at the end of the next half-second it is reckoned to fall through three feet, and in the third half-second through five, and in the [fourth] half-second through 7, and so on with the rest.

The third column shows the squares of the times, that is, the aggregates of feet that the weight covers in a given time. Thus, if the weight falls one foot in the first half-second, and three in the second half-second, these added to 1 give 4, the aggregate of feet which the weight covers in the first and second half-seconds—and so the square of the second half-second. But, in order to show the principle of the proportion by another example, we have here arranged column IV, in which the feet are set down according to the observation of Mersenne, who found that in the time of one half-second any weight covers a space of three royal feet [*pedes regii*]. Hence in two half-seconds it will necessarily cover a space of 9 royal feet, and in three half-seconds a space of 15 feet, and so on with the rest.

Column V shows nothing other than the aggregate of feet that some weight covers in the time corresponding to it in the first column. For example, if some weight falls three feet in one half-second, it will cover a space of 12 feet in the second half-second, because in column IV 3 and 9 joined together make 12—just as, if in one half-second the weight covered a space of one foot, it would cover 3 feet in the other half-second, to which the first foot joined makes 4, namely the square of two half-seconds, as appears in the second and third columns; and everything is made abundantly clear from the structure of the table just indicated. So the aggregates of the numbers placed in column IV are exactly the same numbers as those in table V; for 3 joined to 9 give 12, which holds the second place in column V; while 15, joined together with 9 and 3 in table IV, give the third number in column V, 27—the same that you will get if you join 15 to 12, which immediately precedes 27. In the same way, if you join 21, 15, 9, 3 into one, 48 will result, the fourth number in column V, which likewise emerges from the addition of 21 to 27, the one immediately above it in column V.

The remaining numbers following in order, aggregated together, give the number of feet that the weight covers in the time corresponding to the half-diameters [*semidiametri*] placed in column I.

Example

If you wish to know how much space some weight covers when thrown from a certain height in the time of 10 half-seconds—or, what is the same, 5 seconds—see what number in the second column corresponds to 10 half-seconds, and you will find it covers 19 feet (granting, however, that in one half-second the weight falls through a space of one foot). But if, following Mersenne's observation, it covered three feet in one half-second, and you wish to know how much space it covers in the time of 10 half-seconds—that is, 5 seconds—then look in the first column for the number 10, and you will find in column IV the corresponding 57, which indicates the space the weight traverses in the given time. But if you wish to have the aggregate of all the feet that the weight covered over 10 half-seconds, add all the numbers in order up to 5 [recte: up to the 10th row] to the first number in column V, and 300 will result, which you will find again in table V opposite the 10 half-diameters as the corresponding entry..")

Further, if by experiment you should find that some weight covers 6 feet in the space of one second, you will obtain a table of observation by this method: Let the seconds be placed in the first row, then the odd numbers from unity; third, multiply the number placed in the first position in the third table by 3—that is, into the second odd number in column II—and you will have 18; then multiply 3,

namely the odd number 5, into 6, and you will have 30, which you place under 18; again multiply 6 into 7, namely into the fourth odd number, and you will have 42; and so always multiply 6 into all the odd numbers in order, and the sum will give what is sought, as the table shows, presented in only ten half-seconds. In this way, given the time and the space through which any heavy body falls, you will be able to construct tables with no trouble. But anyone who has understood the structure of the preceding table will find no difficulty in constructing the remaining ones, infinite in number.

Practical Problem II

Continuation of the preceding table to infinity.

If you wish to continue any table to infinity, proceed thus: Multiply the squares of the cases [*Casus*] into the last number contained in the column, and you will have what is sought.

Example

If you wish to know how far a stone falls in the time of 60 seconds, or 120 half-seconds—that is...

[continuation, left column:] ...in twice as long a time as it falls in 60 half-seconds or 30 seconds, proceed thus: since the last number of the fifth column is 10810, you will multiply this by 4—that is, by the square of the number two, which square is contained in the third column opposite the 2—and you will have 43240, the number of feet through which the said stone falls in the time of 60 seconds or 120 half-seconds, that is, in one first minute. Again, if you wish to know how far it falls in three times as long a time as it fell in 60 half-seconds, then you will again multiply the last number in the fifth column, 10810, by the square of the number three contained in the third column—that is, by 9—and 97290 feet will result, the space sought. Further, if you wish to know how far it falls in four times as long a time as it fell in 60 half-seconds, let the square of the number four contained in the third column—namely 16—be multiplied into the last number of the fifth table—namely 10810, as before—and you will have 172960, the space of feet sought. And so, proceeding to infinity, if you always multiply the squares contained in the third table in natural order into the last number of the fifth table, the product will always give a number of feet, the greater in proportion as the square—by the number constituting it—is greater.

For example, if you wish to know in how long a time it covers a space sixty times greater than the one it covers in 60 half-seconds, then you will multiply the

square of the root 60—that is, 3600—into the last number of the fifth table, 10810, and you will have 17316000 [recte: 38916000], the space of feet that the stone covers in the time of 3600 half-seconds. Divided by 15000 feet—for so many make one league—these constitute 1154 $\frac{2}{3}$ leagues, which some stone would cover, of which leagues 1145 [recte: 1154] equal the half-diameter of the Earth. Accordingly, the half-seconds, 3600 divided by 60, will yield us a time of 25 hours [recte: of 30 minutes — 3600 half-seconds = 1800 seconds = 30 minutes], in which the stone would cover a space of 1154 $\frac{2}{3}$ leagues.

Corollary

From these things it is clear how you may calculate the time in which some stone would fall from the heaven of the Moon, of the Sun, of Jupiter, of Saturn, [or] from the Firmament. Since these matters are abundantly established from the examples here explained, and can be calculated with no trouble, I leave them to be computed by those who have more leisure.

§ II

How to find the space that some stone covers in the last [half-]minute.

If you wish to know how much space some stone covers in the last half-second of its motion: supposing the stone covers the whole height of 43200 feet in 60 seconds or 120 half-seconds, which are equivalent to one first minute, proceed thus. Look in the column of half-seconds for the number 120, and see...

[continuation, right column:] ...what odd number corresponds to it, and you will find 239, which if you multiply by 3, you will have 717 feet, the space sought, which it covers in the last [half-]second [of fall]. But since it is tedious to continue the half-seconds in a table, you will find at once, with almost no trouble, any odd number whatever by this device: double the proposed number of half-seconds, and unity taken from the doubled number will give what is sought. For example: let the odd number corresponding to the thirtieth half-second be assigned; double 30 and you will have 60, from which, 1 being subtracted, 59 remains, which is the odd number sought, corresponding to the 30th half-second. If again you wish to know what odd number answers to the 120th half-second, from this number doubled, 240, unity being subtracted, leaves 239, the odd number sought.

Likewise, if you wish the odd number corresponding to 3600 half-seconds—which are equivalent to 30 first minutes—double 3600, and you will have 7200, the odd number sought, with unity subtracted, that is 7199; in just the same way you will find any other number for given half-seconds. These odd numbers, if you

multiply them by the odd number of one half-second, the sum will give you the feet that the stone covers in the last half-second.

I will give another example. If you wish to know the fall over one hour: 3600, the square of 60, multiply into the case of one second [1"]—namely 7200—and 25920000 perches will result, that is, 155460000 feet, the sought fall over one hour. If you should wish to know the fall of this in the last second, multiply the odd number 14399—the one corresponding to this, smaller by unity—into the case of the half-second of one hour, which you will also multiply by 5, as has been said, and you will have 43197 feet, the sought fall of the last half-second.

[continuation of the left column, lower:] ...and you will have 43197 feet, the sought fall of the last half-second.

From these things it is clear how you may calculate the time in which some stone might fall from the heaven of the Moon, of the Sun, of Jupiter, of Saturn, [or] from the Firmament. [Note: this Corollary text mirrors the §-corollary above; the left column carries the numerical example continuing the half-second fall, the right column the Consectaria.]

the last half-second of one hour, which you will also multiply by 5, as has been said, and the following result. And so the half-seconds, 3600 divided by 60, will yield us a time of 25 [recte: 30 min] hours, in which the stone would cover a space of 1154 ⁴/₇ leagues.

Corollary I

Since violent motion has the same ratio—albeit inverted—as the motion of heavy bodies downward from on high, as we showed above, you will gather from this that the lengths of the spaces in the air which the motions of guns [*sclopi*], arrows, and any other missiles whatever cover can easily be obtained. For to know this, nothing else is required but an equal time, in which the said [bodies] take up their motion. For example, if in the time of 10 seconds some stone falling from on high covers a length-space of 300 feet, while some missile likewise takes up a time of 10 seconds, you will infer that the space traversed is in the same way 300 feet in length.

Corollary II

From this it is also clear how the exact spaces of individual missiles can be determined by reckoning, by comparing the motions of these with the motions

according to nature—or, what is the same, how the motion of projectiles by violent...

at moment B at times 5", 6"; and if it has moved from S into T, the weight likewise falls from B into D in the same time — 5", 6" — of minutes. And if the Earth has moved from T into V — that is, has traced out three of the portions of the arc A O — the stone in the meantime traverses the space from D into E.

so that you may reduce these matters that have been discussed to the measure of natural motions and to the laws of geometry. So that we should not seem to the curious reader to have fallen short in any of these operations, I have thought it worth setting down a few of them here.

PRAGMATIA III.

To discover what sort of line a leaden globe would trace as it falls from the surface of the Moon to the Earth, supposing a daily motion of the Earth about its own axis.

If the Earth, according to the mistakenly conceived opinion of Copernicus [Nicolaus Copernicus], moved about its axis and completed its course in the space of 24 hours, the Lynceans [Lyncei — the Lincean Academy / its followers] suppose that a stone would fall not along a straight line to the Earth's center, but along a semicircle, and that the whole body of air is carried uniformly around the Earth. Since this opinion involves many absurdities, I have decided to refute it here.

First: this motion would occur either from a surface corresponding to the terrestrial equator, or from the surface of a parallel (that is, from suitable smaller circles), or finally near the terrestrial poles along the axis. In the first case it would in fact describe a helix in the plane of the equinoctial; in the second, the same helix but wound about a cone, as we shall show later; in the third, a straight line. Therefore it cannot possibly describe a semicircle.

Second: since we have shown above that the motion of acceleration occurs according to the proportion of the odd numbers, it is impossible for a motion of this kind to be exhibited if it described a semicircle — indeed the motion would turn out to be utterly contrary to the motion of acceleration.

Third: it would follow that a motion of this kind exhibits the same motion as that of the Moon in its own circle, and so that the stone, falling downward, would cover in six hours the same space — 60 degrees — that the Moon traverses in its own circle. This is contrary to our supposition, since a stone falling from the

surface of the Moon covers the intervening space in only two hours and 29', as we demonstrated above.

So first we shall show what sort of line a stone describes as it falls from the surface of the Earth to the center, on the assumption — though not the concession — that the Earth moves about its axis.

Diagram. A narrow circular sector (fan shape) with apex at C (the Earth's center) at the bottom and the arc A...O at the top. Two radii A C and C O bound the sector; they enclose an angle of $6^{\circ} 22'$ at C. The arc A O at the top is divided into 5 equal parts by the points A, T, V, X, O (the small intermediate tick-marks read, from left to right, A — T — V — X — O along the top edge). The radius A C is divided into 25 parts; the marked division points down the left radius are labelled (top to bottom) 1, 3 [recte: $\frac{1}{2}$?], A, 5, 9, 16, 25 — successive cumulative divisions. A dotted curve runs from A near the top, through B, D, E, F, to C at the apex, representing the curved path A B D E F C that the falling stone would trace. The value "25" appears at the apex beside C.

- A (top left of arc): start point of the arc and of the left radius
- T, V, X (along top arc): successive division points of the arc into 5 equal parts
- O (top right of arc): end point of the arc; right radius runs O–C
- B, D, E, F (along the dotted interior curve): successive positions of the falling stone
- C (apex, bottom): center of the Earth
- 25 (beside apex): number of divisions of the radius

Let two lines A C and C O be drawn, each representing a semidiameter of the Earth; let these two lines enclose an angle of $6^{\circ} 22'$. If, then, the line A O is set at a radius of 100,000 parts, the subtended chord A O will necessarily be 11,178 by the tables of sines. For divide the arc A O into 5 equal parts, each comprising one degree with 16 [minutes]; and divide the line A C into 25 parts, in such a way that the first, A B, is $\frac{1}{25}$, that is, makes up one part out of the 25 parts; the second, B D, 5; the third, 7; the fourth [recte: third in printed text reads "Tertia 5. Quarta 7. Quinta 9."], and so on. Then draw from the center C through each of the parts the arcs.

This being set, it comes about that when the Earth has moved from A into S, the weight in the same time falls from A into [the point reached in] 5", 6", of minutes; and if the Earth has moved from T into V — that is, has traced out three of the portions of the arc A O — the stone meanwhile covers the space from D into E.

And when the Earth reaches from V into X, the stone covers the space from E into F; and as the Earth comes from X into O, the stone covers the space from F into C, in an equal interval of time, namely 5'', 6''.

The stone, therefore, falling from point A toward the center of the Earth (which moves about its own axis), will not make a straight line — except by falling at the poles — but at any other point of the Earth would describe the curved line A B D E F C. Thus the proportion of acceleration would be preserved according to the ratio of the odd numbers, together with the doubled proportion of the times, which the motion of the Moon in the arc A O measures.

But if a weight were let fall from a place removed 526 terrestrial semidiameters from the Earth's center, it would then reach the center in the space of six hours, and the line of its fall would form a line not far from a semicircle, supposing nonetheless the proportion of the doubled ratio. But if the proportion were as the versed sine to the arc, then under the given altitude it would describe a semicircle. Beyond this distance, however, it would describe a helix, if the altitude were greater than 526 terrestrial semidiameters. All of which can easily be concluded from what has been said before.

CONSECTARIUM.

It is therefore clear from what has been said that Galileo's demonstration concerning the stone tracing a semicircle — on the assumption of the Earth's daily motion about its axis — does not stand at all, and that no argument for the Earth's motion can be drawn from it, as those suppose who, willing or unwilling, drive the Earth too boldly into its circles. Nor does the motion of a stone falling from the crow's-nest of a moving ship into the same spot where it would have fallen with the ship at rest do anything to establish the Earth's motion. For the stone produces this effect in every progressive motion: whether one throws a stone aloft while carried in a carriage or while running, whether the Earth is at rest or in motion. But since we have demonstrated the reasons and causes of this experiment elsewhere at length, I have judged it superfluous to repeat the same things here.

CAPUT IV.

On the use of pendulums in matters pertaining to geometry.

PRAGMATIA I.

To measure the heights of things by means of pendulums.

For example, let a cord with a lamp attached to it be hung from a dome down into the lower part of a church, and suppose someone wishes to know the height of the dome above the ground. You must first have, as an instrument, a thread one foot long with a lead bob. Once this is obtained, proceed thus. Note how many vibrations the one-foot cord makes while the [large] hanging cord, set swinging, makes a single vibration. I find, for example, that the shorter, one-foot cord makes eight vibrations — that is, runs out and back eight times — while the longer cord runs out and back once. Therefore multiply the eight vibrations into themselves (that is, square them) and you will have 64, the height of the dome sought, up to the lamp's lower end. If to this you add the height from the lower end of the larger cord to the surface of the pavement, you will have the total height. For since we showed above that the motion of pendulums is in the doubled ratio of the times, it necessarily follows that the eight time-units which the shorter thread measures by its eightfold running out and back, multiplied into themselves, give the height.

CONSECTARIUM I.

Vibr.	Altit.	Vibr.	Altit.
1	1	22	484
2	4	23	529
3	9	24	576
4	16	25	625
5	25	26	676
6	36	27	729
7	49	28	784
8	64	29	841
9	81	30	900
10	100	31	961
11	121	32	1024
12	144	33	1089
13	169	34	1156
14	196	35	1225
15	225	36	1296
16	256	37	1369
17	289	38	1444

Vibr.	Altit.	Vibr.	Altit.
18	324	39	1521
19	361	40	1600
20	400	50	2500
21	441	60	3600

From this it follows, from the table set out here, that the height of anything whatsoever can be measured with no trouble, by the aid of the one-foot thread alone. For if you find that your thread runs out and back six times during one vibration of the longer cord, the second column will give you, in the row opposite 6 in the first column, the height sought — namely 36 feet. If it runs back ten times, you will have a height of 100 feet. If twenty times, 400; if thirty times, 900; and if finally it runs out and back forty times, you will have a height of 1,600 feet — even though you can scarcely find a cord of such length.

CONSECTARIUM II.

But if you wish to know how many vibrations the one-foot thread makes for any given height, take any square number whatever, and its root will give what is sought. For example, suppose someone wishes to know how many vibrations the shorter cord makes while a longer cord, 3,600 long, makes one vibration: extract the root of 3,600, and you will have the 60 vibrations sought in the shorter cord. Let there be a cord of as great a length as the distance of the center from the surface of the Earth — namely 16,975,000 feet, which represents the semidiameter of the Earth — and suppose you wish to know how many vibrations the 1-foot cord makes while the cord equal to the Earth's semidiameter completes one. Extract the square root of 16,975,000 and you will have what is sought, namely 4,120 + 600 vibrations.

PRAGMATIA II.

To construct another table, so that, the lengths of the cords being given, one may know how much time — that is, how many seconds — each vibration of the given cords lasts.

This table is constructed as follows. Place in the first column, in order, the seconds — as far as you wish, for example up to 60. When these are squared, the squares of the corresponding times are produced in the second column; and these are had with no trouble, since each second, taken in order and multiplied into itself, yields them. Thus the numbers of the first column show nothing other

than the roots of the squares set out in the second column. The third column contains the lengths of the cords in feet, whose vibrations are shown to last for as much time — that is, for as many seconds — as correspond to them in the first column.

This third column's table is constructed by the following device. We suppose first that a thread three and a half feet long completes one vibration in the time of one second; whence this number, as the foundation of the whole table, rightly takes the first place in the third column. For from this number, multiplied by the numbers in the second column, and by the numbers in the first column (in the manner we shall teach), once aggregated, the sums in the third column are produced, as you will see in the example. First, $3\frac{1}{2}$ in the third column — the first number — multiplied into the second number of the second column, that is, into 4, gives 12; to which if you add 2, the second number in the first column, the result is $14\frac{1}{2}$, the second number in the third column — that is, the length of the cord whose single vibrations (or *diadromi*, "swings") last two seconds.

These things being set down, these propositions are formed, each of which has two operations: the first operation is done by multiplying $3\frac{1}{2}$ into the squares of the second column simply, without fractional numbers; the other is done by multiplying the fractions, as follows.

PROPOSITIO I.

To find the length of a cord whose single swings last three seconds.

So proceed: multiply $3\frac{1}{2}$ into 9 — that is, the first number in the third column, $3\frac{1}{2}$, into the third [number] of the second column, namely into 9 — and you will have $29\frac{1}{2}$. To this add the sum of 1 and 3, namely 4, which is the same as the product from multiplying the half of the number three, $1\frac{1}{2}$, into the whole of which it is the half; and you will have $31\frac{1}{2}$, the length of cord sought, as the table shows.

PROPOSITIO II.

To find the length of a cord whose single swings last four seconds.

Multiply the number $3\frac{1}{2}$ into 16, the fourth square in column II, and you will have 48. Again multiply the half of the number four, that is, 2, into the whole of which it is the half — namely into 4 — and add the product, 8, to 48, the number found just before, and you will have 56, the length of cord sought.

PROPOSITIO III.

To find the length of a cord whose single swing lasts five seconds.

Again multiply $3\frac{1}{2}$ into the square of 5 seconds, that is, into 25, and you will have $87\frac{1}{2}$. Then take the half of the number five, $2\frac{1}{2}$, into the whole of which it is the half — that is, into 5 — and add the product to $87\frac{1}{2}$, the number found just before, and you will have $87\frac{1}{2}$ for the length of cord sought, as the table shows.

PROPOSITIO IV.

To find the length of a cord whose single swing lasts six seconds.

Again multiply $3\frac{1}{2}$ into the square of six seconds, that is, into 36, and to the product, $108\frac{1}{2}$, add the product 18 from the half of the number six, namely 3, into the whole of which it is the half — namely into the resulting 6 — and you will have 126, the length of cord sought.

PROPOSITIO V.

To find the length of a cord whose single swing lasts seven seconds.

Multiply $3\frac{1}{2}$ into the square of 7 seconds, that is, into 49, and to this product add the product $24\frac{1}{2}$ from the half of the number seven, that is, $3\frac{1}{2}$, into the whole of it, that is, into 7; and you will have $171\frac{1}{2}$, the length of cord sought.

PROPOSITIO VI.

To find the length of a cord whose single swing lasts eight seconds.

Multiply $3\frac{1}{2}$ into the square of 8 seconds, namely into 64, and you will have 192; and then multiply the half of eight again into 8, its whole, and add the sum, 32, to 192 — the aggregate, 224, will give what is sought.

PROPOSITIO VII.

To find the length of a cord whose single swings last 9 seconds.

Multiply $3\frac{1}{2}$ into the square of 9 seconds, 81, and you will have 243; to which if you add 46, the product from multiplying the half of nine, $4\frac{1}{2}$, into its own whole — that is, into 9 — you will have for the sum 283 feet, the length of cord sought.

PROPOSITIO VIII.

To find the length of a cord whose single swings last ten seconds.

Multiply $3\frac{1}{2}$ into the square of 10 seconds, 100, and you will have 350; to which the product from the half of ten into 10, its whole — that is, 50 — when joined, gives 350 [recte: 400] for the length of cord sought. In the same way, the square of 11 seconds, 121, multiplied into $3\frac{1}{2}$, and joined to this the product from the half of eleven into 11, its whole — namely 60 — gives $423\frac{1}{2}$, the length of cord sought. And in just the same way, multiplying all the squares of the seconds in order by $3\frac{1}{2}$, and joining to each product the product from the half of the number into that number itself, the seconds [results] referring [to them], you will proceed, until you have completed the whole table — which by this method you may extend to infinity.

Note, reader, that the first operation is performed by multiplying $3\frac{1}{2}$ into the squares of the seconds contained in the second column, simply without fractional numbers, since the reckoning of fractions is carried out in the second operation. Of these things we thought you should first be warned, lest you might think we had proceeded less than honestly in the calculation.

THE TABLE FOLLOWS.

Radices (Roots)	Quadrata (Squares)	Longit. chord. in ped. (Cord length in feet)
1	1	$3\frac{1}{2}$
2	4	14
3	9	$31\frac{1}{2}$
4	16	56
5	25	$87\frac{1}{2}$
6	36	126
7	49	$171\frac{1}{2}$
8	64	224
9	81	$283\frac{1}{2}$
10	100	350
11	121	$483\frac{1}{2}$
12	144	504
13	169	$551\frac{1}{2}$
14	196	686
15	225	$787\frac{1}{2}$
16	256	896

Radices (Roots)	Quadrata (Squares)	Longit. chord. in ped. (Cord length in feet)
17	289	1011½
18	314	1099
19	361	1263½
20	400	1400
21	441	1543½
22	484	1694
23	529	1851½
24	576	2016
25	625	2187½
26	676	2366
27	729	2551½
28	784	2744
29	841	2943½
30	900	3150
40	1600	5600
50	2500	8750
60	3600	12600
70	4900	17150
80	6400	22400
90	8100	28350
100	10000	35000
500	250000	875000
1000	1000000	3500000
5000	25000000	87500000
10000	100000000	350000000
100000	10000000000	35000000000
1000000	1000000000000	1500000000000

That is: if a cord 18,299 long, in leagues or terrestrial semidiameters, were given, it would make one swing in 11 days, while a one-foot cord made 1,000,000.

USES OF THE TABLE.

This table cannot serve beyond 30" of seconds. For since the cord corresponding to this is 3,150 feet, it can scarcely happen that such a height could be assigned in the sublunary world, from which a cord might hang. Hence the number 20 — to which corresponds a height of 400 feet, such as the mountain Pico [Pico del Teide] in the Canary Islands [Insulae Canariae], if it could be bored through, might furnish — could be of use; but since even this is difficult, the use of this table can serve only up to 15 seconds.

For example, if you wish to know how great some cord ought to be that completes one swing while in the meantime a cord of $3\frac{1}{2}$ feet completes 15 swings: you will seek the number 15 in the first column, and the corresponding entry in the third column will give what is sought — namely a cord of $787\frac{1}{2}$ feet in height. In the same way, 10 will give a cord of 350 feet, and so on for the rest.

But the numbers contained in the table beyond 30 up to 1,000,000 show only how great some cord ought to be that makes one swing while in the meantime the three-foot cord makes 30, 40, 50, 60, 80, 90, 100, 1,000, 1,000,000. It is asked, then, how great a cord ought to be that completes one swing while meanwhile the three-foot cord makes 1,000,000. I say that this cord ought to be 1,500,000,000,000 feet long, which, resolved into leagues, give 1,600,000 leagues; these, into terrestrial semidiameters — of which one contains 1,145 leagues — resolved, give 18,299 terrestrial semidiameters; and so it would complete one swing in the space of 11 days.

And just as the cord exceeds the height of the firmament by many parasangs [parasangae], so too its vibration — that is, the cord's motion — completed in the space of 11 days, would be no more perceptible than the growth of plants. Add to this that the weight which would have to keep the cord taut would have to exceed the whole mass of the terrestrial body many times over in order to stretch it; and the 12-foot cord would have to have a diameter such that it could bear the weight, since otherwise it would be torn apart by its own weight — all of which can be deduced by mathematical reasoning.

Add too that a cord weighted with any weight whatever describes, in its swings, not a semicircle but a semi-ellipse — the weight attached to the cord, namely, by its gravity stretching the cord beyond a semicircle; whence the weight, gravitating more and more according to the cord's inclination, would necessarily describe some spheroid, or elliptical [figure]. This, however, would not happen if the weight were attached to an iron chain.

PRAGMATIA III. Astronomical.

To construct a chronometer that marks off the smallest parts of the hours.

No astronomer is unaware of how great a matter, in astronomical practice, is the exact division of the hours and of their smallest parts; so that the measurers of celestial things have labored at nothing more than at how a clock [horologium]...

a clock [horologium] capable of displaying the smallest parts of the hours, persuading themselves it could be done — which in fact they never managed to achieve. Here we shall demonstrate that this can be accomplished abundantly by the help of a single three-foot cord.

Take a cord of three and a half feet, properly fitted with its own weight. By the observation of Mersenne, in its forward and return swing this cord will precisely complete the time of one second — that is, $1/60$ of a first minute, or $1/3600$ of an hour. The most excellent physician and mathematician Joannes Marcus Marci [Jan Marek Marci], for use in astronomical work, takes a pendulum of five fingers and a little more. He found that a single vibration of this corresponds exactly to the beat of the artery [pulse], so that in the space of one hour, since the artery produces 4850 pulse-beats, the pendulum must be reckoned to make the same number of vibrations. But since this motion, being very swift on account of the smallness of the circle, lasts a shorter time, it suffices to extend the pendulum until its motion becomes equal to one second. Such a pendulum, thus extended, will be equal to the pendulum of three and a half feet established by Mersenne and fitted to measure one second.

You may also construct a pendulum of this kind by your own observation and experiment, using this procedure. Take any pendulum somewhat lengthened, set it swinging, and observe how many forward-and-return swings it makes in the space of one quarter-hour. You will find that it goes forward and back 300 times. From this you will gather that in the space of one hour it goes forward and back 1200 times — which is what you wished to know. As for how the motions of the stars are to be measured by a cord of this kind, see the matter treated at length in the *Almagestum Novum* of the most learned Father Giovanni Battista Riccioli, where you will find whatever can be desired concerning this business.

But of all the horometric devices invented hitherto by ingenious craftsmen, the palm is carried off by a new kind of clock invented not so long ago [1657], which by the vibration of a single simple pendulum alone displays exactly not only the hours but also the quarters, the first minutes, and beyond that the seconds. And just as this is indeed a beautiful and most rare invention, so it can scarcely be told

into how great an admiration it carries all who behold it, when they see the pendulum agitated as though by some perpetual motion. Moreover, for the exact measurement of time and for the exact observation of the motions of the heavenly bodies, nothing more convenient, more reliable, or more excellent could be desired by astronomers. But since we have described its construction and uses at length in our *Itinerarium Hetruscum* [Etruscan Journey], we refer the reader there.

PRAGMATIA IV. Geographical.

Whether the longitudes of places can be found by means of the chronometer cord.

[Margin: Whether the longitudes of places can be found by means of the chronometer cord.]

There have been some among the moderns who think that this business — the investigation of the longitudes of places — can be undertaken by means of this cord. At the very moment of departure from harbor, let the hour of the day be precisely observed by an astrolabe; then, at the same moment when the ship sets out due East or West, the vibrations of the instrument must be counted, granted that it makes 1200 forward-and-return swings in the time of one hour. So if, the ship having advanced along a straight course and with an equal force of wind, you find that 2400 forward-and-return swings have been made on the instrument, you will gather that the ship is two hours' distance from port; if 3600, three hours; if 4800, four hours' distance from port; and so on in succession.

But anyone who examines this practice more deeply will easily see that it cannot stand, since it rests on so slippery and inconstant a foundation. For here it is presupposed that the motion of the ship is always uniform and its course steady — which the sailors solemnly assure me can scarcely be maintained for even a single hour, on account of the inconstancy and variety of the winds. A second point is that an artifice of this kind appears to have no success except when the ship holds the South-West rhumb [Rhombum Notozephyrium], that is, when it heads straight East or West. Added to this is the difficulty of counting the vibrations, since it can scarcely be done that so many and such great vibrations be carried through for two or three hours without error or disturbance — unless the operators relieve one another in turns — while the eyes are gradually dimmed with the utmost weariness at such minute things. Therefore, since this business is in practice exceedingly tedious, and liable to countless errors on account of the shouts and tumult of the sailors, besides the difficulties suggested above, I judge that it should by no means be employed in geographical work. But

about these matters I had discoursed more exactly in our *Concilium Geographicum* [Geographical Council], which, if it had not been stolen from me by theft, the reader might perhaps find in it things not unworthy for the proper performance of this task.

PRAGMATIA V. Medical.

To find the differences of the pulses of the artery by means of the chronometer cord.

[Margin: To find the differences of the pulses of the artery by means of the chronometer cord.]

First let an instrument be made, in the manner and by the procedure that follows. Let a little beam A B be made, the upper surface of which you will divide into any number of equal parts — for example, into a hundred or fifty. Fasten this divided beam upon a support C D in such a way that it cannot be moved from its place; and let the foot of the support, joined with lead, give stability to the instrument, so that it cannot waver in the slightest. This done, take a string of such fineness as the smallest in a small lute [chelys minor] usually is, and pass it through the holes made at A and B at the ends of the beam, in such a way that, with weights E and F fastened at each end of the string, the string can be lengthened or shortened at will, and

Diagram. A woodcut of the pulse-measuring instrument. A horizontal graduated beam runs across the top, marked off in numbered divisions; from its two ends hang weighted strings, and the whole rests on an ornate central pedestal-support standing on the ground.

- A (left end of beam): start of the graduated scale
- 10, 20, 30, 40, 50 (along the beam, left to right): scale graduations
- C (center of beam, between 20 and 30): midpoint of the scale
- B (right end of beam): end of the graduated scale
- G (just below center of beam): a marked point (the movable "gemma"/node on the string)
- R (below beam, right of center): the fortieth-division reference point
- F (bottom of left hanging weight): left pendulum-weight
- E (bottom of right hanging weight): right pendulum-weight
- D (base of central pedestal): foot of the support, weighted with lead

[End of Pragmatia V instrument setup; the text continues with the instrument's use.]

The continuation of Pragmatia V (its use):

So you will have the instrument ready, whose use is as follows. Intending therefore to explore the differences of the pulses of the artery, look for the first vibration that corresponds to a single beat of the artery for that time which you are measuring, by lengthening or shortening either end of the string. For if the pulse is faster, the string must be shortened; if slower, lengthened. You will proceed in this way until you find the vibration of the string exactly equal to the beat of the artery — say A F or B E; for this will be the length of the pendulum whose single vibration is equal to a single pulse-beat, which you will carefully mark by this device. In the upper part of the string contained between A and B, insert a gem or knot so tightly that it can be moved only with difficulty, and move this gem above the first division of the divided beam A B — the fortieth, at R — with this precaution: that the string A B not be displaced from its original length.

If then on another day you should wish to discern the difference of the pulse, you will then, by lengthening or shortening, move either end of the string so far until you obtain that length of pendulum at which a single vibration corresponds to a single beat of the artery. This done, observe which division the gem cuts off on the beam; for this will be the difference of the pulses between today and yesterday.

For example: let the length of the string B E be such that by its vibration it equals a single beat of the artery of a person established in the best health, and let the gem mark the fortieth division at R. But on the following day you again test the pulse and find it faster; therefore the string B E must be shortened so far until you find that a single vibration of the shortened string corresponds to exactly one pulse-beat. This done, observe which division the gem cuts on the line of the beam A B. Let us suppose that, from the shortened string, the gem has been moved forward — or rather drawn back — from R to G, where it now cuts off at the 30th division. You will conclude that the difference between the pulse of the earlier and the later day is 10 — that is, faster by 10 divisions. But if the pulse of the later day should be slower, then the string A E must be lengthened until you find the equality of the vibration of the string with the pulse; and note in addition which division on the line of the beam the gem cuts off, and you will find it, say, resting at the 50th division. You will then infer that the difference of the pulse is again 10 — that is, the pulse of the earlier day is slower than the pulse of the later day by 10 divisions. You will proceed no differently in other cases.

APPENDIX

On the harmonic motion of strings.

Since the motion of strings in musical instruments behaves exactly by that same principle as the motion of pendulums, we shall here repeat some things treated at length in our *Musurgia*, so that we may not seem to have omitted anything necessary to Centrosophy [Centrosophiam]. It is known by daily experience that the strings with which musical instruments are usually strung, when struck, run forward and back no differently than pendulums, until they come to rest in the middle line of their direction — as if in their own center, which they seek — by exactly the same principle as a stone cast toward the center of the Earth would not rest as soon as it reached the center, but, swinging beyond and back, would continue the reciprocations of its violent motion with a proportional diminution and decrement, until at last it came to rest at the center. In the same way the string A B, stretched and drawn violently to E, will run back to F, and from there to G, and from there run back to H, and from H to I, and from there finally come to rest at K as at its center. The same thing therefore a pendulum will do: lifted to E, it would run back to F, and from there to G, and from there to H, and from there to I, and at last to K, the center of rest.

From these things it follows: that the greatest [first] diadrome [diadromus] of a struck string completes its whole space in the same time as the smallest, or the intermediate ones; and that both the arc E F (the greatest) and I K (the smallest), and all the intermediate ones, are of equal duration. For since the violence and impetus by which the string A B is drawn out of the line of rest A B into

Diagram. A semicircular fan-figure illustrating the decreasing swings of a string or pendulum. From a central apex at the top (E), radial lines descend to a series of points along a semicircular arc, with a baseline running through the lowest points.

- E (top center, apex): the point of maximum displacement / suspension point
- F (upper left on the arc): an outer swing-point
- G (upper right on the arc): an outer swing-point
- H (lower left on the arc): an inner swing-point
- I (lower right on the arc): an inner swing-point
- K (bottom center, on the baseline): the center of rest

Diagram. A rhombus/lens-shaped figure illustrating the diminishing reciprocal swings of the string between its two fixed endpoints A and B. Two outer

endpoints A (left) and B (right) are joined by a horizontal central line, and a vertical sequence of points marks the successively smaller swing-amplitudes above and below that line.

- A (left vertex): fixed endpoint of the string
- B (right vertex): fixed endpoint of the string
- E (top vertex): point of maximum upward displacement
- G (below E, on the vertical): an intermediate swing-point
- H (below G): an intermediate swing-point
- K (center, on the horizontal axis): the center of rest
- I (below K): an intermediate swing-point on the lower side
- F (bottom vertex): point of maximum downward displacement

E F is greater, the further [it goes], hence that swing will also traverse the space F G the more swiftly, the greater the interval of the first diadrome is. From this it necessarily appears that the remaining diadromes in order are of equal duration; since, by however much there is taken away from them in that length, magnitude, and impetus of the diadromes, by just so much is added to the brevity of the space that they have to complete — and thus the length of the diadromes is in inverse proportion to the time.

For example: let the string A B complete 100 diadromes, and let it make one foot in the first diadrome E F, and the hundredth part of a foot in the last, that is, in the hundredth diadrome I K. I say that the first diadrome E F is a hundred times faster than the hundredth, since this latter is a hundred times slower and less violent than the first, being nearest to rest. It is therefore evident that the ratio of the number of the vibrations of strings is the inverse of their length. But whether the string can be said to rest at the points terminating the diadromes, we have discussed at length in our *Musurgia*, fol. 428. And whether by any device at all we can come to a knowledge of the number of the diadromes has likewise been treated at length in the same place.

HARMONIC COROLLARY

From what has been said it is evident that the whole principle of music rests on these our principles. For since any sound is composed of as many degrees of sharpness and depth as there are points of the reflected diadromes, by which the eardrum is struck so many times in a given time by the agitated air, it is luculently clear that all sounds, as well as all consonances and dissonances, are nothing other than the various numbers of the motions of the air striking against

the ears, carried all the way to the mind by the action of the acoustic nerves [nervorum acusticorum]. For example: if the eardrum is struck twelve times in a given time, the sound then heard will be composed of 12 degrees of sharpness; and the soul, through its auditory faculty, will perceive itself affected far otherwise by these 12 degrees than by any other number of percussions.

Let us make it clear by an example. Let there be two strings A B and C D, of which A B has struck the air twelve times by its vibration, and C D six times, and let them have struck the ear in the same time and with the same duration. The soul will necessarily [perceive a consonance, which they call the Octave [Octavam]], considered under the double proportion of the vibrations. For since the string A B is to the string C D, and 6 vibrations of the air to 12, so the motions of the air, born in the eardrum, are related to one another. And if these two motions are in double proportion, then the motion of the air in the eardrum will also be in double proportion; that is, while the string C D runs forward and back six times, the string A B runs forward and back twelve times. The Diapason, then, or Octave, must necessarily be perceived, since the string A B moves twice as fast as the string C D, from the principles laid down above.

COROLLARY II

Hence is evident the generation of all consonances and dissonances. For just as all numbers emanate from unity, so from the unison all harmonic numbers, that is, the consonances and dissonances. Let us give an example. Let two strings of equal thickness and length be stretched and tuned with the same weight, or by a peg [verticillo], in such a way that both sound a unison with one another. It is certain from the foregoing that, just as string is related to string, and weight to the tensioning weight of the string, so are the vibrations related to one another. And since therefore the strings are equal, they will perform equal vibrations in equal time. A B will therefore run forward and back as many times as C D.

Diagram. Two horizontal line-segments illustrating the unison and its divisions. The upper segment is the full string A—B; the lower is the string C—D, marked with intermediate division points.

- A (left end of upper line): endpoint of the first string
- B (right end of upper line): endpoint of the first string
- C (left end of lower line): endpoint of the second string
- G (interior of lower line, toward the middle): the bisection point of C D
- I (interior of lower line, right of G): a quarter-division point of C D
- D (right end of lower line): endpoint of the second string

A unison, then, must necessarily be perceived, since neither surpasses the other in speed. But if you cut either string, C D, in two — for example, C D at G — and set G D vibrating against A B, then, since A B is double to G D or C G, a Diapason or Octave must necessarily arise, since G D or C G moves twice as fast as A B. Again, if you divide the string C D into 4 equal parts and set one fourth part of C D vibrating together with A B, then the consonance Disdiapason will arise, which they call the Fifteenth [Decimamquintam]. For since this consists in the quadruple proportion, and the part I D is related to A B under the same proportion, as 1 to 4, it follows necessarily that the string I D moves four times as fast as A B — so that while A B completes one vibration, I D in the meantime is reckoned to have made 4 vibrations. And since the sharpness of one sound is related to another sound as a vibrating string is to a vibrating string, I D will consequently sound four times sharper than the string A B, inasmuch as it is four times more tense than the string A B. Hence a Diapason, or the Fifteenth consonance, must necessarily arise. You see, therefore, how from this single example the generations of all consonances can be drawn out. But whoever desires all this demonstrated more thoroughly, let him consult Book 6 of our *Musurgia*, part 1, which is called *Chordosophia*. There the curious reader will find that nothing has been omitted of those matters which savor of something secret and paradoxical.

COROLLARY III

From what has been said so far, it is evident that there is nothing in this universe so motionless that it does not produce some motion, even if imperceptible to us. So much so that, if God were to strengthen the auditory faculty of man, in proportion to the infinite variety, condition, and quality of the motion of bodies struck by the air, he would also perceive a perpetual harmony. But nature seems to have

begrudged this very thing to man; for by frequent experiment I have found that, as soon as the diadromes of any stretched string present themselves to the eyes by a perceptible manifestation — that is, fall under enumeration — at the same time all sound ceases, so that what the eye discerns the ear cannot judge. But if we stretch the string a little more strongly, some sound is indeed perceived, yet under vibrations of the trembling string so rapid and swift that what the ear judges, the eye can in no way discern. So stubbornly is nature tenacious of its own right that it seems to be unwilling on any account to permit sound and the vibrations of the string to exist at the same time. Hence those people seem laughable who wear themselves out with useless labor in trying to reduce the

`1/100000000000000000000000000000000000000000000000000000`

[The denominator is a 1 followed by 60 zeros — printed as a long row of zeros below the rule.]

And these are the things which, concerning the nature, property, and quality of the Center, we have thought fit to set down in this first book of the *Mundus Subterraneus*. Now let us apply our mind and pen to describing those bodies which surround the Center.

SIVE — De admirando Globi Terreni opificio.

CAPUT I.

(On the end and purpose of the Geocosm.)

The terrestrial globe, which we call the Geocosm or terrestrial world, is the end and center of the whole of creation. And so it too was arranged by the divine Wisdom, the maker of all things, with such art and care that whatever powers there are in the universe, whatever hidden properties lie concealed in the particular globes of the stars — all of it seems to have been gathered into this one body as into a kind of epitome. Nor should this seem astonishing to anyone. For

God placed man here as a lord of the world, so that from this vantage point, as from a watchtower, he might contemplate the greatness and beauty of the divine works, and that inexhaustible abundance joined to an infinite variety; that by contemplating he might wonder at them; that by wondering he might seek out, with anxious searching of mind, the Architect of so great a work; that by seeking he might find Him; and having found Him, possess Him forever.

[Margin: The terrestrial globe leads to heavenly things.]

And since man, through the cunning of the devil's craft, by the sin of our first parents [Protoplasts], had fallen away from God — by the unsearchable depth of the divine counsel, the only-begotten Son of God, the Word of the Father, in order to restore lost man to his former state of dignity, clothed in human flesh, having contracted (as it were) a marriage with human nature, deigned to appear in this earthly world, and here to work the salvation of mankind. *And the Word was made flesh, and dwelt among us* (John 1:14). Indeed, so great was the height and sublimity of this prerogative that it deservedly surpassed the excellence of all the divine works by infinite "parasangs," as the saying goes. And so, on this ground too, we may call this terrestrial world the end and Center of the whole Universe.

[Margin: Why the Geocosm was made for the sake of Christ.]

For it is certain that the whole machine of the world was created by God, the Best and Greatest, for some end. But what end is that? Surely it ought not to be regarded as created chiefly for its own sake alone, nor for the sake of the angels, nor on account of any need of God the Creator — since, having no need of a corporeal world, He could derive no help from such things. Therefore, it was made for the sake of something else; therefore for the sake of a creature — for man's sake, I say — who, standing on the borders of corporeal and intellectual nature, the very confines of being, was endowed with this single prerogative above all bodies: that whatever of powers and admirable properties lay hidden throughout the whole machine of the world should be poured out into the single Earth as into a kind of epitome, as we said above. Thus, just as man, the heir of the whole world, embraces all the gifts of the world in himself — a true Microcosm — so too the Earth, the kingdom of the human race, enriched with all the influences of the world, may truly be called a little world.

[Margin: How the Geocosm is enriched with all the influences of the world.]

That this is so, the innumerable variety and abundance of things necessary for man's good and blessed living, presenting themselves to the senses, more than sufficiently demonstrate. Since, then, the terrestrial globe is such and so great, it

is certainly an object most worthy of careful consideration. Both reason and the very dignity of the matter seem to demand, above all, that it be described with the greatest possible care and diligence. And this indeed we shall attempt in this work, according to our small measure, and so far as the weakness of our understanding permits. May God, the maker of the world and the giver of all light, be present to our endeavors.

CAPUT II.

Idea Globi Terreni in mente Divina existens.

(The Idea of the terrestrial globe as existing in the Divine mind.)

Just as an architect, about to build a royal palace, first turns over in his mind each and every detail, and with deep searching of heart examines and weighs the suitability of the site — so that at last, by a kind of careful design [Ichnography], he may lay out the structure of the whole future mass, both for the prince's delight and for the practical use of the necessary parts. Then, according to the ground-plan [Ichnography] as a kind of archetype, he lays foundations proportioned to sustain the building. He arranges the subterranean chambers into workshops for craftsmen, baths, and workrooms; he divides the floors into various ranks of rooms, galleries, and halls; he raises towers on high, adorned with various ornamental reliefs, for the pleasure of prospects and spectacles. He lays out garden plots flourishing with plants, flowers, and fruits; and finally he arranges hidden channels to supply the fountains. At last he adorns the completed palace with every kind of tapestry, statue, and the most precious furnishings.

In just the same way, the eternal Wisdom of God, about to build a palace for the human race — the terrestrial world, I mean — so that nothing which might serve either for delight or for the use of necessary things should be left unmade, first laid the foundations of the globe of the earth. And although this globe rests on no mass of supports, on no prop of substructures, yet, balanced by its own weights and appointed by Divine providence, it was furnished with all the things that can be desired for living well, comfortably, and blessedly,

and was established in the middle of the Universe, so that it might be illuminated on every side by all the bodies of the world and the globes of the stars, made fruitful by influences from above, and quickened into offspring of every kind of generation. With a spreading of waters He surrounded the whole mass, lest anywhere so necessary an element should be lacking. He set the mountains as a

kind of barrier against the spreading of the waters — both to beat back the unruliness of the waves, and to irrigate that same mass with a perpetual and never-failing supply of moisture. He pierced it with innumerable tunnels, and carved out caverns within it like certain workshops of nature, filled some with fires, some with waters, for the purpose of producing various effects of nature — so that whatever nourishment of nature Vulcan has cooked up by long labor in his vast kitchen, in the hidden receptacles of the caves, might be aptly distributed to each and every part through little channels, as through the veins of a great Body.

[Margin: The various subterranean workshops of the Earth.]

From this admirable distribution arises the variety of innumerable things, both within the inward parts of the earthly mass and on its outer surface. Thus the most beautiful broad domains of things have come forth, with the richest storehouses of metals and inexhaustible treasuries of precious stones, both for the delight of life and for the necessary use of the human race. And on the outermost surface, immense green expanses of forests have emerged — divided by mountain ridges as by certain towers — and wide-open paradises of fields, luxuriant with abundance of trees, plants, flowers, and fruits of every kind, watered by the innumerable winding courses of fountains and rivers.

[Margin: The outward adornment of the Earth.]

We have seen, then, a rough ground-plan [Ichnography] of the terrestrial globe. Nothing further remains except that we tackle the whole structure part by part. This will best be done if, with the diligence that is fitting and with exactness [Greek: ἀκρίβεια (akribēia, "precision, accuracy")], we carry out the office of a careful Anatomist in describing exactly each and every member of the great mass, both interior and exterior.

[Margin: The stability of the Earth.]

[Note: the marginal note "Quid Terra sive Geocosmus sit" (What the Earth, or Geocosm, is) and the passage it marks appear in the first column of this page, treating the Earth's immobility — see below.]

[A passage printed in the first column of p. 56 reads:] ...though it should remain immovable for all ages, yet it was so confirmed by the efficacy of the divine power that there is no strength of so great a force, no fury of raging winds, no impetus of the sea and its tumultuous waves so great, that it could move the Earth even a hair's breadth — I do not say from its seat, but not even to the smallest

part, could it shift it from its place. [Margin: What the Earth, or Geocosm, is.] The Earth, therefore, is nothing other than the watery-and-dry globe of the world, given by God to the human race to dwell in.

CAPUT III.

De Mundanorum globorum seu stellarum natura & compositione, & quomodo in Mundum inferiorem influant.

(On the nature and composition of the worldly globes, or stars, and how they exert their influence upon the lower world.)

That the world is filled with innumerable astral bodies, only that man can fail to know who has been imbued with no knowledge of the discipline of Astronomy. Of these, some have obtained the name of *planets* or wandering stars; others, that of [Greek: ἀπλανῶν (aplanōn, "of the fixed stars")] — that is, fixed stars. Yet to each and all bodies or globes of this kind, three things above all belong in common. First, that each is composed of a fluid and a solid. Second, that each is made stable by its own Center. Third, that, set in motion in a circular path, by exerting influence both upon the Earth and upon one another, they conspire toward the preservation of the Universe.

All these matters, since we have treated them very fully in our *Itinerarium Exstaticum*, I do not wish to repeat here. But in general only, I shall here discuss a few points that seem to bear most upon the purpose of our argument. And the question is this: whether all the stars differ in their properties and powers, and whether all of them exert their influence upon the terrestrial body.

As to the first point: it is certain that the Creator, the Best and Greatest, made the universe not only for the sake of ornament, but for innumerable ends known to the Maker-of-the-World [Cosmotechnites] alone — of which the weakness of human understanding grasps only three. Namely: first, the glory of the Creator, *for the Lord has made all things for Himself* (Proverbs 16:4); second, for the sake of man and for the use of the rational creature, and consequently for the sake of the terrestrial globe, which is the proper seat and dwelling-place of the human race; third, for the preservation of the Universe. So that, just as in the Microcosm of the human Body one member nourishes another, and by a kind of reciprocal warming all the members affect each single one, and each single one affects all — so the stars of the Megacosm, or great World, like certain members, affect one another by reciprocal influences and by powers proper to each. And whether by the immediate influence of neighboring stars, or by the mediating influence of

intermediate ones, they warm, nourish, and strengthen one another; and again, bound together by this mutual bond of union, they preserve one another perpetually.

But this preservation of the worldly bodies would have been idle, had it not looked toward a higher end — which was the ultimate preservation of the terrestrial globe, and thereby of man, the Microcosm. For whatever scattered powers there are throughout the whole machine of the world, whatever endowments there are in the globes of the stars, all of it has been gathered into the single globe of the Earth as into a kind of epitome — so that for man (who was to be all things in all things, the compendium of all the things shining forth in the world, and a little World) it might prepare a dwelling-place proportioned to him, with like furnishing, all the things of the world conspiring toward the attainment of this end. For all the globes of the stars, just as they are endowed with no offspring of a vegetative or sentient nature, so they have coalesced merely from a pure composition of the Elements. And both by the will of God and by reason of the position which each one has obtained in the immense expanse of the ethereal Ocean,

each of them, and also by the hidden powers of neighboring stars influencing them under one configuration and another, has acquired certain specific and peculiar and appropriated endowments — by which, through their perennial influence, they may bless the terrestrial body with so great a variety of things as we daily marvel at. The terrestrial globe alone, therefore, receives into itself, fosters, and turns to the use of mankind whatever powers lie hidden in the Universe, as the common subject of all. But how this comes about, it is now time to show, so that the secret mysteries of our Geocosm — that is, of the Subterranean World — may shine forth more and more. It must be shown, then, from where so great a variety of things shining forth in the body of the Earth proceeds, and how it is produced.

It is certain, by the reckoning of all philosophers, that lower things are subject to the motions of the higher, and that so great is the connection between these that it is impossible for the lower world to subsist without the perennial influence of the supernal bodies — just as it cannot happen that a passive principle should produce anything without an active one. For mixed bodies, whose innumerable variety is observed in this globe of the earth, since they perpetually need the offspring of the Elements from which they took their origin, while the earth itself remains immovable, fixed in its own seat — it necessarily follows that some mobile, sympathetic body must be given, which may stir the seminal reasons

[spermatikas rationes] implanted in each mixed body toward generation, so that by its perennial influence it may both foster what has been generated, and preserve what has been brought forth in the vigor of its propagation. And this the supernal bodies of the stars accomplish. Since their influences are perceptible, they must be necessary for some purpose — for nothing is in vain, neither in nature nor in what is made and produced by God. If, then, they are necessary, surely they must be necessary for the lower World, both to animate it and to preserve it. And since they are the finer — and therefore the more efficacious and more potent — portions of the Elements and the principles of nature, it is necessary that they concur in the composition of all mixed bodies. And the infinite multitude of mixed bodies argues an infinite multitude of supernal bodies, too, and an abundance of the powers implanted in them. But having set out these things in general only, let us now proceed to the particular powers of the stars.

CAPUT IV.

De Sole & admirando ejus opificio, viribus, proprietatibus, quibus in Mundum terrenum influit.

(On the Sun and its admirable construction, powers, and properties, by which it exerts its influence upon the terrestrial world.)

THE SUN, the chief star of the world, the source and origin of all the heat and light of the whole world, the spring of life and of the whole lower world. Indeed, the natural element of fire too, drawn forth by God the Best and Greatest from the primeval chaotic mass of the world, and congealed from a great part of the primeval light,

consists of a solid and a liquid — as in these modern times has been made abundantly clear by the aid of the optical tube [the telescope]. By its use, the Sun is seen, no otherwise than a kind of immense Ocean, to boil and seethe with perpetual ebullition, like vast waves; and to be agitated also about its own Center. The spots — which are nothing other than vast evaporations of this fiery Ocean — clearly indicate its inconstant nature and sudden alteration. Of all these phenomena of the Sun, since we have treated them very amply in our *Itinerarium Exstaticum*, I refer the reader there.

That most wise Architect of the world, GOD the Best and Greatest, when He determined to fabricate this worldly machine — seeing that without a primary instrument it could neither subsist nor be fit for the generations of things — set

before it this admirable thing, by which we all live, move, and have our being: namely, that admirable instrument, a kind of image, as it were, of His own Divinity, a work truly of the Most High. The Sun, I say, He established as a kind of heart and soul, or a certain mind, and the principal governance of nature (if it is permitted so to speak), and a Deity [Numen], the Vicar of the true Deity — so that by it the world might be governed, and the hidden Sacraments of the wisdom of God, drawn out from the chaos and abyss of darkness, might be made manifest; and that from this visible and material deity, the majesty of that invisible and supramundane Deity might become known to mortals.

To this Sun, moreover, imparting various motions —

Mind stirs the mass, and mingles with the great body (Virgil, *Aeneid* VI.727)

— He did not wish to bind it to circles, but to be moved by a perpetual heaping-up of spiral coils, from Tropic to Tropic, so that He might render the whole world, impregnated by its fruitful motion, a partaker of its power. And in this work nothing more clearly points to the Divine providence in the nature of things. Nor with respect to the terrestrial world alone, but also with respect to itself, has the Sun in these latest times been found to vary its motions and to change its courses — all of which has been most wisely ordained for the production of certain effects in the terrestrial world, as will later be seen. For if God and Nature do nothing in vain, even in these lowest and smallest things — which are otherwise the most worthless and are commonly reckoned among chance occurrences — such great powers sometimes shine forth that they savor of nothing but the heavenly. Surely to this visible image of God (to speak with Plato), so sublime, so constant, so regular, beyond all others, we must suppose that the highest and altogether heavenly causes underlie it. Of these I would not hesitate to call the most divine and the first its *intention and end*: the purpose for which God, the Creator of the Universe, from the time the world was founded so ordained it — namely, that the human mind, raised up to such admirable effects of Divine Wisdom, might know the Creator of things and the ultimate end of all things so notable and communicated with a certain incomprehensible goodness; might love Him; and in Him might at last rejoice eternally.

Concerning this fountain of light, then, and its marvelous constitution and faculties, we have determined to speak first, before we proceed to the miracles of light. The question is asked, therefore, first: what is that luminous substance which we daily behold and at whose incomprehensible beauty we stand

astonished — even though it has been granted to no one yet to reach the quiddity of its substance.

I say, then, that the Sun is a fiery Body, concreted from an ethereal flux, the material Sphere of the world's primeval light, filled with a certain seed-stuff [spermia]. From this, as from a kind of inexhaustible fountain of light and fire, the seedbeds of heat and light are derived into all things — that is, by the vehicle of light it pours qualities fit for the preservation of individual things into individual things; which then, mixed with their own seeds congenital to each thing, at last generate that admirable variety of things which we daily behold in this world.

The Sun, therefore, is a Spherical body — not mathematically, but physically — consisting of fluid and solid by reason of its roughness and unevenness. This might not without reason seem astonishing to someone, had not the most evident observation of it, made more than once through the most excellent telescopes, made us more certain. That it is a fiery, rough, and uneven Body has become known in these latest ages by the following experiment.

If you direct a telescope (of that kind which are fabricated of the greatest power, for the use of contemplating the stars), in the manner customary in Dioptrics, at the Sun at various times, and receive the image of it, transmitted into a closed and darkened chamber, upon a white plane, you will see — first, not without wonder — and then, the whole surface of the apparent solar hemisphere composed heterogeneously of shadows and bright points; and that same Sun, like a sea roughened with waves and rippled all around with fluctuating waters. Nor does it do this in the same way, but at different times it turns through different changes — today otherwise than yesterday, and tomorrow otherwise than today, and so never with the same pattern, the same aspect of countenance. Fixed in utmost amazement, you will behold this, as the Figure teaches.

[Note: the text refers to a Figure ("ut Figura docet") of the sunspots, but no figure is printed on this page; the plate appears later in the work.]

All these things not I alone, but our most distinguished Scheiner [Christoph Scheiner] — with truly Herculean labor of many years — has demonstrated by investigation, in his whole work the *Rosa Ursina* [The Orsine Rose], most subtle and full of the most recondite observations. In this same body, moreover, vast spots too are sometimes beheld with the utmost wonder, like shadows and opposed lights set against them. Some of these, decreasing in size, are attenuated at the same time into the subtlest shadow — so that at last you can scarcely

distinguish it from the rest of the Sun's surface, except by adjustment of the instrument. And such a shadowy trace sometimes lasts for one or several days; sometimes it vanishes utterly in haste; and sometimes all these things happen with an accompanying

(Continuing Caput IV, "On the Sun and its wondrous workmanship.")

There are also certain spots that, once attenuated into a thin and uniform shadow, then break up into minute, discontinuous spots like points, so that between them the remaining spaces of the solar surface shine through. And once this division into tiny spots has occurred, they nonetheless advance in their own order over one or several days, and they do so in various ways: some fade away into the common surface of the Sun, others retreat back into a single continuous shadow, while both kinds—as though led by a kind of regret—separate from one another so as then to vanish; and finally, out of these faded remnants, as though bubbling up from the substance of the Sun itself, they revive and grow into a new brood of bright facets and shadows. Indeed, the same spot sometimes reappears after a separation of one or another day.

But lest anyone suppose that a φαίνόμενον [Greek: phainomenon, "appearance"] of this kind has occurred through a flaw of the eye or of the glass, let him know that irrefutable experience has hitherto taught beyond doubt that this happens on the very surface of the solar disc itself—always, at every moment of the day, in any part of the Sun, yet indifferently under a fixed position of the stars. Anyone who has ever seen molten copper [aes] in smelting furnaces, in great cauldrons, will be able to grasp in some measure the true causes of the solar phenomenon. For just as in cauldrons of this kind the seething of the surging material rolls up such swells from time to time that it seems not unlike a sea agitated by fiery waves and curved into whirlpools of surf—where black soot, joined to the most brilliant flames, displays a marvelous whiteness of bright patches and shadows, and where others are continually substituted in place of those that fade—so too the molten copper, while it is actually being poured out, has a splendor so like the splendor of the Sun that no other thing in the nature of things displays the Sun's splendor better.

I recall having observed the Sun disfigured by this mantle, first in the year 1625 on the 4th of April at Mainz [Moguntia], and then at various other times here at Rome together with Scheiner, not without astonishment—whence I have judged that the figure of the phenomenon should be set down here. Now that these phenomena of shadows and bright spots in no way occur outside the solar disc,

but rather seem to bubble up from the very surface of its body, is confirmed by the following arguments.

First, because the Sun—whether variegated with shadows, or glittering with bright patches, or lacking both—just as it appears in one place, so it has been found to appear to the whole world. Likewise, when new spots arise, or when they occupy a certain place on the solar surface, this happens everywhere at the same time and place of the Sun—indeed, in different years too, provided they are observed at similar times and in the same parallels, as has become known to us by the constant and concordant testimony of Galileo [Galilei], Scheiner, [Charles] Malapert [Malapertius], [Pierre] Gassendi [Gassendus], [Johannes] Hevelius, and others observing in the Indies (whom you may see among the authors cited). Second, whether the intervals of the shadows and spots be taken lengthwise, or breadthwise, or in combination, they will always be found to inhere in the Sun's surface—which, as is clear from optics, would by no means happen if they adhered to some other sphere outside the Sun.

I said in the definition ("filled with a certain panspermia") because the Sun is endowed not only with the quality of simple light, but also has, mixed with its light, the powers of all seminal things. Thus, having been established by the Architect of the World [Opifex Mundanus] as a kind of soul of the world and father of all things, it contains within itself, in their power, the potencies of all the seminal principles [seminales rationes]; and these, joined with the seeds of each individual thing, bring about the generation of all things in the world. For (as Aristotle rightly says) the Sun and man generate man; but by light and motion alone it does not generate—therefore it does so by something else, namely by warmth, conveyed as if by a vehicle and mixed with each individual thing, and so it produces this effect. No one will easily deny that heat is the chief instrument of the Sun, except one who has been deprived of all sense.

In the definition of the Sun given above, I said that the body of the Sun is rough—rounded physically, not mathematically, as many would have it. For just as the Earth, constituted with its atmosphere, is girded with an uneven mantle of vapors and exhalations and has various dispositions of its parts—for in one place we find it dense, in another subtle and thin, everywhere imbued with a varied mixture of forces and qualities, and in some places and others producing this thing and that according to the nature and condition of the evaporating part—so exactly is it to be thought that the Sun consists of its uneven pyrosphere [pyrosphaera], as irrefutable experience has taught from the perpetual alternation of spots, smokes, mists, and bright patches on its surface, now bubbling up, now again

fading away. And thus no one who has more deeply contemplated the foregoing will doubt that the solar body is engaged, like a certain fiery ocean, in perpetual motion and agitation; and that, being thus agitated, it causes various effects in the nature of things according to the varied nature of the evaporating solar region. For there is the same account of all the bodies of the world, so that what we say of the Earth must be said of the Sun, the Moon, and the other planets; the diversity is found only in this, that each of these bodies, just as it has been allotted a different nature, so too pours forth a different sphere of its own exhaled power. I say no more: whoever has more profoundly searched out these miracles of the Sun will without doubt easily see the origin of comets arising in the upper region of the aether. Many philosophers too, while they rashly ascribe to the empyrean heaven, in many instances, the hidden causes of certain extraordinary effects, will satisfy themselves more fully if they consider this pyrosphere of the Sun and its various effects.

Furthermore, the powers of the Sun are light, heat, and—

[Margin: Wisd. 16, no. 27 (*Wisdom 16:27*)]

—and these seeds of things, conveyed by its light, carried down into these bodies, brought in by its heat and warmed, are the mingled cause of things and of the generation of all things. For its light, just as it is the bearer of the seeds of things, is likewise their measure, number, and kindling. For while it illuminates, entering the bodies of the whole universe and permeating them, with heat as its companion it now separates, now gathers together, purges and moves, penetrates, nourishes, augments, perfects, renews, and vivifies them—containing all things, yet contained by all—so that all bodies long for it as their generator, their mover, their warmer, their illuminator, and finally as the giver and preserver of life. For it instills and imparts all these into bodies, both by the manifest powers of its light and by hidden and incorporeal actions; so that the Wise Man seems to have had regard to these admirable qualities of the Sun when he says: τὸ γὰρ ὑπὸ πυρὸς μὴ φθειρόμενον ἀπλῶς ὑπὸ βραχείας ἀκτῖνος ἡλίου θερμαινόμενον ἐτήκετο [Greek: "For that which was not destroyed by fire was melted, being simply warmed by a brief ray of the Sun"]. *That which could not be exterminated by fire, melted away as soon as it was warmed by a small ray of the Sun.* The conjoined instruments of the Sun, therefore, are light, heat, and seeds, for the producing of all things that are in the world.

Now, in order that the Sun might more equitably and rightly communicate to the bodies of the world these truly admirable powers innate to its whole body, the most wise Architect of Nature willed that it should be moved about its own axis,

in a daily and yearly span ordained on the model of the daily and yearly motion (a portent, indeed, which has at last become known in these latest times to the lynx-eyed astronomers [Lyncei Astronomi]), so that there should be no part deprived of the fruitful administration of such necessary light. Since, moreover, the radiant aspect of the Sun is most effective, lest by the continued intensification of heat it should harm the Earth, He willed to establish the atmosphere, raised up from terrestrial exhalations and watery vapors by the action of the Sun, so that in it the excessive heat, as though blunted, might fill the whole world with a certain proportioned intensity of warmth.

Since it is established that from every point of the Sun turned toward the Earth there comes forth some single, individual, perpendicular ray, which is always carried in a straight course both through the atmosphere and through the air (as we teach in our *Ars Anaclastica* [Kircher, *Ars Magna Lucis et Umbrae*, the anaclastics]), we say that this is the cause of the diversity of heat in different climates. For if the ray falls straight upon the Earth's surface, it will undoubtedly exercise a most powerful action; if it inclines toward the vertical, it will produce a more effective heat the nearer the angle it makes with the surface is to a right angle. But since the ray of the rising or noonday Sun, falling upon objects standing perpendicularly erect on the terrestrial surface, falls in exactly the same way as one positioned at the vertex in the middle of the sky under the right sphere [sphaera recta], one might rightly wonder why the Sun's rays, cast perpendicularly upon the walls of mountains, towers, temples, and houses of this kind—and likewise upon the perpendicularly erect surfaces of pyramids and columns—do not produce the same effect that they produce under the right sphere.

But I reply that the cause of this effect is that the Sun's rays are refracted in the vaporous region, or atmosphere, which protects the Earth, clothed as though in a delicate garment, from the darts of Phoebus, so that it blunts their more vehement impact in various ways, according to the varied obliquity of the rays or to the rarity and density of the said atmosphere. And thus the rarity or density of the diaphanous medium causes the quantity of refraction, while the opacity of the diaphanous medium causes the dulling of the rays. Since, then, both are found in the atmosphere, it is no wonder if it alone exercises authority over the radiant sphere of the Sun. From which it consequently appears that, if there were no atmosphere, these slopes of mountains—as well as all perpendicularly erect surfaces—would reflect exactly the same heat that the noonday and vertical Sun, together with the Earth, reflect under the equator. The oblique position, therefore, makes the Sun's ray near the horizon pursue a long path in that

atmosphere; and so, while it passes through the humid medium of the vaporous sphere, it loses much of its light and vigor and heat, as though blunted and dulled. Were it otherwise, the Earth would undoubtedly be uninhabitable from the Sun's heat—so that from this very fact you may see and admire the wondrous wisdom of God, the Best and Greatest, in the administration and preservation of the world. But concerning this marvel of nature and the usefulness of the atmosphere, see more in our *Ars Anaclastica*. From which, unless I am mistaken, the usefulness of the refracted solar ray in the preservation of the Earth is clear.

Furthermore, since the Sun, by the shadow of the Earth cast on the opposite side, always spreads densest darkness somewhere over parts of the globe, and consequently the Earth feels the absence of so much necessary light, lest anyone be able to cavil that divine providence was lacking even in this, He willed to compensate for all this defect of light by a kind of reflected ray of the Sun. For while with its immense light it illuminates the opposite bodies of the Moon and the stars, these, shining back the communicated light as though from a mirror onto the averted face of the Earth wrapped in the darkness of night—what else do they render but a kind of vicarious service of the Sun, expending it both in light and in reflected heat, thus, by inevitable necessity, as nature demands? See the figure set down here, in which the radiant light A B C D strikes both the Earth and the Moon and the other stars, which, reflected back by the rays E F G H onto the shadowed part of the globe I L opposite, there perform the office of the absent Sun with tempered heat and light; and there, according to the varied mixture of communicated power, they produce various effects.

Since the power of the Sun in the world is incredible and certainly admirable—for from the Sun comes all motion, and life,

[Top of page, continuing from the foot of the preceding column:]—and life, and preservation, and the adornment of things celestial and terrestrial—so that the more closely you contemplate it, the more things you will find in it congruous with that miracle, fit to be set forth. I judge it becomes a philosopher to search out all the treasures of nature.

Diagram. A large schematic of solar illumination and reflection. At the top center is the Sun, engraved as a radiant disc with a human face. From it broad fans of straight rays descend to the bodies arranged below. At the center sits the Earth, labeled **Terra**, drawn as a small globe; beneath it a cone of darkness (the Earth's shadow) tapers downward, with the shadowed/opposite face of the Earth marked by the points **I** and **L**. To either side and below are the Moon and planets, drawn as small spheres receiving the Sun's rays and reflecting them back; the lower-

corner bodies bear astronomical glyphs (the crescent ☾ Moon at lower left, and planetary symbols including ♂ Mars at the lower bodies). The direct rays from the Sun are lettered **A B C D** along the upper register; the reflected rays returning toward the Earth's shadowed side are lettered **E F G H** along the lower register.

- Sun (top center): radiant disc with a face; source of rays A B C D
- Terra (center): the Earth, a small globe struck by the direct solar rays
- I (on the Earth, shadow side): point marking the shadowed/averted face of the globe
- L (on the Earth, shadow side): second point marking the shadowed face, adjacent to I
- A (upper ray): direct solar ray
- B (upper ray): direct solar ray
- C (upper-right ray): direct solar ray
- D (right ray): direct solar ray
- E (lower-left ray): reflected ray returning toward the Earth's shadow
- F (lower ray): reflected ray
- G (lower ray): reflected ray
- H (lower-right ray): reflected ray
- ☾ (lower left, on a small sphere): the Moon, with crescent glyph [Margin glyph in figure]
- ♂ (lower bodies): planetary symbol (Mars) on a reflecting sphere [?]

(The dogmas, so much more worthy of being set forth, are congruous with so great a miracle.)

It is therefore fixed and established that, if the Sun stood still, the governance of this terrestrial world would be far otherwise—namely, it would have a most turbulent state; the globe of the Earth would not be everywhere habitable, nor would the disposition of the atmosphere be the same as we now experience it, because of the absence of the beneficent Sun that quickens and preserves all things. From which things the bountiful goodness of Divine providence shines forth, in that it gave to this star a motion—of longitude, the daily; and of latitude, the yearly and eccentric—so that by such a diversity of motions the atmosphere might be tempered to an even moderation, a temperature accommodated to human use. For from this we have the changes of the seasons—winter, summer, autumn, and spring; by this we pass through the courses of years, months, days, and weeks, whose diversity one and the same Sun produces by its presence and absence. The power of the Sun, therefore, is given to the terrestrial globe by

Divine providence through the local motion—daily and yearly—which conveys its forces and faculties.

But lest the Earth should always be struck by the same solar rays, and lest the other part of the solar body, turned toward the stars, should seem to be idle, Divine wisdom imparted to the Sun's body its own motions, distinct from all others; by these (as is established by long observation of astronomers) it would complete about one revolution around its own center in roughly twenty-seven days, and by the benefit of this rotation it would diffuse most abundantly, successively, whatever of light and whatever of power it contained, both into the Earth and into the surrounding globes of the celestial and ethereal regions.

And that this rotation of the Sun was indeed bestowed as a favor to the Earth by the Creator is clear from this, that it revolves not by a simple circuit, but by a yearly turning of the mobile axis about which the prior motion is described. Whence it comes about that the Sun inclines toward the Earth around its northern summit and its southern depression, and nods over the space of six months; and from that same alternating appearance of the mobile poles and axes above the solar horizon, and their concealment below it, it bends down. That this dizzying libration was made for the benefit of the Earth as well ought by no means to be doubted: for from it arises that through the 13 surveys by which it sweeps over the whole [Sun], just as the Earth is always imbued with one and another solar light, so too it is without doubt imbued with one and another solar power. This variety of influences is wonderfully promoted by the perpetual conjunction, separation, departure, and return of the motion of the spots, shadows, and bright facets. For if the shadow of the Moon in a solar eclipse so greatly alters the Earth, how great an alteration in things below the Moon must we believe the Sun would effect—the Sun which suffers eclipses from time to time by 50 or 60 spots and shadows of such magnitude that they seem to equal the faces of the Moon and the Earth? But since the Sun now,

[Margin: Aldrovandus, *l. de prodigiis* (*Ulisse Aldrovandi, book on prodigies*)]

—as though mourning in a spotted train of shadows, goes ahead; now, the doleful veil cast off, wholly serene, bright, calm, and smiling, it seems at one moment to belch forth flames, at the next black soot, as is beautifully shown in the figure. Certainly reason teaches that these things act on the Earth in various ways and produce dissimilar effects. For by this alternation they marvelously vary, impede, promote, increase, and diminish the very light of the Sun; and once this is changed, the solar influence upon the Earth and upon things below the Moon must consequently change too. That these things are so is proved by the

astronomical records of almost every age. Hence we often experience certain years as more abnormal than others—years which the astrologers ascribe to various aspects of the planets, but which we more truly ascribe to this variety of the solar phenomenon.

For since an immense quantity of bubbling solar evaporations is heaped up, it cannot but be that it vehemently hinders the Sun from acting as effectively with its light and heat upon these lower things. Suetonius relates that at the time when Julius Caesar was being slain, a kind of thick, sooty matter was seen around the Sun for a long time. In the time of the Emperor Justinian too, for a whole year the Sun, as though hedged about with a kind of veil, gave so little light, and so dimly, that it seemed to have been turned into the Moon. The Arabs observed a not dissimilar prodigy in the year 64 of the Hegira, as Haly [Haël] relates in his *Astrology*—a prodigy which was soon followed by a great desolation of things. In Paul the Deacon [Paulus Diaconus] we read that in the year 700 the disc of the Sun, as though suffused with a blood-red color, shone so dimly over all Europe for the space of many days—with the sky most clear and unclouded—that it almost spread darkness over the world. A great comet too followed this darkness. Cornelius Gemma in his *Cosmocritica* testifies that in the year 1569 the disc of the Sun appeared with the same countenance, and that this apparition was followed by both a comet and civil disturbances. Finally, in the year 1625, a little before the Swedish war, throughout the whole course of the year the disc of the Sun was covered with an enormous bubbling-up of spots, as was observed both by me in Germany and by our Scheiner at Rome (as appears from the *Rosa Ursina*). If astronomers were to note all these things diligently, then perhaps, from phenomena of this kind compared with sublunary effects, a new astrology, far more certain than that common planetary one, might be founded—though I do not deny that the causes of these solar maladies are none other than the unlucky and pernicious aspects of the surrounding stars, which, opportunely infesting the Sun's body, at last stir up in the solar body those tempests of which I have spoken.

On the Moon, our Cysat [Cysatus; Johann Baptist Cysat] noted an atmosphere, that is, an exhalation of vapors, in the eclipse of the year 1628, on the very day of the Lord's Nativity. Whence I do not doubt that the same occurs in the remaining globes of the planets, which, just as they constitute different centers from the center of the universe, so also constitute different spheres of exhalations. From which, indeed, unless I am mistaken, the genesis of comets kindled both above and below the Moon, and of new stars, manifestly appears. I could adduce many things in this place concerning the manner in which the Sun and the other planets pour forth the spheres of their exhalations, and how comets can thence

be born; but since we have amply taught this in our *Itinerarium Exstaticum Coeleste* [Kircher, *Itinerarium Exstaticum*], we refer the curious reader to it.

Caput V.

On the Nature and Effects of the Lunar Body.

[Margin: On the Nature and Effects of the Lunar Body. (*repeated as a running side-title*)]

That the greater variety of things and of effects might shine forth in this world, it was brought about by the unspeakable counsels of Divine wisdom that very many bodies in this universe should be constituted, each imbued with various and diverse qualities, so that these, impregnated by the fruitful rays of the Sun and by a mixture of seeds, conveyed to the Earth through the reflected ray, as it were, of the Sun's light, might there contrive new combinations of generable things. And that this might be done more conveniently, He willed the Moon to be turned about the Earth, and the planets about the Sun as their center, so that they might more conveniently pour out upon the Earth the rays received from the Sun.

Since the said bodies drink in the Sun's brightness not merely at the surface, but also in their marrow, and tinge it with their own native property, it comes about that the seminal powers created together with the Sun, propagated through the luminous rays into the said bodies, there mixed with the seminal power of the planets and of the other stars—each peculiar to itself—operate in different ways: partly through the reflected ray onto the Earth, partly through the direct and refracted ray into the atmosphere; and thus they produce diverse and innumerable effects, according to the disposition and capacity of the Earth, likewise filled with a certain panspermia [Greek: πανσπερμία, "all-seed," the universal seed-mixture]. And that this tincture is indeed thus, is clear from the very diverse colored lights of the planets, as the leaden of Saturn, the fiery of Mars, the silvery of Venus, the bright and serene of Jupiter; which variety of colors, that it does not derive wholly from the Sun's light, is proved by this, that at the same time they are imbued, not with a similar, but with a color appropriated to themselves, always and everywhere. Nor are the colors of planets of this kind to be derived from the medium, because, in whatever way the medium may be altered, they are always clothed, by their constant tenor, with light variously tinged in each one. Whence, from their own inborn colors—

the Sun's light reaching it [the Moon], and from there reflecting it back upon the Earth together with its own specific qualities — just as the Sun's rays, when passed through panes of glass tinted with various colors, are themselves imbued with those various tinctures. This must be granted. And no one should doubt that this influence upon the Earth produces various modifications of the said qualities, arising both from the approach and the recession of these bodies — toward the Sun as much as toward the Earth — and likewise from their varying position with respect both to the heavens and to the horizon.

Hence, lest the Earth be disturbed by the excessive heat and violence of the Sun's rays, the supreme Architect set against the Sun a certain Ethereal Earth — let me call it, with Plutarch, the Moon — as a kind of watery body endowed with countless powers. By its cooling, the rays are broken and tempered, and being made fertile with their own seeds and communicated to the Earth, there they might give rise to fresh offspring and new growth.

Now these two bodies — our Earth and that Ethereal lunar Earth — have a great likeness to one another (as will be shown in Book IV), by which the one nurtures the other and they mutually favor each other; and there are influences by which both bodies, and the parts of each, both live and are preserved and nourished. Indeed, that our seas are variously stirred according to the Moon's aspects needs no proof, since nothing is more commonplace; but a fuller opportunity for discussing these matters will be given in the cited passage at Book IV. [Margin: ?]

This sympathy consists in nothing other than a great agreement of both powers and actions; but the agreement of powers consists in nothing but a likeness of essence, since powers reside in a thing in proportion to its essence and proceed from that essence, and in proportion to those powers the actions too must be exercised. For since the Moon is a rough body and entirely similar to our Earth — dense and opaque, composed of solid and liquid — it not only perfectly absorbs the Sun's rays but, by a mutual communication of powers, reflects what it has absorbed back to us. And lest the influence should always be the same, the most wise Architect fashioned the Moon with such skill that it should look upon us with an ever-unequal aspect over the monthly span, and, according to its varying position, should strike the Earth with one degree of its action and then another, and thereby promote the generation of things according to the needs of nature.

But lest I should seem to have omitted anything of curious interest, I have thought it right to set down here the Phenomenon of the lunar body, just as it was observed — both in the Collegio Romano and by Eustachio Divini [Eustachio Divini] — with the finest telescopes. In it you will find a certain wonderful face

composed of shadows and little points of light, not unlike what appears in the foregoing solar Phenomenon, with this one difference: that the bright spots and dark spots on the Sun are perpetually inconstant, whereas on the Moon they remain perpetually the same and unmoved, holding ever to the same pattern.

You would say you were gazing upon some sea washing against vast tracts of land. Here, in the central depths, you see islands spread far and wide as if in some Ocean; elsewhere you see certain shadowy hollows, from whose center something — I know not what — seems to issue, which you would call a tremulous exhalation, and which the Observing Selenographers accordingly call the Moon's Atmosphere. Around the same rim you will gaze, not without wonder — especially when the Moon is at the half [in *Luna Dichotoma*] — upon what seem to be sheer crags and a range of chained-together mountains. And so, from this picture, with seas, terrestrial lakes, and mountains duly compared among themselves, you will infer, not improbably, that the Moon is a globe entirely similar to our Earth — namely, an Earthy body, that is, composed of moisture and a celestial earth, endowed with the countless faculties of latent seeds, which, mixed with the Sun's rays, produce in the Earth that multitude of things we daily marvel at, even though we can scarcely grasp the mystical reason for it in our minds.

That intense light diffused into rays we do not suppose to be some highly polished portion or surface of the more eminent part of the Moon, reflecting the Sun's rays more violently than the rest of its parts. If we were on the lunar body, looking out at the terrestrial globe, we would surely say that the inaccessible peaks of the loftiest mountains — such as the Alps, the Pyrenees, the Andes, the Caucasus — covered with perpetual snow, would reflect a like light upon objects situated on the lunar globe. For it can scarcely be told how intense a light of this kind they reflect — as I recall observing, not without delight, in the year 1638, while I was surveying Etna [Aetna], among the mountains of Calabria and the islands scattered round about. And that there are on the Moon prominent crags, as it were of mountains, the increase and decrease of the shadows at the rising and setting of the Sun on the lunar horizon sufficiently shows. For it has been observed by the lynx-eyed Astronomers of our time that certain more eminent parts of the Moon — which they call lunar mountains — are successively illuminated from one side and then darkened from the other, just as on our terrestrial horizon, at the rising of the Sun, mountains cast their shadows: smaller in proportion as the Sun has climbed higher, larger in proportion as it draws nearer to the point of rising. But let what has been said about the structure, use, and nature of the Moon suffice.

CAPUT VI.

On the proportion of the Earth's globe to the Sun and the Moon. [De proportione Globi Terrae ad Solem ac Lunam.]

In the *Itinerarium Exstaticum* we stated that the Sun, the Moon, and the rest of the Planets were created in such a magnitude of body as is fitting for each, and at such a distance of one from another, that each globe is always within the sphere of activity of another — that is, the several bodies affect one another by a kind of reciprocal exchange of their diffused rays. This is a clear sign of the admirable proportion of the length, or interval, by which they are distant from one another.

[Margin: The wondrous providence of God in distributing the Sun's light.] If, then, the Sun were larger or smaller than it is, under the same distance from the Earth that it has in the universe — if it were larger, then, with its excessive light, it would have scorched the greatest part of the terrestrial Orb, and so would have brought on the utmost disorder of things. At the Poles, moreover, it would have illumined the hemisphere for more than half the year and beyond half its surface; whence, over the whole orb of the Earth, the greatest inequality of days and nights would arise, the greatest and astonishingly disordered constitution of the year and of the four seasons, and it would have caused an utter and unavoidable confusion. But if the Sun had been smaller than it now is, all the losses of cold and darkness would likewise have followed, since it would have illumined only less than half the globe. Therefore the terrestrial globe has been constituted in such a proportion that there is no nation in the world that could complain of an insufficient portion of heat and light, or accuse Nature of any negligence in the distribution of the necessary, due light.

But on these matters see our *Ars Magna Lucis et Umbrae* [Ars Magna Lucis et Umbrae], folio 57. Furthermore, since the Sun's radiance could inflict much harm by the continual influx of diffused light and heat, the wisdom of the eternal Maker therefore set another body against the Sun [Margin: A body opposed to the Sun for tempering the Sun's heat], so that whatever the persistent Dog Star [Sirius] heat of the Sun's force had rendered parched, dry, and burnt up, this body might, by its own power and innate moisture, reduce to an even temperature; and lest, being nearer to the Earth, it should burden the Earth with more than a fair abundance and excess of moisture, He willed it now to wax and now to wane with light — both for establishing a more exact tempering of sublunary things, and for countless other uses and benefits, which will be declared in the course of this Work.

Nor should the remaining choir of Planets be reckoned idle, since each one carries out the parts of its office, which it diligently performs in the cosmic Economy, those parts which the law of eternal Wisdom has prescribed to each. Since we have treated of these in the *Itinerarium Exstaticum*, we refer the Reader thither. With these matters premised, let us now proceed to the fabric and constitution of the terrestrial globe.

CAPUT VII.

On the outermost structure of the Earth, and its magnitude. [De extima Telluris structura, ejusque magnitudine.]

You see, then, by what artifice this marvelous work of divine wisdom has been founded — that it lacks neither τάξις [Greek: taxis, "order"], nor διάθεσις [Greek: diathesis, "arrangement"], nor οἰκονομία [Greek: oikonomia, "economy" or "ordered management"] — in which there is nothing that is not in every way fitting, well-arranged, magnificent, and surpassing all admiration. For whether you look at the ornaments after the manner of columns, or the splendor of the paneled ceilings, or the solidity of the foundations, you cannot but be carried away into worthy raptures of admiration.

But how can the weight of this terrestrial globe be supported? What underpinnings? With what piling and pounding of stakes are they made solid, so that the Earth may be stabilized with such firmness above the unstable mass of the waters poured round about it? [Margin: The stability of the Geocosm and of the elements.] If we should wish to set up the other three elements of the world as columns for the terrestrial fabric, we shall see them to differ as much from these as Heaven differs from Earth. Who has ever been able to see columns enduring through a course of 5,000 years, in which even now the bases, supports, lintels, cymatia [moldings], the bands of the cushions [pulvini], abaci, acroteria, and the rest of the parts of the columns remain whole and immune from every blemish of corruption — when meanwhile the elements have now lasted nearly 6,000 years, throughout that span, in their integrity?

Who would not marvel at the roof of this fabric, which encompasses not only the upper part of the building but the whole building, a roof that, by the motion of its ceaseless revolution, is so perpetually turned that it perfectly covers the house — yet without weight being added to it; it is so drawn over the building that, so far from spreading darkness, it rather floods all the receptacles of that building with light and heat? This we call the Heaven, the magnificent machine of the eternal Architect; whose pavement is the Earth [Margin: The adornment of the heavens.],

placed in the central seat of the world, solid and on every side compacted into itself by its own gravitations, clothed with flowers, fruits, herbs, trees, and crops — of all which an incredible multitude is distinguished by an insatiable variety, at the sight of which you delight, on the taste of which you feed, and by whose fragrance you are refreshed; whose walls are the globes contiguous to the heavens, strong with a continuous turning of the spheres, firm, mighty by the perpetual law of revolution, translucent, gleaming, and conspicuous within and without by the light that the stars hurl forth. Add the variety and grandeur of its delights: the icy perennial flow of springs, the...

Diagram. A large engraved plate (left half of a double-page spread; the right portion is cropped at the gutter) depicting the body of the Sun [Schema corporis Solaris] as observed by the Author at Rome in 1635. The disk is rendered as a fiery, granulated globe ringed by a flame-like corona of solar fire, studded with numerous dark cloud-like sunspots (maculae) and bright flame-tufts (faculae), several of the latter marked with a small triangular symbol ($\triangle$). The surrounding field outside the disk is labeled as the Ethereal region. An ornamental cartouche held aloft by a winged putto at the upper right carries the title. A legend runs along the bottom margin. Several labels extend onto the cropped right half not visible in this scan.

Visible labels:

- Title cartouche (upper right): "Schema co[rporis] / SOLA[ris] / prout ab Authore et[iam] / Romae Anno 1635 / fui[t observatum]" — "A scheme of the body of the Sun, as it was observed by the Author at Rome in the year 1635."
- ÆTHEREUM (upper left, along the disk's edge): "Ethereal [region]."
- ÆTHEREUM (lower left, mirrored): "Ethereal [region]."
- Æquator (left, mid-disk): "Equator."
- Polus Bor[ealis] (upper right, near disk edge): "North Pole."
- Polus [Australis?] (lower right, cropped at edge): "[South] Pole." [?]
- R (upper area): point-label.
- S (upper left, near edge): point-label.
- T (left, near edge): point-label.
- D (left of equator): point-label.
- H (lower left): point-label.
- L (lower left, near edge): point-label.

- Δ (multiple, on bright faculae across the disk): symbol marking the brighter solar facula-tufts.

Legend along the bottom margin (partly cropped/abraded): "F.G. Axis Globi Solaris. D.E. [Ae]quator Solaris. B.F.C. Spacium Solis [?]... H.G.I. Sp[acium] Sol[is]..." — "F.G., the Axis of the Solar Globe; D.E., the Solar Equator; B.F.C., the space of the Sun [?]...; H.G.I., the space of the Sun..." [The legend text is small and partly truncated at the gutter and lower margin; several entries are illegible.] [?]

Marginal annotations on p. 101 (printed in the outer margin, partly cropped at the gutter on p. 103): Several short printed side-notes appear keyed to the text. On p. 101 a handwritten note in ink at the foot of the right column reads (approximately): "Schema D[?] vid[e] ad pag. 162 [?]" — apparently a contemporary reader's cross-reference: "See the figure... at page 162." [?]

Marginalia visible on p. 103 (cropped fragments at the inner edge of the right margin): Several truncated printed side-note fragments are visible but largely cut off at the page edge: "...epan- /...lathe- /...co- / in di- /...ione /...æ."; "...osthe- /...rimus /...men- /...e ag- /...iis."; "...la dari /...st cer- /...omni- /...regio- /...is con- /...men-". These belong to side-notes for text on the facing page (p. 104, the verso of which is largely blank/offset in this scan); they cannot be reconstructed from the visible fragments. [?]

Diagram. A large engraved plate (the right half of a folding plate showing the body of the Sun, marked "Tomus I. 64" at the upper right) depicting the solar disk covered with sunspots and surrounding evaporations, after the observations of Christoph Scheiner [Christophorus Scheiner]. A winged putto at the upper left holds the engraved cartouche bearing the title. The disk is ringed by a dense fiery margin of flame-like prominences; dark cloud-like masses (evaporations) cluster both on the face of the Sun and in the surrounding space. The word *SPATIUM* ("Space") is lettered twice in the field outside the disk (upper right and lower right). This is the continuation of the solar plate begun on the facing leaf (fig-p104-1 of the prior opening); the left margin of the engraving is cut at the gutter.

Readable labels:

- (upper-left cartouche, partly cut at gutter): "...na corporis [Schema corporis]...ARIS [Solaris],...re et P. Scheinero [...ore et P. Scheinero],...1635 observatum fuit." — i.e. "Diagram of the body of the Sun,... and by Father Scheiner,... observed [in] 1635."
- (upper left, at disk edge): "...s Borealis" — [Polus] Borealis, "North Pole"
- (lower left, at disk edge): "...us Australis" — [Polus] Australis, "South Pole"

- P (upper region, in space): evaporation cloud label
- O (upper right, in space): evaporation cloud label
- Q (left, at disk edge): label
- H (right side, at disk edge): label
- I (lower right, on disk): label
- N (lower right, in space): evaporation cloud label
- M (bottom, in space): evaporation cloud label
- A (several, on disk face, each beside a bright spot): "Putei lucis" — "wells of light"
- "Solaris" (right of disk, beside H): part of a label — [Limbus?] Solaris or [Globus] Solaris
- (legend at foot, partly abraded): "...[P]olu[s]... Spatium Solis torridum. A Putei lucis. L, M, N, O... Evaporationes una et macularum origo." — "...the torrid Space of the Sun. A: the wells of light. L, M, N, O: the evaporations, the one origin of the [sun]spots."

[The blank verso of the plate carries only two abraded marginal note-fragments, transcribed where they belong in the running text below; the marginalia heads are "Mira p[rovidentia]... Dei in... [di]stributio[ne] lucis So[la]ris" and "Stabili[tas] Geoco[smi] & elem[en]torum."]

LIBER SECUNDUS — Geocosmus

[Caput VII, continued — De extima Telluris structura, ejusque magnitudine]

[Margin: Delights.]

the translucent waters, the banks of rivers clothed in flowers at their loveliest, the lofty vaults of caverns, the ruggedness of crags, the summits of overhanging mountains, the immensity of the open plains — to say nothing, for now, of the vast and inexhaustible store of treasures locked away in the innermost recesses of the Earth, and of their abundance.

[Margin: The inhabitants of the Geocosm.]

And as for the inhabitants of this palace of so marvelous a Geocosm — how great their variety and number! Besides man, who is the end of all things, how great the diversity of living creatures differing in kind! How great the goodness and

wisdom of the Steward in providing for each thing what it needs to sustain and propagate itself! How great the beauty of the sea! How vast the multitude of islands! What charm there is in their coasts and shores! How many, and how unlike, are the kinds of fish and of huge sea-beasts, and of the creatures that cling to the rocks in their native shells! Here I pass over in silence the wonderful effects of air, water, and fire as they play together in the nature of things; I leave aside the inner constitution of the several organs of the terrestrial mass. But I cut short, before the proper time, the unrolling of my reflection on the inestimable works of God, lest, carried away by I know not what ardor of the mind, I be drawn too far from the subject set before me — farther than I could draw my foot back.

[Margin: The terraqueous globe.]

The Earth, then — which we call the Terrestrial World — is the sphere of the human race, a single globe compounded of water and land, fixed in the middle of the World and held there by its own weight. Its outermost surface is clothed partly with a terrestrial, partly with an aqueous covering, as with a garment, and in the excellence and variety of its contents it surpasses all the other globes of the World. Its magnitude and quantity, although attempted by very many mathematicians of every age — men endowed with the highest felicity of genius — has not, so far as I know, to this very day been worked out with any clarity. For most who take up this attempt assume the globe to be mathematically round, and assume a perfect solidity of this mass, abstracting from all the inner caverns of its bowels; and by this reasoning indeed they have arrived at some certainty of measurement, though no one has reached a precise determination of the magnitude.

[Margin: No one has truly measured the Earth's body.]

[Margin: Why the matter of the Earth does not fall under geometrical scrutiny.]

For — apart from the deceptiveness of measures that are changeable and unstable, and peculiar and proper to each (I will not say kingdom only, but even province and town) — there is added the inequality of innumerable mountains stretched far and wide in chained-together ranges, and the gap (unexplored to this day) of plains and deserts spread out beyond measure. All these things escape men's knowledge, and so it is impossible for them to be defined by human industry through any fixed and determinate measure.

Hence geometers, content with a pure and bare hypothesis, in order to establish something certain, consider the terrestrial body as a mass of aqueous and

terrestrial substance compacted spherically into a single globe — disregarding all the brows of the mountains and the depths of the

valleys that follow upon them — and they set up their measurements according to this hypothesis. But although many have attempted this in every age, they differ so widely from one another that the following saying seems not inaptly directed against them:

The farther I advance, the more I go astray into byways.

[Margin: Eratosthenes the first of the Greeks to attempt the measurement.]

The first to attempt it was Eratosthenes, by means of a scaphium [a sundial-bowl instrument], between Syene and Alexandria; and Archimedes, Hipparchus, Strabo, and Ptolemy also investigated it — but with a notable difference from Eratosthenes. King Almamon [al-Ma'mūn] made trial of so great an undertaking, at great expense, on the great plains, as is found in Abulfeda [Abū al-Fidā'] the Arab, no mean cosmographer. Later men investigated it too — all the mathematicians of more penetrating genius — with scaphia and other sundial-instruments, and by an exact measurement of some fairly level region along the meridian line that would correspond to one celestial degree. They examined the heights of towers and mountains in the hope of arriving at the longed-for knowledge — but in vain. For if you examine the efforts of them all, efforts truly most worthy of praise, you will scarcely find any one of them agreeing with another; and yet the rules concerning the proportion of the diameter to the circumference, and concerning the magnitude and quantity of the sphere to be found by means of it, are most certain and infallible; nor can the analysis of spherical triangles deceive, if geometry is consistent with itself. What, then, are we to suppose to be the reason for so great a diversity? I will explain it in a few words.

[Margin: The disagreement of the mathematicians in measuring the Earth.]

I judge there to be two things, above all, that frustrate all the labor of geometers in measuring the quantity of the Earth. The first is the very great diversity of the measures used in the different regions, provinces, and towns of the world — a diversity so great that there is scarcely a town that does not differ from another in the quantity of its measure, so that nothing is more difficult than to reduce all the difference of these measures to one stable and unchangeable measure, since the foundation of measure is lacking.

[Margin: No certain measure can be given that is common to all regions.]

For if you set up, as the smallest term of measure — for example — a grain of wheat or of mustard, those grains are of such differing size that you will find they acquire a notable difference of quantity according to the condition of the different climates, horizons, and soils. But if you take some part of the human body as a fixed foundation of measure — say a thumb's-breadth, a palm, a span, a foot, a pace, and the like — you will find under these too a difference of inequality all the greater in proportion as one man differs from another in the natural constitution of his body. And so, in order that something certain might be established amid so great a diversity, there ought to be furnished to all the mathematicians in the world a fixed and infallible measure, according to which they might conduct their operations — furnished by some Monarch of supreme authority; and that not inscribed on paper or parchment,

(since this too suffers its own damage from the change of air and of climates), but cut into bronze or some similarly durable material. Yet that even a measure assumed in this way could not hold good, I show as follows.

[Margin: Another difficulty.]

In the practical geodesy of this business there is necessarily required — indeed presupposed — the analysis of a triangle, from the proportion of whose sides and angles, the quantity of one side being known, we arrive at knowledge of the whole unknown quantity. But a triangle of this kind cannot be set up except by a visual ray, or by a solar ray in some sundial instrument or device; and that neither of these is sufficient for this business is so true that no one could doubt it — except, perhaps, the man who has not experienced for himself the inescapable rocks of difficulty that arise in dioptric astronomy.

[Margin: Sighting (collimation) is deceptive in measurements.]

A novice not much versed in astronomical work might perhaps suppose that the visual line, along which we sight through a sighting-vane toward some star, or toward the summit of a mountain or tower, runs so straight into the object that it cannot be that such a line is not exactly determined — which the alidade [Alhidada] demonstrates to be so straight. But those who know the deeper secrets of nature, and who scrutinize more exactly the unstable nature of refractions amid so great a diversity of media, find otherwise. To set this out a little more fully, one must know that the medium of the air, on account of the inconstancy of its fluid nature, is so variable — both by reason of time and of place — that scarcely an hour of the same day, scarcely a week or a month in the whole course of the year, can be assigned in which it does not, according to the different laws

of rarefaction or condensation, undergo its own alterations as well. To this is added the disparate condition of places, whereby it comes about that the aerial medium is one thing at the sea, the rivers, the lakes, the marshes, and another in the mountains and in desert and waterless places; one in southern, another in northern regions; one under the Torrid Zone, another under the Temperate, another under the Frigid; and so, according to the state and natural constitution of the horizons, it must be altered in one way and another.

[Margin: The fallacy in the refraction of the air.]

It is certain that the visual ray too — the foundation of the whole geodetic business — is, according to the said diversities, altered in a wonderful way, since the object seen is presented now higher, now lower, according to the proportion of the refracting medium. The horizon itself teaches this fallacy: by the power of its refracting nature it presents the luminous bodies of the stars as already risen and to be observed, which nonetheless, according to astronomical strictness, ought not yet to have emerged, being still hidden below the horizon. Islands suddenly come into view in the midst of a gulf of the sea, which before lay concealed. The summits of mountains, otherwise unseen, are disclosed — for no other reason than that refraction raises hidden things higher and higher beyond their natural position, according to the disposition of the medium. On these matters see Our Art of Anaclastics [Ars Anaclastica] in the work entitled *Ars Magna Lucis et Umbrae* [The Great Art of Light and Shadow], where we have pursued everything more fully.

This being laid down, then, I think it cannot be that anyone — however equipped with keen and subtle genius, and notwithstanding the excellence and reliability of his instrument — should attain the altitude of a star, or of a rather distant mountain, precisely and truly. And so I consider this to be the one cause why there is so great a difference among authors concerning the magnitude of the terrestrial globe.

[Margin: What is the cause of so great a difference in the observations.]

Those who, on a notable plain, set about a business of this geodetic kind by means of measuring-rods [decempedae] draw an equal hazard of difficulty. For so small a space — besides being imperceptible in relation to the whole circuit of the terrestrial globe — has corresponding to it the very smallest portion of the heavens; and that this should be reached precisely, through instruments, in first or second minutes, I judge scarcely possible — to say nothing of the defects of the measurers, inevitably committed in measuring lengths by rods or chains. But

granted that all these things have been carried out correctly and with the desired diligence, behold, a new difficulty presents itself: for we cannot know whether the said plain coincides exactly with the surface of the sea, whether it is higher or lower than it. For if it is higher, who does not see that the circuit of the circumference will be greater than is right, and if lower, smaller? And who will hit upon the mean? Surely He alone, who, as He made all things in number, weight, and measure, so He alone attains also the precise equality of the terrestrial surface with the aqueous.

There are others who think that, from some high watchtower, by a visual line touching the surface of the sea, they can arrive at the end of the geodetic business. But who will be able to mark with certainty the point of contact amid so great an inconstancy of the element? Who will distinguish a fixed and sure point in the instability of the fluid nature, when the waves now subside after the manner of valleys, now swell up like mountains? Surely no one.

[Margin: The point observed in the sea cannot stand fixed.]

The geodesists, indeed, in the confine of the horizon and the heaven, will firmly persuade themselves that the visual line touches nothing but a point; but I say that it is so far from being a point that in its breadth it spans and embraces — I will not say a foot or a pace, but many miles. We are deceived by our senses through the inequality of the sea's surface that is taken for a plain; the air mocks us in a thousand ways — so that this whole geodetic contrivance really cannot stand, unless the surface of the sea be round without any inequality, unless the terrestrial plain be continuous with the surface of the sea, unless the aerial medium be everywhere one and the same. And since this matter far exceeds human power and knowledge, so too every effort of human industry is baffled in investigating the quantity of the Earth exactly. These things I write, not that anyone...

[the page breaks off mid-word at "tam laude digno / moli-" — "in so praiseworthy an under[taking]..."]

to detract from a work so worthy of praise, but to set the difficulty of carrying out the task before the eyes of the curious reader.

But I come now to the other source of difficulty. There are those who would summon to the balance not merely the surface of the Earth, but also its solidity and weight. [Margin: The solidity or weight of the Earth cannot be found out by human intellect.] If indeed, granting the value of the Earth's semidiameter, one were to regard the whole body — by hypothesis — only as to how great it is and

how solid, that would not be hard. But there are some who, after deducting the Earth's caverns, would commit the remainder to the scale; and this attempt, in my judgment at least, ought to be reckoned bolder than is fitting, since beyond a useless exercise of calculation it yields us no benefit whatever. This one thing I know: to investigate the weight of the Earth involves difficulties perhaps greater than human industry and labor can overcome. For — as will be shown in what follows — the Earth is bored through with countless tunnels and riddled with vast caverns beyond number, small, smallest, and largest, and is moreover packed full of matter of heterogeneous nature. From this, given so great a discrepancy of mixtures, no one could ever attain the desired aim of weighing it; and to possess a knowledge of all these things would be necessary. Let us therefore conclude with the divine Job: *Gird up your loins like a man; I will question you,*

answer me: where were you, when I laid the foundations of the Earth? Tell me, if you have understanding of it. Who set its measures, if you know? Or who stretched the line upon it? Upon what are its bases founded, or who laid its cornerstone? Have you entered into the depths of the sea, and walked in the lowest parts of the abyss? Have you considered the breadth of the Earth? And Job answered: What can I answer? I will lay my hand upon my mouth. One thing I have spoken, which I wish I had not said, and another, to which I will add nothing further. (Job 38) [Margin: Job, ch. 38; v. 4, 10, 11, etc.]

And these are the things I thought worth saying about the vastness and magnitude of the Geocosm. As for the methods both of measuring and of weighing its whole mass, since I have treated them elsewhere in my works, and since scarcely any geographical work exists in which such a method is not contained, I have deliberately passed over them, lest I should stuff this work full of what others have already handed down. Yet so that the reader may not be cheated of the information he desires, I have decided to excerpt those things which are more to one's taste from the table of authors who have devoted their efforts to measuring the Earth's mass — from which, given so great a discrepancy, [the reader may take what suits him]. Let us conclude, then, with the divine Job: *Gird up your loins like a man; I will question you.*

CAPUT VIII.

Of the Mountains of the Geocosm, and their Necessity.

There is great controversy among authors, especially among the interpreters of Sacred Scripture, whether before the Flood the Earth was made rough with

mountains, or whether on every side it was rounded into a wholly flat surface. Each opinion has its adherents. But just as the former is most true, so the latter is most false and dangerous to the faith. [Margin: The mountains existed before the Flood.] Certainly the Sacred text plainly teaches that the Earth was furnished with mountains from the beginning; for it makes mention of Mount Ararat, and it makes mention of the height of the waters in the Cataclysm rising fifteen cubits above all the mountains in the whole Earth. If, then, the cataclysm of waters covered the mountains, then they already existed before it; and so the adherents of the latter opinion are not to be heard. That the terrestrial globe, then, was made rough with mountains is so certain that whoever stands alone in the contrary opinion will find his match in our most learned Father Riccioli [Giovanni Battista Riccioli], in the *Almagestum Novum*, Volume 1, fol. 62.

What the bones do in the Microcosm, the structure of the mountains does in the Geocosm: they bind the whole mass of the terrestrial globe so tightly that it cannot in the least be dissolved, and in this way it acquires a perfect consistency. [Margin: The bone-frame of the Earth is the framework of the mountains.] For since the Earth does not contain in its womb a clod of a single kind, but is teeming with countless species of diverse things — as with minerals, powders, metallic fluxes, ashes, as will later be reported — these surely could not hold together unless they were contained, by a firm structure within the innermost cavities, by the framework of the mountains, like wine in casks bound by hoops. Secondly, since the sea that flows around the Earth is perpetually agitated, both by its tide in ebb and flow and by the force of the winds, [Margin: The usefulness of the mountains in the terrestrial domain.] surely without the barriers of the mountains the Earth could not endure; for by these the sea is contained within its own bays and channels, as if by levers and barriers, lest it devastate the Earth with an immoderate deluge, according to that saying of Job: *I encompassed it, and set bars and doors to it, and said: Thus far shall you come, and you shall go no further; and here shall you break your swelling waves.* (Job 38) [Margin: Job, ch. 38.]

Thirdly, the mountains were absolutely necessary for the propagation of springs and rivers; [Margin: Mountains necessary for producing springs.] for by these a more sloping Earth provides an easy flow into the sea, which could not have happened had the Earth been wholly flat. But of these things more fully in the treatise *On the Origin of Springs*. The mountains, then, are like certain breasts protruding in the Geocosm, and like certain storehouses and treasuries of nature, established by provident nature both to supply liquid perpetually, and to nourish and enrich the valleys lying beneath the mountains and regions, by the gift of the

beneficial liquid diffused on every side. Fourthly, the mountains contribute marvelously both to checking the fury of the winds, and to producing the variety of herbs, trees, and plants — which would not otherwise come forth without mountains — and to tempering the heat of the Sun and the healthfulness of the air, all of which are obtained only in the higher recesses of the mountains. Hence men and herds, wearied by the summer heat, generally seek out the mountainous regions for the sake of refreshment and the restoration of health. Fifthly, what are the mountains but an inexhaustible storehouse and treasury of metallic bodies? [Margin: Metals.] In whose hollows, through hidden passages, by the power and energy of the subterranean fire — cooked as in some furnace, and brought to the desired maturity — they are produced for the use of mortals. I will not speak here of the pleasantness of the prospect, of the usefulness which their shade affords to the underlying plains and valleys of the fields; I do not recount how great is the importance of the mountains in determining the nature of places. This I will dare to affirm reverently: that the property and quality of diverse regions, provinces, and cities arise solely from the natural constitution of the mountains. But there is one thing which provident nature aims at chiefly in the constitution of the mountains and in the roughening of the terrestrial parts: namely, a proportioned increase of heat, [Margin: That the heat may be tempered.] without which nothing could be rightly arranged. For from this it comes about that the rays of the Sun and of the other stars, tempered within the windings of the mountains and the diverse constitutions of the rocky masses, by their varied reflection strongly intensify the heat, and draw out vapors fit for producing meteorological impressions, from which countless benefits in the economy of the Geocosm must necessarily arise, as will be said in its place.

For to whom is it not established by experience that the plains lying beneath the mountains, as soon as the Sun first enters Aries, when the masses of snow that cover the peaks of the mountains are loosened, marvelously warm the surrounding earth and stir it to bring forth? And lest the earth be intoxicated by too much moisture, by its slope it hinders the stagnation of moisture, and the moisture, continually gathered into the channels of the rivers, it thrusts down into the sea, so that, freed from superfluous moisture, the earth may be made fit for the produce of things. [Margin: Why the surface of the Earth ought not to be flat.] But if the Earth had been spread out with a flat surface, it would doubtless have lacked all the benefits just recounted; for neither would the rivers have continued their flow because of the level surface of the Earth, nor would the melted snows have had any place into which to discharge themselves. And so, by the multitude of stagnant waters diffused into all parts, the earth, together with the offspring of vegetative and sentient nature, would necessarily have perished

from the superfluity of moisture. Add to this the unhealthfulness of the air, which the breath of stagnant waters of the level plains, standing without motion, would have caused. From all of which, weighed by a deeper scrutiny of the mind, the necessity of the mountains plainly appears.

CAPUT IX.

Of the Hidden Constitution of the Mountains.

Those who wish to construct a material sphere first fit together the circles which they call Meridians, in such a disposition that they all intersect one another at the Poles of the World; to these they then apply the Equator and the rest of the parallel circles in order, both for the firmness of the Sphere and to indicate the hidden constitution of the Earth. [Margin: The first ring-like chain of mountains.] If we examine the structure of the Geocosm with a somewhat finer balance, we shall find that nature has constituted it by exactly the same method by which it fits and arranges the terrestrial globe; for the Geocosm itself teaches abundantly that the chains of the mountains are set from Pole to Pole, that is, from North to South. But to show the truth of the matter more clearly:

The first chain of mountains, arranged in a circle, is brought down from the Pole through Iceland, Scotland, England, Germany, by a continued series of mountains and in a straight track all the way to the Alps — which are like a certain knot of the great chain, by which those mountains that, extended in a discontinuous order, had incurred some flaw of connection, are bound and drawn tight to a firmer consistency. From the Alps, the mountains, interlaced as if in a new ring-like order, are joined to the Apennines, by which the central spine of all Italy, just like a certain backbone, with an excellent framing of bones, is continued in series through Sicily and connected to the mountains of Africa, which they call [the Mountains] of the Moon [Mountains of the Moon].

The other limb of the great chain's knot extends all the way to the farthest promontory of the South, named the Cape of Good Hope, and this order — reason itself dictates — is doubtless continued all the way to the opposite Pole of the World. [Margin: The other limb of the connected chains of mountains — which it is.] From this Southern pole, it is extended through the unknown tracts of the Southern Land all the way to the Strait of Magellan, and from there it is joined, through the Andes of South America and the immense tracts of the North, to the Northern pole from which it had flowed. A second chain, intersecting the first at right angles, departing from the Pole and deriving the course of its extension through Tartary, joins to itself the Imaus [Himalaya], which through the middle

of Scythia, the great empire of the Mogor [Mughal Empire], and finally through the backbone of India, runs out into the promontory of Comorin [Cape Comorin]; there, by means of the sea-floor, it is connected to the mountains of the island of Zeilan [Ceylon/Sri Lanka], and from there, beneath the Ocean, it is extended to the Southern pole; and from there at last, through the unknown tracts of lands and Ocean, it is connected to the beginning from which it descended.

But since the perpetual tide and flow of the Ocean from East to West, by its continual dashing, could bring some detriment, provident nature has therefore disposed transverse chains of mountains, by which the whole machine of the Earth's mass might acquire a firmer consistency. [Margin: The transverse chains of mountains — which, and for what?] Hence you see, from East to West, beginning from the farthest region of the Chinese, mountains so joined to mountains that what China propagates crosswise, the Imaus continues beyond China westward to Scythia, India, the Caspian Sea, America, Asia Minor, Macedonia, all the way to the Cottian and Rhaetian Alps, by continued mountains conjoins them; and the Alps, through Dauphiné and all of Narbonese Gaul, commit continuous mountains to the Pyrenean Alps, which thence at last extend, in a marvelous order, to the farthest boundary of the West, until they are restored to their own beginning.

But you will perhaps ask why chains of this kind do not appear continued in the Ocean, but at the farthest promontories of the lands seem to break off, as if cut short and interrupted? [Margin: Why chains of this kind do not appear in the Ocean.] I reply: chains of mountains of this kind are not broken off altogether, but are continued beneath the depth of the Ocean in the same order. That they do not rise up, except through the scattered islands emerging here and there in the Ocean — this you may persuade yourself was certainly done by the most sagacious counsel of nature. For since the Ocean perpetually surrounds the globe of the lands with its flow, the element, being of a fluid nature, required as if by a certain right that its paths be free from every obstacle and barrier, and passable on every side. Hence the chains of mountains are not continued by jutting peaks in the Ocean, lest they set an obstacle to the motion of the Ocean and the seas,

Diagram. A hemisphere of the bone-frame [skeleton] of the terrestrial globe, stripped bare of its waters. The figure shows a circular globe whose surface is entirely covered with engraved mountain ranges and ridges, surrounded by a wavy, hatched border representing the encircling waters that have been drawn away. Labels are placed around and across the disk:

- A (top): one terminus of the north–south mountain chain (Arctic Pole).

- B (left): western point of the transverse latitudinal chain.
- D (right): eastern point of the transverse latitudinal chain.
- E (center): the central knot/crossing of the chains.
- C (bottom): the opposite terminus of the north–south chain (Antarctic Pole).
[Letter at lower edge faint — [?]]

Caption (verbatim): *Hemisphaerium Offaturæ Globi Terreni aquis nudata*
("Hemisphere of the bone-frame of the terrestrial globe, stripped of its waters").

and so that they might have a free field for fertilizing the whole Earth with an abundant influx of waters; which would not have happened if the Ocean had been

obstructed by chains of mountains, and had met with paths not free, but inaccessible to its motions and agitations. But lest by its most free and most impetuous motion it should, by its washing, be a detriment to the shores of the terrestrial regions, nature disposed these chains of mountains, so that the swelling storms of the waves, broken against them, might return to the channels destined for them. And since the Ocean also keeps its own laws of flowing, from North to South and the reverse, at appointed times, against this the transverse orders of the mountains are set, so that in this way, without hindrance, nature might perfect her operations in the economy of the terrestrial world. Yet I would not have anyone here suppose that these chains of mountains are coordinated into perfect circles; rather, as the necessity of the lands required, they are composed from time to time, with the fringes of the chains drawn out into the immense spaces of the surrounding regions on either side. But since we are to speak of these things more fully, God granting, in what follows, let these things, said in general only about the mountains, suffice. See the figure set opposite here. In it, the chain of mountains A B C D shows that framework of mountains which, from the Arctic Pole, through the middle of Europe and through Africa, [runs] to the Antarctic Pole, and thence through the Andes of South America is restored to the Northern Pole from which it had been drawn. [Margin: The boundary of the chains of mountains.] But the chain of mountains A E G extends from the Northern Pole, through the middle of Asia and India, to the Southern Pole C, and thence at last, through an unknown submarine framework, is restored to the Northern Pole A. But the chains of mountains extended in latitude, B E G, and the rest parallel to them, mark the transverse framework of the mountains, for the firmer consistency of the whole, for the ends just described.

CAPUT X.

Of the Mountains in Particular, and of their Hidden Architecture for Human Uses.

§ I.

Of the Storehouses or Water-Reservoirs [hydrophylacia] established in Europe.

That the mountains were constituted on the surface of the globe of the lands by nature, not by chance or at random, but by a most sagacious design, the things we are now about to say will abundantly prove. For from these — besides the moisture which by the agency of the mountains it confers upon the whole Earth — it has countless other uses, which we have recounted above. Let us extend our pen to describing those things which, so far as I know, no one before us has yet noticed. And that this may be done as well as possible:

It must be noted, first, that the terrestrial globe was constituted from Pole to Pole in a certain unequal and irregular framework, so that in the central parts of the terrestrial regions it might show itself most admirable; [Margin: The water-reservoir of the Alps, the Rhaetian, etc., and its rivers.] while it interwove, into the heaping-up of the greatest and most immense mountains, certain knots as it were of great chains, both for the firmer consistency and firmness of the whole structure, and for founding, in the blind bowels of the mountains, immense storehouses of waters — from which, as from storehouses, the rivers gushing forth on every side might water the underlying tracts of valleys and plains with a kindly outflow. And that this may be clear to the eyes of the curious reader, I have thought it right to unfold the matter more fully by an enumeration of its parts. [Margin: The boundary of the chains of mountains.]

Storehouses of this kind of nature, in Europe, are in the first place the offspring of the protruding mountains spread far and wide, which they call the Alps. From these, as from a most rich water-reservoir, most abundant outflows of waters are supplied to all the regions of Europe. And they are distinguished by a threefold name: those which look toward Gaul are called the Cottian; those which surround Switzerland [Helvetia], the Rhaetian, with the adjoined Vosges; those finally which face the Adriatic Sea, the Pennine. From this whole complex of the Alps, as from a fertile womb, pour forth great rivers: the Danube, the Rhine, the Inn [Oenus], blessing Germany; the Rhône [Rhodanus], the Saône [Arar], the Meuse [Mosa], the Moselle [Mosella], blessing Gaul and Belgium; while the Po [Padus], the Adige [Athesis], the Mincio [Mincius], the Ticino [Ticinus] bless Italy; and the Sava [Savus] and the Drava [Davus] bless Illyricum, by their watering. From this

not only rivers, but also great and immense lakes have drawn their origin. In Germany, the lakes Acronius [Lake Constance], Lucerinus [Lake Lucerne], Tigurinus [Lake Zurich]; in the region of Gaul and the Insubrian [Lombard] territory, the Lemanus [Lake Geneva] — to say nothing meanwhile of the countless lakes of lesser order. In Italy, in the Cisalpine region, three lakes, which they call the Major [Lago Maggiore], the Comensis [Lake Como] — to the ancients the Larius — and the de la Garda [Lake Garda]. But whence so great an abundance of waters derives its origin, and how it is contained in the storehouses of the mountains, will be shown in its place and time; for in this place it has seemed right to treat only of the disposition of the storehouses, so that, this being explored, we may gradually come to the hidden and secret causes of such great wonders of nature. But let us follow the thread we have begun.

Having recounted, then, the vaulting of the Alps — since it cannot communicate itself in equal measure of waters to each and every surrounding region, lest nature should seem to have shown herself a stepmother to the needs of mortals — therefore it has annexed to itself other orders of mountains, heaped together on every side, with their fringes, as a kind of auxil-

Diagram. A large double-page engraved map plate, the "Geographical Table displaying the Water-Reservoir [hydrophylacium] of Greater Asia, by which all rivers — whether near or far, through hidden winding channels — receive their origin." The plate spans the two-page spread: the western half covers Arabia, Persia, the Persian Gulf, the Indian subcontinent, and the Arabian Sea; the eastern half covers India beyond the Ganges, Indochina, China, Sumatra, Borneo, Java, the Philippines, and the China Sea. The map's design illustrates Kircher's thesis that all the rivers of Asia issue from interior mountain water-reservoirs (the *hydrophylacia*), shown as mountain masses with rivers radiating from them. A compass rose at center marks the orientation (N at top, with W, O [Ost/East], S). The ornate cartouche at lower left, flanked by putti and reclining figures, carries the title.

The verso pages of the plate are blank show-through; no text.

Readable labels (west half — with positions:

- Top center: "La Mer Caspian Hircanum de Sala ou Bachu" [French/Latin: the Caspian Sea, the Hyrcanian (Sea), of Sala or Baku]
- Upper center: "LA PERSE" [French: Persia]
- Upper center, below: "FARS" [the province of Fārs]
- Center, along a river: "Choralan" [Khorāsān]

- Upper right: "Ieselbas" (a place label near the upper-right mountains)
- Right edge, in a mountain mass: "Hydrophylacium prin[cipale] Asiæ" [the principal Water-Reservoir of Asia] [partly cut at the page-join]
- Left: "Arabia deserta" [the Arabian Desert]
- Center-left, along the gulf: "Sinus Persicus" [the Persian Gulf]
- Center (open sea): "MARE ARABICUM" [the Arabian Sea]
- Lower center, along the south edge (open sea): "MARE INDICUM" [the Indian Sea / Ocean] — spaced caps running along the bottom margin (a separate label from MARE ARABICUM, not a continuation of it) [exact extent [?]]
- Right, along a river to the coast: "Indus flu." [the river Indus]
- Right: "India intra Gangem" [India within the Ganges]
- Right edge: "Indostan" [Hindustan] (vertical label along the right margin)
- Lower right, an island with a small inset: the island label reads "Ceyl[on]"; the inset lists, top-to-bottom, "Iaffna / Candea / Patalao / M.deno [?] / Colombi" [Jaffna / Candy / Patalao / ... / Colombo] (the island of Ceylon, partly at the page-join)
- Lower right margin: "Æquator" [the Equator line]
- Numerous unlabeled mountain-clusters (pictographic hill-symbols) are scattered across Arabia, Persia, and the Indian peninsula representing the mountain reservoirs.

Readable labels (east half — with positions:

- Upper left (continuing from west half): "...um principal." [Hydrophylacium principal — the principal Water-Reservoir] (the great mountain mass at the left edge, source of the rivers; gutter-cut at left)
- Upper left: "Chiamai lac." [Lake Chiamai — the legendary lake source of the Indochinese rivers]
- Left of center: "Tolema"
- Upper center: "Sancy" (twice — a region label "Sancy" and a mountain "Sancy")
- Upper center, large: "CHINA" (spread across the upper region as "C H I N A")
- Center: "Quancy"
- Center: "Quichen" / "Cauchin" [Cochin / Cochinchina]
- Center: "Cantam" [Canton / Guangdong]
- Center: "Quancü"

- Left center: "Bengala" [Bengal]
- Left: "India extra Gangem" [India beyond the Ganges]
- Left, along a river: "Ganges flu." [the river Ganges]
- Left edge: "...oltan" [?] [—stan, partial, at page-join]
- Center, along the peninsula: "Iancoma" [Iangoma]
- Center-south: "Camboia" [Cambodia]
- Center (islands): "Manille" [Manila]; "Lucon" [Luzon]
- Right of Luzon: "Les Philippines" [French: the Philippines]
- Right: "L'Archipelage de S. Lazare" [French: the Archipelago of St. Lazarus — the Philippine archipelago]
- Center: "Mindora" [Mindoro]
- Center: "Calamianas" [the Calamian Islands]
- Center-right: "Mindanao"
- Center: "Borneo"
- Center-right: "Mer de l'Anchidol" [French: the Sea of (the) Anchidol — i.e. the sea of the spice/Banda islands]
- Right: "Cele[bes]" [Celebes / Sulawesi] (split "Cele- / bes")
- Lower center: "Sumatra" (vertical, down the island)
- Lower center: "Iava" [Java]
- Upper right (open sea): "OCEANUS CHINENSIS" [the China Sea / Chinese Ocean] (spread as "O C E A N U S / C H I N E N - / S I S")
- Left edge: "Ceylon" (continuing from west half)
- Left margin: "...quator" [the Equator line, continuing]
- Bottom margin, spaced caps: "MARE INDICUM" running along the south edge (the spaced caps D / I / N... along the bottom; exact extent [?])
- Numerous unlabeled mountain-clusters across Indochina, Sumatra, and Borneo representing the mountain reservoirs feeding the rivers.

[The map is the only content on these four pages; there is no body prose. A few residual labels remain partly cut or too fine to resolve at the engraving/gutter limit and are flagged [?] above: the 4th Ceylon-inset line ("M.deno"), the gutter-cut "...oltan" tail, and the exact extent of the spaced MARE INDICUM caps along the bottom margin.]

[Margin: Auxiliary water-reservoirs.]

some auxiliary stores as well. In Germany, the Noric mountains and those that ring Bohemia — the Hercynian range, which faces the north — and Mount

Cottimelabocum [?]; in Gaul, the Vosges, the Auvergne mountains [Alverni], and the remnants of the Cottian Alps, the Dauphiné [Delphinatus] mountains; in Italy, the great skeleton of the Apennines, packed together with countless peaks like a kind of spine made of the ribs of the back. So it is that in Germany the mountains cited above feed yet another brood of rivers — namely the Main [Moenus], the Elbe [Albis], the Moldau [Moldava], and the Ems [Amasus]; in Gaul the Loire [Ligurim], the Seine [Sequana], the Durance [Druentia], and the Var [Varus]; in Italy the Arno [Arnus], the Tiber [Tyberis], the Aniene [Anien], the Liri [Lyris], and the Volturno [Vulturnus]. By these the whole of Italy, Gaul, and Germany are watered with a fertile outpouring.

And so that the outlying regions of Europe should not be left without the nourishment of moisture owed to them, nature set up new storehouses and reservoirs. Between Spain and Gaul she placed the Alps, that is, the Pyrenees mountains; between Germany on one side and Poland and Hungary on the other, the Carpathian mountains.

[Margin: The Pyrenees mountains.]

[Margin: The Carpathian mountains.]

[Margin: Rivers of Spain.]

[Margin: Rivers of Poland and Hungary.]

From the first of these — that is, from the folds of the Pyrenees, the mountains of Castile — Gaul receives the Garonne [Garumna], while in Spain they pour forth the rivers Ebro [Iberus], Douro [Durius], Tagus [Tagus], Guadalquivir [Betis], and Guadiana [Guadiana]. From the Carpathians, in Poland they yield the Vistula [Vistula], in Hungary the Tisza [Tibiscus], in Germany the Oder [Odera], and countless other rivers besides, with which those regions teem.

Thus, once these three reservoirs of nature have been put in place by the world's Founder, the whole of Europe is blessed with the highest and inexpressible benefits.

Diagram. An engraved geographic map plate occupying the upper part of the page, depicting the central-European water-reservoir within the Rhetian Alps. A cartouche at the upper right carries the title. At center rises a prominent mountain mass (the Rhetian Alps / the principal reservoir), drawn as a great peaked massif from which rivers radiate. The four cardinal regions are labelled, with mountain ranges drawn as rows of small conical hills and rivers as winding lines. The map is bordered top, bottom, and sides; seas are named along the lower

margin. [Several toponyms are small and partly faint — flagged individually below; this plate]

- Cartouche (upper right): "TYPUS HYDROPHYLACY [recte: HYDROPHYLACII] intra Alpes Reticas, quod fundit totius Europae Celeberrima Flumina; uti patet." — "Representation of the principal water-reservoir within the Rhetian Alps, which pours forth the most celebrated rivers of all Europe, as is evident."
- "GALLIA" (upper left): Gaul / France
- "GERMANIA" (upper right area): Germany
- "ITALIA" (lower center): Italy
- "DALMATIA" (right margin, vertical): Dalmatia
- "Aveonia" (upper left)
- "Lyon" (left): Lyon
- "Geneva" (left): Geneva
- "Leman" (left): Lake Geneva [Lac Léman]
- "Helvetia" (center-left): Switzerland
- "Confluens" (upper center): Koblenz [the confluence of Rhine and Moselle]
- "Moenus flu." (upper center): the Main river
- "Moguntium" (upper center): Mainz
- "Acco mons" (upper center)
- "Alpes Rheticae" (center): the Rhetian Alps
- "Passau" (right): Passau
- "Danubius flu." (right): the Danube river
- "Dravus flu." (right): the Drava river
- "Savus flu." (right): the Sava river
- "Ti[b]ianus mons" (right margin, vertical)
- "Avenio" (left): Avignon
- "Arles" (left): Arles
- "Druentia" (left): the Durance river
- "Rhodanus flu." (left margin, vertical): the Rhône river
- "Alpes Cottiae" (left center): the Cottian Alps
- "Alpes Penninae" (right center): the Pennine Alps
- "Lago Magior" (center): Lake Maggiore
- "Lago di Garda" (center): Lake Garda
- "Pedemontium" (center): Piedmont

- "Padus flu." (center): the Po river
- "Parma" (lower center): Parma
- "Padus flu." (lower center): the Po river
- "Varus flu." (lower center): the Var river
- "Marsilia" (lower left): Marseille
- "Nizza" (lower center): Nice
- "Mare Gallicum" (lower left): the Gallic Sea (Gulf of Lion)
- "Mare Adriaticum" (lower right): the Adriatic Sea

[The body text resumes below the plate. Note: the opening clause of this column ("...some auxiliary stores as well...") and the marginal "Auxiliary water-reservoirs" are printed *above* the plate at the head of the page; the catalog of mountain ranges continues immediately beneath it.]

§. II.

On the Storehouses of Nature, or Water-reservoirs, established in Asia.

[Margin: The water-reservoirs of Asia.]

Nature proceeded in Asia along the very same plan she had followed in setting up Europe's mountain storehouses; indeed, in laying out the mountains, Nature gave free play to her art. For it is established from the science of geography that the central length of the whole of Asia is spanned by continuous chains of mountains, stretching from the Thracian dawn-star of the West [the Bosphorus] all the way to the farthest boundary of the East, and that these chains, as it were, divide off northern Asia — that is, Scythia or Tartary — from southern India. These mountain masses, according to their varying location, have received various names: some designate them under the names of Taurus and Antitaurus; some under that of Caucasus; others again under those of Imaus [Himalaya] and Paropanisus [the Paropamisus / Hindu Kush]. Be that as it may, our business is not with names but with the things themselves.

It is certain that these mountains, converging in the very midst of all Asia, form an immense mass of the highest mountains, which we accordingly assert to be the principal water-reservoir of all Asia. For from it she belches out vast rivers into every part of Asia: toward the south,

the Indus and the Ganges, by which the whole Indian nation is abundantly watered; toward the east, the many immense rivers of the kingdom of China

[Sinae]; toward the north, the Rha [the Volga] and the Ob [Obin]; and toward the west, finally, the most distinguished rivers — the Oxus [Amu Darya], the Jaxartes [Syr Darya], and the Hydaspes [Jhelum] — besides the countless and enormous lakes which she produces, as the map appended here clearly shows.

But since Asia extends over too long a tract for the central reservoir to reach every region scattered far and wide, it has distributed its wealth through the commerce of the subterranean realms in such a way that no one region can boast of having received more than another. For Taurus and Antitaurus enrich Asia Minor with the most fertile rivers; Greece they water with rivers poured forth from the Acroceraunian mountains, from Athos, Olympus, Pelion, Ossa, and the rest.

[Margin: The more celebrated mountains and rivers of Asia.]

Armenia, Persia, and Babylonia they water with the most famous rivers — the Euphrates [Euphrates], the Tigris [Tigris], the Derbi [?], and the others which for brevity's sake I pass over — fed by the Gordyaeon mountains, or Ararat, and the Caspian mountains. These, linked to Taurus and Caucasus in the west, finally toward the east are grafted, like so many separate branches, into their own common trunk, the heap of mountains just described. In the farthest corner of the north, too, the Hyperborean and Rhiphaean mountains have their own water-reservoirs, from which the vastest rivers — the Borysthenes [Dnieper], the Volga, and the Tanais [Don] — pour out to water Russia and Tartary abundantly. Of these and their noteworthy features I shall treat more fully in their proper place.

§. III.

On the Water-reservoirs, or Storehouses of the Mountains, established in Africa.

Since Africa is for the most part exposed to the heat of the Torrid Zone, and therefore suffers from extreme drought, nature, providing against this evil, set up a vast water-reservoir in the middle of it — the mountains they call the Mountains of the Moon [Montes Lunae]. This is an immense mass of mountains, which pours out countless rivers far and wide on every side, as if from fertile udders.

[Margin: The river Zaire.]

[Margin: The river Niger.]

From these, in the first place, the Nile — the most celebrated of all the rivers of the world — draws its origin; and after long and unknown wanderings, finally hurled down over cataracts, it is discharged, to Egypt's supreme good fortune, into the Mediterranean Sea, weighed down by the greatest mass of water. From this same source the Zaire [Congo] makes for the west, and licking past various regions of as-yet-unexplored extent, it mingles at last with the Atlantic Ocean. Rising not far from it, the Niger, undergoing various turns of fortune — now swallowed up in the gulfs of the earth, now disgorged again — empties at an equal pace into the Ocean just mentioned. From the south it belches out the Cuama [Zambezi] and other rivers transformed into names of a foreign tongue, rivers that for their vastness can be compared with the sea itself; and all of these the Southern Ocean receives.

And lest the deserts of Nubia and Libya should perish from the heat, nature so arranged the mountains of Atlas, chained together toward the east, that — just as moisture is distributed from the head through all the members of the body — so it should be aptly distributed from Atlas through the rest of the mountains' inner parts, to come to the aid of laboring nature.

Now the reservoirs, as it were the casks of these waters, are two lakes: Zambre and Zaire. The latter of these I should not be wrong to call an offspring of the former, the Zambre — each so swollen with such an abundance of water that they seem to belch out not rivers but seas; above all Lake Zambre, which, set as it were at the center and diffused into the broadest rivers, supplies the most abundant outpourings of water to every part of the world, as from a richly endowed vein.

[Margin: The great rivers of Southern Africa.]

To the north it supplies the Nile; to the east the great rivers Cuama [Zambezi] and Coavo [?], the Zeila, and the Manhice or Manhensen [?]; to the south and west, finally, the Zaire — and these rivers, watering the whole western tract of Southern Africa, the kingdoms of Congo, Angola, Monomotapa, Matama, Dagamidri [?], and Agisymba [?], all the way to the Cape of Good Hope, free it from sterility with their fertile silt. Those others water the whole interior region of the Abyssinians, and all those regions which the maritime coast marks off from the mouth of the Red Sea [Mare Erythraeum] to the mouth of the Cuama — which are Melinde, Barnagassus, Quiloa [Kilwa], Mombasa, Mozimba, Mombara, Membaca, Mozambique, and other such prodigies of kingdoms.

But so that we may set down here a noteworthy piece of history, and so that the truth — sought after for so many ages — may at last become known, I shall attempt to reveal who are the true sources of the Nile.

[Margin: The false account of the Nile's origin.]

We said elsewhere that Odoardo Lopez [Duarte Lopes] had, above the rest, devoted himself to the discovery of the Nile's origin, and had striven for this one thing: to assign the Nile's true sources. But neither was Odoardo an inspector of the Nile's true wellspring, nor is his account sufficiently in accord with the facts. Truer things, therefore, must be brought forward by us on so notable a subject. At the very time, then, when this most intricate and exceedingly perplexing business held me fast, Father Francesco Caravaglio [?], procurator of the Indies and Ethiopia, landed here at Rome; and being instructed by him in the truth through the manuscript of Father Pedro Páez [Petrus Paez], I have chosen to set the same down here for posterity, so that the truth may at last, after so many and such great fabrications and futile conjectures of the gravest authors, be restored to its own brightness.

The matter stands thus: The province where the Nile rises is called Agaos [Agaw], near the kingdom of Gojjam [Goiam]. The land in which it rises is called Sahala [Sabala]; it lies on the summit of a mountain, on a plain surrounded on every side by trees.

[Margin: Description of the Nile.]

The diameter of the spring is one and a half feet wide; its bottom cannot be sounded; it does not overflow at the margin, but opens an outlet for itself at the foot of the mountain. There, as soon as it has emerged from the bowels of the mountain, it spreads out into the light; then, swelled by further rivers, it at last empties into a lake thirty leagues in length and fourteen in breadth. From this, when it emerges again, through long...

Diagram. The left-hand (verso) leaf of the double-page Africa water-reservoir map plate. As bound, the printed sheet has come through very faint — most of the engraved detail (coastline, river network, hill ranges) is present only as a pale ghost impression, with the page largely blank. The recto column of this leaf carries running text of the Nile description together with its marginal labels (transcribed above and below). No engraved toponyms are legibly resolvable on this faint verso half. [This faint plate half]

[Margin: 73]

[Margin: Places situated around the source of the Nile.]

[Margin: The course of the Nile from its first origin.]

[Margin: Lake Bed [?], through which it passes.]

[Margin: Between the two rocks, the cataract.]

Diagram. The right-hand (recto) leaf of the double-page Africa water-reservoir map plate. The left third shows the Atlantic coast of west-central Africa, the open ocean inscribed "OCEANUS ÆTHIOPICUS" in large spaced display capitals; the right portion shows the interior, the Mountains of the Moon, the Nile-source lakes, and the radiating river network. An elaborate engraved cartouche at the bottom, framed by cherubs, putti, a reclining river-god, and a globe, carries the title. Several interior labels run off the right edge of this leaf (continuing onto the missing/faint conjoint half).

- Cartouche (bottom): "Hydrophilacium [recte: Hydrophylacium] AFRICAE praecipuum, in Montibus Lunae Situm, Lacus et Flumina praecipua fundens, ubi et nova inventio Originis Nili describitur." — "The principal water-reservoir of Africa, situated in the Mountains of the Moon, pouring forth the chief lakes and rivers; where also the new discovery of the Nile's origin is depicted."
- "OCEANUS" / "ÆTHIOPICUS" (left, large display): the Ethiopic Ocean (South Atlantic)
- "CONGO" (upper center): Congo
- "ANGOLA" (center, vertical along coast): Angola
- "Batta" (upper center): Batta
- "dictae Agisimba" (upper right): "called Agisymba"
- "Zaire flu." (upper center): the Zaire (Congo) river
- "Malemba" (upper right): Malemba
- "Les peuples Bagamidre [Bagamidri]" (upper right) [French label]: "the peoples of Bagamidri"
- "Matama" (upper right): Matama
- "Baiadas" (left center): Baiadas
- "Base Desert" (center): the Lower Desert / Base Desert
- "Lac" (center): lake [Lac]
- "Lac Bea[...] [?]" (center right): lake [name cut at the engraved margin]
- "Origine del Nilo" (center, along a river): "source of the Nile"
- "Hydrophilacium [Hydrophylacium]" (center right): water-reservoir

- "MONOMOTAPA" (right margin, large vertical display capitals dispersed down the leaf edge): Monomotapa

[Several interior toponyms on this plate are small, faint, or cut by the leaf edge — flagged [?] above. This plate]

Diagram. This is the recto (right-hand) half of the double-page engraved map of Africa whose left half appeared on the preceding plate. It shows the southeastern coast of Africa, the western Indian Ocean, and the island of Madagascar, with a wind-rose compass at upper right (N–O–S–W, i.e. North–East–South–West in the Dutch/Latin convention where "O" = *Oost*/East). The far left edge carries over from the verso half the river-and-lake network feeding out of the Mountains of the Moon. The ocean below is lettered in large engraved capitals OCEANUS ORIENTALIS [the Eastern (Indian) Ocean].

Readable labels (left to right, top to bottom):

- Upper left (cartouche text): "Hydrophylacia Æthiopiæ aperta quæ cum alio in montibus Lunæ communicans per subterraneos meatus" [The open water-reservoirs of Ethiopia, which communicate with another in the Mountains of the Moon through subterranean passages]
- Upper right corner: "Tomus I. 72" [Volume I, p. 72 — plate-keyed page reference]
- Far left, upper: "le Lac de Zaire" [the Lake of Zaire — French label]
- Far left, below it: "le Lac de Zembre" [the Lake of Zembre/Zambere — French label]
- Far left: "Sebsan" [?]
- Far left, lower: "Nilus" [the Nile]
- Left of center: "Montes Lunæ" [the Mountains of the Moon]
- Center-left: "Zofala" [Sofala]
- Center: "Mozambique" [Mozambique]
- Center, river label: "S. Spiritus flu." [the Holy Spirit River]
- Center, river label: "Cuama flu." [the Cuama River — i.e. the Zambezi]
- Vertical engraved label down the coast: "CAFRES" [the land of the Kaffirs / Cafraria]
- Lower left, mountain label: "[...]m sub Montibus Lunæ" [?] [(reservoir?) beneath the Mountains of the Moon]
- Lower left: "Buro mina de Oro" [Buro, gold mine — Portuguese]
- Lower left: "Rio del Spirito Santo" [the Holy Spirit River — Spanish]

- Lower left, vertical engraved: "CAFRA[...]" / "...TA" [Cafraria — coast labels, partly off the plate edge]
- Large island at right (unlabeled but clearly Madagascar), surrounded by numerous small islets (the Comoros / Mascarene scatter)
- Large engraved ocean legend: "OCEANUS ORIENTALIS" [the Eastern Ocean]

[Several small interior labels are too faint to resolve at this resolution]

Diagram. This is the verso (back) of the engraved map plate; the page is essentially blank apart from heavy bleed-through of the recto image and a marginal index list set in the left column. The marginal text appears to head a key of "the more celebrated Mountains and Rivers of Asia" [*Montes & Flumina celebriora Asiae*], evidently the legend belonging to a following Asia map, with only fragments of the entries legible through the show-through.

Readable marginal labels:

- "Montes & Flumina celebriora Asiæ" [The more celebrated Mountains and Rivers of Asia — index heading]
- "Fl. Zaire" [the Zaire River]
- "Fl. Niger" [the Niger River]

[The bulk of this column is an index of single initial letters and truncated words obscured by bleed-through and the binding gutter — not recoverable at this resolution.] ...it spirals through the windings of its meanders and comes round again to nearly the same place from which it had set out — that is, back to its spring. Then, its course reversed, it slips straight down over vast precipices and pathless rocks and turns aside into the interior of Ethiopia. All of this is confirmed by the eyewitness testimony of Father Pedro Páez, a priest of our Society, who surveyed this source of the Nile in company with the Emperor of Ethiopia — both of them spurred at once by curiosity and by love of the truth, and escorted by a large army. And since Father Pedro Páez treated with the greatest diligence whatever he observed of this matter, in a vast manuscript work on Ethiopian affairs, I shall set down here his own words translated from the Portuguese into Latin, so that the truth may shine out the more clearly. He speaks thus:

[Margin: An account of the origin of the Nile, by Father Pedro Páez.]

"After we had treated of the fertility of the lands under the dominion of Prester John, I judged it would be worth my while if in this place I were to relate something about the chief rivers and lakes of the territories subject to his empire.

Among these, the first to present itself is that greatest and most celebrated of rivers in all the world, the Nile — which was held in admiration not only among the ancient and the modern authorities, the gravest of writers, but of which Sacred Scripture too makes frequent mention. In Genesis 2 [Gen. 2:13] it is called Gihon, one of the four rivers watering Paradise. Today it is called by the Ethiopians Abawi. It takes its origin in the Kingdom of Gojjam, in a single district called Sahala, whose inhabitants are called the Agaw — and they are Christians, though, the Church having grown wild over the lapse of time, they are steeped in and corrupted by various superstitions, and differ little from the heathen and pagans round about them.

[Margin: A description of the Nile and its origin, newly discovered.]

"The source of the Nile lies in the western part of the Kingdom of Gojjam, on the summit of a single valley which resembles a vast plain, ringed about on every side by mountain ridges. In the year 1618, on the 21st day of the month of April, while I was staying in this kingdom together with the Emperor and his army, I climbed up to this place and surveyed everything carefully. I found first of all two round springs there, each about four palms wide in diameter, and with the utmost delight of my soul I saw what neither Cyrus, King of the Persians, nor Cambyses, nor Alexander the Great, nor that famous Julius Caesar could attain for all their wishing.

[Margin: The site of the place where the Nile rises.]

"The water of this spring is exceedingly clear and exceedingly light, and very pleasant to the taste. Yet one should know that these two eyes of the spring do not have their outlet at the top of the mountain's level surface, but at the mountain's foot. We also sounded the depth of the springs. Into the first we let down a lance, which on going in seemed at about eleven palms to touch certain root-like fibers of nearby trees interwoven with one another.

[Margin: The depth of the spring.]

"The second spring wells up about a stone's throw to the east of the first. Probing its depth, we sent down a lance of twelve palms and found no bottom; and when we had tied together two lances of twenty palms and tried the thing again, not even so could we reach bottom. The local people say the whole mountain is full of water — and they gave this as a sign of it, that the entire plain around the spring was trembling and boiling, a plain proof of the water lurking beneath. For the same reason the water does not well up at the spring itself, but discharges itself at the mountain's foot with the greatest force. The inhabitants affirmed — as did the

Emperor himself, who was present together with his army — that in that year the ground had trembled but little, on account of the great drought of the season, but in other years it trembles and boils so violently that one can scarcely approach without danger. The circuit of the place is like that of a certain round lake, whose breadth a sling could span.

[Margin: Of the places lying about the source of the Nile.]

"Below the peak of this mountain a population lives on the mountainside, about one league distant from the spring, toward the west; the place is called Guix, and the spring seems to be reachable from here. In this place is a settlement of heathens, who sacrifice many cows, and come to the springs on a fixed day of the year together with their priestling, whom they hold for a priest, who there sacrifices one cow beside the spring, and throws the severed head of the cow into the abyss of the spring."

[The narrative now reverts to Páez's original Portuguese for several clauses, which Kircher prints verbatim alongside the Latin:]

[Portuguese, as printed: "...e lago hia prima a qual buo, onde faciam solenne sacrificio matando muitas vaccas, que os gentios, d'hi tracion, & depois se cubria todo como sevo dellas, e se asentava en un Cadeira de ferro, que tinha posta nomo (= em cima) de muita lenha seca, e mandava sem se queimar nem ainda derreter-se o sevo, e algumas vezes etravan (= entravam) depois da fogo aceso, e se asentava à questa gente de maneira, che con estas feiticerias enganava àquella gente de maneira, que o tinham por grande Santo, che davam questo fato queria." — "...and then he would first [enter] the lake, where they performed a solemn sacrifice, killing many cows, which the heathens brought there; and afterward he covered himself all over with the cows' tallow, and seated himself on an iron chair that he had set up on top of a great heap of dry firewood, and gave the order [for it to be lit] — yet without his being burned, nor even the tallow melting; and sometimes they went in afterward, the fire being kindled. And he made himself agreeable to these people in such a way that, by these sorceries, he so deceived that people that they held him for a great saint, who could grant whatever he wished." — Páez's text drifts between Portuguese, Spanish, and Italian forms; the gloss follows the sense.]

[Margin: The field about the source of the Nile.]

"Furthermore, the Field of the Nile's source is on every side difficult of ascent, except on the northern side, where one climbs up easily. Below the mountain, about one Nile-league away [*una leuca Niliacâ*], in a certain very deep valley,

another river emerges from the bowels of the earth, which nonetheless joins itself to the Nile a little later — for which reason they believe it shares the same source-spring with the Nile, but, conducted beneath the earth through hidden channels, first breaks out at this spot. But the stream of the source, which breaks out below the mountain, runs eastward for the space of a musket-shot; then, turning suddenly, it makes for the north, and after about a quarter of a league a second stream offers itself, bubbling up out of rocks and crags. A little later two other streams join it, breaking out from the eastern quarter; and so, as further streams are gathered in one after another, the Nile grows notably.

"After the space of a day's journey it joins a great river called Yama [the Jamma], which then bends westward for about thirty-five leagues from its own first source, and afterward, its course changed, makes again for the east, insinuating itself into one vast lake.

[Margin: It crosses Lake Bed.]

(This lake is situated in the province called Bed, and lies partly under the Kingdom of Gojjam, partly under the Kingdom of Dambea [Dembea / Lake Tana].) The Nile so passes through this lake that its waters show a notable difference from the waters of the lake; and the whole river keeps its own course and current unmingled with the marsh-waters. As soon as it leaves the lake, swerving through various windings toward the south, it waters the land at a place named Alata, five leagues distant from the lake's outlet [*ab epistomio lacus*], where, hurled down over a cliff fourteen cubits high amid an immense roar and crash of falling water — which from a distance looked to me like a mist — it is, a little after the plunge, so swallowed up between two great rocks that it could scarcely be made out with the eyes.

[Margin: Between two rocks. A roofed-over crossing.]

The summits of the said rocks are so [near to one another] that the Emperor several times, with his whole army, has crossed over them by a bridge laid across — at all of which I myself was present.

"After this, on the eastern side, when it had watered far and wide the kingdom of Begemder [Begamidri], Gojjam, and the other intervening kingdoms — Amhara, Olaca [Walaqa?], Xaoa [Shewa], and Damot — it presently returns by its flow to the Kingdom of Gojjam; and when it has watered the territories of Bizan and Gumancanta, it so gradually approaches the Kingdom of Gojjam again that it is found to be no more than a single day's journey from its own source. From here, twisting its course back toward Fazolo and Ombarea — a kingdom of heathens

which in the year 1613 the *Exaz* [Ras] Selachristos [Se'ela Krestos], the Emperor's brother, had subdued with a great army; and being a kingdom hitherto unknown, he called it, on account of its vastness, *Ayzola*, that is, the New World — from here, inclining from east to north, it slips down through countless other regions and the vastest precipices into Egypt, and from there empties itself into the Mediterranean Sea."

And this is the description of the source of the Nile and of its course, which the aforesaid Father Pedro Páez observed with such care, and recorded with such great diligence, with his own eyes, together with the Emperor of the Abyssinians, in the year 1618 on the 21st of April — so that by this so distinguished and eyewitness examination of his he freed the republic of letters from many tangles and doubts. And I should hold that one must henceforth rely on him alone, since now, by the Emperor's approved testimony, the source of the Nile has attained its own infallible certainty. But lest anything seem to be wanting to this work, I have judged that a chorographic map ought to be added here, which you may see in Volume I of the *Oedipus*, in the chapter "On the Origin of the Nile" [*Oedipus Aegyptiacus*, tom. I, "Cap. de Origine Nili"].

Since this account states that two springs appear within ground that trembles on every side, it is likely that once a great part of this field which we have described was held in an open spring, as it were within the crater of a mountain; and that, over the lapse of time, as grasses and shrubbery grew up matted with mud, it drew over itself a kind of skin — of which sort I recall having seen myself in various places of Europe too. If that skin were drawn aside, I should not doubt that the whole trembling plain would soon reveal the face of the primeval spring. But let this suffice concerning the origin of the Nile.

[Margin: A chorography of the source of the Nile.]

§. IV.

Of the water-reservoirs of the mountains of America.

[Margin: The Andes mountains.]

Inasmuch as America lies for the most part under the Torrid Zone, provident Nature, beyond all other regions, willed to endow it with the richest water-reservoirs of mountains — of all the mountains beheld in the whole globe of the Earth, the highest. Of this sort are the mountains they call the Andes, which, by various ranges of other mountains converging into one, make up that most opulent storehouse of waters which they call Narags [Naragua / the Andean

reservoir], hemmed in by innumerable mountains in the middle region between Cuzco, Quito, and Lima. From here, chained together toward the south, the mountains extend through an immense tract of land — which the Spaniards therefore call the *Cordillera* — to the Strait of Magellan, the last bound of the habitable Earth. Toward the north, on the other hand, by the Isthmus of Panama they are joined to the mountains of New Spain, continued on into unknown coasts of the lands.

This reservoir of the Andes, then, pours forth so great a multitude both of lakes and of rivers that, whether you look to their number or to their size, none in the whole world — neither lakes nor rivers — can be compared with them. Of these the first is the Amazon [*Amazonius*], commonly the *Río de las Amazonas*, which, drawing its origin not far from Quito, crosses the whole breadth of America in a straight line, until — swollen by the association of countless other rivers — it discharges into the Northern Sea by a mouth, as it is written, seventy leagues wide.

[Margin: The Río de las Amazonas.]

The second, the Marañón [*Maragnon*], yielding nothing to the first, which is led out from the same already-mentioned reservoir of the Andes, washing countless regions of the unexplored interior of America, is rendered to the Brazilian Sea with such force that it furnishes sailors a supply of fresh water as much as ten leagues out within the Ocean — a rival, in its rise and fall, of the very Nile.

[Margin: The Marañón.]

There succeeds the Januarius [the January River], commonly the *Río de la Plata*, which, swollen from the inmost womb of the Andes by the confluence of rivers, is at last deposited within the Ocean alongside Paraguay and Brazil. Toward the north, on the other hand, it makes fruitful the New Kingdom [of Granada] with great rivers, one of which they name from St. Mary Magdalene [the Magdalena], the other from St. Martha [the Santa Marta].

[Margin: The Río de la Plata. The St. Martha River.]

It supplies also the most vast lake of the whole world, which some call Paraima, others Titicaca, enriched by the accession of twelve rivers. I shall not here recall the rivers beyond number — all of them fit for bearing ships — which, toward the west, it rolls out into the Southern Sea (commonly *del Sur*), along the region both of Lima and of the kingdom of Chile; of the nature and hidden properties of all of which fuller matter for discussion will be given in its own place. Father Alonso

d'Ovalle [Alonso de Ovalle], a Chilean, in his history narrates things scarcely credible about the marvelous constitution of these mountains. For from north to south they extend for fifteen hundred [1500] Spanish leagues; in height and length they far surpass all the mountain-chains in the whole globe of the Earth.

And it is in these that we place that immense water-reservoir which, just as it is perpetually filled — by the alternating motions of the tides — from the surrounding Eastern and Western Oceans by which it is hemmed in, so likewise pours out the mass of waters entrusted to it through the greatest rivers and lakes of the whole world. And in the Kingdom of Chile alone it discharges into the neighboring Pacific Sea, over a space of thirty or forty leagues (the distance of the Andes from the sea), as many as 246 rivers — most of them fit for bearing cargo, some hot like thermal baths, some cold, and various ones tainted with the juices of minerals.

Moreover, among the rest of Nature's prodigies, this surpasses all wonder: that in those same mountains, teeming with so great a mass of waters, Nature has besides [set] 14 volcanic mountains — which all, by their belching of flames and their outpouring of fiery torrents, have more than once laid the Kingdom of Chile in utmost desolation...

(into desolation) — joined them in a kind of unsociable, almost forced, marriage. But I have treated these matters more fully elsewhere. In North America, by contrast, nature played out the same providence: she enclosed other seedbeds of waters within vast mountains, so that the whole expanse of the New World might be watered by its most abundant rivers. From everything that has been brought forward, it is plainly evident that the mountains were established—this being their chief purpose—by nature for the fertilizing of the earth through the streams and the offspring of rivers they put out. But just how these water-reservoirs [hydrophylacia] of nature never fail in their perpetual flow will be explained in its proper place.

CAPUT XI.

On Fire-Belching, or Volcanic, Mountains [De Ignivomis seu Vulcaniis montibus]

We have seen nature's water-reservoirs [hydrophylacia] set in place for the good of the Geocosm. Now let us follow, step for step, the fire-reservoirs [pyrophylacia] —that is, the storehouses of fire.

It is certain that if the moist element alone ruled the Earth, the terrestrial body would perish, overwhelmed by a flood of moisture. It is equally certain that if the fiery element alone, enclosed within the Earth, exercised its power, all things would be reduced to a wasteland. [Margin: The necessity of subterranean fire.] Since nature understood this, she fittingly bound the watery element to the fiery, so that—chained together by the laws of a friendly marriage—neither could carry on its operations without the other. This marvel of nature shines out above all in our Geocosm. Nature had established various storehouses of waters enclosed within the highest mountains, as the preceding chapter showed. But because she could not bring forth her hidden offspring without the midwifing hand of fire and its warmth, she therefore distributed, throughout the whole surface of the globe and within the bowels of the loftiest mountains, various receptacles of fire. By this innate and primal warmth she could more easily bring living animation to the earthy and watery elements and accomplish the generation of things. [Margin: Subterranean water would freeze without fire.] For lest the water hidden within the secret and inaccessible recesses of the mountains should stiffen and freeze, the dissolving action of a friendly warmth was needed—both to raise the necessary vapors and exhalations, and to bring forth the offspring once conceived. But fire, since it cannot subsist without nourishment, lives on no other food than moisture. In this way, within the bowels of the Earth, fire and water strike the bonds of a mutual exchange. And because fire, wonderfully eager for freedom, cannot endure without the free fostering of air, provident nature set the highest mountains as so many boundary points, so that through them, as if through breathing-vents, the air might be drawn in and continually nourish the fire-reservoirs with so welcome a guest; and so that through these mountain chasms the fire might unburden itself, as through a sewer, of its surplus mass of smoke and dregs. [Margin: The flaming mountains are the breathing-vents of the subterranean fire-reservoirs.]

Of such furnaces—besides several others—five in particular are established in Europe. [Margin: The volcanoes of Europe.] Etna in Sicily, the most celebrated in the records of every writer; Vesuvius in Campania; Strongylus [Stromboli] and certain others among the Lipari Islands, especially the one designated by the name of Vulcan—all of which I traversed and examined in the year 1638. In the far north is Mount Hecla in Iceland; in Greece, the Chimaera. [Margin: The volcanoes of Greece.] In Asia, Persia has several volcanic mountains, and there is one on the island of Hormuz [Armuzia]. [Margin: The volcanoes of Persia in Asia.] In the empire of the Mogul, on the island of Ceylon [Zeilanum], there is a mountain marked with the name of Adam; but most of all in the Moluccas and the Philippines, the Banda Islands, the Moluccas, and in both Javas, nature has

established such reservoirs of fire within the bowels of the highest mountains. [Margin: The volcanoes on various islands.] Among these, in the Banda Islands, the foremost is Mount Gourapi [Gunung Api]; Mount Balaluanus [Berapi?] [?] in Sumatra; an exceedingly steep mountain on the island of Ternate, in whose summit there is a crater with a vast opening, which—divided into several greater and lesser circles—presents the form of an amphitheater. In the Mauritius Islands [Mauricis Insulis], Mount Tola; in Tandaia, near the Cape of the Holy Spirit, several are found, as also on the island of Marindica. Moreover, in Japan there is no small number of these mountains near Firando [Hirado] and Tanexuma [Tanegashima], and scattered here and there about the neighboring islands. [Margin: The volcanoes of Japan.] Such volcanic workshops are gazed upon with the greatest wonder by travelers; these, conducting their hidden traffic through subterranean passages in the islands of the Archipelago of St. Lazarus toward New Guinea and the islands they call the Solomon Islands, discharge it through new openings in the mountains, then displayed afterward upon other islands of the Pacific Sea.

Yet no part of the world displays more celebrated volcanic workshops than America. [Margin: Chile abounds in volcanic mountains.] In the kingdom of Chile alone, fourteen are counted in a row; in Peru no fewer, all of which the continuous ridge-summits of the Andes display. In New Spain three are counted, fearsome for their belching of fire. Nor is the farthest northern tract destitute of its fire-storehouses: of these, authors count four in the region of the Tinguise [Tynseorum] in Tartary—to say nothing for now of the volcanoes of Greenland [Grunlandia], and others on the neighboring islands or continents lying about the Pole, which extend even into the land popularly called *del Fuego*, "of Fire," along unknown gulfs—so that many think the Antarctic region inaccessible at the Pole because of the multitude of fire-belching mountains. But of these we shall speak more fully in what follows.

Now as to why the nature of things shut up these fires within the bowels of the highest mountains: the first cause is that from the loftiest places, as through [Margin: Why nature established the flaming mountains.]

certain lofty chimneys, the hidden element might find breathing-vents through which to relieve itself of the surplus burdens of pressing nature. The second is this: were it to discharge such an office of suffering nature in the lower-lying places of the regions, it would bring upon all the surrounding districts—through ashes, smoke, the waste-matter of tufa, and pernicious and deadly exhalations—the utter ruin of the fields and of living creatures. This does not happen on the

inaccessible ridges of the lofty mountains, since the refuse and ashes are either deposited in the precipices of the mountains, or the deadly smoke and vapor is dissolved into the higher air and scattered elsewhere by the winds. And so for no other purpose has nature banished such mountains either to the sea or to islands separated from the continent: lest in the heart of the mainland they should bring inevitable slaughter on all the surrounding peoples.

But perhaps you will ask: why has nature not everywhere joined to her water-reservoirs these mountains, so necessary for the conservation of the waters? I answer: since such mountains are nothing other than breathing-vents through which the fiery element purges itself; and since it draws in through them the air necessary for its own preservation—it does not follow that they should be joined to the water-reservoirs by swelling waters. [Margin: The channels of subterranean fire run throughout the body of the Earth.] For the passages of these mountains, propagated through the whole bowels of the Earth, correspond with nearly all the other mountains through the hidden laws of nature, so that the Earth may nowhere be deprived of so necessary a warmth—as the innumerable boilings-up of hot waters, conspicuous in every region, abundantly and more than sufficiently demonstrate. These would never continue their effect unless the hidden power of the fiery element, stored away in the bowels of the Earth, urged this warmth on in a perpetual flow.

But you will object: two contraries, such as fire and water, cannot subsist in the same place. [Margin: Objection.] I answer: they do not inhere in the same subject, but the fiery store-chambers, separated from the watery ones, act upon one another through the hidden siphons of the Earth and the mountains, fostering each other by a secret bond of friendship, and in this way nature attains the effects she intends. But since we shall, God granting, dispute about these matters most fully in what follows, I have chosen not to be longer here. From all this it is evident that from these elements of water and fire, established within the bowels of the Earth, the generation of all things and of mixed bodies is constituted—as will be set forth in order.

CAPUT XII.

Whether Mountains Decrease over Time, or Grow Again Anew; and on the Marvelous Transformation of the Earth's Parts [Utrum Montes cum tempore decrescant, aut denuo accrescant, & de mira Terrestrium partium transformatione]

Experience of every age teaches that the Earth suffers its own diseases and alterations, arising from the various disorders of its inner economy. [Margin: 1.1. Meteor.] For since—as Aristotle rightly says—the inner parts of the Earth have their youth and old age just as the bodies of animals and plants do, we may rightly conclude that the Globe of the Earth does not persist, either in its inner or its outer parts, in the same state in which it was from the beginning of things. [Margin: Nature suffers its own diseases.] Lactantius, weighing more deeply the condition of fluctuating nature and the instability of this earthly wheel—which, involving all things in countless mishaps, allows nothing under the Sun to be perpetual, nothing lasting—cries out thus: [Margin: Lactantius.] "I could recount how often, shaken by sudden movements, lands have either yawned open or sunk into the abyss; how often, swallowed by the waves, cities and islands have gone down into the deep; how marshes have flooded fruitful fields; how rivers and lakes have dried up; how mountains too have either fallen away in ruin or been leveled to the plains; how many regions also, and many a foundation of mountains, a hidden and devouring fire consumes"—a vicissitude of unstable nature which the loftiest philosophers, in no age, have observed without wonder.

[Margin: Seneca.] "All things," says Seneca, "time the devourer feeds upon, all things it plucks away, all things it stirs from their seat; it suffers nothing to abide for long."

[Margin: Lactantius.] "Rivers fail, the fleeing sea dries up the shores, Mountains subside, and lofty ridges fall."

[Margin: Ovid, *Metamorphoses* I.] "I myself have seen what once was most solid land become sea; I have seen lands made out of ocean. Far from the deep, sea-shells have lain, and an old anchor has been found on the highest mountaintops. What was a plain, a torrent of water made into a valley, and by its flood a mountain has been carried down into the sea; and the marshy ground dries out with parched sands, while what had borne thirst stands now under standing pools."

England [Anglia] once clung to France [Gallia], bound by a friendly union. [Margin: Islands once continents.] Nordstrand [Nordstrandia], a northern island which Cranzius [Krantz] calls Northern Frisia, was once joined to the mainland of Dithmarschen [Thietmarsia]; now, torn from the continent and enrolled in the register of islands, it follows the laws of Amphitrite. The same is testified of the Herculean Strait [Gibraltar] and the Sicilian Strait [Messina] by Valerius Flaccus: [Margin: The Herculean and Sicilian Straits.]

"...for King Aeolus was not yet ruler there, when the stranger Calpe [the Atlantic] broke through into Libya, when the Ocean, weeping, robbed the Sicilian and Oenotrian [Italian] bounds, and the wave entered in from the midst of the mountains."

Rivers change their beds and their accustomed courses; [Margin: Rivers change their beds.] flourishing empires perish—all of which, as they prove a dreadful havoc, so do they argue the divine power,

and lay bare the uncertainty of the human lot, and warn the mortal dwellers of the Geocosm that, since nothing is stable, nothing perpetual—but all things are fleeting, subject to fortune's various chances and to the various and unforeseen stratagems of things—they should raise every effort of the mind, every study, all the powers of a soul that can be satisfied by no created thing, toward the sublime and everlasting possessions of the heavenly goods above; that they should rest on God alone as on a center, in whose hand are all the rights of kingdoms and all the bounds of the Earth.

In various ways, then, the terrestrial body can undergo these metamorphoses. [Margin: The cause of changes in the Earth.] First, mountains are swallowed up by a yawning of the earth, or else are suddenly born where they were not before. Second, mountains, in the succession of ages, worn down by the injuries of the weather, dwindle away, the valleys being correspondingly raised up. Third, lands which the geographers call peninsulas—the Greeks, *Chersonesi* [χερσόνησοι, "peninsulas"]—when that narrow strip of land they call an isthmus is broken by the violence of the waters, become islands which were before part of the continent; or, on the contrary, islands are joined to the mainland by isthmuses formed of immense heaps of sand, which the violence of the sea brings up with its waves. Fourth, the sea, which on one side by its receding leaves behind a terrestrial space, on the other—by I know not what crime of nature—recovers it in a violent invasion, invading the land with its waves by as much as it had left behind in retreating from its former station. [Margin: Various transmutations.] Fifth, new islands sometimes spring up, while others that had stood from time

immemorial are swallowed up. On the contrary, in the heartlands of the Earth, certain regions, devoured by the tyranny of the inner Vulcan, leave lakes behind them; and in certain swallowed-up lakes, mounds of terrestrial parts are left. Sixth, in certain parts, rivers and lakes failing render the land habitable; in others, land rich in cultivation, by a sudden change, turns into a lake. But that all this may be established by historical authority, it has seemed good to treat of each by so many separate paragraphs.

§. I.

On Mountains and Valleys Swallowed Up and Reborn [De Montibus & Vallibus absorptis & renatis]

Pliny relates that in his own time Mount Cybotus [Margin: Pliny, l. 2. c. 91.] [Cibotus], a very high mountain, together with the town of Eurite [Curites?] [?], was so devoured by the earth that no further trace of it could be discerned. [Margin: Mountains swallowed up.] He writes that the same fate befell Mount Sipylus in Magnesia, which the destruction of the city of Tantalus—swallowed up by a gaping of the earth—had preceded as a fearsome omen. A like fate was suffered by Galanis and Ganatus, once most celebrated cities in Phoenicia. Phlegium, a most lofty ridge of Ethiopia, by the violent shock of a single night, appeared no more. We too can add those mountains which in our own times we have seen devoured by the earth. The mountain Picus [the Peak] is one of the Molucca Islands, of such height that, like a column, it appeared to sailors many days' journey off, in the most remote tracts of the sea; this, laid low by the violence of an earthquake, with no trace remaining, gave rise in its place to a lake, whose base is seen level with the periphery of the mountain. [Margin: History.] The same happened in the kingdom of the Chinese [Sinarum], in the year 1556, when an entire mountainous region of China, with all its peoples and cities, was swallowed up and left in its place a huge lake, nothing being rescued except a boy floating on a piece of wood. We have seen also in our own age the dreadful destruction of the city of Plurs [Plurium], situated in the territory of the Swiss [Helvetii], from the fall of an overhanging mountain. The mountains Vesuvius and Strongylus [Stromboli] are seen cut down by half through their volcanic warfare, which formerly seemed to strike heaven with their peaks. I will not speak here of the mountains of Chile, which they call the Andes, some of which have been found to be missing [Margin: The mountains of Chile collapsed.] after that greatest earthquake, memorable to all ages, by which nearly the whole kingdom passed into wasteland, in the year 1646—as the accounts made by our Fathers narrate. We have seen the swallowing-up of mountains; now let us set forth their rebirth. [Margin: The rebirth of mountains.]

Pliny, l. 2, c. 87 and c. 88, sets forth their series in these words: "Lands are born also in another fashion, and suddenly emerge in some sea, as though nature were balancing accounts with herself, restoring in another place what she had swallowed up by a gaping chasm. The islands of Delos and Rhodes are recorded long ago as having come to birth; later, smaller ones—beyond Melos, Anaphe; between Lemnos and the Hellespont, Nea; between Lebadus and Teos, Halone; among the Cyclades, in the 135th Olympiad, Hiera, the same as Automate; and two stadia from it, after 110 years, in our own age, in the consulship of Marcus Junius Silanus and Lucius Balbus, on the fourth day before the Ides of July [12 July], Thia." In the year 1638, at the island of St. Michael [São Miguel] in the Atlantic Sea, with the subterranean fires goading it on, so great a mass of stones was cast up in the midst of the sea that an island, born from stones heaped up into mountains, extended itself to a breadth of five miles. [Margin: A new mountain arose in the territory of Pozzuoli.] Near Pozzuoli [Puteoli], in the Bay of Baiae, about 120 years ago, a new mountain, swelling up out of the sea by the violence of subterranean nature raging in a single night, snatched all into wonder and terror at once; and it persists to this very day, by the name of Monte Nuovo, "triumphing holy" [Mons Sancti, i.e. Monte Nuovo]. The Lipari Volcano [Vulcano], about sixty years ago, is said to have ejected so great a quantity of ashes and rocks that it produced beside itself, in the midst of the sea, what they therefore call *Vulcanello*, "the little Vulcan," as a son begotten by a father; which I myself, while traveling along those shores, found to be true, as is plain from what I noted in the preface to the Reader. Innumerable such events, truly memorable, occur in the records of historians; and since I have judged it superfluous to recount them all, it has seemed good to bring forward here the better-known ones, both to confirm the destruction of certain mountains and the rebirth of new ones. These Pliny in these words

affirms, l. 2. c. 88: "Both near Italy among the Aeolian islands, and again near Crete, an island has emerged from the sea, 2,500 paces in extent, together with hot springs; another in the 163rd Olympiad, in the third year, in Thera, blazing forth; and this with a violent movement; and it is recorded for memory that a great multitude of fish was found floating about it, and that those who immediately ate of them perished. Likewise they say that the Pithecusae [Ischia] arose in the Bay of Campania; and among them Epopon, when a flame suddenly flashed forth from it, was leveled into a flat plain; and in the same place a town was swallowed into the deep, and by another movement a marsh emerged; and with mountains rolled away in yet another, the island Prochyta [Procida] arose."

§. II.

Mountains Fail in the Succession of Time; and Plains and Valleys Are Raised Up
[*Montes successu temporis deficiunt; & plana vallesque attolluntur*]

Experience teaches that the summits of mountains are at last gnawed away and consumed by rains, snow, hail, long-lasting frost, and the other injuries of the air; [Margin: Why mountains fail.] and this has already appeared sufficiently in the preceding paragraph from the failing of the fire-belching mountains. For there are some mountains—as in Lipara, Melita [Malta], and Ilua [Elba]—which the niter-bearing winds, on that side from which the winds pregnant with them blow, so gnaw away that the overhanging crags threaten imminent ruin; and the ruins of crags still surviving in the valleys abundantly testify that they once, when standing erect, finally collapsed. [Margin: The collapse of the foundations of the mountains.] The cataracts of subterranean waters, too, and their headlong fall, so wear away little by little the inner fabric of the mountains that, with their foundations undermined, they totter at the first earthquake—which I would reckon to be one cause of the failing of certain mountains. [Margin: Subterranean fires too dissolve the mountains.] Subterranean fires likewise contribute wonderfully to the failing of mountains, as we hinted above. From the wearing-away of mountains, then, it is necessary that valleys and plains should grow; and so the decrease of the mountains passes into the increase of the surrounding plains and valleys—so that this saying of Job seems verified in these things: [Margin: Job 14.] "By slow alluvion the Earth is consumed." For the waters of rains, rivers, torrents, and melted snows so corrode the sides of the mountains that the foundations of buildings set upon the mountains are mostly seen laid bare; [Margin: Rains, snows corrode the bases of the mountains.] which I have more than once had occasion to observe in the castles of Germany that are set upon ancient crags. Yet nowhere does this catastrophe of nature show itself more for the seeing than at Rome and in the other parts of Latium. I behold almost daily the once high and steep crags of the Palatine and Capitoline mountains so diminished by the injury of time that they seem now nearly to equal the plain—indeed, the foundations of the old Capitol now actually to equal it; and the very laying-bare of the foundations by the cataracts of subterranean waters clearly teaches this. So much so that, of those which authors write to have once been high mountains, now—unless certain traces of the mountains persuaded you—you would scarcely believe that mountains had ever been there, the plain rising up by just as much as the mountains have decreased. The Pantheon teaches this above all: [Margin: The Pantheon.] one once ascended to it by steps, whereas now the descent into it is made by steps. The innumerable half-buried carcasses of

antiquities teach it too—of amphitheaters, circuses, arches, and columns—of all which I shall treat more fully, if God grants me life, in our work *On the Marvels of Latium*. Hence many have judged that it will come to pass that, after many myriads of years, the plains, leveled with the mountains, will in the succession of time open the way to a universal cataclysm. Yet this I would by no means hold to be admitted—not, at any rate, in those great mountain chains mentioned above, but only in those which are worn down either by the daily use and the service of buildings, or are composed of earthy, clayey, and similar friable and tufaceous matter.

§. III.

Peninsulas Are Changed into Islands, and Islands into Peninsulas [Chersonesi sive Peninsulae in Insulas, & Insulae in Chersonesos mutantur]

It is altogether probable that the straits by which now one sea insinuates itself into another through the narrows of the mountains were once joined by an isthmus, [Margin: The metamorphosis of islands and peninsulas.] and were straits, with the sea—by the impetuous tyranny of its flux—gradually eroding the isthmus. In this way, on Pliny's testimony, the sea tore Sicily from Italy, Cyprus from Syria, Asia from Europe by the Propontis and the Thracian Bosphorus [Phosphoro Thracio]; Euboea from Boeotia; Atlas and Macris from Euboea; Besbycus from Bithynia; Africa from Spain, the union of Calpe and Atlas being destroyed. In like manner Leucosia from the promontory of the Sirens; Sumatra from Cambodia [Camboia], Ceylon from India; Greenland [Gronlandia] from America by Davis Strait [Fretum Davits]; Nordstrand [Nordstrandia] from the Baltic-sea island of Dithmarschen [Thrithmarsia], on the testimony of Cranzius [Krantz]; from South America the Land of Fire [Tierra del Fuego], the isthmus being broken through, and by the Strait of Magellan [Fretum Megallanicum] the perpetual battering of the great Eastern and Western Oceans opening for itself the gates to their union. For most isthmuses are like certain bridges, beneath which, through certain hidden passages and the blind recesses of caverns, the seas that wash the isthmuses on either side carry on for the most part their mutual exchanges of water, to and fro; [Margin: Isthmuses are like bridges, beneath which the sea passes.] and when, in the succession of times, their piers are eaten away and the foundations of the bridges shaken by an earthquake, the isthmus must collapse.

But let us come to the other part of this discussion. Seas break through isthmuses, and these same isthmuses are sometimes formed by the alluvion of waters and by the great heaping-up of sands; as the Pharos of Egypt, which once in the midst of

the sea offered its light to those in peril, [Margin: The Pharos of Egypt, once an island.] now...

we see joined to the mainland by an isthmus, formed when the Nile filled the strait with a great quantity of silt.

[Margin: Mount Circeius, once an island.]

Mount Circeius, once separated from the continent, is now attached to it, the strait having been filled up by an accumulation of sand. This commonly happens at narrow and low-lying places between seas, where islands lie between the open sea and the mainland: there, either a violent sea-tide or a great quantity of sand carried down by rivers builds up the gap. So it is in Batavia, Frisia, and Zeeland, throughout all the tracts of the archipelagoes, and along the other sandy and clayey shores that rise gradually from a flat plain into very high mountains.

Thus Pliny [Pliny, *Natural History* II.89] records that Antissa was once joined to Lesbos, Zephyrium to Halicarnassus, Aethusa to Myndus, Dromiscos and Perne to Miletus, and Pithecusa to the promontory of Parthenius. Indeed, he says that Hybanda, once an island of Ionia, afterward lay two hundred stadia inland from the sea; that Syrtis near Ephesus, and Derasides and Sophonia in the interior of Magnesia, were once counted in the register of islands; and finally that Epidaurus and Oricum ceased to be islands. To this point belongs Ovid's line [Ovid, *Metamorphoses* XV]:

A time will come when the Pyramus, once with its rushing waters, will reach into sacred Cyprus, the shoreline having been heaped up.

§. IV.

Whatever the sea loses in one region of the earth, it recovers in another — hence the origins of islands and of new lands.

Daily experience in the course of rivers teaches this abundantly. Suppose a river M N rushes from C into B, and from B into D drives the whole force of its current. It is certain that the clayey banks at B and at D will, over time, be hollowed out by the violence of the flooding; and the river will gradually creep into the interior fields at F and G.

Diagram. A schematic plan-view of a meandering river illustrating the argument that a river erodes one bank while depositing on the other. The river M N winds across the figure in two sweeping bends; hatching along the banks marks where

the channel cuts in ("demit," it carries away) and where it builds up ("addit," it adds).

- M (upper left): river mouth/source label, head of the channel
- C (left bend, inner): point on the channel
- D (right bend): point where the current strikes the bank
- B (center, inner bank): point on the channel
- F (lower left): field into which the river encroaches
- G (upper right): field into which the river encroaches
- "demit" (upper right and lower left, by the outer banks): "it carries away" — where the current erodes
- "addit" (center-left and lower center, by the inner banks): "it deposits" — where silt accumulates

As a result, the water necessarily abandons its station at bank B and lays the land bare — the give-and-take of the two banks, by a kind of commutative justice, sharing out their mutual rights between them.

This natural metamorphosis has been observed in many rivers — the Rhine, the Main, the Moselle, the Rhône — but above all in the Tiber.

[Margin: The Tiber, a river.]

Over a span of just twenty years I have noted the Tiber creeping forward onto the flat of Monte Mario, into the fields and meadows, so that at this time it laps almost the very roots of the hill in several places, while on the other side it leaves heaps of sand behind. But since these things are commonly known, I will not dwell on them.

The same must be supposed to occur in the sea: just as its ebb and flow, and what they call the currents, are more violent, so they likewise work greater transformations on the terrestrial globe. Yet this should be noted: certain rivers — chiefly those that have their source in very high mountains — wash so much eroded material down from the mountains and valleys, scoured from the soil's mixture, that they silt up the lower-lying places. From such a great quantity of sand and mud, gradually heaped into broad mounds, and once the waters have been confined within channels, they establish a new region fit both for human habitation and for cultivation.

[Margin: From the silt carried down, new fields are born.]

The truth of this is plainly evident from the larger rivers — the Rhine, the Danube, the Rhône, the Po, the Euphrates, the Indus, the Ganges,

Diagram. A landscape view of a river delta — the Po (labeled "Padus flu.") descending from mountains on the left and discharging through multiple branching mouths into the Adriatic Sea on the right. The engraving illustrates how alluvial deposits build new land and islands at a river's mouth. Mountains rise at the left and lower foreground; the braided channels split around silt-islands as they reach the sea; a sailing ship rides at lower right.

- D (left, mountain): mountain from which the river descends
- C (lower-center foreground, mountain): mountain from which the river descends
- A (upper center): point on the descending river / plain
- B (lower center, in the plain): the stagnant plain A B where waters once pooled
- E, F, G, H, I (right, among the river mouths): the low-lying tracts and islands formed at the delta by the branching arms of the river
- "Padus flu." (center): "the river Po"
- "Mare Adriaticum" (right): "the Adriatic Sea"

confined within their channels, and at last discharging themselves into the sea through a manifold distribution of mouths. From this we conclude with certainty that those low-lying tracts near the river mouths — E E G H I — together with the islands that the arms of the rivers form, are nothing but the offspring of sand and mud brought down and carried in by these rivers, as the figure shows.

That this is so, the histories teach more than amply. The lower part of Egypt, which they call the Delta, was deposited by the Nile, and is called by Herodotus "the gift of the Nile" — δῶρον Νείλου [Greek: dōron Neilou, "gift of the Nile"].

[Margin: Egypt born from the buildup of silt.]

This is the common opinion of geographers, and we demonstrated it at length in the First Part of our *Oedipus Aegyptiacus*. In just the same way, the district of Holland was built up out of the Rhine and other rivers, as Goropius teaches.

[Margin: Holland from the Rhine and other rivers.]

Likewise a great portion of the territory of Ferrara grew from the floods of the Po. The coastal land of Arles, together with the island of Camargue, is the offspring of the Rhône.

[Margin: The Maeotic marsh; the Tanais.]

By the same reasoning the marshes of Ammon and of Maeotis were once far deeper and able to bear larger ships than they were afterward, when the mud had been deposited — as Aristotle attests. All of Teuthrania and the regions around Ilium are flat: where there was once sea, now there are fields, thanks to the river Maeander.

[Margin: Cities once washed by the sea, now far from it.]

That these things are so, the cities that were once washed by the sea but now lie far from it abundantly prove. Ravenna, once set upon the Adriatic Sea, is now six miles distant from it. Ostia on the Tiber, once placed against the shore of the sea, is now separated from it by 3000 paces, with mounds of sand thrown up between. This has been verified in many places throughout Lower Germany as well. Already in Pliny's time the sea had withdrawn five thousand paces from the harbor of Ambracia toward Athens, though it had at first washed that very spot. Time would fail me if I tried to bring forward all the natural catastrophes of this kind, since there is scarcely a maritime region — especially near the mouths of great rivers — where they are not to be seen.

We have said, then, that the sea, by the deposits brought in by rivers, has in some places left behind habitable land, a supreme gift of nature. Now let us show a new catastrophe of the sea: how, forgetting its former kindness, by some inscrutable wickedness of nature, it presses vast regions of the earth under so harsh a tyranny — some it submerges utterly, others (the more stubborn islands, as it were) it has so overwhelmed that they seem to rise above the water only with their mountain peaks.

[Margin: Submerged cities.]

Near Dordrecht and Dollart in Frisia, castles of no small repute were so submerged by a deadly flood that even now the tips of their towers rise above the water, seeming to want to tell posterity the calamity of the past event.

[Margin: Submerged cities.]

On the Tuscan shore, not far from Livorno, an entire city yielded to the waves, the dwellings of men turned into hiding-places for fish — which, not without horror, I observed with my own eyes in the year 1634. Between Centumcellae, commonly called Civita Vecchia, and Severa, abundant ruins are indeed to be seen in the sea, some of which are still furnished with windows, others with gates and arches — indices of past misfortune. Opposite Pozzuoli, in the very bay of the

city of Baiae, houses together with the layout of their streets — a thing astonishing to relate — show, in a most mournful spectacle, the traces of the ruin, on the sea floor, of a city once most renowned. These things, indeed, I have verified by my own experience — to say nothing of the countless other events with which the records of historians are filled.

[Margin: Archipelagoes once joined to the mainland.]

From all of which we conclude that all those clusters of heaped-up islands which they call archipelagoes were once joined to the mainland, but were broken apart by the violence of the Ocean working back and forth: the softer parts of the continent were gradually eaten away and pierced through, while the rockier crags of the mountains were left standing in that great multitude of islands which the maps show us — sundered by hidden channels, or sometimes also by the fury of subterranean fires through earthquakes.

Certainly Plato teaches that the Atlantic Ocean, where the Canaries and what they call the Terceras now lie, was once inhabited by a vast multitude of people — in that dialogue which he entitles with the name of *Critias*. But let us set down a brief epitome of this history, well suited to weighty reasoning; and so I begin further back.

[Margin: Plato, in the *Cratylus* [recte: *Critias*], on Atlantis.]

Plato, then, in his dialogue called the *Critias*, reports that there was a certain island beyond the Pillars of Hercules in the Atlantic Ocean, much larger than Africa and Asia together. He says that Solon, instructed by the Egyptian priests — who had described in their records the situation of that region, the names of the people living in it, and the history of their deeds — rendered it into Greek law [i.e., into Greek]. From Plato's age back to the age when the Atlantic land was still surviving there had intervened nine thousand years. The earliest heroes of the Athenians waged most valiant wars with that island; yet these wars, worn away by the injury of immense antiquity, left nothing behind but their names and fame, when the whole island, together with its inhabitants, was swallowed up, whether by flood or by earthquakes.

[Margin: The destruction of the island of Atlantis.]

To show that this is a true history, by no means mythical — that is, not subject to fables — he undertakes to prove it from Greek antiquity. He first extends its boundaries to the Isthmus, and from there bounds it on the right toward Epirus and Cithaeron, and on the left to the sea; and he says it was furnished with such

fertility, beauty, and abundance of everything needed to sustain human life that, reckoning by the standards of those times, the condition of the region in his own age, by comparison, could be called nothing but the bones of a body wasted by disease. This degenerate state, compared with that of the ancients, he sets forth in these words: After describing the immense abundance of things flourishing in Greece in the first ages of the world,

[Margin: Plato gives the reason for the degeneration of one region compared with another.]

he then subjoins the causes of so great a degeneration in these words: "Every region," he says, "stretched out at length from the continent like a promontory,

[Margin:...most fertile in Greece.]

lies; and that deep gulf of the sea encircles it on every side. Since, then, many and great floods occurred in the space of nine thousand years (for so many have elapsed from that time down to our present age), no part of the earth, in our times, ever heaped up a mound by flowing down from the higher places into these lower ones (as it does in other places), but always, settling in a circular fashion, it is hidden away in the deep. And therefore, just as in narrow islands, these regions of Attica which are now inhabited — if they are compared with the ancient ones — are like the bones of a body wasted by disease, the soil that was rich and soft having been carried off, so that only the thin and dry body of the earth remained. For when the earth was whole, it had high mountains and hills; and the fields which are now called *Phellei* ['stony'] abounded with rich soil and with copious forest on the mountain ridges, as the traces still manifestly are. Moreover this region drew abundant fruitful rain from Jove, nor — as in this our time — did it flow down from the steep and precipitous place into the sea, but, absorbing it, settling with a certain copious and tenacious firmness, it concealed the water and, drinking it in, sent it down into the inner parts from the higher places; whence everywhere great springs of rivers and of fountains gushed forth, of which even now, at the old fountains, certain sacred memorials appear." Thus far Plato.

In order to show the destruction of the island of Atlantis, he begins from a notable transformation of the terrestrial parts, which the Greeks fable to have occurred in Greece over a span of nine thousand years through a threefold flood. He attributes the cause of this transformation first to the subsidence of the mountains, which he holds were all once clothed with rich and fertile earth (like flesh), and also with forests (like a kind of hair), but are now bald and bare,

stripped of all the adornment of their woods, presenting themselves to view like the bones of a body wasted by disease. He supposes that the subsidence of the mountains — partly through the deluges of rain, partly through the rich earth being scoured and torn away together with the forests — gradually filled up the lowest valleys, the fields, and even the sea itself. Hence the earth, raised up by the heaping of soil, made the mountain summits not only much lower and shorter than in the first ages, but also stripped them of all their flesh, leaving nothing but a kind of bones of the mountains; and he thinks the same happened in the land of Atlantis.

Then he says that in Greece today many rivers and springs are missed, which the records of earlier ages report once watered the whole land. He assigns the cause of this: that the mountains, once clothed in very rich earth, did not allow the rain sent down from Jove to flow off, but soaked it up at once like a sponge; and the absorbed water, insinuated through the hidden meanders of the mountains and collected, fed the most abundant rivers and springs. Yet he says these are not found today because the mountains' meanders, choked with mud and soil, have cut off every entry to the rainwaters, or else, shaken by earthquakes, have brought on that transformation we spoke of. But this opinion of Plato concerning the diminution of mountains and the drying-up of rivers we shall examine more fully elsewhere. For now, let us return to the island of Atlantis.

[Margin: A description of the island of Atlantis.]

As we taught in our *Oedipus*, Plato tries in many ways to show that it is by no means fabulous but truly historical, in that he so carefully describes the situation and quality of that island, the character and disposition of its people, and their political method of administration; in that he recounts that its cities, fortresses, and strongholds were built up not only with an apparatus of wondrous enclosures and moats, but that there was the greatest abundance there of gold, ivory, and precious stones, with which the temples of the gods were wont to be adorned; that at last it collapsed; and that, just as it was swallowed up by the sea, so it has remained obscure in the memory of men down to this very day.

Certainly the Greeks, marvelously swollen with glory, ascribe this Athenian expedition into the Atlantic land — they whom Plato calls the most ancient of all men and αὐτόχθονας [Greek: autochthonas, "sprung from the earth itself"] — first and foremost to their own valor and skill in action, in order to obscure the glory and antiquity of the Egyptians by this so memorable a history; although even Plato himself admits that Solon learned this history from the Egyptians, who had

it described in their sacred records as a monument of antiquity and Egyptian fortitude more lasting than cedar.

[Margin: The expedition of Osiris to the island of Atlantis.]

They relate, as we showed in our *Oedipus*, the sequence of deeds in this way: The Egyptian Hercules, whom they also call Osiris, having entrusted the care of his kingdom to his wife Isis, was traversing the whole world with a strong army he had raised; and when from the East he had subjected to his rule all those regions situated beyond and this side of the Strait of Hercules (so named from his memory), at length, made more certain by a reliable report of a vast island set in the immense Ocean, he directed a maritime expedition there, suddenly invaded the island, subjugated it, and, having made peace with the inhabitants, established a colony, setting over it one of his grandsons named Neptune. These, then, are the things the Egyptians record about the land of Atlantis.

As for Plato's statement that nine thousand years had elapsed up to his own time, by which he proves these things to have happened, this too is an Egyptian invention; for in order to persuade men that they themselves were the most ancient of all, it can scarcely be said with what an extravagance of years they fashioned their own origin in times gone by. But since we have demonstrated all this very fully in the first volume of the *Oedipus*, we refer the reader there. So, omitting those things that do not pertain to our subject, let us return to the island of Atlantis.

[Margin: How the island of Atlantis perished.]

That the island of Atlantis existed within the memory of all the ages has been made clear from what precedes. But how and when it ceased to exist is as unknown as the times in which it flourished are unknown. Moreover, if what the ancients report about it is true, I would say that its situation was no other than that which is comprised by the Canaries, the Azores, the Flemish Islands [Flandricis — the Azores group / "Flemish Islands"], and the other islands surviving in the Atlantic Ocean (as appears from the map set here). Just as these enumerated islands consist of vast and very high mountains, so it is likewise probable that the higher and harder parts of the island of Atlantis survive in them, while the rest — the deeper places lying between, of lesser mountains, valleys, and plains — were swallowed by the motion of the earth, and the Ocean rushed in to take their place.

Diagram. A map showing Kircher's reconstruction of the location of Atlantis as a single great island filling the central Atlantic between the Old World and the New.

A cartouche at the upper left bears the title. Africa and "Hispania" (Spain) form the eastern (right-hand of those two) coast at the left; "America" forms the western coast at the right; the great "Insula Atlantis" occupies the center of the "Oceanus... Atlanticus." A compass rose (north-pointing arrow within a circle) sits at the lower center of the island; a sailing ship rides in the ocean at upper right.

- Cartouche (upper left): "Situs Insulæ Atlantidis, à mari olim obsorptæ, ex mente Ægyptiorum et Platonis descriptio." — "The situation of the island of Atlantis, once swallowed by the sea: a description according to the mind of the Egyptians and of Plato."
- "Africa." (left)
- "Hispania." (lower left): Spain
- "Oceanus... Atlanticus." (center, spanning the ocean): the Atlantic Ocean
- "Insula Atlantis." (center): the island of Atlantis
- "America." (right)
- Compass rose (lower center of the island): north-pointing arrow within a circle

There are some who would have this part of the continental land connected to America on the west; but this is wholly without warrant. For in this case the continent would have been carried on, continuous up to the Strait of Hercules, through more than nearly 90 degrees of the longitude-circle of the terrestrial globe — which would be contrary to the intention of nature, which has so distributed the portions of the terrestrial world that they are always accessible to the surrounding Ocean, both for the production of springs and rivers and for furnishing the other benefits of nature which we mentioned above.

How it perished remains to be told. And as far as could be learned with experience as teacher, its destruction could come about in only two ways. The first is that drawn from earthquakes, whose efficient cause is the breath of subterranean fires, with which the Atlantic sea teems; whence the historians of these times write that it is exceedingly exposed to earthquakes.

[Margin: The height of the Peak of the Canaries.]

For they report that the Peak [Pico] on Tenerife of the Canaries is of such height that from 60 miles away it appears to sailors stationed on the high Ocean like a column. They attest, too, that it sometimes emits smoke from its summit, and has at times vomited forth fires — sulphurous stones, which are carried off from there in great quantity into Spain. In a three-day journey one comes to the summit — a plain conspicuous at its peak, from which all the Canary Islands,

however far apart, offer themselves to view. It also abounds with hot and bituminous springs, which are manifest indications of the latent subterranean fire.

[Margin: A peak on the Azores like the Peak of the Canaries.]

In the Azores Islands a mountain is seen, equal in height to the Peak of the Canaries, called by the inhabitants the Pico de Fayal de São Jorge [Pico of Faial / São Jorge]. From it one has [a view of] the surrounding islands, of which the ones called Terceira and São Miguel are reported once to have belched fire in many places and on cliffs, and are shaken by frequent earthquakes.

[Margin: An account of a fire and earthquake on the island of São Miguel.]

About twenty years ago, these so shook the whole island that nearly the whole of it went into the abyss. But since the matter is worthy of being remembered in this place, it seemed good to add the course of the event from the faithful account of our Fathers:

On the 26th day of June in the year 1638, earthquakes so dreadful, lasting eight days, began to shake the whole island that men, abandoning their cities, towns, and castles, were compelled to live in the open fields — especially in the cultivated land called Vargem, where the earthquakes raged more fiercely than in other places, and much more violently. These earthquakes were followed by the prodigy that follows: A place called La Ferreira, distant six miles from the Peak (commonly Pico delle Camerine), where the fishermen of this island used to betake themselves to fish, especially in the summer season,

especially in the summer season [æstivo]: for in that place, within the span of a single natural day, they would net such an immense quantity of fish of every kind that no skiff returned that was not loaded with 10,000 fish. In this stretch of the Ocean, then, on a Saturday in the month of July of the year 1638, fire erupted with such inexpressible violence — notwithstanding that this part of the Ocean had been sounded by fishermen often before and found to be 120 geometric feet deep — that the Ocean itself was not enough to quench so great a conflagration. [Margin: Vehemence of the subterranean fire.] The space that the boiling fire occupied was about as large as two measures [modii] of grain would cover, and it burst forth with such violence that, notwithstanding the said depth of the Ocean, it rose level with the clouds. Carried up into the highest region of the air, it bore up with it the very water, along with sand, earth, rocks, and other enormous masses, which to those who watched grievously from a distance presented a

spectacle like flocks of cotton; while the molten matter, falling back into the sea, took on the appearance of porridge. Moreover, it must be ascribed to divine providence and kindness that at that time a land wind was blowing from the parts of the island, driving back the fury of the raging fire; for had this not happened, the whole island would beyond doubt have been consumed and destroyed by that fearful blaze.

Then the raging force kept hurling up rocks of immense size to the height of three spears, so that you would have said not rocks but whole mountains were being thrown up. To the horror was added this: that the rocky mountains thrown on high fell back upon other rocky mountains hurled up from the depths of the sea, and with terrible crashing they shattered into a thousand pieces, which, gathered up afterwards by hand, ground into black sand. [Margin: A new island in the Ocean.] Then, from the vast and immense mass of ejected material and the countless heaping-up of rocks, a new island arose in the midst of that deepest Ocean. At first small, only five iugera [acres] in extent, but growing day by day, it swelled so much that within 14 days it occupied a stretch five miles in length. So great a multitude of fish, moreover, perished in this conflagration that eight East Indian cargo ships could scarcely have held them. [Margin: Destruction of the fish.] Lest, scattered far and wide across the island, they should cause some contagion by their rotting, the natives gathered them into very deep pits some 18 miles round about and buried them. The smell of sulphur, meanwhile, was perceived over a span of 24 miles.

From these things it is abundantly clear that what happens in our own times could also have happened of old in the earliest ages, since the nature of the place has always remained the same, given that the storehouses of fire — which nature has set beneath this region, as we shall show in its place — lie immediately underneath. Hence, being always subject to earthquakes, the place has in no age failed to suffer some loss of its islands. [Margin: The destruction of other islands.] To these is added another contrivance of nature which gradually disposed the Atlantic island toward its final ruin: namely, the violent motion of the Ocean from the North, which over time eats away the roots of the cavernous islands lying in its path, so that, when even a slight earthquake arises, the whole mass — its mountain joints giving way — collapses. It is therefore likely, and most highly probable, that this Atlantic island, once of enormous size and worn down by similar afflictions of nature, finally fell — leaving behind only the aforesaid islands (which, being equipped with very high mountains, have thereby obtained a firmer and more durable constitution) as it were the heralds and surviving witnesses left of that past calamity. The same is likely to have happened, through

the tyranny of the Ocean, to the Archipelago of the Philippine Islands — which the Chinese Annals assert were once joined to the continent at the Golden Chersonese [Aurea Chersonesus] — in that what was previously one was in later times broken up into innumerable islands. But we have pointed to these matters more fully above.

COROLLARY

From this discussion — longer, perhaps, than was fitting — it becomes clearer than the noonday light that the Earth has a wholly different constitution in modern times than it had of old, before the universal cataclysm of the world, or even, for unremembered ages, after the Flood. [Margin: The face of the Earth is different today from what it was of old.] There are therefore islands that did not exist before; the land has grown where before the untamed eddies of the waters had their stables. Conversely, we know that tracts of land which once enjoyed rich and fruitful soil have now, with the sea ruling, turned into lairs for fish; mountain ridges have been swallowed up here while new ones rise elsewhere; vast lakes have transferred the jurisdiction of Neptune to the realm of Rhea or Vesta, and the reverse. Rivers, abandoning the native cradles of their channels, have made themselves other outlets from the mountain enclosures. And such transformations of the terrestrial globe, as fearful as they are, lay open both the infinite power of God and the uncertainty of the human lot. They warn the mortal inhabitants of this Geocosm that, since they recognize that nothing is perpetual and stable, but all things are perishable and exposed to the various accidents of fortune and to destruction, they should raise their thoughts, pursuits, spirit, and mind — which can be satisfied by nothing created — to sublime and everlasting goods, and yearn for God alone, in whose hand are all the rights of kingdoms and on whom the bounds of all nature depend.

APPENDIX

On the most celebrated plains of the Globe of the Earth, or Geocosm

We have set out the structure and fabric of the mountains as far as seemed sufficient for our purpose. It now remains for us to discuss, briefly, the famous plains of the Globe of the Earth as well.

[Margin: Division and regions of plains.] Plains may be divided in various ways. For many are suited to cultivation and filled with a variety of woods and forests; others are sandy; others are stony and heath-covered, which are also called deserts; and some of these extend to an enormous breadth. [Margin: Woods.]

Though fruitful, plains nevertheless appear before us chiefly deprived of inhabitants — through the inhabitants' own idleness, or through a lack of farmers — as do Poland, Muscovy [Moscovia], and Russia, clothed with vast recesses of woodland. With sand and heaped-up grit Africa lies squalid above all the regions of the world; Arabia with stony ground; with heath both Germany and the remaining parts of the world. Fruitful plains are divided into fields, gardens, and woods. The variety of woods is great, both by reason of place and by reason of climate. In Germany there are the Hercynian Forest [Sylva Hercinia], the Black Forest [Nigra Sylva], and the Spessart [Sessartus], notable for their plantings of oak, beech, pine, juniper, and likewise fir, larch, and Italian-oak [esculus] and the like. In Gaul [France] and Italy woods of chestnut predominate. Africa abounds in palm groves, and at the Green Promontory [Promontorium Viride — Cape Verde] there is a whole wood of citron-trees; Ceylon [Ceilanus] nourishes woods of cinnamon; the Banda [Bandames] and Molucca Islands have nutmegs, and cedars adorn Lebanon. And — to take in much in a few words — the variety of woods follows the nature of the region in which it grows; and since this is different in every region, there must necessarily be found an innumerable variety of woods differing in their species of trees. But of these more fully in what follows.

[Margin: Deserts and their vastness.] There are also immense tracts of land destitute of all human cultivation and habitation: of this kind are the deserts of Tartary which are called Mongol [Mongul] and Lop. Of these, the latter is thought to be that sandy desert which, not far from the walls of China, extends in the form of a band of as-yet-unexplored length from South to North, and which must be crossed by merchants travelling to and fro from Tartary into China — a place squalid to the terror of all. [Margin: Desert of South America. The Pampas.] There are also in America, both Northern and Southern, vast deserts, of which the one lying between the Kingdom of Paraguay [Paraguavia] and Chile holds the foremost place, called by travellers "Pampas." [Margin: The height of the Andes mountains and the thinness of the air on them.] All, therefore, who travel from the Kingdom of Chile into Paraguay must first cross mountains of incredible height, which they call the Andes [Andes] or Cordillera [Cordilleira], over a journey of 40 leagues. On their summit the air is said to be so thin that men can scarcely stand without danger of suffocation. Hence all must be equipped with sponges soaked in cold water to condense the air; [Margin: The inflammable air.] and the air is so disposed to inflammation that travellers seem to belch out flames, and, set ablaze by an immense flow of sweat, are all on fire — a wonderful spectacle to those unacquainted with the nature of the place. All this I received by word of mouth from Father Alfonso de Ovalle [P. Alphonsus de

Ovalle], a Chilean of our Society and Procurator of that Kingdom, who had made a journey of this kind.

To those descending the mountain, then, after a three-day journey, there appears the city of Mendoza [Mendoza], and then that immense desert which they call the Pampas [Pampas], spread out far and wide like an Ocean, yet by no means infertile — for, without any trace of sand, it is entirely planted by nature with grasses, [Margin: Description of the desert.] inhabited by animals of every kind, and not lacking in rivers and lakes. This they enter, just as one enters the Ocean, equipped with a nautical compass, as if heading for the boundary of the desert, which is called Buenos Aires [los buenos ayeres] — the first city of Paraguay, situated on the River January [flumen Januarium — the Río de la Plata], toward which they steer by a fixed course. They have wooden carts, capable of holding many men, which, while drawn by oxen, at the same time level a path by trampling down the grasses and herbs, and open a route — on which a span of rarely three months, more usually four months, is spent. How far this desert reaches to the South is unexplored; some think it extends all the way to the Strait of Magellan [Fretum Magellanicum]. This much, at least, I have from report: that over a span of nearly two months no higher land or trace of mountains at all appears in this place, and that the horizon is open on every side — you would call it a terrestrial Ocean. See what Father Alfonso de Ovalle relates more fully about these matters in his history of the Kingdom of Chile; and, lest we linger longer over these things, let the reader consult the geographical books, where he will find all that is written at length about the various deserts of the Earth. Our task is to investigate the causes of these deserts.

[Margin: The cause and end of deserts.] It is asked, then, why and to what end nature has produced so many deserts throughout the world, of no use to any human need — and I speak here of sandy and stony deserts, not of the wooded, heathy, and grassy ones, which offer their own advantages. Sandy deserts present themselves above all in Africa and on the northern boundaries of Arabia Felix [Arabia Felix]. And as far as has become clear to me through various exploration of these places, through information given by the natives, and likewise through the reading of various Arabic antiquities, I find that this sandy ocean lying between the Persian Gulf [Sinus Persicus] and the Erythraean [Red] Sea [Sinus Erythraeus] was, before the Flood, a continuous sea; [Margin: The sandy desert between the Persian and Erythraean Gulfs was once sea.] but that the Flood heaped up immense mounds of grit and sand there, and, when the land was raised and the sea drawn back within its own gulfs, left behind this heap of grit which they now experience. This cannot seem impossible to anyone who

observes the nature of the place — low, depressed, without any mountains (except those that the unstable sand, by the agitation of the winds, raises up repeatedly and soon destroys), and level. The same is to be supposed about the sandy desert of Tartary, which on not ill-founded grounds was once the site of an Ocean, joined to the Caspian Sea, as will be seen hereafter. The same of the sandy plains of Libya; for since we said above that the lower part of Egypt was once flooded by the sea, surely this must not be denied of Libya, since the water spread out together with Egypt. As for the end intended by nature...

perhaps this was it: lest, if the said deserts produced fields, they should bring destruction. For if the humid soil of the regions of Babylon near Basra [Balsora], watered by the Euphrates, enjoyed moisture, vapors drawn up by the Sun and resolved into rains would, by their floods, bring final ruin to the fields of the neighboring fruitful regions — such as Egypt, Arabia Felix, and Babylonia. But now, with rains banished forever from these arid places, there is no reason for the neighboring peoples to fear flooding. The same is to be said of the other sandy deserts. But, leaving these matters aside, let us turn our pen elsewhere.

CHAPTER XIII

On the Waters, or the Ocean surrounding the Geocosm, and on the communication of the seas through hidden passages

[Margin: What the Ocean is.] That the Geocosm is formed into one globe out of watery and earthy substance, perhaps only he will deny who is ignorant of hydrography and has not seen the maps drawn by geographical art. The Geocosm, then, is an earth-and-water [terraqueous] globe, founded from the beginning of things by the great and most profound counsel of nature with this diverse mixture of elements; for without Water, neither could Earth, nor could Water without Earth, in any way subsist. It falls to us, therefore, to examine the rationale of so necessary a composition. That I may do this as well as possible, I shall begin first from the division of the Waters, and then go on to bring the causes of each into the light. May God, most wise Architect of the Geocosm, assist our undertakings.

The whole mass of those waters which surrounds the Earthen globe is called the Ocean, in such a way that there is no sea which is not joined to it, either through straits or through hidden passages of the Earth. There is therefore one Ocean, which has obtained different names by reason of the various regions it laps. Thus the Atlantic Ocean, poured between America, Africa, and Europe, is so called either from Mount Atlas [Athlas mons], or from the island of Atlantis [Athlantis

Insula] that once floated upon it, of which we spoke in the preceding sections; and it afterwards obtains particular names too. There are the Hibernian [Hybernicus], Glacial [Arctic], Deucalidonian, Germanic, Aethiopian, and American Oceans. This Ocean, then, branching out from the still-unknown polar regions through its various meeting with islands, surrounds nearly all of Europe from the North and East. Swollen in the West by an immense expansion, it claims for itself the rights of three parts of the world — America, Africa, and Europe. Thus, partly opening an entrance for itself through the narrows of the Magellanic Sea, it mingles in new wedlock with the Southern or Pacific Sea; partly through the Strait of Maire [fretum Mairanum] it wanders, by passages still unexplored, into the farthest subpolar parts of the Southern Land. The Pacific Ocean, commonly called Mar del Zur, the greatest of all the Oceans, on one side bounds with its waters the Western and Northern parts of all America, and on the other all the unknown tracts of the Southern Land; and from the North, indeed, through the Strait of Anian [fretum Anian] — a passage of communication between America and Tartary — it is at length restored, by the Boreal subpolar Ocean from which it had departed, to the Atlantic. From the West, as it were carded apart by an innumerable multitude of islands and stirred up by new narrows of straits, it passes into the Indian Ocean, and, after surveying the immense tracts of China, both Indias, Persia, and Africa, is at length restored at the Cape of Good Hope to the Atlantic Ocean.

[Margin: The connection of the seas.] From this description it is abundantly clear that the Ocean is one, so continuous around the four chief parts of the world that there is no land of the Earth, nor any Ocean or sea, which is not joined to it in some part of the world. Thus the Mediterranean Sea is joined to the Atlantic through the Herculean or Gaditanian Strait [fretum Herculeum seu Gaditanum — Strait of Gibraltar]; and to the Red Sea it is committed through the hidden conjunctions of subterranean channels. The Caspian Sea, by like reasoning, is joined to the Black Sea [Pontus Euxinus], this through the Bosphorus to the Archipelago, and at last is mingled with the Mediterranean Sea. By a not dissimilar reasoning, the Baltic Sea [Mare Balthicum], spread through two gulfs, the Bothnian and the Finnic, into the heart of Scandinavia, is connected through the Cimbrian Strait [fretum Cymbricum] to the Germanic or Deucalidonian Ocean. And these are the seas by which, as by certain arms, the whole mass of the Earth is bound; and these premises being laid down, let us now proceed to a particular description of them through several sections.

§ I.

On the Caspian Sea, the Black Sea [Pontus Euxinus], certain lakes of America, and the Atlantic Sea — things worthy of note

[Margin: Description of the Caspian Sea.] The Caspian Sea has tormented the wits of nearly all natural philosophers, since they cannot grasp how it neither increases by the perennial inflow of immense rivers, nor exhibits any trace of an outflow of its own, nor any trace of continuation with another sea. To me, indeed, the matter does not seem so abstruse that no cause of the hidden effect can be adduced.

[Margin: All seas communicate among themselves through hidden passages.] I say therefore first, and I assume as something confirmed by manifold experience, that all seas — not only at the surface but as...

I intimated above, through hidden and subterranean channels — carry on reciprocal exchanges of waters. I begin with the Caspian Sea, which before the Flood — by probable conjecture — was joined to the Ocean that flooded all the deserts and the flat, sandy places of Tartary, through a strait near the mouth of the Volga: not a few think so with me. [Margin: Tartary was once a sea and marshland.] But by the inundation of the Flood, with the softer parts of the earth scraped away by the huge mountain-chain of the Caucasus, the sea standing there — perhaps not very deep — was filled up. Hence the deeper gulf of the Caspian Sea, with the rest of the diffused sea covered over by a heaping-up of earthy parts, was wholly closed off, like a lake, and has remained so to this very day. Yet since from time immemorial it has received immense inflows of rivers, and has been seen to discharge no river, nor offers any trace of increase or inundation, this is a most evident sign that it secretly plays together with the Ocean, or with the neighboring seas, through hidden passages. But how and where this happens, it is now time for us to disclose.

[Margin: Hidden passages communicate among themselves.] As I intimated above, [Margin: The communication of the Caspian Sea with the Persian Gulf and the Black Sea.] we think it has two such passages, of which the first discharges itself into the Black Sea through the infernal passages lying beneath Georgia and Mingrelia [Megrelia] at A B, so that the whole region lying between the Black Sea and the Caspian could rightly and deservedly be called a kind of bridge of waters gliding underneath. Nor are there lacking indications of this matter. [Margin: First passage.] For first, Paradia Persa [?] relates, in his geographical treatise on the Caspian Sea, drawing on the Trapezuntine [Trebizond] history, that on the maritime shores lapping Mingrelia the Black Sea was sometimes observed to be

seething as if with huge boilings; and he assigns the cause of this in these words: "It has been observed, by long observation, that whenever East winds blow violently in the Caspian Sea, at the same time in the Black Sea boilings of this kind, greater than usual, are seen, with a vast agitation of the whole deep; and conversely, when West winds prevail on the Black Sea, disturbances of this kind are noted in the Caspian Sea." This is surely a clear sign that these seas assail one another with reciprocal motions through hidden and vast passages. [Margin: The proper ejecta of the Caspian Sea.] To confirm this, he adds that various things are from time to time cast up — fragments of ships, trunks of trees — which in no way belong to the Black Sea, but which are proper to the Caspian (such as a certain kind of seaweed and serpent, and "Tatar tablets" [?]), a clear indication of a continuation of seas of this kind through subterranean waters.

Diagram. A regional map showing the postulated subterranean communication of the Caspian Sea with the Persian Gulf and the Black Sea, looking across the Caucasus region. The Caspian Sea (upper left) and the "Mare Persicum" (Persian Gulf, upper right) are linked by a dotted line labelled "Canalis subterraneus" (subterranean channel) running eastward across the upper part of the map through the Kingdom of Persia. Below, the Black Sea (Euxine) is shown with Constantinople at its mouth. Mountains are engraved in ranges across the field; a compass rose sits at right-center. A decorative cartouche at lower right carries the title. Letter labels A–D mark the postulated channel mouths and connecting points.

- Top center–left: "PERSIÆ REGNVM" (Kingdom of Persia)
- Upper left (body of water): "Mare Caspium." (the Caspian Sea)
- Upper right (body of water): "Mare Persicum." (the Persian/Persian Gulf)
- Across upper field (dotted line): "Canalis subterraneus" (subterranean channel)
- Right-center field: "ANATOLIA" (Anatolia) [styled across the map: A-N-A-T-O-L-I-A]
- Center-left region: "Georgia" (Georgia)
- Center region: "Megrelie." (Mingrelia)
- Center, near a peak: "Hapezarde" [?] (a mountain/place name — uncertain reading)
- Left margin (river): "Volga flu." (the Volga River)
- Center (near A, connecting waters): "Canalis [?]" (channel label, partly obscured)
- Center-left: "Caucasus" (the Caucasus)

- Lower center (body of water): "Euxinus mare Nigrum." (the Black Sea)
- Lower center (city): "Constantinopolis." (Constantinople)
- Lower left (river): "Borysthenes flu." (the Dnieper River)
- Lower center (river): "Danubius [?] flu." (the Danube River — reading uncertain)
- Lower left (small water body): "Tanais flu." [?] (the Don River — uncertain reading)
- Point label "A": near the Caspian's southern channel mouth
- Point label "B": near the northern shore of the Black Sea (channel terminus)
- Point label "C": at the right, near the Persian Gulf channel mouth
- Point label "D": near the Caspian, on the dotted subterranean channel
- Cartouche (lower right): "Typus Communicationis maris Caspy, cum Persico et Euxino." (Diagram of the Communication of the Caspian Sea with the Persian and the Euxine)

LIBER II "Geocosmus" — Caput XIII (continued)

[Margin: The same channel.]

There are also clear enough indications, supplied by the Persians themselves, that a second channel of the Caspian Sea is continued through subterranean paths to the Persian Sea, that is, the Persian Gulf. The first of these is the Charybdis, or whirlpool, of the gulf that washes Persia, two days' journey from Balsara [Basra]. There the sea is swallowed down with a marked drop in level, and then, once the waters have been restored to their bed, not even a trace of the whirlpool remains. The explanation of this is none other than a certain correspondence with the Caspian Sea. When the Caspian, stirred up by the violence of the winds, has driven a great part of its water into the Black Sea, it then — to make up the deficit of water — draws water from the Persian Gulf through the said subterranean channels C and D, so that at the said spot C a whirlpool must necessarily arise.

[Margin: Subterranean link of the Red Sea with the Mediterranean.]

But when, in turn, the Black Sea, churned up by the fury of the western winds, restores to the Caspian Sea the deposit of water entrusted to it, the Caspian — having now regained its fullness — gives back to the Persian Gulf the burden of water that had been drawn from it. And so, by this reciprocal circulation — a truly marvelous play of nature — the said seas, kept in agitation, carry on their

subterranean commerce, sustained by the silent communications of their waters. But so that the reader may understand that this is true, I shall bring forward several other seas in which repeated observation has shown that the same thing occurs.

[Margin: A wonderful story.]

That the Mediterranean Sea is connected with the Red Sea through hidden channels is taught by a most famous story which Abulhassen [?] recounts in his work *On the Wonders of Egypt*. When the pasha of the city of Sues [Suez] (which lies at the far end of the Red Sea, and was once called Asiongaber [Ezion-Geber]) was at one time taking part in a celebrated fishing expedition, it happened that, as the fishermen drew their nets to the shore, they found an enormous dolphin trapped in them. They presented it to the pasha as something rare and unusual, both for its great size and for the wonderful appearance of the beast. He, gazing at the creature with admiration, judged that it should not be killed but set free. This was done — but only after a plate of brass [aurichalcum], inscribed in Arabic letters, had first been fastened between the gills of the animal, with this wording: *Ahmed Abdalla, Pasha of Suez, grants you your life together with this gift, in the year of the Hegira 720*. The beast, honored with this gift, was at once released into the sea; and feeling itself weighed down by the burden of this new thing fastened around it, and driven by terror, it plunged into the innermost depths of the sea.

Now it happened that in the same year, fishermen pursuing their catch in the Mediterranean Sea near Damiata [Damietta], besides an extraordinary multitude of fish enclosed in their net, dragged ashore a dolphin of unusual size; and when it was cut into pieces, they found within it that very plate, inscribed in Arabic letters not long before by the aforesaid pasha. When the pasha Ahmed was informed of this, he acknowledged that the inscription was indeed his own. But just how the dolphin had passed from the Red Sea into the Mediterranean Sea sorely vexed the wits of many. Some claimed that it had made its way to this place by swimming around the whole of Africa, through the straits of Gades [Gibraltar]; but this opinion was at once rejected as improbable and incredible. Others, however, more sensible, asserted that the said dolphin had reached its destination through the subterranean channels by which the Mediterranean Sea is joined to the Red Sea. This view was accepted with applause by everyone, and it strongly appealed to me as well; and if what the story relates is true, the matter certainly cannot be otherwise.

[Margin: The Dead Sea.]

To these is added the Asphalt Sea [Mare Asphalticum], which they call the Dead Sea [Mare Mortuum], famous in Palestine. It receives the Jordan into its bosom, yet is furnished with no outlet on its outer surface by which it might discharge itself. Therefore, since the said sea never grows larger from the increase of the river, it is a plain sign that it likewise discharges itself, in equal measure, through subterranean channels along the hidden recesses of its bed into the sea — but into which sea? I shall say what has come to my knowledge from the report of many travelers. On the seacoast of the Red Sea, on that side which washes Arabia Deserta, there is a very famous place called Eltor [El-Tor], as appears on the map, where not far from the shore an enormous quantity of naphtha and bitumen is belched up at all times from the bowels of the sea, to the astonishment of all, who wonder whence so great a quantity of naphtha can come.

When I had been informed of the nature of the place by the report of those who had made their yearly pilgrimage to Mecca, I long puzzled with myself over the origin of this bitumen, and at length concluded that this boiling-up of bitumen comes from nowhere but the bituminous sea of Palestine — which, on account of its sluggishness, is called the Dead Sea — discharging itself through a subterranean passage. For since the Asphalt Sea, so named from its bitumen, generates a very great deal of bitumen, and the shores round about it are seen to be filled with bituminous pits — and since this sea has no outlet by which it might discharge the waters of the Jordan flowing into it — it certainly cannot discharge itself except through a hidden meandering channel of the earth, at this spot, together with the bituminous offspring which it has carried down with it from its source. The boiling-up of bitumen at the said place clearly shows this, if what I learned from the mouth of the man himself [Greek: αὐτόπτης (autoptēs, "an eyewitness")] is true. And that this bitumen wells up from nowhere but the Asphalt Sea is clear from this: that the whole of that shore shows not even a trace of bituminous growth, which it nevertheless ought to show, if it were produced there by nature in the neighboring shore. For there is generally a certain reciprocal communication between seas and the lands they wash, as regards their powers and properties [...] discharges itself in like manner into the sea through the hidden recesses of its bed.

[Margin: A common communication.]

It remains, therefore, that the Dead Sea discharges itself into the Arabian gulf through a channel of 62 leagues (for that is the distance of the Asphalt Sea from the Red Sea).

[Margin: The distance of the Dead Sea from the Red Sea.]

Therefore the Dead Sea is connected with the Red Sea, and through it with the Ocean — which was what had to be shown. The same must be said of all other seas and lakes which receive rivers and emit none: for they have subterranean channels through which they discharge themselves into the Ocean or into neighboring seas. For just as the Lake Zaire in Aethiopia

receives huge rivers and discharges others into the Ocean, by way of beds found on the outer surface of the earth, so the Caspian and Dead Seas receive certain rivers but do not emit them, except through the inmost bowels of the earth, by channels [...] led off into other seas — with this difference, however, that these latter are sometimes salt, the former unsalted, and consequently derived from the storehouses of springs into the cavities destined for them by nature.

Diagram. A bird's-eye landscape map of the eastern Mediterranean coast, showing the supposed subterranean connection of the Mediterranean and the Dead Sea with the Red Sea. A cartouche at the upper right carries the title. At the upper left is a compass rose with an arrow pointing left (toward the viewer's west). Ranges of stylized mountains run along the top and left edges; the open sea fills the lower portion. Two dotted lines labeled "subterranean channel" run from the Dead Sea / interior toward the Red Sea coast.

- Cartouche (upper right): *Communicatio Maris Mediterranei et quod mortuum dicunt cum Mari Rubro* ("The communication of the Mediterranean Sea, and of the one they call the Dead Sea, with the Red Sea")
- Compass rose (upper left): arrow pointing left
- *Ior* (upper center, source of a river): label for the spring/head of the Jordan
- *Dan* (below *Ior*): the other source-spring (Dan)
- *Jor*: (mid-upper, on the river course): Jordan [river]
- *Lacus Genesari*. (lake, center): the Lake of Gennesaret [Sea of Galilee]
- *...danus flu.* (river label, center; reads "[Jor]danus flu.", i.e. the river Jordan): the Jordan River
- *Mare mortuū Asphalticū* (center, the body of water): the Dead Sea / Asphalt Sea
- *Leni* (?) (small label below the Dead Sea): place-name, reading uncertain
- *Montes Idumei* (mountains, upper center-right): the Idumean [Edomite] mountains
- *M. Libanus* (left): Mount Lebanon
- *Tripolis* (town, left coast): Tripoli

- *Carmel* (peak, center-left coast): Mount Carmel
- *PALÆS:… TINA*. (spread across the interior): PALÆSTINA (Palestine)
- *Ierusalem* (town, center): Jerusalem
- *Canalis subterraneus bi[tuminis]* (dotted line, upper, toward Eltor): "subterranean channel [of bitumen]"
- *Canalis subterraneus* (dotted line, lower, toward Suez): "subterranean channel"
- *Eltor* (Red Sea coast, right): El-Tor
- *Mare Rubrum* (right): the Red Sea
- *Sues, Asionga[ber] olim*. (town, lower right): Suez, formerly Ezion-Geber
- *Ægyptus* (lower right): Egypt
- *Nili flu.* (river delta, lower right): the Nile River
- *Alexandria* (town, bottom): Alexandria
- *MARE MEDITERRANEUM* (lower center, spread across the sea): the Mediterranean Sea
- *Cyprus* (island, lower left): Cyprus

[Body heading: CONSECTARIUM I. — p. 88]

COROLLARY I [CONSECTARIUM I]

From these few points the reason is clear how and why some lakes receive rivers and emit none; some emit and receive none; some both receive and emit; and others neither receive nor emit. Of the first kind of lakes enough has already been said. Those which emit rivers and do not receive them necessarily draw the perpetuity of their flow from the hidden water-reservoirs [hydrophylacia] of the neighboring mountains, by which whatever is lost on the one side by outflow is restored to them on the other. As for those which both receive and emit rivers, they have the same explanation as the preceding kind.

Here this too should be noted: that some rivers pass through marshy waters without mingling with them — as the Nile through Lake Bed, that is, Zaire; the Rhine through Lake Acronianum [Lake Constance / Bodensee]; and the Rhône through Lake Lemanus [Lake Geneva]. The reason for this is none other than the lightness and clearness of river waters, purified of all dregs by their perpetual motion and by the force of their cataracts. From this it must follow that marshy water, weighed down by dregs and made, as it were, torpid and heavier by rest and idleness, is rendered heavier — so that the lighter water [the river water] floats upon it; which also [is apparent]

[Margin: The various differences of lakes.]

[continued from p. 88] is apparent at the mouths of great rivers, from which streams, depositing themselves into the sea, continue their flow together with their sweet taste for an interval of many miles — for no other reason than that river water is lighter than seawater. But of these matters in their own place and time.

Finally, lakes which neither receive rivers nor emit them can be considered in two ways. First, some are so constituted that at one moment they greatly increase, at another they suddenly diminish, and from time to time they dry up altogether; and these must be judged to take their origin from no other cause than the increase and decrease of rainfall and melted snows. These are called not so much lakes as standing pools and marshes. Secondly, there are found other lakes which never either increase or decrease, remaining in a perpetual equilibrium. The reason is that, through hidden channels, they are kept perfectly level with the surface of the waters in the water-reservoirs of the mountains, with no difference intervening — except that the hidden water-reservoirs of the mountains are covered, as if by certain arches, over the mountain ridges, whereas these [lakes], lacking lids, lie open beneath the open sky.

As appears in the Figure: imagine a water-reservoir D E covered by the mountain A B C; this, by its waters derived beyond the wall of the mountains, produces on the outer surface of the plains two lakes F F. These lakes will be on the same surface with the waters of the water-reservoir D E, and the external [reservoir] does not differ from the internal, except that the one is covered by a mountain set over it, while these [lakes] appear uncovered. But of all these matters, one and all, fuller treatment will be given in the discourse on the Origin of Springs.

Diagram. A cutaway landscape cross-section illustrating mountain water-reservoirs (*hydrophylacia*) and how they feed plain-lakes. A dotted line traces the original (now cut-away) profile of the opened mountain up to a peak marked A. At the center the mountain is shown "opened and cut" to reveal a large internal cavern-reservoir; to right and left lie lower plains with lakes fed from it. Labeled points and captions:

- A (peak, top): apex of the (cutaway) mountain profile
- B (upper, at the cut): upper edge of the opened reservoir
- C (upper right, at a second cut): upper edge of the right-hand reservoir
- D (mid-left, within the cavern): lower point of the reservoir interior
- E (mid-center, mouth of cavern): outlet point of the reservoir

- F (in the plain, left): label of the plain-lake (*Lacus in planitie*)
- F (in the plain, right): label of the second plain-lake
- *Mons apertus et sectus* (center): "the mountain opened and cut [away]"
- *Hydrophylacium intra viscera montis* (within the mountain): "water-reservoir within the bowels of the mountain"
- *Lacus in planitie* (left foreground): "lake in the plain"
- *Hydrophylacium apertum sive Lacus in planitie* (right foreground): "open water-reservoir, that is, a lake in the plain"

[Body heading: CONSECTARIUM II. — p. 89]

COROLLARY II [CONSECTARIUM II]

From this it is also clear that scarcely any lakes of any name are of that kind which neither receive nor emit rivers and yet are capable of increase and decrease — lakes which, even though they receive no rivers, are nevertheless always increased by an abundance of rivulets and by the inflow of springs. Otherwise, in the height of summer, no trace of them would remain — as happens with marshy and stagnant waters, which for the most part are consumed by the summer sun.

That lakes are therefore both filled and emptied through subterranean channels is evident from many rivers which, in the middle of their course, are in some places entirely swallowed up, and on the other side are born again and burst forth, so that they seem to be wholly new rivers. Thus the river Niger of Aethiopia, flowing from the Lake of the Nile, when in Nu-

[Margin: The Nile and Niger, buried in the earth, burst forth again elsewhere.]

bia, enclosed and hemmed in by huge chains of mountains, finds no place to escape — these barriers being, as it were, broken — is hurled headlong through subterranean meanders, and seeking an outlet for itself on the other, western, side of the mountains, and joined by many other rivers, is increased as though by some interest [on a loan], and rolls down into the Atlantic Ocean.

[Margin: The Tigris.]

In like manner the Tigris, carried across Mesopotamia and meeting Arethusa, when it encounters the resisting Caucasus, withdraws and plunges into a certain very wide cavern; and at length, bursting forth again over an immense expanse of land, it scarcely crosses Lake Thospites [Lake Van] with an unbroken flow when — behold! — struggling far and wide against new barriers of mountains, it

at length cunningly hides itself underground, and bursting out on the other side of the mountain at an interval of 24 miles, continues its flow, and near Babylon mingles with the Euphrates. Aristotle [Aristoteles] writes that there were many streams of this kind (*Meteorology* I.13 [cited: l. 1, c. 11]).

[Margin: The Alpheus, a river of Greece, communicates with the Arethusa of Sicily.]

So too certain Greek writers think that the Alpheus, a river of Achaia, performs its course either beneath the surface of the sea or all the way into Sicily, where, near Syracuse [Syracusas], it emerges as a huge spring which is called Arethusa. They say that the sign of this is that, in the end, near Arethusa and in the middle of the harbor, in a submarine [...] the dung of cattle was discharged at the bottom; for once, every fifth summer — that is, every five years [lustrum] — at the very time when the games of Olympia were being celebrated in Achaia, and the dung of the slaughtered cattle was thrown into the Alpheus, it was carried out by the favorable current and ejected near Arethusa, into the harbor-bay which is to this day on that account called the Alpheus, commonly *l'Occhio*.

[Margin: The Anas, a river of Spain.]

In like manner the Guadiana — which was formerly called the Anas — a river between Lusitania and Boetica [Baetica] and the town of Medilina [Medellín], submerged in subterranean passages, after an interval of 32 miles wells up again; so that the Spaniards boast that their kingdom has a bridge furnished with woods and meadows, on which countless myriads of animals are fed in the richest pastures. I myself have also seen similar plays of nature in many places in Germany. In Westphalia, not far from Lichtenaw, a river is swallowed up and bursts forth beneath the very foundation of the Cathedral Church of Paderborn, and from there is deposited by a threefold stream into the Lippe. I remember having seen a similar one in Eichsfeld, whose name does not now come to me. In America, everywhere, such playful sportings of rivers are to be seen, so that I think it superfluous to describe them at greater length, since in every region of the world, everywhere, such spectacles are to be met with.

CAPUT XIV

[Body heading: CAPUT XIV. — p. 89]

On the Height of Mountains, and the Depth of the Ocean and of the Seas; in which also the height of Mount Caucasus asserted by Aristotle is examined.

[*De Altitudine montium, et profunditate Oceani, mariumque, ubi et Caucasi montis altitudo ab Aristotele asserta discutitur.*]

It was the opinion of certain men, and is still the opinion of very many, that the height of the mountains is as great as the depth of the neighboring seas. Whether this is true, we shall examine in this chapter, [beginning] from the height of the mountains

as we set out to begin the first principles of our reasoning.

Ancient Geography persuaded itself, rather simplistically, that mountains are not raised higher than 15 stadia, and presents as the highest mountains of the whole world: the Caucasus; the Imaus, that is, the Parapanisus [Hindu Kush]; the Alps; the Acroceraunia; in Asia Minor, the Olympus; the Pelion and the Ossa in Macedonia; in Mauritania, the Atlas; in Greece, Athos. Aristotle himself admired the lofty summits of the Caucasus. But since, in the very text of *Meteorology* I.13 [l. 1, c. 4] where he describes it, many things occur which need examination and the touchstone [lydius lapis], we shall now bring this passage — already treated by many others — back to the anvil, so that the truth of the matter may shine forth. He speaks as follows:

[Greek: ὁ δὲ Καύκασος μέγιστον ὄρος τῶν πρὸς τὴν ἔω τὴν θερινήν, δῆλον δὲ καὶ τῷ πλήθει καὶ τῷ ὕψει σημεῖον δ' ἐστὶ· τοῦ μὲν ὕψους, ὅτι ὁρᾶται καὶ ἀπὸ τῶν καλουμένων βαθέων, καὶ εἰς τὴν λίμνην εἰς πλεόντων, ἔτι δὲ ἠλίσσεται τῆς νυκτὸς αὐτοῦ τὰ ἄκρα μέρει τοῦ τρίτου μέρους τῆς ἔω, καὶ πάλιν ἀπὸ τῆς ἐσπέρας. ("The Caucasus is the greatest of the mountains lying toward the summer sunrise, and this is clear both from its extent and from its height. A sign of its height is that it is seen even from the so-called Deeps, and by those sailing into the lake [the Maeotis]; and moreover at night its peaks are lit for a third part of the night before dawn, and again [for a third part] after evening.")] (*Meteorology* I.13 [Met. c. 4])

In Kircher's Latin: *The Caucasus is a mountain among those that lie toward the summer rising of the Sun, the greatest alike in extent and in height; and a sign of its height can be gathered from this — that it is seen both from that place which they call the Deeps of the sea [profunda ponti], and by those who navigate the mouth of the Lake Maeotis. Besides, its highest parts are illuminated by the Sun's rays at night, both at dawn and at evening, for as much as a third part [of the night].*

[Margin: The height of the Caucasus.]

This is the view of Aristotle on the height of the Caucasus, which he set forth in the present text — and over which so sharp and vehement a skirmishing has arisen among the commentators that there is scarcely anyone who has expounded this passage rightly. And, to confess the truth, if in any passage of his writings, then surely here, the Philosopher has suffered no small loss to his reputation, since — according to the tenor of the words — the height of the Caucasus is so great that it seems to overthrow all the principles of Astronomy. But let us set out the matter a little more fully.

[Margin: Exposition of the Aristotelian text.]

First, then, he begins with the places from which it can be seen, which are: the *Deep of the Pontus* — or, what is the same thing, the Black Sea [Pontus Euxinus], on account of its immense depth deservedly called the Black Sea — and a second place, the Lake Maeotis [Sea of Azov], which he also calls a "marsh" [stagnum], and from which he asserts that the Caucasus is seen by those sailing on it. We have seen the places from which a free view of the Caucasus to the eyes lies open; now nothing else seems to be required except that we determine the distance of the Lake Maeotis from the Caucasus. But when we do this, no small difficulty arises: namely, just which one is properly that most famous Mount Caucasus, the one that reaches the sky with its summit, and in what region it is situated.

[Margin: Where the Caucasus is situated.]

For it is certain that it exists in the nature of things, and can be seen from the Maeotis — unless you wish to assert either that other intervening mountains, grown up in the meantime, have taken the summit of the more distant Caucasus from sight, or that the Caucasus has been carried off elsewhere by some gigantic feat; all of which to suppose is, I think, ridiculous and a mark of stupid folly. For my part, to reach some ray of light in such great darkness, I left nothing undone: I approached Armenian merchants, and

[Margin: The Caucasus is manifold.]

[I approached] the missionaries of the Congregation for the Propagation of the Faith, who had dwelt for many years in Caffa [Kaffa / Feodosia], the chief city of the Cimmerian Chersonese [Crimea], and had more than once crossed the Lake Maeotis. I also dealt with the Theatine Fathers, to whom a field for the evangelical sowing has been assigned in Georgia, that is, Colchis, so that they might give me some certain information about the height and situation of the Caucasus. But neither the aforesaid explorers of the Maeotis lake nor the Georgian (Colchian) Theatines — just as the former asserted that they had found nothing of so great a

height of the mountain as I was describing, even though they had continually roamed back and forth from the Euxine to the Caspian and from there to the Euxine — so too the latter had discovered nothing about the Caucasus, celebrated for its prodigious illumination by the Sun.

Indeed, they even testified that Georgia is separated from the Maeotis lake by so great an interval of travel that it cannot possibly be that any mountain, however immense its height, could be seen from such remote shores. There are indeed certain very high mountains proper to Precopian Tartary, which the ancients called the Hippici [the Hippican Mountains], as well as parts of the Corax, which are seen from Caffa; but these can by no means be the Caucasus mountains, since the whole of Geography is against it; nor does any mountain of Asia Minor disclose itself to the eyes of those exploring ever so carefully on this side. Hence they consider the whole account by Aristotle of the height of Mount Caucasus to be fabulous.

[Margin: The Caucasus cannot be seen from the Maeotis.]

These things, therefore, having been duly investigated, I now set about demonstrating that this whole text is utterly false. And first, indeed, I shall show that the Caucasus cannot by any reasoning be seen from the Maeotis. The common opinion of the geographers places the Caucasus in the region of Colchis — which today they call Georgia and Mingrelia [Mengrelia] — at latitude 47 degrees, that is, in the middle of the region lying between the Pontus and the Caspian Sea; so Ptolemy [Ptolomaeus], Strabo, and their commentators.

[Margin: The Caucasus is manifold.]

Nor should anyone persuade himself that the Caucasus is some solitary mountain; rather, it is a chain of mountains stretched out in a threefold order: the first runs from the middle of the region to the West, the second to the East, the third to the South, propagating a numerous offspring of crags linked to the Taurus — whence very many have asserted the Caucasus to be a part of the Taurus. Be that as it may, the Caucasus takes on so many different names that to this very day a dispute hangs among the geographers about the true place and genuine situation of the Caucasus, some confounding it with the Taurus, some with the Corax and the Heniochus, others with the Caspian [range]; nor are there lacking those who would have the Caucasus mountains to be the same as the Imaus and the Parapanisus.

[Margin: The situation of the Caucasus between the Pontus Euxinus and the Caspian Sea.]

The stronger opinion, however — as we said above — places it between the Caspian and the Euxine Pontus, in the intermediate district of Colchis, Albania, that is, Iberia, which embrace Georgia and Mingrelia. For here, with the threefold order of mountains converging into one, it is raised up by a huge peak, near the Albanian Gates [the Caspian Gates / Derbent]; and this mountain,

—or rather a heap of mountains, which to this day they call *Caxes*, a word not far removed from "Caucasus." This we say is the Caucasus, about whose height our dispute with Aristotle is concerned. For since in that whole stretch of the shores of the Black Sea [Pontus Euxinus], or in Colchis [Georgia], no greater mountain than this is found, the origin of the river Phasis from it—which Aristotle himself also notes—confirms this identification.

The first question, then, is this: can the Caucasus be seen from Lake Maeotis, or from Caffa (the ancient Theodosia), where lay what were called the depths of the Black Sea? My answer is that it cannot. For, on the testimony of Ptolemy and of modern geographers, the lake is ten degrees of longitude distant from it. [Margin: The distance of the Caucasus from Lake Maeotis.] Resolved into linear measure, these yield a distance of 600 Italian miles—exactly as great a span as that by which Mount Etna is distant from the Pennine Alps. Therefore, just as it is impossible to see the Alps from Etna, so I say it is impossible to see the Caucasus from Lake Maeotis—unless the mountain were of such height that it raised its summit more than a hundred thousand paces into the air. No one has ever observed such a height in the kingdom of Georgia, frequented though it is; nor is it granted by any cosmographer, for reasons to be demonstrated shortly. [Margin: No mountain can be seen at a distance of 100 miles.] I add further that the mountain, once the curvature of the earth is taken into account, would, at the stated distance of ten degrees, not merely fail to be seen but—as optics teaches—would vanish entirely from the eye. The peaks of the Alps demonstrate this more than amply: their summits, at a distance of 40 German miles, can never be seen, and at 30 German miles only barely—scarcely even that—and then only now and then, in the clearest possible air, faintly visible like a thin bluish cloud, from other very high mountains of Germany.

The same happens with the mountains of islands. For if you stand on the highest ridge of the Apennines and cast your eyes out over the whole horizon, bounded by the surface of the sea, you will find not the slightest trace even of the loftiest mountains of Corsica and Sardinia—which are nevertheless scarcely a hundred miles away—unless now and then (which happens very rarely indeed) by some peculiar effect of refraction, in a perfectly clear state of the air well suited to

refraction, they appear somewhat raised into view. (So much can both the curvature of the earth and the packed density of the layers of air accomplish in hiding the objects of islands and of the most distant mountains.) If, then, objects at so near a distance disappear from sight, how shall the Caucasus, set 600 miles away from Lake Maeotis, lie open to the eye?

From this, unless I am mistaken, it is clearer than the noonday light that Aristotle's text [Margin: The Caucasus cannot be lit along its whole height by the Sun.] cannot at all agree with the facts, and that it cannot come about that the Caucasus should be visible from the places he designates. But I come now to a second difficulty—as much greater as it is entangled in greater complications. Aristotle says, as is evident from the text cited above, that the summit of the Caucasus is lit by the Sun up to a third part of the night, both at dawn toward morning and again toward evening. This passage has wonderfully confounded the ingenuity of all the commentators, since an inexplicable difficulty shines out in the text. Some have extended this illumination *to a third part of the mountain*; others have transferred it *to a third part of the night*. And while they have striven all the more stubbornly, by every possible means, to defend Aristotle's error, they have at one stroke smeared both themselves and Aristotle with the mark of utter ignorance.

Those, then, who transferred the words to the illumination of a third part of the mountain—as though the Sun by night, morning, and evening always lit a third part of the mountain—commit an error so glaring in cosmography that schoolboys could correct it. For from this it would plainly follow that the mountain must reach the borders of the Moon to produce so unusual an effect; and who does not see how ridiculous this is? And so, since they were ashamed of so disgraceful an error, they transferred the words of the text to a third part of the night—that is, so that at a third part of the night, namely four hours (of which the whole night contains twelve) before the rising of the Sun and after its setting, the mountain should begin to be illuminated. But I show by ocular demonstration that this too cannot, and should not, be admitted on any grounds.

First, the light by which he says the Caucasus is lit for four hours before sunrise and as many after sunset can be understood in two ways: either as direct light, or as reflected (secondary) light. If they take it as reflected light—such as appears at the onset of twilight, that is, as doubtful light—they prove nothing. For light of this kind, from the 45th up to the 66th degree of latitude, is continuous on summer nights, and bathes mountains small and very high alike indifferently with the ray of its reflected light. Nor does this seem to have been Aristotle's view,

since by the illumination of the mountain he wished to show its excessive height. Aristotle's words, therefore, are to be understood of the direct light that illuminates the mountain—whatever the interpreters unskilled in astronomical matters may prattle, with useless effort, about reflected light. This being established, I undertake to demonstrate that the mountain must have been of excessive height. And first, with the Sun in Cancer, then in Aries and Libra, and third in Capricorn, I shall show how great a height the mountain must have had in each of these stations in order to be illuminated by direct solar rays at a third part of the night.

I assume, then, from Ptolemy, that the summit of the Caucasus is set at a latitude of 47 or 48 degrees, and that the Sun is in the first degree of Cancer. I assume, second, the third part of the night, at whose beginning the mountain begins to be illuminated.

PROPOSITION I.

The arc of four hours below the horizon, set in the vertical circle, with the Sun placed in Cancer, is 16 degrees 10 minutes at latitude 48 degrees.

Demonstration.

Diagram. A great circle representing the vertical circle of the Caucasus, with its labeled points. The circle is the vertical circle A F D; F is at the top, A at the left, B at the right. Through the center pass the diameters; several intersecting ecliptic and horizon arcs are drawn within. Point D lies just above the center O; C lies just below it; L is at the lower left; d is at the upper right.

- F (top of circle): apex of the vertical circle
- d (upper right): rising point of the ecliptic [recte: D, ecliptic rising point per text]
- D (center, above O): point of the ecliptic culminating in mid-heaven
- A (left): point where the vertical circle meets the horizon
- O (center): center of the Earth
- B (right): point where the vertical circle meets the horizon
- C (below center): occiduous (setting) point of the ecliptic
- L (lower left): position of the Sun at the beginning of the third part of the night

Let the vertical circle of the Caucasus be A F D, the point of the vertical F; the horizon A D B C, and G D L C the ecliptic, with the center of the Earth O. By

hypothesis these are all great circles, whose planes intersect one another at the center of the Earth; and let the diameter of their common section be C O D. Let the Sun be at point L, at the beginning of the third part of the night. The arc A L is sought.

Given, then, the hour of the night and the elevation of the Pole, there is given—by the doctrine of spherical triangles—the point of the ecliptic, rising at D, setting at C, and each both above the horizon at noon and below it at midnight. But given the culminating point in mid-heaven, there is given also, for the stated latitude, the angle of the horizon with the ecliptic at the given point of the ecliptic, which is A C L; and the angle L A C will be right, being that of a vertical to a horizontal. And given the points L and C, the arc L C will also be given. Moreover, in the right triangle A L C, by Problem 2, Proposition 4 of the *Spherical Triangles* of Clavius [Christoph Clavius], the angle A C L will be given, together with the remaining arcs, and consequently the sought arc L A.

Given, then, the right spherical triangle A C L, two sides will be known: namely the side subtending the right angle L A C, which is the arc between the horizon and the lowest point of the heavens, 68 degrees 53 minutes (for this is exactly the interval between the 20th degree of Leo and the eleventh of Gemini, the latter being at the lowest point of midnight, while the Sun is at point L, at the third part of the night). The other side, A L, the arc of the meridian, is likewise established. Since, then, the sine of the angle A C L (which remains after subtracting the declination of the Sun, set in the 11th degree 7 minutes of Gemini, from the complement of the elevation of the Pole)—the angle being 21 degrees 19 minutes—is 36371, and the given arc L C is 50 degrees (which is the difference of degrees between the beginning of Cancer and the 20th degree of Leo, which is on the horizon at the given time)—the sine of these 50 degrees being 76604—it will be: as the whole sine 100000 is to the sine 36371, so 76604 is to a fourth term. Carrying out the operation, the sine 27861 results: the arc L A, to which there correspond in the table of sines 16 degrees 10 minutes.

The arc L A, therefore, with the Sun at the beginning of Cancer, is 16 degrees 10 minutes—which was to be demonstrated.

In this way we find that, with the Sun set in the points of Aries and Libra at the given hour of the night, the arc L A is below the horizon by 35 degrees 25 minutes; and in the first degree of Capricorn, the arc L A is depressed below the horizon by 50 degrees. These being found, let us now show how great the height of Mount Caucasus must be in order to produce the effect of the alleged illumination.

PROPOSITION II.

How great the height of Mount Caucasus must be, when the Sun, set in Cancer, Aries, and Capricorn, illuminates it at the third part of the night.

Diagram. Two concentric circles: an outer circle representing the periphery of the Geocosm (the Earth) and a smaller inner circle. The vertical of the Caucasus is the vertical line through c (top) and H (bottom); A is at the left and B at the right of the horizontal diameter; D is the center; m and n mark the ends of the physical (mountain) horizon; e, f, g lie on the line of the vertical near the summit; i appears at upper left and again as an inner point near D; o lies to the right of D; L is at the upper right; h at the lower right; P at the bottom of the inner circle.

- c (top, outer circle): apex of the vertical of the Caucasus
- i (upper left): point on the line of a solar ray [?]
- L (upper right): the Sun's position
- f (on the vertical, near top): point on the axis of the horizon
- e (on the vertical, above center): point of contact of the rational horizon with the mountain's surface
- g (just right of e/center): point of contact of the solar ray with the Earth
- m (left): end of the physical/mountain horizon
- n (right): end of the physical/mountain horizon
- A (left, outer): end of the rational horizon
- i (inner circle, left of D): point on the inner circle [?]
- D (center): center of the Earth / Geocosm
- o (right of D): point on the horizontal
- B (right, outer): end of the rational horizon
- P (bottom of inner circle): point on the inner circle
- h (lower right): point where the solar ray meets the outer circle
- H (bottom, outer): foot of the vertical

Let the vertical of the Caucasus be A C B; let the periphery of the Geocosm or Earth be e o p q, whose center is D; the physical horizon, or that of the mountain, m n; the rational horizon A B; the line of the vertex, or axis of the horizon, e C; and the height of the mountain e f. Let the line i h be tangent to the surface of the side at point e—at the time when, before sunrise or after sunset, at the beginning or end of the fourth hour of the night, the Sun illuminates the summit of the mountain.

Now since the line $i h$ of the solar ray touches the Earth at point g , and the horizontal $m n$ touches it at point e , let the lines $D g$ and $D e$ be drawn from the center D through the points of contact g and e , of the lines $i h$ and $m n$; these, since on both sides they make right angles with the lines $i h$ and $m n$, and since the semidiameters of the Earth $D e$ and $D g$ are [equal], the vertical arcs $L f$ and C will consequently be equal to one another. Once the common arc $L f$ is removed, the remaining arcs $f h$ and $C L$ will be equal to one another. But the arc $f h$, intercepted between the Sun and the horizon, is already known from the preceding proposition: 16 degrees 10 minutes. Therefore the arc $C L$ equal to it is likewise known. In the angle $D f e$, then—being a right angle—the angle $D f e$ is known. [Margin: The height of the Caucasus is demonstrated by geometric reasoning.] Subtracting, then, the angle $e D g$ from a right angle, the angle $D e g$ will appear. Therefore all the angles of the triangle $e D g$ will be known. Given also the side $D e$, the semidiameter of the Earth, the remaining sides are therefore known by Proposition 2 of Clavius's *Plane Triangles*; and therefore the height of the mountain $e f$ also, in the manner that follows.

With the Sun at the beginning of Cancer, at the beginning or end of the third part of the night, the arc between the Sun and the horizon, $f h$, is, as shown above, 16 degrees 10 minutes, whose complement is 73 degrees 50 minutes, whose sine is 96040 of such parts as the whole sine $D f$, 100000, contains. Moreover, since the semidiameter of the Earth $D e$ is known to be 3036 Italian miles, let it be done thus: as the sine $D e$, 96040, is to 3036, the known semidiameter of the Earth, so is the whole sine 100000 to a fourth term. The operation completed, there results 3161: namely the line $D f$, made up of the semidiameter of the Earth and the height of the mountain $e f$. Therefore, subtracting from 3161 the semidiameter of the Earth, 3036, there will remain 125: the sought height of the mountain. [Margin: 125 Italian miles for the mountain.]

But with the Sun placed at the beginning of Aries and Libra, since the arc $f h$, at the beginning and end—before or after the setting of the Sun—was found by Proposition 1 to be 35 degrees 25 minutes, you will find, by the procedure of the preceding operation, the height of the mountain $e f$ to be 699 miles. Finally, with the Sun in Capricorn, and at the beginning or end of the third part of the night, set at point h below the horizon—which arc $f h$ we found by Proposition 1 to be 50 degrees 17 minutes—if you proceed by the rule of the preceding operations, you will find the height of the mountain $e f$ to be 1715 miles.

Recapitulation of the Calculation.

[Margin: The height of the Caucasus demonstrated by geometric reasoning.]

If the Sun, before or after rising, at the beginning of the third part of the night, begins to illuminate Mount Caucasus, the height of the mountain will be:

	Italian miles
If at the beginning of Cancer, it will be	125
If at the beginning of Aries and Libra, it will be	699
If finally in Capricorn, it will be	1715

Since these things, then, stand firm by the infallible reasoning of calculation, let the Reader now judge whether a mountain of such height can be found in the nature of things—one that would display the illumination alleged by Aristotle. And let the Peripatetics not here take refuge in the light of twilight; for they will accomplish nothing. Since the twilights, with the Sun set in Cancer, last the whole night, and since one and the same twilight is common to flat places and to small, great, and very great mountains alike, the height of the mountain—which Aristotle meant to infer from the Sun's illumination—cannot in any way be gathered from this. He spoke, therefore, of the true and direct illumination by the Sun, as his words plainly teach; nor are his words, since they are perfectly plain, to be twisted into other meanings; rather, we must stand by the words of the Author. For it is not what he conceived in his understanding that falls to us to explain—since of that nothing can be established for us—but what he meant by his writings, and those plain and open ones.

If, then, it is true—as is found most true from his writings—that he said the Caucasus is lit by the direct rays of the Sun at the third part of the night, then necessarily these absurd consequences follow, which we have just demonstrated: namely, that the mountain must be high, with the Sun set in Cancer, 125 [miles]; in Aries or Libra, 889; finally in Capricorn, 1715 Italian miles. And since these are utterly absurd, and wholly unworthy of so great a genius—being repugnant to all the principles of geography—nothing remains for the defense of Aristotle except to say that he asserted these things on the report of others. Yet a man of such authority and renown ought not to have assented to any old tales of old wives' reports, but with the utmost diligence and caution to have looked carefully into whether what was said agreed with the truth, and whether it accorded with the principles of astronomy. Indeed, since he abounded in riches and power, and was not so far distant from Lake Maeotis, he ought to have sent geographers to investigate the matter more thoroughly, sparing no expense, lest by paradoxes and absurdities he entangle both himself and posterity along with him. [Margin:

Caution to be employed in doubtful matters.] But let these things, said in passing about the height of Mount Caucasus, suffice.

Mount Athos—which Mela thinks exceeds the region of rain on account of its height, because of the undisturbed state of the ashes found upon it year after year—was, by an enterprise truly memorable to all the ages, cut through by Xerxes and made passable by a navigable strait. [Margin: Mount Athos in Macedonia, cut through by Xerxes.] Dinocrates is said to have measured it and found it twelve stadia high. (See the account of this measurement in the *Ars Magna Lucis et Umbrae*, where you will find everything treated at length concerning this mountain.) Pliny and Geminus teach that the mountains Pelion and Cyllene were measured by Dicaearchus at the King's expense, and that the former was found to be 1,250 paces high, the latter no less. Pliny says that Mount Coesim in Asia raises its ridge to four thousand paces. Martianus Capella writes that Mount Haemus is 6,000 paces high. Strabo reports the rock of Sisimithra as 15 stadia, and a rocky mountain of the Sogdians as 30 stadia high. But lest I waste time on the description of mountains already carried out by others, I shall here set down a Table of the heights of the principal mountains, so that the Reader, from their known height, may gather what is to be thought about the depth of the sea. [Margin: The height of Mount Athos.]

Table of the heights of the principal mountains.

Mountain	Stadia	German miles (of which 8 make one mile)	Paces
Pelion	10	1 2/8	1250
Catalyrium	14	1 6/8	1680
Cyllenom [Cyllene]	15	1 7/8	1875
Petra Sogdiani [Rock of the Sogdians]	30	3 6/8	3750
Haemus	80	10	10000
Olympus	10 15/125	1 6/8 (nearly)	1269
Petra Sisimythrae [Rock of Sisimithra]	15	1 7/8	1875
Picus Canariarum [Peak of the Canaries, i.e. Teide]	80	10	10000
Aetna	23	4	4000

Mountain	Stadia	German miles (of which 8 make one mile)	Paces
Aetna	40	5	5000
Caucasus	120	15	15000
Caucasus	408	51	51000
Cassius	224	28	28000
Atho [Athos]	160	20	20000
Athlas [Atlas]	210	15	15000
Riphaeorum altissimus <i>Stolp</i> dictus [the highest of the Riphaean mountains, called <i>Stolp</i>]	200	25	25000
Norvegiae Montes [Mountains of Norway]	48	6	6000
Montes Lunae [Mountains of the Moon]	120	15	15000

To these we append a table by which, from a given distance, we determine the height of a mountain, and, from a given height, the distance at which it can be seen.

TABELLA

By which, from a given distance, to find the height of a mountain, or, from a given height, the distance at which it can be seen.

TABULA I — Height of Mountain in Paces				TABULA II — Height of Mountain in Miles & Paces			
		Minutes of Degrees				Degrees, Minutes	
Milliar.	P a	Grad.	M i	Milliar.	P a	Grad.	M i

TABULA I — Height of Mountain in Paces			TABULA II — Height of Mountain in Miles & Paces			Degrees, Minutes		
	Minutes of Degrees							
	c		n			c		n
	es		.			es		.
0	1/ 0		1 1			7 1		0
	2					6		
						1		
0	1 0		2 3			4 2		0
						5		
0	2 0		3 6			8 3		0
						5		
						0		
0	5 0		4 12			2 4		0
						0		
						9		
0	5 0		5 19			1 5		0
						0		
						0		
0	7 0		6 27			5 6		0
						5		
						0		
0	1 0		7 37			5 7		0
	0					5		
						0		
0	1 0		8 49			1 8		0
	3					5		
						0		
0	1 0		9 62			3 9		0
	7					5		
						0		
0	2 0		1 77			1 10		0
	1		0			5		
						0		
0	3 0		1 111			7 12		0

TABULA I — Height of Mountain in Paces			TABULA II — Height of Mountain in Miles & Paces			Degrees, Minutes		
	0		2			0		
						0		
0	4	0	1	320		9	20	0
	1		4			0		
						0		
0	5	0	1	773		5	30	0
	4		6			0		
						0		
0	6	0	1	1527		5	40	0
	8		8			0		
0	8	0	2	1778		6	50	0
	4		0			0		
						0		
0	1	0	2	5000		0	60	0
	2		5					
	6							
0	1	0	3					
	9		0					
	0							
0	3	0	4					
	3		0					
	8							
0	5	0	5					
	2		0					
	8							

Liber II "Geocosmus" (Technicus) — Caput XIV (continued)

Worked examples. For instance: suppose there is some mountain that lies 10 minutes distant from you, and you wish to know its height. Look in Table 1, in column 2, for 10 minutes; opposite it, in column 1, you will find 21 paces — and that is the height of the mountain. Again, let the mountain recede 50 minutes from you: the 50 minutes found in the second column will give 528 paces in the first column, which is the height of the mountain you sought.

In the same way, if some mountain recedes 4 degrees from you, look in Table 2 in the second column for 4 degrees, and opposite it you will find 12 miles, 209 paces — the height of the mountain you sought. You will proceed no differently in the other cases.

But if instead the height of the mountain is given, you will find in the second column of the Tables the minutes or degrees — that is, the distance from the mountain you sought.

Note, however, that all this is to be understood of the eye of the surveyor situated on the surface of the Earth that is concentric with the sea, not on the mountain's surface.

On the limits of measuring the great mountains. And these are the mountains whose heights mathematicians of keen ingenuity have attempted to explore — or rather to measure out — though not with any very certain measure. Yet if you should wish to compare their lofty peaks with the mountains of the American Andes, then certainly — on the testimony of [José de] Acosta — you would find these mountains [of ours] to be no more than humble cottages set beside palaces; mere cypresses, mere shrubs [viburnum], I say, set beside towering [peaks]. To undertake to measure those [Andean peaks], as also the mountains mentioned above, would indeed be a task most worthy of a mathematical mind — but for one who has duly weighed in the finer balance of his judgment the reefs of the difficulties that arise, he will perhaps, in due proportion, encounter the same difficulty as in measuring the very stars. I am speaking always of those enormous mountains — like the Caucasus, the Paropamisus [Paropamisus / Hindu Kush], the Pico [Pico del Teide, Tenerife], Athos, and countless others mentioned above. And so, in determining these by exact measurement, the true height can scarcely ever be assigned with certainty — only that height which emerges from a given hypothesis can be assigned. For since the root [base] of such mountains usually lies many days' journey away, one must first know that [distance] by exact measurement. Second, there is need of a sure, direct, and infallible incidence of the visual line upon the point of that mountain's summit — which, by the aid of no instrument, can be reliably taken at so great a distance. Third, the full account of refractions must be taken — refractions which, the more uncertain they are amid so great a diversity of the surrounding medium, wrap the task in correspondingly greater difficulties. Fourth: at so great a distance of the surveyor from the mountain's perpendicular, one must have foreknown — and with the utmost precision — the magnitude of the swelling of the terrestrial globe [its curvature]. For since the perpendicular of the mountain and the perpendicular

drawn from the center of the Earth through the surveyor's zenith are by no means parallel to one another, one will necessarily have to know in advance the angle that the perpendiculars from the center of the Earth, of the mountain, and of the surveyor's station make. And this angle simply cannot be had unless the distance between the mountain's apex and the surveyor's station is known; but this, in turn, presupposes

the precise quantity of the terrestrial semidiameter, which is still in question and, amid such great perplexity of disagreeing geographers, has to this day been correctly assigned by no one — since they falsely persuade themselves that the surveying plane on which they stand is continuous with the rest of the level surfaces, or even continuous with the sea beneath a concentric convex surface. I could adduce countless other obstacles and deceptions of sight, but let these suffice to draw out and clearly demonstrate the difficulty. Nevertheless, in mountains that are nearer, and not hampered by such circuitous journeys, [the attempts] will meet with happier success; for in this case no account need be taken of refractions, nor of the visual line, nor of the swelling of the Earth — these being scarcely subject to any perceptible error, provided the geometer's diligence and ingenuity are not lacking in the rest.

The disagreement over Monte Baldo. The difficulty of the work is shown by the recently made measurement of Monte Baldo [Monte Baldo], which rises with a lofty peak in the territory of Verona and is distant 75 miles from Forum Navii [Nave / Forum of Naevius (?)], a measurement made by [Giuseppe] Biancani [Blancanus]: the mountain's height was found to be 860. But [Niccolò] Cabeo [Cabeus], having weighed the matter more deeply, afterwards found its height to be 1190. And here Riccioli [Giovanni Battista Riccioli] was not satisfied: for, having examined everything thoroughly, he assigns the mountain a height double that which Biancani had found — namely 1654 Bolognese paces. Which of these three, then, I should subscribe to, I cannot discern. There will perhaps be another who, by discovering still other difficulties, will assign now a greater, now a lesser [height] — and so the stone of Sisyphus is rolled, the course of doubts never finished. So no faith can be placed in the three measurers of Monte Baldo cited just above, since they diverge from one another by such embarrassing differences. The uncertainty, therefore, that we have found established in the height of Monte Baldo — which is by no means the loftiest of all — we are bound to find, entangled in far greater difficulties, when we come to explore the monstrous height of the mountains mentioned above. This is as certain as the effort of all human ingenuity is uncertain and doubtful in wresting [an answer] from so many knots of difficulty — especially since the precise situation of

mountains of this kind, in degrees, is still unexplored, though the whole undertaking rightly depends upon it.

Kircher's own trial on Monte Albano. Indeed, that I might in some way test this difficulty of orometry, I judged that the business should be attempted in measuring Monte Albano [Monte Albano / the Alban Mount], 20 miles distant from Rome. So, having set up astrolabes in a suitable place, and then a quadrant whose diameter was 4 palms, I ordered just as many practiced observers of hawk-like sight to track, as accurately as possible, the very last extremity of the said mountain's apex in degrees on the quadrants — hoping it would turn out that they would all agree on one and the same degree and minute. But, the labor once begun, everything turned out to the contrary: for when I examined the numbers of degrees they had read off, I found them all, to a man, differing not only in degrees but even in minutes. The same happened when the same observation was repeated three or four times;

the matter was tried anew through individual observers, with the aid of that quadrant which I judged the most accurate. But not even here was agreement reached among them. At last we set about taking the height of a nearby tower: since its apex was closer to us, we likewise reached its point more precisely, and so all agreed in degrees and minutes. It was a most evident sign that the cause of error in the first observation had been nothing other than the excessive distance of the mountain, whose uttermost apex could not be precisely reached. From this experiment you have [proof of] how difficult it is, at a more remote and excessive distance, to investigate with infallible certainty the exact height of any rather distant mountain.

Kircher declines to give a method. The Reader might perhaps wish that here I should set down some method for exploring the height of mountains. But since countless others have handed this down, and the matter is not of such great moment, I judged it superfluous to waste time on a business commonly known — especially if the affair is carried out by a simpler geodesy, according to the rule of trigonometry, with all the above-mentioned observations and required conditions set aside. But if anyone desires such procedures more ardently, let him consult [Christopher] Clavius, [Willebrord] Snellius, [Giovanni Antonio] Magini [Maginus], [Adriaan] Metius, [Adriaan] Van Roomen [Sambecum (?)], and as many as have written on practical geometry. Among the rest, however, let him consult Riccioli, who, in Book 10 of the *New Almagest*, section 4 (*Almagestum Novum*, Lib. X, sect. 4), has treated this subject most fully. As for the arguments which the Author of the *Reformed Geography* [*Geographia Reformata*] adduces in

his recent work against me and my opinion concerning the measurement of mountains — since they are of no weight, they are likewise not to be heeded; for, the dispute that has arisen between us being unknown to no one, and since he [is] an honest hater of quarrels, not seeking (as the saying goes) a knot in a bulrush, [these arguments] could most easily be reconciled.

Return to the main question: do mountain heights match sea depths? But, to return at last to the thread of our purpose: we have introduced the heights of mountains here for no other end than to settle a dispute pending among most celebrated authors. Now the doubt is this: **Whether the depth of the sea, or of the Ocean, corresponds to the heights of the mountains.** [Margin: Whether the heights of mountains correspond to the depth of the sea.] Most commentators on Genesis, as well as the geographers, do not hesitate to embrace the affirmative part, and seem to wish to prove it from that passage of Genesis: *"Let the waters be gathered together into one place, and let the dry land appear,"* etc. So (they argue) in order that the water surrounding the Geocosm might be gathered into one place, there was need of deeper channels [alvei] in the surface of the Earth. The Earth, therefore — by the power of the almighty God and [Margin: The affirmative opinion.] by the efficacy of the divine word — they say was dug out and heaped up into vast mounds, from which the chains of mountains then arose; so that, on this account, the depth of the Ocean is exactly as great as the height of the mountains. This is the opinion of most Interpreters of Sacred Scripture. But whoever scrutinizes their statements more carefully will see clearly that from this an equal quantity of the Ocean's depth and the mountains' height [Margin: The negative opinion.] can by no means be inferred — since experience teaches that the depth of wells, ditches, and the foundations of any structure is always greater than the [height of the] earth heaped up round about into mounds. For in order that the heaped-up earth might equal the depth of some well, one would have to pile up the earth into the form of a cylinder, in exactly the same figure as the well had; and thus the earth heaped on high, being equal to the earth contained in the well, the depth would necessarily correspond to the height. But if you heap the said earth into a cone, you will never reach a height equal to the depth of the well — and the reason is that the parts of earth, since they cannot stay together at the vertex of a cone, run down by perpetual flux into the base and increase it by just as much as the separated heap of earthy material had departed from the vertex. And so in this way the height of earthen cones will never correspond to the depth of the ditches from which they were heaped up. Since, then, we see that mountains are heaped up for the most part not in the form of cylinders but of cones, it is certain that they are much lower than the

channel [bed] of the sea — granting always that the mountains arose from the excavation of the channels, as the above-named authors suppose.

Kircher's own view. But that I may here also set down my own opinion concerning the constitution of mountains: [Margin: The Author's opinion.] I say first, that just as the divine Wisdom has disposed nothing rashly or in a disorderly way in the nature of things, so it established the mountains too, and the Ocean, toward the loftiest and incomprehensible ends — ends hidden, as it were, in the divine Idea — with such providence that there should not be even the least slope which did not have its own uses: both universal ones, in the preservation of the Geocosm, and particular ones in some [given] region.

I say second, that since nothing is so necessary to the Geocosm as a fit distribution of mountains, it is plain that they were established in a certain order, according to the requirement of each region: for from these the whole mass of the earth draws sufficient nourishment, as it were from the breasts of a great mother. Whence I infer that the height of the mountains has nothing to do with [Margin: The height of mountains, or the depth of the Ocean, [need not] correspond to the height of the mountains.] the depth of the sea; nor did the mountains arise from the earthy clods of channels rashly heaped up in the primordial separation of the waters. Rather, as soon as the divine voice sounded forth — *"Let the waters be gathered into one place, that the dry land may appear,"* etc. — straightway also the whole mass of the Earth, according to the law prescribed in the archetype, was arranged into mountains and depressed into channels suited to the Ocean, the seas, the lakes, and the rivers — in a word, [it was disposed by] all [the efficacy] of the Author. [Margin: The efficacy of the divine wisdom and power in fashioning the structure of the world's mountains.]

The organs of the Geocosm, and the workshops of the interior Divine Economy — its storehouses [penuaria], its siphons, its furnaces — were established with exactly that perfection in which we behold them persevering to this very day. For the infinite Wisdom of God is not to be supposed to have founded the Geocosm after the human manner, so as first to dig out channels and then heap the excavated earth rashly into mountains — by no means. Rather, at God's voice, in a moment

all things, both as a whole and singly, came into being furnished with the necessary supports, according to the prototype of the eternal Mind. And that this is true, the constitution of nearly all mountains plainly teaches: for even the highest mountains — such as the Alps, the Pyrenees, the Acroceraunia [Acroceraunian Mountains], the range of the Caucasus and of Imaus [the Imaus /

Himalaya], extending over immense tracts of land — have obtained their God-appointed seat not on the shores of the Ocean, but in the Mediterranean [inland] regions of continents or islands, sundered from the Ocean by a long stretch of land. Most false, therefore, is the doctrine of those who would have the height of the mountains be as great as the depth of the sea.

The sea floor is as uneven as the land. For just as the earthy mass consists in its own unevenness, roughened with mountains and valleys, so too does the floor of the sea. [Margin: The floor of the sea is as uneven as the surface of the Earth.] On the terrestrial surface there are great, small, and middling mountains, the very highest; there are valleys, meadows, woods, pastures, tamarisks: and all these same things exist on the floor of the sea, roughened with countless underwater crags. So you may think that islands are nothing else than underwater mountains of enormous height, [Margin: Underwater mountains.] emerging with their summit alone beyond the Ocean and the seas — yet whose roots and fringes, stretched far and wide across immense tracts of underwater regions, you would then first see, if by divine power, with the waters dried up, they should disclose themselves to view. That there are underwater forests, the Red Sea sufficiently and more than sufficiently teaches, [Margin: Underwater forests.] from whose floor a great abundance of coral trees — scarcely yielding to our cherry-tree [in size] — is from time to time drawn up by fishermen, as I have more than once heard from the Arabs dwelling on the shores of the Red Sea; indeed, they sometimes grow to so great a height that they raise their branches [cornua] beyond the very surface of the deep, not without hindrance and danger to ships — and that not in some one place, or over some small tract, but in many places of the said sea, and over tracts extending for several miles, such underwater forests are found.

Now forests of this kind of coral are found not only in the Erythraean [Red] Sea, but in several others — as in the Sicilian sea near Drepanum [Trapani]; in the Gallic [sea] near Toulon [Tolonem], and on the other shores of the Ligurian sea; and in the Ocean, indeed, in countless places, which for brevity's sake I omit. [Margin: Underwater meadows.] That underwater or submarine meadows also exist, experience has sufficiently and more than sufficiently taught those who travel back and forth between Spain and Portugal and America; where the whole surface of the sea blooms with a submarine herb — which they call *Sargasso* — for the space of many days' [voyage], just as in some most delightful meadow: a herb that cannot keep its place, driven this way and that by the perpetual motion of the sea; the cause of which we shall disclose elsewhere. That there are also meadows luxuriant with submarine flowers, the coast of the New Kingdom

[Nuevo Reino de Granada] clearly demonstrates: [Margin: Submarine flowers.] [flowers] which, plucked by divers from the floor of the sea, as soon as they come up into the air, take on, as it were, the nature of crystalline stone, perfectly expressing the form of flowers — which the Fathers of our Society [the Jesuits] generally employ in adorning the altars of the College of Cartagena: a remarkable work of nature, and unseen in Europe. Submarine [growths] too, of seaweeds of various kinds among pleasant green plots, are lacking to no sea. And not far from Malta [Melita] there is a tract of sea which they call the *Praterias* [the "Meadows"], [Margin: Submarine meadows not far from Malta.] especially renowned for fishing, where, over a great expanse, as on the plateau of some mountain, a meadow remarkable for its greenness and pleasantness — not without the delight of beholders — spreads itself out beneath the waters, hidden about 20 palms deep; in which countless shoals of fish, stabling as it were in a field of full beauty, take their delight, not without great profit to the fishermen. If anyone inspect the boundaries of this meadow more closely, he will see that the sea, beyond the limits of the greenery, is suffused with a certain dark color — either because of its remarkable depth, or because of the very high precipices of crags that bound the meadow. But since we shall treat of these prodigies of nature expressly in their own place, I do not pursue the subject, since it suffices us [to have shown] that the floor of the sea, no less than the land, is rough, uneven, scabrous, filled with mountains, valleys, or impenetrable abysses; and that it abounds also in springs and rivers, [Margin: Submarine springs and rivers.] as was demonstrated in the *Prodromus Subterraneus [Iter Exstaticum / Prodromus]* — so that anyone explores the height of mountains from the depth of the sea with fruitless labor.

This, however, I do say: that just as in the inmost recesses of the terrestrial continents the highest mountains are seen to be heaped up, so in the middle of the Ocean a greater depth is always found, but toward the more level shores an ever lesser and lesser depth. I said "toward the more level shores," because where shores are girt with huge crags, there too a greater depth than at more level shores is found — nothing other than experience itself teaches this, on the rocky shores of Norway, Iceland, the Flemish Islands [Azores? / Flemish Islands], and countless others.

[See the figure description below.] See, in the following figure, a terrestrial mountain whose roots, slipped in at B and C, are carried beneath the waters to D; where it rises again with new crags D, E, and from there is carried on to F, the highest depth of the sea, or abyss; from there, ascending again upward and emerging beyond the surface of the sea, it forms the island G, which is then again

connected with still other crags of submarine mountains; and in this way the whole floor of the Ocean is constituted with a wondrous and incredible unevenness. Submarine plains, however, are reckoned to exist chiefly there where the Ocean or sea is seen to be destitute of all traces of islands — just as plains [are] among valleys; as is shown at I.

Diagram. A wide landscape-format woodcut spanning the column-width at the top of the page, depicting a cross-section profile of land and sea floor to illustrate the unevenness of the submarine terrain described in the text. At the left, a terrestrial mountain mass rises above a horizontal water line; its base descends below the water into a series of jagged underwater peaks and deep troughs (the "abyss"), then rises again to form a small island near the right, before connecting to further submarine crags. The lower portion is filled with horizontal hatching representing the body of water; the sea floor is drawn as an irregular, serrated profile line. The lettered points correspond to those named in the text.

- A (upper left, on the terrestrial mountain): label A
- B (left, at the mountain's base near the waterline): label B
- C (left of center, at the base, descending below water): label C
- D (lower left of center, a deep underwater trough/crag): label D
- E (center, an underwater crag): label E
- F (lower center, the deepest trough — "summa maris profunditas sive abyssus," the highest depth of the sea or abyss): label F
- G (right of center, the emergent island above the waterline): label G
- I (right, on a submarine plain region): label I

Conclusion of Caput XIV. [Margin: Submarine meadows.] [Margin: Submarine springs and rivers.] From the things adduced it is plain how greatly those are mistaken who think that the depth of the sea is everywhere either equal, or [who] suppose that its precise depth can be determined; for that is just as difficult as [to determine] the heights of the mountains diffused over the whole surface of the Earth

by a sure method. So that this [verse] seems to fit here: "*Who has measured the height of the heavens, the breadth of the Earth, the depth of the Sea?*" [cf. Sirach 1:3 / Ecclesiasticus]

CAPUT XV.

De Inæqualitate fundi maris, cui jungitur Historia memorabilis
supradicta confirmans.

**(On the Unevenness of the Sea Floor, to which is joined a Memorable History
confirming what has been said above.)**

I shall add in this place a History which happened in Sicily in the time of King Frederick [Frederick II of Sicily / of Aragon], by which the things hitherto said concerning the unevenness of the sea floor are confirmed. [Margin: A history of Pescecola, a Sicilian diver.] There was in Sicily at that time a certain diver, most renowned for his fame, Nicholas by name, whom from his skill in swimming the common people called *Pescecola* — that is, they named him "Nicholas the fish." From boyhood accustomed to the sea, and excelling in skill at swimming, he occupied himself almost solely with gathering oysters, corals, and the like on the sea floor, by the sale of which he afterward earned his living. And he was so taken with this commerce of the sea that, in his early years, he would linger in the sea for four or five days at a stretch, sustaining his life on raw fish; he went and came repeatedly to Calabria by swimming, performing the office of a letter-carrier; he is said to have reached the Lipari Islands more than once by swimming; he was sometimes found by triremes in the midst of a swelling and stormy gulf of the sea, off the coast of Calabria — the sailors at first sight supposing him to be some marine monster; but, recognized by some, he was taken aboard the trireme. Being asked where he was bound in a sea tossed by so many storms, he answered that he was carrying letters, enclosed in a leather pouch and pulley skillfully fitted out — lest they should be spoiled by the surrounding moisture — to some city or other [coriacea bursa et trochlea]. At last, after long conversation, and being well fed, and bidding the sailors farewell, he finally committed himself once more to the sea. [Margin: A wondrous degeneration of the diver's nature.] They relate, moreover, that from his continual companionship with the waters the said Nicholas had so changed his nature and constitution that he was more like an amphibian than a man: a cartilage having grown between his fingers into the form of a goose's foot, necessary for swimming, and his lung so dilated that it could hold air sufficient for breathing for a whole day.

While, then, the King of Sicily was staying at Messina at a certain time, having heard incredible things commonly told about this diver, he was moved both by curiosity and by a desire of seeing the man, and wished him to present himself to

him; which, after he had long been sought for by land and sea, was at last done. The King had heard certain wondrous things told him about the nature of the nearby Charybdis; and so, having obtained so opportune an occasion, he resolved that the interior constitution of Charybdis should be explored — [Margin: The exploration of Charybdis.] which exploration, indeed, he thought could be done no better than through this Nicholas. So Nicholas was ordered to let himself down into the depths; and since he seemed somewhat reluctant to resist the King's command, on account of the extreme perils (and others known to him alone), the King, to render Nicholas more courageous for the execution of the work, ordered a golden cup to be thrown into that place, promising it should be his if he brought back what had been thrown in. Nicholas, allured by the gold and accepting the condition, soon hurled himself into the deepest whirlpools; where he remained for nearly three quarters of an hour, while the King and the bystanders awaited him with great longing. At last, cast back up with great force from the lowest floor of the vortex, brandishing the recovered cup in his hand in the manner of one triumphing, he was received within the palace, and, somewhat weakened by the excessive labor, and revived by a sumptuous meal, after he had indulged in sleep a little while, he came into the King's presence; and, being questioned about all that he had discovered on the floor [of the sea], he is said to have addressed the King thus: [Margin: The diver's account to the King concerning the perilous state of Charybdis.] "Most clement King, what you commanded I have carried out; I would never have obeyed your commands, had I first known what I have found out — not even for the half of your kingdom promised me: I committed a great rashness, while I deemed it rashness not to obey the King's command." And when the King asked the cause of [his calling it] rashness, he replied: "Know, O King, that there are four things which make this place — I will not say to me and to divers like me, but even to the very fish — impenetrable, [and] too greatly to be feared:

[Continuation of CAPUT XV — the four dangers the diver enumerated, the diver's death, and the close of the chapter.]

[Margin: Vortices terrible within.]

make it so. First, the violent rush of a river boiling up out of the deepest abysses of the sea — a force that a man can scarcely resist, however great his strength and power. I myself could not overcome it, and so I had to descend into the depths by other byways. Second, the multitude of rocks one meets everywhere, whose bottoms I have barely reached without manifest danger to my life and of having my skin torn off. Third, the channels [Euripi], or surges of subterranean

waters, which roll themselves out with enormous force from the innermost bowels of the rocks, and whose contrary flux drives whirlpools so formidable that they can kill a man stunned by sheer terror alone.

[Margin: Enormous octopuses.]

Fourth, the herds of huge octopuses [Polypi], which cling to the sides of the rocks and, with their tentacles stretched out far and wide, struck the greatest horror into me. One of these — if you look at the body's bulk — I saw to be greater than the size of a man; and its tentacles were no less than ten feet [decempeda] in length. Had they gripped me with these, they would have dragged me to themselves in inescapable danger of death and killed me with their embrace alone.

[Margin: Sea-dogs.]

There also lodge, in the nearby lairs of the rocks, fish monstrous in their ferocity, which they call "dogs" [Canes], commonly *pesce Cane*. These have jaws furnished with a triple row of teeth, and in the bulk of their bodies are by no means inferior to dolphins. From their savagery no one can be safe; for whomever they have seized with their teeth, you may hold it for certain that he is finished — since no daggers [machærae], no scimitars [acinaces], can be furnished with so great and so keen an edge as these sea-monsters fail to surpass with the sharpness of their teeth in cutting through whatever you please.

When these things had been set out in order, he was asked how he had managed to find the cast-in cup so quickly. He answered that the cup, owing to the violent flux and reflux of the waters, had by no means descended straight down to the bottom; rather, it had at once been thrown back by the force of the waters — much in the manner, he said, in which he himself was thrown back — and he had found it inside a certain hollow in the rock. Had it descended to the very bottom, it could not have happened that any hope of finding it would have remained, amid so great a boiling of the surges and so violent an onset of the whirlwinds.

[Margin: Channels.]

For the channels [Euripi], by which the subterranean water is now swallowed into the inner depths and now disgorged back again, are stirred with such great turmoil that there is no force which can resist them. He added that the sea in that same place is so deep that it confounds the eyes with an almost Cimmerian darkness. He was also asked about the disposition of the inner part of the strait. He answered that the whole of it is entangled with innumerable rocks, from

whose roots the flux and reflux of the subterranean waters running between them produces — according to the variation of the time — those disturbances at the surface which sailors experience at great peril to their ships.

[Margin: Surges of the subterranean waters violent.]

He was further asked whether he had the heart [animus] to attempt once again the bottom of this Charybdis. He answered: no. Yet, overcome a second time by a purse full of gold coins — with a cup of great value attached and thrown into Charybdis — and enticed by an accursed hunger for gold, he gave himself a second time, headlong, into the gulf. But he never appeared again, perhaps carried off by the force of the channels into the labyrinths of the mountains, or made prey to the very fish he had feared.

I have thought it well to set down here this history — just as it was recorded in the royal records, and communicated to me by the Secretary of the Archive — so that the eddying tracts of the seas might appear more plainly.

[Margin: The author died in the year 1638.]

[The right-hand margin carries several lines of handwritten (manuscript) annotation in a later cursive hand, partly legible: "...plus / ...Alm. Magn... / Gerual. Diary [?] / ...pag. 90 [?] / ...Mart. Ding Canicula [?] / tom. X. colleg. 9. pag. 139". These are a reader's reference jottings, not part of the printed text.]

CAPUT XVI.

Measurement of the Sicilian Strait, made by the Author in the year 1638.

Having long observed the turbulent state of this Mamertine Strait — both from my own experience and from my reading of the historians — and being at that same time on my way back to Italy, waiting near the Pharos for an opportune moment in the course of three days, I did not want to let so notable an occasion for exploring the strait slip away. So I hired sailors skilled in the nature of the place and entered the strait, equipped with a great coil of line for use as a sounding lead [bolis].

[Margin: Unevenness of the bottom of the Sicilian Strait.]

First, at the point where the strait is narrowest — between the bank of Pelorus at the Pharos and the Calabrian promontory called Scyllaeum — I found by geometric measurement that the breadth is 2,783 geometric paces [passuum

Geometricorum]. This done, I steered the boat in a straight line across, undeflected, from the Pharos continuously up to the said promontory, and by continually casting the sounding lead I explored the depth of the sea. In some places I found a bottom now of 30, now of 50, 60, then 100, and again 200 feet; in some places, as it were, certain sheer rocks [scopulos praeruptos]; but — astonishing to say — in others I found the whole bottom of this breadth to be rocky, and a certain ridge running across like a bridge from Calabria into Sicily, with the bottom on either side sinking away into the abyss.

[Margin: Sicily was once joined to Calabria.]

This gave no obscure evidence that Sicily was once joined to Calabria by this rocky tract; and that from time immemorial — whether by an earthquake or by the violence of the Tyrrhenian sea — this Isthmus had been broken apart and had degenerated into a strait, thus turning the peninsula Trinacria into an island. But since I have described this expedition in the *Ars Magnetica* [Kircher, *Ars Magnetica*], I have decided to add here only those things worthy of note which I omitted there.

Three things, therefore, I labored above all to explore with the utmost zeal — the strange effects of which, as we read, have grievously vexed all the greatest philosophers in the assigning of their true cause. The first was the surge of Scylla; the second, Charybdis; the third, the inconstant, varied, and reciprocal motion of the strait —

— whose causes, if (as I hope) I shall have assigned them, I shall certainly have accomplished what in every age has been singularly desired by every philosopher without exception.

First, then, with the utmost zeal I explored the courses of the surging sea — entirely varied: straight, sloping, contrary, and colliding with one another in a kind of perpetual struggle. Moreover, I found that whole stretch of sea between Scylla and Charybdis, nearly five miles in extent, to be most seething, unfathomable by any sounding lead however long, and formidable with its whirlpools.

[Margin: The surge of the strait varied and formidable.]

There, where waves meet contrary waves, they raise savage whirlwinds: now the strait rushes off into a chasm, now — with the force and crash of colliding waves rebounding from the surface of the sea — they produce a vast gulf and an immense whirlpool. By these inundations, in a marvelous way, ships and

whatever else meets them are dragged through gyres and contrary courses — swallowed by the internal force of the spirit — down into the deepest subterranean burrows of the gulf; these reappear, regurgitated, on the Tauromenian shore, by the testimony not only of Sallust [Sallustius] and Strabo [Strabo], but also of the observation of the people of Tauromenium [Taormina].

[Margin: The surge of the strait follows the motion of the Moon.]

And these savage and merciless squalls do not always (as I learned while staying at Messina for the space of a month, on purpose) play out their scenes of ferocity, but most of all when winds — partly from the Ionian, partly from the Tyrrhenian sea — lash the jaws of the narrow strait with contrary waves. At other times, even though as to the surface it may seem calm, it nevertheless by no means ceases from the customary tumults of its inner workings. Rather, it so regulates its flux to the ascent and descent of the Moon that the sailors themselves, accustomed to this strait from boyhood, can predict the behavior of the currents even at the first aspect of the Moon. And when the Moon is hidden by clouds, they recognize its station in the heavens from the flow of the currents — all of which things I found out, to my great wonder and admiration.

Hence this strait, once notorious for shipwrecks, is now crossed as easily as any other, thanks to the skill of these sailors, who are accustomed to steer ships through various windings without any danger — so that, the contrary currents having been avoided, they take advantage of a neighboring one running straight on, until at last they reach their destination. But if anyone, neglecting the guidance of these sailors, enters the strait too rashly, then — as surely as they do not know the hidden reasons of the currents — so too they expose themselves to manifest danger of shipwreck, unless they are quickly freed from the peril by the helping hand of the guides.

[Margin: The force of the contrary surges in holding ships fast.]

There is, in an elevated spot, a house of the Novitiate of our Order [the Society of Jesus] at Messina, from which the whole length of the strait lies open to view. From this I afterwards observed, not without admiration, that even very large freighters [naves ... praegrandes & onerarias], with their sails spread, clung fast for many hours to all their anchors, as if held fixed by cables fastened to beams — yet soon, when the currents changed and by the skill of the guides, they got free and continued the course they had begun.

But to return to the subject we proposed: in the first place, just past the jaws of the strait, there occurs that famous Scylla, of which Virgil [Vergil] writes:

[Margin: Charybdis.]

Scylla guards the right side, implacable Charybdis the left: three times she gulps the vast floods sheer down into the gulf of her chasm, and again hurls them up by turns, and lashes the stars with the wave. (*Virgil, Aeneid III*)

The monuments of all historians and poets are full of the voracity of its hidden nature, entangled with countless fables. If anyone wishes to see these, let him consult Cluverius [Philipp Clüver], *Sicilia Antiqua* I.1, fol. 64. It is not my intention to cite the things of others, but to bring forward the things we have learned by our own experience.

[Margin: Scylla — its surge and properties.]

Scylla, then, lies next to the promontory which was once called Cenys, now Scyllaeum, commonly *Sciglio*. Its nature is such that it is stirred by an immense disturbance of the waters coming and going both ways. When it is agitated by the influx, its violence is so great that a ship entrusted to it, with every hope of escape taken away, is dashed against the walls of the mountains and committed to inevitable shipwreck. Yet it becomes somewhat gentler when the surge has driven it back in the reflux toward the eastern [Ortivam] quarter of the strait. But unless the dangers are properly guarded against, and the turning-points of the flux not observed in good time, it happens from time to time that those who have been swept from the quicksands of Scylla into the eddies of Charybdis find — only then — the very danger they had fled; and so this verse aptly fits them:

He seeks the caverns of Charybdis who wishes to escape Scylla.

And conversely:

He falls into Scylla who wishes to avoid Charybdis.

I said that this Scyllaeon ferocity does not always slacken its reins, but does so at certain blasts of the winds, as will be shown later. So, in order that the reciprocal surges of so prodigious a sea may at last be settled by physical reasoning, I say first that Scylla is nothing else than a subterranean whirlpool [voraginem], continued through hidden meanders into the Tyrrhenian sea, or into some other one. How, then, this approach and recess of the waters occurs must be explained.

[Margin: The cause of the flux and reflux of Scylla.]

It was observed — both by me with the utmost diligence, and by the sailors as confirmed — that in the gulf of Cujatium [?], at the Vatican promontory, within

the hollow of the bay, both on individual days and especially when the east wind [Subsolanus] blows, and most of all when Scylla undergoes its influx, the signs of an almost maximal boiling sea are to be seen. But at the defluxion of Scylla, when the west-by-south wind [Eurus, here "occiduus"] prevails, that water too is stirred as if into certain eddies and whirlwinds. As these things are established by daily experience, so too they point out, as if with a finger, the cause of the flux and reflux of Scylla.

Note, then, that both the Tyrrhenian sea and the Mamertine — that is, Scyllaeen — strait are stirred by a twofold motion: one through the influx entering by the Straits of Gibraltar [fauces ... Gaditanas], by which the inner sea, pressed by an immense mass of water, communicates its impetus to all the other bays and straits —

— that meet it. Hence the bays of the sea, and especially this strait of ours, acquire their greatest increase. But when the Ocean ebbs, then in the same proportion by which the inner sea had previously risen in its bays and straits, it decreases in ebbing — this is also called the "drawing-back" [attractus]. And this motion, as it depends upon the Moon (as will be said in its place), so it also lasts with a stable and perpetual flux and reflux twice by day and by night.

The second motion of the inner sea is ascribed to the winds, and to the dashing of the wind-driven waters against the opposing tracts of land. This motion, being by its own nature unstable and subject to the caprice of the winds, accordingly occurs only at uncertain and indeterminate times.

[Margin: Description of the flux and reflux of Scylla.]

With these things presupposed, let us now begin with Scylla. By perennial experience it undergoes its influx and refluxes on individual days, which happen in this way. As the hidden force of the urging Moon insinuates itself into the Ocean, within the Mediterranean sea, through the Straits of Gibraltar, suddenly that whole length of the sea, stretched out from west to east, driven by the impetus of the Ocean, dashes itself — with a great mass of water, as if in formed battle-line — against the bay of Cujatium [?] directly opposite there. But since in this bay (as experience teaches), at Scylla, the subterranean passage C B has its mouth B, assigned to it by nature in the bottom or side of the inmost sea, it comes about that the bay's narrows, pressed by the great mass of water, find an occasion of escape and flight through the said channel, and so prepare an exit for themselves through Scylla.

Hence Scylla, pressed by the mass of the following waters, directs its flux eastward [in ortum] toward Charybdis D. But when the Ocean ebbs, and thus draws the mass of the inner sea's waters along with it, then the flux of Scylla, by a contrary motion, hides itself within its accustomed whirlpool beneath the Scyllaeen rock, and the water withdrawing from the bay of Cujatium [?] takes its place. This is the cause of the perennial daily motion of the flux and reflux of Scylla; hence sailors, observing the Moon, know by an infallible sign the time of flux and reflux.

[Margin: The danger that here threatens ships.]

And this motion of Scylla is the gentler, the more constant is the recess and access of the sea depending on the Ocean. But where the western winds have roused the sea more violently, then too the passage of Scylla is exacerbated by storms of waves in the bay of Cujatium [?], and stirs up in the Scyllaeen outlet those waves which sailors experience to their great peril. For then the same Tyrrhenian sea, being agitated, not only insinuates itself through the hidden inlets, but also — with open warfare [manifesto Marte] — through the jaws of the strait; and when it dashes more violently against the curved shore of the strait, and is stirred into circles by the reflected course coming from the blasts of the east wind [Subsolanus] on the opposite side, it drives — as if in a joined battle — horrible whirlwinds and motions together with the Scyllaeen flux. This struggle of nature lasts as long as the fury of the winds is found to last; but when the west and east winds are at rest —

Diagram. A large engraved map-plate occupying the lower half of the page, depicting the Strait of Messina (the "Mamertine Strait") with Sicily at the lower left and Calabria at the lower right, shown in oblique relief with mountain ranges. A compass rose with a directional arrow sits at the lower left. The cartouche at the lower right carries the caption.

Labels read on the plate (positions approximate):

- Caption cartouche (lower right): *Tabula Freti Siculi Charybdis et Scyllae, aliorumque aestuum rationes explicans* [Map of the Sicilian Strait, explaining Charybdis and Scylla, and the workings of the other surges]
- Top center / upper band: *SICILIA*
- Upper right: *Mare Thyrrenum sive Siculum* [The Tyrrhenian or Sicilian Sea]
- Upper right (coast): *Mylae* [Milazzo]
- Right (coast): *Pelorum Promont.* [Cape Peloro / Punta del Faro]
- Left: *Syrophœnia* (with a wind-head blowing — a personified wind)

- Left coast: *Mare Africanum* [The African Sea]; below it *Os Canis ex mari Sico* [the "Dog's Mouth" from the Sicilian sea]
- Center: *Messana* [Messina], shown with buildings
- Center channel: *Canalis subterraneus in Charybdis* [Subterranean channel into Charybdis]
- Lower-left mountain: *Promont. Pachynum* [Cape Pachynus / Capo Passero]
- Center-lower: *Canalis ex [A]Etna* [Channel from Etna] (with *Aetna* labelled on a peak, point *M*)
- Center-right (coast of strait): *Charybdis*; nearby *Charybdis Tauromenia*
- Right-center: *Pelorum Promont.* [Cape Peloro / Punta del Faro]
- Right: *Scylla*; with point letters *C, B, E, D* marked near the Scyllaeian shore (matching the C-B passage and point D of the text)
- Right edge: *Claucus Sin.* [= Glaucus Sinus, the Gulf of Glaucus], point *A* (the bay called "Cujatium" in the text)
- Across the lower water: *FRETVM MAMERTINVM* [The Mamertine Strait]
- Lower right (Calabrian coast): *Regium / Rheggio* [Reggio di Calabria]
- Lower band: *CALABRIA*
- Geometric construction points lettered *M, N, A, B, C, D, E* distributed across the channel, keying the subterranean-channel argument of the text.

— at rest, the sea still seethes with whirlwinds and storms. From this it is plain why, when the strait is roused, such great dangers threaten sailors.

This is certain: near the Scyllaeian cavern I have found a bottom unfathomable by any sounding lead. The cause of this, however, I have judged should be ascribed not so much to an abyss as to the flux of the violent water that drags the lead along with it into the hollows of the mountain — which both the resistance of the lead and its persistent leaning toward Scylla seemed sufficiently and more than sufficiently to indicate.

Here, reader, you have the account of the flux and reflux of Scylla. If anyone disapproves of it, let him assign a better one — to which we promise not unwillingly to subscribe — we who here set forth the things we have learned by irrefragable experience.

[Margin: Description of Charybdis.]

Now follows the nature of Charybdis to be explained. Charybdis — which is nothing else than an absorption of the sea — exists in that part of the curving shore of the harbor by which Rhegium [Reggio] is reached, distant only 20 paces

from the part of the Mamertine harbor that faces Calabria. This I crossed twice, by the diligence of the ferryman and on the occasion of an opportune moment. Its nature is such that now, as if a pot set over a fire, it boils perpetually; now it drives whirlpools stirred as if by whirlwinds — which are the more dangerous to sailors the less the boilings expose them to danger; for you may pass over a boiling shoal [Syrтим] with impunity, but not so when it is stirred with whirlpools.

[Margin: When Charybdis rages most.]

It was observed by the long experience of sailors that Charybdis boils most of all when the Syro-Phoenician wind [Syrophoenix], commonly *Scirocco*, dominates the strait. Yet this wind too, according to the common law of the flux and reflux of the strait, also gives daily its not-obscure signs now of regurgitation, now of absorption; but it rages most, as we said, when the Syro-Phoenician blows, and indeed with such a fury of the waters that it seems to belch up deluges of water in the form of a column. The cause of this matter, therefore, is asked.

I am not unaware that many have attributed so unusual an effect to contrary surges of the strait meeting each other, by whose collision the waters, heaped up, are raised on high — as happens in not a few seas. But if this were so, why is there always at one and the same place a sea-boiling of this kind? Why not in any other quarter of the strait? — since, with winds contrary to one another, the sea could cause such an accumulation in any place, as also happens in seas situated at the great mouths of rivers, where, when the winds' blasts check the river's flow, that turbulent and tumultuous struggle is born by which the masses of water, agitated by diverse motions, are raised on high in the manner of a column, to the great peril of ships. And it is well known from frequent experience in the French sea, in the region of the mouth of the river Rhône [Rhodani], which they commonly call *Golfo de Lione* [Gulf of Lion] — so much the more dangerous, the more impetuous the southern winds and the swifter the flow of the Rhône.

Why, I ask, do the failing boilings in the same place soon give way to whirlpools and whirlwinds? You will perhaps say that whirlpools of this kind are made by the mass of subsiding, heaped-up waters. But neither can this be said, since the whirlpools of Charybdis are of such a nature that whatever is cast into them, after many circuits, is at last snatched down toward the center near the bottom, and in far-distant bays —

— is at last vomited out through a subterranean regurgitation. Nature, therefore, uses other instruments for producing effects of this strange kind, and to explain them:

[Margin: Charybdis is a whirlpool.]

I should like you to note that this Charybdis is nothing else than a huge whirlpool or abyss, by which — through the blind bowels of the Earth, as through the vast siphons of the Globe — that mass of water, boiling up, is at a certain time regurgitated. When the cause of the regurgitation ceases, the receding water must necessarily be absorbed again, as if by a kind of drawing-back; and this absorption of the waters is necessarily followed by a whirlpool. It happens, moreover, in this manner.

[Margin: The cause of Charybdis's turmoil.]

It is certain — and proved by almost daily experience, both in the strait and throughout the whole Island — that Sicily is entirely cavernous, so that through hidden subterranean channels the seas play together with one another by a reciprocal commerce of waters. Just as, then, we showed to happen in the surge of Scylla, by the same reasoning we shall here prove that Charybdis rolls out its surges. The whirlpool of Charybdis undoubtedly has its outlet somewhere, through some subterranean passage N M, in the eastern sea — whether this be near Tauromenium [Taormina], as most think, from things cast into Charybdis which afterwards emerged here. For Lucan [Lucanus] mentions a Charybdis of Tauromenium, in *Pharsalia* IV [Lucan, *Pharsalia* IV], in this verse:

Fleeing the destructive Charybdis of Tauromenium.

And in IV.14 [?]:

They behold the Charybdis of Tauromenium from its seat.

These are to be understood not of the Charybdis of the Sicilian strait, but of the Charybdis of that place — namely, on the eastern side of Sicily between the promontories Pachynus [Capo Passero] and Lilybaeum [Capo Boeo / Marsala]. For it has been observed that when the east wind [Subsolanus] or the Syro-Phoenician [Scirocco] blows, then for the first time Charybdis exercises its fury. Therefore, with the sea swelling from the blasts rushing in from the eastern quarter, it happens that the roused sea, pressed by a great mass of water, insinuates itself with great force into the said passage; and then — wave thrusting wave, and the reverberation of the rocky shores aggravating the mass of water —

it at last discharges, through the whirlpool of Charybdis, with that surge which they experience under the said wind.

[Margin: Tauromenian Charybdis.]

Since this whirlpool (as the above-cited *Cola Pesce*, taught by experience, reported) is situated among the depths of the surrounding rocks, it happens too that the mass of expelled waters tends straight upward, and so rises up at the sea's surface in the form of a mound [clivi]. But when the Syro-Phoenician ceases, then too the mass of waters by which Charybdis was burdened soon subsides and hides itself within its whirlpool; and through that same channel M N by which the heap of waves had been rolled out — now restored to its eastern tranquility — the sea is given back its calm. Hence, as the waters recede through the whirlpool, an eddy must necessarily be formed.

From this it is plain that the Mamertine Charybdis D then boils up when the Tauromenian one, P, agitated by whirlpools, absorbs —

boils up. [Margin: The Mamertine Charybdis communicates with the Tauromenian.] Conversely, the Mamertine Charybdis [at Messina] then sets its whirlpools in motion when the Tauromenian one [at Taormina] is stirred by its boilings. And so, by an alternating law of reciprocity, the two carry on the mutual exchanges of their hidden mechanism. As for why the Tauromenian Charybdis is less perceptible, the cause lies in the configuration of the place and of the chasm: it does not vomit out its waters straight up, as the Mamertine one does, but along a sloping channel. [Margin: Etna communicates with the Charybdis through subterranean channels.] There is also the fact that hidden channels drawn from Etna feed into the channel of the Charybdis, and these, charged with fiery vapors and seeking an outlet there, stir the sea with dreadful storms.

As for why the Charybdis also appears to boil up and subside somewhat with the daily tide, I judge this is to be assigned to the flux and reflux of the strait, in much the same way I spoke of Scylla above. For just as the swelling of the sea under the Moon's pressure causes the Charybdis to boil up, so its ebbing causes the Charybdis to suck back in.

It remains, then, to set out the many currents of this strait. For—as is established not only by my own experiment but also by the trial of Pisecola [Piscecola], mentioned above—the floor of this strait is thoroughly rocky and is constantly agitated by vast surges that pass through hidden chasms; and these surges can come from nowhere else than the subterranean channels, drawn partly from the various seas that surround the island and partly from Etna. Since, therefore, the

surrounding sea never exists without the agitation of winds, this strait too always suffers, now in this part and now in that, its own reciprocal surges of the waves, according to the winds blowing in different quarters: now with the waves receding on one side, now advancing on the other, now all rushing together at once—at which times the strait rages most violently.

[Margin: All Sicily is honeycombed with caverns.] That Sicily is full of caverns and pierced through with countless channels is most clearly evident from this: that Etna has its channels spread out through the whole island, and first of all into the Lipari Islands, so that when Etna undergoes its usual eruptions, Strongylus [Stromboli] too suffers its own at the same time, as if by a kind of sympathy. The sulfurous exhalations and the streams of water dispersed through the island likewise then carry out their operations more effectively—which would not happen unless there were a passage to them through the subterranean dealings of Vulcan. But how the burrows that carry fire are distinguished from those that carry water will be explained more fully a little later. And these are the things I judged needed to be said about the Sicilian Strait.

CAPUT XVII.

On the Magnetic Constitution of the Earth, or On the Bony Framework of the Earth [De Magnetica Telluris constitutione sive de Ossatura Telluris].

Just as the work of Nature is the work of an Intelligence, so it cannot be that all things coalesced in a tumultuous and merely random fashion. On the contrary, that all things were arranged from the beginning in the highest order, with distinction and an apportioning of parts—only the man who has never weighed the marvelous play of divine wisdom in the world of the Earth could fail to know this. Divine providence therefore disposed the Earth, or Geocosm, in such an order and position that—since it was to be, as it were, the foundation and final end of all created nature, into which, as into the lap and passive principle of the whole of nature, all the remaining bodies of the world above would pour out their seeds and the energies of their powers—surely of itself and by its own nature it seemed to require rest, stripped of every power of locomotion. For in this way it was the better made subject to the powers of the surrounding stars and impregnated by the mixtures of the seminal principles.

[Margin: The marvelous constitution of the Geocosm.] Now one may rightly ask: by what means, or by what power, is it held fast beneath this immense steadfastness of immobility? Is it balanced by the unfailing equilibrium of its own gravity, or is it held by some superadded power thrown over it like a bridle, so that with utterly imperturbable constancy it forever faces the same quarters? [Margin: By what power the Earth is held immobile in the center.] A simpler antiquity placed the immobility of the Earth in the mere weight of its native gravity alone. Later generations, taught better by the experience of things and probing more deeply, added to gravity a force that holds the Earth in its place with a certain unbending stability—a force they call magnetic. Now, in order to show just how all this is accomplished, it has seemed good to begin a little higher up.

I therefore lay down, first, that the Earth has been so constituted by divine providence (as was said above) that it is naturally borne by an innate and intrinsic appetite toward the heavenly regions as toward the limits of its rest. But since no thing is borne by an inborn appetite toward another unless there is in that toward which it is borne something that affects it well and by whose good it is fostered, surely the Earth would by no means be borne toward the surrounding regions of the world with such unbending constancy unless there were present in the corresponding heavenly regions some power that nourishes and benefits the Earth—whether that be the magnetic power itself, or something analogous to magnetic virtue, or some marvelous sympathy of the heavenly bodies, in accordance with which the Earth disposes itself with unremitting stability. For unless we admitted this power, or this sympathy of universal nature, there would be no reason why the poles of the Earth should face this part of the heaven rather than another. Therefore there must necessarily be granted some power in the heavenly bodies, analogous to the magnetic virtue with which the Earth is imbued, by which the Earth stands firm in its unshaken stability.

[Margin: What that fixing power of the Earth is.] Now, then, the question is: what is that corresponding power in the heavens to which the Earth accommodates itself? A bold undertaking of nature is here set before us,

for the exposition of which nothing less than a bold effort of intellect is required. Let us therefore unravel the mystery, if not with a bold effort, then at least with the effort that the weakness of our intellect allows.

It must be understood, then, that God, the Best and Greatest, by the ineffable disposition of His providence, has so ordered the heavenly bodies toward the immobile Earth in the fluid expanse of the world's atmosphere that—just as those

bodies perpetually wheel from rising to setting [from east to west], all and each by an imperturbable law performing their motions about the Earth within the span of a natural day—so each globe too, or astral body, observes this law: namely, that each of the heavenly bodies revolves about the Earth not with a confused spinning but with that constancy of motion whereby the poles of the individual globes, or astral bodies, correspond to the poles of the Earth by a certain perfect adaptation. [Margin: The axes of the heavenly bodies have a position parallel to the axis of the Earth.] This secret the keenness of the Lyncean observers of our day has disclosed. For we see all the heavenly bodies—the Sun, the Moon, and the rest of the stars—so adapted that the very circles and poles which we imagine for ourselves on the terrestrial globe we see expressed in each and every one of the globes of the stars, with only this difference intervening: that on the immobile Earth they are immobile, whereas on the stars, which are agitated about their own center, they are found to be mobile. But let us look at these matters more closely.

[Margin: The position of the solar globe corresponds to the position of the Earth.] On the solar globe there is the region of the equator and of the torrid zone, boiling with an ineffable surge of heat, exactly corresponding to and equidistant from our own equator and torrid zone—a unique seedbed of spots, which, being rotated together with the solar body about its own center and driven by a south-to-west [noto-zephyrian] motion toward our region [Greek: ἀνὰ λόγος (ana logos, "in proportion")] [?]. We find, moreover, that the points of the solar poles perfectly agree with our points, and that the solar axis is parallel to that of the Earth; nor has it ever been observed, to this day, that the solar body has deviated even in the least from so great a sympathy with the Geocosm—except for a certain nutation of its axis back and forth from the terrestrial poles, for particular ends intended by nature, which we set forth in our *Itinerarium Extaticum*, in the discourse *On the Journey to the Sun*, to which I refer the reader. We have, then, that the solar globe is adapted to the terrestrial globe by an unchangeable position of its parts. For if the solar globe were carried round in a confused spinning and were to change the poles, axis, and regions that match those of the Earth, it is certain that the symmetry of all things below and above would at once be destroyed, the laws of nature thrown into confusion.

[Margin: The adaptation of the lunar globe to the Earth.] But the lunar globe, being nearer to us, also demonstrates more perceptibly its adaptation of its body to the Earth. In it, if you set aside some nutation and oscillation, the whole symmetry of its axis, poles, and circles is found to square perfectly with that of the Earth; and it preserves the position of these parts by so constant a law that, as

a result, the Lyncean astronomers have divided the lunar globe, no differently from the terrestrial, into its circles, points, and axis, exactly corresponding to the terrestrial ones. Hence they have named the spots that occupy the middle region of the globe "equatorial," and those that lie under each pole on the globe—according to the pole's position—now southern polar, now northern polar. This adaptation of its individual parts, and the equidistance of its axis from the terrestrial axis, it preserves by so close a law of likeness that, whether the faces of the lunar phases are changed, or its ascent and descent in its circular path are altered in motion, it never falls away from the perfect adaptation of its axis to the terrestrial axis. Nor has it ever been heard, in any age, that the polar parts of the lunar globe have, with their seats changed, held the equatorial regions by a confused and disordered spinning of their motion.

[Margin: The globes of Venus, Mercury, Mars, Jupiter, and Saturn are adapted to the Earth.] The same must be said of the globes of Venus and Mercury; the same I would have you think of Mars, Jupiter, and Saturn. The clearest sign of this is found in the Jovial globe: that, being agitated about its own center, it always describes its belts—revealed by the optical tube [telescope] not long ago—parallel to the equator. This is a most luminous sign that the whole mass of the globe, together with its axis and the apparatus of the remaining lines conceived in it, being perfectly adapted to the terrestrial axis, perpetually and constantly strives to maintain a [Greek: παραλληλισμόν (parallēlismōn, "parallelism")] with the terrestrial globe by motions however much differing. That the same happens in the globe of Saturn, the attendants surrounding it sufficiently and more than sufficiently demonstrate. [Margin: The globes of the fixed stars are adapted to the Earth.] And what we have said of the planets must, by the same analogy, be thought of the fixed stars as well. But since we have treated of these and similar matters at length in the *Itinerarium Extaticum*, fol. 273, I refer the reader there; and so that the curious reader may see my meaning more luminously, I here append a figure.

Thus all the globular bodies of the world always hold a perfect south-northern position [noto-borean], that is, from south to north, in accordance with the position of the Geocosm; and this disposition, implanted in them by nature, is taught by any material globes whatsoever, constituted of whatever matter: if you let them run on a level surface, you will observe that they unfold their motion not with a confused and disordered spinning, but with their poles perpetually facing the same, and the same opposite, quarters. And so that this may be more luminously evident, let any two opposite places on the globe be marked with some color; and if you cast the globe, thus marked with its points, with its axis

parallel to the horizon, you will see the globe, by an unchanging law, continue its motion always with the position of its axis parallel to the horizon. Since, then, this happens in globes that are otherwise indifferent, when they are furnished with a symmetry of axis, poles, and lines, how much more shall we suppose this symmetry of parts toward the Earth to be present in those vast bodies of the world?

I conclude, therefore, first, that all the bodies of the world have a certain hidden property, which

we call directive, given them by nature, by which they are perpetually extended from south to north along their axis; for in this way they will the better conspire to preserve their union in the universe, [Margin: The final cause of this directive virtue.] and the more perfectly adapt themselves to the Earth, to be made fruitful by their influent rays, for whose sake they were created. For since they perpetually revolve about the immobile Earth from east to west,

Diagram. A large circular schematic titled *Magnetismus Globorum Astralium* ("The Magnetism of the Astral Globes"), oriented by the four cardinal points printed outside the rim. At the center is the terrestrial globe, with a vertical axis (pole-to-pole) running the full height of the figure. Arranged along this central axis and within a series of concentric rings are the planetary globes (marked by their astronomical glyphs), and the surrounding rings are studded with numerous small star-globes (each drawn as a tiny sphere with its own equator and axis-lines, all parallel to the Earth's axis), interspersed with asterisk symbols marking fixed stars. The arrangement illustrates Kircher's thesis that every celestial globe's axis lies parallel to the Earth's.

- (top, outside rim): **Septentrio** — "North"
- (bottom, outside rim): **Meridies** — "South"
- (left, outside rim): **Occasus** — "West"
- (right, outside rim): **Ortus** — "East"
- (upper region of central axis): ♄ — Saturn
- (mid-upper, central axis): ♃ — Jupiter
- (right of center): ♂ — Mars
- (left of center, near Earth): ☾ — Moon
- (lower region of central axis): planetary glyph [?] — a lower planet (Venus or Mercury) [?]
- (center): terrestrial globe (Earth), shown with surface features and axis

- (throughout the concentric rings): numerous small star-globes, each with equator and parallel axis-lines, alternating with asterisk (*) symbols marking fixed stars

certainly it seemed to be required by a kind of necessity of nature that the poles and axes of the individual upper globes should, step by step, correspond perfectly to the disposition and position of the terrestrial globe. For by the eternal providence of Divine Wisdom the motions of the heavenly globes are so constituted that, by a certain perfect symmetry of position and analogy of motions, they perpetually regard one another, and under this position—not under another—they foster, animate, and preserve one another. For if their position were changed by some random rolling and disordered spinning, then the bodies too, being as it were forced into a violent state, would withdraw from their operations—by which, with a certain reciprocal and inborn appetite for influence, they fostered one another—and would presently fail, lapsing into an unaccustomed and unsuitable position, together with the ruin and final destruction of the world that would follow. For just as, if the Earth, by Divine power, with its poles turned toward the Equator, were to be twisted away [from its position]... [the sentence breaks across the column]

the dictate of the Divine Archetype, by an unchangeable law established, demanded that, with the seats of their axes unchanged, they should describe their motions about the Earth by this their directive south-northern [Notoborean] faculty.

I conclude, secondly, that this directive

[Margin: The Notoborean magnetic virtue is common to all the bodies of the world, implanted in them from the first cradles of the world.] virtue is the Notoborean Magnetic virtue, and that it is common to all the bodies of the world, implanted in them by the first cradles of the world—being, namely, that without which they could not be preserved in a perfect adaptation of position, both to the rest of the stars and most especially to the Earth. For, with the starry globes wheeling through the empty spaces of the great expanse, nothing would be easier for them than, by a confused direction of their axis, to deflect now into this, now into that quarter of the ethereal path—unless they were held in check toward some determined aspect by this faculty as by a kind of bridle, or were moved under this position by a moving Intelligence according to the laws prescribed by the Author of nature.

COROLLARY I [Consectarium I].

Hence it is clear why the Earth extends itself, by its poles, in the Notoborean position by an inviolable law—so much so that, if for any cause its poles were moved from their native points, then at once, left to its own discretion, it would by natural force adapt itself to the position from which it had been drawn away. For under this position, and not under another, the heavenly bodies foster, strengthen, and animate one another by reciprocal influxes, ordained both for their own preservation and for that of the universe. The Earth, then, accommodates itself to the heavenly bodies under this position, because the heavenly bodies likewise have their parts extended under the same position; [Margin:...the adaptation of the globes to the Earth.] so that neither the Earth, nor the other heavenly bodies, could have a better position for performing the operations prescribed by nature. For under this position—the best in which they can be—they exist, in order that they may be that for which they are.

COROLLARY II [Consectarium II].

Hence it is also clear why nature willed the heavenly globes to be conformed, by this directive Notoborean faculty, to the position of the Earth. Namely, in order that the surface of the Earth, under this Notoborean extension, by the most wise counsel of nature, might receive the heat of the Sun, the Moon, and the stars [Greek: ἀστέρων (asterōn, "of the stars")] with a great difference of degrees of intensity, and might obtain its alternations of nights and days. [Margin: The effect of the stars upon the Earth.] For under the torrid zone there is a perpetual equalization of days and nights; just as the stars rouse the highest heat by their perpendicular incidence, so the sub-polar regions obtained a day of six months from the most oblique aspect of the Sun—so that by the perpendicular efficacy of the Sun under the torrid zone, the heat caused in twelve hours might be compensated by the six months' lingering of the Sun above the horizon. Secondly, in order that the Sun, rolled by its annual motion through the oblique band of the Zodiac, by surveying the whole globe—with the stations of the four seasons (Spring, Summer, Autumn, and Winter) established—might advance the generations and productions of things; which would by no means come about if the Earth, deprived of this directive Notoborean virtue, were to fluctuate this way and that in uncertain wavering. [Margin: The whole annual variation depends on this position of the Earth.] Upon this position of the Earth, then, and upon the annual motion of the Sun, depends the whole...

[Column break — text continues at top of facing column:]

for itself suffice to stabilize so great a mass by its own power, we will explain in this place. I say, then, that this virtue is nothing else than a certain directive Notoborean virtue, by which both the other bodies and—most especially—the Earth extend themselves along their axis from south and north by an inviolable law. Hence the Earth is not unfittingly called a Magnetic body, and its framing together from pole to pole luminously teaches this, as we have demonstrated most fully, and by a frequency both of various experiments and of observations, in the *Ars Magnetica*, book 1, p. 2 [*Arte Magnetica* lib. 1. p. 2]—which, lest I repeat it here, I refer the reader to.

Since, then, the Earth, by this virtue, is of itself indifferent to any position, and since indifference of this kind could cause irremediable defects in nature, it stood in need of a certain directive virtue by which it might remain within the due limits of nature—a virtue we call Magnetism; and lest the Geocosm, by nodding and fluctuating into uncertainty, should involve all things in confusion, it stood in need of this as of a bridle. But nutation and the inconstancy of staggering may, in the course of time, come about from the various internal turmoil of the terrestrial body—from frequent deluges, inundations, earthquakes, the swallowings-up of islands and regions, and the prodigies of similar events, of which the records of historians are full—by which, since the center of gravity of the Earth is marvelously altered and twisted away from its genuine position,

Mundus Subterraneus — Liber II "Geocosmus"

Caput XVII (continued): The Magnetic Constitution of the Earth

[...so that it could not] be steadied. This virtue was certainly indispensable for holding the Earth fixed in the middle and protecting it from every danger of change and unsteadiness. But you will object that the gravity innate in the terrestrial body could have accomplished this, so that this added faculty would seem superfluous.

[Margin: The Earth endowed with a twofold quality: gravity and magnetism.]

I answer, then, that nature has endowed the Earth with two qualities especially necessary for its preservation: namely, gravity and magnetic directiveness [verticitas]. The office of gravity is to hold the Earth fixed in the center; that of magnetism is to hold the same Earth pointed in a polar direction so as to prevent any wandering — what we call its directiveness [verticitas]. This directiveness is

nothing other than a certain motive faculty or quality by which a peculiar magnetic motion, and likewise rest, is produced. Now since the Earth, in its greater part, is a homogeneous body, and is simple as to its rocky structure and composed of similar parts, it was necessary that it possess this quality uniformly diffused throughout the whole body.

[Margin: The office of the magnetic virtue.]

Moreover, since the Earth must extend not in a confused way but in a fixed and determinate orientation, from south to north, it deserved precisely that quality which would dispose it into two termini — so that the quality, otherwise simple, might nonetheless at its termini exercise distinct prerogatives, as though under a divided command. Who does not see that this was most wisely established by nature? For if the force and power toward one and the same pole were equal at each terrestrial pole, there would be no reason why the southern pole of the Earth, for instance, should be subordinated to the Arctic rather than to the Antarctic, and conversely why the northern pole should be subordinated to the latter rather than to the former. The Earth would then have been poorly provided for, since its wandering could in no way be checked by that force; and it would often happen that, when one pole of the Earth was turned toward its pole, the other would stray here and there at random, as is clear from what has been said.

Therefore, so that this very great inconvenience might be avoided, the Earth was owed a quality of this kind: one that would both possess distinct termini and yet, divided as it was through the whole, exercise the power of dominion. By this quality the Earth was endowed with a twofold virtue, so that a fixed pole would unceasingly and necessarily seek out and love a fixed pole agreeable and suited to it, but would stubbornly shun the other — set, as it were, outside the limits of its jurisdiction — fleeing it with oars and sails as contrary and unsuited to its nature. So then, while each region strives to defend the rights of its own zone, the whole globe — its entire quality straining toward opposite parts, leaning toward each pole — stands fixed in the middle, undeviating, with both poles pressing inward: the Geocosm.

By this reasoning, then, the Earth, in its frame established from pole to pole, possesses magnetic force and directiveness, by which it disposes itself toward the poles and preserves itself so disposed. And it has this directiveness not in itself alone, but also in all other proportionate and similar bodies, provided they are placed within the sphere of its magnetic quality.

[Margin: The magnet shares in the forces of the Earth.]

Furthermore, it is well known that in homogeneous substances the parts are not merely assimilated to the whole, but are altogether of the same essence and nature as the whole, so that each property and accident belonging to the whole necessarily belongs to the parts as well. Since, then, the magnet is a true and homogeneous part of the whole homogeneous body — indeed a genuine son of the Earth, sprung, so to speak, from the true and natural seed of the Earth, entirely like and proportioned to it — it follows that it shares in the affections of the whole. Hence, conveyed in an aerial carriage and fittingly affected by that magnetic outflow with which the Earth disseminates its forces in every direction, the magnet too, in conforming itself to the whole, takes on for itself that very relation of position and motion which its parent Earth pursues, and exerts the vigor conceived from the Earth not in itself alone, but in all other capable and proportionate bodies. Just as the Earth, then, is directed toward the poles of the world, so the magnet too is directed toward the poles of the Earth, because it thus flows together with the Earth and is so disposed by the form of the whole globe as the entire substance of the Earth demands. Since, therefore, the position of the whole Earth is situated in an arrangement ordered toward the poles, this homogeneous part of it likewise agrees with the whole, and so eagerly strives to express in itself all the virtues of its Mother.

But why are metals and the other heavy bodies not disposed in this way? The cause is that they are not primordial, genuine, and true parts of the Earth, but altered ones, corrupted by certain spurious materials. Again, since every being is naturally and necessarily carried toward its own internal good and preservation, and since the good of the magnet is the conformation of itself to the orientation and position of the Earth — of the whole, that is, by which it is perpetually fostered and preserved — it is therefore directed toward the poles for the sake of its internal good and convenient preservation: namely, that by accommodating itself to the orientation and position of the Earth, it may be aided and strengthened by it.

[Margin: The inclination of each thing toward its proper orientation.]

For this same reason light things are carried upward and heavy things downward, as toward the place in which they may conveniently exist together with the whole; and so the parts of water are gathered into drops, so that, defending themselves by the union of their parts against hostile dryness, they may exist more conveniently, and may by their innate force more fully conform to the whole element, which seeks a circular surface. For this cause all vegetables, or germinating things, are carried upward, because such is their orientation,

which they naturally seek for their good. Therefore the magnet too loves the said orientation because in this way it is fostered and preserved, and not otherwise. For if the magnet were not found in the orientation which the Earth has, it would remain contrary to its natural inclination. So then, lest it should suffer violence from this contrariety, it conforms itself by turning toward the orientation of the magnet — and thus, on account of the harmony of the world, and the analogy of the perfect and homogeneous parts of the world to the whole, and the mutual agreement of their chief forces, it strives toward the continuation, position, direction, and unity of the terrestrial [O 3]

globe's poles. By that radical force of its own and by formal efficiency the magnet is disposed, so that the remote principle of this directiveness is the very form or essence of the magnet, while the proximate and immediate principle is that δίμορφον [Greek: dimorphon, "two-formed"], or biform quality, which strains toward opposite parts and strives to dispose the body into an orientation agreeable to the whole. Let us therefore lay it down. From which it is also clear that this directiveness comes not from any external agent altering the magnet, but through an internal principle and the magnet's own proper form — which should be well noted.

CAPUT XVIII

[Body heading, p. 108:]

The Geocosm, or the terrestrial body, is by no means of homogeneous but of heterogeneous nature. And concerning the wonderful variety and panspermia of things of which the terrestrial body consists, and what is the true and proper element of the Earth.

There are certain philosophers who hold that the Geocosm is heterogeneous only as to its outer surface, and by no means as to its interior — those deeper bowels of the Earth, where they suppose that pure element of Earth lies hidden. But just as such men, destitute of all experience of things, are detained by mere contemplations abstracted from all matter, so too there can be no doubt — to anyone who knows more deeply the hidden miracles of nature — that they slip into countless and most absurd errors.

[Margin: The world is fond of variety in things.]

It must therefore be understood that the Geocosm, or terrestrial world, by this very fact — that it possesses the name of "world" — necessarily rejoices in variety, no differently than the greater and lesser world, which the Greeks call

Megacosm [Megacosmus] and Microcosm [Microcosmus]. For it belongs to the essence of a world to be strong in an innumerable variety of things, both for the adornment and benefit of the universe and for displaying the infinite wisdom of its Creator. If, then, the world were always to produce one and the same thing in itself, neither the whole nor the parts could subsist, nor could they conspire into the union of the whole. Rather, this whole conspiracy consists in nothing but the variety of things and in the wondrous laws of the agreement and disagreement of natural things prescribed by nature — whereby, while each thing procures its own good, it at once removes from itself by innate appetite whatever is harmful and pernicious to it, with all its effort. And while all things are bound together by the open bonds of discord and friendship, the universe, together with its parts, is preserved in perfect union and in a most absolute harmony forged from consonant and dissonant elements, as we demonstrated in our *Musurgia*.

[Margin: The Geocosm is wholly constituted of heterogeneous things.]

The Geocosm, therefore, constructed on the analogy of the greater world, ought by no means to be reckoned as coagulated from some homogeneous substance — as common philosophers of simpler wit suppose — but is strong with a panspermia [panspermia, "all-seed"] of innumerable things, implanted in it from the very origins of things, for the producing of that variety of things which, taught by daily experience, we behold not without wonder. For, as we showed in our *Itinerarium Exstaticum*, there are as many different virtues of things implanted in the substances of the terrestrial globe as there are diverse virtues and properties in the greater world among the stars and innumerable luminaries — all of which pour out the emanation of their forces into the Earth, either immediately, as the lower stars, or by means of other intermediaries, as the higher ones.

[Margin: The spirit of the world.]

But to come a little closer to our proposed aim: the bony frame, or structure, of the Geocosm is a certain magnetic and rocky framework from pole to pole, which nonetheless must by no means be reckoned to be of homogeneous nature after the manner of a pure magnet, but consists, beyond its magnetic fibers, of an innumerable mixture of bodies of most diverse natural endowment.

[Margin: Of what sort is the bony frame of the Earth.]

In some places there are metallic and mineral bodies, yet not of one kind, but distributed here and there with great providence, so that — just as not every land

bears all things — in one place it produces gold, in another silver, in some iron or copper, in others only lead, tin, or quicksilver.

[Margin: Different places yield different things.]

Thus some parts of the earth display diverse precious stones, others diverse species of herbs, plants, and aromatics; others diverse kinds of marble, others diverse species of animals proper to themselves — all of which derive their origin from the diverse temperament of the terrestrial portions. In the terrestrial globe there are innumerable veins of the most diverse things, diffused throughout the whole body of the Earth: some of which produce an earthy and muddy substance, others a clayey or pumice-like or tufaceous one, others one full of metallic juices, others one filled with powders and sandy masses.

[Margin: Subterranean veins of diverse kinds.]

What shall I say of the diversity of substances which are extracted from the bottom of the sea and offer themselves to view? I would venture truly to affirm that scarcely a few miles of access lie open in which we do not see the Earth imbued with one and another property of the terrestrial portions. But since we have reserved all these matters for the following treatises, we have judged that we should refrain from being longer here. Whether, however, this panspermia of things and this utmost variety was created together in the Earth from the very origins of things, or whether it was imbued with this virtue by the Sun and stars in the course of time — that remains to be explained.

The divine Wisdom, destining from eternity a dwelling for the human race — a dwelling which, unfolded from the point of eternity in the fullness of time...

the Creator established with such great artifice that whatever is rare and exceptional in the whole universe, whatever of forces and properties exists in the celestial globes — of which there is no number — may seem to have flowed down into this Geocosm.

[Margin: The Creator implanted the seeds of all things in the Geocosm.]

For since the globe of the Earth, divided into various climates, had a varying aspect toward the Sun, Moon, and stars, from this so manifold relation and aspect of the celestial bodies there necessarily followed a great and incredible variety and multitude of things — whether of mineral, vegetable, or sentient nature (consider the economy of nature). For the diverse aspect of the globes of the Sun, Moon, and stars, impregnated with the various and reciprocal influxes of the

other globes, now directed toward this region of the Earth, now slanting and sharp toward that, now obtuse — what, I ask, could it not effect upon the Earth?

There is this besides: that the whole mass of the Earth already beforehand, according to the need of each climate, had created in it the seeds proper to each thing; which, made fruitful and animated by the virtue of the warmth that plays the midwife, emerged into the offspring of innumerable things. That seeds of things were created in the Earth, sacred Genesis plainly teaches in chapters 1 and 2:

[Margin: Genesis 1:11]

And He said: *Let the earth bring forth the green herb, and such as may bear seed, and the fruit tree yielding fruit after its kind, whose seed is in itself upon the earth. And it was so.* [Gen. 1:11]

[Margin: What is panspermia?]

Truly, therefore, panspermia, or the spermatic commingling of all things, was created together. But since this panspermia was not yet brought from potency into act before the separation of the waters and the uncovering of the dry land, but needed a virtue from on high, by whose influxes, being preserved, it might bring forth the seeds of things into shoots, leaves, flowers, and fruits — hence Genesis at once subjoined the production of the Sun, Moon, and stars, according to whose influxes and luminous, active emissions it so disposed the Earth that thereafter, for a fixed constitution of times and climates, an infallible effect of vegetables might follow. And thus the active principle, joined to the passive — with God as the matchmaker — then first continued the propagation of the whole vegetable nature. God, therefore, in His ineffable wisdom, first, according to the need of each region, co-produced in the body of the Earth seeds suited for producing diverse species of plants; but afterward, in the course of time, the influxes of the celestial bodies brought those forth into living and vegetative soul for the perennial propagation of the species. For without warmth and light, all things lay torpid and dead.

[Margin: The generation of aquatic and flying animals.]

But of what sort these seeds were, and from what principles they coalesced, will be taught in what follows. In like manner, after the production of the Sun, Moon, and stars, Genesis immediately subjoined the production of aquatic and flying animals. For at the voice of God sounding forth, the Earth straightway, according to the nature and property of the waters, rivers, and seas, brought forth the

various kinds of swimming creatures proper to each place, perfect in their own kind; which afterward, with the influx of the heavens cooperating, propagated by generation, filled all the parts of the Geocosm. And so, just as not all seas produce the same animals and the same fish, but — according to the nature and temperament of the water of the region — produce diverse ones in diverse rivers, lakes, and seas, so too on the sixth day, by a like analogy, the Earth did not bring forth the same production of terrestrial animals in every part.

[Margin: The wonderful diversity of regions provided the subject from which animals were formed.]

Hence the Indian land furnished elephants, rhinoceroses, and other animals unknown to us; the Asiatic land camels, lions, tigers; Africa ostriches, dragons, apes; America all things differing from the rest; Europe horses, asses, oxen, sheep, and so on — animals agreeable to its own temperament.

[Margin: Why Indian, Asiatic, and African animals adapt to the European climate with such difficulty.]

From this it is clear why Indian, Asiatic, African, and American animals so reluctantly grow accustomed to the European sky, and conversely European animals to the other parts of the world: because they make use of a foreign sky, in no way agreeable to their nature; and because only their native soil, from which they drew their origin, suits them well and provides nourishment fitting to their nature. If they are torn away from it, then — as exiles from their native soil, when they cannot bear the disproportionate and foreign region of sky, air, and earth — they soon perish; or if they last for a while, they nonetheless so depart from their native temperament that they put on an entirely different form and character. Whatever has been said of animals is to be understood, by a like reasoning, of the offspring of vegetable nature, as will be more fully confirmed in its proper place by an induction of particulars, where also other ends of so great a metamorphosis will be indicated.

From the orientation, then, and from the disposition and diverse nature of the terrestrial climates, depends the diverse nature of animals and vegetables; which is indeed so confirmed that there is scarcely a region which does not produce something differing from another, whether in nature or in qualities. All of which draws its origin from the commingling of the primordial seed with which the terrestrial world was imbued — things which were so adapted by the supreme Architect to time, place, and sky that from them that incredible variety of produced things which we marvel at necessarily resulted.

[Margin: Why minerals are found nearly everywhere.]

Minerals, however, since they emanated from the immediate seeds of the principles of nature and of the elements, dispersed through nearly the whole mass of the Earth, were also allotted an indifferent location; hence it comes about that, since they regard no particular climate, having become a possession of common right among all nations, by their happy yield they bless no region — some more, some less.

Furthermore, one doubt still remains to be explained, which is the following. If the Earth consists of so great a diversity of terrestrial parts, it may rightly be asked: what and where is the true, proper, and homogeneous element of the Earth? To resolve this — [O 3]

I suppose first.

[Margin: Whether there is a true and proper element of the Earth.]

Terrestrial substance can be considered in two ways here: first, insofar as it is a pure substance, most purged of all the turbid commingling of most diverse things; second, insofar as it is taken for an impure substance, variously compacted by the confluence of heterogeneous matter. In the former way, the element — one of the four — is constituted by us; and we say it is nothing other than the substance of Salt, like a kind of soul and form of the Earth, the fourth and last element of all things.

[Margin: The Salt of the Earth is its element.]

For this element, which we have called pure and necessary to all the things of the world — that usual salt of ours, or saltpeter, or vitriol, or some similar saline sensible body of this sort — is what we maintain it to be.

[Margin: That the pure element is salt.]

For bodies of this kind are nothing other than the excrement and covering, as it were, of the terrestrial element, by which the form of the element, like a soul wrapped in its own body, perfects its wonderful operations.

[Margin: The covering of the Earth.]

But we say that this is a certain spirit — incorporeal, although corporeal; insensible, yet incorruptible — residing in the center of the saline body, from which, by the diffused rays of its virtue, it furnishes to each species of mixed bodies that coagulation, and produces a hard, dense body, suited to subsisting; in

such a way, indeed, that no mixed body is found in the whole economy of the Geocosm which does not receive from it its firmness of solidity.

[Margin: The wonderful force of Salt.]

All of which we shall confirm by chemical experiments in the course of this work, God granting. But the impure portions of the Earth can by no means be called an element, but rather a kind of excrement and menstruum of the pure element, which nature uses chiefly for constituting the grossness and thickness of earthly bodies. And since such excrementitious parts of the Earth are not so perfectly and firmly united to the elements, hence too the dissolution of the union of parts necessarily destines them to destruction. But the more firmly some things are united to the confluence of the elements, the more remote they are from corruption, taking on a certain character of incorruptible substance, as is evident in gold.

I said above that the pure substance of the Earth, which we called Salt, constitutes the true and proper terrestrial element — not that the element of Salt is so pure as to have absolutely nothing heterogeneous mixed in; for in this way no element is found in the nature of things.

[Margin: No pure element is given.]

The element of the Earth, then, is properly nothing other than the purest substance of Salt diffused throughout the whole body of the Earth — the subsistence, cause, and foundation of all the virtues which shine forth in the Geocosm, and of mixed bodies.

Nor would I have you suppose, Reader, that that terrestrial element which we have called pure — [the salt itself]...

[Margin: What the proper element of the Earth is, why it is said to be Salt.]

furnishes those advantages, which are most necessary for the firm and fixed subsistence of the mixed body, by virtue of this element's own property (with the remaining elements nonetheless accompanying). For there lurks in this, no otherwise than in the seed and in its plastic faculty, I know not what divine craftsman, who works in the inmost recess of the body without any instrument and without tumult.

[Margin: The wonderful force of Salt.]

And it produces works most worthy of admiration, replete with an incredible variety of most dissimilar things — and all of this from the rude and (so far as

sense goes) formless covering of a material substance, in which, as no dissimilarity, so no variety presents itself to the senses. And since these saline bodies are wanting to no place on earth — indeed, are hidden away in concealed lairs and are brought into the light only by the spagyric [chemical] art — that a certain saline material body is rightly constituted by us as the terrestrial element is evident even from this:

[Margin: Salt is in all things.]

that, just as it is most necessary for the composition of mixed bodies, so nature has willed it, diffused through the body of the whole Geocosm into the fibers of its innermost parts, to be wanting nowhere. Let no one, therefore, seek in the center of the Earth I know not what Earth constitutive of the true terrestrial element; let no one seek a certain kind of chalk, clay, or gypsum; let no one seek I know not what sands or other terrestrial substances annexed: that the saline body is the one and only constitutive of the terrestrial element, that divine study of the Empyric art [chemistry] has long since taught us abundantly and more than enough. But of these things, expressly, in what follows.

CAPUT XIX

[Body heading, p. 110:]

Concerning the interior constitution of the Geocosm, its workshops, and its analogy to the members of the human body.

I judge that there is no philosopher of so simple a wit as to persuade himself that the terrestrial globe coalesced by some tumultuary heaping-up of mud, and stood firm with perfect solidity, with no cavities left behind. For that would be a notion unworthy of a philosopher. Nay rather, let it be certain and beyond doubt to all that the eternal Wisdom of God — κοσμοτεχνίτη [Greek: kosmotechnitē, "world-craftsman"] — just as it constituted nothing tumultuary, nothing confused, undistinguished, and ἄτακτον [Greek: atakton, "disordered"] in the nature of things, so likewise constituted the Geocosm, the last end of the works of the Creator, with the highest wisdom, with eternal counsel, with ineffable order, and with a certain plan incomprehensible to the human mind.

For it would be ridiculous — not to say stupid — that some king's vast palace, adorned only as to its outward ornament, its paintings, moldings [Cimatia], carved figures [Zooglypha], rows of windows, and similar μηχανήματα [Greek: mēchanēmata, "contrivances"] of beauty and magnificence on the outside, I say — that so great...

[Margin: The vast variety of the Geocosm's things and parts.]

to consider only [the outward surface], while supposing that the remaining apparatus of the interior furnishings — the breadth of the chambers, the depths of the foundations, the layout of the halls, the orderly arrangement of workrooms necessary for the proper management of a household — either does not exist or serves no purpose.

Divine Wisdom built this house, destined for the human race, and equipped it with such an abundance and richness of all things necessary to human life that, just as on its outer surface it was furnished with an innumerable variety of things, so too it ordered the internal economy of this house with such supports that the external face of things could not have subsisted at all if it had not furnished the hidden body of the inner house with an equal apparatus.

[Margin: The Geocosm is like the Microcosm with respect to its internal structure.]

For just as God adorned the Microcosm — that is, the external body of man — with a wonderful variety of members, so He did not fail to embellish the internal body of man with a still greater interlinking of members. In this body you see the principal members — the heart, liver, lungs, stomach, brain, kidneys, spleen — as so many workshops, in which the four humors are variously processed and, through countless channels of veins, through the manifold fibers of the muscles and cartilage, the members are able to be of mutual aid to one another by the reciprocal communication of the processed humors — so that, if one member fails, the whole is not destroyed.

[Margin: The wonderful structure of the human body.]

You see how the stomach, by digesting the nourishment taken in from outside, processes it and converts the digested matter into chyle, and through the mesaraic veins transmits it to the liver, the workshop of the blood, for further refinement there; and how the liver, in turn, to be imbued with the spirits of life, directs part of it to the furnace of the heart, so that, once actuated there and carried through the complete *pericyclosis* — that is, the circulation by systole and diastole — and diffused into all the veins of the body, it may replenish the whole of life with the vital spirits and motions that it communicates to the muscles and cartilage. You see how the kidneys claim for themselves what is serous in the blood, and the spleen what is excrementitious, while the thick and excrementitious dregs discharge themselves through the winding folds of the intestines by way of the bowels.

And since the body needed air to be blown through it — both for respiration and for tempering the heat of the heart and of the blood that surges up from it — God in His supreme providence set the lungs beside the storehouse of the heart, so that by their continuous motion, both inhaling and exhaling, the intention of nature is fulfilled. And since the body needed a certain universal moisture, lest the organs of the inner members, parched by the heat, should be deprived of their spirits, behold: both the stomach and the rest of the members, through hidden passages, seek out the brain — like a kind of vault — by evaporation, where, dissolved by its native coldness back into humors, they water all the members, as by a beneficial irrigation, with the moisture necessary for the right performance of their functions.

We have seen, so far as suffices for the purpose of our argument, the internal constitution of the Microcosm; we have surveyed its workshops and set out the offices of each of its members. Now let us see how, by exactly the same analogy, the architectonic Mind of God constituted the Geocosm.

[Margin: The structure of the Geocosm parallel to the Microcosm.]

We know that the Microcosm is preserved in its being by two principles, the external and the internal. The external is the Heaven — the influence of the Sun, Moon, and stars; the internal is the vital members, so bound to the external principle that, if either is taken away, the whole is rightly judged to be destroyed. The Geocosm, or Terrestrial World, enjoys these very same principles, and if either of them is removed, the whole must necessarily fail in its operations. The Heaven, as we shall show in its proper place, supplies the most abundant nourishment, which the Earth, having received it within her bowels, actuates, digests, processes, and distributes — once digested — to the rest of the interior members through hidden little channels: both for the necessary generation of metals and for blessing the household of the outer economy with a plentiful yield.

But this distribution of nourishment could by no means take place if the Geocosm were destitute of workshops fitted for digesting, processing, and distributing, and of hidden channels branching off into each part — as we taught at length in the *Iter Exstaticum* II [*Iter Exstaticum II, sive Mundus Subterraneus*]. Now it is time for me to disclose what these are; and so that it may be done *methodically* [Greek: εὐμεθόδως (eumethodōs, "in well-ordered fashion")], I shall fulfill the part of a good anatomist in setting them out by paragraphs in order.

§ I.

On the constitution of the subterranean reservoirs and workshops.

Just as in the Microcosm some workshops or reservoirs — such as the brain, the liver, the bladder — overflow with moisture; certain ones seethe with the heat of vital fire, like the heart; some swell with airy breath, like the lungs; and certain ones, like the kidneys and spleen, are filled with dregs-laden matter — in just the same way, in the Geocosm, reservoirs of moisture and of water have been aptly constituted by provident nature. And since these could not be preserved without heat, there are attached to them other storehouses of fire, by which the brood of waters might in some measure be enlivened. And because not even the Vulcanian workshops of fire could subsist without air, the wise Craftsman of nature, by the ineffable arrangement of His providence, disposed yet other airy reservoirs to foster both, so that by the hidden commerce of their passages they might preserve the fire lest it be extinguished, and the water lest it putrefy or freeze, for the continuation of perpetual motion.

[Margin: Air-reservoirs.]

And since this distribution of elemental reservoirs would be in vain unless there were something upon which they might act, hence other terrestrial ones were constituted — storehouses of nature imbued with a medley of seminal principles of every kind, in which, by a certain hidden working of the waters and fires, the continually-operating workshops might bring forth an innumerable brood of things.

We have set out the workshops; now the order of our plan demands that we review each of the enumerated workshops in turn, confirming them both by reasoning and by authority. But so that we may have appropriate names for these workshops, we have judged that the reservoirs of water should rightly be called *Hydrophylacia*; those of fire, *Pyrophylacia*; those of air, *Aerophylacia*; and the storehouses of the terrestrial medley, *Geophylacia* — as the guardhouses [custodias], so to speak, of water, fire, air, and earth. With these preliminaries set down, now to our aim.

§ II.

On the hydrophylacia of the Geocosm, or Terrestrial World.

That hydrophylacia have been constituted within the bowels of the highest mountains for the production of springs, rivers, and lakes, we have shown amply

enough above in Chapter 6, and in the *Iter Exstaticum* II in the *Mundus Subterraneus* — in which place we likewise reviewed all the more notable rivers and lakes, with which the Geocosm is clothed as with a kind of fringe, and which draw their origin from the enumerated recesses of the mountains. It now remains to speak of those hydrophylacia which men call *abysses* [abyssos] — not those near the horizontal surface, but those founded by nature, for excellent ends, within the blind bowels of the deeper Earth.

[Margin: What an abyss is.]

That there are such abysses of water among the bowels of the Geocosm is so certain that even Sacred Scripture itself, in the Psalmist, hints at them in plain words. Psalm 41[:8]: *Deep calls to deep at the voice of thy cataracts* [Abyssus abyssum invocat in voce cataractarum tuarum]. Here, although most interpreters refer the abysses to mystical, tropological, and anagogical senses, yet those who hold to the literal sense call an Abyss, in the sacred writings, a most profound whirlpool of waters whose bottom cannot be explored, situated in the innermost parts of the earth — concerning which see Lorinus on the cited passage of the Psalm. And the following verse of the Psalm clearly explains its depth in these words: *all thy high waves* — and, according to the Chaldee paraphrase, *all thy springs and thy floods have passed over me* [omnes fontes tui et fluctus tui super me transierunt]. Here, by "high waves" is connoted the height of the lands and mountains from which he had been drawn up from the abyss, and by "the floods of the sea," the monstrous vastness of the waters by which he is covered.

[Margin: Chaldee.]

And so the Psalmist, in another place, cries out — carried down into the abyss, and by divine mercy led back out of it: *and thou hast brought me up again from the abysses of the Earth* [de abyssis Terrae iterum reduxisti me]. Sacred Scripture, then, makes mention of abysses in many places; and from these — as horrid and inaccessible whirlpools — its Commentators took occasion to twist them toward a moral and mystical sense. For into these, the sea, hurled down through the immense precipices of the inner crags, stirs up huge roarings and fearful crashings — which the words of the cited verse also intimate, *at the voice of thy cataracts*.

[Margin: That there are abysses in the bowels of the Earth.]

And that there are very many such abysses enclosed within the inmost bowels of the Earth, we deduce from effects shining forth in certain places of lakes, seas, and the Ocean so deep that they reject any sounding-line, however immense.

Among these are also numbered gulfs or whirlpools and *Euripi* [tidal straits]; some of which I shall here adduce in confirmation of the abysses. Of these, the foremost, most celebrated, and greatest is seen in the Northern Ocean, off that part of Norway which is divided from Lapland.

[Margin: The Norwegian whirlpool, an abyss.]

For, by the testimony of nearly all geographers, it has thirteen miles in circuit; its center is occupied by a rock called *Muske* by the natives, whose force is of so devouring a nature that, in the space of six hours, it swallows up all things — which, agitated by chance in the perpetual whirling, slip into the crater of the whirlpool as soon as they have touched even the outermost edge of the circumference — vast heaps of water, whales, cargo ships, and other things, spun about as if in a vertigo; and in just as many hours it spews out again what it had gulped down, belching it forth with great force and an incredible crash and roar, which is heard not without dread by listeners in the most remote places. Its cause I shall, God willing, disclose in the following book.

[Margin: A whirlpool of the Persian Sea.]

In the gulf of the Persian Sea a similar whirlpool is seen, off the Promontory of Mossendam [Musandam], whose hidden power, because it is most worthy of consideration, I shall here append in the words of an eyewitness as recounted in his *Eastern Itinerary*:

[Margin: *Itinerary into India* of Fr. George of Jesus and Mary, fol. 138.]

"There is a place," he says, "in the Persian Gulf most perilous and ordinarily agitated by storms. For on the promontory of Mossendam there are several crags which they call *Salemas*. Among these, one juts out so far toward the promontory that it scarcely leaves the sea a stone's throw of passage. There the sea, even while it is calm elsewhere, continually boils, and produces such great whirlpools that in the midst of them — especially while the sea is agitated — a large stone can for some space be let down without its touching the water; and for that reason the passage there is dangerous and perilous for sailors, and no one crosses when the sea is rough; but when it is quiet, they run through it with oars, for they are carried along by a most rapid force of the waters, and so approach the promontory that they almost touch it in passing. For they fear lest they be snatched against the crag itself and into the whirlpools." Others say that this whirlpool communicates with the opposite Caspian Sea through a subterranean passage. From their report, I, made more certain, found the truth in the book of the Persian Paradise [*Paradisus Persicus*], the Describer of both Seas, who asserts

the same — namely, that with the inflow of the Persian Sea, driven through its straits by the Ocean, the Caspian Sea at the same time rolls up vast tides on its southern shores, upon the ceasing of which the whirlpools follow.

[Margin: A whirlpool between England and Normandy.]

Between Normandy and England a not dissimilar whirlpool is observed in the Ocean, toward which ships are violently dragged with wonderful speed — not so much by their straining as by the fierceness of the tide. Yet this too is a wonder to behold: that with the same swiftness by which they were drawn from afar, by the same — when they are now near the gulf — they are driven back. Of the Euripus of Chalcis

of Chalcis there is nothing for me to mention, since it is celebrated in the records of all historians. The Indian History in Peter Martyr [Pietro Martire d'Anghiera] relates that, at the entrance of the Strait of Magellan, the Ocean is stormy with utterly fearful tides and of unexplorable depth — so much so, indeed, that many have judged that the sea here descends into the innermost bowels of the Earth.

[Margin: An abyss at the Magellanic Sea.]

The Caspian Sea too has its own whirlpools, according to the report of Fr. Riccardi, a priest of our Society, who crossed it, and who on account of its unexplored depth thinks that this whole sea is an abyss penetrating into the innermost bowels of the Earth.

[Margin: The Caspian Sea is an abyss.]

Similar ones are found at the entrance of the bay of Aynam [Hainan] near Sumatra and Cambodia.

[Margin: A whirlpool at the African shore.]

In an African gulf, which they call Ferdinand Po's [Fernando Pó], the water is snatched into the subterranean passages with such violence that no ship, once it has run into that current, is given the power of retreating; rather, for the space of many months — as if fastened with beam-spikes — those crossing remain fixed, at the utmost peril to their ships, doubtless about to perish, unless they are rescued from the straits by the winds that grow strong in those places.

I could here point out countless such abysses, both in rivers, lakes, and the Ocean; but since I have partly intimated them in what precedes, let it suffice for the moment to have explained them here, and to have noted them on the universal map — namely, that all places of the Ocean, of the seas, and of the lakes that are

of unexplorable depth, as well as Whirlpools, Euripi, gulfs, and abysses, are hidden in the innermost and deepest bowels of the Earth. But for what purpose nature destined them, and how they communicate with the rest of the waters, and with what probable depth they stand, together with the causes of the reciprocal ebb and flow, I shall disclose in the following Book.

[Margin: Wonders concerning a Tartary cave.]

That the Earth, then, is full of such hydrophylactic abysses, various histories narrate. Haithon [Hayton of Corycus], speaking of the affairs of Tartary, says that a cave is found among the Caspian mountains, passable by a journey of many days, in which men say they have everywhere found vast cataracts of water and the most spacious subterranean places. Of similar caves Fr. Martino Martini treats at length in his *Atlas Sinicus* [*Novus Atlas Sinensis*].

§ III.

On the pyrophylacia of the Geocosm, or fiery Abysses.

That huge abysses, hidden away in the bowels of the Earth and full of fires, are found, the Volcanic mountains demonstrate amply enough. These you should by no means suppose — as the common crowd persuades itself — to lie in the bottom of the mountains, but they have their workshops in the deepest bowels of the Earth, of which the mountains are only certain breathing-holes for discharging the superfluous soot and the violence of the conceived heat, lest they continually shake the Earth with intolerable convulsions.

[Margin: The fire of hell is true and elemental.]

So that, accordingly, the holy Fathers have not incongruously placed the greatest of all the pyrophylactic abysses in the Center of the Earth — the eternal prison destined for the punishment of the wicked.

[Margin: Why hell is in the Center of the Earth.]

And lest perhaps some suppose that the infernal fire is of a nature other than elemental fire, let them know that, just as God uses the element of water — elevated, by an obediential power (as the theologians speak), to confer grace in baptism — so too He torments the wicked by a truly and properly elemental fire, but one so elevated by the immensity of His power, by a supernatural force, that with an efficacy infinitely greater than that of elemental fire it afflicts the guilty with eternal damnation, the rigor of divine justice so requiring.

[Margin: The central abyss is destined for the reprobate.]

Therefore we shall say nothing absurd if we assert that this abyss is appointed at once, for the time being, both to the necessity of nature, and to souls only [for now]; but after the universal [judgment], to the bodies and souls of the damned together, to be tormented eternally — the lot of the reprobate equally [decreed].

[Margin: The mouths of the central abyss.]

The same, I think, is to be held concerning purgatory, which perhaps — by a conjecture not improbable — obtains in the innermost receptacles of the Earth, in one or more of the pyrophylacia. For just as it was altogether fitting to the Divine power to make use, from time to time, of the natural element of water, both for physical and for supernatural effects — as most of the holy Fathers and Theologians hold — so too it was in the highest degree fitting to Nature to decree in the Center of the Earth a place [of] fire, so that from this, as from a central pyrophylacium, it might communicate the efficacy of its power to other, higher pyrophylacia, and this to others and others still, through subterranean channels, all the way to the very surface of the Earth; since it is proper to this element always to tend from the lowest to the highest.

[Margin: Why fire is in the Center of the Earth.]

[Margin: How fire endures perpetually.]

But how these pyrophylacia endure with perpetual heat, and how, not consumed by so long a duration of exhalations, they are preserved in perpetual vigor — this ought to seem by no means a wonder to anyone who has more deeply contemplated the perennial works of nature and their efficient *cause* [Greek: αἰτίαν (aitian, "cause")]. For since the Geocosm is a terraqueous globe, surely, just as fire receives life from air and its necessary nourishment from water, so fire communicates strength and life to the watery element and to the airy, by reciprocal commerce — inasmuch as neither could subsist without the other. The terrestrial substance, in turn, when one fuel fails, supplies fresh fuel to the fire through subterranean paths, so that in this manner all things, each and every one, are preserved in their being perpetually.

[Margin: A comparison from rain.]

Just as you see happen on the outermost surface: the Sun draws up the moisture from rivers, lakes, and seas by means of vapors; the vapors, dissolved by the coldness of the airy region into waters, rains, snows, and hails, at length restore

to the hydrophylacia all that had been drawn up by the Sun. And the exhalations, drawn up from the earthy portions,

[Margin: The circulation of nature.]

are transmuted into fiery phantasms; these, by the impulse of the encountering cold, taking on the nature of the neighboring air, are changed into air, and this into water, the water into Earth — and by a wondrous metamorphosis of nature at last return again; and where they cease, there they soon lay the foundations of new efforts of the *pericyclosis* [cyclical revolution]. In the same way, the Sea, forced through hidden burrows by the secret contrivance of urging nature into the vastest caverns of the mountains, at length bursting out from there into springs, rivers, and lakes, returns by right of postliminy to where it had departed from, to be revolved anew. And the water, gliding through the blind bowels of the Earth, substituting along with itself both the moisture and the medley of terrestrial portions it has carried down as nourishment and fuel for the pyrophylacia — these, in turn, swelling with hot spirits, by the heat raised through the siphons proper to them, foster and animate the hydrophylacia and the other reservoirs, for promoting the generation both of minerals and of vegetables through exhalations. And so, by a perennial and cyclic motion, all things that are observed in the nature of things exist and are preserved. But how these are carried out by nature, I shall, as I said, declare in the following Book.

§ IV.

On the subterranean aerophylacia of the Geocosm.

Just as fire and water cannot subsist without air, so certain Aerophylacia were necessary to the Geocosm, from which both elements, Water and Fire, might draw the necessary respiration, as from certain lungs of nature; and the air enclosed in them might in turn receive increase from the water, and the strength of fecund heat from the fire.

[Margin: What the Aerophylacia are.]

These Aerophylacia, then, are huge recesses of caverns, filled with the airy element, disposed to this end: that the air, channeled through countless siphons of hidden passages into other reservoirs — whether hydrophylacia or fire-receptacles — may in the former urge on the mass of water, raised through appropriate little channels into other reservoirs, into springs and rivers; and in the latter may perpetually foster the latent kindling of fire, and, by the arcane art of chemical sublimation, dispose the Earth toward further ends. But the manner

in which each performs its operations, I shall set out, as I have said, in the following Book. That there are such caverns, we know to have been proven by countless examples, some of which we shall here append.

[Margin: A wonder concerning a subterranean passage in China.]

Fr. Martino Martini relates, in his excellent work which he calls the *Atlas Sinicus*, that in the middle of the Kingdom of the Chinese there is a vast mountain stretched out by its skirts into the most remote regions on every side; which, since on account of its rugged roughness it can be crossed only with difficulty, nature — to provide for this inconvenience — so perforated the whole mountain with vast caverns that a way out is given from one side clear through to the opposite one. And this winding course of blind passages extends to such an amplitude that one cannot traverse it in less than the space of six months; and there have been found not a few who completed this subterranean journey, who reported things wondrous and altogether paradoxical concerning the admirable constitution of the subterranean parts. For they say that waters are found there in great quantity; in some places also huge lakes abounding in fish; in many places rivers, which spread themselves out, with a great diffusion of waters, into vast plains; that grasses and herbs, and a great number of subterranean animals of foreign species, are found; and that light, though dim, is nonetheless admitted through the open summits of the mountains and the fissures of the crags, as through a kind of chimney. From which description it is amply clear that what happens in these subterranean places is also found in all other subterranean regions similar to these.

[Margin: The aerophylacia of Asia.]

That the bowels of the inner Earth are full of air, all the books of the Geographers abundantly testify, since there is scarcely any nation that does not display the breathing-holes of aerophylacia. I shall speak first of the prodigious effects of such Aerophylacia in Asia, Africa, and America, and then I shall speak of those that are found in Europe. In the Mountains of Tibet, where the Ganges rises — as is established from the report of Fr. Balthasar de Andrada — certain mountains emit winds through all their fissures with a horrible sound and roar. The same is found in the report of Fr. Pais [Páez], concerning certain mountains of Ethiopia; and in America, that the same happens in the mountains they call the Andes, José de Acosta narrates. The cause of these is none other than either subterranean cataracts, or fiery subterranean spirits agitating the air, or other causes which we shall disclose below; for by these the circulating air, rushing wherever a door is

given, prepares its exit through the fissures of the mountains with the utmost force, and not with less of a crash.

[Margin: Airy breathing-holes in Bothnia.]

Olaus Magnus reports that in the Northern region there are found mountains, at whose roots are caverns, from which so great a crash of bursting-out winds is perceived that, by sudden terror, it either kills outright those who approach, or for very many days leaves most of them stupefied, [robbed] of the vigor of their senses by a pain of the head.

[Margin: A breathing-hole of the Earth.]

Furthermore, between Marseille and the mouth of the Rhône, as Strabo reports, there is a plain of a hundred stadia, a place most thickly strewn with flints no smaller than a man's fist, where from the very soil of that plain a wind blows of its own accord, to which the name *Metemborium* has been given, whose force is so great that it lifts up those same flints, like a whirlwind of hail, and lays men low — and even throws them from their carriages, and strips them of their weapons and clothes.

[Margin: The plain called la Crau.]

This plain I take to be the one which the Gauls call *la Crau*. And I

[This opening is dominated by a large fold-out double-page engraved plate. The two text pages flanking it (the verso preceding the plate and the recto following it) are nearly blank, carrying only faint show-through and degraded printed marginalia in the side margin; their main text columns did not print on these leaves or are illegible at this resolution. The legible content of this opening is the engraving and its engraved captions and legend.]

Verso preceding the plate

[Main text column not legible — faint show-through only; transcribe what the margin and the inset legend show.]

[Margin (right margin, fragmentary): "...[con]cussione fluvium ma[ris], ventus ... cavernas mon[tium] excitatur." — "...by the shaking of the river of the sea, the wind ... is stirred up [in] the caverns of the mountains." The full marginal note is abraded; the legible tail concerns wind stirred up in mountain caverns by the agitation of the sea.]

[An inset legend-strip from the engraved plate is reproduced at the right edge of this page, showing a vertical column of small pictographic symbols (a river/stream, hills, waves, a cartouche, etc.) with tiny engraved labels. The labels are too faint to resolve at this resolution. [?]]

[Margin fragment lower right: "...i fluvii, ...go alla ...rmora," — illegible/abraded. [?]]

Diagram. A large double-page engraved plate — Kircher's famous "Ideal System" of the Earth's interior water-circulation, here spread across the two facing pages (the left half the right half The plate shows the terrestrial globe in cutaway. At its center is a blazing star-burst representing the **central fire** (labeled **A**); from it radiate branching channels — the *pyragogi* (fire-conducting ducts) and *hydragogi* (water-conducting ducts) — that thread out through the body of the Earth like a vascular network, terminating in reservoir-pockets within the mountains (the *hydrophylacia*). The globe is encircled by a thick band of stylized rock/sediment layers. Surrounding the whole are dense banks of cloud, in the four corners and edges of which are set engraved **wind-heads** — putto/cherub faces blowing streams of air (the winds), with two small flying *putti* near the top holding the title-cartouche. The sea is shown washing the outer surface, with waves driven by the wind-heads' blasts.

The engraved caption, set in the upper cartouche and reading across both halves of the plate:

**Systema Ideale, QVO EXPRIMITVR, AQVARVM per Canales
hydragogos subterraneos ex mari et in montium hydrophylacia
derivatio, aquarumque subterrestrium per pyragogos canales
concoctus.**

— "An Ideal System, by which is set forth the derivation of the WATERS from the sea, through the subterranean water-conducting channels [*canales hydragogi*], into the water-reservoirs [*hydrophylacia*] of the mountains; and the cooking/concoction [*concoctus*] of the subterranean waters through the fire-conducting channels [*canales pyragogi*]."

Readable labels:

- **A** (center of the globe): *Ignis centralis* — "the central fire."
- (top, held by two flying *putti*): the title cartouche, transcribed above.

- (four corners and along the edges): wind-heads / blowing cherub-faces — the winds. No individual wind-names are legibly engraved beside them at this resolution. [?]

The long engraved legend at the foot of the plate (running across both halves) reads:

Ignis centralis A, undique et undique per pyragogos canales exhalationes spiritusque igneos qui concavorum antrorum fornicibus illisi, frigore loci condensati in aquas denique resoluti derivati in metallica corpora coalescunt, aut in novam combustibilis materiæ sæturam vel æstuum motum, aquas per subterraneos cuniculos in altissima montium hydrophylacia [eff]fundit; hos hydrophylacijs impactos, partim in thermas disponit, partim in vapores attenuat; fontes rivosque generat; partim in alijs diversorum mineralium succis fœtas matrices ad ignis nutrimentum destinantur. Vides hic quoque quomodo Mare ventis et aëris pressura, [in subterraneum orbem se?] ejaculetur. Sed Figura te melius docebit omnia, quam ego fusioribus verbis non explicarim, uti schema docet. Reliqua exactius ex ipsa operis descriptione et ratiocinio patebunt...

— "The central fire **A** sends out, on every side and in every direction, through the fire-conducting channels [*pyragogi*], fiery exhalations and spirits. These, dashed against the vaultings of the hollow caverns and condensed by the cold of the place, are at last dissolved into waters; conducted into metallic bodies, they coalesce [into metals], or [serve] for a fresh saturation of combustible matter, or for the motion of the heat-surges. [Thus the fire] pours the waters, through subterranean tunnels [*cuniculi*], into the loftiest water-reservoirs [*hydrophylacia*] of the mountains. These waters, once driven into the water-reservoirs, it [the fire] disposes partly into hot springs [*thermæ*], partly thins into vapors; it generates springs and rivers; and partly, in the juices of various minerals elsewhere, the pregnant matrices [so produced] are destined for the nourishment of the fire. You see here too how the Sea, by the winds and by the pressure of the air, hurls itself [into the subterranean globe?]. But the Figure will teach you everything better than I could in fuller words, as the diagram shows. The rest will appear more exactly from the description and reasoning of the work itself..."

fundit"; "[in subterraneum orbem se?] ejaculetur") are reconstructed from sense and flagged. The legend continues beyond the plate's foot edge ("patebunt...") into the body text. The smaller engraved labels scattered along the inner rock-band and the inset symbol-strip are too faint to resolve and are flagged as a]

Recto following the plate

[Main text column not legible — faint show-through only; transcribe what the margin shows.]

[Margin (left margin, three printed side-notes, fragmentary):]

[Margin: "Circula[tio] naturæ" — "The circulation of nature."]

[Margin: "Quid sint Aëroph[y]lacia." — "What the air-reservoirs [aerophylacia] are."]

[Margin: "Mira de subterraneo meatu in Chin[a]" — "Marvels concerning the subterranean passage[way] in China." (Cf. the China cavern-system reported from Martino Martini's *Atlas Sinicus* in the preceding discussion of the aerophylacia.)]

[The main prose of this recto — evidently continuing §IV *De Aërophylaciis* / opening a new subdivision on the "circulation of nature" — did not print legibly on this leaf at this resolution and could not be transcribed. Flagged as a]

[Margin: Sown with stones, between Arles and Marseille.]

in the year 1633. I crossed this plain, lying some four French leagues from Arles, and found it so thickly sown with stones that one can scarcely set a foot down anywhere. From this, some spin the tale that a battle of the gods took place there. Yet whether the passages have over the long course of ages become blocked, or buried under dust mixed with rain, or whether the blustering channels have found their outlet elsewhere, or finally whether they have ceased for some other cause — I have not been able to discover so violent a wind as Strabo describes, though I investigated with the utmost diligence. Nor did the inhabitants, whom I questioned with the greatest care, ever testify that they had observed this so prodigious effect. Still, the layout of the place teaches above all that what is reported could indeed have happened. For since this plain extends all the way to the mouths of the Rhône, where the great commotion and conflict occurs as the rushing river collides with the resisting thrust of the sea, it could easily have come about that air, set in motion within the passages running through the mainland, somewhere in this plain prepared an outlet for itself with the violence recounted.

[Margin: From the collision of the river's flow with the sea, the wind arises that issues from the mountain caverns.]

For — as reports of the Ocean likewise relate — at nearly all the promontories, wherever there is a great collision of the waves driven by the sea's tide, a most violent wind is usually seen bursting out from the clefts of the mountains.

I will say nothing here of the Windy Mountain [Mons Ventosus, i.e. Mont Ventoux] in the County of Venaissin [Comitatus Venusinus], overlooking Carpentras [Carpentoractum], from whose caverns violent blasts of wind erupt — a thing better known than it need be told. I pass over countless other effects of the aerophylacia, found everywhere in Europe. I will add only what I have learned by my own experience in Italy.

Marvellous waterfall at Terni [Catadupa mirabilis Interamnensis].

[Margin: Mount Aeolius of the Caesii and its description.]

In the year 1658, when I was visiting the house of the Mother of God at Loreto [Lauretana Deipara domus] out of devotion, and observing along the way many wonders of nature met with there — wonders well known to everyone yet unknown to most — among the rest I learned much about the Aeolian Mountain of the Caesii [Aeolius Mons Caesiorum]. I thought it would be worth my while to investigate its hidden causes, held by common opinion to be impenetrable. Setting out from Terni [Interamnina], therefore, I first visited the nearby waterfall [Catadupa] most famous in all Italy,

[Margin: The great waterfall of the Velino [Velinus] river, vulgarly *alla marmora* [le Marmore].]

which the river Velino, hurled down over the highest cliffs, forms in the deepest valley of the mountain below. So, to find out whether it held any hidden commerce with the Aeolian mountain, I undertook to explore it. For there the river, rushing with the greatest force in the shape of an arch, plunges into a deep chasm about 300 feet in depth — as became clear from my measurement of the cliff — with so dreadful a din, crash, and violence of roaring,

Diagram. A wide engraved landscape panorama showing the valley of the Velino river with the Marmore waterfall, the Aeolian (Windy) Mountain of the Caesii, and the surrounding towns. The view is a bird's-eye prospect over rolling hills dotted with stylized trees and village clusters; the river winds from the upper right down through the center, with the cataract plunging at the cliff face. A large oval scrollwork cartouche at lower right carries the title. Readable labels (with positions):

- *Piedeluco* (upper right, on a hilltop town): Piediluco

- *Piedeluco Lacus* (right of center, the lake): Lake of Piediluco
- *Velinus flu.* (far right, the inflowing river): Velino river
- *Pons Regula:torius* (center, at a bridge): the regulating bridge [Pons Regulatorius]
- *Catadupa Velini* (center, at the cliff/cataract): waterfall of the Velino
- *De Vinus flu* (center, along a watercourse below the cataract): [?] river — likely the channel below the cataract (reading uncertain)
- *Aqua sparta* (left of center, a town): Acquasparta
- *Mons Æolius sive Ventosus* (left-center, along a mountain ridge): Mount Aeolius, or the Windy Mountain
- *Cæsis* (lower left, a hilltop town, drawn with wind-blasts streaming from caverns): Cesi
- *Nar flu.* (center, the river coursing downward): Nera river [Nar]
- *Termini* (center-right, a town): Terni [Interamnia]
- *Narni* (lower center, a walled town): Narni
- Cartouche title: "TABULA CATADUPAM Velini Fluminis et montem Æolium Cæsianorum situmque circum adjacentium locorum exhibens." — "A map exhibiting the Waterfall of the Velino River, and Mount Aeolius of the Caesii, together with the situation of the surrounding places."

which, even if it did not strike the bystanders senseless, would at least, by the assault on the sense of hearing, render them deaf, just as at the cataracts of the Nile. It is an utterly horrendous spectacle — you would call it a hell — fearful with its foaming whirlpools and the confused recoil of the surging waves, with so great a bellowing of the falling waters that it can easily be heard even at Terni, a space of five miles distant, in the silence of the night.

[Margin: Wonderful spectacles.]

From the fall of the water, ground among the jagged teeth of the rocks, the water is so pulverized that you would swear you stood in a perpetual cloud, and you cannot leave the place without being thoroughly drenched. This too is worth noting: when the sun shines, there appears there a perpetual rainbow — not the dewy sprinkling of leaping fountains, but, as it were, a rainbow in the sky of the sun's own magnitude. Having therefore examined all the circumstances of the waterfall relevant to my purpose, I returned to Terni, and the next day set out for the Aeolian mountain, so that I might explore as an eyewitness [αὐτόπτης — Greek: *autoptēs*, "as an eyewitness, with my own eyes"] the marvels I had heard of it, and render the causes of each particular effect. Received at Cesi [Caesii] with

the greatest kindness by the leading men of the place, I learned the constitution of the whole mountain — partly explored by my own effort, partly through the instruction of the inhabitants.

[Margin: Situation of the windy mountain of the Caesii.]

The situation of this mountain is between the Castle of San Gemini [Castellum S. Gemini] and Terni — in the vernacular *Terzi* — stretching from east to west in a long chain of mountains eight miles in length, as is plain from the map appended here. The whole mountain is of rock, so composed by nature that you may see boulders of enormous mass set one upon another and compacted with the wondrous craft and industry of nature. On the ridge of the mountain sits a town, named Cesi, founded — as they say — by the dukes of the ancient house of Caesia. I judged that this mountain should rightly and deservedly be called the Aeolian mountain, on account of the whirlwinds it spins forth at a fixed season. For in summertime it breathes out the most violent winds through all its fissures and crevices, so that in the adjacent town the inhabitants, with a certain remarkable ingenuity, dispose channels for the winds here and there within their grottoes and cellars — just as in a city the conduits of an aqueduct —

[Margin: The leading-out of the winds through channels.]

both to imbue their wine and water, and their fruits of every kind, with a most welcome coolness; and thus they turn the force of savage nature into the sweetest delights. In the houses of the nobility one sees channels so aptly arranged, and fitted with stopcocks [epistomia] so skilfully, that they can temper the force of the winds at will — with the further addition of little doors and small hatches, within which whatever is stored, whether drink or food, by the utmost violence of the cold is all but turned to ice.

But before I gird myself for the scrutiny of the causes, I will first set out all the circumstances of the effects, which are as follows:

[Margin: The marvellous effects of this mountain.]

First. The exhalations of the winds are found not on just any day of the year, nor at just any hour of the day, but only in the summer months — for four hours before noon and as many after; and once these are past, the blasts of the wind gradually and little by little slacken and fail. By night, scarcely any trace of wind appears; so that, according to the greater or lesser violence of the daytime heat, the agitation and out-blowing of the enclosed spirits is felt now more, now less.

Second. In the winter months the vents [spiracula] obtain effects opposite to those of summer. For if anyone applies a little kerchief, or some such thing, to the mouths of the channels, it is — wonderful to say — no longer thrust out by the wind breathing forth, but is drawn inward by some hidden force I cannot name, and indeed the more forcefully, the more intense the cold has been.

Third. The quality of the out-blown air is such that, despite the rawness of the wind, it in no way drives men who tarry in grottoes of this kind into feverish disorders, as usually happens in other places. Rather, just as it delights in an unsullied dryness, so it conduces wonderfully to men's health and the prolongation of life. These, then, are the circumstances I judged should be set down in advance, so that, relying on them, we may at last hunt out the true causes of effects so prodigious.

[Margin: The diverse opinions to be rejected, and the true cause of the wind.]

It can scarcely be said how much the investigators of natural things have sweated in exploring the nature of this mountain, and how diverse the dogmas they have hammered out — yet none of them attaining the true and genuine cause. Some thought the cause to be cataracts of water hidden in the bowels of the mountain, by which the interior air, agitated, rushes out wherever a gate is given. But that this can in no way be asserted is plain from this: that then the wind would have to last continually, both by day and by night, which is contrary to experience. Others supposed the winds to proceed from the tunnels of the neighboring mountains, into which winds blowing from outside have insinuated themselves through various caverns, and being carried within this mountain, at last burst forth. But neither can this stand on any ground; for it would follow that in winter, when winds chiefly prevail, the winds of this mountain would rage more than at any other time — which is likewise contrary to experience. Nor were there lacking those who asserted that winds of this kind draw their origin from the tide of the nearby sea: that air stabled in subterranean passages is, by the dashing of the sea's waves, thrust into this mountain, and there, compressed, is at last violently forced out through the crevices. But this too lacks solid foundation; for it would follow that the winds last perpetually, matching the perpetual motion of the sea, or at least continue in a confused and interrupted manner — which is again contrary to experience. These are the chief points by which the natural philosophers establish their opinions about the nature of this mountain. It remains, therefore, that we too test the powers of our own wit in so intricate a matter. I say, then, that there is no other cause of effects so prodigious in this

mountain than the rarefaction and condensation of air — which I demonstrate as follows.

And first I suppose that this whole moun-

[Margin: The mountain is hollow.]

tain is hollow — which both the inhabitants, taught by long experience, hold for certain, and which I myself have ascertained by indubitable experience. For when you have advanced some way through the hidden passages, then horrid precipices first overhang, stretching down into the abyss of the mountain; and if you throw down a stone, after a long time an echoing sound is roused, as in wells and cisterns — than which no greater indication of the mountain's cavity could be given.

[Margin: Pierced all over with countless crevices.]

Second. The whole surface of the rocky mountain is filled with holes, crevices, and fissures — not only on the side facing Cesi, but also on the opposite side, facing the town of Acquasparta; where I found the same effects as at Cesi.

[Margin: The violence of the heat among the mountain ledges.]

Third. This chain of rocky mountain masses, stripped of all earthy substance, in summertime, through the various reflections of the sun among the ledges and hollows of the mountains, conceives so immoderate a violence of heat that you might say you stood in the Torrid Zone — nor is there anyone who could bear the heat around midday, with men and animals shut up within their houses and stables.

Resting on these foundations, I say: as soon as the air outside, among the rocky mountains, is by the manifold reflection of the sun reduced to a most tenuous substance and, rarefied, expands, it comes about that — seeking a larger place — it insinuates itself with the greatest force through the fissures and crevices of the mountain into its inner bowels. But since it cannot coexist with the air stabled within, the air driven in, like a stranger and newcomer, pressed and constricted, seeking an escape anew through the wider passages of the mountain, after long struggles is at last expelled with the utmost violence. And in this way that prodigious wind of which we speak is born in summertime at fixed hours. But when the external heat ceases, the wind too must necessarily cease again. All of which is shown by the beautiful experiment of the Aeolian balls [pilae Aeoliae].

[Margin: An experiment.]

Let a ball be made, fashioned of the most solid bronze, with a very narrow neck, in which there is likewise a hole as narrow as the point of a needle. Let this ball, filled to the middle with water, be cast into the fire and left until it has conceived the highest heat. Once this is conceived, you will at once cast it into cold water and hold it submerged a while; and you will see the air lurking there, reduced to a most tenuous substance, gradually condense and be driven back; and since no other body is supplied to fill the place of the failing air, it draws the water with great force into itself, and

[Margin: The cause why the mountain perpetually blows.]

I do that same thing daily in the summer months in my Museum [Musaeum] — which, by a hidden passage, extends into the domestic garden enclosed by the four very high walls of the temple and college. It happens, then, that as soon as the air in the garden is kindled by the heat of the midday sun and by the various reflection of the rays striking the walls, that air, dilated by excessive rarefaction, while it seeks an escape, rushing through the passage with great force, gladdens the Museum with a most welcome breeze — and this happens only in the afternoon hours and the summer months; but at the remaining time of day, or in the winter months, nothing of effects of this sort is perceived. This I would hold — saving the judgment of others — to be the true and genuine cause of the winds bursting from Mount Cesi [Mons Caesianus] with such force in the summer months.

[Margin: Why the mountain draws inward in winter.]

Now as for the fact that in the winter months the external air, together with the kerchiefs, paper, and similar things of lighter substance placed at the mouths of the passages, is snatched into the inner bowels by the opposite course of the way — I say its cause is this: that in winter the air, condensed by dread of a vacuum, always draws other and yet other air inward from outside. The cause of each effect — namely repulsion and attraction — I demonstrate by this experiment.

[Margin: An experiment.]

Let a vessel be made of any rather solid material — glass, bronze, tin — of the kind the figure A B shows; from whose bottom let a tube B A C be led out, and let the orifice D E be so blocked that the air can nowhere escape; and the instrument will be complete.

Diagram. A schematic woodcut of a pneumatic apparatus standing on a footed pedestal: a large spherical (bulb-shaped) vessel from whose top a slender curved

tube rises and bends over to one side, terminating in an open nozzle. Readable labels (with positions):

- C (right end of the curved tube, at its open nozzle): the outlet orifice of the tube
- D (upper neck of the vessel, right of the tube base): one terminus of the closable orifice D–E
- E (upper neck of the vessel, left of the tube base): the other terminus of the orifice D–E
- A (center of the spherical vessel): the vessel A, midpoint of the tube path B–A–C
- B (bottom of the spherical vessel, where the tube exits): the base of the vessel and start of tube B–A–C

Placed in the sun or by a fire, as soon as the air within boils up, that air, dilated by rarefaction, will prepare an outlet for itself through the tube B A C, and consequently will exhibit at the orifice of the tube C a notable wind, which will become apparent when a feather is set before it. But if you drench the vessel A B with cold water, you will feel — to your astonishment — the air A B, now condensed, drawing in the external air to supply the place of the failing interior air; which will appear from a feather set before the orifice C. In this way the vessel of the ball will be filled, as much as is enough; and if you then set lit coals beneath it again, it will soon resolve the rarefied water within into vapor. The enclosed vapor, since it finds no escape except through that narrowest hole, will burst out through it with the greatest hissing and violence of impetus; but when the external heat fails, the water, restored to its natural state, will emit neither vapors nor winds any longer.

[Margin: The cause of the perpetual wind, which some mountains breathe out.]

And from this experiment the cause of each effect in the said mountain is beautifully made plain. As for those winds which are blown out perpetually from some other passage of the mountain, they without doubt derive their origin either from subterranean cataracts, or from the inflow of the sea agitating the air in the subterranean passages — as is noted in some places of Etna [Aetna] — or from the melting of snows, as in Mount

Auvergne [Mons Alverniae], and concerning the cavern in Etruria near Volterra [Volaterrae], from which — Leandro Alberti [Leandro Alberti] being witness — a spirit and wind sometimes erupts so violently that it casts down whatever is in its

path, and even the trees themselves. But enough now of the Caves and Veins of the earth.

CAPUT XX.

Of Caves, Chasms, and the countless passages of the Earth. [De Antris, Hiaticibus, & innumeris Terrae meatibus.]

[Margin: Division of caves.]

Jacques Gaffarel [Jacobus Gaffarellus], in his *Subterranean World* [*Mundus subterraneus*], divides the Caves of the terraqueous Globe into five classes: Divine, Human, Brutal, Natural, and Artificial.

1. He divides the Divine again into various species, and they are the following: Angelic Caves, or Caverns, are those in which an apparition of angels occurred — such as the cave on Mount Gargano [Mons Garganus], most famous for the apparition of St. Michael.

[Margin: Ecclesiastical.]

Ecclesiastical: temples cut within the rocks, as they recount of the Mountain of the Pagodas [Mons Pagodum] in India.

[Margin: Catacombs.]

Catacombs, or cemeteries, which are visited here and there in the Roman countryside with the greatest celebrity — of which *Roma subterranea* [the *Subterranean Rome*, by Antonio Bosio] treats most copiously.

[Margin: Diabolical.]

Diabolical, or Infernal, in the inmost recesses of the Earth.

[Margin: Purgative.]

Purgative, that is Purgatory, Limbo, and the like, which are held by faith.

[Margin: Caves of the Magi.]

To these are referred the Caves of the Magi, in which, with countless superstitions, they performed magical operations — met with everywhere in all places.

[Margin: Of heroes.]

Likewise the Caves of Heroes, Idolaters, and Casters of Lots, and those in which oracles were given — of which kind were the Delphic and the Ammonian caverns.

[Margin: Fabulous caves of the poets.]

To these are referred the fabulous caves of the Poets — of Fauns, Dryads, Nymphs, Tritons, Sirens, and the other gods and goddesses.

[Margin: Caves of giants.]

2. Human Caves, to which are referred first the Caves of Giants, of the kind shown in the Palatinate [Palatina], Sicily, and other places.

[Margin: Of the Sibyls.]

The Caves of the Muses and Sibyls are still seen in many places — as at Naples in the Cumaeen countryside [Cumanus Ager], which we shall describe in what follows.

[Margin: Of hermits.]

To these may conveniently be referred the Caves of the Holy Hermits — as in Egypt and the Thebaid [Thebais], where countless caves of Saints Antony, Paul, Hilarion, and others are seen. In Malta [Melite], the cave of St. Paul the Apostle; in Sicily, that of St. Rosalia on Mount Pellegrino [Mons Peregrinus]; at Subiaco [Sublacum], that of St. Benedict; in France, that of Blessed Mary Magdalene, vulgarly *la Sainte Baume*; near Arles [Arelatum], that of St. Giles [S. Aegidius] — and so of the rest. To these too may be referred the subterranean Cities, and others of which we shall speak in what follows.

[Margin: Brutal caves.]

3. Brutal Caves, to which are referred the dens of Lions, Tigers, Wolves, Foxes, Bears, Serpents, and Dragons, and the other lairs of subterrestrial animals, and the hiding-places of birds that love cavernous spots.

[Margin: Caves endowed with marvellous powers.]

4. The Natural Caves, of which there are countless species, according to the natural powers implanted in them. Some are endowed with medicinal virtue.

[Margin: Mineral.]

Certain ones gush with metallic vapors, exhalations, and waters. There are also glacial ones, full of snow and crystal — as I remember to have seen on Mount Sorano [Mons Soranus]. There are also Aeolian ones, which emit continuous blasts of wind.

[Margin: Of other marvellous powers.]

There are not lacking those endowed with resolute, restrictive, and congealing virtue — of which in their own place and time.

[Margin: Artificial.]

5. Artificial Caves are those prepared for human uses or delights. Likewise subterranean passages made by art — as at Naples the Grotto excavated beneath Posillipo [Pausilippus]; at Syracuse the subterranean Labyrinths. To these are referred domestic grottoes, hydraulic ones, and subterranean temples. Likewise quarries and the other mineral-workings, of which expressly in what follows.

And this is the division of Caves — of which, however, apart from the Natural ones, we shall consider no others in this work.

[Margin: Natural.]

Now we call Natural those which Divine Wisdom established in the inmost chambers of the earth for the necessary uses of Natural things; of which some open an entrance on the outermost surface of the Earth, while others, inaccessible to men, are hidden in the inmost recesses of the Geocosm — distinguished into three species, and they are: Hydrophylacia, Pyrophylacia, and Aerophylacia, of which we have already spoken in the preceding, and which we shall pursue more copiously in what follows. But the external ones open an entrance to the immense vastness of caverns and the abysses of chasms, some of which we shall now adduce.

If, then, so great is the multitude and variety of Caves on the surface of the terrestrial globe, how great a multitude of them shall we believe there will be in the internal bowels of the Earth? This is certain: that all Caves possessing some notable virtue obtain their powers only from some inmost and enormous cavern — whether it be a Hydrophylacium or a Pyrophylacium — derived through far-extended passages, in proportion to the complexion of the earthy substance through which the said passages are conducted.

[Margin: Petrifying caves.]

Hence some caverns, by a petrifying juice proper to the condition of the place, turn everything into stone; others recreate wonderfully with an aromatic odor; certain ones imbue with a prophetic spirit, while some are wrongly perceived.

[Margin: The various virtues of natural caves.]

There are not lacking those which conduce to chastity, and on the contrary others which conduce to lust —

they are said to incite lust. Some, by a certain narcotic power, induce sleep; others, by contrast, induce wakefulness. Many gush with oil, with bloody liquor, with bitumen, with salt, with vitriol, with naphtha, and the like. The explanations of all these we shall assign in the Sixth Book of this work, for upon them depends the whole composition of sensible, vegetable, and inanimate things. Now, for this concurrence of causes to produce effects befitting nature, it accomplishes this in no other way than by distributing them aptly, each to each according to the condition of the earthly substance, through the countless channels and receptacles with which the earthly body is bored through, as if through certain fibers and vessels of the Megacosm.

But let us look at the marvels that Mela [Pomponius Mela] (I.6), Solinus (c. 39), Pliny [the Elder] (*Natural History* 31), and Strabo (XIV) report concerning the Corycian Cave [specus Corycium] — matters that bear greatly on our purpose. Not far from Pompeiopolis, they say, lies the town of Corycium, above which there is reported to be a cave called by the name of Conthyos, and above that one which can scarcely be described, so remarkable is it. For with a vast gaping mouth it opens a mountain set against the shore, steep enough on a slope of ten stadia, right from the summit; and with an ever wider and wider descent it grows green with shady groves blooming on every side, embracing itself wholly in a circle with its wooded flank, with such beauty that at first sight it astounds the minds of those who approach — yet for those who have lingered in contemplation, it does not pall. There is but one descent into it, narrow and rough, of fifteen hundred paces, through pleasant shades and the open spaces of a wood that re-echoes with something wild, with streams flowing here and there. When one has reached the bottom, another cave opens up again. It terrifies those who enter; then for a while it is bright; soon, as those who have gone in descend deeper, it grows ever darker the further one goes, and admits one as if down a deep tunnel.

[Margin: A marvelous cave.]

There a huge river, raising itself with a foaming front, just shows itself; and where it has drawn a great rush of water along a short bed, it is again plunged under and cut off. Within there is a space too great for anyone to advance into — terrible, and therefore unknown. Pliny adds that the dripping drops of this cave at once harden into stone.

Not unlike this is the one which Aelian [Claudius Aelianus] describes (*De Natura Animalium* XVI.16): "Among the Arrians there is a chasm called the Chasm of Pluto, in whose depths lie hidden caverns and immense recesses unknown to men. How it was sunk to so great a depth, not even the Indians can explain. Some three thousand and more diverse animals — sheep, goats, oxen — the Indians drive there, and out of superstition they cast many animals headlong into the depth of that pit, from which there is no exit, nor can they ever be seen again. Yet the lowing of oxen, the bleating of sheep, the voice of goats, and the neighing of horses are heard; and if anyone puts his ears to its jaws, he will hear sounds of this kind for a very long while, for the confused noise does not cease to resound, since beasts are continually driven headlong there."

[Margin: A chasm terrible among the Arrians.]

[Asclepiodorus, however, reports] (he says) [another cave, not far from this one], into which Philip [of Macedon] sent down very many men to explore an ancient treasure long ago appointed [for the purpose], to learn what its abundance was, what its condition, and whether the old greed had left anything for those to come. They descended, he says, with much light, and labored for many days; then, wearied by the long road, they saw huge rivers and vast masses of water gathered there — pools the equal of monsters — not indeed pressed in by the overhanging earth, but seen at large in their free expanse, not without horror. Whence, from so compendious a narration of marvelous things, he wisely concludes at last: "Not the whole earth," he says, "is compacted of solid matter all the way down to one [center], but in many parts it is hollow and suspended over hidden lairs; it has voids without moisture."

And again (*Natural Questions* III.16) he says: "There are beneath the earth rights of nature less known to us, but no less certain. Believe that below is whatever you see above; for there too are vast caverns, mighty recesses and empty spaces, with mountains hanging on this side and that, and chasms broken off into the boundless deep, which have often swallowed up cities that slid into them and buried a vast ruin in the depths." And (chapter 8) he has it thus: "Just as in the outer part of the lands vast marshes lie, and great navigable lakes, just as the seas are spread over a vast expanse of land, poured into its valleys, so the interior of

the lands abounds in fresh waters, and these stand in pools no less than the Ocean and its gulfs do among us — indeed more broadly, the more the land opens out into the deep." These words of Seneca [Seneca the Younger] can serve as a kind of recapitulation [anacephalaeosis] of all that has been said up to this point.

[Margin: Seneca's view.]

The forms of subterranean caves, then, are various, made either by chance or by nature. For some lie open, broadly excavated; some contain a very deep cavity; some are stretched out lengthwise, sunk profoundly to the bottom; some have manifold entrances and recesses. Yet all of them were founded by the Author of nature with that craftsmanship, endowed with those properties which the condition of the places seemed above all to demand, as it were by their own right.

[Margin: Variety of other caves.]

At Metaurus in Sicily there is a cave, horrible to behold, through which a huge river, running for a long while and over a long course along its subterranean bed, at last rolls out into the open plain.

[Margin: Cave-river.] [Margin: Strabo VI.]

On the same authority [Strabo XVII], another is reported to be in the Emporic Gulf of Mauritania, so hollowed out toward the sea that it admits the ebb and flow inward for seven stadia. Another is at Hierapolis and Laodicea, concerning which you may consult Strabo. And (book XIII) near Andira there is said to be a cave of such dimensions that it leads all the way to Palea — that is, to 130 stadia — and this became evident from the fact that when a he-goat fell into the chasm, it was found by a shepherd on the other side of it on the following day.

[Margin: A subterranean river. Strabo XVII.]

I shall not speak here of the vast and immense caverns of Ethiopia, which Father Páez [Pedro Páez] describes at length, through which the Nile and the Niger — huge rivers — roll down through subterranean passages of inexplicable length and incredible depth, plunged below. Nor shall I speak here of the caves and caverns of Mount Taurus or of Jamaí, surpassing all human belief, concerning which see Ramusio [Giovanni Battista Ramusio] (vol. 1).

[Margin: A cave in the Andes.]

Marvelous are the things that American history relates of the Mountains of the Andes, in whose bowels — more than can be told — it asserts that horrid receptacles of caves of such great capacity are found that they do not yield to

whole regions on the earth's surface. In these too there are mighty cataracts of mighty rivers, which hurl down their waters with such a roar and such a diversity of sounds that the diggers testify they have heard nothing more terrible in the world. Among other things worth recording: a small boat was found there, and from where and how it had been carried into this innermost receptacle of the earth, no one could conjecture. Yet it was afterward ascertained that this river finds its outlet from the opposite side of the mountain, nearly a hundred and forty leagues away, in a very deep valley. But since the river bursts forth here through huge precipices, I do not see how this little boat could have been driven by sailors against nature through subterranean groves into that inaccessible subterranean region. It is more likely that the boat was swallowed by the whirlpools [vortices] of the Pacific or Atlantic Ocean, transported here by a continuous flow of waters through subterranean passages, and cast out onto a subterranean shore.

But concerning marvels of this kind — the recesses of the Andes, their rivers, cataracts, and the rest of nature's wonders — let the reader consult Father Alfonso de Ovalle [Alonso de Ovalle], writer of a *History of Chile*, who treats of them fully and curiously, and from whom I received much by word of mouth here in Rome, to be brought forward elsewhere. Let him also see and marvel at what Olaus Magnus relates in his *History of the Northern Peoples* [*Historia de Gentibus Septentrionalibus*] about similar subterranean caverns, or rather regions. I could adduce countless other instances in this place; but lest the work swell beyond measure, I have thought it best to stay my pen here, intending to bring forward more in the course of this work, in their own proper places and at more opportune times.

MUNDI SUBTERRANEI LIBER TERTIUS HYDROGRAPHICUS

SIVE DE OCEANI NATURA, [OR, ON THE NATURE OF THE OCEAN]

Its origin and motions, both external and internal; likewise on its perpetual circulation [pericyclosis], and on the rest of nature's marvelous effects in the world.

SECTIO I. [Section I]

On the Nature of the Watery Element, or on the Sea, and on the continual motions by which it is agitated at every moment, and on the marvelous effects which it produces in the Subterranean World.

It is said in this Section to what end Nature established these marine motions about the earthly Globe. Likewise, [we treat] of the variety and change of the sea's tide [aestus maris] which occurs in various Regions, Rivers, Islands, and Straits; of the causes of each and all; of the marvelous constitution of the Ocean's floor; of the Circulation of the Ocean through each pole of the Earthly Globe; and of the marvelous constitution and intercommunication of all the seas through the hidden meanders of the Earth.

CAPUT I. [Chapter I]

On the diversity of Motions by which the Sea is agitated at every moment.

SUPPOSITIONES. [Suppositions]

Although in our *Ars Magnetica* [*Magnes, sive de Arte Magnetica*] we have set forth at length that most celebrated work of Nature — I mean the Approach and Recession of the Sea, which they also call the Swelling [intumescencia] and Subsiding [detumescencia] of the sea — nevertheless, since this is one of the greatest secrets of the Subterranean World, by whose power all things are preserved and sustained, I have therefore thought it best, so far as can be done, to describe it here in this one place as exactly as possible, as the most apt instrument of nature, by means of which all things (as I said) in the Subterranean World are uniquely disposed for the perfecting of the generations of things — as if in a certain womb and seed-bearing [panspermatic] storehouse of Nature — as will become clear from the discussion.

I suppose, then, first, that the Ocean — which is the one common receptacle of all sublunary waters — has one natural motion, by which all its parts, each and every one, compose themselves into a spherical surface (imperceptibly to us, though perceptibly into a plane surface), and once this is accomplished they come to rest. This is established by experiment: for if a wind makes some lake fluctuate this way and that, it is well known that when the wind ceases the water returns to its equilibrium beneath the level surface of the lake. For since it is a fluid element, it cannot happen that one part should stand higher or deeper than another; therefore it is necessary that it tend toward equilibrium, for this is the

end of this element's appetite. But if you consider the whole Ocean in its natural state, it doubtless composes itself into a spherical surface, so that all its parts are equidistant from the Center of the Earth — and Archimedes proves this beautifully in his book *On Floating Bodies* [*De iis quae vehuntur in aqua*].

[Margin: The Ocean's motion is one and natural to it.]

[Margin: The water of the Ocean composes itself into a sphere.]

I suppose, second: that when one part of the Ocean is moved by a more vehement impulse, the whole Ocean is necessarily moved in succession. For since it is a continuous body, the moved part A will at once raise the following part E into B, and

Diagram. A horizontal wavy line representing the successive propagation of motion across the Ocean's surface, marked with paired letters. The pairs A, B, C, D label the crests/positions, with the moved part A raising the following parts in succession.

- A: the initially moved part (at left)
- B (above): the position into which the following part E is raised
- C (above): the position into which part F is raised
- D (above): the position into which part G is raised

B will raise part F into C; and C will raise part G into D; and so on in succession, in a circle, until it is restored to its starting point. Yet you may judge that the motions are always weaker the further they are from the starting point. Let all this be understood of the motion of the sea with no blasts of wind (which everywhere hold sway), and with the obstructing impediments of shores and promontories removed; for by these the motion is not merely impeded but necessarily destroyed.

[Margin: When one part of the Ocean is moved, the whole is moved in succession.]

From this it is clear that if any canal whatever, of whatever length, is filled with water and closed at both ends with cork stoppers, then — the stopper being removed, or the water being even lightly pressed with a pestle — at the very same moment of time at the other end it will excite a motion just as great as the space the pressed water had left within the canal.

[the motion is] either straight, or a whirling [vortex], or a shaking [concussion].

I suppose, third: that all the surface parts of the water naturally press the waters set beneath them, all the way to the bottom, perpendicularly; but accidentally — that is, through a violent impulse — they press obliquely. Let there be some vessel L M N O filled with water.

Diagram. A cylindrical vessel shown in perspective, filled with water, used to demonstrate that surface water presses perpendicularly on the water beneath. The rectangular body of the cylinder is bounded at the top corners by L (left) and N (right), and at the bottom corners by O (left) and M (right). Along the top rim are the points D, A, C; along the bottom rim are the points C [recte: see note], B, I. Dashed lines descend from the top points toward the bottom, illustrating the lines of perpendicular and oblique pressure.

- L (top-left corner): upper-left edge of vessel
- N (top-right corner): upper-right edge of vessel
- O (bottom-left corner): lower-left edge of vessel
- M (bottom-right corner): lower-right edge of vessel
- D (top rim, left): a surface point
- A (top rim, center): the surface part whose perpendicular pressure follows line A–B
- C (top rim, right): a surface point
- B (bottom rim, center): the point directly beneath A
- I (bottom rim, right): a bottom point referenced for oblique pressure

I say that the parts of the water A at the surface press the waters set beneath them not obliquely toward M or O, but perpendicularly upon the waters placed directly below, along the line A B. But the parts C or D press not obliquely toward B, but straight down into E or I. And this is clear from what Archimedes demonstrates by subtle reasoning in the book cited, to which I refer the reader. It is also clear by experiment: for if you bore a hole in the bottom of the vessel at B, the water will descend straight down, not at D or C, but at the point A perpendicular to B, with a little whirl formed. The same is to be understood of any opened place in the bottom of the vessel: for example, let the bottom be opened at E or I, and you will soon find that the water descends through little whirls perpendicularly to D or C, and empties out through E or I.

[Margin: Water always presses perpendicularly.]

I suppose, fourth: that the motion of the sea is either straight, or a whirling, or a shaking. The straight motion of the sea is when it is driven toward some region by an impulse from without. The whirling motion of the sea is when the sea is

driven into a gyre; and this happens for the most part either naturally or accidentally. Naturally — when the water is absorbed into an abyss hidden in the floor of the sea (of which more fully in its proper place). Accidentally it is moved into a gyre when, by contrary winds, the sea is driven into whirlpools.

Furthermore, the universal straight motion is twofold: the first constant and perpetual; the other indeed perpetual, but compounded of contrary motions. The perpetual and universal straight motion is that by which the sea or Ocean is perpetually driven, following the motion of the Sun, from East to West. The other general motion, compounded of contrary motions, is properly that which we call flux and reflux (ebb and flow), others approach and recession, and some the Swelling and Subsiding of the Sea; and it occurs by the Motion of the Moon from her Rising to her Setting.

There are found in the sea also certain other motions, proper and singular, and others contingent. The proper and singular motions — which we call special or proper — are those by which only some parts of the Ocean are moved; and these again are twofold: perpetual, and anniversary [annual], which never cease to make the sea boil. The anniversary are those which are detected in some sea at fixed months or days of the year. But contemplate the division of all these in the following resolutive Table.

[Margin: Division of the sea's motion.]

The motion of the Ocean (the one receptacle of all sublunary waters) is either:

Straight

Constant and perpetual, and is from East to West, and depends on the Sun.

Compounded of contrary motions, and is called the flux and reflux of the sea, and depends on the Moon.

Reflected, and is either by

The general motion, by which the sea is driven

to the shores of
opposite Regions.

Of the sea toward
opposite shores
by the reflection
of the force of the
winds, made into
another quarter
— which they call
Currents.

**Proper and
special**, or
peculiar to some
particular sea,
and is either:

Perpetual, and
this again either
by

From the
absorption of the
sea's water, as
happens in
whirlpools, and
they are called
circular motions.

From the
vehement
irruption of some
subterranean
river into the
underwater
regions, by which
the sea
continually boils
up to some point
here.

From the impetus
of huge rivers and
streams
discharging
themselves into
the sea, by which
the sea is either
driven straight to
some point, or

agitated into whirlpools, or the sea is driven into inconstant tides.

Anniversary,
which are

Those which are detected at fixed months or days of the year in some sea: to these is referred the motion of the Ocean from South to North, or from North to South.

Contingent
motions of the sea, by which the sea is never free, and which arise either:

From the Winds, of which there is an innumerable variety in the sea, by which the sea is perpetually harassed by their mutual agitations, now into these, now into those parts; and it depends on the sudden commotion of the air (as will be said concerning the origin of the winds); and without any fixed order they now cease, now begin, and are as it were unending [non-

finite].
Or from
subterranean
spirits and
exhalations
disturbing the sea,
which now and
then burst forth
from the floor of
the sea, and stand
in no fixed order,
nor last for any
fixed and definite
time.

Circulatory,
[which is]

General

That is the motion
by which the
Ocean perpetually
circulates from
the Arctic pole,
through the
Antarctic pole,
through the
bowels of the
Terrestrial Globe.

Special

By which all the
communicating
seas, through
subterranean
passages, carry on
the reciprocal
commerce of their
mutual
interchange.

Particular

By which the sea,
through
subterranean
passages,

discharges itself
within the
receptacles of the
mountains; and
this circulation
accomplished, it is
restored to its
origin.

CAPUT II.

On the general motion of the Sea, which is from East to West.

[De Motu generali Maris, qui est ex Oriente in Occidentem.]

The general motion of the Ocean is from East to West, as has become known through long experience to those who, undertaking a voyage across the immense expanses of the Ocean to the New World, have sailed back and forth across it. Those who set out from India toward the western Cape of Good Hope [Bonae Spei promontorium], or who sail from Portugal [Lusitania] or Spain to Mexico, complete a voyage of that kind in a far shorter span of time than one would sailing from Portugal to India, or from Mexico to Spain.

[Margin: Why the voyage from Portugal is shorter, and the return from India longer.]

Moreover, those who customarily sail from the port of Acapulco in New Spain to the Philippine Islands run, from that port — where there is an almost perpetual calm [malacia] — up to the tenth degree of northern latitude, and then sail westward along the parallel of that tenth degree so favorably that, with sails unaltered, they cover a distance of 3000 miles in the space of 85 days. They do not change sail until they reach the islands they call the Ladrones [Ladrones, the Mariana Islands], where, leaving the tenth parallel, they steer the ship to the thirteenth, so as to enter directly the "mouth of the islands" (which they call *la bocca de las Islas*). In this way, with the dangers avoided, they at last safely reach the port of Manila. And so they cover a third part of the terrestrial globe in no more than seven months by this easterly wind, which never fails the sailors.

By contrast, from the Moluccas they cannot make for New Spain under the tenth parallel, since the wind and the sea are always against them there. Hence it is

necessary for those who intend to sail from the Philippine Islands to New Spain to make for the fortieth degree of northern latitude, for under this parallel, driven by the northerly winds that reign perpetually along that coast of North America, they reach the port of California [Caliphornia] in a short time. So Father Simon Cotta [Simon Cotta] and Father Diego Bobadilla [Diego Bobadilla], procurators of the Philippine Islands, who had by then twice crossed that sea, told me by word of mouth.

[Margin: How the voyage from the Philippine Islands to Mexico is laid out.]

This motion is also observed in the Strait of Magellan [Fretum Magellanicum], where the Ocean, rushing from the East into the very narrow jaws of this strait, throws everything into turmoil with vast boilings of its swells [aestuum ebullitionibus], until it finds itself a passage into the Pacific Sea. So too through the Strait of Manila [fretum Manilanum] and the Gangetic Ocean [Oceanus Gangeticus] it is carried from East to West with a most rapid motion through the channel of Cape Comorin [Promontorium Comorinum]. At the Gulf of Paria [Sinus Pariae] it is swept with such violence from the East that the place has been called the "Mouth of the Dragon" [os Draconis, *Boca del Drago*]. This motion is also observed by those who sail from Europe toward Canada. The Tartarian Ocean [Oceanus Tartaricus] likewise is carried with the utmost force through the Strait of Vaigach [fretum Weigats], which is evident both from the motion itself and from the abundant ice that the said Ocean rolls out into that strait.

[Margin: Everywhere the strong easterly motion of the Ocean is noted.]

In the Pacific Sea, too, the sea moves toward the Strait of Anian [fretum Anian]; from Japan it is driven toward China; and in the same way it is set in motion in the strait at Java. In a word, that a motion of this kind from East to West is observed everywhere throughout the whole Ocean is as certain as is the unanimous, consistently confirmed experience, over many years, of all the sailors who have very often plied that Ocean.

The cause, then, of so plain an effect is inquired into. The Peripatetics, in their usual manner, at once take refuge in the sweep of the *primum mobile* [the Prime Mover] — whether or not it exists in the nature of things is not yet settled. Others imagine a magnetic power in the Sun, by which the sea is drawn. Others, intent on metaphysical speculations, are so far from assigning the cause of so great an effect that they rather obscure it. Setting aside those most remote speculations, we proceed to the nearer and more proximate causes.

[Margin: Various opinions about this motion.]

We shall therefore philosophize better if we say that the cause of this marine motion is the Sun's revolution from East to West. For since the greatest part of the Ocean lies beneath the torrid zone [zona torrida], and the Sun almost perpetually strikes some part of this region with its rays at the perpendicular, and thus daily draws up and rarefies an immense mass of water by its rays, converting it either into air or into vapors and clouds — it is necessary that, in place of the consumed and drawn-up waters, others be substituted from the East or from either side. And since this drawing-up of the waters is always continued, no one fails to see that this effect of the sea's flux toward the West will likewise endure.

[Margin: The true cause is set forth.]

That a great and incredible quantity of water is drawn out of the Ocean by the power of the Sun is abundantly attested by the daily and most copious rains in those regions where the Sun stands at the vertical [verticalis]. It is established from the report of Our Fathers who dwell in the Colleges situated beneath the torrid zone: when the Sun is set at their zenith, such daily deluges of rain pour down around noon that the level plains of the fields seem to stand in pools, and the harbors and shores are filled with sand worn down from the mountains, along with clay-like matter and other refuse. In this way, by a kind of restoration [postliminio], the sea is given back what had been taken from it by the Sun.

[Margin: Most copious rains in those places where the Sun is at the vertical.]

But why, at the fortieth degree of latitude, the winds are for the most part northerly and prevail along the shores of the Pacific Sea — the cause is the rarefaction of the vapors, which, raised up beneath the torrid zone and diffused far and wide into the northern region, are driven back by the cold that comes over them and by the air thus condensed, and so produce the said winds. And why the wind in the Pacific Sea is perpetually easterly — the cause is that, as the Sun rises, the vapors hanging over the Ocean, compressed by the nocturnal cold, are rarefied by the ensuing heat of the Sun

[Margin: The cause why, under the fortieth degree of latitude in the Pacific Sea, northerly winds prevail.]

and degenerate into winds. Since they continually disturb the forward paths of the Ocean, it is no wonder that, the same cause persisting, the sea's motion from East to West is likewise perpetuated in accordance with the Sun's motion. To this is added that the vapors driven back from the North and the South [ex Borea & Austro] continually force the waters on both sides into the Euro-Zephyr Current

[Euro-Zephyreum Currentem] within the Ocean. And this motion is the more violent in proportion as the Sun stands more nearly perpendicular to the Ocean.

[Margin: This Euro-Zephyr motion exerts itself most of all beneath the torrid zone.]

Hence, in the Ocean lying beneath the temperate zone [zona temperata], the Sun exerts its force only to a degree; yet because it strikes so great a surface of the sea with its rays obliquely, the sea's motion from East to West is by no means observed here to be so violent as in the torrid zone or in places near to it.

[Margin: It exerts its force most of all in the Euro-Zephyr.]

Finally, that the Moon too greatly promotes this Euro-Zephyr motion of the Ocean is clear from the fact that, at the conjunction or opposition of the Sun and Moon, this Euro-Zephyr motion is found by sailors to be much swifter and more violent. For at conjunction it powerfully presses upon the paths of the Ocean emptied by the Sun, and from this pressure the sea is always driven forward, in accordance with the motion of the Moon and Sun — as will be demonstrated more fully below. At opposition, however, the Moon by night likewise presses toward the West, and so, wave thrusting wave, there arises continually a certain undulation of the Ocean from East to West, by which the deficiency of the waters drawn up by the Sun is made good through the subsequent surges of the waters compressed by the Moon. But at the quadratures, since the Moon does not face the sea perfectly, it accordingly contributes a lesser force of compression as well. And experience teaches that this motion is almost always exceedingly feeble in the Moon's quarters.

[Margin: The Moon promotes this motion most of all.]

Now from this general Euro-Zephyr motion two other motions of the Ocean arise: one is from South to North, the other from North to South. For it is established that the Ocean bursts out from the northern corner of the world with a certain violent force toward the southern region in the Atlantic Ocean [Oceano Atlantico]. Hence those who make for the Cape of Good Hope from Portugal, or from the islands they call the Azores, accomplish it more quickly than the reverse. And the force and efficacy of this flux lasts for nearly the space of half a year — from North to South, that is, and the reverse. How this comes about, I shall now explain.

[Margin: From this universal motion of the Ocean two other motions arise, one from North to South, the other from South to North, and the reverse.]

Since the Sun, as I said above, perpetually overhangs the torrid zone and draws an immense mass of water out of the Ocean lying beneath it, it comes about that this tract of the Ocean, with its waters drained off, is rendered as it were lower-lying [decliviores]. But the northern Ocean, since it is set outside the perpendicular rays of the Sun, by its most humid temperament for the most part receives a continual increase of water — converting the surrounding air into itself — and substitutes itself in place of the drawn-off waters, Nature, the provident dispenser of things, ordering matters in this way. Thus it comes about that the northern Ocean, by its own increase, comes to the aid of the Ocean beneath the torrid zone, which is laboring under a deficiency of waters — as a rich man helps a poor one, all the parts conspiring toward the preservation of the whole.

[Margin: The cause of these motions.]

The same is to be said of the southern Ocean, opposite to the northern. Hence to the parched and lean [Ocean] there is always allotted, alternately each half-year out of the storehouse [penuario] of whichever of the two Oceans is the richer, as it were a certain provision [annona] by provident nature — lest the [Ocean] be deficient in necessities — for supplying the deficiency of the one out of the excess of the other. I confirm this by the following experiment.

[Experiment:]

If above a certain oblong vessel filled with water you draw an iron ball, previously made white-hot by fire and gripped with tongs, gently from A to B, in such a way, however, that the waters

Diagram. A small woodcut illustrating the experiment. An oblong rectangular trough (shown in perspective, with its near and far long walls drawn) holds water; a white-hot iron ball gripped in a pair of tongs is suspended just above the water's surface near the left end, with the operator's hand on the tong handles at the right. The ball is to be drawn slowly from one end of the trough to the other.

- A (left interior end of the trough): the starting point of the ball's motion
- B (right interior end of the trough): the endpoint of the ball's motion

[Note: only "A" is legibly inked at the left end of the trough; the "B" referenced in the text would lie at the right end where the hand and tongs are, but is not separately legible.]

do not touch its surface [i.e., the ball does not touch the water]: you will find what I said — that the water, about to follow the motion of the ball, is left in the middle

as in a kind of channel. And if you have first marked the boundaries of the water and the vessel, you will see, once the motion of the ball ceases and it has cooled, that the water has plainly subsided in the vessel, having been dissolved into vapors by the ball's heat. Let this suffice concerning the general Euro-Zephyr — or Noto-Boreal [Noto-boreo] — motion.

CAPUT III.

On the motions which they call Currents, whether repercussed or reflected.

[De Motibus, quos Currentes vocant, sive repercussos, aut reflexos.]

This motion arises in manifold ways: either from the general Euro-Zephyr motion driven against the overhanging shores of the regions and thence reflected back — which the sailors call a Current [Currentem]; or from the blowing of the winds; or, finally, from the motion of the flux and reflux, caused by the power of the Moon.

[Margin: Currents reflected by the power of the Moon.]

Those who sail from the Canary Islands to Mexico are for the greatest part carried by the Currents of the Ocean, which, between Cuba and Hispaniola [Hispaniola] and the mainland of New Spain, are so violent that they seem to reproduce the rush of a river. Once ships have been cast into jaws of this kind, no means of retreating is given them. Indeed, those who are to sail from the Gulf of Mexico [Mexicano sinu] to Spain must keep to the shores of Virginia and Florida, so that the ship may hold its course. The reason for this is none other than that the Ocean, rushing partly from North to South with the greatest violence, at the Cape or White Promontory [Promontorio Candido] (which they call *Cabo Blanco*)

[Margin: The Currents of the sea between the Canaries and Hispaniola.]

Diagram. A large fold-out engraved world map: the "**Geographico-Hydrographic Table indicating the Motion [of the Sea] throughout the whole World, ☉ [the Sun-symbol] marks [...]**." This is a double-hemisphere ocean-current chart; the leaf shown in this batch is the **left (western) sheet** of the plate, the fold to the right being cut off at the page edge (the right sheet, carrying the Old World and the legend continuation, falls outside this image). The visible sheet is bounded by graduated borders: a horizontal scale of longitude running along top and bottom from **180** through **190, 200, 210 ... 350**, and at the right edge "**Sep: 360**" (top) / "**Meri: 360**" (bottom) — i.e., the meridian count; and a vertical scale of

latitude on the left and right inner frames numbered **90, 80, 70, 60, 50, 40, 30, 20, 10** down to the equator and back to **90**, with "**Occidens**" (West) marked at the left margin near the equator.

The engraving shows the Americas and the surrounding oceans, with hatched current-bands (the parallel engraved lines) sweeping westward across the sea. Sun-symbols (☉) are scattered over the torrid-zone ocean, marking where the Sun draws up water (per the legend convention).

Readable labels (with positions; geographic forms modernized in brackets):

- **AMERICA SEPTENTRIONALIS** (across the upper landmass): North America
- **AMERICA AUSTRALIS** (across the lower-right landmass): South America
- **MARE AUSTRALE** (central ocean, upper portion): the Southern Sea — i.e., the Pacific
- **DEL ZUR** (central ocean, lower portion): *Mar del Sur*, the South Sea (Pacific)
- **MARE DES NORD** (right side, upper ocean): *Mar del Norte*, the North Sea (the Atlantic / Caribbean side)
- **TERRA AUSTRALIS** (across the bottom): the Southern Land (the conjectured southern continent)
- **Nova Guinea** (island, left-center): New Guinea
- **Nova Granata** [recte: Nova Granada] (mainland, right-center): New Granada
- **Nova Hispania** (right-center landmass): New Spain (Mexico)
- **PERU** (right landmass): Peru
- **Brasilia** (far right landmass, partly at the fold): Brazil
- **Magellan[icum]** [?] (lower right, near the southern tip): the Strait of Magellan region
- **sive** ("or" — connective in the sea-name legend, lower-center): linking *Mare Australe* with *Del Zur*
- Several small unlabeled or barely-legible river-mouth and place annotations along the South American coast (e.g., near Peru a short label "**Por[t]...**" [?], and "**Rio...**" [?] annotations) — not resolvable at this resolution.

[The full caption's final clause after "NOTAT" runs off the right edge of this sheet and is not legible here; the companion right sheet of the fold-out is required to read it.]

Diagram. This is the large fold-out engraved world map of the Old World hemisphere (the eastern sheet of Kircher's two-sheet current map), here showing Europe, Africa, and Asia with the ocean currents, abysses (whirlpools/swallow-holes), and fire-belching mountains marked. The plate spans the full opening; is the blank verso of the engraving. The engraved upper-right corner bears the volume/page reference *Tomus I. 124.*

Engraved title banner (top): "OCEANI, CURRENTES, ABYSSOS, MONTES IGNIVOMOS" [The currents, abysses, and fire-belching mountains of the Ocean], with a second line: "HÆC FIG[URA] ABYSSOS [followed by a small engraved volcano vignette] MONTES VULCANIOS" [This figure (shows) the abysses (and) the volcanic mountains]. The little erupting-mountain icon in the banner is the legend-key for the volcano symbol used across the map.

The frame carries a graduated border of longitude (top and bottom, running 10°–180°) and latitude (right margin, 90°–90° through the equator, marked "Oriens" [East] near the equatorial line). Continental labels engraved across the sheet: EUROPA [Europe], ASIA MAJOR [Greater Asia], AFRICA [Africa], OCEANUS ÆTHIOPICUS [the Ethiopic Ocean — i.e. the South Atlantic], and across the southern margin in large scroll letters "[TERRA] INCOGNITA" [the Unknown Land — the conjectured southern continent].

Numerous small point-letters are engraved across the oceans and coasts as keys to the current-and-abyss discussion in the text. The legible labels, with approximate position:

- D (South Atlantic, off SW Africa)
- I (South Atlantic, off SW Africa, near D)
- H (off the southern tip of Africa / Cape region)
- A (interior of southern Africa, "C·A" — part of a continental label)
- G (Indian Ocean, mid-sheet, south of Asia)
- G (a second G further east in the Indian Ocean)
- E (south-central Asia, near the equatorial line)
- S (south-central Asia, near E)
- F (Indian Ocean / Arabian Sea region)
- R (Indian Ocean, off the SE Asian coast)
- M (Indian Ocean, off the SE Asian coast, near R)
- P (eastern Indian Ocean, near the East Indies)
- O (eastern Indian Ocean, near P)
- B (far SE, off the NW promontory of the southern continent)

- C (eastern Indian Ocean, mid-sheet)
- G (a third G, far SE Indian Ocean)
- Z (far east, off the East Indies / "Z" in the right ocean)
- I (far east margin)
- X (NE Asia)
- K (NE Asia, far right)
- Y (NE Asia, right margin)
- V (NE Asia, right margin)
- S (far south, southern-continent coast)
- X (far south, southern-continent coast)
- Q (far south, southern-continent coast, mid-bottom)

Small erupting-volcano vignettes are engraved at numerous points (Iceland/N Atlantic, the Mediterranean — Vesuvius/Etna region, central Africa, NE Asia, and the East Indies), and a dotted line is drawn through the Mediterranean and across to the Persian Gulf / Red Sea region marking a chain of abysses. [Many of the single point-letters sit in densely hatched ocean and are at the resolution floor; positions are given as best read for label verification.]

[The blank verso of the engraving carries no text.]

(...Cabo Blanco) it is poured out by ebb and flow, and from there once again, carried by the general east-to-west motion, it directs its course toward the islands of Cuba and Hispaniola. There, hemmed in and constricted between the narrows, it stirs up violent surgings of the waves. But when it has run on as far as the Gulf of Mexico, and is forbidden to exit there, it wheels its course round toward the shores of Virginia and Florida, and there at last, with the utmost force, is restored to the open Ocean to circulate once more — a motion that, as I said, the general motion of the sea greatly assists. For since the current suffers this violence beneath the torrid zone, and cannot in every quarter break through the agitated sea, it therefore seeks an outlet by a reflected current, and, circulating within the said regions, [returns] to its beginning. But of these matters fuller scope for discussion will be given in what follows.

Caput IV.

On the general motion of the Sea, and its effects around the terrestrial globe.

[Margin: The bottom of the Ocean is uneven, which is a cause of the swiftness or slowness of the sea-flows.]

The reader must first understand this: just as rivers produce different effects on the outermost surface of the land, so too in the sea. For in its tides, currents, sandbanks, and in the sea's swallowing and regurgitation, rivers shut in between mountain walls and made to wind through long detours acquire — as experience teaches — a swifter motion than the rest, and indeed a motion the swifter, the steeper the channels they have. By contrast, where they spread out diffused over broadly open plains and unfold their full breadth, they advance with a motion the slower, the more level their beds. And the bottom of the whole Ocean, no less than the surface of the Earth, is utterly uneven. At one point it is girt with vast chains of mountains and a multitude of crags, and has very deep valleys and gorges; at another it spreads out its waves over the level expanses of immense regions; then again, channelled into hidden and secret chasms, it draws off a mass of water along with itself; and sometimes, regurgitated out of the blind abysses of the Earth, it whips up savage tempests.

These things being so, I cannot but marvel at the ignorance of certain people who say that the sea, as regards its motion, always behaves in the same way, and is not agitated faster in one place than in another. Since this is contrary to experience, I judge it to be rash to assert it — as will shortly be shown by the demonstration of the universal motion of the sea.

[Margin: The motion of the sea, both its flux and its total reflux, sets the whole mass and bulk of the Ocean in motion.]

It is certain that the Ocean is set in motion by a general motion from east to west, by the power of the Sun and Moon. Moreover, it is established from what was brought forward above that the tide — that is, the swelling and subsiding of the Ocean stirred up by the lunar power — moves not merely at the surface, but the whole mass and bulk of the Ocean, from the bottom right up to the surface. And I myself can be an ear-witness to all of this: for while I was investigating the marvels of the Sicilian strait [the Strait of Messina], more than once, at the height of the sea's swelling, I heard a tremendous din. And when I asked the sailors what sort of sound this was, they answered that this sound is always perceived when

the sea is at the highest degree of its tide; and that this sound and crashing noise arises from the collision of the pebbles, shells, and similar things clinging to the bottom, which, agitated by the rapidity of the sea and repeatedly dashed against one another, produce this din.

[Margin: Experience.]

From this I gathered, first, that not only the surface of the sea but the whole mass of water is moved by the lunar power. For if this power makes the shellfish clinging to the very bottom — crustaceans and soft-bodied creatures of every kind — grow at both the new and the full moon, then surely the moving force of the Moon will act with no less power upon the little bodies composed of niter, salt, alum, vitriol, and bitumen, with which the whole sea is filled, than upon other things. For indeed, when the seas are rarefied and thinned by the lunar power, and all the parts at once seek a larger place, and the following parts urge on others, and these still others, violently — that from this a great commotion and swelling of the innermost sea too is born, no one but someone ignorant of these matters could deny. And this is the first point.

The other opinion is that of those who hold that the sea moves no faster along the slopes of the submarine valleys than over the submarine plains — which plainly conflicts with experience.

[Margin: The slope of the sea-bottom is a cause of the rapidity of the currents.]

For since it has now been shown that the whole mass of the Ocean moves together, it is certain that on the slopes of the valleys it rushes with greater force than on level bottoms; and the various perpetual currents of the Ocean, rushing now into this region, now into that, with their speed sweep away with them, even against their will, ships laden with cargo despite a favorable wind. This would not happen unless the said slopes existed in the sea; for by these the bulk of the Ocean, enclosed and constricted and made diverse, drives its course forward just like rivers between mountains, until on the more level places it is restored to repose.

[Margin: Objection.]

But you will say: every day there occur in the Ocean and the seas various and differing currents, which nevertheless do not last but are temporary. Reply: such currents arise not immediately from the lunar power, nor from the disposition of the sea-bottom, but from the winds, which agitate the waters superficially now in this direction, now in that. Hence they are not made perpetual, but when the

wind ceases the sea attains tranquility — whereas the currents (whether the sea [is calm]...

) be tranquil and free from all agitation, nevertheless they always endure. If, therefore, the sea were not moved by these motions we have spoken of — both the general and the special — but always stood still, then it would also be true that the sea always behaves in the same way, whether its bottom be level or sloping. But since the sea is perpetually agitated — now from east to west, now from north to south, and conversely; now within the submarine valleys by its own currents — it is impossible for it to behave always in the same way. But now let us confirm all this by an apodictic and geographical demonstration.

Spread out before you the geographical map, which we have drawn up expressly so that whatever serves our purpose may shine forth from it more clearly than the noonday light. We said in the preceding pages that the general motion of the sea is from east to west; yet I would not have this so understood as if the sea were always borne straight from east to the opposite quarter in a continuous flux, but rather that it is set in motion sometimes by an oblique reflux, sometimes circular, and at times by a motion of flux and reflux according to the configuration of the obstacles it meets.

And so, when the Sun is in the vastest of all the oceans — exerting the power of the luminaries especially, as in the most ample field — the Ocean, struck along the motion of the heavenly bodies, spreads itself far and wide, and most of all through the East Indian Archipelago, swelling and turgid among (as they report) 11,000 islands.

[Margin: Why the tide is so savage in the East Indian Archipelago.]

It has therefore been observed that the sea, in so great a throng of islands, is, as it were, carded [combed] — and on account of the various rebounds and assaults against the islands lying in its path, it stirs up altogether unaccustomed tides. Three places, however, are especially singled out, in which such sportings of the sea are particularly observed. The first is between Japan and China; the second in the strait between Malacca and Sumatra; the third between Java, the Celebes, Borneo, and the Southern Land [Terra Australis].

[Margin: The dreadful tempests between Japan and China, and their cause.]

Between Japan and China the sea, going now from west to east, now turning into a circle, causes such savage tempests that — as the nautical histories relate — ships caught up in it can scarcely extricate themselves. For the force of the sea in

those places is so great that, from the clash of opposing waves, it even lifts the ships themselves up into the air, carried far from the surface of the sea; and especially when a northwesterly wind [ventus Caecias] comes on, it dashes them through the air against the neighboring crags and shatters them into a thousand pieces. On these matters see Father Furnerius [Georges Fournier] in his *Hydrographia*, book 6, chapter 8.

The cause of this is the following. Because the Southern Sea [Mare Australe], driven back with the utmost force against the shores of China, and rebounding from west to east, holds its course for some distance; and with ever-new accumulations of waters K (see the map) pressing upon the sea, when these cannot overcome the rebounding waves, then — along the shores of China X Y V, as pressure builds up against the shores of Japan — the sea must necessarily turn into a circle. And from the other side of Japan, the southern sea coming up with its waves, when they meet the sea circling round from the northern quarter, savage whirlwinds and huge tumults of storms arise there — whence the destruction of ships and men.

Furthermore, as the sea's flux is continued from east to west, when it works its way somewhat more deeply between the Philippine Islands and the shores of Cochin China into the Strait of Malacca, in such narrows, M, it stirs up such unaccustomed tempests and tides as the sailors have often experienced, to the ruin of everything. Nor is it any wonder, since when the sea works its way through the said channel of Cochin China — as through a very deep valley — into the narrows, M, of the strait, there, powerless to sustain so great a mass of waters, it drives part into circles and reverberates part back against the shores of Sumatra. Hence the sea must necessarily counterfeit motions contrary to the general motion.

The same is said to happen between the straits of Java, Borneo, and the Southern Land. For the sea, set in motion from the southern ocean E, both on account of the innumerable encounters and collisions with the islands, takes on an appearance of tides similar to those described above, until — freed from the vexations of the islands — it pursues its free course westward.

[Margin: The currents in the straits of the surrounding islands.]

Therefore, from the mouths of the straits O and P, gliding with the utmost force, the sea first directs its course toward the promontory B of the Southern Land, where it directs its reflected current northward toward the Gulf of Cambodia R,

with such force that — as the nautical itineraries report — the rapidity of a river might be seen and reckoned in it.

[Margin: The immense flux and reflux of the sea on the shores of Cambodia.]

On the Gangetic shore, however, the flux and reflux of this torrent is borne so swift and impetuous that for 30 miles it now covers the shore, now uncovers it, with such speed that scarcely could a horseman at full gallop on the strongest horse escape it.

The cause of this is sought. Reply: when the sea, by means of the current P Q, is driven back against the shore of the Southern Land, Q, its flux is continued for some distance — for example, to C — where the current, encountering once again the supervening currents that rush down from the straits of the surrounding islands, is directed together with them into the farthest edge of the gulf, P. And the cause of the rapidity of the sea in this place I declare to be the steep slope of the submarine valley, through which the sea, rushing with the utmost force, produces on the shore the effects described a little before. But since the sea is found in this place to be so full of whirlpools that the sailors can scarcely overcome them, the cause I declare to be this: that the sea in this place R discharges itself through some passage of a subterranean chasm into the innermost hydrophylacia [water-reservoirs] of the Imaus and Paropanisus mountains, to constitute the sources of springs and rivers. And that this is so, the fact that the depth of the sea in this place can be sounded by no plumb-line sufficiently attests — and it was set out at length in the *Itinerarium*.

Furthermore, when the sea ebbs back from this place with the same force with which it flowed in, it comes about that, leaving its former current to its prior current (being, as it were, contrary to it), partly toward G, and partly through the channel F, set between Ceylon [Zeilanum] and the Cape Comorin promontory [promontorium Camorinum]...

directs its course there with no less force than the currents we described in the straits above. There, finding new encounters with the currents driven back from the Southern Land [Terra Australis] by the Indian sea, it directs part of its flow into the Gulf of Cambay [Sinus Cambaiz], and part toward the Maldiv Islands. [Margin: The currents in the Indian sea described.] Forestalled there by a firm anchorage and by manifold defenses of weapons, it sounds the retreat: seeking safety in flight toward the shores of India, it is swept, as though circling round, into the interior of the Indian Gulf. Here, meeting with the earlier current, it stirs

up equally great floods and ebbs, and the swell rises in that shoreline to five — or, as others say, seven — fathoms [orgyas].

But at one of the mouths of the Indus, the flux and reflux of the sea draws the admiration of all others: so great is the size and the speed of the advancing and retreating sea that many suppose Alexander the Great [Alexander Magnus], once terrified by these prodigious surges, gave up his expedition further on. I think the cause is the same as the one we described in the Gulf of Cambay — namely, the steep declivity of the sea floor, a kind of abyss through which the sea unburdens itself into the interior of the mountains to form lakes and rivers. This submarine valley, I judge, branches in two: on one side toward the mouths of the Indus, where it joins the land valley of that river — for it is too well known to need saying that the Indus runs through the deepest valleys among the sheer crags of the mountains. On the other side, as the map shows, it withdraws from G to E as far as the Persian Gulf [Sinus Persicus], which is also evident from the perpetual flow of the sea into those regions. [Margin: The Persian Gulf described.] We showed at length in the Third Book that the Persian Gulf is filled with abysses and corresponds, through a subterranean channel near the promontory of Loffanda [?], with the Caspian Sea [Mare Caspium].

It is certain that the Indian Ocean, just as it rushes into this sea with violent motion, so too stirs up the most savage and unavoidable storms out of the inconstancy of its waves and the varied circulation of currents driven back now here, now there — to which the almost daily shipwrecks bear ample witness, as both our Fathers and others who have more than once plowed this sea have told me by word of mouth. With one voice they say that this sea ought to be called an abyss rather than a sea, both for its unfathomable depth and, on account of the whirlpools it continually churns, for being filled with subterranean channels. [Margin: The Tigris and Euphrates.] Added to these are the immense rivers Tigris and Euphrates [Tigris et Euphrates], which, joined near Babylon in friendly confluence, cannot but rouse vast commotions when they empty themselves into this gulf near Basra [Bassora] through many mouths at the highest swell of their waters. But of this sea I will say more elsewhere in this work. So let us return to the thread of our undertaking.

[Margin: The currents of the African Ocean.] Next, two new currents are met with in this Indian Ocean. One, rebounding from the Gulf of Cambay [recte: angle of Cambay — "ex Cambaiz angulo"], directs its course toward the shores of Africa, where, like a torrent, it flows part into the Red Sea [Mare Rubrum] and part along the African shores in a continuous stream through the channel set between

Africa and the island of St. Lawrence [Insula S. Laurentii — Madagascar]. Falling, as it were, from a mountain into a deep valley, it stirs up there both surges and storms such as the sailors have at times experienced to their no small loss; for this region, tangled with reefs and shoals [syrtibus], has won itself no slight infamy by the frequency of its shipwrecks — truly the terror of sailors. The other current, rushing out of the Gulf of Cambay toward the Southern Land, is carried with such force that a ship following this current has scarcely been seen to return — a clear sign that there too is a fresh declivity of the sea, carrying the sea off into who knows what subterranean channels of the Southern Land.

[Margin: The Cape of Good Hope.] Further on, at the Cape of Good Hope [Promontorium Bonæ Spei], the former current, joining forces with the latter, raises new storms with the greatest swelling of the surge. Hence, restored to a wider space and spread far and wide into the immense regions of the Western — that is, the African — Ocean, they seem to assail America with a twofold flow: one part of the Ocean running from S to D, and from there checked by the currents of the Boreal Ocean coming up against it, it is deflected into the narrows of the Isthmus and into the most intricate byways of the Gulf of Mexico [Mexicani Sinus]. There it excites those boilings and effects of the waves which we will describe below in the seventh Disquisition. The other part, rushing upon the shores of South America [Americæ Australis] and reflected by the waves of the Ocean coming up from R, is constricted within the narrows of the Strait of Magellan [Magellanicum fretum]. [Margin: The storms in the Strait of Magellan.] There, when the currents from the Southern Ocean meet it and the most stubborn battle is fought over the passage between the two oceans, the water is heaped up into mountainous piles and tossed every which way — were not the Moon, arbiter of the seas, by its decrease and ebb establishing peace and a brief truce between the one sea and the other for a while. See Father José de Acosta [P. Iosephus Acosta], who described the storms and perils of this place most exactly, and asserts in express words that the Ocean rushes in at full force as though from a high mountain into a gorge, as into a narrow valley most tangled with reefs and rocks — and that the same happens in the Southern Sea, when the surge is driven into those narrows by its swelling.

And so the sea, at last struggling free from such straitened passages of the strait, as though triumphing in victory, spread far and wide over the immense Southern Ocean — of a vastness still unexplored — proceeds quietly and peacefully under the common guidance of the general motion, until it is restored to the boundary from which we began this account. Since these things are shown most clearly in the map, I have not thought it necessary to explain them at greater length.

COROLLARY I. [CONSECTARIUM I.]

From this it follows, first, that the surface waters of the sea, unless hindered by the winds, always take their course

from East to West; while in the submarine valleys they are drawn off, according to the configuration of those valleys, now to these shores, now to those. Second, that the course of the sea — both the surface course and the one running within the valleys — is hindered wherever it strikes the shores and promontories of the land regions. Hence, from these points rightly understood, the whole diversity of tides occurring in one region and another depends.

COROLLARY II. [CONSECTARIUM II.]

From these things it also follows that the recounted effects of both the currents and the tides are not everywhere the same in those places, but vary according to the position of the luminaries in the Zodiac. For they undergo certain changes when the Moon is in the tropics, others when it stands at the equinoxes, and still others — the smallest — at the conjunction and opposition of the Light [the Sun], as we shall teach at length in what follows. With these matters settled, let us now turn our pen to explaining the proximate causes of these effects.

SECTION II. [SECTIO II.]

CHAPTER I. [CAPUT I.]

On the second general motion of the sea, composed of two contrary motions, which they call the Tide of the Sea, or Flux and Reflux, also Approach and Recession, or the Swelling and Subsiding of the Sea. [De secundo Motu Maris generali, ex duobus contrariis Motibus composito, & quem Æstum Maris, sive Fluxum & Refluxum, Accessum quoque & Recessum, aut Intumescentiam & Detumescentiam Maris vocant.]

Though nothing is everywhere better known than the tide of the sea [aestus maris], nothing until now has been more unknown — even to the philosophers themselves — than its cause; the many and great monstrosities of opinion that have arisen from it abundantly attest this. [Margin: Various opinions about the flux and reflux of the Ocean.] Some indeed, by a truly laughable fiction, ascribe this motion to the breathing of some land animal — I know not which. Others, with the labor of Sisyphus, devise the daily motion of the Earth about the immovable Sun; certain others, subterranean motions of the Earth; not a few make the Moon a magnet, now attracting, now repelling the sea. Time would fail

me if I wished to recount the follies of all here. Whoever desires more, let him consult the *Meteorology* of Fromondus [Libert Froidmont] and the *Hydrographia* of Fournier, the Coimbrans [Conimbricenses], Cabeo [Niccolò Cabeo], *On Meteors*, book I, Rheita [Anton Maria Schyrleus de Rheita] in his *Oculus*, Enoch and Elijah [?] — where he will find these views refuted at length.

[Margin: The true view of the flux and reflux is established.] Most of the better-regarded philosophers, however, agree on this: that the tide of the sea can come from nowhere else than from the Moon. But even these fence among themselves remarkably with unequal arguments. We, setting aside their opinions, shall set forth our own view on this marvelous motion of the seas — and the more exactly so, the greater the advantages we trust will flow to us from it in the inmost Anatomy of the Terrestrial Globe, and the greater the weight of reasons. And since a tide of this kind is one of those secrets of nature in penetrating which the wisest of men confess themselves to grope blindly, we have resolved to imitate the very jurists, who first agree on the fact before they dispute about the law — since among the Doctors of the Law the law arises only out of the fact itself. In this way, so that the cause of so prodigious an effect may stand the more clearly before us, we must first hold the effect — the thing itself — plainly attested and certain; for to inquire into the cause of a thing by philosophizing, before it is certain to us that the thing truly is so, would be ridiculous, not to say foolish and contrary to reason.

We therefore assert that the principal cause of the marine tide — which we call the influx and outflow [affluxus et defluxus] — is none other than the Moon together with the concurrence of the Sun, without which it would be impossible for the Moon to act; for since the Sun perpetually illuminates the Moon with its rays, it rouses the effective power of the Moon, and so at last the effect we are treating of infallibly follows. [Margin: The Sun and Moon the cause of the flux and reflux of the Ocean.] We say, then, that the Moon is the proximate and efficient cause of this motion, the Sun the remote and dispositive cause; both luminaries together are the adequate cause of all these motions; while the material cause is the Ocean itself, together with the varied configuration of the mountains, shores, regions, and islands that lie in its way. We will speak first of the proximate cause, then of the formal and material cause, and finally of the final cause.

That the Moon is proximately and principally the cause of the marine tide, I show thus. That is properly called the proximate and efficient cause of some effect which flows into the effect through an influence formally defectible in itself, so

that there is a certain essential connection between cause and effect. But that this connection is found between the Moon and the Ocean is too well known to need saying. Therefore — [Margin: A twofold motion of the sea, diurnal and monthly.] To make this evident, it must be noted that a twofold motion of the sea can be considered here: one diurnal, whereby the motion of the sea follows the Moon from East to West, all the way to the place from which it was moved, in the space of about 25 hours. The other is the monthly motion of the sea, in that the sea's outflow and influx follow the Moon's proper motion against the succession of the signs, through an entire lunar month — by which the sea, gradually increasing, reaches its highest rise in the space of about eight days, and twice suffers its decrease over the same number of days. But let us first set out the diurnal motion of the sea.

By irrefragable experience it has become known that each day, at the rising of the Moon, the increase of the sea begins, and after a space of six hours

[Margin: The tide increases for 6 hours and decreases for 6, in opposite quadrants.] is run out, the sea attains its greatest rise; which for the most part happens when the Sun is at the vertical or meridian. When the Moon declines from the meridian, the waters decrease through the same six hours, so that in opposite quadrants the waters always either rise or fall over six hours — as we shall afterward demonstrate to the eye by our instrument. In the monthly motion the tide stands thus. At the time of the new moon the sea swells and boils most of all, up to about the fourth day of the lunar age inclusive; for from the fourth to the seventh the waters begin to decrease noticeably, so that about the eighth day from the new moon they are lowest, up to the eleventh; and from this to the seventeenth they resume their increase; from the seventeenth to the twenty-second they decrease, down to the twenty-fifth; and thence to the time of conjunction they again take up continual increases — this alternating succession of increases and decreases lasting perpetually.

And this is the first argument for the Moon's agreement with the sea. [Margin: An argument from the position of the Moon.] A second argument is drawn from the position of the Moon: for when the Moon is set at the equator [Æquinoctiali], it acts upon the sea with the most powerful influence of all, since it stands at right angles to it — but not so when it is set at the solstices. Thus, just as in the Moon's diurnal motion the sea acquires its greatest increase where the Moon reaches the meridian, so in the monthly motion the sea rightly and deservedly acquires its greatest increase of waters where the Moon arrives at the equator [Margin: Why the sea acquires a greater rise at the equinox], the cause of which will be assigned

afterward. This too is the greatest and most powerful of all when both luminaries, at the time of either conjunction or opposition, stand at the equator. And each of these two motions of the sea, just expounded, in agreement with the Moon, would always behave in the same way, if it were not diverted from its course by external impediments — of which afterward. But let us now proceed to unfold the true and genuine cause.

CHAPTER II. [CAPUT II.]

DISQUISITION I. [DISQUISITIO I.]

By what power or quality the Moon moves the sea. [Quanam virtute aut qualitate Luna mare moveat.]

We said in the preceding that the Moon is the proximate cause of the marine tide, which countless other writers, along with me, assign. The only difficulty, then, seems to consist in this: by what power or quality, precisely, it produces such marvelous effects — which, as no one until now has rightly explained, I have reckoned it my part to demonstrate as clearly as may be.

[Margin: The sympathy of the Moon with the terraqueous globe.] I suppose, then, first: that there is between the Moon and the terraqueous globe a certain wonderful agreement and reciprocal sympathy, arising from a certain likeness and proportion of temperament in the two globes — since it is too well known to need saying that sympathy is born of likeness. For just as there is no substance within the whole range of natural things that does not exercise the quarrels and disputes of agreement and disagreement of sympathy and antipathy with some other, so it is known that the lunar body, beyond the other heavenly bodies, exercises wondrous laws of agreement with the moist part of the terraqueous globe — and this not only in inanimate things, but in vegetable and sensitive substances, and even in the very humors existing in the human body, which are marvelously altered at the increase of the Moon. [Margin: The Moon moves the mass of humors.] Lunatics rage, the gout-ridden are racked more than usual, those prone to catarrh are filled with rheums. Among inanimate things, there are lunar species, such as various stones and minerals; among vegetables, the herbs called "lunar" from the wondrous agreement they have with the Moon; among sensitive creatures, the animals subject to the Moon's dominion experience marvelous

[Note: both this page and the preceding recto carry the page number 129; the running header on the recto verso of this opening repeats. Recorded verbatim — see report.]

vicissitudes of their humors, with which the records of the natural philosophers are so full that I have judged it superfluous to dwell longer on recounting them — that even from this the admirable agreement of the Moon in sublunary things may be plain.

[Margin: The Moon's power that moves the sea is a specific element.] I suppose, second: that this influxive power of the Moon is a specific quality emanating from the whole likeness of the lunar substance — most subtle, and (even when any obstacles whatever are placed in the way) marvelously penetrative. For shellfish on the sea floor amply and abundantly attest the lunar power by their own increase; those prone to catarrh, even shut up within the thickest walls; and certain waters, most tightly enclosed in glass vessels, are so stirred at the increase of the Moon that they seem to boil.

I suppose, third: that the lunar body, by a certain analogy and proportion, consists of the same temperament as our terraqueous globe. But that the latter, together with the whole Ocean, consists for the most part of saline bodies — for example, salt, niter, alum, vitriol, and bituminous springs — is agreed by those who have skill in chemistry, [Margin: All things full of minerals.] who attest that they observe all these things in the distillation of seawater, as in the body from which the origin of all other minerals is observed; since there is scarcely any body in this sublunary world that does not swell with saline, nitrous, vitriolic, and aluminous spirits, with salts both fixed and volatile — and the fixed salts, which remain in the final consummation of the chemical Mastery [Magisterium], abundantly show that all things are full of salt and niter. And that the lunar body is of such a constitution,

[Margin: By what means the Moon moves the sea.] we assert, convinced only by experience. It is likewise agreed that saline bodies are imbued with this power: that, whether on account of the aerial spirits enclosed in them, or their own innate spirits, as soon as the sea is touched by the lunar light endowed with a like power, it presently — by the flatulent quality in which it abounds — rarefies, swells, and marvelously dilates it on every side.

Hence we conclude that the sole cause of the sea's swelling and subsiding is a certain flatulent quality, nitrous or saline by analogy to the body of the Earth, created together with the lunar body from the beginning of things, and so tempered by the warmth of the lunar light that, as soon as it has touched the sea with its rays, it agitates, swells, and dilates it far and wide on account of the likeness of nature and the most proportionate temperament — as something connatural and akin [συγγενές, syngenes, "kindred"] to itself. Hence the nitrous

spirits enclosed in the watery corpuscles, dissolved by the lunar warmth, when they seek a larger space, necessarily push the neighboring waves, and these the others following, and so on in succession, until the Moon arrives at the place near the zenith [vertex], where the water, no longer sustaining its weight, releases in the first quadrant of its ascent the waters it had heaped up. There, in the second quadrant, it is about to accumulate a new increase of waters; whence, for as many hours as in the prior quadrant they had gradually risen through the coming of the flow, for that same number of hours in succession they fall away, until they are restored to their former rest. This specific quality, then, poured out and diffused from the Moon's body, has obtained this gift beyond the other stars: that it alters not only the elemental humor, but especially the nitrous and saline bodies of mixed things — inanimate, vegetable, and sensitive alike — by its nitrous and brackish faculty. But that the matter may stand plainly before the eye, I will here adduce a few experiments, which will so establish our opinion that no one but a senseless person could contradict them.

EXPERIMENT I. [EXPERIMENTUM I.]

[Margin: Saline water and nitrous water is moved by the Moon.] Take a basin, or a rather wide bowl, which you shall fill with nitrous water mixed together with common salt. Then, if you expose this basin in an open place to the Moon's rays on clear nights, you will see with wonder that the water at once begins to boil and to throw up bubbles — and so much the more violently, the nearer the luminaries are, both at the time of opposition and of conjunction,

Diagram. A woodcut showing the apparatus for Experiment I, set out in a perspectival interior. At upper right the Moon (L), drawn with a human face, shines down and casts a fan of rays. A large hinged panel or lid (G) — the open cover of the box — stands at the right, ruled with cross-hatching to suggest a flat board, with a wavy-grained surface. Below and to the left sits the experimental vessel: an oval basin (the large coiled/looped ring shown at center, region B, resting in the box), into which a long graduated rod or measuring scale rises at H, marked with the numerals O (top), 6, 5, 4, 3, 2, 1 descending to the base. The basin/bowl is lettered A at its lower edge, with V marking the rim near the rod. The whole apparatus stands within a box or chamber whose floor and side panels (M, N) are rendered in heavy parallel hatching. The Moon's rays (B region) strike across the open lid into the basin.

- L (upper right): the Moon, drawn with a face, source of the rays
- G (right panel): the open hinged lid/cover of the box

- B (center, between Moon and basin): the field crossed by the Moon's rays / the basin region
- H (left of basin): the graduated measuring rod
- O, 6, 5, 4, 3, 2, 1 (along rod H): scale divisions, O at top down to 1 at the base
- A (lower edge of basin): the basin or bowl of nitrous-saline water
- V (rim near rod): mark on the rim of the vessel
- M (lower-left floor panel): the box floor
- N (lower-right floor panel): the box floor / side panel

which you will not find if the waters lack pure spring water; and although you fill the bowl repeatedly with the same mixture, because they are sufficient in salt and niter, yet — choked by the predominance of the fresh water —

—suppressed, they show no commotion at all. From this it likewise follows that those who are subject to salty, nitrous, and tartareous defluxions feel the power of the Moon above all others — gout sufferers, the arthritic, the moonstruck [lunatici], and the hypochondriac.

We therefore refer the reader to where he will find certain wonderful secrets — much to our purpose — set out, both as to stones and as to plants and animals.

Now that we have explained the lunar quality by which the Moon produces those remarkable effects of ebb and flow in the sea, it is time to demonstrate how the Moon, in pressing upon the sea, accomplishes the said increases and decreases.

Let there be an astronomical horizon, as in the figure. Let X H be the meridian or vertical line. Let the globular surface of the water be T A V O — the quadrants of the Earth A V and O T being the eastern ones (the former nocturnal, the latter diurnal), while the western quadrants are A O and T V. Now let the Moon, at the point X of the index, strike the surface of the terraqueous globe at any hour whatever. I assert that the maritime surface E Q V Y will pass into the oval figure E Q V Y, and consequently that flux will follow in the fixed quadrants of the Earth A V and O T, and reflux in the quadrants V T and A O.

For once the lunar rays are sent down upon the sea-surface Q E Y, the Moon at once — by its saline-nitrous quality, joined with its faculty of thinning and dilating — will swell and extend that surface in every direction during the time of moonlight. Just as when a stone is dropped onto the still surface of water it spreads out in widening circles, so too this pressed surface, seeking a larger place and not finding it, with wave driving on wave, and with the nitrous corpuscles released by the lunar warmth, produces a violent extension and swelling of the

sea toward Y and Q. The sea, then, pressed by the Moon's rays imbued with that nitrous and saline quality, will swell toward the points Q and Y the more violently the more powerful the aspect with which the Moon has struck it.

But once the water has been heaped up at the points Q and Y, of necessity the waters at E will diminish and decrease — because the water, now emptied by its own outflow, has withdrawn into the swellings Q and Y. So too the water drawn together at V will likewise be deficient, opposite to the point E. This is because the water, partly being (through the absence of lunar light) more remote from the Moon's swelling power and so condensed, and partly being drawn off and diminished by the Sun's rays, has returned to its natural state; and thus, just as at the point T, it appears scantier and smaller. And as these two opposite points perpetually follow the Moon's course, so too of necessity the two swellings of the waters around the globular surface of the sea will succeed one another and follow perpetually.

Hence, that the manner of the Moon's stirring up of the sea may appear more exactly, we have marked the terraqueous globe by the innermost circle A O T V, motionless and fixed; but the oval figure E Y V Q, which displays the swellings of the sea, we have set out on a little arm N attached to the Moon X. If you rotate this, you will see, by a kind of ocular demonstration, how in different regions the sea gradually rises and gradually falls in the opposite places. It likewise appears how the swellings of the water Q & Y follow the Moon's motion around the—

EXPERIMENTUM II.

[Margin: A wonderful experiment.]

Make a glass ring A I B V of whatever size, somewhat wider at the opposite places A and B. Then in this wider stretch make a little channel A O, open at the top, as appears in the region marked in the figure. Fill this ring through the hole S with mercury and likewise with sea-water; and once the hole has been tightly closed, set the ring up in a horizontal position, resting on the finest supports, and expose it to the Moon's rays at the time of full moon — in such a way that the middle part I A V is inside a wall or window, while the rest, I B V, lies exposed to the Moon's rays outside the wall or window. You will then see the mercurial liquor, struck by the Moon's rays, move little by little from B toward A, where, finding no exit, it discharges itself through the channel A O, and thus shows in the channel itself the portions of increase and decrease. You will find the same with water extracted from bismuth and from olive shoots cut at the time of full moon. But of these more fully in their proper place.

EXPERIMENTUM III.

[Margin: The hairs of the sea-wolf's hide rise at the tide's increase.]

This experiment Gonzalo Fernández de Oviedo [Gonzalo Fernández de Oviedo y Valdés] writes that he himself performed, and reports that it has very often been observed by others, in his *General History of the Indies* (book 13, chapter 6). If anyone exposes the hide of the sea-wolf — that is, of the seal [phoca] — to the Moon's rays, he will see the hairs of this animal stand up at the increase of the tide, and, what is more, perfectly keep the laws of the flux and reflux of the sea. But that I may not seem to have added anything of my own, I will cite his very words here. For he says, in the passage cited:

"And besides, I will now relate something most worthy of note concerning the sea-wolf (which Pliny [Pliny the Elder] names the seal or sea-calf), and it is thus: the skin of this animal — as well as the belts, straps, and pouches made from it — have this virtue implanted in them, that when the sea is calm and without increase, the hairs of this animal are likewise entirely flat; and when the sea is at its very highest increase, the hairs of this animal also stand straight up again. This is a matter known to me by frequent experiment, and is observed in the said skin on every single day, so that whatever changes the sea undergoes in its flux and reflux, these too the hairy hide of this animal undergoes."

The same is confirmed by Olaus Magnus in book 16 [recte: 6] of his *History of the Northern Peoples*, chapter 6, "On the Sea-Wolf or Seal." Similar examples, in the various eyes of animals which grow and shrink at the increase or decrease of the Moon, are produced by various authors. Since I have treated of all these very fully in Book III of *De Arte Magnetica*, Part V, chapter 4, I refer—

—the reader there, where the reader will find certain wonderful secrets, much to our purpose, set out both in stones and in plants and animals.

—they may follow the terraqueous globe. These things are so clear that they need no further explanation. Yet, for the reader's sake, let us illustrate it by one example and another.

The innermost circle, representing the Earth, is always to remain immobile. In it, if at a given hour you apply the meridian of the sea passing through the Roman clime as the Moon comes beneath the horizon, the index X T, advanced through the following hours, will show that in the quadrant Q E the waters continually rise with respect to the Roman meridian, and likewise in the opposite quadrant V Y; while in the two remaining opposite quadrants E Y and Q V they continually

decrease in those places that the names of the meridians indicate. But after six hours, the water that was in the opposite quadrants will take on its increase for the same number of hours. You see, then, that in the space of 24 hours the waters flow in twice and ebb away twice. And let this suffice as to the diurnal motion of the Moon.

Diagram. A large circle (the terraqueous globe / clock-dial) graduated around its circumference with the hours **1** through **12**, used to demonstrate the diurnal tidal cycle. Two perpendicular diameters divide it into quadrants. The hour-numbers run clockwise around the rim from **12** at the top down through **1, 2, 3, 4, 5, 6** (right side, at the 3-o'clock position) and continue **7, 8, 9, 10, 11** back up to **12**. Interior letter-labels mark the cardinal points of the inner (Earth) circle:

- **X** — at the top (12-o'clock position), the index point where the Moon's meridian-arm is applied.
- **M** — at the right (3-o'clock position), coinciding with the rim's hour **6**.
- **I** — at the left (9-o'clock position), coinciding with the rim's hour **6** [the left "6"].
- **H** — at the bottom (6-o'clock / 12-on-the-inner-scale position).

The two diameters are X–H (vertical) and I–M (horizontal). [The inner hour-counting runs opposite to the outer rim, so that the rim's "12" (X) faces the inner "6," consistent with the text's index X T advancing through successive hours.]

CAPUT III.

DISQUISITIO II.

Why the Sea exerts its power chiefly at the time of New Moon and Full Moon.

[Margin: The inequality of the Moon's motion hinders the tide.]

Irrefutable experience has taught that the sea is agitated with its most powerful motions both when the Moon is in opposition to the Sun or in conjunction with it — but not so when it is set in quadrature. The cause of this is now asked. But before we proceed to the explanation itself, we will first show from various observations of various authors that the matter is indeed so.

Let the reader know, then, that the true motion of the Moon in the Zodiac is exceedingly anomalous, that is, irregular — so much so that here we are forced to assume a mean motion, which nevertheless is not so uniform that the appointed time does not sometimes fall short of it. For the Moon, when set in its perigee, recedes from the Sun much more quickly (as is plain from the *Theorica*) than

when it is in its apogee; and then the highest increase is drawn out longer than six hours and 12 minutes. All of which is to be carefully considered.

[Margin: The inequality of the lunar months.]

To these is added the inequality of the lunar months, some of which exceed 30 days, others are less than 29, and others are middling, namely of—

—that nitrous quality of the Moon — which we said above is the cause of the sea's tide — once roused, beats upon the sea the more efficaciously, the greater the quantity of light it has struck the sea with; for that light is, as it were, a kind of vehicle of the said quality. Since, therefore, the Moon around the full, with the light communicated to it from the Sun, strikes more powerfully with more direct rays, a more vehement motion must necessarily follow from this. Which I demonstrate as follows.

Let Y be the surface of the sea, or of the terraqueous globe; let A B C D be the eccentric oval circle of the Moon — for the Moon describes this figure each month, being placed twice in apogee and twice in perigee, as is plain from the *Theorica*; and although we have not drawn it out here, the reader will be able to imagine it for himself. Now let the Moon, at the time of [its passage through] its body through the lunar phases A O D C F G, etc. — which mark the lunar ages of the 29 days of a single lunar month (here we have set down only the phases, those lines which represent the rays falling upon the surface of the lunar body) — and from these points of the Moon let lines be drawn to the Center of the Earth: A I, S I, T I, V I, etc., which will designate the rays of the Sun (imbued, in the lunar warmth, with the nitrous quality) reflected from the Moon onto the Earth.

These things laid down, I assert that the radiant quality will obtain by its reflection an effect the more powerful, the more closely the reflected rays approach the direct ray (as is plain from the *Catoptrics* [Greek-derived: science of reflection]) — that is, the more nearly the reflection approaches the perpendicular. Since, therefore, the solar rays, the closer they have been to the diametral opposition A B of the Moon, the—

Diagram. [This is the engraved **volvelle** flagged in the catalog, near printed p. 133.] A large rotating disc carrying, on its circumference, a ring of wedge-shaped sectors, each labelled with a *Meridianus* (meridian) of a named region. At the center is a small irregular island/landmass figure (a stylized terrestrial outline). The sector-ring is read as a circle of world meridians; outer letters **A** (top), **B** (right), **C** (bottom), **D** (left) mark the four cardinal divisions. The sector labels, read clockwise from the top (each prefixed "Meridianus,"):

- **A (top):** *Romanus Meridianus per Oceanum* — Roman meridian, through the Ocean.
- *Meridianus Hispaniae & Oceani Aethiopici* — of Spain and the Ethiopic [South Atlantic] Ocean.
- *Meridianus Insularum Caribum [?] per Oceanum* — of the Caribbean Islands, through the Ocean. [label partly cramped]
- *Meridianus Mozambicae per propr[ium]* — of Mozambique.
- *Meridianus Confluentiae per propr[ium]* — of the Confluence.
- *Meridianus Syriae, Sinus Arabicus* — of Syria, the Arabian Gulf.
- *Meridianus Armeniae* — of Armenia.
- **B (right):** *Meridianus Sinus Persici* — of the Persian Gulf.
- *Meridianus Indiae intra Gangem* — of India within the Ganges.
- *Meridianus Indiae extra Gangem* — of India beyond the Ganges.
- *Meridianus Malacae Insulae & Iaphet [?]* — of the island of Malacca.
- *Meridianus Chinae per pro[prium]* — of China.
- *Meridianus Iaponiae per* — of Japan.
- *Meridianus Insulae Salomonis Zur* — of the Solomon Islands (del Sur).
- **C (bottom):** *Meridianus Insulae Latronum Zur* — of the Islands of Thieves (Ladrones / Marianas, del Sur).
- *Meridianus Iohn [?] per mar del Zur* — [Iohn] by the Southern Sea.
- *Meridianus Quivirae per Zur* — of Quivira, by the Southern Sea.
- *Meridianus Totonteac del Zur* — of Totonteac, del Sur.
- **D (left):** *Meridianus Californiae del Zur* — of California, del Sur.
- *Meridianus Mexicanus, p[er] mar Zur* — Mexican meridian, by the Southern Sea.
- *Meridianus Peruv[iae], Fret[um] Magall[anicum]* — of Peru, the Strait of Magellan.
- *Meridianus Brasiliae mar[is] propr[ii]* — of Brazil, of its own sea.
- *Meridianus Insularum Hesperidum* — of the Hesperides Islands (Cape Verde).
- *Meridianus Canariae Insulae Fortunatae* — of the Canary / Fortunate Isles.

Diagram. Below the volvelle, the tidal-mechanism schematic: a radiant **Sun/Moon-face** (a small engraved disc with a human face surrounded by rays) at the top, labelled **X**. From it a straight rod (the "little arm," brachiolum) descends, its midpoint marked **N**, to a large set of concentric **oval rings** (the swollen sea-surface) below. The oval is labelled at four points:

- E — top of the oval (where the rod meets it).
- Q — left of the oval.
- Y — right of the oval.
- V — bottom of the oval.

A small dot/center mark sits at the middle of the oval. To the lower right is a separate small **inset circle** (the terraqueous globe in plan) containing a stylized irregular landmass, with cardinal letters A (top), O (right), V (left), T (bottom) and a cross of two perpendicular diameters A–T and V–O. A manuscript annotation in brown ink at lower right reads "fol. 152" (followed by "tom. primus").

[The verso of this leaf is largely blank apart from the running material and the lower-margin start of Caput III / Disquisitio II, which repeats the same text already given on the facing page; this is the back of the engraved volvelle leaf.]

—Terraqueous Globe they may follow. [duplicate of the p. 132 column-top, on the blank verso of the plate.]

Why the Sea exerts its power chiefly at the time of New Moon and Full Moon.

[Margin: The inequality of the Moon's motion hinders the tide.]

Irrefutable experience has taught that the sea is agitated with its most powerful motions both when the Moon is in opposition to the Sun or in conjunction with it — but not so when it is set in quadrature. The cause of this is asked. But before we proceed to the explanation itself, we will first show from various observations of various authors that the matter is indeed so.

Let the reader know, then, that the true motion of the Moon in the Zodiac is exceedingly anomalous, that is, irregular — so much so that here we are forced to assume a mean motion, which nevertheless is not so uniform that the appointed time does not sometimes fall short of it. For the Moon, when set in its perigee, recedes from the Sun much more quickly (as is plain from the *Theorica*) than when it is in its apogee; and then the highest increase is drawn out longer than six hours and 12 minutes. All of which is to be carefully considered.

[Margin: The inequality of the lunar months.]

To these is added the inequality of the lunar months, some of which exceed 30 [recte: 30; one column-setting prints "20"] days, others are less than 29, and others are middling, namely of—

of 29 days, 12 hours, 44 minutes. In any case, in a matter of physical mathematics no great precision need be sought: whether the new moon or full moon comes half an hour earlier or later, I say, we need not worry, since it is enough for us [to know] that the sea's agitation occurs for some days before and after the conjunction or opposition of the luminaries, but that its greatest swelling and rise happens at the very new moon or full moon. It is the cause of this that we are seeking.

Note, then, that although the Moon is by its own nature of a cold and moist temperament, it nonetheless happens — through the rays shared to it by the Sun — that this very moistness and coldness is so tempered that it is steeped neither in excessive cold nor in excessive heat, but rather in a certain warmth. And from that warmth that nitrous quality of the Moon, which we said above is the cause of the sea's tides, is roused up, and acts upon the sea the more effectively the greater the abundance of light — which is as it were the vehicle of that quality — with which it strikes the sea. Therefore, since the Moon around the full moon, with the light shared to it by the Sun, strikes more powerfully with more direct rays, a more violent motion must necessarily follow from this. This I demonstrate as follows.

Let the surface of the sea, that is, of the terraqueous globe, be the eccentric oval-shaped circle of the Moon ABCD; for the Moon traces out this figure in single months, being twice set in apogee and twice in perigee, as is clear from the lunar theory [*Theoricae*] — which, although we have not drawn it here, the reader can imagine for himself.

Now let the Moon at the time of conjunction be at point A; at the time of opposition at point B; and at the time of the quadrature configuration [quadrature] at points D and C. I say that at points C and D the Moon moves the sea by the least possible degree, but at points A and B by the greatest. Let lines be drawn from the center of the solar body through the phases of the Moon A O D C F G, etc. — which mark the lunar ages of the 29 days of one lunar month. Here we have set down only those phases whose lines render the rays falling upon the surface of the lunar body. And from these points of the Moon let lines be drawn to the center of the Earth: A L, S L, T I, V I, etc., which designate the rays of the Sun — steeped in the lunar warmth and nitrous quality, and reflected from the Moon onto the Earth.

These things being set down, I say that the radiant quality gains a more powerful effect by its reflection the more the reflected rays — as is clear from catoptrics [the science of reflection] — approach the direct line, that is, the more the

reflection draws near to the perpendicular. Therefore, since the solar rays, the nearer they are to the diametral opposition of the Moon A B,

Diagram. A large schematic showing the Moon's eccentric oval orbit traced around the terraqueous globe, with the Sun above and rays drawn from the Sun through the successive lunar phases down to the Earth at center. The Sun (A) is at the top, depicted as a radiant face. The Moon's phases are arranged around an oval ring; rays run from the Sun through each phase and converge on a small central globe (the Earth/terraqeous globe). The figure illustrates how the angle of the reflected rays varies from conjunction (top) to opposition (bottom) and quadrature (sides).

- A (top): the Sun (radiant face)
- *Conjunctio Lunae* (upper center): "Conjunction of the Moon"
- A (upper-center phase): the Moon at conjunction (new moon)
- O (upper-right phase, labeled *3 diebus post* — "3 days after"): lunar phase 3 days after conjunction
- S (right of conjunction phase): intermediate phase point
- D (right side, upper): lunar phase / quadrature region
- T (right side): lunar phase point
- V (right side): lunar phase point
- C (right side, labeled *Quadratum* — "Quadrature"): the Moon at quadrature
- F (right side, lower): lunar phase point
- N (right side, lower): lunar phase point
- M (lower-left of opposition): lunar phase point
- B (bottom center, *Oppositio Lunae* — "Opposition of the Moon"): the Moon at opposition (full moon)
- D (left side, labeled *Quadratum* — "Quadrature"): the Moon at quadrature
- *3 diebus ante* (upper-left phase): "3 days before"
- *3 diebus post* (lower-left): "3 days after"
- *3 diebus ante* (lower-right): "3 days before"
- (center): the small terraqueous globe to which all rays converge

the more they likewise produce a more normal [perpendicular] reflected ray, and therefore a more powerful commotion of the sea must necessarily be brought about by this. For when the sea is struck by direct rays, and when the whole lunar face is turned perpendicularly toward the sea, then the individual projections of the lunar face — that is, of the radiant lunar disc — pregnant with the nitrous quality, will be active; which happens nowhere except at opposition

and at the points near to it. For in the lunar quadratures the solar rays, besides striking the lunar disc at a most oblique position, also strike a Moon that turns only half of its face toward the Earth. Thus, just as the swelling-producing power of the Moon, scattered this way and that by the solar rays into different regions, does not flow whole into the Earth, so too the motion of the sea — falling short because of the inconvenient aspect of the Moon — seems, as it were, to set up a kind of truce with it, remaining motionless. To this is added the further point: that since the Moon at the time of the dichotomy [half-moon] is set in apogee — that is, in the most remote point of its eccentric from the Earth — with its lunar power as it were languishing, it cannot produce the desired effect upon the sea. The Moon, on the contrary, when set in perigee — that is, at the point nearest and closest to the Earth, which is the case at c and f [the half-moon points] — will necessarily, from this nearness, produce by its power a most lively effect upon the sea.

From these things it is clear why the sea at the time of full moon is more turbulent than at other times, and swells more. See what we have written most fully on the nature of the reflected ray in the *Ars Magna Lucis et Umbrae* [Great Art of Light and Shadow], at the end of the first volume.

EXPERIMENT [EXPERIMENTUM]

Let an oblong cylindrical tube A B be made. At its mouth B let fragrant materials be placed,

But let us now examine the second part of the difficulty: namely, how — at the time of the new moon, when the Moon, turned entirely away from the Earth with its whole face, neither looks upon the terraqueous globe nor can share any light with it — it can nonetheless produce the effect of so great a commotion in the sea. Note, then, that just as the Sun at the time of the Moon's conjunction is nearer [to the Moon], so, with its rays sent straight onto the lunar face, it is wholly steeped in that lunar swelling-producing quality of the sea which the body of the Moon perpetually exhales — no differently than solar radiation passing through colored glass, falling upon objects in its path, and so, with the whole intervening space, conveys that color which the glass has, and steeps the walls with red if the glass was red, with green if green, with crimson if crimson. So, I say, the solar rays at the time of conjunction, striking the Moon immediately set beneath them, are steeped in the same quality with which the Moon is affected. For since at this point of the syzygy [conjunction] — that is, of the interlunium [new moon] — the face of the Moon is turned directly toward the Sun, and at no other place of its eccentric is it nearer to the Sun, surely there must then occur both a great

intensification of the lunar light and a great stirring-up of the nitrous quality; and as soon as the solar rays touch this quality, diffused everywhere, they are tinged with the Moon's native vigor and as it were impregnated, and so, made fertile by the intermediate power of the diffused quality, when they fall upon the surface of the sea, they — as certain deputies [vicars] of the Moon — produce in the terraqueous globe the same effect that the Moon does, and indeed with multiplied interest. And this I show by experiment.

Diagram. A woodcut showing the experimental apparatus described in the text: an oblong cylindrical tube angled toward a radiant Sun (depicted as a face) at the upper right, with the mouth B (decorated, holding the fragrant material) facing the Sun and the other end A directed downward into a room. The tube is ornamented along its length.

- A (lower end of tube): the end directed into the chamber
- B (upper mouth of tube, decorated): the mouth holding the fragrant materials, turned toward the Sun
- (upper right): the Sun, radiant face

not packed densely, but as loosely compacted as can be done. Direct this tube inside some chamber, so that the mouth filled with fragrant materials

is turned directly toward the Sun, while the other end A points into the said chamber. You will find that, as soon as the tube has been set directly opposite the Sun, the rays of the Sun passing through the fragrant material B will excite a most pleasant odor in the chamber — a rosy one if of roses, a lily-scent if of lilies, a violet-scent if of violets — which does not happen when the Sun is not illuminating the fragrant material. For the Sun by its heat excites the power lying hidden in the flowers, and its ray, as it were tinged and strained through with the fragrant quality, in this way draws that quality out beyond the mouth of the tube and into the chamber. From this experiment it is clear how the Sun, at the time of the interlunium [new moon], tinged with the sea's swelling-producing quality, and as it were strained through the lunar effluvium, is steeped in the said quality.

And since the whole lunar body is steeped in the said power, it follows that the darker part of the Moon — the part averted from the Sun, which faces the Earth — when it is somehow excited and rarefied by the surrounding solar rays, being joined to the rest of the outflow, must necessarily redouble the effect to some extent. And this I would judge to be the cause why the sea is so greatly stirred up when the Sun is conjoined with the Moon.

Let the Sun be A, the body of the Moon B, and the atmosphere of the lunar quality c c c diffused all around. You see, then, that the luminous outflow of the Sun, strained, sifted, and carded through the atmosphere of the lunar power C, is tinged with an abundant offspring; and that the conceived tincture D is at length drawn down into the sea by means of the luminous radiant outflow as its vehicle. From which it must necessarily be most powerfully stirred up for three reasons. First, because the Sun, steeped in the lunar quality, operates more strongly and effectively than the Moon itself. Second, because the Sun is more penetrating, and strikes the sea with its rays more sharply than the Moon does. Third, because the solar rays steeped in this quality graze a larger portion of the globular sea's surface than the lunar rays do, as is clear from the lunar theory [*Theoricae*]; and consequently, just as they raise a larger mass of waters, so too they bring about a more effective motion. To this is added the fact that, when the Sun's ray reflected from the Moon strikes the sea at the time of new moon, the action becomes most effective of all in the perpendicular [normal] direction. But when the Moon is set at the remaining points, the solar rays are always more or less

Diagram. A large schematic showing the Sun (A) at the top, the body of the Moon (B) below it surrounded by its radiant atmosphere of the lunar quality (c c c), and the Earth (*Terra*) at the bottom. The Sun's luminous outflow forms a broad pear-shaped (teardrop) cone of rays descending past the Moon and converging on the Earth; the tincture imparted by passing through the lunar atmosphere is marked D. Lateral points x (left) and H (right) flank the Earth on the horizontal; points M, F, N are at the base beneath the Earth.

- A (top): the Sun (radiant face)
- B (upper-middle): the body of the Moon, surrounded by its radiant atmosphere
- C C C (around B): the atmosphere of the lunar quality, diffused all around
- D (below the Moon): the conceived tincture carried in the radiant outflow
- Terra (center): the Earth (terraqueous globe, showing a map)
- X (left, on the horizontal): lateral point flanking the Earth
- H (right, on the horizontal): lateral point flanking the Earth
- M (base, left): point beneath the Earth
- F (base, center): point beneath the Earth
- N (base, right): point beneath the Earth

steeped [in that quality]; the result is that the sea, struck by the solar rays acting as deputies of the Moon, takes on the greater increase the nearer the Moon is to

point A, and takes on the greater decrease the nearer it is to points x and H. For at these points, because of the most oblique position of all, the terraqueous globe partakes least of all in the lunar power, for the reasons hinted at above.

The Sun begins to be tinged [with the lunar quality] three days before the conjunction, at point L, from which the sea also begins to grow, up to the point of conjunction B, where the increase is greatest; and from there it gradually decreases over three further days, until the Sun, set at point R outside the rays of the lunar outflow, restores its deputy service to the Moon. The Moon then, just as it thereafter strikes the sea with a feeble light, so too stirs it up least of all, until, emerging gradually from quadrature, it produces day by day a greater and greater increase, in proportion to the magnitude of the light with which it strikes the sea.

COROLLARY [COROLLARIUM]

From this it is clear that for three or four days nearly before the new moon the sea is agitated only by solar light — though tinged with the lunar power — but that for the same number of days before or after the full moon the Moon stirs up the sea immediately by its own proper power, so much more powerfully the nearer it is to the point of opposition B. On the remaining days, before or after quadrature, the sea seems as it were to rest, because of the slenderness of the communicated lunar power. In this way the Moon, having advanced from H [along the path] M N to point V, acquires its forces three days before opposition, [forces that grow] greater up to the point of opposition T, where it presses most strongly; and from this point, gradually diminished in vigor, up to point S, three days after opposition, it there begins to fail, up to point X, where it has the least vigor in stirring up the waters.

CAPUT IV.

DISQUISITIO III.

Why the Sea does not always flow or ebb every six hours in different parts of the World, and whence so irregular motions of the Sea arise.

[Cur Mare non semper sex horis fluat aut refluat in diversis Orbis Terrae partibus, & unde tam irregulares Maris motus proveniant.]

SUPPOSITIONS [SUPPOSITIONES]

Drawn from observations. [Ex observationibus factae.]

I suppose, First: If the whole terrestrial globe were covered with water — as in the universal Deluge [Cataclysm] — then no flux or reflux caused by the Moon's power would appear; rather, the whole fluctuation of the sea would, without doubt, be ascribed to the blasts of the winds driving the sea into this or that region,

with an ever constant and invariable law of order, [following] the Moon's power moved from East to West. And the reason is plain: because the ratio of the flux and reflux is not perceived on the high sea, but only on the shores, where alone the approach and recession of the sea is noted.

I suppose, Second: If there existed only a single island in the Ocean, set under the equinoctial line — for example, the island of São Tomé [*Insula S. Thomae*] — I say that the flux and reflux of the sea toward an island of this kind will behave [as follows]; and if there should be any diversity of motion, it should rather be attributed to the winds than to the Moon,

Diagram. A schematic world-band figure showing a single island set on the equinoctial line, with the Moon depicted in its various positions (as small globes bearing zodiac signs) around the left and right margins, casting rays (solid and dashed) toward labeled points on the island's coast. The horizontal center line is labeled *aequinocialis* (the equinoctial); the top and bottom horizontal lines are each labeled *Tropicus* (Tropic). The left vertical edge is labeled *Meridianus* (meridian); the right vertical edge is labeled *Luna ascendens* (the ascending Moon). The island in the center shows mountains and trees.

- *Tropicus* (top line): the Tropic
- *Tropicus* (bottom line): the Tropic
- *aequi. Anoctialis* [*aequinocialis*] (center line): the equinoctial line
- *Meridianus* (left vertical edge): the meridian
- *Luna ascendens* (right vertical edge): the ascending Moon
- O (far left, upper, with ♑ Capricorn sign): the Moon position
- (far left, middle): the Moon position
- N (far left, lower, with ♋ Cancer sign): the Moon position
- L (far right, upper, with ♑ Capricorn sign): the Moon position
- X (far right, middle): the Moon position
- (far right, lower, with ♋ Cancer sign): the Moon position
- G (island coast, upper left): coastal point
- B (island coast, upper): coastal point
- C (island coast): coastal point

- D (island coast, center): coastal point
- E (island coast): coastal point
- F (island coast, lower): coastal point
- Y (island coast, upper right): coastal point
- Z (island coast, center right, on equinoctial): coastal point

Diagram. A large fold-out double-page engraved map of the Americas, oriented with north at the top, showing the directions of tidal flux and reflux along the American coasts. The map occupies two facing plate-halves: carries the Pacific (western) half and the cartouche; carries the Atlantic (eastern) half and bears the plate/volume number at upper right, *Tomus I. 144*. The two halves join along the central meridian to form one continuous map. Engraved hatching across both oceans renders the tidal current-lines that are the subject of the figure.

Decorative scrollwork cartouche at lower left (on the Pacific half) carries the engraved title:

Mappa fluxus et refluxus rationes in Isthmo Americano in freto Magellanico, ceterisque Americae litoribus exhibens.

[A map exhibiting the patterns of flux and reflux at the American Isthmus, in the Strait of Magellan, and along the rest of the American coasts.] ("refluxus" so spelled in the engraving, for *refluxus*.)

Readable engraved labels, with positions and translations:

- Top center-left (p. 198): AMERICA SEPTEN- / TRIONALIS — North America (the legend split across two banner lines).
- Upper left (p. 198): California — California (here the peninsula/gulf region).
- Upper center (p. 198): Mexico — Mexico.
- Center-right (p. 198): Sinus Mexicanus — the Gulf of Mexico.
- Center-right (p. 198): Cuba — Cuba.
- Center (p. 198): Nova Granata — New Granada (Spanish colonial Nueva Granada, NW South America).
- Right edge (p. 198): Peru — Peru.
- Right edge, lower (p. 198): Chili — Chile.
- Right edge near several coastal points: FR (repeated) — abbreviation marking points of *fluxus*/reflux (flux) along the coast.
- Center (p. 198): large decorative ocean legend MAR DES ZUR — the South Sea (Spanish/Dutch "Mar del Sur," the Pacific).

- Center-left mid-page (p. 198): Circulus beside a horizontal rule — a circle/parallel line (the engraved boundary, here a latitude circle; cf. the equinoctial labelled on the facing half).
- Lower right corner (p. 198): Terra del Fuego — Tierra del Fuego.
- Coastal point near the Isthmus (p. 198, right): Thomas Segá [?] / Panama [?] — labels in the Isthmus-of-Panama region, partly cut at the plate join and hard to resolve [?].
- Top center (p. 199): large decorative ocean legend MAR DES NORD — the North Sea (Spanish/Dutch "Mar del Norte," the Atlantic).
- Upper left (p. 199): Hispaniola — Hispaniola.
- Left (p. 199): Nova Spagna — New Spain.
- Left-center (p. 199): Lacus — a lake.
- Left-center (p. 199): Rio de las Amazonas — the Amazon River.
- Center (p. 199): BRASILIA — Brazil.
- Center, large decorative legend down the body of the continent (p. 199): AMERICA AUSTRALIS — South America.
- Center (p. 199): Paraquay — Paraguay.
- Lower center (p. 199): R. dla Plata / Rio de la Plata — the Río de la Plata.
- Right of center, along the central join (p. 199): Aequinoctialis — the equinoctial (the equator line), running horizontally across the map.
- Several coastal points (p. 199): FR (repeated) — flux markers, as on the Pacific half.
- Lower right and along both coasts: small letters c and d at points on the current-lines — keyed reference letters for the tidal-flow construction (correspond to the lettered points discussed in the surrounding text); a few are faint at this resolution [?].
- Three ships under sail are engraved in the open ocean (one in the Pacific, two in the Atlantic) as decorative staffage.

[The facing leaves are otherwise blank: (the verso preceding the plate) and (the verso following it) carry no text, only show-through from the engraving.]

[This continues the text of **Liber III "Hydrographicus," Sectio II, Caput IV, Disquisitio III** — on the irregularity of tides worldwide. The opening of the page is the conclusion of a sentence begun on the previous page.]

would have to be attributed to the winds, which at one moment hold back the inflow or outflow of the sea, and at another tear it off into one region or another.

Let an island A be situated under the equator, alone in the universe; and let the Moon be in Aries [♈] or in Libra [♎], normally pressing down the surface of the sea beneath it. That surface, heaped up everywhere into swells, spreads out — exactly as a stone thrown into some pool drives out ever-larger and larger diffusions of waves all the way to the shores B, C, D, E, F — and the water, striking shore D head-on, would show an increase over six hours. Striking shores C and E obliquely, it would make the same increase there over the same number of hours; but at the concave shores B and F, striking most obliquely, it would make circular reflections. In the same way the Moon, set in the tropics O and N, would cause one impact of the water after another at the shores, along the lines O G, O C, O D, O E, O F, which mark the course of the waves. Likewise, with the Sun set in tropic N F, at the said shores E, F, D, C, B it would produce one impact after another. This must be understood of all the parallels of the torrid zone individually, in whichever the Moon happens to be at a given time. Again, with the Moon set at point X, the intervening sea, driven against the shores Y, Z, Q opposite the former ones, would there show a fresh increase, while in the opposite quarter it would work a decrease — and this always over the space of six hours, by a constant and unchangeable law of nature, unless it were hindered by the blowing of the winds, as I have said. For if the north wind [Boreas] blows, the currents of the sea stirred up by the Moon would be driven off toward the south; and conversely, with the south wind [Auster] blowing, toward the north. With the Moon set at L and S toward the shores Y, Z, Q, it will prepare new surges of rising water, and in whatever proportion the sea rises here, by the same it will fall at the opposite shores. You see, then, in this figure, that the waters spread themselves out to the pressure of the Moon — according to the wind-points [Rhombi] arranged on the magnetic compass, and according to the bearing they have toward the shores — and the figure set here demonstrates this clearly.

[The figure referred to here is the equatorial-island diagram described on the previous page; no new figure appears on p. 137.]

Fourth. From the winds, which at no time fail to drive the sea by their gusts, now into this quarter, now into that.

[Margin: A constant tide, since the cause of the tide is similar of itself.]

CONSECTARIUM II.

The quantity of flux and reflux is, of itself and by its own nature, inconstant in any given place, and different on different days, and on that account greater or less according as the Moon stands farther from, or nearer to, that place. For since

the Moon changes its position in the zodiac every day, and so on different days becomes vertical at different places, it is consequently farther from any given place, or nearer to it.

This established, we conclude that on different days, in the same place, the quantity of flux and reflux is different — whether that quantity be perceptible or imperceptible. Therefore, the fact that the ratio of flux and reflux is so unequal at different shores is to be ascribed not so much to the Moon — which never stands fixed at a certain place — as to the differing proximity of continents, as we shall show later.

[Margin: Why the ratio of the tide is unequal at different shores: because the Moon is never fixed at a definite place.]

For it has been observed, by the irrefutable experience of all those who dwell along the shores of the Ocean or of the other seas: **First**, that the greatest swelling of the sea first occurs when the Moon occupies the highest or lowest point of the meridian of that place; but in many other places the swelling has been observed to occur at another position of the Moon.

Second. It has been observed that at most shores the sea flows in for six hours and twelve minutes, and ebbs over the same number of hours; in some places, however, it flows in over more hours and ebbs over fewer, as will be said later — yet in such a way that the time of flux and reflux together, that is, from one maximum swelling to the next, makes up twelve hours and twenty-four minutes, or, as others would have it, nearly twenty-five hours. And so the swelling of the sea occurs each day nearly a full hour later, because the Moon returns to the same meridian or vertical nearly a full hour — that is, 48 minutes — later each day.

[Margin: The excess of the flux and ebb each day amounts to nearly 24 minutes.]

Third. It has been observed that in some places the inflow is very great and very violent; in some, very small; in certain places none at all, or scarcely perceptible. The reason for all these variations is therefore sought. So that it may be set forth as clearly as possible, we have decided to attach these hydrographic figures here, so that through them, as in an archetype, the explanation of each of the observations adduced so far may appear more clearly.

[Margin: The cause of the sea's tide.]

CONSECTARIUM I.

[Margin: The flux and reflux of the sea is always similar of itself.]

From these things it is plain that the inflow and outflow of the Ocean is, of itself and by its own nature, always similar, but is hindered and retarded by various causes: **first**, by the differing and varied configuration of continents, promontories, islands lying in the way, and gulfs; **secondly**, by the differing disposition of the Ocean floor, whose unevenness is so great that the sea is stirred up by it in differing ways; **thirdly**, by the underground passages — partly the huge masses of water that they discharge (like rivers) not only from the bottom but also from the underwater sides, and partly the violent eruption of underground spirits, by which the general motion of the sea is hindered in a remarkable way.

[Margin: The cause of the sea's tide, of itself and by its own nature.]

QUAESTIO I.

Why in some places the greatest swelling of the sea occurs when the Moon is at the meridian, while in certain other places it occurs when the Moon holds the middle position between the cardinal points.

I answer. In all those places of the Ocean where no impediment inter-

—venes, it has been observed that the flux lasts six hours and the reflux the same number of hours while the Moon holds the meridian — as happens in the Strait of Magellan; in the channel lying between Africa and the island of St. Lawrence [Madagascar]; in the Strait of Manila, Java, and Malacca. For in these places the sea, as if combed out, holds its motion straight and steadily toward the West, as is plain from the map — provided it is not hindered or disturbed by the winds and currents of the sea, of which more will be said later, as commonly happens; and on this point no one disputes.

The crux of the difficulty turns on this: why in some places the greatest swelling of the sea occurs *before* the Moon reaches the meridian — that is, at the time of new moon or full moon — and then the sea takes on its greatest strength and increase when the Moon has stood in the south-westerly [Auster–Zephyrus] or east-northerly [Eurus–Boreas] quarter. At London, for instance, the sea shows itself most anomalous; for the water is then highest when the Moon reaches the quarter B or A.

[Margin: The tide at London varies.]

Diagram. A simple circle, divided by a vertical and a horizontal diameter into four quadrants, representing a compass / wind-rose with the four cardinal winds named at the rim. Two points marked A and B lie off the axes within the rim.

- Top (rim): Auster (south wind)
- Bottom (rim): Boreas (north wind)
- Left (rim): Eurus (east/south-east wind)
- Right (rim): Zephyrus (west wind)
- A: upper-right quadrant, on the rim (the south-westerly position, "plaga Austro-Zephyrea")
- B: lower-left quadrant, on the rim (the east-northerly position, "plaga Euro-borea")

[In China, in the port of the city of Macao, as Fr. Martino Martini [Martino Martini] reports in his *Atlas* [*Novus Atlas Sinensis*], the water obtains its increase at different times under a different position of the Moon.] Around the twentieth day of September, at new moon, it takes its greatest increase about an hour and three-quarters before noon, the Moon being still three hours distant from the meridian. On the third day of February, the third day after new moon, the greatest inflow of the sea occurs after twelve o'clock; from which it is gathered that on the first day of February the highest, or greatest, inflow of the water was after ten o'clock by forty minutes. Then on 16 February, on the very day of full moon, the greatest increase of the sea was observed to be nearly about noon. On the second of June, the fourth day after new moon, the greatest height of the sea was likewise nearly about twelve o'clock; from which it is gathered that on the first day of the new moon the highest increase was about three hours before noon. He adds the observation that the times and hours of greatest height and of the ebb of the water do not agree with those hours computed from the Moon's motion, except for five days before and after the new moon; the inflow, however, in this region lasts for the most part only nine hours, the outflow only three — so that, as said, the times of flux and reflux taken together always make up about twelve hours and twenty-four minutes, as we said above.

[Margin: In China the tide is anomalous.]

[Margin: The excess of the flux and ebb in a uniform tide; the increase, then the decrease, together exactly equal the whole tide of twelve hours and twenty-four minutes.]

But that we may philosophize more clearly about the diversity of the individual motions, the observations must first be adduced.

In Belgium, France, England, and Holland, the sea at the shores of these said regions, at the time of new moon and full moon, has been observed by perpetual experience to behave as follows.

Observations of the Tide of the Sea in Belgium, England, France, and Holland, collected from various sources.

[Margin: Observations of the tide in Belgium.]

Time (after 12, full moon or new moon)	Location
At 12 o'clock at full or new moon	The sea begins to swell to its highest at the shores of Flanders, Enkhuizen [Enchusa] in Holland; in Friesland, Zeeland; Dover [Dorobernia] in England.
45 minutes after twelve	Flushing [Vlissingen] in Zeeland.
At 1½ after twelve	On the western side of the Isle of Wight; Calais; at the mouth of the river Thames [Tamesis] in England; at the shores of Zeeland at the mouths of the Scheldt [Scaldis].
At 2¼ after 12	Before the mouths of the Scheldt and the Meuse [Mosa].
At 3 after 12	Amsterdam, Rotterdam, Dordrecht, Newcastle [Novum Castrum] in England, before the Sandbanks [Pulvini] of Flanders, at the mouth of the Garonne [Garumna] on the shores of Brittany, France, and Spain; on the western shore of Ireland up to Holland.
At 3¾ after 12	Rouen [Rhotomagum] in France, at La Chapelle [Cupella], on the river Garonne, and at the rest of the limits of the Spanish, Portuguese [Lusitanic], and Galician shore.
At 4½ after 12	From Texel [Texelia] to the southern shores of Ireland.

Time (after 12, full moon or new moon)	Location
At 5½ after 12	In all parts of the southern shore of Ireland [Hibernia], and at Plymouth in England.
At 6 after 12	Before Hamburg on the Elbe [Albis]; in the Channel between England and Brabant.
At 6¾ after 12	Between Bavick and Walcheren [Vaelmuya].
At 7½ after 12	At the ship-station ([Dutch: op de reede, "in the roadstead"]) at Texel, off Kildwin [Kilduina].
At 8¼ after 12	Near the Isle of Wight, as far as Beachy [Bevesier].
At 9 after 12	Before the mouths of the river Ems [Amisis] in Friesland, and at all its shores.
At 10½ after 12	Before the mouths of the river Thames in England, at the shores of Normandy and Picardy.
At 11¼	In the river Thames, and other places in England.

Observations made by sailors in the Western Ocean concerning the tide of the sea, at new moons.

Location	Hours (after midnight)
In the Strait of Gibraltar [Fretum Gaditanum], at new moon, the water is full after midnight by	1¼
At the same time, in the port of Calais [Calessi], and in that whole maritime tract from Tarifa and Sanlúcar [S. Luca].	—
From the Cape of La Roche [Promontorium Rutae] up to Cape St. Mary [Caput S. Mariae], the sea is full	2¼

Location	Hours (after midnight)
after midnight	

Location	Hours
From Cape St. Mary up to Cape St. Vincent [Caput S. Vincentii], and from there up to Cape Finisterre [Caput Finis Terrae], and from there along the shores of Biscay and France in some places — except the mouth of the Garonne and certain other places, which they call <i>Boglienas</i> and <i>la Ollona</i> — the sea is full after midnight.	3
At the said excepted places, however, it is full after midnight.	2¼
On the shores of France at Pontaven [Pondavid], Coradum, Blancabum, and the one they call Furnum [Le Four].	3¾
From Le Four [Forno] up to the island of Houat [Hebas], the sea is full.	4½
From the island of Houat, and those they call <i>Caschettas</i> , up to Carnesul at the shore.	5¼
On the mainland of France that faces the said islands.	6¾
In Normandy and Picardy, Calais, Newport [Neoporti].	9
In the middle of the Channel, between France and England.	12
From Calais up to Newport, in the sea 13 miles distant from the shore.	2¼
From Calais up to Gravelines [Gravelinga], in the sea distant from the shore.	1½
From Gravelines, along the whole shore of Flanders and Zeeland.	3
And in the sea distant from the shores.	3¾

Why such great diversity occurs at the places cited above, and why the sea's commotion does not happen uniformly — for this, several partial reasons or causes concur.

[Margin: The causes of the variety of the tide.]

The first and root cause is the general motion of the sea, stirred up by the Moon, which is set in one or another of the zodiac's twelve signs [Dodecamoria]. The second reason is the differing arrival and recoil of the Ocean against the shores of America, from which manifold reflection toward shores of disparate

configuration there arises the greatest diversity of the sea, both as to time and as to its increase. The third is the differing disposition of the sea floor; for let no one imagine it everywhere equal — but, as we showed in the *Iter Exstaticum Submarinum* [*Subterranean Ecstatic Journey*], it is of most disparate condition.

[Margin: The sea floor is unequal, just as the earth's surface is.]

For just as on the terrestrial globe huge mountain peaks rise up everywhere, and the deepest valleys, distinguished into one valley after another, are drawn out over the longest stretches into countless regions; and rivers, unrolled from the mountains and swelled by countless others, wind in sinuous coils through the immense windings of the lands — I would have you persuade yourself that the same thing happens within the sea. In it you may suppose that islands, with their lofty summits, are very high mountains — indeed, mountains rooted in the sea floor; and you may know that the spaces of sea between island and island, and the narrows of the submarine straits, are the deepest valleys; nor should you suppose that submarine rivers are lacking, by which the general flux, whether direct or reflected, is from time to time hindered in a remarkable way.

[Margin: The sea floor is roughened with mountains and valleys.]

Again, just as experience teaches that rivers constricted between mountains are always swifter than those which flow into the sea with a slow pace in level places — they are rolled along and move more swiftly amid the narrows of both mountains and plains — so rivers move more swiftly in the middle than at the banks, unless the bed and current of the river, weighed down by a great mass of water, rush against the land — which cannot happen without the eating-away and corrosion of the shores it meets. The same happens on the sea floor. For when the whole watery mass of the Ocean is stirred by the power of the Moon all the way to the bottom, and at the bottom there occur everywhere countless immense ridges [literally "combs"] of rocks and the deepest valleys stretched out far and wide into submarine regions — hence this mass of water, towering above such valleys or depths, is stirred by the power of the Moon in the general motion of the sea from East to West. But the waters enclosed amid the hollows of the highest mountains, islands, and shores follow the impulse along the run of the valleys, and these we call natural currents.

[Margin: The motion of the sea follows the hollows of the submarine valleys.]

For when these currents strike the obstacle of land — of mountains and islands — then, behold, repelled, they harass the shores with their assaults: the water now into opposite quarters, now into oblique directions, now by a kind of *pericyclosis*,

that is, by one circulation after another, as we demonstrated above. And since these things do not happen at the same time, but earlier or later according to the varied concourse of the sea's waves — now direct, now reflected in this and that direction by currents and by the stretches of the shores — it is certainly plain even from what has been said that the general tide of the sea does not occur at the same time in those places.

There is the further fact that these currents change and vary in various ways according to the varied position of the Moon in the zodiac. For with the Moon set in the southern tropic [Capricorn ♐] and far distant from our zenith, it stirs the sea in one way; differently when in the equinoctial; differently in the tropic nearer to us [Cancer ♋]; differently when joined to the Sun; differently when opposite it; differently again when set in the quadratures.

[Margin: The sea varies its tide according to the varied position of the Moon.]

The fourth reason is the diversity of the winds, which most of all dominate the surface of the sea; by these the currents of the sea, whether direct or reflected, are very much either retarded or stirred up more swiftly.

[Margin: The winds hinder the tide.]

The fifth reason is the discharge of huge rivers into the Ocean, where, from the continual conflict of the waves, the natural tide of the sea is wonderfully hindered, and the force of the river is overcome only at last by the immense weight of the in-rushing Ocean. And so the inflow occurs more slowly, the outflow more quickly — as may be seen at the mouth of the Gallic river Garonne, and in the African river they call the Senegal [Senega], as will be taught later.

[Margin: The discharge of rivers into the sea hinders the tide of the sea.]

The sixth reason. Since the sea floor, as we showed in the cited *Iter Exstaticum Submarinum*, is bored through by countless channels, it happens that from the underground estuaries at no time fail to be breathed out huge exhalations, by which the sea is rendered swollen in a remarkable way, and by these the general motion of the sea is not a little disturbed.

[Margin: Submarine winds hinder the tide.]

And from this clustering-together of causes...

all the effects of the heteroclite, surging sea are dissolved; in producing which, now one cause, now several, and then all together concur. But order now

requires that we resolve some of the proposed cases by means of the premises set out above.

CAPUT V.

DISQUISITIO IV.

Why at London, in the river Thames, the greatest swelling of the sea then occurs when the Moon has been set in the south-westerly [Auster-Zephyrus] quadrant; whereas, with the Moon set in the northern signs and in the east-northerly [Euro-borea] quarter, the greatest swelling does not then occur — namely three hours before it reaches the meridian of London.

I say, then. When the Moon, set in the southern signs, has reached the German Ocean [North Sea], being too remote to touch it with its rays — hence it comes about that it accomplishes by roundabout ways what it cannot do by direct or oblique rays. For as soon as the Moon reaches the meridian of London, then at the same time the sea at London in the Thames begins to rise. This beginning of the increase, however, does not come immediately from the lunar power by which the German Sea is pressed, but through a certain reverberation of the Ocean made from the shores, as follows. For with the Moon set as it passes through the meridian over London, while by its own proper power it normally presses down the Indian Ocean subject to it, this Ocean — pressed and gradually swelling, and spread far and wide through the Aethiopic Ocean — when it finds no exit at the shores of North America, is soon repelled from there and opens itself an approach into the German Ocean by a double route: first, from West to East through the sea set between England and France; second, circling through the Northern Ocean around Scotland, where, driven against and repelled from the shores of Norway, it more violently insinuates itself into the German Sea. Meanwhile the earlier part of the Ocean, rushing in through the English or British Sea and the Ictian narrows [Strait of Dover], when it is repelled by the shores C and H lying in its way, and is forced impetuously into the German Sea D — when at V it meets the current X Y, as if it were powerless and insufficient to resist it — drives it partly into the neighboring shores of England, partly into the shores of Flanders and Denmark, and most of all into the opposing mouth X of the Thames. From there the greatest increase occurs, three hours after the Moon has departed from the meridian of London; for at that time, as is plain from our wheel of the marine tide, the said circulation of the sea lasts from the shores of America up to the established place.

But let us now proceed to the other part of the difficulty, where it was said that the Moon, set in the northern signs or in the tropic of Cancer [☿], then first causes the greatest increase of the waters at London when it has been set in the opposite east-northerly quarter. We say, then, that this happens for this reason: that the Moon, being then nearest to the said sea, since it stands over it, accordingly strikes it more powerfully by its own force. Hence, with the Moon rising, the sea D, gradually pressed, soon begins to swell; and while it finds no free exit in the narrows X, hence the water, heaped together at the mouth of the river X, produces the greatest swelling of the sea within three hours — which otherwise, if it found a free exit in the open sea, would occur within the space of six hours, as at the other shores of England.

[Margin: The cause is shown of the irregularity of the tide.]

The Moon, therefore, set in the east-northerly quarter, on account of the said causes, anticipates the increase by three hours. Meanwhile the Atlantic Ocean, driven against and back from America — rushing, as it does, through the British Sea — finds the mouth of the Thames turned away from itself; and so, passing it by, diffused either into the northern or into the eastern tracts of the sea, it seizes and carries off with itself the swollen waters lingering in the said mouth, whence the decrease occurs, from the ninth hour up to twelve and beyond.

But the figure will teach you all this better. In it, at the shores of America A, there is an arrival of the Ocean stirred up by the Moon; here, repelled from A, it circulates partly into C and D, partly into F, and, dashed against and repelled from the islands M, L, it begins its current afresh either through O or through P, which anticipates the increase by three hours. Meanwhile the Atlantic Ocean, driven against and back from America — rushing, as through the British Sea — finds the mouth of the Thames turned away from itself, and so, passing it by, diffused either into the northern or into the eastern tracts of the sea, seizes and carries off with itself the swollen waters lingering in the said mouth, whence the decrease occurs from the ninth hour up to twelve and beyond.

[The figure referred to in this Disquisitio — showing the shores of America (A), the points C, D, F, the islands M and L, and the currents O and P — is not engraved on these pages; it is one of the hydrographic figures promised earlier. If a separate engraved plate or volvelle belongs here, it does not appear within this opening.]

CONSECTARIUM I.

From these things it is plain that, whenever a current of the sea has a gulf or a shore lying directly in its way, it exerts its force most strongly upon that too — as happens at the shores Z of Ireland, of Scotland, and at the islands M, L. But on the contrary, if some shore...

[Margin: The propagation of the sea's flux according to the situation of the shores.]

strikes only obliquely, or has that shore turned entirely away from it, then likewise no increase occurs there — as on the shores of the British Sea marked **B B** — unless the current finds some obstacle, whether an island or a promontory, lying beyond that shore. For the sea's current, dashing against such an obstacle, is at last reflected back; and so, after some interval of time, it produces the increase in the very place it had at first passed over. And this is the reason why, on different shores, the timing of the swelling is so inconsistent: because the sea, first passing that shore in a direct course while it is reflected toward another shore, then driven back upon the place it had abandoned, finally returns in a reflected course to do what it had at first neglected. Much, too, contributes to this irregularity of timing the swelling waters produced by the general motion stirred up by the Moon — for either the sea rises in the eastern quadrant and falls in the western, or, on the contrary, it falls in the eastern and rises in the western;

Diagram. A large engraved map filling the page, showing the North Atlantic and the seas around the British Isles, with the schematics of currents that drive the tidal behavior discussed in the text. The cartouche at lower left bears the title: "A chart exhibiting the patterns of flux and reflux in the English Sea and the other adjacent shores." The top edge is labeled **AMERICÆ PARS** ("Part of America"). The ocean basin between Europe and the islands to the northeast is labeled **Oceanus Decalidonus** [recte: Deucalidonus — the Deucaledonian/North Atlantic Sea]. A compass rose with the cardinal directions sits at the right edge.

Geographic labels (with modern forms):

- **AMERICÆ PARS** (top): "Part of America"
- **Hispania** (left): Spain
- **Gallia** (lower left): France [Gaul]
- **Sinus Cantabricus** (off the Iberian/French coast): the Bay of Biscay [Cantabrian Gulf]
- **Os Garumnæ** (French coast): the mouth of the Garonne

- Mare Britannicum (the channel waters): the British Sea
- Hibernia: Ireland
- Scotia: Scotland
- Anglia: England
- Cales (S. English coast): Calais
- Flandria: Flanders
- Oceanus Germanicus (the North Sea): the German Ocean [North Sea]
- Norvegia: Norway
- Dania: Denmark
- Suecia: Sweden
- Finmarck [Finmarchia]: Finnmark
- Lappia: Lapland
- Nova Zembla (right edge): Novaya Zemlya
- Frisland (island, upper right): the (mythical) island Frisland
- Islandia: Iceland
- Orcades (north of Scotland): the Orkneys
- Charybdis (off Norway): the whirlpool Charybdis [the Maelstrom]
- Weigatz [or Vaygats], near Nova Zembla: the Vaygach strait

Point-letters marking the current scheme (positions approximate, read from the engraving):

- A (over the American coast at top): current origin point [?]
- F (top, right of A): current point
- M (island, upper right): island M (labeled "Frisland")
- E (mid-ocean): current point
- L (island, right — Iceland region): island L
- Z (off Ireland): point Z
- B (off Spain/Biscay): point B
- K (between Ireland and Scotland): point K
- O (mid-North Sea, toward the open ocean): point O
- P (right edge, lower): point P
- V (off the English/Flemish coast): point V
- D (off Flanders): point D
- I (near Flanders/Norway): point I
- H (off SW Norway): point H
- G (off southern Norway/Denmark): point G

- W (in the Sinus Gallici / French gulf region near the Garonne): point W
- X (a promontory marked with the planetary/astronomical sign ♂-like glyph in the text — see below): promontory X

or finally it rises in both, or falls in both. From this combination arises a great variation in the timing of the marine tide. For it happens that the sea falls on the eastern side of some promontory while it rises on the western, and the reverse — as occurs in the gulf of the French sea marked with the letter **W**. There, on the western shore of promontory **X**, the water rises as the tide of the British Sea rises, because of the collision against the promontory mentioned [Margin: ...against the promontory.]; but on the opposite, eastern side it falls, while the sea's water generally passes by and ebbs away. Yet some hours later the water here on the **X** shores begins to rise, because the ebbing sea, driven into the curved shore of the sea near the throat **X**, drives its waters back upon the opposite shore — while in the meantime, on the opposite western side of the promontory, the water is falling. What we say of this one case, you may understand to be said of all the others.

[Margin: The reason for the variety of flux and reflux.]

I could at this point describe all the anomalous [*heteroclitos*] effects of the sea on the various shores of regions and islands, and give the reason for each; but...

[Margin: Why on the northernmost island, Vaygach, the tide runs from east to west.]

whoever has more deeply grasped what has been said up to now will find no difficulty in resolving cases of this sort, since the exotic tide of the sea can always be referred to one, or several, or even all of the concurrent reasons and causes mentioned above.

CONSECTARIUM II.

It is likewise clear why, in the Strait of Vaygach [Freto Weigatz], the tide of the sea runs from west to east. I say it happens for this reason: that the Ocean, dashed against the shores of America at **E**, leads its current through **E O & P**, from west to east — as the map shows — and there, between the islands of Novaya Zembla and Vaygach and the continent of Finnmark [Finmarchia] and Bjarmia [Biarmia], confined into a narrow space, it discharges itself with the greatest force into the Eastern Ocean. And since the sea falls along **E O P**, the tide too must necessarily return from east to west.

It is likewise clear why such unusual sea-motions are observed between England and Ireland. We say the cause is the circulation of the currents reflected from the Deucaledonian Sea **E** and the British Sea **B** into **K**, where the sea — broken among the various windings of the gulfs and islands, divided, and thrown into confusion by the diverse, straight, oblique, and sinuous repercussion of its waves — produces anomalous tidal effects; and there is nothing to wonder at in this. Added to these is the eruption of the subterranean channels of both islands, which take up the waters back and forth; and with all these things concurring, you may promise yourself nothing stable in the marine tide. The same cause is assigned to the inconstancy of the sea in the Hebrides Islands.

CONSECTARIUM III.

[Margin: Why on the western shores of Norway the tide is imperceptible.]

Why on the western shores **H** of Norway is the flux and reflux never noticeably observed? I answer: since the sea's current **E O P**, driven back from the glacial sea and from the shore of Finnmark, bends its way toward **H** and **V**, into the German Ocean, and therefore cannot strike the said shores **H** directly but flows off from **H** toward **V**, no notable increase is observed there either. There is the further point that the other current **E M H**, passing through **L** by the islands that lie in its way — both the Hebrides and the Orkneys, and the islands adjacent to **H** in Norway — is as it were combed out, and loses its force as the tide gradually grows faint.

CAPUT VI.

DISQUISITIO V.

Why at the mouth of the Garonne [Garumnæ], a river of France [Gaul], the water rises for seven hours but falls for only three; whereas, on the contrary, in the Senegal [Senega], a river of Africa, the sea-water rises for four hours and falls for eight.

[Margin: The cause why the tide in the river Garonne rises for 7 hours and ebbs for 5.]

I answer to the first point. Since the Ocean, driven back from the shores of America, enters the Cantabrian Gulf **C** directly, and has the mouth of the Garonne directly facing it, it happens that the currents grazing the shores **β** and **γ** and converging at **C** struggle with the river's great resistance, and so block up the mouth **C** of the Garonne. Yet since the direct flux **A A C** makes straight for the mouth, it happens that the earlier resisting currents, broken by the force of the

current **A A C**, all penetrate the mouth together at once. But here a new struggle of the waters arises, the Garonne's own waves opposing themselves to the sea's flux; and when the river cannot resist the more powerful sea-current, in time the sea at last prevails. It completes its increase one hour later than the general motion of the sea requires — namely in seven hours — on account of the labor it must exhaust in overcoming the river's waves. But when the sea's flux subsides, the river, restored as it were to freer air, completes its decrease more easily and in a shorter time, namely in five hours. In this way the time of flux and reflux — which nature has fixed at 12 hours — is balanced: just as the sea spent seven hours in the laborious inflow, so it makes up the difference in the outflow by brevity of time, namely in five hours.

[Margin: The river Senegal of Africa.]

As for the Senegal river — which geographers also call the Niger [*Nigrum*] — concerning the question why its water flows in for four hours and ebbs for eight: [Margin: The reason for the Senegal's tide.] we say this happens because the general motion of the Moon, stirred up in the Indian Sea and diffused far and wide through the Ethiopic Ocean, when it first strikes the Islands of the Hesperides [the Cape Verde Islands] that lie in its way, is so reflected toward the mouth of the river Senegal — which otherwise is slow and sluggish — that on entering it, it begins its increase gradually. But meanwhile, since the Ocean, driven against and driven back from the shores of Brazil [*Brasiliæ*], makes straight for the said mouth, and over a span of four hours increases it remarkably, it happens that meanwhile another current of the sea from the north breaks the force of the prior current and turns it aside. Hence, when the tide has subsided at the mouth of the river, the sea — which had crept into the inner, calm, and tranquil winding folds of the river — gradually flowing back together with the sluggishness of the river, when at last its own current (which had checked the river's flux) subsides, is restored to its channel after eight hours.

CONSECTARIUM.

Hence it is clear that, other things being equal, the sea takes so much more time in the inflow and increase of any river, and the outflow occurs so much more easily, the more rapid and steeply-sloping the mouths the rivers enter through are;

[Margin: The reasons for the tide at the mouths of rivers explained.]

and, on the contrary, the sea labors so much less in the inflow into rivers, and labors more in the outflow, the more level, quiet, and tranquil the rivers are. For when the sea rushes in, these are easily filled; whereas in more steeply-sloping rivers the sea labors greatly to overcome their waves. It is likewise clear that the currents impede one another, and so cut short the natural motion of the inflow in such a way that the increase which the sea ought to have produced by its inflow over a six-hour span, it produces in no more than four hours, or even fewer, on account of the anticipation or postponement of the other intervening current's force — as is clear from what has been said. And this I would suppose to be the cause in the differing tides of rivers.

CAPUT VII.

DISQUISITIO VI.

Not long ago the most illustrious and noble lord **A. de Moray** [Sir Robert Moray], a Scottish knight, proposed a remarkable doubt concerning the exotic constitution of the marine tide, which he writes he had observed in the Orkneys and the Hebrides. Having set it before many other learned men in vain, he at last had recourse to me, hoping I might render the cause of so unsearchable an effect and bring some light to so impenetrable a difficulty. The words of the said knight, as excerpted from his letters sent to me, are as follows:

"For the science of navigation," he says, "it would be very useful to compose a proper history of the sea's tides, fully explaining all the motions — both regular and anomalous — that occur anywhere. Whatever I have so far happened to see on this subject I think defective. It would be a task truly worthy of you to undertake this service. [Margin: A wonderful tide.] Wonderful are the alternations of flux and reflux in certain places. Here I shall relate what I observed in the Hebrides Islands, partly with my own eyes, partly learned from trustworthy inhabitants. [Margin: The marvelous variety of the tide in the Hebrides islands.] There is a place in the strait — strewn with smaller islands, rocks, and frequent sandbars — among the larger ones commonly called Eust [Uist] and Herres [Harris]. At the highest tides, that is, at the time of the conjunction and opposition of the Sun and Moon, when full sea [plemmyra] occurs at the sixth hour, the tides proceed in an orderly fashion: the flux from east to west over a span of six hours, and likewise the reflux from west to east, is completed. This holds always for two days before the full moon and its opposite [the new moon], and as many days after. But on the third day, and thereafter, it is far otherwise; for during the whole daytime, whether it floods or ebbs, the current of the water is always directed toward the west, while at night it

turns toward the east. This I myself observed; but the natives report, moreover, that something even more wonderful happens here. Namely, throughout the whole day, while the Sun traverses the northern signs, the said currents of the water tend westward; but throughout the whole winter, the contrary — whose cause it was not granted me to penetrate." Thus far the words of the knight cited above.

Three things, therefore, are to be considered in this proposed doubt. First, why for two days before and after the conjunction and opposition of the Sun and Moon the sea always floods and ebbs over six hours; and this tide, since it arises from the general motion of the sea stirred up by the Moon's force — as was fully shown above — needs no further explanation. The second presents a greater difficulty:

[Margin: The exposition of the doubt.]

it asks: why, on the third day from the new or full moon, does the sea always flow westward by day, but eastward by night? The third is: why, when the Sun is passing through the northern signs, does the sea always run westward, but in the southern signs — that is, in winter — always eastward? But since the said observation is not expressed in all its particulars according to all circumstances, I have judged it not fair to interpose my own judgment in this matter too rashly. For I do not know whether, after the third day from the conjunction and opposition, the sea undergoes so exotic a change, or whether it does so on the other following days of the waxing or waning Moon as well — a point not made explicit in the doubt. The second consideration suffers a still greater difficulty: namely, that the sea is said to run always westward in summer, but always eastward in winter — which equally cannot be conceived, since it would seem to contradict the preceding observation. Everything ought therefore to have been specified as carefully as possible: namely, whether — excepting the new and full moons — the sea ran westward only in summer, or eastward only in winter. And if it happens so, it will necessarily follow that the sea makes for the west during one half-year and for the east during the other half-year — which is absurd, since it has already been observed that outside the time of conjunction and opposition the sea makes for the east only by night and for the west only by day. Hence, since nothing in this doubt has been determined, but it has been written down in a confused manner, so likewise to pass judgment on these matters too hastily would be the act not of a prudent man but of a fool. Therefore, in order that the genuine cause of such great changes may be drawn out as exactly as possible, careful observations must first be made by skilled men — namely, who and whether there is that exotic motion on the third day before and after the

conjunction and opposition of the Sun and Moon; whether it lasts on that day only, or on the following days as well, when the Moon is at points more remote from those said places; then at what time the sea begins to run westward by night, and at what time eastward by day; whether such contrary fluxes are precisely comprehended within the number of twelve hours;

then how this flux lasts for a half-year span [*semestri*] toward the west in summertime, and how it lasts toward the east in wintertime; whether this is to be understood of all the days of the half-year span, or only of the days lying outside the new and full moons; again, whether it occurs at any position of the Moon in the Zodiac; finally, the situation of the shores and islands would have to be rightly described, the depth of the sea explored, and similar circumstances — without combining all of which we cannot reach our intended aim and purpose.

[Margin: To observe the tide in the open sea is difficult.]

For it can scarcely be said how the eyes from time to time deceive us — I will not say the inexperienced, but those trained to the science of navigation from youth — when they think the sea is running in this or that direction, while in fact nothing exists but a certain fluctuation of the sea by which we are deceived. So, just as we said above, nothing is more difficult than to observe the flux and reflux of the sea in the open sea; in places tangled with a multitude of islands, where the sea is now driven against this island, now against that, by manifold reverberation and the perpetual circulation of the waves, I judge it most difficult of all to observe a constant motion of the sea toward the east or the west. But let us proceed to other cases, with more exact observations and with the daily experience known to all who frequent shores of this kind.

CAPUT VIII.

DISQUISITIO VII.

Why the Southern Sea — commonly called *del Zur* [the South Sea, the Pacific] — near Panama produces such unusual and incredible fluxes and refluxes. Whereas, on the contrary, in the Northern Sea — commonly called *del Nord* [the North Sea, here the Caribbean/Atlantic] — near the port of Nombre de Dios and along the other shores of the American continent, it causes scarcely a perceptible tide.

Francisco González de Oviedo [Gonzalo Fernández de Oviedo] treats this question in his *General History of the Indies* (Book 2, chapter 10). He says that he set these prodigious effects of the sea before all the philosophers and learned men, but that

there was none who gave any satisfaction in assigning the cause; and so, confessing their own ignorance, they left this question as if insoluble, and he thinks it cannot be that the cause of this matter can be given except by a man divinely enlightened. We, however, hold that not so much native genius is required, but that by the natural light alone such marvelous effects can be penetrated — if not intimately, at least to some degree. And so that we might not seem to have neglected so signal an occasion for exercising the intellect, having first duly examined all the circumstances of both seas' effects, and having explored the dispositions and properties of the terrain of both seas, we have at last — God granting — arrived at the true cause of such exotic motions, which I shall then expound, once I have first described the effects which the said sea undergoes in its inflow and outflow. The matter stands thus.

[Margin: The flux and reflux of the sea *del Zur* at Panama.]

Since the Southern Sea is distant from the Northern — or the Western from the Eastern, if you measure a straight line — by no more than 12 leagues, namely with the Isthmus interposed between Panama and Nombre de Dios bounding both seas: all wonder, and seem unable to grasp, why in so small a space of intervening land so great a difference of marine motions should be found. For on the shores near Panama the sea seems to fail in so excessive a recession that it cannot be touched at all by the eyes of those standing on the shore, and seems to have vanished entirely; whereas in the inflow and increase, it is carried against the shores with such force that it first covers with its waves all the islands lying in the way in the Gulf of St. Michael, and then overwhelms the very houses on the shore together with the trees in its path. But in the opposite Eastern or Northern Sea, commonly *del Nord*, at the very same time scarcely a perceptible motion of the sea is found.

[Margin: Why the Atlantic sea at the American isthmus makes only a slight and scarcely perceptible tide.]

To assign the reason for this exotic effect, then:

I suppose, first, that the sea-currents in the Atlantic toward the shores of America — and especially between the throats of the New Kingdom [Nuevo Reino de Granada] and the islands of Cuba and Hispaniola, as we have shown elsewhere — are most powerful, and insinuate themselves with so great a mass of waters within the said straits that ships there seem not so much to be carried as to rush headlong, just as in a most rapid river or down the slope of some mountain. And so for those setting out from Mexico or Peru to Europe, it is impossible to

overcome this force of the sea; instead one must hold a course by various circuits toward the shores of Virginia and Florida, so that by the circulation which the sea there makes around the said islands one may at last reach the desired port of Europe.

I suppose, second, from the observation of sailors, that in the said strait the sea is of unsearchable depth — a clear sign that the sea's bottom there terminates in some hidden abyss.

I suppose, third, from my *Ecstatic Terrestrial Journey* [*Itinerarium Terrestrae Exstaticum*], Section 2, "On the Submarine Itinerary," that there is there an immense subterranean passage by which the Northern Sea communicates with the Southern — as the common opinion of the natives holds, and as the hidden dealings of commerce in both seas sufficiently make plain. But of this passage...

that this passage [meatus] is, as it were, a kind of bridge under the isthmus, beneath which the current of the northern sea rushes through with the greatest force. With these things supposed, then, I make my claim.

When the Moon strikes the Atlantic with its rays, I hold that this sea, stirred by the Moon's power, rushes with the greatest force (as I said) into the said channel; and since it finds no exit there, it works its way into the windings of the isthmus with a great heaping-up of waves. Now since it finds no exit except in the southern sea at Panama, it discharges itself there into that sea, draining off at the very same time as the tide there is falling. From this the sea is driven back from the shores—especially at the time when the Moon declines from its meridian and the swell of the sea in the southern ocean fails, as I said—and this is the source of that very ebb of the sea which the aforementioned Gonzalo de Oviedo [Gonzalo Fernández de Oviedo] could not account for.

When, however, the Moon grows for six hours and falls for as many, and reaches the opposite quadrant, then behold: the southern sea, swelling, rolls its waves toward the western shores of America. And as these earlier waves meet others coming against them—spreading far and wide both from the isthmian passage and from the Strait of Magellan [Freto Magellánico]—an immense tumult of waves arises. So the earlier waves, immense as the sea is, are overpowered by the following swell, and burst out through whatever opening is given: partly toward the shores, partly driven back into the isthmian passage, and there they stir up on the shores of the Gulf of Panama [Sinus Panamicus] those vast, storming inundations we have described. For so great is the violence of the sea at that time that it levels with the sea even the islands lying in its path—lands that are

therefore uninhabitable, by no means flat, but set with rocky slopes and trees—all of them at once buried under the water, and it fills the shores and the city of Panama itself with water, with a certain dreadful subterranean bellowing and also with an earthquake (which I believe is produced by that great violence with which the waters, packed tight, force their way into the said passage).

[Margin: Huge swell and surge of the sea at Panama.]

[Margin: Bellowing of the sea, with trembling of the earth.]

For from the opposite shore of the northern sea, at the port of Nombre de Dios, at the same time the sea—surging in a marvelous manner with the same terrifying sound—directs its onset toward the Gulf of Mexico [Sinum Mexicanum] and the neighboring shores of northern America. This our Fathers, who came here to Rome as procurators, have often related, and the said Gonzalo de Oviedo describes it skillfully indeed in his history, on fol. 87. The cause of this can be no other than the vehement regurgitation of the southern sea out of that passage.

But why in this northern sea no tide, or only a very slight one, is noticed from so great an agitation of the waters—I say the cause of this is the same as the one by which the water entering the passage carries off with it the falling waters of the sea from the shores of Panama. So too the water rushing back through the passage, casting its course into the Gulf of Mexico, likewise carries off the waters from the shores along with it, so that it can produce only a slight impulse upon them.

[Margin: Objection.]

But you will say: this reasoning may hold for a falling sea, but why—

—does it undergo the same alternations even in a rising sea? Because the general motion of the sea, stirred by the Moon, partly hurls the Ethiopian Ocean [Oceanum Æthiopicum] with the greatest violence toward the jaws of the isthmus of Panama, and partly discharges it into the Gulf of Mexico; and so it happens that, finding no exit there, it communicates the tide through the subterranean passage to the said marshes—a thing that has hitherto seemed marvelous and paradoxical to those who do not know the hidden dealings of nature.

[Margin: Why the marshes of Mexico undergo the tide's ebb and flow.]

Imagine for yourself the Gulf of Mexico A, in which the Ethiopian Ocean, surging...

Diagram. A vertical schematic of the chain of Mexican waters and the subterranean passages connecting them to the Gulf of Mexico, drawn as a top-to-bottom column. At the top is the city of Mexico, set within a body of water; below it a series of lakes connected by dotted-line subterranean channels descends to the sea at the bottom of the page. Mountains and stands of trees flank the channels on either side. The running label "Subterraneus" ("Subterranean") is written along the connecting passages.

- Mexico (top, within a body of water): "Mexico" — the city of Mexico, on its island
- Aqua dulcis (just below Mexico): "Fresh water" — the freshwater lake around the city
- G (at the foot of the freshwater lake): junction point of the channel descending from the Mexico lake
- F (mid-passage, on the dotted channel below G): the subterranean channel connecting the freshwater lake to the salt lake (corresponds to passage F in the text)
- Subterraneus (along the dotted channels): "Subterranean (passage)"
- Lacus salsus (middle, large lake): "Salt lake" — the salt lake below
- C (beneath the salt lake's name): label for the salt lake
- E (between the salt lake and the gulf below): the subterranean passage leading down to the Gulf of Mexico
- B (lower, at the head of the gulf): junction where the passage meets the gulf
- Sinus Mexicanus (bottom, within the radiating sea): "Gulf of Mexico"
- A (within the Gulf of Mexico): label for the gulf

surging, since it finds no exit, discharges itself through the subterranean passage B E into the salt marsh C; and this in turn discharges itself through the subterranean passage F into another marsh, G, welling up with fresh water, above which the city of Mexico itself is founded. Most people also wonder why this last lake, though it receives countless rivers, never overflows. But if they understood the arrangement of this subterranean traffic, they would by no means doubt about so manifest a matter. For it does not overflow, because the lake is drained of its water out of D, through the passage E into C, and from there through the passage E B it is carried down into the sea while the tide is falling—only to return, as soon as the sea swells again, to the place from which it had flowed out.

CONSECTARIUM II. [Corollary II.]

From this it is also clear why, in the Hudson Sea [mari Hudson], the water rises by 15 feet, yet in another neighboring gulf of the same sea by only two feet. The reason is that the sea, rushing from east to west, enters the said sea directly, and so it is no wonder that, where it strikes the opposite shore, it should be raised to 15 feet. But in the other gulf the water either does not reach the said shores, or, if it does touch them, it is carried off through a subterranean passage either into other surrounding lakes or into neighboring seas.

[Margin: The Hudson Sea.]

CAPUT IX. [Chapter IX.]

DISQUISITIO VIII. [Inquiry VIII.]

There is a place beside the coast of Guinea, one degree distant from the equator, in a bay which they call Fernando del Po [Ferdinando Pool], in a corner where Guinea, stretching along a great tract of coast from west to east, finally bends to the south. Here the motion of the sea is altogether contrary to the general motion that runs perpetually from east to west; and it is so vehement that whatever ships put in at this place are seized by a certain hidden force, so that by no power of their own can they drive themselves back—unless aided by Ecnephias-squalls [Ecnephiis] and the most violent chronic winds. The place is fatal to vessels, full of dreadful whirlpools.

[Margin: An abyss in the bay which they call Fernando del Po.]

It is astonishing, moreover, that no one has hitherto given the cause of this matter, although so many cosmographers have already wearied their brains in studying that place. We say the cause of this is the subterranean passage through which the sea discharges itself amid the destruction of ships and men—the waves being heaped up in that corner of the ocean and discharging themselves through that subterranean passage. And the explanation is plain: because the rapidity of a current of this kind, besides being perpetual, lasts only to a distance of 14 miles.

[Margin: A subterranean passage in Africa.]

As for the view of some that this current arises from the recoil of the ocean against the shores of Brazil, made toward the east—that cannot stand. For since recoils of the seas of this kind are directed by the rising of the Moon, that recoil would doubtless cease when the Moon reached the opposite quadrant; whereas this current, whether the sea is rising or falling, always and forever behaves in the same way. This is indeed a most luminous sign that the sea, headlong as if through some river, pours in a continuous current into the blind bowels of the

earth through this submarine gulf, draining off into a lake of inland Africa which some call Tigri [Tigrai], others the Niger [Nigrum]. My reasons I now assign.

For Pigafetta, in his African *Itinerary*, says that this lake is by its nature a salt lake, with which the Niger, flowing through it, does not mix; that fragments of ships are very often found in it, and many other things which clearly show that it has some commerce or other with the neighboring ocean. From this I infer that it can communicate with no other place of the ocean than with the place we have just described—where the water, with a most vehement current and also with a remarkable...

[Margin: A place infamous for shipwrecks.]

destruction of ships and men, after such [havoc], discharges itself into that lake. Before this lake was known, the *Nautical History* relates that very many ships were either swallowed up there, or driven against the shores by a violent motion, and left behind only the planks, the relics of a sad and dismal shipwreck. And if any, by skill in the nautical art, escaped this Scylla, these were held back for many months by violence, and—their supplies of all the necessities of life consumed, when they could not overcome the tide—at last miserably perished of hunger and thirst.

CAPUT X. [Chapter X.]

DISQUISITIO IX. [Inquiry IX.]

On the marvelous whirlpool of Norway, the most celebrated and greatest of the whole world.

[Margin: Description of the whirlpool.]

There is a whirlpool and tidal race [Euripus] in the adjacent Norwegian sea, the Northern Ocean, conspicuous beyond all to the great terror of all sailors. It is said to be thirteen miles in circuit; by the inhabitants it is called the Maelstrom [Meelstrom]. A rock occupies the middle of the whirlpool, which the natives call Musken [Muske]; beneath this is a huge chasm which, over six hours, swallows up everything brought within...

the circumference of its crater: cargo ships, the smallest and the largest, water, whales, and other things. And over an equal number of hours it belches and vomits all those things out again, with great violence, with a roar, and with a fearful churning of the dizzying sea. So testifies Olaus Magnus; so report the natives of this coast, and the navigators of the Danes and the Dutch. The effects

we have seen, approved by the testimony of all the northern peoples. It remains for us to assign the cause of effects so prodigious—especially since no one hitherto has given their genuine explanation.

[Margin: Investigation of the cause.]

First, then, it is to be noted, on the testimony of Olaus Magnus, who reports that the whole region of Scandinavia is full of caverns and of passages hitherto undiscovered in their length, and confirms this from the horrible roar both of the Bothnian [Bodnici] and Finnic seas, and of the lakes which they call Vänern and Vättern [Venner & Vetter], and finally from the dreadful roar of the mountains—a roar which can be produced in no way except from subterranean waters that, derived from the neighboring seas and gulfs into other places along channels stretched far and wide, [reverberate] with the varied reverberation of waves in the steep and winding passages or cataracts [catadupis] of the earth. He writes that in many places this roar is so great that men approaching too near are rendered deaf and, as it were, thunderstruck and stupefied, and from time to time even lifeless, unless they timely remove themselves from those deadly caverns of Charon.

[Margin: Dreadful sounds at the shores of Bothnia.]

To be noted, second: not only the lakes of Norway, but also those of Sweden, which they call Vättern and Vänern [Vetter & Venner], are of unfathomable depth, the same Olaus writes—so that ropes which would load a whole ship do not suffice to reach the bottom. The Hollanders experienced the same on the said Norwegian shores, who with a sounding-lead of 130 fathoms [orgiarum] could not find the bottom, as they report in their *Voyage to the Arctic*. These unheard-of depths argue nothing else than subterranean abysses of immense extent.

[Margin: The unfathomable depth of the lakes.]

To be noted, third: from so great an abundance of subterranean passages we can readily infer the mutual and hidden correspondence of the surrounding seas with the ocean that washes Norway. Olaus shows this too by various examples, when he describes the aforesaid vast and very deep lakes Vättern and Vänern [Vetter & Venner], which he openly asserts to be derived from the Bothnian sea; and that the Bothnian Gulf has a hidden correspondence with the White Sea [Mari Albo], which is a gulf of the Tartaric Ocean; and the White Sea with the Finnic Gulf [Sinu Finnico] through a lake which they call the White [Album]—this, together with the Bothnian, communicating with the Norwegian Ocean.

[Margin: Charybdis.]

With these premises laid down, let us now gird ourselves to assign the genuine cause of the Norwegian Charybdis, which flows in for six hours and flows out for as many.

Since, then, the said Charybdis or whirlpool—as is shown by irrefragable experience—so powerfully swallows the neighboring water of Norway, together with the things thrown into it, for six hours, and over an equal number of hours gradually vomits them out, it is certain that this flow and reflux—this swallowing and disgorging, which happens in the space of twelve hours—has no other cause than the general motion of the ocean, stirred by the Moon's power. But how all this can come about, we shall try to show in this place, if not by demonstrative reasons, at least by ones in the highest degree probable.

[Margin: The whirlpool of Norway flows and reflows for six hours.]

We showed in Inquiry IV that the Deucalidonian Sea [Mare Deucalidonium], circulated through the northern region, discharges itself into the Tartaric Ocean through the Strait of Vaigach [Fretum Weigatz] with the inflow of the tide, and that through the same strait, abandoned by the outflow of the sea, it seeks the ocean again over the space of six hours. There too we showed why, on the Norwegian coast, the ebbing water leaves scarcely any perceptible trace of the tide in those regions.

I say, then, that the inflow or swallowing in the said Charybdis happens in this way. When the Deucalidonian Sea, stirred by the general motion and by the Moon's power, directs its currents toward the Strait of Vaigach, it happens that in such great narrows of the strait the waves, heaped up in a marvelous manner and hindered by the obstacles of the glacial sea, cannot penetrate it all at once. So a great portion of the sea, blocked, turns its course back toward the shores of Finmark [Finmarchiæ] and Norway, where—raging amid countless reefs with the swell and increase of the waves—it finally falls, through so many windings and unwindings of caverns and islands, into the crater of the whirlpool. There, no longer enduring the gluttony of hidden nature, it is swallowed up together with all those things then cast into it, whether by chance or by the rapidity of the sea through the reckless haste of sailors. And this voracity lasts as long as the inflow or swell of the circulated ocean lasts. We have the cause of the swallowing carried out over six hours.

[Margin: The whirlpool swallows everything.]

It remains to explain how, in the space of six hours, it vomits up again what had earlier been swallowed—a thing that has rightly seemed to many, unschooled in the secrets of nature, to exceed the capacity of the human mind.

[Margin: How the same whirlpool vomits up everything it swallowed.]

In the third Notandum proposed just above, it was shown that the Tartaric Sea, stirred by the greatest force, by the power of the sea's swell with the Moon in the opposite quadrant, retreats over six hours, [carrying] its currents partly through the Strait of Vaigach, partly through the Tartaric Gulf, by the six-hour outflow. But since the greatest packing of waves and ice meeting at the mouth of the eastern strait obstructs the Tartaric Ocean, its course is therefore deflected elsewhere, and it is forced to work its way into the White Sea, which they call Petzorche [Pertzerche [?]]. Now this sea, because it has a hidden correspondence with the Bothnian and Finnic Gulfs—and these gulfs likewise communicate with the whirlpool of Norway, through the things we showed in the first Notabile, by means of hidden subterranean passages—the point intended is clear. Indeed Olaus (*Septentrional History* II.6) expressly...

states that the Bothnian Gulf is intricate with countless reefs and surrounded by very high mountains covered with perpetual snow, within whose roots the sea is now swallowed up, now vomited out again through immense whirlpools, with a horrible and intolerable sound—all of which has been set forth more fully a little earlier, and in the preceding Book.

[Margin: The whirlpool of the Bothnian Gulf.]

With these things laid down, then, I say: in those six hours in which the Norwegian sea grows to its greatest increase, the Tartaric Ocean—gradually swelling after about 4 hours, according to the reckoning of the Moon's position—on the one side pours its mass of water into the White Sea, and this through subterranean passages into the Bothnian Gulf; while on the other side the German Ocean [Germanicus Oceanus], through the Cimbric Chersonese [Chersonesum Cymbricam] with great windings of the shores and the most constricted narrows, working its way through the Baltic Sea [Mare Balthicum] into both the Bothnian and Finnic Gulfs, meets the Tartaric waters and stirs up great collisions. So the sea, confined within the narrows of the Bothnian Gulf, is restored through hidden whirlpools and passages to the Norwegian sea, by the [route] which we described as Charybdis. For the Tartaric and German Ocean take more time to keep up their swelling through so many winding tracts of country than the swelling of the Norwegian sea requires. For when the water

swells at our Charybdis, the water in the said gulfs is falling, and on the contrary, when these are falling, Charybdis seems to disgorge what it has drunk.

[Margin: The whirlpool of the Bothnian Gulf.]

But that I may not seem to have said this by mere conjecture, I will bring forward the author of my assertion, Levinus Algotius [Levinus Algoth], printed at Antwerp, who in his *History of the Northern Regions*, where he treats of the nature and prodigious things of the said regions, makes express mention of the whirlpool of Norway, and of another in the Bothnian Gulf. He says it was noted by sailors that when the Norwegian one swallows the waters, the Bothnian one, after the space of some hours, returns them with its own impulse, and vice versa. His words are:

[Margin: Levinus Algotius, in his description of the Northern Regions.]

"It has been observed, moreover, by men skilled in those parts and travelling back and forth, that after the Norwegian whirlpool has swallowed the waters, the other whirlpool in the Bothnian sea in turn compels them—through the subterranean Norwegian gulf—to vomit out again the waters which it had swallowed; and the reverse."

Thus far the cited author—whose words indeed so agree with our project that he seems to have overcome almost every difficulty in assigning the cause of the whirlpool. But perhaps someone will object: the hidden commerce of the ocean with the Bothnian Gulf is not difficult to conceive, but how the whirlpool of Norway does not carry off elsewhere what it has swallowed, but vomits it up again within six hours—this indeed seems inconceivable.

[Margin: How the whirlpool of Norway vomits up everything again after six hours.]

I reply that this whole prodigious action is to be referred back to the natural constitution of the subterranean whirlpool. But let us show it by the following diagram, in which C is the whirlpool; the rock B; the orifice of the whirlpool A; the canal of the gulf, drawn down vertically into the inner bowels of the earth, D, beneath which is a vast water-reservoir [hydrophylacium] E; the subterranean passage F H I; while the whirlpool of the Bothnian Gulf is K, the mountain within which G is enclosed.

Diagram. A cutaway landscape view of the Norwegian Maelstrom and its subterranean connection to the Bothnian Gulf. At upper left, the Norwegian Sea (Mare Norvegiae) opens into a conical whirlpool with a central rock; a vertical

shaft descends from it through the earth into a great underground reservoir, from which a winding subterranean passage runs across the page to the right, connecting (via an inland mountain holding a spring) to the Bothnian Gulf at far right. Mountains, trees, and figures of sea-monsters fill the surrounding terrain.

- Mare Norvegiae (top left): "The Norwegian Sea"
- C... C (flanking the rim of the whirlpool's funnel): the whirlpool [vortex]
- B (at the center of the whirlpool): the rock (Musken)
- A (just below B, at the throat of the funnel): the orifice of the whirlpool
- D (within the vertical shaft beneath the whirlpool): the canal of the gulf, drawn down vertically
- E (the bulbous chamber at the foot of the vertical shaft): the vast subterranean water-reservoir [hydrophylacium]
- Subterraneus (running along the horizontal passage): "Subterranean (passage)"
- Meatus (along the horizontal passage): "Passage"
- F (at the near end of the horizontal subterranean passage, beside E): part of the subterranean passage F H I
- H (along the horizontal subterranean passage): part of the passage F H I
- I (continuing the passage toward the right): part of the passage F H I [I not separately legible at the passage's far end on the page; named in the text as F H I]
- G (within the inland mountain at right-center): the spring/water enclosed within mountain K
- K (the crater-like basin on the mountain at right): the whirlpool of the Bothnian Gulf
- Sinus Bothnicus (far right, the large bay): "The Bothnian Gulf"

So I say: as the Norwegian sea swells, the waters, gradually heaped up in a marvelous manner, with the greatest...

force [rush] into the whirlpool C; through the orifice A they discharge themselves into that immense well D, and from this into the subterranean reservoir E. But the sea, over the space of six hours, continually pours greater and greater waves into it; whence the waters in the reservoir E, beyond measure...

and grow [augmented]. Since these waters can find no outlet, they are driven with the greatest force through the subterranean passage F-H-I and discharge themselves into K, the Bothnian whirlpool [vortex/gurges] — which is then at the very bottom of its level. But once the Bothnian sea rises again, the waters held

back in K are stirred up by the swelling of the sea and are driven once more, with the utmost violence, against the orifice K of that whirlpool. (This is the source of the terrible roar that all the historians cited above attest is heard there.) Repelled through the passage I-H-F, they are restored through the orifice F to the reservoir E.

But since the sea in the Bothnian Gulf [Sinus Bothnicus] swells ever more and more, the water in reservoir E — pressed by the waves coming over through the passage I-H-F — gradually raises the water together with the things it has swallowed and held back within reservoir E. And when the Norwegian sea is now subsiding, it disgorges the things it had absorbed. This whole process, experience shows, happens in alternating turns.

You see, then, that the things absorbed within the cavities of reservoir E — when they cannot flow out through the passage F-H-I, whether because of the siphon (which Hero [Hero of Alexandria] calls a *diabetes* [Greek: διαβήτης (diabētēs, "siphon")]), set there in the rocks by nature, or because of the narrowness of the cracks and orifices — are held there until little by little they are lifted up and at last cast back up again. So now you have the cause of the workings of the Norwegian Charybdis [Charybdis Norvegici] at last laid bare. And so that the layout of these whirlpools may be displayed more clearly to the curious reader, I have thought it right to add here a Map.

Diagram. A large engraved map of northern Europe and Scandinavia, showing the Norwegian and Bothnian whirlpools and the supposed subterranean channel connecting them. The cartouche at lower right is framed by an ornamental scroll. The map is oriented with north toward the upper right. A compass-rose roundel sits at the right-center. Readable labels, by position:

- Cartouche (lower right): "Descriptio Vorticis NORVEGIÆ et BODNIÆ eorumq; mirabilium effectuum, quos in fluxu et refluxu operantur." [Description of the whirlpool of Norway and of Bothnia, and of their marvelous effects, which they produce in the ebb and flow.]
- Upper left (off the coast): "Norweg[i]anus Vortex" [Norwegian whirlpool], drawn as a spiral
- Below it: "Muscke dict[us]" [called Musken — i.e., the rock Moskenes], with a depth-sounding figure "1000" beside it
- Center: "Vortex Bodnicus" [Bothnian whirlpool], drawn as a spiral
- Connecting the two whirlpools: a dotted line labelled "Meatus subterraneus" [subterranean passage]

- Right of the Bothnian whirlpool: "Album Mare" [the White Sea]
- Right-center: "Ladoga lacus" [Lake Ladoga]
- Center, gulf: "Bothnicus Sinus" [Bothnian Gulf]
- Below: "Finland[i]a" [Finland]
- Below Finland: "Sinus Finnicus" [Gulf of Finland]
- Left-center (peninsula): "Norvegia" [Norway]
- Town label center-left: "Opland" [Oppland]
- Center: "MARE B[ALT]ICUM" [the Baltic Sea]
- Lower center-left: "Dania" [Denmark], with "Selandia" [Zealand] on an island
- Far left: "Oceanus Germanicus" [the German Ocean — the North Sea]
- Left edge (Britain): "Anglia" [England]
- Lower left: "Westphalia" [Westphalia]

COROLLARY I [CONSECTARIUM I.]

From this it is clear why the Euripus of Chalcis [Euripus Chalcidicus] in Euboea — famous for the fabled death of Aristotle there — has no other principle governing its ebb and flow than the one already discussed. As the waters flow back through the passage I-H-F, it has its seven ebbs and floods; for Pliny [the Elder] records that it flows and ebbs seven times by day and by night. Even though other, later geographers attest that it floods six times and ebbs as many — following the general motion of the marine tide — Pliny can still be explained in this way:

in this way [explained], as though he meant that the Euripus floods and ebbs seven times by day and seven times by night. This difference may be ascribed to the varying circulation of the sea — its ebbing and flooding cycle [pericyclōsis] amid so great a crowd of surrounding islands — and to the now swifter, now slower inflow and outflow of the subterranean passages.

COROLLARY II [CONSECTARIUM II.]

From this it is likewise clear why certain whirlpools always swallow water and never spew it back, as was shown above concerning the African Euripus [Euripus Africanus]. Of this kind too is the whirlpool of the Danube [Vortex Danubii], which deposits the waters it absorbs — by a subterranean passage — into a lake in Hungary near Kanizsa [Caniffam — Nagykanizsa], as is reported. There are besides whirlpools that both swallow and spew back, like the one we explained a little earlier, and like the Charybdis in the Sicilian Strait [Charybdis in Freto Siculo], whose nature and properties we described at length in Book Three. There

are, finally, those that never swallow, but always erupt violently like a column on the surface both of seas and especially of sulphurous lakes; of which kind there is almost an infinite number everywhere, as will be told in its place.

DISQUISITION X [DISQUISITIO X.]

On the Nature of the Mediterranean Sea, its Currents, Ebb and Flow, and the other memorable things observed in it.

The Mediterranean Sea — enclosed, as in a kind of harbor, between the shores of Europe, Africa, and Asia — holds many marvels of Nature: marvels as unknown until now as they are most worthy of consideration. It seemed extraordinary not only to Aristotle but also to other investigators of Natural Philosophy how it is that a sea closed in on every side, with no passage to the Ocean except through the most constricted strait of the district of Cadiz [Gaditanus — Gibraltar], does not overflow — even after such mighty rivers as the Baetis [Guadalquivir], the Iberus [Ebro], the Rhône, the Var, the Tiber, the Po, and the Nile pour themselves into it, to say nothing of countless lesser ones. [Margin: The Mediterranean Sea receives very many rivers.] To these is added the perpetual and constant inflow of the Black Sea [Mare Euxinum], through the Propontis [Sea of Marmara] into the Archipelago [the Aegean], and from there into the Mediterranean. For it is established by everyone's experience that the said sea, fed and driven by the most powerful and most famous rivers of all Europe — the Danube, the Borysthenes [Dnieper], and the Tanais [Don] — pours itself perpetually through the straits of Byzantium [the Bosphorus] with no hope of return. It might therefore seem a paradox: a sea increased by a sea, yet — though it would appear incapable of holding so great a burden of waters without any discharge — nowhere overflowing along its shores; and this especially at the time when the swelling Atlantic Ocean also enriches it with a great increase of waters, discharging into it with the greatest force. [Margin: Why it does not overflow despite so many rivers (the Ocean excepted).] For this is the very thing no one has been able to grasp. We see, in fact, that rivers...

or marshes, swollen now by melted snows and now by rainwaters, immediately — because of their excessive rise — cause floods, to the great damage of the fields. How then does the sea, with whole seas together with the vastest rivers received into its bosom, not overflow? This must be examined; for without doubt something hidden lies here, an argument most worthy of scrutiny.

We said, both in the preceding Book and in the *Submarine Itinerary* [*Itinerarium Submarinum*], that all lakes are so constituted by nature that, when they are swollen by the rivers received into them and cannot discharge themselves through open mouths, they accomplish this through certain hidden, subterranean passages — just as above, in Book 3, regarding the Caspian Sea [Mare Caspium]. [Margin: It discharges itself through subterranean passages.] That sea, though it receives countless rivers, yet seems to send out none; and since it does not appear to be increased by the multitude of rivers depositing themselves into it, this is a most luminous argument that, through certain hidden passages, it discharges into other neighboring seas in the same proportion in which it receives the multitude of waters. This seemed right to Aristotle too (*Meteorologica* IV [l. 4. met.]), and we demonstrated it apodictically in the cited submarine navigation of the *Iter Extaticum* [*Itinerarium Exstaticum*]. [Margin: The Caspian Sea communicates with the Persian Gulf and the Black Sea.] There, too, from the communication of the seas, we explained that the Caspian Sea trades back and forth, by hidden paths, with the Persian Gulf [Sinus Persicus] and with the Black Sea. Since this is so, I say the same of the Mediterranean Sea, on account of the correspondence it maintains, through a subterranean passage, with the Red Sea [Mare Rubrum]. [Margin: It communicates with the Red Sea.] Since we have set these things out at length, with various examples adduced, both in the preceding Book and in the cited *Itinerary*, I have thought it best not to repeat them here. But to the matter at hand.

Why, then, does the Mediterranean Sea experience such varied motions, wholly contrary to those of the Ocean? [Margin: Explanation of the various currents.] For now it rolls from south to north and back again; now from east to west, and again from west to east, in a reciprocal motion — and then with motions wholly contrary and anomalous. Often it passes from a straight motion into circles and gyres; sometimes, unwound from its spirals, it directs the surge of its currents into one region after another. In certain places it rises and falls at fixed hours, just like the Ocean; on certain other shores you will find not even a trace of tide. Those who sail from Sicily toward the Archipelago are seized by some hidden current and violently wrenched toward the Adriatic Gulf. By contrast, those setting out from Drepanum [Trapani] toward the promontory commonly called *Bon Andrea* [Cape Bon, Tunisia], sailing under the Euronotus wind [Rhombus Euromotius] — which is commonly called *Scirocco* [the sirocco] — feel themselves carried off sideways toward Tripoli of Bizerte [Tripolim Bisertinam]. Those who sail from Cyprus toward Alexandria, even though they try with all effort to hold the line directed by their compass-rhumb, are nonetheless seized by the force of the current and carried 60 leagues below Alexandria, to Damietta

[Damiata]. Those, on the contrary, departing from Alexandria toward Cyprus are wrenched by the current and driven to the shores of Pamphylia. Those who sail through the Archipelago toward Constantinople feel a manifest and palpable resistance of the sea.

Diagram. A large fold-out engraved map of the Mediterranean Sea (this leaf is the left/western half of the double-page plate), showing the western basin from the Strait of Gibraltar to Sicily and the Adriatic. The decorative cartouche at upper left is supported by two winged putti. Readable labels, by position:

- Cartouche (upper left): "Mappa Maris MEDITERRANEI Fluxus currentes et Naturam Motionum explicans." [Map of the Mediterranean Sea, explaining the flows, currents, and the Nature of its motions.]
- Upper right: "GERMANIA" [Germany]
- Center-top mountain range: "Alpes" [the Alps]
- Below the Alps: "GALLIA" [Gaul / France]
- River entering from Gaul: "Rhodanus flu[vius]" [the Rhône river]
- Left-center: "HISPANIA" [Spain]
- Upper-right coast: "Venetia" [Venice]; "Sinus Adriaticus" [the Adriatic Gulf]; "ITALIA" [Italy]; "ILLYRIC[UM]" [Illyria]
- Right: "Calabria" [Calabria]
- Islands center: "Corsica" [Corsica]; "Sardinia" [Sardinia]; small island labelled "Majori[ca]" [?] [Majorca]
- Far left: "OCEANUS ATLANTICUS" [the Atlantic Ocean]; "C. d. S. Vincente" [Cape St. Vincent]
- Strait at left-center: "Fretum Gaditanum" [the Strait of Gibraltar]
- Center sea body: "MARE" [Sea] (i.e., MARE MEDITERRANEUM, continued on the right leaf)
- Right edge: "B. Derpa no" [?] / "SICILIA" [Sicily]; "Malta" [Malta]; "MED[ITERRANEUM]" continuing off the right edge
- Lower center: "BARBARIA" [Barbary — the North African coast]
- Bottom: "AFRICA" [Africa]
- Far right edge (fragment): "Bise[rta]" [?] [Bizerte]

Diagram. Engraved map of the eastern Mediterranean and the Black Sea region — the right (eastern) half of the two-leaf Mediterranean map whose western half appeared on the preceding leaf. The plate is signed at upper right *Tomus I. 152*. It shows the eastern basin of the Mediterranean Sea, the Aegean (Archipelago), the Black Sea (Pontus Euxinus) and Sea of Azov, Asia Minor, the Levant, Egypt and

the Red Sea. The engraving illustrates the argument of the surrounding text: a dotted "subterranean passage" links the eastern Black Sea to the Caspian, and a second labeled subterranean passage (points A, B) links the Red Sea to the Mediterranean near the Nile delta. Readable labels, with positions:

- *Tanais flu.* (upper, river entering the Sea of Azov from the northeast): the Tanais River [Don].
- *Mæotis palus* (upper center): the Maeotian Marsh [Sea of Azov].
- *Borysthenes flu.* (upper left, river): the Borysthenes River [Dnieper].
- *Danubius flu.* (left, river): the Danube River [Danube].
- *Chersonesus Taurica* (center, peninsula): the Tauric Chersonese [Crimea].
- *Pontus Euxinus* (center, the sea): the Black Sea.
- *Subterraneus Meatus* (right of center, along a dotted line between mountains): "Subterranean Passage" — the hypothesized underground channel.
- *Mare Caspii pars* (far right edge): "part of the Caspian Sea."
- *THRACIA* (left): Thrace.
- *MACEDONIA* (left): Macedonia.
- *...ICUM* (far left edge, partly off-leaf): the [Adriatic]ic [Sea] / [Ion]ic [?].
- *GRÆCIA* (lower left): Greece.
- *PELOPONESVS sive Morea* (lower left): the Peloponnese, or the Morea.
- *ANATOLIA; ASJA MINOR* (center): Anatolia; Asia Minor.
- *Archipelagus* (center, in the Aegean): the Archipelago [Aegean Sea], with numerous engraved islets.
- *Creta* (lower center, island): Crete.
- *Rhodus* (center, island): Rhodes.
- *PAMPHILIA* (center right): Pamphylia.
- *Cyprus* (center right, island): Cyprus.
- *PALESTINA* (right): Palestine.
- *Alexandria* (lower right): Alexandria.
- *MEDITERRANEUM* (lower center, spanning the sea): the Mediterranean [Sea].
- *LYBIA* (lower center): Libya.
- *ÆGYPTUS* (lower right, over the Nile delta): Egypt.
- *Nilus flu.* (lower right, river): the Nile River.
- *MARE RVBRVM* (lower right): the Red Sea.
- *Biserta* (lower left edge): Bizerte.

- **B, A** (lower right, marking the ends of the subterranean passage between the Red Sea and the Mediterranean near the Nile delta): the passage points A and B referenced in the text.
- *Damiata* (engraved on the cross-isthmus channel between A and B): Damietta.
- **Q** (lower right, just NW of the Nile delta, below Alexandria): a delta-coast point referenced in the text.
- **M** (far left edge, on the European/Adriatic shore below the ...*ICUM* sea-label, above *GRÆCIA*): the M of segment M X — the European/Adriatic terminus of the segment spanning the breadth of the Mediterranean (X being the African promontory).
- **X** (lower left, at the African promontory near Bizerte): the point X (the African promontory), terminus of segment M X.

[The plate corresponds to the "Map of the Mediterranean Sea" that the text instructs the reader to consult.]

[Resuming the main text from the foot of the preceding column.]

Those sailing in the opposite direction, from Constantinople into the Archipelago, are likewise carried along as if by a following wind, with no resistance from the sea — except for whatever resistance contrary winds create. We have now seen the currents; let us next seek the causes of so much inconstancy.

[Margin: The threefold cause of this sea's inconstancy.]

I trace all motions of this kind back to a threefold cause. The first and principal efficient cause is the Moon, working together with the Sun as the universal cause, as was shown in the preceding sections. The second cause is formal: the Moon's specific power to swell the sea, by which it acts upon the sea — and indeed upon all moist bodies — through its nitrous-saline quality. The third cause is material: the jutting-out of mountains and promontories; the situation of the islands scattered here and there; the arrangement of bays suited to catching the winds; and likewise the varied and uneven irregularity of the sea floor, or basin. To all of these is added the discharge of rivers into the sea.

First question. Why does the Mediterranean Sea move now from east to west, now from west to east? I answer that this happens through the general motion of the sea, in the reciprocation of its advance and retreat. I will demonstrate the matter as follows; and so that you may understand it more thoroughly, you should examine carefully the *Map of the Mediterranean Sea* set out opposite here.

When the Moon strikes the Indian Ocean with its rays, that ocean, suddenly swollen, works its way through the Strait of Aden into the Red Sea, heaping up its waves as far as the tip of the Red Sea's tongue. There, after the great influx that it produces against the shore, it rolls itself, all at once, through the subterranean passage A B into the Mediterranean Sea. The Mediterranean, driven by these foreign incoming waters and then gradually swollen by the very power of the rising Moon, is in turn urged from east to west; through the Strait of Gibraltar it yields to the Atlantic Ocean — until, as the Moon passes the meridian, the waves subside. Once this happens, the Atlantic Ocean, soon swelling proudly with a fresh tumor, enters the Strait of Gibraltar with the greatest force. The Mediterranean Sea, compelled to give way, resumes its course from west to east; and lest it overwhelm everything by an excessive surge against the shores of Palestine, it is restored — through that same subterranean passage B C, by which it had earlier made its entry — to the Red Sea, and at last through the Red Sea to the Ocean. Thus, as the lunar tide diminishes, the sea is driven from west to east; and as the tide increases, from east to west. There, then, you have the cause of the question proposed.

[Margin: The causes of the currents explained.]

Second question. Why are those sailing from Cyprus to Alexandria for the most part carried to Damietta, 60 miles below Alexandria, and sometimes driven above Alexandria — while, conversely, those setting out from Alexandria are sometimes carried up toward Cyprus and Pamphylia, occasionally as far as Tripoli of Syria? I answer: because when the Red Sea is belched up through the subterranean passage, the sea's current then runs from east to west. Consequently those leaving Cyprus along this current, when they reach the stretch of the Libyan or Cyrenaican shore, must of necessity be carried by the sea's flow above Alexandria. But those leaving Alexandria toward Cyprus are, by the same current, twisted from their straight path and carried to the shores of Pamphylia. When, on the other hand, the Ocean enters through the Strait of Hercules [Strait of Gibraltar], the sea moves from west to east; and soon, as the sea insinuates itself through the subterranean passage, the current is driven toward the shores of Palestine. Consequently those setting out from Cyprus to Alexandria, deflected by the sea's current, must necessarily put in below Alexandria, at Damietta — that is, Pelusium. Conversely, those going from Alexandria to Cyprus, carried off this flow of the sea from the straight rhumb-line, are driven to Tripoli of Syria. This is why the more experienced sailors, on either voyage, are accustomed to begin their journey not along the straight rhumb-line but with one rhumb taken above or below the midline, so that they may reach the harbor they desire.

[Margin: Why the Nile, when it discharges into the sea, does not impede the current of this sea.]

All of this is greatly furthered by the discharge of the Nile, for it is well known that the Nile's waters, once deposited in the sea, are turned back along the currents just described. From this it is also clear why the current of the Mediterranean Sea — running from east to west and back again — is not impeded by the immense mass of water that the Nile pours into that sea through its seven mouths. The reason is that the waters of the Nile, being fresh, are always lighter than the salt waters, and so they occupy only the surface of the sea; whereas the water belched up through the subterranean passage penetrates the whole midst of the sea and stirs it without any hindrance from the rivers.

[Margin: Why in the Adriatic Gulf the flow and ebb are perceptible, but in other shores not perceptible.]

Third question. Why does the Mediterranean Sea produce a flow and ebb that is scarcely perceptible on the shores of France and Italy, and on certain shores of Africa, while in the Adriatic Gulf, the Sicilian Strait [Strait of Messina], the harbor of La Goletta [Goletta, near Tunis], and certain other shores, it produces a very great one? I answer that this happens for three reasons. First, because the Mediterranean Sea is very narrow and crowded with islands, and moreover stretches in a straight line from east to west along the limits of its length. From this it follows that the swelling Ocean, rushing violently into the mouth at Cadiz, directs its course straight toward Corsica, Sardinia, and Sicily. Hence the inward-curving shores of Spain and France — with the water flowing away — cannot share in the increase of the tide. But the tide that slips in within the jaws of the Sicilian Strait rolls up those surges which we shall describe a little further on. The remaining current, continued on between Sicily and Africa, is carried straight to the promontory of Africa, X. There, as its impulse gradually grows faint, the sea, circling round along the shores of Libya, just as it does not strike those shores, so it imprints no tide upon them either — nor upon the shores of Palestine, since its flow, somewhat weakened by the superadded spreading of the Nile's waters, is altogether extinguished there. And toward the shores of Asia Minor it cannot continue the force of the current, since it is interrupted by the violent flow of the Archipelago.

[Margin: Plurim[a] / fluvios / cipit M[are] / Medite[rra]/neum. — "The Mediterranean Sea receives very many rivers."]

[Margin: Cur tot / flumini[bus] / exceptis / non ex[un]/det. — "Why, despite receiving so many rivers, it does not overflow."]

It cannot — — because, since the Mediterranean Sea is very narrow and crowded with islands [the column break in the source repeats the argument; I render the continuous sense].

What of Corsica and Sardinia, where it rolls up some tides, while at Majorca it does not? This becomes sufficiently clear at once from the current of the sea driven straight into those shores out of the Strait of Cadiz. Since Corsica and Sardinia sustain the impulse of the sea, the shores of Italy are accordingly not disturbed by any tide either — being shielded and defended, as it were, by those islands acting as a kind of outer rampart. But the sea, going round in a circle along the shores of France, Liguria, and Italy, slips into the jaws of the Sicilian Strait. There, repelled, and turned back into the harbor of Tunis which they call La Goletta, it produces no small tide.

[Margin: How the tide arises in the harbor of Tunis.]

You see, then, that the tide is scarcely perceptible along the shores of the sea, on account of the varied arrangement of the sea and of the islands and projecting lands. Hence it comes about that the waters, stirred up by the Moon, spread themselves out too quickly, and — dashed against and broken upon the shores and the neighboring islands — are in no way able to preserve a regular motion of flow and ebb.

This is also proved by the following experiment. If you cast a stone into the middle, A, of any round vessel filled with water, you will at once observe the water spreading itself out into circles and diffusing itself regularly and uniformly, producing there a proportionate increase and decrease.

Diagram. A small woodcut in the left column showing a round vessel (seen from above) filled with water, with concentric circular ripples spreading from a central point labeled A. Below the round basin is a band of hatched shading (the vessel's base/wall in cross-section). The figure illustrates the regular, uniform circular diffusion of ripples from a stone dropped at the center.

- A (center of the round vessel): the point where the stone is cast in.

Next take a vessel A C, drawn out lengthwise and full of water, and again cast a stone into its middle. You will see the circular ripples, on account of the unevenness of their radii, soon broken and flowing off in another direction, leaving nothing in the rim of the vessel beyond a disordered, tumultuous swell.

But if you allow a little board, V, to float on it, you will see that it stops the broken water-circles from dashing against the rim of the vessel.

Diagram. A second woodcut in the left column showing an elongated, rectangular vessel (vas A C) seen from above, full of water. Point A is at the top, point C at the bottom; concentric ripples spread from a center point. A small floating board labeled V sits at the middle. The water-lines are drawn irregularly broken near the sides, illustrating how ripples in an elongated basin are fractured by the unequal radii, and how the floating board V damps their impact on the rim.

- A (top of the elongated vessel): one end / the point where the stone is cast in.
- V (middle): the floating board that breaks the impact of the ripples on the rim.
- C (bottom of the elongated vessel): the other end.

I should like you to understand that the same thing happens proportionally in the Mediterranean Sea. For the waves born from the tide are at once dashed against and stifled at the neighboring shores and islands — except in the straits, where the tide, hemmed in as if among narrow passages, exerts its full strength. Historians relate that for this reason no small flow and ebb occur between the island of Cherchel [Cherehenes — island/town off the African coast, Caesarea/Cherchell [?]] and the African mainland.

Now let us explain how the flow and ebb come about in the innermost corner of the Adriatic Gulf. Since the sea, as I have said, [is driven] from east to west — that is, since the sea stretches from east to west into an immense length between the shores of Asia, Europe, and Africa, namely 60 degrees, which make 3,500 Italian miles — therefore, just as the power and influx of the rising Moon (whose slight breadth the sea cannot accommodate) is exerted along the length of the sea, so that even thus, when it cannot do otherwise, it may be carried along: and so, when the Moon rises, the sea, thrust toward the west, begins to swell, until the Moon has stood in the line of the Euronotus [the east-south-east point, ESE], which they commonly call the Scirocco. Then the whole force of the sea is gathered together, partly toward the west, partly toward the mouth of the Adriatic Gulf (since the breadth M X — which runs from that mouth M as far as the shores X of the African Gulf — is the greatest of the whole Mediterranean Sea, as the Map shows). Thus, insinuating itself with violent motion through the jaws of that mouth into the Adriatic, in the far end of that gulf it will soon, by the successive thrusting of the waves, cause an increase and a decrease.

But the reason it leaves no trace of a tide on the side-shores of the gulf is that the sea's flow imprints no impulse upon them (being too oblique). And this flow and ebb will last until the Moon reaches the opposite quadrant, as was explained at length above.

Now let us show how so great a force of the lunar tide arises in the Sicilian Strait. Since the Mediterranean Sea, as we said above, lies 60 degrees — that is, an interval of four hours — from the shores of Syria to Cadiz, it comes about that the Moon, when it has risen four hours above the Mediterranean Sea, then first causes the Atlantic Ocean, struck and compressed by the lunar rays, to begin its increase. Therefore, the sea being swollen to the utmost, and the waves of the Ocean successively gathering strength, having entered with the greatest violence through the jaws of Cadiz, drive the swollen waters of the Mediterranean — the Moon now descending — toward the east with the utmost violence, and most of all toward the mouth of the Sicilian Strait that lies directly opposite them. There it produces the aforementioned tide, most worthy of wonder: in the perpetual inconstancy of flow and ebb, perpetually constant.

[Margin: The equality of the flow and ebb in the Sicilian sea is constant.]

And although the tide takes on various forms of motion — now surging up, now sinking down, now bending to the sides, now breaking into whirls and eddies, now into ebullitions, as we showed above in Book V on Scylla and Charybdis — nevertheless the common tide, amid such great disturbance and confusion of motions, keeps so constantly to its period of six hours of flow and as many hours of ebb that the pilots of the ships, given the time at which the Moon will [occupy] the horizon or the meridian, or some other part of the sky, define by infallible reasoning the increase and decrease of the sea and its tide. And conversely, given the increase and decrease of the sea — even with the sky overcast by clouds — they declare the position of the Moon with certainty and without any error. This I should never have believed, had I not, after making an examination, learned the truth of the matter from the sailors themselves.

The remaining [matters concerning] this strait —

[Margin: The board floating in the elongated vessel keeps it from being broken[?] — the smaller marginal note beside the second figure, partly trimmed: "the floating board V... so that... it does not break..." [?]]

[Margin (top, partly cut): *freti accidentia vide si placet, lib. 2. Ubi ea ex...men alii exotici motus alicubi occurrerint, hîc* — "see, if you please, the circumstances of

the strait in Book 2, where they are [treated]... where any other unusual motions occur here."]

constantly, so that ship-pilots, given the time at which the Moon stands on the horizon or the meridian or some other part of the sky, can determine the increase and decrease of the sea and its tide by an infallible reckoning. Conversely, given the increase and decrease of the sea — even when the sky is covered with clouds — they can announce the position of the Moon with certainty and without any error. I would never have believed this had I not learned the truth of the matter by direct examination from the sailors themselves. The remaining matters concerning this strait—

[Margin: *refluxus in mari Siculo constantia*. — "The constancy of the ebb in the Sicilian Sea."]

[The following passage belongs to the close of the preceding Mediterranean discussion, printed in the inner column beside the table:]

except in straits, where the tide — confined as it were within narrow passages [angiportus] — exerts its full force. Hence, between the island of Cherchel [Cherchenes / Cherchel, Algeria] and the African mainland a considerable flow and ebb occurs, as historians report. Let me now explain how the flow and ebb come about in the innermost corner of the Adriatic Gulf. Since the sea, as I have said, [runs] from East to West—

[The sentence breaks off at the fold; the discussion of the Adriatic continues beyond this opening.]

The Tide-Table

TABULA — "A Table indicating the time of the tides in the various harbours of the German Sea [Maris Germanici — the North Sea], extracted from the hydrography of Fr. Fournier [P. Furnerii]."

The table is a single grid printed across the central fold. The left-hand stub-column **Dies** ("Days") carries the age of the Moon in two paired sub-columns: *A Novilunio ad Plenilunium* ("from New Moon to Full Moon," days 0–15) and *A Plenilunio ad Novilunium* ("from Full Moon to New Moon," days 15–30). Each of the sixteen data rows therefore serves two lunar days (e.g. day 0 / day 15). The sixteen data columns are each headed at the top by a compass rhumb (the wind/quarter that a given harbour faces) and labelled again at the foot by the reciprocal rhumb together with the list of harbours to which that establishment-

Top compass headings (left→right): N./S. · N¼NE · NNE · NE¼N · NE · NE¼E · ENE · E¼NE · E · E¼SE · ESE · SE¼E · SE · SE¼S · SSE · S¼SE.

	N	N	N	N	E	E	S	S	S							
Days	N.	¼	N	E		E	E	¼		¼	E	E		E	S	¼
(New→Full / Full→New)	/	N	N	¼	N	¼	N	N		S	S	¼	S	¼	S	S
	S.	E	E	N	E	E	E	E	E	E	E	E	E	S	E	E
0 / 15	1	1	1.	2.	3.	3.	4.	5.	6.	6.	7.	8.	9.	9.	1	1
	2.	2.	3	1	0	4	3	1	0	4	3	1	0	4	0.	1.
	0	4	0	5		5	0	5		6	0	5		5	3	1
		5													0	5
1 / 16	1	1.	2.	3.	3.	4.	5.	6.	6.	7.	8.	9.	9.	1	1	1
	2.	3	1	3	4	3	1	3	4	3	1	3	4	0.	1.	2.
	4	3	8		8	3	8		8	3	8		8	3	1	3
	8													3	8	
2 / 17	1.	2.	3.	3.	4.	5.	6.	6.	7.	8.	9.	9.	1	1	1	1
	3	2	6	5	3	2	6	5	3	2	6	5	0.	1.	2.	2.
	6	1		1	6	1		1	0	1		1	3	2	6	5
													6	1		1
3 / 18	2.	3.	3.	4.	5.	6.	6.	7.	8.	9.	9.	1	1	1	1	1.
	2	9	5	3	2	9	5	3	2	9	5	0.	1.	2.	2.	3
	4		4	9	4		4	9	4		4	3	2	9	5	9
												9	4		4	
4 / 19	3.	3.	4.	5.	6.	6.	7.	8.	9.	9.	1	1	1	1	1.	2.
	1	5	4	2	1	5	4	2	1	5	0.	1.	2.	2.	4	2
	2	7	2	7	2	7	2	7	2	7	4	2	1	5	2	7
											2	7	2	7		
5 / 20	4.	4.	5.	6.	7.	7.	8.	9.	1	1	1	1	1.	1.	2.	3.
	0	4	3	1	0	4	3	1	0.	0.	1.	2.	0	4	3	1
		5	0	5		5	0	5	0	4	3	1		5	0	5
										5	0	5				
6 / 21	4.	5.	6.	7.	7.	8.	9.	1	1	1	1	1.	1.	2.	3.	4.
	4	3	1	3	4	3	1	0.	0.	1.	2.	3	4	3	1	3
	8	6	8		8	3	8	3	4	3	1		8	3	8	

Days	N.	N	N	N	N	N	E	E	E	S	S	S	S	S	S	S
(New→Full / Full→New)	/	N	N	¼	N	¼	N	N	N	¼	S	S	¼	S	¼	S
	S.	E	E	N	E	E	E	E	E	E	E	E	E	E	S	E
									8	3	8					
7 / 22	5·	6·	7·	7·	8·	9·	1	1	1	1	1·	1·	2·	3·	4·	4·
	3	2	6	5	3	2	0·	0·	1·	2·	6	5	3	2	6	5
	6	1		1	9	1	6	5	3	2		1	6	1		1
								1	6	1						
8 / 23	6·	7·	7·	8·	9·	1	1	1	1	1·	1·	2·	3·	4·	4·	5·
	2	9	5	3	2	0·	0·	1·	2·	9	5	3	2	9	5	3
	4		4	9	4	9	5	3	2		4	9	4		4	9
							4	9	4							
9 / 24	7·	7·	8·	9·	1	1	1	1	1·	1·	2·	3·	4·	4·	5·	6·
	1	5	4	2	0·	0·	1·	2·	1	5	4	2	1	5	4	2
	2	7	2	7	1	5	4	2	2	7	2	7	2	7	2	7
					2	7	2	7								
10 / 25	8·	8·	9·	1	1	1	1	1·	2·	2·	3·	4·	5·	5·	6·	7·
	0	4	3	0·	1·	1·	2·	1	0	4	3	1	0	4	3	1
		5	0	1	0	4	3	5		5	0	5		5	0	5
				5		5	0									
11 / 26	8·	9·	1	1	1	1	1·	2·	2·	3·	4·	5·	5·	6·	7·	8·
	4	3	0·	1·	1·	2·	1	3	4	3	1	3	4	3	1	3
	8	3	1	3	4	3	8		8	3	8		8	3	8	
			8		8	3										
12 / 27	9·	1	1	1	1	1·	2·	2·	3·	4·	5·	5·	6·	7·	8·	8·
	3	0·	1·	1·	2·	2	6	5	3	2	6	5	3	2	6	5
	6	2	6	5	3	1		1	6	1		1	6	1		1
		1		1	6											
13 / 28	1	1	1	1	1·	2·	2·	3·	4·	5·	5·	6·	7·	8·	8·	9·
	0·	1·	1·	2·	2	9	5	3	2	9	5	3	2	9	5	3
	2	9	5	3	4		4	9	4		4	9	4		4	9
	4		4	9												
14 / 29	1	1	1	1·	2·	2·	3·	4·	5·	5·	6·	7·	8·	8·	9·	1
	1·	1·	2·	2	1	5	4	2	1	5	4	2	1	5	4	0·
	1	5	4	7	2	7	2	7	2	7	2	7	2	7	2	2
	2	7	2													7

		N		N		N		E		E		S		S		S
Days	N.	¼	N	E		E	E	¼		¼	E	E		E	S	¼
(New→Full /	/	N	N	¼	N	¼	N	N		S	S	¼	S	¼	S	S
Full→New)	S.	E	E	N	E	E	E	E	E	E	E	E	E	S	E	E
15 / 30	1	1	1·	2·	3·	3·	4·	5·	6·	6·	7·	8·	9·	9·	1	1
	2·	2·	3	1	0	4	3	1	0	4	3	1	0	4	0·	1·
	0	4	0	5		5	0	5		6	0	5		5	3	1
		5													0	5

Foot of each column — reciprocal rhumb and the harbours to which it applies (left→right, matching the data columns above):

- **S./N.** — Mouth of the Elbe [Ost. Albis.]; Enkhuizen [Enchusæ]; Hoorn [Hornæ]; Latus Fla. H. [Flanders shore? — abbreviation uncertain [?]]; Barwick [Barvici — Berwick]; In the Sicilian Strait [In Freto Siculo] G.
- **S¼SO** — Ad Mosam (to the Maas estuary [oftium]); Vlissingen [Flissingæ — Flushing]; Middelburg [Middelburgi]; In Beveland [In Bevesier].
- **SSO** — In Zeeland [In Zelandia]; to the Thames river [Ad Tamisin fluv.]; outside the harbour of Calais [Extra portum Cales.].
- **SO¼S** — To the Belle-Île [Ad Bellam Insulam]; before Vlissingen [Ante Vielingam]; before the Maas [Ante Mosam]; from Calais to Gravelines [A Caleto Gravelingam usque].
- **S.O.** — Amsterdam [Amstelodami]; Rotterdam [Roterodami]; Dordrecht [Dordraci]; before the dunes [pulvinos] of Flanders [Ante pulvinos Flandriæ]; before the Garonne [Ante Garamum]; in Gascony [In Gasconia]; Biscay [Biscaia]; Galicia [Gallicia]; Hibernia [Hybernia — Ireland].
- **SO¼O** — Between Calais and Calais [Inter Calecum, Caletum Rhotomagi — between (?) and Rouen [?]]; Ad S. Malo (to Saint-Malo); La Rochelle [Rupellæ]; the Scillies [Serlingæ]; on all the shores [In omnibus partibus] of Galicia, Gascony, Lusitania [Lusitaniæ — Portugal], Hibernia.
- **O.SO** — Texel [Texeliâ]; up to Calais [Caletum usque]; to St. Paul outside the harbour [Ad S. Paulum extra portum]; toward the southern coast of Ireland [Ad Australem plagam Hyberniæ].
- **O¼SO** — Plymouth [Pleimuthi]; Dartmouth [Dortmundæ]; Walmer [?] [Valmudæ]; the harbour of Milford in Ireland [Mulforti portu Hyberni].
- **O.** — Saint-Malo [S. Malo]; Antwerp [Antverpiæ]; Bremen [Bremæ]; Tessel/Texel [?] [Tessaliæ]; G.; Gouda [Goudæ].
- **O¼NO** — Bristol [Bristonia]; between Foy [?] and Walmer [?] [Inter Fogam & Valmudam]; before St. Nicholas [Ante S. Nicolaum].

- **ONO** — Texel [Texeliæ]; the Lizard [Lezarti]; before the Land [?] [Ante Terram]; at sea [In Mari].
- **NO¹/₄O** — From Wight up to Be... [A Wicht usque in Be...] along the shore [juxta littus].
- **NO** — In the Seine [In Sequana]; in Portland [In Portlandia]; on all the shores of Friesland [In omnibus littoribus Frisiæ].
- **NO¹/₄N** — Outside the dunes of Wight [Extra pulvinos Wicht].
- **NNO** — Dieppe [Diepæ]; Saint-Valery [Ad S. Valerium]; on all the shores of Picardy and Normandy [In omnibus littoribus Picardiæ & Normandiæ].
- **NN¹/₄O** — In the Thames [In Tamesi] H.; Étretat [?] [Estrehami].

[Text below the table — use of the table and the volvelle]

[The two text columns at the foot of printed p. 153 explain how to construct the table and operate an accompanying four-circle volvelle.]

the days from 15 up to 30, which are the days of the Moon's age. In the third column let the hours be written, from 12 up to 12, together with their corresponding minutes — as you see — which arise from the continuous addition of 48 minutes to one another. Thus you see the New and Full Moon at hour 12 in the table answering to 12, min. 0. If to these minutes you add 48, you will have 1:48 for the hour after the New or Full Moon on the first day. If to 48 you add 48, you will have 96; from which, with 60 cast off, there remain 36 — for the second day from the New Moon... ..up to 30, which are the days of the Moon's age.

[The volvelle.] Let the third circle, which represents the Moon's age, be divided into 30 parts, and at the thirtieth let an index be set which points to the rhumbs. Let the fourth circle, displaying the Sun's circle, likewise have an index extended to the rhumbs. Their use is this: when these four circles are joined at the centre — in such a way that each one, except the first two, which are fixed, can be moved separately — set the index of the Moon over the rhumb of the wind which a given harbour faces, and you will have in front....

[the tidal phenomena of the strait, look — if you wish — at Book 3, where we have demonstrated these matters exactly. Let this much suffice concerning the motions of the Mediterranean Sea. If, however, any unusual foreign motions should turn up somewhere that we have not set out here, their explanation can nonetheless be easily deduced from these principles of ours already laid down.

SECTIO III. ARS PLEMMYRICA [The Art of the Tides]

CAPUT I. On the use and practice of the marine tide [aestus marinus] in the art of navigation.

Now that in the preceding chapter we have reasoned at length about the nature of the sea's ebb and flow, it remains — for the benefit of those who plow the sea on unending voyages — to teach as well some of the usefulness that the flux and reflux of the sea tends to afford us. This too we shall carry out carefully, as precisely and exactly as can be done.

Now the Moon holds a particular dominion over moist things, so that there is no sea that does not swell at the time of the new or full Moon; nor is there any compound body — whether of the vegetable or of the sentient economy — that does not abound in moisture more at the times of conjunction and opposition, and less at the quadratures. The cause of this is none other than that this swelling of the sea follows the Moon's motion most exactly, and the said bodies keep step with it so precisely, to the very point, that sailors use no other rule for recognizing the hours of ebb and flow than the one the astronomers use for knowing the hours of the day and the Moon's place in the Zodiac. From which we conclude that the sea's motion is driven in exact step with the Moon's motion. But so that we may proceed methodically, we shall comprise the whole art in a few propositions.

PROPOSITION I.

To recognize, by the following table, the highest swelling of the sea in any port at a given hour.

Construction of the Table.

In the first column write the numbers from 1 up to 15; and in the second column from 15 up to 30 — these are the days of the Moon's age. In the third column write the hours from 12 to 12, together with their corresponding minutes, as you see, which arise from the continual addition of 48 minutes to one another. Thus you see that the new and full Moon at hour 12 in the Table answers to 12, min. 0. If to these minutes you add 48, you will have 1·48 for the hour of the first day after the new or full Moon. If to 48 you add 48, you will have 96, from which, casting off 60, there remain 36, for the second day from the new or full Moon. If

to 36 you add another 48, you will have 84, from which, casting off 60, they give 24 min. for the third day from the new Moon; and so for the rest.

In the remaining columns, moreover, the hours with minutes calculated in the said way are displayed, insofar as they correspond to the rhumbs of the winds [rhombi ventorum], in those parts that correspond to the Moon's position in the sky.

Use of the Table.

Take the Moon's age in the first column, and in the second column the hour with minutes; and in the following columns you will have the hour of the sea's highest rise in those places that are indicated by the regions of the world on the mariner's compass [pyxis nautica] by the rhumbs of the winds. For example: if you wish to know at what hour the sea's maximum rise occurs at Amsterdam on the tenth day of the Moon, look up the Moon's age 10 in the first table, and proceed sideways across to the column marked lower down "Amstelodamo" [for Amsterdam], and you will find 11·0 — that is, 11 hours after midnight, when the highest rise occurs there. The letters NE, SO, indicate the Moon set either in the NW or the SW, and so for the rest.

Sailors, however, find all this more readily and easily by means of the mariner's compass. But since few are skilled in handling the mariner's compass, we shall prescribe a still easier method, by which anyone may detect the hours of the sea's swelling at any time.

Let four circles be made, set one within another. Let the outermost and widest be divided into 32 rhumbs of the winds, to each of which sailors assign three hours, so that half a rhumb contains $1\frac{1}{2}$ hours and one quarter-part of a rhumb contains $\frac{3}{4}$ of an hour. Let the second circle be divided into 24 hours, from 12 to 12, as you see. Let the third circle, representing the Moon's age, be divided into 30 parts, and at the thirtieth let an index be set, to point out the rhumbs. Let the fourth circle, exhibiting the Sun's circle, likewise have an index extended to the rhumbs. Their use is this: with these four circles joined at the center — so that each one (except the first two, which are fixed) can be moved separately — set the Moon's index over the rhumb of the wind that some port faces, which you will have before you [in the]

Diagram. The printed (woodcut) tidal instrument [organum maritimum] occupying the upper half of the page, captioned (in italic): "The Marine Instrument by which, given the rhumb and the Moon's age, the fullness of the tide is found for any place whatsoever." It is the schematic of the four-circle

volvelle described in the facing text. The figure shows two concentric scale-rings drawn within a sun-rayed border (a sunburst of triangular rays surrounds the whole). The figure caption beneath the construction reads "Usus Instrumenti" [Use of the Instrument]. A horizontal and a vertical diameter cross at the center.

- Outer ring (the rhumb / hour ring): bears Roman-numeral hour divisions running around the rim. Reading clockwise from the top, the upright legible numerals are I, II, III, IV, V, VI, VII, VIII (the apex group), continuing down the right side IX, X, XI, XII. On the lower arc the numerals are printed inverted (engraved to be read by the rotating slip) and are only partly resolvable: forms reading as VII, VI, V, and a four-stroke group, with XII at the bottom, then up the left side XI, X, and toward IX/the top. [Several lower-arc inverted numerals are indistinct — flagged [?].]
- Inner ring: a finer graduated scale with tick-marks (no numerals legible at this resolution), corresponding to the hour/minute subdivisions.

[The printed page 154 carries this construction-diagram in its upper half; the rotating engraved instrument — the volvelle slip itself — is the separately mounted plate that follows, engraved to be cut out and pivoted at the center.]

Diagram. The engraved, mounted **volvelle slip** (an inserted intaglio plate, with no printed caption) — the working rotating instrument corresponding to the schematic on the facing printed page. It consists of two engraved circular discs joined within a rectangular plate-border:

- **Upper disc — the Moon's-age ring [tertius circulus, ætas Lunæ]:** a graduated annulus numbered in Arabic figures **1 through 30** running around the rim (the sequence 1, 2, 3 ... 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 ... up to 30 is legible, each at its own tick). At the foot of this disc a small pointer-tongue projects, engraved "**Index** ☾ " [the Moon's index — engraved "Index C," the lunar-crescent form], which points to the rhumb/age divisions.
- **Lower disc — the Geocosm (terrestrial globe) face:** an engraved map of a hemisphere showing landmasses and seas (continents drawn with shoreline and islands, the ocean hatched), representing the Sun's circle / the globe over which the tide is read. Across it lie two radial pointer-arms pivoting from a small circle at the disc's center, each engraved "**Index Solis**" [the Sun's index], one bearing the solar symbol ☉.
- Between the two discs, near the rim, is engraved a small decorative **rosette / compass-star ornament** (a circular foliate-and-petal device).

- **[Margin (manuscript, foot of plate, in a contemporary hand):** "fol. 154 tom[us] primus, deese a in dis[?]" — a binder's/owner's placement note, "folio 154, first volume, [it is] lacking..." — the closing words are an abbreviated cursive and not fully legible [?].]

Use of the Instrument.

[Proposition I continues, the text resuming beneath the diagram on printed p. 154:]

[which you will have before you in the] table set out; then set the Sun's index at the day of the Moon's age, and the hour that this solar index cuts on the hour-circle will be the hour sought, at which the sea's highest rise occurs in that place or port which faces the rhumb already marked.

For example: since Amsterdam faces the NE or SW wind, apply the lunar index to this rhumb on the instrument, and the solar index to the given day of the Moon's age — say, to 17 — and the index will cut for you the hour 4:36 min., the sought hour of the sea's highest rise. But if instead you set the Moon's index over SW and the Sun's index over the 17th day of the Moon's age, the index will likewise mark off for you the same hour on the hour-circle — namely the hour 4 and 36 min., the sought hour of the highest tide.

The same, briefly, by calculation.

Multiply the proposed day of the Moon — say, 17 — by 4, and the result is 68. Then [divide] this by 5, and the quotient will be $13\frac{3}{5}$ [the printed fraction is indistinct [?]]. Join the whole hours to the hours that the rhumb of the given place shows — say, 3 — and you will have 16. Subtracted from 12, this leaves 4 hours with 36 min., which remained over from the residue of the division. And this is the sought hour of the sea's rise.

PROPOSITION II.

To find, by another method, the sea's highest rise everywhere, for each single day of the Moon's age.

In the preceding proposition we set out the method by the mariner's compass; now we shall propose an easier one by means of a table, from which I say you may recognize the sea's highest rise more quickly than even by the observations of ship-masters, which we have also drawn out. For they construct this table quite differently from the way we did in the preceding one. In that one, indeed, they fitted the new moon to hour 12 of the night; in this one, to hour 3 before

midnight, with the Sun and Moon situated in the north-east, or Noto-Zephyrean, quarter — that is, with the Sun and Moon placed midway between East and North, or between West and South. Whence for the new-moon day itself they construct such a table:

[Note: is a second scan of the same printed page 154 (the "Organum Maritimum" opening), with the mounted engraved slip lifted away so that the underlying printed text and the upper diagram's rays show through; it carries the same caption, the same two text columns, and the same catchword "T A-". No new content beyond the already-transcribed p. 226 opening.]

LIBER TERTIUS — HYDROGRAPHICUS

SECTIO III — ARS PLEMMYRICA (The Art of the Tides)

CAPUT I — On the use and practice of the sea-tide in the nautical art

PROPOSITIO II (continued)

[This opening (printed folio 155) is occupied entirely by the full-page **Tabula Universalis Incrementorum Maris** — the "Universal Table of the Sea's Risings, arranged according to the monthly motion of the Moon" — which the preceding text introduced for finding the sea's highest rise on each day of the Moon's age. The table spans the two-page opening; its left half (Moon's age 0–13, New Moon to Full Moon) is transcribed first, followed by its right half (Moon's age 14–30, Full Moon to New Moon). The body text of Prop. II resumes after the table on the following pages; none of it appears on this opening.]

Table header (verbatim): **TABULA Universalis Incrementorum Maris, juxta menstruum Lunæ motum disposita.** ("Universal Table of the Increments [Risings] of the Sea, arranged according to the monthly motion of the Moon.")

NOTA (key, top-right of the verso): The marginal fractions answer to minutes as follows — | Fraction | Minutes | |---|---| | $\frac{4}{5}$ | 48 min. | | $\frac{3}{5}$ | 36 min. | | $\frac{2}{5}$ | 24 min. | | $\frac{1}{5}$ | 12 min. | | 0 | 0 |

[Margin (key): " $\frac{4}{5}$, $\frac{3}{5}$, $\frac{2}{5}$, $\frac{1}{5}$, 0 respondent [answer / correspond to] 48, 36, 24, 12, 0 minutes." The cell entries are given in hours and minutes (H.M.); the small fraction printed beside each whole hour is the minute-part, read off this key (e.g. $3\frac{4}{5}$ = 3 h 48 m).]

Row labels (left margin, two blocks):

- Upper block — **Horæ ante Meridiem, sive à Media nocte, in quibus fit Novilunium aut Plenilunium** ("Hours before noon, or from midnight, at which the New Moon or Full Moon falls"): rows 12, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.
- Lower block — **Horæ post Meridiem, sive à Meridie, in quibus fit Novilunium aut Plenilunium** ("Hours after noon, or from midday, at which the New Moon or Full Moon falls"): rows I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII.

[Convention: Arabic row/cell figures (1–12) denote forenoon hours; Roman cell figures (I–XII) denote afternoon/evening hours. Each cell advances by $\frac{4}{5}$ hour (48 min) both down each column and across each row, wrapping 12 → I and XII → 1.]

Left half — *Ætas Lunæ à Novilunio ad Plenilunium* (Moon's age, New Moon to Full Moon): columns 0–13

Hour (row)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
(unit)	H . M	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
12	1 2 0	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	13 $\frac{2}{5}$
1		4 $\frac{4}{5}$	5 $\frac{3}{5}$	6 $\frac{2}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	11 $\frac{1}{5}$
2		5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III
3		6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III	III $\frac{4}{5}$
4		7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$
5		7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$
6		8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$
7		9 $\frac{2}{5}$	10	11	11	12	I $\frac{2}{5}$	II $\frac{1}{5}$	III	III	IV	V $\frac{2}{5}$	VI	VII

Hour (row)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
			$\frac{1}{5}$		$\frac{4}{5}$	$\frac{3}{5}$				$\frac{4}{5}$	$\frac{3}{5}$		$\frac{1}{5}$	
8		10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	$I\frac{2}{5}$	$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$
9		11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	$I\frac{2}{5}$	$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$
10		11 $\frac{4}{5}$	12 $\frac{3}{5}$	$I\frac{2}{5}$	$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$
11		12 $\frac{3}{5}$	$I\frac{2}{5}$	$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$
12		$I\frac{2}{5}$	$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI
I		$II\frac{1}{5}$	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$
II		III	III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$
III		III $\frac{4}{5}$	IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$
IV		IV $\frac{3}{5}$	$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$
V		$V\frac{2}{5}$	VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3
VI		VI $\frac{1}{5}$	VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$
VII		VII	VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$
VIII		VII $\frac{4}{5}$	VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$	$5\frac{2}{5}$
IX		VII $I\frac{3}{5}$	IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$	$5\frac{2}{5}$	$6\frac{1}{5}$
X		IX $\frac{2}{5}$	$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$	$5\frac{2}{5}$	$6\frac{1}{5}$	7
XI		$X\frac{1}{5}$	XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$	$5\frac{2}{5}$	$6\frac{1}{5}$	7	$7\frac{4}{5}$

Hour (row)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
XII		XI	XI $\frac{4}{5}$	XII $\frac{3}{5}$	$1\frac{2}{5}$	$2\frac{1}{5}$	3	$3\frac{4}{5}$	$4\frac{3}{5}$	$5\frac{2}{5}$	$6\frac{1}{5}$	7	$7\frac{4}{5}$	$8\frac{3}{5}$

Right half — *Ætas Lunæ à Plenilunio ad Novilunium* (Moon's age, Full Moon to New Moon): columns 14–30

Hou r (row)	14	15	16	17	18	19	20	21	2	2	2	2	2	2	28	29	30
(uni t)	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H . M	H . M	H . M	H . M	H . M	H . M	H. M.	H. M.	H. M.
									.	.	.	.	.	.			
12	14 $\frac{1}{5}$	15	15 $\frac{4}{5}$	16 $\frac{3}{5}$	17 $\frac{2}{5}$	18 $\frac{1}{5}$	19	19 $\frac{4}{5}$	2 0 $\frac{3}{5}$	2 1 $\frac{2}{5}$	2 2 $\frac{1}{5}$	2 3	2 3 $\frac{4}{5}$	2 4 $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3
1	III	III $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	I X $\frac{2}{5}$	X $\frac{1}{5}$	X I	X I $\frac{4}{5}$	X II $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$
2	III $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	X I	X I $\frac{4}{5}$	X II $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$
3	IV $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	X I $\frac{4}{5}$	X I $\frac{3}{5}$	X II $\frac{2}{5}$	1 $\frac{1}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$
4	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	X I $\frac{4}{5}$	X II $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$
5	VI $\frac{1}{5}$	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	X II $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7
6	VI I	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$

Hou r (row)	14	15	16	17	18	19	20	21	2	2	2	2	2	2	28	29	30
7	VI I $\frac{4}{5}$	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$
8	VI II $\frac{3}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$
9	IX $\frac{2}{5}$	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$
10	X $\frac{1}{5}$	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11
11	XI	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$
12	XI $\frac{4}{5}$	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$
I	XI I $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 $\frac{1}{5}$	1 0	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$
II	1 $\frac{2}{5}$	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 0 $\frac{1}{5}$	1 1 $\frac{4}{5}$	1	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$
III	2 $\frac{1}{5}$	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 0 $\frac{1}{5}$	1 1 $\frac{4}{5}$	1 2 $\frac{3}{5}$	1	I $\frac{2}{5}$	II $\frac{1}{5}$	III
IV	3	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 0 $\frac{1}{5}$	1 1 $\frac{4}{5}$	1 1 $\frac{3}{5}$	1 2 $\frac{2}{5}$	I $\frac{1}{5}$	II $\frac{1}{5}$	III	III $\frac{4}{5}$
V	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	1 0 $\frac{1}{5}$	1 1 $\frac{4}{5}$	1 2 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II	III	III $\frac{4}{5}$	IV $\frac{3}{5}$
VI	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	1 1	1 1	1 2	I $\frac{2}{5}$	II $\frac{1}{5}$	II I	III $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$

Hou r (row)	14	15	16	17	18	19	20	21	2	2	2	2	2	2	28	29	30
										$\frac{4}{5}$	$\frac{3}{5}$						
VII	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	1 1 $\frac{4}{5}$	1 2 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II I $\frac{4}{5}$	II I $\frac{4}{5}$	IV $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$
VIII	6 $\frac{1}{5}$	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	1 2 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II I $\frac{4}{5}$	II I $\frac{4}{5}$	I V $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I
IX	7	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II I $\frac{4}{5}$	II I $\frac{4}{5}$	I V $\frac{3}{5}$	V $\frac{2}{5}$	VI $\frac{1}{5}$	VI I	VI $\frac{4}{5}$
X	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II I $\frac{4}{5}$	II I $\frac{4}{5}$	I V $\frac{3}{5}$	V $\frac{2}{5}$	V I $\frac{4}{5}$	VI I $\frac{4}{5}$	VI $\frac{4}{5}$	VI II $\frac{3}{5}$
XI	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	II I $\frac{4}{5}$	II I $\frac{4}{5}$	I V $\frac{3}{5}$	V $\frac{2}{5}$	V I $\frac{4}{5}$	V II $\frac{4}{5}$	VI $\frac{4}{5}$	VI II $\frac{4}{5}$	IX $\frac{2}{5}$
XII	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11	11 $\frac{4}{5}$	12 $\frac{3}{5}$	I $\frac{2}{5}$	II $\frac{1}{5}$	III	II I $\frac{4}{5}$	I V $\frac{3}{5}$	V $\frac{2}{5}$	V I $\frac{4}{5}$	V II $\frac{4}{5}$	V II $\frac{4}{5}$	VI II $\frac{4}{5}$	IX $\frac{2}{5}$	X $\frac{1}{5}$

[Margin (folio number, recto top): "Fol. 155"]

TABULA

For ascertaining the maximum increases of the sea, with the Sun and Moon set in the east-northeast quarter [Euro-borea plaga].

Moon's age [Ætas Lunæ]	♂☉	1	2	3	4	6	7	8	9	11	12	13	14	1
Hours of the sea's increase [Horæ incrementi maris]	3.0	3 $\frac{4}{5}$	4 $\frac{3}{5}$	5 $\frac{2}{5}$	6 $\frac{1}{5}$	7 $\frac{4}{5}$	8 $\frac{3}{5}$	9 $\frac{2}{5}$	10 $\frac{1}{5}$	11 $\frac{4}{5}$	12 $\frac{3}{5}$	13 $\frac{2}{5}$	14 $\frac{1}{5}$	1 5. 0

Moon's age [Ætas Lunæ]	16	17	18	19	21	22	23	24	26	27	28	29
Hours of the sea's increase [Horæ incrementi maris]	15 $\frac{4}{5}$	16 $\frac{3}{5}$	17 $\frac{2}{5}$	18 $\frac{1}{5}$	19 $\frac{4}{5}$	20 $\frac{3}{5}$	21 $\frac{2}{5}$	22 $\frac{1}{5}$	23 $\frac{4}{5}$	24 $\frac{3}{5}$	1 $\frac{2}{5}$	2 $\frac{1}{5}$

This table is composed by continuous addition of hours and of fifths of one hour. These fifths are, however, easily converted to clock-minutes in this way: since the Moon returns to the point it set out from 48 minutes later, if you multiply the numerators of the fifths in the fractions by 12, you obtain the clock-minutes wanted — for 12 minutes is a fifth of an hour, as is clear from dividing 60 by 5. For example, in the fraction $\frac{4}{5}$, multiply 4 by 12 and you get 48; likewise $\frac{3}{5}$ multiplied by 12 gives 36; $\frac{2}{5}$ by 12 gives 24; $\frac{1}{5}$ by 12 gives 12; and 0 by 0 gives 0.

You will also see that this table agrees exactly with the preceding one. For if in the preceding table you take the column NO or SW and proceed along the days of the Moon, you will find the sea's increase advancing in precisely the same way, according to the hours set out there: 3.0 on the first day of the Moon, 3 hours 48 minutes on the second day, 4 hours 36 minutes, and so on for the rest — which correspond beautifully to the table presented here:

♂☉	1	2
3.0	3 $\frac{4}{5}$	4 $\frac{3}{5}$

This is indeed a fine discovery. But since this table shows the sea's increase only for 3 hours before midnight, with the Sun and Moon set in the east-northeast [Euro-borea] or south-southwest [Notozephyrea] quarter, I have therefore — to make the table as universal as possible — arranged it by the method that follows. For from this, given any hour of the natural day at which the conjunction or opposition of the Sun and Moon falls, and given also any day of the Moon's age, I teach how to find the hour of the sea's increase.

Use of the Table. [Usus Tabulæ.]

Suppose you wish to know, on the first day of the Moon, at what hour the highest tide occurs, with the Moon set in the east-northeast or south-southwest position. Look up the hour 1 in the top row and the hour 8 before noon along the side — the position where the Moon stands, say, in the east-northeast — and the cell where they meet gives the answer: namely, the 10th hour. Likewise, if it is the 12th day of the Moon and you want to know — with the Moon then set in the east-northeast quarter — the tide at hour IV after noon: look up the 12th day of the

Moon in the top row, and along the side of the hours IV after noon, and the cell where they meet gives the answer: namely, 1 after midnight. Proceed no differently in the other cases. Note here that these numbers 1, 2, 3, 4, etc. indicate hours after midnight, whereas I, II, III, IV, etc. up to 12 indicate hours after noon.

Further, if a new moon [novilunium] or full moon [plenilunium] falls at any given hour — these being listed in the first column — for example: if you wish to know, supposing a new moon falls at hour 5 after midnight, when the sea's greatest increase occurs on the first day of the Moon, then look up 5 after midnight in the first column and 1 in the top row of the table, and the cell where they meet gives the hour as 7 and a half hours [7 cum $\frac{1}{2}$ hor.], the time sought. Proceed no differently in the other cases. But since these matters are far too easy to need any further explanation, I shall move on to other things.

PROPOSITION III. [Propositio III.]

To construct a universal instrument of flux and reflux for the whole globe of the earth, [drawn] for elevation 42 degrees. [ad 42. gr. elevat.]

First, let there be a movable circle marked with the letters A B C D, divided into 24 parts, which mark out the meridians around the globe of the earth, each one hour's space apart from the next; to these are inscribed the regions and seas in the order you see. Around this outermost rim draw an oval figure E F, G H, about which the first circle can conveniently revolve, furnished with the numbers and lines you see. Finally, let another, immovable circle, divided into 24 hours from 12 to 12, surround the oval figure — and you will have the instrument ready.

Its use is as follows. If you wish to know the increases and decreases of the tide at Rome throughout the whole compass of the ocean, then set the index A over the given hour of the Moon's ascent on the oval figure, and you will have the increases and decreases of the tides represented there for the whole globe of the earth, in every place at once. But note that the number of hours described on the oval figure marks the tides of the sea, which it makes by rising for six hours and falling for as many hours. You see, then, that as the Moon ascends above the horizon, for six hours continuously [the tide]

[the tide] rises, until it reaches the meridian, where the increase is at its maximum — as the watery swelling shows in the figure. The differences of the increases are aptly marked by the lines inscribed on the oval figure; and just as these increase or decrease proportionally, so they fittingly display the proportional increase or decrease of the tide in the division of the lines by points, on the assumption that the maximum increase is always 6 points.

Diagram. A large circular volvelle (the tide-instrument of Proposition III), occupying nearly the whole page. The figure shows three concentric rings:

- The **outermost ring** carries an hour-scale running 1–12 twice (the 24 hours of the natural day), read clockwise around the circle: at the top, beginning near "12," then 1, 2, 3, 4, 5, 6 (right side), then continuing 7, 8, 9, 10, 11, 12 (bottom and left side), back up through 6, 7, 8, 9, 10, 11 to the top. This is the immovable outer circle "divided into 24 hours from 12 to 12."
- The **middle (cross-hatched/stippled) band** is the oval figure E F G H, bearing the point-graduations of the tide. Around it are scattered single-digit numbers (1, 2, 3, 4, 5, 6 ...) marking the proportional tide-points, and the inscriptions "**Crescit**" (it rises) along one half and "**Decrescit**" (it falls) along the other.
- Reading labels around the band: E at the top (the cardinal point E of the oval figure); A on the left side (the index); the words **Crescit** (upper-left to lower-left, rising quadrant) and **Decrescit** (lower-right and again at bottom-left, the falling quadrants); small numerals 1–6 repeated through each quadrant marking the six points of tide-rise and tide-fall.
- Letters of the oval (E, F, G, H) lie at the four cardinal positions; E is legible at top, and an F-like mark appears at upper right near the decrescit inscription. [The letters G and H, and the inner index lettering, are partly lost in the hatching — read with care; 2 such peripheral labels flagged [?].]

The instrument as a whole models the ocean tide rising for six hours up to the meridian and falling for six, in opposite quadrants simultaneously.

[Sub-heading / rubric within Prop. III, set in italic:] *The wheel by which, for a given hour and a given meridian, the increases and decreases of the sea throughout the whole globe are found.* [Rota qua data hora & dato Meridiano, incrementa & decrementa maris in toto Orbe reperiuntur.]

Again, if you wish to know in what places the increase or decrease occurs, proceed thus: set the index A under point E of the oval figure, and you will see, among the seas lying beneath the meridian of Rome, the sea at the height of its increase in the Indian Ocean and in the Solomon Islands [Insulis Salomonis], which lie opposite the meridian of Rome. At the same time you will see, in the ocean lying beneath Persia and Mexico, the tide at the lowest point of its increase; and the remaining places, on the graduated lines, show the degrees of increase and decrease expressed in their own numbers, in each of the regions to which they correspond.

Again: if the index A is moved under the 1st hour of the Moon's ascent and increase, as described on the oval figure, you will once more see the increases and decreases throughout the whole globe of the earth; and so one must proceed through the remaining hours in order. For example: if you wish to know what the increase on land is at the time when the Moon has been five hours above the horizon, set the index A above the hour 5 — not on the outer circle, but on the inner circumference of the oval figure — and then compare the increases and decreases of any places whatever with the regions to which they are assigned, and you will have the answer. You will also see that whenever the sea's tide rises for six hours, it falls during the next six hours in the following quadrant, and the reverse; so that in opposite quadrants the sea is always rising and falling at once — all of which is shown most clearly on the instrument.

The outermost circle, divided into 24 hours, shows at what hour it is anywhere throughout the whole globe of the earth, by this procedure: if you wish to know, when it is 8 hours before noon at Rome, what hour it is in those places and regions inscribed on the circle A B C D, set the index of the Roman meridian above the given hour at Rome — namely 8 — and you will have the answer; for the hours

that correspond to the remaining regions will give what you sought. Thus in Syria it will be 12, in China 6 after noon, and so on for the rest.

PROPOSITION IV. [Propositio IV.]

To observe by an instrument, in the open sea, from where the flux and reflux arises — that is, from which quarter of the world it comes. [Undenam fluxus & refluxus, sive ex qua parte Mundi proveniat, in Albo mari per instrumentum observare.]

Let a mariner's compass [pyxis nautica] be set upon an axle CD. Let this axle extend below the water in proportion to the size of the ship — say, six paces — and let the axle have arms B B B, so that, with these driven firmly against the outside of the ship, the axle can turn freely within them like a body rotating on its poles in every direction, and as it turns can carry round with it the compass resting on top of it. Below the water, at its end, let it have attached to it a net E G [naffam E G], made of leather or even of thin sheets of brass, stretched out in the manner of a sleeve, pierced at its far end G, and fitted to the axle in such a way that it can revolve freely with the axle — and the instrument will be ready.

Diagram. A woodcut schematic of the current-finding instrument of Proposition IV. A vertical axle descends through the ship's side into the water (the water shown as horizontal wavy hatching). Labels:

- **A** (top): the mariner's compass [pyxis nautica] mounted on the head of the axle.
- **B, B, B** (three positions down the upper axle): the bracing arms driven against the ship's side, drawn as paired rounded clamps.
- **D** (on the axle, just at the waterline / lower axle): the lower part D E of the axle.
- **6** (in the water beside the axle): the depth-marker (paces below the surface).
- **E ... G/a** (lower right, the conical net): the leather or brass net stretched like a sleeve, tapering to its pierced far end G (a small letter resembling "a"/"G" at the net's point).

So, if you wish to know which way the sea-currents run, fix an instrument of this kind to the ship's side, wherever the sailors find most convenient, with the part D E of the axle thrust below the water, its brass net sunk to 6, 7, 8, or more paces by its arms. And in this way it comes about that the flowing water carries the net along according to the current's flow and direction; and the net, so carried, consequently turns round with it the axle attached to it, together with the compass; and the compass needle within its rim will show in which direction the current presses. By means of this instrument the courses and directions of the individual currents can be accurately recorded.

This is a thing not only useful to sailors but absolutely necessary; for they often suppose that with sails spread they are making for some place under a favorable wind, when in fact, owing to the sea's hidden motion, they are so far from drawing nearer that in time they find they have rather fallen far back — as happens to those who make for the island of St. Helena [Insulam S. Helenæ].

PROPOSITION V. [Propositio V.]

To construct a clock of the marine tide that may perpetually demonstrate all the increases and decreases of the tide and the degrees of them. [Horologium æstus marini construere, quod omnia æstus incrementa & decrementa, gradusque eorum perpetuo demonstret.]

Long and much did I ponder by what means a kind of clock-mechanism might be devised that would perfectly show, by its index, the increases and decreases of the tide in their degrees. At last a certain method occurred to me, which I do not so much describe as merely point out in a few words to ingenious mechanics.

In some public harbor that is governed by the marine tide, let a small round tower A B be built, in the form of a well-shaft; it must be founded within the ground B C, at a depth equal, as far as can be done, to the sea-bottom. At the bottom let it have openings D, so that the seawater may readily work its way into the hollow of the column; while above ground it may rise to whatever height B A you please. This done, let a round float [orbis] E be made of the finest latten [aurichalco] or brass, hollow within and sealed, to the end that no water may penetrate, and so that, full of air, it may float on the surface, as is usually done with a cork float. At its center E let a cord F be fastened, which is wound twice or three times around the axle G H, and at whose end a leaden weight is hung, so that the cord may not unwind. On the face of the column let another wheel K L M N be made, which marks on its circumference the increases and decreases of the sea over six hours. Then let an index be fixed to the end of the axle, which can turn this way and that on the immovable surface of the wheel K L M N — and you will have the machine ready. You will record the increases and decreases of the sea on the outermost surface of the clock's wheel by observation, with this ingenuity.

At the hour when the sea is at the lowest point of its increase, let the index be set on the meridian line, or on the horizontal — it makes no difference. And since the brass float, fixed to the cord, floats freely on the water, it comes about that as the water rising within the column gradually rises, together with the float swimming upon it, in step with the sea's successive increase — and since the cord, from which the float hangs, is wound around the axle, and the index is fixed to the end of the axle —

Diagram. A woodcut of the tide-clock of Proposition V: a tall round tower (well-shaft) standing in the sea, shown in section. Labels:

- A (top of the shaft): the top of the tower A B.
- H ... G (top crossbar): the axle G H spanning the top of the shaft.
- F (upper interior): the cord F running down from the axle.
- I (mid-interior, on the cord): a mark on the cord / the suspended weight.
- E (lower interior, the spherical float): the hollow brass float E swimming on the rising water.
- B (just below the float, at a rule across the shaft): the level B (within-ground portion B C below).
- D (near the foot): the openings D admitting seawater.
- C (at the very foot, with hatching for the foundation): the foundation B C in the ground.

- A vertical **scale 1–10** runs up the left interior of the shaft (the feet of increase).
- At the upper right, set apart as an inset, is the **dial K L M N**: a round graduated face (drawn like a compass-rose) with letters **K** (top), **L** (right), **M** (bottom), **N** (left), bearing the index that registers the tide in feet.

[Margin: Omnia in Mundo contrariis constant.] *All things in the World are composed of contraries.*

[Margin: Nihil sine motu consistere in Mundo potest.] *Nothing can subsist in the World without motion.*

[Margin: Humor quiescens putredini obnoxius est.] *Standing moisture is liable to putrefaction.*

[Margin: Mare in perpetuo motu & circulatione versatur.] *The sea is engaged in perpetual motion and circulation.*

— the index, [being so fixed,] the axle will necessarily turn together with the index. The moving index, on the outermost surface of the outer wheel, will likewise show in order the degrees of the increases or decreases.

For example: if the increase of water in the column has risen to one foot, the moving index will mark on the dial [Tabula] a space proportionate to the increase, and there on the dial you will accordingly mark I, that is, an increase of one foot. If the water, together with the brass float, has risen 2 feet within the column, then see how far the index has advanced on the outer circle, on the rim of the wheel assigned to the measure of feet; and in this way you will observe all the degrees of increase as far as feet, up to the maximum increase. When the water, together with its brass or cork float, has reached this maximum, you will then mark the limit of the index too with a special sign. As the sea falls, the water within the column will likewise descend together with its steel float; so that if it has descended one foot, you will mark the limit of the index in the same way, on the smaller circle within the dial; and so on in turn, until you have completed all the feet of increase and decrease on the dial — and you will have the device finished, contributing not so much to the great adornment of the harbor as to the profit of sailors.

These are the things I thought worth communicating, in a few words, about the clock of the sea-tide, to ingenious craftsmen, who, should they weigh this matter duly, will, I do not doubt, find it a rich harvest of new inventions.

CHAPTER II. [Caput II.]

On the Pericyclosis or Circulation of the Ocean. [De Oceani Pericyclosi seu Circulatione.]

I think no one is of so dull a mind that, considering more deeply the providence of the divine Godhead in the governance of Nature, he is not carried away into the highest admiration. The Architect and Maker of the World had founded the World most constant under certain perpetual laws of change; and just as He resolved to preserve the astral bodies of the World by a certain perpetual and unwearied revolution, so too He was pleased to preserve the elemental World by a perpetual circulation [pericyclosis] of the elements, with a certain ceaseless conflict and a counter-craft [Antitechnia] of contrary qualities. Hence there is in the nature of things no substance that is not furnished with a motion of its own or another's, deprived of which, the whole nature of things must necessarily pass away into nothing.

This principle of motion is observed above all in the watery element, which, by the condition of its fluid nature, cannot rest — being, indeed, above all in need of motion (without which, with no surviving remedy, the whole elemental nature would collapse). And it is plain from experiment: water that is not moved at once putrefies, breeds worms, shuns the air, takes in malignant impressions — the mother of innumerable diseases. Rainwaters caught within the bounds of ditches, left unmoved, first grow green, then turn black, and at last degenerate into frogs, toads, serpents, and insects of every kind, with great danger of airy infection. And how great a harm to nature would have been brought about, had that vast body of the Ocean been left without motion? Without doubt the whole elemental nature, languishing and at last overthrown, would have collapsed through a certain infinite abundance of putrefaction that would thence have overflowed into the earthly body; the springs and rivers, the lakes and pools, would have ceased; all vegetables would have vanished, with the consequent destruction of every living thing.

To avoid these harms to nature, the Author and Founder of Nature, GOD Best and Greatest, willed the Sea to be in a certain perpetual motion, stirred by the hidden influences of the Moon, the Sun, and the other stars. Hence, besides the motion of the tide — which surges in the fourfold flux and reflux within the space of a natural day — and the others pointed out above, He turns it also by another circular motion, unknown to this very day. And just as He set the Ocean [moving] from East to West according to the daily motion of the luminaries, so He

established another [motion] from the North Pole to the South; [Margin: The Ocean is absorbed beneath the Arctic Pole and regurgitated beneath the Antarctic. (Oceanus sub Polo Arctico absorbetur, & sub Antartico regurgitatur.)] by which the Sea, sucked into a vast whirlpool beneath the Arctic Pole and swallowed up, through unknown recesses and unexplored windings of its channels, with tortuous and incomprehensible meanderings at last emerges again at the Southern Pole. Just so, in the human body, in the course of a single natural day, the blood has been discovered — in these latest times — to circulate through all the channels of the veins; and the cause of this is none other than that the whole of nature — the heavens, the elements, the humors of the human body — connected and corresponding to one another by a certain perfect analogy and wondrous proportion, might in this way be preserved in their being.

But perhaps you will say: who showed you those whirlpools of the polar regions of which you speak? Who ever saw them? I ask you in turn: the origin of the sea's motion, as it discharges itself through subterranean passages into springs and rivers — neither you nor any other mortal has ever seen it; therefore it does not exist? A very poor inference indeed, which could be applied to countless other things. I say, then, that no one has indeed seen those whirlpools; yet that they exist can be shown both by reason and by experience and by authorities — and first by this reasoning:

[Margin: It is proved that the Sea is absorbed beneath the Pole. (Probatur Mare sub Polo absorberi.)] Since these regions are unsuited for the convenient sustaining of human life — both on account of their half-year of light and half-year of darkness — it was fitting, lest the nature of things should seem to be idle in those regions, that the beginnings of the hydro-circulation [hydro-pericyclosis] should be established beneath these fixed points; for from this circulation the marine water, through

[...the marine water] is drawn off through the unknown windings of the earth, channeled as it were into a kind of subterranean belly. There it meets the subterranean fires that are present everywhere, and is digested and concocted, as it were, into a seed and nourishment of nature and of all things. Its earthy body, which was congenital to it from the beginning, draws to itself the saline spirits, while the mineral clods draw into themselves that unctuous moisture necessary for completing the maturation of metals. And the species of plants draw — by a kind of magnetic power — whatever was most suited to their nature. Whatever portion of the waters remains undigested and unconcocted is expelled through the Antarctic Pole, to be more perfectly digested and concocted by a repeated

circulation. For in this way that vast body of the sea, teeming with innumerable dregs and the rubbish of terrestrial mixtures, is prepared — through such a circulation, digested and purified by the continual concoction of the subterranean fires — into an ever new seed and nourishment of nature.

[Margin: The second reason.] **Second reason.** If that circulation through both Poles did not exist, the sea beneath the Pole would without doubt remain forever condemned to frost and irresoluble ice, motionless. But an unmoving sea induces the worst putrefactions; the worst putrefactions produce exhalations and vapors; and the regions lying round about, affected by these, could not be preserved without great slaughter of men and animals.

[Margin: 3rd reason.] **The third reason** is this. For the past two centuries the entire terraqueous globe has become so well known to us through frequent and most difficult voyages that scarcely a corner of land or sea remains that has not been detected and explored — except the regions lying beneath each Pole. Indeed, after so many attempts by the Dutch and the English, after the loss of so many men extinguished by hardships, hunger, thirst, and cold, frustrated in their hope, so far were they from attaining the sub-polar tract that not even [Margin: Many have attempted access to the sub-polar tract, but no one has reached it.] the foremost of them were able to advance beyond the eightieth parallel of latitude — the clearest signs of an inaccessible sub-polar district. What did Davis [John Davis] not attempt? What did Hudson [Henry Hudson] not attempt? What did the Dutch not attempt in their threefold voyage toward the North, with Barentsz [Willem Barentsz], a man most skilled in astronomy, as director of the whole navigation? While he pressed too eagerly toward the goal he had set himself, he was extinguished by the force of the cold in the midst of his enterprise. And Hudson, cast out into a small boat by his rebellious crew, was never seen again.

[Margin: The sea around the Pole is most rapid.] **The fourth reason** is that of those who, partly by their own eyes, partly by what they have committed to writing, perceived that the sea beneath the Pole cannot be overcome on account of its rapidity. Geographers report marvels about a certain English Minorite monk of Oxford, whom — translated to the Pole by Magical Art, they say — found there a certain black rock thirty-five leagues in circuit, beneath which the Ocean, drawn in with incredible speed through four channels [Euripi] into the sub-polar region, is absorbed beneath that said region through an immense whirlpool. Whatever may be the case regarding the truth of this narration — for even if it seems fabulous to many, I would not on that account judge it altogether to be

rejected, since this sub-polar whirlpool has many Geographers as its supporters and is established by not incongruous attestations.

The English, carried to those shores — as Purchas [Samuel Purchas] reports in his Geographical relations — were warned by the natives of Greenland not to proceed further if they wished themselves and their ships to be safe; for the sea toward the Pole is so surging and so rapid that a ship once entered can by no human industry be drawn back. The *Atlas Novus* relates that sailors at Spitsbergen engaged in whale-fishing told how no ship advancing beyond the 82nd parallel of Northern latitude returned, and that the boats of their men that strayed too incautiously through those districts never appeared again; and that the sea there, rushing forth as if from some mountain, sweeps everything along with it — clear testimony indeed that beneath the Pole, or in the parts near it, there is an immense whirlpool, by which water drawing water, together with the ships floating upon it, is absorbed with irremediable violence.

[Margin: Pet. Joannes Faber in his *Panchymicum*.] All this is confirmed both by Petrus Ioannes Faber [Pierre Jean Fabre], physician, in his *Hydrographia*, and in his *Panchymicum* (book 4, ch. 7), in these words: "*There are in the North four channels [Euripi], whose interiors, on account of the rapidity of their motion, are never bound by ice, and which rush toward the Arctic Pole with such headlong violence that no one could express it in words; for there the Ocean is swallowed and devoured by the land, and there are many who have seen these channels, and have witnessed the peril of several ships which, snatched away by these very channels, were never seen again.*" And in chapter 8: "*A marvelous secret of nature, whose reasons and causes no one has yet investigated, because this motion was unknown until it became fairly well known through voyages.*"

But whoever desires to know more about the marvelous constitution of this sub-polar region — about that immense whirlpool, and the rapidity of the sea drawn in through the four channels — let him read the *Nautical Observations* of the following authors: Hugh Willoughby [Hugh Willoughby], knight; Richard Chancellor; Stephen Burrough; Charles Jackman; James Hall; Martin Frobisher; John Davis; Jacob Cnoxen of 's-Hertogenbosch; [Margin: Giraldus Cambrensis.] and Giraldus Cambrensis [Gerald of Wales] — the last of whom describes it in the following words: "*In the Northern part is found a certain immense whirlpool of the sea, toward which all the waves from remote parts seem to be moved; as if by a conduit they flow together and are devoured, and pouring themselves there into the secret recesses of nature, are as it were swallowed into an Abyss. And so if a ship by*

ill fortune should fall into it, it is snatched and drawn with such force that the irrevocable power of voracity immediately absorbs it."

These reasons will suffice to establish that sub-polar whirlpool, by which the absorbed sea — circulated through the inmost vitals of the earth by ducts incomprehensible to the human mind — is at length [Margin: The sea is vomited forth again beneath the Southern Pole.] regurgitated at the other, opposite Southern Pole, as I shall demonstrate a little further on.

Diagram. A circular plan-view schematic showing the constitution of the Arctic Pole [*Poli Arctici Constitutio*]. The figure depicts a great circular ocean spiraling inward to a central whirlpool (a tight vortex at the center), surrounded by a ring of mountainous coastlines drawn around the rim. Gaps in the encircling land mark the four channels (the four *Euripi*) through which the Ocean flows inward. Readable peripheral labels, by position around the rim:

- Upper-left (along the coast): *Americæ Borealis* — "of North America."
- Left side: *Groenlandia* — "Greenland."
- Lower-center (an island in the rim): *Spitzberga* — "Spitsbergen."
- Right side: *Tartaria* — "Tartary."
- Two box-cartouche channel labels on rim gaps: *Euripus* — "channel / strait" (marking the inflow straits; one upper-right cartouche, one lower-center cartouche beside *Spitzberga*).

Full rim set (clockwise): *Americæ Borealis*, *Euripus* (upper-right cartouche), *Tartaria*, *Euripus* (lower-center cartouche), *Spitzberga*, *Groenlandia*.

Diagram. A circular plan-view schematic showing the constitution of the Antarctic Pole [*Poli Antarctici Constitutio*]. The figure is a plain disk of radiating lines converging on a central point, depicting the place where the sub-polar sea is regurgitated and flows outward from the Southern Pole. No peripheral place-labels are present (in contrast to the Arctic figure above); the disk shows radial striations emanating from the center.

is regurgitated [*gurgitatur*], concerning which Petrus Ioannes Faber, cited a little before, speaks thus in the place quoted: "*Those who have sailed to the Southern Pole have seen that influx of waters at the Antarctic Pole rushing against them with such violence that in no way is it permitted to go against it, either by oars or by sails; just as around the Arctic Pole they are borne with such rapacity toward the Pole that no ship can by any means extricate itself from the rapidity of the waters, if it should by chance come into the very channels [Euripi] of the Ocean.*"

[Margin: Observation of the chief navigators.] The same is attested by the *Account of the discovery of the new Strait in the Magellanic Sea*, commonly called *de Maire* [the Strait of Le Maire]; in which those Dutch chief-navigators, after they had reached nearly the 60th degree of Southern latitude, on account of the contrariety of the waves and the dreadful headlong rushes of the waters, were not permitted to proceed further.

[Margin: Herrera in his *History of America*.] The same is testified by Herrera [Antonio de Herrera] in his *History of Southern America*. "*From the Kingdom of Chile*," he says, "*a maritime fleet was dispatched by royal counsel to discover the regions of the Southland; but it was impossible for it to proceed beyond the 70th degree of latitude, on account of the rapidity of the waters perpetually rushing against them — even in calm air and without winds.*"

[Margin: The Pole could not be approached on account of the violence of the onrushing waves.] The Dutch Hollanders too attempted this route toward the Southern Pole; as the inhabitants of New Holland [New Zealand / New Holland] report — their *Itineraries* mention it here and there — who, having pushed deep within the immense expanses of seas along the shores of the Southland, when they found the sea always as if headlong, driven back by the violence of the waves, judged that route by no means to be pursued further, since nature had denied access to it.

These are surely clear signs that the sea somewhere in the sub-polar region suffers a violent eruption and regurgitation. This too was the reason why, from the sixtieth degree all the way to the Southern Pole, no knowledge of the situation and constitution of the sea, or of the lands and islands, has reached us to this very day — so that it does not seem to lack a most hidden mystery of nature, that it has thus far remained unapproached and unexplored. For toward the sub-polar tract, sailors carried whether by chance or by deliberate intent, and absorbed by the force of the sea, have been unable to send back any messenger of so great and so unhappy a fate; while those carried toward the Southern Pole, surrounded on every side by the regurgitating sea, have not been able to overcome its onset.

[Margin: Georgius Bruyn in his *Theatrum Urbium* supposes there is a Paradise somewhere beneath the Pole.] When these matters were more closely considered, Georgius Bruyn [Georg Braun, of the *Civitates Orbis Terrarum* / "*Theatrum Urbium*"] supposed the Pole to be inaccessible — and therefore that God had established the terrestrial Paradise, translated there beneath it, impervious to human footsteps. But since these things do not agree with reason, he would perhaps have thought better, in agreement with us, if he had conjectured the

cause of the inaccessibility of such places to lie in nature's pericyclosis from Pole to Pole.

A distinguished philosopher, not long ago, when he had read with the greatest admiration this pericyclosis of nature in my *Itinerarium Extaticum terrestre* [*Iter Exstaticum*], proposed to me in a letter he sent the following doubt: Why has nature so girded the sub-polar region with a perpetual concatenation of Islands that the Ocean scarcely has access to it — on one side by Greenland, Spitsbergen, and Greenland; on the other by the as-yet-unexplored shores of America and of Asiatic Tartary — which, separated from one another by a fourfold narrow of straits, admit only a small quantity of Ocean? I replied that this was done by the admirable ingenuity of nature: first, so that they might, as it were by a wall, blunt and restrain the violence of the Ocean driven thither. Second, so that the said Regions might be as it were certain boundaries, which would show that one should proceed no further there, where with savage chances and deadly perils the sea would carry everything topsy-turvy, with the irremediable ruin and destruction of ships and men. Hence too nature seems to have set in opposition the glacial sea, which — rising up with its masses like mountains — so obstructs access to the surging sub-polar sea-region that it removes all hope of penetrating beyond the eightieth or eighty-second degree of latitude, as is clearly evident in the Dutch expedition toward the North. But at the opposite Pole, the very onset and violence of the regurgitating sea turns aside of its own accord those attempting to approach it, while they cannot overcome the trouble of the onrushing waves.

Here you have our opinion concerning the circulation of the sea from Pole to Pole — described, perhaps, more fully than was fitting. But to what end, or what utility it confers upon the Earth, will be shown fully in its proper place in what follows. Read, if you please, what we discuss more fully concerning this secret of nature in our *Itinerarium Extaticum II* — which is also called the forerunner of this work — Dialogue 1.

CAPUT III.

De Salsedine Maris, ejusque origine, necessitate, aliisque Oceani
Mariumque accidentibus.

On the Saltness of the Sea, its origin and necessity, and the other accidents of the Ocean and Seas.

[Margin: The great variety of opinions on the saltiness of the sea.] We have consulted thirty-three authors of great name who treat most fully of the saltiness of the sea, in order to examine what causes of so celebrated an operation of nature they might bring forward. But it can scarcely be told how great is the diversity of all their views, how great the confusion of opinions. Certainly one cannot suppose that the Ocean itself rolls up as many tides as those who, befogged with this kind of mental fog, roll them up in their minds. A certain person, since he had at that time no knowledge either of the Ocean's nature or of Geography — the latter being then unknown — went astray in many things, as may be seen in *Meteorologica* book 4, concerning which below. [Margin: No element is given pure and simple.] His followers and adherents, while they strive to defend their Master and vindicate him from errors, fall into graver ones; and in this way errors are propagated chain-fashion in the lecture-halls, while truth itself is not attended to, but in place of truth that most rotten *αὐτὸς ἔφα* [Greek: *autos epha*, "he himself said it" — the Pythagorean appeal to the master's bare authority] is ignorantly babbled — when it is not even ascertained, by the rules of knowing, whether the thing in question truly exists, what it is, and in what it consists. Instead, they contend with singular mental exertion over the difficulty of the proposed question. Add to this experience, the Mistress of all things, without whose assistance nothing in physics can be rightly unraveled. Hence many, leaving aside the proximate causes, take refuge in remote ones and in I-know-not-what metaphysical speculations. Some establish their opinion by absurd and ridiculous fictions. There are those who come close to the truth; and some recede from it as far as scarcely anyone could imagine.

We wish to contend with no one, but, following the thread of our own principles, we shall here set down our own opinion among the rest — which, even if we do not demonstrate it *ἀποδεικτικῶς* [Greek: *apodeiktikōs*, "demonstratively," by strict proof], we shall nevertheless so establish by various experiments that all who are accustomed to weigh matters in the balance of fair reasoning will concede it to be, if not true, at least not far removed from the truth — that is, most probable.

[Margin: No element is given pure and simple.] I suppose, then, first: that no element, pure and simple, considered in physical terms, can naturally exist in the nature of things; but that all bodies are mixed and elementated, packed with a manifold mixture of things, and that the individual elements exist wrapped up within one another. Hence no element can be so purified that a true resolution into the simplicity and purity of a simple element be possible — which we shall prove in innumerable ways in their proper place below.

I suppose, second: that prime matter, compounded in physical compositions, is the salt of nature inhering in all bodies, implanted in it from the first beginnings of the Chaotic mass; without which they could neither have consistency and subsistence, nor be preserved in their being — inasmuch as it (to speak chemically) fixes all bodies.

[Margin: Nothing in the nature of things is destroyed.] I suppose, third: that nothing in the nature of things is regularly destroyed, whether from the elements, or from the vapors and exhalations drawn from them, but that the individual things are restored to their elements. In this way vapors are drawn from the sea, which, a little later condensed by cold and resolved into rains, snows, hails, hoarfrost, dew, and mist, are restored to those elements from which they were extracted. The same is to be said of earthy exhalations.

These things being laid down, I say first: that saltiness was implanted by nature, in the primordial founding of things (as soon as the water, digested into its channels by the voice of God, uncovered the Earth), in the Ocean and in all the other waters — yet in such a way that, according to the proportion of the waters and of the other natural bodies, the quantity of salt inserted into them is found to vary. [Margin: Salt gives consistency to all bodily things.] For since salt, the earthy element, gives to corporeal things their consistency and (as the chemists say) their fixation, or a certain palpable density, which they would never have furnished without the fixative element salt — it follows that brackishness was necessary both to the sea and to all things. Moreover, since the Earth together with the Ocean and the Seas forms one globe, just as the whole mass of the Earth is imbued with salt, so too the sea — which, sucking the salty humor from the Earth on every side as it were from breasts, draws it as its nourishment — afterward, through subterranean passages, restores by right of nature to the Earth, as a kind of debt owed, the salty humor (which it had drawn off and sucked out), according to Supposition 3; or rather the Earth, by a kind of reciprocal attraction, takes back from the sea what it had granted to the sea, now constricted within the subterranean prisons. But how this happens will be explained hereafter.

[Margin: Salt the earthy element.] Salt, therefore, according to our opinion, is the terrestrial element, or a certain seed of nature, furnishing to all bodily things both consistency and nourishment. The clearest sign of this is that there is no body — whether from the sensitive, the vegetable, or the inanimate kingdom — which does not subsist and is not nourished by this, or which, when destroyed, is not resolved into it.

You will say: The salt waters of the sea are actually converted into fresh waters through the resolution of the extracted vapors, which cannot happen without the reparation of the salt. Therefore the conclusion is false. That this objection may be set forth more clearly:

[Margin: Salt is twofold, fixed and volatile.] It is to be noted that salt can here be considered in two ways: fixed and volatile. We call that salt *fixed* which is naturally inserted into all and singular things, and cannot be separated from them at all. But that we call *volatile* which, by reason of its spirituous substance, is separated from the fixed salt and flies off. This laid down: Granting the antecedent, I deny the consequent. The reason is that although the Sun draws vapors from the sea, which afterward, resolved, return into sweet rains, it does not therefore follow that such waters are so separated from all radical salt that not even tiny little portions of salt remain — even if these are scarcely discernible to the sense by taste. And experience teaches this to be true even in any spring water whatsoever; for water of this kind, distilled through an alembic, always leaves a little salt at the bottom, as is well known to the chemists.

COROLLARIUM I.

Corollary I.

[Margin: Salt virtually included in the Chaotic mass.] Hence it is clear that the terraqueous globe, still lying hidden in the Chaotic mass, contained salt within itself virtually from the first beginnings of things, but first burst into act on the third day, when the separation of the waters into their own channels, distributed by God, laid bare the Earth — free from the mass of waters by which it lay enveloped. And in this way many controversies about the origin of salt, with which the commenta[tors...]

Diagram. A large fold-out engraved plate depicting a full disk of the Moon, printed across two facing leaves (the left half the right half and bound to face printed p. 162. The engraving shows the lunar disk in selenographic detail: dark maria rendered in fine horizontal hatching, bright highland regions stippled, and numerous craters drawn as small rings with central points. A prominent rayed crater near the disk's center (lower middle) is drawn with radiating spokes. The plate is enclosed within a double ruled border.

No engraved or printed labels (place-names, point-letters, scale, or caption) are legible on the plate at this resolution. The only lettering present is a later manuscript annotation in the right margin in a cursive hand:

- Top right (manuscript, ink): "Tomus I 6.2" [recte: "Tomus I" with the page reference] — i.e., Volume I
- Below it (manuscript, ink): "pag. 162" — the facing printed page
- Below that (manuscript, ink): "Kircher mundus Subterraneus" — identifying the work

[The plate carries no Latin body text]

with which the records of the commentators are filled, can be resolved.

Daily experience teaches that salt is necessary for man and for the other animals — the one seasoning of all foods. For whatever salt does not correct is not corrected; and whatever is not corrected becomes wholly unhealthy, indigestible, and rotten to the man who consumes it. Salt is truly the natural medicine against diseases. Not without reason, then, does Homer [Homerus] call it divine, as that which preserves from corruption everything that we see. I would add that the principles of all generative things derive their origin from salt. This is why the poets imagine even Venus Aphrodite [Venerem Aphroditim] as born from the foam of the sea, as though by this very emblem [Greek: ἐν τῷ τύπῳ (en tō typō, "in the figure/emblem")] they meant to set forth the generative power of salt dispersed throughout the sea; and for the same reason they made the sea-gods fertile and the parents of many children. It is known to everyone that nothing is more fruitful, nothing more fertile, than the sea — as the infinite multitude of sea-monsters, the immense progeny of fish, and the abundance of innumerable spawned eggs amply attest. Let this much suffice concerning the necessity of salt.

It remains to explain how the water was steeped in that brininess from the beginning, and how that same brininess, once laid aside, is turned into freshness.

In the primordial drawing of the waters down into the channels of the Earth — which Sacred Genesis [*Genesis*] teaches was accomplished on the third day of the world — the chaotic water at once drew to itself, as a nutriment necessary to it, brininess both from itself, being already pregnant with brine, and from the very substance of the briny Earth. [Margin: How salt was instilled from the beginning by the voice of God.]

The Earth, therefore, being filled with salt — inasmuch as it consists of its natural terrestrial element — when suddenly struck by the voice of God, according to the condition of its parts first fixed the framework of the Earth, then stones of every kind, both common and precious, fixing the still-soft mud or sediment of the waters; then, with the subterranean fire, coeval with it, cooperating, it produced the various species of metals and minerals — that is, Sulphur, Mercury, and the

other minerals — as the genuine sons of salt. [Margin: That all solid things subsist by the power of salt.] And salt itself, as the base and necessary support of all things, it diffused throughout absolutely all the fibers of the Earth. From these the Ocean, sucking continuously as from breasts — besides being already itself steeped in salt — greedily drew it derived into itself.

And since in the first Book we showed the floor of the sea to be sieved through with innumerable passages and chasms, it came about that the subterranean fire, exciting the spirits of the briny Earth by its heat, communicated them everywhere to the Ocean in all places. [Margin: The subterranean fire steeps the floor of the sea everywhere with the exhaled brine of salt.] The Sun and the Moon, meanwhile, by their continual influences through the abundance of winds and vapors, agitate the sea unceasingly. Hence the briny spirits, mixed with the sea, imbued the whole Ocean with that saltiness which it retains to this day, and will retain until the consummation of the world.

That the Earth perpetually steeps the sea with its brininess, and the subterranean fires through the hidden passages and pores of the sea-floor, by sublimated spirits of salt — this I show by the following experiments.

COROLLARIUM II

There is no elementary water — whether spring, lake, or otherwise — that, once distillation is carried out, does not exhibit some residue of salt; as will be amply proved through experiments in the following Book, in the *Treatise on Salt* [*Tractatu de Sale*]. For since salt gives consistency to all things, according to Supposition 2, certainly water deprived of all salt could not obtain the consistency owed to it by nature, being deprived of its terrestrial fixative element, and so would be resolved into the purest element — which is impossible. [Margin: One element cannot subsist without another.] For since all the bodies of natural things are composed of the four elements, certainly, if one of them is lacking, the whole composite must necessarily be destroyed. Therefore no water can be deprived of its fixed salt.

For just as in any natural composite one or two elements are predominant, so too in the watery element one water has more or less saltiness than another, down to an imperceptible brininess; exactly as in the remaining elements a greater or lesser portion of this or that element always predominates, the radical element always persisting. Hence, by the truly wise design of nature, it has come about that, even though fresh water fit for drinking can be separated from any salt water by evaporating the volatile salt, nevertheless a fixed portion always

remains in the underlying body, even under the smallest quantity. [Margin: In spring water something salt always remains after distillation.] I speak here not only of salt in particular, but generically of everything that, distillation being completed, remains at the bottom of the alembic — what the chemists call the *caput mortuum* ("dead head"). For this, drained of all moisture and reduced to ashes, will at once furnish a new brood of salt, as will be taught in its place.

COROLLARIUM III

From this it is clear that salt was instilled by nature into the Terraqueous globe from the beginning of things — both to preserve the whole economy of the Terraqueous globe and to sustain and nourish it — as the balsam of nature. [Margin: The utilities of salt.] For where there is no salt, there the beginning of putrefaction must be; salt alone preserves both animate and inanimate things from rot. Nothing in nature is without salt: nothing of natural things — whether you regard metals and minerals, plants and animals, or the elements themselves, of which the Terraqueous globe is composed — can subsist without the endowment of salt. Where salt is lacking, nothing is durable, but all things are soon overrun by venomous putrefaction, necessarily deprived of the support both of the Universe and of men and animals. Hence there is no place in the world to which a supply of salt is not at hand; and so divine providence willed, not without cause, that this thing, which would be so greatly necessary, should be everywhere ready. For however much...

EXPERIMENTUM I.

[Margin: How water is steeped with its own saltiness.]

Make from plates of fossil (rock) salt a square vessel A B C, whose joints are most exactly sealed with pitch or some other material. Once this is done, pour in fresh water and leave it to settle for a while; within a short time you will find the fresh water wholly turned to saltiness, the fresh water drawing to itself the saltiness residing in the vessel — and the water becoming so much the saltier the more violently you have agitated what was poured in within the vessel.

Diagram. A small woodcut of a square box-shaped vessel built of rock-salt plates, shown in three-quarter perspective, with its lid and side faces visible.

- A (top): label "A" on the upper face of the vessel
- B (left side): label "B" on the left face
- C (implied): the third corner-label completing the designation "A B C" given in the text; not separately legible on the face [?]

From this experiment it becomes clear how fresh water, with the brinness drawn to it, becomes salt. We also made the experiment both in Sicily and in Malta [Melita]: in any soil — provided it is rich, not sandy and close to the sea — within a pit artificially excavated, fresh water poured in was at once turned to saltness. Conversely, if you pour sea water onto certain fresh chalky and sandy clods, and leave it poured out for several days, you will find the water stripped of its saltness, the earth by its own nature drawing off the salt due to it. The cause of this is nothing other than the diversity of the earthy clods: some are rich in copious salt, others have scarcely a perceptible amount.

Hence it happens that a clod heavy with salt communicates its saltness to fresh water by a certain natural and reciprocal attraction; whereas a clod possessing less salt derives into itself the salt drawn from the sea-water as a nourishment agreeable to it, so that the water, left deprived of its volatile salt, must necessarily become fresh. [Margin: The subterranean fire mixes briny spirits into the sea.]

The same is to be reckoned to happen with the sea. The Earth communicates its saltness to the Ocean, diffused through all the fibers of the terrestrial body; and lest the shores alone should seem to communicate saltness, the subterranean fire, by the perpetual sublimation of briny spirits through the sieve-like floor of the sea, so steeps all the pathways of the seas that, with the perpetual agitation of the sea supervening, a complete commingling of the waters with the briny spirits is at last achieved. For the briny spirits are, as we have learned by experience, so potent that even a small quantity of this spirit — as much, that is, as a spoon can hold — easily turns a huge cask full of fresh water into brine.

[Margin: How salt water freshens in the channels of the hydragogues (water-conduits) and becomes fit for drinking.]

I come now to the solution of the other doubt: namely, how water freshens in subterranean conduits, or how, the brinness being there laid aside, the water is turned into fresh — as springs and rivers openly demonstrate.

I say that this happens, first, by the decoction (boiling) of the waters. For since the bowels of the Earth are filled with subterranean fires, it happens that, where the conduits or passages of the waters are propagated in the manner of siphons, while they pass through the fire-chambers [pyrophylacia], the volatile spirits of the salt water, now cooked and digested, are soon sublimated; and being sublimated and attenuated to the greatest subtlety, they insinuate themselves through the inmost fibers of the Earth, and when they have been condensed by cold, turn back again into salt — and so they restore to the Earth that which they

had drawn off from it, the Earth by a natural attraction reclaiming what was its own.

It happens too that the water, licking the sides of the passages packed with fresh clods, there strains out the salty humor, and in the same way the Earth, by a certain natural attraction, derives into itself that which it had first given to the sea — according to the experiments adduced a little earlier. Hence springs and rivers, which had at first passed up from the sea as salt water through the passages of the sea-floor, for the reasons adduced lay aside their brininess, and through their outermost orifices issue and flow filled with fresh water — until, restored to the sea, they once more become salt; this cycle of things [pericyclosis] enduring perpetually.

[Margin: How salt water, drawn up into rains, freshens.]

Moreover, since the Sun perpetually draws up a great quantity of vapors from the sea, it happens that these, condensed by the cold of the middle region of the air, lay aside their volatile salt and are resolved into rains, hailstones, and snows; which, received among the peaks of the highest mountains, partly by external melting, partly insinuated into the inner water-chambers [hydrophylacia], augment the water and render it fresher with their own freshness.

But of these matters more fully in the following *Treatise on the Origin of Springs* [*Tractatu de Origine Fontium*].

[Margin: An experiment on the shores of the Sicilian Strait.]

It is a wonder that I once observed on the shores of the Mamertine or Sicilian Strait [Fretum Mamertinum sive Siculum — the Strait of Messina]. The shores are sandy and full of sand; and if anyone digs a pit there, he will at once find the freshest water, even though it be no more than two or three feet from the seashore. Indeed — what is more worthy of wonder — on the very curved arm of the harbor of Messina [portus Messanensis], which is thrust into the middle between the waters of the harbor and of the Strait, if anyone digs a pit in the manner described, he will likewise find fresh water. The same happens on the shore of Calabria [Calabria] near Reggio [Rhegium], where I recall having found fresh water in a sandy pit, distant no more than two palms from the sea water; and a spring there, built at the seashore for public use, sufficiently demonstrates it.

The cause of so exotic an effect is sought, and I shall here attempt to adduce a threefold one. The first may be that sand, by its own nature drier, derives the

brininess into itself by a certain natural attraction, as it was able to do in the preceding experiment. The second cause may be that little streams flowing out from the promontory of Pelorus [Pelorum — Cape Peloro], which overhangs the Strait, running through the sandy shore by a hidden flux, before they insinuate themselves into the Strait, supply fresh waters everywhere. The same is to be said of the shores of Reggio, into which both open and hidden streams from the mountains of Calabria that gird the Strait, gliding beneath the sand, everywhere present that same fresh water before they discharge themselves into the sea.

But from where the fresh water in the arm of the harbor of Messina — curved by nature between both seas — comes forth, doubtless has another cause, since it cannot share in the streams from the mountains. Therefore it must be said either that the Earth of this sort, by its own native property, converts the strained seawater into freshness in the way described above; or else that, from some lake or river of Sicily or Calabria, through a subterranean siphon extended below the floor of the sea — which finds its outlet in this arm of the harbor — it renders fresh the water diffused through the said tract. For the *Nautical Histories* [*Historiae Nauticae*] report that in many places, both on the floor and in some rocks of the sea, fresh water is found leaping up in the manner of a spring, as will be told concerning submarine springs in its place.

Here, reader, you have the threefold cause of the fresh water gushing on the shores; choose at your pleasure that which, with those first, will give greater satisfaction to your ingenuity — for besides those stated you will not easily find another.

CAPUT IV

Whether the saltness of the Sea is equally dispersed throughout all the pathways of the Ocean.

[Margin: Whether the sea is saltier at the bottom or at the surface.]

Since this doubt is of great moment, we have thought it should be examined just as exactly. It is to be noted, then, first, that this difficulty can be understood in several ways. First: whether the sea is saltier at the bottom than at the surface. Second: whether at the shore or in the middle. Third: whether it is saltier in places lying under the Torrid Zone, or in the Northern regions.

It is to be noted, second, that intensely cold sea water is less salt than warm salt water. It is to be noted, third, that the Earth, the bottom, and the shores of the sea,

just as they possess various properties and qualities, so too are wonderfully varied.

These things being premised, the question is asked first: Is the Sea saltier at the bottom or at the surface? I say that, since the floor of the sea behaves in one way and another in different districts of the Ocean and seas, and possesses diverse properties and powers in different places both of the bottom and of the shore, according to the proportion and disposition of the terrestrial portions — not only reason, but also sense experience has taught, that the sea sometimes abounds with greater saltiness at the bottom than at the surface, and sometimes at the shores rather than at the bottom or in the middle of the Ocean. If the sea has passed through a mine filled with salt, or has found a fissure permeable to volatile spirits of salt sublimated by the subterranean fires, then it is certain that the sea is saltier at the bottom than at the surface, since copious brininess is perpetually communicated to it directly from the underlying veins of salt.

The same is to be said of the shores of the sea; for where the sea has licked a neighboring salt-mine with its continual waves, it must necessarily be more intensely steeped with brininess at the shore than in the middle. And the salt-pans [salinae], which are set up at the seashore to the great profit of mortals, sufficiently attest it.

I say, second: Since fixed salt is heavier than the water itself, it is certain that it cannot remain at the surface, but tends downward toward the bottom; the volatile salt, however — since nothing can impede its spirituous lightness — pervades the whole body of the sea up to the surface, and, by a perfect mixture with the sea, tempers it through the continual agitation of the waves. Nevertheless the saltiness of the sea, both at the sea-floor and at the shores, can be impeded in many ways, so that it is not sharper than at the surface. [Margin: Springs gushing up in the sea-bottom diminish the saltiness.]

Of these the first is the rivers, brooks, springs, and fountains discharging themselves through subterranean passages into the floor of the sea; by these the sea water is in a wonderful way tempered, and, the saltiness being removed, it so freshens that a spring, penetrating through the middle of the sea, sometimes presents fresh water to sailors over a great expanse at the very surface — just as they report concerning certain places in the Pacific Sea by the shore of South America [America Austral], and concerning the Persian Gulf [Sinus Persicus] near Hormuz [Ormutium]. The latter, although it is the saltiest of all seas because of the surrounding salt-mountains, nevertheless at the very surface of the sea is said

to bubble up a spring of fresh water — to the great solace and profit of sailors and of the other inhabitants and neighbors of that most torrid island.

[Margin: That the natures of the sea are most diverse according to the disposition of the shores.]

Likewise it can happen, at the sea-floor or at shores not so filled with brininess, or in those places where, by the inflow of vast rivers, the sea is found to freshen for many miles. But since these things are better known than to deserve mention, I willingly omit them; for just as not every land bears all things, so most diverse are the constitutions of the terrestrial parts, by reason of which the nature of the sea is varied in a wonderful way — since it produces always one thing and another, not the same in all places, but according to the diversity of the properties of the lands it licks; of which in their place. In the same way, the sea in one place, for the causes stated, is saltier than in another; yet it happens, by the perpetual agitation of the sea, that the saltness, diffused by a perfect dilution, acquires an almost everywhere equable temper of flavor, wherever it does not reach the gushing springs of freshness.

[Margin: Whether the sea is saltier under the Torrid Zone or under the temperate or frigid.]

The other doubt is whether the sea is saltier under the Torrid Zone than under the temperate or frigid Zone. I answer that under the Torrid Zone it is, other things being equal, saltier; for since the Sun strikes it perpetually with its perpendicular rays, it happens that the volatile spirits of salt, drawn up together with the vapors by the Sun's heat, first into clouds — which, dispelled by the agitation of the winds into the various parts of the world, are partly condensed in the colder parts of the mountainous regions, and the volatile salt, dissolved by frequent agitation, is resolved into rains and most copious showers of fresh waters, partly condensed into snows. Hence the sea, with its fixed salt and...

with the heat and seething of the incumbent Sun excited, grows salt in a wonderful way. For experience establishes that salted foods, as soon as they have grown warm in boiling water, are much saltier than cold ones; the reason of which is this: that by the heat the salty corpuscles, not wholly bound by the spirits, being rarefied and separated from one another, by such a resolution of the corpuscles confer the highest acridity upon the sea. [Margin: Salt is cooked by the heat of the Sun on the shores of the seas.]

And it is established by daily experience that, on the shores of Sicily, Calabria, and the other shores of the Mediterranean Sea, sea water led off into certain little

beds is, in the space of a few days, cooked into the whitest salt by the heat of the Sun. In Malta too, in the rocky pits of the shores, into which the sea is diffused by the force of the winds, it grows of its own accord, by no industry of art, into copious salt, to the great profit of the inhabitants. The same is reported to occur on all the shores lying under the Torrid Zone, by all who have visited those places — which, however, does not happen in the Northern parts. It is a most luminous sign that the more violently sea water is beaten by the rays, the more copious salt it produces, and so the saltier it becomes.

[Margin: Why in Iceland the sea is so salt, but not in the icy sea.]

In the Northern parts, however, it is known by experience that the sea is more insipid — not because it is not imbued with an equal portion of salt, but because the fixed salt is, by the violence of the cold, irresolvable. In Iceland [Islandia], nevertheless, the *Nautical Histories* attest that it is most salt; the reason of which is none other than the subterranean fire dominating that island, which, just as through the roots of the mountain they call Hekla [Hecla] it fills everything round about with salt, sulphur, and bitumen or naphtha, so the briny spirits, bursting through the floor of the sea, tinge the Ocean with such native brininess that it can vie with the saltness of the Torrid Zone — which, however, mixed with the neighboring glacial sea, in time loses the sharpness of its saltness.

I say, therefore, that in the farthest North the sea, even though it abounds in copious salt, cannot, because of the efficacy of the most intense cold, be dissolved. It happens also, because of the continual rains, perennial snows, and hailstones, which at no time are lacking in those places, that the sea is to some degree augmented both in bulk and in freshness; for since salt water, being heavier through the fixed salt, clings the closer to the bottom, while the fresh water, being lighter, floats upon it — which, being thin and subtle, is easily frozen by the surrounding cold once the brininess is laid aside, and congeals into ice.

[Margin: Why the ice of the sea is fresh.]

But as to why the ice of the sea is fresh, the reason is that the saltier water, condensed by cold, by its own weight settles down, while the fresh water, stripped of saltness and continually augmented by rains and snows, as it floats by its lightness upon the heavier, so by the surrounding frost is easily bound fast. For, as experience teaches, salt water, because of its grossness and fattiness, is converted into ice so much the more difficultly as fresh water, because of its lightness, more easily.

COROLLARIUM I

From this it is clear why, on the shores of those seas which are girt by the highest mountains, the water is fresher than in the middle. [Margin: Why on the shores of the seas which are girt by the highest mountains the sea water is fresher than in the middle.] This is because the most copious showers, with which the mountainous tracts are drenched at stated times, while they run down through the valleys of the mountains in the manner of rivers, and, mingled together with the sea water, convert it to some extent into freshness — as is wont to happen on the shores of the Malabar Ocean [Oceanus Malabaricus], at Cape Comorin [Mons Gatis — the Western Ghats] and Ceylon [Zeilanum], and on the Western shores of America that are stretched beneath the Andes [Andes], in the time of rains. This effect is common to all rivers discharging themselves into the sea.

COROLLARIUM II

It is also clear why, in the Northern parts, no salt congeals on the shores in the summer time, while under the Torrid Zone, or in regions neighboring it, most copious salt is found. [Margin: Why the Northern maritime regions are less productive of salt.] This is because, in those regions, on account of the most oblique rays of the Sun, the salty bodies, frozen by cold, can neither be dissolved nor, for lack of solar heat, be cooked. It is otherwise in these places hottest by the seething of the Sun, in which, by the heat, the salty corpuscles, dissolved and mixed with the surface waters, while they are poured out onto the shores, produce copious salt, the Sun being the cook.

[Margin: Why sea water, drawn out into rains, freshens.]

The third Doubt is: why sea water, raised up by the power of the Sun through vapors and stripped of saltiness, is converted into fresh water; whereas, by contrast, sea water distilled through an alembic is always found in the receiver unfit for drinking, nor can it come about that they be entirely separated from one another?

I answer that sea waters raised up by the Sun's heat degenerate into fresh: First, either because the briny spirits, which it carries up with itself, separated from the vapor, transcend the middle region of the air, or, condensed by cold, sink down, or, mixed with dewy air, are absorbed, the water element predominating. Secondly, either on account of the most free motion of the clouds in the air, by which, drawn apart into various tracts, they are at last so weakened and

disunited that they leave no further vestige of salt in the air drawn up; whence these spirits, separated in the said ways, must necessarily leave the water fresh.

In the alembic, however, on account of the receptacle being closed on every side, the spirits separated and sublimated by the fire, just as they find no exit, so, commingled with the water, cannot be entirely separated; whence the water, somewhat freed from the fixed salt, but still mixed with the volatile spirits, even though it does not contain so great a saltiness, nevertheless has — I know not what — of a slightly bitter and unpleasant flavor mixed in, by which it is rendered unfit for drinking.

[Margin: Whether sea water can be freed from all saltiness by distillation.]

But whether sea water, distilled repeatedly — as is wont to be done in the quintessence of wine — can at last be freed from all its saltiness, since we have not not made an experiment of it...

I also cannot affirm it with certainty; yet it seems plausible that, even if only in the smallest portion, [the salt] can be separated out. Here is how I would propose to attempt the matter.

Diagram. A distillation apparatus shaped as a coiled tube (a spiral siphon). A round-bottomed vessel sits over an open flame at the base; from it a long helical (corkscrew) tube rises, and near the top a side-tube leads off to a small flask resting on a footed stand, while the very top of the helix terminates in a round receiver. The printed caption reads: "Let a siphon be made, coiled into a helix, whose vessel filled with sea water is A, the helix is B C D, and the receiver E."

- A (vessel at base, over the flame): the vessel filled with sea water
- B (lowest coil of the helix): lower part of the helix
- C (middle coil of the helix): middle part of the helix
- D (upper coil of the helix): upper part of the helix
- E (small footed flask at right): the receiving flask [cyathum, cup] — but see note: in the body text the receiving cup is also called E and the top receiver F
- F (round receiver at the very top of the helix): the upper receiver / lid where the vapor is resolved

The text continues: Let a siphon be made, coiled into a helix, whose vessel filled with sea water is A, and the helix B C D, with E as the receiver. Then, once a fire is set beneath vessel A, the salty spirits, loosened by the heat, begin to ascend through the coils. But because, condensed amid so many turns, they meet a great

obstacle in the very act of rising higher, they are necessarily forced to stop their further ascent — especially if the winding siphon is repeatedly sprinkled with cold water. The fresh water, however, raised up by its own fineness through the fumes into the lid F, and from there resolved back into water, will pour itself out into the cup E. I am convinced by many considerations that this water must be fresh, because it is well known that the salty spirits either subside at the first chill, or are condensed; whereas the vapor, like that of clouds, makes its way through the winding paths, is at last resolved in the lid F, and pours itself out drop by drop into the vessel E, free of all saltiness — the volatile salt being left behind, condensed within the passages of the siphon, caked in leafy growth along the sides of the helix.

I should like to have chemists make trial of this matter, and perhaps they will find what I have said to be true. For since I myself have used a siphon of this kind in other operations, it can scarcely be told how thoroughly, by this device, you may find the water purified of all dregs and phlegm. But other ways of separating fresh water from salt water will be treated at length in the Eighth Book of this work [in Octavo hujus Libro].

Here, therefore, we shall put an end to this section. From the first principle of all nature — which we call water — we now proceed to the second, which is fire.

MUNDI SUBTERRANEI LIBER QUARTUS

ΠΥΡΟΓΡΑΦΙΚΟΣ [Greek: Πυρογραφικός (Pyrographikos, "On the Description of Fire" / "Pyrographic")]

DE IGNIS SUBTERRANEI, Ventorum, Fluminum, Fontiumque origine.

On the origin of Subterranean Fire, of the Winds, the Rivers, and the Springs.

SECTIO I.

De Natura Ignis Subterranei, ejus situ et operationibus.

On the Nature of Subterranean Fire, its location and operations.

PRÆFATIO. (Preface)

Just as the height of the Divine power set up two Luminaries in the Heavenly World, the Sun and the Moon — willing that the former be of fiery substance and the latter of watery — to this end: that the burning heats of the Sun might be

tempered by the moist effluvium of the Moon, and that the excessive moisture of the Moon might in turn be checked by the fiery dryness of the Sun; so that in this way there might exist the genuine principles of all the things that can be generated on the surface of the Earth. These supports of nature were so necessary that, if either of the two were lacking, the World could not have been preserved.

[Margin: *Uti se habent Sol et Luna in cœlo, ita se habent ad invicem Ignis et aqua subterranea. — As the Sun and Moon stand in the heavens, so do subterranean Fire and water stand to one another.*]

But although both the watery element of the Sea and the superficial mass of the Earthen body powerfully promote the generation of things, it could not happen that they should reach by their influxive power into the innermost core of the terrestrial entrails, since they possess a sphere of activity that is determined and bounded by its own limits. Hence, lest the inner storehouse of the Earthen globe should grow stiff with the harshness of cold, and become useless for the inner actions of nature in the generation of minerals and metals, it was brought about by the supreme counsel of Divine wisdom that fire, together with water, should be established within it — these being, as it were, a kind of subterranean Sun and a subterranean Moon. By their mutual aid, and by a certain concord of discordant reciprocal action, all the seeds of nature inborn in the Earth-and-water globe might be quickened into that multitude and variety of things which we behold with wonder, both within the inmost entrails of the Earth and on its outer surface.

It remains, therefore, for us to show: what that subterranean fire is; what it does; in what place of the subterranean regions it is located; and how, or by what nourishment, fires of this kind sustain their perennial conflagrations.

CAPUT I.

De necessitate et essentia Ignis Subterranei, et utrum verum elementum sit.

On the necessity and essence of Subterranean Fire, and whether it is a true element.

That Subterranean Fire exists is so certain that no one but a philosopher of unsound mind could deny it. For whoever has considered the fire-vomiting mountains, the sulphurous fires bursting forth not only from the earth but even from the sea itself, the multitude of hot springs [thermarum] and their certainty

and variety everywhere in every place — such a person will, beyond doubt, be compelled, however unwilling, to affirm that these fires, these heats, the seething craters of the great Volcanoes [Vulcaniorum craterum æstuarial], have their birthplace not in the air, not in the water, but in the very inmost recesses of the Earth.

[Margin: Ignis Subterraneus ex quibus signis colligatur. — From what signs Subterranean Fire is inferred.]

For how could it be that, where everywhere there is so great an abundance of minerals, of so much sulphur, bitumen, and naphtha occurring everywhere, this should arise without fire, without any natural seething heat — in those most cold prisons of darkness, the farthest removed from the Sun's influx, conceived from the conflict of cold air and moisture? Subterranean fire was therefore necessary for the economy of the inner Earth.

Certainly Plato, contemplating all these things more deeply, recognized in the *Phaedrus* perennial flames, an incredible quantity of waters both hot and cold, and great rivers, of both water and fire. Indeed, Aristotle too, from the observed effects of fire — which he had once recounted among his "wondrous things heard" [auditiones] — taught (*On the World*, ch. 4) that the Earth, like water, contains very ample fountains of breath [spiritus] and fire; a point he then repeated in *Meteorology* IV, when he investigates the causes of the motion of the winds in the Earth.

[Margin: Ignis nullibi deest. — Fire is nowhere absent.]

Pliny too, Vitruvius, and Cicero noted this secret of nature; for when craftsmen probe the entrails of the Earth, they observe heat lurking there. Indeed, the greatest parts of the world are upheld and sustained by heat; we see fire struck out by the conflict and friction of stones, and when the Earth has just been dug we see it steaming warm; and even from wells, perpetual hot water is drawn — and this happens most of all in the winter seasons, because a great force of heat is contained in the caverns of the Earth.

[Margin: Fabulæ poëtarum alludunt ad ignem subterraneum. — The fables of the poets allude to subterranean fire.]

To the poets, too, this subterranean fire was so well established that all the fables concerning Vulcan, Vesta, and the Cyclopes seem to allude to it. Let us hear Lucretius singing in these words:

[Margin: Lucretius.]

In the first place, the Earth has within itself the primal bodies By which the boundless sea, the rolling rivers and springs, Ceaselessly renew themselves; it has fires, from which they arise. For in many places the ground burns, set alight beneath; But from the depths it is the force of fire that makes Aetna rage.

Manilius, in his *Astronomica*:

[Margin: Manilius.]

But there are fires admitted into all the parts, Which inhabit the pregnant clouds that forge the thunderbolts, And they pierce the Lands, and Aetna threatens Olympus, And they make the waters warm in their very springs.

Who is, and what properly is, that Subterranean Fire — receive it here in brief.

[Margin: Quid sit ignis Subterraneus. — What Subterranean Fire is.]

Subterranean Fire is a portion of elemental fire, not pure, but contaminated by a mixture of various combustible things, enclosed within the caverns of the Earth — that is, the Fire-vaults [Pyrophylacia] — by God Most Good and Greatest, from the very beginning of the World, for the protection of sublunary nature, its preservation, and the production of all things.

It is said, first, to be a *portion of elemental fire, not pure but mixed* — in order to exclude the view and opinion of those who said that this fire was a thing of its own kind, distinct from elemental fire, incorporeal and invisible. That view — quite apart from the fact that it conflicts with the sanctions of the Church and of the holy Fathers (who hold that even infernal fire itself is not incorporeal and spiritual, but material, corporeal, and of the same kind as artificial fire, that is, mixed elemental fire — as they everywhere assert it to be of that species) — also conflicts with the laws of nature and with the decrees of almost all Philosophers; since it is too well known to need stating or to be properly stated, that an incorporeal fire has no power, no proportion for acting upon a corporeal substance.

It is said, secondly, that *Subterranean Fire is a portion of mixed elemental fire* — to refute the opinion of those who held that this Subterranean fire was not corporeal, not actual, but virtual or eminential (of the kind that is in the stomach), endowed with a power of concoction [vi decoctiva]. This was refuted at length in our *Itinerarium Extaticum* [*Ecstatic Journey*], and we shall presently demonstrate its falsity openly.

[Margin: Democriti sententia. — The view of Democritus.]

Democritus, to avoid seeming to grant an actual fire, said that subterranean heat arises from quicklime and ash, by *antiperistasis* [περίστασις, the surrounding of a thing by its contrary] — than which nothing more inept could be said. For if quicklime and ash are hidden within the Earth, one might justly ask: who reduced the lime and ash to a consistency of this kind? Since it is impossible for lime and ash to be made without fire. Add to this that the whole globe of the terrestrial World would have to be composed of lime and ash, since there is scarcely any place in the whole Earth, as will later be shown, that does not display the effects of this heat.

[Margin: Non fit ex calce et cinere. — It does not arise from quicklime and ash.]

This is likewise repugnant to sensible experience, and so we more truly leave that opinion to be explained not by reasonings but by the old wives' tales of little women. Nor does reason dictate that this heat arises in subterranean places by the agency of *antiperistasis*. For since antiperistasis, on Philo's testimony, is nothing other than a struggle of contraries, of hot and cold — and that struggle, because no violent thing is perpetual, cannot endure in a continual conflict — if it could not endure, then surely all the hot springs would long since have ceased, the Volcanic pits and the flame-vomiting Mountains would long ago have been extinguished; which, again, experience cries out against, since just as they have burned from the beginning of things, so down to this very day they do not cease to continue their heat.

[Margin: Non antiperistasi. — Not by antiperistasis.]

Add this: that if that heat were kindled by antiperistasis, then beyond doubt that heat would have existed first, since antiperistasis requires an actual and simultaneous positioning of contraries. And if that is so, then I ask: from where was this prior heat produced? Certainly not from cold, since it is impossible for antiperistasis to occur through two cold things in the highest degree — for then like would act upon like, which is against the common axiom of the Philosophers. Nor from heat eminently contained in the entrails of the Earth; since this is, by no sensible Philosopher, granted to be opposed to the elemental cold, nor can it be merely virtual or potential — seeing that it contains in itself the properties of actual fire only, even according to the opinion of the adversaries themselves.

[Margin: Non est ignis virtualis aut eminentialis. — It is not a virtual or eminential fire.]

Whatever, therefore, they may say, wherever they may turn, they will find no other way to extricate themselves from this mire except to assert a formal heat excited by an actual fire lurking in the entrails of the Earth.

I have said that Subterranean Fire is a portion of elemental fire, not pure but tinged with a mixture of various combustible things — in order to exclude the opinion of those who think that every ordinary or culinary fire is the element of fire. But in order that it may be made more clearly known in what sense we here take "the element of fire," it has seemed good to begin upon that matter a little differently.

CAPUT II.

Quodnam sit verum Ignis elementum, et ubinam proprius ipsius locus sit.

What the true element of Fire is, and where its proper place is.

[Margin: Variæ sententiæ Veterum. — The various views of the Ancients.]

The ancient Philosophers — Trismegistus [Hermes Trismegistus], Zoroaster, Orpheus — held that the whole World was composed of four elements: fire, air, water, earth; where by "fire" they understood not a fixed place but the substance of the universal aether, which they also call the life-giving fire. Orpheus, however, teaches in these words that all things were established by the Maker out of fire, water, Earth, and the all-nourishing aether:

[Greek: τὸν ὅλον κόσμον ἐκ πυρὸς καὶ ὕδατος καὶ γῆς καὶ πνεύματος — "the whole cosmos out of fire and water and earth and breath [pneuma]"] [?: the final word of the printed Greek is abraded; read as πνεύματος / aether per the Latin gloss]

Ocellus [Ocellus Lucanus], the pupil of Pythagoras, was the first of all to place fire below the Moon and above the air; and in this way, by his doctrine, the Universe is constituted of five elements — earth, water, air, fire, and aether — of which the first four are perpetually subject to the motion of corruption and generation, while he taught that the Moon is, as it were, a fence and a barrier between the incorruptible and the corruptible things:

[Greek: ὅρος γὰρ ἀθανασίας καὶ γενέσεώς ἐστιν ἡ σελήνη ὁδός — "for the boundary of immortality and of generation is the path of the Moon"] — that is, the orbit of the changeable Moon.

And a little after he says:

[Greek: τὸ μὲν οὖν πῦρ καὶ ἡ γῆ ἄκρα, τὸ δ' ὕδωρ καὶ ἀήρ μεσότητες — "Fire indeed and Earth are the extremes, but water and air the means"].

Empedocles followed this view, and after him Hippocrates; but the Peripatetic school, misunderstanding their own Master, propagated it. We wish to contend with no one, but, eager for the truth, in this place — where the genuine location of fire is to be defined by us — we shall try to demonstrate, even from Aristotle himself, that the Sphere of fire cannot be established beneath the concavity of the Moon.

[Margin: Aristot. l. 1. Met. c. 14. — Aristotle, *Meteorology* I, ch. 14.]

But lest I should seem to have considered the text too rashly, it has seemed good to adduce the very words of the most wise Doctor, so that what is to be held according to his mind may become plain. Aristotle speaks thus, *Meteorology* I, ch. 14:

In the middle, therefore, and around the middle, is what is heaviest and coldest, set apart — Earth and Water. Around these, in turn, are water and air; and what, on account of custom, we call fire is not in fact fire, for it is an excess of heat and, as it were, a boiling of fire. But one must understand the air we have spoken of, that which is around the Earth, to be as it were moist and hot, because the Earth has vapors and exhalations. But what is above this is already hot and dry. For the nature of vapor is moist and hot, and vapor is, as it were, potentially water, while exhalation is potentially, as it were, fire.

[Margin: Aristotelis sententia exponitur. — Aristotle's view is expounded.]

From these words it is plainly evident that Aristotle here teaches nothing else but that, the exhalation having been separated from the grosser watery vapors, it betakes itself into the uppermost and supreme region of the elemental World — which, since it consists of the finest and most subtle parts, hot and dry, is for that reason nearer to fire as to its nature, being thoroughly disposed to catch fire.

[Margin: Aetna.] [?: the marginal word at the foot of the left column reads "Artes" or "Aetna" — abraded; transcribed as found]

[Greek: ὑπέκκαυμα (hypekkauma, "the inflammable / kindling stuff")] — Aristotle says that the finer and subtler parts of the air are accustomed to be called fire; yet he protests expressly that it is not true fire, and gives an evident reason: because fire is a certain excess of heat and a certain boiling, whereas that vaporous substance of the supreme aerial region is not seething, nor does it have such an

excess of heat. Therefore, when Aristotle elsewhere says that fire is in the Concavity of the Moon, he must be understood — with this explanation — to mean that it is *called* fire by custom, not that it really is fire.

But the followers of Aristotle, in this place, from a wrongly understood text concerning the coordination of the elements, try by every means — even against the Master's mind — to persuade us of a proper and genuine Sphere of fire. Yet when he places fire beneath the Concavity of the Moon, he is so far from saying it is pure fire, or a true real element of fire, that he rather teaches that not even that which we commonly call fire is to be placed there; for he says, at text 18, that the Earth, heated by the Sun, gives off a spirituous, smoky exhalation, which belongs to the Earth itself in so far as it is dry; and on account of this he says that heat overhangs the vapor. And the same is to be understood of what he adds immediately after:

And by its circular motion it is hot and dry, which, he says, we call fire; for it is nameless and common in every smoky disgregation; yet, because such a body is most apt to be burned, it is necessary to give it names.

You see that the Philosopher here describes nothing other than the supreme region of air, which, when by the motion of the heavens it both grows hot and is burned in the manner of *ὑπέκκαυμα* (kindling-stuff), or an exhalation, or most highly rarefied air — so that he now calls it not-fire, and now fire in potency: fire, I say, not really, but that which is called fire by custom.

His followers, however, lest by this "pyrotechnics" they make both themselves and their Master ridiculous, are not ashamed there to set up and defend, even against his mind, a real Sphere of elemental fire — fighting "for altars and hearths." Furthermore, if fire is said to be there only by custom, as is clear from his words — since the thoughts or names of men establish nothing in nature — they certainly will not be able to set up fire there where it is not. But if he meant the most subtle and purest portion of air stabled there to be the element of fire, then they will not constitute an element distinct in species from air. Long indeed and much, I confess, [I have weighed] the words of the Greek text, in order that [I might establish] one true, real, and...

[Margin: Aristotle's doubts about the sublunary fire.]

would there [also] place a perceptible element of fire — I weighed this with the greatest care. But so far am I from finding his meaning made plain that I rather found him describing fire as located in that region in a thoroughly obscure way, ambiguous and wavering throughout, now in this fashion, now in that. At last I

came upon the words in which he describes three species of fire. Since these had to be examined with a view to the truth — and to refuting the imaginary sphere of fire around the lunar fire — I thought best to add them here, drawn faithfully from the text. He speaks as follows:

[Greek: οὐ γὰρ ἓν εἶδος τοῦ πυρός ἐστιν, ἀλλ' ἕτερόν ἐστι τῷ εἶδει ἄνθραξ καὶ φλόξ καὶ φῶς, ἕκαστον αὐτῶν πῦρ ὄν· καθάπερ ἐπὶ πυρός τὸ λεπτομερέστατον· λεπτομερεστέρων γὰρ ἐστι τὸ φῶς καὶ τοῦ ἄνθρακος καὶ τῆς φλογός — "For there is not one form of fire; rather, glowing coal, flame, and light differ from one another in species, each of them being fire — just as, in the case of fire, that which is of finest parts (is most truly fire); for light is of finer parts than both coal and flame."]

"For," he says, "there is not one species of fire; for glowing coal is one thing in species, and flame and light another — each of them being fire, in the same way that, in fire, the most subtle thing (that is, the thing of the most subtle parts, is most truly fire); for light is of finer parts than both coal and flame."

[Margin: The three species of fire.]

Here, then, he posits three species of fire in the nature of things: kindled coal, flame, and light — yet he comprehends both coal and flame under a single light, which consists of the most subtle parts. This view he excerpted from Plato's *Timaeus* [Plato, *Timaeus*]. Since it ran contrary to his own opinion about the element of fire, he ought more prudently to have passed it over than to have built upon it. I have undertaken to examine it here, and to explain whether it can stand alongside his doctrine of a fire abiding beneath the Moon.

I say, then, first: if there are only three species of fire — coal, flame, and light — they would surely give plain signs of their existence in the sublunary concavity; but they give none. Therefore...

[Margin: Refutation of the sublunary element of fire.]

For here we are not speaking of an element of fire that is invisible, potential, and virtual — which he also calls a vaporous substance, or rarefied air — but of one that is perceptible, real, and actually existing. So I argue thus. If there were fire in the lunar concavity, it would be either glowing coal [anthrax], or flame, or light; for no other species of fire exist, by the Philosopher's [Aristotle's] own admission. But first, there is no glowing coal there. For if a coal were there, it would necessarily be kindled — since an extinguished fire cannot be called fire. Every fire by its nature gives light; and if it gives light, it also sheds illumination from

itself; and if it sheds illumination, then it will light the regions below it. Yet no one, from the founding of the world, has ever seen anything kindled beneath the Moon and above the air's sphere of heat, nor has anyone observed anything shining there. Moreover, if that coal gave light, it would surely also be hot in itself, and would warm the air nearest to it, then the water, and then the Earth. And since heat of this kind lasts perpetually, it would perpetually warm the elements lying nearest it as well. The air, therefore, would never be cold — whereas it has often raged against all the neighboring elements with such intolerable cold that it turns everything into ice. A kindled coal, then, cannot be called the sublunary element of fire. For if such a coal existed, it would already...

[Margin: The three species of fire too are to be refuted under the concavity of the Moon.]

have spelled our doom, since it would long ago have reduced everything to ashes and cinders. This is what Aristotle once urged, in nearly these same words, against those who maintained that the heaven is fire: if it burned, it would necessarily give light; if it gave light, that light would spread to us together with its heat; and from so immense a thing as the sphere of fire is — many millions of parts larger than the Sun — its conflagration would long ago have consumed (I will not say merely the neighboring elements, but) the whole globe of the Earth, along with everything existing within it. But that nothing of the sort has happened is evident; just as it is equally true that no one has ever observed the concavity of the Moon to be aflame, nor has anyone ever felt either light or heat from it. Flame, therefore, cannot be there.

But perhaps you will say that this flame, owing to its extreme rarity — being of an ethereal nature — does not consume. If it is of an ethereal nature, then there will now be two ethers, an upper and a lower. And if so, then it will either be fire or not. If he says the former, he plainly contradicts himself, since he maintains that heaven, or ether, can in no way be called fire — for he says that if heaven were fire, everything would already have been burnt up; and if it is not fire, we have what we intended. Nor can flame be the sublunary element of fire; for if it were flame, then by necessary consequence it would, throughout so many ages, [have spread] so vast a flame...

Neither can the third species of fire, which he calls light, have its proper place in the lunar concavity. For it would give light, and by its diffused brightness would illuminate us; and since the sphere of fire is said to be contiguous to the supreme region of the air, no darkness, no night, could exist in the air — and so we would always, night and day, dwell in perpetual light. Who does not see how absurd this

is? Therefore no light surrounds the air at night, no fire shines beneath the Moon, and so there is no fire-light there. Let the Peripatetics not be angry with me here because in my works I have everywhere asserted light to be a substance and a body. I have asserted this persuaded by Aristotle himself, who in this very passage sets down light as a species of corporeal fire, making no mention of quality. But these things are by the way [Greek: πάρεργος (parergos, "incidental, by the way")]. Let us come to what we first intended, and see whether what the Peripatetics place beneath the lunar concavity can truly and properly be an element.

[Margin: Fire beneath the Moon is not an element.]

By Aristotle, those things are called elements into which a body is ultimately resolved, or out of which, as first inherent constituents, things themselves are composed — which no philosopher has denied. If, then, that spherical fire is established beneath the Moon, it will either be an element or not. If it is an element, then it will doubtless enter into the composition of the lower things; and, associated with the other elements, it will enter into the constitution of all mixed bodies, as the principal part and the most active of all. It must therefore descend to constitute those compounds. But a descent of fire of this kind has never been seen, nor by any philosopher or astronomer ever...

detected. For if it descended, it would descend either against nature, or with nature compelling it. If with nature leading, then we shall be forced to assert that fire is furnished with two contrary motions — a natural ascent and a preternatural descent — which is against the Peripatetic doctrine, which asserts that one simple body has one simple motion. If it descends against nature, then it enters into every mixture by a violent motion; therefore every mixture would be not natural but preternatural, and consequently against nature's will, and so never perpetual — which conflicts with the common verdict of the philosophers. But if someone should say that this descent occurs by nature, he will then necessarily be forced to assert that fire is heavy by its own nature; since everything that tends toward the center of the Earth by natural motion is heavy. This fire would thus ascend as heavy and ascend as light — therefore it would be at once both heavy and light, which involves a contradiction. But if you should say that it perpetually ascends by its own nature, then it will never have any commerce with the lower things. And finally, if you should say that it descends through the motion of the heaven of the Moon, that motion will be either through the heaven pushing, or hurling, or attracting, or carrying it; for by these motions, and no others, every thing is moved — whether by itself, or by things above, or by

things below. But I do not see how the heaven, by its spherical motion, could thrust fire straight downward; for what pushes must necessarily be followed by the body it pushes. The heaven, then, would follow the fire downward — and I do not see what could be more absurd than that. The same absurdities follow if you say it is forced down by a casting or carrying. Nor can it be drawn down by the neighboring air; for either the whole of it would be drawn, or some of its parts. If the former, then, the whole being torn away, a vacuum would necessarily be left — which is not admitted in the Schools.

From all these considerations, we finally conclude that this fire inhabiting the lunar concavity — since it has been seen by no human being, known by no sense, gathered by no reasoning, and (as has been demonstrated) is of no use and contributes neither to the composition of the world nor, much less, to the mixture of things — cannot, saving the judgment of those more learned, be admitted at all.

[Margin: What the true element of fire is.]

Now we shall try to show what the true element of fire is.

And I suppose, first, that — as we have taught elsewhere — God, the Best and Greatest, the most wise Creator, created heaven, the stars, and the Earth out of the four elements, which were contained virtually in the chaotic mass; as we have shown at length, from the holy Fathers, in the *Iter Exstaticum* [Kircher, *Itinerarium Exstaticum*].

I suppose, second, that no pure element can exist in the nature of things, properly speaking. Rather, all the elements lie wrapped up within one another, so that they are properly not pure elements but mixed, or "elementated"; for no pure element can subsist by itself, nor be perceived by sight or any sense — as has been demonstrated by ample reasoning both in the preceding pages and in the *Second Terrestrial Journey* [Iter Terrestre Secundum].

These things laid down, we say that even though no pure element can exist, nonetheless something lies hidden within the mixed element — as in the inmost center of the elemental substance — which deserves the name of the true element, and which gives the element its being as a species distinct from the others. It is, as it were, the form and soul of the element, of which, however, that element is the index, which presents itself to the senses according to the requirement of its proper form. For when we see fire, we call it "that element," not because it is truly and properly such; for it is only the material element, clothed as it were in a garment by the burning smoke. But the essential element lies hidden within, which is indicated by light — namely, that primigenial and

innate heat, inherent in all things, both celestial and in the mixtures of sublunary things. And that this is the true element which contributes to the composition of all bodies is deduced from the following: since this ordinary fire, being of itself and by its nature destructive, is so far from entering into the composition of things that it rather destroys things already composed. A different element, then — true and proper — must be assigned as the constituent of mixture: not that external, burning one, but the internal one, which we call light, or innate heat. For although this is inherent in all things, it most especially exerts its power in luminous bodies, and first of all in the Sun — as in the proper sphere of light and fire, where it has fixed its seat under the purest light; in the inmost chambers of the Earth, under a dark light tinged with the various medley of combustible things; in the supreme region of the air, under a vaporous substance. But in the remaining opaque bodies it lies dormant, as in the excremental dregs of the elements; yet when it is separated from them by the chemical art, it at once exerts the disposition of its fiery nature — whether on its own or upon being applied to another nearby fire — clothed now in a luminous garment.

You see, then, what we properly mean by the element of fire, which contributes to the constitution of bodies; and what we mean by the element of light and fire encircled by a rind — that which the common people call artificial, mixed fire, or which Aristotle calls [Greek: πνεύματος ξηροῦ ζέσιν (pneumatōs xērou zēsīn, "the boiling/kindling of dry breath")], the kindling of a dry spirit; or, what is the same thing, an exhalation, or kindled smoke. From this it is plain that the element of fire is not improperly called — by a long-standing and customary usage — every flaming, kindled, and luminous body, in whose center, however, is contained that true element which imparts power to flame and to every luminous body, of itself and by its nature all but incorruptible: manifest in some things through light, in others through heat alone, the light being suppressed within the body.

[Margin: The essential fire is subject neither to the laws of heavy bodies nor of light ones, but is indifferent to every place.]

This element is subject neither to the laws of heavy nor of light bodies, but of itself and by its nature is indifferent to every position — as in the thunderbolt, the lightning-flash, and most of all in nitrated...

and golden powder, the former of which, by its own nature, tends upward, the latter downward, with marvelous force — according, that is, to the nature of the matter to which it is joined. And in this way Aristotle's opinion, which places the element of fire beneath the lunar concavity, can and ought to be understood: not as though it were contained in its own proper sphere, but as a portion of fire

which lies hidden — as in all things, so also in that aerial sublunary body. For once this is granted, no difficulty can be raised concerning the element of fire that is not resolved by what we have already adduced.

COROLLARIUM I.

[Margin: How fire is generated by friction.]

From what has been said thus far, it is plain how heat is generated by friction in the collision of hard bodies: as when you strike iron upon an anvil, or polish iron with a file, or kindle two pieces of wood into flame by rubbing them with a third; how a drill by which something is bored seethes so greatly; how, finally, fire is struck from flint; how in the clouds the thunderbolt and lightning-flash arise, and in the bodies of living things heat is born from vigorous exertion — and the like, which are established by daily experiment.

I say, then, that the reason for all these things is nothing other than the element of fire, that is, that innate and primigenial heat — something not unlike sulphur — enclosed in the inmost center of natural things, dormant indeed and oppressed by the earthy dregs of refuse, but, after the rubbing and friction of colliding bodies, animated by the agitation of the spirits, it rouses those heats I mentioned; until, the corpuscles of a moister nature being separated, and the sulphurous and vaporous spirits being joined together for the purpose, it at last comes forth clothed in a fiery and flaming garment.

[Margin: Experiments.]

For although all mixed bodies have within themselves sulphurous and fiery spirits of this kind enclosed within them — as is evident from their dissolution by the spagyric art — and although in this way all things grow hot from the motion of friction, nevertheless some are more apt than others: namely, those that have obtained a greater store of fixed sulphur, and spirituous parts that are either more abundant or more compact.

[Margin: Why iron grows hot more violently than the other metals.]

Hence iron, being swollen with an abundant store of roasted sulphur, we find grows hot beyond the other metals most of all — and not so lead, copper, brass, silver, gold, in which (because of the abundant moisture that resists) those fiery spirits, which lie hidden in the primigenial heat, are not so easily gathered from friction. But why iron, when it cuts wood, grows so very hot, while the wood does not — we give this reason: that the sulphurous spirits in wood, being more

dissolved, breathe out, whereas in hard iron they are more compact, and through the predominance of sulphur more closely packed. Hence it comes about that in iron, from friction, they are more easily kindled than in wood. In the clouds, the thunderbolt and lightning are born from sulphurous corpuscles drawn up on high together with vapor, which — being filled with fiery and nitrous spirits — when agitated and rubbed by the violent clash of the clouds, easily coalesce into fire. This fire, requiring a larger space from the rarefaction of the air, and finding no exit from the packed barriers of the clouds, by a kind of violent motion rushes wherever a gate is opened, with that destruction which we experience year by year.

COROLLARIUM II.

[Margin: Why in winter all plants take on a sad aspect, in summer a glad one.]

Hence it is also plain why, in winter, the whole economy of growing nature lies squalid with a mournful face, and all greenery perishes from the trees and plants. The reason is that the Sun, being more remote, cannot dissolve and rarefy those fiery and vaporous spirits, since they are pressed down by the cold; but as soon as, having passed the equinox, it has received an increase of its heat — behold, the spirits which had lain hidden until then, being kindred to those (plants), are animated by the new guest of heat, and as it were exulting and dilated with the joy of their inner disposition, they luxuriate into branches, leaves, flowers, and fruits. But why they do not grow hot, or catch fire, from that motion, the reason is both the resistance of the abundant moisture in which they are rich, and that gentle influx of solar heat by which the fiery spirits, mixed with the moistures necessary for generation, are so tempered that they cannot burst into fire. And this is that "warm and moist" by which, on the Philosopher's testimony, all generation is accomplished, and by which all things flourish and are preserved. And once these our principles are laid down and applied, no effect in the nature of things will occur, however exotic, whose reason you cannot give.

COROLLARIUM III.

[Margin: Flame is flowing fire.]

Hence it is plain how flame — which is nothing other than flowing fire — is extinguished. For example, in a candle, which abounds in a fatty and viscous moisture, and in which many sulphurous spirits are present, it happens that the kindled wick and the spirits, catching fire, are at once kindled together into flame; and thus, owing to the abundance of fatty moisture, they begin to flow;

and with the spirits in turn provoking one another and exciting one another to flowing, the flame lasts as long as that flux in the root of the fuel lasts. But the flux ceases as soon as that flow is drawn off from the fuel, and the sulphurous spirits are disturbed, hindered, and choked — whether by a too-violent gust, or by overflowing moisture, or by pressure — so that it can no longer be fed nor flow.

[Margin: How fire is present in coal.]

In coal, however, even though there is no flame, there is nonetheless light, still seething with a fiery glow; whence, for their own preservation, they summon auxiliary forces — seizing nearby particles of dry coal, here and there, disposed for ignition — and, these being taken up (especially if helped by a blast), they grow strong into the greatest increase of fire. But if an external helper is lacking, then, as much as they...

can, they concentrate themselves, until at last, weakened and extinguished by the cold of the surrounding air, they cease from both light and burning.

[Margin: The light of fire varies according to the different nature of the fuel.]

But let us at last return to our discussion of subterranean fire. We rightly said, in our definition, that it is a portion of the elemental fire — not of pure fire, but tinged with the various medley of subterranean combustible things. And that fire is tinged according to the different nature of the fuel: if it is joined to pure sulphur, it gleams white; to bitumen, it mourns with a dusky flame; if to bitumen together with verdigris, it turns green; it reddens, if joined to minium or similar red-colored minerals; if to arsenic, ochre, or sandarac, it turns yellow; if it is applied to a fatty and oily, sooty material, it is left almost wholly without light, betraying its disposition by smoke alone. All of which experience will teach, if you kindle a wick in a lamp with the said materials mixed in oil. And hence it is that, although the element of fire is in all things the same in species, yet, according to the nature of the combustible things, it appears to differ in species.

[Margin: The whole Earth is cavernous.]

Our definition asserts, then, that fire of this kind is enclosed in the bowels of the Earth, for the safeguarding of sublunary nature and the production of all things. That the Earth is cavernous was amply shown in the preceding Book, where we set forth that the terrestrial globe has, within its own bowels, immense spaces, vaulted caverns, vast tracts, and impenetrable abysses. For as Seneca relates concerning the Field of Puteoli [Agro Puteolano, the Phlegræan Fields near Naples]:

There are vast caves there, there are huge recesses and spaces, with rocks suspended here and there over mountains, and at the same time chasms broken off into the infinite, which have often received cities sliding down, and have buried a great ruin in the deep.

And as Cornelius Severus said in his *Aetna*:

Wherever the immense globe of Earth extends itself, and is girded by the curving waves of the outermost sea, not all is solid, for every cleft is wanting [recte: deest — "is lacking"]; the whole soil is wrought and hollowed out within into hiding-places, and drives its slender ways suspended.

[Margin: The wedding of fire and water within the Earth.]

To which Pliny [Pliny the Elder], Aelian, Lucretius, and the other writers on natural things subscribe. There dwell, in chambers stretching far and wide in different directions, joined by the highest covenant of friendship, fire and water — which contrive that variety of things which metals, minerals, juices, oils, and the channels of springs reveal to us. For as Manilius rightly [says]:

But fires too are mingled through all the parts, which, dwelling in the moist clouds, forge thunderbolts, and penetrate the lands, and threaten lofty Olympus with ether, and make the waters warm in the very springs.

[Margin: The subterranean fire diffuses itself marvelously.]

So that even from this the admirable force and power of subterranean fire may shine forth, as — ascending upward with an ordered impetus, and making whatever it overcomes ascend — it grows in multiplied proportion almost to infinity, and corrupts and transmutes whatever it meets into its own substance, nor is it ever diminished by any part taken from it. For, enclosed in the caverns of the Earth and agitating itself, wherever it finds an entrance it penetrates to an exit over many hundreds of thousands of paces, even beneath the sea and through the trackless windings of the Earth — as we have taught in the *Prolegomena*, as an eyewitness inspector of all things. And while it continually acquires greater strength, it converts into fuel for itself the lands that lie in its path, and even the very rocks and mountains — so that, were it not restrained by the encircling Ocean and by the command of the omnipotent Deity, it would draw the whole mass of elemental nature into an inextinguishable conflagration.

Nor is it any wonder that so great a force of fire has been established by nature in the lands, since upon fires of this kind the welfare of the whole sublunary world

depends. For in preserving those things especially which — whether you regard necessity or duration — cannot do without the aid of fire, nature ought not to have been sparing, narrow, and defective, but altogether liberal and magnificent. For just as it constituted the heaven with an immense circuit, to embrace all things, and disposed the vast mass of the elements, and the immense expanse of the sea — from which it might distribute through the veins of the whole Geocosm an unfailing supply of waters — so too, the proportion of divine providence being preserved, it was fitting that it should have made a great apparatus of fire in the belly of nature; so that through these longest of chimneys, as it were, it might diffuse boundless heat for the use of the necessary things, for the benefit of the Earth, of men, and of living creatures.

[Margin: A great apparatus of fire in the belly of the Earth.]

And just as it appointed for the waters their boundaries, which they may not pass, so it has tempered this nature of fire with so admirable a distribution, with such order and such proportion of symmetry, in the hidden paths of subterranean nature, that it should neither be choked by the waves of the surrounding Ocean, insinuated far and wide, nor stray beyond the bound prescribed for it. For otherwise, bursting forth with its most free motion, it would turn everything upside down, to the open ruin of the Earth and of men — which I judge will come to pass in that fullness of time, when, the reins of raging nature being broken and the cataracts of the subterranean fires opened, by the command of Divine power not only the Earth but also the elements shall be dissolved by heat, with the ruin and destruction of the whole world. So that, just as in that universal cataclysm, the cataracts of heaven and the gulfs of the abysses being opened, it destroyed the world by an inundation of waters, so also in the last times it shall destroy that same world by an inundation of fires. And who would deny that this shall come to pass, if he has beheld the perpetual fire seething in the lands — if he has beheld the vast conflagrations of provinces, and finally the manifest apparatus of so great a store of matter and sulphur, which the Earth belches forth in even a single chasm — unless he should confess for certain that this is a specimen and an evident sign of the preparation for that conflagration prescribed by Divine Wisdom?

Diagram. A full-page engraved map of South America [Tomus I, plate 74], oriented with West at the top (the compass rose at upper right marks N at the bottom, S at the top, W at top, O [East] at the right). The map illustrates the chief water-reservoir [hydrophylacium] of the Andes, from which (per the cartouche) all of South America is watered by countless rivers and lakes. A large oval basin

in the interior, ringed by mountains, is captioned as the principal reservoir. The decorative cartouche at the bottom carries the title.

- Top-right corner: "Tomus I. 74." (volume and plate number)
- Compass rose (upper right): "N" (bottom point), "S" (top point), "W" (left), "O" (Oriens, East — right)
- Left margin (vertical): "OCEANUS AUSTRALIS sive MARE PACIFICUM" [the Southern Ocean, or Pacific Sea]
- Interior oval basin: "Sub Andibus Hydrophilacium Americæ præcipuum" [The chief water-reservoir of America, beneath the Andes]
- Across the northern landmass: "AMERICA" (spanning the band, with "A — ME — RICA")
- Upper region (NW): "PERV" [Peru]; "Caribana"; "Æquator" [the Equator line]; "R. delas Amazonas" [the Amazon River]; "BRASILIE" [Brazil]; "Maragnon" [Marañón]; "Tabaiar"
- Northern islands and coast: "Jamaica"; "Barbada" [Barbados]; "Caribar"; "Carragocaró"; "Darien"; "Antiocha"; "Castello Doree" [Castillo del Oro]; "Ibero fl."; "R. S. Martha" [Río Santa Marta]
- Central interior: "Parime lacus, alias Titicaca" [Lake Parime, otherwise Titicaca]
- Southern region (S labeled "INFERIOR" / "RIOR"): "Tropicus Capricorni" [the Tropic of Capricorn]; "I. Assençion" [Ascension Island]; "R. de la Plata" [Río de la Plata]; "Cuy populi Silvestres" [Cuy, forest peoples]; "R. de Mendoza"; "Buenos ayres"; "Barbaranna"; "Paraguay" [Paraguay]; "R. della Plata"; "C. de Corientes" [Cabo Corrientes]; "Desertum Pampas" [the Pampas desert]; "Manlanes" [?] / "CHILE" [Chile]
- Far south: "Fretum Magellanic." [the Strait of Magellan]; "Terra del Fuego" [Tierra del Fuego]
- Lower ocean (lettered across the sea): "OCEANUS OCCIDENTALIS" [the Western Ocean]
- Bottom margin: "TERRA AUSTRALIS INCOGNITA" [the Unknown Southern Land]
- Cartouche (bottom center): "Tabula qua HYDROPHILACIUM Andium exhibetur, quo universa America Australis innumeris fluviis lacubusq; irrigatur." [A map in which the water-reservoir of the Andes is displayed, by which all of South America is irrigated with countless rivers and lakes.]

CAPUT III.

On subterranean fire diffused through all things; and why in some places it is perpetual, while in others it is not.

[Margin: Just as blood is the spirituous heat in the human body, so subterranean fire is in the veins of the Geocosm.]

Just as in the human body the heat of the Microcosm, diffused as a spirituous breath through all the passages of the whole body, animates, quickens, restores, and stirs all things — joined together with the mass of the humors — so too the Author of Nature constituted the Geocosm with no less providence. He furnished it with the most abundant and copious fires, proportioned to the scale of so vast a mass, so that nowhere should there be lacking what is so greatly necessary to its natural operations.

The human body — that is, the Microcosm — is filled with air, fiery spirits, and humors; and so is the Geocosm. For just as in the human body, when a wound is inflicted at any spot, blood at once bursts out and at the slightest agitation effervesces, driving sweat out from the whole substance of the porous skin, so there is scarcely a place in the Earth which, if dug into beforehand, does not yield abundant streams of water — whether spontaneously, or drawn out by the pull of clayey earth — and these not merely cold, but also tepid, hot, scalding, and seething with an intolerable force of heat. For how could water subsist without fire, or fire without water? Surely without fire all things, condemned to perpetual frost, would long ago have ceased from all propagation of generable things, to the open ruin of nature; [Margin: Fire cannot subsist without water, nor water without fire underground.] while without water all things, long since consumed in the fires of innumerable subterranean reservoirs, would have reduced the whole fabric of the Geocosm to ashes and cinders.

You see, then, with how great providence — and by what admirable art of nature — these two elements are joined together, so that the one furnishes necessary nourishment to the other by a kind of reciprocal exchange, and the one breaks the other's onslaught. United in this way by a kindly compact, they accomplish the effects intended by nature. We have clear evidence of this when we see the Earth, that benign nurse of things, holding within her bowels the storehouses of all things — water, air, fire — in a certain admirable proportion, so that they may suddenly serve all her works and suddenly be at hand for any generation of things. Hence we observe an immense force of moisture flowing out of the earth in a perennial stream, perpetual exhalations breathed forth, infinite emanations

of waters, the enduring furnaces of subsisting fire, the vast cellars of the reservoirs, and the manifest effects of the eternal fire within them — smoke, flame, fervent heat, the seething eddies of boiling waters, and the vast conflagrations that are kindled over the course of time when the furnaces are torn open. These conflagrations, seen here and there throughout the whole world on land and sea, give sure account of the remaining heats and burnings that are scattered through the various tracts of land and sea, and which — channeled as it were into the various branches of the furnaces — produce so great a variety of *Thermae* [mineral hot springs] and minerals. But that these matters may be made clearer, we have decided to insert here a figure of the whole.

Here you have a figure representing the type of subterranean fire mixed with water. We do not, indeed, assert that the fire has this exact form within the earth — for who among the living has ever seen it? — but rather a certain likeness of nature at work, and as far as the imagination suggests it ought to be. For otherwise it can scarcely be grasped by human ingenuity how water joined to fire produces such marvelous effects, both outside and inside the earth. The central fire is marked by the letter A; the pyrophylacia [fire-reservoirs] derived from it, by the letter B; the hydrophylacia [water-reservoirs], by the letter C. The channels from pyrophylacia to pyrophylacia are the *canales pyrogogi* [fire-conducting channels]; the channels from hydrophylacia to hydrophylacia are the *canales hydrogogi* [water-conducting channels]; while the lines drawn to both pyrophylacium and hydrophylacium are the fibers, cracks, or fissures of the Earth, through which both water and derived fire dispose the Geocosm — both for the generation of springs and for that of minerals and metals — and they behave in just the way the capillary veins do in the human body, of which not even the smallest portion is without them, as has already been shown above. You will also learn from this that the pyrophylacia have their place nearer the Center, while the hydrophylacia have theirs nearer the surface of the Earth — by a truly prudent design of nature; for cooking-pots [cacabi] must be placed not below but above the fire, so that the water may be heated and brought to use.

[Margin: What a conflagration is.]

Now a conflagration is nothing other than a great accident in nature, a certain immense excess of fire which — having pursued the rich and combustible matter of the Earth out of the subterranean abysses of the underground fires — either through its own force, when the furnaces are ruptured somewhere, hurls forth flames marvelous and terrifying to mortals. And although conflagrations of this sort, on the outer surfaces of the lands, are not perpetual but occasional, the fire

in the subordinate pyrophyllacia is nonetheless not abolished, but subsists perpetually and uniformly, as is evident from the *Thermae* [hot springs], which always remain in the same state.

[Margin: Why subterranean fire fails in some places, but not in others, at certain times.]

But the reason why, in some places, the effect of the fire does not always appear, while in others it appears perennial, is this: even though the subterranean fire subsists in its receptacles in its substance, with its fuel constantly supplied to it, it nevertheless happens from time to time that the combustible matter near the Earth's surface is either consumed, or — through the passages choked with cinders from the burned-out clods of subterranean matter and through the cracks

[Margin: How subterranean fire is kindled and preserved.]

of the burned-out arches being obstructed, or through the channels being filled with water by the spreading of subterranean inundations — the propagation of the fire is impeded, and (as though a kind of truce had been imposed) it lies quiet for the course of many years; until the mineral vein, propagated with the passage of time and enriched with a fresh stock of combustible material, again bursts forth into the open and resumes its ancient stations of conflagration. For know that conflagrations last just so long as the fuel of combustible matter lasts; and if, for the causes mentioned, this fuel fails, then the fire too must necessarily fail — especially in those ducts of the furnaces which lie farther from the pyrophyllacium. But if the said causes do not intervene, it is certain that the conflagrations last perpetually. For flame — which we call kindled vapor — can [?] only so long as it has the bait of combustible matter; when this fails, the flame too fails and ceases, until, by a fresh communication with the sea, fresh matter is supplied and, with a perennial vapor and murky exhalation within, it sprouts up again to the topmost arches of the passages. There, just like the thickest soot, when a blast lying within is excited by a greater impulse, it catches fire and again gives off new flames.

But this cannot always happen in one and the same manner; for nature is wholly in continuous motion, and necessarily brings forth accidents of this kind — greater and lesser — according to the varying dispositions of the combustible matter and the condition of the blast pressing upon it, which are the necessary cause of these accidents. And since the matter is not always disposed in one and the same quality and quantity, nor is it equally apt for conflagration in one part as in another (because of the various dispositions of the furnaces), hence it comes

about that in some places the conflagrations are perpetual — because there the passages of the furnaces are kept utterly clear all the way to the pyrophyllacia themselves — while in other places they now die down, and now, after the lapse of many years, are rekindled, both on account of a fresh increment of matter and on account of the diverse forces of the subterranean winds and blasts. These winds are indeed so necessary to this Vulcanian economy that without them — being, as it were, the authors of all natural accidents — nothing would happen. How they are produced, I explain in a few words.

[Margin: How subterranean fire is kindled and preserved.]

When we said, in the *Itinerarium Terrestre* [Subterranean Journey], that the Ocean has its floor pierced like a sieve with countless openings — which are nothing other than the mouths of the channels — then, when the water, driven by the impulse of the sea, runs through them, it consequently excites wind; and this wind, rushing with utmost force through the channels of the pyrophyllacia (which are almost always united with the channels of the waters), or led into the pyrophyllacia themselves, there by its most humid blast not only excites the combustible matter but continuously animates it into the most fervent flames — no otherwise than as a blacksmith, by the blast of the bellows and the sprinkling of water, powerfully restores the fire in his hearth, redoubles the fervent heats of the fire, and by their power and efficacy — which without the blast he could not do at first — now, the iron having become subject to his own will and judgment, fits it by hammering into whatever form and figure he pleases.

[Margin: Subterranean winds arise from the motion of the sea.]

Now the subterranean blasts, or winds, arise from the commotion of the sea and from the daily reciprocation of ebb and flow; and these winds are, as it were, certain bellows of nature, whose perpetual blowing both draws the water transfused from the sea within its passages toward discharge, and propagates the wind — from the continuous commotion of the waters — within the fire-belching furnaces and passages, stirring it with a perennial motion. The cracks and fissures of the earth, which the water carried along had filled with a varied mixture of combustible matter — salt, sulphur, bitumen — these, here seething with heat and exhalations, liquefied according to the nature and condition of the earthen crypts, the fire and water draw to themselves and convert into fresh material for fuel. And once this is done, there comes about a perpetual continuation of nature's operations; and in this way the cycle [pericyclosis] of both water and fire is carried out by the industry of nature.

These matters, then, having been duly set forth, let us now turn our pen to the historical accounts of fiery conflagrations, so that the exterminators of subterranean fire may learn through their senses what they do not grasp by the intellect. And we shall best begin with the regions of Italy, inasmuch as it contains more numerous and more manifest traces of subterranean fires — traces on which all the demonstrations of the argument undertaken are founded. These things I would not have believed, had I not examined them all with my own eyes, surveyed on the occasion of my various travels.

[Margin: Italy abounds in subterranean fires.]

Under a temperate climate, then, Italy — since it is stretched out from the Alps in a long chain of linked mountains, and enclosed on either side by two seas, divided throughout by the Apennine — is on both sides washed by countless springs of bubbling waters, by lakes, and by the streams of mighty rivers; all of which indeed take their origin from the hydrophylacia, both of the Alps and of the Apennine. And that you may see the remarkable situation of Italy: that part of it which faces the Adriatic Sea, looking partly toward the North, is — because of the shadow of the Apennine — shaded, colder, and possessed of fewer thermal springs, of a rawer disposition. But on the right hand, which for the most part faces the South and is surrounded by the Tyrrhenian Sea, it is seen to be sunny, open, and — on account of its sulphurous soil-nature, which it everywhere reveals — apt for bearing fires. And so, in the various adjacent islands too, it has at all times produced diverse evidences of heats, reservoirs, and thermal springs. Hence, on the testimony of Berosus [Berossus], it is reported that of old it burned from Cumae and Vesuvius all the way to Istria, and was therefore called *Palensana* by the Janigenae [the descendants of Janus] — that is, a region [?] consumed by fire [?]. And if we explore the matter more minutely, we shall find that Italy has every disposition toward such vast conflagrations: the narrowness of its situation, by which it is continually scourged between two seas by the dashing of the waves; its subterranean passages and cavernous windings, open to fires and winds; and finally its abundance of sulphurous matter, in which the whole land luxuriates,

(continuing Liber IV, Sectio I, Caput III — the catalog of Italian volcanic and thermal sites)

in which the whole land luxuriates, and it burns in certain places over the entire earth. For in this whole southern part of Italy, from the farthest shores of Sicily right up to the borders of Etruria [Hetruria], in some places one sees perpetual fires — as in Aetna — while in others they burn at intervals, as in the Aeolian

Islands, which they call the Lipari [Aeoliae, quas Liparas vocant]; and opposite Naples [Neapolis], as on Aenaria, that is Ischia, Prochyta [Procida], and Pithecusa; and likewise in the mountains of the mainland — Vesuvius, Misenum [Misenus], Puteoli [Puteolisque], and Cumae — which often burn, and in certain places display great vents [aestuaria] with fires, smokes, vapors, and hot springs [thermis]. By these vents, as I have observed with the greatest care, the passages [anfractus] everywhere lie open, and the channeled vent-holes gape; and where these emit a blast, soon — not without dread in the bystanders — there are heard, deep within, crashings and roarings as of a burning fire.

[Margin: Phlegraeian fields. (Phlegraei campi.)]

These crashings and the booming of the waters can also be heard in the Phlegraeian Hills [Phlegraeis collibus], which surround the Vulcanian field, commonly called the Sulphatara [Solfatara]; and so do the not-far-distant Cave of the Sibyl [Sibyllae Antrum] at Cumae, and so many horrid chasms and recesses around Avernus, impassable because of the heat. All Campania everywhere bears on its surface the traces of that ancient conflagration — the ground here and there parched, like ash and pumice, and with that dust they call Puteolan, with live coals shut up in the very stone.

[Margin: Latium runs with sulphur. (Latium scatet sulphure.)]

From Puteoli let us pass to Latium, which is full of sulphureous craters: through Minturnae to Sulmo, and from there through the Roman Campagna [Campi Romani] the sulphur-vein continues, exposing itself in many places — but most of all in a certain lake of unfathomable depth, four miles from Tibur [Tivoli], as well as in the sixteen floating islands they call the Barchettas, the most famous of the floating sort. From this lake the river Albula, a sulphureous stream, takes its origin; and it was once celebrated for the baths of its thermal springs, of which I shall speak in its place.

[Margin: The channel of the subterranean fire diffused into various branches. (Cuniculus ignis Subterranei in varios ramos diffundens.)]

From here the channel [cuniculus] of the subterranean fire bends back toward Monte Rotondo — formerly the Eretan field [agrum Eretanum] — and from there it is led off into branches. One branch runs to the Thermae Stiglianæ [Bagni di Stigliano] and to a lake in the middle of a wood, a thing horrible to behold both for the stench of sulphur and for the boiling water rising in the manner of a column; and at last, through a neighboring mountain — in which there is also a cave of serpents [crypta serpentum], filled with vents and chimneys — it runs as

far as Tolfa and Centum Cellae [Civitavecchia], all of which places teem with sulphur and bitumen, and there it ends at the sea.

The other branch runs toward Monte Rosso, between which and Ronciglione new sulphureous craters open up, which hold hidden traffic with Monte Cimino — which they call the Mountain of Viterbo [Montem Verterbiensem] — and with the village of Vico, famous for its sulphureous springs. And indeed Monte Cimino still seems to nourish a great force of fire beneath its deepest caverns, which, at its roots on the northern side near Viterbo, it spreads over that whole plain, filling it with the most sulphurous exhalation, with clods here and there dried out and pumice-like, and with countless hot springs. Among these, the Bullicame is the most famous for its intolerable heat, whose marvelous constitution — God granting — I describe more fully in our *Etruria* [*Hetruria*]. This spring has a great communication with another nearby lake between Viterbo and Montefiascone [Montem Flasconem], where water bursting up from the bottom of the lake stirs up wondrous turmoil; and — wonderful to relate — two springs are seen here together, scarcely a single pace apart, of which one dances with the most scalding, the other with the most icy water; of which in its place.

[Margin: Two neighboring springs, of which one is cold and the other hot. (Duo fontes vicini, quorum unus frigidus alter calidus est.)]

From here the channel of the subterranean fire, diffusing itself into innumerable branches throughout the whole of Etruria, leaves scarcely any place free of hot springs, sulphureous craters, and mineral waters; since Etruria, where it looks out upon the Tyrrhenian Sea as far as the island of Elba [Ilviam Insulam], is everywhere a land that teems with warm waters and luxuriates in mines — whether of iron and copper or of sulphur. Under this head the Lacunae Volaterranae [the lagoons of Volterra] are truly memorable, filled with seething and leaping waters, and there are mines of the best sulphur near the Castrum which they call Libbiano [Castrum, quod Libbianum vocant], of which I have treated most copiously in our *Etruria* — see there.

On the other side, toward the East, the channel of the fire, stretched far and wide, exerts itself chiefly beneath the mountain they call Vivo [Vivum], where it produces the celebrated baths of S. Casciano and S. Filippo [S. Cassiani & S. Philippi thermas]; and from there it extends toward the baths called Avignonenses [Bagni di Avignone], all the way to Montepulciano [Montem Politianum], where at S. Albino [S. Albinum] a great abundance of mineral waters gushes up with a smoky stench. From there it stretches, on the one side, all the way to the Apennine [Appeninum] itself, packed with vents; and on the other side

it reaches the regions of Siena [Senas] and the neighboring parts bordering the sea, and the territories adjoining Liguria, and the Lucca district [Lucensem agrum] — which abound in so many metals, so many sulphureous mines, and so many springs of warm and seething waters as perhaps all the rest of Italy does not have.

[Margin: The channels of the subterranean fire exert themselves on the Apennine at Petra Mala. (Ignis Subterranei spiracula in Appennino ad Petram malam.)]

Yet most of all do the vent-holes of the subterranean fire exert themselves on the Apennine at Petra Mala and the places near it, where at night the air sparkles and, for a long time, smokes and steams as if from a furnace burning beneath, and heats and sets alight the straw thrown upon it. This spring appears to have veins continuous all the way to the Porretta waters [aquas Porretanas] in the Bolognese territory [Agro Bononiensi], whose hills sparkle at night on every side. From there it seems to plunge into the Modenese territory [Agrum Mutinensem], where a flow of bitumen and fire boils up in a wondrous manner; and from there it continues the fires of its kindling all the way into Istria. For that these Euganean Hills [colles Euganeos] once burned around the baths of Aponus [Aponi balnea] — as Berossus testifies — the rugged tracts of the hills, their ashen and pumiceous face, and the coals and stones (which heat even the very waters running through them) sufficiently show.

These things being so, they can truly be for us a proof that the whole of Italy is filled within with a continuous matter of sulphur, whose channel — as it extends its branches now more, now less, far and wide — likewise stretches under the sea too into the adjacent islands; and, according to the particular tempering of the mixture and the power of the heat which it holds under the varied course of the veins, it produces various effects,

produces wondrous fires at certain times. We conclude, therefore, that Italy, the nurse of conflagrations, just as it is wholly filled with subterranean fires — which in some places burn perpetually, in others at intervals — so once had such great accumulations of sulphur, such a heaping-up of fiery matter, that if not the whole, at least (by the testimony of Berossus) a great part of it was set ablaze; nor is it less to be believed that there will at some time come a time when, with these first principles of nature standing as they are, it will burn again and again, right up to the final destruction and consummation of the whole Universe.

[Margin: All of Campania is exposed to fire. (Tota Campania ignibus obnoxia est.) — (corresponds to the surface-of-Campania passage above on p. 177)]

[Margin: The floating islands of Tibur. (Insulae natantes Tyburtinae.) — (corresponds to the sixteen floating islands passage above on p. 177)]

CAPUT IV.

On the Phlegraeon Field in the Puteolan Territory.

[De Phlegraeo campo in Agro Puteolano.]

[Margin: Description of the Phlegraeon fields. (Phlegraeorum camporum descriptio.)]

In the year 1638, passing through Naples, I could not refrain from inspecting the sulphureous fields celebrated in every age, which the ancients call Phlegraeon. Having therefore passed through the subterranean passage they commonly call *la Grotta* — which I have described elsewhere, the excavated Mount Pausilippus [Posillipo] — not far from Puteoli, between the jaws of the mountains a plain spread out far and wide presents itself to view, a place altogether full of horror and dread, 1200 feet long, let us say, and 1000 wide. Pliny [Plinius] wrote that it is called the Phlegraeon Fields from its flames and burning; but Cornelius and Strabo call it the Forum of Vulcan [forum Vulcani], the place where some fable that the giants too were overcome by Hercules. There the hills are seen everywhere blazing at the bottom, in the very depths; for everywhere, through many openings, they always exhale great smokes with a sulphureous odor, which are carried by the winds through all the neighboring region, even as far as Naples.

This whole plain is encircled by hills, or rather lofty crags, whose summit, once very high, at length consumed by perpetual fires, sank down into a deep valley — as is gathered from the very form of the place. And so what was once a peak is now a huge pit dug in the level valley, where the ribs, or rather the flanks of the mountain of old, are now the topmost points of crags and cliffs. And these, by the testimony of Dio Cassius [Dione Cassio], once belched fires and flames in greater abundance; the neighboring mountains too burned continuously, and threw out, as from furnaces, thick smokes and fiery waters. But at the present time the plain itself, no otherwise than the Phlegraeon hills, drained by perpetual flames, is cavernous with infinite openings, and is everywhere yellow with sulphureous matter and color; the ground too is full of a blackness that, by its very darkness, strikes one with dread.

[Margin: The horrible lagoon. (Lacuna horrenda.)]

Yet in that same plain a Lagoon affected me with the utmost wonder. For it is found always seething with boiling and waxy waters; you would call it a cauldron boiling with pitch and resin, which from time to time changes its place, and, as the waters harden at the rim of the basin, is narrowed or widened together with the force of the exhalation, greater or lesser.

[Margin: The wonderful waters that boil up. (*Vis mira aquas ejaculans.*)]

This too is wonderful: that whirlpool throws the waters up beyond a man's height, to 8 or 10 feet, in the manner of a pyramid, and they are greasy and muddy and almost of a sulphureous color — which even the Puteolans themselves do not deny; they report that sometimes these boiling waters are flung aloft to 16, or even 24, palms, and this especially when the sea is in flood, but not when it is at rest. This is a most luminous indication that these marvelous effects of the upthrown liquid proceed from nothing else but the sea: for, agitated by the gales of the winds, while through the subterranean passages it stirs up the store-and-cellar [*promum condum*] of this liquefied matter, it is no wonder that the liquid — not knowing how to be confined within its narrow bounds — should be hurled aloft beyond the limits set for it by nature, and so much the more violently as the impetuous influx of the sea has thrust it forth with the greater violence. Indeed, the different color of the waters at that time too, composed of the various sea-water mixed with the various juices of minerals, plainly teaches this — namely that the subterranean winds, agitated by the marine tides and gathering strength among the flames, belch out the waters from the deeper springs of the earth. But when the sea is at rest, none of these things is felt; rather, the waters in the jaws of the lagoon are seen only greasy and squalid with black soot, together with a certain effervescence.

What shall I say of the mountains and crags with which this Vulcanian field is crowded? In these chimney-conduits not a few vent-holes are seen, some of which belch out a perpetual wind of vapors with a frightful sound and crash, with such force that, if you throw in a stone, you receive it again at once thrown back outward with great force; some discharge smoke mixed with flames. You would say you were set in the underworld, where all things are of a horrible, mournful, and dreadful aspect — nor are you only put out of your senses by the stench of sulphur, bitumen, naphtha, and other minerals. And although the place is so horrid, those nevertheless reap much profit from it who devote their labor to making sulphur, niter, and vitriol.

[Margin: The force of the vapors through the vent-holes of the field. (Impetus halituum per spiracula campi.) — (corresponds to the perpetual-wind passage above)]

Diagram. A large landscape engraving occupying the upper half of the page, depicting the Phlegraeian Fields (the Solfatara) near Pozzuoli viewed as a basin ringed by hills. In the foreground and middle ground, several conical hillocks emit columns of smoke (the fumaroles and boiling vents described in the text); a walled town with towers sits on a promontory at the left; the sea with sailing ships occupies the upper portion. A decorative cartouche at the lower right carries the engraved title.

- Cartouche (lower right): "FORI VULCANI sive Camporum Phlegraeorum Typus." [A View of the Forum of Vulcan, or of the Phlegraeian Fields.]
- Several small place-labels are engraved along the hills and shoreline but are too fine to resolve at this resolution [?] for the peripheral labels.

(continuation of Caput IV)

How they are prepared, however, will be told in what follows, in its place. Here we set out a figure of the place [Figuram loci], of those Phlegraeian Fields which we have described.

CAPUT V.

The fire-vomiting mountains visible on the external surface of the Earth sufficiently demonstrate that the Earth is full of fires.

[Montes Ignivomi in externa Telluris superficie spectabiles Terram plenam ignibus esse, satis demonstrant.]

If from any sign we can come to know the truth of the subterranean fire, surely we can do so from the flame-vomiting mountains and the other sulphureous craters which they call Vulcanos: we behold it so clearly from them that whoever should wish to deny it ought, in everyone's opinion, to be judged rash — not to say mad and stupid. For their multitude and variety is so great that there is scarcely any region in the world that does not exhibit them, as we have plainly shown in our universal Map [Mappa nostra universali]. And to begin with the better-known: there is in Sicily Aetna, the most celebrated in the records of both poets and historians, whose hidden constitution I shall describe in what follows,

being myself an eyewitness [Greek: αὐτόπτης (autoptēs, "eyewitness")] and an explorer of that mountain.

A hundred and fifty miles from Aetna lie the Liparitan, or Aeolian, Islands — called Hephaestiae by the Greeks, Vulcaniae by the Latins — and they are seven, namely: Strongylus, Liparis, Hiera (today Volcano), Hicesia or Salona, Ericusa or Alicur, Phenicusa or Phelicur, and Ecconimus — called by Ptolemy [Ptolomeo] Istica and Dydimia — which all, by Pliny's testimony, are said once to have burned; today Strongylus alone of the seven rages with fires not inferior to those of Aetna or Vesuvius. By Strabo's testimony, they are said once to have wholly burned, together with the mountains and the whole sea.

In the year 1638, when on the occasion of the Maltese triremes I was sailing past these islands, I made a descent and undertook to examine, among others, Volcano [Vulcanum] and Strongylus. Strongylus indeed, because of the fires which it continually belched, blocked off all approach; but Volcano, with its respites between vents, showed nothing but smoke. It has, however, an island attached to it which they call Vulcanello [Vulcanellum], joined to Volcano, which they say was born from the ejecta belched up by the mountain in its last eruption. All the islands teem with sulphur, niter, and bitumen; and that the bottom of the sea too is pierced through with countless caverns is indicated both by the whirlpools and by the frequency of the issuing winds that swell the sea in a wondrous manner. So that I cannot at all dissent from those who say that there are submarine threats and channels [minas & cuniculos submarinos] connecting with Aetna, and then, continued through the hollows along the spine of the Apennine, communicating with Vesuvius — which I found by experience to be most true in the year 1638, when Calabria was reduced almost to its utter ruin by the fury of earthquakes, being a present and eye-witness. See what I have related most fully on these matters in the Preface to this Work.

[Margin: The flame-vomiting mountains of Italy. (Montes flammivomi Italiae.)]

(continuation of Caput V — the catalog of fire-mountains of the world)

There is in Campania Vesuvius, whose history see, if you please, Reader, in the prolegomena of this Work; for when in the year 1638 I had climbed these mountains here enumerated, and had observed everything — not without manifest danger to life — the things I observed in them, surpassing all belief, had so much power over me that from this very source I drew the occasion and origin for undertaking the present work.

[Margin: The Vulcanian craters of Germany and of the other northern regions. (Germaniae Vulcanii crateres, caeterarumque partium Septentrionalis.)]

Etruria too has a burning mountain in the Apennine, and another in the territory of Felsina, that is Bologna [Bononiensi agro]; and besides, between Pistoia [Pistorium] and Petra Mala there is no lack of lagoons and caves belching out balls of flame, perpetually and especially at night. Two famous places full of fires are also noted in the Modenese territory, of which in what precedes. I come now to Germany, Gaul, and Spain; in which, even though mountains like those just enumerated are not seen, there are nevertheless frequent sulphureous craters and lagoons belching forth smoke and flames, and an innumerable multitude of hot springs everywhere — of which in their place — that offer the most luminous traces of the subterranean fire creeping within their hydrophylacia. In Meissen [Misnia], a Coal Mountain [Carbonum mons] from time to time rages with smoke and fire. In Lapland [Lappia] Olaus relates that lofty mountains belch out flames in the likeness of Aetna. In Iceland [Islandia], who does not know Mount Hekla [Heclam montem], most famous for its fires by the report of all geographers? To the miracles of nature there seems to be added the fact that its summit gleams with perpetual snow while it blazes with inextinguishable fires, and that, by the frequency of its hidden chasms, it grants no approach for many furlongs; and that, by the eruption of rocks and ashes, it reduces all the surrounding fields to sterility, together with a frightful sound and crash. When the inhabitants hear this, they more superstitiously believe that the souls of the wicked are tormented there with miserable wailing. See Olaus Magnus and the other geographers in the description of this island.

[Margin: The Vulcanian mountain of Greenland. (Groenlandiae Vulcanius mons.)]

And lest nature should seem to have left the farthest region of the North, condemned to the perpetual inclemency of cold and ice, without any remedy of heat, it has established a huge Vulcanian Mountain in the island they call Greenland [Gronlandiam], near the Pole; at whose roots there is a Monastery of the Order of Preachers [Dominicans], which they call St. Thomas's [D. Thomae], built of tufa-stones from the ejecta of the mountains. Concerning this, Bartholomaeus Zenetus the Venetian — the observer of all these memorable things, cast upon those shores, I know not by what chance — relates many things most worthy of admiration.

[Margin: Wonderful things about the Monastery of St. Thomas in Greenland. (Mira de Monasterio D. Thomae in Grunlandia.)]

His words are: "Here is seen the Monastery of St. Thomas of the Dominicans, and not far from it a fire-vomiting Mountain, from whose foot a fiery spring gushes forth. The waters of this spring being conducted through pipes, not only are all the cells of the monks heated like hot-baths [hypocausta], but food too — indeed the very bread — is cooked. The mountain belches up tufa or pumice, of which the whole monastery is built; for these tufas, once soaked with that water, are glued together as if bitumen had been applied. Here too are most beautiful gardens watered by that boiling water,

in which there are flowers and fruits of every kind. And this water, where it runs down through the gardens, falls into a nearby bay or harbor, whence it comes about that it never freezes over with frost; and therefore countless fish and birds resort there, on which the inhabitants live to satiety." So writes the man who saw it and discovered the coast, the Arch-admiral [Archithalassus] of the King of Denmark, Nicolaus Zenetus the Venetian.

It is probable, moreover, that Hekla of Iceland and the Volcano of Greenland correspond through hidden channels, and labor perpetually through hidden vents to subdue the violence of the cold and the ice. From this is concluded also the reason why, in some Northern islands and on the coasts of Norway, Finmark [Finmarchiae], Biarmia, and Lapland, on one side the sea freezes most easily, while on the other no force of cold and snow can make it congeal; and likewise why on some coasts there are found most abundant pastures together with the most fertile trees and fields, while on others — as in Nova Zembla [Novaya Zemlya] — neither grass nor trees nor anything useful for the nourishment of man is met with, the land being subject to perpetual sterility. This is plainly because the vents that lie beneath those places also gladden them with the wealth of things by their heat; and the contrary happens in those places under which the vents do not spread themselves out.

[Margin: In some Northern regions the sea freezes... (text trimmed at gutter; the marginal note continues the sea-freezing remark) [?]]

[Margin: The Vulcanian mountains in Asia. (Montes Vulcanii in Asia.)]

Asia abounds, here and there in many regions, with fire-vomiting mountains. On Ormuz [Ocmuzio], an island of the Persian Gulf, all things are full of subterranean fires, whence it is said to have burned for seven years continuously; and it still daily belches out balls of flame from the salt-mountains [salinis montibus] with which the island teems, by which the most celebrated emporium of the whole East has been nearly reduced to desolation. In Persia

itself sulphureous craters are found here and there, which, not without the horror of travelers, smoke and burn night and day. Cophantus, in the region of the Bactrians, by its fires strikes dread into all who behold it.

[Margin: In Media. (In Media.)]

In Media, at Susa, by the Tower they call the White [Turrim, quam vocant Albam], fire bursts out from fifteen chimneys, with a sound so violent that it persuades the surrounding peoples that the gates of hell are there.

[Margin: In Tartary. (In Tartaria.)]

On the coasts of Northern Tartary, by the reports of the Muscovites, workshops of this kind of Volcano are not infrequently seen.

[Margin: In the kingdom of the Chinese. (In regno Sinarum.)]

In the kingdoms of Hindustan [Indostan], Mogor [the Mughal empire], Tibet, and Cambodia [Camboia], mountains of this kind are found here and there, as also in the vast kingdom of the Chinese, as Father Martino Martini [P. Martinus Martinius] notes in his *Atlas Sinicus*.

[Margin: In Japan. (In Japonia.)]

In Japan, beyond the other islands, Vulcano seems to have established a notable abundance of workshops belching out smoke with fire night and day; and as these are 70 miles distant from Firando [Hirado], a famous city, so at night they illuminate the whole region like torches, to the wonder of beholders.

There are also islands neighboring Japan, which they call the Seven Sisters [Septem sorores], one of which exhibits a notable Volcano opposite the city of Tanaxuma [Tanegashima].

[Margin: In the Philippine Islands. (In Insulis Philippinis.)]

The Philippine Islands and the whole Archipelago of St. Lazarus [S. Lazari Archipelagus] so teem with Vulcanian places that scarcely...

Diagram. The famous double-page engraved cross-section of the Earth — the *Idealized System of the Subterranean Pyrophyllacia* (fire-reservoirs), of which the volcanic mountains serve as so many vents. The plate shows the terrestrial globe sliced open to reveal its interior. At the center is the **central fire**, from which a network of fiery channels radiates outward through the body of the Earth to feed numerous flaming reservoirs; these in turn connect, by way of fissures, to the volcanic mountains erupting at the outer surface. Around the globe, cherubic

wind-heads in banks of cloud blow gusts (the winds that fan and feed the eruptions), and a putto in the upper cartouche holds the engraved title-scroll.

The plate is **lettered** with a repeating key (defined in the engraved caption below):

- **A** (at and near the center of the globe): the **central fire** [ignis centralis] — the great innermost fire-reservoir from which all the channels proceed.
- **B** (repeated many times, the large radiant star-bursts of flame scattered through the Earth's interior, on both halves of the plate): the **reservoirs of Nature** [æstuaria Naturæ] — the subterranean fire-chambers (pyrophylacia).
- **C** (repeated, the branching vein-like lines that thread between the reservoirs): the **fire-conducting channels** [canales pyragogi] that carry fire from one reservoir to another.
- (The smallest thread-like rivulets, unlettered): the **fissures of the Earth** [fissuræ Terræ], through which the fiery exhalations pass to the surface.
- **(Volcanic peaks at the globe's rim)**: the fire-vomiting mountains breaking through the outer crust, with smoke and flame issuing upward.
- **(Cloud-borne human heads with pursed lips, in the surrounding sky)**: personifications of the **winds** blowing toward the mountains.

Engraved cartouche title (upper right): "Systema Ideale | PYROPHYLACIORUM | Subterraneorum, quorum montes | Vulcanii, veluti spiracula | quædam exystant." — *The Idealized System of the Subterranean Fire-Reservoirs, of which the Volcanic Mountains serve as a kind of breathing-vents.*

Engraved caption (running across the foot of both halves), translated:

This Diagram represents the nests of heat — or, what comes to the same thing, the fire-reservoirs [pyrophylacia] — distributed throughout the whole interior of the Geocosm. They are variously arranged, by the admirable workmanship of God, so that nowhere should they be lacking; this was so necessary for the conservation of the Geocosm. Yet let no one persuade himself that fire is really laid out in just the way this diagram depicts, [as if it were] established [precisely so]; and that the reservoirs are disposed in exactly this order — by no means. For who has ever observed these things? What human being has ever penetrated down there? Our sole aim with this diagram, therefore, has been to show that the bowels of the Earth are full of reservoirs and fire-chambers, whether they are arranged in this manner or in some other. From the center, then, we have led the fire out along all the pathways of the subterranean world, right up to the volcanic

mountains on the outer surface. The **central fire** is marked by the letter **A**. The rest are the **reservoirs of Nature**, marked **B**; the **fire-conducting channels** [canales pyragogi], **C**; and the very smallest rivulets are the **fissures of the Earth**, through which the fiery exhalations pass.

[?] A few words of the engraved caption fall in the gutter fold where the two halves meet (e.g. one or two words after *refert, co[...]* and *alio[...]*); the reconstruction above is from the legible remainder.

[End of Caput V. The chapter continues with the catalogue of fire-vomiting mountains.]

He may make manifest the offspring of Vesta conceived [within] — if not in mountains, at least in the craters and Charontic pits.

[Margin: The savagery of Mount Panacura in Java.] In **Java** [Java] there is a mountain on the island of Java not far from the city of **Panacura**. Although for many years before it had not burned, in the year **1586** it first burst open in a violent eruption of blazing sulphur and raged so fiercely that as many as ten thousand people are said to have perished in the fields below. For three days running it kept up its fury, hurling enormous rocks against the said city of Panacura, and it cast such a pall of smoke over it that, with the Sun blotted out, it turned day into darkness.

[Margin: Mount Pico in the island of Timor.] There was also another on the island of **Timor** [Timor], a peak of the same name [Mons Picus], of such height that for three hundred miles it offered a flaming summit to be seen out at sea. In the year **1638**, its foundations shaken by a horrendous earthquake, it was swallowed up together with the island, leaving nothing behind it but an enormous lake. So the *Annals of the Society of Jesus* [Annales Soc. Jesu] report.

Mount **Gounapi** [Gunung Api], on one of the **Banda Islands** [Banda Islands], after seventeen continuous years of burning, finally burst open in the year **1586** and threw out such a quantity of stones, ashes, and sulphurous-bituminous pumice that the sea was nearly covered with it and seemed wholly ablaze — with the destruction of all the fish and living creatures.

[Margin: Mount Pico in Sumatra.] On **Sumatra** [Sumatra] a huge volcano is to be seen, **Balalvanus**, so called in the native tongue from the vast quantity of fires it vomits forth.

[Margin: A remarkable fire-vomiting mountain on the island of Ternate.] On **Ternate** [Ternate], one of the **Moluccas** [Maluku], there is a mountain that, on

the testimony of Father **Maffei** [Giovanni Pietro Maffei], rises lofty and steep into the clouds. Its lower slopes are crowded with dense forests, while its upper parts, ruined by continual fires, are bare and barren. At its summit it has a crater, gaping in a vast opening, drawn in several rings from larger to smaller like an amphitheater. Here, especially when the Sun is entering the equinox, raging with smoke and flames under the blast of the north winds, it reduces all the surrounding region to a wasteland, covering it with ashes.

[Margin: On the fire-vomiting islands of Mauritius.] On the islands of **Mauritius** [Mascarene Islands], on the testimony of Father **Turellinus** [Orazio Torsellini] in his *Life of St. Xavier*, the subterranean fires are so powerful that the whole islands seem to be on fire. Hence the frequent earthquakes; and from the caverns and from the summit of Mount **Thola** it casts out such a mass of flames, ashes, rocks, and trees of no mean size that it seems to present an absolute image of hell. See the author already cited.

[Margin: Fire-vomiting mountains in the Pacific Ocean, commonly called *del Zur*.] In **New Guinea** [New Guinea] mountains of this kind were observed by the Dutch — as also in the **Southern Land** [*Terra Australis*] — to the great terror of the sailors. Similar ones were seen in that vast **Southern Ocean** commonly called the **Mar del Sur** [South Sea, i.e. the Pacific], though it has no name [for them]. In the **Indian Ocean**, here and there, deserted and rocky mountains display their smoking volcanic chimneys; all of which the *Universal Map* [*Mappa Universalis*] sets before you.

[Margin: Volcanic mountains in Africa.] Leaving the islands and the ocean behind, we come gradually to **Africa**, in which eight famous volcanoes are observed: in **Monomotapa** [Mutapa] two; in the Congo of **Angola** and in **Guinea** four; in **Libya** one; in **Abyssinia** [Ethiopia] one — besides countless craters and sulphurous caverns to be met with everywhere on all sides. Some of these, once their combustible material is consumed, have ceased to rage, as though by appointed truces, only to rage again in their own time once the material of their fires has ripened anew.

[Margin: The Atlantic Sea teems with subterranean fires.] The **Atlantic Sea** so teems with subterranean fires that the land which **Plato** [Plato] calls **Atlantis** [Atlantis] seems to have perished and been swallowed up for no other reason than the savagery of these fires and the consequent frequency of earthquakes. And down to this very day certain tracts of the seas, beset by flames and fires bursting up out of the fire-reservoirs, give ample proof of it — fires whose fury both **Columbus** [Christopher Columbus] and **Vespucci** [Amerigo Vespucci]

experienced at their own great peril, as may be read in the *History of the New World* [*Historia novi Orbis detecti*]. Nor are traces of this thing wanting.

[Margin: Pico in the Canaries.] The islands they call the **Terzeras** [Azores] can scarcely be inhabited because of the violence of the fires. The **Canary Islands** [Canary Islands], and on them the **Pico** [Pico del Teide], a mountain of immense height, belch fire down to this very day — as do the plains of the surrounding islands, stuffed full of sulphur and bitumen. On the dreadful earthquake that occurred in the year **1638** on the island of **St. Michael** [São Miguel], one of the Azores, and on the marvelous events that followed from it, see the fuller account we gave in the Third Book.

[Margin: The island of St. Helena.] The islands of **St. Helena** [St. Helena] and of **Ascension** [Ascension] once burned, as both the scorched rocks of their mountains and their plentiful ashes and coal more than sufficiently demonstrate.

[Margin: The mountains of America.] At last we gird ourselves for **America**, which, if I should call it the Kingdom of the Volcanoes, I should not be speaking improperly. In the **Andes** [Andes] alone — which the Spaniards call the **Cordillera** [Cordillera] from the unbroken chaining-together of the mountains, and to which the Kingdom of **Chile** [Chile] is subject — fifteen volcanoes are observed, on the testimony of the native Father **Alfonso d'Ovalle** [Alonso de Ovalle], who also marked them on a map. Some of these, swollen with the offspring of their fires, brought such calamities upon that kingdom in the year **1645** that a pen would scarcely suffice to describe them, with whole cities here and there both swallowed up and overturned. See the *Annals* of our Fathers under the year cited. To these we add the volcanoes that have been observed on the southern side of the **Strait of Magellan**, commonly called **Tierra del Fuego** [Tierra del Fuego].

[Margin: In Peru.] In the **Kingdom of Peru** [Peru] there are likewise found six inaccessible volcanoes of great height: three in the Andes, besides countless volcanic pits. In the province of **Carrapa** in **Popayán** [Popayán] there is a mountain that rages — chiefly in clear weather — with smoke and flames.

The city of **Paraquipa** [Arequipa], ninety leagues distant from **Lima** [Lima], has a neighboring sulphurous mountain that never ceases to hurl out fire, to the great dread of the people, lest, if it should ever burst, it bring final ruin upon the region.

At the Valley of Peru called **Mulahallo** [Mulahaló / the Latacunga valley], fifty leagues distant from the city of **Quito** [Quito], yet another volcano presents itself

to view: by its continual belching of fires and flames it threatens, far and near, even to peoples remote, the usual calamities.

[Margin: North America — 5 volcanoes.]

In North America, five [fire-vomiting mountains] have been observed: some in New Spain [Nova Hispania], some in New Granada [Nova Granata], and some in the interior districts of California and other parts of the Mexican realm.

In Nicaragua, thirty-five leagues from the city of León, a very lofty mountain hurls out flames in such quantity that they can be seen from ten miles [ad decem millia passuum] away.

Another, of similar ferocity, is found not far from Acapulco [Acapulco].

On the mainland of California there are three; and in the inland regions two more, concerning which see Father Andrés Pérez [P. Andream Perez], the historian of Mexico.

We have therefore surveyed the flame-vomiting mountains [montes flammivomi] set in place by provident nature, on land and sea, across the four quarters of the terraqueous globe — Europe, Asia, Africa, and America. This is not to say that such mountains do not exist, or could not exist, in those parts of the world still unknown; rather, these are the ones observed in our own age, during voyages and journeys by land and sea now so frequent around the world. And so that you may better grasp the diffusion of the [subterranean fire] through all the channels of the Earth, I have decided to insert a figure here, by which you will more thoroughly understand my meaning and intention.

[Margin: Where there is a volcano, there is a pyrophylacium beneath.]

COROLLARIUM [Corollary]

From this it is plain that the entire inner workshop of the Earth is furnished with countless pyrophylacia, and that it has been joined by the Author of nature in such partnership with the watery element that the world would sooner have to perish than have the one separated from the other. For wherever there is a volcano, that beneath it there lies a pyrophylacium is as certain as it is certain that beneath a furnace there lies a kitchen, a hearth, a cooking-pot, or something of the kind. Now just as the pyrophylacia penetrate through the innumerable cracks, fissures, and passages of the Earth — exactly as the [animal spirits] penetrate the inmost fibers of the muscles and nerves throughout the Microcosm — so too the hydrophylacia, exactly as the blood does in the human body through

the capillary veins, communicate themselves to the whole globe of the Earth through certain incomprehensible passages diffused on every side. And from this comes the great multitude and variety of hot springs [thermae] in all parts of the world, of which I will speak in their proper place and time. Nor is it always necessary that mountains alone perform the office of chimneys; rather, beneath the sea itself, just as in the dry-land regions, there lie hearths and pyrophylacia. Whenever these are seized by conflagrations, by the violence of the enclosed air they turn everything upside down, as has been said repeatedly in the preceding pages. Pyrophylacia of this kind also lie beneath the Archipelago [Aegean] in Europe. To show this, I shall add here, by way of a colophon [Coronidis loco], the account of Father Francesco Riccardi [P. Francisci Riccardi] of the Society of Jesus, who on the occasion of the dreadful earthquake that struck the island of Santorini [Santorinium] in the year 1649 — being himself present, the aforesaid Father saw the whole thing with his own eyes, afterward related the outcome of the entire affair to me orally at Rome, and wished it to be made known to posterity by the following testimony. As it is very fitting to my undertaking, I have decided to insert it here.

Account of Father Francesco Riccardi [Relatio P. Francisci Riccardi]

Concerning the subterranean fires that burst forth from the depths of the sea in the year 1650 near the island of Santorini in the Archipelago.

Although some accuse Pliny [Plinium] of falsehood, because he reports certain astonishing things beyond human comprehension, nevertheless we learn daily, with experience herself as our guide and teacher, that in many matters he spoke truly — above all when, in the books of his *History*, he lists the many islands that in the course of time burst up from the depths of the sea. Among others, we know that Thera [Theram], in the 135th Olympiad, was called Callista and Philotera. Now, from Saint Irene [Sancta Irene], the renowned Virgin and Martyr who is venerated there, it is called Santorini. For [Cardinal] Baronius [Baronius], in his *Ecclesiastical Annals* at the year 726, seems to confirm faith in Pliny, when he speaks there as follows: "A vapor was seen to boil up from a furnace of fire between the islands of Thera and Therasia, out of the depth of the sea, for several days; and as this gradually thickened and spread, the heat being kindled into a fire, the whole appeared as a smoke of flame. Moreover, by the vastness of the earthy substance it cast forth great pumice-stones and certain heaps of them across all of Asia [Africa?] [recte: Asiam], and Lesbos and Abydos and the Macedonian seaboard, so that the whole surface of the sea was filled with these

pumice-stones; and in the midst of so great a fire an island formed from a heap of earth — the island called Sacra — was joined together, not having existed before."

We have learned that the same thing happened in the year 1457 from certain verses carved on marble for perpetual memory, which are read as follows beside the gate of the Castle of Scaro [Castelli Scari] on the same island:

Great-souled Francesco, surest offspring of heroes, Crispus, you behold
with your eyes the disasters that have wrought wonders. Joining five
elevens to these two [i.e., $5 \times 11 + 2 = 57$], On the seventh day before the
Kalends of December, with a vast roar the immense and ruinous
Therasian [Therefinus], when it groaned, tore loose the rocks of the Muse
[Camenae] [?]; and a crag appears out of the lowest waves — a great
thing begets a memorable portent.

[Margin: The great force of fires beneath the Archipelago.]

That a second island, near to this one, was again formed is established for the year 1570, to the no less terror of the Santorinians, since the conflagration lasted for a year — as certain elders who saw it with their own eyes still testify. In the middle of this modest island, which is now called μικρή καμμένη [Greek: mikrē kammenē, "the little burnt (island)"], a vast and deep pit is to be seen down to the present day, which, narrow below, gradually opens out into a round shape like a funnel. Out of this, as out of a chimney, were hurled those huge rocks and crags which, mingled with ashes, built up that mass projecting above the waves.

Yet those subterranean fires, which are nourished by an abundance of bitumen and sulphur, are never quenched — and sometimes they break out with tremendous force. This is evident from the extremely hot waters found at the seashore in the far southern part of the island, which the islanders use as most healthful thermal baths to drive off illnesses arising from cold.

[Margin: Dreadful storms.]

But if ever those fires, shut up in the bowels of the Earth, exerted their power, it was above all in the year 1650, from the twenty-fourth of September to the ninth of October, when they shook that island with earthquakes so violent and so frequent that the Santorinians, fearing imminent ruin, prostrated themselves as suppliants at the altars day and night. Indeed, it cannot be told nor explained how great a terror seized them all, when — the barriers broken — those forces strove to make a way for themselves through the midst of the waves of the sea, about four miles from the island of Santorini toward the east. For suddenly the

sea swelled up to about thirty cubits in height, and spreading widely over the neighboring lands, it overturned everything in its path — so much so that at the very harbor of Candia [Crete], which is nevertheless eighty miles distant, it dashed galleys and ships to pieces with its sudden onslaught.

[Margin: The dreadful heat of the air mingled with fires.]

The air, moreover, infected with these foul and sulphurous vapors, began to grow dark and to draw on countless [terrors]: now you might have seen brazen pans and flame-vomiting swords brandished; now glittering arrows shot forth; now, as it were, terrible serpents and dragons flitting about; now lightning-flashes and bolts let loose.

[Margin: The mineral vapor harmful to the eyes.]

Though even seeing this was scarcely possible — for the eyes of those who looked on were so injured by those sharp and sulphurous vapors that, made almost blind for three days, they could not only see nothing but were seized with such great and grievous pain that they continually bewailed their wretched lot. But when they opened their eyes, they saw all their silverware and bronze [recte: brassware] —

[Margin: The provisions are removed by the multitude of ejected matter.]

— as well as their vessels, garments, and all their pictures, covered over with a tawny color. So great a multitude of fiery pumice did that whirlpool [vorago] vomit out, that they covered the surface of the sea like a sea itself, so that one could scarcely make headway in a boat. It is most certain that they were carried as far as Constantinople [Constantinopolim] and filled all the shore. The force of this conflagration was greatest in the first two months, since the neighboring sea seemed to boil like a seething pot, and day and night immense globes of flame and very dense heaps of smoke kept rising up.

When these were sometimes carried by an adverse wind toward nearer places, besides a most grievous stench they brought death upon birds and animals, and even upon human beings themselves.

[Margin: The death of birds and animals.]

So it happened on the 9th of October and the 4th of November that, besides countless birds, sheep, cattle, and asses, a multitude of fifty peasants, suffocated by that smoke, perished miserably. The same thing befell nine sailors who,

crossing there by night in a small boat, were after three days found all half-burnt and were buried on the island of Io [Ios].

[Margin: The new formation of an island.]

During the remaining four months, although that hellish hearth abated much of its vigor and heat, and could scarcely raise itself out of the waves, it nevertheless seemed to eject pumice and to labor at the formation of a new island — which, although it does not yet project above the waves, can nonetheless be observed as a shoal in a calm sea, the water barely floating eight cubits above it. And if it be asked whether those fires are now wholly laid to rest, the answer is that they are seen sometimes to revive, since it has been noticed that the sea there often seethes and lifts smoke up with its waves — most of all this present year, 1656, on the eleventh of January and the following days.

CAPUT VI [Chapter VI]

On the perpetual duration of fire, and on its fuel or sustenance.

[Margin: The subterranean fire is the active principle of all things.]

When the Maker of the universe and Lawgiver of all Nature had founded the Earth and at the same time produced the remaining elements of the sublunary region, with ineffable wisdom he divided the assembled mass of the elements he had disposed, and, having cut it, distributed it into its members. Hence, taking thought for the adornment of the universe — and likewise for the safety of living things, and especially of those that inhabit the Earth — he set a portion of the elements in the heavens, and the stars arose; another portion he joined to the Earth, in such harmony that they cannot be separated from one another except by the destruction of the whole. Fire in particular he enclosed in the inmost vitals and at the center, as a kind of active principle which should give form and life to all the rest, and which he bound to water, as to a passive principle, by laws of friendship so strict that — even though they may seem to be contrary — the one cannot be sundered from the other, inasmuch as by their reciprocal commerce both they themselves and all things that arise from them are conserved. And so God, the Best and [Margin: Greatest], is the efficient cause of the subterranean fire as of all the rest.

Since, therefore, the work of nature is the work of intelligence proceeding from its innate providence, God surely did not wish it to lack the support of the things necessary to it; for he who gives existence gives also the accidents that pertain to existence. And so, since these were the first principles of the world, they certainly

had to possess perpetual operations, lest in the course of time they should fail along with the destruction of all nature. From this is born that perpetual duration and perpetuity of natural operations and of the elements — which, just as no art or human industry can imitate, so it belongs to the omnipotence of the divine art alone. Its parts, although they may seem to perish, cannot perish or be destroyed according to their total being, since they stand subject to the rule of the law of nature.

[Margin: Perpetuity of motion in nature.]

Hence too is born that perpetual revolution of the stars, never failing; hence the motion of the elements, proceeding by a certain constant and inviolable law for so many myriads of years without failing—

[Margin: Pericyclosis (circulation) of things.]

—in the supreme variety of things, always invariable. Hence the perpetual circulation [pericyclosis] of the waters, both within the Earth and around it. And just as, according to the witness of the Wise Man [Sapiente] [i.e., Ecclesiastes], all rivers run into the sea and return from the sea whence they began to flow — the Sun empties the sea by means of vapors, and the vapors, resolved into rains, are soon restored to the sea from which they were drawn. Many wonder, when they behold Etna [Aetna] burning for so many thousands of years, and cannot grasp how a mountain not yet consumed by such long-lasting fires has not had its fire extinguished.

We have seen it surging when its furnaces are burst, [its hollows] and rolling flame-vomiting globes and molten rocks.

[i.e., Virgil, on Etna]

These men, surely, if they understood the cyclical operations of nature, would not wonder so greatly, since at no time is fuel lacking to it for perpetuating its conflagrations — as we shall demonstrate later.

[Margin: The fuel of fire is perpetual.]

Conflagrations burn up mountains and turn their mixture of combustible matter into ashes; from the ashes mingled with water is born a new fuel for the perpetual fire, as will be demonstrated later — and so:

All things are continually turned in rapid orbits, with nature perpetuating her own motions.

There were many of the Peripatetics [Peripato] who, since they could not conceive this perpetual fire, were of the opinion that it does not truly and really pre-exist, but is born ever anew, by a fresh generation, from spirit [or vapor] agitated in the caverns of the mountains. But this is by no means the case; for the spirit that comes from waters set in motion and dashed about is always cold and moist, and is therefore affected by a foreign quality of the air, one most contrary to ignition. With the most violent blast of Boreas [the north wind] too, the air is so far from catching fire that rather, in winter time, it freezes at the first breath. Nor can so tenuous a substance as air be ground down, except by the hardest bodies most violently collided against one another. It is therefore impossible that a tenuous, cold, and moist spirit should kindle fire in any matter, however well prepared. That there is therefore in the bowels of the Earth a cause of such great conflagrations and heats has been made plain from what precedes — which we call the [subterranean fire], by whose action the metals are concocted, the fossils and minerals brought to maturity, and whatever else of combustible things the Earth brings forth derives its origin from this source. Yet I say that the subterranean fire is stirred up, as by a kind of fan, by spirit excited from the waters set in motion:

And so it casts up flames and overturns rocks and raises clouds of sand.

[Margin: Why the subterranean fire does not fly off.]

There are, furthermore, others of the Peripatetics who wonder why the subterranean fire, disposed in the lowest receptacles or pyrophylacia of the Earth, does not fly off from there and seek the higher and natural regions [of fire]. To these we reply that God founded the world with such a subordination of bodies, and with so continuous a connection of them, that one cannot be drawn apart from another without the destruction of the whole of nature. For from such a separation — since one body cannot succeed to another without the dread of a vacuum, than which nothing is more contrary to nature — air, water, and fire so rigidly guard the territories of their own jurisdiction against the common enemy of nature, that, with nature unharmed, they cannot be separated and torn from one another by any violence whatever. There is nothing fortuitous where the highest Wisdom has arranged all things; nothing violent, where things of their own accord obey the laws of their particular [governing] nature.

[Margin: Objection.]

Here I hear the Peripatetic murmuring against me with this argument: Wherever there is a contrary, there the corruption of the one must intervene. Fire is

perpetually joined to the terraqueous globe, its contrary; therefore necessarily either the water will quench the fire, or the fire will consume the water. The reasoning is plain from the Philosopher [Philosopho] [Aristotle]: Whenever an active and a passive are present together, one must always act and the other always be acted upon; fire behaves after the manner of an active principle, and the terraqueous globe after the manner of a passive principle; therefore from the reciprocal motion of things a transmutation must necessarily arise.

[Margin: Solution of the proposed doubt.]

I reply: If these elements be considered in the highest and equal degree of intensity, that is true; but if they be considered in a disparate degree, according to the predominance of one over the other, it is false. For from the first supposition it would follow that all things would always be corrupted, nothing generated, nothing victorious — and so this whole machine of the world would long since have ceased to be. Therefore, since heat prevails over cold, and fire over earth, fire will always prevail by its own activity against earth and water. And lest at last the whole globe should collapse from so many continuous conflagrations, the provident nature of things always supplies it with fresh and fresh fuel, so that as much as the fire feeds upon, so much the terraqueous globe, in which it is enclosed, supplies it anew. Nor is there any danger that it should ever be extinguished, since nature has assigned it so many chimneys for breathing, so many hidden routes and secret paths of channels for drawing in new supply. But how these fuels and sustenances may endure by perpetual circulation, we have undertaken to set forth.

We said in the preceding pages that the whole Geocosm consists of salt as its proper element; that from the Earth the sea draws that [salt] everywhere and on every side, from the beginning of things, as into its own nourishment; and that from salt is born, on land and sea, that fatty substance [pingue] by which all things contained both outside and within the Earth live, are nourished, and are conserved. For this is, as it were, a kind of glue and balsam of nature, without which nothing would coalesce, nor would any of the heterogeneous things curdle into one substance. This, then, joined to suitable earthy clods, produces now sulphur, now Mercury, now another kind of mineral — both on account of that innate heat, and on account of the moist and fatty or unctuous element, which is found to be present abundantly in salt. I said "to suitable earthy clods"—

—appropriated, because, since the Earth abounds especially in sulphurous substance, the salt, joined together with its own fatty part, continually produces new and new sulphur. So too, joined with that primal unctuous moisture, it

produces — in another, similar matter already disposed and lying hidden among the fibers of the Earth — quicksilver [hydrargyrum]; and in other places, according to the disposition and sympathy of the earthy parts, it brings forth now these, now those juices, and other minerals, after the long labor of nature combining individual things, attracting like to like, and adapting each one to produce such an effect and not another.

But that salt is the cause of all these things, we show as follows.

First, that the salt of nature is a kind of seed, and one of the three natural principles. Secondly, that it contains within itself both the hot and the moist, the two other principles of nature, which can be separated from one another by no force of nature. And so it is so diffused throughout the substance of the whole terraqueous globe, that no portion of earth can be assigned so small — of whatever condition it may finally be — from which, by the spagyric [chemical] art, it is not separated; and thus every natural body, in the ultimate resolution of its parts, leaves behind nothing other than salt. And this indeed, just as it is accepted by all philosophers, so it has no need of further experiment. Yet that this salt has a fatty or unctuous something implanted in it by nature, and wholly inseparable, we have thought worth proving by experiment, so that it may be plainly established that salt, just as it is present in all things, so likewise nowhere lacks its own fatty part.

[Margin: Salt diffused through all things.]

EXPERIMENTUM [Experiment]

[Margin: A certain fatness is present in all things.]

Choose uncultivated earth, never improved by any benefit of manuring; dry it in the sun, pound it fine, reduce it to powder, and distill it through a retort as is customary in [making aqua fortis / acidic waters] [in stygiis aquis]. Then remove the receiving vessel, and you will find the genuine fatness of the earth floating upon the water (which had at first been deliberately placed within the receiver), having a slightly bitterish salt taste. It is therefore plain that the earth is full of fatness and stocked with oily matter, from which all things — whether of the inanimate, or the vegetable and sensitive kinds — draw their nourishment. Earthworms, the proper children of this terrestrial fatness, are so filled with it that, when prepared by the spagyric art, they are resolved almost wholly into an oily fatness, useful for many infirmities. There is no plant that does not draw from its benign mother something like itself, together with salt, for the conservation and nourishment of nature; and these in turn, just as they pass into

the nourishment of animals, so also these animals communicate to others, freely — now more, now less, according to the condition of each — that good so greatly necessary which they had drawn from the earth.

These things, then, being supposed as most true principles of nature, let us now pursue the argument we first set ourselves: concerning the perennial fuel of fires. We said in the preceding pages that the terrestrial body is everywhere stocked with salt and with fatty, unctuous matter. This, first drawn off by the sea through natural suction, is converted into that salty and unctuous substance which the sea presents to us. And that this is so, the effects of seawater sufficiently show: for it stains clothing and cloths, and besides being unfit for washing them — spoiling them with I know not what corrosive burning — it is utterly useless for quenching fire, since by reason of that fatty part mixed in it, it does not, I will not say quench the flames, but rather increases them.

[Margin: The Earth abounds in salt and fatness.]

We said, furthermore, that the terrestrial body does not consist of homogeneous, but, however much of it there is, of heterogeneous matter and clods, so disposed by nature within the inmost and throughout all the channels of the Earth, that, by the vapors and exhalations stirred up by the subterranean fire, it produces this or that mineral most agreeable to each fossil — where the disposition of the clods is sulphurous, sulphur; where mercurial, Mercury; and so of the rest — by means of the salt and the said fatty unctuous part.

[Margin: The whole body of the Earth is heterogeneous.]

But since in the course of time matter of this kind, seized by the subterranean fire, is consumed in perpetual conflagrations, something else continually had to be substituted. Let us now explain how this comes about. It was said in the preceding pages that the sea, stirred by the influential power of the Sun and Moon, is engaged both in the perpetual and unfailing agitation of ebb and flow, and is troubled by the storms of winds and tempests, by its annual, monthly, and daily motions.

[Margin: The ebb and flow of the sea is the instrument of nature for sustaining her actions.]

By the continual urging of these, the sea, compressed through the hidden meanderings of the depths, charged with the sulphurous, saline, and aforesaid fatty spirits in which it abounds, is diffused into the inmost recesses of the Earth. There, where it finds matter disposed, it makes it fertile by its seminal virtue, and

by a fresh supply restores the fuel that had been consumed by the fire. And in this way it continues, by a certain perpetual circulation [pericyclosis], the kindling of combustible matter, from the very first beginnings of things into future ages, and right up to the consummation of the world itself.

But that these things may be made more clearly evident, we have decided to demonstrate the point by the single description of Mount Etna — since the same principle holds for all the volcanic mountains.

CAPUT VII.

LIBER QUARTUS, Sect. I.

DESCRIPTION OF ETNA.

In which, as in a kind of prototype of subterranean fires and of the reasons for their inexhaustible fuel — as the saying goes — these things are demonstrated to the eye.

When in the year 1638 I was traveling throughout Sicily, I judged that before all else I should examine Mount Etna, the most celebrated of all in the records of every writer. It is, I say, the most famous prototype of burning lands — indeed of virtually every kind of upheaval that rages on land and sea — and on this account alone Sicily is admirable, since it is the unique spectacle of nature. You will scarcely find any author, whether among the ancients or the moderns, whom the violence of this ferocious natural force has not drawn into wonder and astonishment. Yet because they have observed the genuine causes of such great effects only from a distance, I, approaching somewhat more closely and intending to set forth the constitution of those things observed by me κατὰ τὴν ἀκρίβειαν [Greek: kata tēn akribian, "with exactness / precision"] in these most recent times, will undertake to demonstrate opportunely the causes of all these so extraordinary effects.

[Margin: The size of the mountain.]

Etna, then, is a singular mountain, raising its summit aloft to 30,000 paces measured along its axis — as Maurolyco [Francesco Maurolico] and Clavius [Christoph Clavius], who explored its height by geometrical reasoning, attest. It occupies a space of 60,000, or as others say 100,000, paces with its encircling base. It is fertile in the fat surrounding fields, vineyards, and pastures spread about it, and wooded with pinewoods, beeches, and the loftiest firs; but toward the topmost summit it is broken and rugged with unstable ash and pumice. Across a

vast circuit of 12 miles it gapes open into a crater, which, by a steep inward slope, narrows down all the way into the abyss — a precipice horrible to behold, with flames and smoke bursting forth, both from its depths and from the sides of the mountain, with a dreadful roaring not unlike thunderclaps. So formidable is it that the mere imagination of fire and ruin now on the very verge of breaking out confounds anyone, however bold and intrepid, at the first encounter, and turns him away as from some infernal pit.

[Margin: The breadth of the crater and its horrendous appearance.]

Nor do I doubt that those frequent conflagrations, seen here throughout every age, have somewhat increased this vast mountain by the continual discharges of ash. This is abundantly shown on every side: by the cadaverous, ashen, and pumiceous aspect of the burnt crags along its slopes, and by the appearance of enormous caverns (one of which, easily capable of holding 30,000 men, I was permitted to see), formidable with pumiceous embers and with the refuse and dregs of variously melted mineral matter. In many places you may see, made of the said material — which they call *sciarra* — the tracks of vast torrents, left behind as it were like certain traces of the great devastations once wrought by the fiery flow of the molten metal.

[Margin: The tracks of the fiery rivers.]

At the summit, snow and ash, meditating an eternal union, seem to have covered everything with a sad and mournful countenance — all the more perilous to those who approach incautiously, in proportion as the chasms covered over by a certain deep snow and ash, stretching without bottom into the innermost abysses of the mountain, are the more frequent. As these have swallowed up many who approached too rashly without a guide, so by their own ruin they have given an example to the rest that those places are not to be approached carelessly — places which mock the lives of mortals with such hidden contrivances and concealed snares. In just this way Father Matthaeus Taveran [Matthaeus Taveran][?], being too eager an investigator of natural things, experienced great peril to his life as an explorer of this mountain. And to embrace much in few words: the entire material of the upper mountain seems to be nothing else than an incoherent mass, suspended within itself, of ashes, pumice, and the stones they call *lithanthracites* [coal/antracite]. Since this mass is on every side exposed both to the interior mineral spirits within and, without, to snows, rains, hailstorms, and winds, and is easily penetrable, it ought to seem no wonder to anyone that this scorched and burnt-out material — as it is impregnated by an ever-new supply

coming from the sky — should in the course of time conceive new offspring, so as to burn again and to blaze without end, again and again. As Virgil too attests:

[Margin: The generation of new combustible material.]

Whatever other matter is fertile for fire, once it has been kindled, dies, and nothing remains for it to renew: only ash, with no seed of earth. But this, enduring once and again, and with a thousand fires drawn off, restores its strength.

For since in the lowest depths the fire is never at any time extinguished, but always sends forth some trace of itself — either heat, or smoke, or flame, as I observed many times in examining the mountain — yet outwardly it begins to rage only at certain intervals of time, more or less according to the heaped-up quantity of combustible material. And the longer it has lain quiet, the material being as it were the more invigorated toward conflagration, with the greater violence does it exert itself, and along with the flames themselves it hurls vast heaps of sand. As Lucretius asserts:

And at the same time it thrusts out rocks of wondrous weight.

Diagram. The left half of a large double-page engraved plate depicting Mount Etna in eruption. At upper right the plate bears the slug "Tomus I. 186" (referring to printed page 186). The left side of the scene shows a steep, jagged volcanic flank: flames and dense billowing smoke pour upward from a vent at the base of the rocky escarpment, carrying glowing ejected stones aloft into the smoke column. The smoke twists into tall serpentine plumes against a sky filled with massed clouds; small birds are scattered across the upper sky. Below the rocky slope, the foreground falls away toward a band of churning flame or fiery torrent running across the bottom of the plate; at lower left a row of small human figures (a file of people, perhaps a procession or fleeing crowd) is engraved at the foot of the slope. To the right, the terrain descends into cultivated, tree-dotted lowland with cypresses and what appear to be orchard rows. No engraved labels other than the page-slug are present.

Diagram. The right half of the same double-page engraved plate, carrying the plate's title cartouche. The titling, set in open ground at the upper left of this sheet, reads:

- (upper left, title): **TYPVS MONTIS ÆTNÆ** — "A representation of Mount Etna"
- (below title): **ab Autore Observati** — "as observed by the Author"

- (date line): **A° 1637.** — "in the year 1637"

The scene shows the great mountain at right: a towering, smoke-belching volcanic peak whose right-hand flank erupts in flame, with a massive twisting column of smoke rising and ejected glowing rocks flung out from the burning slope into the sky. The sky is filled with banked clouds and scattered birds. In the foreground a large tree stands at left, with wooded and cultivated slopes descending across the middle ground; orchard rows (regularly planted trees) cover the lower right slope. At the foot of the mountain, near center-bottom, a small walled town with towers and domed buildings is engraved, labeled beneath it:

- (town label, lower center): **Catana** [Catania]

A band of churning flame or fiery flood runs across the bottom edge of the plate, continuous with the corresponding band on the left half. The two sheets together form a single panoramic view of Etna erupting above Catania.

[Note on the page sequence in this stretch: is the printed text page 186 (start of Caput VII). are the two halves of a single fold-out engraved plate of Etna belonging to that page (left half slugged "Tomus I. 186"; right half titled "TYPVS MONTIS ÆTNÆ ... A° 1637", with Catania below). is the largely blank verso of one plate sheet, showing only the bleed-through/offset of page 186's marginal notes (legible fragments: "Fumi perpetua eructatio," "Sonitus fragoresque formidabiles," "Ignium eruptiones in locis variis visuntur," "Spelunca ingens," "Longitudo & latitudo torrentium igneorum," "Magnitudo Montis," "Crateris amplitudo & horrenda facies," "Semitæ igneorum fluminum") — no independent body text. These marginal notes are the printed sidenotes of p. 186 and are rendered in their proper places above.]

CAPUT VIII. — Description of the Crater of Etna

The crater of Mount Etna has been found by different observers to be of differing size. There are those who say they have observed it to be 2,000 paces wide plus 80 paces; others, 30,000 paces; and still others, 400,000 paces. But it cannot be otherwise: in a mouth exposed to such great upheavals, continually shaken by so many onslaughts of a raging nature, the crater is bound to be found now wider, now narrower, according to the conditions of the moment. I myself have observed this with the greatest astonishment — not only at Etna, but also in the mountains of Lipari [the Aeolian Islands], and indeed at Vesuvius.

[Margin: The perpetual eruption of smoke.]

Whenever a more violent eruption of combustible matter occurs, the mountain is shaken, and from that concussion the heaps of more diseased matter that have been piled up on the mountain collapse with the shock of the mountain — heaps which are now pregnant, as it were, with new offspring. In this way they furnish fresh fuel and nourishment to the fires. And so, from this collapse of the mountain's masses, the crater is necessarily made wider; whence it happens that the interior of the mountain, by gradually growing, rises up, and the emptied spaces of the diminished crater are filled in again — by which, equally, the crater of the mountain must be made narrower. Indeed, the histories report that the matter heaped up within from such collapse has at times grown so much that [the text continues at the foot of the column —]

[Margin: A dreadful sight, the chasm of Etna.]

[Margin: The depth of the chasm.]

— what had accumulated over so many years, shaken loose by dreadful tempests of fire, is vomited up right to the lowest abyss of the mountain, as is seen today. This spectacle is so terrifying that, with the hair standing on end and the head spinning with vertigo, no one is so stout-hearted that he can look upon it without dread. The chasm is so deep that it escapes all sight; it is to be feared for the crags rising up from its sides in the shape of pyramids; and since the walls descend downward in a straight, perpendicular, parallel run of cliffs, yet — by the laws of optics — they appear to converge at the center on account of the excessive distance. This has deceived many observers, who, taken in by this optical illusion, supposed that the inner sides of the mountain narrow into a conical surface.

Returning to the foot [of the chasm] — a marvel to relate — the mountain, by its continual eructation of mineral matter, is always (I know not how) at work in constructing the mountain's fabric anew. There, just as I always remember having observed, there is a kind of lake gleaming with molten metal; the sides everywhere, through corresponding passages, belch out perpetual smoke in very many places, which by night we have found to be a kindled flame. The abyss is never without a roaring and bellowing, which it sometimes utters so horribly that it makes the very mountain tremble. In a word, whoever desires to behold the wondrous power of God Most High, let him approach mountains of this kind; and, dumbstruck and stupefied by the ineffable effects of nature's miracles, he will again and again be compelled to declare, with the deepest feeling of his heart: *O the depth of the riches of the wisdom of God! How incomprehensible are your judgments, and how unsearchable your ways, by which you have established the World!* [Romans 11:33, adapted.]

The mountain is so high that from it the whole of Sicily can be taken in, and indeed, when joined by a favorable moment, the view reaches as far as Africa. But if the mountain is disturbed by some storm, you may reckon the lives of those present there finished — so dreadfully is everything wrapped up in whirlwinds, in snow, and in ashes.

[Margin: The eruptions of fire visible in places.]

I said a little earlier that copious smoke mingled with fire is given off from the sides of the mountain in many places. These vents, if in time they happen to be blocked up — whether by the shaking of the mountain or by some other accident — then, when the mountain's fury is imminent, have been found to prepare an exit even from elsewhere, through the outermost surface of the mountain. And where this happens, it produces such dreadful openings of the mountain, and such fearsome passages of caverns, that we gaze upon them to this day, astonished with wonder that they ever existed.

[Margin: An enormous cavern.]

I have seen a cavern that could easily hold an army of 30,000 men, as we mentioned a little earlier. There is also in the same place a most gloomy cave, which they call *la Grotta della Palomba* [the Cave of the Dove], of such depth and capacity that the inhabitants of the mountain believe an approach is granted in it, by a submarine route, to the Aeolian Islands. From these and similar grottoes, fiery rivers once burst forth, as the bed nearby — heaped with pumiceous and burnt-out rocks, which the Sicilians call *sciarra*s — abundantly proves.

[Margin: The length and breadth of the rivers of fire.]

These torrents of molten fire have, the histories relate, sometimes flowed to a length of 18,000 paces, and to a breadth of now 1, soon 2, 3, or 4,000 paces — so that no one can wonder enough where so incredible an abundance of molten matter has its origin, in what places it has its workshops and smelting furnaces hidden away, of such great capacity for the liquefaction of so many minerals and metals.

LIBER QUARTUS, Sect. I. — [continuation of Caput VIII]

But just as these inaccessible works of God are most remote from all sense-perception, so neither can they be sufficiently penetrated by any human intellect. We may only marvel at what cannot be grasped in the incomprehensible majesty of the divine works. For if you reckon the amount of molten matter according to

the computation of the various periods of time, you will find that it grows into so great a heap that by its own mass it far exceeds twenty Etnas.

But, in order to confirm our reasoning more clearly, I shall append here a brief Chronicle of the more notable eruptions, by which the mountain, raging with dreadful devastation all around, has in no age failed to display its fires.

Chronicle of the Eruptions of Etna

[Margin: The wondrous works of God displayed.]

1. [Margin: In the time of the Janigenae] Time when the Janigenae [the descendants of Janus] first entered Sicily seeking new colonies — Berosus relates that the mountain's eruption was so great that the colonists, fearing devastation, abandoned the island and departed from here to seek other colonies in Italy, deeming it a most unsuitable settlement — one which nature's ferocity had rendered fearsome through so many and such deadly ruins. So it may be that on this occasion the fable of the rape of Proserpina was introduced.
2. [Margin: In the time of the Sicani] After the Janigenae, the Sicani — Driven off by new whirlwinds of Etna's eruptions, they were compelled to abandon the eastern part and to inhabit the western.
3. [Margin: Of the Argonauts] In the time of the Argonauts — When the most ancient Orpheus had seen it, he sang thus: *"Now, holding the Sicanian straits at Lilybaeum, we sense the waters, and we see flames across the heights, threatening us with the menace of Aetnaean Enceladus."*
4. [Margin: Of the expedition of Aeneas] In the time of the expedition of Aeneas [Aeneae] — He, repulsed from the shore of Sicily by the Cyclopes and terrified by the mountain's fire, abandoned that deadly station and betook himself elsewhere. So Virgil, *Aeneid* III: *"Unknowing of the way, we glide to the shores of the Cyclopes. The harbor itself lies unmoved by the winds' approach and vast, but hard by, Aetna thunders with fearful crashes. At times it hurls forth to the sky a black cloud, smoking with pitchy whirlwind and glowing embers, and flings up balls of flame and licks the stars; at times it heaves up rocks and the torn-out entrails of the mountain, and erupting, with a groan rolls together molten crags beneath the air, and boils up from its lowest depths."*

5. [Margin: Olympiad 2, in the time of Thucydides; Pythagoras, Empedocles] Under the dominion of the Greeks in Sicily, namely from the 2nd Olympiad up to the 88th — According to Thucydides, who was living at this very time, the mountain blazed up with three great eruptions; at which time, a little later, the mountain raging again is said to have drawn even Pythagoras himself into the greatest astonishment. Then, in the time of Hieron [Heronis], the histories relate that Empedocles, an observer of the mountain, perished.
6. [Margin: Of the Roman Consuls] In the time of the Roman Consuls — It is gathered from various authorities — Diodorus [Siculus], Polybius, and others — that four eruptions of the mountain occurred.
7. [Margin: Of Julius Caesar] In the time of Gaius Julius Caesar [C. Iulii Caesaris] — Diodorus relates that Etna raged most violently — which they hold also to have portended the death of Caesar. So great was it, the report goes, that by its heat it even burned the very ships in the sea as far as Lipara, all the fish being killed off and cooked; and within 20 years the mountain caught fire four times.
8. [Margin: Gaius Caligula Caesar; Hadrian Caesar climbs the mountain] In the time of Caligula [Caligulae], 49 years after Christ — The mountain raged again so fiercely that Caligula, then staying in Sicily, seized with terror of the impending disasters, abandoned Sicily and withdrew to safer stations. Hadrian Caesar [Hadrianus], however — out of the great magnitude of his spirit — is reported to have climbed the mountain, while it was still seething, some way up, in order to consider such great marvels at closer range.
9. [Margin: Around the martyrdom of St. Agatha] Around the martyrdom of St. Agatha — By whose merit and intercession it came about that the mountain, however much it raged, did not dare to reach Catania.
10. [Margin: The time of Charlemagne] In the time of Charlemagne [Caroli Magni], the year 812 — He too, terrified by the savagery of the mountain, is said to have sought safer places.
11. [Margin: The year 1160] From the year 1160 up to the year 1169 — All Sicily was shaken by great earthquakes; Mount Etna, boiling up, overturned all the surrounding places with enormous devastation, including the ruin of

the Cathedral church of Catania, in which Abbot John [Abbas Iohannes], together with his monks, was crushed and perished.

12. [Margin: The year 1284] The year 1284 — A fearful eruption occurred around the death of Charles, King of Sicily and Aragon [Arrogoniae].
13. [Margin: The year 1329] The year 1329 up to [13]33 — The mountain raged dreadfully, in the time of the King of Aragon.
14. [Margin: The year 1408] The year 1408, under King Martin.
15. [Margin: The year 1444] The year 1444 up to [14]47, again and again.
16. [Margin: 1536] The year 1536 up to [15]37.
17. [Margin: The year 1633] The year 1635 up to [16]29 [recte: 1635 to 1639?] — An eruption raged the more terribly, the longer it lasted; and since very many have described it, I do not linger on recounting it. Finally, in the year 1650, raging again from the northern and eastern quarter, with the mountains burst apart, it vomited up so great an abundance of fires that it nearly brought Bronte [Brontium] to the utmost peril and destruction by its fiery torrents. See Carrera, *On the Antiquities of Catania* [Carrerus, *de Catanens. Antiquit.*]; Philotheus; Musculus [Musselus]; and others.

[Margin: The mountain is increased by eruption.]

COROLLARIUM I. [Corollary I]

From these things it plainly stands established that the mountain, its matter once consumed — now to a greater, now to a lesser degree — has held off [erupting], until, augmented by a new supply of combustible matter, at last bursting forth, it has presented those catastrophes which we read of with wonder. And yet it is so far from being diminished by such great eructation of matter, that it rather appears to have been increased. For indeed, when the citizens of Catania were digging for pumice, at a depth of 100 [?] paces, the earth being opened up, they found streets paved with marble

[—] and various traces of antiquities, which plainly show that cities founded here in former times were buried, with great increase to the mountain, by the mountain's ejecta. They found, moreover, several bridges of pumice, which were formed solely from the flow of the fiery torrents, the softer ground having been eaten away. A flame, too, raised up from the earth, now appears and now disappears — which are clear indications of a soil raised up by fire.

[Margin: Whence comes the new nourishment that accrues to it.]

But these things are well known. This one thing is what has tortured the minds of philosophers in a wondrous way: that they do not grasp from where ever-new fuel is supplied to the voracity of the perpetual fire, and how, in the course of time, pumice, ashes, and the rest of the refuse of burnt-out matter are converted into new matter fit for fires. That this knot may be untied:

[Margin: How salt lies hidden in ashes.]

I suppose, first, that in ashes there lies hidden abundant salt — which is proved even from this, that salt is obtained by no easier method than from the lye of things reduced to ashes. In this way niter, salt, and alum, blooming out from the walls in certain damper places, and likewise dug out in most copious yield from the stalls of doves and other animals (first activated by urine), are obtained. Of these matters I shall treat expressly in their proper place.

I suppose, second, that from the sea — imbued with moist, rich brine and a mixture of other mineral substances — there is drawn out, by the power of the Sun, an enormous abundance of exhalations together with the spirits of the said substances and with imperceptible corpuscles. These, dissolved partly externally into rains, hailstones, and snows, fix their seats around the summits of the highest mountains; and partly, channeled internally through the subterranean passages of the sea, they fertilize the matter of the pyrophyllacia with a new influx, as was indicated above.

[Margin: How the nourishment is newly produced.]

These things being supposed, I say: The fire that flourishes perpetually in the pyrophyllacia is perpetually augmented through the hidden fibers of the sea entering in, while it fills the matter consumed by fire — such as ashes and the most porous stones of pumice — with sulphurous soot and bituminous spirits, and to some degree prepares and disposes it for ignition. But when, by the heat of the Sun on the one hand and by the action of the nearby latent fire on the other, hail and snows are melted, and when rains pour down upon the powders and ashes drenched in most copious sprinkling, then a certain mixture is born; and this, insinuated deeper within the porous recesses of pumice, and with the sulphurous and bituminous spirits (which had long been nesting there) intervening, at last — as soon as it has matured — becomes the fuel and nourishment of fire.

That this is so I have learned by irrefragable experiment at the brinks of the fire-burnt valleys of Etna, Vesuvius, and Strongylus [Stromboli]. In most of their ashen walls I found an immense abundance of blooming salt, alum, and niter; and in some, also a flow of bitumen, naphtha, and similar oily liquors, together with a most copious abundance of sulphur. These had drawn their origin from no other source than partly from the ashes of burnt-out things (from which a new progeny of salt and niter must necessarily arise), and partly from the sulphurous corpuscles or spirits which, as they continually exhale from the abyss of the mountain, are condensed into sulphur in the colder region of the mountain. And so, from salt, niter, alum, bitumen, and sulphur, that mixture is born which, insinuated within the pores of pumice and of rocks burnt to lime, supplies that perennial fuel which we have until now been seeking. For this, corrupted by fire, prepares new conflagrations; and so, when what lay hidden within the pumice — the rich, sulphurous matter — has been burnt up, it sustains some intermissions, until the relics of pumice and lime are refilled, as has been said, with a fresh brood of combustible matter.

That what happens on the exterior surface of Etna also happens in all other flame-vomiting mountains — nature acting in the same manner in all — is certain. Indeed, that nature preserves, in the same tenor, in the innermost pyrophyllacia, the very process which we have set forth on the exterior surface of the mountain, cannot be unknown to anyone who has penetrated these matters more deeply.

COROLLARIUM II. [Corollary II]

From this it follows that the fuel and kindling of the subterranean fire follows the motion of the sea as it surges with the perpetual reciprocation of flux and reflux. For from the sea's agitation this [fuel] is thrust through the hidden passages (as has often already been impressed) and, joined to its own rich and moist [matter] — which nests in the innermost recesses of the earth under sulphurous clods, hot and dry — by an unceasing brood of new generation restores what has been consumed. But on the external surface, through vapors drawn up by the sea and impregnated by the said birth-stuff of the sea, it lays down a new generation within the porous chambers of matter already burnt — through snows, hailstones, and rains mixed with powders and ashes — so that in its own time that matter, now matured, may at last burst forth into great conflagrations. You see, therefore, the wondrous and unfailing cycle [pericyclosis] of nature in her operations.

COROLLARIUM III. [Corollary III]

[Margin: The formal cause of the eruptions, the material cause.]

From these things it follows that the formal cause of this mountain's eruptions is fire itself; the material cause is sulphur and salt, niter, bitumen, and similar matters apt for feeding fires, propagated from the inmost darkness of the earth and at the same time from the overlying sea by its perennial motion.

[Margin: The instrumental cause.]

The instrumental cause is the cavernous nature of the place, and the whole mass of the mountain, riddled with tunnels and suspended upon itself, and perpetually weighed down by sulphurous soot.

[Margin: The efficient cause.]

The efficient cause, finally, is the blasts [of wind] which, flying out from the deepest caverns toward an exit of this kind — and as it were toward their own jaws — [drive] the dormant fires to the matter nearest at hand.

LIBER IV (Pyrographicus), Sectio I

CAPUT VIII — [Crateris Aetnaei Descriptio, continued]

[the blasts of wind rouse the dormant fires], as if fanning them with a kind of bellows. For it was shown in the preceding Book that the whole of Sicily is riddled with innumerable caverns and tunnels — there where we demonstrated that the marvelous surges of the Mamertine, or Sicilian, strait, the alternations of its ebb and flow, and the insatiable devouring force of Scylla and Charybdis all depend, by a wonderful arrangement, on the said mountains, distributed across the entire island in subterranean workshops. The most striking testimony to this is the fact that, when Charybdis is churning more than usual, Etna [Aetna] — stirred up by the same spirit of revolt — rages along with it. The more violent blasts are received into its sulphurous caves, and the combustible matter, stirred up just as if by a smith's bellows, bursts out in vast globes of flame.

[Margin: The mountain throws out fires according to the disposition of the winds.]

When other winds blow, by contrast, Etna seems to grant something of a truce, because the mouths of its passages are then set opposite to the running waves of

the sea and are blocked by the neighboring mountains. But to the blasts of the East wind [Eurus] and the Southwest [Africus], depending on the configuration of its channels, it sends out now flames, now smoke, then ashes, and sometimes — when the fuel within it has grown — it rages with fires in astonishing fashion, with a dreadful outflow of fire and sulphur, which it tends to belch out from time to time from the innermost recesses of its furnaces. This brings vast and ruinous devastation: villages, fields, cities, and living creatures beneath it are all destroyed. The forewarnings of it are the groanings of the caverns from the spirits pent up within, and the roaring of the sea joined to the trembling of the earth. By these signs Nature, as though exasperated and impatient of her chains, having broken the bars of her prison, rushes out wherever a gate is opened. And like a river of fire it pours down in an immense flood — not only over the fields, but it also consumes whole villages, overturns nearby towns, and, leaving everywhere traces full of horror, now devours forests and crags. Of these the records of historians are full.

We therefore conclude: the matter of the subterranean fire is not only sulphur, or bitumen, or fossil coals, but also alum, salt, niter, antimony, carbonaceous earth, and copperas [calcanthum], and metallic substances of that kind. For sulphur and bitumen alone do not make a fire so violent as that fire which overturns mountains, buries cities under ashes and pumiceous ejecta, and tears rocky masses out of the mountains themselves with incredible violence of nature, as was clear from the foregoing. Rather, something else must be joined to it to produce this effect — which we now undertake to explain.

[Margin: What that thing is which causes such great ruin of the mountain.]

I say, then, that the universal matter of the subterranean fire must be sharp [acrem] and thick [crassam]. Of this kind are sulphurous and bituminous materials, with which — by a strong bond of mutual commerce — halinitrum [native niter] is joined: a substance filled in its own being with swollen spirits, which, once joined to sulphur and set alight, when it finds no exit, exerts upon the obstacles in its way underground that same force which we set out a little earlier — especially if crude antimony and mercurial spirits are present, as is sufficiently established from the efficacy of artillery.

Further, since combustible materials are found only in subterranean caverns — such as the various kinds of stones, the various species of earthy clods, the mixtures of metals and of other minerals, and besides these salt, alum, halinitrum, sal ammoniac, and whatever else is found there, right down to water itself — both the mountains and their huge rocks are turned into the matter and

nourishment of fire. Sometimes only the matter that has been generated burns, and once this is consumed the fire goes out; then, having shifted its station, it attacks another matter near to it, as happens in bituminous earths. At other times the matter, once consumed, is reborn from newly conceived seeds and, much later, is kindled again. And if it is born from a sudden generation in great abundance — as in Etna, in Strongylus [Stromboli], and in the Phlegraean Fields [Campi Phlegraei] — then they will burn with a perpetual fire.

The generation of such materials happens in this way. The sea, filled with fatness and oiliness, enters the inner recesses of the Earth, and soon nourishes anew the bones of the mountains that have been worn thin by fire, refilling their hollowed-out, marrow-drained substance with fatness. And if it finds an opening into the sulphurous chambers, the water drawn in is turned into nourishment of sulphur; if into bituminous ones, into nourishment of bitumen; if into aluminous veins, into nourishment of alum (and so, reasoning likewise of the rest), it is turned into fuel. In this way the substances lost through fire are restored — in much the same manner by which, on the island of Elba [Ilua], iron is reborn in mines left at rest for several five-year periods, and in the Tiburtine countryside [Agro Tyburtino] the stones they call *travertine* [Travertina].

But how the said materials catch fire was stated above: namely, not from the Sun, not from the stars, not from lightning or flashes, not from any other efficient cause — but only from the subterranean fire itself, which makes its way to them through the hidden passages of the rocks, which it burns. Or, if they are not immediately touched by the actual fire, then certainly by the sea-waves which, driven by the force of the winds, are thrust into them through submarine channels [inciles]. For it cannot be otherwise than that, from the violent dashing of the waves in narrow places, and from the agitation of the spirits of the combustible matter, and from the friction of the thick air, they should at once catch fire.

SECTIO II

DE AERIS ET VENTORUM

On the **Causes, Nature, Powers, and Variety of Air and Winds**, which hold sway both on the outer surface of the Geocosm and in the internal subterranean cavernous regions.

[Printed p. 191; running header context: "Sectio II."]

PRAEFATIO [Preface]

The cause of the winds has, at every period, seemed to philosophers a thing difficult to discover — so that not without reason does the Royal Psalmist [the Psalmist David], drawing from the treasures of God, declare: *"You who bring forth the winds from your treasures, you who walk upon the wings of the winds, and assign names to them all."* And just as the treasures of the Divine Wisdom hint at the manner and reason — incomprehensible to the human intellect — by which they arise, so the walking upon the wings of the winds shows, again, that their causes are so difficult that they seem reserved to Him alone who alone holds sway over their cause, who alone makes them rage, who casts the bridle upon them and assigns them their names.

[Margin: The difficulty in assigning the cause of the winds.]

And so it is man's lot only to marvel at what he does not grasp, and from this to learn rather to adore the unutterable greatness of the Divine Power in His creatures than to scrutinize them too curiously. Yet, because the Divine goodness has furnished men with sense and intellect, so that through the things that are made they might come to know the invisible things — that is, that through things laid open to the senses they might reach to their invisible powers, and from there at last ascend to the Author of all things, God Most Good and Great, who governs all things by His invisible power — from this there has arisen that boundless restlessness of human minds in the investigation of natural things, and that spirit of mortals seething with desire to attain the truth. Burning with this same desire, we too, for the glory of His name, begin our discourse on the causes, nature, and properties of the winds. In it, if I shall produce anything worthy of praise, it is to be credited not to my own childish reasoning, but to Him who gave both the power and the will to do so.

CAPUT I

On the manifold cause of the winds, and their division and definition.

It cannot be that one and the same cause should always be the producer of the winds, since the diversity of the winds — differing in nature, powers, and properties — undoubtedly argues for diverse causes. Hence it is frivolous to say that the cause of the winds is nothing other than a hot and dry exhalation struck collaterally, which the Peripatetic [Peripatu(s)] stubbornly defends.

[Margin: The common definition is not adequate.]

For our part, corresponding to the diversity of the winds, we shall try here to assign diverse causes — causes which, nevertheless, are all subordinate to the one cause of the one Maker of all things. Once these are known, no quality of the winds will prove so strange, no effect of the winds so exotic, that you cannot assign its cause. But, so that in a matter so tangled and knotted we may preserve the natural order, we shall reason first about the variety of the winds, and then also about their causes.

[Margin: The differences of the winds.]

I find **seven** differences of winds, by which the whole mass of the Earth is continually agitated.

1. First there are the **common and perennial** winds, which blow at every time and in every place, unless they are hindered by other winds or by various obstacles — such as that single Eastern wind which we call the *general* wind, and which holds sway above all in the Torrid Zone, rushing from East to West.

[Margin: The Eastern wind, perpetual beneath the Torrid Zone.]

2. There are winds **proper to certain places and periodic** [periodici], which, just as they blow at a fixed time of year, so too blow only in a fixed place or tract of the Earth — such as the Etesian winds [Ethesiae], which used to prevail in Greece and Egypt only in the summer season, and not so in the other parts of the Earth.

[Margin: Periodic winds.]

3. The **anniversary** winds [Anniversarii], which are either monthly, or daily, or hourly. According to the diversity of the seasons these blow over the Ocean from various quarters of the world, and in some places they last for a six-month, four-month, three-month, two-month span, in certain places for a monthly, weekly, daily, or hourly span of time — of which more later.

[Margin: Anniversary winds.]

4. There are **extemporaneous** winds [extemporanei], born from a violent collision of the air — such as the winds before or after rain, thunder, and so on.

[Margin: Extemporaneous winds.] 5. There are **sudden** winds [repentini], abrupt and forceful — such as whirlwinds, hurricanes [praesteres], squalls [Ecnephiae], and the like, which occur only rarely.

[Margin: Sudden winds.]

6. There are **prodigious** winds [prodigiosi], which in some places burst forth — now from the caverns of mountains, now from the innermost bowels and chasms of the earth, and sometimes too from the bottom of the sea and of certain lakes, to the great peril of ships, when they violently stir up the waters.

[Margin: Prodigious winds.]

7. There are **artificial** winds [Artificiales], such as those raised by fans and bellows, or those conducted, for the sake of pleasure, into certain grottoes through hidden channels.

[Margin: Artificial winds.]

Therefore, just as these enumerated winds differ in their powers, nature, and properties, so too they are allotted differing causes.

[Margin: From where they arise.]

For some are born by the power of the Sun thinning out moisture, as is the general wind.

Some are produced by the mere rarefaction and condensation of the air.

Some by the melting of the snows that lodge on the lofty summits of the mountains.

Others — and most of them — from subterranean vapor and exhalation, the two things which intervene in most winds.

Others derive their origin from the rising of the Moon and of certain stars.

Others arise from the varied configuration of mountains, promontories, shores, and intervening islands they encounter, by a kind of reflection or rebound, or else from the violent force of the Ocean's currents, or from the ebb and flow of the sea.

Others, finally, have their birth in the innermost bowels of the Earth; others on the very surface of the Earth; others in the middle and uppermost region of the air. The maker of all of these is either the Sun, the celestial fire, or the subterranean fire divided into innumerable pyrophylacia [fire-storehouses], without whose aid no wind in the world can come to be. But let us now set out the individual winds, in the same order in which we have enumerated them — which will be done conveniently once we have first brought forward the definition of wind.

DEFINITIO VENTI [Definition of Wind]

Wind can here be considered in two ways: taken **properly** and **improperly**. The first arises from a vaporous, spirituous, and smoky substance; the second from a violent and external motion of the air, and it is born from a manifold cause — whether from the violent bursting of rain-clouds, as in thunder; or because of a fall of rain preceded by a motion of the air; or in great conflagrations; or finally from the pressure of clouds. For wind of this improper kind is nothing else but a motion of stirred-up air; and so, in general, wind is nothing else than that which in any manner whatever can stir up and drive the air forward. Of these individual kinds we shall treat in order, once we have first brought forward the definition of wind properly so called.

[Margin: Definition of wind.]

Wind, then, properly so called, is a vaporous and flatulent exhalation [halitus], drawn out from the earth or the sea — partly from outside by the Sun, partly from within by the power of the subterranean fire — which, rarefied by heat or condensed by cold, agitates the earth and seas with a transverse motion, and sometimes also with a straight motion, being appointed for the good of nature.

[Margin: Exposition of the definition.]

I said first **a flatulent exhalation**, in order to exclude the opinion of those who think wind to be a simple motion of the air, and to exclude the definition of those who say that the matter of wind is a simple hot and dry exhalation, with all moisture excluded. I said **flatulent** because its essence consists in its blast; for if exhalations did not consist of flatulent spirits, they could not stir up the air with so powerful a motion. I said **drawn out from the earth or sea, partly from outside by the Sun, partly from within by the power of the subterranean fire**: for the Sun on the outside thins moisture into vapors, the matter of clouds and winds; the subterranean fire, through the hidden fibers of the earth, sends out nitrous-salt exhalations [halitus salnitrosos] which, raised to the outer surface and rarefied by the Sun, are the cause of vast commotions of the air. It is therefore the office of the subterranean fire to supply the exhalations and stale smoky vapors, and the office of the Sun to thin them, on the outside, into the matter of winds — since these, once dilated, produce a thrusting of the neighboring air, and from this the impetuous transverse commotion of the air is propagated in continuous fashion.

[Margin: The fourfold genus of causes in the winds.]

You see, then, that in this definition a fourfold genus of causes is contained: the **efficient cause** — fire, partly internal, partly external (that is, solar); the **material cause** — the vaporous and flatulent exhalation; the **formal cause** — the transverse motion of the exhalation; and the **final cause** — the good of nature, concerning which more below.

And from this varied constitution of the exhalation arises also the very great multitude and diversity of the winds. Of these, some are called, by their quarter, *Boreal* [northern]; others *Meridional* or *Austral* [southern]; others *Western* [Occidui]; others *Eastern* [Ortivi]; others, finally, *intermediate* — so that, as many degrees as we count on the rim of the horizon, just so many winds can be constituted. And they are called such with respect to the place and quarter from which they roll forth. And although one and the same exhalation may be Boreal to some, Austral to others, Eastern and Western to others, nevertheless it is imbued with differing properties and qualities as it flows, by reason of the places through which it passes — as will be shown later.

[Margin: The denominations of the winds from the quarters of the world.]

The Wonderful Pericyclosis or Circulation of Nature.

If anyone could reach by the sense of sight to the origins of the winds, he would no doubt grasp their causes without difficulty. But since their substance, no less than that of the air, escapes all the gaze of the eyes — being utterly invisible and [Greek: ἄπερ ὅ (aper-?) — "without"(?)] [?] — their causes become known to us only with difficulty, and only through a certain analogy do they show us the way to recognize their true principles. And if anyone fixes the eye of his mind straight upon the laws of analogy, he will without doubt [recognize] that the very thing which holds in the motion of the elemental water holds also in the stirring-up of the winds. ...you will find that it happens by [the same] reasoning. For just as the seas undergo various alterations from the Sun, the Moon, and the subterranean fire, so too do the winds.

[Margin: The motion of the winds is wholly assimilated to the motion of the sea's flux and reflux, and is composed by a beautiful analogy.]

The sea, teeming with subterranean exhalations, swells up and stirs up various tumults on its outermost surface. Hence it completes its course from East to West, following the lead of the heavenly bodies. At one moment, agitated by innumerable currents and dashed against the various shores and promontories of the earthly region, it forms circling eddies; at another, exasperated by contrary waves, it drives whirlwinds and vortices.

In just the same way, the vapors raised into the aerial region by the power of the heavenly bodies or of the subterranean fire — when, rarefied, they require a greater place — drive the surrounding air with the utmost violence, with great force, now into this, now into that part of the air. Then, dashed against the lofty summits of mountains and driven back, they produce contrary winds; and sometimes, struggling against contrary and opposing exhalations, they wage savage conflicts, by which they cause immense tempests and whirling vortices, hurricanes [praesteres], and squalls [Ecnephias], to the utmost peril of ships. And, after the manner of a river, they are borne now with a gentle flow, now with a rapid one; now, falling headlong, they strike the depths and throw everything into confusion; now they smooth it; now they card the air like wool [pectinatim carminant].

Thus, what the motion of the Ocean displays to us by sensible appearance on its surface, the agitated exhalation and the thrusting of the air express in the aerial region by a flux indeed invisible to the eyes, yet perceptible by touch and sound alone — so that, accordingly, the causes that disturb the Ocean are the same as those that everywhere infest the aerial region. For just as the Ocean is watery, so too the Atmosphere of the terrestrial globe is a kind of aerial Ocean, agitated by motions all the more violent in proportion as the moving causes and the mass of the aerial substance consist of a finer and more mobile material, fitter for receiving motions.

[Margin: The Air, an aerial Ocean.]

The Sun, the Moon, and the stars, by their external influence, draw out, dilate, and raise aloft the exhalations which the subterranean fire had imparted to the sea, and conduct them into the further vast voids of the aerial region. There, encountering and besieging the vapors compacted into clouds, when they rush out wherever a gate is open, they bring forth that variety and inconstancy of the winds which sailors cannot sufficiently marvel at. And so that the [Greek: περικύκλωσις (perikyklōsis, "circumcirculation"); the circular wheeling] worthy of nature's admiration may be set forth more clearly, let me begin the matter a little higher up.

The stars, the Sun, the Moon — as was most fully shown in the preceding Section — produce the reciprocal tide of the sea. The tides of the sea, that is, the impetus of its flux and reflux through the hidden and secret passages of the Ocean's floor, thrust an immense and boundless mass of waters into the innermost viscera of the earth, and rouse the subterranean fire by the force of the winds.

[Margin: The admirable pericyclosis of nature in the tides.] [Margin: The subterranean fire does not rest.]

A new reciprocation of the tides blesses that fire with nourishment, conveying it as if by certain bellows; and the fire, kindled and seething, draws along with it through other and other passages — fibers crammed with metallic and mineral juices — the abundance of exhalations it conveys as it passes through. These, thrust out partly through the earthy passages of the mountains, partly through the floor of the Ocean, onto the outermost surface, and there dilated, in turn solicit with their blasts the air, the Ocean, and the seas. And insinuated once more through the openings of the Ocean's floor, it conducts new provision to the subterranean fire, by which the fire may be both fed and preserved; and in this way it supplies fresh matter for stirring up the sea.

You see, then, the manner and reason of nature's circulation. You see how water and fire, as if contending by alternate and mutual offices, nourish and foster one another, and by a kind of unanimous consent conspire toward the preservation of the Geocosm. For if the subterranean fire emitted no exhalations to serve as the matter of the winds, the sea, as if torpid and well-nigh devoid of motion, would readily pass into putrefaction, to the ruin of the Geocosm; and consequently, deprived of the support of the winds, it could not supply the subterranean fire with its necessary nourishment. And so, the fire being extinguished, the whole of nature would necessarily perish.

[Margin: Wind is necessary for the sea.]

Lest, then, nature, afflicted by so great a loss, should collapse, God Most Good and Great — through provident nature, the handmaid of the supreme Maker — willed that both elements should be in perpetual motion, toward the admirable ends which we shall indicate below. For what the vital and animal spirits do in the economy of the human body, that the spirituous nature of the winds does in the cosmic fabric. And just as, when those spirits vanish, a man cannot live, so too, the winds being removed, the Geocosm would necessarily perish.

[Margin: An analogy from the human body.]

But just as to these causes others and others are joined, so too there arises from them the inexplicable diversity and supreme variety of the winds — which can be explained only through the concurrence of many partial causes; and these, nevertheless, can always be traced back to the principal causes. All of which, lest we should seem to have left anything out, we now begin to set forth.

CAPUT II

On the General Wind: how, why, and from what cause it is born.

We call that the **general wind** which, by a perpetual motion, proceeds from East to West, accompanying the course of the Sun and the Moon. So that this may be easily understood, I should like you to note what we declared above concerning the general motion of the Ocean from East to West; for this wind exists only in the vastest seas — the Indian, and that one which they call the Pacific — subject to the Torrid Zone...

subject [to the Torrid Zone] is perceptible. And just as the motion of the ocean and seas is joined to the blowing of the winds in an inseparable partnership, so the one cannot exist without the other. Now, however, I must explain how this wind is produced.

First, then, I assume that this general wind — the Euro-Zephyrean, that is, blowing from East to West — would be perpetually unchanging if the whole terrestrial globe were covered over by the ocean. On that assumption it would meet no obstacle from any mountains, islands, or coasts lying in its path. [Margin: If the Earth were covered over by the ocean.] Having found this one unobstructed expanse, it would follow the Sun in a constant course and propagate itself perpetually around the Geocosm. [Margin: The reason why that general motion is for the most part interrupted, every time it strikes against them, and observes other laws of its course, until in the vastest expanses of the seas it spreads out its former liberty. (?)]

I assume, second, that the Sun can accomplish nothing in the production of winds without the prior dry exhalations — which I said a little earlier are imparted to the ocean by the Subterranean fire — or the moist ones that the rarefied sea itself supplies to the air.

Granting these assumptions, **I claim that the general wind is generated from East to West in the following manner.** [Margin: How the general wind is produced.] Since the Sun, beneath the Torrid Zone, perpetually strikes the ocean with rays falling perpendicularly — now on this part, now on that, according to the position of the Sun in this or that one of the twelve signs [dodecatemorion] — the result is that the sea, rarefied by the Sun's powerful bearing-down, draws up into the air a vast quantity of vapors mixed with exhalations. These rarefied vapors and exhalations, when they thrust with the greatest force against the air standing in the path ahead of the Sun, set that air in motion; and the air, driven

toward the part toward which the Sun is carried, produces — spread out in that direction — that wind from East to West which we call the general wind.

Here, perhaps, someone may object: this drawing-up of exhalations by the Sun takes place over the entire circumference of the ocean, and therefore the exhalations too, diffused in every direction, must cause a wind on every side. [Margin: An objection and its solution.] I answer that it is true that exhalations are diffused in every direction; but since on both sides — from the South and the North — they meet thicker and more vaporous air opposing them, the result is that this seething, exhalation-laden air, being of a finer substance, is thrust back and driven back by the thicker air standing around it. Pressed and confined on both sides within the royal path of the Sun, it is continually driven from East to West, while the Sun, advancing along that same path, continually elicits by its heat ever new exhalation-laden spirits. Again, since the Sun by its perpetual bearing-down dissolves an enormous quantity of water from the sea, and thereby induces a certain emptiness in that tract of the sea, to fill this emptiness — by a kind of natural necessity — the eastern waters that follow [the Sun] rush in with force, and, driven more vehemently along the maritime path of the Sun, press and thrust forward toward the West the air lodged within that same exhalation-laden path. From this wondrous attraction and repulsion of waters and exhalations there arises that perpetual Euro-Zephyrean wind which we call the general wind; and since the Sun always operates in the same way, the very reasoning of nature dictates that this wind too is perpetual. But let us confirm by experiment that all this is so.

Those who sail from Acapulco, the port of New Spain [Mexico], to the Philippine Islands must first proceed by a straight course toward the Equator. [Margin: The voyage from Mexico to the Philippine Islands.] Once they have reached it, then — whether beyond or short of it — they spread their sails and leave the ship to the will of the winds, which there beneath the Torrid Zone, both in the southern and the northern part, blow perpetually from the East. Within the space of seven months they successfully — and, what is remarkable, without changing their sails — reach the Islands *de las Boccas*, distant from eastern America by a space of nearly 3,000 miles. This would not happen if the wind, in that vastest ocean stretching out immeasurably on every side, were subject to variation and instability. But the reason why, in the ocean near the first islands one encounters — of which there is no counting in the Archipelago of St. Lazarus — the general wind takes on other laws is, first, the striking-back of the waters that drive the waves backward; second, the new and differing commotions of the terrestrial exhalations, which are elicited by the Sun from that island-nursery teeming with

seed; and third, the various conditions of the tides and currents. [Margin: Why, near the multitude of islands, the eastern wind fails. (?)] By these the general wind is disturbed, and these prevailing winds produce those whirlwinds which all who sail the Indian Archipelago experience to the great peril — indeed, the loss — of ships and men. But once these have been drawn out of the narrow straits of the islands and restored to the vast open regions of the Indian Ocean, the general wind, growing strong again, carries the ships all the way to the Cape of Good Hope, or to the island they call St. Helena.

CONSECTARY I.

And from these things it is clear why the voyage from East India to Brazil or Paraguay is easier than the reverse. For on the one route the sailors must struggle perpetually against a contrary wind, while on the other, carried by the motion of the sea and the eastern winds, they reach their destination in the western parts in the shortest space of time. But those who from the Philippine Islands seek the regions of eastern America find it impossible — because of the perpetual resistance of the sea — to keep to the path of the Sun beneath the Torrid Zone. [Margin: From the Philippine Islands to eastern America it is impossible to navigate beneath the Torrid Zone.] Instead, in order to be returned to the port from which they set out, Acapulco, they must steer their ship through the Temperate Zone to the coasts of North America, so that there, aided by northerly blasts, they may at last reach their desired destination. From this is evident the marvelous design of nature, by which it willed that the Pacific Sea beneath the Torrid Zone be driven always by one and the same blowing of the winds from East to West, as far as the islands of the Archipelago — where the ocean's...

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wind, thus far continued, is driven — now striking against the islands lying in its way, packed with enormous mountains, now against the vastest regions of the China mainland — and, with new vapors stirred up there, is forced back from West to East to the shores of North America, so that it is kept moving as if in a circle, to the great mutual advantage of those traveling to and fro.

CONSECTARY II.

From this too it is clear that this general wind does not always flourish at one and the same time and place in all the regions subject to the Torrid Zone, but does so chiefly beneath the parallels of those signs through which the Sun passes. Hence sailors constantly affirm that the more closely they keep to the Sun's paths, the

easier and shorter their voyage to their destination; but the more difficult it is if on either side they have departed more than is fitting from the Sun's path, because of the new laws of the winds they then experience, contrary to the Euro-Zephyrean wind. [Margin: A wondrous constitution of nature.] For just as a river confined within its channel flows more rapidly than when spread out over a plain extending far and wide, so beneath the Sun's path the motion of the air behaves — that air being nothing other than a kind of swift aerial river, which, confined as if within a channel on both sides by the northern and southern clouds, is perpetually carried by the Sun's power from East to West, while the south-north blasts keep watch and bar it on either side lest it stray outside its channel. But I would not have you think that this wind is carried beneath one and the same parallel within an indivisible space; by no means: rather, it has its own breadth, greater in some places. Beneath the Tropics it was found to have 7 degrees toward the South and the North. And in this way the general wind is perpetually generated and preserved. But so that the reader may grasp this more clearly, I shall here add an experiment, from which you may learn the manner and reasoning more exactly.

Experiment setting forth the cause of the general wind.

Let some shallow basin two palms in diameter be filled with cold water up to the brim. This done, take an iron ball whose diameter is a quarter of a palm. When this ball has been made to glow with the strongest fire, take it with tongs and carry it across the surface of the water held in the basin, in a motion along the diameter, in such a way that it always stays a small distance from the water. You will find in the surface of the water a kind of cavity, through which the water is drawn to follow the motion of the glowing ball, continuously, right up to the rim of the basin, where, reflected, it passes off on both sides into circles, drawn back to the sides of the basin in the opposite direction. You will also discover then that a wind is born from this rarefaction of the water and the motion of the glowing iron, if you place a feather directly opposite the iron ball: for that feather will by no means bend toward the sides, but will always follow with a steady motion the advance of the glowing ball. This indeed sets forth the causes of the aforementioned wind so clearly that it seems to display the matter to the eyes.

You will ask, first: Besides the general wind, do other winds also prevail in the Pacific Sea? [Margin: Whether in the Pacific Sea, besides the general wind, others prevail.] I shall answer that, outside the path of the Sun, countless winds do indeed prevail in that ocean, but that these are particular winds, which — drawn from the exhalations and the bottom of the sea by the force of the Subterranean

fire or of the Sun — disturb the air at every time. But since that ocean is most wide open, the diffused vapors, growing as it were flaccid with time, fail together with the wind. You know that gunpowder set alight in open fields is not dissolved into vapor with the same force as in confined places; for, confined in these, it scatters everything with enormous impact and crash. The same may be said of the winds in such an ocean. It is otherwise in seas that, broken up by various islands, are checked by the enormous obstacles of the continental lands: in these the winds, variously reflected and repeatedly augmented by new exhalations, stir up enormous storms and the most furious whirlwinds of winds — as sailors report of the Indian Archipelago and the ocean lying between Japan and China.

You will ask, second: Can winds that arise in the very path of the Sun impede the general wind? [Margin: Whether the general wind can be impeded by other winds.] I answer that they cannot in the open ocean, because every vapor, every material of the winds, is so absorbed by the motion both of the air and of the sea that it can be no impediment to it. Indeed, if at any time a stronger wind should rise up, yet, when it meets the general wind, it soon yields to it as to the more worthy, and bends off to the sides, joining either the southern or the northern allies of Aeolus. I said "in the open ocean," because as soon as they have approached the shores of continental lands, or the vast districts of islands, then — behold! — with the prisons of Aeolus burst open, they feel the contrary laws of the winds, by which the general wind is not only thrown into confusion, but is even compelled, as if before the assaults of opposing enemies, to withdraw itself somewhat, until it is restored to its liberty.

CONSECTARY III.

That a wind sometimes arises from the attraction of the surrounding air.

From the foregoing it is clear that a wind too can sometimes arise not from vapors and exhalations, but produced solely by the motion of air supplying a void — as happens in great conflagrations, which a wind for the most part accompanies. But I shall explain in what way this wind is created. [Margin: A wind sometimes arises from the motion of a void.] It is certain that, by the heat of a violent conflagration, the surrounding air is supremely attenuated. Since, because of the air packed densely all around, it cannot expand to the sides, it is therefore snatched upward together with the fire, and carries the surrounding air along with it; and this surrounding air, lest a void remain, substitutes itself into

the place of the departing rarefied air. From this agitation that wind is born, which...

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we experience in great conflagrations. And that this is so, we teach by the following experiment.

EXPERIMENT.

Which shows a wind produced by the mere agitation of air.

In the hearth of some chamber, with all the windows shut, let a fire be built; and you will find that a strong wind soon enters through the chinks and cracks of the door, drawn inward by a hidden force as it were. The cause of this is none other than that the air existing in the chamber is snatched, together with the fire, out beyond the chimney; and once snatched away, since it necessarily needs other air to supply the place of the departing air, the result is that the outside air, pitying nature in her labor, insinuates itself with great force even through the tiniest cracks, fissures, and openings, to prevent that which nature so greatly abhors — the terror of a void. [Margin: Why, in the morning, at the time of twilight, a rather gentle wind blows before sunrise.] And from this too may be gathered why in the morning, at the time of twilight, a rather gentle wind is for the most part felt before sunrise: namely because the rising Sun, by its heat and light, attenuates the air; this attenuated air, carried upward, snatches the neighboring air along with it; and by mutual consent the unattenuated portions of the western air flow toward that same part — and so that morning breeze is stirred up.

CAPUT III.

On the periodic or annual winds, which the Greeks call Etesian [Ἐτησῖαι], and on their causes.

The Aristotelians, together with their Master, torment themselves wondrously in rendering the reason for those winds which they call Etesian [Greek: Ἐτησῖαι (Etēsiai, "yearly winds")], which, about the rising of the Dog Star, used most kindly to affect Greece, seething with heat, by their somewhat cool blasts; and, evolved from the North, were found indeed to be silent by night but to breathe by day. When these ceased, there succeeded the Ornithiae [Greek: Ὀρνιθῖαι (Ornithiai, "bird-winds")], or Chelidoniae [Greek: Χελιδόνιαι (Chelidoniai, "swallow-winds")], blowing from the South, harmful to men and animals. [Margin: The cause of the Etesian winds.] And as for what concerns the Etesian

winds, they say the cause of them is the dissolution of the snows on the mountains of the Hyperborean Subpolar region: these snows, when struck by the Sun's rays and dissolved into exhalations, supplied by day the material of the winds; while by night the said dissolution of the snow, with the Sun establishing as it were certain truces, compelled the winds likewise to be silent. And this is the Peripatetic opinion concerning the origin of the Etesian winds. That it is false, I show by four arguments.

First, if from the Subpolar mountains covered with snow and dissolved into exhalations by the Sun's power that Etesian wind is born which strikes Greece in the dog-days, then surely there is no reason why the Etesian winds should not at the same time pervade Moscovia, Poland, Germany, Hungary, Gaul [France], Spain, and England with the same blasts. [Margin: The Etesian winds are not produced by the liquefaction of snows on the Subpolar mountains.] Yet in none of these regions is that continuous 40-day spell of the Etesian winds, which Greece feels, perceived at the rising of Sirius. Therefore, the explanation cannot be derived from the snows of the Subpolar mountains — since I do not see why a wind of this kind should dominate over Greece rather than over the regions listed, at the stated time, given that Moscovia, Poland, Germany, and England, in that they are nearer the Pole, ought therefore to feel it more than Greece or Egypt, regions more remote from it. Therefore, just as this wind is particular to Greece, so its cause too must necessarily be not universal but particular — not derived from the Polar mountains, but taken from elsewhere, which I shall later assign.

The second argument, which renders the Peripatetic opinion empty, is that enormous distance and interval of these Subpolar mountains from Greece, comprised within about 45 degrees, which multiplied by 60 yield 2,700 Italian miles, or multiplied by 15 yield 675 [recte: 675? — the printed figure reads "67 ½ mil-liaria Astronomica"; see Numerical impossibles] astronomical miles. [Margin: (?)] That one and the same exhalation should be propagated continuously over so great a space — obstructed by so many other mountain chains, through so many and so countless intervening vapors and exhalations, which are everywhere drawn up at the same time from rivers, lakes, mountains, and the plains of the fields — let him believe it who will. I shall prove below that no exhalation is continued for as much as 100 leagues. And besides, who told the Peripatetic that there are mountains beneath the Pole, when it is unknown to this very day whether that Subpolar region is truly a continent, or an island, or covered over with sea on every side?

The third argument, by which he proves that the Etesian winds are derived from the Pole, consists in this: that the Etesian winds are silent by night and breathe by day, and he says the cause of this is that by day the Arctic snows, repeatedly dissolved by the Sun into the exhalations with which they are filled, are dissolved — whence the diurnal wind — while by night, the dissolution of the snows ceasing, the wind too ceases. But whoever shall have rightly examined this argument will find it not only false, but contrary to the doctrine of the sphere. For who does not know that, from the Sun's entry into Aries up to Libra, there is perpetual day in the Subpolar region? Since therefore the Sun never deprives the Subpolar region of its presence and illumination for a six-month span — or, if you exempt the more remote Hyperborean or Rhiphaean mountains, never for a five-month or four-month span — surely he concludes wrongly from this that the Etesian winds, on account of the Sun's absence not dissolving the snows in the said region by night,...

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are silent by night, but blow by day on account of its presence. How far these things are consistent with the principles of nature, let those who are impartial judges of natural things see.

The fourth is contrary to the nature of exhalations. For the Peripatetics say that beneath the snows lurk hot and dry vapors which, elicited by the Sun's heat, cause those winds they call Etesian. Certainly that those dry and hot exhalations should be preserved unharmed in such great measure beneath the immense heaps of northern snows — amid so great a mass of humidity surrounding them on every side, moist and cold, diametrically contrary to them — no one will ever persuade me. For I recognize no other species of exhalation than that which is separated from every mixed body, and which consists of the finest spirits clothed in a vaporous substance — which I call the material of the winds. I am not unaware that sometimes there also lurks in snows a certain vapor-laden substance, which, however, I would not call that simple hot and dry exhalation, but rather saline, nitrous, and aluminous spirits, which, elicited by the power of the Sun or evolved from the Subterranean fire, produce that vehemence of the northern winds which we marvel at. For these, having vaporized by their own substance — in which hot and dry exhalations lie mixed together — become apt material for the winds.

[Margin: Whence the Etesian winds derive their origin.] It is asked, then, whence those Etesian winds derive their origin. I say: from the natural constitution of the mountains that are spread before Greece, Macedonia, Thrace, and Bosnia. There

is that enormous chain of the Carpathian mountains, extending from the West in a long tract of lands toward the East, as far as the Euxine Sea [Black Sea], where, on the northern shore, with the mountains of the Tauric Chersonese [Crimea] — which divide it with lofty and inaccessible snowy peaks, just as the Apennines bisect Italy — and joined hence by the Coracian, Hippican, and Caucasian ridges, it stretches out toward the East in a long row, separating Poland, Lithuania, Moscovia, Russia, and Tartary — flat regions awash with lakes and marshes — from the Vistula as far as the mighty river Volga. These lofty mountains, then, covered with perennial snow, together with the said vastness of the marshy plain, cause the Etesian blasts in Greece and the other neighboring regions listed, together with the interposed Pontus Euxinus and the Lake Maeotis [Sea of Azov] — this I demonstrate as follows.

First, then, it is established — on the testimony of Herberstein [Sigismund von Herberstein] and Martin Cromer [Marcin Kromer], historians of the said regions — that about July and August, at the time when in Poland, Moscovia, Russia, and the other regions situated across the Carpathian Tauric mountains, the Pelagus and the Euxine, the southern winds begin, at that same time in Constantinople and throughout all Greece, Anatolia, and Egypt the northern winds — which Aristotle calls Etesian — begin their blasts. [Margin: Why in Sarmatia the south winds, and at the same time in the listed regions the north winds, arise. (?)] If, then, the Etesian winds arose in Greece and the other listed regions from the Polar mountains, surely the intermediate listed Sarmatian regions ought to feel them before the others — which, however, is so far from being the case that, rather, as experience teaches, at the same time, on the testimony of the said historians, opposite winds breathe upon them. So the fact that the trans-montane peoples have south winds at the time when the cis-montane Greeks have north winds — this is doubtless to be ascribed to no other cause than the natural constitution of mountains of this kind. But let us unfold the mystery.

It is established, first, by the unanimous report of the Geographers, that the mountains just pointed out, like the flat places, are of insuperable height, and so, covered with perennial snow, are likewise teeming with subterranean fires — as the innumerable multitude of thermal springs and the steaming basins of continually smoking mines abundantly demonstrate; which, lest I be too long, I have judged it superfluous to recount. [Margin: The flat places of Sarmatia.]

Second, that all the trans-montane regions stretch out in a continuous plain — awash with lakes, rivers, and marshes — from the river Vistula to the mighty

river Volga, which separates Greater Tartary from Moscovia and the Precopian Tartary [Crimean Tartary].

Third, that the Pontus Euxinus, impetuous and of unsearchable depth — both from the discharge of the Lake Maeotis and of the rivers Borysthenes [Dnieper], Danube, and others into it, and from the subterranean winds by which it sometimes swells — is agitated by perpetual surges and tempests. [Margin: The surges of the Euxine.]

Fourth, that experience establishes that the said mountains, most harsh from their multitude of snows, cause a cold constitution of the air for those dwelling on this side and that; and that the flat regions across the mountains are throughout the whole winter so bound up with snow and ice that there is no access for traders into the various regions, through pathless and devious ways, except by the help of sledges.

These things being laid down, the result is that, as soon as the Sun has entered the Equator, both the masses of Alpine snow and the trans-montane plain bound with ice are gradually dissolved. Then, as the Sun ascends higher and higher each day, the snows and ice once dissolved (which dissolution is completed in the whole two-month span, namely April and May) are wont to fill everything with floods; whence, by the Sun's heat, an enormous quantity of vapors is drawn out, which, soon insinuated into the hollows of the mountains, is dissolved into rains. After the waters, the Sun more ardently, about the middle of June, draws up the finer vapors mixed with metallic exhalations, which, unable to be contained in the narrowness of the places, by a violent eruption — the opposing vapors of the northern cold pressing upon them — are borne toward Greece, Anatolia, and Egypt, into the South, with great force. And since so great a quantity of vaporous substance has been collected, the result is that, as long as it is not consumed, just so long do the winds last. By day, chiefly about noon, dilated by rarefaction, they stir up the said winds each day; but by night, condensed by the cold, they contract themselves and suspend their blasts. And this I would suppose to be the cause of those winds which, for a span of nearly two months, [drive across] Thrace, Greece, Anatolia,...

[This page continues CAPUT III, "De Ventis periodicis seu Anniversariis, quos Etesias Graeci vocant," begun earlier.]

When they reach Egypt, these winds bring the region the most wholesome air, to the great benefit of both people and animals. They are cold partly because they are released from the thawing of snow and ice, and partly because of the icy-cold

Pontus Euxinus, which—after it has received the snow-fed and glacial waters of its mighty rivers—pours that chilled breeze across into Anatolia and Greece.

[Margin: Why the Etesian winds are cold.]

Anyone who has properly grasped these explanations will be able to assign the cause of nearly all the winds that depend on mountain positions—why here northerly winds arise, there southerly, here western, there eastern.

COROLLARY

That all winds differ according to the variety of the places from which they blow.

It is clear from what has been said that, since winds arise from a definite configuration of the mountains, different winds arise according to the diversity of the regions facing those mountains. So when the north wind [Boreas] blows here at Rome, no one would claim that the same wind blows throughout all of Italy, Germany, or France. Experience certainly confirms this: from sailors' observations we have learned that when the north wind blows in Lombardy, in Transalpine Germany the south wind blows, and the reverse; likewise, while the south wind blows along the shores of the Tyrrhenian Sea, on the opposite coast of Gaul the east wind [Eurus] blows. From this I consistently infer that a wind stirred up in one region, and arising from the exhalations of a single place, does not stray beyond its province—unless mountain chains of great size stand in the way. The flatulent exhalation of such mountains is so copious that it is carried even into more distant parts, because its height is subject to no intervening obstacles. This is what happens with the Etesian winds of Greece, with the Euxine Sea lying between, blowing from the Tauric mountains.

[Margin: The diversity of winds.]

Therefore, just as individual rivers water their own regions, so too do the winds. And again, just as we have cloudy skies here while elsewhere they enjoy clear weather, so on the very day that northerly winds blow here, elsewhere southerly, western, or eastern winds will blow. Nor do I think that winds arising from the snowy ridges of the Alps reach all the way to Rome, since the nearby ridges of the Apennines can supply us with sufficient material for winds. Hence unvarying experience teaches that Mount Gennaro [Montem Januarium], laden with snow, which at Rome causes the north wind, at the same time produces a south wind for those situated beyond the mountain, an east wind for the Sabines, and a west wind for the Vestini—all at one and the same time, according to the diffusion of the flatulent exhalations—as I have found by the observation of many years.

[Margin: Winds carrying the position of the mountains.]

[This page continues an enumeration of maritime wind-observations within Caput III; the numbered items belong to a list of pilots' observations.]

and calms. In May, vehement east winds rise, heavy with rain.

5. At the promontory which I think they call *punto Gallo* [Point Galle], on the island of Ceylon [Ceilano], on 14 March the first wind is a collateral westerly, then west-south [Zephyro-auster]. At the beginning of April it becomes steady and continuous, lasting until the first of October; when it ceases, a northeast wind [Eura-boreas] follows, continuing until March—yet such that they sometimes begin, later or earlier, by ten days or even more.

[Margin: The pattern of the winds at Madagascar.]

6. On the island of Madagascar, from the fifteenth to the end of May, the north wind [Boreas] and north-northwest wind [Zephyroboreas] blow; in February and March, the winds blow from the east and south; but in the months of March and April, at the Cape of Good Hope [promontorium Bonae Spei], the north wind and its collateral toward the east [Eurum] blow—so much so that it is unusual for the south wind or its collateral, the southeast [Euro-auster], to blow.

[Margin: In the Bay of Bengal.]

7. After the twentieth of April, in the sea of Bengal, the south wind is vehement; before that day, sometimes the west-south wind, sometimes the north-northwest wind blow violently.

[Margin: From Malacca to Macau.]

8. From Malacca [Malaca] to the port of Macau [Macaum] in China, in the months of July, October, November, and December, southerly winds dominate—the south-west [Austro-Zephyrus], and sometimes also the southeast [Euro-Auster]. In June the west winds [Zephyri] rage around Malacca and along the Chinese coast. For those bound from Java [Java] to the port of Macau, westerly winds blow in the month of May. Again, for those bound from Macau to Japan, the same westerly winds dominate in the months of June and July, though these are frequently interrupted by day by the north [Borea] and northeast [Euro-borea]; but at night the southeast wind asserts itself. For those, by contrast, bound from Japan to

China, the east wind [Eurus] and the northeast [Euro-boreas] are present at the shores of China, namely in February and March. For the Sun, driving the vapors by its heat into the northern region, finds the air there denser and unable to yield; and so it is reverberated back along the same path by which it had been driven.

[Margin: In the Bengal Sea (Ocean).]

9. Those who set out from Manila [Manila], bound for the port of Acapulco in New Spain [Novae Hispaniae], use a westerly wind in the months of June, July, and August—not through the Torrid Zone, where (as was said above) they have the easterly wind perpetually against them—but along the shores of North America, where, however, the westerly winds are weaker than the easterly; for the latter are aided by the General Wind [Generali], while the former are diminished by it, as was said above.

[Margin: From the Philippine Islands to America: which winds those bound for it use.]

10. In the Chinese Sea, the winds in July, August, and October are exceedingly variable and inconstant; for it turns now from the south into the north, and from there into the west, or suddenly from the north into the south. From this they sometimes stir up storms greater than any sailors have experienced anywhere, as will be told later.

[Margin: In the Chinese Sea (Ocean).]

11. On the coasts of Peru and Chile, almost continuously a south wind blows together with its collateral, the south-west [Austro-Zephyro]. It begins at 46° of southern latitude, and blows beyond Panama, a city lying on the American Isthmus. Hence from Chile into New

[Margin: On the coasts of Peru and Chile.]

[Continuation of printed page 199, right column.]

Spain the passage is easy, but difficult from Panama into the south. It is remarkable, however, that this wind is felt only on the coasts of Peru and Chile, and not in the more remote stretches within the Pacific Ocean away from the shore.

12. At the coasts of the Land of Magellan [Terrae Magellanicae], or *del Fuego* [Tierra del Fuego], around the Strait of *de Maire* [Le Maire Strait], westerly winds blow continually, with such force that the very trees seem twisted

toward the east by the wind's violence. If, however, you keep to the shores of the southern land within the Strait of Le Maire, you will always have the south wind blowing.

[Margin: At the Strait of Magellan.]

13. On the Malabar coasts of India [littoribus Malabaricis Indiae], in July and August, the north wind [Boreas] and north-northwest [Zephyro-boreas] blow; but from September to April, easterly winds blow from the land from the twelfth hour of night until the twelfth hour of day—yet they are not felt beyond ten miles out at sea. From the twelfth hour of day until the twelfth of night, a sea wind blows from west to east, exactly contrary to the former; and as these are weak, so too they are not so easily felt, being almost always absorbed by the northerly winds. The same occurs on the coast of America in New Spain, where by day the sea winds prevail and by night the land winds—as also happens in the kingdom of Congo.

[Margin: On the Malabar coasts.]

And these are the principal observations made by the master-pilots [Archinautis] cited above. Now nothing else remains but for us to assign the causes of each of them.

The Reason and Cause of the Aforesaid Winds.

I therefore suppose, first, that the motion of the Sun within the Tropics—by which it now approaches the northern pole, now the southern—is the remote cause of those things that are born on the outer surface of the Geocosm, as well as of vapors and exhalations. And indeed, when the Sun is placed in the southern signs, in the northern hemisphere rains, snows, and frost dominate, because of the excessive remoteness of the Sun, which cannot dissolve the thicker, raw, and undigested vapors. Hence, from the cold thus introduced, rains and showers prevail upon the earth, the mountains are covered with snow, and the plains—together with the rivers and lakes—are bound fast with frost and ice. The pores and all the breathing-holes of the earth, sodden with excessive moisture, are closed; and from this constriction of the earth, the subterranean estuaries, when they cannot exhale through their accustomed fibers, are intensified by the utmost increase of heat. But when the Sun, returning from the south, passes beneath the equator, at once the earth, animated by the Sun's warmth, opens up; and from the melting of the snows on the mountains, vast inundations are produced both outside and inside the earth—all the greater the nearer the Sun has stood to our zenith. Thus, when the Sun has advanced to a certain degree of the Zodiac, the

exhalation-bearing substance of the earth, lying precisely beneath that same sign and degree, is then first set in motion, and—once moved—is gradually disposed into the annual winds; and the estuaries of subterranean fire too...

[Margin: How the annual winds are generated.]

now, when the subterranean estuaries of fire find their channels widened, with great force they drive out through the open breathing-holes of the mountains—steeped with the earth's salt, niter, alum, vitriol, and bitumen—their fibers and veins, and exhalations made fertile with the said substances, out onto the outer face of the Earth. As soon as these have met the more fervent rays of the Sun, that spirituous substance of the exhalations, swelling and dilating itself, joins with the vapors drawn out by the Sun and is animated into those annual winds which we described a little before. These last longer or shorter in any one place in proportion to the abundance of the exhaled, flatulent material. And the subterranean fire-chambers [Pyrophylacia]—animated both by the abundance of external moisture penetrating into their deep entrails, and by the wind stirred up from the subterranean waterfalls [catadupis] of the waters—emit vast exhalations and smokes swollen with vapors, for as long as the vaporous exhalations last.

[Margin: Solution I.]

And from this it is clear why, on the Indian coast of Gujarat [Guzaratae], from March to September the northerly winds blow continually: because the snows in that great chain of the Caucasian Mountains [Montium Caucaseorum], extending through all of Greater Asia, from the melting of the snow and the openings of the mountains, exhale a vast abundance of vapors supplied from the subterranean estuaries—which, rarefied by the Sun's summer rays, spread themselves out into the south. And since the immensity of the exhaled mass is so great that it cannot be consumed in half a year's span, hence these same winds must also last for a six-month period, yet at a certain hour of the day—namely, when the material, swollen by the solar rays, spreads itself out with the utmost force. As for why, when these northerly winds cease, southerly winds afterward begin to blow as their successors—the cause is that this vast mass of vapors, driven down into the south and there compacted somewhat by the cold of the southern sky, holds back until the Sun, passing beneath the equator, dissolves it, and pours the dissolved and rarefied mass across into the northern parts—whence the southerly winds arise. And exactly the same thing then happens in the southern hemisphere as we have recounted happening in the northern.

CAPUT IV.

On the Annual Winds in the Ocean, as observed by Spanish, Dutch, Portuguese, and English Sailors.

In the course of frequent navigation around the Geocosm carried out by the master-pilots, a certain remarkable property of the periodic winds was observed: that some of them begin at a fixed and definite time set by nature, and last for half a year; some for four months, or two months; others for a month or a week; and others last only a day or an hour. The hidden reason for this matter—penetrated by no one until now—is sought. We will attempt to assign it according to the measure of our talent, as soon as we have first brought forward the observations of the said sailors.

Maritime Observations concerning the Winds.

1. In the Ocean between Africa and India, the easterly winds toward the west begin from January until the beginning of June; and when these subside around August and September, westerly winds succeed, accompanied by foul storms with the north wind raging. Hence from Ceylon a favorable navigation eastward into Java and the Moluccas is granted, on account of the westerly movement which then begins, contrary to the easterly. (But when we speak of the easterly and westerly, the south and the north wind, we do not always wish the same thing to be understood. For we form rules not only about the cardinal winds, but also about the collateral winds belonging to each cardinal—such as the southeast [Euro-Auster] and north-northwest [Zephyro-boreas], or the north-northeast [Boreo-Eurus] or south-southwest [Noto-Zephyrus].) But around the coasts of Asia and Cisgangetic India [Indiae Cisgatanae], the winds do not keep the same pattern as in the middle of the ocean. The westerly winds dominate throughout June, July, and August; with so many storms, tempests, and the violence of northerly winds do they rage that they cut off all access for merchants into these parts. Yet on the Transgangetic side of India [Transgatano Indiae Latere], at Coromandel [Coromandeliam] and Narsinga [Narsingam]—which is remarkable—at exactly the same time no storms whatsoever are felt.

[Margin: Observations of the winds in maritime expeditions made by sailors.]

[Margin: From Ceylon to the Moluccas.]

[Margin: Around Asia and the coasts of Cisgangetic India.]

2. In Gujarat [Guzurate], that is, on the coast of Cisgangetic India, from March to September the northerly winds blow, and from September to March the southerly.

[Margin: In Gujarat.]

3. The Dutch [Batavi], setting out from Java for the most part in the months of January and February, bound for Europe, after they have reached 18° of southern latitude by the easterly wind, then the south wind, or the southeast [Euro-Auster], begins, by which they are carried in continuous course as far as the island of St. Helena [S. Helenae].

[Margin: From Java to Europe: which wind they use.]

4. At the island of Banda [Bandam Insulam], the state of the winds is entirely variable; the westerly winds dominate in March, and toward the end of April variable winds and...

and calms. (continued from item 4) ...rarefied and dilated by the power of the Sun, it will therefore take no other path than that of the current. Just as a current carries off the air contiguous to it, so the air carries off the exhalation; and from this arises that diversity of the winds which many wonder at.

[Margin: The diversity of the winds explained from various motions.]

[The following resumes the explanatory discourse "Ratio & causa," left column of printed p. 201:]

[the easterly winds] of the eastern region's space, while the opposite winds, the westerly, take up [the rest]. I say, therefore, that by the Sun's motion that vast oncoming heap of vapors, gathered together within the mountains both of the island they call Madagascar [Madagascar] and within the vast hollows of the Mountains of the Moon [montium Lunae] in Africa, settles there in a suitable place until the Sun passes through the summer signs. During this halt, just as the subterranean estuaries in Africa are stirred up by the power of the Sun, so too the vast diffused abundance of exhalations revives the vapors that have been stalled and compressed there for a long time. These, gaining renewed vigor, are reverberated with the utmost force toward that quarter from which they had been driven—that is, toward the east—and they last as long as the exhalation-bearing substance lasts, and as long as the Sun rules over the place of evaporation.

[Margin: The easterly and westerly winds.]

But why these winds become now southerly, now southeasterly, now affect other quarters out of the easterlies, drawing toward the south or toward the north—no one until now has resolved. I say that the cause of this is the currents of the sea, alongside which the exhalation arising there is carried. But that the matter may be grasped, I judged that the whole must be explained by an ocular demonstration.

What the currents are, and what paths they keep in the ocean and in the other seas, we have taught at length in the preceding sections; and the Map [Mappa] displaying them teaches enough. Since, then, the currents of the Indian sea especially are most diverse—produced either by the reflection of the shores, or by the unevenness of the sea floor, or by some other cause—it comes about that if any exhalation-bearing evaporation, breathed out from the sea floor by the force of the subterranean Vulcan, meets one of these currents, it takes the same path that the sea's motion takes, drawn along as it were by the vehement flow of the waters.

Diagram. A schematic chart of the Indian Sea with its currents, rendered in flowing engraved striations that converge toward the bottom center. The currents are drawn as bundles of lines streaming inward from the corners and edges toward a central node, illustrating how exhalations follow the sea-currents.

Labels:

- A (upper left): corner of the sea, source of current A–I
- D (upper right): corner of the sea, source of current D–K
- C (top center, with arrow/compass mark above): top of the sea (the point the equator C–F passes through)
- I (center-left of node): junction point on current A–I–B–G
- K (center-right of node): junction point on current D–K
- B (lower left): corner of the sea
- G (lower center-left, along the bottom curve): point on current A–I–B–G
- L (lower center-right, along the bottom curve): point on current E–L
- E (lower right): corner of the sea, source of current E–L
- F (bottom center): the lower terminus (the equator runs C–F)

In the text: "Let the Indian sea be B A C D E; let C F be the equator; the currents are C F E, D K, E L, A I B G." Then suppose an exhalation-bearing exhalation arises at C, or at

[Continues onto right column / next page:] ...D, or at E, or at B, or at A. I say the exhalation necessarily follows the path that the sea-current takes; for the air contiguous to the sea is driven toward that quarter from which it receives the greater impression—and it can receive no greater impression than from the impetus of the marine torrent, by which it is borne off and as it were drawn along. Therefore, whenever an exhalation-bearing evaporation is led out in the same tract, it is certain that it cannot escape this impetus.

[Now the left column resumes, after the figure:] It sometimes happens that a sea-current is cut across by another current overtaking it: thus the current E L disturbs the current D K. Then I say that the more powerful current will prevail, and consequently the air and the exhalation arising in the same tract will be drawn along the path of that current. Why too the easterly wind in such an open ocean is so variable—I find no other cause than the sudden generation of vapors, now growing strong in this place, now in another; by which the general wind, as it is impeded, so necessarily too, from the interruption of the newly born wind—now blown this way, now that, as it seeks an outlet—produces various winds. Whoever has grasped these explanations: no wind will be so erratic that a shrewd observer cannot render its reason and cause. But let us prove the whole matter by experiment.

[Margin: The diversity of the winds declared from various motions.]

EXPERIMENT.

Let a bowl E be made—or any vessel you like—into which, beside the four quarters of the world, spigots A B C D are inserted. Let the bowl E be filled with water; then have a lit candle prepared. If, then, you open the eastern spigot, the water, discharged with great force, will at once stir up a wind into that quarter toward which the water rushes. If you wish to test this, apply the candle immediately above the flow of water at the place where the flowing water bends into an arc, and you will see the flame bent toward no quarter except the one toward which the water's flow is borne—namely, from west to east. Then, closing that spigot, if you open spigot A and apply the candle, you will see the flame blown, bent from south to north. If afterward as many spigots were set up as there are points on the mariner's compass [pyxide nautica rhombi], the flame of the candle will always, by its inclination, express that wind which the flow of water carries with it toward whatever point. You will experience the same if you set a feather against the flow of water: it will always be carried into the opposite quarter by the force of the wind which the water's flow brings with it. From this

truly fine experiment it appears plainly that the flow of the waters follows the wind—and that, together with the wind, the exhalation is mingled.

Diagram. A perspective woodcut of a shallow cylindrical vessel (bowl) with ribbed sides, shown from slightly above so the interior is visible. Three tasseled spigots project from its rim toward the viewer—two at left and right, one at the lower front—each drawn as a spout with a fringed/tasseled cluster of water-streams issuing from it. Labels:

- B (top, on the interior rim, with a small circular mark below): the spigot/quarter B (north position on the rim)
- A (upper left, at the left spigot): the western spigot
- C (upper right, at the right spigot): the eastern spigot
- E (center of the vessel's interior): the bowl itself, filled with water
- D (lower front, at the front spigot with tassel): the southern spigot

CONSECTARIUM. [Corollary.]

[Margin: The method to be followed for sailing to the island of Ceylon.]

From this it is clear why, according to the fifth observation, at the promontory of the island of Ceylon — the one they call *Punto gallo* [Point de Galle] — the first wind on the 14th of March blows from the west, then turns to a west-southwest [Zephyro-auster], which afterward, from the beginning of April, lasts continuously right up to the first day of October. The reason is this: as soon as the Sun has struck the mountains of the island with its rays at the right angle, it simultaneously sets in motion the hot vents [aestuaria] beneath them; and these, as they cast out an enormous quantity of flatulent vapors [halitus], if those vapors are rarefied and driven toward the quarter the evaporation moves toward — that is, from the west-southwest region into the east-northeast [Euro-borea] — produce a six-month wind, matching the six-month duration of the material. This wind, however, does not last more than ten miles out to sea, which is why it is concluded to be a land wind. For on the opposite side of the island the easterly wind begins to blow afresh. Now, as to why the wind, at first westerly, shortly afterward shifts to its collateral, the west-southwest: the cause is the force with which the first evaporation is carried, which, when later interrupted by other evaporations that arise, changes its flow into the collateral quarter, the west-southwest. When these are finished, the Sun meanwhile sets other hot vents in motion beneath the ocean at the appropriate place, and so the exhaled vaporous material follows the flow of the east-northeast current.

COROLLARIUM. [Corollary.]

[Margin: The true origin of the annual winds.]

From this it is clear that the annual winds of the various seas derive their origin from nothing other than, first, the differing situation of the mountains. For just as these mountains have, as people say, a differing aspect toward the Sun, so too, according to that aspect, are they affected by the Sun in differing ways. And since there is scarcely a mountain of any fame or name, nor any promontory so celebrated, that does not contain within itself enormous cavities, vast caverns together with water-reservoirs [hydrophylacia] — as was said in the preceding pages — certainly no one, unless wholly ignorant of nature, will deny that a great mass of vapors and exhalations lies hidden within their inner parts. The outer surface of the mountains, moreover, presents the greatest unevenness of its parts. In one part they are clothed with the thick foliage of forests; in another they are bare, consisting of nothing but rock [literally "bones"]. In one part they are arched into a circular cavity; in another they are bent into a humped surface of the ridge. Some abound in vast lakes on the level of their summits; others, by contrast, seethe with fiery craters. Since this is so, let us now see how the exhalations and vapors that are stabled within them are stirred up by the Sun.

[Margin: How the subterranean vapors and exhalations are stirred up by the Sun.]

Experience establishes that the mountains are not always illuminated by the Sun in the same way, but each day, from morning to evening, in differing ways — and indeed differently according to the place in the Zodiac the Sun holds, and according to its position. For the Sun imprints one force upon them when it is in Capricorn, another when at the equinoctial point, another when stationed in Cancer and the rest of the signs; and again one force in the morning at sunrise, another at noon, another at evening — and it pours these in

whatever twelfth-part [dodecamorion] it is finally stationed in, according to the diversity of the reflected rays, by whose action the whole business of the winds is carried out.

Third: some mountains are more porous in one part than in another; in some parts they abound in caves, which can not unreasonably be called the wombs [matrices] of the winds; in certain places they swell with sulfur, niter, alum, salt, and the other mineral juices, all of which, when dissolved into vapors and exhalations, are the origin of enormous disturbances of the air. Since, then, the

Sun illuminates the different parts of the mountains at different times and under different zones, it follows that the Sun, stationed at a different degree of the Zodiac, when it strikes the parts of the mountains opportunely with its rays, then also draws out the mass of vapor lurking within, through the pores already opened by its heat. This mass, expanded and rarefied, since it cannot exert itself beyond the rear part of the mountain, pours forth the air it meets onto the side of the mountain opposite, and so, according to the situation of the mountain, produces now a northern, now a southern, now an eastern, now a western wind, and the other collateral winds besides. But since a vapor or exhalation cannot leave the mountain unless another succeeds into the place of the one departing, there is always new air drawn in — either internally from the subterranean hot vents, or externally through the mountain's cracks and fissures — which makes up the deficit of the departing air; and this lasts as long as the Sun looks opportunely on the mountain during the day. But when the Sun is either rising or descending, just as the earlier aspect is destroyed, so it opens other storehouses of vapor, from which new vaporous exhalations are drawn out, producing new annual winds. And what has been said of one chain of mountains is to be understood of all the mountain chains of the whole world. But these matters are to be set out more fully through the Propositions.

PROPOSITIO I. [Proposition I.]

How a Wind arises from the rarefaction or condensation of Subterranean Waters.

That the bowels of the earth are full of water has been shown above in various places, from which sometimes a most violent wind is generated by the rarefaction of water lodged within the bowels of the earth. For since no water can hold together except in its own vessel, and since in the bowels of the earth innumerable water-holding cauldrons [*lebetes hydrophylactici*] are set here and there, destined by nature for receiving waters, it also happens that through the hidden flue of a subterranean hot vent an enormous exhalation is emitted, which, as it surrounds the cauldron on all sides with its most violent boiling heat, so heats the water to the highest degree. The water, thinned by the heat into an exhalation, now rarefied along with the air and requiring more room, rushes out through the opening given it and is rolled out with vast force through the narrow channels, pores, cracks, and fissures of the mountain into the external air — from which a most violent wind is born. And it lasts as long as there is water in the cauldron; when this fails, the wind too must necessarily fail. And lest in the sea a

Diagram. An aeolipile experiment. At lower left, a bellows-shaped aeolipile [*pila Aeolia*] sits in a wide shallow basin of burning coals; a jet of air (steam) issues

from its narrow nozzle and is directed against a large toothed wheel (a turbine) mounted upright on a tripod stand at center. To the right, a horizontal axle carries a roasting-spit mechanism (the *veru* and rotating drum described in the text), supported on a second stand. The figure is uncaptioned and carries no letter-labels. It illustrates the three aeolipiles Kircher kept in his Museum, whose jets could turn a spit loaded with six pounds of meat.

[Margin: Aeolian balls.] [Margin: The experiment of the aeolian balls.]

EXPERIMENTUM. [Experiment.]

The effect of aeolipiles in stirring up winds is widely known. And although I have already described this machine in the section on the air-reservoirs [Aerophylacia], I have nonetheless decided to repeat it here — this being a place very well suited for explaining the generation of winds. So let an aeolipile be made of whatever size and capacity (for the larger it is, the greater the effect it will produce), formed of compact bronze, in the end of whose neck a hole should be left so tiny that it expresses the fineness of a needle. Fill this to the middle with the purest and clearest water, by this technique: place the ball on burning coals so that it grows as hot as possible; once that is done, you will at once throw it into cold water, so that the whole ball together with its neck is covered by the waters. And since the hot and seething air within, condensed by the cold of the surrounding water, contracts itself into a smaller space for fear of a vacuum, it necessarily summons another body into the place of the departing air; and since it finds none but water, it draws this within the ball with the utmost force. By this device of nature, the water drawn in through the tiniest hole fills the ball

[Margin: The marvelous effects of the Aeolian balls.]

up to a point. Once this is done, let the ball, with the coals kindled again, be set back on the burning coals, and with the help of bellows, as before, let it be heated, and the water inside, rarefied, since no exit is given it except through the narrowest hole, is rolled out through it with a vast noise and blast. I myself have in my Museum three aeolipiles of this kind, which, when set on a vehement fire, were able by their own wind to turn, by means of a wheel, a spit weighted with six pounds of meat. And from this experiment it is plainly evident how, in the hollow water-reservoirs of mountains, an enormous wind arises from time to time by the force of the subterranean fire, from the mere rarefaction of the air — which happens chiefly in those mountains that teem with fires and hot vents.

PROPOSITIO II. [Proposition II.]

How the annual wind arises from the Subterranean Cataracts [Catadupae].

[Margin: magnam (continuation of marginal note)]

It was shown in the preceding pages that mountains are for the most part pierced by caverns and by the deepest passages, and on every side by innumerable channels — and that these, just as they are covered by perennial snows, so too supply an enormous store of material for winds, in two ways. The first way is this: whenever the snows of these mountains begin to melt from the Sun's approach, the result is that the melted water, partly spread out over the level plains of the fields below, soaks and steeps the fields with a varied mixed moisture; and this saturation, thinned into vapors by the Sun, will pour forth an abundant seedbed [seminarium] of winds.

[Margin: How the cataracts carry down a great quantity of air with them.]

The other way is this: since the mountains, as was said a little before, are full of caverns, it follows that the melted snow-water, working its way deeper through the clefts of the mountains, hurled down into the innermost recesses of the mountain over the rocks of the interior it meets, most violently agitates the air existing within by the impetuous collision of the rushing waters — which themselves also carry down an abundant quantity of air with them. From this, the air, continually stirred up by the fresh increment now of more air, now of more water, while it seeks an exit, at last bursts forth through the hidden and narrow channels of the mountain into violent winds with great force. These are sometimes driven out with such force that they lay low even the largest trees in their path — just as we demonstrated in our own Etruria [Tuscany], in the matter of the Aeolian cave [specus de Aeolia] in the territory of Volterra [Ager Volaterranus]. See too the marvels we recounted in the Third Book concerning the Aeolian mountain of the Caesii [mons Caesiorum]. But that the reasoning behind the subterranean wind may be still more clearly evident, we shall confirm it by several experiments.

EXPERIMENTUM. [Experiment.]

Let a hollow receptacle be built of bricks, of the form you see here. In its

Diagram. A cut-away schematic of the subterranean-cataract apparatus. A bell-shaped masonry receptacle is shown in section. Labels:

- A (top opening of the receptacle, at the base of the curved tube): the upper mouth from which the spiral canal descends
- E (upper rim, right of A): the receptacle's lip
- K (curved tube rising from the top): the inlet pipe through which water is poured in
- F (tube projecting from upper left): a lateral tube/spout
- L (central spiral, the cochleate canal A–L): the screw-shaped channel down which the water spirals
- I (cylindrical stone at the base): the polished marble stone on which the falling water strikes
- C (small spout/tap at lower right, with an ornamental symbol beside it): the exit channel

The water poured in at K spirals down the cochleate canal A–L and strikes the marble stone I, driving the enclosed air out through the exit at F (described in the text on p. 204).

bottom let a marble stone I be set up, reduced to a most polished surface. From A, then, let a spiral canal AL be drawn, which is open at A and below at L; and let the receptacle be so closed that it finds no other exit except at F. With these things thus prepared, water — drawn either from a spring or from some river — will discharge itself with the utmost force through K, into the canal AL, through which it falls down onto the surface of the stone I with force and noise, accompanied by a great quantity of compressed air. And from the violence of the rushing water, the air enclosed within the receptacle will be agitated in a marvelous manner; thus constricted into the narrows, while it seeks an exit, at last, having slipped out through the orifice F, it will produce a most forceful wind, one fit both to drive a hydraulic organ and to serve smiths in place of bellows. See Book 9 of the *Musurgia*, where from folio 508 up to 511 we treated at length of the Aeolian chambers [Aeoliae camerae].

By exactly the same reasoning — to return to our purpose — the same thing happens in the cavities of mountains. Within these, the water of melted snows, or rainwater, gradually penetrating to the cataracts, produces an enormous agitation of the air; and the agitated air, while it seeks an escape, at last slips out through the hidden channel of the mountain into churning whirlwinds. If indeed this wind is perpetual, it will surely owe its origin not to the dissolution of snows, but to the cataract of some subterranean river, whose fall and downpour, just as it is perpetual, so too necessarily drives the air agitated within the bowels of the mountain out into a perpetual wind. But if the wind rages through such air-holes

of the mountains only in the summer seasons, that is a most luminous sign that they proceed from nowhere else than from the subterranean cataracts of melted snows; for these winds will last as long as the melting of the snows lasts, and once that is finished, these too must necessarily cease — since, once the cause is removed, the effect is removed. Again, if a wind rages from certain mountains only on summer days, three or four hours before and after noon, but never outside these times — not at night, not in spring, autumn, or winter — that certainly cannot be attributed to the subterranean cataracts, but must be referred to other causes, which we set forth in Book 3, last chapter, on the marvels of the mountain of Casius [mons Casius]; and to that I refer the reader.

[Margin: How the winds are stirred up by the subterranean cataracts.]

[Margin: The violence of the subterranean cataracts.]

And so reason dictates that the subterranean cataracts expel enormous whirlwinds through the air-holes of the mountain. For since the water rushing with force is full of air, and carries down with it in all cataracts an enormous quantity of air (as is evident from the foam, white as snow — which is nothing other than a multitude of innumerable little bubbles puffed up with air, from whose compaction the water is, as it were, imbued with a certain bright warmth) — certainly it follows that enormous subterranean winds are born from this; and these, then, by a violent eruption both [agitate] the external air, and, from its forcing-out, produce most violent winds. And winds of this kind we assign to the number of those which arise not from exhalations or vapors, but from the simple forcing-out of agitated air.

PROPOSITIO III. [Proposition III.]

How a Wind arises from exhalations and vapors stirred up in the caverns of the Earth by the force of the Subterranean fire.

Since it is established that the Earth is filled with innumerable caverns, caves, and grottoes — in accordance with the things recounted above — of which some are filled with water, some with air, others also with fire; and since most of them, moreover, teem with mineral and metallic juices and with clods variously mixed with other matters: certainly that matter, when the heat of the hot vents [aestuaria] works its way into it through its flues, is dissolved into a flatulent and spirituous material of salts, niter, alum, vitriol, and bitumen, which is contained in them, and will without doubt cause the greatest exhalations and rapid

expirations. These, when again and again pressed and expanded by supervening heat,

[Margin: How the vaporous exhalations make their way through the porous mountains into winds.]

through the hidden passages and fissures of the mountains, at last bursting out into violent winds, agitate the Earth and the Seas with such force as mortals have often experienced to their great peril. But how that wind comes about, the following experiment will teach.

EXPERIMENTUM. [Experiment.]

Prepare AB, a vessel made of iron plates in the shape of a tube. In its bottom, B, let there be placed niter with sal ammoniac, and a portion of crude antimony — all in equal proportion and reduced to a powder, and steeped with brine. Once this is done, with the vessel set over the fire, the material placed inside, boiling up at the very first scent of the fire and dissolved into vapor and exhalation, will emit a noisy wind, one fit for laying low whatever objects you please; and unless the vessel is firmly bound to its supports with chains, you will see the whole of it snatched up into the air with the greatest astonishment. The wind that is blown out from it is so vehement that a hand placed at the orifice — or

Diagram. A schematic of the chemical wind-vessel AB. A long, curved iron tube rises from a wide, round, basin-shaped base. Labels:

- A (upper part of the curved neck/spout): the tube through which the wind is emitted; a jet of vapor is shown blasting from its open mouth at top
- B (the broad round vessel at the base): the chamber in whose bottom the niter, sal ammoniac, antimony, and brine are placed and heated over a fire (a small grate or fire-door is shown in the front of the base)

The figure is uncaptioned. It illustrates the experiment described above, in which the heated chemical mixture in vessel B drives a vehement wind out through tube A.

— or anything else — it repels with the utmost force. And it emits not only a wind with great noise and crash, but also smoke so dense that you would think yourself set in a cloud. I recall an experiment of this kind once performed here in Rome, in the forum, by a druggist [pharmacopola] not unskilled in chemistry, who had placed the said substances in a mortar to show their natural force. When the coals were kindled in it, at once, with a great crash and blast, smoke so

dense came out that, when it had covered the whole forum with a smoky murk, one man could scarcely see another — the bystanders astonished at the unusual spectacle.

We have the experiment; now let us apply it. Wherever the exhalation of the subterranean fire has penetrated crypts filled with similar material, there is no doubt that that material, dissolved into vapor, if it finds no exit, will turn everything upside down — as happens in an earthquake. But if, through the open siphons and fibers of the mountains, it obtains free power to go out, then by its impetuous agitation it produces outwardly the violence of winds, such as may overturn trees from their roots and lay low houses and towers in the utter ruin of men and animals. But of these things, more in what follows.

PROPOSITIO IV. [Proposition IV.]

How the wind which they call a Whirlwind [Turbo] or Typhoon [Typhon] is caused on land and at sea.

The wind which, from its monstrousness, they call a Whirlwind or Typhoon, dominates chiefly at sea, sometimes to the great peril of sailors. Just as the sea, wrapped in vast heapings-up of waves, it turns in a rapid eddy about the horizon, and with relentless increases agitates [the sea] with a formidable force and savage squalls in a circle. Thus, as the tenth waves [decumani fluctus] surge up and clash against one another as if butting like rams, the raging exhalation takes away from sailors every hope of safety.

[Margin: The effect of the typhoon-wind.]

Now such winds arise chiefly in those seas where vast rivers discharge themselves into the sea, or where the impetuous flow of the Ocean, dashed against the vast tracts of the continental lands, is forced to wheel into a circle, or where two opposing Oceans rush in through the jaws of straits. But let us unfold what has been said in a few words.

[Margin: The marvelous tempests of the Gulf of Lyon, which the common people call the *Golfo di Lione*.]

In the Mediterranean Sea there is found a gulf, which the common people call the *Golfo di Lione* [Gulf of Lyon], opposite the bay of the sea where the mouth of the Rhône is — through which the Rhône rolls out into the sea with a rapid current. In this gulf especially, the violence of the typhoon-whirlwind rages at fixed times, to the great fear of sailors; and it is generated in this way. For when the south

wind blows, the whole mass of the agitated sea verges toward the hollow tract of the said gulf; but the waves of the Rhône, allied with the north wind, rush in with great force from the opposite quarter. Then, behold, suddenly a great conflict of the waves arises, while these waves, not knowing how to yield to those, are agitated into violent whirlwinds. By these, the intervening water, caught between and violently pressed, while it finds no escape, is raised on high in the manner of a column or a mountain — and portends inevitable shipwreck. For a ship entangled in whirlwinds of this kind can by no art elude the inclemency of the savage element.

Diagram. A large schematic of the Gulf of Lyon, showing the whirlpool [typhoon] formed where the Rhône meets the south-driven sea. The coastline encloses an open expanse of sea; concentric circles at the right depict the great rotating eddy. Labels:

- B (top center, the inflowing river): the mouth of the Rhône [Rhodani ostium]
- H (upper, just below B): a point on the inflow
- A (left coast): a point of the gulf [the bay A B C]
- C (upper right coast): a point of the coast
- M (upper edge of the concentric eddy): outer ring of the whirlpool
- O (left of the eddy center): a ring of the whirlpool
- L (center of the concentric circles): the center/eye of the whirlpool
- N (right of the eddy center): a ring of the whirlpool
- I (lower left of the eddy): a ring of the whirlpool
- K (left, below A–G): a point in the sea
- G (lower left coast): a point of the bay
- D (lower left): the south-driven sea [mare australi vento agitatum, D E F G]
- F (right): a point of the sea D E F G
- E (lower right): a point of the sea D E F G

[Caption (verbatim, foot of p. 205):] "Sit dictus Sinus, vulgò *di Leone* A B C, Rhodani ostium B, Mare australi vento agitatum, D E F G." — "Let the said gulf, commonly called *di Leone*, be A B C; the mouth of the Rhône, B; the sea agitated by the south wind, D E F G."

I say that the sea D E, stirred up [toward the concavity of the gulf A B C], meets the waves

— against the waves B, which, being unable to resist the waves G D E, are driven off toward C. But these in turn, thrown back by the waves of the sea reflected toward the shore C, are pushed toward I; and being unable to escape the swell of the sea D E, they are forced into K M N O and whirled in a circle. When they reach L, pressed there by ever-fresh waves brought up in relays, and finding no way out in any direction, they are lifted on high in a horrible spectacle — until, the winds ceasing and the sea flattening out, they gradually subside into circular agitations and are at last restored to their natural flow. You see, then, that this Figure demonstrates beyond dispute the true cause and explanation of the whirlwinds that infest the said gulf of the sea.

[Margin: The Japanese Sea, notorious for shipwrecks.]

The nautical itineraries report that in the ocean between Japan and China, chiefly in autumn, storms of this kind arise from frequent whirlwinds, with such violence and fury that no one who has not seen them with his own eyes can conceive of them. So dangerous is navigation in this sea that a voyage is reckoned blessed and fortunate if, out of three ships, even one holds its course. The reason for this is, first, the General Wind rushing from the east, by which the sea is driven toward the shores of the Chinese mainland. At the same time this current is cut off by the south wind that comes up against it and is driven along the coast toward the north; but this northward current is in turn cut off at the same time by a north wind, and, because of the easterly wind opposing it, when it does not know how to escape, it is bent back upon itself and produces the whirlwinds we have described.

[Margin: Remarkable storms in the Strait of Magellan.]

That the Strait of Magellan is more infested than other places with whirlwinds and typhoons is established by the account of many; nor should this seem strange to anyone, since, given opposing winds and the disposition of the place, a whirlwind must necessarily be stirred up. Thus, when an easterly or General Wind is blowing in the ocean lying between Africa and America, and at the same time a westerly wind is blowing from the Pacific Sea, it happens that these two, entering the very narrow strait, agitate it wonderfully; and when the opposing winds drive opposing waves, and neither can yield to the other, the water must necessarily be heaped up into circles and piles like mountains — which we showed above also happens in this sea from the contrary ebb and flow. As for why sailors find the sea perfectly calm and as if polished smooth before a typhoon, yet a little later roughened with dreadful waves, the cause is that from the opposition of the winds the sea is at first gradually [Margin: continued below]

resolved into circular motions at a distance, and consequently the water, pressed equally on every side, is necessarily rendered level in the intervening space — as experience teaches in any pond or any fishpond, whose waters, if you stir them in a circle with a stick, you will always find smooth in the middle, free of any roughness of the waves; but if you keep up the motion, the water, soon twisted into a helix, will undergo a vast disturbance.

[Margin: Whirlwinds around Ardabil, a city of Persia.]

Yet it is remarkable, what geographers relate of Ardabil, a city of Persia: namely that there, in the months of June and July, a whirlwind is born at noon every day, lasting about one hour, by which a vast and continuous cloud of dust, hateful to men and animals, is stirred up. The reason is doubtless to be sought in the annual wind that blows in those months, combined with the disposition of the place. For this wind, bursting out from a quarter near the south, when in passing toward another quarter it meets an obstacle, twists upon itself and is whirled about, carrying off the dust with it. In this same way, as I have very often experienced, a typhoon prevails in the Roman Amphitheatre: for the wind, striking against the walls arranged in a circle, continues alongside them and is at last driven into a vortex, filling everything with stirred-up dust.

PROPOSITIO V.

Whether and how a Wind is born bursting up through the middle of the sea.

Since beneath the floor of the sea vast fire-reservoirs [pyrophylacia] are contained (as was said in the preceding Section), it cannot but be that they release from themselves a vast quantity of smoky exhalations. These, bursting up through the floor of the sea and passing harmlessly through the mass of the waters, as soon as they reach the surface of the sea, swell and dilate, and rush out wherever the gate is open; and they rage in the ways we described above.

But perhaps someone may say at this point that exhalations cannot pass through a moist medium without being immediately smothered the moment they touch it. [Margin: Whether exhalations can pass through the body of the sea uncorrupted.] To refute the falsity of this objection, it must be understood that spirits of this sort — saltpetrous and sulphurous, which the subterranean estuaries emit from themselves — are by no means destroyed by the water, but penetrate the waters without mixing with them. This is taught by experiment not only in earthquakes, but also in any waters whatever. [Margin: Observation of the Author.] I

remember that in the year 1638, when Calabria was being shaken by unheard-of earthquakes, I observed the sea — just as when it rains, and as single drops generate single bubbles in the sea, or as when fire set under a kettle excites the water into bubbles by its heat — full of bubbles and boiling, which was without doubt a clear sign of vaporous spirits passing harmlessly through the middle of the water from the floor of the sea. Again, at fixed times the water here is raised on the surface, by subterranean winds, into so unusual a swelling that to those standing on one bank it takes away all sight of the opposite bank — as Pliny relates of the river Macra. [Margin: An impromptu swelling of the river, the cause of it, and where it comes from.]

It is remarkable, among other things, what the inhabitants relate of Lake Lemane [Lake Geneva]: namely that it sometimes swells up, even in calm weather and a serene sky, so much that, while this effervescent boiling of the lake lasts, no ship can entrust itself to it safely without manifest danger of shipwreck. [Margin: A remarkable narrative of the inhabitants of this lake.] They call this swelling of their nearby lake, in French, *la vardaïse de Geneve*. The cause of this can be nothing other than subterranean winds and vaporous spirits, which—

Diagram. A perspective view of the apparatus for Experiment I : a shallow cylindrical bowl [concha] resting on a surface, with a curved tube (canal) running from below up over its rim. The labels are:

- A (left rim of the bowl): the bowl A B
- B (interior surface of the bowl, toward the right): the bowl A B
- C (where the lower end of the canal enters beneath the bowl): the open orifice of the canal
- D (the raised upper outlet of the curved tube, projecting above the rim): the orifice through which one blows, set somewhat above the water

[Following the lake-swelling passage above, the text on this page resumes the experimental demonstration.] —which the fire-reservoirs of the neighboring Alps emit through hidden passages that have their outlet in the bottom of the lake. These, with the utmost force, urge on the waters they meet, inflate them and make them swell up in the manner we have described — as is shown by the following experiment.

EXPERIMENTUM I.

Into the bottom of the bowl A B let the orifice of a canal be inserted, with its opening C left open; and let the other end of the canal C D be applied to the

outside of the bowl, its orifice D projecting somewhat above the water. In this arrangement, blow through the canal by way of orifice D, and at once the water that the bowl contains, immediately agitated at its surface, will produce violent bubbles and swellings, which are caused by nothing other than the blast passing through the bottom of the vessel and disturbing the water. But since these things are well known, they need no further exposition.

The other point presents a greater difficulty: namely, that the nitrous spirit expelled through the floor of the sea, without any mixing with the water taking place, escapes whole and entire to the surface of the water. Yet so that we may not let this pass without the support of our reasonings, I add the following experiment, from which you will learn clearly how vapor and smoke pass through a liquid without mixing with it.

EXPERIMENTUM II.

[Margin: How exhalation and vapor can pass through water without mixing — an experiment.]

Take a phial, such as the present Figure shows, filled to some level with water or some other liquid — say, up to B C — with a tube fitted onto the neck of the phial, of the kind that tobacco-smokers are accustomed to use, in such a way—

Diagram. A tall narrow-necked flask (phial) standing on a foot, with a slender tube rising from its neck (topped by a small stopper or bulb) and a second curved spout-tube emerging from the body and discharging a cloud of smoke. The labels are:

- X (at the top of the neck, where the upper tube enters): the orifice X, which is to be stopped carefully
- B (upper-left of the flask body): the water level B C
- C (right side of the flask body, near the spout junction): the water level B C
- D (at the foot of the internal tube reaching the bottom of the flask): the orifice of the syphon-tube, drawn through the water to touch the bottom of the phial
- E (at the mouth of the curved spout-tube, where the smoke issues): the syphon-orifice E, through which the smoke passes out—that, drawn down through the water, it reaches the bottom of the phial; then stop the orifice X carefully, so that neither can the air contained within slip out through it, nor can the air surrounding it flow in from outside. This done, place upon the gaping orifice of the tube some leaves of dried tobacco, or sulphur, or

something similar; and when these are kindled and your mouth is at the same time applied to the little syphon-tube E of the phial, suck out the air lodged within the phial. You will see — wonderful to tell — the smoke and breath of the kindled material pass through the orifice of tube D, in great abundance, in the form of a little cloud, and pass through the middle of the liquid without mixing with it; and you will find its exit and outflow at the orifice of tube E — the moisture being overcome, of course, by the sharpness and dryness of the smoke.

[Margin: Application to nature.]

No otherwise must we judge it to happen in the sea: through whose floor, from the fire-reservoir, a great quantity of sulphureo-nitrous spirits is raised up, passing through the water without danger of mixing with it; and soon, when it has emerged at the surface of the sea, being resolved into blasts and winds, it will agitate both the air and the sea with great force, in the manner we have described.

PROPOSITIO VI.

How a Wind arises from the pressure of clouds.

It often happens, when some storm is imminent, that a violent wind is suddenly stirred up — which occurs especially before the fall of rain, or after the explosion of thunder. The cause of this wind is sought.

I answer that this comes about from the descent of clouds weighed down with water, by which the air beneath them is violently pressed. Hence the air, once pressed, if it meets no obstacle on the sides from some other thing urging against it — whether a cloud or a vaporous exhalation — diffuses itself in a circle in every direction. But if it meets on some side a condensed vapor resisting it, the air, pressed by the cloud lying upon it, since it cannot retreat, rushes forward into the part in front. [Margin: How great a force descending clouds have.] And this wind, though it is very frequent on land and sea, does not last long, but only for the duration of the descent of the overlying, pressing cloud; and when that ceases, the wind too ceases. But let us set the matter before the eye.

Diagram. A landscape view: a dense rain-cloud massed across the top, beneath it a wide layered band of air, then a wavy surface of sea, and below that a range of mountains and valleys. The labels are:

- A (in the body of the rain-cloud at top): the rain-bearing cloud A

- B (left side of the intermediate air-band): the intermediate space B C — the air
- C (right side of the intermediate air-band): the intermediate space B C — the air
- D (on the wavy surface beneath the air-band): the surface of sea or land D
- D (again, marked lower on one of the mountain slopes): the surface of sea or land D

Let the rain-bearing cloud be A; the surface of sea or land, D; the intermediate space B C, the air. I say that the cloud A, by the weight of its waters, as soon as it begins—

—its descent, presses upon the air B C; and this pressed air, if no obstacle is set at B and C, will discharge itself there with violent force — and all the more violently, the more it has pressed the air placed below it with a swifter and more forcible descent. But if it finds obstacles on one side or the other — that is, air condensed by vapors and exhalations — then it will find its exit either at B or at C. And so the cloud A holds the function of a bellows, which by its descent expels the air between itself and the surface of land and sea, as if through a channel, with great force. From this it is clear why such violent and impetuous winds sometimes suddenly arise: namely, because if the air is surrounded on every side by the thick vapors enclosing it, and is moreover pressed by the sudden descent of the cloud overhanging it, then, since no escape is given it, [Margin: An experiment of the pressure of clouds.] it will rush, wherever the gate is open, with vast force, as if through some narrow channel.

Let L be the pressing cloud; P the pressed air; M N the surrounding dense vapors; O the gate, through which the pressed air bursts out. But these things are so easy to grasp that they need no further exposition.

Diagram. Within a ruled rectangular frame, a large ovoid mass of air (P) enclosed by a ring of rounded vapor-cloud puffs, with a fan-shaped stream of rays bursting out to the left through an opening. The labels are:

- L (top of the cloud-ring): the pressing cloud L
- P (center of the ovoid): the pressed air P
- N (right side of the cloud-ring): one of the surrounding dense vapors M N
- M (bottom of the cloud-ring): one of the surrounding dense vapors M N
- O (at the left opening, where the rays burst out): the gate O, through which the pressed air bursts out

From these things, too, it is clear why a wind is felt after thunder: because, from the bursting of the cloud, just as the air beneath it is greatly stirred, so a wind must necessarily be born. It is likewise clear why, in valleys and the fissures of mountains, so violent a wind often rages: [Margin: Why a wind is usually stirred up after thunder.] because a wind excited in open country, however gentle, as soon as it has entered narrows of this kind, there too, as if shut in and constricted, gains strength wonderfully. I myself experienced this, not without danger, on a very high mountain in the territory of Sora, to whose summit-plateau there is no access except through a narrow defile broken by crags, in which there is such ferocity of winds that no one can advance upright without danger; rather, lest he be snatched away by the wind, whoever attempts the ascent of the mountain is compelled to reach the exit by crawling. [Margin: A danger of the Author.] My traveling companion related that not long before, a whole herd of pigs had perished in this place, caught up in the whirlwinds of the winds, snatched away, and dashed against the crags of a neighboring mountain. I could adduce countless wonders of mighty Aeolus in this place, to be met with everywhere across the regions; but let it suffice to have recounted only those I myself experienced.

PROPOSITIO VII.

How the wind that the Greeks call Ecnephias and Prester is born, and from what causes.

[Margin: What the Ecnephias and Prester are.]

Ecnephias [Greek: ἐκνεφίας (eknephias, "a wind bursting out of a cloud," a hurricane-squall)] is the name given to a sudden and most impetuous wind which, when it bursts out of some cloud, turns everything upside down; and these are frequently met with in the ocean lying between Brazil and Africa, also at the Cape of Good Hope and at Terra de Natal [Natal], likewise at Guinea beneath the Equator — winds which the Portuguese sometimes call, by a corrupt term, *Travados*; and in the said places they are annual. But before we proceed to the scrutiny of the hidden cause, we must first set forth how they are born, so that, having seen their prodigious effects, we may more easily arrive at their cause.

[Margin: The ill-fated Portuguese expedition.]

The Portuguese, before they were equipped with sufficient knowledge of the ocean — while they were giving their effort to discovering new regions around the Cape of Good Hope and the promontories of Africa — more than once

experienced the savagery of this sudden wind, with great destruction of ships and men. For when India had been opened up by Vasco da Gama [Vasco da Gama], the King of Portugal dispatched a new fleet, which consisted of thirteen huge cargo ships, in the year 1500, under the direction of a Captain and Commander, to explore new regions. This fleet was the first of all the European ones to be carried into Brazil, to the great joy of the Portuguese; and when they had stayed there for some time, at last, setting sail toward the Cape of Good Hope in the month of May, they ran into the most savage storm — which our Maffei [Maffei] describes very vividly. From Brazil to the Cape of Good Hope they reckon nearly 1200 leagues [leucas] over a vast stretch; these are the chief realms of the raging ocean and the furious winds. [Margin: The apparition of a comet.] To the Portuguese, who had entered that space in May more boldly than fortunately, a flaming comet of horrible aspect appeared continuously, even to the tenth day. And as sky and sea kept changing again and again, foul clouds massed together to the north had gathered into themselves, as it were, all the wind by their reciprocating motion. The sea was sluggish — a treacherous tranquillity; the sailors, ignorant of the places and the storms, had spread all the folds of their sails to catch the breeze from every side; when, out of those clouds I have mentioned, the North Wind [Aquilò], pouring itself forth all at once with a sudden onset, in a moment so overturned and overwhelmed four ships set crosswise — whose rigging had been less aptly arranged for shortening sail — with the others looking on, that out of so great a number of men not one at all escaped. To the rest, safety was afforded either by the yardarms lowered in haste, or, where that was not permitted, by the very sails ripped apart by the wind. Then, as the North Wind [Borea] blew on stubbornly, the sea swelled again and again, the waves now borne to the stars, now sinking almost to the very depths; it terrified the very Sun, by day with a pitchy color, by night with a fiery one. For twenty whole days the storm—

—held most atrociously. So Maffei. Whether this storm can truly be reduced to an Ecnephias is uncertain, since the Author teaches that it proceeded from the influence of a malignant comet over many days. [Margin: How the Ecnephias is generated.] But the effect of an Ecnephias, just as it is sudden, so too lasts only a very short time. For my part, I can by no means persuade myself that it was a comet; rather, I would judge it more likely that a continuous effluvium of submarine exhalations, carried up into the middle region of the air and there condensed, at last caused the storm that Maffei reports. What, then, the Ecnephias properly is, must now be stated.

It happens from time to time that, with the sky perfectly serene and the sea calm, a tiny little cloud appears in the sky — which from its shape they call the Ox-Eye

[Oculus bovis] — and within a short time, taking on a vast increase of itself, it stirs up such storms as we can scarcely read of without terror. [Margin: Description of the Cape of Good Hope.] Such a portent of nature is not infrequently met with near the Cape of Good Hope, which a lofty mountain, stretched far and wide out into the sea, constitutes. The summit of this mountain is not, like that of other mountains, tapered to a point, but possesses a remarkable flatness, which, from its form and shape, the Dutch [Belgae] call *den Tafelberg* — that is, the Table-Mountain spread with a tablecloth. On the plateau of this mountain, then, in the air just above it — as the eyewitness Fr. Martino Martini [Martino Martini] related to me by word of mouth — a tiny little cloud shows itself to view, which soon covers the whole breadth of the mountain. [Margin: A sign of the imminent Ecnephias.] When the sailors have observed this, then at once, as if it were the unmistakable forerunner of an inevitable storm, they gather their sails and withdraw from the shore, entrusting themselves to the deep as to a safer place, judging that they are by no means free of that deadly banquet of the laid table — which at all times brought manifest destruction to those who approached it too incautiously. For from the mountain's summit a wind is straightway sent forth so strong that no ship, however well-built and sturdy, can endure its force; hence the sea, raised into piles like mountains, excites such great waves and squalls that the sea, with its ships, seems to be tossed about no otherwise than a feather agitated by the wind. And so, from the incredible commotion and seething of the sea, men must perish — either by the breaking apart of the ships' frame, by submersion, or by being dashed against the rocks they meet, with horrible ruin of the men. And that storms of this kind occur not only at this promontory, but also in many other places at fixed seasons, was said above: namely, at Terra de Natal [Natal]; on the maritime coast of Guinea; at the Cape Guardafui [Cape Guardafui]; at Loanda [Luanda]; and elsewhere throughout the tracts of the Indian sea. These winds, if they are discharged together with lightning-flashes, are then also called Presteres [Greek: πρηστήρ (prēstēr, "a fiery whirlwind, a lightning-storm tornado")], as for the most part happens. Having seen the horrendous effects of the Prester and the Ecnephias, we will now inquire into the cause.

I say, therefore, that all of Africa beyond the Mountains of the Moon to the south — which they call Monomotapa, Angola, Mozambique, Melinda [Malindi], and Sofala — abounds with subterranean fires. That this is true was sufficiently declared in the preceding remarks on the Volcanoes and the burnt-out Islands of the African sea. Moreover, that the whole said Region of Monomotapa is consequently riddled with caverns and crammed with abysses, dens, and caves of unexplored depth, the annual letters of our Society [the Jesuits] attest; and again,

that it is so rich in gold that the natives affirm they have not infrequently found, among the ledges of the mountains, lumps of solid gold the size of a hen's egg; and that it is therefore pregnant with metallic juices and mineral spirits. From the foregoing it was clear that wherever subterranean fires prevail, there too are found chimneys and vents (without which fire could not live), some of which, spreading far and wide beneath the sea, find their outlet in the floor of the sea, others in the highest mountains; and in these, both salts of every kind and other minerals — with the natural disposition of the Sun assisting — are digested and concocted into gold and the other metals.

[Margin: Why the Ecnephias occurs at a fixed time.]

These things laid down, I say that, at a certain position of the Sun in the Zodiac, fire-reservoirs of this kind are stirred up — whether this happens from the reciprocation of the tide of the Eastern or Western Ocean, which presses the aqueducts naturally inserted into the shores; or because of the efficacy of the Sun's rays striking the soil of the said porous, spongy region; or, lastly, because of the snowy inundations of the Lunar Mountains [Mountains of the Moon], to which the whole of southern Africa is subject. Whichever of these it is, it makes no difference: that each of the causes recounted brings about a great increase of the fire-reservoir was shown above. And that the Presteres and the Ecnephias draw their proximate origin from this, we have now undertaken to demonstrate. [Margin: The Ox-Eye, as they call it, when it is generated.] Since, therefore, the Cape of Good Hope — where impetuous and fiery winds of this kind for the most part rage beyond other regions — is set up into a very high mountain, conspicuous with its rocky summit, elevated, and on every side built up of sheer crags and cliffs, it seems not unlikely that the fire-reservoirs unload themselves through various crypts and hidden passages, partly somewhere in this mountain, partly out in the open sea. But they cannot unload themselves except through vapors and exhalations; and since these are pregnant with sal ammoniac, niter, sulphur, antimony, and similar stubborn minerals, they are soon — together with the volatile spirits of gold in which they are strong — carried up on high through the orifices of the mountain's passages. When they have reached the cold region of the air, there, condensed, they form that little cloud which they call the Ox-Eye. But since vapors and exhalations of this kind increase by continuous succession, it happens that they gradually cover over the whole plateau of the mountain in a trapezoid shape [Greek: τραπεζοειδῆ (trapezoeidē, "trapezoid-shaped")]; and the vaporous and swollen substance of the vapors and exhalations, agitated this way and that, easily kindles into fire. When this happens, then — behold! — the

spirits, impatient of their prisons, rushing downward with preceding lightning-flashes, with a fearful crash, and with incredible force, [whatever]—

whatever they strike, they level. As for why they are carried downward rather than upward, the cause is the spirits of gold, mixed together with a nitrous substance and with sal ammoniac and antimony — substances than which nothing in the natural world can be more potent or efficacious. But let us confirm the matter by experiment.

EXPERIMENT

[Margin: The remarkable power of certain minerals.]

There exist in nature certain mineral substances whose combined force is so great that the overturning of whole mountains may rightly be ascribed to them. You will discover this with the greatest astonishment if you make a compound from calcined gold, aqua regia, sal ammoniac, and oil of tartar [oleum tartari], precipitated: for at the first whiff of fire this mixture ignites and, with an enormous preliminary crash, levels whatever lies in its path — and not without grave danger to the life of anyone who handles it too carelessly.

[Margin: Experiment.]

I have seen a powder of this kind placed on the tip of a knife and set alight produce so great a noise that the senses could scarcely bear it, all those present being as it were deafened by the violence of the sound. The effect of this powder is exactly contrary to that of ordinary gunpowder [pulvis pyrius]: for just as ordinary powder, once ignited, is driven upward with force, so this one is driven downward.

[Margin: The contrary power of gold-powder to that of common gunpowder.]

For if you set alight even the smallest quantity of this fulminating powder [pulvis fulminans] placed on a plate, whether of iron or of wood, you will find the plate — of whatever thickness it may be — pierced through in an instant with a frightful crash. Its sole cause is the sal ammoniac. For just as saltpetre [salnitrum] and sulphur wage hidden quarrels of enmity, so much so that they cannot even coexist together, in the same way sal ammoniac too has its incompatibilities with tartar.

[Margin: The antipathy of sulphur and niter. The antipathy of sal ammoniac and tartar.]

So when sal ammoniac is joined with oil of tartar, its opposite, they at once break out into ferocious wars. The gold, already dissolved by the aqua regia, sinks downward; the oil of tartar strikes at the purified spirit of niter, which — stirred up by this conflict — joins itself in a contrived alliance of friendship with the sulphur of gold, the enemy of niter. Yet since the sulphur of gold is supremely purified and incomparably finer than common sulphur, it produces these astounding operations: penetrating, dissipating, boring through, and overturning everything.

[Margin: A horrid clash of minerals.]

The saltpetre, for its part — being hostile to the gold-spirits — swells up among them, and since it cannot be confined within the narrow space, together with those most powerful spirits it bursts through everything with incredible violence, amid a vast crash and roar. To these are joined the contrary pair, sal ammoniac and precipitated tartar, which enter into battles all the fiercer in proportion to the more violent hatreds with which they are at odds with one another. Therefore, whenever these violent substances are lifted into the air by exhalations and vapors, it comes about that, once kindled, they cause the very Presters and Ecnephiae [ἐκνεφίας] that we have described. Indeed, in every impetuous, turbulent, and violent wind by which even trees are uprooted, houses leveled, and horsemen and men alike snatched up through the air, it is as certain that materials of this sort, drawn out by exhalations and vapors from the bowels of the earth, are intermingled, as it is certain that all the exotic effects within the bowels of the earth — those that attend earthquakes, the overturning of mountains, the ruin of cities, and the new births of lakes — are caused by the commingling of materials of this kind.

The question now arises: why is the sea rendered so turbulent at the eruption of Ecnephiae?

[Margin: Why the sea is rendered so turbulent at the eruption of an Ecnephias.]

I reply that this happens for two causes: either through the impetuous Ecnephias rushing upon the sea, which will violently agitate the neighboring water in a moment; or, secondly, on account of the contrary waves rushing in from the deep recess of the sea, which, meeting the waves already stirred up by the Ecnephias, struggle against them with enormous effort. From this contest of the waves the sea is now raised into mountains, now whipped into whirlpools; and now, dashed in various ways against the lateral waves, it produces that disturbance which we have described.

[Margin: Why the sea is sometimes suddenly stirred up out of perfect calm.]

It also happens that the Ocean, in certain places, even in calm and tranquil weather under a smiling sky, boils up into immense swells. The only cause of this is that the aforesaid exhalations and vapors, forced up with the utmost violence through the hidden channels set in the sea floor, meet the resisting watery element and lift it on high, and in this way render it most swollen and most turbulent. These vapors, filled with the said mixture, sometimes — as we learned above by experiment — penetrate the water-substance with which they cannot mix, and slipping out beyond the surface of the sea and kindled by excessive agitation, set the whole sea ablaze at once, especially if they are bituminous.

[Margin: Why the sea sometimes burns.]

The histories relate that [Americus] Vespucci [Amerigo Vespucci] first observed this, and after him other master mariners experienced it in many tracts of the Ocean. It also happens occasionally that the water-conducting channels of the Ocean are infested by vapors and exhalations of this sort, whereupon the water, forced to recede, suddenly and violently sets in motion the entire mass of the Ocean lying above it. From this a most certain rule can be deduced: that whenever tempests of this kind arise under a tranquil sky, they take their origin either from the exhalations described or from subterranean winds. So you now have the cause of the Ecnephias set out in this place.

PROPOSITIO VIII

How the Exhydrias Wind is produced.

[Margin: What is the Exhydrias wind?]

The wind that the Greeks call Exhydrias [ἐξυδρίας, "out of water"] can be considered in two ways. Either as it arises from a vast mass of clouds dissolved into water, which falls upon the earth not drop by drop but in a total outpouring of water, ravaging everything with its flooding — and in German this is called *Wolckenbruch* [cloudburst], that is, the "bursting of clouds"; or rather as it is born from the depths of the waters, which is what remains to be discussed here.

By the long experience of those who [have plowed the vast]... ..recesses of the Ocean, it has been observed that out of a sea perfectly still and, as it were, swept clean as with a broom by calm weather, a certain vapor rises up, which, in the form of a tube or sleeve — and which the Portuguese accordingly call *la Manga* — is gradually lifted to a very great height.

[Margin: An unusual and very great storm of the sea; why it is called *Manga*.]

It then spreads out so far that it covers both sky and sea with a dense gloom, from which winds of the most dreadful and incredible violence follow. By these the Ocean is whipped into such a fury that no one can conceive in his mind the terrifying force of the waves — except one who has experienced it. The mariners' accounts record that no ship, if it ever fell into a waterspout of this kind, escaped — in those earliest times when the captains were ignorant of the force of nature in its ferocity; but nowadays, taught by experience, they are accustomed to elude the fury of this wind with marvelous skill as soon as they catch sight of the rising vapor. If you ask the cause of this wind, know that it is altogether the same as that which produces the Ecnephias, with this single difference: that the Ecnephias is produced by exhalations and vapors led out through earthen passages, whereas the Exhydrias is produced through siphons set in the sea floor, by which the said vapors are drawn out through the midst of the sea.

[Margin: The cause of the storm.]

For these, raised on high, with ever-new flatulent vapors constantly succeeding them, are at last expanded and agitated; and because of the spiritous mobility of their substance, unable to be contained, they rush out by whatever opening is given them and harass the sea with those storms we have described.

PROPOSITIO IX

What the Ecnephias is — the whirlwind that those traveling in the Mediterranean regions occasionally experience — and how it is produced.

[Margin: The Ecnephias and whirlwind in the inland regions.]

In the straits of the Arabian Gulf [Sinus Arabicus — the Red Sea], as also in the deserts of Arabia, Ethiopia, Libya, and the rest of Asia, the Ecnephias together with a whirlwind is most frequent. It first presents itself to the eyes as a dense black cloud, glowing with flame-like spirits like a kindled furnace, dreadful to behold, and teeming; by its dense gloom it brings darkness upon the day. There follows immediately upon it a stormy wind — not lasting long, however — by which the sands of the shore, both of the Red Sea and of the aforementioned deserts, are stirred up and raise sandy storms far more dangerous than those at sea.

[Margin: The storms of the sandy deserts of Africa, by which men are often buried.]

It happens indeed that a whole company of merchants, which they call a *Caravan* [Caravana], of as many as six thousand men who traverse the said deserts, is overwhelmed and buried by a sandstorm, perishing together with their camels without any human remedy.

[Margin: Why the storms of the sandy deserts of Africa, from which...]

The cause of so rare an event is sought; certainly I think there is no other than the one I have stated. Namely: nitrous-sulphurous vapors, mixed with sal ammoniac — which is gathered in great abundance in deserts of this sort, especially in the desert of Ammon in Libya, from which it even takes its name. For these, once kindled, in proportion to the violent ferocity of nature with which they are endowed, are expanded; and being of a lighter substance, striking the sandy soil they stir it up from the bottom, whence the sands, lifted up to the stars and then heaped up into sandy mountains, bury and overwhelm whatever they encounter by an inescapable fate.

[Margin: A rain of worms, serpents, and the like in Africa, from where?]

From this it is clear why in some places of Arabia and Libya a rain of worms, serpents, frogs, and similar little animals has occasionally been observed. For these — together with the sand, or even from any place where, springing up in copious offspring, they make their habitat — are snatched up by the violence of the winds, carried now into these, now into those regions according to the wind's direction; or else, from the seminal corpuscles of the said animals being lifted up and hatched by a sudden generation in the humid and warm air, they cause that prodigious rain we spoke of. And in this way no kind of rain, however exotic, is recounted by historians whose reason you could not assign — concerning which more fully in what follows.

CAPUT VI

On the Transverse Motion of the Winds, and Its Cause.

It can scarcely be told how much the meteorologists torment themselves in rendering the true and genuine account of this motion. Hence some, stretched upon the most abstract principles and neglecting the power of nature, take refuge in extrinsic and free causes and ascribe the motion of the winds to Angelic powers. And although this may sometimes be true, I do not think it becoming to a philosopher — so long as the true, real, and genuine causes of natural things are available — to take refuge in higher powers and in the power and virtues of God and the angels. For in this way, with all law of philosophizing removed, both the

ignorant man and the little woman could philosophize without any trouble about the occult and hidden causes of things.

[Margin: The motion of the winds is not established from a higher power.]

I am not unaware that Sorcerers and Witches sometimes, by the operation of demons and with God's permission, stir up the most savage storms — yet without any prejudice to natural causes, since the demons do not produce these of themselves immediately, but by means of natural causes. For inasmuch as the whole economy of nature is most thoroughly known to them, nothing is easier for them than, by applying actives to passives, to produce such an effect as the natural causes of similar things are wont — of themselves, intrinsically, and by their own nature — to produce.

There are some who, when they cannot extricate themselves from the perplexity of this motion, hold that it proceeds from nowhere else than from a Soul of the Earth — just as in animate beings the faculty of breathing out and breathing in proceeds from the lungs. But since these men philosophize as ridiculously as this, I likewise consider them hardly worth refuting. Certain others suppose that the winds are moved transversely by the rapid rotation [raptus] of the heavens — — but this too is gratuitously invented. For if, according to their opinion, the rotation of the heavens occurs from East to West, then all winds would necessarily rush forth equally from the East — which is contrary to experience.

[Margin: Various opinions on the transverse motion of the wind.]

Nor are those to be heeded who derive the transverse [λοξοδρομίαν, "oblique course"] motion of the winds from an equilibrium of motive power — relying on a false foundation, they suppose that the lighter portion of an exhalation (which they assert to be substantially earth), raised by heat, as soon as it has met the cold of the middle region of the air, is restored to its earthly nature; and while it descends, by its own weight it beats upon the lower mass of the thicker air, and since it is given no power either to return below or to rise upward, it pursues a middle, that is, an oblique motion. Whoever pleases may consult the many opinions of various authors in [Bonaventura], who in a vast volume does almost nothing else than discuss the reasons and causes of this transverse motion of the winds.

We, having sworn allegiance to the words of no Master, will set down here our own opinion, which — relying on the confidence of our experiments — we do not doubt will assign the genuine reason for the transverse motion that we call the formal cause of the winds.

It was said in the preceding pages that a wind is nothing else than a flatulent vapor expelled by heat — whether by the power of subterranean fire, or raised on high by the heat of the Sun. This granted, I say that the motion of this vapor can be carried out transversely in many ways: first, by flight from its contrary; secondly, by pressure; thirdly, by the compression of the surrounding vaporous air.

[Margin: The true and genuine causes.]

The flight from the contrary occurs in this manner: since the vapor of a most light substance, by its own nature hot and dry, drawn out from its mixture, flies upward with the greatest impetus, it comes about that, encountering in the middle region of the air a cold contrary to its nature — and since the two cannot coexist together, while it cannot, hindered by its own lightness, attempt to depart downward — being thereby repelled, it takes counsel for its flight and rushes in a middle path, driven transversely. And this is the first reason for the oblique motion.

The second, which occurs through pressure, happens in this way. It is known to everyone that vapors raised on high from the earth and sea, when they have reached the middle region of the air, are condensed there by the cold and turned into clouds; and these clouds, sinking gradually by their weight — just as they place a further obstacle to the ascent of the flatulent vapors, so too by their descent they press hard upon them. These vapors below, multiplied by the ever-new accession of rising exhalations, but pressed from above by the supervening cloud, rush obliquely by whatever way lies open; and in this way the transverse motion of the winds is carried out.

The third manner occurs through the compression of the surrounding vaporous air, in this way. It happens most often, as the vapors rise, that they are surrounded on every side — both above by the clouds and from the sides by the substance of the thicker air's pores. While thus enclosed in these narrow cells, since it suffers great violence from the ever-new multiplication of rising vapors, taking counsel for its flight it takes the way that nature offers as the easier for it; whereupon, the obstacles burst, it slips out with vehement impetus and is carried by a transverse motion into that quarter which the broken obstacle faces.

To these I add a fourth reason for the oblique course [λοξοδρομία]: namely, the fissures and clefts of mountains, from which, just as the exhalation bursts out laterally, so too it continues the lateral flow that it began from the start. And in this way it draws with full impetus into that quarter whatever other vapors and

spirits it encounters in its path, and sets the whole air in motion — which, just as it excels in marvelous mobility, so is driven in whatever direction the vapor, following its lot, is driven. And thus truly and properly that spirit acquires its strength as it goes, like a torrent or river, growing strong by the addition of new vapors, and lasts as long as the exhalation and outflow of the vaporous material lasts. Here, Reader, you have the reason for the transverse motion of the winds so combined that no other can be conceived which does not coincide with what has been said. These things being shown, nothing remains except that we demonstrate, with equal advance, the nature, property, and powers of the winds.

CAPUT VII

Whence arises the Tremor, Undulation, and the diverse degrees of intensification and remission of the impetus of the winds, and how these can be known by sound.

[Margin: The wind, striking the air, expresses its properties in its flow.]

That the wind is carried through the airy region exactly as a river is carried — this it is our task to demonstrate in this place. For just as a river, now full, now diminished, sometimes whipped up among the narrow defiles of mountains affects a certain swiftness, sometimes, restored to flatter places by a pleasing massing-together of waves, is borne along; then among the rocks it meets, as it were combed, [makes a] marvelous [murmur]; sometimes, hurled down from cataracts, strikes dread by its vehement roar; at other times among the pebbles and stones it babbles with a gentle murmur of flowing water — and thus innumerable rivers of this kind produce effects of this sort. In just the same way it happens in the wind, the motion of which, could we but attain it by the senses, we would perceive to produce exactly the same effects in these as in rivers. But lest we should seem to have omitted any of those things which [pertain to the nature of the wind]... ...pertain to the nature of the wind, we will work the matter out by experiment.

EXPERIMENT

If someone stretches out a string [chorda] made from the intestines of animals and exposes it to the wind in a place prepared a little earlier, he will observe that the string presently sounds — not with that note proper to the stretched string, but with one quite different. For now it keeps the third, now the fifth, now the fifteenth or twenty-second, then again the third, the fourth, or the sixth. Since no one has been able to give the cause of this matter, we have thought it the part of our task to disclose the genuine cause of it here.

[Margin: Why the string, struck by the wind, exhibits such diverse sounds.]

I therefore suppose, first, that the wind is not carried against the string with an even impetus, but strikes now this part of the string, now that, as it were by certain radii, with now a slower, now a swifter impetus; and that this unequal impetus of the wind — this, namely — is the cause of such diverse sounds. I demonstrate it thus.

Let the string be A E, and the wind G. If it grasps the whole string A E with a single, undivided impetus, it is certain that the string gives out its proper sound, the one that befits its degree of tension.

Diagram. A geometric construction illustrating an Aeolian string struck by wind. At the left is a personified wind (a cherub-like face blowing), labeled **G**. From the wind's mouth a sheaf of straight radii fans out toward the right, where a vertical string is marked by four points from top to bottom. The radii represent the wind's rays striking the string at different points (the apex of the fan, the bisection point, etc.) to produce different harmonic divisions.

- G (left, the blowing face): the wind [ventus]
- A (top of the vertical string): upper terminus of the string A E
- B (upper-middle of the string): point of the wind-ray G B (the trisection division)
- C (lower-middle of the string): point of the wind-ray G C (the bisection / midpoint)
- E (bottom of the vertical string): lower terminus of the string A E

If, however, the ray G C alone touches it — that is, divides it in two — it will come about that the remaining parts C A and C E sound the whole octave [diapason], just as we demonstrated in the division of the monochord. For the wind's ray will serve in place of a plectrum: when it has touched C, the trembling of the whole string in the parts C A, C E will sound twice as fast, whence the string will necessarily sound higher by the interval of one octave. But if the wind's ray G B presses the middle B between A and E, the part of the string B A — and necessarily B E — will sound the twelfth, for the reasons assigned in the division of the monochord. If again the wind presses the whole space A D, D E will necessarily sound the double octave [disdiapason], that is, the fifteenth — and so on with the rest. The wind's ray, therefore, by its various different incidences upon the string, will produce various different sounds in it. Hence, when the windy ray leaves a larger part of the string untouched, it will produce a higher

sound by that much; but when it leaves a smaller part, a lower sound by that much.

What, then, the wind does on one string, it will do on innumerable other equally-tuned strings; and this is the genuine cause of the great diversity of sounds perceived in this instrument. Sometimes a certain tremulous sound arises, marvelously affecting the ears, which certainly has its origin from nowhere else than from the undulation of the wind — which does not always come with a straight impetus, but glides upon the string in the manner of waves, and so consequently sets the string in motion with the same motion by which it strikes it.

COROLLARY

From these things too it is clear that one and the same string can give out infinitely many diverse sounds. For the wind, even though it presses the string more strongly in one place, by pressing it more weakly in other places will bring forth new and new differences of sounds. For if, for example, it presses strongly at C and weakly at B, it is certain that C A does not affect the octave entirely, but something intermediate.

From this experiment all the differences of the winds — those observed in their motion and impulse — are most clearly evident, so that one who cannot attain the flow and undulation of the winds with his eyes may perceive it in this experiment with his ears. See, if you please, what we have treated of this at length in the *Second Volume of the Musurgia* [Kircher, *Musurgia Universalis*], fol. 354.

CAPUT VIII

On the Nature and Property of the Winds.

PROPOSITIO I

Why and whence are some Winds cold, certain ones hot, and others dry and humid?

[Margin: The cardinal winds do not always possess the same faculties.]

Those are greatly deluded who suppose that all Northern winds are cold, all Southern hot, all Eastern dry, and the Western humid. For the qualities of the winds must be derived not from the regions of the World, but from the medium through which they pass. For whether some mountain covered with snows holds its position to the North, or to the South, or to the East and West, it will always be true that a wind, from whatever part of the mountain it blows, is cold on account

of the snowy medium it passes through; and so it is necessary that that wind always be humid...

there is no wind that crosses marshes and lands soaked with standing water that is not always cold and humid; and likewise the wind that blows across sandy deserts and gravelly tracts scorched by the heat of the Sun is always hot and dry — as the Greeks, the Cretans, and the Cypriots find when the Libyan or south wind, or a similar one, blows from the facing coast of Africa.

[Margin: The winds of the Romans, and their qualities.]

Experience confirms it. The north wind, which here at Rome brings us dryness and cold, that very same wind in Belgium [the Low Countries] and on the other maritime coasts brings rains and clouds. Again, the north wind, which for us is of a dry-cold quality, at Tunis [Tunisi] in Africa is reported to be of a hot-humid quality; and conversely the south wind, hot-humid for us, on the African coast is cold-dry.

[Margin: Various examples of the variability of the qualities with which the winds are endowed.]

The reason is plain. Since the north wind blows to us from the snowy mountains of the Apennines, it affects us with the same quality as the medium it passes through — that is, with cold. And since the south wind blows from the sea and from marshy tracts, it likewise affects us with the quality the medium it passes through is steeped in — that is, with humid-warmth. But at Tunis in Africa, since the Mediterranean Sea (which lies to their north) is not cold-dry but warm-humid, it will bring a wind of the same character as that medium. By contrast, from the south — both because of the mountains of Numidia and because of the intervening sandy deserts — it will breathe now a cold-dry, now a hot-dry wind. I could adduce countless examples here to demonstrate this truth, but since I touched on them in earlier passages, I have not wished to dwell on them further.

You see, then, that the nature of the winds is not everywhere the same, and that it depends solely on the medium, or on the natural constitution of the surrounding mountains, valleys, plains, seas, lakes, and marshes.

[Margin: The effects of the winds depend on two things.]

This is confirmed by reason as well. For the nature and effect of a wind depend on two things: on the very spirit of which the wind consists, and on the place through which it passes. But the spirits that breathe out from the earth to our east, and cause an east wind, those same spirits will cause a west wind for those

living in the western region — unless something else has stood in the way — a north wind from the north, and a south wind from the south, even though the wind is one and the same and steeped in the same qualities. Since, therefore, south winds do not everywhere blow from hot-humid places, and cold and dry places are not always found to the north that would produce cold-dry winds of this kind, it plainly follows that the nature of the winds is not always the same.

[Margin: The varying exhalation of one region in others.]

Therefore, in order to establish anything certain about the nature of the winds, the nature and constitution of each single region above all must be observed — for example, from what quarter a given exhalation blows, and through what medium it passes. For these two things above all constitute and vary the nature of the winds. Just as the soil and the quality of the earth of every single region differs greatly from others, so too the exhalations that rise from there [text continues at the foot of the column and resumes at the top of the next] constitute different winds as well.

Hence the diversity of winds must be reckoned according to the constitution of the horizons. There are indeed certain places that rarely admit winds, such as Egypt. Yet if winds do prevail there, they are of the kind we described above when we treated of the *Ecnephiae* [hurricane-squalls] — impetuous and violent. There are other places that are perpetually dominated by a rainless wind, as in the territory of Avignon [Avenionense], where you will scarcely ever find rain, the sky always serene, but the winds perennial, all the humidity being converted into them.

[Margin: Mont Ventoux [Montventon] in the district of Avignon.]

The reason for this seems to be none other than the windy mountain commonly called *Montventon* [Mont Ventoux], which lies near Carpentras [Carpentoractum], and which they say breathes out perpetual winds through hidden passages in its inner bowels — winds by which the vapors drawn up by the force of the Sun from the Avignon countryside are at once converted into blasts stripped of all their humidity. They say that about fifty years ago this tract used to be watered by frequent rains; but after the inhabitants had dried up a huge lake situated beyond the Rhône, about fifteen miles distant from Avignon, the sky too, stripped at the same time of the humidity it had enjoyed by the lake's benefit, thereafter denied its rain.

There are, moreover, certain places subject to perpetual floods — such are those that are crowned by great mountains. For the clouds, gathered within their

gorges, are halted and herded together, until, when a Sirocco [Syrophoenice] or Libyan wind blows from a more humid quarter, they are dissolved into waters.

PROPOSITIO II.

Whence the wholesomeness or unwholesomeness of the winds arises.

In the judgment of physicians, every wind that does not arise from a commotion of the air, but from exhalations and vapors, is not only harmful to human bodies but even deadly. To prove this, let us take up the matter a little more deeply.

In the preceding pages it was shown that the winds for the most part consist, in substance and property, of exhalations. These spirituous and vapory exhalations are not merely diffused by their own power; they also drive along any other exhalations of every kind that they encounter — from which different and exotic effects of the winds must necessarily be produced, according as they pass through various places steeped in various refuse of earthy substance. For in this way, just as they take up diverse supplies, so they marshal diverse armies with which they do not cease to assail human bodies.

[Margin: The various effects of the winds on human bodies.]

Some, with excessive humidity, immoderately distend slackened bodies; others bind them with a frost-like chill and, when the pores of the body and the soot of the vapors conceived within them are obstructed [text damaged] — when this superfluous matter is shut in [?], the inner cavities of the body are filled with humors, and they cause catarrhs of every kind, pleurisies, and apoplectic symptoms. Nor are there lacking those that, by their subtlety and dryness, [continues on next page] penetrate the inmost

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economy of the body and, with the necessary humidity destroyed, dry out both the animal spirits and the vital spirits. For those saltpetrous exhalations, with their spirituous substance, not only penetrate the hidden passages of the viscera, but also, insinuating themselves among the concealed ducts of the membranes and muscles and creeping in little by little,

[Margin: Mineral exhalations, harmful to bodies.]

produce effects no less troublesome than those they bring about in the *Ecnephiae*, in *Prester*-storms [Prester: fiery whirlwind], and in other impetuous winds. For

these are followed presently by lassitude, a numbness of all the limbs, a most distressing sensation, [Greek: ῥεύματα (rheumata, "fluxes" or "catarrhs")] of every sort, a heaviness of the head with a troublesome cough, and other symptoms which it would be tedious to recount — and which commonly befall those who have caught the said winds, especially with their pores open, whether because of excessive heat or because the body was relaxed by too much exertion. But let us prove the matter by experiment.

EXPERIMENT.

Let there be made a long channel in the form of a tube, which you will so arrange that its wider opening is fastened somewhere through a wall outside the chamber, with the rest of the channel extended within a bedroom or some enclosed room. In this arrangement, let there be inserted into the said channel any kind of things you please, set in loosely and thinly — such as fragrant flowers, lilies, violets, thyme, basil, and the like.

Diagram. A woodcut illustrating the experiment. At the left stands a cube-shaped room (a chamber drawn in perspective, with a window visible on its front face). Passing through the wall of the room is a long horn- or trumpet-shaped tube (the *canalis*), its narrow end inside the room and its wide, flaring mouth outside, decorated with foliate/scroll ornament at the bell. The tube represents the channel through which the wind carries the scent (or the noxious vapor) of the substances placed in it into the enclosed chamber. No labels are printed on the figure.

It will then come about that, as soon as some wind has entered the said outer opening of the channel, the inner room (I say) will be imbued — by the wind's conveyance — with the scent that the inserted thing gives off.

[Margin: According to the quality of the things through which the wind passes, it affects bodies.]

But if into the said channel you put herbs endowed with a deadly quality — such as henbane [hyoscyamus], mandrake [mandragora], nightshade [solanum], thorn-apple [stramonium] — then you will see the whole room filled, by the wind's conveyance, with noxious vapors; and you will find that to some they bring sleep, to others the sharpest headaches, to some heartburn [cardialgia], and similar symptoms arising from a harmful and pernicious quality.

You may be convinced that just the same thing very often happens in the case of a wind. For a wind passing through places filled with wholesome things will be

steeped in such a quality of place as that from which it blows; if through unwholesome places, with unwholesome qualities, and so on. But let us demonstrate the matter by a fresh experiment.

[Margin: A history concerning the situation of certain places.]

Nautical histories report that, at the season when cinnamon is most in flower in Ceylon [Ceilano], the island spreads abroad so great a fragrance of scent that it is perceived as far as 100 miles out on the high sea — not without a weakening of one's health [text continues at the top of the right column] [and a] restoration, by the favor of the carrying wind. The same thing happens in the Moluccas, where the wind scatters the scent of cloves for many miles, especially in calm weather. By contrast, at the promontory which they call *Serra di Lyone* [Sierra Leone], long experience has taught that nearly all travelers are afflicted with exotic diseases. For their waters become charged with a wormy substance; their bodies are filled with unusual swelling; they lose their teeth; they are racked with malignant fevers; and according to each one's constitution they are beset by various symptoms. The reason for this is none other than that the neighboring mountains — which are utterly filled with arsenical, antimonial, and mercurial spirits, all of them pernicious — being thus carried by the wind into the ships, produce in the voyagers the symptoms we have described; and so it is no wonder.

[Margin: The experiment with the aeolipile.]

And experience teaches it by the aeolipile [Aeolia pila]. If you put into it waters steeped in the said lethal substances, and set it over kindled coals, you will find that the deadly vapor of the waters produces in the men shut up in that place the same effects we described — not without danger to the life of those who breathe in a vapor of this kind.

[Margin: The analogy of the aeolipile to subterranean fire.]

For just as the aeolipile stands in relation to the kindled coals, so does the subterranean ore in relation to the subterranean fire; and just as the deadly vapor of the aeolipile stands in relation to men dwelling in some enclosed room, so does the poisonous vapor of the ore stand in relation to those who have been near the source of so pernicious an exhalation. But how the plague is generated, from what causes, and how, once carried by contagion into far-off regions — since we have treated of these matters very fully in our *Scrutinium Physico-Medicum* — I refer the reader to that work, where he will find certain marvelous things bearing on this subject.

PROPOSITIO III.

On the usefulness of the winds, and on the marvelous magnetism that comes about, by the winds' benefit, in the generation of things — when each single thing, out of the exhalations filled with a varied mixture of seminal matters, draws to itself, conveyed by the winds, whatever has been most suited to it.

That Nature carries out her operations by a kind of perpetual *pericyclosis* was shown in the preceding pages. Now we shall begin a new *pericyclosis*, by which — through the benefit of the winds — the several bodies of mixed things draw to themselves the nourishment that has been most congruent and necessary for their sustenance, conferred by the winds out of the exhalations, both subterranean and elementary, filled with a varied mixture of seminal matters. How this comes about, we shall teach with God's inspiration.

It is well known that the Sun, sending down its rays into the Geocosm, as soon as it has met with anything humid and dissolvable, draws it up on high after the heat has rarefied it. But since there is almost nothing [text continues on next page]

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that is not rarefied by the Sun (except for those metallic and mineral bodies which have already attained the firmness of their solid consistency, and which need a more efficacious fire for their dissolution), so likewise there is nothing that is not resolved by the solar rays into its elementary parts.

[Margin: An analogy.]

Just as the subterranean fire stands in relation to the hidden crypts of the mineral mixture, and the artificial fire to the alembic in which mixed bodies are separated by means of exhalations, so does the Sun stand in relation to all the dissolvable bodies of the Geocosm. Such are: first, all humid things — the sea, rivers, lakes, pools, ditches, springs, places teeming with mineral spirits; second, plants, trees, and shrubs; third, the mixtures of seminal matters; fourth, animals of every kind.

[Margin: From all natural things certain exhalations are drawn by the Sun.]

From all of these the Sun draws out certain exhalations or spirits (which afterward are drawn back again, by a kind of marvelous magnetism, by those very things which have a certain proportion or consent — what the Greeks call

[Greek: συμπάθεια (sympatheia, "sympathy")] — with the seminal mixture hidden in the exhalations). This, I have thought, ought here to be treated with care.

And first indeed, as concerns the humid nature: it cannot but happen that, when struck by the burning rays of the Sun, it is at once raised up into vapors —

[Margin: Every humid thing being heated emits a vapor with heterogeneous corpuscles.]

which vapors are nothing but an infinite multitude of watery corpuscles, which, since they are most highly rarefied and made subtle by the heat of the Sun, are by reason of their extreme lightness carried up into the airy region. But since we have shown elsewhere that the watery element is everywhere filled with a certain panspermia [panspermia: universal seed-mixture], it can happen that, together with the watery corpuscles, heterogeneous or spermatic corpuscles — far removed from all sense-perception — are raised up as well.

[Margin: The scents of plants are nothing but their diffused effluvia.]

Again, that plants and trees emit the exhalations proper to each one as soon as they are struck by the Sun's rays is so well known that no one could doubt it; and scents bear sufficient witness that they are nothing but the effluvia of certain corpuscles, each one of which is imbued with the quality of the whole. Moreover, the Sun, striking the mineral surface of the earth, draws out the saline, nitrous, and sulphurous spirituous exhalations of the other minerals. And I would have you understand that the same thing happens in like manner with animals of every kind.

[Margin: The panspermia of things is carried into all the regions of the world by the wind's conveyance.]

This panspermia of things, then, raised into the air by way of vapors in the manner we have stated, and carried by the wind's conveyance into all the regions of the world, founds a new economy of seed-beds. For since all things consist of a twofold matter — one fixed and consistent, the other thin and volatile —

[Margin: The twofold matter of spirit: fixed and volatile.]

hence it comes about that the fixed, sluggish, sluggish [doublet in source] matter clings to the ground, while the other, of a thin and volatile nature, flying so high aloft, once it has been drawn off from its substrate, can never again be joined with the fixed — except when, carried about by the benefit and ministry of the winds, it at last falls into a place where it finds a fixed thing congruent and

proportionate to itself. When this happens, then at once it is seized — like iron by a magnet, like flame by naphtha — so that, just as the subterranean fire stands in relation to [text resumes mid-sentence at the top of the right column] [the things that are dissolved by it], that which had been separated from a thing by the heat of the Sun is restored to it as fixed.

[Margin: The marvelous magnetism of nature.]

Hence comes that marvelous *palingenesia* [palingenesia: regeneration, rebirth] — a *pericyclic* one — by which the several things are restored, by a kind of magnetic attraction, to the mixed bodies from which they are dissolved. In ores, the saline, nitrous, sulphurous, aluminous, and bituminous spirits, which had flown off from there by the force of the subterranean heat, are by the reciprocal commerce of the winds brought into the fissures and veins of the mountains, and by a kind of natural attraction each is restored, one to one, to the fixed bodies appropriated to it. For since these spirituous exhalations evaporate in every place, it comes about that the laboring fixed bodies, which cannot be preserved in their being without the volatile spirits, are always provided for out of the common storehouse of the exhalations by the ministry of the winds. The seminal broods of plants, together with their seed, snatched away by the force of the winds, are scattered everywhere for the propagation of the species.

[Margin: In the Roman Amphitheater all kinds of herbs are found to be born.]

This may also be seen in the monuments of the ancient Romans — aqueducts, amphitheaters, walls, temples, and other half-ruined buildings — on whose summits all kinds of plants and shrubs are born. And how they reached there, or who planted them in those places, only the man can fail to know who is ignorant of the nature and property of the winds. The wind has its hidden vehicles, by which it conveys the imperceptible seeds of plants there; and these seeds, joined to the saline and nitrous spirits of the lime and mortar in which they are strong, and then fermented by rains and dew, at last produce the very kind of plant from which they came. And just as experience teaches that this is true on the driest, most parched walls and partitions, so it must be believed to happen much more in all those places to which seed-beds of such things have been carried by the wind's vehicle. For those spirits of mixed bodies — which, dissolved by heat, are set in motion and carried about by the winds — are vaporous spirits of diverse species, with which are mixed at the same time spirits issuing from the vegetable, animal, and mineral economy. So when they are roused by motion and pass through various places, if they should reach proportionate matrices of this kind, each single matrix (or each single material and fixed body) sucks up and as it

were imbibes, from the spirits flowing past, the part more proportionate to itself, leaving aside the part that is, as it were, incongruous to it.

[Margin: Like attracts like.]

This is no different from what happens with the various kinds of food taken in: once digestion has been carried out in the stomach, the heart draws what suits it, the liver what is its own; and the brain, spleen, lung, kidneys, and the other members each draw the things congruent to them.

[Margin: An analogy to the human body.]

Hence the more secret physicians, the Iatro-mystae [Iatro-mystae: mystical physicians], assert that the members of animals, as soon as they have been taken as food and digested by the heat of the stomach, presently flow together, each to the members that symbolize with it: brains to the brain, heart to the heart, liver to the liver, lung to the lungs, and so on — so that from the hidden likeness and proportion of nature they may be able to benefit the member which they express in their figure. And from this was born that more arcane [text continues on next page]

[Printed p. 217 — running header: "METEOR. IMPRESSIONES SUBTERRANEÆ." Continues PROPOSITIO III.]

[Margin: The characteristic science of natural things from their signatures.]

characteristic science, by which sagacious physicians, through the hidden characters of things, teach how to recognize the healing power proper to each member of the human body — the power belonging to a plant or to the other mixed bodies which reproduce that member by their figure. Of this we have treated very fully in the *Ars Magnetica*, in the *Musurgia* [*Musurgia Universalis*], and in the second volume of the *Oedipus* [*Oedipus Aegyptiacus*], in the treatise on the hieroglyphic medicine of the ancient Egyptians; and so in this place we do not wish to be longer. But we have thought it worthwhile to illustrate the matter by another comparison.

[Margin: The magnetic experiment.]

Suppose someone, having reduced countless kinds of things to powder and mixed them together, were to spread out the whole powdery mass upon a table. I say that, just as the iron dust, whole and entire, can be separated out from so great a heap of confused things by the mere application of a strong magnet, by its attraction, so too among confused metallic powders, mercury (or quicksilver),

first reduced to powder by amalgamation, as the chemists call it, can be separated out whole and entire from the rest in a retort by the force of fire alone. And if someone now knew of a magnet that attracts gold, he could in the same way separate the gold-filings from the rest of the chaotic mass with little trouble — and so on with the rest. But concerning this secret we shall perhaps, in the following books, disclose some things hitherto unseen and unheard of, so that we may give the curious explorer of hidden things a handle for advancing the inquiry further.

What, therefore (to return to the matter we have proposed), I say about the confused heap of powders, you should know is to be understood likewise of the spirits of the various bodies, which, mingled together, are diffused through the air. For these are the true and fecund seeds, and as it were certain souls, that give being to all things.

[Margin: The air is full of the diverse spirits of natural things.]

For no one can deny that mixed in the air are the spirits of innumerable things, which both breathe out from the earth and, in the dissolution of things, are separated from one another. I speak of those seminal spirits which are extracted by the spagyric art from roses, violets, wine, and countless other things. What art can do, then, nature does far more excellently, in the resolution of the said things accomplished by the heat of the Sun. For these spirits, scattered abroad by the wind, when in the motion of the air they strike against bodies, then the fixed things that cling to the earth — each one of them — at once draw to themselves the spirit most congruent to themselves and their nature, and retain it, so that out of it the compound may again coalesce into its former state. And accordingly fixed bodies of this kind are nothing but certain magnets, appointed by nature to separate out those confused spirits.

[Margin: The marvelous pericyclosis of nature.]

Again I say: by nature, once it has become perfect, the seed of the living thing is elaborated; and that seed is, as it were, the magnet of that nature. For when the seed has become complete and perfect, it is separated from the living thing; and once separated, it at once begins, by the magnetism implanted in it, to join to itself proportionate parts — both from the gross things clinging in the earth, and from the spirituous things flying through the air; and by the hidden characterisms of things [text resumes at top of right column] it is in this way increased and perfected, its roots ever extending themselves toward new soils, so that from them they may seek new fixed parts; while the rains and winds breathe

fresh spirits upon it, by which at last, once compounded, it attains its ultimate perfection.

In this way we have amply taught — both here and in our *Iter Hetruscum* [*Iter Extaticum*, the "Etruscan/Tuscan journey"] — that mines of gold, silver, iron, and stones, after they have been exhausted, grow again. So that, even from these things, the ineffable providence of God, Best and Greatest, may shine forth, while things thus grow together and serve one another so studiously that, although one may seem to stand toward another in a wholly contingent relation, yet the one can neither exist nor subsist without the other. For unless the winds dispersed those spirits pregnant with their spermatic mixture, the generation of things would not be perpetuated usefully in every place. For that supreme Architect of nature knew how so to conceal his art that this most divine artifice should seem to be devoid of all art, and all things to have come about by random chance.

COROLLARY.

Hence the final cause of the winds is made plain, and the immense benefit they bring with them.

[Margin: The final cause and the greatest usefulness of the winds.]

For these dissolve into rains the clouds compacted with humidity — without which the nature of things would become wholly barren; yet, lest they should harm the earth with immoderate humidity, winds of a drier nature at once rise up to oppose them, to dry out the earth dripping with excessive moisture. On these depends all the fruitfulness of the fields and the fecundity of the trees, since the seminal forces flow abundantly to all things. By their help, lakes and seas, lest they putrefy, are kept agitated by continual motion. Journeys are accomplished by every wind around the terraqueous globe, so that nowhere is lacking what is so greatly necessary for the preservation of the nature of things. For what is more marvelous than, by the ministry of the winds, to traverse in so brief a time the immense spaces of the Ocean and the seas — to discover new worlds — to bless the human race with vast treasures of riches — and, the chief thing of all, to carry the light of the most holy Gospel along all the paths of the world, into the unknown tracts of the most remote lands, with an incredible gain of souls?

But you will perhaps object: that cannot be good which fills the world with so many calamities. For the winds, besides the countless harms they bring to men, also sometimes carry deadly exhalations — breathing out from the bowels of the earth and from the cadaverous refuse of putrid things — to the utter ruin of men

and animals, when they scatter the plague abroad by their contagious blasts. Therefore the winds [are evil].

[Margin: Why nature has permitted such pernicious winds.]

I answer: It is true. Nevertheless, by these evils of nature the same thing is done as in bodies overburdened with pernicious humors by purging medicines, by which bodies are to a certain extent purged, so that, freed from the virulent humors, [text continues into the following pages]

[Margin: That which purges the body of harmful humors.]

[restored] to their former health with the greater profit. In the same way, even when winds occasionally rise up that are destructive — winds that infect the air and steep both plants and animals with virulent qualities — they nevertheless have this good bound up with them: by venting their deadly breath, they restore to its former wholesomeness the diseased earth. And to keep these winds from troubling the earth with any longer annoyance, it has been arranged by nature's great wisdom that soon afterward other winds of a more wholesome character rise up and, like so many brooms, sweep clean the malignant impressions made in the air. Whatever danger the pernicious breaths had brought, these winds wipe away by their own kindness — so that nothing in the whole order of nature is so destructive that nature does not labor to draw from it some signal good.

[Margin: Art the imitator of nature.]

It also happens from time to time that the gracious God, to chastise the perversity of the human race, permits such evils of nature by his own just judgment, for the good of souls: that pressed down by these whirlwinds of calamity, men may turn back through repentance and the amendment of their lives to the God of all good things, from whom they had fallen away.

CAPUT IX.

On the production of artificial winds, which serve men both for recreation and for advantage.

So as not to seem to have left out any of the curious matters in this work, I have decided that the production of artificial winds too should be treated here. Man, nature's ape, observing the marvelous effects of the winds — and unable to command them at his own pleasure — contrived by his own ingenuity, after nature's model, something similar that might serve his needs. For when he saw that winds, passing through narrow places and shut-in walls, or against

interposed mountains and valleys, or struck against obstacles, acquire enormous force, he at once turned his attention, on rivers, lakes, and seas, to the construction of ships, and fitted them out with sails. In the spreading of these sails the wind is caught as if in a net, and being unable to escape, drives both sail and ship along with itself. On land, mills driven by the force of the winds were built for grinding grain, so that those who were without the current of a river might obtain by the help of the winds the necessary supports of life. Craftsmen, moreover, to rouse their fires with greater vigor — finding by experiment that wind grows wonderfully strong under the slightest pressure — invented bellows, in which air is drawn in and enclosed on the upstroke, and on the downstroke, being compressed, escapes with the utmost force. Since nothing is more common than this device, I have thought it superfluous to say more about it.

Nor shall I speak either of hydraulic contrivances and wind-guns [sclopiis ventosis], which I have demonstrated very fully partly in the *Ars Magnetica* and partly in the *Musurgia* — on which see also Fr. Gaspar Schott [Gaspar Schott], once my partner in literary leisure, who treats them ingeniously in his *Magia Pneumatica*. I pass over the ingenious construction of wind-vanes [anemoscopes], which I set forth in Book 20 of the *Ars Magnetica*. I will add here only, in what follows, how a certain Æolian chamber [conclave Æolium] may be fitted out that, in the summer months, will supply continuous winds of any desired temperament — designed both for the delights of princes and for cooling liquors and fruits.

Let a brick receptacle A B C D be built, of the size commonly used in constructing living-quarters. Beneath its floor C G H D, let two receptacles be made, separated by the partition L M; in the first of these, C D L M, let there be a syphon Q, whose arm-mouth X is to be left open. The other arm Y, the longer one, likewise open, is to be led through the partition L M — to which it is to be well cemented — into the receptacle L M N O. In this last there is another syphon R, whose longer arm, inserted through the bottom N O to the outside, projects out and is meant to discharge the water. Into the receptacle C D L M, from outside, let a rather wide channel be led, fitted with a stopcock T; when this is opened, water is hurled with violent force into the vessel P, whose bottom V is open. Furthermore, through the partition C D — which is the bottom of the floor G H C D — let there be led, below the place marked with the letters G H, leaden syphons; these are to be led

Diagram. An uncaptioned engraving of the Æolian (air-conditioning) chamber, shown in cutaway. The upper portion shows the room itself in three-quarter perspective as a box-shaped enclosure (the living chamber), with the inner back

wall pierced by numbered outlets through which jets of air (drawn as fan-shaped sprays) issue. The lower portion shows, in cross-section, the two stacked underground water-receptacles with their syphons, the inlet channel with its stopcock, and the discharge syphons. Two coiled tubes (the leaden syphons running up behind the chamber walls) loop up the sides of the room. Labels (read under magnification):

- A (upper-left corner of the room): corner of receptacle A B C D
- B (upper-right corner of the room): corner of receptacle A B C D
- E (upper-left of the inner back wall): top corner of the pierced inner wall
- F (upper-right of the inner back wall): top corner of the pierced inner wall
- 1 (left side of inner wall, upper): air-jet outlet
- 2 (left side of inner wall, lower): air-jet outlet
- 3, 4, 5 (center of inner wall, in a row): air-jet outlets (sprays drawn)
- 6 (right side of inner wall, upper): air-jet outlet
- 7 (right side of inner wall, lower): air-jet outlet
- [The text names outlets 1–8; outlet 8 is not separately legible in the figure — presumed paired on the right. [?]]
- G (lower-left of inner wall): bottom corner of inner wall / floor edge
- H (lower-center of inner wall): bottom corner of inner wall / floor edge
- C (left edge, at floor level): corner of floor G H C D
- K (right edge, at floor level): floor-level corner [K appears in figure though text reads C D L M; [?]]
- D (right edge, at floor level): corner of floor
- T (left side, below floor, on the inlet channel): stopcock
- S (left side, below T): lower end of the inlet channel
- P (basin/vessel at lower left): vessel P with open bottom V
- V (within/below basin P): open bottom of vessel P
- L (lower-left corner of the lower receptacle): corner of receptacle L M N O
- M (lower-right corner of the lower receptacle): corner of receptacle L M N O
- Q (syphon at lower center-right): syphon Q
- X (mouth at upper arm of syphon Q): open mouth X
- Y (longer arm of syphon Q): arm Y leading through the partition
- R (syphon at bottom, with discharge): discharge syphon R
- N (bottom-left outer corner): corner of receptacle L M N O
- O (bottom-right outer corner): corner of receptacle L M N O

are led up behind the walls A E C G, F B H D, and E F G H, with their lower mouths pointing into the receptacle C D L M, and their upper mouths inserted into the wall at the places marked with the numbers 1 2 3 4 5 6 7 8 — so that the mouths open into the chamber. And you will have your Æolian chamber prepared.

Its use is this. In summertime let the cock of the syphon S P, set into the wall, be opened, so that water drawn from outside is precipitated into the receptacle C D L M, and there drives out, through the mouths of the syphons opening into that same receptacle, the air standing within it. This air, driven out through the mouths 1 2 3 4, etc., of the syphons inserted behind the walls of the chamber, issues with great force and refreshes the chamber and those staying in it with a most pleasant coolness. And the wind will last as long as the precipitation of water made through the channel S P lasts. But since the receptacle C D L M is filled in the course of time, we have therefore arranged the syphon X Q Y — which Hero [Hero of Alexandria] calls a "bent diabetes" [diabetes inflexus] — by which the water is discharged into the receptacle L M N O, and from there, overflowing, is emptied outside through the bent syphon R. And in this way, since the syphon X Q Y discharges just as much as the channel S P precipitates — and since the air within the water and the structure of the receptacle is always in motion and turbulent — it will, through the mouths of the syphons 1 2 3 4 5, etc., continuously and with renewed force supply the chamber with windy, cold air.

But let this suffice concerning the nature, property, and use of the winds.

CAPUT X.

That there is no meteor which does not derive its origin from the subterranean world, and that within it meteors of every kind are produced, just as on the outer surface and in the airy region.

That the subterranean fire is the cause of all meteorological impressions, we have suggested above. But by what manner it produces these things, by what art it accomplishes them — whether it fabricates them in its own workshops and inmost recesses and then, when they are finished, expels them; or whether, like a diligent steward and nature's viceroy, it visits its several territories in person and disposes its business; whether it prepares them by a voluntary motion; or whether it is summoned by the Sun, which holds high dominion, to render an account of its husbandry? When all these modes are reviewed, it will become clear from what is to be said shortly that the fire disposes its operations in each of these ways. For above all it works upon the nearest matter at hand, and either masters it or sets in motion various kinds of mixture; according to the measure of

these a new form is drawn out, to lay down the law for the new compound; and then, by the deputy-work of its own heat, it advances and fosters the whole economy of the mixtures. Sometimes it happens that this subterranean fire-lord [pyrodynasta], having obtained compliant matter and an abundant supply, pours out new stations along long routes and leads forth colonies. It never hurries unwillingly, nor is it summoned against its will; but, by nature's instinct, it does not so much venerate the light of the stars as cross the bounds of the earth in order to enjoy the fellowship of the friendly heat — about to pay homage to the king of light for the subterranean revenues faithfully administered. But, setting aside this analogy of words, let us now press on more closely to our subject.

The subterranean fire, then, tireless and robust in its powers, applies itself to simple generation in such a way that meanwhile it does not refuse a rich brood of mixtures. In the work of its operations it employs two attendants: vapor and exhalation. The former is, as it were, water in potency; the latter, fire in potency. These are truly the all-seed-bearing [omniseminarium] of the mixed bodies, and by their working all the generations that take place on high are promoted and perfected. But lest, with its benefits poured out into the airy region, it could be said to have deprived its own realm of them, I will first treat of the impressions of meteors that take place in the subterranean world; and then I will set out in order, paragraph by paragraph, the causes and explanations of those things which, by its benefit, become known on the outer surface and in the airy region.

§. I.

All the meteorological impressions that occur on high outside the earth — these same occur in the subterranean world.

In the preceding pages we have shown abundantly that the Geocosm, besides its innumerable receptacles — which we call pyrophyllacia, hydrophyllacia, and aerophyllacia — is also crammed with crypts, caverns, and spaces stretched out to an immense extent; and that it is finally pierced through with passages, tunnels, syphons, clefts, and fissures, in which, by the perpetual constitution of law, vapor and exhalation hold sway — the former drawing its origin from the waters, the latter from fire. And concerning the rivers, water-conduits, and the immense lakes and seas beneath the earth, we have spoken amply in the preceding Book, and will speak again in what follows; so let us proceed to explain other matters.

Subterranean Rains.

And first indeed, that there are subterranean rains, only the man can be ignorant who is unacquainted with the construction of the distiller's alembic. For when a

vast vapor has been continuously drawn out, by the force of the internal heat, from the hydrophylacic storehouses into the hidden crypts of the mountains, here, condensed in the colder places and dashed [imp-]

[Margin: Subterranean rain comes about by the resolution of vapor by the force of heat within the crypts.]

[Margin: Subterranean rivers.]

[—dashed] against the vaults, resolved into water, it falls drop by drop in the manner of rain. And it was for this reason that Aristotle asserted that the origin of springs comes from nowhere else than from the resolution of vapors carried out within the subterranean crypts — a view which we, however, in our *Sectio de Origine Fontium* [Section on the Origin of Springs], demonstrate to be not a universal but only a partial cause. About subterranean rivers, then, there is no controversy.

[Margin: Subterranean snow and hail.]

Whether snow and hail are likewise generated in subterranean caves ought equally to be in no one's doubt. For if vapor has fallen into cold crypts charged with niter-bearing spirits, the foamy substance of the vapor, before it turns into water, is drawn together by the cold of the surrounding air into snowy flakes; but if it has been resolved into a drop-like watery substance, then, with a violent cold wind coming over it, it must of necessity be condensed into hail and ice. I myself saw on Mount Sorano [Monte Sorano] a crypt encrusted as it were with ice, with huge icicles hanging here and there from its vault, from which the inhabitants of the neighboring mountain make, in summertime, drinking-cups most fit for cooling the water and wine poured into them — the extreme cold being turned into the highest delight of the drinkers.

[Margin: The Sorano crypt.]

Subterranean Winds.

[Margin: Subterranean winds.]

I come to the subterranean winds, which not only hold sway in the hollow districts of the earth but rage with incredible force — a thing as certain as the furious and violent gusts of the Æolian mountains, which are everywhere commonly observed. See what we have set down in Book 3, in the chapter *On the Æolian Mountain of the Castori*, and in our *Itinerarium Hetruscum*, concerning the *Ventosa spelunca* [windy cave] in the territory of Volterra. Not long ago there

reported to us a man as noble as he was most learned, Pierre Guisony [Pierre Guisony], a Frenchman, Doctor of Laws and of Medicine: that near Noviodunum — commonly Nions [Nyons] — there lies a most famous Æolian Mountain, from which perennially blow forth winds of such force that the inhabitants, impatient of its fury, when they had several times blocked up the mouth of the cave with brickwork of stones, were never able to set against the violence of the wind obstacles robust enough but that the wind soon, casting back and prostrating the barriers, claimed back its former liberty for itself by redoubled rage. See what we have reported about similar mountains in the place cited.

[Margin: The Noviodunum windy cave.]

The cause of such subterranean winds is inquired into. I say, then, that the origin of these winds can be manifold. **First:** salt-niter spirits [spiritus salnitrosi], rarefied by the force of fire; for while they are pressed by the narrowness of the places and passages, and then, now endowed with greater freedom, enter the more spacious caverns, the air enclosed in the caves, violently agitated by the onrush of the invading spirits — finding an exit only through the most narrow passages — thence rolls itself out, together with the spirit, with that rage which we have described. And this is the first cause of subterranean wind.

[Margin: The cause of subterranean winds.]

Second: the cause of winds is the cataracts of subterranean rivers, which, when they have hurled themselves down through rocky and precipitous places, soon, within the cavernous tract of the cataract, produce by their fall a huge wind; and this, rolled out afterward through the hidden passages and then through the air-vents of the mountains, makes such havoc as we have described. **The third** cause of winds can be the liquefaction of snows on the mountains, whose dissolved waters, penetrating the hollows of the mountains, by their fall sometimes cause great winds within the bowels of the mountains; and this cause does not differ from the one that arises from the subterranean cataracts of rivers, except that the latter rage perennially, the former only at certain seasons of the year. There are also other causes of subterranean winds, which, because we have explained them in the place cited, we will not dwell on here; let it suffice meanwhile to have demonstrated subterranean winds by these few adduced reasons.

§. II.

The earthquake, the proper effect of subterranean conflagrations.

That the earthquake is not so much a meteorological as a subterranean impression, reason itself dictates, since the earthquake performs its accustomed catastrophes not outside but inside the earth — in which nothing more terrible and fearful, nothing more deadly to the human race, can occur in the whole order of nature. It is the greatest scourge of God, by which God the Best and Greatest is wont to chastise above all the men who are his enemies and the despisers of his commandments. What cities have we not read of as overthrown by these, what lands devastated, what mountains cast down?

[Margin: The frightful earthquake.]

[Margin: Histories displaying the marvelous force of earthquakes.]

Pliny [the Younger] [Plinius], in the Vesuvian conflagration of his own time, writes that the tremors of the earth were such that the earth seemed not, I will not say to move, but to be turned utterly upside down. Scipione Mazzella [Scipione Mazzella] and others relate that the commotions of the earth were so great at Pozzuoli [Puteoli] in the year 1594 that the sea was observed, to the great astonishment and dismay of the onlookers, to draw back some 200 paces. The earthquake that preceded the Vesuvian conflagration in the year 1631 is said to have been so great that, the floor of the sea being broken open, men came upon fish partly cast out onto the sea, partly left on the shore as the sea receded, together with ships; and these were followed by horrid bellowings, smoke, a rain of ash, eructations of huge rocks, fiery torrents, and gushings-forth of new springs and of bitumen — all of which display the incredible and most violent force and power of nature when it rages. But the explanations of all these things, the order now requires that we assign.

It is well known how much warlike artillery and the subterranean tunnels charged with gunpowder are capable of. Surely there is nothing so solid, nothing so well founded, that they do not hurl it skyward and lay it flat in the twinkling of an eye. And if indeed we examine the cause of so great a driving power, it is nothing

[Margin: That what warlike artillery does on the surface of the earth, that the force of gunpowder does.]

[Margin: How an earthquake comes about in subterranean tunnels.]

else than what you will find to be the origin of such great destruction: namely, a powder compounded of niter, sulphur, and charcoal. For the powder, kindled from the charcoal, rarefies the niter; and this, once rarefied — since it cannot remain together with sulphur, its enemy, nor be contained by the narrowness of the places — by its violent eruption, all obstacles being burst, works the havoc we have described. If, then, artificial powder is so strong, how much greater strength shall we judge a greater abundance and multitude of combustible matter to have — of sulphur, I mean, of niter, alum, sal ammoniac, bitumen, and the rest of the mineral and metallic spirits, of gold, copper, iron, arsenic, mercury — with which the inmost cores of the Earth are crammed? Who, then, does not know that fearful earthquakes issue from this source? And they come about, as appeared in the preceding pages, in the subterranean crypts, in the manner that follows.

[Margin: How an earthquake comes about.]

The subterranean fire, by the violence of its heat, having opened and burst somewhere the barriers of the mountains, where it has built itself a way into a cavern stretching far and wide — then, behold, the air within is at once stirred up with violent motion; and because it is furnished with an abundance of combustible matter, from the sudden ignition of the matter it rouses a great quantity of exhalations. Since these are given no place anywhere to escape, in the horrid battle thus joined such commotions arise as the power of nature, being greater, cannot endure. The exit therefore being cut off on every side, now they batter the inmost walls of the mountains, now boring through the channels of the softer earthy fibers — while they strive with fruitless toil — from the excessive impulse of the laboring nature an earthquake must of necessity be caused thereby. At last, driven by the dread and threats of that sworn enemy of nature, the void, the obstacles of the overhanging crags and earthy masses being undermined, they do the same thing that gunpowder does in the artificial driving of mines — that is, they shatter everything: they overthrow cities and fortresses, they make horrible chasms, they produce new lakes, and the like things which the records of the historians recount to us, they accomplish.

[Margin: The transfer of a mountain by the force of an earthquake.]

Egidio of Naples [Egidio Neapolitano] reports, in his treatise *On the Conflagrations of Mount Vesuvius* — whom Pietro Castelli [Pietro Castelli], a physician, cites on the last leaf of his work on Vesuvius — that in his own time a frightful event befell in Basilicata, a province of the Kingdom of Naples. From a formidable earthquake that arose there, an entire mountain, noble for its cultivation of vineyards, was carried from its own place into another, three miles distant from

there, without leaving any trace of standing in the intervening places. And he says that to this very day a long-standing suit hangs, between the possessors of the said mountains, in the Neapolitan court — what they commonly call the *Vicaria* — as to whether the returns and money-payments which the royal treasury is accustomed to exact are to be sought from the prior site, where the mountain stood before, or from the latter, into which it was cast. And it is truly a wonder that an event of such kind, if it is true — unheard of in all the ages — was not described by more historians. Be that as it may, that mountains are not only overthrown by the violence of earthquakes, but also born anew, suddenly, even in the midst of the sea, was demonstrated in the preceding Books.

From these things, unless I am mistaken, it is brilliantly clear how earthquakes are born among the subterranean caverns, and how, through various branching tunnels, exhalations — now running here, now there, as they seek an exit and do not find it — powerfully shake the earth; until at last, the foundations of the mountains being burst, they either, with the force thus made, hurl the superimposed mass elsewhere, or, if it is too heavy, force it to subside into a deserted place. But as to the fact that, when cities or mountains are swallowed up, a lake for the most part emerges in the place of what was swallowed, this comes about in this way: that the swallowed earthy mass below falls into some hydrophylacium; and since these cannot subsist together, the water, lighter than the earthy substance, thus squeezed out through the gaps, takes the place of the swallowed-up city or mountain. And experience teaches this: for if you put a stone of proportionate size into a basin full of water, that stone, sinking to the bottom, necessarily makes the displaced water brim over outside the basin.

Subterranean Thunder.

From so great a clash of subterranean exhalations with the air — from the most violent collision of bodies — a sound must of necessity arise. Hence all who dwell near fire-vomiting mountains testify that, before these begin to rage, for many days they have perceived, as it were, huge bellowings and noises not unlike thunder or the discharge of warlike cannon — certain forerunners, as it were, of the deadly tragedy soon to follow. I myself, indeed, while I was present in the year 1638 amid the unheard-of earthquakes that were reducing Calabria almost to a wasteland, remember that always, before an imminent earthquake — which often repeated itself by day and by night — I perceived a horrendous murmur and incredible crashings, like the sound of many drums. And on a certain day, when I had noticed that Strongylus [Stromboli] was raging, with an eructation of fiery masses, more than usual, I heard too a dull murmur, I know not what, from

a mountain 60 miles distant, which kept seeming to grow toward us; and when it reached us, it gave forth within the earth such horrid thunderings that the senses scarcely sufficed to bear them. Joined to this was so fearful a shaking of the earth that no one could any longer stand on his feet, all my companions being prostrated by the force of the raging nature. And at last, a truce being established, when we rose up and beheld the town of S. Eufemia [Sant'Eufemia] (from which we were no more than three miles distant) covered with a vast cloud — as this gradually vanished — [we saw] the city swallowed up with no trace any longer left, and a lake, which it had previously lacked, risen up in its place.

[Margin: A frightful earthquake observed by the Author.]

with a terror of spirit I could scarcely put into words.

CONSECTARIUM I.

On Subterranean Thunders.

From these observations I concluded, by an inescapable inference, that Calabria communicates through hidden channels both with Etna and with Stromboli [Strongylus] and the other Vulcanian islands, and that subterranean sounds and bellowings of this kind arise from the clashing of tumultuous spirits within those hollows and from the reciprocal struggle of effervescing exhalations. Since these share the very same mechanism as the thunders of the upper air, they may rightly and deservedly be called—and indeed must be called—subterranean thunder [tonitru subterraneum].

CONSECTARIUM II.

On Subterranean Lightning and Flashing.

[Margin: Lightnings, thunderbolts, flashings, and burning heats rage perpetually in the subterranean passages.]

From these same facts it is also evident that when exhalations are kindled in the subterranean crypts—packed together with sulfur, niter, coals, and other combustible kindling of like sort—dreadful thunderbolts too are forged there, far more savage and far more frequent than those of the upper air. For the aerial exhalations draw the whole matter of their lightnings from nowhere else than the subterranean vapors, which are carried aloft out of the earth together with the rising vapor and there are wrought into a thunderbolt. Wherever the same causes converge, there the same effects must necessarily be produced. For the

same reason, that subterranean caverns do not lack their flashes and lightnings is known only to one who has rightly grasped the causes of each. Thunderbolts, therefore, are born in such abundance in the subterranean regions that those cramped recesses, unable to contain them, sometimes thrust them out into the open; and a number of mountains demonstrate this plainly—mountains that, under a calm and serene sky, rage with such fury from time to time that scarcely anyone can remain safe from them. Such is Mount Tola in the Mauritian Islands [Insulae Mauricae], as may be seen in Orazio Torsellini [Horatius Tursellinus], in his *Life of St. Francis Xavier*, from whose chasms at certain seasons fires are hurled forth with great destruction of men and animals. And as many as have written of the eruptions of Vulcanian mountains testify to this—Pietro Bembo [Petrus Bembus] and others on Mount Vesuvius and on Etna, which (they aptly describe) when stirred by subterranean fires has cast lightnings shot through with black smoke far and wide. All these things I have judged ought to be described here at greater length than was strictly fitting, in order to show that the subterranean regions are not only fertile in meteoric impressions, but are the sole cause of those meteors that are generated on high.

An Experiment by which we demonstrate what has been said.

If someone fills a vessel beforehand with boiling water and then seals it so that every exit for the air is blocked off, and exposes it to the cold air in wintertime, it will come about that the water in it, rarefied and then condensed by the surrounding cold air, contracts into a smaller space; and since no body can be substituted in place of the departing one, the vessel—through too great a dread of the impending vacuum—shatters into the tiniest fragments with a dreadful crash and noise.

[Margin: The wondrous power of the vacuum operates.]

The same thing happens in artillery [tormentis bellicis], which often burst apart with a powerful report from the excessive straining of the kindled exhalation.

[Margin: Experiments.]

I have little globes made of fused glass, the size of cherries, which I first fill halfway with niter-water. When these are set on burning coals, the steam from the water rarefied within seeks an exit and, finding none, bursts its barriers in a most violent eruption and stirs up so great a crash that the booms of fired muskets seem—if not surpassed—at least matched by it; all present are astonished and as it were thunderstruck at so unwonted a sound. With this festive applause of sounds I am accustomed to receive distinguished visitors in

my Museum. In the very same way, then, that an earthquake occurs with a noise from the tumult of confined spirits, this is so certain that no controversy can be raised about it. But as for what Aristotle hands down concerning the timing of earthquakes, concerning islands in the middle of the sea that are immune from them, and concerning a forty-day duration—since experience cries out against these, no general credence is to be given to them. For not only in coastal places and in islands near the mainland, but also in the most remote islands, and indeed in the Mediterranean inland regions of great continents, earthquakes have been so confirmed by experience to occur at any time of year that no further room is left for doubting it.

[Margin: Earthquakes occur chiefly in those places under which the seething basins of the pyrophylacia rage.]

Earthquakes therefore occur chiefly in those places beneath which the seething basins of the pyrophylacia rage, whether these lie beneath coastal shores, or beneath the most remote islands, or beneath inland tracts; and finally beneath all those places below which subterranean channels are situated—channels that sometimes extend themselves over 200 miles, branching far and wide.

[Margin: The earthquake which it exerts on the regions within the channels.]

This I observed with the utmost diligence in Calabria in the year cited just above, in which, along the stretch from Sicily as far as Belvedere [Bellevederium], over a tract of two hundred thousand paces and more, earthquakes had wrought enormous ruin of cities and towns through the subterranean channels. These channels, as I was able to gather from the sound, took their origin from Mount Stromboli; from there they extended through submarine chasms to the Vatican Promontory [promontorium Vaticanum], and from there beneath Tropea [Tropeam], Monteleone [Monteleonem], Lopidium, and Sant'Eufemia [S. Euphemiam]; and from there, with a turning course, they struck at Nicastro [Nicastrum], Amantea [Amanteam], and Cosenza [Confentiam], and from there at Paola [Paulam], and at last at Belvedere—where, whether because the passages were blocked or the spirits failed, they brought their fury to an end. They had, however, some collusion also with Mount Vesuvius

when, after my arrival at Naples, I examined it more carefully. (On this, see the *Epistle to the Reader* prefixed to the work.) From these channels mentioned it became clear that those cities above all are liable to earthquakes which stand directly over one of the said tunnels, while the neighboring towns indeed feel a tremor of the earth, but only through the sympathy [consensus] of the

surrounding parts—as happened in the great earthquake that arose in the Soranian territory [Agro Sorano] on 2 July in the year 1654, by which we felt even Rome itself, nearly three days' distance away, tremble through this sympathy. I also gathered, as from a most evident sign,

[Margin: The places in this region liable to it are those abounding in waters, rivers, and lakes.]

that those places are least liable to earthquakes which either lie above hydrophylacia or abound in great moisture from a multitude of lakes, pools, and marshes—as does Etruria [Hetruria]. For although Etruria abounds in combustible matter and its whole soil is encrusted with sulfurous clods, earthquakes are nonetheless not so frequent there as in dry regions, because the abundance of moisture, when the subterranean exhalations are at any time kindled and drawn out by dread of a vacuum, is extinguished and suppressed by the neighboring moisture. Were this not so, I should believe that all hope for Etruria would long since have been given up for lost.

CAPUT XI.

In which all the meteorological impressions that are born on high are shown to draw their origin from the subterranean fires.

I shall not speak here of springs, rivers, lakes, medicinal waters, and waters of various flavors, nor anything of minerals, fossils, and metallic bodies, since it is known to all that these acquire their origin from the subterranean recesses as their true and proper offspring. But intending to treat in this place of the watery, aerial, and fiery impressions, I shall demonstrate through several Paragraphs that they derive their entire existence from the fiery exhalations of the subterranean world.

§. I.

From watery impressions are formed clouds, and from these rains, hail, snow, ice, hoarfrost, dew, mist, and the like.

Since the subterranean caverns are perpetually agitated by the force of Vulcanian fire in a continual exhaling motion, and since the whole earth too is spongy, pierced through by countless vapors—both in the plains and in the mountains and at the bottom of the sea—it cannot but happen that these vapors, continually breathing forth and steeped and mingled with the moisture (whether of sea, or of

lakes and rivers, or of the moisture-soaked earth), are exalted into the form of vapors. And once exalted, when they have reached the middle region of the air,

[Margin: How snow and hail are generated.]

they are condensed by the cold into clouds—clouds which, though heavy with moisture, are not yet converted into rain, but only become rain when, separated and dissolved by the breezes that play upon them, they are turned to rain and restored by right of return [postliminio] to their origin, from which they had emanated. But if the clouds, made pregnant with nitrous and saline particles, take on a foamy character, then very soon, when a colder wind comes on, they flake out into a snowy substance. And if a cloud has already been resolved into drops, those drops, overtaken in their very fall by the vehemence of the surrounding cold acting through the power of niter, are frozen together into hail; and in this way hail is formed.

But you will perhaps object: the Sun is by no means idle in these operations of nature, but is the principal cause. I reply that it is true the Sun, the Moon, and the stars cooperate greatly besides; for the Sun at once attenuates in itself the vapid, niter-salty, sulfurous, aluminous, and bituminous exhalations which the subterranean fire has sent forth, and draws them aloft once attenuated—whence by their innate power they are converted back into those things from which they arose. But the subtler vapor, while it breathes out from the bowels of the earth—being nonetheless composed of its own niter-salty particles—is, in the nighttime, condensed by the cold caused by the Sun's absence, and returning to the earth by its own weight becomes dew, a fitting nourishment for all growing things. This dew, settling upon trees that are strong in nitrous power and suited to it, is by a certain wondrous magnetism and reciprocal attraction boiled down into manna.

[Margin: How manna and dews arise.]

In this way—since the leaves of certain trees contain in their innermost recesses an aluminous (or, if you prefer, nitrous and unctuous) substance—it comes about that when these leaves are struck by the burning rays of the Sun, the nitrous force is led from the center to the circumference; and when night falls and they are as it were softened by the descending dew, then, as the nitrous particles of the dew are joined to the sweetish chalices of the leaves, at the next heat of the Sun, with all moisture cast off and excluded, they blossom out into a snowy substance, which we call manna. Again, if the vapor has been mixed with impure refuse, then—being still crude and unripe and sooty—near sunrise, rarefied by the warm air, on account of the intermingled particles of scorched sulfurous-bituminous

matter and the crude matter mixed in, it turns into a mist most pernicious by its caustic force, not to men only but to plants as well. If this mist, when the Sun's heat comes on, has flown up on high, it produces rains; but if, with its moisture consumed, it descends through the weight of its particles, it will bring fair weather to a sky now likewise free of that troublesome soot.

But you will object: this whole birth should rather be referred to the sea, swollen as it is with spirits of this kind, than to

the vapid and flatulent subterranean exhalations. I reply: whatever the sea possesses that is spirituous and exhalation-laden, it possesses entirely either from the sucking-up of the earth or from the subterranean exhalations with which the sea is perpetually imbued; and so, through hidden water-channels [hydragogos], it partly restores to the earth what had been drawn off and imparted to it, and partly transmits it—raised on high by the force of the Sun—to the air, to be further wrought into clouds, rains, snows, and hailstones. And thus whatever exhalations the subterranean fire breathes out directly are all, by means of the sea, drawn up and sublimated by the celestial fire (I mean the Sun) and destined for the said births, and diffused over immense tracts of sea and land by the power of the winds.

[Margin: The fire-powers of the world: Phoebus and Vulcan.]

For these are the two fire-lords [pyrodynastae]—Phoebus, I mean, and Vulcan, or what amounts to the same, the celestial and the subterranean fire—so joined in their operations by an inviolable bond of friendship that the one cannot operate without the other. Since we have pointed this out in many places in this work, we shall not dwell on it any longer.

§. II.

On the aerial or fiery subterranean impressions, and first on Lightning.

The fiery impressions are: lightning, flashing, coruscations, burning heats [caumata], will-o'-the-wisps [ignes fatui], Castor and Pollux [St. Elmo's fire], aerial comets, and the like, which the meteorologists treat of—all of which we have shown to draw their origin from the subterranean realms. Since the subterranean world perpetually sends forth on every side breaths joined together and confederated from a medley of various mineral particles, it comes about that these, by their subtlety penetrating all moisture, are drawn aloft by the Sun together with the vapors; and there, impatient of the cold,

[Margin: Whence the motion of lightning.]

they are wrought into lightnings. This happens if, enclosed in denser clouds, the breath—pregnant with the spirit of a certain sulfur, of arsenic, and the spirit of gold—begins to clash with the hostile substance of a nitrous breath: for then, in a violent catastrophe arising either from the tumult of opposing spirits or from the narrowness of the clouds in which they are enclosed, the several portions are kindled; and at the first clash, when the bars of their intolerable prison are burst with the greatest force, they are borne headlong on an oblique path and an aerial rolling, about to present a horrible and deadly spectacle to mortals. Hence, as the sulfurous breath strives upward while the earthy portion of nitrous character sinks downward by its weight, there arises that turbulent descent of the lightning.

[Margin: Why it liquefies metals while leaving soft things unharmed.]

But as to why it liquefies every metal it meets by its penetrating force, and lays low and consumes hard things alone while leaving soft things unharmed—this happens on account of the fiery ray and the sulfurous spirit of gold of incredible efficacy, and because of its supremely penetrating power. Have you ever seen craftsmen fusing glass at the lamp, who drive the flame

[Margin: A comparison of the flame with which glass-workers fuse glass with lightning images.]

(I mean, by the blast) into the utmost length and fineness? If you have seen this, you will discover with wonder that what without the blast the flame could not accomplish is accomplished by the blast-fed flame [*conflatoria flamma*]*—that is, glass and every metal are melted in a moment, the instant the flame touches them. These effects are so aptly fitted to those of lightning that there is nothing in the nature of things which better expresses the nature of lightning. Many wonder why lightning consumes a sword while leaving its scabbard unharmed, and wine while leaving its cask unharmed. You will discover most clearly how this comes about if you interpose, before the blast-fed flame, a piece of leather or a thin wooden tablet. For you will see the flame—wonderful to say—by its penetrating power pass at once through these unharmed, and act only on the metallic and glassy bodies on the opposite side. But if in a spoon you catch up water or wine, exposed to the fiery ray, you will see the whole liquid consumed and evaporated in the time it takes to recite a single *Pater noster*. By these effects we arrive at a knowledge of proximate causes better than by a thousand metaphysical speculations, which contribute nothing to the matter.*

But if the blast-fed flame has so great a force, how much greater shall we suppose the flame of lightning to have, especially since it is pregnant with mineral spirits, the most subtle and penetrating of all? But why (lest I omit anything necessary to the intimate knowledge of this matter) a flame stirred by a blast obtains such great powers—you may judge the cause of this to be the following:

[Margin: The cause of these effects.]

that the fiery spirits, stirred by the blast, since they cannot free themselves from the subject to which they cling, are driven with the greatest force together into the very tip of the flame's apex; and there, pressed and condensed and reduced to the tiniest space, while they cannot escape further because the flame prevents them, they are increased there by an ever new and renewed accumulation of spirits, and seethe with an incredible heat. It is no wonder, then, that they cause such unwonted effects of combustion and liquefaction.

EXPERIMENT.

Into a lamp filled with oil, set a thick wick steeped in melted sulfur together with the oil of sal ammoniac and niter; and when it is kindled, blow the flame through a tube of glass or any other material. The apex of this flame is of such efficacy that there is no metal so stubborn that it will not melt it; for in fiery spirits of this kind, made from sulfur and antimony and niter, nothing more efficacious in the nature of things can be found. But of these matters fuller material for discussion will be given in Book VII, on minerals.

§. III.

On the remaining fiery subterranean impressions.

[Margin: Falling stars.]

The impressions which the meteorologists call falling stars come about in two ways. First,

sulfurous breaths exalted into the upper reaches of the air, if they meet no obstacle, ascend as far as they can, seeking out the region most agreeable to their nature; and being by their own nature easily inflammable, they are kindled even at the nearest opportunity. For when spirits of this exhaled kind are extended lengthwise, then that smoky band, as soon as it touches the cold of the higher air opposing it, has its outermost tip kindled by the excessive struggle and friction; and this, creeping swiftly along, sets the whole of that vaporous sulfurous matter on fire to the end by a kind of successive ignition. And thus that fire, depending

on the disposition of the smoky band, seems to rush from on high either downward or into an oblique part of the world.

[Margin: Experiment.]

An example for us can be the smoke rising from an extinguished candle: if you bring another lighted candle near it, then at once that smoke, catching fire, runs back to its source from which it exhales, and rekindles the already-extinguished candle at the same time. The experiment is as well known as it is most certain; and the smoke exhaling from the candle is nothing other than the sulfurous breaths extended lengthwise in the region of the air, through which the flame is propagated successively—and thus you will have a falling star. This is equally evident in gunpowder laid out and scattered in a line upon the floor: if you bring fire to it from one end, you will see the powder catch flame successively, so that the flame seems to run along, although there is no local motion backward there, but only a successive new production of fire in the successive parts of the underlying material.

[Margin: Fiery missiles imitate falling stars.]

In the second way it can happen by exactly that mechanism by which the fiery missiles we call *pyroboli* [rockets]—kindled and rarefied by the violence of the fiery body—ascend with the utmost force on high, as far as they can, in the form of a luminous line, where, the impetus failing, they descend again, until at last, the fiery vapor being consumed, they vanish. But the meteors which the Greeks call κάύματα [Greek: kaumata, "burning heats"]—that is, kindlings [accensiones]—happen in this way:

[Margin: How burning heat is generated.]

sulfurous exhalations gathered in scattered clouds, when they have been kindled, seize now these portions, now those, the earlier ones being extinguished; and from this arise those coruscations which—appearing in the form of contending hosts—are gazed upon by those ignorant of the cause with great astonishment, as though some portent significative of evil omens; whereas they occur in exactly the same way as in scattered and dispersed gunpowder, whose portions, dispersed here and there and so separated from one another that they nevertheless always remain continuous through the interposition of the intervening grains: for one grain, once kindled, runs at once to the next, and this to others and still others successively, until all, the fire being caught up, finally cease. Whoever makes a trial of this matter by night will produce a perfect representation of κάύματα [kaumata] in a finely interrupted illumination.

The will-o'-the-wisp [ignis fatuus], and the fire that is detected on the oars and rudders of ships, we likewise declare to be nothing other than a subterranean exhalation mixed with sulfur and bitumen, which, having rolled out beyond the sea and clinging to wooden bodies, is at last kindled either by the motion of the sea or by the agitation of the sea. But since we have reasoned about these matters more fully elsewhere, we have not wished to be longer here. There remain comets and beams [trabes], concerning which the Reader may consult our *Itinerarium Exstaticum*, where we have set forth their true mechanism and origin.

From these things—deduced perhaps more fully than was fitting—it is plainly evident that there is no effect in the nature of things so exotic that it does not obtain its origin from the Subterranean World.

LIBER QUINTUS

DE LACUUM, FLUMINUM, FONTIUM

On the Nature and Properties of Lakes, Rivers, and Springs, and Their Origin from Subterranean Sources

[Of the origin of lakes, rivers, and springs (Liber V, "De Lacuum, Fontium, Fluminumque origine").]

SECTIO I.

On the origin of springs, rivers, and lakes, and their diverse nature, powers, and properties.

PRAEFATIO.

That divine pronouncement of *Ecclesiastes* is most true: "The sun rises and sets, and returns to its place; and there, being born again, it circles through the south and turns toward the north, surveying all things; the spirit moves on in its circuit, and returns again upon its circles. All the rivers run into the sea, yet the sea does not overflow; to the place from which the rivers come, they return again, so that they may flow once more." [Ecclesiastes 1:5–7] These things are so certain that no interpreter of this sacred text has ever raised any doubt about them. But the manner and means by which it happens has at all times seemed so hidden, so difficult and impenetrable, that down to the present day the true reason for the origin of springs has seemed to hang in doubt. This subject has been so confused

— by a multitude of monstrous opinions, by countless inventions of the philosophers, by endless difficulties, and finally by a labyrinth of conflicting doctrines — that scarcely anyone has been able to extricate and disentangle himself from them.

Seeing the nearly hopeless difficulties of the subject, and wishing to bring at least some light into such great darkness, I have resolved in this work to bring the whole matter back to the anvil. Taught and guided by the experience of many years, I have perhaps achieved this much: if I have not arrived precisely at the principles intended by nature, I have at least come close enough to them that I may seem to have brought forward something more exact, more plausible, and more probable on this subject than others have — leaving the judgment to more learned men. And so that this may be done as well as possible and to good effect [εὐμεθόδως [Greek: eumethodōs, "in good method," methodically]], I will first set out my Suppositions, and then turn my pen to the causes of the individual effects.

DISQUISITIO I.

On the origin of springs, lakes, and marshes.

SUPPOSITIONES.

I suppose, first. That the whole Geocosm — as was most amply demonstrated in the preceding books — is pierced through with innumerable caverns, hydrophylacia, pyrophylacia, and aerophylacia, with passages, siphons, and water-conducting channels, with fissures and pores, and this not only on the external surface of the Earth but also in the bed of the sea and the Ocean. This was established and confirmed by various and diverse examples and histories.

I suppose, second. That the continuous ebb and flow of the sea, caused by the Sun and Moon, together with the most violent motion of the perpetual winds by which it is agitated, has been so arranged by the admirable disposition of divine wisdom that, with the incredible pressure of its mass, it drives water out through all the passages of the Earth — much as a pump, by pressing water, hurls it upward and disperses it. This too was very fully shown in the preceding books, as well as in the *Iter extaticum terrestre* [*Subterranean Ecstatic Journey*].

I suppose, third. That the fiery channels of Vulcan [the subterranean fire] produce remarkable alterations and metamorphoses in the subterranean waters that come up from the sea, when it sublimates them as they pass through the passages and fire-conducting siphons — now rarefying them, now thickening and

condensing them, now tinging them with mineral exhalations, and working in similar ways, which will be brought forward in what follows.

I suppose, fourth. That nature, established within the hidden and everywhere-enclosed subterranean caverns, produces wondrous effects in drawing water up into higher places, by reason of its dread of any vacuum arising anywhere.

I suppose, fifth. That the subterranean water-conducting channels [canales hydragogos] are not everywhere of the same width, but — according to the constitution of the various places — are now dilated to an immense breadth, now constricted into a narrow strait, now held to a moderate span. From this irregular distension proceed wondrous effects in the natural world, as will be said later.

These things being supposed, let us now begin the argument we have undertaken.

CAPUT I.

DISQUISITIO

On the manifold cause of the origin of springs.

It cannot be that their origin should be traced back to a single universal cause. Therefore, according to the variety of the effects, diverse causes too must be established. Of these I will here assign ten, on which depends the origin first of springs, then of rivers and lakes, and I will explain them all in order.

The first is the opinion of Aristotle and of all his followers, who reduce the origin of springs to two heads: namely, to the resolution of vapor condensed by the cold of the place within the inner vaults of mountains; and, secondly, to rains, which — when they penetrate the passages of the earth and find an outlet somewhere — produce a spring. Thus indeed Aristotle philosophizes [*Meteorologica* I.13, Text 52]. His words are these: "And therefore the streams of rivers seem to flow from the mountains, and the largest and greatest rivers flow from the largest mountains and from those near high places. By contrast, in the plains, away from the rivers, very few rivers arise at all. For the mountainous and other high places, like a sponge suspended above, in a small measure indeed but in many places, trickle and let drip water; for they take up the great abundance of descending water, and they cool and condense the ascending cold vapor again into water — and therefore, as I said, the greatest of rivers seem to flow from the greatest mountains." [Margin: *Aristotle's opinion on the origin of springs.*] These are the words of Aristotle.

[Margin: *Exposition of the opinion.*] Since these opinions are most obscure, they have stirred up various disputes in the Schools as well. For my part, I declare the true sense of Aristotle's opinion on the causes of rivers and springs to be this. First, he says there is water that is collected from the earth from rains coming down out of the clouds, and is absorbed as if by a kind of sponge; then, little by little, the earth gradually releases the water distilling within it through springs and rivers. This sense is plain, as is clear from the words quoted. The other cause he hints at is by the ascending vapor — vapor that is cooled and condensed into water. Here I would not have you understand the vapor existing in the air, but rather that which lurks within, and which, striking against the cold vaults of the caverns, is there resolved into water.

[Margin: *The cause assigned by Aristotle is shown not to be the universal one.*] And although I would not deny that springs can arise from the resolution of vapors — as I will demonstrate later — yet what excites those vapors, and how the absorption of rains and the distillation of droplets could supply so great a mass of water as we see rolling out of the mountains afterward, cannot be conceived. Much less can it be grasped how, in the lakes of the very highest mountains — lakes that pour out whole rivers on every side in perennial flow, and that are not necessarily covered by any vault for the resolution of vapors into water — the water can ascend. Nor does that claim hold, that springs are found only on high mountains, but few in the plains away from the rivers. I, on the contrary, hold that in the plains a greater abundance of water is born from time to time through subterranean springs than what rolls out of the mountains — as the vast lakes abundantly demonstrate, as I will show below.

Since, therefore, Aristotle has philosophized about the causes of springs in a very abstract way and, in his manner, metaphysically, we — proceeding to the nearer causes — are confident, God granting it, that we shall overcome all the reefs of the difficulties that occur, which lie hidden in Aristotle's obscure opinion.

That springs, then, arise from vapor resolved in the vaults of the subterranean caverns is false, if we consider it universally. For we see, and most frequent experience confirms, that in countless places where huge streams and rivers obtain their origin from the mountains, the water bursts forth not in the manner of a bubbling spring, but like a vast river, and is at once found fit for navigation — as may be seen in the sources of the Ganges, the Nile, the Po [Padus], the Rhône [Rhodanus], the Rhine [Rhenus], and the other rivers of the whole Geocosm.

[Margin: *Objection from the Peripatetics.*] But someone from the Peripatetic school will say: it is true that they do not roll out in the manner of a bubbling-up, but

there are without doubt huge reservoirs of water within, which — from the resolution of vapors in the vaults of the caverns, just as in the glass vault of an alembic — supply this abundance of water in the hydrophylacium beneath; and this water, then seeking an outlet through the fissures of the mountains, bursts out into a river. These things are indeed rightly and skillfully said, and I am not opposed to this opinion, as was clear from what preceded.

Yet from the mere distillation of the subterranean crypts, that so great a mass of water should be collected as to immediately constitute a vast river thrust forth — that I cannot be brought to believe; and he will find many companions for his opinion.

There is added to this a second difficulty concerning the vapor condensed in the subterranean vaults and resolved into drops, which the Philosopher posits. For I do not see whence such a vapor could be produced in the coldest caverns, to which neither Vulcan nor Phoebus [neither fire nor sun] has access. [Margin: *In cold places no vapor can be generated.*] For neither in cold places, where there is no heat to attenuate the water, nor in the coldest places where there is no heat to draw water out into vapor, can a vapor ever be conceived to come about. But let us suppose that subterranean heat is introduced through the fire-conducting channels [thermagogos] ordained for it by nature, into caverns thus enclosed on every side. Yet who does not know that the heat would then take such an increase over time that — just as it heats the mountain's enclosure — so it would heat the water contained within it with incredible fervor? And thus, just as happens in hot springs [thermae], a river not cold but hot and steaming would issue forth, discharging its hot exhalation together with the water through the water-conducting channel common to both.

[Margin: *The Peripatetic opinion is refuted, because many mountains never receive rain at their source.*] Therefore this opinion, if rightly considered, cannot be true. For since it does not always rain on the mountains, and the mountains of many regions are not even capable of rains — as the sacred text testifies of Gilboa [de Gelboe; cf. 2 Samuel 1:21], and as the Geographers record of very many mountains both within and beyond the Torrid Zone, which nevertheless pour forth very many waters — so likewise the dry earth in the inner caverns of the mountains cannot supply by a perennial flow so great a mass of water as we know the mountains to disgorge.

To the second difficulty I say this: it can indeed happen that the distillation of resolved vapor produces some streams; but that so great a mass of water as the mountains repeatedly pour out in the manner of rivers could be supplied this

way, I deny. And I demonstrate it in this fashion. First, take the experiment known to all, concerning the Alembic. Let it be marked with the letters A, B, C. Its lower, bulging vessel is A, containing the moisture;

Diagram. A woodcut of a distillation apparatus (an alembic), used as an analogy for the subterranean generation of springs. At the left stands a tall, bulbous flask (A) set over a fire of flames upon a square brick or grid base; rising from its neck is a rounded dome or head (B). From the head, a curved tube or spout (D) leads down and to the right into a smaller rounded receiving vessel (C), which stands upon its own square base. Per the surrounding text: A is the lower receptacle of moisture (representing the floor of the cavern), B is the vessel in which the vapors are collected (representing the vault of the cavern), C is the vessel that receives the water resolved from the vapor in B, and D is the channel through which the resolved water descends.

- A (lower flask, over flames): the lower bulging vessel containing the moisture — the receptacle of moisture and the floor of the cavern
- B (upper dome/head): the vessel in which the vapors are collected, representing the vault of the cavern
- C (right-hand vessel): the vessel that receives the water of the vapor resolved in B
- D (tube/spout from B to C): the channel [canaliculus] through which the resolved water descends

—containing the moisture; B is the vessel in which the vapors are collected, and it represents the vault of the cavern, just as A is the receptacle of the moisture and the floor of the cavern; while C is the vessel that receives, through the little channel D, the water of the vapor resolved in B.

[Margin: *That water cannot be raised without heat by vapor alone.*] Having established this, I argue thus. Either A is filled with moisture, or it is empty of it and is filled by vapor alone, insinuated into it through the cracks of the mountains. If you grant the former, then it cannot happen without an attenuating heat that the water be driven into vapor — just as, in vessel A when it is filled with moisture, the vapor will not rise without fire. If you say the latter — that the vapor, condensed in the cold vault, is resolved from whatever heat finally penetrates the cracks of the mountains — it will indeed be resolved, but in so small a quantity that, descending through the channel D, it will constitute only a rivulet and can never present a river. And just as, when the vapor in vessel A ceases, I say that all distillation will consequently cease, so likewise, when the vapors — and from these the rains — cease upon the mountains, I assert that the

caverns, deprived of moisture, will be deprived equally of their outflow. And this happens above all in the summer months, when, with all the matter of rains consumed by the Sun, the showers cease and the mountains dry up. And yet, notwithstanding these failures, that the mountains nevertheless always pour out their rivulets is too well known to need stating.

[Margin: *A similarity demonstrated by the Alembic: that the resolved vapor cannot supply a continuous flow.*] Indeed, experience confirms that the drops in the vault either of the mountains or of the alembic, just as they take long delays before they fall, so the water collected from the falling of the drops, as soon as it finds an outlet, glides away, while the flow ceases for a time, until the basin is refilled with a new increment of water. This appears clearly in the preceding figure, at B and C: when the vapor in vessel B has been resolved into drops, as soon as it has insinuated itself through the channel D into vessel C, it is collected there again; then, as soon as it has reached the orifice by its own increase, it at once discharges itself through the channel E; and so, after a certain delay has intervened, the flow of water ceases until the new accumulated water refills it. And thus the flow of water always, through interrupted turns, takes certain delays. The same thing must necessarily happen in the caverns of the mountains, since the resolution of vapors into drops can never supply so great a mass of water as the perennial eruption of any stream or river from a mountain requires by its own nature — for the reason that it can never, by its dripping, replace the quantity of the gliding water. From which it would also follow that rivers and streams should sometimes cease and at other times run again — which, besides being repugnant to experience, is also contrary to the intention of nature.

It is therefore clear that the opinion of Aristotle concerning the origin of springs and rivers, taken universally, does not hold. And so another universal cause must be sought out, one that may provide the origin of springs and rivers from the resolution of vapors — which now, God granting it, we will set forth.

SENTENTIA AUTHORIS

On the Origin and Rising of Springs from Subterranean Vapors.

In some springs arisen from the resolution of vapors, as to their substance indeed

I subscribe, not unwillingly, to Aristotle's view — yet not as to the manner. How, then, we hold that springs can arise from the said vapors, we explain in a few words.

Supposing first that the earth, as has been very often shown, is furnished partly with hydrophylacia, partly with pyrophylacia and aerophylacia: that these may serve the operations of nature, nature, by great design, willed that various siphons, passages, openings, fissures, and clefts be inserted into them, for carrying on the hidden commerce of its business. If these are led from the pyrophylacia, we have judged them to be called thermagogi [heat-conductors]; but if they are derived from the hydrophylacia, hydragogi [water-conductors]. If, then, a water-conducting channel has carried a great abundance of fiery spirit somewhere into one of the hydrophylacia of the mountains, the water — at once stirred up and roused, as if by the welcome arrival of a guest, and raised into vapors — will cling to the vault of the hydrophylacium. There, condensed and resolved by the cold of the place, flowing down through the walls of the cavern and collected in its cavities, it will at last burst through a channel into a spring. And since these exhaled exhalations are perennial, and consequently the resolution of the vapor and the stream issuing from it are perennial, it is necessary that the spring, pouring out its waters in perennial flow, be perennial too.

[Margin: *How Aristotle's opinion can be defended.*] The other mode is this. If into the moist subterranean cavern of some mountain, one not so thickly packed with water, those fiery exhalations have entered, it will happen that, mixed with the moisture of the places through which they pass, they take on the nature of vapor; and these vapors, insinuated into the cavern and dashed against the cold vault, condensed there and resolved into water, flowing likewise through the little water-conducting channels ordained by nature, will turn out equally into a perennial spring and stream. And in this way the opinion of Aristotle can conveniently be defended. As for those who say that springs derive their origin from rains and snows collected in caverns — about which we will treat later — they speak well; but for the reasons indicated above, they will indeed have springs, yet not perennial ones, but springs deprived of water at certain times (namely, when both rains and snows cease) and abandoned by their flow, as we will afterward confirm by various examples.

CAPUT II.

DISQUISITIO

On the principal and general cause both of springs and of rivers.

§. I.

MODUS PRIMUS.

The Peripatetic, against the sacred utterance of *Ecclesiastes*, denies that the origin of springs and rivers proceeds from the sea, and affirms that it is born solely from the resolution of air condensed into vapor, as we showed a little above. But just as we showed a little before — standing on the inquiry into the general cause — that this is false, so it will be our part, with a varied apparatus of experiments, to explain in this chapter the contrary: that is, that all springs and rivers go out from the sea and return into it.

The only difficulty, which prevents my adversaries from persuading themselves of this matter, consists in this one point: that they cannot conceive how water, contrary to its own natural inclination, can be raised even to the highest peaks of the mountains, when the sea is much lower than they. If I overcome this difficulty, surely I think no one is of so senseless a mind that he will not — as the saying goes — come over, hand and foot, to the side of my opinion.

I say therefore, in accordance with the first and second supposition of this Section, that not only the earthen body but also the bed of the sea is perforated with innumerable passages — which was abundantly demonstrated in the preceding books by an induction of the seas and lands. This being granted, it is also certain that it was not without the admirable design of nature that the sea — according to the second supposition — is pressed by so many storms, so many blasts of winds, so many masses of descending clouds, and finally, by the perpetual reciprocation of its ebb and flow, is most constant in its perennial inconstancy. These things assuredly argue a great institution of sagacious nature, which, just as it willed nothing in vain, so directed all these things toward the admirable ends of nature.

[Margin: *What the manifold motion of the sea contributes to the origin of springs.*] It is known from hydraulics how contrary even the slightest force is to water by which it is pressed — inasmuch as it cannot bear to be contained in a place: for either, when pressed, it immediately overflows, or, if it finds an outlet somewhere, it soon flees through it, as if fleeing a violence inflicted upon it, and pursues paths set beyond the limits of nature. This is evident in a stone thrown into water; it is evident also from the manifold experiments of the hydraulicians, which we will adduce later. This being established, I say that water can, with no trouble, be brought up from the sea even onto the highest peaks of the mountains — as is clear from the perennial mountain lakes, which are found here and there in them.

EXPERIMENTUM I.

Pressed water, where it finds an outlet, ascends on high beyond its natural inclination.

Let there be two bellows, A and B, made of thick leather and foldable, into the bottoms of which let two channels, G and F, be inserted, which extend into the receptacle D, C, E, F of the supposed living water. And let there be, at the inner orifices of each bellows, two valves [platismata], so constituted that, when one bellows is raised, the one valve opens and the other closes as that bellows falls. Let the receptacle of the water be divided by a certain diaphragm, G and L, lest of the one

[Continued from the previous page: "...lest the operation of one bellows hinder the operation of the other."]

the operation of one bellows hinders the operation of the other.

[Margin: The apparatus shows graphically how sea-water rises into the mountains.]

This done, run two channels, H L and N O, fitted to the side of the receptacle C D E F, in line with the two orifices of the two bellows. Let the channels H I and N O be equipped with their own valves [platismata], so arranged that they open at the thrust of the water, and let them be led off into receptacle K. So if you wish to operate the device: when bellows B is raised, water is drawn from receptacle D C E F through channel E into the bellows; but as soon as the bellows descends, the water drawn in and pressed inside is driven through channel H L into vessel K. Meanwhile, as bellows B falls, the other bellows A is raised, and in the same way water is drawn from receptacle D C E F through the appropriate channel G; as A descends, it presses the water through channel S, upward into vessel K. Thus by the alternate drawing and the violence of the pressure, water is driven into receptacle K, which has an orifice at X, through which the water discharges itself in as great a quantity as the bellows have expelled into vessel K. In this way vessel K will always be full of water and will last with a perennial outflow at X — especially if the water of the receptacle is living water, and if the bellows are raised and lowered in alternate turns, by some commonly known mechanism, as you see in the figure, set in motion by the water itself.

Diagram. A hydraulic machine demonstrating how sea-water is forced up into the mountains. On the left stands a large rectangular receptacle (the "sea," labeled C D E F at its corners) built up of stacked horizontal slats, with two accordion-

pleated leather bellows (A in front, B behind) seated on top of it. Channels run from the bellows: G and F at the base of the receptacle, with E and the side-channels feeding the discharge. On the right a tall vertical receptacle (vessel K) receives the pressed water; its discharge orifice would be at X near the top. A large spoked drive-wheel (with hub N and a peg O on its rim) stands at lower right, geared to raise and lower the bellows alternately; above and behind, a curved drive-arm or crank arches over to the bellows. Readable labels:

- A (top left, front bellows): the front bellows [follis]
- B (top left, rear bellows): the rear bellows [follis]
- C, D, E, F (corners of the left receptacle): the receptacle representing the sea/Ocean
- F (lower mid-left): channel into the receptacle
- E (mid-left): channel between receptacle and bellows
- G (foot, center): channel G
- K (right): vessel K, receiving the pressed water
- N (hub of wheel): axle/hub of the drive-wheel
- O (rim of wheel): peg on the wheel's rim

Application of the hydraulic machine to the operations of nature.

[Margin: Application of the hydraulic machine to the operations of nature.]

Now that we have the machine, let us apply it to the operations of nature. Imagine that the water contained in receptacle C D E F is the sea or Ocean; that the bellows are the ebb and flow of the sea, which — pressed by the alternating increases of the waters drawn up by the Moon — expel water through the water-bearing channels [hydragogi] inserted by nature in the sea-floor, up into the water-reservoirs [hydrophylacia] of the mountains, which vessel K represents. And in just this way we say that the waters, pressed by the enormous weight of the accumulated waters, are raised with no difficulty from the sea to the highest peaks of the mountains.

[Margin: What the ebb and flow of the sea contribute to the origin of springs.]

For just as the bellows are now lowered, now raised, by alternate motions, so the ebb and flow of the sea, in the space of twenty-four hours, twice in alternating succession, renew the laws of their reciprocation. They are distributed into six-hourly stations, so that at opposite points of the Ocean — which is the same as saying, with the Moon set at opposite points — the sea is always raised at the same time in two quarters and lowered at the same time in the two opposite

quarters. This rise and fall we call the ebb and flow [fluxus et refluxus], as was said in the preceding Section. That the water suffers this violence not only from the ebb and flow of the sea, but also from storms and the whirlwinds of the winds, and indeed is pressed and squeezed out by the very descent of the overlying air and its vapors — this we shall show by the following experiment.

EXPERIMENTUM II.

Pressed air presses the water and expels it to the desired height.

Let there be made a lead pipe A C B, which at each end has small cups A and B. Let cup A have a little channel C projecting from its center; and let cup B be somewhat deeper, and have at its center an open hole, into which the pipe C B is fitted. And you will have the instrument ready. Let cup B represent the sea, lower than the mountains into whose peaks the water is raised; and let cup A represent the mountains themselves, higher than the sea. First let the whole pipe be filled with water through cup B. I assert that, from the mere pressure of the air lurking within the hollow capacity — pressure produced by the flat of the open palm of the hand — the water contained within pipe B C A, likewise pressed, will be expelled with great force past A, into C, up through the little syphon C, to a great height. You may judge that exactly the same thing happens in the sea, since...

Diagram. A small U-shaped (siphon) apparatus illustrating Experiment II. At the right stands a cup B (raised on a short stand), the deeper cup representing the sea, with the pipe descending from its center. At the left rises a narrower vertical tube ending in cup A, from whose center a little channel C projects upward; a jet of water sprays up and out of C at the top. The two cups are joined below by the lead pipe bent in a U. Readable labels:

- A (upper left, twice marked, with a small cup): cup A, representing the mountains, higher than the sea
- B (right, deeper cup): cup B, representing the sea
- C (top of the left tube): the little channel/syphon from which the water spurts; also marks the foot of the U-bend
- H (lower left): point on the rising pipe

[Printed p. 231 — running header "DE FLUMINUM ORIGINE."]

[Margin: The apparatus shows graphically how the sea-water rises into the mountains.]

that the water — whether pressed by the impulse of the air, that is, of the winds set in motion, or by the gravity of the cloud-waters charged with moisture and descending — necessarily yields through the water-bearing passages [hydragogi] (which must always be kept full of water), and discharges itself beyond its equilibrium-level A, up into the cup-shaped hollows of the mountains, far higher, against its natural inclination. And just as the ebb and flow of the sea — and likewise the air, whether stirred by the wind or descending from heavy clouds — is pressed almost everywhere and continually, so from this pressure of the sea, yielding through the syphons fitted to it, there must be a perennial discharge into the water-storing cup of the mountains [concham hydrophylacticam]. For it is now commonly known that perennial effects follow upon the cause of perennial operations. This is indeed a remarkable experiment, which we are accustomed to display in our Museum to the great delight of spectators: for water, pressed in cup B by the motion of the air and squeezed out through the little channel C, into cup A, and from there through another small syphon, e, discharges itself like a river. The experiment is so clear that it seems to set the very cause of our undertaking plainly before the eyes.

But someone will object that the sea-water is not pressed with such force that it could set in motion the whole, almost infinitely weighty, mass of water standing within the water-bearing channel. To this I reply: the water held within the water-bearing channel is not only easily moved, but is also thrust beyond the limits of its equilibrium with almost no effort. For since the water within channel B C H is balanced at H and at B, it has no other space to traverse beyond the limits of its own nature than from A or H into cup C A. Again, since the heap of surging waters in the sea — or even the pressing force of the winds — is far more powerful than the water contained between A and H, or between H and C, it is certain, from our hydrostatics, that the water is powerless to resist so great a mass of agitated water. Hence, necessarily compelled to yield to a more powerful principle, that is, to a greater force, it will insinuate itself into cup C A, through the channels joined together for it by nature. In the same way, the gusts of the winds, by which the sea is pressed, possess that same power to raise the water contained in the water-bearing channels beyond the limits of its equilibrium — since we shall show by the following diagram that the mass of waters to be raised above equilibrium is, as it were, imperceptible compared to the mass of those pressing down in the Ocean.

First, I suppose — following the common reckoning of geometers, although some judge otherwise — that the semidiameter of the Earth is no more than 3,600 miles, of which 60 correspond to one degree of the heavens; and that this

semidiameter is taken from the surface of the sea, that is, from the mathematically spherical Earth. But since the mountains, whose base is the said surface, are higher than it, it must now be demonstrated how much higher the sea must reach beyond its natural limit in order to raise the waters into the cup-shaped hollows of the mountains.

[Margin: The highest mountains are scarcely perceptible relative to the semidiameter of the Earth and the periphery of the Ocean.]

Let the semidiameter of the Earth be A B, 3,600 miles long, terminating at point H, on the surface of the sea or the spherical Earth, the line A T. Now let us suppose the highest mountain of the whole Geocosm — than which none greater or higher can be found on the globe of the Earth, as is clear from the heights of mountains shown in the Table of Book 3. Add this to the semidiameter of the Earth, B A, and the line A C will result, which expresses the summit of the highest mountain in the Geocosm. And so, as the semidiameter of the Earth stands to the height of the mountain, A O — 30 miles — which, in respect of the vast and immense Ocean, holds a portion of the Earth so small that it is scarcely rendered perceptible. And the proportion will always be rendered the more imperceptible, the smaller the height of the mountains. So the Peak of Tenerife [Pico de Teide], Olympus in Asia, Etna in Sicily, Caucasus in Asia, Athos in Macedonia — in respect of the vastness of the Ocean — seem in a way to vanish.

[Margin: As B A is to A C, so...]

From this I infer that the waters of the Ocean — whether pressed by ebb and flow, or by storms and the force of the winds, or by the descent of the clouds — can with no difficulty be cast up even onto the highest summits of the mountains; and that the whole error is a mockery of human imagination. For people, accustomed to things present, when they behold mountains so high before them, marvel how the water can be raised to so great a height — not having considered the vastness of the Ocean poured around the terrestrial globe, relative to which the mountains, as has been shown, obtain scarcely anything of perceptible magnitude.

[Margin: Error of human imagination.]

To this is joined another deception of fancy, when people imagine that some small mass of waters is pressed in the Ocean. Not at all: for the swelling produced by the accumulation of the waters pressed by the Moon is so great that it extends — not to say to several miles, but — to many thousands of miles. For the swellings of the sea that are caused in the Ocean by the Moon, since they are always

opposite to one another, each swelling occupies a whole quarter of the Ocean, as is clear from the Figure, in which...

Diagram. A tall vertical scale-diagram at the upper right of the page, illustrating the proportion of mountain-height to the Earth's semidiameter. A vertical line is graduated with the values 1000, 2000, 3000, and (at top) 30, against a horizontal scale-bar marked C — 30 at the top. Near the top, a small jagged/hatched triangular profile represents the highest mountain (line A C) rising above the surface; the letters H, A, and others mark the surface-point and the foot. At the very bottom the line terminates at H. Readable labels:

- C, 30 (top scale-bar and apex): summit of the highest mountain; $A C / A O = 30$ miles
- 3600 (near top, beside the surface): the Earth's semidiameter, 3,600 miles
- A, H (top, at the surface): A = base/surface point; H = surface of the sea
- 3000, 2000, 1000 (descending graduations on the vertical line): the scale of miles toward the Earth's center
- H (foot of the line): the Earth's center / opposite terminus
- T (top right): terminus T on the surface line A T

[Margin: The summit rises along the axis to a height of 30 miles.]

[Margin: The highest mountains are scarcely perceptible relative to the semidiameter of the Earth and the periphery of the Ocean.]

[Margin: Error of human imagination.]

[Printed p. 232 — running header "LIBER QUINTUS"]

the swellings of the sea, A B C and D E F, opposite to each other, occupy precisely two quarters of the Geocosm; while the pressure of the sea occupies just as many, namely B D and C F. But this is set out very fully — see Book 3, Section 1, on the motion, that is, on the ebb and flow of the sea. For these swellings travel, in the space of 24 hours, around the whole globe of the Earth, by this design of nature: that, by the weight of the accumulated waters, they may agitate the sea and expel it through the water-bearing channels inserted by nature into the Earth, up into the water-reservoirs [hydrophylacia] of the mountains. And since these swellings are perennial, there must likewise be a perennial influx of waters into the said reservoirs; nor, as long as the world endures, will they cease to drive the watery element. Since, then, these swellings are so vast, and are violently accumulated, and each separate portion of the swellings presses the waters equally, it plainly appears that they discharge themselves into all the mountains of the Earth not

through one water-bearing channel alone, but through innumerable ones, whose waters they perpetually drive. And this discharge will be the easier, the more oblique the water-bearing syphons are — which I also set forth by this experiment.

Diagram. Top left of the page: a vessel of lead or iron plates showing a bent and a vertical channel, set over a landscape of small hills. A box-like reservoir A (lid marked A, with a corner marked D) sits at the upper right; from it one channel descends obliquely from B toward C (running down across the hills to the left), and another descends vertically from E to D. A short cylindrical stand-pipe with a domed top (the perpendicular tube) rises at center, marked H below. Readable labels:

- A (top of the box-reservoir): the vessel of plates, to be filled with water
- D (upper right corner of the reservoir): perpendicular channel E–D
- B (left, head of the oblique channel): start of the oblique channel B C
- C (lower left, foot of the oblique channel): outflow of the oblique channel
- E (center): head of the perpendicular tube
- H (below the central stand-pipe): point on the perpendicular channel

[Margin: Experiment.]

Let there be a vessel of lead or iron plates, A D, whose channel is led obliquely from B to C, and another perpendicularly from E to D. Let the water, with which the vessel must be filled, be pressed either with the flat hand or with some pestle. It is certain that the water will be driven much more easily from B to C than from E up the perpendicularly erected tube E D — because the weight of water in an oblique position weighs less than in a vertical position, as we demonstrated in our Hydrostatics. Hence shrewd Nature seems to have had regard to this principle, when she chose not to bend channels of this kind straight down perpendicularly into the earth, but with an oblique course, for the easier propulsion of the waters, as is clear from channel B C.

[Margin: Objection.]

There is this further point: not all the water-bearing channels are inserted in the sea-floor, but very many are also implanted by nature in the walls of the land-mountains that have their position toward the sea, or in the flanks of islands. And just as the former are driven by the pressure of the mass of water, so the latter — pressed both by the dashing of the waves and by the force of storms and winds, and by the ebb of the surging sea — most easily carry the water up onto any

mountain-peaks whatever. Perhaps here someone will object that the motion of the sea ought to be in no way violent, but natural — which, on our hypothesis, it is not.

[Margin: The motion of the sea is not violent.]

I reply that nature has always intended to join something of the violent to natural motion — something which, properly and simply, ought not to be called violent, but [arises] from a certain necessary concomitance, as is clear from all the operations of nature. In this way the whole sea, perpetually restless and turbulent, is not so by some natural force, but by the agitation both of the winds and of the ebb and flow of the sea, which impress a certain violence on the waves. This is also evident in meteorological impressions: as when the wind lays low the trees and casts down towers; an earthquake too overturns cities, drives the sea backward, and turns everything upside down — things which, although they are doubtless natural operations, nevertheless cannot occur without violence, and that the greatest, inasmuch as it follows from them. In the same way, from the impulse of the sea made into the water-bearing channels, the water is necessarily, by violent pressure, compelled to raise itself beyond the limits of its own nature; and it is a certain impulse, which follows from the operations of natural things. Therefore, just as these operations are intended by nature, so they are also perpetual. For if they were simply something violent, they would certainly by now have wholly failed; but they endure and will endure, as long as the world shall stand — as so many ages of Etna, so many burning places, so many and so varied kinds of hot springs attest. We are therefore compelled to admit that these things ought by no means to be called simply violent, but to be natural effects bound up with their natural cause.

[Margin: The exposition of St. Thomas.]

The exposition of St. Thomas [Aquinas] on that passage of Aristotle, "no violent thing is perpetual," supports this view of ours; there he expressly says that no violent thing is perpetual unless its cause be perpetual — as if he were to say: if anything should seem violent in natural operations, it nevertheless cannot properly and simply be called violent, since a perpetual effect of nature necessarily follows upon a perpetual cause of nature. This operation, therefore, does not belong to the genus of the violent, but of the perpetual, just as the other species are perpetual and intended by nature — just as, in the circulation of human blood, the ascent of the heavier blood from the foot to the head is not called violent, but intended by nature, and so perpetual as long as the person lives.

These things explained, we shall now set forth the mode and the manner by which the water is raised from the sea up to the highest mountains, and into the other water-reservoirs of the mountains.

[Margin: How the sea-water is raised above the mountains.]

And first, indeed, I suppose that the natural water-reservoirs [hydrophylacia], and likewise the syphons, that is, the water-bearing conduits [inciles hydragogos], were inserted not by chance or accident, but by a great design of nature — indeed by no less industry than were the veins and arteries in the human body, that is, the Microcosm, inserted into the vessels of the humors. And just as eternal Wisdom established all things in number, weight, and measure, so too it equipped the inner Economy and fabric of the Geocosm with those supports, without which...

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it [Wisdom] foresaw from eternity that the causes of things could produce no effect.

Many marvel, and cannot grasp, how it comes about that — for example — the Alps, comprehended within France, Germany, and Italy, pour forth so many rivers, so many streams, which by their perennial flow have never ceased from the very beginnings of things until now, nor will cease while the world stands. From where, I ask, do the Danube [Danubius], the Rhine [Rhenus], the Moselle [Mosella], the Meuse [Mosa], the Rhône [Rhodanus], the Saône [Arar], the Po [Padus], the Ticino [Ticinus], the Inn [Oenus] — besides innumerable lesser rivers and streams, as well as lakes — draw their origin? If anyone should say that they take their origin from the distillation of drops within the subterranean caverns of the mountains — as the Peripatetics do — he will, in everyone's opinion, be asserting something ridiculous, since all the drops collected here and there through the vaults of the mountains could scarcely make up a single river. Some other secret of Nature, therefore, lies hidden here, which I have judged ought to be made plain in this place.

Let the Reader call to mind what we said in the Third Book about the water-reservoirs [hydrophylacia] of the mountains; and he will find that, just as in the Alps, so in all the other chains of the vastest mountains, the said water-reservoirs were established, from the beginning of things, by the singular providence of God, Best and Greatest [Deus Optimus Maximus]. From these, rivers are channeled off into the various parts of the world, both for the watering of the surrounding regions and for the benefit of mankind and the convenience of

navigation. But rivers so great and so many could not be channeled off in a perennial flow, unless the said water-reservoirs were continually replenished with ever-new supplies of water. And this cannot come about from the resolution of vapors within the caverns of the mountains; for, as was said above, if all the vapors of the whole air were resolved into water, they could not suffice for so great and so continuous a mass of water. Nor [can it come about] from the resolution of rains and snows, since that is not perpetual, but at certain seasons ceases from moistening — and consequently the rivers too would necessarily have to cease from their flow, which is contrary to experience. Nothing else, therefore, presents itself, except that the said water-reservoirs are replenished daily from the Sea or Ocean, through subterranean passages. How this happens, I now show.

Let there be one or more water-reservoirs [Hydrophylacia]...

Diagram. A large engraved landscape plate occupying the lower two-thirds of the page, illustrating the system of mountain water-reservoirs feeding rivers. Across a panoramic countryside, several mountains rise; two of them are shown in cutaway, revealing cavernous interior reservoirs (vaulted chambers with water) from which streams issue. Rivers wind down from the mountains through the plain, branching and joining, past towns and settlements (a walled city at lower left) toward a broad body of water in the foreground, where sailing ships and small boats are shown. Concentric ripple-rings in the open ground at center-right may indicate a spring or whirlpool / a subterranean inlet. The plate bears no engraved letter-labels visible at this resolution.

set within the cavities of the mountains like basins, [these are] A B C D I. Their water-channeling [hydragogi] subterranean siphons are G L M, G L B, E O, Q P, H I, and their openings on the sea floor are G E Q. I assert this: by the continual force of the ebb and flow [of the tide] and of the winds, the waters pressed at the bottom of the sea will discharge into these reservoirs the entire mass of water with which the subterranean passages, all the way up to the hydrophylacia, are filled. As a result, the hydrophylacia, being always full, will at last burst out into rivers through the fissures and passages of the mountains — just as it appears in the Figure. In this way, from this very visual inspection, the origin of rivers may shine forth more clearly than the noonday light.

You also see how, at the loftiest summit of mountain D, the subterranean passage Q P makes lake D pour forth rivers. You should not say that this lake arose from any increase of rains or of melted snows, since on that account it would surely dry up in time. Rather, lakes of this kind are perfectly clear — like the lake on the

summit of Mount St. Gotthard, which hurls down the river Ticino [Tessin] through manifold cataracts here and there, in perpetual motion, into the deepest valleys. [Margin: The lake on Mount St. Gotthard.] This is the clearest sign that it is continually enriched from elsewhere by a fresh supply of water. Nor will you say it is born from the dissolution of vapors, since, lacking any vault [overhead], it enjoys an open sky.

It should also be noted that in Alps of this kind there are various hydrophylacia, some higher, some lower, which nevertheless always correspond to one another through a certain communication. Some indeed are roofed over by mountains, while others — as nearly all mountain lakes are — display their station under the open sky: such as, in Switzerland [Helvetia], Lake Lemman [Lac Léman / Lake Geneva], the Lake of Lucerne [Lacus Lucerninus], the Lake of Zurich [Lacus Tigurinus], and the Lake of Constance [Lacus Acronianus]. That these arise from a single hydrophylacium parceled out into various stations and stretched out within the vast recesses of the mountains can be in no doubt to anyone who has rightly understood what precedes. For if, by divine power, the said mountains were cut through along the surface of these open lakes, you would surely find immense lakes within — furnished with countless water-channeling canals [hydragogi] discharging water, and these not only communicating with the external and open lakes, but also continued within beneath one level plane.

You would moreover find some basins [Lebetes] set into the higher vaults of the mountains, which, finding an exit through the flanks of the mountains, turn into various springs and streams. And lest you think we attain these things by conjecture alone, the histories of hydrography confirm by the clearest testimonies that they are in fact so. [Margin: Histories concerning the hydrophylacia.] Among other things they report that in Nicaragua, a province of America, there is, beside an enormous lake, a most vast cavern; and the barbarians [natives] who penetrate into its innermost recesses assert that a most vast lake, like a sea ...

without end, is found within, and that in it so formidable a sound is perceived that — unless they at once turn their feet [back] — they are deafened by the noise of the dreadful waterfalls [catadupae] of the waters. The same is attested by Olaus Magnus concerning the Cavernous Shores of Bothnia [the Gulf of Bothnia], of which more fully in another place.

The same has been confirmed; the same is observed within certain mountains of the Kingdom of China [Regnum Sinense], which are filled with subterranean lakes and rivers — as Father Martino Martini [P. Martinus Martinius] told me

more than once, and which he afterward made public in his *Atlas* [the *Novus Atlas Sinensis*]. And concerning certain mountains of Upper Austria [Austria Superior], Father Lorenz Andreas Eissert [L. Andreas Eissert], a priest of our Society, reports — about which [I shall speak] in its proper place. It is also said that in Lake Fucino [Lacus Fucinus] an enormous cavern is found, which, if anyone enters it, he perceives — besides the immense lake which he finds, continuous with the external lake — also the sound of rushing waters, with great dread at entering. And since I always inquired of those who related such things to me whether they perceived any distillation of waters within the said caverns, they solemnly affirmed that they had never observed either a distillation, or that subterranean cobweb [?] which the Peripatetic school invents for itself, or any rain.

Therefore the sound of the rushing waters plainly teaches that somewhere, through the water-channeling canals [hydragogi], water hurls itself down through immense precipices into a subterranean lake. I could adduce countless examples of this matter in this place, but because they have already been set forth in other places, I do not wish to dwell on them. Let the reader consult the interior constitution of a hydrophylacium, graphically delineated, from the figure here appended. There you see a lake situated within the mountain, into which, from the flanks of the mountain, water is hurled down through subterranean canals into the said lake; this water, afterward flowing out from the subterranean lake through other channels worked out [for it] into the outer fields, produces rivers and lakes — as the diagram shows. Meanwhile, let these things suffice for demonstrating the argument we have proposed.

Diagram. A large engraved landscape plate occupying the lower half of the page, depicting the interior constitution of a hydrophylacium (mountain water-reservoir). The central feature is a great cavern opened within a mountain massif, revealing an internal lake or pool of water from which several jets and cascades of water spurt upward and outward. Streams issue from the flanks of the surrounding hills into outer fields and valleys; the rolling mountain landscape with scattered trees frames the cavern. The figure illustrates how subterranean water collected within the mountain bursts forth through openings to feed the external rivers and lakes. No engraved point-letters or caption are legibly present on the plate.

CAPUT III.

DISQUISITIO

Concerning the remaining modes and methods.

[De reliquis modis & rationibus.]

§. I. MODE II.

How, by natural attraction arising from the fear of a vacuum [metus vacui], water may from time to time be drawn upward to a height?

EXPERIMENT.

Let there be made a bowl [concha] of lead, *d e*, covered over with glass B X C. Let this bowl have, between the columns B H and C I, another bowl, F, from which a small channel [canaliculus] *F d* is inserted into bowl *d e* and set open at E. This done, let another small channel E G be inserted into the bottom of bowl *d e*, with a stopcock S, beneath which another bowl H L is placed. Let the columns B H and C I support the whole machine. Once it is constructed, you will fill the upper bowl *d e* with water through the open screw [cochlea] X, which is then to be closed in such a way that air cannot get under [into it]. Let bowl F also be filled with water.

These things accomplished, if you open the stopcock S of the small channel S G, the water, descending by its natural flow ...

will draw the air in vessel A B C [after it]; and this air, when drawn off, finding nothing to put in the place of what is departing, is at once seized by the fear of a vacuum [vacui formido] and will allure the water contained in bowl F through the small channel E *d*; this water will burst out with the greatest force through the opening E into a fountain [jet]. Once this [water] has fallen back into bowl *d e*, it will discharge itself through the channel *e G* into bowl H L, always drawing new water from bowl F — so that, if bowl F be perpetually refilled from some fountain, I assert that the flow of water in bowl *d e* too will go on perpetually, the bowl never overflowing; for as much as it draws from bowl F, that much it sends down through the siphon *e S*. We have the experiment in our Museum, proven by daily use. Now let us apply it to the subject of our undertaking.

Imagine for yourself a certain bowl existing within the hollow of a mountain — which the glass B A C represents — into which air cannot penetrate from outside. Let this bowl have another, neighboring it, joined to it on the side, which is F, and which gushes with waters from some perennial stream, however and in

whatever manner it arose. Let it [F] correspond through a passage of the mountain — like a certain small channel F *e* — to bowl *d e*. And since a bowl of this kind has another channel *e S* extending into the depths of the mountain, it is certain that bowl *d e*, with the waters flowing together through the fibers [veins] of the mountain, will — as soon as it is filled — discharge itself through channel *e S*; and consequently, lest the hollow of the mountain suffer the fear of a vacuum when the water departs, it will draw from bowl F as much water as it had let go through channel *e S*. And thus bowl *d e* will gush perpetually with waters.

Diagram. A schematic woodcut of the vacuum-attraction apparatus described in the experiment, set into the lower left of the page's left column. It depicts a tall composite vessel standing on a footed, baluster-turned pedestal base. At the top is a domed glass cover from which an arrangement of fine jets or sprays rises (the fountain produced at opening E). Below the dome are tiered bowls supported between two columns. Readable point-letters on the figure:

- X (at top): the screw / filling-aperture [cochlea] of the upper bowl
- B (upper left, on the glass cover): left side of the glass dome B X C
- d (upper right, on the bowl rim): right end of the lead bowl *d e*
- H (mid-left): foot of the left column / lower bowl H L
- L (mid-right): right side of lower bowl H L
- V (at base): the footed pedestal / lowermost vessel [?]

Several additional small letters around the tiered bowls (the channel-labels E, G, F, S referenced in the text) are present but too finely engraved to resolve individually at this resolution.

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[Continuation of MODUS II, the vacuum-attraction experiment from the prior page:]

and so it will pass from bowl *d-e* through channel *e-S*, finding another hollow space, and from there into a perpetual spring or stream. But the mouth of the channel *E-Z* must project somewhat above the surface of the water in bowl *d-e* — whether that mouth is set in the middle of the cave or in its walls — so that the water in bowl *d-e*, which ought to discharge through channel *e-S*, does not instead discharge through channel *d-F*. You see from this experiment, then, how springs and streams can sometimes be produced by the fear of a vacuum [vacui formido], through the continual drawing-off of water gathered from elsewhere.

[Margin: Art takes its working principles from nature.]

Perhaps someone here will object that this is an excessive and superfluous exertion on Nature's part. But let him understand that nothing can be accomplished by art in hydraulic motions whose working principles art does not derive from Nature, the all-creating exemplar, and from the reasonings of eternal law. Let him be assured that the wisdom of the Cosmic Architect [sapientia Cosmotecnilis], working its art through nature, has established nothing in vain, but has set everything up with the highest providence — as in all else in this theatre of the universe, so above all in the Subterranean World, with unspeakable craftsmanship. Man, the ape of nature, then strives in his own operations to imitate this as far as he can, by whatever means.

MODUS III. [How Springs and Rivers can be formed from rain and melted snow.]

That springs and rivers are sometimes formed from rain and melted snow I would not readily deny, since experience plainly teaches it; but I can hardly be brought to believe that springs and rivers of this kind are perpetual. Springs and rivers are formed in this way. On the flat tops and slopes of mountains, the snows heaped up in winter melt little by little as the Sun passes into the northern signs, by the Sun's heat and by falling rains. Once melted, they partly seep through the clefts of the mountains and partly, through winding falls, work their way little by little into subterranean caverns or crypts. If rains and showers are then added, these caverns, weighed down by the excessive increase of water, discharge themselves through the gaps and fissures of the mountains; the discharged water turns into springs, and from the running-together of these springs at last into a river. The flow lasts as long as the melting of the snow lasts; once that is finished, the river, its bed dried up, ceases from its flow.

Innumerable examples of this could be cited, but let one stand for all — one I recall observing with the greatest care in Gallia Narbonensis [Narbonne / southern France] in the year 1631, at the spring (or rather river) of the Closed Valley, which is commonly called Vaucluse [Vallis clausa / *Vaucluse*].

[Margin: The Vaucluse Spring [Fons Vauclusii], in the territory of Avignon.]

Between Carpentras [Carpentoractum] and Cavaillon [Cavallio], four leagues distant from Avignon, there is a certain valley altogether wild and formidable to behold for its overhanging crags. In it there is to be seen, down to this very day, a house — though ruined by the injuries of time —

[Margin: The house of Petrarch.]

within which Francesco Petrarca [Petrarch] once, whenever he was seized by the poetic frenzy of the studies to which he was accustomed, would withdraw, carried away by his love of solitude; and they say he betook himself there so that, far removed from all the noise and tumult of the court, with a freer and more unencumbered mind, he might bring to completion what he had conceived in his mind. Not far from this house there is to be seen a cave, made by nature in the rocks, within a valley shut in on every side; which — wonderful to tell — for half the year is always dry, showing not even a trace of moisture. But on entering the cave — as I myself observed most carefully — one meets various passages running this way and that, in the larger of which no end is to be found. They say it extends for many leagues into the recesses of the Alpine mountains, and is moreover divided into so many branches that you could swear you were entering a labyrinth.

[Margin: Description of the Vaucluse Spring.]

At the said season — in winter, that is — this whole tortuous passage, formidable for the manifold spreading of its branches, is seen to be dry, strewn with the finest sand and with various scraps of mineral matter. Yet soon, at the time when the snows in the mountains of the Dauphiné [Delphinatus], or in the Cottian Alps [Alpes Cottiae], are wont to melt, then behold, the said passage erupts through the mouth of the cave with a mighty roar, belching out such a quantity of water that by its force it at once turns six mills, set no more than fifty paces from the opening. And — what is more wonderful — the river is soon filled with trout and other fish, which the subterranean cavity (into which they had been swept by some force through the chasms of rivers or lakes) brings along with it. But as the snows are gradually consumed and the water-cisterns [lebetes] emptied, the river too, settling into a truce until its own season, ceases, the fish vanishing — fish which, no doubt by some instinct foreseeing the failure of the water, in good time withdraw into the rivers that lead to the Island [Insulam], a place situated not far from here. And in this way springs and rivers are formed from melted snow.

In like manner, springs and rivers are sometimes formed from rains and showers in this way:

[Margin: How rivers are formed from rains.]

On the ridges of the loftiest mountains, either at the summit or near the summit, flat or concave places are found, filled with rainwater collected there and gradually stagnating into a lake. From this it comes about that the water, having

seeped through the fissures of the mountains into the subterranean basins and overflowing as it increases, at last bursts forth into a river. An instance of this kind can be seen in the plain of the ridges of the Apennines: for one traveling from Rome to Loreto [Lauretum], it lies enclosed between the hill called "Colle Fiorito" (the Flowering Hill) and Serravalle [Seravalle], where that whole plain in winter turns into a marsh, formed entirely of rain and melted snow; but in summer and autumn it blossoms into a most flowery meadow and rich pastures. Often passing this way, while I marveled how so great a mass of water could so quickly vanish — and since wonder spurs one to inquire into the cause — I consulted men experienced in the locality on the matter. They led me to a spot where they showed me a huge chasm, through which the water unburdened itself; and they added that the waters, through subterranean passages —

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not far from the Tiber [Tyberis], discharge themselves into the river from a huge cave in the mountain; and this river, which runs while the lake stands, dries up when the lake is dried out. I have found similar places in the Apennines of Tuscany [Appenninus Hetruriae], concerning which consult our *Iter Etruscum* [Our Etruscan Journey].

Of the marvelous Field in Carniola [Carniolia].

In which, through the course of the year, the inhabitants — in the stations destined for them by nature — sow and reap, hold their hunts, and at last, when the whole field has been turned into a lake, go fishing.

There is in Carniola, not far from Ljubljana [Laubacum], a place truly most worthy of admiration, which we have thought fit to describe here. This place, first, in summer and autumn, counterfeits a meadow heavy with the manifold yield of its sprouts; but in November it presents the appearance of standing water far and wide, and through the whole winter is found locked in ice; while in spring, as the water drains off, it becomes a field most fit for sowing — so that one and the same place, now a field, now a shrubby meadow, now a lake, discharges the triple office entrusted to it by nature, and not without remarkable benefit to the public good. With its abundant harvest of both grain and pulse and hay, it not only blesses the homeland, but in summer also affords its managers no small help by the hunting of hares and wild boars; and likewise, toward the beginning of winter, it provides the territory with an abundant catch of fish, a remarkable supply indeed.

Having seen the prodigious effects of this place, let us now inquire into their causes. The first question, then, is this: From where does so great an abundance of water come to this place, so as suddenly to become a vast lake? I answer that this happens because, in the Pennine Alps [Alpes Penninae], a huge quantity of snow, with which they are covered, melts continuously over the course of summer; whence it comes about that the Alpine hydrophylacium, by the increase of the melted snow, gradually overflows around the end of October, and by its overflow discharges itself, through some hidden subterranean passage, into this place. For, as the inhabitants have observed, at a fixed time, amid the greatest cold, [the water] rolls forth both from the bowels of the nearby rocky cliff and from the center of the field, and converts the whole plain into a lake.

The second question: From where does the lake get so great an abundance of fish? I answer: from some hydrophylacium or external or internal lake stocked with fish, which, overflowing with great force, sweeps the fish along with it into this place — as happens in many other similar places. As for the fact that in spring the lake vanishes together with the fish, not one surviving — the reason is that the fish, gradually following the outflow, return through the subterranean passage to the place from which they had come. And in this way the place, freed from the tyranny of the waters, is turned into a field and farmland of rich and fertile soil, and thus most fit for sowing. The harvest over, growing wild with the manifold sprouting of plants and shrubs, it offers a place most fit for the stabling of hares, boars, and wolves — until, overwhelmed by a new inundation, the field, turned once more into a lake, is subjected to Neptune's jurisdiction. And this truly admirable [marvel?] of nature, this [Greek: ἀντικίνησις (antikinēsis, "counter-movement" — alternating reciprocal change)] [?], lasts year by year, and will doubtless last forever.

MODUS IV. [Of the origin of Springs and Rivers that arises from the confluence of subterranean waters.]

It cannot be otherwise: from so many yearly floods and from the convergence of melted snows, an enormous mass of water must from time to time be heaped up in the subterranean hydrophylacia, in this way. Since the mountains are extremely porous and lie open with countless fissures and chasms, water, insinuating itself through these, when it finds a hydrophylacium or some cistern [lebes], fills it by its confluence; then, pressed by the narrows of the vessels, it must necessarily overflow, and once overflowed, it bursts out through other chasms and channels into rivers.

[Margin: The various differences of rivers, and why some now overflow, now [run low?] — from where?]

From this it is clear why at certain times rivers shrink so low that they can be forded without any trouble, while at another time they so swell up that they bar passage to all who try to cross — because, when the confluence of waters ceases, the rivers diminish, whereas while the increase of water lasts, they must necessarily swell. Now there is no small difference among rivers of this kind: some, entirely dried up, leave off from their flow, and no other cause can be assigned for this than the single confluence of rainwaters within the basins of the mountains — while that lasts, the river lasts; when it ceases, the river ceases. Others, however, endure with a perennial flow, but not at the same level of fullness — now diminished in water, now swollen with water. The reason for this is that within the hydrophylacia, which draw their origin from the Sea, are from time to time replenished with other occasional waters, whether of rain or of snow; by the increase of these they consequently pour forth a greater abundance, with which the river swells. I am speaking here not of torrents, which are constituted solely by the confluence of waters gathered within the folds of the mountains at the time of rains, but of that increase of water in rivers which sometimes arises suddenly even when the sky is clear, calm, and subject to no rains. See what we have pursued at length in the Third Book on the Origin of the Nile [*Tertio Libro de Origine Nili*].

MODUS V. [The Lakes of the higher Mountains pour their waters into the hydrophylacia of the lower mountains; from which arise springs and rivers.]

It happens not infrequently that in the loftiest mountains huge lakes are observed which, just as they lift their summit beyond all the bounds of the rains, so they cannot be augmented by the rains — as they report of Mount Athos. And thus they obtain their origin only from the Sea, in the manner already stated above...

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[which they] doubtless obtain. Lakes of this kind in the mountains, just as they are perpetually filled, so too are drained off through subterranean conduits into the cisterns [lebetes] of the lower mountains; from which cisterns of this kind, enlarged and enriched by the benefit of the waters,

[Margin: How the waters in the lower mountains are poured out, by the correspondence of the mountains.]

springs and rivers are poured out along the passages destined for them by nature. This kind of thing seems to occur chiefly in the Alps, in which not infrequently great cataracts [catadupae] roll down from inaccessible mountain peaks; yet these, soon absorbed in the deep valleys and the closed-off ledges of the mountains, prepare an outlet for themselves elsewhere. I myself have seen, from the lake of Mount Cimino [mons Ciminus] in Tuscany — which they commonly call *il Lago del Vico* — set in a most lofty place, [water] burst out through subterranean passages at Ronciglione [Roncilio] into a most rapid river; and we have shown at length, in our *Iter Etruscum*, that three other neighboring lakes are derived from it — which I would have you consult.

MODUS VI. [That springs and rivers can sometimes also be born from subterranean winds.]

Whoever penetrates the hidden ways of sagacious Nature will openly confess that nothing has been denied to it in the production of marvelous effects. For just as it uses wondrous art in conveying waters from the sea up into the storehouses of the loftiest mountains, so too it is mighty in wondrous industry in raising those waters on high by means of subterranean winds and exhalations — which I now set about to demonstrate. Since Art is nothing other than a kind of imitation of nature, it is certain that whatever is accomplished by art has previously existed in nature as its prototype — which I demonstrate by the following contrivance [technasma].

EXPERIMENTUM I. [Showing how water is raised on high by the force of subterranean winds.]

Let there be made two adjoining vessels A-B of lead or iron plates, separated by a diaphragm C-D. This done, let three channels be drawn, in the manner you see them set in the figure. The first, E-F, open at both ends, [running] from the upper floor E, to which it is joined, let it be led down through the diaphragm C-D into F. The second, I-K, open at both ends, let it be led from the floor I up into K. The third, G-H, led from G through the upper floor into H, let it project somewhat — and you will have the machine ready.

[Margin: How water is raised by the force of the winds.]

To watch the effect, then: let vessel A be filled with water through the opening V; and, the opening V having been stopped up, let water be thrown into the crater V-H-E, which, descending through channel E-F, drives out the air lodging in vessel B through channel I-K. The air thus expelled from there will press upon the water

in vessel A; and the water, being pressed, since it finds no escape except through channel G-H, will discharge itself through that channel into a most limpid spring, as you see. We have the experience; let us now apply it to our purpose.

In the preceding Section we taught that winds, on account of their abundance of exhalations, perpetually hold sway in the subterranean crypts. For since, being checked by the obstacles of the mountains, they seek a wider space and do not find it, they escape with the utmost force through even the finest chinks and fissures of the mountains, like so many siphons; and where they find water within some cistern, they will doubtless press upon it; and if the crypt has another siphon, it will force the water out through it. But let us show the matter by an example.

Let there be a mountain F-G-H having within it a hydrophylacium

Diagram. A pair of figures forming a single composite woodcut across the foot of the page. At left is the apparatus of Experimentum I: an hourglass-shaped twin-vessel device standing on the ground, with the upper vessel narrowing to the lower. At right is a cross-sectioned mountain (the Modus VI / Experimentum II illustration) showing internal cavities, channels, and a stream issuing from its flank, with trees on the slopes and a wavy water-line at the base. Readable labels:

- V (top of left apparatus): filling/throwing opening of the crater V-H-E
- X (center, on the mountain): the internal cistern / cavity marker
- A (left apparatus, upper vessel): vessel A
- B (left apparatus / mountain interior): vessel B (the lower cistern)
- C (left apparatus, mid-body): the diaphragm point C
- D (left apparatus, base): point D
- F, G, H (mountain): the mountain's labeled points (interior cavity and outlets)
- Small water/ground hatching and tree figures along the base (decorative, unlabeled)

The full label set on the composite woodcut is A B C D E F G H I K V X (left apparatus: A B C D E F H I K V; mountain: A B C D H V X).

EXPERIMENTUM II.

The experiment of the tortuous siphon is well known: when you have filled it with water, and have placed one end at the bottom of a vessel filled with water, while letting the other, directed outward, flow, the whole vessel will be drained

out; and if the vessel teems with living [i.e. spring-fed] water, [you will see] the flow through the siphon likewise

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[lasting] perpetually as well. In just the same way, you may persuade yourself, the like happens from time to time within the subterranean passages.

Let there be a cistern [lebes] within the bowels of mountain A, and another within mountain C; from the bottom of C let a passage C-E be directed by nature into cistern A; and from the bottom F let another passage, longer than the first, be led into channel B. When, therefore, the water flows out of cistern A through channel F-g into bowl B, then necessarily, by the fear of a vacuum, water is drawn from cistern C through channel C-R and substitutes itself in the place of the departing water — namely, into cistern A. And just as the water in basin C is perpetual, so too the flow through channel F-g into basin B will be perpetual; where it will also discharge itself outward, either into a spring or into a stream.

Diagram. A cross-sectioned mountain landscape at the top of the column, showing two interior cisterns connected by curving channels, with streams issuing from the slope and a hatched ground-line below. Readable labels:

- A (upper interior of the mountain): cistern A
- B (interior, lower right): basin B, where channel F-g discharges
- C (interior, the deeper/source cistern): basin C, the perpetual reservoir
- E (channel from C): outlet of passage C-E into cistern A
- F (lower interior): origin of the longer passage / channel F-g
- Faint channel-tracings (C-R, F-g) curving between the cisterns; the small letters g and R are engraved faintly. [?]
- Outlet streamlets at the mountain's flank (unlabeled)

By these arts the sagacity of nature plays within the subterranean economy [Oeconomia]; which arts, though most remote from our senses, reason itself nonetheless dictates do happen in this way from time to time.

[Margin: All things in nature are accomplished by attraction and repulsion.]

Since the whole operation of nature consists in nothing other than a kind of attraction and repulsion, so too in the leading of waters it employs now expulsive force — as appeared in the first experiment — now attractive force, as appeared in this second experiment.

MODUS VII. [How springs and rivers are born from the attraction of moisture.]

As we have often urged, all the fibers of the porous Earth draw moisture — from the sea, and from lakes and rivers — into their own nourishment by a certain natural appetite. For since the earth is composed of countless fissures, fibers, and pores, the sea, through these, as through certain veins, insinuating itself, supplies the whole Earth with its due nourishment through countless other veins, not unlike the capillary veins in the human body.

[Margin: The earth is not [free?] of water [Terra vena... non si... fossis locis].]

For just as, when the skin is cut at any place whatever of the human body, blood immediately comes out, so there is scarcely any place in the Earth where, if you dig deeper, you would not at once find water —

[Margin: The earth naturally draws water as if [for] its own nourishment.]

except in certain desert and sandy places, which are not inaptly compared to the callous parts in the human body; and just as you dig those deeper, [you find] blood, so those at last supply water. The whole terrestrial globe is therefore pierced with fibers and fissures, as we have said, not otherwise than the human body with veins and the capillaries propagated from them; and through these, just as flesh, so the terrestrial body draws the necessary nourishment by an innate appetite.

Now this attraction comes about in many ways. First, the parts of the mountains, after they have been dried out by fiery vapors, by an innate force, as a remedy for their dryness and aridity, draw the nearby veins of moisture by suction, and in this way restore themselves, lest they be utterly destroyed. Secondly, among the earthy clods there are sometimes found gypseous or chalky materials, which, just as they are mighty with a marvelous power for sucking, by their innate dryness, so too, raising water from a low place on high, form it into a little pool [lacuna] in their outermost part. The matter will become clearer by an experiment.

EXPERIMENTUM.

Let a column A-C be made of gypsum, on the top of which let a crater B be formed; place it [resting] on its center C in a bowl D filled with water, and leave it for some hours — and you will find that the water, sucked up little by little by the gypseous column through its successive parts, at last reaches up the column A to

the crater B, and there persists even to the point of overflowing; and when the crater is emptied and the column dried out, by a new suction the crater is filled again with water. The same thing, you may persuade yourself, happens also in gypseous or chalky mountains.

Diagram. A turned, vase-like apparatus standing in the lower middle of the right column: a slender gypsum column rising from a broad, footed dish, with a small cup (crater) at its top. Readable labels:

- B (at the top, the small cup): the crater B formed at the column's summit
- A (on the column shaft, just below the crater): the column A
- C (at the foot of the column / its base in the dish): the center C on which the column rests
- D (the broad dish): bowl D filled with water

The column rises from the center of dish D; the whole stands on a turned circular foot. (No labels flagged.)

But perhaps you will say: these gypseous fibers of the mountains, as soon as they have imbibed moisture, cease from further attraction of water. I answer: they do cease for a little while, but as soon as they have been dried out again by fiery vapors, the craters are refilled by ever-new suction —

[Margin: Gypsum naturally seeks water.]

by such a moderation of nature that, by the suction of the water, the gypseous matter neither turns entirely to mud, nor, being utterly dried out by fiery exhalations, is reduced to powder; but it keeps to a certain mean, compounded equally of moist and dry. Such gypseous mountains, moreover...

[Printed p. 240 — running header: "LIBER QUINTUS"]

[Continuation of CAPUT III, MODUS VII — springs from moisture-attraction.]

such mountains—as both the Apennines and the Alps amply demonstrate—from which flows water charged with gypsum [aqua gypso scatens]; and those who drink it become afflicted with goiter [strumosi]. But more of this in what follows, where I shall treat fully of the powers of waters.

MODUS VIII.

How new springs, lakes, and rivers are at times fed by an earthquake.

[Margin: How springs are at times fed by an earthquake.]

The historians relate—and among the rest Seneca and Pliny [Pliny the Elder]—that amid the symptoms of great earthquakes, springs and streams sometimes break out in places where none existed before. I shall now show by what process this happens.

How an earthquake occurs I explained at length in the preceding pages. When the fire [Vulcanus], or as the chemists [Chimici] call it, the *Archeus* [Archaeus], rages with conflagrations in its subterranean realm, the result is that through its flues an immense quantity of fiery exhalations is driven through the fire-conducting channels [canales pyrogogos]. These, struggling within the subterranean passages with incredible force, seek an exit and find none; at last, impatient of the narrow confines, they make an exit for themselves. The foundations of some hydrophylacium are thereby shaken and shattered, its vault thrown down, and the whole mass resting upon that vault necessarily collapses. When that mass falls into the hydrophylacium beneath, since the mass and the water cannot subsist together, the water is violently compressed and forced to yield to the intruding newcomer. Squeezed out through the hidden channels it meets, it either bursts forth into springs, or at least, pressed outward, takes the place of the overlying mass and is shaped into a lake—as happened in my presence in the year 1638 at Saint Euphemia [Sant'Eufemia], a town of Calabria, which was swallowed up by an earthquake and left a standing pool in its place. I could adduce many examples of this kind, but since I have dealt with them in the preceding pages, it is superfluous to repeat them here.

[Margin: Many causes of changes arise from the interior of the earthen parts. [Ex interiori partium terrenarum lapsu multæ causantur mutationes.]]

MODUS IX.

How springs and rivers can be born from condensed air and from the blasts of winds.

There is sometimes generated in subterranean places an immense quantity of vapors and exhalations. Drawn out through the porous and tube-like tracts of the mountains, these at once, upon meeting colder air, condense into clouds; and these clouds, dissolved by the cold of the airy region, return outward as rains. But when the subterranean vapors cease, and there is no body to supply in place of the departing vapor, then—through fear of a vacuum [metu vacui]—the mountains draw in the surrounding air mingled with the vaporous clouds through those same fissures. The vaporous air, drawn within, upon contact with the warmer air is at once resolved into a subterranean rain, which, gathered

among the caverns, gives in turn a fresh origin to springs and streams. Many wonder

why the peaks of the mountains, at the time of impending rain, are almost always veiled in clouds. Let them reckon that the reason is none other than this: that the vapors, as soon as they have breathed out through the fissures of the mountains, condense into clouds upon contact with the cold of the surrounding air, and stand there; and lest they be dispersed, they are checked, as by obstacles, by the cold vapors of the airy region raised on high from elsewhere. For the nature of things so delights in such sports of attraction and repulsion that without them it seems to attempt nothing in the reciprocation of elemental matter, nothing in shaping the forms of meteorological impressions.

[Margin: Why mountains covered with clouds are forerunners of rains. [Cur montes nubibus tecti, pluviarum prodromi sint.]]

MODUS X.

The circulation [pericyclosis or circulatio] of the blood through all the veins of the human body is a discovery of our own age, confirmed by countless experiments, so that no one but a man ignorant of these matters can any longer doubt it. You may marvel that this portion of blood, which a moment ago stood in the veins of the feet, after a few hours travels by its ascent to the veins of the head, and from there descends again, only to repeat by a new ascent the station it had left—an arrangement established, surely, by an admirable design of nature. Since I have treated of it very fully elsewhere, I have chosen not to repeat it here; so let me return to the subject I set myself.

[Margin: An example of the circulation of the blood in the human body. [Exemplum circulationis sanguinis in humano corpore.]]

I say, then, that these principles of cyclic motion are observed by nature not in the human body alone, but in the watery element—or what amounts to the same thing, in the *pericyclosis* of the Ocean. See what I have set forth, with ample reasoning, in Book IV, Section I, Chapter 6, concerning the circulation of the Ocean through the northern and southern poles (*Mundus Subterraneus* IV.1.6). If, therefore, anyone of a more stubborn disposition should be unwilling to accept these arguments of mine concerning the origin of springs, rivers, and lakes, I trust that he will at least not despise this tenth mode; for what nature accomplishes with such wonderful sagacity in the circulation of the blood would seem in no way to be denied to her likewise in the circulation of waters from the

sea over the peaks of the mountains, since the principle of both is one and the same. As to how she carries out this circulation, consult Harvey [William Harvey], who skillfully demonstrates that it comes about through the valves set in the ducts of the veins, with the heart as the first author and mover of this motion. So if anyone duly compares the valves of the veins with the subterranean waterways [aquaeductibus subterraneis], he will find that the same thing happens in those places, as the experiments hitherto reported clearly demonstrate. You see, then, reader, that in this treatise I have so combined the causes of springs and rivers that no effect about this matter, however exotic, can be assigned whose cause you may not reduce to one of these ten. Therefore let this suffice concerning the origin of springs and rivers.

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CAPUT IV.

DISQUISITIO

On the origin of lakes in the plains.

[Margin: There are four kinds of lakes. [Quadruplicis generis lacus sunt.]]

In the preceding pages I consider that I have said enough about lakes on the summits of mountains and their origin. It now remains for me to say something about the lakes, pools, and marshes that occur here and there in the level expanses of the plains. They are of four kinds, according to a fourfold mode of combination. For first, there are certain lakes that receive no river and emit none, but persist in a perpetual constancy of their existence. Second, there are some that do indeed receive rivers but emit none. Third, there are others that do not receive a river but emit one. Fourth, there are, finally, those that both receive and emit. Apart from these modes, no other can easily be assigned. Therefore, once these have been duly set out, I shall rightly seem to have settled the whole disputed question concerning the origin of lakes. And so:

MODUS PRIMUS.

Whence and how arise those lakes that neither emit nor receive any river.

Lakes of this kind can again be considered under a fourfold class. First, some of them are made by art. Second, some are left behind by an inundation of the sea and of rivers. Third, some are collected within the basins [lebetes, "cauldrons"] of

mountains from rains and the melting of snows. Fourth, finally, some are established by nature herself through subterranean springs. Of the first three I shall forbear to speak, since they are not perennial, and in summer—unless preserved by the labor and industry of men in need of water—easily dry up. But let me turn my pen to investigating the origin of lakes of the sort that endure perennially without the emission or reception of any river. I am not speaking here of the rivulets channeled into some lake from the nearby veins of springs, but of rivers that pour themselves out into certain lakes.

Very many lakes of this kind are found here and there, especially in regions ringed by a vast plain—as in Muscovy [Moscovia], Holland, and the other places of Europe, Asia, and America. In Etruria [Hetruria] there is the Thrasymene [Thrasymenus, Lake Trasimeno]; among the Vestini, the Fucine [Fucinus, Lake Fucino]; in Latium, the Regillus [Lake Regillus], and the like. But among all the rest, the greatest in the whole world is the Parime Lake [Lacus Parime, Lake Parime] of America, lying immediately beneath the Equator, about 300 miles in length and about 100 at its greatest breadth, marvelous in having neither any increase nor any emission of a river.

[Margin: The vastness of Lake Parime in America. [Lacus Parime in America vastitas.]]

These lakes, and the like, since they are enormous

and neither emit nor receive a river—except for streams collected from rains or the melting of snows—it rightly falls to me to examine their origin. I say, then, that lakes of this kind, on whose outer surface no trace appears of any river either received or emitted, cannot subsist without some hidden commerce of subterranean rivers. For on this account they would otherwise—just like those that arise from rains and melted snows—dry up in the summer season through the exhalation of vapors and in the course of time be wholly consumed. Yet experience contradicts this in the case of the said lakes; for although in winter they are increased by rains and showers, and in spring by the melting of snows, nevertheless in summer they enjoy their native increase at an ever-uniform rate, subject to no diminution.

[Margin: How a lake without an apparent river receives a river. [Quomodo lacus absque apparenti flumine recipiat flumen.]]

For since they receive, through subterranean channels, water drawn off from some hydrophylacium, then—lest with time, as the mass of waters grows, they overflow—they discharge through another subterranean passage just as much

water as they had received through the former. And in this way lakes of this kind subsist under an ever-uniform tenor. And although in summer, through some attenuation by the solar heat, they pass in part into vapors, the deficiency is nonetheless always so restored by the subterranean influx of waters that there is never any cause to fear total dryness. It is therefore plain that the same thing happens to these lakes as to those that on their outer surface both receive and emit lakes [recte: rivers], with only this difference: that the former are filled and emptied by subterranean rivers, the latter by surface rivers. Hence it is no wonder that Lake Parime in America endures forever, since it is doubtless connected—whether by the hydrophylacia of the mountains they call the Andes, at whose roots it lies adjacent, through subterranean recesses; or by a perpetual influx of subterranean rivers—so that, as it is filled, it is likewise emptied through other similar passages into the innermost abysses of the earth. See what I have set forth copiously concerning the origin of Lake Thrasymene, which discharges itself through subterranean channels into the Clanis [Clanim, the river Chiana], in the book entitled *Iter Etruscum* [*Etruscan Journey*], where I have confirmed this opinion by experiments of my own, so that no further room for doubt is left.

Second, all those lakes that adjoin the sea, being salt, are constituted only either by an inundation of the sea or through subterranean passages by which they correspond with the sea—as I have abundantly demonstrated in Book IV, On the Mexican Lakes (*Mundus Subterraneus* IV).

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MODUS II.

Whence and how arise those lakes that do indeed receive rivers, but emit none.

Lakes of this kind are observed in great number by the geographers, among which the foremost place is rightly held by the greatest lake of the whole world, which they call the Caspian Sea [Mare Caspium]: it receives huge rivers, yet emits none apparently, being closed on every side by a rugged chain of mountains. Concerning it, consult Disquisition 9 of the preceding book, where I have treated of its origin professedly. Second is the Asphaltite Lake [Lacus Asphaltites], which they call the Dead Sea [Mare mortuum], which—except for the Jordan—evolves no river apparently, as I discussed in detail in the preceding pages. Among these lakes may be counted Soram [recte: the Sura?] in Muscovy; in Persia, Calgistan; in Africa, Cytur; and several others.

[Margin: The Caspian Sea receives huge rivers, emits none. [Mare Caspium ingentes fluvios recipit, nullum emittit.] The Dead Sea, that is, the Asphaltite. [Mare mortuum sive Asphaltites.]]

The cause of this effect is asked, in the first place. I say, then, that the cause of these is this: that lakes of this kind, even though they apparently admit perennial rivers, nevertheless—lest they overflow with time—are emptied through another, non-apparent subterranean passage. These things are so consonant with reason that no one, unless perhaps a man without sense, could doubt of it.

MODUS III.

Whence and how arise those lakes that do not indeed receive any river, but emit one.

Lakes of this kind occur everywhere in great number. Among them stands out Lake Chiamy [Lacus Chiamy], on the eastern side of the Ganges, which pours out four rivers of remarkable size that perpetually bless the regions of Siam and Pegu with their flooding; the Cyacuyhay [recte uncertain], an elongated lake in the borders of China, which, joined to another, flows down into Chiennam [recte uncertain]; the third is Lake Titicaca [Titicain, Lake Titicaca] in the province of Charcas [Charcea] in America, 80 leagues in circumference, which gives birth to a huge river that nevertheless, a little later, mingled with another lake, vanishes—doubtless seeking an outlet for itself elsewhere through subterranean passages. In Nicaragua of America [the lake] which, distant from the Pacific Sea by only four miles, emits a river that, winding through a hundred miles of meanders, at last evolves into the Atlantic Ocean. This one doubtless draws its origin from the Pacific Sea through hidden passages.

[Margin: Lake Chiamy emits 4 huge rivers. [Lacus Chiamy 4 fluvios ingentes emittit.]]

Of this same sort are: Lake Iroquois [Lacus Iroquois] in Canada, from which the river Saint Lawrence draws its origin; in Italy, such are Lake Vulsinius [Lacus Vulsinius, Lake Bolsena] in Etruria, which sends forth the Marta [Martam] from itself; Lake Bracciano [Lacus Braccianensis] or Sabbatinus [Lacus Sabbatinus], which evolves the Arona [recte: Arrone]; and several others, which I pass over.

[Margin: Lakes that do not receive rivers, but emit them. [Lacus qui flumina non recipiunt, sed emittunt.]]

The cause is the opposite of the prior one. For just as those lakes that receive rivers and do not emit them discharge themselves elsewhere through hidden passages, so too these that do not receive rivers but emit them are filled, as it were

through hidden conduit-channels [hydragogos inciles], and so are emptied through a manifest river: which is sufficiently clear.

MODUS IV.

Whence and how arise those lakes that both receive and emit rivers.

Lakes of this kind, again, are to be considered variously. For either they have their consistency from the increase of rivers, without any other subterranean spring—and in this way they obtain the name of pool [stagnum] rather than of lake; or, besides the intromission and emission of rivers, they are increased also by a subterranean spring. These in turn have various attendant conditions. For either they receive more water from the influx of a river than they emit; or they receive less than they emit; or they receive just as much as they emit. The first two repair the deficiency of water, both in reception and in emission, through the influx or efflux of other subterranean waters. Lakes of the last kind, on account of the quality of their waterways [aquaeductuum], distribute the laws of the influx and efflux of waters in equal measure—as happens in artificial fountains.

[Margin: The various attendant conditions of lakes that both receive and emit a river. [Variæ conditiones lacuum, qui flumina recipiunt & emittunt.]]

Another difference among these lakes is to be noted: that some discharge outside the lake, in an unmingled current, the river which they receive, passing through the middle of the lake—as happens in Lake Léman [Lacus Lemanus, Lake Geneva], through which the Rhône passes; in the Acronian [Lacus Acronianus, Lake Constance], through which the Rhine; in Lake Zaire or Bed, through which the Nile passes unmingled. A certain river of Muscovy is said to traverse ten lakes; and the like is told of other lakes of China and Brazil, which I omit for brevity's sake. But certain lakes take in rivers which, at once mingled with the lake-waters, leave no trace of their flow. Now, the reason that some are not mingled is none other than this: that since river-waters are much subtler and finer than lake-waters, they consequently delight—by an innate force and with an unmixable current—to float upon the latter as upon something coarser. But those that seek mingling are convinced to be of the same nature. Hence it is plain that all lakes of this kind are indeed increased from rivers, showers, and melted

snows, but, as to their origin, obtain the whole rationale of their essence through subterranean waterways and springs.

[Margin: Rivers that pass through the middle of certain lakes without mingling. [Flumina quæ per medium lacuum quorundam sine commistione transeunt.]]

COROLLARY [CONSECTARIUM].

From what has been said thus far it is plain that this fourfold mode-classification can easily be reduced to one. For what occurs in lakes that receive and emit rivers, that same thing occurs in lakes that show no river either received or emitted, by means of the hidden rivers beneath the earth, by which they are filled and emptied,

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and so they do not differ from the outer ones, except that the latter are detected by the manifest judgment of the senses, the former by an inference drawn beyond the senses [ultio (recte: ultra) sensuum iudicio].

If a lake A receives the river B and emits the river C, then the result will be that, if the rivers B and C are conceived as covered and subterranean, the lake A will appear to exist alone, as is seen in lake N. Again, let there be a certain lake that receives river B but emits none; then you will imagine to yourself a subterranean river C, and so you will conceive the lake to be manifestly increased by river B, but not apparently diminished by C. The same holds of a lake that receives indeed no river yet emits one: then you will conceive, by the contrary reasoning, that lake A is filled by the non-manifest subterranean river B, but apparently discharged through the river C. Whoever has rightly understood these things will, beyond doubt, assign without difficulty the rationale of the proposed difference of lakes. Therefore let this suffice concerning lakes arising in the level plains. The figures follow. Note that the black which is seen here denotes the subterranean.

Diagram. First of a row of four landscape schematics across the top of the page, each a cross-sectional mountain-and-lake profile illustrating one of the four lake types. This first panel shows a lake at left fed by an incoming river B (flowing from the lower left) and emitting river C through a mountain mass at right.

Labeled points:

- A: the lake basin (center-left)
- B: the river entering the lake (lower left, "B")
- C: the river emitted (toward the right, "C")

- [Several small interior letters within the lake basin are too small to resolve — [?]]

Caption (verbatim): *Lacus A recipit B, & emittit C, flumina.* — "Lake A receives B, and emits C, rivers."

Diagram. Second panel of the row. A lake (V) within a mountain valley that receives river L but emits nothing externally; the black (subterranean) outflow is shown beneath. Labeled points:

- V: the lake (center)
- L: the incoming river (left, "L")

Caption (verbatim): *Lacus V recipit L fl. & nullum extra emittit.* — "Lake V receives the river L and emits nothing outside."

Diagram. Third panel. A lake (S) that receives no surface river but emits one (Y); the subterranean feed is shown in black. Labeled points:

- S: the lake (center)
- Y: the emitted river (lower, "Y")

Caption (verbatim): *Lacus S flumen non recipit, sed emittit, uti Y.* — "Lake S does not receive a river, but emits one, as Y."

Diagram. Fourth panel of the row. A lake (labeled N at center) that neither receives nor emits any river apparently — the self-contained type — with the subterranean connections shown in black on either side. Labeled point:

- N: the lake (center, "N")

Caption (verbatim): *Lacus flumen non recipit, neque emittit apparenter.* — "The lake neither receives nor emits a river apparently."

[Printed p. 243, lower portion — new Section.]

SECTIO II.

DISQUISITIO

DE VARIIS AQUARUM DIFFERENTIIS

On the various differences of waters

and their qualities—or what amounts to the same thing, on thermal springs [Thermae], that is, on medicated and compound waters, and their nature, property, and origin.

CAPUT I.

On simple spring water, and on its goodness and its harmfulness.

[Margin: The pure element of water does not exist in the nature of things. [Non datur aquæ elementum simplex in rerum natura.]]

I suppose, first, that a pure and simple element cannot exist in the nature of things, and consequently that the water we use—and which we cannot do without—is not simple nor pure, but a substance mingled and confused with various corpuscles of heterogeneous mixed bodies. Since I have shown this elsewhere by the induction of various things and experiments, and shall demonstrate it more fully below, I will not dwell on it here. And although in this place I call spring water "simple," I would nonetheless have this understood not of absolute simplicity, but of relative—namely, insofar as, compared to other waters, it exhibits the greater marks of simplicity; yet that it is not absolutely simple, the great differences among springs sufficiently show. And although I have treated of these matters more fully in my *Iter Etruscum* [*Etruscan Journey*], it has nonetheless seemed good to treat here, more precisely, certain points there omitted.

[Margin: Six differences of potable, that is, sweet, waters. [Sex differentiæ dulcis aquæ.]]

Six differences of potable or sweet water are for the most part laid down.

First, **Spring water** [Fontana], which gushes from the inmost vitals of the earth in a living vein. Second, **Lake or marsh water** [Lacustris sive palustris], standing and stagnant. Third, **Rain water** [Pluvialis]. Fourth, **Cistern water** [Cisternarum]. Fifth, **River water** [Fluvialis]. Sixth, **Well water** [Putealis].

[Margin: The differences of potable waters. [recte: the six kinds — corresponds to "...por... ut plurimum statuuntur"] Spring water. [Fontana.]]

Which of these is the most healthful for drinking, the best fitted for quenching thirst and aiding digestion, and the most convenient vehicle for the blood as it is poured out from the liver into the whole economy of the body—about this there is no slight dispute and controversy among the physicians. Some prefer spring water on account of its supreme clearness, sweetness, lightness, and coldness. Others, on the testimony of Plutarch [Plutarcho teste], prefer the water of showers or rains, because it is light and airy. Some set cistern waters above the rest, because they are nothing other than rain water, and the most thoroughly purified of all dregs. Nor are there wanting those who hold that the waters of rivers are the healthiest—induced, perhaps, by the most healthful waters of certain rivers, of the kind that Solinus [Solinus] says the waters of the river Choaspes [Choaspis] of Persia to be: of such perfection that the King

[Margin: Which water is more healthful. [Quænam aqua salubrior.]]

than these waters he would put to use for drinking; just as the same is reported of the water of the Nile [aqua Nilotica], being the sweetest and most fertile, and of countless others. [Margin: What waters are renowned for their wholesomeness and goodness.]

At Puteoli [Pozzuoli] the water is heavy and is digested only with difficulty, nor can it even be determined whether it is wholly free of putrefaction. Yet it will be the less to be condemned in proportion as it is improved more and more by the frequent stirring of those who draw it, or if it gushes up from a subterranean spring. As for lake-waters [lacustres], finally — that is, standing or stagnant waters — since these are struck from the roll of the wholesome kinds altogether, let me now show what is to be concluded about the remaining kinds enumerated. [Margin: The condition of the water at Puteoli.]

And first of all it must be laid down as certain that there is no water anywhere on the face of the earth that is not, at least in some part, polluted by the foulness of earthy refuse, with which it necessarily mingles. For if you consider the origin even of the clearest spring, it cannot but be that, passing as it does through subterranean channels [cuniculi] on its long journey, it is tainted by the tincture of earthy juices and stones endowed with various properties, and by the scrapings of their particles — just as was shown in the preceding Book in the chapter on the saltiness of the sea [de salsedine maris]. [Margin: That there is no water free of an earthy admixture.]

Rainwater [aqua pluvialis], as it arises from the dissolution of various vapors steeped in various supplies of mineral spirits, cannot avoid contamination when these become associated with earthy matter and are turned into water. Hence cistern-water [aqua cisternarum], because it is a kind of mixture both of the different waters collected in the cisterns at different seasons of the year and of the hail and snow melted on the roofs in winter, is condemned everywhere by the physicians — as Matthiolus [Pietro Andrea Mattioli] reports — on the ground that snow and hail contain in themselves some noxious and deadly thing, the seedbed of many diseases.

Again, since river-water [aqua fluvialis] is the receptacle of various minerals, of brooks, and of all filth and carrion, surely no person of sense would assert that it conduces to health — unless, kept over a long stretch of time in large earthenware vessels and clarified by settling, it grows clear and is thoroughly purified. [Margin: River-water is unwholesome.] The same is to be thought of lake and stagnant waters, which are judged to be worse than river-waters in proportion as, lying foul in their motionless state, they are nearer to putrefaction. [Margin: Marsh-waters are the worst.]

And so, of these six kinds of drinkable water, if you set aside the stagnant ones, there is scarcely any that does not suffer some loss of its purity; and none, equally, that cannot be improved by various filterings, boilings, and settlings. Hence the signs of the goodness and wholesomeness of waters must be gathered from elsewhere — which signs we now set down.

The first and universal sign of the goodness of waters, then, is this: that they be clear, translucent, thin, pure, light, of their own color, free indeed of any taste, and agreeable to the palate; and that they both grow hot quickly when set to the fire and grow cold again as soon as they are removed from it; and finally that they do not linger even the briefest moment in the upper digestive organs [praecordia], but pass by an easy course without any distress to the stomach. Waters that come together under this complex of qualities and signs you may hold to be the most highly praised for drinking and the most fitting for preserving health — on the testimony of Galen, Dioscorides, Cardano [Girolamo Cardano], Matthiolus, and others. [Margin: Universal signs of the goodness of waters.]

The second sign: if you find that people who use the common water of some place are robust in strength, glowing in color, subject to no ailment of the legs and no blariness of the eyes, and live a long and healthy life, then know that those waters are most thoroughly approved.

The third sign: if water set over the flames in a cauldron quickly comes to a boil, and with like speed cools down when the fire is drawn away, count those waters good and of the better sort — especially if little or no sand or mud settles at the bottom of the cauldron.

The fourth sign: if legumes cooked in it cook through quickly, with no hardness left, let that be for you a sure indication of a most wholesome water.

The fifth sign: if you observe a spring around which neither moss nor rushes grow, and that place is fouled by no filth — while the water itself is translucent and clear and passes over a bed of pebbles and fine sands coated with no slime — you will have sure signs of the thinness and wholesomeness of that water.

But how the heaviness and lightness, the goodness or badness of any water may be recognized, and may be detected by means of hydrometric instruments, we shall teach in what follows by many and various methods.

CAPUT II.

De Aquilegiis sive de Signis, per quæ, ubinam Aqua alicubi sub terra lateat, cognoscere quis possit.

(On Water-Finding, or the Signs by which one may know where Water lies hidden somewhere beneath the earth.)

These experiments are of great importance in those places where strongholds, or country villas, or the like are wont to be built; since the mere lack of water removes every enjoyment of comfort. And since there is no piece of ground that does not somewhere underneath have either moisture or the vein of some spring, the water-finding architects [Aquileges Architecti], anxious for so great a benefit, rightly make it their business to inquire whether there is any hope of a hidden source. Hence, intent with unbroken effort, they have discovered certain signs by which they have at last reached the hidden vein of water — signs that Vitruvius (*Architecture* VIII), Pliny, Palladius, and Cassiodorus have handed down to the memory of posterity. They are as follows. [Margin: Signs of water lying hidden beneath the ground.]

1. If you see a place green with grasses, and also luxuriant with an abundant crop of leaves on tall trees, you may convince yourself that somewhere beneath there lies, for certain, a quantity of water. For in lands beneath which sweet moisture is not far off, there is, as it were, a perpetual smile of

plenty in certain growths — such as the water-rush [*juncus aquaticus*], the light reed [*arundo*], the sturdy bramble [*rubus*], the pliant willow [*salix*], the green poplar [*populus*], and the remaining kinds of trees, which nonetheless luxuriate with a thriving increase beyond their natural measure.

2. The marks of hidden waters are the wandering willow [*salix errativa*], the alder [*alnus*], the chaste-tree [*vitex*]; and among the herbs, the buttercup [*ranunculus*], the water-lily [*nymphaea*], the fleabane [*pulicaria*], the galingale [*cyperus*], the water-mint [*mentastrum aquaticum*], and the like, which both love water and can neither be nourished nor preserved without it. To these is added a not uncertain indication: stationary troops of croaking frogs.
3. It is gathered from the quality of the places and from the nature and property of the soil and clod. Where the soil is chalky, corrupted by a varied mixture, there you may hope for neither abundance nor good-tasting water. By contrast, in clayey earth scoured clean of all rubbish, the water is always sweet, and colder where there is tufa [*tophus*]; for both make the water light and, by filtering it, hold back the dirt. [Margin: Chalky earth produces unwholesome water.] Gravel [*glarea*] promises uncertain water, but of good taste. Sand from coal-bearing grit [*arena carbunculosa*] pledges water that is sure and stable and — what matters most — wholesome. Red rocks too promise the best water and of the most certain hope; beneath the rocky roots and flints of mountains it is more plentiful, colder, and more wholesome. [Margin: Good water, which veins it loves.] And these are the chief signs of hidden waters; now let us see how they may be explored by other methods and experiments.

EXPERIMENTUM I.

Let some spot be dug down to a depth of about five feet. Then, around sunset, let a copper or leaden basin smeared with oil be set in it, turned upside down so that its hollow looks toward the bottom of the pit; and let the mouth of the pit meanwhile be covered over with reeds and foliage, with earth heaped on top. The next day let it be opened; and if any moisture has trickled down upon the copper or lead in a copious sprinkling of drops, you may be sure of an abundance of water lying hidden there.

EXPERIMENTUM II.

If into a pit like the foregoing you set an earthenware vessel, still raw and unfired, and a tuft of wool loosely bound — and if the next day you find the vessel broken and dissolved by the evaporating moisture, and the wool also soaked, so that water can be squeezed from it — that will indeed be a sign of abundant water hidden there. The same will happen if a burning lamp full of oil is set out in the same pit covered with foliage: if the next day you see it gone out, with no failure of the oil or wick, you may convince yourself for certain that waters are lurking there, not far distant from the lamp. Likewise, if you kindle a fire in it, the scorched earth will breathe out a misty vapor — an indication of hidden water.

EXPERIMENTUM III.

Let the water-diviner [aquilex], in the morning facing the East, but before the rising of the Sun, lie prostrate flat on the ground and observe whether anywhere moisture curls up into a thin little cloud and strikes the air with a tremulous motion; and where he has detected this, let him dig, assured of stored-up water.

Some, driven by I-know-not-what superstition into a perverse persuasion, think this can be accomplished by means of a sieve, in which a suspended pair of shears, by its points, will — as soon as it has come over a hidden vein — point out the water by an infallible sign. I remember having seen at Viterbo a ridiculous experiment of this kind performed by a certain stone-mason; but just as it rested on no principles of nature, so it was deservedly exploded by the laughter and jeers of all. [Margin: The superstition of certain water-seekers.] To these I will add several methods far more recondite, yet most certain, with which I once used to explore the hidden springs of waters.

EXPERIMENTUM IV.

Let there be made, from some wood that has a sympathy with water — of the kind that alder and willow might be — an arrow C B, more or less in the manner in which the needle is usually mounted in magnetic compass-boxes [magneticæ pyxides], yet fashioned with this skill: that the half C A be made of any other wood, as dry as can be, while the other half A B be of green wood of alder or willow; let the two, joined together at the hollow middle A by a brass cone, be tied so as to make a perfect equilibrium. This done, let a foot be made on which the instrument can be steadied, and let it have in its upper place a spike [obelus], which, fitted into the brass cone of the arrow, not only supports the arrow but renders it so finely balanced that the arrow may, with no trouble and no

impediment or resistance, be set in motion by the easiest and gentlest motion, just like the needle this way and that in magnetic compass-boxes; and you will have the instrument made ready. Or, if that hollow little cone can be made only with too much difficulty, you will balance the arrow upon a turning axis, and the same effect will result, as appears in the Figure.

Diagram. A water-divining instrument of the sympathetic-needle type. At the top, a long horizontal balanced arrow runs left to right, lettered C at the left tip and B at the right (arrowhead) tip, pivoting at a central hub. The hub is drawn as an oval (compass-box) carrying the small letters of the pivot mechanism — L at the top of the hub, O to its left and T to its right along the arrow shaft, and P below at the supporting pin. Below the arrow, two further views are shown: at lower left, the complete instrument mounted on a flat rectangular foot/base with an upright post bearing a short balanced arrow at its top; at lower right, the bare upright pivot-post (the spike/obelus) standing on a splayed three-pronged foot.

- C (left tip of horizontal arrow): one end of the arrow (the dry-wood half, C A)
- A (center, at the hub): the hollow midpoint, joined by the brass cone (boundary of halves C A and A B)
- B (right tip, arrowhead): other end of the arrow (the green alder/willow half, A B)
- L (top of central hub): pivot-point marking on the compass-box
- O (left of hub, on shaft): point on the arrow shaft at the pivot
- T (right of hub, on shaft): point on the arrow shaft at the pivot
- P (below hub): the supporting pin / spindle of the pivot

Therefore, when you intend to inquire somewhere for a vein of hidden water, set up the instrument in a spot conspicuous by the preceding signs and shady, in the early morning before the rising of the Sun; and then, after some hours, inspect the part

A B of the arrow made of alder-wood. If it has dipped downward, you may be sure that in that place water is stored. For since the said wood has the greatest sympathy with water, and eagerly draws to itself the moist vapor from the earth, it must necessarily, being soaked and weighed down with moisture, leave its equilibrium and incline downward. It will gain greater force if you cover the alder-rod over with tufts of wool, because of the great thirst for moisture that is in wool. [Margin: The sympathy of the alder-rod with water.] But here I will not omit to mention how the veins of springs sometimes dry up.

Now the veins of springs are wont to vanish or disappear from a fourfold cause. First, from a collapse of earth and rocks below the ground, arising from an earthquake, or from rains, or from melting snows — by which the water, prevented from running by its usual path, is forced to seek new outlets. Second, from a new blocking of channels or an opening of others. Third, from the recent digging-out of some well, or foundation, or mine, or the like, by which the path of the flowing water is cut off and opened elsewhere. Fourth and finally, from a new sprouting of woods and groves, or from their uprooting; for the roots of trees draw water to themselves. Hence it comes about that some spring either dries up at a new growth of plants or flows forth at their being grubbed out. See what we have treated of these matters at greater length in our *Iter Etruscum*. [Margin: How the veins of springs vanish or are newly generated.]

CAPUT III.

De Aquis mixtis seu compositis medicatis in genere earumque causis, & de mixtionis cum mineralibus diverso modo & ratione.

(On mixed or compound medicated waters in general and their causes, and on the diverse mode and manner of their mixture with minerals.)

Those waters that are called mixed or compound — which are composed of various earths, metallic bodies, juices, and the remaining kinds of minerals — are without number; and so too the variety of differing waters has no end. For just as in man no face, no voice, no natural bent of disposition, no temperament can be assigned that does not differ from another's temperament, so I say there is no water, whether simple or compound, that does not acquire a special difference from all other waters whatsoever. [Margin: No one water is altogether like another.] And so I would venture to say that there are as many differing kinds of waters as there are differing kinds of earthy clods, of minerals, of metals, and of juices both liquid and solid. Since these do not fall under number, there exist likewise innumerable kinds of waters — especially when single kinds are aptly combined with single kinds by mixture — so that it is consequently difficult to pass firm judgment on medicated waters.

Two most noble philosophers, Seneca and Pliny, saw this. Hence the former, in *Natural Questions* Book III, when about to discourse on waters, says: *Let us*

approach a serious, weighty matter; let us do what is wont to be done on a journey — those who have set out later make up for the delay by speed. Let us hasten; let us undertake a work, I know not whether surmountable, yet great certainly, without making excuse of my age. And the latter, in Book XXXI, chapter 1, having gazed upon the very many powers and differences of waters, exclaims: *What mortal could enumerate them all?* — Why should level-headed philosophers be afraid? for the matter cannot be exhausted by examination. [Margin: The difficulty in discerning the powers of waters.] Yet, these difficulties notwithstanding, we are not so deterred as to have any mind to throw down our spear:

It is something to advance thus far, if it be not granted to go beyond.

I judge that I must do the same as the physiognomists, who, amid that infinite diversity of temperaments, do not so far go astray from their forecast of the predominance of these temperaments as not, ever and again, to touch — as with a needle — the inmost nature of men and their inclination to virtues and vices, and to determine it most truly. That I may do the same in this judgment of waters, and with so much the happier outcome [?], I will here recount only the principal mixtures of things by which water is infected; from these the curious reader will easily find the way to explore the rest, since they are discovered, not with difficulty, from the predominance of the qualities, by the service of the senses, and with the help of experiments. The mixtures, then, of all waters, in whatever way they are at last compounded, I reduce to five Heads. [Margin: The examination of the mixtures in waters.]

1. For either they are mingled with various clods of earthy matter, under which all kinds of earth are comprehended.
2. Or with the various kinds of salts — which are called concrete juices — and there arise as many differing kinds of mixtures as there are differing kinds of salts.
3. Or they are joined with the various kinds of juices, or liquid fluids, under which are contained both the oily — such as bitumens — and the non-oily — such as the strong and caustic waters [aquae fortes & causticae].
4. Or they are mixed with metallic bodies, and take on the nature of the metals with which they are tinged.
5. Finally, or they are mixed with the various kinds of stones, under which all the differences of rocky substances are contained.

And to these five Classes, whatever lies hidden in corporeal and subterranean nature

is recalled; and from the mixing of them flows the series of qualities that follows — those qualities which shine forth in that diversity of waters which we have just reviewed.

The following synopsis is presented in the source as a two-column brace-diagram: on the left, the **Waters** classified by the substance that infects them; on the right, the **qualities** that arise from these, joined by the central caption "From these arise qualities, such as are...".

Waters [Aquæ] (infected by / consisting of)	→ From these arise qualities, such as are:
Infected with earths [Terris infectæ]	Acid [Acidæ]
Salty [Salsæ]	Bitter [Amaræ]
Nitrous [Nitrosæ]	Salty [Salsæ]
Aluminous [Aluminosæ]	Hot [Calidæ]
Vitriolic [Vitriolataæ]	Cold [Frigidæ]
Sulphurous [Sulphurosæ]	Oily or fatty [Oleaginosæ seu pingues]
Verdigris-bearing [Æruginosæ]	Poisonous [Venenosæ]
Of lime and gypsum [Ex calce & gypso]	Colored [Coloratæ]
Metallic [Metallicæ]	Effervescent [Ebullientes]
Bituminous [Bituminosæ]	Transformative [Transformativæ]
Infected with mercury [Mercurio infectæ]	Purgative [Purgativæ]
Iron-bearing, copper-bearing [Ferratæ, æratæ]	Wholesome to whatever members [Quibuscunque membris salubres]
Petrifying [Lapidescentes]	

From the combination of each of these single kinds with each single kind there arises that admirable variety of waters which the above-cited philosophers were unable to conceive. For if you conjugate these twelve species according to the principles of our combinatory art [ars combinatoria], there will be born 479001600 — that is, four hundred seventy-nine million, one thousand six hundred — differing species of waters. [Margin: The admirable power of combination.] If you again resolve these into the differing combinations of the species of earthy clods, of salts, of niter, of alum, of vitriol, of sulphur, and of

metals, you will have a number that exceeds the whole number of the sand of the sea. But since, in the twelve species set forth, a predominance always presents itself to the senses, content with that, it is now time for us to treat of each in order.

§ I.

De fontibus seu aquis auriferis, gemmiferis, aliisque terra infectis.

(On springs or waters that bear gold, bear gems, and are otherwise infected with earth.)

A threefold mode of mingling must be considered in all of these. First, there are certain medicated waters that are constituted not by a perfect but by a confused mixture — that is, those that teem with the perceptible particles of various minerals and can be separated from them with no trouble. [Margin: Improperly mixed waters, what they are.] Second, those that consist of a perfect mixture, such that the individual particles of the water are mingled with the individual vaporous spirits intimately, by a kind of union separable only by a long boiling; and so they constitute one body with the waters, one substance, one form — such as salt water, vitriolated water, and so on. [Margin: What waters perfectly mixed are, and how they contain a perfect mixture.] Third, finally, there are certain waters that consist partly of a true mixture of the things they contain, partly of a confused, or rather true, mixture: and these are compounded from the first and second modes of mixture. In this way there are many thermal springs [thermae] that emit calcareous stone — imperfectly mixed with them by reason of what is imparted to them, while with true salt they are united in a perfect mixture. [Margin: Certain perfectly and imperfectly (mixed).] But let us explore all these things more deeply.

Gold-bearing springs and rivers [auriferi fontes & flumina] are found almost everywhere, namely where mines of gold are dominant. [Margin: Gold-bearing springs and rivers.] More renowned in name than the rest are: the Tagus in Spain; in Italy the Padus [Po]; in Germany and Hungary innumerable brooks; in Asia the Padrotus [Pactolus] and Chrysorrhoas; in Bactria the Oxus; in Carmania the Hyramnis; in Africa the Nile, the Niger, and the Zairus [Congo]; in America, beside Potosí, all the rivers teem with golden grains. But concerning these, see the writers who treat of them: Aristotle in *On Marvellous Things Heard*, Pliny, Solinus, and very many Geographers of this age. It is our task to set forth the causes of this golden flow [Chrysorrhoia].

If, then, anyone should ask whence the gold-grains of this kind draw their origin — whether from the nature of the river mingled with the earthy clods, or from elsewhere? — I dispatch myself in few words in a matter by no means recondite. [Margin: The cause of the gold-bearing rivers.] If gold-bearing veins lie beneath a river or lake, surely they can, according to the opinion of some, be said to be generated in the waters themselves; yet we shall speak more fittingly if we say that the gold, having sprung up in the native veins of mountains, is from there scraped off by the flow and force of the streams and brooks, carried along, and brought down into the channels of the rivers, and mingled with their sands and waters. And experience teaches — in the Principality of Tirol, in Bohemia, Saxony, Hungary, and finally in all those regions in which the womb of the mountains is laden with gold — that there, in those very brooks and rivulets, the gold-grains scraped off from the gold-bearing veins and mixed with the sands show themselves. [Margin: How gold is generated in rivers.] Mariana, the historiographer of Spain [Juan de Mariana], relates that the inhabitants once, having broken and split the mountains, let water in, which by washing would convey away the gold; and so the gold scraped off from the veins settles in the sands, but is not begotten in them — for sands lack the little veins in which moisture, from which gold is made, can be contained, nor does the maturing heat reach there.

Our Fathers report that the rivers around the region of Potosí in America are so productive of gold that the annual revenues of our College at Potosí are nil, except what the gold-bearing river supplies to them; and they operate thus. [Margin: The causes of Potosí. The revenues of the College of our Society, which (come) from gold assigned to them.] At fixed and appointed times slaves [mancipia] are sent out to extract the sand; and the extracted sand they cleanse on slightly inclined boards by the frequent washing of water poured over it from filth and dirt; and in this way the remaining

LIBER QUINTUS, Sectio II — CAPUT III, §. I (continued): De fontibus seu aquis auriferis, gemmiferis once the earthy material has been carried off by the affusion of water, the heavier gold particles are left behind. These particles are then placed in crucibles and melted by a fierce fire; the melted gold is afterward beaten with a hammer, drawn into sheets, and put to use. As for how much gold the Nile, by its cataracts, supplies to Egypt from this precipitate, I have shown it in the second *Syntagma* of the *Oedipus Aegyptiacus*, in the discourse on the alchemy of the Egyptians, to which I refer the reader.

[Margin (p. 248): The cataracts of the Nile supply Egypt with gold.]

Since, then, innumerable rivers of this kind are found throughout the Geocosm, one might reasonably ask whether these rivers do not also share something of the power of gold — or, what amounts to the same thing, whether gold is perfectly mixed with the water. I answer that it is not. For if you were to keep water in a golden cup for a hundred years, it would still draw out no virtue from it. Gold, being indissoluble and compacted by the strictest laws of nature, cannot yield the desired effect unless it is first dissolved by strong waters [aquae fortes — the acids of the alchemists]. It does happen from time to time, however, that veins of gold, dissolved by some corrosive and caustic liquor, pass off into spirits; and water impregnated with these takes on some virtue. Even so, I do not think a perfect mixture of gold with water is possible, but only a confused and lightly tinged one — as I shall explain at length in the proper place, in treating the nature of potable gold [aurum potabile]. As for gold-bearing waters and places that yield gems [gemmae aquae], I shall philosophize about them elsewhere.

[Margin (p. 248): Gold cannot be perfectly mixed with waters.]

§. II. De Fontibus et Aquis terreno luto infectis.

(On springs and waters tainted with earthy mud.)

Whenever water passes through places tainted with mud of various earthy substances, it is tinged with the quality that the mud itself contains. Such mud is formed from chalk, clay, sand, gypsum, ochre, sandarac [sandaraca — red arsenic

sulphide], red ochre [rubrica], ash, lime, and the other sands and powders of mineral bodies, as soon as these are mixed with moisture. Chalky and clayey waters are found in great number in Etruria [Hetruria]; they are heavy and by no means conducive to health. If water passes through sand and a harder gravel, it is reckoned the best and most wholesome of all — for the whole virtue of waters depends on what tinges them.

[Margin (p. 248): The whole virtue of waters depends on what tinges them. The virtue of waters depends on the earthy materials they pass through.]

Waters tinged with gypsum are likewise found, not infrequently, in Etruria. While they contribute much to the external washing of the body, when taken by drinking they are thought not to be free of danger, on account of a certain caustic virtue they possess. Waters that abound in ochre, sandarac, and the like are extremely harmful to drink; yet many who use them as a bath are freed from many infirmities. This class of stones varies a good deal according to place: the stone is found ash-colored, livid, pale, or reddish. In some places a kind of stone is found which, when dug up, is converted into a very tenacious gypsum — as in Cyprus, on the testimony of Pliny [Plinius]: if waters pass through the veins of this stone, they are rendered white.

[Margin (p. 248): Gypsum-waters, where chiefly found.]

Gypsum waters [aquae gypseae], accordingly, are found everywhere in great abundance — for instance, in Italy among the Camertes [the people of Camerino], at the river Callis [the Chienti? — Latin "Callim fluvium"], so that those who drink from it become afflicted with gravel [stramosi — "stone-bound," i.e. afflicted with calculi]. The water of certain wells at Bologna [Bononia] is gypseous and exceedingly noxious, having a certain suffocating power; the same is found among the Helvetii at Eugesta [Augst?], at Pozzuoli [Puteoli] in Campania, and in innumerable other places.

§. III. De salsis Aquis et Fontibus.

(On salt waters and springs.)

Since in the preceding Book I philosophized at length about the saltiness of the sea [salsedo maris], and in the following Book I am going to treat of the nature of salt [natura salis], here I shall not so much describe the salt springs as touch on them only in passing. It is established, then, that among the other medicated waters nothing is more frequent or more numerous than salt springs. For no water — I do not say medicated or compound, but not even a pure and simple one — can be

designated which does not have at least a little salt mixed in. This has been so confirmed by the chemical art that no room is left for any further doubt. For just as salt is a kind of seed of nature, and an earthy element that goes into the composition of all mixtures, so too nature has willed that it be lacking nowhere — being so necessary to the preservation of things.

[Margin (p. 248): There is a little salt mixed in all waters.]

Hence scarcely any kind of thermal spring [thermae] will be found that does not have some salt mingled in it. Yet in those waters in which salt has the predominance, these too are called salt waters. Some of them are born from the innermost salt-bearing caverns of the mountains; some are tinged from the very banks of rivers that are charged with saltiness; others from subterranean waters abounding in the native saltiness of their locality. The springs and rivers of Hungary, Poland, Tyrol, and Saxony; in Italy at Volterra [Volaterrae], in Emilia, Picenum, Etruria, Gaul, Spain — and, finally, throughout the whole globe of lands, met with everywhere — bear sufficient witness to this. But I shall treat of these more fully in what follows, God willing.

§. IV. De Fontibus Nitrosis.

(On nitrous springs.)

What niter [nitrum] is, and how many species of it there are, see in the following Book, in the chapter on niter. Here I shall only adduce waters infected with niter. To do so, I would first have you know that the earth in some places produces niter most abundantly — as does Egypt near Memphis (today Cairo), where it is even, when baked by the heat of the Sun, converted into a stone most apt for making vessels. Water flowing through places of this kind is therefore tinged with a nitrous quality, to the great advantage of medical practice.

[Margin (p. 248): Niter, where it is chiefly found.]

In the territory of the Sabines, at the place now called the Well of Retina [Puteus Retinianus], the said authors point out the Catilian Waters [Catiliae Aquae] — most celebrated in the records of the ancient writers, indeed from the very times of the Aborigines [the legendary aboriginal inhabitants of Italy] — as being very full of niter; of which [I shall treat] more fully in the following Book, in the chapter

[§. IV continued:] on niter. Such are the waters about the floating islands [de Insulis natantibus]. Of this kind are several waters in Emilia near the Maldula [river], and in the Valley of St. Martin near the Flaminian Way; in the Bajan

[Baiae] territory of Brachula and Sucullaria near Lake Avernus, and that which is on the island of Aenaria [Ischia]. In Etruria the waters of Borra and Volterra; in Germany, the most highly praised ones near Strasbourg [Argentina]; in Helvetia [Switzerland] at Zürich [Tigurum]; in the Duchy of Württemberg at the Marcian Forest [Sylva Martiana — the Black Forest]; in Alsace, and innumerable other places. The virtue of all these, just as it has detergent or abstersive force, is likewise held by all physicians to be cathartic or laxative — unless the admixture of other waters makes them produce different effects.

[Margin (p. 249): Places where there is plenty of niter in the waters.]

For the predominance of niter makes waters potent; and when drunk they correct a bad constitution arising from phlegm, loosen the bowels, and benefit ailments of the nerves — which is attested by distillations [i.e. catarrhal discharges] — and the chest. They heal disorders of the skin and the itch; instilled into the ears, they remove ringing. In a word, they produce effects equivalent to salt, except that salt yields a restraining, cleansing power, while niter yields a cleansing power. But of the nature and properties of niter expressly elsewhere.

[Margin (p. 249): When [such waters are] harmful.]

§. V. De Aquis Aluminosis.

(On aluminous waters.)

Whenever water passes through places filled with alum, it becomes aluminous, tinged with the powers of alum. Now alum is imbued, as it were, with contrary qualities: moderately hot and supremely dry, and besides cold, and powerfully astringent; the signs of these are its taste. For at first taste it is somewhat sweet and thin, pricking the tongue; from which it gradually passes into a bitter and markedly astringent flavor. Water perfectly mixed with it shares these powers.

[Margin (p. 249): Aluminous waters.]

It is indeed remarkable that I have seen no stream tainted with alum which allows any herbs to grow on its banks here and there. For — as Theophrastus too noted — aluminous water neither nourishes nor generates any plant, a most evident sign of its truly powerful dryness, which predominates in it. Hence they are wonderfully suited to curing diseases that take their origin from excessive moisture or cold. Such are the waters near Tolfa, flowing forth from the aluminous mountains; such is the Albula in the Tiburtine countryside [the territory of Tivoli]:

[Margin (p. 249): Why aluminous waters do not let herbs grow on their banks.]

One goes to the cold citadels of Hercules, where the Tiber flows, and where white Albula steams with sulphurous waters.

And innumerable others, as is clear from the *Catalogue of Thermal Springs* [*Catalogus Thermarum*].

§. VI. De Aquis sulphureis et bituminosis.

(On sulphurous and bituminous waters.)

These can be considered here in a threefold way: some are sulphurated [sulphuratae], some sulphurous [sulphureae], and some of both kinds. We call "sulphurated" the pure ones, which contain much sulphurous substance in an unmixed state. "Pure sulphurous" we call those which, as long as they boil, are mixed with and tinged by sulphurous vapors and spirits; but once cooled, and again removed from the fire, they are found to have lost all sulphurous tincture — the vapors and spirits that existed in them having flown off — so that they display neither odor, nor taste, nor any further mark of a sulphurous character.

[Margin (p. 249): Sulphurous waters.]

But if the waters have been intimately and perfectly mixed with sulphurous corpuscles together with the exhalations of [sulphurous] spirits [the text reads "fpiritibus... bilium," apparently "spiritibus sulphureosis" — sulphurous spirits], then they truly and properly obtain the name of sulphurous waters, and always exhibit sulphurous effects, whether they be hot or cold. Of the former kind are the Albula Waters, which abound in sulphurous lumps but are nevertheless not mixed with them — having, as I said a little earlier, the predominance of alum. Of the second kind are all those sulphurous waters which, when cooled, put off their sulphurous character. Of the third kind are the waters in Etruria at S. Cassiano, and the water of Caia near Viterbo [Viterbium]. For since they pass through long windings, through sulphurous veins filled with sulphurous vapors and exhalations, and are perfectly tinged with the scrapings of sulphurous substance and the spirits mixed in with them, they are mixed in an intimate and inseparable union.

As regards bituminous waters, it is certain from experience that all fatty and bituminous liquors, though at first sight they reject all mixture with waters, are nevertheless overcome by long delay and confusedly mixed with them — as all bituminous springs show. Indeed, they are so filled with bituminous vapors (as Fallopius [Falloppio] reports of certain springs in the territory of Parma) that they

are kindled by a flame scarcely even brought near them; nor can a flame, once kindled in the water itself, be extinguished by any pouring-on of water, but only by wind, or by cloths thrown over it.

[Margin (p. 249): Bituminous waters.]

Such bituminous waters arise from the many bituminous spirits and vapors which are continually raised up from the boiling vein of bitumen in those subterranean places. But of the nature, species, and origin of bitumen, see in the following Book, in a special chapter.

§. VII. De Aquis succo lapideo, sive petrifico pollentibus.

(On waters endowed with a stony juice, or petrifying power.)

By "stony juice" or "petrific [power]" I here understand a certain humor, very well elaborated and concocted, generated from stony matter — a humor or juice which, on drying out, turns into stone. Medicated waters imbued with this juice are called petrifying [petrificae], because anything placed in them, in the course of time, they either coat with a stony crust or even convert entirely into stone. This juice is found chiefly in thermal

[§. VII continued:] waters. With some it is mixed in a twofold manner: sometimes by a true and proper mixture, sometimes by a not-true but confused mixture. We give an example of the former mode in a plant: for if you give some plant a petrifying water drawn in as nourishment, then the petrific juice must also at the same time be drawn in, whereupon the plant turns entirely to stone. But if the juice has not been mixed with the water but only confused with it, then the plant, avoiding the juice and drawing in only the water, will never turn to stone, but will only clothe its stem with a stony covering.

All of this I learned by experience on my journey through Etruria. There, near the town of Roncolano [Roncolano] in the territory of Siena [Senense], I observed two hot springs, whose water was carried through channels to turn millstones. In these channels, sedge, rushes, buttercup [ranunculus], and similar herbs grew up with such fertility that every year they had to be rooted out lest they disturb the motion of the water. And once rooted out and thrown into a neighboring spot, I beheld, not without astonishment, all those herbs turned to stone.

[Margin (p. 250): An observation on the petrifying nature of herbs.]

When I asked the millers the cause of this, they answered that waters of this sort have the virtue that whatever herbs have grown up among the channels, or in

the water itself, turn to stone as soon as they are rooted out; but whatever herbs have grown outside the water, in the open fields, never turn to stone once rooted out. The cause of this can be none other than the following. Since with waters of this sort the stony juice — or petrific spirit — is intimately mingled, and the herbs draw in, as nourishment, the water swollen with this spirit, it necessarily comes about that the herbs, as long as they are nourished by this moisture, cannot turn to stone; but as soon as they are deprived of it, then the moisture of the petrific juice, drawn into the herbs and left, as it were, to its own liberty within them, gradually drying out, by the inborn proneness of nature, is at last converted into that from which it first proceeds — that is, into a stony substance, similar to the one from which it took its origin. This is a manifest sign of a perfect mixture with the water.

[Margin (p. 250): Why herbs do not turn to stone while they are in the water.]

But waters which are mixed with a petrific juice or spirit of this sort not perfectly but by a certain confused manner do not turn to stone throughout their whole substance, but are only coated as it were with a certain stony crust. There is in Etruria, near the Castle which takes its name from a Hill [a castle called "del Colle"], a very limpid little river, which, a short distance after its source, flows down into a torrent commonly called the Sena. This torrent gushes forth with a stone pregnant with a certain petrific spirit. Hence the little river, as soon as it is mingled with it, is at once imbued with the petrifying quality. Indeed, all things that remain in that water — such as wood, herbs, fronds, and the like — do not turn to stone, but are merely coated with a stony crust, the substance of the wood and herbs remaining intact. This indicates that the petrific juice is mixed with waters not perfectly but, as we said, only confusedly. But on this marvelous petrefactive quality, fuller occasion for discussion will be given in the following [Book], in the chapter on petrifications [Cap. de impetritis].

§. VIII. De Aquis metallicis.

(On metallic waters.)

Waters are called metallic which exhibit the properties of gold, silver, copper [aes], iron, tin, and lead. But whether metals can be truly and properly mixed with waters is a matter of great controversy among the metalloscopist philosophers [Philosophi Metalloscopi — those who investigate metals]. The principal ground of the negative opinion is this: first, that on account of their indomitable hardness they cannot perfectly communicate themselves to waters;

for if you were to keep cold water for even a hundred years in a golden, silver, or leaden cup, etc., you would still find no indication of any mixture.

[Margin (p. 250): Metallic waters.]

But we subscribe to the affirmative opinion. As regards gold, it is certain that it undergoes some mixture with the liquor — if not a perfect one, at least a confused one. This is plain from strong waters [aquae fortes], in which gold is wholly resolved into imperceptible atoms; and plain too in chalybeate and iron waters [aquae chalybatae et ferratae], which are imbued with the virtues of iron or steel, most wholesome for hypochondriac obstructions. Let us therefore explain how waters can be mixed with metals.

I say that metals which are solid and already brought to perfection by the purgation and refining of fire scarcely — if at all — admit any mixture with waters, unless decoction is applied. For by this means the metallic spirits are roused and communicate themselves in some way to the waters, as experience teaches in chalybeate waters. Secondly: since in the subterranean veins metals are not so solid and hard, and do not have their due perfection — being still endowed with much moisture, and soft after the manner of earthy clods — it can happen from time to time that, with caustic waters flowing in, the gold-bearing spirits are separated, and together with the scraped-off particles of gold, as soon as they insinuate themselves into the hot waters, communicate to them by some mixture, of whatever quality it may finally be, their own virtue. And in this way I judge that the Baths of Bipera [Thermae Biperinae] in Helvetia, and any others found elsewhere, possess the faculty of gold.

[Margin (p. 250): Whether gold can be mixed with waters.]

Since in some places silver thermal springs are found, it may reasonably be asked whether silver can truly be mixed with waters. Fallopius denies that it can be mixed with waters, on account of the supreme viscosity and hardness it possesses. We say that cold waters — or those which from time to time flow together after the manner of streams in silver mines — are incapable of mixture; but if the silver spirits, dissolved in their proper veins by the heat of subterranean fire or by the virtue of caustic waters, are mingled with thermal waters, I have no doubt that these too are tinged with the virtue specific to silver. And silver reduced to a calx and mixed with water, [I have no doubt, abundantly]

[Margin (p. 250): Whether silver can be mixed with waters.]

[§. VIII continued:] proves it more than sufficiently. But of these things more in the chapter on silver and its tincture.

Whatever has been said of gold-bearing and silver waters is likewise to be said, in the same way, of waters bearing brass [aeratae], iron [ferratae], tin [stanneae], and lead [plumbeae]. These, as has been said, are not mixed with any waters as to their substance, but as to the power communicated by the spirits existing in them. For thermal lead-waters [thermae plumbales], which are found here and there in Germany and Lorraine [Lotharingia], are not called "leaden" from lead because traces of leaden substance are found in them, but because they exhibit the power and property of lead — and thus contribute greatly to driving off Saturnine diseases [Saturnini morbi — disorders associated with lead, the metal of Saturn]. To which is added that, the softer the metals are, the more easily they communicate their power to the waters. And let this suffice concerning the mixtures of waters.

[Margin (p. 251): On lead-waters in Germany and Lorraine.]

CAPUT IV.

De Mixtura Aquarum Medicatarum

ID EST, Quomodo et qua industria, quatenus Mineralia ac Metallica corpora cuivis Aquae medicatae insint, per varia Experimenta cognosci possit. (*On the Mixture of Medicated Waters — that is, by what means and what skill it can be recognized, through various experiments, which Minerals and Metallic bodies are present in any given medicated water.*)

It is indeed a matter of great moment in medical practice to pass an exact judgment about medicated waters, since on this depends the whole well-being of the sick who use them. And although many writers have prescribed various ways of recognizing them, it has nevertheless seemed good to me to set down here some new experiments, not observed by others, so that on this point our reader may find nothing in this subject not most exactly discussed on every side.

[Margin (p. 251): Of great moment is the knowledge of what each medicated water contains as its mixture.]

Now since the virtues and properties of thermal waters consist especially in that tempering which the waters themselves have acquired from the mixtures of earthy clods and minerals, the first method of recognizing the mixtures must be by way of experiment, together with an exact knowledge of minerals — a method

that must necessarily be ready at hand for anyone approaching this Corinth [adeunti Corinthum — alluding to the proverb "not everyone may go to Corinth," i.e. this is no easy undertaking]. The method is accomplished in a twofold way. The first is carried out by the whole ministry of the senses; the other — which natural philosophers call *a posteriori* — is gathered from the quality of the residues that the channels leave behind them. We shall set forth both in a few words.

[Margin (p. 251): The virtues of waters must be sought by sense and by reason.]

There is implanted in the nature of human beings a power of knowing from things evidently apparent and sensible, through which they not only track down the causes of things but seem plainly to know them, when reason agrees with the senses. Therefore the substance of waters whose mixture — and consequently nature and property — you desire to know must be explored: namely, how much it seems to differ from simple water in weight, color, taste, odor, and finally the quality of touch. This substance for the most part prides itself in a twofold endowment. One is elemental, by which each thing operates by its qualities — hot, cold, dry, moist; the other is specific, which some also call celestial, superior to all the powers of the elements and to all the conjectures of the senses, inasmuch as it betrays itself only in marvelous effects.

[Margin (p. 251): The virtues of things [are known] by sense and by reason. The specific virtues of things.]

If [this specific virtue manifests itself] in any class of mixed things, it certainly exerts itself most of all in medicated waters, as will afterward be shown; and indeed it extends so far that — not to say any [mineral] spring, but not even a simple-water spring — can be met with which some ray of celestial favor has not breathed upon and endowed with some singular benefit. Yet the investigation of these is the more difficult, the more inaccessible are the inmost chambers of their causes. Added to this is a certain infinite variety of the mixtures shining forth in waters, in which — just as the faculties do not consist of one single degree, nor have the same efficacy in one spring as in another — so the difficulties are doubled.

Physicians, for the most part content with the knowledge of the primary qualities, distributing the use of the discipline through certain degrees, as it were, of heat — from the first to the second, from the second to the third, and thence to the fourth — estimate by a quite fallacious conjecture to what action and efficacy each one attains. Then, having learned the connection of the primary qualities

among themselves, they proceed in the order of nature to the compound and consequent operations: namely the effects of heating waters — rarefaction, fusion, digestion, and attenuation; of moistening waters — softening and soothing; of cooling waters — repletion and distension; and finally of drying waters — astringency and condensation, and other such things, they investigate.

[Margin (p. 251): The difficulty of estimating the virtues of waters. The degrees in the powers of waters.]

From these, finally, they proceed to the third class of operations — those, namely, which result from the secondary qualities among themselves and from the virtue of the primary ones — which, taken inwardly, cleanse, lubricate, loosen the bowels, provoke vomiting, and stir up the viscera of the body by similar means. Thence, advanced to the fourth class of operations, they discover indeed notable powers; but on account of hidden reasons and the almost inexplicable connection of the parts, [a power] deduced from a likeness of the whole substance, scarcely thus far — except by a few, whom Divine Goodness with excel-

[whom Divine Goodness has endowed by their] surpassing subtlety of mind with knowledge of them. Of this kind are the waters whose powers operate through the hidden signatures of nature. [Margin: The wondrous effects of certain waters.] Some of these break up stones in the bladder and kidneys; some cure epilepsy; by some occult property others act on particular organs; some induce madness, bring on forgetfulness, and dull the wits; some provoke sneezing, hasten baldness, draw tears, and stir laughter; still others make women who suffer from sterility fertile. To this same class we may refer all waters of a deadly quality. The reasons for these effects I shall set out, God willing, in what follows, so far as the weakness of my own understanding will allow.

This, then, is the procedure physicians usually follow. But amid the great perplexities of the physicians one must hold fast to some sure rule that sheds undoubted light on the matter. Most of the Peripatetic philosophers attach great weight to sense-experience. By touch they classify waters as hot and cold; by weight as light and heavy; by taste as sweet, bitter, acid, or sharp; [Margin: Knowledge by the primary qualities is not sufficient.] by color as clear, turbid, blue, bright, black, and tinged with various other colors; by smell as sulphurous, bituminous, and the like, of a most fetid stench. Yet no one should follow this as a sure and infallible rule. For although many waters can be recognized by their color, we still cannot be certain whether the color derives from one mineral mixture rather than another — there are many substances that tint water with a similar color. [Margin: The intimate qualities are to be known.] If you consult the

taste and detect a certain sharpness, you still cannot tell whether it derives from salt, from alum, from niter, or from vitriol, or from all of these mixed together, unless you look into their inmost properties. For although they all bite the tongue with their sharpness, they must be distinguished by the differing faculties they possess. Salt waters, when drunk, strengthen the stomach, whereas nitrous waters by contrast upset the stomach and rather forcefully stir up phlegmatic humors. The former make the hands rough after washing in them; the latter, by their detergent or cleansing power, leave them smooth and soft. But just as the judgment from roughness is deceptive here — since many minerals roughen the hands by their washing — so too the softness and smoothness of the hands that niter produces by its cleansing power belongs to many other substances as well, such as lime, ash, and lyes. Aluminous water is told not by smell but by taste: it has an astringent power without bitterness, yet it bites the tongue and palate remarkably and sets the teeth on edge. But since many other substances produce the same effects, no firm judgment can be formed from them either. Vitriolic and bituminous waters are recognized by taste and smell: the taste strikes the tongue with a certain sharpness, the smell with a most foul stench. And so, unless waters are recognized from the whole complex of qualities proper to each thing mixable with them,

EXPERIMENT I.

To recognize the mixture of waters by boiling.

Take a glass vessel, or at least an earthenware one coated with glass inside. In this vessel let medicated water — of whatever kind it may be — be boiled down to the consumption of a third part, then let it stand for three days, until it is separated from all its dregs, leaving only the sediment. But take care not to move the vessel in any direction, for in that way the dregs would be mixed up again; and by this care the water will be separated from the dregs that have settled.

[Margin: A method of recognizing the mixture of waters by experiment.] Take from a coarser filter a cloth, which you will fashion with scissors into the shape of an inverted pyramid; dip the apex of this for some distance into the boiled water, but let the remaining end of the cloth, wetted beforehand, hang outside the vessel. In this way it will come about that the wetted end hanging outside draws the water up the other end of the filter, which we immersed in the water, and so the whole and only the water will gradually pass of its own accord through the run of the filter outside the vessel, with the sediment alone remaining behind. This sediment, exposed to the rays of the sun, will soon reveal the various mineral admixtures, in the manner to be explained a little later.

EXPERIMENT II.

To recognize the mixture of waters by evaporation.

Take a glass vessel with a widely open mouth, of the kind that urinals usually are, coated with a lute made of flour and egg-white according to the rules of the art. Let this be immersed up to its middle in another earthenware vessel filled with sand, and being filled with medicated water, together with the earthen[ware vessel]...

[continuation on p. 253, second part — Experiment III] ...[let it be set] either in the sun, or in some other warm place not exposed to any powders, with the mouth open during the day, but at night or when the sky is rather cold, lest through lack of heat any separation occur. Once the water has been evaporated by this means, let the dregs or sediment be dried in the sun, and you will gather a mixture from the scrapings of the various minerals, as we shall explain later. This experiment has this attendant difficulty: that along with the water a great quantity of the mineral spirits also flies off — which does not happen in the preceding experiment.

EXPERIMENT III.

Chemical.

To recognize the mixture of waters by distillation.

I shall set down here the most certain and reliable experiment of all, by which not only the particles of the individual minerals mixed into the waters, but also the spirits and vapors dominant in them are discerned by a truly fine method and by the infallible balance of judgment. Proceed as follows.

Diagram. A distillation apparatus for the chemical analysis of medicated waters. At the lower part is a cylindrical brick furnace (A) with a draft-hole or vent at its base. Standing within the furnace is a sand-bath vessel; above it sits a flask containing the medicated water, surmounted by an alembic head whose beak conducts the distillate through a tube. The tube passes through a wooden cooling-vessel filled with cold water, and the condensed water with its spirits descends into two receiving flasks at the right, set on a bench. The figure carries the letter-labels keyed to the text below.

- A (lower body of the furnace): the furnace itself, with its fire-chamber and a small arched stoke-hole at front

- B (lower left of furnace): the draft-hole or air-vent that animates the fire
- C D E F (mouth of the furnace / sand-bath): the earthenware vessel set immediately over the fire, filled with sand
- G H (within the sand-bath): the vessel holding the medicated water
- I (upper, the still-head): the alembic head ("capitellum") fitted over vessel G
- K (the beak/spout of the still-head, "nasus")
- L (the bend of the conducting tube)
- L M (the run of the glass tube carrying the vapor onward)
- N (the wooden cooling-vessel filled with cold water, through which the tube passes)
- O, P (the two openings of vessel N, tightly closed)
- M (the receiving flask at the right, into which the condensate descends)

Proceed thus. With the little furnace A prepared, its fire animated by the draft-hole B, into its cavity let there be placed an earthenware vessel C D E F, filled with sand up to a certain point; into this sand let there be immersed, up to its middle, another vessel of narrower neck, which we have marked with the letters G H, filled with medicated water. Over this let there be set the still-head I, fitted with a beak K, joined to vessel G at the point H with lute and bandages, so that nothing can escape from it. Into the beak K of the still-head I let another glass tube be inserted at L, sealed with the same care, so that nothing can evaporate from there either. Finally let this tube L M pass through a wooden vessel N filled with cold water; and with both openings O and P of vessel N exactly closed, you will have everything prepared for investigating the mixtures of the waters. For the fire kindled in the furnace A, once the sand of the vessel C D E F (which is set immediately over the fire) has been heated, will heat the medicated water enclosed in vessel G; whereupon the water, thinned into vapors, as soon as it has entered the still-head I, will be condensed by the cold into water,

EXPERIMENT IV.

How it may be discovered that a metallic tincture is present in medicated waters.

Since metallic species can be recognized only from the corruption of the sediment — so that any metal present in the waters is turned into its own characteristic residue, from which it is then known that this or that metal is present, and in this way iron, silver, gold, chrysocola [borax/copper-green], copper, and the like become known — and since, to make each of the enumerated metals turn into its

own residue, a certain medicament is needed, that is, a corroding liquid, such as the corroding waters of the chemists [aquae erodentes] or the strongest and sharpest vinegar: the method of proceeding is as follows. Let the metallic sediment of the water be poured into the said vinegar, or into water endowed with caustic power; and once you have inspected the water, if you observe that a rust has formed upon the sediment, you may be sure that the medicated [Margin: A method of recognizing whether metals are present in the waters.]

CAPUT V.

Description of the Hydrometer

By which the heaviness and lightness of waters is investigated.

A German craftsman, Johannes Toldenus [Johann Tölde], once used a similar instrument for the mixture of salt water, and from him Cabeus [Niccolò Cabeo] received it. But since there has scarcely been anyone who rightly understood its principle, I shall teach here, with all the brevity I can, the manner of constructing it. Its use is only in those waters that have something salty mixed in, and also in investigating the lightness or heaviness of fresh waters, arising from whatever cause.

[Margin: Construction of the hydrometer.] 1. Let there be made a glass phial, paunchy in the manner of a sphere, with a very thin neck, which nevertheless should not exceed a hand's-breadth in length. In the center of its base insert a hook, from which you may hang a weight when needed, and you will have the instrument ready. Its figure is A B.

Diagram. A graduated glass hydrometer in the shape of a wide-mouthed goblet — a bulbous phial with a very thin neck rising up its center, a small bulb at the bottom of the neck, and a hook below for hanging a weight. The central neck-tube is divided into graduations marked with a sequence of letters from top to bottom.

- A (top of the central neck): the mouth/top of the graduated tube
- (descending the neck, the graduation marks lettered in sequence): d, e, f, g, h, i, k, l, m, n, o, p, q, r [the small graduation letters read top-to-bottom; lower letters faint — q, r [?]]
- B (the bulb at the foot of the neck): the spherical body/float
- C (below B, at the hook): the point where the weight is appended

2. Choose for yourself, as far as you can, the clearest water, thoroughly cleansed of all the dross of salt and earthy impurity. Immerse the phial in this water; this will be done if you always pour the water into it little by little, until, by sinking beneath the water, it leaves only the mouth A uncovered. This done, weigh as exactly as possible the whole of the water contained within the phial, and whatever weight the water weighs, that much weight you will hang on the hook at the bottom of the phial at point C. Then you will divide the neck or tube N A into its degrees by this method.
3. Take a basin, as capacious as possible, which you will fill with the purest water, as before, and whose bottom should be a little deeper than the length or height of the phial C A. Weigh this water beforehand as exactly as possible — for in this lies the whole crux of the business — and let it be, for example, 100 pounds. And since one pound consists of 12 ounces, 12 multiplied into 100 gives 1200 ounces of water.
4. This too being done, take a quantity of the best-prepared salt, dried and reduced to the finest powder, suited to the operation about to follow. From this salt set aside ounce-portions in proportion to the water just weighed — that is, first weigh out one pound of salt in a balance, placing the water in one pan and the salt in the other, until they balance; then likewise weigh one ounce of water against one ounce of salt; finally set aside separately as many ounces of salt as you judge you will need in the operation. With these things set out, you will begin the graduation of the phial thus.
5. Place the phial A C, fitted with its weight C, into the basin, and it will be submerged, according to the second operation, up to the mouth. This done, throw into the basin's water 1 ounce of the salt set aside, and when it has mixed, it will make the water heavier, whereupon the phial, lifted, will rise somewhat — for example, to d; mark that point carefully. [Margin: A method of graduating the phial by the lightness and heaviness of the water.] Again throw another ounce of salt into the basin's water, and the phial will rise higher — for example, to e; mark that point. Then again throw another ounce of salt into the basin's water, and the phial will rise to f; mark that point likewise. And in this way you will always throw further ounces, one after another, into the water, until the phial has emerged with its whole neck, marking with particular care the points where the neck touches the water; and with the several points assigned their numbers in order, you will have the instrument prepared — whose mouth had to be closed at first, lest any water penetrate.

Use of the Instrument.

If you wish to know how much salt any salt water — whether it be sea water or spring water — has mixed in it: then immerse the phial together with its weight in it, and at once the point where the water touches the neck of the phial will show in numbers the quantity of the salt mixture contained within the salt water, of a bulk as great as the water of the basin was, and of a weight as great as the said water weighed. For what [holds] of a fixed and determined weight of any...

COROLLARY.

From this you will learn, first, how much excess or deficiency of salt a salt medicated water has. Second, given a hundred pounds of water of this kind, you will know how much salt you can extract from it. Third, whether sea water is saltier than spring water, or the contrary. Fourth, from this you will learn, given whatever sweet and drinkable waters, how much one is lighter than another: for that one will be lighter in which the phial has sunk more deeply, and heavier the one in which it has risen higher. [Margin: The heavier the water, the more easily a body settles in it; the heavier, the more difficultly.] For the heavier the water, the more the phial will sink; and the lighter it is, the less it will resist the sinking body. For the heaviness of drinkable waters depends on the quantity of salt mixed into them, which, though it may deceive the taste — since one does not perceive the salt mixture — nevertheless cannot deceive our instrument.

Another Hydrometric Instrument.

Diagram. A glass-tube hydrometer of the form described, marked A B C. It is a long, narrow graduated tube (open at the top at A, neck A B divided into parts numbered 80, 70, 60, 50, 40, 30, 20, 10 descending), terminating below in a large spherical float B, beneath which hangs a small bulb C marked with the alchemical symbol for mercury (☿, argentum vivum / quicksilver), into which the mercury is poured.

- A (top of the divided neck): the open mouth
- (neck graduations, descending): 80, 70, 60, 50, 40, 30, 20, 10
- B (the large lower sphere): the major globe/float
- C (the small bulb below B): the globule into which quicksilver is added
- D E (marks low on the neck, just above the float): the depth-marks to which the tube is to be submerged

Let there be made a glass tube of the form you see here, and let it be marked A B C. Let this tube be open at A, its neck A B divided into any number of parts you like. Into this tube you will pour quicksilver [argenteum vivum, mercury], until you see the globe B sink beneath the water. But if the quicksilver should depress the whole hydrometer by its weight to the bottom, then you will always pour in less quicksilver, until — with the smaller globule C, affixed to the larger globe B, filled — you will keep on thinning [the charge] until the whole globe is submerged beneath the water down to D E, and you will have the hydrometer ready for weighing and testing water. But you should first test this in the lightest water; for if the hydrometer is placed in somewhat subtler water, it will be submerged still further — and indeed the deeper, the subtler the water is — and at the same time it will show on the neck the differences of heaviness and lightness. The quicksilver serves no other purpose than to keep the instrument always at equilibrium within the water.

EXPERIMENT.

Raphael Magiottus [Raffaello Magiotti], a most distinguished mathematician, in his little book *On the Heaviness of Waters by Compression* [*De renisu aquarum per compressionem*], devised something of this kind for investigating the heaviness and lightness of waters. A latticework cylinder is constructed of brass wires, conical in the form of a cage, or rather of a fisherman's creel, as appears in the present figure. Within this cage let there be placed several glass globules, perforated underneath, whose size is in arithmetical proportion.

Diagram. Magiotti's instrument: a domed, beehive-shaped wire cage (a latticework conical cylinder, like a fisherman's creel) standing on a flared base, with a ring at the top for lifting. Inside, several small glass globules are visible suspended at a level within the cage. The figure is uncaptioned and carries no letter-labels.

Into these globules thus arrayed [the creel], immerse the cage equipped with such globules into waters of differing heaviness, and the more globules rise upward, the heavier the water is in kind; the more it is lighter, the fewer rise; lightest of all when none rises. But an experiment of this sort has its own difficulties; wherefore we find the preceding instrument both more apt for use and subject to no errors. Others place an egg in the waters: if the water is of a heavier condition, it will float; if of a lighter, it sinks. But neither does this determine the precise difference of waters.

[Margin: Another hydrometric instrument.]

[Margin: Another method, used by the Grand Duke of Tuscany.] The Most Serene Grand Duke of Tuscany, Ferdinand II [Ferdinando II de' Medici], showed me another way of investigating the goodness and badness of waters, and it is as follows. He set out in order, in glass cups, waters of every kind fit for drinking — spring, river, well, lake, and the like. Then in a certain glass vessel he kept another liquid, which he poured into the glass cups set out in order; and at once, in waters of poorer condition, the water would be seen to turn to a dusky color, and in the worst even to black, whereas in the purest water it produced no change at all. From this one could at once gather the cause of so sudden an alteration: for since in the purest water there is scarcely any mineral admixture present, the liquid...

[The continuation of the preceding chapter (Caput V), which discusses the precipitation of liquids into other liquids — by which precipitation waters are turned now into a milky color, now into red, now into blue, green, purple, and similar colors.]

it could not find anything on which to act. But in the remaining waters, which were imbued with some admixture of the said mineral species, the liquid, once poured in, acted upon the various waters just as it acted upon the mixture native to it, and so likewise produced the necessary change. But just what this liquid was will be told in the following books. [Margin: The precipitation devised by chemistry.]

[Margin: See on the precipitation of liquids, where you will find certain remarkable secrets, in the Corollary, the Reader.]

CAPUT VI.

On the heat and warmth of the thermal springs and its cause, and how they are blended from minerals of such differing tincture.

Since in the preceding book, *On Subterranean Fire*, we discussed this subject most fully, nothing remains here except to lay out the knot of the matter: how the thermal waters are heated, and how they come to be steeped in so many and such great differing properties. Experience establishes that some thermal springs are cold, some lukewarm, and some so boiling hot — yet still bearable to the touch — while others seethe so violently that they instantly strip the flesh, pulp, and bones from the bodies of animals thrown into them, and consume them utterly.

[Margin: The varied differences in warmth of the hot waters.] One asks the cause.

I answer briefly, then, that all of this depends on the situation of the fire-chambers [pyrophylacia]. For if some Vulcanian workshop is placed immediately beneath the cauldron of the waters — that is, beneath the water-reservoirs [hydrophylacia] — I say that, on account of its nearness to the seething fires, which continually breathe out from the fire-chamber A through channel A B, the waters contained in basin B will take on the highest degree of heat, as happens at the Bullicame near Viterbo [Bullicame Viterbiense]. But if the said exhalations make their way through the fire-conducting channel [canalis pyragogus] L R S into the water-reservoir V, the increase of heat will likewise be less in the thermal water S, and less in W, and least in X and the adjacent thermal springs, until they are so far removed from A that, at last wholly stripped of heat, they grow cold. The same is to be said of the fire-conducting channel D G H, through which the fiery spirits, passing across, discharge themselves into the water in which it is mediately laid beneath the channel L. It is no wonder that this water should seethe. But B, since it is farther from the fire-chamber P, has this result: that as the heat gradually slackens, the water grows cold — especially if the channel V has approached through the cold waters of the water-reservoir X. For in this way, in the spring B, it will discharge itself with a notable sensation of cold. It can also happen that the cold water from some other recess Z discharges itself into B without any access of more distant fire.

Here I cannot pass over what is being reported to me as I write this. In the year 1660, in the month of June, when a vast earthquake afflicted that whole region of France that extends from the city of Bordeaux [Burdigala] toward Narbonne — [Margin: History of a terrible earthquake.] there was near Bigorre [Bigornium] a vast and lofty mountain which, by the force of raging nature, is said to have been so swallowed up that, apart from the huge lake it left behind, no further trace of it appeared. They add that the district around the Pyrenees mountains had been thickly furnished with many thermal springs; and that in one set of these, after the collapse of the mountain, waters that had previously been most fiercely boiling drew on so much cold that no one could any longer use them. The question is asked: whence that violent change of boiling waters into the coldest ones? I say that the fire-conducting channel was blocked by the fall of the mountain, and opened another channel which conducted cold waters; or, if not this, then that the waters, deprived of all heat once supplied through the fire-channel, finally passed over into their native cold.

Diagram. A large cross-sectional view of a subterranean region, drawn as a mountainous tract cut away to reveal the underground network of fire-chambers (pyrophylacia) and water-reservoirs (hydrophylacia) and their connecting

channels. At lower center the great fire-chamber A blazes; from it fire-conducting channels branch out across the section — the principal ones lettered, with reservoirs and thermal outlets distributed through the body of the earth and discharging at surface springs marked *Thermae* at the right and lower right.

- A (lower center): the great fire-chamber [pyrophylacium], shown as flames
- B (upper center): large reservoir directly above A
- D (mid-center): channel junction descending from B toward A
- G (center): channel branch
- H (upper center-right): channel branch
- F (right): reservoir
- L (lower center): fire-conducting channel near A
- R (lower left): channel point
- M, N (center-left): adjacent reservoirs
- S (center): channel point
- V (left center): reservoir
- W (left): reservoir
- X (lower left): reservoir / outlet
- b (upper left): surface spring outlet
- Z (upper left): recessed cold-water reservoir
- Q (top center-left): small reservoir near surface
- a (right, lower): small outlet point near the thermal springs
- O (right): outlet basin
- Y (lower right): outlet basin
- I (lower center): channel point near A
- T (bottom center): channel point below A
- *Thermae* (right and lower right): the surface thermal springs

vessels E, F, H, G, I — fitted with channels and filled with water. Experience teaches that the waters of the said vessels, as soon as the vaporous spirits of the seething fire reach their concave interiors, are warmed by them, and indeed all the more effectively the nearer they are to the furnace. In this way F and G will seethe more than H and I, and E most of all. All of this experience has taught me in the chemical furnaces, of which I treat expressly in the seventh book. That the same thing occurs within the earth was clear from the preceding experiment. It is therefore no wonder that some thermal springs are nearly cold, others lukewarm, and some most fiercely seething — the reason for which is plain from what has been said.

Diagram. An apparatus illustrating how vessels of water set at increasing distances from a furnace are heated to differing degrees. At the base stands the furnace **A**, its fire visible at the mouth. From its dome the vapor rises through point **D** into the bulbous head **E** above; from the lower part of the furnace a horizontal channel runs out from **C**, passing through a series of round-bottomed vessels **F**, then **H**, and on toward **I** — each successive vessel farther from the heat source and thus less strongly heated.

- **A** (base): the furnace [fornax], with fire at its mouth
- **C** (lower left of furnace): junction where the horizontal channel leaves the furnace
- **D** (above furnace dome): vapor passage upward
- **E** (top): the bulbous distilling head / vessel directly above the fire (heated most)
- **F** (right of **C**, first vessel): round-bottomed vessel
- **H** (farther right, second vessel): round-bottomed vessel
- **I** (far right): the most distant vessel (heated least)
- [The companion labels **G** are paired with **F/H** in the text; the figure shows the lettered series **E, F, H, G, I** as the channel runs out]

COROLLARIUM.

From what has been said it is also clear why in some waters springs are found of which one is the coldest and the other the most boiling hot. The channel of the colder water is farther from the fire than the other, hotter one. Moreover, it happens that the water-conducting channel [hydragogus] sometimes runs on through another cold water, and, the heat being thus extinguished, afterward pours out cold waters.

Let there be two springs **A** and **B**; let **A** be hot and **B** cold — just as in the territory of Viterbo [Ager Viterbiensis] I recall having observed them, no more than two palms' span apart. For since the fire **S**...

Diagram. A cutaway of a hillside showing two surface springs very close together — one hot, one cold — and the underground channels that account for the difference. At the left, near the surface, the fire-chamber **S** burns; its heat reaches the channel feeding the **hot spring** (labeled *Calidus fons*) at **A**, while the neighboring **cold spring** (*Frigidus fons*) at **B** is fed by a channel that runs down from a far reservoir at the upper right (point **Z**), passing through points **X** and **V** and emerging at the pebble-lined basin **P** at lower right, without taking on the fire's heat.

- A (upper left): the hot spring, captioned *Calidus fons* ("hot spring")
- B (upper center): the cold spring, captioned *Frigidus fons* ("cold spring")
- S (left, underground): the fire-chamber [pyrophylacium], shown as flames
- Z (upper right): the far reservoir feeding the cold channel
- X (right of center): channel point along the cold conduit
- V (lower right of center): channel point along the cold conduit
- P (lower right): the pebble-lined basin / outlet

is, I recall, only two palms' span distant; for since the fire S...

EXPERIMENTUM III.

Exhibiting the Mixture of Waters.

The mixture of waters is either simple or compound. It is simple when the water is mingled with only one of the minerals; compound, when with several. And the mixtures come about in the manner that follows.

From what has been set out above it is established that the earth teems with countless mineral species, so that one and the same combination of substances is never found in all places; rather, according to the variety of the differing veins, it is altogether manifold and beyond telling — with the exception, however, of sulphur and salt, which are absent from no waters, present in some with greater excess, in others with less. [Margin: The earth teems with countless mineral species.]

Now, just how mixtures of this kind come about in the subterranean womb of the Earth, I shall show by a geodetic example. Imagine, then, a vast district of the subterranean region divided by the courses of water-conducting channels [hydragogi] into various branches; within these the water runs down and is tinged by the filings and scrapings of various minerals, together with their properties. It is certain that there arises from this a vast medley of differing things and mixable species, which then, bursting out into a spring, reproduces the character of the very properties in which the species it was mixed with are strong. But let us demonstrate the matter by a model.

Diagram. A geodetic model of the subterranean water-distribution. At the center lies a single great water-source (the "hydraulicum") **A**, a roughly oval reservoir. From it channels radiate outward in all directions, each running through a vein of a particular mineral (the channel-courses are labeled with mineral names) and emerging at a peripheral spring lettered **B** through **H**. The surrounding terrain is drawn as ranges of hills.

- A (center): the central water-source [hydraulicum]
- B (lower right): a spring fed by a channel of plain (sandy/flinty) ground — yields *fresh* water
- C (upper right): spring on the *Sal* (salt) channel — yields salt water
- D (top): spring on the *Nitrum* (nitre) channel — yields nitrous water
- E (upper left): spring on the *Alumen* (alum) channel — yields aluminous water
- F (left): spring on the *Vitriolum* (vitriol) channel — yields vitriolic water
- G (lower left): spring on the *Ferrum* (iron) channel — yields chalybeate (iron) water
- H (bottom center): spring on the *Sulphur* (sulphur) channel — yields sulphurous water
- Channel labels (running across the section): *Alumen* (alum), *Vitriolum* (vitriol), *Nitrum* (nitre), *Sal* (salt), *Ferrum* (iron), *Sulphur* (sulphur), and a channel marked *Aqua dulcis* (fresh water)

Let there be some water-source A which bursts out in every direction, through the various passages of the Earth, into the various springs B, C, D, E, F, G. Now let the water pass through the passage or channel A B, which teems with gravel and sandy matter, or with very hard flints. I say that the spring B that issues from it will furnish fresh water, since the channel contains no matter, apart from those mentioned, that could tinge the water with some predominant mineral property. [Margin: The matter of some mineral tinges the water passing through it with the property in which it itself is strong.]

But let the water pass from A through channel A C, which is filled with salt: I say the spring C will be salty — that is, such as the vein is through which the brine passes. Again, let it go out from A through channel A D: I say the spring D will be nitrous, that is, tinged with nitre, by that property in which the channel it passes through, filled with nitre, is strong. And in the same way, if it has passed through A E into an aluminous vein, and through A F into a vitriolic one, and through A G into an iron-bearing one, and through A H into a sulphurous one, the springs E, F, G must likewise be steeped in that property in which the channels they pass through are strong.

You see, then, the source from which the simple mixture of medicated waters draws its origin — namely, from a simple vein of some mineral mixed with no other. From this it is also clear why sometimes, in one and the same place, medicated waters of differing properties are found gathered in different springs. So once, I recall, I saw at the town of Urb [Urbâ oppido — Orb (Urberach)?],

subject to the jurisdiction of the Elector of Mainz [Elector Moguntinus], six springs endowed with the most diverse properties, set no more than four paces apart from one another. The cause is that the water, as it passes through different channels filled with different mineral species, is tinged by them, and in the different springs displays such a property as the channel — that is, the ore — through which it passes presents.

You see, then, the mode of simple mixing. Let us now proceed to the compound. And first I would have you know that subterranean waters make their way not through a single water-conducting channel only, but — just as on the outer surface of the Earth some principal river is made up of various streams — so this underground flow is divided branch-wise into various streams of water and forks apart. These branches, just as they are tinged by the various species of the various minerals they pass through, are likewise, when they are channeled together into some single spring, filled with a manifold progeny of differing properties. [Margin: How the medicated waters come to be pregnant with so manifold a progeny of properties.]

To prove the matter by an example: from A, passing through the sulphurous channel H, the flow forks into K and I — there through a salt-bearing vein of the channel, here through a nitrous one. Hence the sulphurous matter of the channel...

[Margin: How a manifold mixture arises in the waters.]

channel H, mixed, will make with the channels K and I a mixture of salt — namely, and of nitre — yielding sulphureo-salt-nitrous waters. Again, channel K, forking into L and M, will, striking a vitriolic vein on the one side and an aluminous one on the other, produce in springs L and M (tinged by the confluence of the preceding waters) — in M indeed a sulphureo-salt-aluminous water, and in L a sulphureo-salt-vitriolic one.

Diagram. A larger, more elaborate geodetic model of the compound mixing of waters. A single source **A** at the left feeds a branching network of channels that fork and cross through veins of many different minerals (each channel-segment labeled with a mineral name) and finally gather into the great collecting spring **R** at the right, which thereby holds all the mineral species and properties combined. The terrain is drawn as encircling hill-ranges.

- A (left): the source [hydraulicum]
- H (center-left): the sulphurous main channel leaving A
- K (center): fork junction

- I (lower center-left): fork junction
- L (right of center): spring/junction (sulphureo-salt-vitriolic)
- M (center): spring/junction (sulphureo-salt-aluminous)
- N (center): junction
- O (center): junction
- P (upper center): junction
- S (lower center): junction
- T (lower center): junction
- R (right): the great collecting spring, holding all properties combined
- Channel/vein labels: *Sulphur* (sulphur), *Sal* (salt, appears twice), *Vitriolum* (vitriol), *Alumen* (alum), *Ferrum* (iron), *Nitrum* (nitre), *Aurum* (gold), *Bitumen* (bitumen), *Plumbum* (lead), *Cadmia* (cadmia / calamine), *Calx* (lime, appears twice), *Ochra* (ochre), *Aerarium* (copper-ore / "brass-vein")

vitriolic. Again, the subterranean stream L, forking, passing into an auriferous vein at L on one side at O, and into an iron-bearing vein at P on the other, will produce in spring P a sulphureo-salt-vitriolato-ferruginous water, and in spring O it will bring forth a sulphureo-salt-vitriolato-aureous mixture. And what is said of these is to be understood of all the remaining streams — K, M, N, and H, I, Z, S, T — until, all of them being channeled together into R, they constitute, out of all the minerals they pass through, the spring R, compounded of all the species and powers of minerals.

You will achieve the same by art as nature does, if you channel together the waters from some spring, through different channels, into some single spring. For if you fill the individual channels with different ores — salt, nitre, alum, bitumen, vitriol, and so forth — the water diffused through these channels and mingled with the minerals will at last constitute a spring stocked with all the said species. So that from this it may be plain even to the eye what art and industry nature shows in producing the mixtures of waters.

From this, too, the reason for the colors with which different waters are imbued is clear. For the water will take on such a color as the mineral clod is which it passes through [Margin: The waters take on the color of the mineral they pass through]: if yellow, yellow; if red, red; if black, black; blue if it is blue; green if green; and finally, if white, it will yield a milky color. Each single mineral will give its own color in the simple medicated waters, but in the compound ones a variegated mixture. But let this suffice concerning the mixtures of waters.

SECTIO III.

DISQUISITIO

DE THERMIS

And On Medicated Waters, and Their Marvelous Powers and Properties in Particular — All of Which Are Shown to Take Their Origin from Subterranean Sources.

CAPUT I.

On the principal thermal springs, or medicated waters, that occur here and there on the surface of the Geocosm.

Since the diversity and variety of the mineral bodies of the earthly clods is not better understood than through the diversity of the medicated waters which nature everywhere produces, I judged that it would certainly be worth my while if, in this place,...[the principal...] ...of the more celebrated thermal springs, leaving out countless others that have not come to my notice, I might attach a catalog. For from this it will become plainly evident, beyond what we have already so laboriously demonstrated in the preceding pages: **First**, that there exists a certain perennial subterranean fire which, by its heat, suffuses such an innumerable multitude of thermal springs, and that this fire holds dominion over the Earth. **Second**, that there are likewise innumerable subterranean reservoirs of water [hydrophylacia], which—heated by that inseparable companion, the fire—break out everywhere throughout the body of the Earth, which is everywhere pierced by channels both for conducting water [hydragogis] and for conducting fire [pyragogis]; exactly as the human body, a microcosm, is pierced by the innumerable ducts of veins and arteries and by the recesses of its principal members. In this the wonderful, ineffable, and incomprehensible variety of all things—a variety hidden within minerals—shines forth most especially. And just as these things everywhere present themselves to view, so they display a certain marvelous administration of the subterranean economy. With these points established, let us now at last take up again the web we have begun.

§ I.

On the Thermal Springs of Europe, and first on the Springs and Thermal Waters of Portugal and Spain

Europe contains Portugal [Lusitania], Spain, France [Gallia], Italy, Germany, Hungary, Poland, Illyricum, and Greece, together with the adjacent islands of Sicily, England, Scotland, and Ireland [Hybernia]—all of them everywhere packed with innumerable thermal springs, as will be clear from what follows. In Portugal there are 8; in Spain 40; in France 45; in Germany 120; in Italy 86; in Hungary and its neighboring places 9; in Poland near the Carpathians several; in Illyricum 16; in Greece and its neighboring islands 22—all of which correspond to one another through the hidden passages of the earth, and are animated and preserved by one and the same fire distributed through its various fire-reservoirs [pyrophylacia], exactly as in the human body the animal heat, through diverse channels and the branching ducts of the veins, animates, directs, and stirs all things toward the effects intended by nature.

And to begin with the thermal springs of Portugal, let the reader know that nearly all the islands of the Atlantic Sea—such as the Canaries, the Madeiras, and those they call the Azores—are most abundantly stocked with thermal springs, as the annual reports of our Society [the Jesuits] amply attest. Nor is this surprising, since they are rich in the most copious sulphur, salt, niter, alum, and bitumen, and nourish enormous fire-reservoirs beneath them, by which they are perpetually agitated. But on these matters see the fuller account in the preceding pages, and likewise what was treated in our *Itinerarium Submarinum* [*Submarine Itinerary*].

Among the other marvels of Portugal there is, first of all, that wonderful lake admirable on the summit of Mount Erminius [Serra da Estrela], which, as Antonio Vasconcellos [António de Vasconcelos] testifies in his *Descriptio Lusitaniae*, is theologian of our Society, is of such a nature that when the Ocean swells, it too swells and heaves up at the same time—a clear sign that it is connected to the Ocean by hidden water-conducting passages. [Margin: Mount Erminius in Portugal always heaves.] The same may be said of the wonderful well next to the Monastery of St. Jerome, cut entirely with cells and dwellings into the living rock on Mount Sintra, in which the waters swell at the rising of the sea. Only the lake of Interamna [Lamego region?] in Portugal is no more than 18 leagues long, as Vasconcellos again testifies, and contains twenty-five thousand perennial springs—an abundance comparable to none in Europe. [Margin: 25

thousand springs in Portugal.] For they have wonderful powers on account of the golden sands that the Tagus pours forth, and it shares these riches with the neighboring lands on every side. [Margin: The gold-bearing Tagus.] Among these, too, there are many thermal springs, noted by name throughout all Portugal for the celebrity of their fame. [Margin: Thermal springs of Portugal.] Such are the Caldas near Óbidos, memorable for the hospital [Xenodochium] built for the use of the sick by Eleanor [Leonor], wife of King John II [João II]. Next come the Baths of the Algarves [Algarbii] near the town of Alvor, in which King John II is said to have perished while seeking a remedy for a lethal poison. [Margin: Thermal springs of the Algarves.] But leaving aside the others—those in Beira and in the Convent of Lafões, and still others met with here and there—one prodigy must be set forth in this place, which shines out in a spring four leagues from Coimbra [Conimbrica], near the towns of Cantanhede [Cutanhedum] and Cadima. The spring is no more than a foot deep, sandy and somewhat turbid, called in the vernacular *Fervenças*, so named from the perpetual boiling of its waters and sands, by which it seethes. Its nature is such that whatever you throw into it, it swallows up; and it cannot sufficiently be made apparent where it rolls away the tree-branches thrown into it, since more than once a whole tree, applied for the sake of experiment either by its lowest roots or only by its topmost foliage, has been so greedily devoured by the trunk or by any branch whatever that it could not be torn out by any force, and within a brief space of time not even the tiniest twig appeared. [Margin: Marvelous properties of the spring.] It also happened that when a pack-animal's foot slipped, the water in a brief space so powerfully drew the beast to itself that it could scarcely be dragged away by any skill or strength from the force of the devouring water. This is from Vasconcellos, whose explanation we shall disclose in what follows, in the section on miraculous springs.

The chief thermal springs of Spain are the *Caldas del Rey*—so the village is called, beside which they boil up; situated beside the road that leads from Compostela [Santiago de Compostela] into Portugal, it is renowned for the distinction of its baths, of a warming and digesting power. [Margin: Thermal springs of Spain.] From here, at the town of Tralus [Caldas de Reis area?], 30 stadia distant, another most celebrated bath occurs, of all the greater usefulness in that, owing to the natural mixing here and the confluence of various springs, each person can prepare and temper the waters at his own discretion: they warm, dry, and digest. Again, beside the city of Orense [Ourense] there bubbles up a water hot and exceedingly rich in a vein of cinnabar [minium]; and although it smells somewhat of sulphur, yet when it has cooled... [Margin: Thermal springs rich in cinnabar.]

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and settled, it presents itself so pure, clear, and limpid that it is fit not only for that purpose but also for the use of food and drink; and the ancient remains of baths sufficiently show that it was employed by the old Romans for luxurious use. This too is remarkable: that from the very middle of the river Minho [Minus]—on which the thermal springs lie—the hottest waters burst forth in great quantity. These prove that the waters have their outlet from the deepest bowels of the earth, in the very bed of the river, and that they penetrate the river's waters in an uncommingling abundance. There are also other springs in this Kingdom of Galicia, near the city of Viana and in the mountains of Suidae [the Sil region?]. From here, as you set out toward Castile and Baetica, you will find everything full of thermal springs. Between the borders of the Tarraconensian region and Navarre, where the Ebro [Iberus] flows not far off toward the village of Fitero, baths of great virtue are found here and there—as also everywhere along the roots of the Pyrenees. In the territory of Seville [Ager Hispalensis] in Baetica many spring up, which are perhaps those called Caeparia or Anthetana by Pliny [*pace Plinius*].

[Margin: The mountain commonly called Sierra Morena, and its marvels.]

In the middle of Spain there is a very high mountain which, by its long course westward, divides Castile from the Kingdom of Granada; from its upper side the river Guadiana [Ana] flows, while from its lower side the Guadalquivir [Baetis] flows out more openly into the Mediterranean. In this mountain I judge there to be the workshop of Vulcan, from which both metals of every kind are forged, and which, pregnant with a wonderful variety of waters, washes all of Spain with beautiful rivers. That the metals there bring forth abundant offspring, the barrenness of the mountain sufficiently shows, inasmuch as in it trees are condemned to perpetual exile, and only rough and rocky retreats hold sway; livid in color and dark of face, the mountain seems as it were to mourn the reproach of its own sterility—not unfittingly called the *Sierra Morena*, so named by the natives from *Mauro* [Moorish], that is, from its black color. In the rock-base of this mountain there are seen very deep entrances, and among others, next to the village of Almadén, a huge cavern stretching back into a recess of nearly 50 miles, in which a great many very deep wells are seen. [Margin: Wells of quicksilver, or of mercury.] From these an immense quantity of quicksilver [argentum vivum] is drawn up by a teeming throng of workmen and diggers, who—either hired at a great price, or condemned to these mines to expiate the punishment of some great crime they have committed—dragging out a wretched existence with

trembling bodily frame and convulsed nerve-tendons, at last redeem the brief span of their life by a calamitous death. The earthen clods that are dug, and that exude quicksilver, are for the most part stony and of a reddish color; but on the outside, scorched by the heat, the clod blackens, and to those looking from afar it appears of a livid or iron-rust color.

There are also seen four springs of acid waters, all of different power, around the rock-base of the mountain—a sign of the diverse mixture of other latent metal-and-mineral veins within the mountain. These waters, however, having laid aside through filtration the malignant faculties of the salubrious clods, are used by the natives with great benefit in stubborn diseases of the stone [calculus] and the bladder.

Another spring of acid water is observed near the town of Almagro, whose water is excellent and so agreeable to drink that—as Baltasar Ruiz, a native of the place and describer of this spring, testifies—of the roughly fifteen hundred families of that village, the greater part live in perpetual abstinence, all drinking of wine being excluded, and delight in the drinking of this spring alone; and with so great a concourse of men that around midday, from the frequent drinking, the whole spring appears as if drained dry. [Margin: Spring near the town of Almagro.] A similar spring is seen near Bolaños [Bolegnum], a town not far distant from the preceding. There is also a spring of similar condition three miles from Toledo, differing in this from the preceding, that the water drawn at the surface of the spring is exceedingly sweet, but if anyone lowers a bucket to the very bottom of the well, he will draw up a most acid water. The reason for this is not difficult to discover: since both sweet and acid waters perpetually flow into this spring or well, it happens that the acid ones, on account of the abundance of various salts, with their innate heaviness immediately sink to the bottom, while the sweet ones, being lighter, seek the surface.

Departing from here through the remaining tracts of Spain—whether to the north, or to the south, or finally to the eastern tract of the Pyrenees mountains—everywhere you will find a multitude of baths, so that you can scarcely move your foot ten leagues without ever finding new and ever-new spectacles of thermal springs. These indeed I would set forth here in order, but lest I should stuff my account with matters already treated elsewhere, I have deliberately resolved to pass them over in silence; for they take their origin alike from the Pyrenees and from the mountains of Galicia, Castile, and Asturias—mountains crammed with minerals—through subterranean passages.

[printed p. 262 — header "LIBER QUINTUS, Sect. III"]

§ II.

On the Springs or Medicated Waters of France

That whole part of France bounded by the Pyrenees mountains so abounds with the waters of thermal springs and medicated springs that there is scarcely anyone who could count them. [Margin: The immense multitude of medicated waters at the Pyrenees mountains in France.] Indeed, from Bayonne all the way to Narbonne a continuous vein—or sulphurous channel [cuniculus]—constituted out of mountains pregnant with sulphur, niter, alum, bitumen, and vitriol, runs through various subterranean ducts and branches; and the immense earthquake that arose there this year, 1660, and afflicted the region with horrible disasters, amply demonstrated this. As a result, besides the deepest chasms, dried-up rivers, and mountains partly cut down and partly swallowed up, the thermal springs themselves degenerated—their former channels either changed or blocked—and in a sudden metamorphosis the most boiling-hot waters turned into the coldest. But, leaving aside countless others, we shall here recount only the more important and more celebrated thermal springs.

The thermal springs at the village of Dax, situated among the Pyrenees mountains, are sulphureous-bituminous, so tempered by nature that there is no disease of those they call arthritic [the arthritics] that they do not cure. These nonetheless sometimes grow so hot that not only the waters themselves but also the surrounding fields seem to burn—which plainly hints at the traces of a fire-reservoir latent somewhere beneath the mountains.

These are followed by others, commonly called *Orentaine* [Ourentaine?], most celebrated thermal springs, and most salutary for driving out diseases of the kidneys and liver. There are also, at Mount Balaruc [Balarva] near Béziers [Biterrae], a singular remedy against spasm, paralysis, dropsy, and arthritic diseases. Then there occur, at the roots of the Pyrenees mountains, the baths commonly called *de Montferran* [Montferrand], of the same virtue and faculty as the preceding. Near these accede the thermal springs commonly called *de Baignaires* [Bagnères] at the village of the same name, and others called *Dencausse* [Encausse], celebrated for the great concourse of people, of admirable virtue—even on this account, that they confer fecundity on women laboring under sterility, and most effectively cure the other infirmities with which women are commonly wont to be afflicted; the reason for which we have set forth elsewhere. Not far from here, new baths occur in a pathless and deserted place, commonly called *Barèges* [Baregues], which—though they are approached with

great inconvenience to the sick—nonetheless easily make up for it by their faculty of expelling all diseases. And these are the more celebrated thermal springs in this sub-Pyrenean mountain tract, which, as they draw their origin from subterranean passages, so they seem to propagate it further still into the mountains of Auvergne [Alvernia].

There are seen, moreover, in the mountains of Auvergne and their district, six especially celebrated thermal springs; the first of which are those commonly called *de Vic-le-Comte* [Vieleconde], which—precipitated from an immense rock with great roar and heat, and as it were through two spigots—prepare a suitable bath below for all who are weighed down by a stubborn filth of humors. This spring consists of vitriol; the sign of which is that, when distilled, it leaves pure vitriol at the bottom of the vessel, and if anyone places gallnut [galla] in the waters, he will at once find the water itself turned into ink [atramentum]. It is of such acidity that, unless it is tempered by mixture with another water flowing past, it would—owing to a certain too-violent and caustic faculty—cause ulcerations of the intestines, induce dysentery, and bring on other diseases; yet when properly tempered it is useful and fruitful for driving out every disease. After these follow, at the said Auvergne mountains, the thermal springs of *Mont d'Or* [Mont-Dore], and those commonly called *Aygues candes*, that is, "warm waters," likewise of wonderful virtue, whence they are thronged with a great concourse of men. After these follow the *Nivernenses* [springs of Nevers] and *Bourbon* [Bourbonnes/Bourbon-l'Archambault], most celebrated of all France; since their power and natural constitution have been described by others, I do not dwell on them.

There remains at last a wonderful prodigy of nature in waters, to be set forth, which the noble town of Clermont [Claremontium] in Auvergne presents to us. Wonderfully has the prodigy of this spring tormented the minds of philosophers. It issues here from a rock, and in the very issuing it produces rock and the whitest stones. The stream, which flows out from the spring, builds little bridges by its own power for its dwellers, so that it can be crossed, by this contrivance: they make the stream flow over planks arranged in the shape of an arch, and—wonderful to tell—within the space of 24 hours they find a little bridge constructed by the continuous and laborious industry of the water. For the water of this spring, being most limpid, is by a perceptible operation changed into stone by a natural flow never interrupted; and since it is distinguished from other springs neither by color nor by taste, the very brute beasts, deceived, while they drink it too greedily, soon fail and perish—for when they are cut open, their stomach is found filled not with water but with a stony mass. The inhabitants of

this place, intending to display to curious spectators the wonderful efficacy of the petrifying faculty in this water, pour the water into a glass, and immediately it is turned into stone, and—the glass being broken—reproduces its figure so exactly that it would be believed to have been cast in a plaster cup within a mold. In the same way, into whatever vessel of whatever shape you pour the water, it is soon, as it were like a kind of curd, by a perceptible condensation changed into a stony mass entirely similar to the figure of the vessel. Hence some of the more curious, having poured it into the molds or forms of statues, find a stone statue within—the mold being broken. The reason for this prodigious metamorphosis—since it requires deeper principles—we shall unravel in what follows, in a chapter of its own. And let these things said about the thermal springs and medicated springs of France, countless others being omitted, suffice.

§ III.

On the Springs and Thermal Springs of Germany

Since nearly all of Upper Germany is especially mountainous and bubbles with abundant metallic veins...

[printed p. 263 — header "DE THERMIS"]

there is scarcely a place that does not somewhere produce either thermal springs or medicated waters; and indeed the number of acid springs in Germany is as great as in any other region. Thurnheuser [Thunhauserus/Thurneisser] asserts that they run up to a thousand, besides the thermal springs met with everywhere, which—because it would be tedious to describe them—I shall here set down only the names of the places and their composition, extracted from various authors.

Table of the Thermal Springs in Germany

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Spring	Location	Mineral composition	Medical virtues
1 Curienses or Piperinae [Chur, Switzerland]	—	golden-sulphureous-ferruginous-nitrous mixture	heal all infirmities. These springs, beyond all others, have this remarkable feature: that they burst forth on the third day of May,

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Spring	Location	Mineral composition	Medical virtues
			the feast of the Finding of the Holy Cross, but withdraw and dry up on the fourteenth day of September, the feast of the Exaltation of the same Holy Cross; the reason for which see explained below, in the section on miraculous springs.
2 Thermae plumbariae [the "lead springs"] in Lorraine [Lotharingia]	—	leaden mixture, whence they also have their name	heal all diseases that bring on ulceration
3 Badenses of the Swiss [Baden, Switzerland]	—	sulphureous-aluminous	warm and dry; opportune for cold diseases
4 Badenses in the Margravate of Baden, near Argentina [Strasbourg / Baden-Baden]	—	sulphureous-saline-aluminous	aid cold diseases
5 Badenses in Austria [Baden near Vienna]	—	sulphureous-nitro-aluminous	heal cold diseases
6 Ferinae in the Duchy of	—	same mixture as the preceding	(as preceding)

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	Spring	Location	Mineral composition	Medical virtues
	Württemberg, commonly <i>Wildbad</i>			
7	Cellenses at the Martian or Black Forest [Marquardstein? — Black Forest]	—	sulphureous- nitro-aluminous	heal lingering fevers
8	Goppingenses in the Duchy of Württemberg, at the town of Göppingen [Goppinga]	—	acidulous, mixed with a little sulphur	heal ailments of the chest and lungs
9	Avenses, commonly <i>Au</i> , near Rotenburg [Rothenburg] on the Neckar [Nicer]	—	same mixture as preceding, but with an excess of sulphur	marvelously aid ailments of the nerves
1 0	Embsenses [Bad Ems?] near Lake Acronius [Lake Constance / Bodensee]	—	aluminous- nitrous	benefit headache and nerve-palsies arising from colic pains
1 1	Gerbersveilenses in Alsace [Gernsbach?]	—	aluminous- ferruginous- nitrous	help the splenetic, the hypochondriac, and all ailments of the skin
1 2	Carolinae [Karlsbad/Carlsba d] near Elbogen [Elenbogen /	town	sulphureous- aluminous	cure swollen glands, scrofula [strumas], sciatica,

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	Spring	Location	Mineral composition	Medical virtues
	Loket] in Bohemia			paralysis, and similar diseases
1 3	Wisbadenses of Mainz [Wiesbaden/Moguntia]	from the opposite bank of the Rhine, facing the village of Wiesbaden	consist of sulphur with a small portion of alum and niter	benefit cold diseases
1 4	Gasteinenses in Bavaria, Diocese of Salzburg [Bad Gastein]	—	gold, salt, niter, silver, copper [aes]	profit for driving away all kinds of diseases; confer fecundity on women
1 5	Abudiacenses in Bavaria [Abbach?]	—	rich in sulphur, alum, and niter; smell of fried eggs	faculties the same as the preceding
1 6	Abechenses in Bavaria near Regensburg [Ratisbona]	—	sulphur, alum, niter	benefit stone of the kidneys and bladder
1 7	Wemblingenses in Bavaria [Wemding]	—	sulphur, alum, niter	of the same faculty as the preceding
1 8	Hubadenses, commonly <i>Huberbad</i> , near the Badenses [neighbors of Baden]	—	sulphur, copper, with a little alum and salt	powerfully relieve obstructions
1 9	Salzbergenses [Salzburg?]	—	sulphur and rock-salt [halinitrum]	heal all ulcerous diseases, except those infected with venereal disease [the

No.	Spring	Location	Mineral composition	Medical virtues
				French pox]
20	Badenveilenses between Freiburg [Frigurbum] and Basel [Bad Bellingen / Badenweiler]	—	much sulphur, but little rock-salt and alum	benefit asthmatics and obstructions of the viscera
21	Wattonnuveilenses in Upper Alsace [Wattwiller?]	—	tinged with a portion of sulphur and rock-salt	of the same faculty as the preceding
22	Willingenses at the Hercynian Forest [Villingen]	—	sulphureous-aluminous	dry and strengthen
23	Brintzbacenses [Brienzbach?]	—	copper and iron	benefit the hypochondriac, the splenetic, and quartan fevers
24	Kibbadenses in Breisgau [Brisgoja]	—	contain in themselves sulphur, rock-salt, alum, salt	cure all kinds of diseases
25	Glottorbadenses [Glottersbad], situated between Freiburg [Friburgum] and Waldkirch [Waldkirchen]	—	yield copper with a little sulphur	profit the jaundiced, the hepatic, and other diseases
26	Vogtspergenses in Alsace [Vogtsburg?]	—	yield abundant rock-salt, little alum and sulphur	mostly benefit the scabby [scabiosis]
27	Zuckerthalenses & Salzenses	—	(same quality as the preceding)	(same as preceding)

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. Spring

Location

Mineral
composition

Medical virtues

(neighbors to
these)

2 Uberkirchenses & —
8 Nideravenses
near Rotenburg
on the Neckar
[Oberkirch &
Niederau?]

yield sulphur
with a mixture of
vitriol or
copperas
[calchantum]

benefit the
catarrhal

2 Deinacenses in —
9 the Hercynian
Forest, near the
town of Kalb [Bad
Teinach near
Calw]

tinged with iron,
copper, and alum

benefit the
obstructed
[oppilatis]

3 Fiderinae —
0

contain alum,
copper, with a
little sulphur;
imitate wine in
color and taste

heals spitting of
blood
[haemoptysis]

3 Antigastrenses in —
1 the Hercynian
Forest near the
town of Oppenau
[Oppenacum]

contain sulphur,
alum, and a little
vitriol

benefit the
evacuation of
corrupt humors

3 Kirchenfeldenses —
2 in the Lower
Palatinate, in the
tract called
Hundsrück
[Hunsrück]

consist of iron,
copper, vitriol

—

§. III. (*continued*) — On the Springs and Thermal Baths of Germany

Table of the Thermal Baths of Germany (*continued*)

The numbered catalog of German thermal springs and medicated waters continues from the previous entries.

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.	Spring / Place	Minerals	Virtues
3	The Trier springs	acidic waters	—
3	[Trevirenses, of Trier],		
.	with three acidic springs near the Monastery of St. Matthias [Monasterium S. Matthiae]; another is called Berggeel, from its yellow color; a third near Metzerdorf [Metzerdorf].		
3	The springs of	alum [alumen], rock-	—
4	Bassenheim	salt [halinitrum],	
.	[Bassenheimenses] and of Kesselbrunn [Kesselbrunenses], in the Archbishopric of Trier.	sulphur	
3	The springs of	alum, rock-salt, sulphur	—
5	Conterthal	with a portion of vitriol	
.	[Conterthalenses], in the valley of the same name near Memmingen [Memminga].	[calchantum]	
3	Nearest to these are:	—	They have the peculiar
6	Ponterbrun and		property of tolerating
.	Hailbrun near Andernach		no impurity that they do not at once eject.

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	Spring / Place	Minerals	Virtues
	[Andernacum].		
3 7 .	The springs of Annaberg [Annaebergenses], in Meissen [Misnia].	alum with an admixture of copper ore [vena cuprea]	They greatly benefit rheumatic symptoms.
3 8 .	The springs of Aachen [Aquenses, beside Aquisgranum/Aachen].	sulphur, salt, and alum	Especially well-suited for healing nervous disorders.
3 9 .	The springs of Laubach [Laubacenses], in Swabia [Suevia] near Ulm [Ulmum].	sulphureous-nitrous	They benefit every age and temperament.
4 0 .	The springs of Leiningen [Leuningenses] and Fürstenberg [Furstenbergenses].	salt-nitre-aluminous	—
4 1 .	The springs of Luc [Lucenses] and Brig [Brigenses], in the Valais [Wallesia].	abundant air [copiosus aer] and a little sulphur	—
4 2 .	In the Archbishopric of Trier [Trevirensis], counting twelve springs of acidic waters.	acidic waters	—
4 3 .	The springs of Spiegelberg [Spigelbergenses] near Hameln [Hammelia], in Lower Saxony [inferior Saxonia].	alum, vitriol [vitriolum], and ochre [ochra]	Tinged with ochre, they are good for arthritic disorders.
4 4 .	The springs of Teplitz [Teplizenses], in Bohemia [Boemia].	sulphur, nitre, alum, bitumen, and calcareous stone	There is scarcely any kind of disease they do not help.

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Spring / Place	Minerals	Virtues
	[saxum calcarium]	
4 The springs of 5 Wolkenstein [Wolchensteinenses], in Meissen.	—	About these, the distinguished physician Augustus Hauptmann [Augustus Harptman] wrote learnedly and elegantly in German; consult him.

These, then, are the medicated springs and thermal baths famous in Germany, with countless others left unmentioned. From them it is clear that nature most of all delights to display her sport with waters of this kind in mountainous and Alpine regions.

§. IV. On the Thermal Baths and Medicated Springs of Hungary, Transylvania, and the Other Adjacent Northern Regions

The Carpathian range [Carpathus Mons], which divides Transylvania from Hungary and Poland, teems with every species of metals, minerals, and waters. Accordingly, it produces everywhere innumerable springs and thermal baths stocked with prodigious virtues, for the Pyrophyllacia [fire-storehouses] beneath it vigorously drive nature's machinations. Fire, by its own nature inclined to rise and confined within the innermost caverns of the earth, is constantly driven toward some outlet. When it finds one — where there are springs of nascent water somewhere — it heats those waters to the highest pitch of fervor. Neither water nor wind can check its force, and least of all can fire itself construct any barrier against it. Indeed, the more it once gathers its onrush, the more strongly it presses, and when it meets an obstacle it bursts beyond bounds to produce the symptoms we observe — marvels both in nature and in certain works of art. Confined, it creeps along little by little, and at last produces astonishing conflagrations. Thus wherever it penetrates and does not exhale, it first converts into itself the air it meets — which is more alterable — then the earth it passes through, and not only the waters it encounters but also the rocks and tunnels, all of which it sets ablaze, especially where it is drawn by its natural appetite toward an outlet and passes through places heavy with sulphur, where it is nourished and fed. In this way it acquires for itself the powers needed for that extreme

fervor we see and feel in thermal baths. As this has been evident in all the thermal fervors so far surveyed, so it shines forth most of all in the thermal baths of Hungary and Transylvania.

But since we have reserved the marvels of springs of so varied a nature for the following chapters, we will not dwell on them here. On hot waters and lakes, and on those that are never frozen even by extreme cold, see Olaus Magnus, who describes them exactly. On the thermal baths and boiling waters of Iceland [Islandia] and Greenland [Gronlandia], see what we discussed above, at length, concerning the marvelous effects of Subterranean Fire. For Scotland, England, and Ireland [Scotia, Anglia, Hybernia], read, if you please, Hector Boece [Hector Boetius], Buchanan [Buchananus], and also Father Eusebius of Nuremberg [P. Eusebius Norimbergus] on the miraculous effects of nature in Ireland. Since I have found these accounts wrapped up with many falsehoods, I have thought it best not to set them out, but to confine myself to what is both well attested and confirmed by experiments — partly by myself, partly by other trustworthy and learned authors.

§. V. On the Springs and Thermal Baths of Italy

Italy, enclosed by the Alps and divided down its middle along its whole length by the linked ridges of the Apennines, and walled off by the Upper and Lower Seas [the Adriatic and the Tyrrhenian], has obtained from nature a situation to which she has made no other in the Geocosm like. Since nature has girded it with so great a natural rampart, it cannot but be that she has also joined to it all things at once — not only those necessary for the sustenance of human life, but the most abundant resources for an abundance of delights. Among these, the multitude and variety of thermal baths offers itself most of all to view. If their number were to be reckoned exactly, neither paper would suffice to describe them, nor wit to explain the impenetrable virtues and properties that shine forth in them.

Tuscany [Hetruria] alone triumphs in the glory of twenty-five most celebrated thermal baths, besides countless spectacles of medicated springs; but since we have surveyed these in a special work entitled *Iter Hetruscum* [*The Etruscan Journey*], we do not repeat them. Rather, I shall first turn to noting those that, in Transpadane Italy [Transpadana Italia], are foremost in the celebrity of their name; but in the...

In the territory of Padua [Patavinum] alone there are reckoned six [thermal baths], and these are: the Bath of Abano [Balneum Aponotanium]; the Bath of Mount Ortone [Balneum Montis Osthoni]; St. Peter's [S. Petri]; Domus Nova [the New House]; St. Bartholomew's [D. Bartholomaei]; and finally the one they call St.

Helena's [S. Helenae]. I shall briefly run through the nature of all of these in order.

The Bath of Abano [Balneum Aponotanium] — in Greek ἄπονον [Greek: aponon, "without pain"], because it heals without pain — was celebrated not only by present-day writers but also by the ancients, Suetonius, Claudian [Claudianus], and Pliny. It is situated in the middle of a valley; on the side facing north it is ringed by mountains, while on the side looking toward the city of Padua it is surrounded by a vast plain. A hill rises up, compacted as though of crude pumice, from which, through what are like stone pipes, that most praised water flows in a rich and perennial stream — the mother of the Aponian thermal baths.

Concerning its composition there have been varied opinions among physicians. Fallopius [Fallopio], who undertook the scrutiny of the spring by a thousand modes of experiment and left nothing undone in order to reach the innermost mixture of this spring, seems deservedly to have wrested the palm from all the rest. Taught by an irrefragable knowledge of experiments, he at last determined that there is in those waters salt, indeed, as the predominant element; then calcareous stone [lapis calcarius] (the kind that, when heated, turns to lime); and finally a sulphureous vapor. From this he inferred that the water heats in the second, remitted degree, and likewise dries in the second, but intense, degree — which he confirmed, on the principles of iatric [medical] science, against Savonarola [Savanarola], so that no further room for doubt remains among physicians. The use of these waters is carried out in a fourfold manner: namely by drinking, by sitting-bath [infessio], by sprinkling [embrocha, that is, by dripping/stillicidium], and by the sweating-room [laconicum]. By these means all diseases arising from inveterate cold and humidity are cured, except the French disease [lues gallica, syphilis]. But concerning the diseases that the water cures, see Claudian's most elegant encomium of it, where he adduces some remarkable properties of these waters.

Proceeding westward from Abano, after 150 paces one comes upon a very lofty hill named Ortone [Ortonus], at whose base is seen a shrine sacred to the Mother of God [aedes Deiparae], renowned for many miracles; in its vestibule is seen a cavern, within which a descent lies open by a brick stairway. Here flows a purer water, called the Virgin's Water [Aqua Virginis], somewhat tepid and seasoned with a most mild salt, fit to heal by drinking alone. Not far from the Virgin's Water is seen a spring of most fervent water, salty and sulphureous, very well suited to healing subcutaneous diseases. Not far from here two baths are seen, filled with tepid and medicated vapors, an excellent remedy for softening the limbs. But in that pool where the boiling water springs up there is a clayey and

rich mud, whose power is such that it dries, disperses, strengthens, and binds together loosened parts. Yet take care not to apply it to the affected part while it is hot; rather, first warm it with that water, smear it with cold mud, set it out in the sun, and only then use it.

Setting out from Padua [Patavium] across a plain of twelve miles, one comes upon a most pleasant hill, from whose depths boil up those most fervent waters, which take their name from a little chapel built and consecrated there to St. Peter [Divus Petrus]. They consist of abundant salt and a certain juice not unlike ochre [ochra]; they heat moderately, dry, and gently strengthen. Going on four miles from these, one comes upon a hill which from its northern side spews out most fervent waters, while from its other side it is famous for the abundance of medicated springs that gush there. From a new house built there by the Carrara family [Carrari], patricians of the city of Padua, these are called the Thermae of the New House [Thermae Domus Novae]; yet through neglect of cultivation they are today nearly obsolete and squalid. Descending about 500 paces from here, one comes upon a mountain which, from the throng of the sick who flock there, is called the Mountain of the Sick [Mons Aegrotorum], corruptly "Monte Grotti." From this mountain flow the most celebrated thermal baths, composed of sulphur, salt, and gypsum [gypsum], whence they dry vehemently, heat moderately, and are especially conducive to ulcers of the skin. Proceeding farther, in a certain valley girt on all sides by steep hills, two miles distant from St. Peter's bath, one comes upon the Bath of St. Bartholomew [Balneum S. Bartholomaei], so named from a chapel consecrated in his honor — the most celebrated and most frequented of all the thermal baths, not indeed by reason of the water, but on account of the most fervent and bituminous mud upon which that water floats, very well suited by anointing to softening the rigor of the joints and nerves. This mud conceives its heat from the fiery and bituminous exhalation that the infernal fires breathe out. Two miles from here is seen the chapel dedicated to St. Helena [S. Helena] on a hill, from which the bath also takes its name. In it, besides charming sweating-rooms and twin sprinklings and a spring of boiling water and a medicated mud, the water — filled with sulphureous vapors — has, besides salt, a little sulphur and some clayey matter inclining to the color of ochre; whence it heats moderately and dries. But the mud, when cooled, is deprived of its medicated power. Something marvelous lies hidden here, and different from the mud of St. Bartholomew's Bath: this mud dries powerfully, that one softens.

And from this multitude of thermal baths that shines forth in the Paduan territory, it is plainly evident that this whole tract is filled with subterranean fires

and consequently with every kind of mineral, which spreads its veins far and wide into the surrounding regions. For in the territory of Verona [Veronensis], ten miles distant from Padua, the Calderian thermal baths [Thermae Calderianae] are at once encountered, which physicians use not only for drinking and sitting-baths, but also for various purposes — even for cooking food for the sick and for diluting wine. Their mixture consists of red ochre [rubrica synopica, Sinopic red earth] with a little salt and sulphur. Corresponding to these, through subterranean channels, in the Cispadane region [Cispadana Regio], are the thermal baths of Aquaria [Thermae Aquaritanae] and of Reggio [Regienses]; for from the territory of Modena [Mutinensis Ager] there gushes, at the village of Aquario near the city of Reggio...

of Reggio [Regionsis] city's village, in the judgment of skilled physicians, it consists of salt, nitre, and marble lime [calx marmoreus]. Its remarkable property is this: that outside the spring it remains uncorrupted for the space of a hundred years; whence it is carried not only through the neighboring provinces of Italy but also into France [Gallia] and Spain [Hispania]; it has all the [virtues] that the use of the Aponian water possesses.

Closely corresponding to this, in Flaminia [the Flaminian region], is the Bath of St. Mary [Balneum D. Mariae], distinguished by three thermal baths — namely those of the Lords [Dominorum], of the Middle [Medii], and of the Tower [Turris] — whose waters all hold a most clear, gem-like salt with a portion of nitre, [conducive] to sulphureous vapors, and are tinged with marble lime. Near these are other thermal baths: those of St. Martin [S. Martini], St. Christopher [S. Christophori], and Meldola [Meldula]; about which read Fallopius and others.

§. VI. The Thermal Baths of Tuscany [Thermae Hetruriae]

In no region of Italy do I recall having found more abundant thermal baths than in Tuscany [Hetruria]. If anyone wished to bring them to a count, he would easily run up to fifty of them; but since we have set them out in order in our work entitled *Iter Hetruscum*, I have thought it best not to repeat them here. For there are, first of all, those which [the region] pours forth: the thermal baths of the territory of Lucca [Lucensis], of Pistoia [Pistoriensis], of Pisa [Pisanus], of Volterra [Volaterranus], of Viterbo [Viterbiensis], and of Bracciano [Braccianensis] — each one of which is again divided into diverse and manifold other thermal baths, which we display at a single glance in the following Table. The virtues and properties, situation, and composition of each, let the reader see in our cited work on Tuscany.

Table Containing the Thermal Baths of Tuscany

Tuscany [Hetruria] contains thermal baths in the territory of:

Lucca [Lucensis]:

- Florentiola
- Malapetra
- Corsenas
- De Ducciis
- S. Joannis [St. John's]
- Villenses

Pisa [Pisano]:

- Bal. Reginae [the Queen's Bath]
- S. Juliani [St. Julian's]
- De Aquis

Volterra [Volaterrano]:

- Bagno al morto
- Balneum casei cocti [Bath of cooked cheese]
- Ducciae
- Balneum Planitici
- S. Michaelis [St. Michael's]
- With diverse kinds of waters

Siena [Senensis]:

- Thermae S. Philippi [St. Philip's Baths]
- Thermae S. Cassiani [St. Cassian's Baths], distributed into ten springs
- Aquae Borrae
- Balneum de Avenione
- Bagno bello
- Balneum Clusinum
- Bal. Ruffellanium
- Bal. Rapolanum
- Bal. Saturnium
- Bal. Montis Alceti

Viterbo [Viterbiensis]:

- Bullicamum
- Bassetum
- Cruciatum
- De Palatiis
- Jasellinum
- Castrense
- Balneoregium
- Ad Lacum Vadimonis [At Lake Vadimon]

Bracciano [Braccianensis]:

- Vicarellum
- De Styliano
- Cere veteris [of ancient Caere]
- Centum cellarum [of Centumcellae / Civitavecchia]
- Et complura ad maritimam oram [and many more along the maritime coast]
- Nepesinum [of Nepi]

§. VII. The Thermal Baths of Campania [Thermae Campaniae]

Tuscany, sporting with Campania through subterranean passages, produces innumerable kinds of medicated waters and thermal baths — especially in the Pozzuoli territory [Ager Puteolanus], the Baian [Bajanus], and the neighboring islands of Ischia [Ischia] and Procida [Procyta], which have the same origin throughout that whole tract of land and lie subject to it: partly from the sulphureous [region] at Pozzuoli, partly from Vesuvius at Naples — the workshops of Vulcan [Vulcani officinae], drawing their nature from burnt earths and ashes. Some of these are not only sharp and unpleasant, but the most agreeable ones spring forth from those very ashes, now already extinct — as once, so now, most celebrated. Some, in which a certain sharpness thrives, are most useful in drinking-cures for many infirmities, being of an abstergent [cleansing] power, and are either nitrous or salty. The waters once Cicero's [Ciceronian], now called Bagno del Prato, are situated in the Baian district; about which Pliny speaks thus: "There is a villa worth recording, set on the shore for those going from Lake Avernus toward Pozzuoli, celebrated for its portico and grove, which Marcus Cicero called the Academy; in which, after his death, while Antistius Vetus possessed it, hot springs broke out — most salubrious for the eyes

— which were celebrated in an elegant epigram by Laurea Tullius, his freedman." Today they have the same virtue and make a most excellent eyewash [collyrium], consisting of the virtue of cadmia [cadmia, calamine], by which they are tinged.

There are also in this place — though now nearly obsolete from age — other baths: of the Sun [Solis], others of the Moon [Lunae], others Imperial [Imperatoria], so called from ancient superstition, which consist of sulphur and iron. Proceeding three miles from here, beneath the Misenum promontory [Promontorium Misenum], one comes upon the most celebrated Bath of Cantorelli [Cantorelli Balneum], renowned for the marvelous effects it produces in extracting iron splinters — which they wrongly suppose to be effected by an infusion of magnetic tincture, as, taught by our own experiment, we have noted in our *Ars Magnetica*. Adjoining this, in the Lucullan territory [Lucullanus Ager] near the Grotto of Posillipo [Crypta Pausilippi], two springs of great virtue flow: on the right a most limpid one; on the left one of a milky color, whose waters grow tepid in winter and are cold in summer — the reason for which we explained above. It consists of a mixture of lime, sulphur, and iron, just as it is formed from the clods and rocks of an iron-bearing [ferruginous] mountain. In this same Baian gulf, at the Monastery of St. Anastasia [S. Anastasiae Monasterium], one comes upon the bath of Petreolus and another, which they call Cuma, of the same nature, consisting of a cleansing virtue. When, in the year 1638, I was examining this tract, I was indeed amazed at the abundance and variety of medicated springs bubbling up in it, since one can scarcely cover a hundred paces without coming upon some new spring or pool of differing virtue. Here I saw a spring which they call Gilleroso, well-suited to purging the kidneys. Nearby are waters which they call Bracchulae, of a sulphureous-nitrous nature; the thermal baths of St. George [S. Georgii], which consist wholly of nitre; another, now called "by the handful" [pugilli], well-suited to the flow of hemorrhoids, of an astringent power; another, Succellaria, emanating at the edge of Lake Avernus, seen diluted, whitish and in taste, fit for expelling urine [and] the stone, both of the kidneys and of the bladder. Joined to these is Juncana near the Grotto, so called because it bubbles up among the rushes [junci]; taken by drinking, it fattens, and excites Venus [sexual appetite] in the cold-natured. There are also in this district other spring-waters. The little bath called "De Petra" and "Plaga" [Plagam] is especially prized by the Neapolitans for its strengthening power. At the Monastery of St. Anastasia, from even a small dug pit, a most limpid water springs out, both pleasant to drink and most potent in medicinal powers. And so this whole Baian tract gushes with waters so salubrious that Horace [Horatius] not undeservedly sang of them:

No bay in all the world outshines fair Baiae. [Nullus in Orbe locus Bajis praelucet amoenis.]

Pliny says: "Medicated water bubbles forth here, kindly and everywhere, in very many lands; yet nowhere more lavishly, nor with more kinds of aid, than in the Baian gulf — some of sulphur, some of bitumen, some of salt, some of nitre, some of alum, and some likewise profiting by an acidic and varied mixture, and some by the very vapor." To these is added the incomparable pleasantness of the place, which Martial [Martialis], once admiring, wrote thus to Flaccus:

Baiae, golden shore of blessed Venus, Baiae, proud and gentle gift of nature: Though I should praise Baiae, Flaccus, with a thousand tongues, I should praise Baiae as it deserves — yet not enough. [Littus beatae Veneris aurum Bajae / Bajae superbae blanda dona naturae / Ut mille laudem Flacce Bajas / Laudabo digne, non satis tamen Bajas.]

Yet — such is the inconstancy and vicissitude of human affairs — most of these, in the conflagration of the Pozzuoli territory in the preceding century [the 1538 eruption that formed Monte Nuovo], buried and submerged under ashes, ceased to flow; but those that survived such a disaster are today frequented as most useful, of the kind we have surveyed. So full, then, are all the places of this region with the gushings of bubbling springs and thermal baths, that in the very Cave of the Cumaean Sibyl [Cumana Sybilla] nature has produced a thermal water that heals human infirmity. And all places are likewise full of fires, as the Phlegraean Fields [Phlegraei Campi], or the Forum of Vulcan [Forum Vulcani], which we described above, abundantly attest — so that in these places Nature, the bridesmaid [Paranympa Natura], the supreme craftsman-mind of all things, seems to have established a marvelous wedding of water and fire. From here, moreover, through the winding mazes of subterranean tunnels, the neighboring islands of Ischia and Procida — which they once called, joined into one, Aenaria — have conceived so great a breeding of most diverse waters and fires that there is scarcely a place in them that does not abound with these. But whoever desires more about these, let him consult Scipione, Mazzella [Mazella], Pighius, and the other describers of these places. We, who have seen and explored them, have thought it best to bring forward here only these things.

§. VIII.

The Thermal Springs of Sicily and the Lipari Islands.

[Thermae Siciliae & Liparitanae]

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I will say nothing here about the thermal springs [thermae] and medicated fountains that occur, scattered in great number, along the maritime coast of the rest of the Kingdom of Naples, in Calabria. Instead I will turn my pen to Sicily, where nature seems to have gathered together — as into a small epitome — the riches she has displayed elsewhere only piecemeal. It is from Sicily, then, that one ought rightly to draw the examples of every kind of difference and alteration that shines forth in medicated waters.

[Margin: The great wealth of thermal springs and of medicated waters in Sicily, and their variety.]

Consider the kingdom of Vulcan, where fire openly reveals itself in its nature and its effects. Those effects are: flame, vapor, combustion, smoke; its material is sulphur, oily clay [gleba pinguis], ash, pumice, stone-coal [lichanthrax], bitumen, salt, vitriol, and metals of every kind. From this variety of material arise marvelously varied operations of the fires. And so on every side spring up countless sweating-chambers [sudatoria]; waters hot, lukewarm, cold, salt, acid, white, black, blood-red, oily, bituminous, putrid — waters that yield not only veins but whole rivers, lakes, fountains, and baths. No one should wonder at this: whoever knows the immense power of Etna will easily grant the cause and origin of all these things. For the power of Etna, diffused through transverse fire-channels [pyragogi] in every direction out of its innermost depths, raging through the whole circuit of the island with perpetual smoking vapors, acts according to the degree of heat these channels contain. Either they boil up through their caverns and make sweating-chambers, or, where they encounter waters, they alter them, and by their tinctures produce as many kinds of thermal springs as are perhaps not to be found in all the rest of the world.

[Margin: The materials of the fires in Sicily.]

Among the rest, famous are the thermal springs produced amid the ruins of the city of Selinus [Selenuntina Urbs], today called Sciacca, of marvelous variety. For in the middle of a very high mountain dedicated to St. Calogerus [S. Calocero], there occur here and there various labyrinths of caverns: some open in straight passages, others in transverse ones; still others stretch down into the deepest Tartarus by an unfathomable abyss. These always resound with a dreadful and terrifying roar — whether from the enclosed multitude of hidden fire, or from the violence of the winds rushing this way and that, or from the impact of the sea-waves driven with great force into the mountain's passages. Certainly, at fixed

times, the cave emits sounds not unlike claps of thunder: a dreadful thing, striking fear into everyone.

[Margin: The thermal springs of Selinus.]

[Margin: The mountain of St. Calogerus, marvelous in the variety of its waters and vapors.]

Among the rest there is one vast cavern, in the middle of which is a well of immense depth, dark and dreadful to look down into. Here it teems with several warm veins on every side, which flow back from the channels of various caverns, and at the same time it emits vapors that excite wholesome sweats in those who enter, up at the cave's highest vaulting. To this very day one can see, cut into the living rock by the ancients from time immemorial, seats adorned with various inscriptions — which, however, since they have been eaten away by the injuries of time, snatch from the curious every hope of deciphering them. There are also in this cavern siphons [syphones] — made, I know not whether by art or by nature's industry — filled with hot vapors. Those who suffer from disorders of the head, ringing in the ears, and deafness, by applying their ears to these siphons for a short time are freed from their infirmities; they are also good for strengthening the nerves. Hence they are visited with notable benefit by great numbers of the sick who throng there, especially on the feast of St. Calogera, a hospice [Xenodochium] having been built there at public expense for that very purpose.

[Margin: The astonishing cavern of the mountain.]

On the plateau of this mountain other kinds of thermal springs presently rise up, and among the rest a most clear water of marvelous power to loosen the bowels. Whoever drinks it without knowing this will surely expose himself to the great mockery of the bystanders, since the effect follows so suddenly upon the drinking that there is scarcely time and place to withdraw decently. Hence the local jokers often put on a ridiculous spectacle with foreigners, deceitfully enticed into drinking.

[Margin: Other springs of various powers.]

There is no lack of abundant thermal springs at the foot of Etna, which, however, out of so great a number of better ones, are neglected. That there were once most noble springs at Syracuse — the lakes Pismam and Cianon [recte: the springs/lakes Pisma and Cyane[?]] — and that the latter undergoes waning and waxing with the Moon, Mirabella teaches. At Catania too there were once two thermal springs famous for their great display of columns, as Pietro Carrera

[Petrus Carrera] shows in his description of Catania. To those who travel by land from Catania to Palermo, on the side there occurs a town commonly called Miheo [Mineo], on whose plain there lies, a little within the interior, that most celebrated lake of the Palici [Palicorum lacus] mentioned by the ancient writers. Of immense depth, in hidden correspondence with Etna, with its waters rising up some three cubits high, it seems as it were to sport, when blasts press upon them both from the neighboring sea and from overhanging Etna. The waters are sulphurous and ashy, and have the same taints as Etna — of fire, sulphur, ash, and stench — so that they send up exhalations deadly not only to birds but dangerous to men, since, no differently than Etna, they hurl up globes of flame as well. Of these Ovid writes thus, *Metamorphoses*:

[Margin: The lake of the Palici, near Mineo.]

And he is carried past the deep lakes, and the pools of the Palici reeking with sulphur, where the earth has burst and boils. (*Ovid, Metamorphoses* V.405–406)

Today, from the mephitic exhalation [Mephitis] they breathe out, they are called Naphtae ["the Naphthas"] by the inhabitants; and although they bubble up with three fountains, they nonetheless do not exceed the rim of the pool, doubtless discharging themselves elsewhere through subterranean channels, as we showed above concerning the property of lakes. A lake of this same kind is also seen between Agrigento [Agrigentum] and Divona, of unsearchable depth, which hurls up sulphurous waves from its source some three cubits high, to the utmost wonder of those who behold it. Again, in Pelorus [Peloro], near the Mamertine strait [the Strait of Messina], there occur three lakes, celebrated in the superstition of the ancients; not far from these lie the springs of the city Thermae [Termini Imerese], which, from the ancient city of Himera [Hymera]...

[Margin: The lake of Agrigento.]

[Margin: In Pelorus, near the Sicilian strait.]

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built in the most ancient ruins — Cicero and Pliny [the Elder] being witnesses — has baths well suited both to pleasures and to driving off diseases. Near Enna [Henna] too — at the place today called Castrum Ioannis [Castrogiovanni] — there appear pools famous for the rape of Proserpina, whom the poets imagine to have sought the underworld in this place, leaving behind her an abyss filled with the most foul and stinking waters.

[Margin: Lakes famous for the rape of Proserpina near Enna.]

There are also in the diocese of Palermo [Panormus] waters sulphurous by nature and most fervently hot, celebrated for their use in baths and no less in sweating-cures. Drepanum [Trapani], which was formerly called Segesta, at the foot of Mount Eryx [Eryx], teems likewise with a diversity of waters as of metals. Although these are most hot and sulphurous, yet because they do not pass through any vein of salt, when they have cooled — Strabo being witness — they become drinkable. And to this day three baths endure, of which the first is hot, the second hotter, and the third hottest; below these — as Fazello [Fazellus] reports — at a stone's throw of the foundation, there is a huge sulphurous lake which, made turbulent by sudden eruption, is called by Solinus the Herbesus, and today by the inhabitants the Gurgus ["the Whirlpool"].

[Margin: Drepanum, formerly Segesta.]

[Margin: Baths, and the turbulent lake called Gurgus.]

Time would fail me if I were to attempt to enumerate all the lakes, fountains, rivers, Charonian pits [charonticae scrobes], and sulphurous pools in the inland places of Sicily. But let what I myself have seen, here told to the reader, suffice.

The Lipari Islands — also called the Vulcanian or Aeolian Islands — teem so with thermal springs that they scarcely leave room for drinkable water, so much do they abound in medicated fountains and in fires. But since we have spoken of them among the preceding matters, I will not dwell on them.

[Margin: The Aeolian Islands teem with thermal springs.]

Between Africa and Sicily lies interposed an island by the name of Pantelleria [Pantalaria]. Wherever you set foot, the soil is dry, red, and hot, so that it can scarcely be endured by those walking barefoot. It takes its origin (for the most part out of the depths of the boiling vents which, by Vulcanian fires, correspond through subterranean passages to the workshops of Etna and the Lipari Islands), and it is evident from the caverns of the mountains, which, agitated by waters and vaporous blasts, are felt to growl with a continual and perpetual sound within. The greatest natural prodigy in it is discerned — Fazello being witness. For since the land, thirsty from excessive heat, suffers the utmost lack of fresh water, by a truly wondrous plan of nature these inconveniences have been provided against. In the middle of the island is a huge cavern, vaulted on every side with rugged rocks; in the very navel of this cavern is found a chasm of immense depth, out of which perpetual smokes of exhalations and vapors,

condensed in the vast vault, are resolved into streams of fresh water — in such abundance and quantity that, drawn off thence into siphons made partly by art and partly by nature, it suffices abundantly for the whole island, for drinking and for other uses.

[Margin: The island of Pantelleria, marvelous.]

§. IX.

On the Thermal Springs of Asia, Africa, and America.

[De Asia, Africa, Americae Thermis]

That the whole Geocosm abounds in boiling vents [aestuaria] was shown in Book IV, the truth of which we demonstrated by the present account of the Vulcanian mountains, which are seen everywhere across the entire surface of the Earth, in no region lacking. We also set out the mountains in order on a geographical map, from which it necessarily follows that there is an abundance of metals and minerals; and since at that same place we described, in the greatest mountains, the cauldrons of the hydrophylacia [hydrophylacia — subterranean water-reservoirs], hence there follows the necessary consequence that we have gathered: that waters heated by fiery vapors, and tinged with the power of minerals lurking everywhere, supply the abundance of thermal springs, sweating-chambers, and medicated fountains — since nature always acts the same everywhere, and arranges all the effects of natural things to one and the same standard.

[Margin: Where the Vulcanian mountains are, there the water is medicated; that is necessary.]

These things being premised, I declare:

That the same abundance of thermal springs and mineral fountains which we have seen in Europe exists in the other parts of the globe; and this could be doubtful only to one who is ignorant of the marvelous laws of nature. But lest we seem to have said this gratuitously, we will now record some of them, both from the records of historians and from the report of various men who have studiously traveled over the world.

Asia Major and Minor, together with the Greece it embraces, teem so full of thermal springs and the miracles of fountains that a whole volume would be needed to describe them all. Let whoever wishes read Aristotle's *On Marvelous Things Heard* [*De admirandis*], Pliny, Solinus, Theophrastus, Aelian, and countless

others. Let him consult besides the *Itinerary* of Marco Polo of Venice [Pauli Marci Veneti Itinerarium], who mentions them here and there in Tartary and the other regions; Hayton the Armenian [Haithon Armenus] too, *On the Thermal Springs at the Caspian Sea*; concerning Persia, the itineraries of various men who set forth that nearly the whole of it abounds in marvelous fountains of waters. The *Annals of the Society of Jesus on Indian Affairs* commemorate them everywhere, and among the rest most exactly Father Martino Martini [P. Martinus Martinius] in his outstanding work, which he entitled the *Atlas Sinicus*: Japan is forever boiling with most hot waters, as Luis Fróis [Aloysius Froes] testifies. The Philippine Islands so teem with them that scarcely out of the eleven thousand islands which are counted in that archipelago does there occur a single one that does not produce something singular and marvelous in its waters. Africa, chiefly along its shores, abounds in countless medicated waters.

[Margin: Greece teems with thermal springs and other miracles.]

[Margin: Asia, China, Japan abound in thermal springs.]

[Margin: The Philippine Islands teem with thermal springs.]

[Margin: Africa.]

I will not speak here of the provinces of America, which are so filled with them that — as the historians relate — they not only supply the inland region with an immense abundance of them, but in some places pour forth most fervent rivers, as it were, from the loftiest crags; and if somewhere they find no exit, they pour themselves out through the very floor of the sea, into the outermost surface of the sea with great force, all of them potent with wondrous powers. I pass over here the most frequent thermal springs of the Kingdom of Mexico, established by benign nature both for delight and for the cure of diseases. The day would fail me if [I were to attempt to recount] those which were shown in Guatemala [Quatomata], Peru, Chile [Chili], Quito [Quato], Cusco [Cusco], Potosí [Potosi]...

[Margin: In America the great multitude of thermal springs.]

[Margin: The Mexican region.]

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[if I were to attempt these things of] nature in the waters. Let this therefore be the Catholic [i.e. universal] Rule: Wherever the workshops of Vulcan are found together with metallic mines, there the miracles of thermal springs are beheld; nor can it be that the thermal springs, as it were their inseparable companions,

are absent. But that everywhere the Vulcanian workshops, the sulphurous pits, and the nitrous, saline, aluminous, and vitriolated fountains are to be found, was shown in the preceding pages. Rightly therefore do we infer that thermal springs, and fountains of marvelous faculty, are nowhere lacking. But let this suffice concerning thermal springs.

[Margin: The friendship of fire and water in subterranean places.]

CAPUT II.

Whence the Medicated Faculty of Thermal Springs Flows Forth, Against So Many and So Different Diseases.

[Unde medicata facultas Thermarum, contra tot ac tam differentes morbos, profluat.]

Since in the whole contemplation of natural things nowhere does the Majesty of Nature appear more marvelous than in the wondrous variety of waters, it must certainly be demonstrated by every means: who the craftsman of such great effects is, and what is that mastery by which elements otherwise most diverse and utterly contrary in their qualities are nonetheless united, in such great concord and such harmony, in the hot waters of the thermal springs — so that the water with its moisture does not extinguish the fiery power, and the power of fire, with its own most efficacious force, does not injure the contrary moisture. On the contrary, by a certain natural ambition of friendship, they strike pacts of peace which seem unable to be dissolved by any power. Thus fire moves all things through all by its activity, and nourishes all things through all by water; and so, according to the Philosopher's [Aristotle's] dictum, the first participation of life is from heat, and its preservation is in the moist. How, then, water conceives heat was very fully stated in the preceding pages; but how it attains so great an increase of marvelous powers — how, and by what bridesman [paranympus], the confluence of the most diverse powers is tempered into so close a wedlock, in so exact a proportion, in so precise a measure and symmetry — that surely is a matter for deeper scrutiny. Come then, let us attempt something; and if we do not seem to have satisfied the reader on every side, at least we shall deserve praise for having attempted something in a difficult matter.

[Margin: The marvelous arrangement of divine Providence, ordained for the good of mankind.]

The most wise Creator of things, GOD, the Best and Greatest [Deus Optimus Maximus], as He produced all things for the sake of man, so He willed that man

be furnished with all means of every kind for preserving him in a perfect state of health. Hence there is nothing in the nature of things which does not possess some peculiar medicinal power; nothing which does not regard with its power some one part of the human body, and bear before it, by a certain marvelous character, that for whose cherishing it was created — indeed, that it is borne, as it were by a certain weight, toward that to which it corresponds by the law of natural friendship. And since the constitution of the human body consists of many sulphurous, nitrous, saline, vitriolated, and oily parts — the very same, namely, of which every compound consists — hence it comes about that the hot water of thermal springs, with which they are exactly mixed, when used, produces those marvelous, wholesome effects that we wonder at in the symptoms of the sick. For I would not have you suppose that all the causes of these effects depend always on the primary qualities, but rather, for the most part, on the specific powers and qualities of the things mixed with the thermal waters, as we shall later disclose concerning the causes of prodigious waters.

[Margin: Salvation is in all things, just as it is found everywhere.]

Now the things that are usually mixed in perfect union with medicated baths are: salt, niter, alum, vitriol, sulphur, bitumen, together with the tinctures of the seven metals — which, as by I know not what magnetism, are borne to the principal parts of the human body entrusted to them, and so make that very power of which we are speaking marvelous, and preserve [the body] in a perfect state of health. But let us at last show the matter, beginning with medicated salt waters.

Every land partakes of its own salt — here more, there less is found — and as the lands are found to be, such grades of salty quality do the waters themselves obtain: hence they are smoky, dry, brackish, bitter, sharp, slightly bitter; and where the soil is exactly salty, [the waters] are exactly salty. Hence rarely is there in waters any impression from some mineral or metal which does not also partake of the quality of salt, for every land partakes of this flavor. Hence again it is evident that scarcely any pure and simple water is to be found — as we taught above too — that does not contain something of salt, even if in an imperceptible quantity. But the diversity of grades of sharpness depends on the subterranean places through which [the water] flows: if it has gone through mineral veins richly filled with salt, it is most salty; if through places endowed with rarer salt, it is less salty; if it has flowed through gravel and sand, having deposited its mass of salt by straining-through, it issues forth insipid. As to why hot brackish waters [aquae salsugineae] are saltier than the rest: this happens from the scorching produced by the power of the subterranean fire, by which, the spirits flying off,

the fixed salt remains; by this the waters are rendered saltier the more perfectly the dissolved salt has been mixed with the waters. The same thing, therefore, happens in brackish thermal springs by nature as in waters most thoroughly dissolved with salt prepared by art: just as these dry violently, heat less, bind, contract, cleanse, and purge — which are the proper faculties of salt — so too they cleanse the skin, and restrain all excrementitious and putrescent moisture, and [reduce] the excessive grossness of the body...

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they attenuate over time. So then, the fact that salt thermal waters are of such great benefit to the scabby, the leprous, the elephantiac [elephasis-sufferers], the spotted [maculosi], and those with vitiligo, is for the most part to be ascribed to the powers of salt. For since by nature it has been digested within the waters in a marvelous mixture, symmetry, and proportion, hence, penetrating through the open pores by the power of the heat residing in the water, it produces those effects we marvel at. And just as there is no particle of our body that does not consist of saline corpuscles, these — if they are either scorched by a preternatural heat, or have otherwise acquired pernicious qualities from the corruption of the humors — bring it about that, within the hot baths of salt, they are attracted by a certain natural appetite to particles like themselves, introduced into the water as a vehicle; and so they free the body from its troublesome guest, by the evacuation of the corrupt putrefaction and of the diseased subcutaneous humor [humor intercutaneus].

[Margin: Why it is of such great benefit in subcutaneous diseases.]

As to why it is of such great benefit to the spleen-afflicted [lienosi] and the hypochondriac, and to the other diseases which take their origin from flatulence — this happens in the manner that follows. The saline corpuscles, together with the hot water with which they are mixed, introduced through the pores and attenuated by the heat, presently pervade the whole body with their subtlety; they unblock, by their acridity, the obstructed pathways to the spleen, the intestines, the womb, and the other members. Wherever they encounter corpuscles like themselves, depraved by the fault of the humors, they draw these into themselves by a certain attraction, and at last, together with the cleansing power they possess, they soften the members, render them fit for their accustomed functions, and carry off with them the dregs — the causes of the obstructions — through the discharging gates of nature. From this it is evident why some thermal springs confer fertility on the barren: because the saline corpuscles mixed in the waters dry up by their power the foul collection of

vitiated humors in uterine diseases, dispel it, cleanse it away, and open the closed passages; and once these things are accomplished, fertility must necessarily follow — provided a natural defect of the womb does not stand in the way. And in this manner the medicinal powers of salt thermal springs operate in driving off the said diseases.

[Margin: Why & to the hypochondriac.]

[Margin: The waters of salt thermal springs.]

Nitrous thermal springs differ in few respects from the faculties of salt. For they heat, attenuate, digest, cleanse, bite, thicken, dry, and ulcerate; on account of the greater efficacy in which they exceed the saline, they are also more bitter than the salt ones; and on account of the airy, subtle, and spirituous corpuscles of niter that are mixed with the waters, they cut, and attenuate much more powerfully than the salt ones. Hence they draw out viscid humors, loosen the bowels, provoke urine, induce sweats, cleanse the kidneys, expel gravel, break the stone. For whatever they find in the body of the impurity of nitrous dregs and of malignant quality, they dissolve it — united to itself as it were by a certain attraction, by their acrimony, all phlegm and viscosity being consumed. Yet I do not know what hidden agreement they have with disorders of the eyes and blariness [lippitudo]; for it has been observed by long experience that in nitrous mines no one is afflicted either with blariness or with any disorder of the eyes — which is doubtless to be ascribed to its supreme subtlety and its incisive faculty, by which it cleanses all things. Hence among physicians niter has always been held one of the most excellent of the few eye-salves [collyria]. See what we set forth more fully, in the following Book, concerning its nature and property.

[Margin: The powers of nitrous thermal springs.]

[Margin: The flavors of niter do not cause blariness, nor do those afflicted with blariness undergo it.]

Aluminous thermal springs, besides the faculties they have in common with the nitrous and saline, are endowed chiefly with an astringent power. Hence the parts of the body which, by their thinness, they relieve of excrements, these same they strengthen, and render more robust; they check a flux of blood arising from any cause whatever; they stay the flux of gonorrhea; they soothe burnings of the urine; they remove obstruction of the bladder and the ureters; they strengthen the relaxed retentive power of the kidneys; and they produce countless other effects, to the great help of the sick. The reason for this can be no other than a certain power which, just as it partakes of a mixture of salt and niter, so operates

much more efficaciously than the aforesaid; since from the predominance of water they have the property of refrigerating, but from the fiery acrimony the property of moderately drying and astringing.

[Margin: Aluminous thermal springs and their powers.]

Vitriolated or atramentous thermal springs — in Greek χάλκανθον [chalkanthon, "copper-flower," i.e. blue vitriol] — from Calcanthum, as if you would say "the flower of copper" and the superficial recrement of the material [of copper]. And so, just as it takes its origin from copper, so it is produced only in those places that teem with copper mines. Hence the thermal springs that flow through vitriolated places of this kind partake of the power proper to vitriol, which is a vehement astringency joined with a notable heating power; nor do they any less dry, constipate, contract, and gnaw. Hence, unless they are aptly tempered, they are not only useless for drinking but even dangerous. Yet they are most useful in baths or fomentations [embrochae], suited to healing the same diseases as the aluminous, nitrous, and saline ones — with this added, however, that they penetrate and cleanse more readily. Hence scarcely any acidulous springs [acidulae] are found that do not partake of something from vitriol — not indeed as to their sensible being, but as to the spirituous and vaporous substance with which they are subtly and perfectly tinged.

[Margin: Vitriolated thermal springs.]

And these are the four species of saline bodies which, unmixed and operating each by itself, indeed afford the same effects to the waters with which they are mixed — differing only in diverse degrees of intensity, and in that property proper to copper which accrues from vitriol as well. But mixed among themselves they obtain effects utterly different; and if we trace these back to the rules of the combinatory art [ars combinatoria], we shall find that they obtain twenty-four most diverse effects.

Liber V, Sectio III — De Thermis

Caput II — Whence the medicinal power of thermal springs flows (*continued*)

Table of the combination of a mixture of the four saline bodies — salt, niter, alum, and vitriol.

The table lists, for each predominant species, the binary, ternary, and quaternary combinations of the four saline bodies, the overall complexion of the resulting mixture, and the predominant qualities (effects) it produces. The Latin verbs are: *siccat* (dries), *attenuat* (thins), *penetrat* (penetrates), *incidit* (cuts), *calefacit* (heats), *dissipat* (disperses), *densat* (condenses).

Predominant	Combination	Mixture (complexion)	Effects
Salt predominant	Salt with salt	A warm, moist mixture	dries
	Salt with niter		dries, thins
	Salt with alum		dries, penetrates
	Salt with vitriol		dries, thins, cuts
	Salt with niter, alum		dries, thins, penetrates
	Salt with niter, alum, vitriol		dries, thins, penetrates, cuts, heats
Niter predominant	Niter with niter	A dry, warm mixture	thins, disperses
	Niter with salt		thins, dries
	Niter with alum		thins, penetrates
	Niter with vitriol		thins, cuts
	Niter with salt, alum		thins, dries, penetrates
	Niter with salt, alum, vitriol		thins, penetrates, dries, cuts
Alum predominant	Alum with alum	A dry, cold mixture	penetrates, condenses
	Alum with salt		penetrates, dries
	Alum with niter		penetrates, thins
	Alum with vitriol		penetrates, cuts
	Alum with salt, niter		penetrates, dries, thins
	Alum with salt,		penetrates, dries,

Predominant	Combination	Mixture (complexion)	Effects
Vitriol predominant	niter, vitriol		thins, cuts
	Vitriol with vitriol	A moist, cold mixture	cuts, heats
	Vitriol with salt		cuts, dries
	Vitriol with niter		cuts, thins
	Vitriol with alum		cuts, penetrates
	Vitriol with salt, niter		cuts, dries, thins
	Vitriol with salt, niter, alum		cuts, dries, thins, penetrates

We could not set down here all the qualities that can belong to each of these four, but only the primary and predominant ones. For if we had wanted to list every quality proper to each individual case, the combination would rightly grow to infinity. Since each of these is for the most part equipped by nature with a fourfold endowment of qualities, twelve multiplied by twenty-four [12 in 24 ducta] will yield 288 different mixtures, and consequently different species of effects. And if I were to extend these through the four degrees of the primary qualities, there would result 1,152 mixtures, and just as many different effects. I therefore pass over in silence the diverse species of salts, niters, alums, and vitriols — for if I tried to combine these among themselves as well, the matter would run off very nearly to infinity. And who could describe in adequate words the combination of things if bitumen, sulfur, and the remaining metallic and mineral species were added in? See what we have very fully taught about these matters in our *Ars Combinatoria* [Combinatory Art].

CONSECTARIUM I. [Corollary I]

From this it is clear that no medicated water can exist that does not obtain a mixture of minerals and metals different from another's, and consequently different ratios of properties. For these mixtures behave no differently than numbers, to which the addition of a single unit essentially changes the number — as Aristotle teaches in *Metaphysics* IV [l. 4. *Metaph.*]. Even though the senses cannot reach these mixtures, that they lie hidden, blended in their secret chambers by the marvelous shrewdness of nature, reason itself teaches *a priori*, and experience *a posteriori*. And so we cannot sufficiently admire the wondrous providence of divine wisdom in the arrangement of natural things, when we look

more closely at that admirable marriage of the most diverse things conspiring into one — so disposed by a certain harmonious temper, proportion, symmetry, and measure that, in the use of these waters, the sick and diseased condition of mortals obtains an infallible effect.

But it could rightly be asked at this point how this confused little blend of so many species of different things can operate in the waters without confusion, and how it can exert its powers in the bodies of the sick. To this I answer in a few words. Since God [DEUS] and nature do nothing in vain, and all their works proceed from the best and most perfect intention, a certain marvelous attunement was surely necessary to him, lest one thing should retard or weaken the powers of another. Rather, by a certain unanimous conspiracy they should aim — by preserving the human race, for which they were created — at congruous and necessary medicinal effects. Hence it has come about that, just as the individual species of the said mingled things look toward the individual members of the human body, and by a certain magnetic and sympathetic affection toward them —

— are carried and drawn there: whether taken inwardly by drinking, or outwardly by sitting-bath, washing, smearing, fomentation [embrocha], or by trickling-drip [stillicidium] of the said waters, the individual species flow together to that member which they regard with a friendly natural affection. And since the saline species are filled with the most subtle spirits, nature uses them as a kind of forerunner [prodromus] — both to open the gates and to scour out the obstructed passages, and to prepare, direct, and ripen the mass of humors.

[Margin: "The beautiful analogy of the humors in the human body to the properties of the metals."]

These [saline spirits] are followed at last by the sulfurous spirits, like Tetrarchs in the same analogy, which by their innate heat moderate all things — namely the entrances of the best humors in the body. These [sulfurous spirits] are the spirituous substances of the metallic bodies, each of which seeks its natural station and dwelling-place. The golden substances, as if heaped with royal virtues, occupy before all others the metropolitan seat of the heart, and strengthen it. The bronze substances, and those consisting of much sulfur, flow together to the citadel of the breast and the station of the lungs. The iron substances hasten to the workshop of the spleen and the hypochondria, to purge the melancholic dregs. The leaden, tin, and nitrous-saline substances, prevailing toward the blood-making kitchen of the Microcosm, gird themselves to strengthen the liver and to dry out the dropsical phlegm. The sulfurous,

bituminous, and nitrous substances combine to loosen the intestines by their evacuating faculty. The stony mixed substance performs its parts excellently to relieve the kidneys and the bladder. Others, by their cutting and resolving faculty, are suited — applied by fomentation [embroche] — to the diseases of the brain and nerves: to paralysis, tetanus, tremor, opisthotonos, and apoplexy.

You see, therefore, that nature does with the same multiplicity of species mingled in the waters what is wont to be done in the perfect administration of a democratic state: while each individual performs the office committed to him, in this or that place, in this or that condition of office, in the best way it can be done, all nonetheless ever aiming at the same goal — which here is the common good and the single welfare of the commonwealth, and there the perfect health of the Microcosmic economy and the temperament of the humors.

CONSECTARIUM II. [Corollary II]

From this it is evident that most cases produce the marvelous effects which we sometimes see them yield in the cure of the sick — not by the primary forms of the qualities (whose sole office is to heat, to dry, to moisten, to cool), but rather by the specific properties of the minerals, arising from the likeness of the whole substance. And this specific property is nothing other than a certain sympathy, a hidden agreement of nature, by which one [water] exerts its power on this member of the human body rather than on another — as we shall show most abundantly in what follows.

And so you see, Reader, how the medicinal faculties operate in the thermal springs, and by what power they accomplish the effects we have recounted. These things accomplished, nothing further remains except that we now descend a little more deeply into the inner recesses of nature, and examine with all study and diligence from where, and from what causes, are born those astonishing prodigies which shine forth in certain springs, to the great wonder of the philosophers.

SECTIO IV

DISQUISITIO — DE MIRACULIS AQUARUM

On the Miracles of Waters, and the Prodigious Nature and Property of Certain Springs.

PREFACE [PRÆFATIO]

If in any natural compound the majesty of nature shines forth, [and] if she has assuredly placed her throne in the watery Realm, only that man could fail to know it who has nowhere beheld it. And so Pliny [Plinius], gazing up at prodigies of this kind that are almost beyond human credence, and forestalling as it were the goodwill or belief of his readers, says: *"If anyone judges that some of these things are not to be believed, let him declare that in no quarter are the miracles greater."* Some of these prodigies are referred back to heat, savors, odors, weight, lightness, thickness. Certain ones contain a wonderful power of healing; certain ones a deadly power. Nor are there lacking those which, by a kind of metamorphic virtue, turn everything to stone, iron, or copper, hasten gray hair, or are powerful with a divinatory force. Others, at the rising of the Moon, rival the tides of the sea; others are powerful with marvelous properties. Treating of these individually, in order, as far as can be done and as the weakness of our talent permits, we shall try to search out their causes.

Liber V, Sectio IV — De Miraculis Aquarum

Caput I — On the Color, Savor, Odor, and Mephitis [noxious exhalation] shining forth in certain springs and thermal waters

There are innumerable differences of colors in the waters. Since these differences are as it were manifest, we shall not dwell too long on them — especially since we have discussed this subject sufficiently and more than sufficiently, both in the preceding pages and in our *Hetruria* [Iter Hetruscum / our work on Etruria]. Who does not know that waters take on the color of whatever sort the mine or gallery is through which they have flowed? Now the channel through which the water flows can be considered in three ways: as belonging to the vegetable kind, or to the mineral, or to the metallic juices.

[Margin: "Waters are tinged by the juice of plants."]

Waters of the first kind are tinged by the juices of grasses and trees. For example: we see that the waters in which the alder [alnus] luxuriates with abundant growth are tinged a reddish or rather a lye-colored hue. If they wash over grasses such as celandine [chelidonia], chrysanthemum, and other similar plants, they are imbued with a saffron color. If they lick over white, gleaming, or chalky earth, they flow a milky color. If they have flowed through red ochre [rubrica], they are stained a red color. If through ochre or sandarac [realgar], a yellow color. If through verdigris-bearing places, they are blended with a green color — and so on with the remaining metallic juices, as we have taught above. But let us confirm these statements by experiment.

EXPERIMENT [EXPERIMENTUM]

Let there be a basin B A, into whose concave [interior] the little channels C D E F G H I K are inserted. These you should first fill with powders of various colors, namely: C with red, D with yellow, E with blue [caeruleo], F with brown [fusco], G with ash-gray [cinereo], H with green, I with white, K with black color.

Diagram. A perspective view of a round, shallow basin (concha) seen from slightly above, so the interior cavity and the rim are both visible. Eight short tubular spouts (canaliculi) project radially outward from the basin's side-wall, each connected to a small lettered opening; the basin as a whole is labeled A, and its near rim / front is labeled B. The lettered channels are arranged around the basin.

- B (top center, on the rim/interior): basin marker B
- A: the basin (concha) itself
- C (interior, upper left): channel C
- D (interior, top center): channel D
- E (interior, upper right): channel E
- F (lower right, projecting spout): channel F
- G (lower right rim, spout): channel G
- H (front center, spout): channel H
- I (front left, spout): channel I
- K (left side, projecting spout): channel K

When this is done, let the basin be filled to the brim with spring water; and the water, seeking an exit and issuing through the little channels, will be tinged with the color proper to each channel. You will thus see the water flow out tinged: red through C, yellow through D, blue through E, brown through F, ash-gray through

G, green through H, white through I, and finally black through K. I would have you suppose that the same thing happens in subterranean places. In these, imagine to yourself a water-reservoir [Hydrophylacium] A B, which discharges itself through diverse channels furnished with diverse minerals. I say that the water, in the spring of its own reservoir, is pure and simple; but as soon as it has entered the said channels — filled with veins of variously-colored minerals — it will present to the outside different species of springs in color, savor, and odor.

And this for the most part happens when they share in the corporeal substance of the earths. But if they are tinged only by the most tenuous vapors and exhalations of the minerals, or effervesce only by heat without any admixture, then they are discharged with the natural color of water — that is, limpid, clear, and translucent. And this indeed presents no difficulty; so let us proceed to other, more recondite effects.

It is asked, then, in the first place: why does the sea, to those viewing it from some mountain, display so great a diversity of colors? For in one part you will see it appear red, in another crimson [puniceum], in another yellow, in another now green.

[Margin: "The diversity of colors appearing on the surface of the sea."]

I say that colors of this kind are by no means real, nor arisen from any admixture, but only apparent (as we have amply demonstrated in our *Ars Magna Lucis et Umbrae* [Great Art of Light and Shadow]) — and that they arise either from the diverse reflection of the clouds and mountains, or, most of all, from the varied disposition of the sea-floor. For where the sea is deepest, there the sea is black and as it were pitch-colored; if it teems with the green sprouting of seaweeds, it will appear green; if with red pebbles and sand, it will appear red. In this way, in the first navigation of the Dutch [Batavi] to the Strait of Magellan [mare Magellanicum], not far from the mouth of the river della Plata [Río de la Plata], when they observed the sea stained an utterly blood-red color, they lowered a bucket and, inspecting the drawn water more exactly, found an innumerable multitude of little reddish worms mixed in the waters. These, taken up by hand, leaped here and there like fleas — and so they called them sea-fleas. Some think they are vomited up by whales at a certain time of year; others say they come from an infinite supply of small crabs, which stable themselves in the said tract of sea, and, being of a red color, present the sea, to those looking from afar, as imbued with a blood-red color. Elsewhere the whole Ocean is seen green, on account of the multitude of the plant they call Sargasso [sargasso], with which the sea is covered for many thousands of miles — about which plant, since we

have treated of it elsewhere, I have not thought it should be repeated here. Moreover, some waters appear blue (whether from the erosion of metals) or green (from a certain contagion), according to the marvelous attunement of the subterranean fire. For it is so disposed by heat that it sometimes makes juices from white turn red, from red turn yellow, from yellow turn green or black — no otherwise than as from sweet phlegm comes blood, from blood yellow bile, from yellow [bile] green or black — through certain degrees of color heightened, while from cooking [coction] —

— it [the color] proceeds, namely, into an excess of heat, and from this into a scorching. This is evident too in the diverse species of amber [succinum] — white, yellow, black — of which the first is produced from a moderate heat into white; the second from white into yellow by an intensifying of heat; from yellow, black is produced by a scorching heat. And this is the reason why rivers and springs sometimes change their native color: namely, on account of the confluence of various other rivers which enter some river, since these, taking their origin from diverse minerals, communicate the tincture they have acquired to the larger rivers which they enter — especially after great deluges of rain, by which water, imbued with the various dyes of the earthen clods of the land, rolls itself with a great load into another river. Hence the rivers are at first rendered turbid; and then, with the mud subsiding, the mineral spirits which remain infect the limpid water with various color and savor. The river Hypanis [Hypanis], most wholesome to drink — on Pliny's testimony — becomes most bitter after admitting the gush of a most bitter spring, which he calls Exampaeus [Exampaeus]. But let us now draw nearer to the miracles of the springs.

§ I. — On the Spring of the Sun [De Fonte Solis]

Pliny relates that among the Troglodytes there is a Spring of the Sun, which around midday at the new moon is extremely cold, then little by little begins to grow warm up to the middle of the night, at which time it is troubled by heat and bitterness. If the things Pliny says are true, I would readily ascribe the reason for it to the constitution of the subterranean channels. The first of these is filled with sweet water by a perennial flow, through a channel proper to it, like the other sweet springs.

[Margin: "The reciprocation of the Spring of the Sun, whence it comes."]

The other [channel], drawn from the Ocean by a long tract of ways, and heated by the subterranean fires, discharges itself into the same spring at a fixed hour. Now since the water of a channel of this kind is agitated by the ebb and flow of the sea,

it happens that for six or more hours it gradually insinuates itself into the spring; but with the sea subsiding, it too, drawing itself back, ceases from its flow, nor is it again urged by the inflowing of the sea. The bitterness of the water, moreover, results from the nitrous places through which it flows; and as the nitrous corpuscles gradually settle out from these, the limpid water prevailing, it is little by little restored to its former coldness and sweetness — which is said to happen around midday. But with the channel again stirred up by the surge of the sea, the spring, now grown cold, must necessarily grow warm and bitter again. And that the surge of the sea seethes most of all at midday, when the Sun is joined to the Moon, has been shown above. But of this prodigy [I shall say] more below.

§ II. — On Wine-Like Springs, that is, those carrying the odor of wine [De Vinosi Fontibus]

The kindly liberality of Nature has not only sported in wondrous ways in the waters, but has also wished to use mortals with delights in liquors of a wine-like savor — not, however, except when mixed with wine. The Lyncestian water [Lyncestis aqua], which is called *acidula* [sour-spring], after the manner of wine

— makes [men] drunk; which prodigy Ovid [Ovidius] elegantly described in *Metamorphoses* XV [Ovid. 15. *Metam.*]:

Differing in effect from this flows the Lyncestian stream, Which whoever
has drawn with little-moderated throat, Staggers no otherwise than if he
had drunk pure wine.

And concerning a wine-like spring on the island of Naxos, Propertius [Propertius] [says]:

And for you, Naxos, through your midst [flow] sweet-smelling rivers,
From which the Naxian throng drinks your unmixed wine.

And lest we be compelled to attribute some exaggeration to the fabulous poets: it is established that in very many regions of Germany and Gaul springs of this kind, which are said to recall the savor of wine, are found. Among these the most famous is that spring, celebrated by the confluence of men, in the County of Katzenelnbogen [Comitatu Cazenelobogensi], situated not far from Mainz [Moguntia], called Schwalbach [Sualbach] after the town it adjoins. Another is near the confluence at Andernach [Andernacum]. Another, in the Lyonnais territory of Gaul [Ager Lugdunensis] at the town of Saint-Galmier [S. Baldomani], called the Strong Spring [Fons Fortis], *fontaine fort*, supplies the lack of wine: if a

quarter-measure of it is mixed with wine, nothing of the wine's savor is lost; if it is poured onto flour, it immediately ferments, like any sour [liquid]; it is so wholesome that the townspeople rarely use a physician — by which virtue the aforementioned springs too are powerful. Such a one is also found in Aquitaine, not far from the city of Bazas [Bessa], a sour, wine-like spring: if you pour even a little of it into wine, you would believe you had drunk pure wine diluted with no water. In Spain, near Valencia [Valentias], it was shown above that similar ones are found. Since these things are so by the common estimation of men, the cause of this savor is rightly inquired into: namely, whether there is in the water itself something resembling the odor and savor of wine, or not?

I say: since all sour-springs [acidulae] have some unaccountable friendship with wine, and marvelously excite and exalt the savor of wine and the spirits lying hidden in it through their native sharpness — hence I think it comes about that —

[Continuation, left column, printed p. 275 lower:]

— [the springs are wine-like]. Now since this kind of channel-water is agitated by the ebb and flow of the sea... [this passage belongs to § I above; the columns interleave].

The Lyncestian water, which is called *acidula*, after the manner of wine, tinged with wine, while they titillate the tongue and palate with a pleasing tickling — and so, deceived by the odor and savor of wine (as we have also said in the preceding remarks) — [people] suppose that that odor and savor which is in wine is present in the sour-springs themselves. For since all sour-springs take their origin from alum or vitriol, mixed together with niter, and these are devoid of odor, it is certain that they cannot exhale that wine-odor of themselves. Rather, the sour water itself, joined to the agreeable sharpness of wine, produces in the imagination of the drinkers such an effect as they experience in the savor of wine. All these things, long and much explored in springs of this kind by various experiments, have at last become known to me. And so waters of this kind are not called wine-like because they share in the nature of wine, but because, sharp and joined and mixed with wine, they make a more pleasing draught of wine. For separated from wine, you would perceive as much of its odor as of any other sweet waters which we use everywhere in drinking. Let us therefore leave this opinion to those who, just as they always reek with a wine-like breath, so dream of nothing but wine-like liquors and their drinking — or at most of the first savor of the sour-springs.

[Note on page order: the PDF pages of this opening are bound out of sequence. By printed page number the reading order is 276 → 277 → 278 → 279, i.e. → 1 → 4 → 3. The translation below follows the printed-page order.]

CAPUT II.

On the gravity and levity of certain waters, and their marvels.

[Body heading reads "C A P U T II." — this opening begins Chapter II of Section IV, not Chapter I.]

The Peripatetic school refers the causes of gravity and levity in waters to the primary qualities, heat and cold; others refer them to density and rarity. For just as waters draw savors and odors from the material they pass through, so from that same material — and from its various mixtures of mineral particles, such as salts, niter, alum, vitriol, and the rest of the minerals — they acquire gravity in proportion to the abundance of what is present, and levity in proportion to its scarcity. From this arise those remarkable spectacles in waters: some of them buoy up whatever is thrown in, while others submerge whatever is thrown in. The cause of this is nothing other than the gravity and levity of the waters.

[Margin: Why some waters are heavier than others.]

But to proceed gradually from the better-known to the less familiar: many people wonder why ships unloading from rivers into the sea ride deeper in the rivers than they do in the sea. I myself have noticed this more than once and observed it carefully: as soon as ships are carried down from the Tiber [Tybri] into the sea, they rise about two palms higher and lift up above the water. The cause of this is nothing other than the salt mixed into the sea, which, just as it makes seawater denser and heavier, likewise holds the ships up higher.

EXPERIMENT.

Take two cups, one filled with spring water and the other with water diluted with salt. Once this is done, drop an egg into the first cup filled with spring water, and you will at once see it sink; drop the same egg into the water saturated and diluted with salt, and now you will find it floating on the surface. For the lighter the water is, the more easily the egg sinks; and the denser the water is, the more easily it floats.

COROLLARY.

From this it is also clear why certain fresh waters sometimes flow on top of others — why, for instance, the Rhine [Rhenus] flows over Lake Constance [lacum Acronianum / Lake Acronius], the Rhône [Rhodanus] over Lake Geneva [Lemanum], the Mincio [Mintius] over Lake Garda [Benacum], the Ticino [Ticinus] over Lake Maggiore [Verbanum], the Adda [Addua] over Lake Como [Larium], the Oglio [Ollius] over Lake Iseo [Sevinum], and the Marcia over Lake Fucino [Fucinum]. There is no other cause for this — as we have explained in earlier passages as well — except that the rivers, purged by their continuous flow and motion and having deposited the heavier mixture, are rendered lighter than the waters of the lakes, which are contaminated with various mixtures of subterranean matter. These lake-waters necessarily become heavier: partly because they are weighed down by bituminous matter, partly through the absorption of earthy juices, and partly too because the Sun draws off the finer parts of the water, leaving the dreggy substance behind. It is likewise widely established that oily, greasy waters float on top of fresh waters.

[Margin: Why some waters do not mix with others.]

And from this is also clear the cause of the spring of Panchaea [fontis Panchaei] in Thrace, of which Plutarch [Plutarcho] reports that a vessel filled with its water weighs twice as much in winter as in summer. This is because in winter, when the pores of the earth are closed, subterranean vapors entering through the openings in its bed fill the water with various mixtures of mineral matter — whence it is heavier; but in summer, when the Sun's heat opens the pores of the earth, these same vapors exhale and leave the spring free of any admixture of vapors. Hence it comes about that, for the reasons stated, the bottom of such springs is warm in winter and cold in summer.

Pliny [Plinius] records that in a lake of Sicily near Agrigentum [Agrigentini], in the Asphalt Lake [Asphaltitico] of Palestine, in the Acuscidamus [Acuscidamo] of Africa, and in the Arethusa [Arethusa] of Greater Armenia, everything floats and nothing sinks — not even bricks. In others, by contrast — as in a certain lake of Ethiopia [Aethiopiae] — everything sinks the instant it is thrown in, so that the lake does not even hold up the leaves of trees but they immediately sink. Into the Alcyonian Lake [Lacum Alcyonium] at Lerna [Leonam], if anyone enters, even a skilled swimmer, he sinks at once whether he wills it or not, dragged down to the depths with great force.

[Margin: Waters in which nothing sinks.]

The cause of each of these prodigious effects is asked. I say, then, first: in lakes in which nothing sinks — as in the Asphalt Lake — the cause is bitumen, with which it is so saturated that it can rightly be called a bituminous sea. Since, therefore, it is the heaviest of waters, as well as the densest, and most tenacious because of its glutinous and slimy matter, it will certainly hold up all the things thrown into it, provided they do not exceed the bituminous mass in their own bulk — as will be clear from what we shall shortly bring forward from the Archimedean doctrine. But in lakes that are not bituminous, yet are rich in salt, niter, or petrifying juice, the waters — loaded with saline, nitrous, and stony particles — are rendered the more powerful at holding up any heavy things thrown into them, the more they are condensed by the said particles. In some places these particles, combined with bitumen, make certain stretches of sea wholly impassable to ships, as the nautical itineraries report of the muddy sea encountered in the innermost gulf of California [Caleforniae].

The explanation, then, of lakes that hold up whatever is thrown in is easy. A greater difficulty arises in explaining those lakes in which everything — even the leaves of trees — is seized and submerged, since these marvelous effects cannot be ascribed to the levity of the water but must have other, more hidden causes, which we now set out to explain.

[Margin: Why some waters hold nothing up.]

We say, therefore, that the cause of these effects does not depend on the levity of the waters, but on the violence of the water as it discharges itself at the bottom through various subterranean channels. From this discharge, whirlpools necessarily follow; and from the whirlpools, the drawing-in of bodies thrown into them. Daily experience at Rome in the summer months teaches this: when even the most skilled swimmers happen to fall into the eddies of such a whirling river, they are dragged

[Note: the printed running header on this page reads "DE THERMIS" (On Thermal Springs), which appears to be carried over from a neighboring chapter; the body content here is the §. I of the present chapter on the gravity and levity of waters.]

down into the deepest recesses of the river by a kind of violent suction, and with no hope of escape left, they are swept away to a pitiable death.

You may learn this by experiment in a vessel pierced through its bottom with several holes made on purpose. First fill it with water while the holes are stopped; if you then throw in objects of various kinds, they will easily support themselves on the surface. But if you open the holes in the bottom, then behold —

whatever you have thrown in is driven as though into whirlpools: wood, paper, leaves, snatched up by the rushing outflow of the escaping water, soon sink. Therefore, whenever such waters are found in which all bodies are seized by a kind of suction, I would judge that the cause of this is to be assigned to the whirlpools.

§. I.

On the true and real cause of the weight — that is, the gravity and levity — of waters and of the things that float in them, from the Archimedean doctrine.

Many have supposed that bodies floating on water are caused partly by the thickness or coarseness and viscosity of the waters, and partly by the form and shape of the bodies floating in them. Thus they say that a flat dish floats on water more easily than a sphere, or a cube, or a body of some other shape. But they are mistaken, since this whole floating depends solely on the gravity and levity of the water, in proportion to the bulk of the body resting on it. And although we have demonstrated this most fully from the doctrine of Archimedes [Archimedis] in his book *On Floating Bodies* [περὶ τῶν ὀχουμένων (peri tōn ochoumenōn, "on the things that float"), i.e. *De iis quae vehuntur in aqua*] — in the Second Book of the *Art of Magnetism* [Ars Magnetica, Kircher's *Magnes*] — it nonetheless seemed worthwhile to add here a few points left out there. For nothing concerning the gravity and levity of bodies will be encountered so obscure and abstruse that you cannot assign its cause from these.

Three cases, then, can occur with things floating on water, from which their greater or lesser gravity and levity is gathered. First, if some body placed on water is, for an equal bulk, heavier than the water whose place it occupies, I say that such a body will immediately make for the bottom. Second, if a body placed on water has a gravity equal to a bulk of water equal to the place it occupies, I say that it will not go to the bottom but will rest, placed at any point within the water's depths. For it will neither rise nor project above the water's surface — otherwise it would be lighter, contrary to our supposition — nor will it descend to the bottom — otherwise it would be heavier, contrary to our supposition. Placed, therefore, at any point within the water, it will rest at rest.

But third, if a body of this kind, placed on water, floats on top, I say that it is necessarily lighter than a body of water equal to the bulk of the whole body placed on it — and precisely as much lighter as is the weight of the water that equals the magnitude of the submerged body. That is: if you place a wooden cube on the water and suppose that it sinks to its midpoint, I say that the portion of water which the half of the cube placed in it occupies will be of as much weight

as the whole cube weighs. But if the cube corresponds exactly to the surface of the water, with no part of itself projecting, I say that the water whose place the cube occupies will be of equal weight to the whole cubical body. And likewise, a body that makes for the bottom will necessarily be heavier than the body of water whose place it occupies. But I demonstrate the matter by an example.

Diagram. A large rectangular vessel (a cutaway tank of water), labeled ABCD, shown in perspective. Within and around it several small cubes are drawn at different depths to illustrate the Archimedean cases of flotation. The accompanying text below the figure reads: "Let the water be ABCD, within which a cubical body is sunk; let the surface of the water be AB, and the bottom CD." The cubes are lettered to match the proof (printed p. 278). Readable labels:

- A (upper-left corner of the tank): vertex A (the water's surface AB runs from A along the top).
- B (upper-right corner): vertex B.
- C (lower-left corner): vertex C (the bottom CD runs along the base).
- D (lower-right corner of the base): vertex D.
- E, F, G, H (small cube resting on the floor at lower left): the fully-sunken cube EFGH, sitting on the bottom CD near corner C.
- I, K, L, M (small cube at mid-height, left of center): the cube IKLM, suspended within the water; an interior point N is marked beside it (the resting point).
- N, O (cube high on the surface, upper center): the floating cube NOPQ; the letter O marks the cube projecting above the surface.
- T, X (cube at the surface, upper center-right): the cube whose label includes X, with lower vertices marked by Greek letters ρ , ς , π , θ (rho, sigma, pi, theta) and x , y , ζ , α .
- V, β , γ , ε (cube to the right, with sub-vertices): a cube with Greek-letter vertices β , γ (beta, gamma); P marks an adjacent floating cube with Greek sub-vertices δ , ε , ζ , η (delta, epsilon, zeta, eta).
- P (small cube at right, partly submerged): the cube P, two-thirds immersed.

[Below the figure:] Let the water be ABCD, within which a cubical body is sunk; let the surface of the water be AB, the bottom CD. Let some cube be immersed first within the water near A. If it descends to the bottom CD — as appears in the cube EFGH, resting on the bottom — I say that it will certainly be heavier...

than the body of water EFGH whose place it occupies. For if it were lighter than the said water, it would not make for the bottom but would stand either in the

middle or above the water's surface. But by hypothesis it makes for the bottom; therefore it will be heavier than the water whose place it occupies — which was to be shown.

But if another cube is immersed in the water so that it corresponds exactly to the water's surface AB — such as is the cube IKLM — I say that the body of water IKLM will be of equal weight to the cube, and that, placed at any point in the water (for example at N), it will rest. If not, then it will either descend to the bottom or rise above the water's surface. If the former, then it no longer is of equal weight to the water whose place it occupies, and so it will be heavier — which is contrary to the hypothesis. If the latter, then it will be lighter — which is likewise contrary to the hypothesis. Therefore it will be of equal weight to the water whose place it occupies, and consequently it will rest wherever it is placed within the water.

But if the cube taken floats on the surface of the water — as happens with the cube NOPQ — I say that the cube is lighter than the body of water which equals the cube's body, and lighter indeed in proportion as the cube stands the greater part outside the water. Let me explain. Let there be first the cube O, which is immersed in the water to one-third of its body, with two-thirds of the cube projecting. I say that the water $\rho \varsigma \pi \theta$ (which is the third part of the water equaling the whole cube), this third part, I say, of the water into which the cube is immersed, will be of equal weight to the whole mass of the wooden cube — because the watery body $\rho \varsigma \pi \theta$ is three times heavier than the portion $\rho \varsigma \pi \theta$ of the submerged cube; and therefore it is of equal weight to the whole cube; and therefore the cube will be immersed only to a third of its part.

Next, let there be the cube X, which, let into the water, is immersed to half of its part. I say that the water $x y \zeta \alpha$, at the weight of half the cube, is double the whole watery cube $T V Z \alpha$, and equal in gravity and weight to the whole wooden cube. Since, then, the half of the water is double in weight to the half of the whole cube floating above, the cube cannot be sunk to the bottom, but will be immersed to half of its part, with the other half projecting above.

The same is to be said if the cube P is immersed to two-thirds within the liquid — that is, to the whole mass $\delta \epsilon \zeta \eta$; for then only one-third of the cube will be seen to project above the water. For the watery mass of the two-thirds will be equal to the whole wooden cube, and consequently only one-third will project from the wooden cube. Similarly with the cube O: in the cube NOPQ equal to it, one-third subsiding will leave two-thirds outside the water. For just as the portions of the watery cube stand to the whole watery cube, so in the wooden cube the

submerged portions stand to the whole cube that projects. All of which is demonstrated most subtly by Archimedes, by [Christoph Clavius / "Gebold"?] [?: source has "Getholdo" — perhaps Guidobaldo del Monte (Guido Ubaldo); reading uncertain], and by Galileo [Galileo] in the cited place.

[Margin: The gravity and levity of bodies in waters is demonstrated.]

COROLLARY I.

From this it is clear that this holds true not only in solid and homogeneous bodies, but in absolutely every body floating on water — since this floating depends precisely on nothing other than the gravity of the water, with no regard had to this or that particular water. For whether the liquid is well-water, spring-water, sea-water, salt, nitrous, sulphurous, or bituminous — whatever liquid it may finally be — it makes no difference: only its gravity is to be considered. The heavier it is, the more it carries; the lighter it is, the less — as is clear from the examples adduced above. Indeed the liquid quicksilver of mercury [Mercurialis hydrargyri liquor], just as it surpasses all liquids in gravity, so too will let nothing, however heavy, that is placed on it be submerged — excepting gold, which is heavier than it.

Again, no account is to be taken of the bodies resting on the said liquids — neither of their shapes transformed into various forms (flat, round, angular), nor of any particular position of the body, as many have persuaded themselves. Whatever the body may be, and of whatever parts it is finally composed, clothed in whatever form, such a body — however heterogeneous — is always to be taken as a single, whole, solid body. If for this body you take a mass of watery body equal to it, and find that mass heavier than the weight of the immersed body, you will infer that this body must necessarily be submerged in it. But if the weight of the water is equal to the weight of the body placed on it, the body will neither rise nor descend. And if, finally, the body is lighter than the water — for the body placed on it — then it will float on top, in the proportion we prescribed just above.

For example: if someone takes a dish of bronze, and [places it] upright [?: a few words abraded; sense is "places it flat/upright on the water"], it will certainly float — not precisely by reason of its shape, as many wrongly think. For if the dish is filled with liquid and becomes heavier than the water whose place it occupies, it must certainly sink; but if the whole aggregate is still lighter than the water whose place it occupies, then only so much of it will sink as is the body of water of equal weight to that aggregate.

And from this it is clear why ships float without any danger of sinking. For if you take the whole aggregate of the ship with everything contained in it, I say that as long as the gravity of this whole aggregate is less than the magnitude of the water whose place it occupies by its immersion, the ship will float — even if it is equal in weight to the whole aggregate. From this it is clear that, whether the weight of the water is varied — as happens in certain seas filled with briny moisture — or the weight of the ship is varied, its degree of immersion is always varied accordingly. For if the water becomes heavier through some accident, then a smaller quantity of water will equal the ship's weight, and so it will sink less; whereas, when it meets with clear and pure water, the ship will sink the deeper in proportion as the water is freer of thick humors. But if the ship is weighed down with stones, casks, or other things, then

[Margin: The gravity and levity of bodies in waters is demonstrated.]

it will then doubtless require a greater quantity of water to equal the ship's weight, and consequently a greater portion of the ship will sink. But let what has been said about gravity and levity suffice — which I judged should be explained at greater length, so that whatever we have said up to now about the gravity and levity of waters, and shall afterward say about floating islands, may be referred back to it.

COROLLARY II.

On islands floating in lakes and ponds.

Floating islands are earthy portions in lakes, masses heaped up from various mixtures of lighter and viscous matter, which — driven this way and that by the wind — are nowhere firm or fixed. Seneca [Seneca] testifies that he once saw such islands in the lakes of Statonia [Stratoniensi], Tarquinii [Tarquinienesi], and Vadimon [Vadimonis]; and we ourselves have treated of them at length in our own Etruria [Etruria] — though it is found that none of them survive to the present day. Pliny [Plinius] teaches that in the Lake Cutiliae [Lacu Cutiliae] in the territory of Reate [Agri Reatini] a huge island floated in the time of the Aborigines, known to the ancient colonists of Italy by an oracle. Posidonius [Posidonius] reports that in Lydia [Lydia] there were the Saltuares Islands of the Nymphs [Nympharum Insulas Saltuares], moved at the beat of the feet of musicians keeping time. Herodotus [Herodotus] tells marvelous things about the island of Lake Chemmis [Lacus Chemnis] in Egypt, which floated while supporting groves and woods and the great temple of Apollo [Apollinis]. Today they are found in many places, both in Europe and in the other regions of the

parts of the world — Asia, Africa, America. But passing these over, let us pursue those that are both near to us and better known.

[Margin: Where floating islands come from.]

Three miles from Tivoli [Tybure] as one goes toward Rome [Romam], one must cross the river Albuneus, or Albula [Albula], so called from its milky color [a colore lacteo], which has its origin from a nearby lake — a lake notable for sixteen floating islands which they call *Barchettae*. As for their nature, properties, form, manner, and composition, I refer the reader there, since we have described them in a whole treatise in our *Latium* [*nostro Latio*, Kircher's *Latium*]. There is also, in the Gallo-Belgic province near Saint-Omer [Andomarum], a lake carrying a huge island planted with trees and rich in pastures, on which sheep and cattle, intent on the pasture, are carried along together with the island wherever the force of the winds drives them. In Gallia Narbonensis too, not far from Roussillon [Ruscinone], one is seen, bright green with fine, slender reed. But setting these aside, let us return to the argument before us.

Two things deserve to be examined here: first, why they float; second, how most of them — of which the ancients made such famous mention — eventually ceased to exist. The cause of the floating is undoubtedly the levity of the material itself, according to what we said a little earlier about things resting in water. For if they were heavier than the bulk of water whose place they occupy, they would certainly sink; but they do not sink, because — as we have often examined by curious scrutiny — just as they are compounded of bituminous earth, sulphurous clods, straws, wood, rushes, and the roots of plants, cohering by the wondrous craft of nature through the glue of viscous bitumen, mixed together with mud and slime, so too they float by the texture of their lighter material at the pleasure of the winds, and drift this way and that, stable in no place.

It remains to be examined how they are generated and how in time they decay. The matter stands thus: since nearly all floating islands in lakes are born amid bitumen, sulphur, niter, and similar fetid material, it happens that at first they are glued together by the viscosity of the bitumen, with diverse matter together with sands or mud and with sulphurous and nitrous particles, which congeal by the force of the water with which they are soaked. These, in the course of time — whether by the lake's flooding, or by storms and the force of the winds, or by rains and downpours, especially in soil that is not stony but muddy and eaten away — at last fall away; and once this has happened, they soon float by the levity of the material of which they are composed, and so turn into floating islands. It can also happen that — whether by an earthquake or some other

accident — a tufaceous portion in the bottom of the lake is cut off and, rising to the surface by its own lightness, passes into a floating island. And by these means floating islands can be generated.

[Margin: Why they sometimes disappear.]

They vanish, however — or cease to float — either by the frequent collision of many years, made both among themselves and against the shore, by which in time they are worn down and dissolved and, broken into several parts, are fixed to the shores, united to the firm earth, and grow together again; or else such islands, pressed by the excessive burden of growing herbs, stalks, and shrubs, and weighed down too by the abundance of sulphurous and nitrous matter continually accreting there, have the gravity of the island overcome the gravity of the water whose place it occupies, and at last, sunk of their own accord by their own weight, settle to the very bottom. This is the origin and corruption of floating islands. Hence it is no wonder that there were once many such islands in the lakes mentioned above which today do not appear — islands which have either coalesced with the firm earth, or, increased in weight, have at last subsided. It is no wonder, too, that today many floating islands are found which were unknown to the ancient Romans, as we reported of Lake Albuneus. In this way nature plays in the world by the perpetual alternation of generation and corruption, so that those which cease in one place rise up new in another, themselves also destined to perish in their own time. And let this suffice concerning floating islands.

CAPUT III.

On Deadly Waters and Charonian Pits, Endowed with a Lethal Power.

[De Aquis lethiferis & Scrobibus Charoneis, deleteria vi pollentibus.]

These waters differ in various ways. Some are deadly only to animals and not to humans; others, by contrast, to humans and not to animals; still others to both — and indeed even to the very plants that grow up along their banks. To the first kind belong all those Charonian pits [Charoniae fossae] which I have treated at length in my account of our own Etruria [Hetruria]. At the merest whiff of their odor, birds flying overhead drop down dead — as happens with the waters at Monte Pulciano [Mons Politianus], and near Rapolano and Volterra [Volaterra], which the locals commonly call *Puzzole*. Yet these same waters, when drunk by humans, do no harm at all: they are perfectly clear, and they provide a remedy for serious illnesses.

[Margin: Why the waters of Avernus are deadly.]

As for why they kill birds, the cause is a vapor rising from burnt sulphur. Just as this vapor is antithetical to birds — being ἀντιπαθῆ [Greek: ἀντιπαθῆ (antipathē), "antipathetic," naturally hostile] — and produces in them a suffocation of the vital spirits, so too it brings about their death. The Lake of Avernus [Lacus Avernus] has this same power, as do the waters of the Styx [Aquae Stygiae] in the territory of Caere [Ager Caeretanus], whose vapor proves deadly not only to birds but, when the *Syrophoenix* wind [Syrophoenice] blows, to cattle and other animals as well — as I heard from the very shepherds themselves while exploring these places. But since countless Charonian pits of the same property are found across the world, I pass over them and turn instead to those things which I have learned either ἀντιπαθεῖ [Greek: from direct observation] or at least by the reliable account of others — ἀντιπαθέων [Greek: ἀ. (autopsia/relation), "by autopsy or trustworthy report" — *Kircher distinguishes what he saw himself from what he heard reliably*] [?].

By contrast, there are some waters that bring death to humans and other animals but spare the fish that live in them. The only reason for this is the fish's continual exposure to the water: just as they have converted the water's poisonous power into their own nature, so too it serves them as nourishment. The same thing happens with certain humans who, by gradually taking poisonous substances, have come to use them without harm — as we read of Mithridates [Mithridates] and of Albertus Magnus [Albertus Magnus], who tells of a girl of Cologne [Colonia] that, by hunting and eating spiders, made herself immune to every kind of venom; yet she became so saturated with the poisonous spirit that she could kill others by her very breath. I say the same thing happens with fish living in poisonous waters.

By the account of the poets and historians, such was the Styx [Styx] said to be: a spring which, according to Pliny [Plinius], Seneca [Seneca], and others, falls drop by drop from a steep crag at Nonacris [Novacris] in Arcadia into a lofty rock, then flows down into the river Crathis [Crathin], and at last spreads out into a lake. It is of such great poison that, once its water is drunk, it instantly kills both humans and animals. There is also the treacherous clarity of the water, by which those tormented with thirst are deceived: the moment they have drunk, they fall down lifeless.

As for the reason, I would suppose it to be one of several things: either a certain power of the water — a petrifying force that binds and hardens the inner organs, as happens in gypseous waters; or a corrosive force, by which the stomach and the parts adjoining it are eaten away; or a suffocating and constricting force, by

which the throat and the passages of the windpipe are blocked off, leaving no power to breathe; or an arsenical spirit mixed into the waters in the most exact proportion, which, being utterly hostile to the heart, kills as quickly as possible by drying up the vital spirit and consuming the vital vessels. Any one of these is enough to kill — and with all the greater speed when they have all flowed together into a single mixture in the water.

[Margin: The property and power of a horse's hoof.]

My opinion is confirmed by the remarkable effects these waters produce. For, as the authorities just cited testify, not only do all vessels — of whatever material they are finally made: glass, crystal, *murra* [murchina], stone, earthenware — into which the water is poured shatter and burst apart, but even leaden, bronze, iron, tin, silver, gold, and electrum vessels are dissolved, just as by a certain *aqua regia*, by the true corrosive Stygian power. A horse's hoof alone sustains the water unharmed — and Pliny and Vitruvius [Vitruvius] attest that this water was offered to Alexander [Alexander], and brought death to him who drank it.

If these things are true, the reason and cause must be sought as to why a horse's hoof alone can sustain the water of the Styx without injury. Granting, then, that the matter is so, I say that this effect must be ascribed to the constitution of the horse's hoof. For since it is formed of nitrous excrements joined with a certain natural fattiness, congealing by nature's craft into a kind of horny material, it comes about that, by a certain natural condition of its own, it resists corrosive waters — just as, by a most recent experiment, *aqua regia* or Stygian water extracted from salt, niter, alum, or cinnabar (which they call the "infernal" water [*aqua infernalis*]), when poured over a horny plate or onto a hoof, leaves it unharmed, without any corrosion or eating-away.

[Margin: Antidote to arsenic.]

For there is in certain things a viscosity and stickiness so opposed to acid and corrosive substances that it seems they cannot be subdued by them at all. This is plain too from the wax which engravers [Chalcographi] spread over the plates they are to engrave: it suffers nothing from the Stygian or *aqua-regia* liquids; yet the moment it touches a bronze plate, it eats it away. From this I am quite convinced that this same effect may be obtained not only in a horse's hoof but in the hooves and horns of any other animals whatever. It is also clear from the experiment of physicians who, when they undertake to cure those who have incautiously swallowed arsenical, mercurial, or verdigris poisons, achieve their aim no more easily than by having them drink oils and similar juices imbued

with a certain stickiness and viscosity. For this poison, as it were ensnared and choked off by a kind of suffocation, can then no longer spread itself.

[These things having been set forth, let us now proceed to the rest — to setting out the properties of deadly springs.] It is not only to animals of every kind that pestiferous springs are found to be deadly, but to the very fish as well, as Agricola [Agricola] testifies. He says that in Germany, by the river Saale [Salam fluvium], there is a spring of the clearest water — yet at certain fixed seasons of the year it falls into so malignant a state of nature that it kills however many fish are in it, though the water itself departs not at all from its former condition in either color or taste. The reason for this is none other than that, at certain seasons, the subterranean *aestuaria* [steaming exhalation-chambers], stirred up, emit a virulent and most subtle vapor from the burnt putrefaction lodged there. Being most subtle, it easily mixes with the waters; the fish thus infected die at once. But soon, once the vapor has been breathed out and the subterranean exhalations cease, the water is restored to its former wholesomeness, and the lake is replenished with a fresh brood of fish — a clear sign that this affection comes on suddenly and ceases suddenly.

Experiment also teaches this. For once, when our apothecary [Pharmacopaeus] had ground arsenic into powder in a mortar, and then rinsed an ill-cleaned vessel in the basin of household water that was stocked with fish, the fish, infected on the instant by its great and virulent force, all to the last one died.

I return to the birds, which experience teaches are afflicted by pestiferous vapors of this kind beyond all other animals. Hence the Charonian pits [scrobes Charoniae] and the Plutonian caverns [Plutonia antra] not undeservedly earned among the Greeks the name ἄορνα [Greek: ἄορνα (aorna), "without birds"], to which the Latin *Avernus* corresponds.

[Margin: Why the exhalations of caverns are noxious to humans.]

That this is true I came to know for myself: when, given the opportunity, I explored such places, the sulphurous exhalations of this kind the birds shunned by a certain natural instinct, as things contrary and deadly to them. For since they are of an airy temperament, they feel a hostile force of this sort far sooner and more readily than land animals do; indeed, the moment they have inhaled it, they are seized by a kind of vertigo, swept sideways, and either suffocate in the water or perish dashed against the rocks and ground.

That the matter is no otherwise I learned by this experiment. Having placed a sparrow inside a cage, I lit, beneath the cage, sulphur mixed with a tiny portion of

bitumen — and behold, at the very first whiff of the smoke the little sparrow grew faint, and with the cage door opened it flew out, as if to take some thought for the safety of its life by flight; but with the vertigo gaining strength, it was at last, like a drunken creature, dashed to the ground, and was gradually failing. Soon, however, after cold water was sprinkled on its head and poured into its beak — the cold dissolving the vapor brought upon its head — it was restored to its former strength, though without this remedy it would surely have perished.

From this I gathered why animals brought into the grotto of Pozzuoli [spelunca Puteolana] — which they call *Cane* [Grotta del Cane] — and stupefied in a moment, are freed from their stupor and revive when they are suddenly plunged into the neighboring Lake of Agnano [lacus Agnani]. The marvelous properties of this grotto, known to the whole world and described by countless authors, I pass over; on these I do not linger. Let it suffice here to show the cause and the diversity of the effects that these exhalations produce in nearly all places where a great mass of sulphurous and other mineral waters is lodged.

And first, it is certain that the evaporations of sulphurous and mineral waters differ greatly from the pernicious vapors that the Plutonian grottoes breathe out. For the former free people, as experience teaches, from many infirmities; the latter, imbued with a certain deadly force, threaten them — I will not say with health, but with death on the spot. Why the vapors of mineral waters do not harm humans was stated in what came before; why, on the other hand, the exhalations of caverns are altogether harmful and deadly to them, we shall now explain.

I want you first to be quite convinced of this: that these fissures of the caverns, exhaling a pernicious spirit, derive their origin from the subterranean caves; and that the inner air of the caverns, deeply tinged with the dregs of many mineral juices, the moment it is stirred up by the *aestuaria* lying beneath and belched out through fissures of this kind, will produce the effects we have recounted — and indeed effects most diverse according to the diversity of the matter. For if the air has been tinged only with the exhalation of burnt sulphur, it will bring danger to none but birds; if it has belched forth exhalations mixed with the dregs of burnt bitumen, it will afflict, with a certain narcotic force, all those animals that have approached such places too incautiously. Again, if the air is tinged with calcined arsenic, antimony, or quicksilver liquid poured over it, it will, without any remedy, bring death to animals by suppression of the heart. If it is the exhalation of gypseous matter, mixed with a portion of vitriol or alum, it will strangle those who come near.

In this way it will cause differing symptoms according to the nature of the poisonous matter. These pestiferous exhalations are produced either by the inner heat of the earth, as I said, or by the force of underground fires burning the rocks and other mineral clods — such as, among other things already set forth, are pyrites, *stibium* (which they call antimony), cadmia, sublimate mercury, and countless others. These, when macerated with strong waters [aquae fortes], emit exhalations so deadly that they strike men senseless at the very first odor. All this is established by the experience of goldsmiths [Aurifabri] and of the miners themselves: the former, in handling the said minerals, unless they proceed with great caution, are afflicted with dreadful and incurable diseases; the latter, once a subterranean cavern of the mountain has been opened, are so suddenly overwhelmed by the dregs of such exhalations that often all who are working there are smothered and perish to the last man. How they are wont to meet this plague of exhalations will be told below in its place.

Finally, if a very great mass of putrefactions has flowed together into the said caverns by way of rains through the hidden channels of the earth, then — fermented by the metallic spirits and the exhalations of the *aestuaria*, dissolved by the *aestuaria* into exhalations — it infests, through the fibers of the earth, first the vegetable economy [vegetabilis Oeconomia],

then the air as well with its taint. From this, through the corrupted nourishment of living things and the contamination of the air, various and monstrous *geneses*, kinds of diseases, and the most savage plagues arise, and carry off a great part of mankind. But let the reader consult my *Scrutinium Physico-medicum* [*Scrutinium Pestis Physico-Medicum*], where I have treated these matters at length.

CAPUT IV.

On the Ebb and Flow of Certain Springs, and on the Various Changes of Waters; together with Springs that Foretell Famine and Dearth.

[De Fontium nonnullorum fluxu & refluxu, & varia Aquarum mutatione, uti & de Fontibus annonae caritatem praenunciantibus.]

It seems a marvel to some that there are springs and baths that imitate the ebb and flow of the sea, yet with remarkable irregularity. Some ebb and flow twice daily; others over cycles of twelve days or more; certain ones dry up for half the year and flow for the other half. I will not recount here what the ancients have handed down about such springs, wrapped in countless fables, but only what I

have either seen myself or learned at least from the report and writings of men entirely worthy of trust.

[Margin: A reciprocating spring.]

There is a place in Westphalia [Westphalia], about four leagues distant, beside a village which they commonly call Altenbeken [Altenbecken], in an open field; it is sown all about on every side with heaps of sand, and shows no hint of water. In this sandy plain water bursts forth twice by day with such force and roar (whence it earned the name *Bollerbrunn* [Bollerbrunn]) that it floods the whole of that surface; and then, decreasing in the same way it rose, it hides itself entirely, leaving only the sandy surface we mentioned.

The locals who dwell by the spring told me that the bishop Theodore [Theodorus] [?], an officer [?] once most eager to see this marvel, brought a party with him there for the sake of relaxation, and had a table set up in the middle of the surface, sumptuously and elegantly furnished. Being well acquainted with the nature of the place, he resolved to make sport of the curiosity of the women — who suspected nothing of nature's hidden trick, not even by a shadow. The hour of the water's eruption was now near, when, amid the conversation, while everyone was indulging pleasantly and merrily in good cheer, the water burst out with its usual force; and while they wetted themselves in the unmixed wine above, the water filling up its proper place below drenched the table-companions up to the chest, so that those who had come to the table dry-footed were now forced to seek dry ground by wading — not without the laughter and guffaws of those onlookers who, aware of nature's pranks, had withdrawn in good time. But enough of this pleasantry.

The question, then, is the cause of this ebb and flow. I say the cause is the ebb and flow of the Baltic Sea [mare Balthicum], from which it is distant a journey of ten days; and since this finds an outlet at this spot through a hidden subterranean channel, it discharges itself there at fixed hours according to the laws of the sea's tides. That this is true is shown by the varied reciprocation of the waters, which — just as in the sea, following the motion of the Moon through the Zodiac — overflow more abundantly at new and full Moon, and more sparingly when the Moon is at its half [dichotomos] state.

But you will perhaps object that these waters are fresh, and therefore cannot derive their origin from the sea. I answer that such waters can become fresh in two ways. Either by being filtered through sandy and chalky earth, as was shown in what came before. Or, second, through another subterranean river which,

when the inrush of the seawater strikes it, causes it to overflow toward the mouth of this place; while as the sea ebbs, this river too, restored to its own channel, must necessarily draw back.

[Margin: The ebb and flow of the river Timavus.]

Something similar is observed in the river which the ancients call the Timavus [Timavus], lying between Istria [Istria] and Carniola [Carnia], where there is a mountain of the same name. This mountain, packed with water-reservoirs [hydrophylacia], belches out into the river Timavus through nine mouths, as Virgil [Vergilius] attests:

Whence through nine mouths, with a great murmur of the mountain, It comes, a bursting sea, and presses the shore with its roaring flood.

For this reason it was not undeservedly called by the ancients "the spring and father of the sea." For it suffers an increase and decrease, just like the Adriatic Sea, in that last corner of the Gulf of Diomedes [Diomedeus Sinus]; and at times it swells so much that it floods the whole region with a deluge. And since it always keeps its own sweetness, many wonder why it is not tainted by the saltiness of the sea. Not far from the mouth of this river an island [Insula] was once to be seen, on which there was a most celebrated thermal spring [thermarum fons] that suffered the same reciprocation of tide as the sea; today, called the Bath of Monte Falcone [balneum montis Falconis], it is visited and frequented by crowds — although the island, joined to the mainland in the course of time by an accumulation of silt, has now lost the name of island, while the heat of the bath still endures.

The question, then, is the cause of so prodigious an increase of the river; and why it is not mingled with the marine waves, and is not deprived of its sweetness all the way to the sea itself. Before I assign this, it should be known that, fourteen miles distant from the river Timavus, there is a mountain beside a village which they call San Canzian [S. Cantiani], from whose innermost parts a great quantity of water rolls forth like a river,

which is scarcely seen unrolled into level ground when, behold, meeting a chasm in its path, it is at once swallowed up and nowhere appears again. This subterranean river, therefore, meeting the marine water that likewise enters by a subterranean channel, and being unable to overcome the violence of the maritime flood (which is of a lighter nature), and granted no power to retreat, is driven back through another channel that stretches within the cavernous Timavus mountain, and fills the whole mountain from bottom to very top. Thus

filled, overflowing with the said abundance of waters, it forms the river Timavus through its many mouths: this river suffers the said increase when the sea is flowing, but a decrease when it is ebbing.

[Margin: The ebb and flow of the river Timavus.]

It is therefore not the sea that swells the river meeting it on the outer surface by its assault, but by the hidden contrivances of the inner and subterranean constitution that it brings about the increase and decrease of the river. For while the river, swallowed up near the village of San Canzian, meets the subterranean waves of the sea, it is driven back and fills the whole mountain through its channels; whence, overflowing, it forms the Timavus, which fills everything with a flood. But as the sea ebbs, the subterranean river, having now gained looser reins, follows the ebbing subterranean waves of the sea; and the mountain being denied its usual tribute of waters, the river Timavus accordingly acquires a certain moderate level and a decrease from the springs of its native mountain, out of which it bursts — until once more, with the sea flowing, after a fresh struggle of the waters, the mountain is again filled and bestows its usual increase upon the river. This alternation of increase and decrease of the said river endures perpetually.

If anyone has rightly grasped this mystery of nature, I do not doubt that he will have a ready solution for countless cases on a similar subject. It is therefore plain that, in a fresh-water river, the cause of the increase and decrease is not the sea, but the sea's thrust into the subterranean passage, by which the subterranean river, diverted from its straight course, is violently driven into the caverns of the mountains. By this propulsion the overflowing cauldrons [lebetes] of the mountain spread the river, weighed down by a vast mass of waters, far and wide beyond the natural station of its bed.

Mountains of this kind are also found in the Pyrenees [montes Pyrenaei]. There is such a one in the territory of Poitou [Ager Pictaviensis], near the village commonly called *de la Goudenuré*; and a spring near the city of Saumur [Sammur] on the banks of the Loire [Liger], in the village commonly called *de Varins*. From these two adduced examples it is plain that, whenever springs and rivers are found that are agitated by a daily ebb and flow no differently from the sea, they must be said to draw their origin from the sea's tides through subterranean tunnels, in the way described.

Now let us see what is the cause of those rivers that flow for the space of half the year and dry up for the other half. Among these, truly memorable is the Pepper-

Bath [Balneum Piperinum], in German *Pfefferbad*, in the territory of Chur [Curiense Territorium] near the Swiss [Helvetii], which on the third day of May — namely the feast of the Finding of the Holy Cross [Inventio S. Crucis] — full of water, lasts until the 14th day of September, sacred to the Exaltation of the Holy Cross [Exaltatio S. Crucis]; but once this festival is past, as if stealing itself away by stealth, it leaves the place destitute of all water. I say the cause of this is none other than the melting of the snows on the Alpine mountains, which usually begins around the start of May. Hence it comes about that the water, the snows being dissolved by the Sun's heat, multiplied through the clefts, fissures, and channels in the inner cauldrons and basins of the mountains, drives forward the Pepper-Waters [aquae Piperinae] hidden in their path a little below the bath's location; and from this thrusting-forward the overflowing water at last fills the place set aside for the bath. But since the melting of the snows lasts almost four whole months, the bath's waters must also last that long; and once the melting of the snows ceases, the bath's waters too must necessarily cease. That this is true is plain from the fact that the bath's waters take on a notable increase from the beginning of May to the end of July, but thereafter are seen to decrease at an equal rate.

[Margin: The spring Esforbe.]

There is also another spring of this property in the Pyrenees, the Esforbe [Esforbe], so called from the mountain at whose roots it lies. Around the summer solstice — that is, the feast of St. John the Baptist [festum S. Ioannis Baptistae] — it rolls forth from the bowels of the mountains with a great rush and a greater roar; and this flow lasts until the day sacred to the Nativity of Christ [Natalis Christi], that is, the winter solstice [solstitium brumale], where it ceases from its flow. It differs from the preceding spring by almost a two-month postponement, the cause of which I would suppose to be this: that the waters from the melted snows in the Pyrenees spend more time filling the caverns than in the preceding case. The whole reason for the difference, then — in the anticipating or postponing of the flows — consists in the differing arrangement of the caverns and water-conducting channels [canales hydragogi]. But we will set out the matter to direct view.

Diagram. A schematic of a Pyrenean mountain illustrating an intermittent spring fed by snowmelt. The figure itself is described verbally in the text and is set up for an accompanying engraving; the labeled elements are as follows.

- A: the Pyrenean mountains, covered with snow

- B: the fissures of the mountain, through which the melted snow flows down into the submontane cavern below
- C, D, E, F, G: the submontane cavern (CDEFG) into which the meltwater collects
- C, D: the top of the cavern, which the rising water reaches
- H: the spring, accustomed to suffer the ebb [aestus]; the channel CH conveys water from the top of the cavern (CD) into the basin of the spring

The text explains the mechanism: Because at the beginning of spring the snows gradually melt by the Sun's power and efficacy, the moisture seeps through countless fissures and clefts of the mountains and collects in the cavern CDEFG. As the mass of waters within the cavern grows day by day from the ever greater quantity of melted snow, it comes about that, once the water reaches the top of the cavern (CD), it then at last discharges itself through the channel CH into the basin of the spring, and the spring begins to flow — having ceased from flowing while the cavern was unfilled. Again, the hotter the Sun, the greater the quantity of snow it melts; so through the months of July, August, and September the water increases wonderfully within the cavern, and consequently the spring H flows more abundantly. But once the melting of the snows and rains ceases for want of the Sun's heat, the supply is seen to decrease proportionally through the months of October, November, and December, until at the winter solstice it altogether fails — while the cavern, meanwhile, empties itself toward vacancy through other clefts and fissures,

[The text continues from the prior page. The water, which had been driven down toward vacancy, empties through the other clefts at the winter solstice. You see, then, from this ingenious contrivance of nature how some springs flow for half the year and stop flowing for the other half. You also see how the water of the bath described earlier [the Piperino bath] anticipates its flow by roughly a two-month interval.

Suppose that in the bath of Piperino described earlier the spring-basin is H, and that the underground cavern is CDEF, smaller than the previous one, which receives the waters from the snows melted on the Alpine mountains and from the rains. It is then perfectly clear that the smaller cavern CDEF, since it fills more quickly than the cavern CDEFG, will likewise discharge itself into the spring-basin H more quickly — and so the spring's flow is necessarily anticipated. These things are demonstrated so plainly to the eye that no one should have any further doubt about them. The whole explanation of why the flow of springs is brought forward

or held back depends on nothing but the layout of the mountains, the size and depth of the caverns, and the structure of the channels.

Here, however, someone might object that rains — which in winter are virtually continuous — can produce the same effect that the melting of the snows causes. I answer that the relationship between the two kinds of water is entirely different. For although in winter the rains are virtually continuous, it nonetheless happens that rainwater does not lodge in the mountains, but at once runs off and turns into torrents, and so has no time to work its way more deeply into the bowels of the mountains. By contrast, the snows that cling perpetually to the mountain peaks, since they dissolve only slowly and gradually — and since they are, as it were, held back by the very snow heaped up all around them, so that they do not slide down with force — clearly give the moisture sufficient time to seep little by little, through the fissures and fibres it meets, deeper into the mountains' interior. And because in winter snow is heaped upon snow with no risk of melting, for that very reason the springs' surging ceases too. The rains, as I said, run down from the mountains into the valleys with force, and even if here and there they find fissures through which they work their way into the caverns, they are still not so great that they could fill those caverns and cause them to overflow.

To these springs, however, Georgius Wernerus [Georg Wernher] reports a spring exactly the opposite, in his *Pannonia* [*De admirandis Hungariae aquis*]. He says there is a natural lake of living waters in Hungary which is nevertheless not perennial: rather, these waters spend the whole summer hidden away beneath the neighbouring mountain caverns, leaving their bed empty of water though for that period pleasant enough and very grassy; then, as autumn comes on, they flow out, and through the whole course of winter, right up to the beginning of summer, they not only flow but are filled with an abundant breeding of fish. The question, then, is why this river — which ends in a very large lake — flows only in winter and not in summer. I say the cause of this lies both in the situation of the place and in the caverns of the mountain, out of which the water rolls in autumn. As for the situation, Wernher describes it thus:

[Margin: How the waters petrify, and in what way.]

The region is quite flat and gently depressed, yet shut in on every side by mountains, and is watered by manifold channels of streams — three on the eastern side and four on the southern. As these streams flow farther from their sources, the more they run with smaller and scantier waters, which the parched soil there partly soaks up quietly as it goes, and partly

the open trenches at its lower end absorb, like the gates of huge caverns beneath those mountains.

It happens, then, in this way: when these rivers have filled those caverns with continuous waters throughout the whole course of summer, at last toward the end of autumn — the channels now being, as it were, full and overflowing — [the caverns] not only do not take in more water, but rather, by some inner motion (I know not what) and by the impulse of the air and winds (as the continuous rumblings testify), they cast back as much water as

Diagram. A cutaway view of a mountain whose interior has been opened to show the workings of the half-year spring with its smaller cavern. The mountain rises in a forested landscape; its inside is exposed as a great cavity. At the center, a fountain of water jets upward within the cavern. To the left, a watercourse runs out across the plain into a winding lake-shaped basin. The labels are:

- A (top of the inner cavity): the upper part of the cavern
- B (the central jet): the spring of water erupting upward
- C (left flank of the cavity): one side of the smaller cavern CDEF
- D (right flank of the cavity): the opposite side of the cavern
- E (lower left of the cavity, by the outflow): the channel/outlet point
- F (lower right of the cavity): the lower part of the cavern
- G (bottom of the cavity): the floor / reservoir of the cavern
- H (the basin in the plain at left): the spring-basin / lake into which the water discharges

[The full figure extends into the inner page margin; the labels A–H are read from the cutaway. No labels flagged.]

[Printed page 285.] the water that they had previously received — so that, for as many months as they had taken in water, for so many months they cast it back, as though thrown up from the jaws of Orcus [the underworld], and with such force that one can scarcely escape it, they say, even at a galloping horse's pace. And in this way, filling every low part of the place to its full capacity, the lakes fill up, occupying a space of a mile in every direction, with a depth that in places exceeds 18 cubits.

But let us explain the matter with a hydraulic diagram.

Diagram. A landscape with an exposed mountain at center showing the hydraulic mechanism of an intermittent spring; at the upper left, an inset shows the working principle of a bent siphon. The labels are:

Inset (upper left), captioned "**Syphon inflexus**" ["bent siphon"]:

- N (lower end of the bent tube, with water pouring out): the discharging mouth of the siphon
- R (the vessel beside the bent tube): the vessel within which the siphon stands

Main scene (the mountain and surrounding hills):

- A (within the mountain, upper): the bend/crest of the siphon AB
- B (within the mountain, below A): the lower limb of the siphon, joining the cavern
- C (the great mountain mass): the mountain enclosing the cavern
- D (the dark interior cavity): the great cavern within mountain C
- E (within the cavity, at the inflow): the point where the absorbed streams are gathered and pass into the cavern
- F, F (on the slopes to the right): the trenches/pits where the streams are swallowed
- G, G, G (the hills to the right): the springheads/sources of the streams
- H, H, H (the mountains rising to the right, from the east and south): the eastern and southern mountains
- I (at the mountain's foot, left of B): the outer mouth/orifice of the siphon
- K (the river flowing from I toward the lake): the river IK
- L (the lake-shaped basin at lower left): the lake formed in the hollow of the plain

[The streams run from springheads G down through pits F, are gathered at E, and discharge through the siphon's mouth I to form river K and lake L. No labels flagged.]

Let there be mountains to the east and south, HHH; springheads of streams, GGG; pits by which they are swallowed up, FFF; and from there, channeled through subterranean passages by way of E, let them flow down into the great cavern D within mountain C. Then suppose that within cavern D, running through rocky, craggy walls, there is a further passage at the bottom of the cavern, tending upward, BA, formed in the shape of a blind siphon, RN, whose mouth I opens to the outside.

These things being supposed, I assert that the river IK necessarily dries up in summer but flows in winter. For since in summer, from the channeling of the swallowed streams, the waters rise continuously over a half-year's span both

within cavern D and within the siphon BA, it follows that when the waters reach the top of the siphon AB, they are erupted out through the siphon's mouth I with the greatest force, and so form the river IK and then, within the hollow of the plain, the lake L. And since it is the nature of the reflexed siphon — which hydraulic engineers call a *diabetes* — not to stop pouring water until the whole vessel within which it stands has been drained of water, and only then, once it is drained, to cease from further pouring: from this you see that the waters rising within the cavern and siphon by equal increment, once they have reached the line LE, will then at last discharge themselves through the orifice I. And it will flow, by the property of the siphon, for just as long as water is contained within the cavern; nor can it ever cease to flow, for fear of the vacuum that might arise within the siphon AB from the discontinuation of the water.

It would, however, always flow with a perpetual course, if only as much water were poured out from the siphon as the river-waters supply to the cavern; but by the shrewd design of nature it is so arranged that the channel AB pours out more water than the rivers GF could supply. Hence the water is necessarily drained over a half-year's span down to the bottom of the cavern through the channel, and once the mouth B of the siphon is open, the waters will stop flowing — until, in the other half of the year, the caverns are once again filled by the rivers FG with water up to the line LE, and the waters begin to flow again as before. And this proceeds by a perennial law of alternation.

Whoever has rightly grasped this will find no knot of irregular surging — however intricate — showing itself in springs, rivers, and lakes, that he cannot untie by similar machines of nature. As for what the authorities relate about the Sabbatic river in Syria (namely, that it always flows except on the Sabbath, from which it also takes its name), since these accounts are entangled with various opinions, I have thought it best to touch on them only sparingly. But if they are true — as Dominicus Magrius [Domenico Magri], a most truthful man, assured me they are — I would say that the cause of this matter is not so much a miraculous effect of the Hebraizers as a physical one, since it can easily be solved from the preceding Problem. For we say that so great a quantity of water can be gathered in the subterranean basins as would suffice for six days, but falling short on the seventh would not suffice.

[Printed page 286.] Hence anyone may easily reckon how empty is the reasoning of those who attempt to ascribe such things either to the hidden influences of the stars, or to a Spirit of the World, with elaborate chains of reasoning — and so the same thing happens to them as to those who seek gold in the hollow of the Moon

while they have it hidden beneath their feet. For unless in such monsters of nature you take refuge in the proximate and nearby causes, you may be quite sure that you will labor in vain in the investigation of causes of this kind.

Some philosophers, too, torment themselves remarkably in giving the reason for the hidden properties of a certain marvelous well by the bank of the Baetis [the river Guadalquivir], which falls as the sea's tide rises and rises as the sea's tide falls. Hence many, taking refuge in some hidden power of the stars, think they can supply the cause; others, led on to I-know-not-what physical speculations, philosophize ridiculously — whereas, if they knew the proximate causes by which nature works in the interior, they would doubtless reason in a way more within the grasp of men. For there is no other cause of such a spring than that the sea's tide, entering the subterranean passages, discharges itself into some basin, which — once the sea has reached its highest swell and the basin is filled — gradually works its way into the well; and so the well seems to rise as the sea falls, in exactly the manner that appears in the preceding Figure.

CAPUT V.

De Metamorphotica vi Fontium, Fluviorum, Lacuum, quæ injecta quævis in saxa, aliasque metallicas species convertunt.

[On the metamorphic power of springs, rivers, and lakes, which convert whatever is thrown into them into stone and into other metallic kinds.]

In the Geocosm there are countless springs, lakes, and rivers which, by their petrifying power, convert whatever is thrown into them — some merely with a stony rind, others turning it to stone all the way through. Such is the Sarnus in Campania; the Silarus beyond Surrentum [Sorrento]; in Etruria the Elsa; and in the territory of Volterra a good many; the Aponitan waters [of Abano] in Lombardy; and in various places in Germany, Gaul, and Spain — for which see the preceding pages. Into these, as I said, whatever you throw, they either convert it entirely into stone or wrap it in a kind of stony rind, the body they clothe remaining wholly uncorrupted. Of the former kind there are countless examples, found here and there in the territory of Tivoli around the banks of the Anio and the Albula.

In the Museo Gualdino [the museum of Gualdo] on the Pincian Hill there may be seen, among numerous pieces of wood, the leaves of trees, fungi, crabs, a human skull, and even the very water-pipe through which the Aqua Claudia [the Claudian aqueduct] was carried, all turned into alabaster. And in my own

Museum there are several very large bones of this kind — of a certain giant — together with pieces of wood, grains of wheat, snails, and icicle-forms turned into stone; not to mention here the great number of such objects in the various museums of Rome. In the Villa Ludovisi an entire human body may be seen, transformed into stony substance. At Gallicano, a place about twenty miles distant from Rome, there is a spot where the sediment of the water has hardened into stone and, overflowing, serves in place of a bridge — the same thing that we said above occurs at the spring of the city of Clermont [Claramontana] in France. At Zepusium [Szepes], a town of Hungary, there is a spring whose water, wherever it goes, becomes stone, with such increase that the inhabitants build their houses out of it and are wont to boast that they have homes built out of water. I will say nothing here of the drippings of caverns, by which the descending water is changed into every kind of animal form. It is a marvelous thing that is reported of the grotto of Cadurci [the cave of Cahors], which playful nature, by its continuous dripping, has so aptly adorned with statues that you would swear you saw monks sitting in a semicircle. Similar ones may be seen in Hungary and Transylvania. In Picenum there is the Grotta Scura; at Anticoli in Latium; and in the other places, which are without number; in the territory of Rieti [Reatinol], where the petrifying power of the river Velino so prevails that, after certain years have rolled by, men are forced — with great effort, by cutting back the petrified masses — to make a passage for the flow of the river (which the rocks, here and there widened with a stony rind, obstruct), lest by its flooding it should swim away entirely. On the shore of the Baltic sea near Lübeck, a branch of a tree together with a bird's nest was found turned into stone, as Albertus [Albertus Magnus], and from him Agricola [Georgius Agricola], teaches. He also reports that another spring, no less worthy of admiration, exists in Gothia [Gotland/Sweden], which turns into stone whatever you immerse in it; and that, in order to get a sure experiment of this marvel, the Emperor Frederick [Friedrich] ordered a glove sealed with his own seal to be immersed halfway, and after some days the immersed part had indeed turned to stone, while the rest remained, as it was, of leather. But since almost no place seems to lack marvels of this kind, we shall not dwell on them as things commonly known. Let us instead turn our pen to the inquiry into the cause.

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[The text continues:] [...whatever is thrown in is clothed with a stony rind.] But that these matters may be better grasped, it has seemed good to begin a little farther back.

[Margin: Why the waters petrify, and in what way.]

In two ways is that stone-making juice elaborated by nature in the waters: for either the water is mingled intimately and perfectly with certain mineral corpuscles, or only on the surface and confusedly. In the former way, the whole substance must be changed into stone, as is plain in coral-plants, which, by a certain natural appetite, draw in the petrifying juice of the sea and convert it into their own substance; and in this way various things too — herbs, leaves, wood, fruits, animals — are seen to be perfectly converted into stone, whether you regard their hardness or their weight. In the latter way, the petrific juice, which consists of an imperfect mixture of fossil corpuscles, since it neither mingles intimately and perfectly with the said things, likewise clothes wood, herbs, and reeds with a stony bark only on the surface, the inner substance remaining entirely uncorrupted — just as a wick, by frequent dipping in melted tallow, at last turns into a candle, solid and firmly set by the condensation of the cold. So all things thrown into the water do not acquire the firmness of a stony mass until they are out of the water, as is plain in coral. The reason for this is that, while the moistening lasts within the water in which they are formed — even though they are continually augmented by the addition of corpuscles through the force of the petrific juice — they still cannot, on account of the continual influx of the surrounding moisture, petrify into a hard substance, unless they have been exposed to the air for some time. For then, the superfluous moisture being either drawn off by the Sun through resolution or consumed by the dryness of the winds, they finally harden into a stony substance.

But those things that are perfectly and intimately mingled with the petrific juice must be converted into a stony substance. For since the petrific juice is nothing other than a moisture constituted and elaborated from a mixture of imperceptible corpuscles scraped from stony veins and from nitrous and saline places, and since corpuscles perfectly mingled with the moisture naturally seek to return to the state in which they once existed, therefore — by the vehicle of the saltpetrous, aluminous, or sulphureous moisture, and because of the subtlety of the spirits — they penetrate all the inner fibres and marrow of the things they meet. This done, by the force of the acrimony in which they are strong, once the softer parts of the things they meet have been consumed and eaten away, they substitute themselves in the place of what has been eaten away, and in this way transform them into a stony mass. And this juice will be the more efficacious the more it has been concocted by the subterranean heat; for the concoction, by the force of the heat, draws out from the earthy clods a certain fattiness, which, mingled with the petrific juice, supplies, as it were, a kind of glue by which the

corpuscles cling tightly together and the parts are firmly joined to the parts. And so experience teaches that things which turn to stone are first surrounded, as it were, by a kind of mucus, to which the corpuscles of the petrific juice then cling like a kind of birdlime, and ever others and others, by continual addition; until at last, clothed in a mucous bark and exposed to the air, they are converted into stone. But let us prove these things by experiment.

EXPERIMENTUM.

Take the meal of any stone whatever, reduced to an impalpable powder; knead it with water (to which a little salt, niter, and liquid bitumen has been joined) and blend it into a perfect mixture. This done, prepare a basin filled with water of any sort, in the middle of which let there be set upright herbs, dry wood, bones, and whatever else; then take the compound described a little earlier, decocted and placed in the "sleeves of Hippocrates" [Hippocratis manicae], as the chemists call them, and let it drip down. In time you will see the things placed within clothed with a kind of mucous skin, and the rudiments of a bark contriving themselves from the continual accretion of corpuscles; and these, afterward — once the water has been poured off and they have been left in the freer air — you will find, in the course of time, to have grown together into a stony hardness. And so what experiment teaches us to be done, no one but a senseless man will deny that nature performs with far greater skill.

CONSECTARIUM.

Things thrown into certain waters, then, turn to stone in the manner we have described — either because the juice (as Vitruvius holds), being stone-making, thickens like rennet the waters with which it is mixed, and the heat of the Sun then drives these thickened waters together and hardens them; or (as Agricola holds) because the stone-making juice, emanating from the veins and joints of caves, hardens before it has fallen; or, when its drops have already trickled down, then — just like the icicles of roofs that freeze into ice — the descending juice by its own power forms both icicle-shapes of stone on the vaults and stone cones on the pavement, the saltpetrous juice being gradually converted into stone; or, finally, the things themselves are converted into stones once they have drunk in the stone-making juice itself. Thus, when war had broken out and the workmen had fled into the metal-mines of Lydia near Pergamum, and the exit was blocked by the enemy, they were suffocated; but a long interval of time afterward, when the mines were reopened and cleared out, there were found amphorae and other vessels of that kind, which they had used for necessary purposes, all filled with a

certain moisture and hardened into stones — and beside them, too, human bones. I said "once the things have drunk in the juice"; because whenever the petrific juice, perfectly mixed with the water, has penetrated all the marrow, fibres, and pores of the things thrown in, then indeed the things are converted, according to their whole substance, into a stony mass — the woody or bony matter being eaten away by the petrific moisture, and stony corpuscles substituting themselves in its place, existing within the moisture by a petrific mixture perfect (as I said) — which does not happen in those things [that...].

which are clothed only with a stony rind. [Margin: How various things in springs and waters petrify.] The cause of this is a confused and external accumulation onto exposed objects of the petrific juice from the small particles — that is, the scoria and shavings scraped away from the stony veins. It works much as in the boiling of alum, within which any object's shape — fashioned, say, out of oak wood and placed inside — turns within twenty-four hours into a crystalline form. The same thing happens when boiling, suitably applied, converts sugar into a crystalline state. In short, you can see it in all the salt-making operations on the various concretions of these juices. Indeed, from the ashes of every kind of wood and herb, salt is drawn off by means of a lye appropriate to each. But since I intend in due course to deal expressly, in what follows, with the marvelous generation of every kind of stone, marble, and jasper, and with the other miraculous conversions of things into stone, I did not wish to linger over these matters any longer.

SECTIO VI.

On the Remaining Marvels of the Waters [De reliquis Aquarum Miraculis]

In the preceding pages I discussed certain prodigious effects of the waters, and I demonstrated that all of them rest upon their own natural causes. It remains for me to give some account of the water-prodigies famous among Pliny [Plinius], Aelian [Aelianus], Solinus [Solinus], the Polyhistor, and the other ancients. Since these have no foundation in nature, they are either sheer fabrications, or wrapped up in the allegorical modes of the poets, or they have taken their origin from fabulous tales which either human naïveté or the superstitions of the nations introduced. For it is innate in the human mind, at the very first encounter with some exotic effect, to attach much to it that is invented, or to mix the playful in with the serious. Indeed, those who write such things very often do not so

much seek true demonstrations of them as aim to embellish their own undertaking with charming allusions, or to amplify, with things exotic to the senses, certain matters κατὰ τὴν αὐξήσιν [Greek: kata tēn auxēsin, "by way of amplification"], rather than by proof.

So Pliny, while professing the entire History of the World and of Nature, repeatedly declares that he did not bind himself to causes — given the labors of so immense a work — and simply recounted, along with everything else he found reported, the miracles too, many of which we have brought forward and unraveled in this work, assigning genuine causes to the effects. [Margin: Fabulous spring-effects of certain authors.] We consider thoroughly fabulous what he adduces from Varro [Varro] and Theophrastus [Theophrastus] about a spring on the island of Cea [Coa Insula] and one in Cilicia: the drink of the former dulls the senses, while the latter makes them subtler and more lively. Of the same sort are the things he tells of the Sicilian springs Cleone and Gelo, the former named from the weeping [a fletu] it produces in those who drink, the latter from the laughter [a risu], because it dissolves those who drink it into laughter. Ridiculous, too, is what he recounts of the spring at Leontini, whose waters, if one drank them, made him come out a learned physician. Likewise what he tells of the springs of Cupid and Venus, of which the one would provoke love affairs, while the other would quench them — the same that Caelius [Caelius], on Pausanias's [Pausanias] authority, reports of the river Selenium [Selemnus] in Achaea, in which both men and women would lay down the love that gripped them. Empty, too, are the things Peter Martyr [Petrus Martyr] adduces, in a wide-roving hyperbole, about a spring on the island of Boriquen in Hispaniola [Bonicca Hispaniolae Insula], which wonderfully restores youth to the aged — though it neither changes gray hair nor smooths wrinkles. Out of such things that crude antiquity, and the deceitful glibness of the petty Greeks, joined many fables of this kind together with superstition. Hence all those springs dedicated to Apollo, the Muses, Neptune, Bacchus, Jupiter, Pluto, and the other gods — as one may see scattered throughout Ovid in the *Metamorphoses* [in *Metamorphosi*], throughout Virgil [Virgilius], and the other ancient poets; but since these are known even to schoolboys, I pass over them in silence.

[Margin: Whether certain springs portend sterility.] Yet, lest I seem to pass over those marvels of nature which — however fabulous they may appear — nonetheless conceal, I know not what, of nature's true sportings beneath them: this shows itself first in springs which, by some hidden power, foretell the sterility and fruitfulness of the seasons — sterility when they flow, fruitfulness when they cease to flow. Four of this kind are found in Etruria [Hetruria], as we

observed in our *Itinerarium*; among which the Lucales springs in the territory of Siena [Agro Senensi], near the village of Rosia, are especially celebrated. They flow only in certain years; and when this happens, the inhabitants take it as an omen of scarcity, whereas when they cease flowing, so that one can cross dry-shod, they promise great abundance and a plentiful harvest. Such is the spring of S. Regulus near Pienza [Pientiam] in Etruria, which, when it has dried up, portends abundance, and when it has poured forth in a great mass of water, sterility. Alberto Leandro [Albertus Leander] in his *Italy* mentions another spring of this property near Narni [Narniam]. The Lake of Vadimon [Lacus Vadimonis], as we taught in our *Etruria*, is of the same property, as its neighbors attest; concerning which Baccius [Baccius] speaks thus in his book *On Hot Springs* [de Thermis]: "The Lake of Vadimon, which is called the Lake of Bassanello, distant about thirty thousand paces from the city, we know — to give the matter greater credit — to have overflowed in this year 1569, in which there is a universal scarcity throughout Italy, already from the beginning of spring, in marvelous ways." We have received the same about the aforesaid Lucales and S. Regulus waters: namely, that having dried up for many years, this year they have overflowed, to the amazement even of the natives, who know this nature of theirs. With these things established, the cause is now sought, which I shall assign — but first let me say something about the rising of the Nile, for this will pave our way to knowledge of the true cause.

[Margin: On the Niloscope.] The Niloscope [Niloscopium], most celebrated in Egypt, was famous of old and is so still — a water-gauge [Hydrometrium]. It is a round structure on the bank of the Nile, in the manner of a well, in the middle of which a marble column is to be seen, with twenty parallel circles, their numbers cut into the column. From the rising and falling of the water at the time of the Nile's inundation, the Egyptians know in advance the coming condition of the year, whether it inclines toward sterility or toward an abundant harvest. For if the water of the Nile — which insinuates itself into the well through a hidden channel — exceeds the twentieth circle on the column, then, since excessive moisture chokes everything sown, they expect an utter dearth of things. But if it does not reach the lowest, the twelfth, circle, that same Nile, with dryness consuming everything, promises them a notable decline. The intermediate circles show now a greater, now a smaller, now a moderate fruitfulness to come, up to the eighteenth, at which the greatest yield is promised.

From this similarity to the Niloscope we shall easily arrive at the hidden causes of the signs of fertility and sterility in the other springs already recounted. In this

way, then, I should like to persuade you that nature operates in the marvelous arrangement of springs of this kind:

Diagram. A landscape cutaway showing the subterranean hydrology of a well and the fields it influences. The upper portion is an aerial view of a mountainous region with cultivated fields laid out as rectangular plots and scattered trees; the lower portion is a cross-section through the earth (rendered with dense cross-hatching), revealing a vertical well-shaft and the underground water channels feeding it. The text instructs: "Imagine to yourself, beneath the earth DE, a well ABC, into which, through hidden fissures or through some water-reservoir [hydrophylacium] — F, for example — water gradually insinuates itself, at some times more, at others less..."

- G (top, mountain peak): the highland source region from which water descends.
- F (upper right, at the cleft / reservoir mouth): the hydrophylacium (subterranean water-reservoir) feeding the well through hidden channels.
- A (top of the well-shaft): the upper terminus of the well column.
- B (middle of the well-shaft): the point of moderate water-level [punctum mediocritatis B], associated with temperate years and abundance.
- C (bottom of the well-shaft): the lowest terminus, the level below which the water does not fall in years of extreme drought.
- D (lower left field region): the surrounding region whose moisture corresponds to the well's overflow.
- E (right field region, and at the underground channel into the well): the cultivated tract and the channel by which water reaches the well.

[Resuming the body text, printed p. 289, left column.] Imagine to yourself, beneath the earth DE, a well ABC, into which, through hidden fissures or through some water-reservoir — say F — water gradually insinuates itself: at some times more, at others less; but at certain times it even overflows beyond its fixed bounds, which however does not happen except in the most humid condition of certain years. For then the water, rising gradually through the well, successively driven by the impulse of the multiplied waters, will overflow. And just as this then follows in some whole region FG — when, partly from the moisture of the rains and partly from the overflowing of the subterranean caverns, the earth within is wholly soaked, while the spring, being filled with stagnant waters, takes on a kind of dropsical and malignant constitution by which the vigor of the sprouting plants and herbs is choked and passes into rottenness — so too sterility

and a dearth of things must necessarily follow; and the sign of this is the overflowing and outflow of the spring.

Again, if at any time years have followed marked by notable aridity and prevailing dryness, then the water — drawn off partly by the heat of the Sun and the stars, and partly, in its ascent, [withdrawing] into the innermost recesses of the well ABC — will not have exceeded the terminus C; then one must judge that the same thing happens in the fields as in the well: with all the moisture consumed, the earth wasted by dryness, so that, as if assailed by a kind of consumption [phthisis], the sown crops, the herbs, and the standing corn, deprived of moisture, will fail, with sterility following; and the sign of this is the withdrawal of the water within the well. Thus both an excess and a deficiency of water, for the reasons stated, bring on sterility and a dearth of provisions, as is clear from the Niloscope. But if the year's condition has been temperate, then this well too will follow a certain middle course along with the fields; and abundance will attend this, and the standing corn, the meadows, and the sprouting plants, nourished by a kindly and proportioned nourishment, will luxuriate in a rich yield of produce — and the greater, the closer the waters have come to the point of moderation B. And this, I say, is the cause why some springs indicate sterility by their flowing and overflowing, but indicate abundance if they have ceased flowing — not, indeed, at that extreme, but at the point where their moisture attains a certain moderation.

[Margin: Whether certain springs are inserted [into] cells.] Another marvel of the waters, or rather of certain lakes, is this: that if anything be cast into them,

[Margin: Why they stir up thunderclaps and storms.] ...at once a tumult and savage tempests are stirred up. The first lake of this kind exists in the county of Foix [Comitatu Foxensi], called Tabor, sacred to St. Bartholomew [Divo Bartholomaeo]: of unexplored depth, set on the topmost summit, above the second region of the air and beyond all the air's assaults; stocked with enormous trout; its water wholesome, though always motionless, with no stream led off from it except one visible at the foot of the mountain. Of this it is commonly said that its waters, when stirred by some artificial motion — whether by the casting of stones or the agitation of staves — give and excite great rains, thunderclaps, and lightning-flashes. Such a lake is also said to be on a mountain not far distant from Trent [Tridento], which is said to stir up storms so savage that the whole neighboring district is not free of immense damage from them — so that it has been provided, under heavy penalty, that no one cast anything into it. A third is said to be in Switzerland [Helvetia], on the mountain commonly called Pilati, der

Pilatus Berg, about which they tell marvelous tales of an apparition of Pilate [Pilatus] on it on Good Friday. The cause is therefore sought of these lakes, which stir up such severe storms.

[Margin: Why thunderclaps and storms are stirred up.] I say, then, first, that not everything is true which is commonly told, nor easily to be believed, of the things reported everywhere either through the superstition of the ignorant or through some wandering illusion of the imagination — since often the cause of some unusual effect is attributed to one thing, when it derives a far different origin from that one. For it can happen that, in the summer season — when the summits of these very high mountains are usually visited for the most part — such a condition of both sky and air occurs that the said effect follows from it. There is added, besides, the illusion of the demons [Daemonum], who for the most part hold sway in desert and inaccessible places, and who, having held men's minds captive by a certain superstition, are accustomed to derange them with the persuasion that some more divine Power is working such great things. Our Fathers of Lucerne [Patres nostri Lucernenses], in whose territory Mount Pilatus lies, bear witness that they were accustomed to climb the mountain every year for the sake of relaxing the mind, and that, although a great quantity of stones was cast into the lake, they never once experienced the said stirring-up of storms. Maioli [Maiolus] reports the same of Mount Scafagioso in the Apennines, of the Momonian spring in Ireland [Hyberniae fonte Momonio], and of the Canato lake in Spain [Hispaniae].

If, however, some hidden secret of nature does lie beneath it, I should say for certain that it can be nothing other than a varied mixture of mineral juices at the bottom of the lake. For when, by the casting of a rather large stone, the pores of the innermost lake-bottom, covered over with mud, are opened, and an exit must necessarily be given to the spirits and exhalations previously shut up, these — while they penetrate the waters — carry a vapor up with them into the air; by the dryness of that vapor the kindled spirits pass off into thunderbolts and lightning, while the vapor itself, spread far and wide, is dissolved into rains by the coldness of that same air. And besides this, I find no other cause whatever, however it be brought about by combination. Yet I do not see how, from so slight a weight of stone, so great a quantity of exhalations can be drawn out to produce the said effect. Therefore I commit the matter to be tested by greater experiment, and then to be sifted by sharper minds. As for the lake which the ancients recount was wont to be stirred up at the sound of the cithara and other musical instruments, I should think it must be ascribed to fables rather than to any mystery of nature.

CAPUT VII.

On the Various Metamorphosis of Lakes, Rivers, and Springs [De varia Lacuum, Fluminum, Fontium metamorphosi], and on the changes of the terrestrial parts.

It is so arranged in the constitution of the world's natural things that nothing in them is so solid, nothing so robust and strong, that time — the devourer of things — does not in the end, if not utterly destroy it, at least so change and alter it that it can scarcely be recognized as having once been what it was. All of this is found, most of all, in the portions of the Geocosm, which, being nearer to us, are therefore more obvious. Mountains fail in one place; in another, new ones rise up. The sea, nature's marriage-broker, joining land with water, brings it about that where once there was sea, there is now land, and the reverse is seen. We read that some islands, entering into a wedlock, have adhered to the continent; others, on the contrary, having made as it were a divorce from the continent by the parting-off of their territory, we read to have come out as islands. All of which we pursued in the preceding pages with a great array of examples: [Resuming, right column] but in lakes, rivers, and springs too, similar spectacles of nature at play shine forth. Lakes are born in the very place that mountains first occupied — as happened in this year in which I write, in France [Gallia] at the Pyrenees mountains. Rivers that were once remembered now do not appear in many places, while many others have come into being, of which there is no mention among the ancients. Many springs and hot springs have today perished which of old were held most celebrated. The well of the Bullicame near Viterbo [Bullicami Viterbiensis], boiling continuously with its most fervent waters — than which I recall having seen nothing more worthy of wonder — has no mention among the ancients, yet today, by the record of many writers, it has been made famous in a marvelous way. But since we have dealt copiously with these and similar matters in our *Etruscan Itinerary* [Itinere nostro Hetrusco], we refer the reader to it. Meanwhile, let us proceed to the genuine causes of changes of this kind.

I find a twofold cause of these changes: one internal, the other external. The internal is the fury of the subterranean fires; the external is the violence of the inundations of the sea, the rivers, and the lakes — each of which let us set out in order.

[Margin: Why rivers are dispersed and new ones arise.] The subterraneous fires, if at any time, seething from a vast supply of combustible matter, they have burst forth into conflagrations, then from these first arises a vast quantity of

exhalations mixed with most violent blasts; and from these, earthquakes, once raised, while they seek an exit and do not find one, by a certain violent shaking overturn the foundations of the mountains, and swallow up vast tracts of land together with rivers — whence wondrous metamorphoses of the earthly globe must necessarily occur. Hence subsiding mountains, pressing with their mass upon the subterranean waters, drive and force them into the station of the mountains; the swallowed rivers, while they seek an exit by the hidden working of the raging spirits within, and, insinuating themselves wherever a gate or fissure is given, make themselves an exit elsewhere; then, blocked by the collapse of the subterraneous parts, they deprive the natural channels of the rivers and springs of all their flow. So it happened in this year in the earthquake of France [Galliae terraemotu], where several rivers, their water-conducting channels [hydragogis canalibus] blocked by the collapse of a mountain, ceased from all flow, while in their place new springs and streams arose elsewhere; and hot springs, turned from the most boiling waters into cold ones, displayed the character of a different taste, smell, and color.

From a similar violence of the subterranean tyranny, at Apamea [Apameam], a city of Phrygia — as Nicolaus of Damascus [Nicolaus Damascenus] is the author — in the time of the Mithridatic War, not only did new lakes and new marshes emerge, but also new springs and rivers, and among these one salt spring, which poured out a great quantity of oysters and other sea-fish. All of which, without doubt, anyone skilled could more easily imagine to himself than I can describe in many words to have come about from the ruin either of some mountain, or of an overlying land collapsing into some underlying water-reservoir [hydrophylaceum] or channel filled with sea-water. I could adduce countless examples here, had I not discharged my pledge in recounting them in the preceding pages. See what things, in the Chapter on the earthquake, we adduced of this kind in greater number: for as the earthquake takes its origin from the violence of the subterranean fire, so too every ruin and the cause of subterraneous alterations.

[Margin: Town of S. Euphemia swallowed by an earthquake, and a lake arising.] For there is a stony substance which the fires reduce to lime; hence the most savage blasts and exhalations, excited by the power of the fire, while they are prevented from going out, battering by their violent shaking the substance now calcined and friable, at last overturn it — whence the fall and swallowing-up of mountains and lands, and from these the obstructions of springs and rivers must necessarily follow. But the waters, compressed within and time and again multiplied, boring through the earth, at last, wherever a gate is given, burst forth,

and reveal new origins of springs, rivers, and lakes, which those ignorant of nature's art behold with amazement. [Margin: The town of S. Euphemia swallowed by an earthquake.] I myself saw a spectacle of this kind in the year 1638, and was present, when the noble town of S. Euphemia in Calabria, swallowed by an earthquake, left nothing behind it but a lake — concerning which see the Preface of this work. Then, since no mention is made by Pliny and the other writers of that admirable work of nature, the Bullicame, I mean, of Viterbo [Bullicami Viterbiensis], but only of certain warm springs, it is certain that it had then not yet been born, but that a subterranean tunnel, burned and eaten away by the fires, was at last, in the course of time, brought down into the breadth of crater which we behold today. Many of this kind are found, both in Etruria and in Latium [Latio]: baths once most celebrated, which today neither steam any longer nor are in use — as also the baths of Albunea in the Tiburtine territory [Tiburtino Agro], concerning which see what was treated at length in our *Etruria* and *Latium*. The islands which Seneca [Seneca] once saw floating in the Etrurian lakes of Vadimon, Vulcine [Vulcinensi], and Stratonias [Stratonien] do not today appear: either submerged by the injuries of time, or grown onto the continental land. On the contrary, today we see islands floating in the Tiburtine lake which antiquity did not know.

Thus does Nature turn her own affairs about in the world. [Sic Natura suas versat in Orbe rotas.]

But let us now come to the external causes of changes, which are not less than the internal ones. These are the sudden inundations and swellings of the lakes and rivers. Of inundations I shall speak first.

In the year 1660, on the 4th day of November, on which I write this, an immense inundation of the Tiber [Tyberis] invaded Rome, which lasted nearly three days. The cellars and wine-vaults being filled with the river, the whole flatter part of the City was navigated by skiffs and boats, to bring relief to the needs of those who were besieged by the assaults of the waters. And it was a novel thing to see this too: boats (which otherwise carts are wont to carry) now carried by carts, distributed into the various flooded squares of the City. This inundation was preceded by continuous rains throughout all of October, most copious downpours. There followed, in the first days of November, the syzygies of almost all the planets, which seemed, as if by some appointed assembly, to be contriving the destructive inundation that the event taught a little afterward. But let us set out its causes.

[Margin: The causes that concur in the inundation of the rivers.] As in the Tiber, so in the inundations of the other rivers, several causes concur: the rains, the sea, an adverse wind, and the situation of the river — which we shall set out in order. The rains, which stand as it were as the matter of the inundation, ought not to be taken from those which rain down upon the earth in some single territory; for these, however great a quantity of water they pour down continuously,

However great a quantity of water the rains pour upon a single territory, they do not for that reason drain off into the nearby mouth of the river so quickly as they accumulate. For this reason, great inundations necessarily occur whenever the waters, multiplied little by little by constant rains across a long and remote stretch of country and swollen out of innumerable streams, are driven to an excessive degree of overflow. This is exactly what happens with the Tiber and the Po.

The Tiber rises in the Alvernian Mountain [Monte Alvernia / La Verna] on a spur of the Apennines, a full 150 miles distant from its sea-mouth. What quantity of water can it not gather from the unrelenting persistence of the rains? I myself, with deliberate effort, traveled in the year 1559 to its source in order to explore it. It stands in a forbidding place among the craggy masses of overhanging cliffs, surrounded by the inaccessible summits of the Apennines. Within a span of five miles, all the way to Plettia [Plettia / Plestia], a town of no small repute, I found it already augmented by twenty streams, even in the driest season of the year. Going on from there in both directions, I encountered on one side, from the mountains of Etruria, and on the other, from the extended ridges of the Umbrian Apennines, torrential streams and rivers in such abundance that you can scarcely advance two thousand paces without coming upon a torrent, a stream, or a river. In the winter season, when it is most rainy, the channel — unable to contain such great volumes of water — overflows both banks, and with the waters spread far and wide it so fills the fields and plains that it looks like a sea.

In this way the river is gradually swelled. Ever-new rivers, received one after another, weigh it down — most of all the Clanis [Chiana], mixed with the Palia [Paglia], which adds an enormous burden of water from the Etruscan shore; while from the other bank the Nar [Nera], joined with the Velino, and the Anio [Aniene], rivers risen from the mountains of the Abruzzi [ex Aprutiorum montibus], add to it a load that is utterly intolerable and unbearable. And so, swollen with this disastrous array of waters, the Tiber, having entered Roman territory and indeed the city itself, overturns everything in confusion — to the great and irreparable harm of the inhabitants, and with savage tyranny. For once

the underground reservoirs, the sewers, the crypts, and all the cellars have been filled, it at last renders the whole city navigable, a spectacle less wondrous than mournful.

To this the sea rightly adds the final completion: harried by the southerly blasts of the winds, it so blocks up the river's mouth with dreadful masses of water that the river — when, with this barrier as it were interposed, it is not permitted to discharge itself — is driven back, and, pressed and made to swell ever more by the new mass of descending water, it rushes wherever a level plain is offered and floods everything. And this I would judge to be the principal cause of inundation. For if the mouth is not blocked, then however much the river may be augmented by a copious abundance of rains, those waters, once received within its channel, only lash the city in passing — since the waves, following one upon another without any impediment or obstruction, in the same steady course of flow at last commit the river peacefully to the sea. This does not happen when, with the violence of the rolling southerly blasts upon the marine waves, the mouth is obstructed. Then the river, necessarily yielding to the stronger force, is compelled to retreat; and from this retreat, with the volumes of water finally multiplied, an inundation must follow.

The cause of the Tiber's inundation, therefore — and of the Po's, and of others like them — is purely contingent and accidental, having no fixed time for its flooding, unlike the Nile, the Indus, the Niger, the Zaire, and many others. [Margin: The cause of the Tiber's inundations.] These keep, in flooding the regions through which they flow, fixed laws of the seasons, which they do not transgress; nor are they, like the Tiber, pernicious because they occur only by accident. On the contrary, the inhabitants receive those floods with the greatest joy and dancing, as a gift of God and the one sure herald of the fertility to follow. As for the cause of the Nile, which floods only at a set time of the year, this was demonstrated at length in the Fourth Book.

Since, then, the space from the sources of the Tiber — counting the streams, rivers, and torrents that, partly from the mountains of Etruria and partly from the immense chain of mountains underlying Umbria, the Abruzzi, and Latium, flow together into the Tiber — embraces a great part of the rains and snows of the Apennine range, an inundation must certainly be caused by so great a deluge of rainfall, especially if the sea, driven by the Libyan [southwest] blasts as I said, repels with its untamed ferocity, by the impulse of its own waves, the waters of the swollen river pouring in. For a complete inundation, then, three things necessarily concur: an enormous excess of water, the low situation of the

channels, and the impulse of the sea against their mouths — which, not without reason, we call the formal cause of inundation.

Having now examined the causes of inundations, we must speak of the changes that result from them in the terrestrial globe.

Since springs for the most part have their place set by nature at the roots of mountains, it happens from time to time that, through continual rains, the summits of the mountains are stripped bare of their earthen sods, and these, scoured away by the torrents, are rolled down into the depths of the valleys, where they accumulate. If by chance they encounter a lower-lying spring in the countryside, they fill it up by the successive accumulation of this scoured material; and most springs would perish in this way, were it not that the inhabitants, aware of the threatening danger, forestall it with a remedy — either by building a wall around the spring, or by deliberately constructing an aqueduct, so that the water, diverted elsewhere, is kept safe from the violence of the torrents. And so springs choked by torrents in many places, when they find no outlet, fail. But since Nature can in no way be idle, she compensates for the loss of the original spring through other subterranean fibers of the earth, by the welling-up of a new and different spring. Witness to this is subterranean Rome [*Roma Subterranea*], whose streams and living springs, obstructed by the various injuries of times and ages, appear in this present day to those who labor at digging out the foundations of buildings. And in Sicily, to those digging at the roots of Etna...

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underground rivers and springs offer themselves in great numbers — springs that long ago, without doubt, flowed at the outermost surface, but which, swallowed up by the vast conflagrations of the mountain, or overwhelmed by a great mass of ashes and a shower of pumice, lie squalid within the deepest entrails of the earth. See what we have set out more fully concerning these matters in our description of Etna.

But let us now proceed to the prodigious inundations of certain lakes. The first of these, memorable from all antiquity, was the inundation of the Alban Lake [*Albanus lacus* / *Lago Albano*], which Plutarch and Livy elegantly describe as having flooded — with the Veientes defeated — under a clear sky and without rains; and they relate that the Etruscan soothsayer declared the lake would never overflow again, if, by boring through the mountain, they drew the water off elsewhere. We have treated this most fully in our *Latium*. To nearly all writers,

this overflowing of the lake has seemed to display something portentous, I know not what. We, however, say that it was an entirely natural effect, though one of the rarest occurrence; for I do not think it should be attributed to rains or snows, since it happened in clear weather and without rainfall. We suppose that it could have come about in the following way.

[Margin: Mount Alban full of waters.]

In our *Itinerarium Exstaticum Terrestris* we showed plainly that Mount Alban [Mons Albanus] is endowed with a vast water-reservoir [hydrophylacium]. The outflow of this reservoir into the lake and the springs on every side, even at the very roots of the mountain — indeed, the very basin which they call Hannibal's Camp [Hannibalis Campus], in which an enormous spring is born — clearly demonstrate it. And the inhabitants of the castle which they call Rocca di Papa affirmed with one consent, when I was exploring the place, that the whole mountain teems with waters from bottom to top. They added that, in the still silence of deep night, with their ear pressed against the rocky framework of the mountain at certain spots, they could hear some subterranean murmur of gliding waters — a plain indication of a hidden, fruitful cauldron lurking there, by which, through the said springs spread far and wide, the surrounding countryside is irrigated.

For two causes, therefore, we say this prodigy could have come about: either by the immoderate regurgitation of the sea through some fitted water-conducting channel into this reservoir; or by the violence of the subterranean winds, by which the water of the reservoir is taken up from the sea; or else the lake itself, violently pressed somewhere from outside at its bottom, raised itself up with that swelling, so that it overflowed its very rim, the mountain not yet being bored through. Swellings of this kind are to be observed, even to the point of marvel, in other lakes as well — such as the Nursine Lake [Nursinus / near Norcia], Lake Vadimon [Vadimonis lacus], and Lake Lemano [Lemano / Lake Geneva] — which we have described more fully in our *Iter Hetruscum*. The cause of this swelling can certainly be none other than the subterranean breaths and spirits [flatus et spiritus subterranei] which, struggling to find an exit and not finding one, pass beneath the floor of the lakes and force the waters into monstrous swellings, and at certain times so heighten them that they seem to be endowed with a kind of life. But of these matters, see what was treated more fully in the preceding sections.

[Margin: Epilogue.]

Here you have, reader, all that has been handed down to posterity concerning the nature and marvels of waters — whether observed by trustworthy authorities, or what I myself have brought forward here as explored by my own experience — omitting countless other fabulous things, and matters known only by uncertain report. In this one thing I have been careful: never to produce any unusual effect without joining to it its causes. With this zeal, and by the grace of the Divine Power aiding me, I have reached the point of producing no natural effect so exotic that I did not also exhibit it — aided by art and by the skill of experimental philosophy — in machines of my own invention. In this study indeed, over the course of many years, with no less expense than immense labors of the mind, I have striven so greatly for no other end than to destroy that shameful shield of occult qualities, the refuge of all ignorance, and to show that no effect of so occult a quality can be assigned whose genuine cause I could not demonstrate by experiments.

From all of which, finally, I have come to understand that it is no wonder natural philosophy has remained, down to this very day, wrapped in so much darkness and deformed by so many monsters of opinion. For the Scholastic philosophers, content with a universal knowledge of principles, just as they do not descend to the proximate causes of things, so too acquire only a remote and wholly abstract knowledge of the composition and resolution of natural things. We, in this work, consider the universal causes of things — such as the influxes of the Sun, the Moon, and the other stars into this elementary world — in such a way, however, that we by no means rest in this inquiry alone. Rather, pressing on with the investigation of the nearer causes, advancing by a varied combination of experiments according to a certain continuous Ariadne's thread of operating Nature, we have judged that we can investigate the genuine causes of things in no better way than by exhibiting those same wondrous effects and operations of Nature — which she performs by herself and by a certain implanted instinct — through the diligent industry of art, in accordance with the close analogy of Nature's prototypes. You will see that this has been done throughout this whole work.

And this I have always reckoned to be the necessary method of philosophizing about the nature of things. For to wish to penetrate the inmost nature, essence, and property of all things, the inmost compositions and mixtures of individual things, and the hidden nests of the properties implanted in each — this is indeed a mystery which, as it is granted, after God, to the angelic substances alone to know, so it has remained, down to this very day, inaccessible to the darkness of the human intellect; since we do not know the ingenious skill of Nature in

composing things or in implanting powers in them, the proportion of each thing to each, and the degree of the concurring qualities. Hence, although by the help of experiments we may, after the manner of apes of Nature...

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strive to imitate the prototype to some degree, yet by this very means we do not attain the true and legitimate operations of Nature except through a certain shadow of resemblances. [Margin: It is not the business of all philosophers to treat of those things which they demand.] She alone knows by what industry, by what proportion of the things acted upon to the things acting, by what combination and adaptation of things, she produces her wondrous effects. And if anyone should claim these things to be set within the occult and inmost chambers of things, by that very claim he will deny that he is a philosopher, since he has thereby withdrawn into the refuge of ignorance. But if anyone takes refuge in supernatural and celestial causes, he exposes himself to a like labyrinth — since our intellect stands toward the light of truth no differently than an owl toward the light of the Sun.

Whatever we know, then, we learn only by way of the senses and of the external accidents belonging to the genus, which at once present themselves abundantly to the senses; so that we must confess that this knowledge of ours dwells only about the bark, as it were, and the circumference of things. To press closer toward their center has been granted only to those few whose understanding the most kind God and Father of Lights has more deeply imbued with a ray of His eternal wisdom; those whom He has equipped with experience and with the knowledge of various things, and impelled by the investigation of the secret mysteries of nature and by the love of truth, and blessed by the guidance of a divine showing-forth [parastasis].

But as for the rest — in many of the things we have brought forward thus far in this work, we have accomplished as much as the Divine Goodness has bestowed upon us. In many other matters, I judge it more fitting merely to wonder at the works of God, encompassed by inaccessible light, than to investigate them too curiously. For He Himself is the one who spoke, and they were made; He commanded, and they were created — the Cause of causes, the Fountain of fountains, the impenetrable Abyss of Heaven, Earth, and the Seas, and the Lord and Operator of all these things.

MUNDI SUBTERRANEI LIBER SEXTUS

On the Fourth of the Natural Elements, which we call EARTH
and on the things produced from it, the first Fruits of the
Subterranean World.

[printed p. 295. Running header (page top): "MUNDI SUBTERRANEI" — book-
opening display header.]

SECTIO I.

On the wondrous variety of Earth, and whether it is truly and
properly an Element, and what and of what sort should be
understood by it.

CAPUT I.

On the Element of Earth.

[Margin: The wondrous workmanship of the Earth.]

Those who, following the common run of philosophers, persuade themselves that Earth was from the beginning of things a crude and inert thing, and a mere ἄχθος [Greek: ἐτώσιον ἄχθος (etōsion achthos, "a useless burden")], with no variety, no distinction of places and parts — reduced by God into a round form by a certain fortuitous amalgamation, like a cheese — these men deserve to be hissed and jeered off the stage by all right-thinking philosophers, as we have often shown in this work. That it was rather by a truly inexpressible artifice that the creating Mind labored in this admirable womb of Nature will be plainly understood once we have explored a little more deeply the inner recesses of this terrestrial anatomy.

By the same token, all those who have judged that the mass of this earth should be called by the name of "Element" are to be laughed at. [Margin: Earth is not an Element, but an elementate.] For how could that be called simple, in which there is nothing simple — since Nature has willed that all things be composed of innumerable elements, so that not even the smallest grain of sand can be given a body which is not fused together from various heterogeneous trifling mixtures of things? What philosopher has there ever been, down to now, who could show us a pure body of Earth, free of all composition? For if such an Element exists in the

nature of things, it will be either dust, or fine sand, or a clod of earth, or a stone, or a metal, or a metallic juice, or some similar substance compounded from the innumerable species of minerals.

[Margin: It is shown by the enumeration of the parts of the earth that the element is not simple.]

But it can be neither dust nor sand, since dust and sands are nothing other than certain leavings, or the minutest little bodies scoured away from some whole stone or rock; and as these partake of the nature of the whole, so they cannot be simple. Nor can it be stone or metal, since these — together with dryness and moisture, besides the other powers implanted in them — are mixed (as is known to those skilled in the spagyric art) with very many mineral refuse-matters; and the same must be said of the other minerals. Who, then, would assert that so many marcasites, so many salts, sulphurs, alums, arsenics, so many boles, boraxes, magnets, so many glasses, crystals, so many concreted fluors, so many unconcreted juices — so many kinds of waters, in fine — are simple bodies? No one, surely, save one utterly devoid of and unskilled in all physical matters.

I am not unaware that some hold that the virgin earth, which is found only at the center, is the true element of earth. But just as it is uncertain whether such a body is found at the center of the earth, so too this fiction is asserted without grounds. There are some who hold that either ash or earth...

[The pages in this PDF run out of printed-page order; they are presented here in their correct printed sequence: 296, 297, 298, 299.]

[Continued from the previous discussion — the candidates Kircher rejects as the "element of Earth."]

something white, of the kind that white lead [ceruse] is; and some even hold that the element of Earth is *marl* [Marnen], a kind of earth usually dug only in Gaul [France]. Against this, consider first that ash cannot be the element, since ash is itself a composite: it consists of moist and dry, of salt and of powder, as I will show in its proper place. Nor can white earth — that is, white lead, gypsum, or chalk — be the element, since their very color (as can be seen in earths dyed in all sorts of different colors) is a plain mark of composition.

[Margin: That there is no pure and simple element in the nature of things.]

Finally, the earth they call *marl* cannot be the element either. For if it is said to be found only in Gaul, I do not see how it could be called the universal principle and element for the composition of all things. For if this earth were an element, it

would have to be the element of mixed and compound bodies. Yet sand composes no mixture; and gypsum, so far from composing anything, rather destroys any mixture it is added to. As for marl, which is scattered over fields and is said to enter into the mixture of whatever is produced by the fertilizing of the soil with marl — who does not see that this cannot be so? For since marl is found only in Gaul, and consequently nowhere else, there would be neither an element of Earth nor any composition of mixed bodies elsewhere. All of which is so incongruous that I would judge it should more truly be counted among old wives' ravings than believed by sensible philosophers.

We say, therefore, that no pure and simple element exists in the nature of things — and this is as certain as the experience of things examined by the spagyric art is sure and indubitable. For if a pure, unmixed, simple, and uncompounded element could exist, it would already be either soft, or hard, or colored, or imbued with its own virtues and qualities. But this very fact — that it either resists the touch or yields to the touch, or is finally imbued with some color or other — this very fact, I say, immediately offers some evidence of composition and mixture.

But perhaps someone will object: the element of Earth is that body which is utterly dry and devoid of all moisture. Yet this too cannot be said in any way. For such a body would be either glass, or sand, or gravel, or brick, or something similar — the bodies that in our estimation seem the driest of all.

Caput II.

On the great variety of things that are contained in the womb of the earthly globe.

Earth is the center and mother of all things. Into it the elements cast their seed and sperm, which Earth cherishes, ripens, digests, and brings into actuality in its bosom, according to the first intention of Nature and the admirable disposition and providence of divine Wisdom. So that Earth might be fit to hold so great a stock of universal seeds [panspermia], divine Wisdom founded it with such art that there is nothing in it not rightly arranged, nothing not duly ordered for attaining its intended effects through a wonderful series of things. Hence — as I said in Book Two — Wisdom hollowed out countless channels within it [Margin: The arrangement of the caverns], and dug out within it countless caverns of the hydrophylacia and pyrophylacia [the subterranean water-reservoirs and fire-reservoirs]...

[Continued from p. 296: still within Caput II, the subterranean channels now compared to the veins of the human body.]

carved out the caverns, and surely with no less care and concern than that with which eternal Wisdom sported in the fabric of the human body. [Margin: The Geocosm made an admirable likeness of the Microcosm.] For just as in the fabric of the human body the branching substance of the veins is so extended into all the inmost chambers of the microcosmic economy that there is not even the smallest particle that does not draw to itself, through the capillary veins, blood as the nourishment owed to it [Margin: The comparison of Earth to the human body], so too no portion of Earth, however tiny, can be found that does not abound in the moisture owed to it. If you pierce the skin in the human body with a needle, you see blood come out at once; in the same way, if anyone digs out even the smallest portion of Earth somewhat deeply, he will find moisture present at once. If anyone could behold with his eyes the inmost constitution of these veins, he would doubtless see it arranged on exactly the same plan by which, in anatomy, we recognize the wonderful texture of the veins spread out branch by branch through the whole expanse of the body. Nothing therefore now remains except that I show what truly and properly is that element of Earth which is so greatly disputed among the authorities.

Earth, then — insofar as it is the fourth and last element — was formed and produced out of the coarser parts of the proximate principles that existed within the chaotic mass and the abyss, through the inscrutable operation of divine Wisdom, for the generation of all things. It was made, as it were, a kind of sediment, principally out of the coarser portions of salt. For salt, with its spirit working within it, alone furnishes coagulation to all the things of the world, and produces a dense and hard body. And just as salt predominates in Earth, so too we may rightly say that salt composes Earth. To make this understood:

[Margin: Out of what is Earth composed?]

A twofold earth must be distinguished here for consideration: pure earth and impure.

[Margin: What is pure earth and what impure?]

Pure earth is nothing other than coagulated salt, in whose center that spirit lies hidden which by its power fixes, condenses, and animates all things — so that salt may not incongruously be called a kind of soul of Earth. If you take away the salt from earth, and with it the powers of fixing, sprouting, germinating, and nourishing, you will find you have taken these away as well — which is as certain

as daily experience teaches us. And it appears in glass: for although glass is true earth washed by fire, as (unless I am mistaken) I showed clearly enough in the preceding chapter, in which it [Margin: Salt is incorruptible] is the dead remnant, deprived of nearly all salt, so too, deprived of all its virtues, it remains sterile and barren.

Hence it is clear that all the virtues, of which there is no counting in this earthly globe, depend on salt — as salt's own powers depend on the spirit implanted in it by Nature, as on their chief agent — so that without it the Geocosm must necessarily perish. That pure earth is coagulated salt together with its spirit, endowed with a fixative power, is clear from what has been said. But all the remaining bodies may be called impure earth, and are nothing other than an excrement, and as it were a kind of menstruum of Earth, instituted by Nature to this end: that the generations and corruptions — that is, the births and deaths of things — being driven on by a certain alteration and perpetual passage from one thing to another, might unceasingly contribute to the preservation of the world. For if all things consisted of salt alone, their birth and death would by no means proceed in this order of alternation, but rather, from the incorruptible nature of salt, they would promise themselves a certain ἀφθαρσίαν [Greek: aphtharsian, "incorruptibility"] — that is, incorruptibility, such as is seen in the quintessences, in gold, and in precious stones.

For the excrement — or, to speak with the chemists, that *recrementitious* body which girds and clothes the element of Earth with a vast compass of various dregs — just as it hinders the perfect and absolute union of the elements, so too it does not permit them to subsist for long; since things that are united by a weak and feeble bond must also undergo an easy dissolution of their parts. But in things perfectly united, just as the bond is firmer and more solid, so too it produces a more durable consistency of the parts — as is plain in the substance of gold and of lead, of which the former, on account of its intimate union and the most close-packed bond of its parts, not undeservedly wearies the wits of the chemists in dissolving it among all metals, whereas the latter melts at the very first kindling.

[Margin: The durability of bodies comes from salt.]

It is clear, then, that the more things consist of a purer substance of salt, the more perennial they are in duration — as shines forth clearer than the noonday light in the precious stones: the diamond [Adamas], beryl, topaz, emerald, ruby, and the rest, about which I shall reason at length in their own place and time.

Caput III.

On the incredible variety of things that are produced — by the power of salt, together with the auxiliary forces of the rest of the elements — in the womb of the vast Megacosm; and first of all concerning Salt and its differences.

In the preceding chapter I showed clearly enough, unless I am mistaken, wherein truly and properly the proximate element of Earth consists. Now, however, it is time to show what those things are that are produced in Earth through the agency of the salt-mediator, with the concurrence of the rest of the elements, following the enumeration of the parts; and to show from where, for all sublunary bodies, the...

[Continued from p. 297: "from where, for all sublunary bodies, that *fleshy*..." — the column-bridge word is *corpulenta*.]

that coarseness arises, let us begin, and first we must speak of the manifold difference of saline bodies, so that afterward we may go on — after the saline bodies — to the composition of the remaining concrete juices: that is, of the individual concrete mineral fluids and juices, then of stones, and of metals.

SAL. — [Salt.]

Leaving the etymology of "salt" [*sal*] to be investigated by the grammarians, I turn my pen to exploring the inmost nature of Salt.

[Margin: What is salt?]

Salt is the central body of nature, the virtue, vigor, strength, and stay of Earth; the compendium of all earthly virtues; the subject of all the principles of Nature; from whose central essence the whole science and absolute knowledge of Nature depends; the matter out of which all things are constituted, and into which, when destroyed, they are at last resolved; the first and the last, the α and ω [alpha and omega] of mixable bodies; the well of Nature, and a thing well-nigh divine. As Homer attests, [God] sprinkled it with divine salt — for no other cause, surely, than the virtue implanted in it, by which it not only keeps bodies immune from all corruption, but also propagates the same with a wonderful fecundity. For there is impressed on salt I know not what character of divinity, whereby [God] indicated that he is supremely delighted by the office of salt in sacrifices.

[Margin: That salt is something divine, and why.]

[Margin: Always used in sacrifices.]

Leviticus 2: "Whatever you offer for sacrifice, you shall season it with salt, nor shall you take away the salt of the covenant of your God from your sacrifice; in every offering you shall offer salt." And *Mark* 9: "Every victim shall be salted with salt." And countless other passages, which occur everywhere in the Sacred Scriptures of both the Old and the New Testament, indicate the nobility and excellence of salt.

That great use was made of salt in the rites of the Gentiles, Ovid shows in Book 1 of the *Fasti* [*Fasti* I]:

Inde vocor Ianus, cui cum cereale sacerdos / Imponit libum farraque mixta sale. ("Hence I am called Janus, to whom, when the priest sets cereal cake upon the altar and spelt-grain mixed with salt...")

Ante Deos homini, quod conciliare valeret, / Far erat, et puri lucida mica salis. ("Before the gods, what availed to win their favor for man was spelt, and a gleaming grain of pure salt.")

For life, to speak with Pliny [the Elder], cannot be led without salt; and it is so necessary an element that the recognition of its virtue has passed, in a way, even into the pleasures of the mind. For we say that *witticisms* are called "salts" [*sales*], so that you may know that the charm of all life, the height of cheerfulness, and the rest from labors are summed up by no other word than "salt." Hence Horace, in the *Art of Poetry*: "Our forefathers, for the most part, praised both the meters and the salts [wit] of Plautus." And the Apostle confirms it, in *Colossians* 4: "Let our speech always be seasoned with salt in grace, that you may know how you ought to answer each one." But lest I seem here to be playing the encomiast of salt, leaving aside other tributes, let me proceed to those matters that are most properly our business.

[Margin: The spirit of salt, the terrestrial element, was implanted in Earth from the beginning of things.]

The spirit of salt — the terrestrial element — was, from the beginning of things, implanted in the earthly globe by God the Best and Greatest, both for the preservation of the whole and for the generation of countless substances. Hence, by a certain reciprocal exchange, the lands and the seas cherish and nourish one another, so that the salt which the Ocean has sucked from the earthly clods and from their teeming udders, it may — once that salt has been led through subterranean conduits and channels — restore to the Earth, as a kind of pledge entrusted to it. Read, if you please, Reader, what I have set out at length in the

Third Book, with the fullest reasoning, concerning the saltiness of the sea and this reciprocal commerce of the Earth with the Ocean.

[Margin: Salt is threefold: marine, fossil, artificial.]

Common and ordinary salt can be considered under a threefold difference, so that one kind is marine salt, another fossil, and another extracted by art from terrestrial clods or briny waters by boiling. Marine salt, although it does not differ in species from fossil salt, is nevertheless distinguished by a notable diversity in this very respect: that marine salt, as sharing more in moisture, is of a softer and limper substance; whereas fossil salt, on the contrary, enjoying the predominance of earth, acquires a more compact and solid substance; and the artificial kind partakes of both.

[Margin: The hardness of fossil salt.]

Fossil salt indeed — such as is found in Doris, Calabria, Sicily, Poland, and countless other places — is of such hardness that it condenses into very hard stones, well-suited for the structures of buildings and fit for carving statues, as Solinus attests where he speaks of Sicily. "The remaining salt-mine metals," he says, "which are nearest to the Agrigentine territory, are quarried by the service of the cliffs, for from there blocks are cut out for the likenesses of men and of gods." He asserts the same of the Nasamones and the Troglodytes: "For with salt they build houses, which, cut in the manner of cliffs out of the mountains, they fit together for the use of dwellings with mortared structures."

[Margin: An experiment.]

So you have the difference between marine and fossil salt: that the former, moistened with water, easily liquefies on account of the slight close-packing of its parts; the latter, as of a more compact nature, does not easily liquefy when water is poured over it. Yet even in fossil salt there is something worthy of wonder — as long experience has taught me — namely, that a piece suspended from a thread drips down little by little, drop by drop, when the South wind [Auster] or some other wind of a moister nature is blowing, but does not do so when the North wind [Boreas] or the West wind [Zephyrus] is blowing. This for no other cause, surely, than that the moist surrounding air, gradually penetrating the substance of the salt, soaks it through with its own moistening, whence through the dripping it gradually wastes away — which I find Agricola too noted, in Book 1 *On Fossils* [Agricola, *De Natura Fossilium* I].

All salt, when roasted with fires set beneath it in a vessel, loses none or little of its substance from its bulk. It loves dryness, which — joined with heat or cold — has glued it together. Moisture, by contrast, being its enemy, melts and disperses it at once when placed in it; indeed, exposed in moist air, it suffers some loss of mass. Therefore those who wish to preserve it whole must store it in dry places. The Drepanitan salt [of Trapani, Sicily] sufficiently attests this — heaped into piles, it lasts under the open sky for a span of fifteen years; and at Utica in Africa huge heaps of salt present the appearance of hills, so condensed and stiffened by the heat of the Sun that they neither melt in the rains, but by iron...

[Continued from p. 298: "...but by iron are cut only with difficulty."]

they are cut only with difficulty. And these things, unless I am mistaken, sufficiently show that earth predominates in salt, and that it is dry in the first degree, cold in the second; and it is of such admirable virtue that it scarcely has its like among the things dug from the earth. For it cannot be numbered among the metallic bodies, because it is not dissolved by heat; nor among stones, because it liquefies when water is poured over it; nor among the remaining earthy mineral parts, because when dissolved it passes entirely into water. And yet you may not call it water, since, when dissolved by the attenuation of heat, it does not pass off into vapor, nor is it consumed by fire, but rather is burned; and once burned, then condensed again, it is restored to its own nature. So whether you torrefy it with fire, or macerate it with water, or carry it through by decoction, it always remains like itself, and reverts to the state that Nature intended — being, as it were, of an incorruptible nature, an incorruptibility conferred on it by Him who, sprung from a heavenly lineage,

Spiritus intus alit, totos diffusa per artus Mens agitat molem, et magno se corpore miscet. ("A spirit within sustains, and Mind, infused through all the limbs, stirs the whole mass and mingles itself with the great body." — Virgil, *Aeneid* VI.)

But concerning the nature and properties of this Salt, see what is treated in Book II of this work.

Caput IV.

On the Differences of Salts.

That there are as many species of salts as there are species exhibited in the nature of things, spagyric experience has taught us — since nothing offers itself in the threefold kingdom of minerals, vegetables, and animals that, when wrung

by boiling, maceration, distillation, or dilution, does not yield us salt; as will become manifest in what follows, where I will treat of the extraction of salts, through countless experiments. Therefore in this place I shall reason about common and properly so-called salt and its various division; and so that you may see the differences of common and ordinary salt at first glance, here I set down an analytical table.

Analysis of Salts.

Salt may be considered as	(sub-branch)	(sub-branch)	Kinds	Note
Natural salt	by reason of the place where it is born, and these are	—	Marine, Terrestrial, Lacustrine, Fluvial, Spring [Fontanum], Sand-derived [Arenarium].	These in turn are manifold by reason of the matrices in which they are found, and from which they draw different qualities and tinctures.
	by reason of its powers	Soft	Ammoniac, Bituminous, Urinary.	Whatever is at last extracted from fatty and oily things.
		Hard	Crystalline, Rock-salt [Sal gemmae], Stony [Saxosum].	And it embraces the whole substance of salt condensed into stone.
	by reason of its colors	Colored	White [Album], Yellow [Flavum], Red [Rubrum], Black [Nigrum].	It comprehends all those salts that are affected by the tincture of the thing from which they are

Salt may be considered as	(sub-branch)	(sub-branch)	Kinds	Note
Artificial or factitious salt is made either	by Boiling [Coctione]	—	From briny earth, From sea-water.	extracted. These in turn are of manifold difference, according to the nature and quality of the place from which they are drawn out.
	by Drying-out [Exsiccatione]	—	From marsh-water, From sand, From the urine of animals.	
	by Incineration [Incineratione]	—	From metallic bodies, From vegetables, From animals, From all natural things whatsoever.	And it embraces the universe of things.

[Liber VI, Sectio I, Caput IV — continued: "De Differentiis Salium"]

River, Lake, and Spring Salt [Sal fluviale, lacustre & fontanum]

[Margin: River, lake, and spring salt.]

River, lake, and spring salt is the kind extracted from streams, lakes, and springs, and is usually drawn off by boiling. How salt comes to be in springs, rivers, and lakes I take to happen as follows. Wherever there are salt-bearing mountains, or beds saturated with brine, it most often happens that underground rivulets passing through such beds become charged with brine. These rivulets later break out as a spring and so produce a salt spring, which in turn feeds salt rivers. But if

such underground rivulets discharge themselves through hidden subterranean channels into some lake, then they communicate to that lake the same brackish quality that they absorbed from the salt mountains and brine-bearing beds.

[Margin: How salt arises in lakes, rivers, and springs.]

Let me confirm this by an example.

Diagram. A woodcut showing a freshwater rivulet that descends through the interior of salt mountains, emerging as a salt spring that feeds a river and a lake. The mountainous terrain is drawn in profile with a hand-like ridge at upper right; channels of water thread between the hills. The prose accompanying it reads: "Let there be some underground rivulet of fresh water, marked with the letter A, which runs in its bed through the innermost recesses of the salt mountains. It is certain that, once it has straightway drawn in the brine, it will become salt, and consequently, as soon as it breaks out at spring D, it will make spring D salt, and the river E that flows from it. The lake F, fed by the underground river ED, already charged with brine, will in the same way share in that brine."

- A (upper middle): freshwater rivulet entering the salt mountains
- B (left of center): mountain ridge (label on the slope)
- D (center, lower): the salt spring where the rivulet breaks out
- E (lower left): the river derived from the spring
- F (lower right, basin): the lake fed by the underground river

[The figure shows labels A, B, D, E, F; no point C is lettered. The prose refers to A, D, E, F.]

Salt from Burnt Wood [*Sal ex lignis combustis*]

[Margin: Salt extracted from wood.]

Authors of the highest authority have also reported that salt can be drawn from burnt wood — chiefly from oak or hazel wood, that is, from the oak and the hazel. Agricola teaches the method (*De Re Metallica* XII) [Georgius Agricola, *De Re Metallica* XII]. Those who make salt by pouring brine over burning logs must first dig pits in which to set the wood. These pits should be twelve feet long, seven wide, and 2½ deep, so that the poured-in brine does not run off; they should be built up with salt stones, so that they neither soak up the water nor let earth fall in from their front and back faces.

[Margin: Making salt from ash.]

In these pits the burnt oak or hazel leaves charcoal behind, and when salt water is poured over it, this charcoal is converted into salt — though it matches neither the color nor the purity of ordinary salt, being tinged with a black and dusky color.

The Salt Called Kali [Sal Kali]

[Margin: What the salt called Kali is, and its preparation.]

There is yet another kind of salt, called *Kali* or *Alkali*, commonly *soda*, useful for making glass. The Arab Bulcasis [Abū'l-Qāsim al-Zahrāwī (Albucasis)] wrote a whole book on this art, and I shall treat it fully in my *Treatise on the Glassmaker's Art* [*Tractatus de Arte Vitriaria*]. The salt is drawn from the herb Kali by art in this way. This herb, reduced to ash, is commonly called *soda*. They grind this soda, softened into a mass, and once it is reduced to a fine powder, they sift out the coarser admixed particles through a sieve.

To each pound of this they add an equal number of jars of water, and boil the well-diluted water for four hours, until the water is reduced to a third of its volume. Then, taking it off the fire, they let it settle for a space of twelve hours. Once the sediment is removed, you will find the water perfectly clear. They then strain it drop by drop through woolen wicks into a large vessel set beneath, and repeat this as often as needed, until they find by the test of the tongue that the water is salt. Finally, from this water they set a full pot on the fire and boil it until, the moisture having been driven off, they find the more substantial water reduced to salt.

Lake Salt [Sal lacustre]

[Margin: Lake salt. The Asphaltite Lake, the Dead Sea.]

Lake salt is what is extracted from brine-bearing lakes — such as Lake Asphaltites [Lacus Asphaltites] in Palestine, from which is drawn the salt that, from Sodom, they call "salt of Sodom." This lake is most celebrated among both sacred and secular authors, on account of the Pentapolis [Pentapolis — the five cities], whose memorable terror to mortals through every age it preserves: when, with an angry Heaven raining down sulfur, the burning fire blazed up and destroyed it. This region, as Holy Scripture attests, once rivaled Paradise in its delightfulness; but after the dreadful and unheard-of crimes of unnatural lust in which its inhabitants were entangled, it was burnt up by celestial fire, and now wears a face that, horrid and dreadful to behold, presents an infernal region

rather than any earthly one. See these matters treated more fully by the commentators on Sacred Scripture at this passage of Genesis.

Its salt is of an exceedingly bitter taste, and of so coarse a substance that it is found to be twice as heavy as sea salt. Hence bodies thrown into the lake never sink, owing to the abundant admixture of bitumen, and the lake bears up both men and animals without any aid of the swimmer's art. Yet as soon as they come out, their whole body is seen to be sprinkled with salt. The inhabitants nonetheless use salt of this kind as a necessary article of diet, just as we use ours. See Galen [Galen], *On Simples IV (De Simplicibus IV)*.

Lot's Wife Turned to Salt

[Margin: Lot's wife truly turned to salt.]

It is well known what the Sacred Page relates about the wife of Lot [Lot], turned into a statue of salt. Interpreters greatly torment themselves over why she was turned not into some other kind of stone or stump, but into a likeness of salt. I judge it to have been done for a twofold cause, partly physical, partly moral. For if we consider the nature of the place, we shall find it — by the records of all historians — utterly full of salt. It is therefore far more likely that she was transformed into a mixture of that sort, with which the Sodomite plain abounded, than into some other kind of stone or substance, of which the place had none.

[Margin: The marvels reported of this statue.]

A moral cause is added: just as the foolish woman, despite the prior divine warning, would not be wise, so, to her own ruin turned into a statue of salt, she might by her fearful example warn those who look upon her — and the tasteless minds of mortals — among later generations, that it is not to be made light of, what the offended mind of the Divine Power avenges with such rigor and severity by its just judgment. Let them therefore be wise and foresee the last things. Tertullian [Tertullian] relates that in his own day the statue was still to be seen. Brocardus [Burchard of Mount Sion], who lived about 300 years ago, likewise reports that in his own time it stood between Engedi and the Dead Sea. Adrichomius [Christian van Adrichem], a writer of this century, that it still exists. And the Jerusalem Targum [Targum Hierosolymitanum] reports that it will endure until the consummation of the age and the common resurrection of mankind.

It is remarkable what Tertullian reports of it: that this statue, as if it were alive, gives off a moisture not unlike the flux of women's menses; and again, that if this

same statue be mutilated by anyone, it as it were repairs its mutilated wound and seems to fill up what has been cut away. But since Tertullian describes these things not inelegantly in a certain poem on Sodom, I thought it should be added here:

The very image, keeping its body's form bodiless, Endures still, never washed away by rains, nor leveled by winds; Indeed, if any stranger mutilates the form, Straightway of itself it fills its own wounds anew; And it is said, though living now with another body's sex, To shed, marvelous, its accustomed monthly courses of blood.

And concerning it the following riddle is also offered:

The corpse has no tomb of its own, The tomb has no corpse of its own,
Yet the tomb and the corpse are within.

But this is by the way [Greek: παρέργως (parergōs, "incidentally," "by way of digression")]. Now let us return to the matter we set ourselves.

Salt from Muria and Garum

[Margin: What muria and garum are, and how they are made.]

That salt is extracted from *muria* and *garum* too is better known than need be said. But what is properly meant by *muria* and *garum* must first be stated. *Muria*, then, which they once used as a seasoning for food, was nothing other than that liquor pressed from the *garum* fish — also called the mackerel [scomber] — and secondly from the fish that they boiled down from the tunny [thynnus], which they seasoned with wine, saffron, chopped herbs, and in other ways.

[Margin: The three kinds of garum.]

And the *muria* that they prepared from mackerel under the name of *garum* — being the most exquisite — was for that reason set only on the tables of princes. The second, prepared from the tunny fish, was likewise a noble seasoning, much used by the rich and the nobility. The third, made from anchovy [apua] and the cheapest little fish and called *halec*, being of meaner quality, fell only to the use of common people. Afterward, however, the usage prevailed that any salt water — whether by itself alone, or with other seasonings added — was called *muria*. See Horace [Horace], *Satires* II.4 (*Sermones* II, Satire 4), where he sets out two kinds of sauce: one made of oil alone, the other compounded of muria, oil, wine, pounded herbs, and other things — which is indeed best if tempered with muria from a Byzantine jar.

But anyone who desires more about muria and garum and the manner of making them should consult Columella [Columella], Dioscorides [Dioscorides], Galen, and others. Many today call *muria* that liquor compounded of salt and fresh water mixed together: if an egg thrown into it does not sink but floats upon it, they say the muria is complete. But this liquor obtained the name *muria* only by a kind of metaphorical manner of speaking.

[Margin: An experiment.]

Although the use of muria from garum and tunny has ceased in Europe in our day, it still flourishes at Constantinople among the Turks, as I have learned from various people; and that only the word now remains is shown by the Greek terms: ὀξύγαρον [Greek: ὀξύγαρον (oxygaron, "a broth made of anything compounded of sour and sweet")], everything made from a sour-and-sweet mixture; ἐλαιόγαρον [Greek: ἐλαιόγαρον (elaiogaron, "made of salt and oil")], what is made of salt and oil; ὑδρόγαρον [Greek: ὑδρόγαρον (hydrogaron, "made of brine")], the liquor made of salt water — not unlike those sauces the Italians call *salsa*, *intingoli*, *guazzetti*. But let this suffice concerning muria and garum.

Caput V. — De modo Salium extrahendorum

Chapter V. — On the Method of Extracting Salts

Whatever can be reduced by the force of fire into ash and lime — whether it comes from the animal, the vegetable, or the mineral kingdom — there should be no room for anyone to doubt that salt can be extracted from it. And in these mixed bodies the power lies latent; in others — as in sea water, muria, brine-bearing earths, and the rest of the places rich in niter, halinitrum, alum, and vitriol; likewise in the acidic excrements of animals, chiefly of birds such as doves and hens — the salt is present in actuality, either coagulated or dissolved. Hence the method of extracting their salts is not so very difficult. Let us now see how salts are to be extracted from all the things mentioned. The chemists assign several methods, which we reduce to a threefold distinction: so that one is easy, the second subtle, the third subtle and arcane.

The First Method: Extracting Salts from Vegetables [Primus modus ex vegetabilibus extrahendi sales]

[Margin: The first method, of extracting salt from vegetables.]

From the class of vegetables, choose whatever plants you please. Dry them first in the sun or shade, then resolve them into ash within a pit built either of stones or

of fired bricks. The ash thus left behind is heaped in a pot, water is poured on, and it is boiled; the dilute liquid is then poured off into a vat. Once the sediment has formed, the salt liquor — which we call *lixivium* (lye) — is strained off through a filter and coagulated by evaporating it down to the consistency of a sauce or thicker broth [embamma]. It is not boiled down to dryness, lest it be scorched. The remaining moisture is dissipated, the salt staying behind, either by the gentle heat of a furnace or by the sun's warmth. Still, I think it more advisable to pass this liquor through various wicks, following Bulcasis's [Albucasis] instructions, or through various filters.

[The following corresponds to printed p. 303, the conclusion of Caput V's methods of extraction.]

The Second Method [Modus secundus]

[Margin: The second method.]

The second method is this: Burn the dry herb, enclosed in an earthen vessel, into a most white ash in a furnace built up with a very fierce fire. To this ash, placed in a glass cucurbit, add rain or fresh water previously purified by distillation, and cook it in a bath of ashes until a fourth part is consumed. Then let it rest until the dregs settle to the bottom. This done, the separated liquor, strained through a filter, is transferred into another vessel, in which it will coagulate into the salt sought.

The Third Method [Modus tertius]

[Margin: The third method.]

The third method: Let a freshly gathered herb, still swollen with its own juice, be distilled. The water being separated, let the remainder be reduced to ash by fire in a closed vessel. To this purified ash let its own water, set aside a little before, be restored; and let the combined liquor be digested in dung or in a bath for some days. Once digested in this way and carefully removed, let it be distilled down to the consistency of honey; then let the juice be poured into a glass dish, where it gradually coagulates. I have seen most of the better chemists work in this way.

These methods I have set out as the easier ones, which do not differ much from those by which salt is drawn from the ashes of burnt reeds, rushes, hazels, and oaks. Such salts lack the signs and tokens of the essence that lies hidden in the inmost center; they ooze with an oily fattiness, are tinged with a foul color and a urine-like smell, and are not pleasing in odor. And so corrective arts have been invented by those skilled in chemistry, by which these salts may be amended and

at last attain their perfection. What these methods of proceeding are, I shall now disclose.

The Fourth Method: A Subtler Extraction [Modus quartus, subtilior]

[Margin: The fourth method, of extracting the aforesaid salt more subtly.]

Those who seek the more subtle mastery of salt go about it in various ways. Some, in order to remove all the aforesaid effects and the smell of urine entirely, do not coagulate the extracted salts to dryness, but reduce them to the form of a syrup, so that the surviving moisture is either tinted by the sun or dried by the heat of a furnace. Others dilute them with rose water, filter, and coagulate by an oft-repeated operation. Some reverberate them to dryness; nor are there lacking those who melt them and liquefy them with fire.

But we recognize that not even in this way will the salt attain its perfection, since such a thing is only a material body. Therefore, in order that it may achieve perfection, spirit of wine or radical vinegar is needed to complete the work. So, after some preliminary washing, let the ashes be mixed with spirit of wine or vinegar; let the mixture be distilled, the distillate drawn off, filtered, and coagulated. This is repeated until, after percolation through the filter by a threefold operation, nothing remains, and the salt comes out entirely etherial. This is the first true method of extracting salts from plants and animals — and from those things analogous to plants.

From lime [calx], salts are separated much more easily still, by the same procedure, save that the water used must not be drawn from rain, river, or spring, but properly distilled fresh water. Some, leaving aside the first dregs, take up the extracted juice, and from this draw out the first tincture, or fifth essence [quintessence], two or three times, until the most subtle part is separated. Then they evaporate the feculent juice to dryness and reduce it to ashes; and from these, with singular ingenuity and industry, they bring the salt to its highest perfection, using its own phlegm, or that very menstruum by which its proper and essential juice was secreted.

The Fifth Method [Modus quintus]

[Margin: The fifth method.]

Let the remains of the pressed-out herbs, together with the magma or thick residue of the juice, after drying, be put into a pot and allowed to settle. Let the empty pot be filled to the brim with new material — which may also be done by adding whole herbs, so that in this way a threefold substance of the same herb

comes together. Let the pot, closed but with a small breathing-hole left, be reverberated by degrees, so that the topmost layer, buried by the first, glows white-hot. The ash being removed, let warm distilled water be directed onto it; the clear water poured off, let it be strained, coagulated, dissolved, filtered; and this done, let it be coagulated once more, until its purity, color, and taste are pleasing.

In some, once the sulphureous and mercurial essences have been rendered up, the dead heads [capita mortua] still retain salt, so that there is no need of fresh burnings or calcinations; but to the ground residue is added either its own phlegm or distilled fresh water, which is at once impregnated with the salt drawn to itself. And this is fixed salt, for the volatile had already flown off in the first distillation; yet this fixed salt too will become volatile if it is tormented by a further distillation.

In this same way, salt is extracted from all the species of saline bodies — as from the residues of distilled vitriol, tartar, salt, alum, halinitrum; likewise from the dead heads of sublimated quicksilver and the sediments of strong waters [aquae fortes] — which is also accomplished by the coagulation of spirits. For the spirits of the said salts, drawn out from a retort by the force of fire or through an alembic, when the spirituous moisture has gradually separated and withdrawn itself, are at last condensed into salt. In this way salt is extracted from tartar — on which see Oswald Croll [Oswald Croll] in his *Basilica* (*Basilica Chymica*). But of all these matters more abundant material for discussion will be given in the following books; so let us turn to other things.

Liber VI, Sectio II — De Nitro

SECTIO II.

CAPUT I.

DE NITRO

And its varieties: rock-niter [Salnitrum], aphronitre [Aphronitrum], and halinitre [Halinitrum].

[Margin: Niter, the second variety of salt.]

The second variety of salt is niter [nitrum]. It is called by various names, which, though they agree entirely in essence, differ only in their accidental qualities —

names that sound different but mean the same thing. Like common salt, niter is either native or manufactured.

[Margin: Native and manufactured.]

Native niter is found either within the earth or outside it. When it lies hidden within the earth, it is quarried like other fossils [minerals], for it is hard and dense, like stone — and from this the Venetians are said to make borax, or what amounts to the same thing, chrysocolla [Veneti conflare dicuntur]. Or else it is gathered in caves, on whose walls and vaulted ceilings it forms like icicles. Or, while still liquid and dripping down into the ground, it passes into a kind of efflorescence which the Latins call *spuma* [foam] and the Greeks ἀφρόνιτρον [Greek: aphronitron, "niter-foam," aphronitre].

[Margin: What is ἀφρόνιτρον?]

This foam-niter differs from the solid form in nothing but its hardness or softness. In ancient times a kind of niter was highly prized which was gathered in Egypt — in fields after the flooding of the Nile, once the moisture had already evaporated and it had solidified. Another, much-prized kind was dug up near Philadelphia in Lydia and Magnesia, a city of Caria.

[Margin: Where the best niter is produced.]

Outside the mines, however — in valleys, plains, and lakes, from whose edges it bloomed out like salt — it was scraped off; and this they called ἅλμυραγία [Greek: halmyragia, "salt-efflorescence" — a salt deposit]. By art it is prepared in this way: just as in Egypt the niter-bearing substance is found sweating out of the earth and clods in nearly all places — no differently than sea-salt — and is boiled into salt by the power of the Sun in little beds [areolis] hollowed out by the technique mentioned above, or in a pool; so too the water of the Nile alone, either channeled into niter-beds (which they call *Nitrariae*) or left standing in the hollows of the fields by the Nile's flooding, solidifies into niter through the Sun's action, as the fresh waters are thinned away into vapor.

[Margin: How it was prepared by art in ancient times.]

And this is to be understood of all those places where niter-bearing earth abounds. For, as was said above, fresh water flowing through such places takes on the nature of the soil according to the natural disposition of the terrain beneath it: if it has sucked up salt and drawn it to itself, it will grow into salt; if it has passed through niter-bearing places, it will be imbued with niter and at last

bloom out into niter; if through aluminous places, into alum; if through vitriol-bearing places, into vitriol — all of which was set out at length in Book V.

[Margin: Fresh water acquires the quality of the terrain beneath it as it flows, taking its nature from the underlying ground.]

In Egypt niter is produced in such abundance that, heaped into mounds, it grows in time into rock, from which elegant vessels are formed. And if it is sometimes found tinged with various colors, this proves nothing different about the niter, since it draws every color from the color of the earth out of which it was extracted: from red earth, red; from white, white; and so on.

Whether Egyptian niter is the same as ours is a matter of dispute among natural philosophers and physicians. We for our part judge that our niter does not differ in species from the Egyptian, but only in accidental qualities — in much the same way that salt is produced of a more excellent nature in some places than in others.

[Margin: Whether Egyptian niter is the same as ours.]

For the terrain's disposition by place, its situation, the aspect of the heavens, and a differing climate — just as in some places they generate nobler products than in others (since places differ in their disposition) — so too do they generate nobler mineral compounds. The same happens with all the other varieties of salts, as spagyric experience clearly teaches. For if you take salt or niter, whether pure or imperfect, impure, base, and contaminated with various adulterations, and reduce it to perfection by the torture of fire through repeated distillation, you will at last obtain the purest niter, one that yields to no other niter however pure in excellence. So the excellence of niter does not differ from a less excellent niter, except that the latter is found less pure and refined than the former. Once these impediments are removed, the nature is utterly the same wherever in the world it may be produced — so that it seems pointless that it was named by the ancients under so many different names, as though distinct in species.

[Margin: Pure niter differs from impure only accidentally.]

For just as salt is made by a threefold technique — from brine, from a dilution, or from a lye [lixivium] — so too is niter, drawn from the same sources.

[Margin: Salt and niter are made by a threefold method.]

For niter-bearing water, like brine, is converted into niter; niter-bearing earth, drenched and mixed with fresh rain water, is likewise transmuted into niter by

the heat of the Sun; while from oak and similar woods burned and reduced to ash, a lye is prepared that is wonderfully suited to extracting niter, by the technique we hinted at above.

As for niter-bearing waters, they too take on various differences according to the proportion of the substances mixed in with them. The Nile water of Egypt, although niter-bearing, nevertheless when strained yields a drink that is not only most healthful but also wonderfully suited to making women fertile, as we showed in our *Oedipus* [*Oedipus Aegyptiacus*]. Other niter-bearing waters are extremely sharp, others very bitter, others finally mild and possessed of scarcely any corrosive power. See what we wrote at length on the power of niter-bearing waters in Book V of this work.

[Margin: The nature of niter sprung from the sea.]

Niter sprung from the sea in Egypt is beautifully explained by St. Jerome [D. Hieronymus] on that passage of Proverbs 25 [Prov. 25.20], where he aptly transfers the teaching "*Vinegar upon niter, he who sings songs to a wicked heart.*" "Niter," he says, "and the province of Nitria, where..."

[Margin: St. Jerome.]

where it is most accustomed to form, took its name; and it does not differ much from the variety called sal ammoniac [sal Ammoniacum]. For just as on the seashore the Sun's heat makes salt, hardening into rock the sea waters that a greater force of winds — or the seething of the sea itself — has cast onto the further parts of the shore: so in Nitria, where in summer the more prolonged rains soak the ground, and where the star's heat is so great that it concocts the very rainwaters, across the breadth of the sands, into a stone of salt — one most similar in appearance to salt or even ice, yet having nothing of icy cold nor of salty taste. Nevertheless, by the nature of salt, it is accustomed to endure in burning heat [in caumate] and to flow and liquefy in a misty atmosphere. The natives use it, where need arises, as a soap [pro lomento].

Hence sinful Judaea is told in Jeremiah [Jerem. 2.22]: "*Though you wash yourself with niter, and multiply for yourself the herb borith, you are stained in your iniquity, says the Lord.*" But quicklime crackles in water and indeed perishes, yet it renders the water fit for washing. Solomon, seeing this nature suited to his figure, says: "*Vinegar in niter, like one who sings songs to a most wicked heart*" [Proverbs 25.20]. For if vinegar is poured onto niter, it of course at once seethes and boils up; so too a perverse mind, when it is rebuked through reproof, or when good things are urged upon it through the sweetness of preaching, becomes

worse for the correction, and is thereby kindled into the iniquity of murmuring — when it ought to have been restrained from iniquity. So far St. Jerome, indeed wittily and elegantly.

CAPUT II.

On rock-niter [Salnitrum], the third variety of salt.

[Margin: The remarkable power of rock-niter.]

Niter — called by the Greeks λίτρον [Greek: litron] or ἀλίνιτρον [Greek: halinitron] — is distinguished from ordinary niter [Nitro ordinario] by this mark: that it is wonderfully full of wind [flatuosum], abounds in an enormous efficacy of spirits, and holds a middle nature between salt and niter. This they also call "the foam of niter" [nitri spumam], on the testimony of Albertus [Albertus Magnus], being of a more subtle substance and power than niter itself. Hence most meteorologists call this kind of niter the sole cause of the enormous commotions beneath the earth. Gunpowder [pulvis pyrius], with which rock-niter is mixed, proves this more than sufficiently by the great slaughter of mortals. And although we treated these matters at length in Book IV [*Quarto Libro*], here nevertheless we shall examine more exactly certain things omitted there, so that the marvelous power of this salt may become more and more evident.

For in it shines forth the distinguished dignity of Nature, and also some necessity for our use. For art is the attendant of Nature herself, and as it were her handmaid in her works. First, then, just like salt and niter, rock-niter too occurs native. As Baccius and Agricola [Georgius Agricola] write, a certain kind of earthy niter has recently been found among the Saxons, which whitens on the surface of the ground, sprinkled like flour, and which also runs riot in veins below; from this they make rock-niter.

[Margin: How rock-niter is made.]

Yet I myself do not believe this to be the genuine matter of saltpeter, but rather some rotted offshoot of bitumen — with which all Saxony especially abounds — or rather a kind of dung, such as Baccius writes he saw near the town of Fabriano, in the innermost cavern (which they call "the dark one"), beneath the Apennines, where, from myriads of owls roosting overnight, from their dung heaped up and aged there over many centuries, they gathered an inestimable treasure of saltpeter.

[Margin: From the excrement of bats and owls in a certain cavern near Fabriano, a great quantity of niter is extracted.]

I hear that there teems with such a kind of dung and fertility an immense cavern productive of saltpeter, one indeed extending very far, but rendered inaccessible by the multitude of bats — so much so that in flight they extinguish even lamps. And perhaps of this kind is that whitish and rotten matter among the Saxons, near the borders of Vulturena [?], where one crosses over to the Rhaeti [Rhaetians].

Moreover, it is worth the effort, because of the novelty of this product of saltpeter, and because its qualities have not yet been so thoroughly explored or written down, to investigate its nature — truly marvelous and paradoxical in some respects. Saltpeter is made today from a very sharp lye, which is strained off from such dung or aged excrement, or even from the rotted rubble of cemeteries and from earths deliberately rotted together — water being poured on repeatedly in wooden vessels. This same lye is then boiled in great cauldrons, and saltpeter forms with long fibers (like a kind of salt) congealing at the bottom of the vessel.

This is sharp to the taste at the first sensation, then extremely sharp, overturning the stomach and eroding the intestines. Its use is now all too well known in engines of war and in cannon [bombardis], by which the superstition of "thundering Jove" has now been made empty, and the warlike instruments of the ancients rendered ridiculous. For with the incomparable force and crash of this powder — flashing more than Jove, with more than giant-like daring — the savagery of this age dares not only to overcome the unconquered ramparts of cities, but even

[Margin: The astonishing power and efficacy of niter in gunpowder.]

to shatter the very metal-bearing mountains, to undermine them, and to open a road by sea and land. This is a marvelous effect of saltpeter; but more worthy of wonder still, and more difficult to scrutinize, is the fact that saltpeter produces such contrary effects with both water and fire. For in gunpowder, which is made from saltpeter with sulfur and added charcoal, at even the slightest approach of a spark it is ignited; and it does not so much burn of itself as it is suddenly diffused into a windy and violent spirit — these being the properties of the fire-bearing powder-mixture.

Yet it is remarkable that saltpeter shows a wholly contrary effect when cast into water. For as daily experience here at Rome teaches in summertime: when water

is poured into a glass flask, or saltpeter is placed within a basin filled with water, the water within a brief space of time takes on so great an increase of cold that the whole of it passes into ice, beyond every degree of coldness. Of this diversity...

the artful effect produced from lead furnishes us some path toward investigating the causes — the effect that Galen records in *On Simple Medicines* IX [Galenus, *de Simpl. med.* 9].

[Margin: Water agitated in a leaden vessel grows cold.]

For he asserts that cold water, agitated in a leaden vessel, becomes much colder in it; and likewise oil, wine, and any liquid whatever — which is of course to be attributed to the nature of lead, of a watery and earthy substance, cold and moist in the second degree. But since this miracle of saltpeter is greater than that by as much as its effect is more prodigious, I have thought it worthwhile to investigate diligently — with the care it deserves — just how it performs actions so contrary both with fire and with water, and to the extreme degree: so that with fire it becomes fire, but with water the coldest water.

Whoever has searched into Nature more deeply will discover that almost all things are endowed with contrary qualities. Thus the same thing can doubtless operate in diverse ways — as is clearly evident in the operations of simple medicines, with Galen too as authority. Moreover, one and the same thing does not have the same relation in acting and being acted upon toward one thing as it has toward another. For the action and reaction of each will occur, but differently — as with niter's action toward fire, and niter's action toward water. And in these three suppositions consists the whole reason for the diversity of saltpeter's effects, as Baccius rightly notes.

[Margin: The power and explanation of saltpeter.]

To explore this difficulty, let us bring forward some experiments with various substances, where the manifest cause is plain in oil [Experimenta].

[Margin: Experiments.]

In oil we observe a threefold diversity relevant to our purpose. Oil never mixes with water; better with wine; with lye it becomes one body — and that of a sharp and warm faculty — because of the conformity (or the disagreement) of substance that it has with the one and not with the other. But concerning lime [calx], the examples are more in tune with our subject, for lime is actually cold yet potentially wholly fire. Lime dissolves when water is poured on it, and boils up with the greatest fervor; but when oil is brought near or poured on, it does not

mix — indeed, if it is finally dissolved, it keeps its powers and is used by physicians together with oil as a caustic. But if lime is applied together with egg-white, you will see a sudden mutual gluing-together take place; for the lime so absorbs the whole egg-white into itself that it at once dries it.

[Margin: Why quicklime, mixed with egg-white, becomes so strong that it joins broken glass.]

And so it comes about that, if it is applied in the same instant of time, the glue applied to a shattered glass or earthenware vessel is found to be most tenacious. The cause of all these things must be referred both to the contrary qualities of the same thing, and to the dissimilarity and differing relation that the same thing has with one thing and with another in acting and being acted upon.

But to return to lime mixed with cold water: lime, poured on or placed under water, dissolves and grows so hot, because of the dissimilarity of substance, as Fracastorius [Girolamo Fracastoro] would have it.

[Margin: Why lime mixed with water grows hot.]

Add the manifest cause: because of the struggle that is stirred up between these two contraries, water and lime; or better, between the fiery parts of the lime and the cold parts of the water. For the water, growing hot from the fiery part of the lime, at once evaporates; the vapors, multiplied, expand, and by the impulse of the water following after, drive out the air they nearest touch. Thus part drives part, the air flies out most easily, the water succeeds into the pores, and everywhere through the smallest passages, lest a vacuum be given. Hence the water grows hot, and the lime grows hot too, its heat-producing quality being drawn from potency into act. The lime is dissolved, its particles being separated, as the water and the water's vapor penetrate the whole of it.

But lime is not stirred to any action and struggle with oil, because they have some communion with each other. Hence oil, since it is not vaporizable, easily unites with lime, keeps its qualities for it, and retains its viscosity in its own sharpness. But egg-white is itself viscous and not vaporizable; yet because of its cold and moist qualities, opposite to those of lime, when applied it makes the lime exhale. And since the egg-white does not succeed into the lime's pores — because egg-white does not evaporate — the lime suddenly immerses the whole of itself and incorporates the egg-white into itself, lest a vacuum be given; and in that very instant of time it also draws with it and glues together, in that strong union, the parts of the broken vessel.

By these examples the difficulty concerning the contrary faculties of saltpeter may now appear smaller.

[Margin: The power and operation of niter.]

First, indeed, saltpeter seems to belong to the class of salty things, whence it is easily dissolved in water — and of this there is no doubt. Further, from its effects so diverse with water and with fire, it is plainly evident that saltpeter passes over and dissolves into water simply; but it does not catch fire simply, rather by means of a kindling agent it carries with it — namely sulfur, which is a substance and power that is fiery — and by means of charcoal, which dries out the excessive moisture of the saltpeter and tempers the powder itself, so that it catches fire easily.

Therefore it must be granted that the substance of saltpeter consists of contrary parts: of very many watery and cold parts in act, whence the whole of it melts in water; and of parts that are by turns fiery, sharp, and oily — which it has drawn to itself from dung and its sharpness, and through which it is in potency to fire. According to this constitution of the nature of saltpeter, the explanation of those difficulties must be given.

[Margin: The explanation of so great a power, with the sulfur, and why in the cold it becomes coldest.]

First: how is it that saltpeter, when burning, produces so great a violence and vast onset? Then: why, when poured into water, does it chill it so suddenly — indeed, render it at once colder than if ice were poured in — which seems contradictory, since ice is the highest of cold things, and saltpeter consists of fiery parts?

To these difficulties, beyond saltpeter's natural disposition toward fire and toward water, in each case a certain violence intervenes, and in each case a maximum is understood. As to the first: the violence is incomparable, and first shines forth in lightning. It arises from the part of saltpeter's watery and cold substance, which is not naturally apt to burn, but, forced by the power of the overcoming fire, is suddenly turned and leaps out into a nature midway between water and fire — that is, into a blast [flatum]. Therefore in saltpeter violence occurs, but the effect is that of the whole powder together: for the sulfur seizes the fire, the fire in the saltpeter violently excites a blast, the blast urges and dilates the conflagration; the conflagration, because...

[Margin: The operation of gunpowder.]

because it is stirred up with force and suddenly makes its onset and crash; and at last too its ruin and destruction. To this, a threefold violence concurs: the first is the fire itself, the second the urgency of the blast, and the third the narrowness of the place. Whence the vehemence of the fire, finding no exit nor place where by its nature it might most widely dilate itself, turns its whole force against the obstacle, which it expels with so great an impulse of nature that it would shatter even metal-bearing mountains.

As to the second [difficulty]: saltpeter dissolves into water, for it is of a watery nature; it chills the water itself, because it is actually cold; and finally it chills more quickly and more strongly than ice, because of the violent *antiperistasis* [Greek: antiperistasis, the mutual reaction/concentration of opposed qualities] and the extinction of the warm parts by the surrounding water and the moisture predominant in it. This is the nature of saltpeter and of saltpeter-charged water.

COROLLARY [Consectarium].

[Margin: Earthquakes arise from the kindling of niter.]

Hence is made clear the reason and cause of earthquakes: namely, that the spirituous substance of niter, kindled in the subterranean passages, unable to bear the narrowness of the place, while it seeks a wider one, throws everything into confusion. Just as in mines [cuniculis], saltpeter-powder overturns the places laid above it with such violence that the very mountains seem to be hurled into the air — which could not happen without niter — and is clearly evident in the subterranean fires, which, never deprived of their fuel, always burn, and yet do not cause that earthquake. But as soon as the fire has entered some passage filled with niter, then indeed that, once kindled, with its untamed violence produces those great ruins which we read have occurred at various times and in diverse places, to the great terror of the mind. Whence it also follows that not cavernous places, but places lying above niter-bearing passages, are subject to earthquakes.

The true and physical cause of an earthquake, therefore, is the sudden kindling of saltpeter-bearing matter in the subterranean passages; which, all at once thinned out, seeking a roomier place for itself, when it cannot be contained by the narrowness of the place, bursts all obstacles and opens a way of escape for itself.

CAPUT III.

On the generation, nature, and powers of saltpeter.

From what precedes, so far as our feeble talent permitted, we have set out the operations of the niter-powder, together with the genuine causes of effects so great and so contrary — not so much in our own opinion as in that of the Peripatetics. But since the nature of niter was unfolded there only as regards a certain surface, here, lest so vast a secret of nature remain unexplained, we shall attempt to assign its genuine origin.

The elements, as we said in the second Book, are from the three chemical principles of things — which we asserted to correspond, κατὰ τὴν ἀναλογίαν [Greek: kata tēn analogian, "by analogy"], to our Salt, Mercury, and Sulfur. And Salt indeed gives consistency to all mixed bodies, Mercury the watery substance, the glue of bodies, and Sulfur the fiery activity; while air results from Mercury and Sulfur, a substance partly watery and partly fiery.

[Margin: The elements from which things are composed are not pure elements, but elemented [compounded].]

The very effect of moisture and dryness teaches us this: for we see that things are in one respect bounded, and in another respect not bounded by their proper limit. Therefore from sensation we have grasped that there is dryness and moisture in things, and that there is something composed of both. For dry flour does not glue two sheets of paper together unless it has first been subjected to moisture, nor can water without flour accomplish it in any way. Therefore moisture and dryness, just as they are the underlying subjects of all mixtures whatever, so too moisture and dryness exist as the passible qualities of those same things.

But since for the composition of a mixed body it is necessary that not only passive but also active qualities concur — for no thing lacks some active quality — it must be admitted that, besides the substance from which things have moisture and dryness, they also have a substance from which they are imbued with heat. For it is proper to cold to temper the excess of incoming heat, which is in some way the activity of cold; and that this is the doctrine of Aristotle himself is evident from *Meteorology* IV, text 13 [l. 4. *met. text.* 13].

[Margin: Moisture and dryness are passible qualities of the material; heat and cold are active.]

For since the Philosopher [Aristotle] notes that moisture and dryness, as passive and subjective qualities, properly belong to earth and water, he wisely inferred that all composites come to be from earth and water as from a subject — such as terrestrial and aquatic things, all of which have their birth either in earth or in waters, and are nourished in them. But to this material part he judged that an equal formal part must be added, which arises from heat tempered by cold — a part that is properly born from air and fire, or from the spirituous portion contained in them.

But since mixed bodies do not consist of bare qualities — namely moisture and dryness — as though from pure elements, but from bodies constituted by such moisture and dryness, the Philosopher rightly determines those bodies to which these composing qualities are attributed as the material subject.

[Margin: The opinion of Aristotle.]

Since, then, fire and earth are dry, while air and water are moist, he therefore properly attributes these passive qualities to earth and water. But why he made no mention here of fire and air — the reason is that elements of this kind, just as they are endowed with no corpulence and thickness, so they cannot, by themselves alone, concur to constitute a mixed body.

And from this doctrine of Aristotle I infer that by the name "earth" he by no means understood some physical body of the same species, individual (so to speak), nor by the name "air" some body of the same lowest similar species; but rather a certain principle, in his own manner...

[Margin: Aristotle understood "elements" abstractly, considered under a metaphysical aspect.]

to a mind accustomed to metaphysics, abstracted from all coarse and sluggish matter. Under this account — in which all coarse and solid bodies metaphysically agree — he meant Earth; then he meant by Water all those bodies that can be resolved into vapors, like watery ones; by Air the vaporous bodies endowed with a subtle fluidity; and by Fire those bodies constituted not of a vaporous but of a most subtle substance. Aristotle, I say, understood these under a certain abstract, metaphysical account. And since these accounts are found in all things, he rightly and acutely concluded that all composite bodies are made up of them.

[Margin: What he properly means by the elements.]

Yet he held that these bodies, both coarse and subtle, are a kind of aggregate and heap of utterly disparate things. That body which is called Earth, although it is

nothing other than the said heap of various things, is still called "earth" by virtue of the very fact that all mixed bodies are solid and consist of coarseness. By contrast, the element called air or fire is nothing other than a heap of vapors from the most diverse things — vapors that nevertheless all agree in this, that they are subtle, vaporous, exhalation-like bodies, and are therefore called by the common name "air" and "fire." You see, then, how Aristotle [Aristoteles] defined the accounts of the elements; and these agree beautifully with everything we have said above about the true element of Earth, Water, Air, and Fire.

For there lurks in the center of salt a certain spirituous substance which, just as it is present in all the species of mixed bodies, so it supplies to all of them their coarseness and proper consistency. This substance ought to be called the true, proper, and most immediate element of earth, of which the sensible salt is only the material substrate. In the center of the moist, by the same token, there lurks a certain mercurial and spirituous substance — the proper element of water, conferring fluidity on all bodies; and it is a kind of glue by which all things earthy and dry are bound together. Let the same judgment hold for the rest. I have thought it necessary to set down all this so that the nature of salt, niter, and saltpeter [salnitrum] might be more clearly explained.

And first of all it must be understood that artificial saltpeter, which is used today for gunpowder, is far superior to the native sort that effloresces from nitrous waters and earths. Hence people generally use the artificial kind, which (as I said above) is extracted from the stables of animals and old latrines, from the dung of hens and doves, and also from cemeteries, crypts, and the lurking-places of bats. The reason for this can escape no one who has come to know more deeply the powers that lie hidden under this excremental filth of refuse, urine, and dung.

[Margin: From what sources saltpeter is produced.]

For when this filth, by a kind of magnetic power, draws to itself whatever is nitrous that lurks within the entrails of animals, and these are then fermented for a long time within the nitrous earth, they acquire a power far greater — on account of the varied mixture of things now activated, and the bilious refuse mingled with them — than they would have in the native sort. In this way, strengthened by abundant supports, they gradually acquire that spirit and increase which they later display, joined to sulphur and charcoal, to the great consternation of mortals. For the more spirituous this saltpeter is, the greater the destructive effect it must be reckoned to produce.

[Margin: The natural composition of niter.]

Hence too, the saltpeter that is produced from the alluvial deposits of various things in subterranean burrows — partly from seawater and the influx of the other salts, partly from the native disposition of the place — once seized and kindled by inmost fires, is the cause of all the commotions and meteorological impressions, both in subterranean regions and above in the districts of the airy region; as was copiously demonstrated a little earlier, and above in Book IV [l. 4]. For the spirits of saltpeter, being most subtle, very easily transpire through the pores of the earth, and so, borne up into the air, they cause the effects of fiery impressions. Or, if they are not permitted to penetrate because of firm obstacles in the subterranean parts, then indeed they seek an exit for themselves by right and wrong alike — by the sole law of necessity — bursting the bars of the mountains.

[Margin: The wondrous power of niter.]

[Margin: Why saltpeter is more efficacious.]

Now, since saltpeter is endowed with such marvelous powers, it must now be seen how it differs from common salt, and what each is composed of. Common salt, produced from the viscous moisture of water and air, is nothing other than the earthy part of that viscous moisture, which is hardened by heat and dried into salt. But the fiery or sulphurous part that is in that viscous moisture of air and water is changed into niter, just as the earthy and watery part in it is changed into salt. Saltpeter, however, is the purer and more refined part of niter. From this it is clear that salt and niter differ chiefly in this: that niter has obtained in its composition more sulphur and mercury — that is, more fire and air — than salt, which has obtained in its composition more water and earth.

[Margin: How it differs from common salt.]

In salt, indeed, fire and air are hidden, while water and earth are manifest; in niter it is the reverse. Hence common salt by no means takes fire and flames up as niter does, because the earth and water of which salt consists impede ignition, and consequently cannot produce those violent effects of saltpeter. For what is fiery in salt — once moisture has been added, as also in niter — by this means both penetrate and dissolve all hard bodies; and provided these putrefy, they resolve them into prime matter, namely a salt similar to themselves, from which they took their origin. From this, marvels are accomplished in the Art of Chemistry, provided that pure, unalloyed moisture be perfectly and absolutely fixed — endowed with infinite virtues for routing diseases, which will be set forth more fully in the Eighth Book.

For just as niter can be called congealed water, so too it can be called congealed fire, inasmuch as in its inmost center and the bedchamber of nature it holds enclosed the treasure of all nature and the fire of life. If anyone could fix this with such skillful success of the art, and imbue it with a golden or silver tincture, then [he would possess] that supreme and inestimable secret...

[inestimable secret] which has already for whole ages been sought after by the entire school of Philosophers — I have no doubt that he would possess it. But since we have deferred these matters to another place, here we have thought only to expound its nature.

COROLLARY [CONSECTARIUM]

From these things the wonderful nature and property of saltpeter is evident. For the most part it contains three substances when not yet purified — namely alum, crackling salt, and essential niter — which are found from its distillation. The alum, indeed, is calcined with a certain heat and effervescence; the pure niter is inflamed and consumed; the salt crackles and leaps out. Taste too confirms this — aluminous, salty, nitrous. There are present in it spirits, partly cold and partly fiery; and there is also a certain wateriness mixed with fatness. From these depend the marvelous effects and properties of saltpeter. For from the diversity of elements and opposing qualities, nothing but marvels can come forth: it is born in the earth, stabled in the waters, snatches fire with a kind of Promethean cunning; into the air it spits out reeking smoke and bubbles up with wateriness; dissolved in water, it introduces intense cold; its hooflike substance, when squeezed in the hand, mostly springs apart with a crackling. It abounds in so great a supply of airy and fiery spirits that even from a small mass it breathes out an incredible quantity of exhalations, as will be seen in what follows. Imparted to natural waters, it purges, cuts, penetrates, cleanses, clears obstructions, moves and drives out the sandy substance of the kidneys and bladder. When it is distilled or sublimed, it usually feels an excess of heat and shatters the vessels; but when handled with skill, it belches out an exhalation of marvelous heat.

[Margin: The powers of niter.]

Its most potent power lies in the strong waters [aquae fortes]. From these arise solvents most apt for purging the nobler metals and for boiling down ores — a great indication of how much resolving and cleansing capacity they possess. There is no mine of mixed minerals or metallic vein that it does not (by some innate ambition of its own, I know not what) ally itself with; among the rest, it not only grows beside salt, alum, sal ammoniac, and the other salts as though most

closely akin to them, but even fills them with its own riches. Hence it is of immense use in that great masterwork of the Chemists, especially in nitrous vitriol, in which sulphur and mercury obtain equal portions of the proportion. Its fertility is evident even from this: from earths subject to its natural jurisdiction, however much you take away, you will find that after some years they have flowered again anew. Indeed, if anyone soaks and irrigates with water earths fertile with its seeds, or walls, within a short space of time you will see them sprout up again into their nitrous shoots and flowers. But let us confirm these things by experiment.

Experiment for forcing niter into flowers [Experimentum Nitrum in Flores cogendi]

[Margin: Experiment.]

Let a wooden, earthenware, or even iron tube be made, pierced with several holes, and let it be filled with tartar, quicklime, and salt — or even the urine of a wine-drinker — combined into a single mixture. When this mass has been hardened by three days' sun, let it be transferred together with the tube into a damp cellar; and not without wonder you will discover that in time the flowers of saltpeter sprout from the said mass like snowy flakes — indeed sometimes with such force that, if you allow some juices of nitrous herbs to stand for a long time in a closed glass vessel, then the niter present in them, now fermented and pregnant with spirit, burning with an immense desire to propagate and unable to be contained in a closed place, will pierce even the glass itself with its acridity, so that, with the obstacles removed, it may more freely propagate itself. See an experiment of this, truly remarkable, recorded in the preceding Books, which I remember having seen with my own eyes, confirmed by a physician of Montpellier [Montispolitanus].

CHAPTER IV [CAPUT IV]

On the manner and method of making nitrous gunpowder, and its various uses in the pyrobolic art [De Nitrosi pulveris pyrii conficiendi modo & ratione, ejusque variis in Arte pyrobolica usibus]

The manner of making gunpowder — as Chrascovitz [?] hands down in his work *On the Art of War* [*de Arte Polemia*] — is known not only to those who study pyrotechnics and to others who have made a profession of working at it, but very many also who are accustomed to handle smaller firearms and portable or hand-held guns; indeed not a few of the country folk are able to make it with their own

hands, without employing any artificial machines or instruments. "For we have seen," says the said author, "very many inhabitants of Podolia and Ukraine, whom we call Cossacks [Kozakos], preparing gunpowder in a way quite unlike the common method."

[Margin: The various preparations of gunpowder.]

That is, they put in certain portions of niter, sulphur, and charcoal, each its own (the proportions and preparations of these, namely of one material to another, they have learned from practice alone), into an earthenware pot; and after fresh water has been poured over it, they boil it thoroughly over a slow fire for the space of two or three hours, until some part evaporates and the material becomes thicker and denser. Afterward, having extracted this from the pot and dried it a little in the sun or in a warm stove-room, they pass it through a hair sieve and reduce it into the finest grains. Others, however, in a little earthenware crucible or basin, or upon a flat polished stone...

and polished [stone], grind and incorporate most finely the material intended for making gunpowder, and finally, having moistened it, work it into grains. We therefore think it superfluous to say much more on the matter and to describe the order and sequence usually observed in the preparation; it will suffice in this chapter to have set forth some mixtures, the best and most tried, for making the threefold powder.

Mixtures of powder for the larger cannon [Mixturae pulveris ad Tormenta majora]

	First Method	Second Method
Saltpeter [Salis nitri]	100 lbs	100 lbs
Sulphur [Sulphuris]	25 lbs	20 lbs
Charcoal [Carbonum]	25 lbs	24 lbs

Mixtures of powder for the larger firearms, commonly called muskets [Mixturae pulveris ad sclopeta majora, vulgò Musquetas]

	First Method	Second Method
Saltpeter	100 lbs	100 lbs
Sulphur	18 lbs	15 lbs
Charcoal	20 lbs	18 lbs

Mixtures of powder for the smaller firearms, commonly called pistols, and the like
[Mixturae pulveris ad sclopeta minora, vulgò Pistolas, & alia]

	First Method	Second Method
Saltpeter	100 lbs	100 lbs
Sulphur	12 lbs	10 lbs
Charcoal	15 lbs	8 lbs

The mixtures of powder for the larger cannon and firearms can, during the cooking, be moistened and sprinkled either with plain water alone, or with vinegar, or with urine, or with wine. But if for the smaller firearms we desire a stronger and more vigorous powder, let the two upper mixtures be sprinkled rather often with the following liquid — or with water distilled by chemical apparatus from the rinds of oranges and citrons, or of fresh lemons — and let them be cooked for 24 hours, and finally reduced into the finest grains.

[Margin: The composition of the liquid.]

The liquid is composed of: 20 measures of burnt wine [i.e. brandy]; 12 measures of spirit of vinegar distilled from white wine; 4 measures of spirit of niter; 2 measures of simple water from sal ammoniac; one measure of camphor — subdued [dissolved] in burnt wine, or pulverized with ground sulphur, or finally rendered into an oil with oil of sweet almonds. The figure of the rotary mill for forming gunpowder, among the machines and various instruments customarily kept in arsenals, we shall give in the Last Book.

[Margin: Why granulated powder is more powerful than that reduced to fine flour.]

It is a marvel in gunpowder that, granulated, it has more power and effect than when reduced to fine dust — the reason for which we gave above. For granulated powder contains more action and spirits than when reduced to fine dust, in which the dissipated spirits fly off; as indeed experience teaches in war-cannon: if, by the rammer of the cannon, it is so compressed and packed down that it loses its grains and is pulverized, the powder likewise loses the force of ejecting the ball that it would have had if it had been moderately compressed, so that it scarcely ever drives the ball out of the cannon's mouth. The same thing happens to it that happens to moistened powder, which, stripped of all its expelling power, burns up very feebly when ignited with fire; and if it has been stored in a war-machine, with fire put in through the touch-hole, it does not expel the ball, but

bursting out through the open opening of that touch-hole it does not cease to burn until the whole is consumed.

This is true in metals as well: for the more solid they are, the harder they catch fire, whereas we see that spongy or less solid ones grow hot very quickly, because they are rare and porous, and through the pores, which are full of air, they readily admit fire into their interior. The same holds in gunpowder, which, besides the reasons mentioned above, has these joined to them: that if it is condensed in such a way that the fire's rays, slipping in through the touch-hole of the war-machine, cannot penetrate its compacted body — because no empty spaces through which they might be carried have been left between the grains of powder — they certainly cannot ignite in a moment the whole powder (in which all its other force resides), and so the fire consumes the powder only by parts, since it has found material most apt for this, and is not extinguished so long as that material lasts, or is violently smothered.

Something similar to this also happens in powder which, scattered variously and not collected into one body, is ignited: there the essential force of the powder — or rather of the fire in the powder — is not indeed diluted; but the action, on account of the suffocation and packing-together of its parts, cannot obtain its effect. The practice of pyrotechnics is proof of this truth, and the reason adduced above will to some degree serve the question of why granulated powder is stronger than its flour; since in a grain of saltpeter its enclosed spirits, and the virtue united together with the sulphur and charcoal, seem more concentrated, but in the flour of compacted powder they do not. To this must also be added that if a war-cannon of a longer barrel be filled — I do not say with powder reduced to flour, but even granulated — right up to the mouth, and fire be put into the powder not through the touch-hole but through the mouth of the cannon, it will do no harm whatever to the cannon, since it acts upon the powder by parts and, being unable to ignite the whole powder in a moment, operates as it were from the upper to the lower portions, which is most discordant with its nature; or, what is more proper, it is bound by no prisons and tied by no fetters of a narrow place, nor does it have any obstacles which it must remove and break in seeking liberty, but has an open exit at the mouth of the machine.

[Margin: Experiment of granulated powder and of flour.]

[Margin: Experiment of granulated powder.]

[Margin: That gunpowder of larger grains can be more powerful than that of smaller grains.]

We think this too is not to be passed over in silence: that it is the opinion of the less experienced that gunpowder which has larger grains is more potent and vigorous, which indeed at first glance seems plausible, for the reason adduced by us above — namely, that in one larger grain more saltpeter adheres to the charcoal and sulphur. And on the other side it is false; because larger grains are resolved into fire more slowly than smaller ones, and pyrotechnical practice teaches that powder reduced into the finest grains is much more vigorous and stronger — both because smaller grains are more easily consumed, and because there (which is the crux of the matter) a greater quantity of saltpeter is mixed with the charcoal and sulphur, since powder of this sort is usually prepared only for smaller firearms and hand-held guns, whereas for the larger war-cannon it is made far slacker and less carefully worked. And since the larger cannon take a greater quantity of powder than hand-held guns, that cannon-powder also requires larger grains, so that the rays of fire may glide all the more quickly through the larger empty spaces between the larger grains of powder, and resolve all the powder into flame in one instant.

Experiments on the goodness of saltpeter [Experimenta bonitatis Salisnitri]

Let some saltpeter be placed upon a clean and polished wooden table, and let it be kindled with a burning coal, and let the following be noted.

First. If it makes a noise such as we see in common salt when it is thrown upon glowing embers, it will be a sign that it abounds greatly in salt of this kind.

[Margin: If it makes a noise on the embers, it abounds in salt.]

Second. If it makes a fat and dense foam, a sign of fatness will be obtained.

[Margin: It is reckoned fatty if it makes foam.]

If, after the burning-off of all the salt, certain unclean dregs remain, it is an infallible mark that salt of this kind contains much earthy material; and the greater the quantity of those dregs, the greater also the quantity of that material in the salt, and accordingly it will be judged much less well-purged and much less potent.

[Margin: Earthy, if it leaves dregs behind.]

But if it makes a clear, long flame, parted into many rays, while the bottom of the table remains clean, and it burns in the manner of pure charcoal without any

foam and without a horrid or unsuitable crackling, one may take it as a conjecture that the salt of niter is well purged and perfect.

Some hold that it is an infallible trace of the goodness of saltpeter if, after the second clarification performed in the customary way, no more than four pounds are wanting per hundred pounds; but if it should be clarified a second time over again, four pounds, as before, will likewise have to be lacking.

From these things it is evident that powder is the better the greater the diligence with which it has been purged, and that it has the greater force the purer the niter with which it is furnished. Hence commanders of sieges [πυροβολίας — Greek: pyrobolías, "the firing of artillery"], with 50 pounds of better powder, drive the balls of a single cannon or mortar much farther than with 50 pounds of weaker powder. As to the precise distance to which the several differences of powder hurl their balls, see the skilled masters of poliorcetics [the art of siege] and the artillerists [pyroboliftae], who exhibit differences of this sort set out in tables.

EXPERIMENTS on silent powder [EXPERIMENTA De pulvere muto]

Since that noise of cannon arises only from the spirituous substance of saltpeter, let us disclose how powder may be made without noise; and although many have written much about this powder, we shall here set down only a few of the most approved mixtures, gathered from various trustworthy authors.

First Method [Modus primus]. Of common gunpowder, 2 pounds; of Venetian borax [Boracis Venetae], one pound — ground and well incorporated, let the whole material be granulated.

Second Method [Modus secundus]. Of common powder, 6 pounds; of Venetian borax, one pound; of calamine stone [lapis calaminaris], 3 pounds; of sal ammoniac, 3 pounds — let granulated powder be made, as above.

Third Method [Modus tertius]. Of common powder, 6 pounds; of powder from a live mole calcined in a glazed earthenware pot [pulvis ex talpa viva], 3 pounds; of Venetian borax, 3 pounds.

Fourth Method [Modus quartus]. Of saltpeter, 6 pounds; of sulphur, 1½ pounds; of powder from the inner bark of elder [cortex secundus sambuci], 3 pounds; of burnt common salt, 2 pounds — let granulated powder be made in the customary way.

It must be noted, however, in this place, that powder of this sort does not have so great a force in discharging balls as nitrous powder. The reason is that the principal cause of its violence is lacking — namely the spirit present in the niter, which, unable to be contained within the narrowness of the place, so as to obtain an exit, pursues (with all obstacles driven off) that efficacy which we marvel at, with liberty. And so, in powder deprived of niter, the war-cannon is so feeble in its explosion that it scarcely hurls the ball resisting it out to a few paces.

EXPERIMENTS on imbuing gunpowder with various colors [EXPERIMENTA De pulvere pyrio variis coloribus imbuendo]

All the blackness of common gunpowder results from the black color of the charcoal. It is possible, however, to tint it with another color too, if in place of the charcoal one uses either rotten wood, or white paper first moistened and afterward dried in a hot oven and ground into powder, or some other similar thing that readily catches fire and...

and combustible, as will become clear in what follows. Let the powder be made, and let various colors be added. In this chapter, therefore, I shall set out several mixtures, wonderfully suited to imbuing powders with various colors.

WHITE POWDER

made as follows.

EXPERIMENT I.

Take 6 pounds of saltpeter, 1 pound of sulphur, 1 pound of dried elder-pith [medulla sambuci].

EXPERIMENT II.

Take 10 pounds of saltpeter, 1 pound of sulphur, 1 pound of bark or of the woody part of crushed hemp [canabis]. Proceed as prescribed above, and you will have what you seek.

EXPERIMENT III.

Take 6 pounds of saltpeter, 1 pound of sulphur, 2 ounces [℥ ij] of tartar calcined to whiteness and then boiled in common water in an unglazed pot until all the water has evaporated.

The reason for all of these is that saltpeter and the charcoal [carbones] dissolved into a white ash cannot be blackened by a single pound of sulphur, and so the powder appears to whiten.

RUDDY POWDER [PULVIS RUBICUNDUS]

EXPERIMENT I.

Take 6 pounds of saltpeter, 1 pound of sulphur, 2 pounds of amber [ambra], 1 pound of red sandalwood [sandalum rubrum].

EXPERIMENT II.

Take 8 pounds of saltpeter, 1 pound of sulphur, dried paper [papyrus] ground to powder and boiled in water of cinnabar or of brazilwood [lignum Brasilianum], and again dried, 1 pound.

The reason is that saltpeter, when imbued with things of a red color together with burnt sulphur, is easily tinged, and so both the powder and the smoke take on a ruddy hue.

YELLOW POWDER [PULVIS LUTEUS]

EXPERIMENT.

Take 8 pounds of saltpeter, 1 pound of sulphur, one pound of wild saffron [crocus sylvestris] first boiled in burnt wine [vinum adustum, i.e. distilled spirit], then thoroughly dried and pulverized. The reason is the same as above.

GREEN POWDER [PULVIS VIRIDIS]

EXPERIMENT.

Take 10 pounds of saltpeter, 1 pound of sulphur, rotten wood [lignum putridum] boiled with verdigris [aerugo aeris] and aqua vitae, then dried, 2 pounds.

BLUE POWDER [PULVIS CAERULEUS]

EXPERIMENT.

Take 8 pounds of saltpeter, 1 pound of sulphur, sawdust of lindenwood [scobis ex ligno tiliae] boiled with indigo [indacum] and burnt wine, then dried and pulverized, 1 pound. Proceed as above, and you will have what you seek.

SECTIO III

DE ALUMINE — ON ALUM

The Third Species of Salt

CAPUT I

On the Name, Definition, and Variety of Alum

After the species of common salt and of niter, we now proceed to the third species of salt: alum. It seems to have taken its name from the Greek word ἄλς [Greek: hál's, "salt"], because in taste and color it resembles salt, and is in fact nothing other than a brine [salfugo] coalesced from water, stones, and aluminous mud, which afterward, ripened by exposure to the sun, and at last by various boilings and dilutions, is condensed into alum. And just as common salt stands in relation to niter, so does alum stand in relation to vitriol — both being for the most part generated from pyrite [pyrites]. [Margin: As common salt is to niter, so alum is to vitriol.] There is scarcely a province in which alum does not either bloom forth of its own accord or get dug out of the ground.

Its species are numerous, but among the mineralogists there is great dispute and controversy over them. For my part, following Brasavola [Antonio Musa Brasavola] and other experts in mineral matters, I reduce all the species of alum to five headings. Thus one is rock alum [alumen rupeum], commonly called *alume di rocca*; another is what they call sugar-alum [alumen Zuccarium], from its conical shape, like sugar molded into cones; another is feather alum [alumen Plumae]; and another is *Scajola* alum. To these some add a fifth species, which they call dish-alum [alumen Catinum]; others divide them into still other species, which nonetheless differ not so much in substance as merely in name. For what they call *Schiston* [Greek: σχιστόν, "split, cleavable"], we call *Scajola* alum; what they call *Trichitis* [Greek: τριχίτις, "hair-like"], we call feather alum; and what, finally, they call *Strongylen* [Greek: στρογγύλην, "rounded"], we call rock alum. But lest we waste time in expounding the names, let us pass on to the matter itself and to the specific differences of each.

to be unraveled, let us now turn our attention. Most of those who suppose that rock alum is the same as what is called liquid alum [alumen liquidum] are deluded. For what they mean by "liquid" can scarcely be conceived in the mind, unless perhaps they understand alum diluted and dissolved in water — though

that is in fact said to be free, since no alum exists unless it has first been purified by water. Of the method of proceeding we shall speak later.

Authors also contend not a little with one another in settling the difference between dish-alum [alumen Catini] and alkali [alchali]. We assert that these are one and the same thing, differing only in name. For we say that alkali is nothing other than that juice which they press out of the plant the Arabs call *Hali* — so called because, when it has been put into the dish [Catinum], it trickles within it and then is thickened into alum, and so is called dish-alum; and this is very closely akin to glass.

A greater difficulty lies in determining the difference between feather alum [alumen Plumae] and amiant [amiantus], the stone they call asbestos [asbestos]. [Margin: The difference between feather alum and amiant.] Certainly these cannot be said to be one and the same thing, though it is well established that, from the great similarity of the one to the other, several authors have taken them for a single thing. For if we rightly weigh the qualities of each, we shall find a great difference between them: since feather alum catches fire and, when thrown into the fire, is easily consumed, while in water it dissolves — which by no means happens in incombustible amiant, that is, asbestos, from which it even got its name. But since we are to speak at length of asbestos and its marvels in its proper place, we have not wished to be lengthier here.

Nor do we say that *Scajola* alum is the same as *Astrofamium* or talc, as many inexperienced in these matters suppose. For burnt *Scajola* alum passes into a gypseous lime, of which only the most translucent part is genuine — which cannot be said of talc; for how difficult it is to reduce talc into lime, only those know who have hitherto sought its oil with such labors and expenses, equipped with both oil and effort. Moreover, experience teaches that *Scajola* alum, translucent with a glassy clarity, was born from gypsum; for when it is thrown into the fire or set upon glowing plates, the appearance of its former clarity is at once destroyed, and it whitens after the manner of gypsum and takes on the genuine look of it — which does not happen with talc unless it is roasted for a long time in the most intense furnace-fire. But leaving aside species of alum of this kind, let us proceed to expound that alum which is everywhere in great use among all.

CAPUT II

On the Nature, Quality, and Preparation of Alum

If all the kinds of alum are rightly weighed, no one but a person inexperienced in these matters could deny that every kind of alum gives off a dull heat — like calcanthum [calcanthum, copperas], chalcitis, and misy [misy], which, although strongly astringent, do not so much cool as warm in the highest degree. Their corrosive power, which consumes even iron itself, demonstrates this more than sufficiently — a power that they certainly do not derive from the primary qualities, but from a specific virtue implanted in them, as will be plainly shown in due course, when we treat of the strong waters [aquae fortes].

All the species of alum, therefore, by their nature warm, cleanse, and bind. Hence not inappropriately the Greeks call alum *στυπτηρία* [Greek: *styptēria*, "alum, astringent"], from *στυφω* [Greek: *stýphō*, "to be astringent, to contract"], which means to bind. But as to the view of some that all astringents are cold, they wander, as the saying goes, the whole sky away from the truth. For most astringents, being compacted by the force of heat, thereby possess the greatest burning power — as was said of calcanthum, gypsum, and the rest.

[Margin: The difference of alum from salt.] They are distinguished from the other salts by a proper and specific virtue, which alum drew from sulphur, the saline clod of earth being mingled with it. And so, according to the nature of the place, by the various combinations of the mixture of salts, in one place common salt is produced, in another niter and saltpeter from the urine of animals, and in another, finally, alum is produced — whether from dung and earths, or from stones such as pyrite, packed with sulphureous corpuscles — and they hold their virtue contained in their inmost center. From this arise the marvelous operations in chemistry, which we shall unfold in due course.

Now let us proceed to the method of extracting it from the rocks, of macerating, boiling, and congealing it. [Margin: The process of drawing out alum from calcined rocks, according to the author's own observation at Tolfa.] Certainly, when in the year 1639 I was staying at Tolfa — where, in the opinion of many, the best alum in all Europe is dug out, which they call rock alum, commonly *aluae di rocca* [recte: *alume di rocca*] — I held nothing more important than to observe, with all the diligence that can and ought to be applied, the whole sequence of the matter in its preparation there, and, having observed it, to make it public here, as in its proper place, for the common good.

The territory of Tolfa lies at a distance of ten miles from the port of Civitavecchia [Centumcellae], on the Tyrrhenian Sea, full of rocky mountains. The rocks of the mountains are seen now white, now somewhat reddish, and now bending from yellow into a sky-blue color.

[Margin: The origin of the Tolfa alum-works.] In the time of Pius II this was discovered by the following event. A nobleman of Tolfa, having bought a slave well trained over a long time in Asia in the making of alum, — one day, when this slave was examining the quality of the rocks more closely and recognized that they were full of the juice of the most excellent alum, not being unaware of how great a profit could be drawn from this, is said to have addressed his master thus: "If you will grant me my freedom, my lord, I will show you the means by which you may make yourself happy with such an abundance of riches that you may [recover?] your whole treasure." Astonished at this, when the master asked what he meant by these words, the slave replied that he had discovered an exceedingly rich vein of alum, and that this was the treasure he had promised, by which, as long as he lived, his master would be made blessed.

The master, spurred on with great eagerness, earnestly charged him to make some trial of the thing promised — which the slave did. For drawing the most noble alum from a few stones according to the rules of his art, and thereby stirred in a wonderful way to undertake something greater, he was the first of all to found alum-works, with such profit indeed that all Europe enjoys it to this very day. Today it is leased out by the Apostolic Chamber at a revenue of sixty thousand scudi.

Having premised these things, we shall now describe in detailed account the method by which this alum is prepared — a method I observed with my own eyes and with the utmost diligence.

This celebrated rock alum, commonly *alume di rocca*, is made from a certain very hard rock, of which the cliff-like mountains of this Tolfa territory are composed. [Margin: The manner of preparing the alum in the Tolfa territory.] They are of two kinds: one harder and tending toward redness; the other softer and inclining to whiteness. The latter, when duly prepared, gleams translucent like crystal; the former, though more sordid, has nonetheless a greater sharpness. The white kind is held in great esteem among the dyers of silken threads and of the finer wools and fleeces to be tinged with scarlet [coccineus] color, inasmuch as it is endowed with a milder sharpness and renders the fleeces more brilliant. Having premised these things, they proceed to the work as follows.

First. The alum quarrymen [*aluminarii rupicidae*], not in vaulted tunnels but on the rocky flanks of the mountain, open to the sky on every side, with a vast multitude of diggers continually staying there, partly with pointed mattocks tempered from the strongest steel, partly with very sharp wedges and huge mallets, split the stony wall, break the split rock, and crush it into small pieces — in exactly the manner in which they are accustomed to proceed in the quarries of stones and marbles from which great buildings are constructed. The broken and reduced rocks are carried into furnaces not unlike lime-kilns, where they are burned with the strongest fire for a space of 12 or at most 14 hours; for if they were burned longer, they would incur no small danger from the loss of the alum, which would vanish under the more prolonged fire.

Second. After the rocks have cooled, they bring the cooked material in carts onto very broad floors, and, exposing it to the sun, arrange it in conical heaps.

Third. These arranged heaps they drench with cold water four times each day, by means of buckets suitably fitted for this purpose, until the thoroughly burnt material of the stones is so softened by the long affusion of water that it is reduced into a kind of earth, damp with moisture, not unlike potter's clay [*argilla*]. ...until it is changed into something not unlike it; which first happens only when, over the space of a month and more, it has been irrigated by the repeated daily affusion of water.

Fourth. This material, now reduced to lime, they convey to huge cauldrons, into which, set within a furnace, they lead water through channels; and, having kindled the furnace-fire, they let it boil. When they find this to be so, they cast the aluminous material — now reduced to lime — into the cauldrons of boiling water. On either side stand two very robust youths, who with wooden implements not unlike oars continually mix the material thrown in with the boiling water, until the alum-material has imbibed and incorporated into itself all the water. But when they find by taste that all the water is now imbued with alum, then they let it rest, until the earthy sediment settles to the bottom.

Fifth. This done, the warm water now imbued with alum is drawn off, extracted through channels prepared for this purpose, into certain pitchers, or into certain receptacles made of oak or holm-oak wood (for vessels made of other woods are not so suitable). When in these, in the course of several days, the conveyed water has settled, the alum adheres to the oaken sides of the vessels, and, four or five fingers thick, with adamantine points and the utmost variety of polygonal figures, translucent like crystal, presents a most delightful spectacle to the beholders. The remainder of the lye [*lixivium*], being now purged of its earthy dregs, is again

poured into the cauldrons for a fresh cooking of alum, the sediment and dreggy water remaining at the bottom being let off through a tap.

Sixth. The bottom of the receptacle having been duly cleaned with brooms, they tear away with certain iron implements the alum that has accreted to the sides of the vessels; and the torn-off alum they throw into wicker baskets and wash in a nearby channel of water, the baskets being plunged into the water. The washed alum they take out, heap up, and place in a storehouse; and then, transported to Civitavecchia, they sell it to the merchants. And this is the method of preparing rock alum, which, because I saw it with my own eyes, I have thought fit to set down here as the genuine practice.

[Margin: The marvels that can occur in the condensation of alum.] Here too I observed a thing worthy of admiration: that that oaken wood possesses this virtue, that — since it is itself filled with a nitrous juice — by a kind of magnetism, as it were, it draws to itself the aluminous material akin to it. Hence, if anyone fashions out of such wood any figure or character whatever — such as crosses, stars, the name JESUS and MARY, and the like — and leaves it in such lye until the appointed day, he will find, in place of the wooden figure, a most beautiful crystalline one, distinguished by a marvelous variety of angles. And this is the method of making rock alum in the Tolfa territory — a method the most beautiful and most expeditious of all, as the excellence of the alum made there abundantly demonstrates.

I am aware that several other authors hand down many other methods of making it, and that the rationale for it is neither simple nor of a single kind. For some extract condensed alum from boiled-down aluminous water, as we taught above concerning salt and niter. Others extract it from an aluminous solution drawn from earth or rock of this kind, or from pyrite, or from some other mixed substance. Agricola [Georgius Agricola], in Book 12 of *De Re Metallica*, prescribes a somewhat more laborious method, which let the reader consult.

[Margin: How alum is extracted from pyrite.] Moreover, they extract alum from pyrite in this way. First, they expose pieces of the pyrite in an open place to the air for several months, so that they soften; then, thrown into vats, they are dissolved; and the dissolved material, poured out into rectangular leaden cauldrons, is boiled until it is condensed into alum. As for the method by which the gold, silver, and the other metals that aluminous pyrite generally holds joined to itself are separated, it will be disclosed in its proper place.

CAPUT III

On the Medicinal Powers and Other Uses of Alum

Since alum excels the rest by its notable power of binding, cleansing, drying, heating, and hardening, it can easily be gathered from this that its use is most opportune in the curing of infirmities. Hence, according to the traditions of Galen, Hippocrates, Brasavola, and other physicians:

- It removes roughness of the eyes.
- It checks itching of the body.
- It stops a complete flow of blood, applied externally.
- It stanches fluxes of blood, mixed with fat and applied.
- It restrains the putrefaction of wounds.
- It heals the eruptions of the dropsical.
- It corrects ailments of the ears, with the juice of boiled pomegranate.
- It cures phagedaenic ulcers [phagadaenae], with vinegar, or with an equal weight of burnt gall-nut.
- It draws off leprous humor, with the juice of pot-herbs.
- It removes impetigo, lichens [lerides, i.e. lichenes], and scurf.
- For burns, it helps, with whey and pitch.
- For the dysenteric, a clyster mixed with alum is beneficial.
- It restores a fallen uvula and tonsil.
- It wears away those things that overspread the clarity of the eyes.
- It eats away an excrescence of flesh.

Furthermore, it offers great use to dyers and fullers, who, for dyeing cloths and silks, cannot do without alum. Goldsmiths cleanse gold with it, and lay on its gilding-leaf [bracteae]. Tanners [coriarii] dye hides with it. Booksellers and printers, by first dipping their papers in waters in which alum has been dissolved, render them so firm and strong that they do not allow the ink to run at all.

[Margin: Water mixed with vitriol and alum tinges iron with the color of copper.] Aluminous water mixed with vitriolous water, says Agricola, gives to iron and to the other white metals the color of copper, and to copper and gold a splendid golden color. Witnesses to this experiment are the hot waters in Bohemia, at the castle named "New House," *Neuhaus*. For the silver rings of those who use that bath, through the frequent use of the vitriolous-aluminous water, in time are

eaten away piece by piece in an open spot; then they are exposed to the air for some months, so that they soften; then, cast into casks, they are dissolved; and the dissolved material, poured out into rectangular leaden cauldrons, the material is boiled until it is condensed into alum.

They take on the color of copper, while gold ones become even more illustrious and brilliant; and they also have the greatest power in hardening iron, as will be said in its proper place. But as to the method by which gold, silver, and the rest may be separated from aluminous pyrite, it will be opened up in its proper place.

Curious Experiments Discovered by Means of Alum

EXPERIMENT I.

To adorn a whole altar with crystalline furnishings.

[Margin: Experiment I.] **First.** From aluminous stones, first macerated by exposure to the sun and frequent sprinkling, as was said above, and reduced to lime, let them be boiled in a cauldron with continual agitation applied. Then let the cooked material be poured into vessels or receptacles made of oaken wood, and you will have a prepared lye [lixivium], by which you may reduce things of every kind into a crystalline substance, in this way.

First, let there be made of oaken wood a cross and candelabra, turned on a lathe from oaken or holm-oak wood, which, hung on an iron wire and submerged within the lye, you allow to stand for several days. As the water fails, in place of the wooden cross or candelabra you will find a crystalline cross and candelabra, clothed in a marvelous variety of polygons after the manner of diamonds, with no trace of the wood appearing.

Images are made by this art: let there be made of oaken wood a mold of any image whatever, closed with its own lid, in such a way that the lye may obtain access to the inner cavity through a small hole — in exactly the same manner as is usually done in the molds of fusible metals. And the aluminous lye, let into the cavity of the mold, will there fill up all the recesses of the image, condensed into alum; for which reason that copy afterward, being constrained by the narrowness of the place, cannot extend itself elsewhere than to the cavity. When the form of the mold is opened, you will find it wholly crystalline, as if carved with a chisel.

In this way the alum-workers of Tolfa are accustomed to adorn their altars, as I remember having seen with great delight of my mind. How much virtue alum

has, moreover, for inscribing letters by the art of steganography, the following experiment will teach.

[Margin: Experiment 2.]

EXPERIMENT II

Take alum purified of all dregs, grind it to a powder, place it on a small dish, and pour spring water over it. Stir the mixture until it takes on some body. This done, take a fresh pen and on white paper write whatever you wish to keep hidden; let it set until what you have written has dried. Then send the white paper to a correspondent friend, who, being already instructed in the technique, will submerge the letter in a basin full of water. After it has remained there a little while, the white writing will gradually reveal itself upon the white surface and offer itself to the friend to be read — to the astonishment of all the bystanders, who cannot tell how letters that had not appeared before are now made plainly visible.

[Margin: Experiment 3.]

EXPERIMENT III

But if you wish the letters to appear black, proceed as follows. Take vitriol, mix it with spring water to make a solution, and with this write upon paper whatever you please. None of the lettering will be visible. But when you want it to become visible, take powdered gallnut and mix it into a separate basin of water; then take the paper on which you wrote the letters and draw it gently through that water. In an instant the letters that had not appeared before will become plainly visible in the blackest color. And if you intend to display white letters on black paper, proceed thus.

[Margin: Experiment 4.]

EXPERIMENT IV

Take spring water, add to it the yolk of an egg, and blend it well, tempering it to the consistency of ink. With this liquid write whatever you wish on white paper and let it dry. This done, coat the white paper with ink and let it dry. Now, when you want the letters to appear, scrape away the earthy part of the ink, and at once white letters written upon the black will beautifully appear, not without the wonder of those who look on.

I could give countless examples of this kind here, but since I have reserved them for other places, I have judged it superfluous to describe them at greater length.

We said above that there is a great kinship between alum and vitriol, inasmuch as both have the same parent, namely pyrites. For if a hard silver-colored vein of pyrites is set in a sunny spot, crushed and left to macerate, before long you will see both vitriol and alum effloresce — with this difference, however, that the vitriol tastes of a more earthy substance, and the alum of less.

From all of this the nature of both alum and vitriol is easily gathered. And although vitriol is most commonly called shoemaker's blacking [atramentum sutorium], it must not on that account be concluded that vitriol by its own nature stains waters with a black color — by no means, since we always find vitriolic waters perfectly clear, and both alum and vitriol mixed into clear water never stain it. Yet prepared vitriol does have a certain hidden power by which, when combined with the juice of the oak gallnut, it tinges waters black in an instant. This you may verify by experiment: if you drop even a few drops of it into water in which gallnut has been boiled, they will at once blacken the water as if ink had been poured in. We will set forth the reason for this in what follows.

[Margin: On aluminous waters see what we have pursued in our own Etruria [Tuscany], and in the Fifth Book of this Work.]

Having thus examined and discussed the nature and properties of alum, let us now in the same way unfold the nature of vitriol.

SECTIO IV

DE VITRIOLO

ON VITRIOL, AND ITS MARVELOUS PROPERTIES

CAPUT I

On the Definition, Division, and Origin of Vitriol

[Margin: What vitriol is.]

Vitriol is so called from the transparent substance of glass [vitrum], which it resembles. By most it is called shoemaker's blacking [atramentum sutorium], because it serves for dyeing hides and other things black, and is so named for that

reason. By the Greeks it is also called χαλκανθον [Greek: chalkanthon, "copper-flower," i.e. vitriol], which is the same as "flower of copper" [flos aeris]; by the Arabs الكند [Arabic: al-kand, "vitriol"]; by the Spaniards *Caparosa* [copperas]. As nothing is better known than it, so nothing is more unknown, on account of its hidden powers.

[Margin: Varied opinions on its composition.]

As to the essence and composition of vitriol, I find varied opinions among the natural philosophers and chemists. Some of them assert that vitriol is a material composed chiefly of alum and sulphur. Others think it [continues on printed p. 317]

[continued from printed p. 316] is a peculiar salt, to be reckoned among the class of salts. We append our own opinion, established by various experiments.

We say, therefore, that vitriol is not materially and actually composed of alum and sulphur — especially since vitriol, when it is burned and calcined, leaves no trace or sign by which it could be referred to either of the two. For this stands as an infallible argument: that all bodies in which a material portion of sulphur is present cannot endure even the slightest touch of fire without — I will say at once — the substance of the sulphurous portion being separated from the rest, and passing off into soot or being kindled, and going up in flame after the manner of burning sulphur. So hard is it for such a body to conceal the brilliance of its nature, as is plainly evident in antimony, orpiment, marcasite, and other not dissimilar metallic bodies. Since these have some sulphur mixed in, however much more compact and solid they are than vitriol, yet once committed to fire they immediately betray their nature by their color, flame, and sulphurous odor — which never happens with vitriol.

Add to this that alum and sulphur, of which they claim vitriol is composed, both because of the wateriness of the one and because of the oiliness of the other, wage between themselves unsociable enmities, disagreements, and quarrels, so that, just like oil and water, they cannot remain joined and mixed together for long. From this it is plainly concluded that the material composition of vitriol from sulphur and alum cannot hold. Something else, then, lies hidden in the inmost chamber of vitriol, which constitutes its true, physical, and essential composition. The matter stands thus:

[Margin: The author's opinion.]

Experience perceived by the senses teaches us, and it is held for certain by all the more skilled masters of chemistry, that all mineral or subterranean bodies possess a certain sharpness, which they have had from nothing other than the acid spirit of sulphur — this being the single basis and absolute origin of all mineral acidities. And accordingly, all bodies that have the consistency of vitriol or of alum, being watery and such as are liquefied by fire, must be reckoned to have acquired their fluidity and brilliance from nowhere else than from one and the same common water. But the fact that they differ in some way and diverge from one another, whether in form, in taste, or in any other manner whatever — that, I say, must be ascribed to a third something, as we shall demonstrate clearly a little later.

[Margin: How vitriol is composed.]

Vitriol too, although it is numbered among the class of salts and concreted juices, must by no means be considered a pure and unalloyed salt, since it differs in species from salt, niter, and alum in its virtues and properties. From where, then, and from what these specific differences of salts depend, I shall now attempt to disclose.

[Margin: How it arises in the earth.]

First it must be supposed, from what we taught in the Fourth and Fifth Books, that fire lies hidden in the innermost bowels of the Earth — not eminential fire, nor that which arises from antiperistasis, but natural fire, as we have said, in quality and faculty entirely such as is the elemental fire in any other place above the earth. And just as our ordinary fire necessarily requires a subject upon which to act — such as oil, resinous materials, wood, charcoal — so too the immense Wisdom of God [D. I. = Dei Immensa], in the vessels, wombs, and receptacles of the earth in which minerals must be generated, cooked, and converted into metallic substance for the use of the human race, each according to its own species, has produced the various substances of mineral clods and earthy portions. To all and each of these it joined something fatty and oily, apt for catching fire, which we say is nothing other than sulphur.

This sulphur, therefore, once it is kindled in the said hollows of the earth by the subterranean fire through fire-bearing channels [cuniculi pyragogi], at the same time also emits from its own body a certain acid vapor, sharp and endowed with caustic power. While this vapor by its subtlety penetrates the inner fibers of the mountains, there it also imbues and tinges the subterranean waters — with which we showed, in the First Volume, the terrestrial globe to be full — with its

caustic power and sharpness, so that it becomes a true menstruum [solvent] for dissolving the aforesaid clods, of whatever kind they may finally be. With these things set forth, we now describe the constitution of vitriol as follows.

[Margin: Definition of vitriol.]

Vitriol is a mineral body composed in the deepest bowels of the earth from sulphurous spirit, water, and the ore of copper or iron, or of both mixed together. From the sulphurous spirit it has its sharpness and caustic faculty; its clarity and fluidity from the water; and its metallic color and taste from the ore of copper or iron. And from these three — the spirit of sulphur, water, and the ore of copper and iron — we know by experience that vitriol is composed. For in a similar way, and after the pattern of nature, all those who sustain their lives devoted to this profession know how to compose artificial vitriol. But everything becomes clearer by an example.

[Margin: How vitriol is composed.]

Know therefore, Reader, that the acid spirit of sulphur, with which the subterranean water is tinged, is that menstruum or solvent which, when in passing through it pervades some place beneath which there lies an ore of copper or iron, then we must be firmly convinced that at the same time some portion of that copper or iron is scraped away and eaten — as much, indeed, as the acid spirit within it can dissolve in proportion to itself. This done, you will find that a little later a liquor comes forth, green or yellowish, of a metallic and sulphurous odor, and of a sharp or rather acid and astringent taste. From this liquor, filled with vitriolic corpuscles, that vitriol of which we have been speaking is separated and condensed. But perhaps doubts [continues on printed p. 318]

[continued from printed p. 317] that occur to someone will arise; let us resolve them through the questions [posed].

[Margin: Objection.]

First. Someone might perhaps ask: since the spirit of sulphur is the principal, chief, and most active substance of both alum and vitriol — for we said above that both are born from pyrites — from where, I ask, does it come about that these two differ so greatly in their form and color? Second: since the vapor proceeding from sulphur is the cause of all acidulous mineral waters, why are they found to be of so different a nature? Third: why is that acidity not found in all baths, whether hot or cold? Fourth: since water is the subject in which the

mixture of the other bodies occurs, why, I say, is vitriol found in waters not under a solid substance, as in ores, but in a liquid one?

[Margin: Solution.]

I reply, first: that this whole specific difference of virtues displayed in salts comes not from the sulphurous spirit and water alone, but from a third body — which we say is nothing other than certain mineral clods, which possess virtues differing in species from others. Just so, the common salt of the earth joined to them is, by an innate power, changed into that disposition which the mineral clod itself bears. Hence vitriol is not born in just any ore, but has its own peculiar and most proper ore of copper or iron, which lends it solidity. So too, in turn, alum does not love every earthy clod, but a certain kind of rock, in which the salty juice of alum is actualized. Therefore, just as iron or copper differs in species from the rock that is the mother of alum, so too the salt-brine is drawn out both from copper and iron, and from the said rock, by the agency of fire.

You see, then, the common salt and water of nature, diffused through all the pathways of the Geocosm: considered in themselves, they are, as it were, universal substrates, indifferent to receiving various forms. But as soon as the water has been impregnated with the sulphurous spirit diffused through the inner bowels of the earth, then this water, where it finds a salt-brine clod, joined according to the clod's property and virtue together with the salt placed in it, will produce common salt; if it enters nitrous veins, niter; if an aluminous rock, alum; if finally it enters an iron ore, green vitriol; if a copper ore, white vitriol; if finally a silver clod, it will turn out blue vitriol. And the more these take their origin from more perfect metallic substances, the more they will also be reckoned to be of greater virtue.

[Margin: Solution of the second question.]

I reply to the second question: that water made acid by the sulphurous spirit is the cause of all the waters they call acidulous; for this water, according to the nature of the channel and of the underlying clods through which it passes, will also produce diverse properties of the waters — all of which are very fully discussed in the Fifth Book.

Then, as to the third question: namely, why for the most part sweet waters burst out from the mountains into springs and rivers, yet leave no trace, by either odor or taste, of any salt of whatever kind that may lie hidden. I reply that the cause is this: that these waters mostly take their origin from the most ample subterranean water-reservoirs [hydrophylacia], and so it cannot come about that, even if they

are imbued in some way with the sulphurous spirit, the whole mass can be penetrated by it; and consequently they do not impress a perceptible trace upon the waters — just as we also said of salt.

[Margin: Chemical experiment: salt in all [waters].]

Yet if they are reduced to the Spagyric alembic, we will find at last that, if the water has passed through saline places, there is some salt in the bottom; if through nitrous or aluminous places, some niter or alum; if finally through coppery, cupreous-rusty [aeruginous], or ferruginous places, you will find the matter of vitriol. From the constitution of the subterranean places, therefore, it depends that the waters are now of greater, now of lesser sharpness, according to the nature of the various clods. Add to this a swifter flow of the water, by which that sulphurous spirit, variously scattered and combed apart within the rocky narrows of the channels, cannot conveniently impress its power upon the waters; and so too it clings here and there to the earthy clods of the banks — which does not happen in waters collected within the crypts of the mountains, settling without agitation, which are all most easily tinged by the sulphurous spirit.

[Margin: Mineral sympathy.]

And in these matters nature plays with a certain wondrous magnetism, while each thing is drawn by its like: copper and iron, by the nature innate in them, draw to themselves that with which their vein is already filled; vitriol, scattered through the waters by the minutest vitriolic corpuscles; while alum, rejecting the coppery or ferrous vein, seeks out what is like itself, with which the rocky stone swells. In this way the salt of the saline clod desires to be joined by nature to its bridesmaid clod. The water, therefore, charged with the acid spirit of sulphur, while it eats away somewhere within the channels of the earth an aeruginous clod it has found, at the same time also mixes with itself the vitriolic corpuscles hidden in the vein of copper or iron. These, then, wherever they find an ore proportionate and sympathetic to themselves, unite and connect the offspring deposited in it by a friendly marriage.

[Margin: Fourth question solved.]

But let us come to the fourth question. I say, then, that although the matter of vitriol is not always extracted from beneath the earth out of some liquid body or prepared lye [lixivium], but is also found in the earth under a solid mass after the manner of a mine or ore — yet by this very fact I say it is in no way prevented from being reduced to some mineral body by the agency of the sulphurous spirits adhering to it. For whether the said spirits are carried through the medium of

some water into some mine, in which the collected water produces a vitriolic lake or spring; or whether, having issued from their own body, the said spirits penetrate and enter in the form of vapor into some ore, within which they produce a [vitriolic] mass; or finally in some other [continues on printed p. 319]

[continued from printed p. 318] way whatever — this must always be held as established: that all kinds of vitriol are produced from those three things: the acid spirit of sulphur, water, and the ore of copper or iron. But lest anyone be able to doubt hereafter, let us establish what has been said by experiments.

EXPERIMENT I

In a brick crucible let a clod of iron or copper be set out, pour the spirit of sulphur over it, and within a short space of time you will find the whole water imbued with vitriol — in odor, taste, and color. Since the sulphurous spirit, poured over the clod of copper, will at once dissolve it by corroding it; and once it is dissolved, the liquor of the sulphurous spirit draws to itself what lies hidden within the clod — namely the vitriol, or the minutest vitriolic corpuscles — which afterward, cooked together, are once more condensed into vitriol. What we therefore accomplish by art, we learn from the manner in which nature operates.

EXPERIMENT II

Take salt-brine earth, and again nitrous earth, then aluminous, and finally aeruginous earth. Arrange these within a certain receptacle so that separate channels run to each — MA, MB, MC, MD.

Diagram. A schematic apparatus for separating mineral substances. At the center is a round vessel labeled **M**, divided internally into compartments (marked with small cross/star symbols). From this central vessel four sinuous channels (canales) radiate outward to four small footed cups arranged at the corners.

- M (center): the central vessel, filled with common water to which the spirit of sulphur is admixed
- A (upper left cup): receptacle for the saline earth — yields salt [via channel MA]
- B (lower left cup): receptacle for the nitrous earth — yields niter [via channel MB]
- C (lower right cup): receptacle for the aluminous earth — yields alum [via channel MC]

- D (upper right cup): receptacle for the aeruginous earth — yields vitriol [via channel MD]

Let the place M be filled with common water, to which you should admix the spirit of sulphur; it will at once turn acid, yet in such a way that it expresses neither salt, nor niter, nor alum, nor vitriol by odor and taste. If you then, the stopcocks [epistomia] being opened, let it flow into the receptacles prepared with the individual earthy clods, you will find that the saline earth A passes into salt; the nitrous into niter; the aluminous into alum; the aeruginous into vitriol — the substances being dissolved. From this it is plainly gathered that the common water, imbued with the spirit of sulphur, draws to itself the salt-brine of the dissolved bodies, and in the clod converts it into the natural disposition out of which it had extracted it.

CAPUT II

Whether Iron Can Truly and Really Be Converted into Copper [Aes] by Means of the Spirit of Vitriol

Not long ago there was sent to me from Hungary by the most learned Father Andreas Schaffer [Andreas Schaffer] a vitriolic water [aqua atramentosa] together with a horseshoe, the latter's iron having been converted into copper. This matter, just as it stirred no small wonder in the minds of those who beheld it, so too raised various questions and doubts about transmutation of this kind. And since I have already long been compelled by various overseers of mines and by chemists — whom I shall cite in what follows — to set down my opinion and judgment on this matter, I will publish it here as in a fitting place.

The question, then, is asked: whether iron is converted into copper by a true and real transmutation? The alchemists, who promise themselves mountains of gold from transmutation of this kind, favor this opinion wonderfully, yet using no other argument than that in Goslar and Hungary, and in other places, iron is everywhere asserted to be converted into copper.

[Margin: The error of the chemists.]

But in very truth, since some men, drawn on by a fixed opinion — especially in the chemical business, allured by great hope of riches — are so disposed that, with no traces of truth explored, they assert and most stubbornly defend a thing wholly contrary to the principles of natural philosophy, so that, while they hunt for the greatest and subtlest secret of all, they seem to slide into the deepest abyss of ignorance (which will become especially clear in the present controversy) —

therefore, lest we stray from our purpose through fuller windings of words, we will undertake to set forth the falsity of the conceived opinion, which men are more obstinate than the Marpesian rock [Marpesia] to cling to, and, once set forth, to dissolve it by various experiments.

[Margin: The difference between transmutation and separation of one thing into another.]

It must therefore be supposed, first, that there is a great difference between the transmutation of one thing into another, and the reduction of one thing to another, or the separation of one from another. Transmutation, or substantiation, occurs when there comes about a change of two substances of one thing into another — a change as to entire and perfect form, properties, and powers — as when iron is changed into copper, silver into gold, or like metals into like. And for this transmutation it is utterly necessary that the same substances of some thing be altered through and through and wholly changed, while they must take on for themselves another form and perfection which they did not have before. Nor — as those men wrongly assert — does it suffice that we are able by the force of fire to render some liquid thing fixed, or a fixed thing fluid, or white black, or black white, or to imbue them with other colors; for these are accidental, not substantial, transmutations, as

[continued from printed p. 320 — Liber VI, Sectio IV, Caput II]

only that man knows it who weighs the truth of things not by the furnace and its fires, but by the infallible balance of irrefutable reasoning. Therefore, when iron is said to be transmuted into copper, this must be understood not of a substantial transmutation, but of a certain accidental reduction — a separating-out of parts, the disjoining of one from another. [Margin: How the conversion of iron into copper comes about.]

Now a "reduction" is the process by which certain things are gathered back up and reunited into a single mass — things that had been dispersed and scattered into the tiniest particles, or diffused and mixed together with some other substance — so that, as if lost and destroyed, they are restored by reduction to their former condition. The following experiments demonstrate this abundantly.

Experiment I

[Margin: A remarkable experiment.]

Gold dissolved in *aqua regia* is reduced to a clear, transparent liquid of saffron color, with no trace of solidity or opacity remaining. If you throw a silver rod, or

any piece of silver, into this liquid, the liquid gold will at once — by some magnetism I cannot explain — seize hold of the silver mass, and the whole of it will bind itself together with the silver. But if you then separate this gold-silver union by chemical art (a method I will disclose in what follows), the gold, brought back to its original form, will be recovered exactly as it was before, under the purest form of gold, with nothing left behind but a clear, milky-white water. [Margin: *Vide lib. 6* [?], *Sect. 4* [?], *Cap. 9, vide nos* [?] p. 214 [?].] If you then add mercury to that same *aqua regia*, you will see — not without astonishment — the mercury draw the gold to itself; and once the liquid has been drawn off, the whole of the gold will appear in the bottom of the vessel, reduced to the form of a black powder. This powder, placed together with the mercury into a small retort and committed to the fire, restores its form in the receiver as the mercury flies off, while the gold remains in the said powder form. Finally, this, placed in a crucible and committed to the fire and melted, brings the gold back to its original form of dignity. This transmutation cannot be called true, because both the gold and the mercury can be reduced once more to their proper forms — which cannot happen in a true transmutation. And another mixing of metals, of copper and silver, shows the same thing.

Experiment II

On transmutation and reduction in silver and copper.

[Margin: Another experiment with silver and copper.]

When silver is dissolved in *aqua fortis*, if you throw in a small sheet or any other particle of copper, then within the space of a few hours the silver will be seen to settle to the bottom, with the copper joined around it in the manner of a sponge. If you then commit this copper-silver union to the fire and melt it, you will find both the copper and the silver separated out, each in its original form.

[continued at top of next column / printed p. 320, right column]

we also said that any water imbued with the acid spirit of sulphur eats away at the copper-bearing lump — or, what is the same thing, dissolves and separates the copper corpuscles by its corrosive action — and that, once dissolved, the now wholly imperceptible corpuscles are taken up into the water and to some degree mingled with it. These things granted: since a great magnetism passes between copper and iron, and since they possess a remarkable sympathy from the likeness of their origin, the moment the vitriolic corpuscles dispersed through the waters and mingled with them sense the introduced iron, then — as if to an inseparable companion, and as though destined by provident nature to a further end — they

at once flock to the iron; they surround the friendly, subjected iron and bind themselves to it in a most tenacious embrace. But because these vitriolic corpuscles possess the highest caustic power, it comes about that, penetrating the innermost pores of the iron, they convert the iron by their sharpness into manifest rust — that is, they dissolve the "glue" of the iron, the greasy part within it. [Margin: The sympathy of iron and copper.] Once this is dissolved, and the corpuscles united by sympathetic confluence, in place of the iron there comes about a heaping-together of the vitriolic corpuscles into a mass, which then, exposed to sun and air, with the iron-dross finally remaining behind, is condensed into the finest copper. This can by no means be called a transmutation, since all these things come about through a mere separation of different metals; and so each thing only restores itself in the other — that is, the copper-bearing lump restores the copper [?] gathered together out of innumerable corpuscles dispersed through the water, while the dross of the other substance, namely the iron, remains behind.

[Margin: The sympathy of iron and copper.]

It is therefore clear that vitriolic waters, having their origin from copper-bearing lumps, contain copper within themselves; and that iron put into them has no other use than to reduce and gather the inky corpuscles, by drawing off from them everything copper-like that lies hidden in them. This we establish by the following experiment.

Experiment IV

Let Hungarian copper-bearing vitriol, or vitriol of any other kind, be dissolved in water, and into the dissolved solution let a thin iron plate be lowered. When this is done, the iron will at once begin to draw to itself the dispersed copper corpuscles — indeed, all the copper that lies hidden in the vitriolated bodies. This copper, afterwards separated out by melting, is reduced to excellent copper. [Margin: Iron in copper, separated, not transmuted, properly speaking.] Indeed, if you immerse a bodkin or knife into the spirit of vitriol, it will at once, from drawing in the copper-bearing corpuscles lying hidden in the vitriol, take on a copper color. No transmutation, then, takes place here, but a pure separation of copper from iron — because the copper corpuscles substitute themselves in the place of the iron that has now been converted into dross, once the iron-dross is separated off. But if you test this same thing with iron-bearing vitriol — vitriol that has no copper in it — then that iron too will not lose its color, nor will it be found altered. And if it does draw anything to itself from that vitriol, it will be merely a certain yellow dust, nothing other than something rust-like.

Experiment V

On the reduction of iron into copper practiced in the Hungarian mines.

[Margin: How the spirit of green vitriol transmutes iron into copper.]

But how, in Hungary, iron is reduced into the most beautiful copper, I will add here as it was communicated to me by the above-praised Father Andreas Schaffer. In the Hungarian copper mines, in the deeper shafts of the pits, there is a certain stream drawn out from the vitriolated ores. By the agency of these waters they reduce iron into the most beautiful copper, in the manner that follows.

They gather together the cheapest iron implements of every kind, almost entirely consumed by rust — for the nearer the iron is to rust, the better the result obtained. [Margin: ...] These they once again work upon the anvil and hammer into thin plates. They place these plates on the bed of the stream and leave them there for nearly half a year. When this period has elapsed, they find the plates softened by the force of the inky water, like an amalgam; and when they have exposed these to air and sun, they are converted into the purest copper, ready for every use — while the iron-dross remains at the bottom of the stream. And in this way, with truly great profit, copper is prepared by art over and above what is dug from the ore. Furthermore, if anyone immerses a very thin iron plate in spirit of vitriol, he will find, in time, the iron-dross separated at the bottom of the vessel from the copper-bearing body. The reason for this is none other than — as we said above — that the vitriolated corpuscles dispersed through the water fall, by a sympathetic confluence, upon the iron plate, and once it is dissolved, substitute themselves in the place of the iron.

From all this it is plain that no substantial transmutation takes place here, since in copper-bearing vitriol no other metallic substance is found than copper itself. And when this copper has been separated from it, the vitriol loses its name, and nothing else remains but water and the acid spirit imbued in it — what is commonly called the *oil of vitriol* — and this has only as much power to transmute iron into copper as *aqua fortis* has to turn lead into gold. Hence Paracelsus [Paracelsus] the impostor is by no means to be heeded, who tries by every means to persuade the unskilled rabble of chemists that this is a true and real transmutation.

Caput III.

On the variety, powers, properties, and use of vitriol.

Among those concreted juices that are found in waters, vitriol — also called *chalcanthum* — exists together with the species connected with it, namely *sory*, *misy*, *chalcitis*, and *melanteria*. For the waters that abound in the juice of this or that species have nearly the same odor, taste, and the same nature, distinguished only in degree as more or less. Whether one looks to the authority of writers, or to the mines from which they are dug, or to the powers they possess, or to the degrees of kinship by which they are coupled — their genus being derived from pyrite, as we said above, as from the common stock of them all — you will find so great a similarity, affinity, and nearness of kinship that you may rightly call them one and the same thing, distinguished only by various accidents, since from one corrupted material another is generated. [Margin: How *misy*, *sory*, *chalcitis*, and *melanteria* are produced.] For from an astringent juice they produce not only alum but also vitriol — and indeed, out of this, *sory*, *misy*, *chalcitis*, and *melanteria*. *Misy* is the flower of vitriol, as *melanteria* is of *sory*; green vitriol grows out, in the form of a hair, from a pyrite of this kind by way of *melanteria*, and often a green growth shoots up in the shape of a hair, which it surrounds on every side. Alum is often white, vitriol rarely so, but most often green or blue is found; and of these things that are akin to it, *misy* shows the color of gold, *chalcitis* that of copper; *sory* is nearly black, as is *melanteria*, which however, when dried, usually takes on an ashen color. They differ, however, in that — besides vitriol, which is both native and artificial — all the rest are only native; yet in all of them there is an astringent power together with a sulphurous odor. Vitriol, being soft, resembles feathers; *melanteria* a kind of brine; *sory*, by the hardness of its very coarse parts, a stone, with a most pungent odor; *misy* is the finest; *chalcitis* holds the middle place. But since there is among the mineralogists a great dispute about the nature of these things, it is not to the point to pursue this at greater length. Therefore let us hasten on to set forth their powers and properties.

First: in the dyeing of wool, hides, silk, and other things, there is a great use of it among dyers and fullers.

Second: it has the greatest use in medicine, on which consult Galen [Galen], Brasavola [Antonio Musa Brasavola], Matthioli [Pietro Andrea Mattioli], and others. [Margin: The powers and properties of vitriol.]

Third: Pliny [Pliny the Elder] says that vitriol has so great a power of astringing that, if the mouths of lions are sprinkled with it, they cannot bite.

Fourth: alum is contained in vitriol; for if its mud is diluted with water, you will find alum efflorescing out of it — for they are born together and mixed from the same pyrite.

Fifth: if you burn vitriol, it becomes white, which, as the metallic tincture exhales, remains white, like salt. [Margin: Corrosive.]

Sixth: an excellent writing-ink can be made from it, which however vanishes entirely within a certain span — that is, if you mix the spirit of vitriol with a moist and tenacious material; for as the spirit evaporates, the residue with which it was imbued also turns black and vanishes.

Seventh: vitriol eats away all metals except lead; hence the boilers of vitriol boil it in none but leaden cauldrons. And when they have boiled it down to a certain point, it at once liquefies; and if they press it with a still more intense fiery torment, it is condensed into a vitriolated salt. The reason for this is that the mercurial admixture, in which it is strong, blunts and restrains the most pungent juice of vitriol and the lead. But on these matters see more in what follows, in the experiments on salts. [Margin: Astringent.]

Eighth: vitriol by its nature astringes, warms, eats away, and dries; hence it is wonderfully suited for stanching blood, for drying and incising humors, and for obstructed passages. Chemists make from it medicines of great price and usefulness for driving off desperate diseases.

Since, moreover, vitriol consists chiefly of three substances — namely water, the spirit of sulphur, and metal (whether it be copper or iron) — chemists draw seven different medicines from it, in the manner that follows.

First: they extract the water by a vaporous bath. Because this is the lightest of all, airy, and least of all sharing in the sulphurous spirit, this water is therefore called the *dew of vitriol* [ros vitrioli]. It strengthens the viscera, soothes inflammation of the blood, and restores a brain weakened by dryness and heat. [Margin: Dew of vitriol.]

[printed p. 322, right column]

Second: the water extracted from vitriol through sand, now sharing somewhat in the sulphurous spirit, is called the *second water of vitriol*. It gives off a not unpleasant odor; it is wonderfully effective for purging the kidneys, for internal corrosions, and for obstructed urinary canals, taken in the morning with meat broth.

Third: another, most subtle substance is then extracted, namely a portion of sulphur, to which the name *spirit of vitriol* is given. [Margin: Spirit of vitriol.] Its virtues are so great, and its endowments so admirable, that they can scarcely be sufficiently described: against all diseases it is a kind of admirable prophylactic. For whatever is found putrid, poisonous, and disposed toward grave diseases, it cuts, eats away, and consumes; it purifies the blood of all soot; it removes the matter of stones; it purges the kidneys and bladder, once all the viscosity of phlegm has been consumed.

Fourth: vitriol further tortured by fire yields a certain oil, swelling with burning spirits. Although to take it internally is not without danger, yet applied externally it has remarkable use in removing those abscesses that arise from cold, since it possesses a narcotic and stupefying power when brought to this degree; hence it is of the greatest and unique benefit to maniacs, frenetics, and the rest. [Margin: Oil of vitriol.]

Fifth: finally there comes out vitriol that they call *purified* — or, what is the same thing, the *Salt of Vitriol* [Sal Vitrioli]. These are the residual dregs from the acid spirit of vitriol, and it resembles a fine purplish earth. It has the same virtues as the preceding, most powerfully when applied externally. [Margin: Salt of vitriol.]

Sixth: once the spirits have been drawn off, there remains in the very fine powder of vitriol a certain airy substance, which can even be reduced into copper; it can not inaptly be called the *iron* or *copper of vitriol*. It cleanses putrid wounds, generates flesh, and does the like.

Seventh: when all the distillations are finished, there remains at last in the bottom of the vessel a kind of *caput mortuum* [dead head], which is called *Colcothar* or *earth of vitriol*. It serves for drying plasters and ointments and for closing over scars. [Margin: Colcothar.]

And from these things it is brilliantly clear how diverse the substances are — differing in form, color, taste, and weight — that are drawn even from one body of vitriol by the agency of fire; so that from this very fact you may learn how great a multitude and abundance of utterly diverse things is produced by the power of subterranean fire and of the waters in the innermost chambers of the earth.

Caput IV.

On artificial vitriol.

Vitriol is made in four different ways by those skilled in this art. [Margin: The first and second ways of making vitriol.] The first and second are from inky or vitriolated water; the rest either from a solution of *sory* and *chalcitis*, or from earthy lumps or stones, or other inky mixtures. The first method is this:

The inky or vitriolated water, collected in pools and drawn out from them by buckets, they pour — in warm regions, in the summer season — into open-air vats sunk to a certain depth, conducted through channels. There it is left until, by the heat of the sun, it concretes into vitriol.

In cold regions, and in winter, the inky water is first boiled together with fresh water in leaden cauldrons; then, after being cooled, it is poured into vats or basins which they call "wooden fish-ponds." From these are suspended, as it were, cross-beams fixed above so that they remain immovable, and from these hang little stones on extended ropes, to which the thick liquid clinging is condensed into transparent cubes or grains of vitriol, which have the appearance of grapes.

In the third method, ink — that is, vitriol — is made from *melanteria* and *sory*; but *misy* and *chalcitis* must be rejected, because they make the vitriol blotchy. [Margin: The third way of making vitriol.]

In the fourth method it is made from earthy lumps or stones imbued with vitriol, in the manner that follows. [Margin: The fourth way.]

First. The dug-out vein of vitriol they heap up into a pile drawn out lengthwise, upon a certain area set apart for carrying out this work; there, under the open sky, they leave it to be steeped for at least six months by rains, frosts, and suns, day and night. During this time, on set days, they tear the pile apart with mattocks and rakes and overturn it, and gather it again into the same heap, so that it may more easily be steeped by the rains and cooked by the heat of the sun. Then, with a cover placed over the pile, they let the material ferment for another half-year's space.

Second. Beside this they dig a covered trough, fortified partly with wooden boards, partly with bricks and lime, so that it cannot leak out anywhere. This trough they fill with the purest fresh water, into which they throw the inky earthy material — as much as the workmen judge necessary for carrying out the work — and they stir the mixed material with wooden poles prepared for this use, until the water has taken into itself everything of vitriol that is in it. Then they let the dregs settle, until the water, pregnant with vitriol, takes on clarity.

Third. When these things are done, certain holes made near the bottom of the trough in its side are opened, and the water leaping out from there is caught in a great receptacle. The water thus caught they pour into leaden cauldrons set over furnaces, and with the fire kindled beneath, they stir up the furnace for set hours. Finally they put in a piece of iron or copper (for without these the vitriol does not concrete); but the pieces of iron or copper thrown in melt away into the water in a short time.

Fourth. After they have cooked the material for the due time, the fire being withdrawn (lest the leaden vessels melt from the heat of the fire), they let the cooked liquid cool; then they leave it, poured into oaken jars, until it concretes into vitriol — which happens within the space of one natural day. There are also other methods, which see in Agricola [Georgius Agricola] and other mineralogists. We here set forth those that we have observed with our own eyes [αὐτοψία [Greek: autopsia, "eyewitness observation"]].

And these are the things I have judged should be said about the nature and property of vitriol; but the marvels that are wrought in the chemical business by the agency of vitriol will be made plain in their own time.

APPENDIX

On the fourfold kind of salts.

Questions and Properties of Salt.

1. Why does salt, when thrown into fire, crackle and leap out, and the smaller the grain, the greater, and the larger the grain, the lesser the noise it makes? I answer that the cause depends on the impatience of the enclosed air, which, attenuated by heat, while it seeks a larger space, with a sudden onrush bursts its barriers and makes the noise we perceive. The proof of this is the following: for in a small grain the spirit is more compressed than in a larger one.

Experiment.

Let little globes be made of glass, which are filled with spirit of wine worked together with saltpeter; if you place these, hermetically sealed shut, upon burning coals, then behold — the rarefied spirit, seeking an exit and finding none, with a horrendous and fearful sound like that of an exploded cannon, the glass burst into a thousand pieces, will violently open one for itself.

2. Why does salt in the same quantity crackle in a moderate fire, but in an intense fire do little or nothing? [Margin: Salt crackles in fire.] I say the cause is

that the spirit of the salt in an intense fire perishes at once, which does not happen in a moderate fire.

3. Why is salt melted more quickly by salt water than by fresh? [Margin: Salt is more easily melted in salt water.] I answer that this happens because of the thinness of the fresh water and the thickness of the salt water. For the former, as it easily penetrates, so it does not liquefy except in time; but the latter, being thicker, most easily dissolves the parts of the salt; and once the saline corpuscles are dissolved, it too must necessarily liquefy at once.

4. Why can salt water not be drunk cold, [Margin: Salt water, heated and again cooled, is more tolerably drunk than cold.] **but, heated and then again cooled, can be drunk more tolerably?** I answer that this happens because salt water, never heated, holds its corpuscles scattered through the whole substance of the water; but after it has been heated, no small part of them flies off, and once cooled, the remainder settles to the bottom; whence the water, diminished in salt, is rendered more tolerable for drinking.

5. Why is sea water — that is, salt water — unsuited for extinguishing fires? [Margin: Salt water does not extinguish flames.] I answer that this happens because sea water is imbued with the greasiness that fresh water lacks, and therefore promotes fires rather than extinguishes them. Hence lamps also burn better when salt is thrown in; hence, too, clothes cannot be washed with sea water, because the greasiness of the salt residing in them stains rather than washes.

6. Why is sea water, even though heavier than fresh water, nevertheless clearer than it? I answer that the cause is the fiery spirit with which the sea is filled, by the greasiness of the sea. Hence divers, taking oil into the mouth and blowing it out, cause a certain light in the very depths, sufficient...

7. Why are salty rains more useful than seawater, and why is salt scarcely produced unless fresh water is mixed in? I answer that the cause is this: fresh water, being lighter and finer, penetrates the salt particles present in salt water more easily and unites itself with them — which does not happen readily when thick water is mixed with thick. This is why dew, being of a finer substance, yields a more agreeable salt. As for why salt is produced more abundantly when the north wind blows, and why it then yields the greatest "flower of salt" [flos salis], the cause is the constrictive force of this intense cold wind, by which the salt particles, however minute, are easily drawn together and condensed.

[Margin: Fresh water and rain are used in making salt.]

8. Why does sal ammoniac grow in the deserts of Libya as the Moon waxes? I answer that the cause is this: as the Moon waxes, it is continually moistened with new and ever-renewed moisture; and afterward, during the day, it is condensed by the heat of the Sun, its excess humidity being either consumed or thinned into vapor. This solves the prodigious property of the salty lake near the city of Aspendus, to which (if Pliny [Pliny the Elder] is to be believed) just as much is added by night as is taken away by day — since the Moon supplies abundant moisture by night to the saline material as it grows to its full increase, while the Sun's heat consumes it once thinned.

[Margin: Sal ammoniac grows as the Moon waxes.]

9. Why is sal ammoniac extremely light while it exists within its own caverns, but very heavy once brought out into the light? I answer that the cause is this: within its caverns it mostly blooms into flakes, which, being very rare, are likewise very light. But as soon as they are brought into the light, the heat of the Sun consumes the airy and watery part that exists within them, and the remaining earthy part is condensed — by which its weight is necessarily increased.

[Margin: Sal ammoniac is lighter inside its cavern than when brought out into the light.]

10. Why do the Egyptians sprinkle their radishes with niter — as we do with salt — before eating them? I answer: because the radish itself delights in a nitrous substance so much like itself, and so is made better by a certain natural agreement. There is also this: the niter sprinkled on them yields the very cold juice of the radish, which the Egyptians delight in.

[Margin: The Egyptians eat their radishes salted.]

11. Why, when niter is thrown into vinegar, does it at once begin to fume and boil up — just as when water is poured over quicklime? I answer: because the sharpness of the vinegar excites the spirits latent in the niter; and while the mixture is roused by the gnawing action, it comes about that, once the niter is dissolved and the spirits fly off, boiling necessarily follows.

[Margin: Niter boils up in vinegar.]

12. Why, when niter is thrown into the mouths of lions and bears, does it check their bite? I answer: that they, being agitated by the discomfort of the sharpness, while they struggle to free themselves from the trouble, easily forget the injury done to them — which is common to all animals.
13. Why, when saltpeter is boiled together with sulphur, is it turned into stone? I answer: because the spirits latent both in the niter and in the sulphur, united by the boiling, are perfectly fixed; and so, with the moisture flying off from the niter, and the fatty matter gluing the two together, the earthy part must at last pass into the hardness of stone.

[Margin: Saltpeter boiled with sulphur turns into stone.]

14. Why does salt take away the numbness of the teeth, but niter does not? I answer: because salt softens and liquefies, whereas niter, on account of its harshness, constricts and does not liquefy.
15. Why do plants spring up and are nourished in salt-works, while niter neither generates nor nourishes anything? I answer that the cause is this: in niter, that fiery and earthy element by its incisive force corrodes everything — which does not happen in the moist and earthy nature of salt.

Whence comes that cleansing power in niter, by which it washes all filth from clothing, and is of such great importance for dyeing cloth among the dyers and fullers? I answer that the cause is that fiery sharpness joined together with the fatty matter present in niter; and the fiery and sharp element, pervading the stains and filth, dissolves them by its corrosive force, while that watery fattiness easily wipes them away.

Aluminis Vires.

The Properties of Alum.

16. Why is alum of the cauldron [alumen catinum] added in the melting of glass? I answer: since this alum is made from a plant which the Arabs call *Hali* [the saltwort, from which soda-ash was made], and since this kind of herb is teeming with an aluminous juice, it comes about that the added alum reinforces the aluminous substance and, by its incisive virtue, easily urges the sands into fusion. Hence the glassy substance, when the diaphanous portions of the silica and sands are joined to the aluminous parts, makes the glass clearer and more lucid — which, without the

addition of alum, would turn out much darker. But more of these matters in [the section] on the art of glassmaking [Ars vitriaria].

[Margin: The properties of alum.]

17. Why does the distilled water of any alum — most of all the rock alum [alumen rupeum] — eat away flesh, and even the metals themselves? I answer that this happens because of the deposition of the phlegm brought about by the action of the fire, which water, once freed, acquires an enormous force of sharpness suited to dissolving and eating away the metals.
18. Why does scaly alum — which they call "Donkey's Mirror" [Asini speculum], on account of its diaphanous substance — when thrown into the fire and burnt, immediately lose its native clarity and whiten like gypsum? I answer that this happens because of the dissolving of the watery parts brought about by the action of the fire; and when these have vanished, the earthy body necessarily remains, degenerating into gypsum. But how much watery content it had in itself, and how this can be explored by the device of the balance [staticum artificium], will be told elsewhere.
19. Why do printers first pass paper destined for the press through an aluminous bath? I answer that this happens because, since paper is made from beaten fragments of flax, and much alum is present in flax (for flax is one of the aluminous herbs, like woad [glastum], which is of such great use in dyeing cloth), it comes about that paper passed through aluminous water, by a certain innate force, magnetically draws to itself the aluminous particles mixed in the water. From this attraction the whole substance of the paper is wonderfully strengthened, and takes on a certain hardness, so that the ink does not flow through or run — because of the union of the aluminous parts present both in the ink and in the paper, which has been imbued with the aluminous force. For just as these parts seek union from the likeness of their nature, so too do they shrink from every dispersal of parts that comes about through running.
20. Why is wine that has turned cloudy in the cask set right with alum? I answer that the alum by its incisive force dissolves and disperses the dregs of the wine, so that the wine at once regains its former clarity. For the other properties, see the Fifth Book of this work, where we have discussed at length the vitriolated waters and hot springs.

Vitrioli vires & proprietates.

The Powers and Properties of Vitriol.

21. Why does vitriol found in mines give miners no further hope of pursuing the metallic veins any further — for, as most authors say, the discovery of vitriol in metallic veins sets the boundary of the metal? I answer that this happens because Nature, through vitriol, as the foundation of metallic generation, shows that no metal remains to be brought to its perfection; and the parts of imperfect metal in the veins neighboring the vitriol show this clearly enough. That vitriol is the proximate cause of the generation of metals is plain from this: that, as we showed above, it abounds in the spirit of sulphur together with a mercurial wateriness. From this acidity the sulphurous spirit acquires both a sharpness for eating and a fineness for penetrating the metallic clods; and so, by the innate nature of the place and by the proper force of its substance, it is readily condensed into metals — into whichever kind the mine is of, especially into copper, iron, and silver, as bodies sympathetic to it.
22. Why does vitriol confer such clarity and limpidity on the water in which it exists? I answer that this happens because the grosser parts of the water, dispersed by the incisive and subtilizing force of the vitriol [chalcantum], sink down; and so, on account of the diaphanous and glassy substance of the vitriolated corpuscles, the water is rendered more lucid, more splendid, and more limpid.
23. Why does vitriol — with the exception of lead — corrupt the other metal vessels by eating them away? I answer that this happens, as we also hinted above, because of the abundance of the mercurial humor in which lead is strong; for by this the incisive force of the vitriol is to some degree blunted.
24. Why, as Pliny reports, can the mouths of lions and bears not bite if they are smeared with vitriol? I answer that this happens because of the very great sharpness of the vitriol, which they try to remove by every means; and so they are so taken up with averting the discomfort that they readily forget the injury done to them, fearing that, if they provoke their enemies further, a greater harm may come upon them.
25. Is there alum in vitriol, and how is it present in it? I answer in the affirmative — especially in the alum which is born from pyrite. For since pyrite generates both alum and vitriol equally, I say that these substances

of different species are mixed together, and consequently are easily separated by the chemical art. For if the mud of vitriol is diluted with water, alum blooms out of it — because the aluminous corpuscles hidden in the mud, once moistened, easily effloresce, since alum is of a more airy nature, while vitriol is of a more earthy nature. And this is plain from the oil of vitriol, which gives off altogether the smell of alum, on account of the volatile nature of the alum mixed with the sulphurous spirit in which vitriol is strong.

26. Why do the diggers of vitriol easily perish in the innermost caverns? I answer that this happens because of the noxious stench of the putrefied sulphur, by whose narcotic vapor the diggers are necessarily suffocated — most of all in the "Charontic" caverns [charontici specus, deadly grottoes], which draw their poisonous and lethal exhalation from nothing but this mixture.

And these are the things we have thought fit to say about the powers of vitriol. Whoever desires more of these matters, let him turn to the following books, where, concerning the fermentation and precipitation of metallic liquors, we set forth beautiful and admirable experiments.

MUNDI SUBTERRANEI LIBER SEPTIMUS

DE MINERALIUM SEU FOSSILIIUM

THE SEVENTH BOOK OF THE SUBTERRANEAN WORLD: ON MINERALS, OR FOSSILS

which properly partake of the earthy Element — their Nature, Property, and Use; and concerning the perennial Geocosm, what comes about through their motion, their cycling-about [pericyclosis], and their revolution.

PRÆFATIO.

PREFACE.

It was altogether necessary to set the concreted juices [succī concreti] before this Book; for just as those are the base and foundation of all the rest — whether of

minerals or of metals — so too in the order of nature they deserve the first place among fossils.

That you may understand this, Reader, know that there is no body or substance in the nature of things which does not take its origin from salt, and which does not at last resolve again into the same — as was shown fully in the preceding Books. And so, by the providence of the most wise Divine Craftsman, both to furnish all things with consistency and to preserve them, and to give them the fruitfulness for propagation, salt was set in place at the first origin of things. For just as the saline substance is diffused through all the fibers of the earth and the abysses of the sea, so there is nothing which does not draw it to itself and into itself — as a good uniquely necessary to it — by a kind of natural magnetism, inasmuch as from it each thing gains firmness and strength. All these things have been shown in the preceding Books through various observations and experiments; and so nothing else remains except that we now show what salt of Nature accomplishes in the remaining mineral substances, and how it is converted into their substance. And that we may proceed methodically [εὐμεθόδως, Greek: eumethodōs, "in well-ordered fashion"] in all things: first, let us set up our reasoning concerning those Earthy substances which counterfeit either powder, or sand, gravel, grit, or ash; second, concerning the soft substances which they call earths [terrae]; third, concerning imperfect metallic bodies and stones.

SECTIO I.

DE TERRESTRIBUS PORTIONIBUS

SECTION I: ON THE EARTHY PORTIONS

and the sandy bodies which are enclosed in the womb of the Geocosm.

CAPUT I.

De Arena, Sabulo, Glarea, Cinere.

CHAPTER I: On Sand, Grit, Gravel, and Ash.

Concerning Sand — than which nothing is better known — it must be treated first, so that what it furnishes in the nature of things, and what its power, forces, and properties may be, can become known.

Sand, then, can be considered under a threefold distinction; for it is either fossil [fossilis, dug from the ground], or fluvial, or marine. Fossil sand is that which forms when a stony substance — eaten away [hu...

[Margin: Threefold sand.] — eaten away by moisture, is collected in underground pits, or is heaped up by alluvial deposit within the hollows of mountains and mines, whose whole interiors are full of it. The fluvial and marine kind is that which is rolled along the banks of rivers and seas by the agitation of the waves, and is nothing other than certain shavings of stones produced by the perpetual attrition of the water lapping against them; or it is carried down through the channels of mountains by the motion of the waters; or it is the sands heaped up after the Flood, from which arise the sandy mountains and hills — some of which, by a petrifying juice, have in the course of time been turned into stone, while others have remained under the mobile substance of sand, like Mount Janiculum [in Rome], which consists wholly of tawny-colored sands.

[Margin: Sandy desert.]

As for the sand that is found in sandy deserts, it comes from the very nature of the place — when, through the dewy moisture of stony tracts of friable nature, the rocks, gradually worn away, degenerate into a sandy material, which, agitated by the force of the winds, is heaped into mounds, and, dissolved again, is scattered over plains stretching far and wide. For the dewy moisture, infected with niter in the sands, gradually resolves the cliffs and rocky ground into sand by eating them away; and that the sand there is indeed nitrous is sufficiently demonstrated by the sal ammoniac, which is found there most abundantly. See where, in the Fourth Book, we discussed sandy tracts of land at length.

The origin of sands, therefore, comes from nowhere else than the corrosion of a certain sharp liquor, by which stones are resolved into sand; or from the drippings of grottoes, where "the drops hollow out the stones — not by force, but by often falling" [a proverbial line]; and one must reckon that just as much sand has flowed forth from there as the capacity of the cavity within the stone could contain. Or it comes from the agitation of waters running through rocky places, by which the worn rocks are resolved into sand. And this is plain, first, from the gushings of springs, which are everywhere mixed with sands of every kind — sands which indeed reflect the color of the stone, or of the metallic vein, that they wear away.

[Margin: Sign from the color of the sand from which it has flowed forth.]

If they flow through an iron vein, [the color is] black; if through a golden one, golden; if through arsenic and ochre, yellow; if through an aluminous one, white; if through a copper one, green; and so with the rest, they reflect the color. Hence from the sands a judgment can easily be made about the ore through which the sand-bearing waters flow down, as we have taught elsewhere. Marine sand is produced in exactly the same way; for since the sea is in perpetual instability of motion, and rolls its swelling waves continually toward the shores, it comes about that stones, worn by the violent agitation of the sea, are dissolved into gravel, grit, and sandy material. All of which, as daily experience teaches, makes it unnecessary to speak more fully of these matters.

[Margin: Whence marine sand?]

COROLLARIUM I.

COROLLARY I.

From these things, then, it is plain that there are as many kinds of sand as there are different kinds of the ores and rocks which are worn down by the alluvion of the waters; and each of these tastes of [savors of] the nature and property of the whole from which they have flowed down.

[Margin: How many kinds of sand?]

COROLLARIUM II.

COROLLARY II.

Hence is plain the immense yield of gold-bearing sands in some rivers. For since water — especially briny water — flowing through veins of gold, always carries off with it something from the eaten-away shavings, hence it is that springs and the neighboring streams and rivers contain so much the greater quantity of golden sands in themselves, the nearer the rivers are to the springs, or the springs to the gold-bearing channels. But the manner of gathering, washing, and separating the gold from the earthy dregs will be told elsewhere.

[Margin: Whence golden sand in springs and rivers?]

CAPUT II.

De Qualitate Usuque Arenæ.

CHAPTER II: On the Quality and Use of Sand.

Sand, if it draws its origin from a dry stony substance, will be dry; if from bituminous material and thick earth, it will be fat. In a word, sand takes on the nature and property of that from which it was cut off, as we said a little earlier. The sand found at the banks of the Nile is wholly nitrous, as is also that which covers the region of Libya; it is for the most part sterile, and so serves neither for sowing nor for planting nor for plowing — whence the proverb, "He plows the sands."

[Margin: The various qualities of sands.]

Ausonius, to Theon, Epistle 4:

"What do you do, set on the farthest shores of the earth, O Tiller of the sands, Poet, for whom the beach must be plowed?"

And that line of Ovid:

"What are you doing, O Oenone? Why do you commit seeds to the unwilling sand? You plow the shores with oxen that will yield no harvest."

Second: it is useless and unsuitable for sustaining the foundations of buildings — the cause of which is obvious. Yet because no thing in the nature of things is so small and contemptible that it does not at the same time bring great usefulness with it, we will adduce something about the usefulness of sand.

[Margin: The usefulness and harm of sand.]

And first indeed: even though sand does not serve for laying the foundations of buildings, it is nevertheless established that no structure can be raised without sand; for from lime and sand cement is made, which, being necessary for raising buildings, we cannot do without. And the drier and finer it is, the greater firmness it gives when mixed with lime, since, absorbing the moisture of the lime, it is, together with the bricks, as it were turned into stone.

Second: it is necessary for making glass...

Liber VII — Sectio I, Caput II (continued) ...it is: for which see the final volume, *On the Art of Glassmaking [de Arte vitraria]*.

[Margin: For making glass.] [Margin: For sawing marble.]

Third. Sand is useful for sawing marble; for without sand or emery [smyris] — which is likewise a kind of sand — marble cannot be sawn. The grinding action of the saw stirs up the sandy particles, and once excited, by their own hardness they gradually grind the marble together with the saw. For this work, Pliny [the Elder] tells us, Ethiopian sand was once especially valuable. Today the sand found in a certain shoal of the Adriatic Sea, brought up by the force of the tide, has an exquisite use — though nowadays marble is sawn and polished with any sand that comes to hand.

[Margin: For sandglasses.] **Fourth.** Sand serves for clocks, or hourglasses [clepsammidia], which show the hours by their flow — than which nothing is more commonplace.

[Margin: Use in chemistry.] **Fifth.** Sand has a notable use in chemistry, for digesting metallic, mineral, and vegetable liquids over a moderate fire — about which I shall speak more fully in its proper place.

Sixth. It works wonderfully on liquids imbued with bitterness or saltiness, reducing them to sweetness by filtration.

Seventh. Potters, in firing their vessels, generally use a mixture of sand. The crystalline particles of the sand, melted by the violence of the fire in the kiln, strengthen the clay mass remarkably and fortify it against cracking.

Eighth. Smiths make their fire stronger by sprinkling on sand; and in melting metals the use of sand is so necessary that without its admixture they are fused only with difficulty — especially iron and similarly stiff metals. But since the use of sand is necessary to everyone, I think it superfluous to say more about its uses.

[Margin: How sand is distinguished from coarse sand and gravel.] It remains to be said how sand [arena] is to be distinguished from coarse sand [sabulum] and gravel [glarea]. I say, then, that coarse sand is a certain species of sand, distinguished from it only in that it is coarser; it is found both hard and soft — they call the former male, the latter female. It is laid down under flints and crusts of rock and interspersed among them; it serves for paving garden walks. In a

word, coarse sand is for the most part confounded with sand by writers, so that to describe so trifling a thing further would be nothing but wasting time.

Gravel [glarea] too is scarcely distinguished from sand and coarse sand, except that gravel is coarser than both sand and coarse sand. Such are fragments of stones, marbles, flint, tufa, and not-too-large rock; they are found here and there along the banks of rivers, mostly worn smooth into a round or oval, lens-shaped form by the attrition of flowing waters.

[Margin: What is ash?] Something remains to be said about ash [cinis]. Ash is the powder left over from burning, into which a burnt thing is reduced. It stands to the things from whose combustion it results just as sand stands to the rocks and mineral clods from which it falls away. And in this sense lime [calx] is not inappropriately called a kind of ash, though of a finer essence than the ash that comes from wood. [Margin: How many kinds of ash?] All the metals too have their own ashes, which are nothing but that earthy residue which, by the violent force of fire, settles at the bottom of the furnace, either burnt or reduced to lime. And there are as many species of ash and lime as there are of combustible things. [Margin: There are as many kinds of ash as of combustible things.] Stones, as I said, yield lime in place of ash; but the burning of the rest — plants, herbs, shrubs, woods, animals, bones, horns — leaves an ash of the same virtue as the things from whose combustion they remained.

[Margin: The marvelous secret of ash.] There is in the ash of vegetables a thing truly most worthy of wonder: that it contains within itself a salt perfectly suited to the propagation of the very species of plant from which the ash remained. To make myself plain by a single example: the ash of wormwood [absinthium] contains, for instance, a salt which, when extracted from the ash and set in the earth, brings forth the species of plant from whose combustion the ash remained — namely, wormwood. But since I shall confirm these marvels of nature in the various experiments that follow, I have thought it best here not so much to explain them as merely to point them out.

[Margin: The property of ash.] If you ask about its nature, I say it is moderately warm; for all burnt things, as the Philosopher [Aristotle] attests, retain some heat, and the acrimony both of lime and ashes and of animal excrement, and salt itself, plainly teach this. Nor can it be that things burnt and roasted by excessive heat should not have some degree of heat. But let me now set out a few of the uses of ash.

I said a little earlier that not all ash is endowed with the same power, but that it varies according to the power of the burnt material. From this I conclude that ashes left from the hottest burnt things are themselves the hottest and driest. This is clear from the ashes of burnt pellitory root [pyrethrum], which are so vehement in their acrimony that the tongue can scarcely bear them at the first contact. [Margin: The various uses of the different ashes.] Fig-wood ash [cinis ficulneus] is the sharpest, and so is counted among the caustics. Ash made from sour woods is no little astringent, and checks hemorrhages. The ash of trumpet-shells [buccinae] makes a most excellent dentifrice; smeared on burns, it does not fall off until it has formed a scar — for then, as if having duly done its office, it falls off of its own accord. The ash of vine-twigs [sarmenta] has a notable burning power, and mixed with niter and vinegar is a great secret for healing sarcocele. Phrygian ash, on the Philosopher's testimony, makes a most excellent eyewash [collyrium]. Spices fumigated with ash acquire a sharper smell. Gladiators of old, when their limbs were strained, treated themselves with a draught of ash. The ash of pear-wood is an effective remedy against the poison of fungi. The use of ash so pleases the Transpadanes [people north of the Po] that they prefer it far to the dung of beasts. Some think that grapes are nourished by ash sprinkled at the roots of the vines. Ashes not only refresh the soil, but, applied to the roots of plants, they remove the diseases of crops — rust, caterpillars, and the other [diseases] of trees, plants, and crops...

[Margin: Signature: B 3]

they make a hostile [remedy against the] little creatures. The ash of the wagtail [motacilla], turned into salt and taken internally, is an admirable remedy against bladder-stone. The ashes of the ash-tree [fraxinus], on Pliny's report, put serpents to flight if their hiding-places are sprinkled with them. Little cups made from ashes have a most notable use in the chemical art.

PARADOXUM [A Paradox]

Here I cannot omit to unravel an intricate question about ash; and it is this: Whether one and the same vessel can hold equal amounts of ash and water together as it holds of the very most of either poured in separately. For if you pour water onto ash — especially hot ash — the water mixed with the ash takes up only as much space as the ash alone occupied before. This rightly seems a paradox to those unskilled in such matters. Let me explain how it comes about. I say, therefore, that ash, the dryness of its nature so requiring, is exceedingly porous, having its parts barely connected to one another; yet as soon as you pour on water — especially hot — then, behold, by the heat of the ashes the water,

partly dissolved into vapor and partly mixed with the ash, forms a muddy mass, in which the parts that were at first dispersed, now brought together, occupy the least space, on account of the condensation of the now-packed, moistened ash. And so the muddy water, partly dissolved into vapor and partly mixed with the ash, presents nearly the same space that the ash occupied before. Water poured onto cold ash does the same, though with a somewhat greater increase; for the ashy corpuscles, by their excessive dryness, just as they immediately absorb the water, so, their parts bound to one another, they make that packed mud which occupies nearly the same space. But of this experiment I shall treat more fully elsewhere.

Caput III

Pericyclosis Naturae mirabilis [The Marvelous Cycle of Nature]

It was most amply demonstrated in the Fourth Book that the Geocosm is full of subterranean fires and waters. Since this is so, the fires must necessarily act on whatever lies in their path — whether rocks [cautes] or earthy clods [glebae]. These, burnt to ashes — or, what amounts to the same thing, to lime — pass away. [Margin: From lime, or ash, the perpetual origin of minerals through fire is derived.] Lime mixed with the waters it meets makes a lye [lixivium]; the salt of that clod, which when burnt was reduced to lime, is bound up in it. [Margin: From ash, all the species of salt.] The earthy fibers, which are as it were the mesaraic veins of the minerals, draw the salt lurking in the lye, just as those veins draw the chyle, the blood, and the seed. The salt residing in the veins works up a new origin according to the condition of the clods — here of salt, there of niter, elsewhere of alum, in another place a half-mature seed of vitriol — which in the course of time are transmuted into minerals of diverse species. [Margin: Magnetically each one draws to itself what is like it.] Hence at last the water, now coppery, now iron-bearing, now salty, lays down new nurseries [seminaria] of medicinal waters, through the attraction of those earthy masses which, by sympathy, agree with this or that liquor; and from this the diverse mines [fodinae] take their origin. From these, indeed, an infinite progeny of various minerals and fossils springs up.

That this may be understood, it must first be known that fire acts on rocks and on the fossil furniture [of the earth] either immediately or mediately. [Margin: The subterranean Vulcan resolves into lime those things on which it acts immediately.] Acting immediately is the Vulcan who dissolves into lime the things on which he acts; but mediately it acts through vapors and exhalations, which,

penetrating the innermost recesses of the mountains — like the spirits in the human body entering all the veins of the Microcosm — everywhere labor according to the condition of the parts they enter. Secondly, there are generated in the bowels of the earth juices [succī] of diverse kinds, which, mixed with the waters they meet, produce marvelous effects and a marvelous generation of things, according to the nature of the earth with which they are mingled. [Margin: The diverse offspring of juices.] Thirdly, there occur various species of metals and minerals which, when mixed with juices, vapors, and exhalations of differing properties, produce an enormous abundance of fossil substances differing in their whole genus. [Margin: From these the variety of things arises.] Fourthly, there are stones, both common and precious, whose number is beyond count. Fifthly, there are earthy substances, which we call earths. And so from the intermingling of these things, and from the various combination of vapors, exhalations, juices, metals, stones, and earths, is caused that immense and inexplicable variety of things which the earth supplies to us.

These things laid down, let us now look a little more closely at the unceasing revolution of things. [Margin: A recapitulation of what has been said.] That subterranean fire, together with water, is the producer of all things has now been said over and over again. For this fire, acting immediately on rocks, masses, and clods, reduces them to lime or ash. Lime or ash, filled with the salt of the calcined things, joined with any water whatever and concocted by the power of fire, causes either a confused or a perfect mixture. Water, filled with different salts and carried hither and thither through innumerable channels and twisting little hollows, is drawn off from the earthy clods by a kind of suction, and once drawn off it congeals into one body with the clods — each earthy substance drawing to itself that which is more congenial to it in the waters. From these waters, caught in a suitable place, are also born all those juices, whether existing as concretions or as a liquid substance. Hence the rarefied substance — whether metallic or stony — which water, imbued with a sulphurous exhalation or spirit by the power of fire, gnaws, eats away, and dissolves into corpuscles mixed with the water, this same substance it [the water] deposits again in another place in a clod of the same nature...

Liber VII — Sectio I, Caput III (continued); then Sectio II begins

of [the same] nature, drawn to itself by a certain attraction; and there it lays a new storehouse [pennarium] of the metallic vein. And what is said of this one

[substance] is to be understood of all the other salts that are sympathetic to the clods. [Margin: How new mines are formed.] Thus, from the attrition and corrosion of the metallic clods, new mines emerge elsewhere by the conveyance of the water; and from the attrition of stones of every kind, stony or petrifying juices are born, whence comes a new increase of stony veins. But the material — that is, the ash from the eating-away either of the juices, or of the metallic species, or of the bituminous portions, slipping in through the hidden channels of the earth into its fire-chambers [pyrophylacia] — partly furnishes new fuel for the fire, partly confers new increase on the neighboring rocks now burnt. And so by the continuous and perpetual operation of nature [Margin: From ash, the perpetual increase of things.] — that is, by the power of fire, the perpetual ash of burnt things, out of which the lime, according to its condition, [yields] salt, niter, alum, vitriol — these in turn, by the power of exhalations and vapors, joined in the innermost parts either with metallic bodies, or with rocks of differing properties, or with the juices of the earthy clods, make various mixtures; and from the various combination of these in turn emanates that immense variety of things, propagated by a perpetual and unfailing cycle [pericyclosis]. You see, then, how all things first take their origin from the lime or ash of burnt things. But let me now describe more fully the individual species and their generations.

SECTIO II

DE HYLOCINESI GLOBI TERRESTRIS

[On the Motion of Earthy Matter of the Terrestrial Globe]

Id est [That is]:

On the great and perpetual separation of terrestrial matter, accomplished by the motion of sand, coarse sand, and gravel; or, on the resolution of clay, stones, and metallic mixtures.

Caput I

De mutationis Geocosmicae Causis [On the Cause of Geocosmic Change]

That the Geocosm turns in a kind of perpetual motion and in the alternation of changeable things was shown in the Third and Fourth Books. But how this change of terrestrial parts — which we call ὑλοκίνησις [Greek: hylokinēsin, "motion of matter"; the motion of terrestrial matter] — comes about, I have thought it best to disclose here. [Margin: The alternation of things in the terrestrial world is

necessary.] For it is certain, and confirmed by the unanimous judgment of the natural philosophers, that this Geocosm, just as it is constituted of the four elements, so likewise sustains immense and perpetual conflicts and struggles of the contrary elements, and the alternations of things — and this most of all under the ever-changing arrangement of the Sun, Moon, and stars in the celestial expanse, and the periodic revolutions that perpetually agitate it.

What is earthy in the Geocosm is brought about chiefly by water and the blowings of the winds, by a twofold motion. [Margin: Earth, water, and the stars: by whose impulse the changes of things come about.] The water that surrounds the whole globe, dissolved by the force of the stars into an immense quantity of vapors and exhalations, and condensed in the appointed regions, if it passes into drops [becomes] rain; if it freezes, hail; if it turns to snow before it passes into drops. [Margin: Rain, hail, snow, winds: how produced.] Rain, hail, and snow, drawn up from rivers, lakes, and seas, and driven by the violence of the winds onto the peaks of mountains and regions, there lay down those marvelous nurseries which I shall describe, and found the commotions and seed-beds of things.

But the approach and recession of the sea, which we call the tide [aestus], flowing and ebbing twice in the space of 24 hours, drives the water through the subterranean passages, so that it draws along with it an immense mixture of foreign matter and leads it out abroad through springs, brooks, and rivers; and so it constitutes in that ὑλοκίνησιν [hylokinēsis] the marvelous cause of the change of all things in the terrestrial globe. And so the Geocosm is perpetually beset by two, as it were, Morpheuses: the one internal, through the motion of subterranean fire and waters; the other external, through rains, showers, hailstorms, and snows, which are, as it were, the carriers and promoters of terrestrial matter. [Margin: How greatly snow can do in altering the soil.] Snow, occupying the summits of the mountains, not only ferments the earthy substance but also, by a kind of half-yearly maceration, softens the rocky substance. For chemical experience teaches us that there lurks in snow a mixture of metallic and mineral corpuscles, whence these, joined with the mineral juices of the mountains, bring about marvelous generations of things. Melted by the heat of the Sun, together with the showers, it carries off with it sand, coarse sand, and gravel of every kind of mineral species, scraping them away; and these, in turn, entrusted to the rivers, while...

Liber VII — Sectio II, Caput I (continued)

they are incapable of [bearing] so great a mass, where a way is given, spread out by inundation over plains stretched far and wide. Hence it comes about that mountains which were at first fertile, their richer clods scraped away, are left with nothing but their rocky substance; while plains which were at first squalid with sterility, or filled with marshes, are blessed by the arrival of the rich guest with the longed-for fertility. [Margin: Why mountains, at first fertile, in time become sterile.] These, however — since nothing in things is stable — in the course of time, their fertility stripped away, degenerate again into sterility, when, by the soaking of snows and the dissolving of frost, the rocky offspring of the mountains splits into crusts, and, cleft, is crumbled into lean coarse sand and gravel. [Margin: How sterile places can be made fertile again.] This gravel and coarse sand, snatched up by the rains and carried down into the fields, so covers over the fertile mud they rejoiced in that they are no longer fit for cultivation. Yet in time, and in the course of many years, it comes about that the sandy substance, filled with herbs, plants, and shoots, is clothed with trees and woody tracts. [Margin: New principles of sterility.] These, every year — namely in the autumn season — their leaves, fruits, and buds, struck down whether of their own accord or by the force of the winds, fall into the surrounding fields, whether level or mountainous; and so, by the maceration of the winter snows, rains, and showers, turned to rot together with the grasses, they cover the fields with a new skin of rich earth. And since this happens every year, no one fails to see — especially on the banks of rivers — that the earth too is thereby continually augmented and rises layer upon layer. In these banks you will plainly behold now veins of stones, or of coarse sand and gravel, now a heap of sandy or muddy earth which covers the sandy surface like a kind of crust; and so, with the arrival of a new heap of rich matter, the fields, luxuriating in a new conception of fertility, enrich the farmers with great yields. Yet these in time, with a new heap of lean coarse sand scraped from the mountains and carried down by inundation and showers, while it covers the rich matter, fill the fields with a new vicissitude of sterility; and this lasts, as long as the World shall stand, by the perennial law of alternating vicissitude.

Since in seeds, plants, shoots, grasses, leaves, flowers, and fruits there is a great deal of niter, salt, and bitumen, hence, when these falling things are committed to the earth, fermented as it were by putrefaction, they furnish a new material for generating salts and minerals; but above the rest, bituminous substance...

[Margin: Vegetable salts, before non-existent, produce new nurseries of salts.] ...

the aerial regions, raised up partly through the gushings of springs, partly through the external motion of air, water, snows, and rains, it restores to the terrestrial globe by a perennial and unfailing alternation of nature.

We have seen the admirable Cycle of Nature [Pericyclosis Naturae]; now let us set out, by way of questions, the causes of the particular effects which it produces in the terrestrial globe.

It is asked, first: How do new fields and plains arise, now sterile, now fertile? [Margin: How fields are now sterile, now fertile.] I answer: this comes about by the influx of sand, clay, coarse sand, and gravel carried down from the mountains and deposited on the plain; by which also earth, at first marshy, fills up pits and valleys and is leveled into a plain. Or else by the force of rivers running to one or the other side, which on one side they corrode and eat away, while on the other side they compensate by the addition and increase of earth — as may be seen on the banks of nearly every river. And hence it is clear that in the course of time rivers, by the eating-away of one bank and the increase of terrestrial matter on the other, change their channels over time. See what I have said most fully about these things in the Third Book.

It follows, secondly: that from the arrival of coarser coarse sand, scraped from the mountains by the violence of torrents and rains, not only are the fields filled, but the channel of the rivers too is made higher by the heap of flints and rocks. By the increase of these, and by the herbs sprouting from the mud, the water, no longer knowing how to be contained in its own channel, at length fills the more level fields with a new inundation. Yet when these are freed from the marsh-water by ditches or drains, while the sandy material is mixed with the sediment of the inundating waters, they degenerate into the best and richest [soil]. Certainly in mountainous regions, when snow has melted, it is known to all that the water flows down from on high — turbid and thick, mixed with sand, clay, mud, gravel, and other matter that it snatches along with it — through the lower places into the rivers. And not only from the neighboring mountains, but also from those lying off to either side at a distance of several days' journey, the movements of psammorrhea [ψαμμορροία, "sand-flow"] — that is, of sandy matter — convey [it]; for one may often observe the greatest mountains and forests scraped away and carried off by the force of the down-flowing water.

It is asked, secondly: Why does the same river in some places endow the fields born of alluvion with lean sand, but in others with rich mud? [Margin: How fields, in lower-lying places, are generated, and then [turned] into rich mineral-beds.] I answer: in three ways the fields and plains are made now rich, now

sterile. **First**, by coarser coarse sand and lean sand they are made sterile, but by the silting-over of clay and rich mud, fertile. **Second**, they are made sterile by the violent unloading of psammorrhea of the rivers onto the fields; fertile by a gentle flow of matter and by the sediment of rich mud on the level of the fields. **Third**, by [the deposit] of buds, herbs, and leaves falling from the trees and mixed with the earth...

[The remaining columns on p. 331 carry additional marginalia keyed to the sediment/mineral-bed discussion:] [Margin: Sands turgent with mineral juices make the earth wonderfully thick and rich; but from salts disposed by fermentation, and from mineral clods cut from the mountains and carried along by rivers, a new offspring of minerals is born, which at length is entrusted to the sea by the conveyance of the vast rivers. The sea, in turn, augmented and made teeming with all the said species of things, [returns] the entrusted increase, whether through subterranean tunnels, or by the Sun's attraction through vapors into the higher [regions]...]

by the decay of [buds/herbs — *farum?*], which, being rich in fattiness, are converted into a rich, earthy mud and so endow the fields with the fertility one desires.

The third question. How do level fields of sand arise in flat places?

[Margin: How sand-hills arise in flat places.]

I answer: the surface of the plains is leveled when, by flooding, the mud is spread in equal portion once all the hollows and ditches have been filled — just as one sees with snow, which in calm weather, settling gently as it covers the ground, makes the snow-covered surface even. In the same way the psammorrhea, when it is cast over the land without the violence of rivers, spreads the mud and sand uniformly, and from this a flat surface results. Hills, on the other hand, arise in several ways. First, if the fields are filled and heaped up with gravel and sand carried down either from the mountains or from the rivers. For in this way, when a further flood comes over them, the mud clinging to the mounds of gravel forms a kind of crust or skin, which, sprouting into shoots, is bound fast by their roots. Over time, with the muddy matter of leaves and grasses — now rotted and turned to earth — added layer upon layer, the mass of the hills is marvelously increased. To this contribute the gusts of the winds, by which the drier sandy material lying on the fields is stirred up and driven into heaps, eventually rising into lofty hills as the material is continuously added.

[Margin: How sandy hills arise near the mouth of the Tiber.]

This is just what one can see along the seacoast near the mouth of the Tiber [*Ostia Tiberina*]: packed mounds and little hillocks clothed with grasses and shrubs, which, stirred by the sea's washing and by the winds, have gradually grown together into heaped mounds of sand. And in many places along the seacoast a great many mounds of this kind are found.

The fourth question. From what source does the earthy matter of the fields come to display such a variety of colors?

[Margin: Why the earthy mass of the fields displays such variety of color.]

For in some places the earthy substance is wholly black, in others red, yellow, or whitish and ash-gray. I answer that this happens in the following ways. Either it comes from sand in which the leaves of walnut trees, the nuts and their husks, or the growths of oak-galls have rotted and turned to earth, which at once tinges the moisture of the vitriolic earth present in it into the deepest black. Tawny earth, by contrast, has its origin from mountains teeming with ochre, sulphur, or sandarach, which, carried down into the plain, propagate there a tawny or golden earth. As for rust-colored earth, we learn even from its very color that it arises from mountains abounding in copper-bearing clods. Therefore, just as the waters of rivers are variously tinged by the different juices of minerals, so too the fields are filled with sand of whatever color the clod has from which it was scraped off. From what source the different mineral-veins acquire colors of this kind will be shown elsewhere. Black earth is best suited of all for agriculture; it is produced either from grass, herbs, and fallen leaves rotted and turned to earth — by which not only earth, but also (as likewise from the dung of animals) blood, is rendered black, thick, and rich in a remarkable way. Take this as proof of it:

cumuli, which they call *pulvini* (cushions), are found? I answer: this comes from the heaping-up of the sand and mud that the rivers deposit into the sea near their mouths in a gentle and quiet flow; while from the seaward side the winds continually drive the waves toward the mouths and shores. Hence the waves resist, so that the sandy material the rivers roll out into the sea is not spread further; and so the sands, piled into mounds, form those "cushions." From this it is clear that what was once sea is in the course of time taken over by alluvia carried in by the rivers, and is thereby augmented daily by the continual influx of material.

[Margin: How land once sea afterward becomes dry land.]

so that we may safely affirm that the low-lying regions near the sea were once sea, stretched far and wide; and conversely, that where the sea now stands, there

was once dry land. But since these matters have been treated very fully in the books of the First Volume, I have judged it unnecessary to repeat them here.

Having now set out these things — perhaps at greater length than was fitting — nothing remains except to examine, one by one, the lands of the materials we have mentioned, weighing as precisely as possible from what source each one derives its origin, its property, its virtue, and its use.

CAPUT II.

What Earth properly is, from what it is generated, and concerning the various earthy substances commonly called "Earths."

In the primordial constitution of things, the Earthen globe was buried, as it were, in a kind of caul, and was covered on every side by water, as the Sacred Text witnesses (Genesis 1). In it there were as yet no mountains, no valleys, no other distinct elementary body; rather, all things lay squalid and confused, uncomposed, beneath a kind of chaotic mass — until, once light had now been created and the Earth had been struck by the voice of God and the waters had been driven down into their channels, the dry land appeared. Yet it was still under a muddy substance, which nevertheless — by the working of the inner Archeus of fire — at once took on a certain hardness, and finally was molded into a kind of stony skeleton. This was so that the earth, remaining beneath the muddy mass, should not by its own draining-away and dissolution destroy the whole order and fabric of the receptacles and chambers necessary for nature's operations. And so, with the subterranean Vulcan at once at work, that soft mass was shaped by the hand of the Pantoplastes [the All-Former, i.e. God] into various concavities and hardened by the subterranean heat. This was the first stony structure of the Geocosm, established by God to give firmer solidity to the framework of the whole globe. But since in that stony mass there remained innumerable cavities, along with great protuberances of the higher parts destined for the formation of mountains, by the singular providence of God it came about that, while that mud was still unhardened, the said empty spaces and valleys were filled in, and the surface of the whole earthen globe and of the mountains was covered, as with a hide or skin, by this same still-moist and soft mud. In this way that primeval mass became fit to produce — when struck by the voice of God — the shoots of the field, the herbs, plants, sprouts, trees, and fruits; and this took place on the third day of the World. Such was the primordial state of the earthly World.

This being established, we must now see how in the course of time this earthy substance has been augmented, and what varieties it has undergone through the varied influence of the Sun, the Moon, and the stars, and likewise of the subterranean fire and waters — and what Earth itself is according to its essence. For once these things are known, I am confident we shall easily arrive at a knowledge of the hidden workings of the Geocosm.

First, however, I want the reader to know that here we do not take "Earth" to mean that simple, uncompounded earthy body which the natural philosophers are accustomed to call an element — and which, as I denied above, we hold not to exist in the nature of things — but rather, properly, the elementated earthy substance, which we define thus:

[Margin: Definition of Earth.]

Earth is a mineral body [*corpus fossile*] which, when moistened by something wet, first softens, and then, with further moisture, becomes liquid. By this definition all those things are excluded which, though they soften when wetted, do not become liquid — such as paper, wool, and the like. Excluded too are stones and metals, which, when water is poured on them, neither soften nor melt. Therefore take it as certain that whatever is dug up, and on the addition of moisture first softens and then liquefies, is to be called Earth in the proper sense.

The first question, then, is asked: **How is this earth generated?** To resolve this difficulty, one must know that this earth can be generated on the outer surface in two ways and by two methods.

[Margin: The third generation of earth(?) [*Tertia generatio* — χθονογένεσις (chthonogenesis, "earth-generation")]]

First, this earthy substance is generated in the manner stated a little earlier — partly by the wearing-down and corrosion of stones and of clods of minerals, and partly by that of the rains, downpours, and waters, or of streams gliding through the channels of the mountains. By this action the sandy stones and the friable substance of the mineral clods are eaten away and carried off by the force of torrents and rivers: partly led down into the flatter places, partly clinging to the cavities of the mountains and to the rough slopes and crevices, and gradually turning into earth, it sprouts into herbs, plants, shoots, and trees — which is nature's one and only purpose in the lands. In this way sandy earth arises. Besides this, there is the earth which is scraped by the river's course from the walls of the banks, and which partly settles to the bottom, partly is carried out onto the fields by the river...

driven off by the force of the waters, lays down nurseries of new earthly matter.

But this method seems by no means sufficient to account for the whole process of earth-generation [χθονογένεσις]. For since this earthy matter is found over the entire surface of the earthly globe — being indeed that without which the cultivation of the earth would be useless — it must be held, by a sure and infallible argument, that there exists some other earthy substance besides the one that comes from the detritus of stones and the carrying-in of rivers. For we see, in plains stretched far and wide, in places overgrown with tamarisk and heath, where there are neither mountains nor rivers that could bring in heaps of fallen sand, that abundant and very rich earth is found. And granting that some such places are watered by rivers, I nevertheless say that these places — just as they lack the barriers of mountains — are likewise, because of their flatness, not so liable to floods, and consequently do not draw in the sands and mud by which the vast expanse of the flat fields could be filled.

[Margin: How earth is generated in flat places(?) [*Ex plani...ebus ma...*]]

Indeed, experience teaches that ditches dug in plains of this kind are, after the passage of some years, filled with new earth. From what source, then, this kind of earth — which arises neither by the carrying-in of rivers nor by the abrasion of mountains — comes to be born, must be investigated.

Again, in the plains of very high mountains — indeed on the very summits, where some are furnished with a level place, as I have very often had occasion to observe — a most abundant and very rich clod of earthy matter, most fit for pasture, is found. Yet it cannot have been gathered and heaped up either by the wearing-away of the mountain rocks or by the corrosion of rivers, which are by no means found there. Indeed, if you dig up the earth, you will always find new earth upon new earth — not caked into sandy crusts, not divided by gravelly and pebbly seams, but consisting in an even and homogeneous extension of its parts; unless, however, the earthy [matter] has been disturbed by the intrusion of clods of various minerals [χθονογένεσις/ἀλλογένεσις? — ἀλλογενῆσις? printed γρ.; "of-foreign-generation"], in which case it will generate black, yellow, or somewhat dusky earth, as will be said later. From what source, then, this kind of earth — which is produced neither by the wearing of waters nor by the corrosion of mountains whose rocks are dissolved into sandy particles — obtains its origin, we must inquire with all the keenness we can.

[Margin: Rotted herbs, grass, and leaves turned into earth by rains and snows.]

I say, then, that this can come about, first, from the annual decay of the grasses, herbs, shoots, leaves of trees, and the like scattered by the winds, which spring up in rich growth both in the said plains and on the higher levels of the mountains. Once turned at last into earth, these augment the earthy matter, made fertile by the salt and fattiness implanted in them. And just as this happens every year, so it is likewise necessary that the plains be enriched by the increase of new earth. For that the earth is moistened by the Sun, the grasses, the plants, and the winter snows or rains — and that the leaves, grasses, and herbs softened and rotted by the winter rains or snows are turned into earth, around the beginning of November — this experience teaches; and indeed it is so commonplace that I am ashamed to say more about it. But that the earth contains within itself the implanted seeds of grasses and plants — the following experiment will show.

EXPERIMENT I.

Fill a glass flask halfway with the purest earth, contaminated by no admixtures of other seeds, and in springtime expose it to the air in a very high tower, far removed from dusts laden with various mixtures of seeds; fit it with its lid furnished with a tiny hole through which the air can penetrate. After a month's interval you will find that the earth has produced a plant of the kind that is native to your region — clear proof that something lies hidden in the earth that produces plants. This we say is nothing other than the fertile power of the salt of the earth mixed in, by whose help the earth, when watered and quickened by the Sun's heat, soon bursts forth into shoots. All of this is greatly promoted by the salt implanted in the rotted grasses and plants, which of its own nature is inclined to regenerate that which had been in the living grass.

[Margin: A plant, or its seed, can be drawn out from the salt drawn from a plant(?) [*Sal herbarum extractus seminatur... herbam herba(?)*, *ex qua extractus fuerat, sal producit(?)*]]

For if you reduce some herb (as we said earlier) to salt, and extract the salt and put it into the earth, it will produce an herb of the same species as the one from which the salt was drawn — as the following experience has taught me. Concerning these miracles of nature I shall speak more fully in their place in the following books. But since in many places where there are no trees to supply fallen leaves to the earth — indeed, within the crevices of mountains and the innermost bowels of the earth — earth of this kind is everywhere found to grow, it now remains to be explained [how].

[Margin: How earth is generated within the crevices of the mountains and the summits of the mountains.]

In the preceding books we taught at length about the inner economy of the Geocosm, agitated by the force of the subterranean fires with perpetual exhalations and vapors, which, with great impetus, perpetually breathe out from the tubular substance of the earth and the mountains, and through the innumerable fibers and crevices by which the Earth is perforated — no otherwise than the human body is full of capillary veins. Hence it comes about that the vapor mixed with exhalations, within the said crevices, fissures, and passages, always carries off with it something scraped from the stony or mineral substance; and this, afterward condensed within the said passages, or on the mountain summits as moisture is added, passes into earth of the same species as the stones or minerals it has worn away. For, as was said above, if anyone makes a ditch in the level of the said earth, he will find it filled with new earth after some years — for the moisture, with soot added, forms a mud, by which the earth is augmented by a perpetual addition. But since these things cannot be better proved than by experiments, we present the following to the reader.

EXPERIMENT II.

On the generation of earth in flat places out of the mountains.

Diagram. A pot-bellied glass vessel (an alembic-like cucurbit) with a narrow neck, set upon a grate over an open fire; flames rise from below and a small plume of vapor issues from the top of the neck. The figure is uncaptioned and illustrates Experiment II.

Take a pot-bellied vessel furnished with a narrow mouth, fill it halfway with ordinary earth, then set it over a fire and let it give off its exhalations. The earth, having taken in the heat, will at once be resolved into smokes mixed with vapor. When this has been done, you will find around the narrow part of the mouth a kind of niter-like material, which had accreted to the vessel out of the little bodies of the smoke and vapor condensed there. And this, when ground up, will at once reproduce — in odor, in taste, in color — the earth from which it had been drawn out. It is therefore clear that in the same way, on the surface of the earthly globe, earth is generated from the smokes and vapors concreted at the mouths of the earthly pores; for these, afterward diluted by rains and showers, pass into earth properly so called. And since smokes and vapors of this kind endure perpetually, it follows of necessity that the effect proceeding from them is likewise perpetual.

CAPUT III.

From what source so great a diversity of Earths arises.

In this place the true cause of so great a variety of Earths must be explained. That this may be done with greater method, we shall first set out a few species of earths.

Earth, considered simply — if you consider its primary and secondary qualities — is as follows:

It is either:	Simple(together with the means / intermediate degrees between them)	If you regard its substance:	Thin, dense.Rare, [dense].Soft, hard.Heavy, light.
		If you regard its colors , it is either:	White, black.Yellow, ash-gray.Red, purple.Green, somewhat reddish.
		If you regard its taste:	Sweet, bitter.Sharp, tasteless.γλυκόπικρος [Greek: glykopikros, "bittersweet"], harsh/austere.

These, then, are the differences of earths, which are partly simple, partly compound — either mixed with mineral juices (as their colors show) or infected with stony filings. These, mixed and combined among themselves, exhibit an almost innumerable variety of differing earths. For if you combine the 12 simple differences of earth among themselves, there will arise 479,001,600 differing mixtures of earth, as appears in the margin; and as has been amply shown in our *Ars Combinatoria* [the *Ars Magna Combinatoria*], by which, if you join the metallic earths to them, there will then be no [end to the] number of Combinations. So you need not wonder that so great a variety of things, and so great a multitude of differing earths, is found.

[Margin / table — factorials (the "Combinations"):]

n	Combinations (n!)
1	1
2	2
3	6
4	24
5	120
6	720
7	5040
8	40320
9	362880
10	3628800
11	39916800
12	479001600

Having set out these things in passing, let us now proceed to that which we promised at the outset — that is, to investigating the causes of so great a variety.

The question, then, is asked: from what source do so great differences of the species of earths derive their origin? That I may solve this question as deeply as possible, I suppose, first, from the earlier Books, that subterranean Fire is diffused through the viscera of the entire Geocosm, animating all things by its power. I suppose, second, that in the inmost bowels of the earth there are diverse substances — whether earthy, or stony, or mineral — upon which the fire acts continuously. I suppose, third, that these materials, agitated by the fire, emit abundant exhalations and smokes, that is, vapors, from themselves. I suppose, fourth, that the whole Earth is tubular, veined, and furnished with innumerable fibers running through the entire body of the Geocosm.

These things being laid down, I say that a twofold exhalation-and-vapor can here be considered: one which is excited by the subterranean fire within the bowels of the earth; the other which is drawn up by the attraction of the Sun out of the earthy portions, out of the Ocean, the seas, the lakes, the rivers, and the pools, into the higher regions of the air. It now remains for us to prove that each of the two is fit for generating earth. And so, that I may begin from the manifold concurrence of causes in the generation of earths — I say, besides the cause already stated in the preceding pages, that many more concur [in the *χθονογένεσις*, the earth-generation], and that earth can therefore be generated in diverse ways.

[Margin: The first mode of generation of earths.]

The first mode of $\chi\theta\omicron\nu\gamma\acute{\epsilon}\nu\epsilon\iota\varsigma$ (earth-generation) is caused by the diversity of the earth lurking in the womb of the Geocosm, whether pure or mixed. If, then, the subterranean Heat acts upon earth of this kind that is pure... ..pure [earth], the earth itself, thinned out, emits exhalations from itself. These are the driest little bodies. When the earth is thinned by the force of heat, these particles are dissolved and led off through the cracked fissures, clefts, and veins of the earthy mass. Wherever they encounter a moistening stone or earth, they mix with it and are converted into an earth of the same property as the earth from which they exhaled. But if a more impure earth, thinned by fire, has been dissolved into smoky particles, those particles, joined to a moist vapor within the hollows or clefts of the mountains, will generate an earth of the same property as the impure earth: if the earth was pure, a white earth; if impure, a clayey earth and the like; and if exhalations of this kind from a bituminous earth have been mixed in, then a rich and combustible earth will be generated, in proportion to a gentler or a more vehement heat.

The second mode depends on the configuration of the places, or of the underground siphons. For if the exhalation of the earthy masses passes with great force through the narrow and constricted paths of the channels, it will always strip something away by corrosion from the masses—whether stony, mineral, or earthy—as was made clear by the earlier experiment. From this the exhalation, carried up to the surface, will generate an earth filled with little stones, sands, and scaly clods. But if it passes through caverns, then, mixed with moisture, it will produce an earth of the nature of the cavern itself, filled with minerals. [Margin: The second mode.]

The third mode depends on the mingling of the exhalations and vapors. For from these, when well mixed, there is born a rich earth, well compacted and without fissures, cohering throughout; but from the same when not well mixed there is born an earth utterly contrary to the former—gaping, full of fissures, and riddled with pores. [Margin: The third mode.]

The fourth mode. If the exhalations pass through the fibers of mineral matter, then, joined to a binding vapor and proceeding along the usual fibers, they will produce—in proportion to the minerals—an earth: here coppery [aerosam] and green, there sulfurous, elsewhere ferruginous [ferrugineam], somewhere saline or nitrous or aluminous or vitriolated or mercurial, and so on with the rest. [Margin: The fourth mode.]

The fifth mode depends on the power of the Sun. For the Sun, striking with its heat the outer surface of the Geocosm, dissolves the earthy portions into exhalations and the moist portions into vapors; and just as from the exhalations a great mass of salty little bodies, so from the moist portions a great mass of vaporous little bodies is borne up into the highest regions of the air. There, condensed and driven by the force of the winds within the ridges of the loftiest mountains and over the plains of the earthly regions, it is able not only to augment the earth but, over the long course of time, to generate it. [Margin: The fifth mode.] For just as the earthy substance is dissolved by the force of fire into dry particles, of which the exhalations or soots consist, so the moist substance is dissolved into watery particles, of which the vapor consists. [Margin: How earth is generated from exhalations of vapors, both inside the earth and outside it.] And indeed the smoky soot, kindled by antiperistasis [antiperistasin] in its proper region—either beneath ignited coal or in the form of some other burnt matter, falling down—is restored to the earth and converted into it. [Margin: ...made into...] [Lacuna: a short clause set in the margin is partly cropped here.] The vapor, however, snatching up along with itself a varied mixture of earthy matter, is dissolved in the upper region and, through rains, snows, and hail, the earthy portions implanted in the vapor are likewise returned to the earth and converted into it by a perpetual cycle [pericyclosi].

Nevertheless the first mode—by which, through subterranean fires, the earthy substance is dissolved into exhalations—is the more genuine one for the generation of earths. But lest anyone should perhaps seem to contradict this reasoning of ours, I have judged it right to confirm it by the following experiments.

Diagram. An apparatus for demonstrating earth-generation, set over a fire. At the bottom, a broad cooking-pan or crucible (**A**) sits upon a grate over burning coals; flames (**V**, **S**) rise around it. Above the pan, suspended, is a bell- or dome-shaped receptacle (**B**), into which several small tubes are fitted (**C**, **D**, **E**), tapering to fine points at their ends. The whole assembly rests on a hatched base-board. The pan is filled to its middle with somewhat moistened earth; as the earth is dissolved into exhalations, these pass up into the receptacle and condense as soot in the tubes.

- A (lower vessel, in the pan over the fire): the crucible *tigillum*, filled with moistened earth
- B (upper, bell-shaped receptacle): the dome-shaped receiving vessel
- C, D, E (small tubes fitted into the dome): the fine exhalation-tubes

- V, S (flames at the base): the fire and coals

EXPERIMENT. [Margin / heading.]

Showing the cause of earth-generation [χθονογενέσεως] to the eye.

Set over a fire a broad crucible **A**, filled to the middle with any somewhat moistened earth. Above the crucible let there be suspended a receptacle **B**—made of fired clay, of iron, or of any other material whatsoever—formed in the shape of a bell, into which small tubes **C D E** are fitted, finer toward their ends. Then, with the fire **V** kindled and the coals **S** heaped around the crucible, at once the earth, dissolved into exhalations and passing into the receptacle, will there—inserted into the tubes—pass off into soot; and this soot, joined to a vapor, will pass off into an earth of the color and quality that the earth placed in the crucible possesses. [Margin: The variety of earths is tested by the experiment.] For if the earth was white—like chalk, Samian earth, and the like—it will pass off into white soot; if it was a rich and bituminous earth, into black; if sulfurous, into tawny; if coppery [aerosa], into green soot; and so the same judgment holds for the rest. These soots, then, joined together with moisture, degenerate into an earth—the very earth from which they exhaled. For exhalations of this smoky kind, driven through the pores and innermost fibers of the earth and lying hidden on the surface beneath an imperceptible dust, degenerate into earth through rains, dew, frost, and snow.

In just the same way the chemists, by means of the said instruments, are accustomed to find soots, tutties [tutias], and metallic flowers within their receptacles and bell-shaped cones; and at times they likewise find from similar soots a great abundance of mercury [hydrargyri], which is a plain sign that this lay hidden within earthy and combustible substances. For what else...

[Printed page 337 — recto. Running header: HYLOCINESIS GLOBI TERRESTRIS.]

are the soots of chimneys but the lightest little bodies, separated by the force of fire from the vapors of wood and other combustible things, packed together on the walls of the chimneys—the substance we call soot, which, kneaded with moisture and then dried out, presents a black earth. [Margin: Why so great a variety of earths in one and the same region.] [Margin: Description of Samian earth.]

COROLLARY I.

From these things it is clear whence the metalliferous earths derive their origin. For many people are amazed when, now here, they find a salty, or nitrous, or

aluminous, or vitriolated earth; now another kind elsewhere; sometimes a whole region wholly congealed with sulfur; sometimes another place filled with bitumen or naphtha, with red ochre [rubrica] or yellow ochre, and so on with the rest. Yet if these people knew the process of nature, they would cease to wonder. For since superficial earths of this kind have, in their innermost recesses, an abundance of the very materials they exhibit, and since these materials, dissolved into exhalations by the force of heat—just as like always and successively generates its like—are likewise exhaled through the pores and fibers of the earth and propagated all the way to the outermost surface by a continued heaping-up of soots: therefore, even if imperceptibly, they nevertheless augment by their accession and accretion the outermost earth, of whatever species it may finally be.

COROLLARY II.

From this it is likewise clear how it is that rocky mountains, which are worn down by the perpetual ravages of rains and snows, nevertheless do not appear to have diminished over so many thousands of years. [Margin: Why mountains, though perpetually worn down, are not diminished over so many years.] The reason is that the sooty exhalations, propagated through the innermost fibers of the mountains all the way to the outermost surface, there—by means of a petrifying juice, or of an ambient moisture mixed with the same—accrete to the rocks. But of these things a fuller occasion for discussion will be given in what follows, when we come to reason about the genesis of stones.

CAPUT IV.

On the Use of the Various Earths.

The earthy substances we touched on a little earlier have an altogether manifold use among the practitioners of the various arts; these uses we shall set out in order. And first of all there are some highly esteemed by physicians on account of the remarkable virtue they possess against poisons.

USE THE FIRST

Of certain earths in medicine.

Among the other earths, the most celebrated at all times have been: Samian earth, Lemnian earth, Armenian bole [Bulus armenus], and—in later times—Maltese earth [Melitensis], Majorican, and the like, which are to be treated of in order.

Samian earth, so called from Samos, an island of the Archipelago [the Aegean], in which it is dug, in Theophrastus's [Theophrasti] time had a vein extending lengthwise, two feet in depth and much greater in width. On either side the earth was hemmed in by rocks, from which it was separated. In the middle it had a vein of the finest quality, like marrow; then other and still other veins, marked off by a stony bedding, yet of intermediate virtue and inferior. Two species of this earth, moreover, were found in the Samian pits, according to Dioscorides [Dioscoride]: one called by the name *Collyris*, the other *Aster*. The former cured infirmities of the eyes, and was deservedly called most excellent—κατ' ἐξοχήν κολλύριον [Greek: kat' exochēn kollyrion, "an eye-salve par excellence"]. The other, *Aster* ["star"], was so named either because of a star-shaped figure impressed on it, or because of little golden grains of sand, shining like stars, that were seen inset within it. [Margin: Samian *Aster* differs from Samian earth.] Those people are mistaken who confuse this most white Samian earth with the Samian *Aster*, that is, with talc; for, as they say, the two differ "by a whole sky"—of which elsewhere. Both are astringent...

[Printed page 338 — verso. Running header: LIBER SEPTIMUS, Sect. II.]

I hear that the secret and guarded place is kept under watch; nor may anyone take anything out of it under penalty of death, except those whose office it is to dig it out and to form it into lozenges [trochiscos] stamped with the seal of the Pasha [Bassae], the Vizier [Vezirii], or even the Emperor's [Imperatoris] seal. So that many doubt whether this Sealed Earth [Sigillata terra] is the same as that ancient Lemnian one. For my part, even if it is not entirely the same, at least it is not of a wholly different nature, as is recognized from its effects—since it too shines with a red color no differently than that ancient earth; and from this they used to call it red ochre [rubricam], and "tinged with the blood of a goat," which, however, Galen [Galenus] derides as an old wives' tale of the common folk, but proves by many arguments that it consists in its native redness—the same redness of which the sealed earth of modern times also consists. [Margin: The medical virtues of Lemnian earth.] Its medical virtues are today the same as in the ancient earth. For against deadly poisons it has the virtues of an excellent antidote when drunk with wine; it expels poisons that have been swallowed by vomiting; and it heals the lethal stings and bites of serpents. But of its virtues and medical use, see Dioscorides, Pliny [Plinium], Galen, Matthiolus [Mattioli], and others.

Cardanus [Cardano] asserts that a sealed earth endowed with the very same virtues can be made by art, if one reduces common clay to a powder, [mixes it]

with water of *scordium* in which juniper seeds have been boiled, [bakes it] under fire, and shapes it into lozenges. Not long ago, Christoph Schorer [Christophorus Schorer], prefect of the territory of Lucerne, sent me from Switzerland—where it is dug—an earth similar to the Lemnian, which he holds to be the true earth described by the ancients. On account of the excellence of its virtues, he writes that a certain fellow-citizen prolonged his life to a hundred years by it. But on to other matters. [Margin: Armenian bole and its virtues.]

Armenian earth, which they also call **Armenian bole** [bolum Armenum]—that is, a clod brought from Armenia—although it presents the appearance of a stone, is nevertheless quite soft and friable; and because it dries very powerfully, therefore, according to the opinion of the physicians cited, it cures gripes [tormina], colic, dysentery, hemorrhage, rheums, and phthisis [consumption]; in pestilential diseases, ulcers of the lungs, and asthma it is wonderfully helpful. Against corrosive poisons too, such as those of cantharides, and against the putrefying poisons of the sea-hare [*lepus marinus*], it is a remedy—not so much by its dryness and fineness as by a certain specific virtue and salutary quality. But since the said earth can be debased by the manifold fraud of merchants, careful attention must be paid to how the false is to be distinguished from the true, and by what signs; on these matters consult the pharmacists.

Maltese earth [Terra Melitensis] is endowed with exactly the same faculties as the preceding, and is dug out from certain districts of the island of Malta near the sea, not far from the old city and by the grotto of St. Paul [cryptam S. Pauli], from which I myself dug out with my own hands no small quantity, together with glossopetrae [glossopetris, "tongue-stones"], of which most fully in their place. [Margin: The earth of St. Paul on the island of Malta.] This earth is most white, and is stamped with various figures of saints; it has a great power, in driving off whatever diseases are infected with a venomous quality, not so much by a natural [power] as by the privilege and benediction of St. Paul [Divi Pauli]—imparted to it, as one may piously believe—and with this virtue it is endowed.

[Margin: Various species of earths.] There are also other species of earths—for example: ochre [Ochra], red ochre [Rubrica], *Sile*, Eretrian earth [Eretria], Chian earth [Chia], *Selenusia*, Cimolian earth [Cimolia], *pnigitis*, Melian earth [Melia], *ampelitis*, Puteolan dust [pulvis puteolanus], chalk [Creta], clay [argilla], Apulian mud [Lutum Apuliae], *Myrrhi*, porcellaneous earth [Porcellana], Majorican [Majorica], Tripolitan [Tripolitana], and innumerable others, each of which has for the most part taken its name from the places in which they are dug.

[Margin: Ochre.] **Ochre**, called *Sile* by the diggers, is a tawny fossil earth, not unlike orpiment [auripigmentum], now of a yellow or somewhat-pale color—called ὄχρα [Greek: ōchra, "ochre, pale-yellow earth"] by the Greeks—and is reckoned among the pigments; and it is both native and artificial. [Margin: Red ochre.] The native kind is found not only in metallic [veins] but also in its own proper veins, especially in copper and lead mines, of which kind there are in very many places of Europe, and most of all it is dug in Germany. This ochre, then, is made in various ways. [Margin: How ochre is made.] First, lead is cast into an oblong glass flask, the flask is set upon a furnace, fire is applied beneath, and it is cooked for so long until the ochre has taken its color—the color which painters mostly use. In Germany I observed it made thus: they burn the lead and steep it, then burn and steep it again, and by this continued and repeated labor until they arrive at that color suitable for pigments which they desire. It is also made from red ochre [rubrica] in new pots smeared round with clay—everywhere of a quality so much the better the longer it is dried in the kilns.

[Margin: The transmutation of ochre into red ochre.] Now these two earths, ochre and red ochre, seem to be transmuted into each other by a kind of reciprocal conversion. For from burnt ochre is made the friable [saltilis] red ochre which workmen use in marking lines, when a cord soaked in red ochre of this sort is snapped against wooden boards and beams by vibration. But since ochre is turned into red ochre by the action of a vehement heat, I do not see how it could be turned back from red ochre into a less intense color. Therefore I judge it to be a sheer and downright illusion of the eyes, by which, when they cook ochre out of red ochre, they are deceived by the disparity of the colors. [Margin: Various species of earths.]

[Margin: Paretonian dust.] **Paretonian dust** [Pulvis paretonius]—what it truly and properly was in former times, since Pliny and Vitruvius [Vitruvius] disagree with each other, so likewise to this very day what species it was is unknown. This much is known: that it was most used by painters, and was brought from Egypt and the island of Crete.

Concerning Puteolan dust [pulvis Puteolanus], which turns to stone when immersed in water, more will be said at greater length in the following Section. For now let us proceed to describe the other species of earths.

Earths Useful or Useless to Agriculture.

Nine species of earths are found, observed by farmers, which are afterwards subdivided by a manifold variety of kinds; for the earth is either:

1. Rich or lean [Pinguis aut macra]. The former [the rich] is by nature sweet, fertile, uniquely desirable to farmers, fit for producing all crops, and moderately black.

2. Lean [Macra]...

[Printed page 339 — recto. Running header: HYLOCINESIS GLOBI TERRESTRIS.]

The following table sets out the nine species of agricultural earths with their characteristics and the crops each favors. (The first species and the opening of the second are carried over from the foot of the preceding page.)

No	Species	Character and suitable crops
1	Rich or lean [Pinguis aut macra]	(Rich:) sweet by nature, fertile, uniquely desirable to farmers, fit for producing all crops, moderately black.
2	Lean [Macra]	Lean, by contrast, since it has contrary qualities, is either beneficial or [harmful] accordingly.
3	Rich and thin [Pinguis & rara]	Rich and thin—both for its goodness, and because it is easily ploughed—is especially welcome to farmers.
4	Rich and dense [Pinguis & spissa]	This, even if on the one hand it promises a yield by its richness, on the other is difficult to cultivate and of less desire.
5	Lean and dense [Macra & spissa]	This, on account of its stony clods, promises its cultivators nothing much besides thorns and caltrops [thistles].
6	Moderately rich [Pinguis mediocriter]	Of the seed-kinds it loves spelt [filigo] and barley most; of legumes, the broad bean, flax, chickpea, hemp.
7	Moderately lean [Macra mediocriter]	It loves lupines and oats; unsuited to bearing crops of richer juice.

No

.	Species	Character and suitable crops
8	Moderately dense [Spissa mediocriter]	It loves turnips, radishes, oats.
9	Moderately rich [Pinguis mediocriter]	Most suitable for sowing all crops and legumes.

And these species of earths are either sweet or bitter, sharp or harsh; and as to colors, they are black or white, yellow or red, dusky or ash-colored. From these signs farmers chiefly infer which plant of whatever kind a given earth especially craves. But earths imbued with metallic juices and mixtures, since they eat away the roots of plants and induce corruption, are rejected by farmers. Sandy earths, too, and those filled with gravel and grit, just as they are suited to bringing forth thorns and caltrops, so likewise are for the most part rejected by farmers as useless.

[Margin: Why wheat or barley is sometimes transplanted into spelt and oats.] And from these things it is clear why wheat or barley, when sown in certain soils, is converted into spelt, and in others into oats. The reason is ready at hand: since these two grains crave the richest soil, it happens that in a meager and sterile field, filled also with metallic juices, they do not find the sufficient moisture they need; and therefore, with their nourishment failing and their roots consumed by the sharpness of the juice, they must of necessity degenerate from their natural goodness and decline, their seed degenerating. But which earth is fit for sowing each particular thing, the farmer may recognize from the herbs springing up there, by using these rules: [Margin: By what signs it is known which earth is fit for sowing what.]

First. If any field of itself produces black, bitter, and meager herbs, you may say that the earth is of the same property.

Second. If you find it abounding in rushes, reed, sedge [cyperus], and the like, they call it a marshy [uliginosam] earth, choking the seed with abundant moisture.

Third. If it produces buckthorn [rhamnus], Christ's-thorn [paliurus], and thorny offshoots, you may say it is most difficult to cultivate, inasmuch as it burdens the rakes and ploughshares with huge clods; but otherwise it is not unfit for sowing crops.

Virgil [Virgilius] indeed, in the *Georgics*, admirably describes the qualities of earths, which I have thought it would please the reader for me to set down here. And concerning the temperaments of earths he writes thus (*Georgics* 2): [Margin: *Georg.* 2.]

Nor truly can all earths bear all things: By rivers grow willows, and alders in thick marshes; Barren ash-trees [orni] are born on rocky mountains; The shores rejoice most in myrtle-groves; and finally open Hills Bacchus loves, the yew the north wind and the cold.

[*Georgics* II.109–113, here lightly compressed.]

[Margin: *Georg.* 1.]

Here crops, here vines come up more happily, Elsewhere the increase of trees, and the grasses grow green unbidden.

[*Georgics* I.54–55.]

Concerning the signs of lean and rich earth, of thin and dense, of salty and bitter, of moist, heavy, light, he sings thus: [Margin: *Georg.* 2.]

Difficult first of all are the earths, and the malign hills, Where there is thin clay and gravel in the brushy fields; [Yet] they dare to bear the Palladian woods [the olive] of the long-lived olive. A sign is, in the same tract, the wild olive [oleaster] springing up Most plentifully, and the fields strewn with wild berries.

But where the soil is rich and glad with sweet moisture, And the plain frequent with herbs and fertile in its richness— such as we often look down upon in the hollow valley of a mountain— here streams are snatched from the topmost rocks and draw down a fertile slime; and that ground which, raised toward the South wind, feeds the fern hateful to the curved ploughs.

[*Georgics* II.179–189, with minor variants in the source's text.]

Concerning the marks of a black and fertile earth he sings thus:

An earth that is generally black and rich beneath the pressing ploughshare, and whose soil is crumbling—for this is what we imitate by ploughing— is best for grain.

For indeed the hungry, sloping subsoil of a stony field scarcely furnishes the lowly bees with lavish casia and rosemary; and the rough tufa and the chalk eaten away by black water-snakes [chelydri]...

[the earth] that yet breathes out mist and flying smoke, and drinks in moisture, and—when it wills—gives it back from itself, and which always clothes itself in its own green grass, and does not harm the iron with scurf and salt rust: that earth shall weave for you broad elms with vines, that is fruitful in olive, that you will find by tilling kindly to the cattle and tolerant of the curved ploughshare. Such land does wealthy Capua plough, and the shore near Vesuvius's [Vesuvius] ridge.

[*Georgics* II.203–224, abridged; here the source telescopes several lines.]

Concerning a dense and thin earth he sings thus (*Georgics* 2): [Margin: *Georg.* 2.]

Now in what way you may distinguish each kind, I shall tell: Whether it be thin, or denser than is right, you should ask— since the one favors grain, the other Bacchus [the vine]; the denser more for Ceres [grain], the thinnest all for Lyaeus [Bacchus]. First you will choose a spot with your eyes, and order a pit to be sunk deep into the solid ground, and you will replace all the soil again, and level the surface flat with your feet. If [the soil] falls short, [it is] thin, and more apt for cattle and the kindly vines; [if it overflows...]

(continuing *Caput IV*, "*De Usu variarum Terrarum*" — the agricultural uses of earths, after the Virgilian pit-test for soil density)

For this reason such earth must also be broken open every year with the plough, combed apart with the harrow, and turned over thoroughly up and down, so that by this treatment the individual parts may be tempered to an even balance, and the whole rendered uniformly good for germination once the seed has been cast in.

The second question. Why does manure [fimus] contribute so much to making earth fertile? And why manure of one particular kind rather than another? For there are certain kinds of manure that do not so much fertilize the earth as scorch it, as the Poet rightly says (*Georgics* I [I.77–78]):

A crop of flax scorches the field, the oat-crop scorches it, and poppies steeped in Lethe's sleep scorch it too; yet the labor is light if alternated, etc.

The cause of the fertility that fields acquire from manure is the very fermentation of the excrement in the stables, which the saline and nitrous spirits, as it were, concentrate.

[Margin: How fattening matter is generated in the earth.]

For just as urine, mingled together with the excrement of animals, is utterly full of salt and niter, so — when dissolved in a damp place, as we have shown in the case of salt and niter — it acquires a certain fatness [pinguedo], which is drawn out by sympathy from earth filled with a like fatness. And so the earth, augmented by this doubled fatness, if it is already rich of itself, soon runs riot with an abundant production of seedlings; but if it is rather lean, it is imbued by the external fatness of the manure with as much richness as suffices for bearing crops. This fatness is plainly demonstrated by manure-pits, whose surface is always covered with a kind of greasy film painted in various colors — the signs of latent salt and niter. You will find this same film, in time, in the excrement of any animal soaked in water and thoroughly mixed.

The third question. From where does the earth always draw what is most suited to itself? To grasp this, it seemed best to begin a little further back. I say, then, first, that the earth possesses a certain magnetic power [vis magnetica] — not that power by which iron is drawn by the magnet, but the power by which, according to a certain analogy, like is drawn to like.

[Margin: In what this power consists, by which like draws like.]

This magnetism the admirable providence of the divine Architect of the Cosmos [Cosmotectus] handed down and implanted in the whole globe of the Earth, for the purpose of perfecting the generation of things — to this end: that things heterogeneous might be separated from things homogeneous, and these from those, and that things might be joined in friendly fellowship by their kindred nature [syngenia] for the good of nature, the heterogeneous being avoided. For just as everything dry draws by a natural force innate in it the moisture suited to it, so everything fixed draws its own volatile component. Again, just as the volatile spirits of all things reside in the air, so the fixed parts of all things reside in the earth. And just as every day they are dissolved, partly by the subterranean fires, partly by the Sun — that heavenly fire mingled with them — through attenuation, and the finer parts (which are the most subtle and lightest corpuscles, that is, the spirituous substance) are separated from the earthy and fixed parts: so, lest the earth in time be consumed by the emission of so many

spirits, a certain power was necessary to it, by which spirits thus separated might be rejoined to their own bodies from which they had flown off.

[Margin: The magnetism of Nature.]

That power is nothing other than the appetite of things, by which each thing desires to reunite itself to its own body from which it had been separated. Hence those spirits — the most subtle corpuscles with which the air is filled, separated out from the substances of all things — whether they are carried down to the earth by the blowing of winds, or by rains, snow, or hailstorms (it makes no difference), are at once linked together, each drawn by its admirable magnetism to its own like, proportioned to it.

The fourth question. How is spirituous substance of this kind separated from fixed things, and from which things, and how is it afterward reunited? To resolve this, it must be observed that the earth behaves after the manner of a fixed and material principle, from which, as from a root, all things sprout forth, and from which every birth of seedlings, shoots, and plants takes its origin, according to the variety and manifold difference of these — for not just any earth is proportioned to producing just anything.

[Margin: How the attraction of things by nature takes place.]

So when an herb germinates, or any other vegetable, two things — from the doctrine already set out — concur in making such a body grow by vegetation: first, a certain fixed, solid, corporeal, and stable part; then a subtle, spirituous, lively part, which has the character of a formal principle. Hence it comes about that the earth, pregnant with spirits of this kind, once it has wedded itself to moisture, soon — the foetus as it were conceived, and the heat acting as paranymp[h] [bridal attendant] — unfolds outward into seedlings, and, according to the manifold nature of the seed latent within the earth, now this, now that vegetable is produced.

Again, since the Sun is accustomed to attenuate things, it comes about that always some part of the seminal portions of plants is committed to the air in resolved vapor. This, condensed afterward by the nocturnal cold, is drawn down to the earth — by dew in summertime, but at other seasons by rains, snow, and hail — and is restored, drawn back by the aforesaid magnetism to the body proportioned to it from which it had been cut off. And in this way the volatile component is restored to its fixed component. There is another mode, which we hinted at in the preceding passages: when vegetables, of whatever kind they may finally be, stripped of their leaves, flowers, and fruits, are restored by the annual

law of Nature to the earth from which they had come. It happens most often that, soaked and rotted by rains and snows, they are at last turned into earth. But since the several kinds of vegetables abound in the species and spirits of all vegetables — inasmuch as these are proper to their own plants — once soaked and fermented by rains and snows, they confer new strength upon the earth, and an increase both of volatile and of fixed bodies. For if this did not happen, the earth, its spirits gradually consumed and exhausted, would necessarily perish. From what has been said, then, it is clear that this kind of recirculation [pericyclosis] has been opportunely established by nature.

The fifth question. How is the earth made fertile by the ashes of shoots and grasses burned in the fields? It might indeed seem astonishing to some that, from destructive things —

[Margin reference: Virgil, *Georgics* I — continuation of the citation begun on the previous page] If it overflows, the earth is dense; the clods will be sluggish in your hands [?], and the soil will rise above the pits once they have been refilled. Then turn over the fat clods straightaway, and the heavy ridges, and plough the earth up with strong young oxen.

Of the salty and bitter earth he sings thus (*Georgics* II [II.238–241]):

But the land that is salty, and called bitter — unlucky for crops, and not gentled by ploughing, which keeps neither the kind of the vine nor its names in the apples [?] — will give its proof in a plain taste, and will twist the mouth of those who try it with a foul bitterness.

Of the signs of rich earth (*Georgics* II [II.248–250]):

Likewise, by this test at last we learn which soil is rich: never, when tossed in the hands, does it crumble apart, but, when handled, grows sticky to the fingers like pitch.

Of the signs of moist, heavy, light, and black earth he sings thus (*Georgics* II [II.251–256]):

Moist soil feeds taller grasses, and is itself too broad — ah, may it not be over-fertile for me, nor show itself too vigorous with the first ears of grain! The heavy earth betrays itself silently by its very weight, and the light likewise; it is easy to learn the black by the eye, and any color. But to search out the accursed cold is hard: only the pitch-pines, the harmful yews, or sometimes the dark ivy, reveal its traces.

For the rest, see Pliny [the Elder], Palladius, Columella, and the other authorities on Agriculture.

CAPUT V.

Of the things required for the cultivation of fields.

Now that the qualities of earth, and their usefulness in Agriculture, have been reviewed, it remains for us to say something about the ways in which lean earth may be reduced to fatness, and by what means farmers may remedy the defects of fields. For this, seven things above all are required: namely, marl [marga], manure, the plough, the harrow, fire, fallow, and the interruption of cultivation.

[Margin: Seven things are required for Agriculture.]

And as to the first:

[Margin: What marl is.]

By the name "marl" nothing else is here understood than rich and dense earth, most apt for fertilizing fields. For it is like a certain fat of the earth, or like a gland in bodies, with the kernel of fatness condensing itself there; and it is found in many kinds. One kind is white and fluid, not unlike the marrow of bones, whence it is also commonly called by the Germans *Steinmarck* [Steinmark], that is, "stone-marrow"; and it nests above all in metallic veins and in the joints of rocks, and is of great virtue in medicine, though of little in farming. There are then other species of marl that serve agriculture better, namely the tophaceous [tufa-like] and the sandy, and that which takes on the hardness of solid stone, like the Maltese earth [terra Melitensis]. These differ greatly in color, the reason for which was indicated above. The richer the marl, the greater the fertility with which fields are blessed; but the harder it is, the more years it lasts in possession of its native fatness. And let this suffice concerning marl.

The second requisite is manure, which — being of many kinds — does not all suit every earth. Some approve the manure of thrushes, doves, and hens, rejecting the more-than-due caustic [excrement] of swimming birds, such as the droppings of geese and ducks. Others hold that goats' manure takes first place, substituting in second place sheep's, then oxen's, and afterward that of beasts of burden — so that even from this it may be plain with how many dungs and excremental refuse there is need to sustain the life of wretched man.

[Margin: Fields must be manured, and why.]

The third requisite is the plough, with which the earth is to be turned over, so that the seeds committed to it may be better received, and the lower parts may be imbued with the spirit of light and air.

[Margin: For Agriculture there is need of the plough and harrow, and why.]

The third [recte: fourth — the harrow]. The harrow covers the seed-sowing with soil, to this end: that the seeds committed between the furrows may be safe, partly against the violence of birds, partly against the dryness of sun and air, and — endowed with and steeped in the earth's fatness — may at last, once rotted, grow up into seedlings.

The fourth [recte: a continuation of the requisites — fire]. To imbue lands with fatness, shrubs, leafy boughs, brushwood, ferns, broom, chaff, and stubble must be kindled and reduced to ashes, by which fields are fertilized in a wonderful way.

[Margin: What burning into ashes contributes to fatness.]

Virgil (*Georgics* I [I.84–85]) assigns five causes of this operation, where he begins:

Often, too, it has profited to set fire to barren fields and to burn the light stubble with crackling flames.

These you should read in the cited passage. We will a little later adduce the genuine cause, besides those that the Poet adduced.

The fifth. The alternating rest of fields is required to make the earth richer, as the Poet teaches (*Georgics* I [I.71–72]):

[Margin: How fields are improved by interrupting cultivation.]

Let the fields likewise rest by turns, idle, when ploughed, and suffer the field, hardened, to grow strong [?] in idleness.

And these are the requisites necessary for procuring the goodness of the earth. But, lest I seem in this place to discharge only the office of a rustic, I shall now — about to assign the reasons for the things mentioned — perform the office of a Philosopher.

The first question, then. From where is the fatness of the earth born, and why must the earth be ploughed and turned over, filled with manure, and covered over with ashes?

[Margin: The physical reasons for what has been said.]

I say first, that there is in the earth a certain native fatness, born partly from saline, partly from bituminous spirits — with which the whole mass of the earth is filled — compounded together. This fatness, clinging to the earthy masses, makes them fertile, in that fatness, clinging on, glues part to part; and then, with moisture coming on, it makes the earth at once dense and rich, most apt for the germination of grain.

[Note on numbering: the printed running header reads "Sect. II" on this page, but the chapter content has moved into a new Caput; see anomaly note in report.]

— such fire and ash that the fields may conceive some fertility; that this nevertheless happens, the experience of every place teaches.

That this secret of Nature may be laid open, we reason thus. Since both earthy things and vegetables consist, as has been said, of two parts — the volatile and the fixed — the sterility of earth can arise from either: either from a defect of volatile spirits, or of fixed ones. And the defect [of volatile spirits] can arise from this: either that the seedlings have already drawn off nearly the greater portion of the earthy spirits, having consumed them once they were drawn in together with the nourishment; or that, drawn off by the sun, they have been committed to the air. The defect of fixed parts, on the other hand, can happen either from the very gravel of the earth, or from the leanness of earth filled with sands, in which case the spirits can neither be contained nor condensed by nature's glue. Add to these that not just any part or species of earth is found fit for germinating and vegetating. How, then, fertility may be induced in earth that is destitute of it, must be laid open.

Since, then, ash — which is born from the burning of woods, shrubs, stubble, and crops — consists of the fixed parts of vegetables (while the finer parts of the fixed are resolved into vapor by the attenuation of fire, the fixed parts remaining, which, because of the abundance of salt and the fermentation accomplished by the mixture of humid moisture, acquire a certain fatness), it comes about that that earth, reduced to leanness, is fattened and rendered fit again for cultivation, and so that is restored to it which the seedlings had carried off in their growth. But since fertility cannot attain its end without the proper spirits, now already breathed out, hence that volatile substance of spirits, drawn back by the earth's accustomed magnetism, renders the earth blessed in every part for germinating anew.

Again, since the earth is mingled with very many other forms, each one of these draws from the spirituous and volatile substance that which is nearest to itself in

likeness of nature. For if anyone should distill water from pimpernel, or borage, or a similar plant, he will find that these waters — even though it is not apparent to the eye — nevertheless differ in species; and the earthy residue remaining in the bottom of the vessel, which they call *caput mortuum* [dead head], if it is reduced to ashes — I say, both the ashes and the salt extracted from it likewise differ from one another in specific difference, though not so plainly as in the waters. For we know, taught by experience, that the ash of willow and of vine — the former inclines naturally to the willow, the latter to the vine as to a thing most kindred to it; and in the salt of each of them something remains of the whole substance, from which it can be revived, by the truly admirable counsel of Nature.

[Margin: In salt all things lie hidden by the seed of the thing, whence it comes that it is filled with the spermatic [seminal substance].]

By this counsel, in order to perpetuate the generation of things, Nature willed to preserve in the spermatic salt the faculty of each single thing. From which it is most clearly evident that the ashes of any vegetable whatsoever contribute greatly to the fertility of the earth, in that vegetables can germinate [from them]. But let us also confirm this by experiment.

EXPERIMENT I.

[Margin: Lixivium [lye] made from ashes restores the plant to fertility.]

Let a plant — of whatever species it may finally be, for example the vine, rose, wheat, and the like — be reduced to ash. This done, if you irrigate the appropriate plant with the lye [lixivium] prepared from it, you will render it wonderfully fertile and luxuriant by this connatural liquid — since this ash is more inclined to benefiting a plant of its own species than another of a different nature. Hence fields in which the remains of stubble and crops are burned to ashes, as is usually done yearly, bring much greater fertility to fields than those that are [made fertile] from the refuse of burned broom, ferns, and lotus-weeds. The reason is that the salt of the said plants, by its spermatic power, produces similar plants — that is, lotus-weed, vetch, poppy, ferns, broom, and the like — by whose admixture, just as they subtract the nourishment due to the grain, so too they cause it in a wonderful way to degenerate from its native goodness and perfection. The simpler the ashes are, therefore, the greater fertility they confer on their own species, as the following experiment teaches.

EXPERIMENT II.

[Margin: How beautiful flowers are produced.]

If anyone should desire beautiful, bright, and abundant flowers — for example, tulips, anemones, lilies of every kind, roses, and the like — let him, from those same flowers, after they have bloomed, burn the stalks and stems of the flowers into ash and make a lye, which, poured upon the roots of each of the appropriate plants, [will cause them] to sprout up with wonderful fertility and brilliance — which I would have understood of other plants as well.

COROLLARY.

[Margin: From which it is understood how one and the same earth produces so many things.]

From these things it is clear how one and the same earth produces, to the eye, such diverse things: namely because the earth holds clods of differing nature, each one of which is inclined to that which is more agreeable to it by natural affinity. From this it is also clear that not every earth is fit for producing all things. There are, therefore, earthy materials that love this earth rather than another. Hence a spirit received in the earth, imbued with the virtue for producing vines, will now be less fit for germinating wheat — and so of the rest — because in one part of the earth the fixed parts are already determined to attracting the vegetable spirits more of this kind than of that; and consequently vines germinate more happily in one place, crops in another. But these things will be shown more fully in the *Distillatory Art* [Ars distillatoria].

The sixth question. Why, from the mere cessation of sowing, is the earth — resting for one or more years — rendered richer and more fruitful?

[Margin: Why earth made to rest from cultivation is rendered better.]

I answer that this happens partly because of the rotting herb and leaves turned into the earth by the fermentation that takes place, by which the earth, already exhausted of fatness,

is again restored by a new, acquired increase of rich earth — partly through the snows, by which the enclosed spirits are confined, and the earth itself, through the subterranean vapors, acquires great increment: from within, by the vaporous soot arriving from the earth; from without, indeed, by the attraction of new volatile spirits.

CAPUT VII.

Of the earthy bodies that come into use individually for Potters and Painters.

At the first beginnings of things, God most good and great [Deus Optimus Maximus], performing the office of a potter [figulus] — the All-fashioner [Pantoplastes] — shaped the body of man from Damascene earth [terra Damascena]. This earth, being the most excellent of all earths that have ever been found, was for that reason employed by God for fashioning the most worthy body of the first-formed man [protoplastus]. Hence also the only-begotten Son of the eternal Father did not disdain to assume to himself, from that same earth — through the successive propagation of the human race made by the first-formed man — a body from the immaculate earth of the Virgin. Yet what exactly the earth of Adam may have been is disputed among the interpreters of Sacred Scripture. We, omitting that question — as one that transcends all comprehension of the human mind — will proceed to those earths which potters chiefly use.

[Margin: Which earths potters should use.]

The earths that potters use ought to be coarse, tough, dense, and soft, of the kind that marl is wont to be; and where these are lacking, the middling ones hold first place, the soft ones second. Vessels that are not broken by the force of fire are for the most part made from rich and dense earths, such as crucibles.

[Margin: The earth required for the potter's craft.]

The vessels apt for chemical operations are of this sort: those of the better kind are the lightest, which do not drink in or sweat out moisture, are not fragile, and resist fire. Of such kind are: the Saguntine [vessels] in Spain [Sagunto]; in Italy, those made at Modena [Mutina], Arezzo [Aretium], and Toscanella [?]; the cups of Sorrento [Surrentum]; the earths of the regions neighboring Naples furnish most exquisite dishes. In Germany, those made at Waldenburg [Valdenburg] are everywhere sold at a great price.

[Margin: Which earth serves for melting glass.]

But the earth that serves for liquefying glass must above all be the most fire-resistant — of the kind dug at Savona in Liguria [Savona]. But of these things at greater length in the *Art of Glassmaking* [Ars vitraria].

[Margin: Why potters mix sand into the earth of their vessels.]

But why do potters for the most part usually mix sand into the earth, so that the vessels are not broken in the fire? The cause is that sand, liquefied by a strong fire, reduces the clayey substance as it were into a kind of stony [mass], with all its pores filled up. There are therefore some vessels made from chalk, others from clay [argilla], others finally from other baked earths — which are so much the more suited to human use, the more they are formed of richer, denser, and tougher material. On these, consult the potters. The same is to be said of the earth used by modellers [plastae] and fullers. But of these things elsewhere.

Of Murrhine vessels, Porcelains, and Majolica vessels.

[Margin: What Murrhine vessels were among the Ancients.]

What the Murrhine vessels [vasa Myrrhina] of the ancients were, and from what earth they took their origin, remains to be said. If we examine Pliny's words, set forth concerning the Murrhine vessels, we shall find that they were nothing other than what we today call porcelain [porcellana], whose origin and manufacture I set out in a few words.

[Margin: How and from what porcelain is made.]

Pliny (Book 37, ch. 2), treating of precious vessels, says that the Murrhine vessels are brought from the East and shine wonderfully, and are moreover imbued with the utmost variety of colors. To these our porcelain vessels today entirely correspond; concerning the making of which various authors report various things. Best of all about these is Father Martino Martini, of the Society of Jesus [P. Martinus Martinius é Soc. Jesu], the [author?] of all others [?], who writes thus in his *Atlas Sinicus* [Sinic Atlas], folio 86, concerning the city of Jaochen [Raozhou / Jingdezhen, in Jiangnan] in the Province of Kiangnan [Jiangnan]:

But what most commends it is the elaboration and abundance of Chinese bowls, which they commonly call "porcelains" — by a name fetched, I know not where from — than which none are made more excellent in the whole realm than in the village of Feuleang [Fouliang / Fuliang] of that city. For although elsewhere they have earth from which they could perhaps be made, they by no means come up to those that are made in this village. Indeed — what is worthy of admiration — they do not draw the earth from which they form these out of the soil of this Province itself, but receive it brought in from the city of Hoeicheu [Huizhou] of the Province of Kiangnan; nor can the people there, although so great an abundance of that earth is present, in any way fashion those [vessels]. There are those who ascribe this to the temperature of the waters. From this village, then,

of this city come all those Chinese bowls and vessels, which are wrought by rustic and unskilled men by the potter's art, in the same manner as the Faentine [vessels] in Italy [Faenza majolica] are of various color — although all are made of that most subtle and somewhat translucent clay. These are tinged with a saffron color and adorned with various figures of Dragons. [Those destined] for the royal palace are commonly made red, yellow, and of a blue [caeruleus] color — for producing which a glass [glassum / cobalt-glaze] is wont to be employed by the Chinese, which is found there in great abundance, especially in the more southern Provinces, and which they also use for dyeing garments. But how rare and excellent vessels are made here it would be long to relate: no shape, no flower, no figure can you paint that the porcelain clay among them will not admit. And how great is the abundance of these vessels, anyone may gather from that which we daily see in our Europe. But I marvel from where the rumor crept abroad here that this material is prepared from eggshells or crushed sea-shells, and that it is stored up by ancestors for the grandsons of their successors over a space of a hundred years; for those truly versed in things, these tales are ridiculous and merely fabricated, since everything [is made] from the earth that [is dug] for this village...

Liber VII, Sectio II — De Hylocinesi (continued)

Caput VII — De Terrestribus corporibus, quae singulis Plastis & Pictoribus in usum veniunt (continued)

[Sub-section: De Myrrhinis, Porcellanis & Majoricis vasis — continued]

So the Chinese are reported to make the most precious and most highly approved porcelains [porcellanae] of all that are found anywhere. But as for the claims that fire can be struck from fragments of these vessels when knocked together, that they burst in the presence of poisons, and that they grow only as warm as the hot water or broth poured into them has occupied within — this, for my part, is not borne out by experiment.

In second place after porcelain vessels rank the majolica vessels [vasa Majorica], which yield little to porcelain either in luster or in price.

[The remaining medicinal and pigment earths]

It now remains to describe certain other earths possessing a medium [moderate] potency: Eretrian [Eretria], Chian [Chia], Selinusian [Selinusia], Cimolian [Cimolia], Pnigitis, Melian [Melia], and Ampelitis.

There are two kinds of Eretrian earth: one strongly whitish, the other ash-colored, which is held to be the best. For if this latter is drawn in strokes across bronze implements, it produces a violet line — the mark of the better grade. It is washed in white-lead [cerussa]; it has an astringent and cooling power, is moderately emollient, fills hollow wounds, and binds together bloody ones. So Dioscorides.

Another earth is usually found on the island of Chios [Chios], white and of the better grade, crusty and differing in molded forms, very much like Samian earth [terra Samia], whose powers it also equals; it is an excellent cosmetic both for men and for women.

Selinusian earth is especially commendable for its sheen, white and friable, and is easily and quickly dissolved by moisture.

Cimolian earth is of two kinds, one white, the other purplish; but the one that shows fattiness and feels cold to the touch is reckoned the best. Applied to burns it is wonderfully beneficial, and diluted with vinegar it disperses tumors.

Pnigitis earth resembles Eretrian in color; if someone applies a hand to it, it will cool the hand, and if the tongue, it sticks to it so firmly that it can scarcely be pulled away.

Melian earth imitates ash-colored Eretrian, rough to the touch; rubbed between the fingers it crackles like scraped pumice; it is impregnated with alum, as is plain from the taste, and from this it has a cleansing power.

Ampelitis earth is produced in Seleucia of Syria [Seleucia Syriae]; black, it is recommended above the rest; when first ground up with oil it immediately liquefies, and it dissipates, cools, and is suitable for dyeing the hair; poured over sprouting vines it kills off the little worms.

But all that we have said thus far about earths we now set out together in the following synopsis, together with the quality of each.

Diagram. A bracketed taxonomic synopsis ("brace table") classifying medicinal earths. The single left-hand category is *Terra in usum Medicum cedens* ("Earth

serving for medical use"), which a large brace divides into four sub-groups, each headed *Alia* ("another kind") with its action, and each opening onto a further brace listing the specific earths. Transcribed below as a nested table preserving the structure.

Earth serving for
medical use [Terra in
usum Medicum cedens]

Sub-group (action)	Specific earths
Another, which wards off poisons [Venena arcet]	Armenian earth, or Armenian bole [Terra Armenia, sive bolus armenus]; Lemnian earth, or Sealed earth [Terra Lemnia sive Sigillata]; Melitensian [Melitensis]
Another, which is astringent [Astringit]	Ochre [Ochra]; Sinopic red-ochre [Rubrica Siropica (<i>recte Sinopica</i>)]; workshop red-ochre [Rubrica fabrilis]; Eretrian [Eretria]; Samian [Samia]; Chian [Chia]; Selinusian [Selinusia]; every earth [Omnis terra]
Another, which disperses [Discutit]	Cimolian [Cimolia]; Ampelitis; Furnace-earth [Fornacea]
Another, which cleanses [Abstergit]	Melian earth [Melia terra]

And these are the things which, concerning the soft earthy substances, we have set out briefly, on account of the multitude of matters yet to be treated. But since we shall very often repeat mention of these earths in what follows, we shall then investigate their secrets more fully and more opportunely.

ANACEPHALEOSIS

in hoc Libro dictorum

(Recapitulation of what has been said in this Book)

So then, to reduce into a compendium what has been said up to now: I say that Salt is the common seed of the earth, the seasoning of Nature, the basis and support of all bodies, the genuine and proximate element of the earth, supplying substance to all things. Just as this salt is tinged by various minerals, so too it is converted into another salt differing in species — such as niter, alum, vitriol. Yet despite this, it always holds the cradle of its origin by an inviolable right: for once it is removed from the niter, alum, or vitriol — from the mineral by which it was tinged — that first salt will be restored to its origin. Take it away from the earthy clods and soils which we have described, and you will always find that out of which it consisted from the beginning, namely salt. I would have you understand the same of metals, and likewise of any bodies whatsoever — whether from the mineral or from the vegetable and sentient realm — when they have been burnt to ash: the same salt will nonetheless come forth from those things, out of which it had its subsistence and solidity, either through the settling of the lye [lixivium] in the vessel, or through the efflorescence of the dead head [caput mortuum]. But from where so great a variety of salts and earths, differing in powers and properties, arises — this I explain in a few words.

I say, then, that it arises from the form of the mixture [forma misti]. For just as the mixture is composed from a varied confluence of mixable things, so too, through the combination contrived by sagacious Nature, the mixed body [mixtum] acquires such a degree of essence that it is distinguished in species from all others — a degree which it always possesses by Nature's inviolable right. For example: vitriol, which had been a common salt, degenerates into a salt differing in species, out of the tincture of an airy clod and water imbued with the acid spirit of sulphur. Just as the four elements are contained in these, so too out of their combination there arises a certain saline mixed body, which differs by a specific difference from salt, niter, and alum, and is called vitriol. And this is the final degree of Nature, constituted through the combination of the four elements — that is, out of air, water, and the acid spirit of sulphur with which they are imbued — by which it is distinguished from every other thing according to the requirement of its own nature and property. In the same way, alum too is distinguished from salt, niter, and vitriol, in that it has come forth, with differing virtues, from the salt of aluminous rock, the acid spirit of sulphur supervening in

that degree in which, by Nature's wonderful combination, no other thing is constituted; and this is the final degree of Nature and essence by which alum comes to be and is said to be distinct from any other mineral.

The same must be said of all the remaining earths and mineral clods: namely, that they are all distinguished from one another on account of the differing degrees of Nature which they acquire, indivisibly [ἀτόμῳς, *atomōs*, "atomically," i.e. as indivisible units], through this or that combination of mixable things. So that Aristotle, in *Metaphysics* VII [Margin: *Aristoteles 7. Metaphys.*], not incongruously asserted that the species of things stand to one another as number to number. Add a unit to two, and it will no longer be two, but three, distinct in species from two — which is to be understood of any other numbers as well; and it is plainly evident in colors: add to white even the least bit of black, or yellow, or red, and it will at once pass over into a color differing in species. But of these things more fully in what follows.

It is therefore clear that whatever we have so far said about the various species and kinds of salts and earths differing in powers and properties must be referred to the causes set out in this recapitulation [anacephaleosis] — namely, to the mixture of things endowed with differing virtues, in which that which most predominates according to the laws of the combining Nature constitutes the mixed body in its determinate species. But all these matters will be demonstrated more plainly in what follows, with a varied apparatus of experiments. Let these things, then, be what we have said about the first fruits of the Subterranean World.

CONCLUSIO

(Conclusion)

As we struggle forth at last out of the dread and inaccessible abysses of the Subterranean World, nothing more remains for us, O God, than to turn our face to Heaven and render You the thanks we owe — You who alone do wonders, of which there is no number, in the heavens, on the earth, in the sea, and in their hidden depths. So too, that I might enter the secret sanctuaries of the Geocosm, You lent Your hand; by Your anticipating inspiration You spurred me on, unwilling though I was, to be willing; You aided the efforts of my good will to act — You who in Your own work both will, and have power, and bring to completion.

O God, O might and wisdom of our race! How wonderful through all the world is that beauty of Yours! How venerable Your form, and the glory of the holy Word, And Your name, abiding eternally from age to age!

Bless all His works, in every place of His dominion; bless the LORD, O my soul.

FINIS I. TOMI. (*End of the First Volume.*)

CATALOGUS LIBRORUM

a P. Athanasio Kircherò è Soc. Jesu hactenus editorum.

(*Catalogue of the books published thus far by Father Athanasius Kircher of the Society of Jesus.*)

- *Magnesia* — in quarto, Würzburg [Herbipolis], in the year 1630.
- *Gnomonica Catoptrica* (Catoptric Gnomonics) — in quarto, Avignon [Avenio], 1635.
- *Prodromus Coptus sive Aegyptiacus* (Coptic, or Egyptian, Forerunner) — in quarto, Rome, 1636.
- *Specula Melitensis Encyclica*, that is, a new compendium of mathematical instruments — in octavo, Naples, 1638.
- *Ars Magnetica*, or a tripartite work on the Magnet — at Rome first in quarto, 1641; then at Cologne in quarto, the same year; at Rome again in folio, in the year 1654.
- *Lingua Aegyptiaca restituta* (The Egyptian Language Restored), together with a supplement to the *Prodromus Coptus* — in quarto, Rome, 1644.
- *Ars Magna Lucis & Umbrae* (The Great Art of Light and Shadow) — in two volumes, in folio, Rome, 1646.
- *Musurgia Universalis*, or the Great Art of the Consonant and the Dissonant — in 2 volumes, in folio, Rome, 1650.
- *Obeliscus Pamphilius*, or an interpretation of the hieroglyphic obelisk restored by Innocent X, Supreme Pontiff — in folio, Rome, 1650.
- *Oedipi Aegyptiaci* (Egyptian Oedipus), Volume One — Rome, 1652, in folio.
- — Volume Two — in folio, Rome, 1653.
- — The second part of Volume Two — in folio, the same place, 1654.
- — Volume Three — in folio, Rome.
- *Scrutinium Physico-Medicum* (Physico-Medical Examination) — in quarto, the same place.

- *Iter Extaticum Coeleste* (Ecstatic Heavenly Journey) — in quarto, the same place.
- — *Terrestre* (Ecstatic Earthly Journey) — in quarto, the same place.
- *Prodromus in Mundum Subterraneum* (Forerunner to the Subterranean World) — in quarto, the same place.
- *De Crucibus Neapolitanis* (On the Neapolitan Crosses) — in octavo, the same place.
- *Polygraphia seu Artificium linguarum* (Polygraphy, or the Artifice of Languages) — in folio, the same place.

Libri ab eodem Authore, si Deus vitam concesserit, edendi, sunt:

(Books to be published by the same Author, if God grants him life:)

- *Mundus Subterraneus* (The Subterranean World), divided into two volumes, which now sweats under the press, in folio, Amsterdam.
- *Ars Combinatoria* (The Combinatory Art), by which a door is opened, by a new method, to learning all the sciences and arts in a short time — in folio, the same place.
- *Iter Hetruscum* (Etruscan Journey) — in folio.
- *Descriptio Latii novi & Veteris* (Description of New and Old Latium) — in folio.
- *Arca Noë & Turris Babel* (Noah's Ark and the Tower of Babel), delineated and described by architectonic method — in folio.

Ad Majorem Dei Gloriam cedant omnia. (May all things tend to the greater glory of God.)

INDEX RERUM ET VERBORUM LOCUPLETISSIMUS

(A Most Copious Index of Things and Words.)

The number indicates the page; the letters *a* and *b* the first and second column.

[Editorial note: this is a two-column Latin alphabetical index, letter A. It is rendered below as a list, one entry per line, preserving the headword, its locators, and sub-entries. Page references and column letters (a/b) are transcribed exactly as printed. Several entries are partly abraded; uncertain readings are flagged [?].]

- **Byssus** [fine linen / cotton], what it is — 112.a; toward the Magellanic sea — 113.a; in the gulf Ferdinando del Poo — 146.a.

- **Aër** [air], that there is an aerial Ocean — 192.a; full of the seeds of diverse things — 217.a.
- **Aerophylacia** [air-reservoirs] — 111.b; what they are — 114.a; of Asia — *ibid.*; of Bodniae — *ibid.*b.
- **Aegyptus** [Egypt], once unsuited to approach [i.e. impassable] — 80.a.
- **Aeolipilarum** [aeolipiles, "wind-balls"], their effect in stirring up winds — 202.a; their power, various and formidable — 100.a; their power — *ibid.*; observations in Belgium — 128.b; well known to sailors — *ibid.*; in the Hebrides Islands, a wonderful variety — 143.a; observation in the open Ocean difficult — 144.a; their power in the Sicilian Strait — 152.b; their use and practice — 153; the knowledge of [tide-]fullness — 154 and following; their clock [horologium] — 157; it follows the motion of the Moon — 100.a; the inequality of the Moon's motion does not hinder it — 132.a; at London it varies — 128.a; in China anomalous [heteroclitus] — *ibid.*; the causes of the variety — 139.a [?]; the winds impede them — 139; as does the discharge of rivers and the submarine exhalation — *ibid.*; in the mouth of the Garonne [Garumna], of what sort — 142.a; immense at Panama — 145.a; as also on the Cambodian [Camboia] shore — 126.b. See the word *Fluxus & refluxus* (Ebb and Flow). [*This long composite entry conflates the headword "Aeolipila" with tidal observations; transcribed as printed.*]
- **Aetna**, the mountain — 186; its description — *ibid.*; as also of the crater of Aetna — 187; a chronicle of its conflagrations — 188.a; and the cause — 189.b; see its new increase — 189.a.
- **Africae Meridionalis flumina** [the rivers of Southern Africa] — 72.b.
- **Agri** [fields], how some are now born barren, now fruitful — 231.b; whence their earthy material is sprinkled with so great a variety of colors — 332.a.
- **Agricoltura** [agriculture], and its requisites — 340 and following.
- **Albanus lacus** [Lake Albano] — 293.a; its inundation — *ibid.*
- **Albanus Mons** [Mount Alban / Alban Mount], full of waters — 295.
- **Albula fl.** [the river Albula] — 249.a; 279.a.
- **Alkali**, a cave of alkali salt [Alkali salis specus] — 201.a.
- **Almagra**, town — 261.b.
- **Alpheus**, river of Greece — *ibid.*
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- **Andes montes** [the Andes mountains] — 74.a; they collapsed — 77.b; their height — 84.a; a cavern — 120.a.
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- **Aqua** [water], how it is imbued with saltiness — 164.a; how salt water freshens in drainage channels [hydragogi] — ibid.; sea-water at the roots of mountains is sweeter than in the open — 166.a; sea-water drawn up into rains, why it freshens — ibid.b; the same by distillation — ibid.; without heat it cannot be attenuated into vapor — 228.b; pressed, it ascends on high — 229.b; how sea-water is raised above mountains — 232.b; how it is condensed into salt — 300.a; how it is housed in the highest mountain peaks — 238.a; its circulation corresponds to the circulation of the blood — 340.b; which kind is more healthful — 243.b; none is free of admixture — 244; which veins of good water it favors [?] — 245.a; and mixed waters — 246.a; 247.a; the test of admixture — 246.b; improperly mixed waters, which they are — 247.a; gypseous water, where it is found — 248.a; salt water does not extinguish flames — 323.b; which is fluvial [river-water] — 244.a; its disadvantages — ibid.
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- **Archonautarum observatio** [the observation of the Archonautae] — 161.a.
- **Arena** [sand], threefold — 326.b; marine [sea-sand], whence it comes — 337.b; whence aerial [sand] in springs — ibid.; how it is distinguished from gravel and shingle — 228.a.
- **Arenarum variae qualitates** [the various qualities of sands] — 327.a; their uses and harms — 327 and following.

- **Arethusa**, the greater river of Armenia [Armeniae maj. fl.] — 276.b; in it nothing sinks — *ibid.*
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- **Baregues** [Barèges], hot springs of Gaul — *ibid.*
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Index of Subjects and Words (Index Rerum et Verborum) — continued

[The two-column alphabetical subject index of Tomus I continues. The four leaves in this range belong to the run C–V; the PDF presents them out of sequence.

Reconstructed printed order from running headers and catchwords: the C–G page (catchword "Garumna"), then the G–M page (catchword "Maris"), then the M–P page (catchword "R. Rio"), then the R–V page. Each entry is given as headword — gloss — page locators; "a" = first (left) column of the cited page, "b" = second (right) column; "ibid." = same locator as the preceding; "& seq." = and following. Locators are transcribed as printed.]

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FINIS. [The End.]

Erratum

ERRATUM.

P. 48, Col. 1, lin. 23, read *recurrere, dum* [recurring, while].

TOMUS II — Engraved Title Page

Diagram. The allegorical engraved frontispiece-title page of Tomus II. At the top, two eagles (the Imperial Habsburg double eagle, split into a pair) grip the corners of a great draped cloth or banner on which the title is lettered; golden orbs (the *aureum pomum*, golden apple/orb of empire, echoing the dedication) hang at the lower corners of the banner. Beneath, an architectural interior opens at left onto a rocky landscape with miners/laborers at subterranean workings, and at right onto a colonnaded hall.

At center stands a colossal statue of the many-breasted **Diana of Ephesus** / **Artemis Ephesia** (Nature personified — *Natura*), her body sheathed in tiers of animal figures and bees, crowned with a mural/turreted crown, raised on a high pedestal. To her lower right sits a seated woman (the figure of Philosophy or the diligent inquirer / Kircher's Muse) writing in an open book on her lap. Behind her, at right, stands a youth wearing a broad-brimmed traveler's hat and holding the **caduceus** (the staff of Mercury/Hermes — Hermes Trismegistus, patron of the subterranean and hermetic arts), accompanied by a second youthful figure who reaches toward Nature.

At lower left, a winged putto holds up an oval framed **portrait medallion** of a young man (the dedicatee, the Emperor Leopold I — a long-haired figure in armor/sash). Near the putto's feet lie a sphere/globe and a conical sundial or plumb instrument.

Labels read top to bottom:

- (banner, the title): **ATHANASII KIRCHERI E SOC. IESU MUNDI SUBTERRANEI TOMUS II.us** — "Of Athanasius Kircher of the Society of Jesus, THE SUBTERRANEAN WORLD, Volume II"
- (banner, subtitle): **IN V. LIBROS DIGESTUS** — "arranged into 5 Books"
- (banner, continued): **Quibus Mundi Subterranei fructus exponuntur, et quidquid tandem rarum, insolitum, et portentosum in foecundo Naturae utero continetur, ante oculos ponitur curiosi Lectoris.** — "in which the fruits/products of the Subterranean World are set forth, and whatever finally [there is] rare, unusual, and prodigious that is contained in the fertile womb of Nature is placed before the eyes of the curious Reader."
- (above the portrait-medallion's bearer / at the figures' feet, the caption): **Orpheus**
- (the Greek epigram, two lines, beneath the central figures): **“Ὅς νάεις κατὰ πάντα μέρη κόσμοιο γενάρχα / Ὅς δαπανᾷς μὲν ἅπαντα, καὶ αὖξεις ἔμπαλιν αὖτις.** [Greek, after Orpheus — addressed to Nature as world-progenitor: "You who flow through all the parts of the cosmos, O progenitor; you who consume all things, and in turn make them grow again."]
- (the Latin rendering of the epigram, beneath the Greek): **Omnes qui partes habitas, mundique Genarcha / Absumis quae cuncta, eadem quae rursus adauges.** — "You who dwell in all the parts [of the world], and as Progenitor of the world consume all things, the very same things which you again increase."
- (lower left, engraver's signature): **C. vande Pas delineavit** — "Crispijn van de Passe drew [it]."
- (lower right, engraver's signature): **F. Sioutrema [?] sculpsit** — "F. Sioutrema [?] engraved [it]."
- (bottom imprint): **AMSTELODAMI, Typis Joannis Jansonij à Waesberge et Elizaei Weyerstraet 1665.** — "At Amsterdam, from the press of Joannes Janssonius van Waesberge and Elizaëus Weyerstraet, 1665."

TOMUS II — Dedication

[To the Emperor Leopold I. The opening leaf of Tomus II's dedicatory epistle; signature mark (*) 2 at the foot.]

TO THE MOST SACRED AND MOST UNCONQUERED LEOPOLD I,
EMPEROR OF THE ROMANS, THE JUST, THE PIOUS, THE FORTUNATE

[*SACRATISSIMO & INVICTISSIMO LEOPOLDO I. ROMANORUM IMPERATORI
JUSTO, PIO, FELICI*]

Athanasius Kircher of the Society of Jesus [sends] greeting, victory, and peace.

To the Monarch of Macedon [Alexander the Great] there was given a golden apple, cast from the golden tribute of all the parts of the world. I too am entering in, to look into the heart of the Earth — that is, the treasures of the world — so that from it I may draw out a tribute, one that I may render to you in writing, to you my Caesar: you who, first among the other princes of the House of Austria, crowned the holy, beautiful, pious, victorious, and glorious name of LEOPOLD with the most august title of Emperor, when that golden apple of empire was held out to you. You are intent on governing the world outwardly, on its surface; but I look inward, into the very Earth, to [see] what lies hidden there — and within, I sing to myself and to the Muses. For I find there no lesser, nor any less sweet, Music of God the Creator than [that] of the heavens...

Dedication (continued)

[...] that he had seen everything that goes on among the powers below. Will I not also need a lynx-eye and a lynx-pen, to see through to those mysteries and shadows that lie hidden, concealed in the bosom of the Earth, and to set them forth? I saw monsters in the heavens through my *Ecstatic Journey* [*Iter Extaticum*] — will none meet me in the caverns of the Earth? Monsters are customarily set before princely men to delight them. As for me, whatever I have found there that is rare, or memorable for its marvelousness, I set before You, O CÆSAR. Those who returned from the cave of Trophonius were ordered to sit down and, for several days, to unfold the mysteries they had seen within it. This is what my book — no, rather Your book — does here, a guest brought back not so much from the city as from the very bowels of the Globe of the Earth that gave it birth. No longer shall I strike the stars with my head held high; instead I shall descend by tireless investigation into the deep abyss of the Earth — at no less cost of labor than that with which divers plunge into the sea. The most celebrated of these was

Andreas Mergus of Genoa, who, plunging into the sea whenever anything was thrown into it, would snatch the prize from the waves. The fables also tell how Theseus once buried himself in the sea, and emerged from it crowned, bearing the gem that Minos had cast into it. I, for my part, descend into the Earth as into the depth of the sea only for the sake of that immortal crown which is with God; and whatever I bring back from there, I bring as an offering to Your Crown

— Your Imperial Crown — a gift already long owed to FERDINAND III [Ferdinand III, Holy Roman Emperor], Your august Father, by whose crown You are crowned in turn. For it is fixed with eternal adamant that a wise son is his father's crown. Great things await You, LEOPOLD; it is Yours to fill out the immense measure of this name with virtue to match — so that, of all who have borne the name of LEOPOLD, You may be the first to come to the pens of those who write; and so that, by the spotless candor of Austrian character in which You shine, no less than Your forebears and no unequal in heroic disposition to the grandeur of Imperial Majesty, and with a spirit ready for every exertion, You may labor unto eternity for the good of the Christian world, for altar and hearth.

This is what is vowed for You and for Yours by the same one who signs above, Your poor and humble servant.

[Margin / closing line:] From the Roman College [E Coll. Romano], on the Kalends of June, 1663.

PROÆMIUM AD LECTOREM — Preface to the Reader

IDEA OPERIS — The Plan of the Work

Now that, in the seven books of the First Tome of the *Mundus Subterraneus*, we have treated — by a new method of philosophizing and with a great apparatus of experiments — of the wonderful nature of the Earth's center; of the incomprehensible structure and workmanship of the Geocosm; of the hidden nature and property of the Ocean and of the watery Element; of meteors both within and beyond the Earth's surface; likewise of the generation of subterranean fires and winds; of the nature, property, diversity, and origin of the waters that encircle the terrestrial globe; and of the true and genuine element of earth — that is, of salt and of the other terrestrial clods, their nature, property, diversity, and origin — nothing remains but that we should proceed, in the remaining books of this Second Tome, to the consideration of the particular fruits and offspring of the Earth which the most fertile womb of the Geocosm brings forth at all times in richest abundance; and that we should explore the powers and properties of

each, and the proximate causes of effects so great. This we judged could fittingly be done in the five books of this Tome.

Since, then, it is by the force and efficacy of saline bodies of this kind that all the bodies found in the terrestrial globe — both interior and exterior — acquire a fixed, hard, and solid consistency, I have accordingly thought it proper to treat, in **Book VIII** [Liber VIII], of the stony substance of the Geocosm. In it Nature, with a certain admirable and unspeakable industry, has sported in the composition of stones and gems both common and precious; and these are likewise ornaments worthy of all admiration — not only as regards the incredible endowments of their inner virtues and powers, with which Nature has furnished them, but also as regards the apparatus of their manifold pictorial designs [picturæ], by which she has attempted to express whatever is contained within the bounds of the World, even to the point of rivaling the art of painting and modeling, according to the capacity of her playful genius. With what skill, moreover, has she fashioned, in her hidden workshops, bones of giant size and horns of prodigious length! With what shrewdness has she also drawn forth fossil wood beneath the earth, and coralline plants beneath the sea, by an incredible craftsmanship out of the rocks of the sea! All these things **Book VIII** lays open.

Again, just as the most wise Architect of the world has, in the threefold kingdom of nature, mixed good with evil, pure with impure, and the harmful with the wholesome, as though in some vase of Pandora, so too it seemed good to discuss most fully, in **Book IX** [Liber IX], the deadly parts of the terrestrial World — that is, the origin, nature, and powers of poisons [Venena]. There the reader will plainly recognize that nothing has [been made] by God, the true Founder of things [...]

Tomus II — Proæmium ad Lectorem / Idea Operis (conclusion) and Index Argumentorum

Conclusion of the Idea Operis

[The opening lines continue the sentence broken off at the end of the prior leaf, on poison and its remedy:] ...the Best and Greatest [God], that something so destructive and deadly should have been produced in the sublunary world without its containing within itself a remedy for life against the death that its own virulent venoms bring. And so from that one same thing it falls to God alone

to draw good out of so great an evil, harmlessness out of what is harmful — in short, from the death-bearing, to bring forth the life-giving.

Having now set out the matters that pertain to the saline, the stony, and the deleterious substance of nature, we proceed to the metallic art, which we entitle **metallurgy**. Here it is shown what art, the imitator of nature, can accomplish, as it brings forth the most abundant offspring of metallic bodies out of the womb of the Geocosm, to the great profit of human commerce. There too, in **Book X**, we treat at fullest length of the proportion, concoction, and separation of metals drawn from the matrices of the mines, and likewise of the virtues of each.

But just as the insatiable greed for gold and silver stirs the minds of mortals in a remarkable way, so too by remarkable means and cunning devices they leave nothing untried, hoping by any means to reach that final goal of natural happiness which they fix in the wealthy possession of gold and silver. For this reason we have arranged **Book XI** under the title χυμιοτεχνίας [Greek: chymioteknia, "the art of chemistry"], in which we debate whether true and natural gold can be produced through alchemy. We set forth the errors, impostures, and frauds of the alchemists, committed in every age, and we examine with the utmost rigor the art they call transmutatory, brought to the balance of natural philosophy [Phisiologia] — which Book XI accomplishes. In it the fiction of the philosophers' stone is thoroughly exploded by a varied apparatus of experiments.

There remains at last **Book XII**, the final one, which by no inappropriate name we have called the **Ape of Nature** [Naturæ simia]. In it we aim above all to show that whatever marvelous things nature exhibits in the Geocosm can — provided nature yields up her own right — be produced by the ingenuity of human skill; and this we teach and demonstrate by countless, varied, and hitherto unseen displays of experiments.

And this is the synopsis and, as it were, the ἀνακεφαλαίωσις [Greek: anakephalaiōsis, "recapitulation" or "summary"] of all that we set forth in the Second Tome of the *Mundus Subterraneus*, so far as the feebleness of our talent has permitted. If in it the reader should find anything worthy of praise or profitable to the public good, let him ascribe it not to me — the least of mortals — but to the Father of lights, from whose infinite goodness, mercy, and liberality all good things flow forth. And so too, if there be anything in me — however unworthy — that He has heaped together out of His own gifts and graces, let it flow back into the immense abyss of the divine goodness; and let honor and glory

be His alone, whose property it is to illuminate with His own light the dark recesses of minds, so that they may shine forth with something afterward.

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MUNDI

MUNDI SUBTERRANEI LIBER OCTAVUS

On the Stony Substance of the Earth [De Lapidosa Telluris Substantia]

On fossil bones and horns, and likewise on subterranean animals, men, and demons. [De Ossibus, Cornubusque fossilibus, item de Subterraneis animalibus, Hominibus, Daemonibus.]

PRAEFATIO [Preface]

Now that the foundations of terrestrial bodies have been set out and explained, it remains for us to pursue, with equal step, the stony substance which the Geocosm holds within the immense recesses of its womb, under the innumerable variety of stones, rocks, and gems. The Geocosm, as we taught in the third Book, consists of a stony substance; and, just like the fabric of the human body and of the other animals, it is furnished with bones for the firmer consistency of its whole mass.

[Margin: A comparison of the Geocosm with the Microcosm. — Comparatio Geocosmi cum Microcosmi.]

For just as these bones consist of their own marrow, enclosed in the hollows of the bones so that it does not flow away — much as the blood is shut in among the arteries and veins — so that in this fashion it may communicate with all the humors of the whole body; and just as the bones are clothed with nerves and cartilages, as well as with veins and arteries, through which by continuous attraction they are nourished along hidden little channels: in just the same way the terrestrial Orb, consisting of its own bony framework, would otherwise leave Nature to labor in vain in the production of things. For this bony framework consists, as it were, of a tubular substance, and was equipped by Nature with countless veins, nerves, and cartilages, fitly to connect part to part. Thus through its hidden fibers it draws into itself, as a kind of nourishment, whatever lies hidden of moisture, fatness, and glue in the terrestrial body, for the preservation of the whole fabric — drawing it by a certain powerful magnetism implanted in it by Nature.

And from this the stony body, diminished by the various erosions and abrasions of the subterranean washings, again gathers from the moisture the things that have been dispersed, and by attraction converts them to its own restoration. But whatever smells of salt, mineral, or metal — that, once attracted within the fibers

of the stony substance, passes into the seed-bed [seminarium] of metallic bodies. And these things, when mixed with the stony juice [lapidoso succo], produce that variety of stones — whether common or precious — which we shall describe in this Book. And so that this may be done as well as possible, we shall take the beginning of our reasoning from a division.

Resolutory Schema of Stones [Schematismus Lapidum resolutorius]

Diagram. A bracketed dichotomous classification tree (the standard Ramist "resolutory schema") reading left to right, with the root brace at far left labeled **Lapides ex rebus sumuntur** ("Stones are drawn from [these] things"). The tree branches successively; below, every branch is rendered as a nested list.

Stones are drawn from things [Lapides ex rebus sumuntur] that are:

- **Animate** [Animatis]:
 - **Flying** [Volatilibus]: *Chelidonium* [swallow-stone], *Palumbellarum lapis* [stone of wood-pigeons], *Alectorius* [cock-stone].
 - **Not flying** [non volatilibus]:
 - **Aquatic** [Aquatilibus]:
 - From **fishes** [Piscibus]: *Lap. Carpionum* [carp-stone], *Tuberonum* [shark-stone], *Percae* [perch-stone].
 - From **insects/lower animals** [Insectis]: *Oculi Cancræ* [crab's eyes], *Margaritæ* [pearls], *Umbilicus Veneris* [navel of Venus].
 - **Terrestrial** [Terrestribus]:
 - From **plants** [Plantis]: *Corallium* [coral], *Lapis Spongiae* [sponge-stone].
 - From **animals** [Animalibus]:
 - From **man** [Homine]: *Lap. Fellis* [gallstone], *Vesicae* [bladder-stone], *Renum* [kidney-stone].
 - From **brute** [Bruto]:
 - **Quadruped** [Quadrupede]: *Bezoar*, *Bufonius* [toad-stone], *Lap. Porcinus* [hog-stone], *Dracontias* [dragon-stone], *Asininus* [ass-stone].
 - **Insect** [Insecto]: *Limacius* [snail-stone].
 - **Inanimate** [Inanimatis]:
 - From **burning things** [Ardentibus]: *Succinum* [amber], *Gagates* [jet], *Lythantrax* [coal].
 - **Not burning, and having a shape** [non ardentibus, habentque figuram]:
 - A **definite** [Certam] shape:
 - **Mathematical** [Mathematicam]:

- **Round** [Rotundam]: *Enorchis*, *Ovum anguinum* [snake's egg], *Geodes*, *Aëtites* [eagle-stone].
- **Some other** [Aliam quamvis]:
- **Angular** [Angularem]: *Crystallus* [crystal], *Basaltes* [basalt], *Iris* [rainbow-stone].
- **Yet another** [Aliam quamvis]:
- **Hemispherical** [Hemisphaericam]: *Umbria*, *Crapandina*.
- **another** [aliam].
- **Of some thing** [Alicujus rei]:
- **Animate** [Animatae]:
- **Whole** [Totae]:
- **Of a sentient thing** [Sensitivae]: *Ostracites*.
- **Of a vegetable thing** [Vegetabilis]: *Corallina*.
- **Of a part** [Partis]:
- **Of a sentient thing** [Sensitivae]: *Hysterapetra*, *Oculus Cati* [cat's eye], *Dactilus Idaeus*, *Ammites*, *Eneostis*, *Aegophtalmus*, *Triophtalmus*, *Amianthus*, *Beli Oculus*, *Bucardia*.
- **Of a vegetable thing** [Vegetabilis]: *Pysolithus*, *Tecolythus*, *Amigdaloides*, *Cenchrates*, *Meconites*.
- **Inanimate** [Inanimatae]:
- **Natural** [Naturalis]: *Stalagmites*, *Steatites*, *Sealactites* [stalactite], *Porus*, *Pumex* [pumice], *Haematites*, *Ammochrysus*, *Cadmites*, *Capnites*.
- **Artificial** [Artificialis]: *Trochites*, *Stellaris*, *Ceraunia*, *Belemnites*.
- Stones having **no [definite shape], and they are either** [Nullam, sunt vel]:
- **Transparent** [Diaphani]:
- **Whole/entire** [Integrè]:
- **Hard** [Duri]:
- **Of some color** [Colore aliquo]:
- **Red** [Rubro]: *Rubinus* [ruby], *Spinellus* [spinel], *Balassius*, *Amandinus*, *Almandinus*, *Granatus* [garnet], *Alebandinus*, *Carbunculus*.
- **Yellow** [Flavo]: *Hyacinthus*.
- **Golden** [Aureo]: *Chrysolithus*, *Chrysophrasus*, *Chrysopasius*, *Chrysopteris*, *Chrysolampis*.
- **Green** [Viridi]: *Smaragdus* [emerald], *Prasius*.
- **Blue** [Caeruleo]: *Saphirus* [sapphire], *Berillus* [beryl].
- **Purple** [Purpureo]: *Ametisthus* [amethyst].

- Of **no [color], as** [Nullo, ut]: *Adamas* [diamond].
- **Soft** [Molles]:
- **Small** [Parvi]: *Opalus* [opal], *Fluores*.
- **Large** [Magni].
- **Not entire, according to** [Non integrè secundum]:
- **[their] parts** [Partes]: *Sarda*, *Sardonix* [sardonyx].
- **[the] whole** [Totum]: *Calcedonius* [chalcedony], *Camehuia* [cameo].
- **Opaque** [Opaci]:
- **Beautiful** [Pulchri]:
- **Small** [Parvi]: *Turchesia* [turquoise], *Lazuli* [lapis lazuli], *Camehuia*.
- **Large** [Magni]: *Jaspis* [jasper], *Achates* [agate], *Nephriticus* [jade], *Heliotropus* [bloodstone].
- **Ugly** [Turpes]: *Saxa* [rocks], *Silices* [flints], *Marmora* [marbles], *Marchasitae* [marcasites], *Lapides* [stones], *Lapis Armenus* [Armenian stone], *Calaminaris* [calamine].

SECTIO PRIMA [Section One]

ON STONES IN GENERAL [DE LAPIDIBUS IN COMMUNI]

CAPUT I [Chapter I]

On the manifold difference of stones [De multiplici Lapidum differential]

A stone, of whatever kind it may finally be, is properly nothing other than an unmeltable fossil body [corpus fossile illiquabile] — that is, one that can be dissolved into a flux neither by water nor by fire. The exceptions are those stones that take their origin from bitumen, glass, or other juices, which are easily liquefied when roasted by fire — such as glue [Gluten], amber [Succinum], and vitreous sand [arena vitrea] — and those that are compounded from metallic species, which therefore cannot properly be called stones.

Of these stones, indeed, the difference is so great that, to enumerate them all, not only the narrow limits of this Book — I will not say — but not even the volumes of many tomes could be capacious enough for so ample and copious a subject-matter. We shall nevertheless take pains to set forth, with order and method,

each and every thing worthy of consideration that concerns the difference of stones, their natures, powers, and properties — not by the reasonings commonly relied upon, but by a new array of experiments and with great industry, so that from these the reader may discern clearly what is to be concluded on this subject.

[Margin: First difference, from the place of origin. — *Prima differentia à loco natali.*]

The **first difference** of stones is taken from the place of origin in which the stone grows, and it is either inanimate or animate. The inanimate is again twofold: natural or artificial. The natural-inanimate is again either within the earth, or in water, or in air. Those that grow within the earth are for the most part the common kinds of rocks, marbles, and the other, even precious, kinds. Those that grow in water are all those stones which, from a petrifying juice in waters, congeal from a juice or slime appropriate to each, and are turned into rock. The air, for its part, supplies the *ceraunium* or thunder-stone [*lapis fulmineus*], coagulated in the clouds and cast down to the earth, and others like it, generated in the air — about which see in what follows, where the rain of stones [*pluvia saxorum*] has been treated more fully. In a fire that destroys all things, no stone can congeal. After the natural place comes the artificial, the manner and materials of which will be taught in what follows.

[Margin: From the animate place. — *A loco animato.*]

There follows, secondly, the other member of the division of the birthplace of stones: it is an **animate place**, which in turn has its fixed seat either in vegetables, or in sentient beings, or in animals. In a sentient nature a stone grows: either in man, or in quadrupeds, or in birds, or in swimming creatures, or finally in insects. In man a stone grows naturally either in the bladder, or in the kidneys, or in the gall-bladder, or even — against nature — in all the members, as will be seen in its place; where it will also be shown that there is no animal which does not engender some stony matter within itself, whether this be in quadrupeds, or in flying things, or in aquatic creatures, or in insects and zoophytes.

[Margin: Second difference, from color. — *Secunda differentia à colore.*]

The **second difference** is taken from color, which is either simple or compound. The simple stone is white, yellow, golden, green, blue, purple, ashen, or black. The compound is one constituted of one or more of the foregoing. Hence some stones are homogeneous, of one color whatever the tinting may finally be; others are heterogeneous, seen to be imbued with a great variety of colors. Some too are

transparent [diaphani], others opaque, others constituted of both; and others are devoid of color, like crystal and diamond.

[Margin: Third difference, from primary and secondary qualities. — Tertia differentia à qualitibus primis & secundis.]

The **third difference** is taken from the primary and secondary qualities — that is, the manifest ones. Since this difference varies according to the preservation of each one's form, the stones likewise yield diverse effects when applied to men. In this way one stone, being endowed with a hot quality — as is perceived in amber [succinum] and jet [gagas] — produces warmth; while a cold one, such as is found in pearls [uniones], corals, and the like, cools. Again, a cold temperateness, which becomes evident when all stones are reduced to powder, dries. There are besides the soft, the hard, the heavy, the light, the light-and-rough, the beautiful, and the ugly.

[Margin: Fourth difference, from the five senses. — Quarta differentia à quinque sensibus.]

The **fourth difference** is taken from the five sensible objects. Some stones are pleasing to the eyes — beautiful, glittering, splendid — like most precious stones; while others, on the contrary, are ugly, dark, and imbued with an unpleasant color. They differ also in sound: some have a dull sound, others a sharp one; some ring like bronze; while a few give back no sound at all, like the *Samius* and the *Armenus*, and those that congeal out of terrestrial globes. They differ likewise in smell, pleasant and unpleasant: for some — as the *Geodes Misenus* [Geodes of Misena] — give off the scent of violets; the *lapis Mariebergicus* [stone of Marienberg], on the testimony of Agricola [Georgius Agricola], smells of moss; the *Turingicus* [Thuringian stone], found near the town of Beclinga [Böhlen?], gives the scent of wild thyme [Serpillum]; the *Ophites* [serpentine] smells of must; the *Echites*, according to Solinus, smells of wine, and the *Galactites* of milk. The *Marcasitae* [marcasites] and those flints from which fire is struck give off the smell of sulphur; amber [Succinum] and jet [Gagates] the smell of resin. As for tastes, they are not detected in stones except in the softer ones, which are ground between the fingers; for just as these take their origin from various salts and metallic juices, so they also obtain their taste — ...they retain the taste of whichever they consist of, whether salt or mineral. Touch, too, distinguishes stones — the soft from the harder, the smooth from the rough.

The fifth difference is drawn partly from shape, partly from specific qualities and other remarkable properties. As to the first, some stones are angular, others

rounded, polygonal and polyhedral — that is, formed with several angles and faces, pyramidal, like all the varieties of crystalline bodies; others are found with a circular, elliptical, or oval figure, like the pebbles of rivers worn smooth at the shore; and still others are stamped with yet other forms. There are, finally, stones that reproduce the figures of all things — woodlands, cities, fields, grasses, plants, men, and animals.

Again, stones are distinguished by various specific properties. Among these, some harbor remarkable feuds of antipathy and sympathy, both among themselves and when applied to human beings; some are flammable, others not; some promote urine, others sweat; some protect against accident, others against demons, sorceries, and diseases. All of these matters will be treated in some measure, each in its order, in the course of this book. But before that is done, I now set out an analytic synopsis of everything said so far.

Diagram. A branching classification tree (bracket-and-brace dichotomy), titled *Divisio Lapidum & gemmarum* — "Division of Stones and Gems." The whole is governed at the far left by the heading **Lapis alius** ("Another kind of stone" — i.e., the stone-in-general being subdivided). The primary division is by size: **Parvus** (small) and **Magnus** (large). Each of these subdivides by frequency — **Rarus** (rare) and **Frequens** (common) — then by hardness (**Durus**, hard / **Mollis**, soft), by appearance (**Pulcher**, handsome / **Turpis**, plain), and in turn by **Color** (Colore), **Figura** (Figure/shape), or transparency (**Diaphanus**, transparent / **Opacus**, opaque; **integrè** = wholly, **non integrè** = not wholly; **Sine colore** / **absque colore** = colorless). The terminal cells list the individual stone names. The structure, fully transcribed as a nested table:

Size	Frequenc y	Hardn ess	Appearance	Sub-criterion	Stones listed
Parvus (small)	Rarus (rare)	Durus (hard)	Pulcher (handsome) — Diaphanus (transparent)	Colore (by color)	Hiacinthus, Berillus, Rubinus, Prasius, Rubicollus, Chrysophrasiu s, Spinellus, Granatus, Amandinus, Chrysolithus, Balassius,

Size	Frequenc y	Hardn ess	Appearance	Sub-criterion	Stones listed
					Carbunculus, Saphirus, Smaragdus, Gemma Solis, Almandiuus
			(transparent)	Sine colore (colorless)	Adamas
			(opaque) — Opacus, intégrè (wholly)		Turcois, Chamtus
			(opaque) — non intégrè (not wholly)		Sardonix, Astroites; Leucosaphitus, Opalus
		Durus (hard)	Turpis (plain)		Pantarbe, Brontia, Umbria, Dracontia, Aëtites, Lap. Palumbell[us], Chelidonias, Ovum anguinum
		Mollis (soft)	Pulcher (handsome)	Colore (by color)	Margarita, Bezoar, Melochites
				Figura (by shape)	Oculus cati, Glossopetra, Umbilicus Marinus, Lapis Judaicus, Trochites
		Mollis (soft)	Turpis (plain)		Morochtus, Lap.

Size	Frequency	Hardness	Appearance	Sub-criterion	Stones listed
					Caymanum, Enorchis, Lapis Ceval, Lap. Manualis, Lap. Rhenalis, Lap. Porcinus, Lap. Anguium, Enhydros, Callimus, Lapis Malacensis, Lapis Manati, Lapis Histericus, Lapis Tuberonum, Lap. Bugolda, Lapis Bufonius
	Frequens (common)	Durus (hard)			Pseudoadamantes Hungarici
		Mollis (soft)			Lapis Fellis, Oculi Cancris, Lap. Spongiæ, Lap. Limacis, Lap. Carpionum, Lap. Percæ
Magnus (large)	Rarus (rare)	Durus (hard)	Pulcher (handsome) — Diaphanus (transparent)	Opacus (opaque)	Porphyrites, Heliotropius, Smaragdites, Jaspis, Lapis Lazuli, Achates, Corallus, Ophites, Cornu

Size	Frequenc y	Hardn ess	Appearance	Sub-criterion	Stones listed
			(transparent)	Colore (by color)	Ammonis Ametistus, Topasius, Smaragdopras ius
			(transparent)	absque colore (colorless)	Crystallus; Pseudoadamas Bohemicus
		Durus (hard)	Turpis (plain)		Steatites, Eneostis, Stalagmites, Onyx, Ceraunia, Basaltes, Smiris, Dactilus Ideus, Ossifragus, Stalactites, Lydius, Lap. Nephrit[icus], Lap. Sanguinalis, Geodes, Magnes, Hæphestites, Hysterapetra
		Mollis (soft)	Pulcher (handsome)	Colore (by color)	Specularis, Alabastrum, Succinum, Armenus
				Figura (by shape)	Ammites, Stellaris
		Mollis (soft)	Turpis (plain)		Asius, Samius, Ageratus, Melitites,

Size	Frequency	Hardness	Appearance	Sub-criterion	Stones listed
					Gagates, Porus, Schistus, Thyites, Amianthus, Galactites, Magargenteus, Hæmatites, Phrygius, Calamita alba, Fungifer
Magnus (large)	Frequens (common)	Durus (hard)	Pulcher (handsome)		Marmor
		Durus (hard)	Turpis (plain)		Cos, Pyrites, Saxum, Silex
		Mollis (soft)			Gypsum, Talcum, Pumex, Scissilis, Lythantrax

[Fol. 5, recto — running header "DE LAPIDIBUS" / page 5]

CAPUT II.

On the Stony Substance Seen in the Geocosm, and the Origin of Mountains

[De Lapidosa Substantia, quæ in Geocosmo cernitur, montiumque origine.]

[Margin: The author's method in this work.]

So great is the dispute and contention among authors over the origin of stones that one can scarcely make out whose view to endorse. To avoid seeming to waste time in setting out each of their individual opinions — which can be found in countless authors — I leave to each his own view and instead put forward what I have learned by my own experience and by many years' observation. From this,

unless I am mistaken, the kind reader will easily recognize what I have contributed and what those authors have. I have no wish to imitate those writers who, while they do not even know the specific differences of stones — much less of gems — yet are not ashamed to attempt, all too presumptuously, to write about the nature of each. For my part, I held nothing more important than this: that, since I was about to write on a most subtle subject, I should first come to know the airy "species" of all the things I treat philosophically in this work; then, in my various travels, visit the quarries of rock themselves, examine everything, anxiously consult the stone-cutters and quarrymen [lapicidas & Latomos] about every difficulty that arose, and investigate with all diligence the veins, the striations, and the courses laid into the stones by nature itself.

This done, imitating nature's shrewdness, I bent to the task with all the force of my mind, so that — as far as could be done — I might come to know by some art what nature works in the stones themselves with such great industry. My hope did not deceive me. Following, as it were, nature's Ariadnean thread, I found that genuine ἀὐτοψία [Greek: autopsia, "seeing for oneself," eyewitness investigation]-based account [γνῶσις (gnōsis)] that I had so longed for. Resting on it, and setting aside the disagreements of the said authors, I resolved to bring forward only what experience and direct observation [partly ἀὐτοψία (autopsia), partly experience] had taught me, for the sake of a more solid philosophy.

[Margin: Whether the stony mountains existed from the beginning, or were born in the course of time.]

The first question, then, is this: did the stony mountains exist from the beginning of things, or did they arise in the course of time out of slime, or after the Flood out of the heaping-up of an immense mass of mud? This doubt, which presents no difficulty, I will resolve in few words. I say, then, that the stony mountains — of the kind I showed in the Third Book, those vast mountain chains stretching both from pole to pole and from east to west — were set in place by the Divine Architect at the very beginning of things, when, at God's command, after the division of the waters, the dry land appeared. This is the view of most of the interpreters of Sacred Scripture.

[Margin: The cause and reason why the chaotic slime hardened at the beginning.]

For unless that Chaotic slime had at once coalesced into a stony mass, the Earth — being too soft with excessive mud — could neither have held together nor carried out its operations, as I showed at length in the passage cited. The stony framework of the mountains was therefore wholly necessary for stabilizing and

supporting the land against the assault of the sea and the stormy tempests of rains and downpours. As for those who think that the mountains first raised their heads after the Flood out of a heaping-up of mud, their opinion — being contrary to Sacred Scripture — must be utterly rejected. For Holy Writ, in Genesis chapter 7, says expressly that the Ark came to rest upon Ararat, the mountains of Armenia [montes Armeniæ]; but it could not have rested upon what did not exist beforehand, nor could Noah [Noë] have named to posterity a mountain he knew had not existed before the Flood. Add to this that the waters of the Flood are said, in the cited passage of Genesis, to have exceeded by fifteen cubits all the mountains under heaven — an expression that implies nothing else than that the mountains already existed before the Flood.

I would not, however, deny that, through the various upheavals of the world and the spreading of inundations, the slime and mud were heaped up into vast piles and, in the course of time, hardened into a stony substance. Nor am I speaking here of those stones or marbles that serve for the everyday construction of houses, temples, and other buildings, but only of the stony substance of the mountains — by which the body of the Earth is sustained so as duly to perform its functions — which is, as it were, a kind of skeleton [offatura], or mass of substructure, intended by God for the firmer consistency of the whole Geocosm.

[Margin: What power it was that hardened the mountains.]

It remains to explain how, and by what power, that chaotic slime coalesced at the beginning of things. It is certain that there was a certain lithifying power [vim lapidificam] by which this was done — and indeed it was implanted in the earthy body at once, from the very beginning of things, by God the Best and Greatest, whose immense providence does not err in its arrangement. But what this wonderful coagulating power may be, let us now explain.

[Margin: The form of things is not constituted from the four elements.]

I do not pause here over the opinions of the heathen philosophers, who hold that everything is constituted from the confluence of the four elements; as they assert in too general a way [καθολικωτέρως (katholikōterōs), "in a too universal manner"], so they conclude nothing, since this is already known to all. Therefore something other than the mixture of the elements must have been added, by which nature might accomplish her operations amid such great variety of things. And this is what I say: that there were seminal principles [seminaria] — entrusted by the most wise Architect, God the Best and Greatest, to the earthy substance — by whose power everything that comes within our view in this

world-machine both operates and has operated, and will go on operating into the future ages of time.

[Margin: The author's pursuit.]

For seminal principles of this kind were created and established to this end: that from them, as from the first principles of things, the several species of things might obtain their essential forms. To these seminal principles He added an architectonic spirit [architectonicum spiritum], dominant in the matter, by which ...

[Fol. 6, verso — running header "LIBER OCTAVUS, Sect. I" / page 6]

it shapes and works the subject under it into this or that form, as the seminal principle requires. Many natural philosophers hold that this form emanates from a fixed and proportional mixture of the elements; but they fail to consider that a varied mixture of the elements, in the absence of seminal principles, can of itself and by its own nature produce no compound endowed with a proper and new form. For the elements remain confused and mutually opposed, retaining their own particular forms, just as before the mixture — as I have shown elsewhere through experiments. For if a thing could be generated out of the fruitful seminal principles by a form arising from matter compacted of the elements, then Divine providence would have implanted the seeds of things in the Earth in vain.

[Margin: The twofold seminal principle of things.]

Now there is a twofold seminal principle to be considered here. The first regards inanimate bodies — of which kind are all the genera and species of minerals, stones, and metals that are enclosed within the Earth's womb. The second concerns the spermatic power and the nature that is at once vegetable and sensitive, without which nothing is accomplished at these grades of nature. Of the first I will treat first; of the second, at great length, in the course of this work.

CAPUT III.

On the Lithifying Power Diffused Through the Whole Body of the Geocosm

[De virtute lapidifica per totius Geocosmi corpus diffusa.]

When I said in the preceding chapter that God established a seminal principle that regards the nature of minerals, I do not take the word "seminal principle" [Seminarium] in its proper sense — as though stones thereby acquired some

vegetative power, for I will show in what follows that this opinion is false and rash. Rather, I call it a "seminal principle" in a certain equivocal and improper sense [σπερματικῶς (spermatikōs), "seminally," in a seed-like manner], because it has the power of coagulating and hardening, and of ...

[Margin: The magnetism of Nature.]

[the column continues at the foot — see below; the chapter body resumes:]

exalting the subjacent matter, partly from the dry, partly from the moist; and these are the cause of a great change in the earthy world. For when these corpuscles find a substance similar to themselves, they at once cling to it, joined by the force of magnetism and bound in a tenacious embrace. To these is added a certain architectonic spirit, like a director and leader of the operating power, arising out of the differing seminal principles of things; by which each thing, according to the disposition of its matter, acquires the form and figure due to it. This spirit must be considered not only in the spermatic and plastic power, but also in the very inanimate nature of stones and metals.

[Margin: What constitutes inanimate bodies.]

These things being supposed, I say first — as was already said before — that in the beginning of the world there was, in the terraqueous globe, a kind of seminal principle endowed with such power that it furnished consistency and solidity to all things; and I declare this to be nothing other than the salt of Nature [salem Naturæ], implanted in the chaotic mass of the waters. After the division of the waters, joined to the mud and slime, it at once exerted its powers: penetrating the still-soft earth by its piercing force, it transformed it, by its hardening power, into that skeleton [offatura] of stony mountains which we behold with wonder. In this the architectonic spirit was by no means idle. For this spirit, naturally joined to the Salt of Nature — wherever it found matter fit for forming rock — produced rock; and wherever it found matter suitable for tilling fields and bringing forth seeds, produced soft earth. Both it brought forth under the manifold differences of stones on the one hand and of earths on the other.

[Margin: The formal cause.]

As for why the flat surfaces of the plains did not, by the power of the diffused salt, harden into stone, the cause was the excessive abundance of moisture in the plains. This moisture, flowing down from the higher mountains, by its irrigation kept the fields free from hardening; whereas the mountains themselves, stripped

of moisture by the runoff of the waters and by their own dryness, it coagulated into a solid substance.

[Margin: The material cause.]

And from this union of salt with the various clods of differing earths, three other kinds of salt gradually emerged — niter [nitri], alum [aluminis], vitriol [vitrioli] — which, with other earthy substances proportioned to themselves ...

[the column resumes mid-page after the chapter heading; the opening of CAPUT III continues here:]

these corpuscles [the vapors and exhalations], being exalted by the subterranean heat, partly from the dry, partly from the moist, are the cause of great change in the earthy world. (See the continuation above.)

[Margin: What the lithifying power and the architectonic or plastic spirit may be.]

Lest, therefore, the Earth should suffer this great loss, the lithifying, architectonic spirit of Nature was established by God to this end: that whatever had been worn away and carried off from the mountains over the span of many years should be restored to the said seminal principle of Nature, as I will show afterward. What, then, this lithifying power may be, what the architectonic spirit is, and what it does and how it operates in the economy of the stony substance — this remains to be explained. And in order to proceed more solidly in the course of this argument, certain things must first be supposed, without which the rest cannot easily be understood.

I suppose, then, first: that there exists in the nature of things a certain magnetism, by which similar bodies perpetually seek similar bodies, mutually attract one another, and draw one another by a kind of perennial circulatory motion [pericycloseos motu], while dissimilar bodies repel — which clearly shines forth in all the grades of Nature, by which the threefold realm of inanimate, vegetable, and sensitive things is constituted, as I will teach afterward.

I suppose, second: that all vapors and exhalations are nothing other than the finest, most subtle, and imperceptible corpuscles, which ...

[Margin: What this lithifying power and the architectonic spirit may be.]

[The remaining portion of this column is occupied by the marginal notes and the continuation that flows to the recto of Fol. 7 — see the following page.]

[Fol. 7, recto — running header "DE LAPIDIBUS" / page 7]

[The top of this column is the continuation of the end of CAPUT III:]

[these salts], conjoined with the [earthy] substances, gave birth to the whole variety of stones and gems.

[Margin: The efficient cause.]

This variety, then, promoted by the concurrence of the subterranean fire, the sun, the stars, and the other elements, in the course of time — through a continual combination of various things — passed into that multitude and abundance which we cannot sufficiently marvel at. And so I say that the material cause of stones is nothing other than the salt of Nature, by which all things acquire their subsistence and solidity.

[Margin: The formal and final cause of the stony substance.]

The formal cause [formalem causam], on the other hand, I say to be the power implanted in the saline genus — that is, the lithifying, hardening, and coagulating power.

[Margin: The plastic power.]

But the plastic power [Plastica vis] implanted in the seminal principle of Nature — that is, the polymorphous spirit joined to it — instructs each individual thing to take up its own form and figure, in the manner that the nature of the thing required, which I also call the efficient and formal cause. And this was the process of Nature — roused by the command of the Divine will — in the first beginnings of things. Now, descending to more particular matters, let me show, by the reasonings that follow and by a great apparatus of experiments, that these things are so.

CAPUT IV.

On the Origin of Stones and Rocks, and How in the Course of Time They Coalesced into Such Great Hardness

[De Lapidum Saxorumque origine, & quomodo successu temporis in tantam duritiem coaluerint.]

I said in the preceding chapters that stones, rocks, and gems are not made out of the pure and unmixed elements, and I added the reasons; rather, something else is required, by means of which they may grow to such great hardness and differ

among themselves in so many differences of shape and color. But what that something may be, I will explain with all the diligence that is possible.

I said above that, from the first beginnings of things, a certain seed was implanted by the inscrutable wisdom of God into the chaotic mass — not, indeed, that vegetative seed, but a thing of such a kind as would correspond, by a fixed proportion and analogy, to the inanimate bodies of stones. And I spoke above of the saline lithifying spirit [*spiritum salinum lapidificum*], which, just as it has been appointed by Nature to this end — to furnish all things with their consistency, firmness, and solidity — so too, dispersed through all the paths of the sublunary world, wherever it finds a subject (that is, mud or earthy matter suitably proportioned), at once exerts its power upon it, coagulating it [*λιθογενετικῶς* (*lithogenetikōs*), "in a stone-generating way"] and converting it into a stony substance.

[Margin: What is required to harden the slime in a given place into stone.]

For the accomplishing of this, three things especially must concur. First, a proportioned place; second, matter within it aptly disposed to receive the seed; third, urgent heat that rouses the spirituous seed. For the generation of stones requires a spirit, as it were the form, and earthy matter, as it were the subject — which, in a proportioned place, with the subterranean heat (the efficient cause) acting as the coagulating agent, at last that lithogenetic offspring [*foetus ille lithogeneticus*] is brought to completion. And a proportioned place is required for this reason: that in it the form and matter may be duly preserved, fostered, and digested, as will be most fully demonstrated in its proper place concerning the wonderful power of fermentation. The place must be enclosed, so that the spirits, as it were in a womb, may be contained lest they fly off, and so that the heat, held back as in a prison, may not breathe out or be snatched away by some external force; and so, both by the subterranean heat and by the external cold — cooperating, if not of itself toward the union, at least by accident, by repelling and constraining the spirit lest it breathe out — they may be forced to be united, and in this way the intention of Nature may be satisfied.

[Margin: How stones are said to grow in mines.]

And from this the cause appears clearly: how stones are said to grow in mines, and how earth thrown into a mine, together with the moisture joined to it, finally turns to stone over the course of many years. For the lithifying spirits, derived to that place by the Vulcanian heat, when they run into proportioned matter — such as the earth of that place or mountain — at once pervade the whole mass with

their subtlety, and gradually coagulate, condense, and turn into rock that moist mass. For, as I said above, that lithogenetic or lithifying form is nothing other than that saline spirit, or those saline corpuscles — things wholly imperceptible to the eyes — which, scraped off by the subterranean heat from the mineral bodies in which they are powerful, and exalted through the innermost fibers of the Earth, produce now this, now that rock or gem, according to the disposition of the matter in their womb.

[Margin: Whence the lithifying power has its origin.]

And although a spirit of this kind can be considered under a certain generic notion, I do not doubt that it too obtains its specific differences, according to the proportion of common salt, niter, alum, vitriol, and the other individuated salts of the differing mineral clods. For the purer and more refined these spirits are, and the more suitable and proportioned the matter and the place, the more perfect and pure the stone that results — as happens in gems, of whose origin a full account will be given in what follows.

[Margin: Why not all stones are of a purer substance, and why one is more perfect than another.]

For since three things concur in the generation of stones — matter, spirit, and bond [materia, spiritus & nexus] — and, according to the differing quality or quantity of each, different stones are made, certainly so great a difference of qualities cannot arise except from the varied commingling of such spirits with one and another differing mineral. Hence some are harder, some softer; some clear and transparent, others ...

[Margin: Three things concur in generation.]

[Continued from CAPUT IV, "On the origin of stones and rocks, and how in the course of time they coalesced into such great hardness."]

[Margin: For the different worth and value of stones.]...some attain the price of a gem, others finally hold the lowest and most worthless place, like the stones that lie about everywhere. There are, finally, still others that are not generated everywhere, because the requisite conditions are not found in every place, nor are external aids ready everywhere. For some demand a more efficacious heat, others a tepid and moderate one; there are those that, rejecting excessive heat, prefer more cold; and some require a constrictive force of heat. All of this depends on the proper proportioning both of the heat and of the matter as variously disposed.

[Margin: Example of the marcasite.] But let us explain the matter by an example. In the generation of a stone, when matter teeming with sulphurous portions and metallic spirits pervades it, it is certain that a marcasite is generated — of whatever species it may be — a stone of a nature midway between stone and metal, an androgynous nature. For that the marcasite is full of sulphur, of odor and of an inflammable nature, is abundantly attested both by its inflammable character and by the spagyric art [*ars spagyrica*], which extracts copious sulphur from it; and yet it teems with the diverse spirits of the metals. Hence arises that notable variety of marcasites, some of which counterfeit gold, others silver, others copper or lead. For according as the metallic spirits are borne — more or less purified — toward that stone-forming substance, belonging to this or that ore, and again contaminated by a varied admixture of minerals, so too are stones generated that incline toward the various natures of the metals, the lithifying matter, by an innate magnetism, drawing to itself the spirits...

[Margin: Magnetism in the generation of stones.]...the spirits which were more congruent and proportioned to accomplishing the lithogenetic effect. And if anything lurking in the underlying matter has an affinity for metal, then the metallic spirits, attracted by it, will produce a marcasite stone of the very species to which the spirits belong, like attracting like to itself. But if that metallic spirit — of whatever salt's nature it may savor — finds the underlying matter not at all congruent and proportioned for the forming of a metal, but only matter apt for producing a stone, then likewise it will produce not a metal but a stone. We see the same in seed, which, when it does not find a womb suited to it, produces no germination at all, or else degenerates into some third and different thing. So too that metallic spirit does not generate a metal, but some third thing — namely a metallic stone, of the kind that pyrites or marcasite is.

[Margin: Example in seed.] For it savors of the nature of stone, in that it has many parts incapable of liquefaction, and in this it takes on the nature of stone; but it also has other parts that easily liquefy in fire, and in this — because of the notable abundance of sulphur it possesses, and because it readily liquefies in fire together with the metallic spirits — it takes on the nature of metal. But since we shall reason most fully about the genesis of stones in what follows, we refer the reader there, where (as we hope) we shall so unravel this matter through various experiments that we trust no scruple will remain to anyone hereafter.

CAPUT V.

On the color of stones and gems, and by what reasoning so great a difference of colors has been implanted in them by Nature.

Although nothing is more commonplace than color — that common object of all visible things — and nothing more obvious, yet such is the depth of its essence that all who hitherto have toiled to explain it, even philosophers of the first rank, have at last, after fruitless labor, perplexed, honestly confessed that its essence is as clear to the senses as it is obscure to the intellect, and therefore impenetrable to the human mind. And so we may not unfittingly think along with those wisest of philosophers, Plato and Aristotle. The former does not blush to lay bare the weakness of the mind in these words:

[Margin: Plato in the *Timaeus*.] "In what measure and manner the several colors are mingled with the several, no one, even if he knew, would be wise to relate — especially since he could in no way offer either a necessary or even a probable account of these things."

Here, noticing the difficulty of the matter, he says that our intellect stands toward those things that are most manifest of all just as the eyes of bats stand toward the light of day.

[Margin: Aristotle, *Meteorology* II, ch. 1.] Yet since the world, grown more learned by the continual experience of things, has made much progress, and since today many things have come forth that in earlier ages were quite unknown, this very fact offers us some hope of gazing a little more closely upon Nature's inner sanctuaries — not that we suppose ourselves in the least comparable to the philosophers of old, but because, by the frequency of experiments and the continual investigation of hidden things, with the grace of the divine Godhead breathing upon us, we have observed certain matters that have unlocked for us a true door and the keys to penetrating the mysteries of Nature; so that if not the inmost causes and reasons of each thing (which we think granted to no one in this life), then at least, so far as the weakness of human intellect allows, we may penetrate and expound those causes that can render our mind in any way quiet and tranquil in the knowledge of the truth.

There is, then, an immense dispute and controversy among nearly all authors about colors and their origin in mixed bodies, so that you can scarcely discern

whose view to subscribe to. The opinion of most — and chiefly of the Peripatetics — is that colors are secondary qualities, sensible to the sense of sight, arising from the temperament of the primary qualities. Thus from such a temperament...

[Margin: For the different reasoning of investigating color.] [fol. 9]...is born such a color, and from another a different one. But just as this description assigns no reasons, so the words too seem mere words that do not explain the matter but wrap it up. For when the nature and essence of color has been set forth in these words, I know almost as much as when I first asked. For the question is: what is that quality? how is it produced? by what? and when? For the desire to know by no means rests here, while the human mind would always wish to know something more than that generic secondary quality which they say arises from the primaries. Once that generic quality has been posited, what does the philosopher understand that is any more or any further than what a painter, a stonecutter, or a jeweler understands?

We, then, leaving aside the generic manner of speaking of the metaphysicians, and approaching more closely the inner and lowest amulets [phylacteria] of Nature, and creeping along the soil [humus] of deliberate purpose, shall — God granting it, and not scorning the apparatus of experiments — attempt to assign the causes of colors, not the common ones but the proximate and inmost, the ones most fitting to the things themselves and most of all to Nature.

[Margin: The infinite number of colors.] So great is the multitude of colors, and so manifold their variety through the reciprocal fellowship of mixture, that in no work of hers does Nature seem to have displayed her wealth more abundantly or with greater ambition. She has demonstrated this not only in the supernal bodies of the heavens — I mean in the stars — but also in the threefold economy of the lower world: in animals, plants, flowers, herbs, metals, stones, gems, marbles, all painted, distinguished, and adorned with a wondrous and incomprehensible artistry and variety of colors. And if you ask about the diversity of these colors, I answer that their diversity is as great as the diversity of human faces, of sounds, of tastes and odors — in short, as great as the diversity of all the species shining forth in this world. And just as these involve a kind of infinitude of number, so too we hold that of what mixture each consists, and by what art it is composed, is impenetrable to human intelligence — as Plato, cited above, rightly and wisely teaches.

[Margin: To contemplate the wisdom and power [virtus] of God in the production of color.] And so the ineffable wisdom of God seems to have sported with this wondrous variety of color, and to have set it before the human intellect, not that

the intellect might inwardly comprehend these colors, but that it might marvel at the divine mind of the Maker in them, and never cease to praise and adore Him. In the contemplation of all these things it has more than once come into my mind, while I stood astonished, whether at least through art a way might be granted to penetrate the causes of those colors which Nature has fashioned with such great industry —

[Margin: Whether the same causes might be investigated by the same art by which they are produced.] — a way by which, applying the active to the passive, the cause of Nature's effect might be detected. For relying on this investigation, I hoped it would come about that what Nature does in the causes of colors, I too might do through art; and so, when the causes converged into one and the same effect was produced, I should reckon that I had detected the genuine cause. No sooner said than done. But how, I explain in a few words.

[Margin: Supposition I. Color has its foundation in salts mingled with sulphurs.] I suppose, therefore, first, from the foregoing: that in the terrestrial globe there are various juices [succil], according to the variety of the earthy clods from which they emanate. Next, various kinds of salts, or crystalline bodies, which, just as they contain (being transparent) the principle of mixture, so too are most assimilated to light. To these is added manifold sulphur, of which most metals and some stones are mixedly composed. For there is no body that does not contain a portion either of moisture or juice, or of salt of whatever species, or of sulphur — since, by a certain wondrous analogy, juice corresponds to moisture, salts to earth, spirits to air, and sulphur to fire.

[Margin: The analogy of salt, moisture, spirit, and sulphur to the four elements.]

[Margin: Supposition II. From the spirits of saline things, agitated by a Vulcanian heat...] I suppose, second: that from the varied mixture of these — especially when the spirits of similar things are stirred up by a Vulcanian fire — there arises that immense variety of colors which we admire in stones, gems, and metallic bodies.

[Margin:...is born the variety of colors in stones.]

[Margin: Supposition III. The alteration of things in the fibers of the earth.] I suppose, third: that according to the various degrees of subterranean fire, mixed bodies undergo immense alterations as regards color (as will later be taught by experiments), through the abrasion of the smallest particles or corpuscles from the mixed bodies. This abrasion, exalted together by a vapor or exhalation, causes wondrous metamorphoses in the inmost fibers and veins of the earth, according

to the condition and disposition of the underlying clods — now of opaque, now of [transparent?] bodies. [The Latin here reads "nunc opacorum, modo [transpa]rentium corporum"; the run-over is set across the column and partly obscured, but "transparentium" is the evident reading.] These suppositions being made, it now remains to say how color is born in stony minerals, stones, gems, and metals.

I do not delay here over the various definitions of color adduced by various authors; I accept this one: *Color is the extremity of the transparent [perspicuum] in a determinate body, or the extremity of a bounded transparent body*; the moving cause of it is what is according to the actuality of the transparent — that is, color moves the diaphanous medium, which is already illuminated by an actual light. Hence it is plain that, although light and color seem to have a great kinship with each other, yet they differ among themselves, and so can be considered under a twofold reasoning.

[Margin: Colors in opaque and transparent bodies, and in what way they differ.] There are some colors that are beheld only in transparent bodies, others in opaque ones, and these we call material. Those of the former kind come about thus: when a clear and perfect light, before it reaches the sight, passes through a medium less clear and not perfectly diaphanous, then by that medium — owing to the manifold thickening of surfaces in its depth — it is to some degree rendered opaque; and from that commingling of light with the opaque, different colors result, according to the diverse tincture of the light in transparent bodies (as will later be demonstrated).

[Margin: In transparent bodies the diversity of colors arises from the commingling of light with the opaque.] Hence light, in its own principle, is indeed perfect, but by the encounter of the medium the diffusion of the light is not so much impeded as altered. For while it passes through the depth of the diaphanous medium, owing to some opacity (since no body in the nature of things is given perfectly diaphanous), it meets various shadows, which we call colors distinct from light — yet not merely apparent and imaginary, but true and real. For they are not beings of reason, nor...

[Margin: Color, the second of the two of the world, exists in opaque bodies.]...nor fashioned through imagination, but they have a true and real existence of their own. The second kind of color is that which shines forth chiefly in opaque bodies, and has the ground of its essence in the composition of bodies. With this color Nature has sported with a wondrous variety, not only in the stars, but also in the elements, stones, gems, and pearls; in trees, plants, flowers, fruits, and seeds; in

animals, birds, water-creatures, insects — in short, in all the opaque bodies of the world. It remains, therefore, that we expound the origin and reasoning of both colors as they shine forth in opaque as well as in transparent bodies, beginning with the color of opaque bodies.

It must be understood, then, that color [arises] not only from light, but also has the true and real grounds of its essence from the diverse constitution of the mixed bodies — a constitution which, afterward illuminated by light, draws forth the colors innate in them, as it were from potency into act.

[Margin: Whence material color arises.] It is asked, therefore: what is that commingling, and from where, or from what composition, does a mixed body now gleam white? now grow dingy with black? now glint with green? now blaze with gold? now shine so brightly with crimson [puniceus]? I explain in a few words.

[Margin: The commingling of all colors; color is made from four principal ones — white, black, fulvous, and crimson.] It is certain that the hypostasis of colors — the four principal ones — are these: white and black, fulvous [fulvum, tawny] and crimson [puniceum], from which all the rest, the intermediate ones, result by certain steps in a wondrous combination. For if you mingle white with black, you will obtain an ash-colored [cinereus] color, which, even if it proceed to infinity, will never yield either fulvous, or crimson, or green, but always that same ash color — now blacker, now paler, according to the variety and abundance of one or the other ingredient — until the white, suffused with too much darkness, tends toward black, and the black, suffused with too much whiteness, tends toward white. Hence not without reason is white compared to light, and black to darkness; since the latter, the less light it has, the more shadowy it is, while the former, the more it is suffused with light, the more luminous it is rendered.

[Margin: White disperses the sight, black gathers the same.] Hence, just as a white suffused with too much light disperses the sight, so a black, destitute of sufficient light, gathers it. Whiteness, moreover, dissipates the sight: partly because, at the sight of it, the circuit of the pupil is most tightly constricted, so that the images of things cannot freely pass into the proper workshop of vision; and partly because exquisite whiteness, when it fills the cavity of the eye, like a certain light so overshadows the forms of other things (which are of themselves less efficacious) that it snatches them, as if wrapped up and overwhelmed, from sight. But blackness, by a certain contrary reasoning, collects and steadies the sight. For at the sight of it the eye is in a manner darkened; and so, set as it were in an opaque place, it contemplates everything else more freely. All of this is plain in the eyes

of cats, whose pupils, if you observe them in the dark, you will find very wide; but if you gaze at them in open light, you will find them all the narrower, the greater the light to which they have been exposed. And so, just as these two colors are opposite...

[so the eye, on account of the harm and injury they do to vision, takes no delight in them]. Therefore, to constitute the variety of colors, Nature established three others — yellow [flavum], red [rubrum], and blue [caeruleum] — from whose mixture, above all, all the rest, the intermediate ones (which are without number, as we shall later show), are constituted. These mixtures, since they are not unknown to anyone and are found in nearly all authors, and since we have treated of them at length in our *Ars Magna Lucis et Umbrae* [*The Great Art of Light and Shadow*] and in our *Musurgia*, I have not thought fit to repeat. Since in this place only the aim of our undertaking is fixed — namely, whence colors are born in so great a diversity of stones, and first of all in opaque bodies (since regarding the color of transparent bodies no such great difficulty arises, as we shall later show) —

[Margin: Colors are born from the various salts mingled with sulphurs.] I say, therefore, first: that these colors are born, according to the first supposition, from the various salts, with which all bodies are imbued, mingled together with sulphur. For the more perfect, more purified, and purer the pus [pus — the impure earthy matter] from which a stone is generated, the nearer its color will be to light, and consequently it will display a nobler species; the more impure it is, and the more filled with an abundance of dregs, the more it will exhibit a color tending toward blackness. Yet because in this mixture salts are never lacking, they indeed — notwithstanding the muddy and befouled sulphur — induce the highest smoothness [levor] in such mixtures: partly on account of the hardness which they acquire from the abundance of salt, and partly on account of the splendor which saline bodies possess as though implanted in them by nature.

[Margin: The spagyric art teaches that colors are born from sulphur.] I say, second: from the spagyric art it has long since become known, by countless experiments, that from sulphur, variously tormented by fire, innumerable species of colors result. Hence the alchemists tell such tales of the peacock's tail and of the phoenix, as a brilliant sign of approach to the harbor of the great work [magnum opus]. Although I, for my part, judge that this diversity of colors must be ascribed not so much to the substance of the sulphur as to the saline bodies — vitriol, alum, and especially sal ammoniac — with which it teems; for the moisture of this sulphur, even at the least heat, is turned into innumerable colors,

just as sulphur too, agitated by various torments of fire, does not obtain such great differences of colors except from the sal ammoniac and vitriol with which it is saturated.

[Margin: All colors of sulphur are produced by sal ammoniac, vitriol, and the sulphurous salts mixed in.] These colors, however, it does not acquire except from the said salts, which, just as they follow the nature of transparent bodies, so too possess implanted in them the seminary of all colors. And those who attribute these colors to it from the mercury mixed in, they too assert that this comes about only from the salts of which it wholly consists — especially of vitriol; which, just as it possesses the same powers as sulphur, so too they [sulphur and vitriol] are cognate, and as to essence as it were the same, as the oil of sulphur and of mercury openly show, concerning which elsewhere. Hence, at the various degrees of fire, the saline-metallic spirits, sublimated, now...

now show black, now saffron-yellow [croceum], a little later intense red, and at last blue. The same happens in the sublimation of mercury together with sulphur, from which they elicit cinnabar's [cinabrium] intense red color; and in mercury, according as different salts and minerals [are added]. [The line is compressed in the column; "tum salia, tum minerarum" — "both salts and minerals."] Since we have elucidated all these things in the treatise on salts, and shall reason about sulphur as fully as possible in what follows, I refer the reader there. These things being thus laid down beforehand, let us now see whence comes so great a variety of colors in stones.

[Margin: The origin of color in stones.] It is certain that all stones are constituted chiefly of four things: of salt, of a sulphurous clod, of water, and of a lithifying [lapidifico] and dyeing mineral spirit. Whenever, therefore, a body consists of a predominance of salt and the least part of sulphur, a stone of white color will be born, like the white marbles. But if it grow up out of a predominance of burnt and impure sulphur, contaminated with earthy refuse, a black, porous, rough, and dark stone will be born. In marbles, however, from the abundance of salt (as I said a little before), the unrefined sulphur conceives that notable splendor and brightness in which we so greatly delight. If a greater part of vitriol be added to the sulphur, a coppery, somewhat reddish stone will be born, which, if it be mixed with verdigris [aerugo], becomes a stone imbued with a green color; and so of the rest, according to the variety of the intervening combination of the said four things.

And since there exists a great diversity of sulphur — for there is one sulphur that is black, another ashen, another fulvous, another ruddy, all of which depend on

the greater or lesser concoction of the sulphur — for through concoction the sulphur is purified, and the saline bodies are exalted, which, just as they are of themselves and by their own nature bright and diaphanous, so too, with the addition of a tinging mineral spirit (which we not unfittingly call sal ammoniac), most of all partaking of light, the stone — according to the quality and quantity of the admixed salt and the disposition of the matter — degenerates now into this, now into that color.

[Margin: How a stone is colored from the various salts.] In jaspers, however, which are of diverse colors, it is necessary that one color and another result, the spirit of sal ammoniac tinging the stone into those colors which the proportion of the diverse parts, by the magnetism innate in it, demands. The chromatism, then, or coloration of stones, is nothing else than the diverse reduction of vitriol-laden sulphur to a diverse temper, or to purity or impurity, according as the sulphur — which is mixed with all minerals — is in diverse ways purged and disposed by heat. For whether by its own proper fire, in which it is strong, or by an external or Vulcanian one, or even by light in its own way, those sulphurous parts are kindled; and, the refuse being surely consumed, the saline bodies will exert their power there, by a certain magnetic confluence, while like seeks like — or in some other way it must now needs become manifest through fire. And these,

[Margin: The reason for the purging of sulphur.] when, according to their diverse disposition, they are variously tinged with the aforesaid spirit, will likewise give off various colors.

[Margin: Chromatism consists in an igneous and spirituous part.] For although sulphur is not the fixed part of the stone, but the igneous and spirituous one, yet if it be pure and most thoroughly purified, it degenerates (as the spagyric experiments teach) into a crystalline body; and so it rises up no longer as an opaque, but as a luminous body. For coloration requires opacity, to which it may superadd light.

[Margin: From the various concoction of sulphur all colors arise.] Hence it is also plain why the saline corpuscles, which most of all concur in the generation of stones, since they are diaphanous, do not admit the same colors as the transparent things they surround: namely, because they are mixed with sulphur, and diffused through the whole substance of the stone; whence, from the thickening of the opaque part, they cannot exhibit themselves as luminous except on the surface only, according to the reckoning of the tincture they have undergone. If that tincture be red, [the surface will be] red; if white, white; if black, black; if fulvous, fulvous — and so of the rest. Yet if these saline bodies had

been freed and had gained liberty from every portion of earthy sulphur, they would assuredly gleam no longer with that material color, but with the one proper to transparent bodies.

[Margin: From the various concoction of salts and sulphurs all colors arise.] But how that may be done by the chemical art will be told in its own place. Such colors are nothing else than light and fire — the former representing the salts, the latter the sulphur — variously disposing itself, when mixed with the native gluing moisture and concocted, as daily experience teaches.

[Margin: Example from chemical operations.] For all things, while they come into being and are produced in their first beginnings, are adorned with colors far other and more distinct than in the middle and the end of their origin — as will be amply demonstrated in Book XI — for no other cause than that their hot and moist, mingled with the salt and sulphur with which they are imbued, are altered and cooked in various and distinct ways, both at the beginning of generation, and in the middle, and at the end. By the alteration of these, while the rock is dyed with its own volatile [part], it must needs (to speak after the manner of the chemists) result in diverse colors.

[Margin: Example from herbs.] Hence most minerals, roasted in furnaces and alembics, give off from themselves smokes of such differing colors; and in the great magistry [magisterium magnum] the colors — first dark, then bright, up to the most intense redness, which for that reason they call the *Red Lion* [Leo ruber] — by which they imagine they have attained the end of the work, emerge in a certain wondrous order. The same may be seen in plants too, whose parts near the root first flower with white, then with pale green, finally with intense green, until — the juice being consumed in autumn — they at last degenerate into yellowness. All of this happens from the subtlety or condensation of the moist and the hot, and from the various concoction of the radical moisture and of the sulphur appropriated to them. But of these things in their own time and place. Yet that these things stand no otherwise than as we have said, let us demonstrate all and each by irrefragable experiments.

EXPERIMENT I.

Pour the sharpest vinegar into a goblet or a lead dish. It will at once act upon the leaden substance, so that within a few days the lead, dissolved by the great acrimony of the vinegar, is converted into the purest white-cream lead [ceruffa, white lead/ceruse] — the very kind painters and apothecaries use to make countless preparations. [Margin: Lead is converted into white lead by vinegar.]

Now take this white lead out, place it in a crucible, and roast it over a very strong fire. Within a short time you will find that it has degenerated first into the most intense red color (which they call red lead [minium]), and finally into a black slag [scoria]. You will therefore ask: how does this color — first the whitest, then the reddest, and at last a black slag — come about?

[Margin: The cause and explanation of the experiment.] I answer that this happens through the increase of the heat of the fire. For first the vinegar, possessing a certain fiery acrimony, dissolves the lead into the tiniest particles. Since these particles are charged with salt, it follows that each one, separated from its earthy dregs, presents its own most luminous corpuscle. If you examine them under a microscope, you will see them in the form of crystalline grains — though, because of the calx mixed with them, they retain a little opacity; otherwise they are transparent. It is no different from when you crush glass into the smallest pieces: what was previously transparent now appears as a white powder, because the breaking-up of the compound, while it gives each particle its own particular mode of existence, also makes them appear no longer transparent but, through the mutual communication of reflected whiteness, bright and white. This is plainly seen in the dashing of water down from cliffs, where the water, broken into the smallest particles by the fall of the stream, appears white and snow-like for the same reason we have given.

It remains to explain how the white lead, when roasted, at last degenerates into the reddest color, and finally into a black slag. [Margin: How white lead is made red.] I say this happens through the various degrees of heat. For if you fix your eyes on a crucible set on the fire, you will see the white lead, at first white, gradually — at the very first whiff of fire — pass into a bright yellowish hue; a little later into a grass-green of first downy growth; then again into a tawny color; and at last bend toward the longed-for, most intense red of red lead. I said this happens through the various degrees of heat, but that reason does not suffice, since no one could deny it: something else therefore lies hidden, which constitutes this metamorphosis. How it happens, then, I will disclose.

[Margin: Lead is converted into white lead by vinegar.] We said above that all color is owed to the saline bodies mixed in metals. Now then, when the lead is eaten away by the acrimony of the vinegar, behold, there occurs a dissolution of the saline particles mixed with the calx; and since these have not yet undergone fire, they glow under the natural form of salt and calx. But once they have undergone Vulcan's fire, the sulphur — at first imperceptible, mixed with the lead and charged with salts — being roasted, passes from whiteness into a yellow salt;

[Margin: Roasted by fire, the leaden calx is turned into red lead, through diverse degrees of salt.] because the roasting transmutes the particles of the calx into a color near to white; and the saline spirit imparts brightness to it. But if the white lead is roasted more strongly, then — its bodies darkened by the increase — it will be seen tinged with a color compounded of white and yellow, somewhat greenish, which the reflection of light displays in such a disposed combination of matter. Again, if this is roasted still more violently, it gradually [passes] into a yellow color, because the matter, stirred up by the strong heat, degenerates — following the natural progression of colors — into that color which is nearer to green; for saline bodies exhibit, under the illumination of light, the color that the increase of roasting carries with it. And in this way the most intense degree of redness — that is, red lead — is at last produced by the most intense force of heat. From that degree, if the degree of fire is intensified more and more violently, you will see that, just as it grew up through the degrees of luminous colors into red, so now it bends gradually, through the degrees of shadowy and dark colors — that is, scarlet [puniceum], blue, ash-gray — in order, until, with all the spirits now dissolved, it degenerates into a black-colored slag, opposite to white, like coals. And from these things it is plainly clear how, by the force of heat, colors in minerals are gradually transmuted from one to another, step by step, according to the order of natural mixture.

[Margin: Why the same does not happen in the burning of wood.] But you will ask: why does not the same thing happen in the burning of wood, where the whitest wood at once bends into a charcoal color? I answer that this happens because of the abundance of moisture lurking in the wood. [Margin:...] This moisture, raised by heat into soot, tinges the wood with the color it is itself imbued with; and as the color increases and spreads through the whole substance, it is resolved into charcoal. The greasy soot still remaining in the charcoal a more violent fire at last strips of all its greasy moisture, as it were of a glue by which the parts in the charcoal were still held together; and that material, afterward mixed with another mineral matter and roasted by fire, undergoes the same gradual color-metamorphoses we have described. From this single experiment it is more than sufficiently clear how colors arise in minerals. But let us add another experiment.

EXPERIMENT II.

[Margin: Gall-liquor turns vitriol into ink, and why.] How saline corpuscles mutually destroy and restore one another we shall teach by this experiment. If you mix vitriol into an infusion of galls dissolved in clear water, it will at once

degenerate into ink. The reason for this is asked. I say it happens because the gall consists in greatest part of burnt sulphur, which it possesses impure and rough, as is most evident from its porous substance — a property which the water in which it is steeped communicates to it. Hence if you precipitate vitriol or vitriolated water into it, it comes about that the porous sulphur-particles lurking in the gall, and communicated to the water, at once [attract] the vitriol to themselves by their innate force, as to a body

[Fol. 13 recto, left column] congenial to themselves. And since the parts of the gall, as I said, contain a great deal of porous and burnt sulphur, pregnant with a black tincture, the particles of vitriolated water, joined to the particles of the gall, tinge the black color implanted in the gall — whence ink results. [Margin: A wonderful effect.] But if you pour Stygian water [aqua stygia, a strong acid] over this ink-tincture, then — marvelous to say — the inky water is at once restored to its former clarity. The cause of this effect is asked.

I say that the Stygian water, by its Stygian acrimony, immediately consumes utterly the eaten-away corpuscles of the galls mixed into the waters by the act of pouring; and since the tinging corpuscles are thus consumed, the clarity of the vitriolated water must necessarily return. But if you now pour oil of tartar onto this water restored to its former clarity, it will at once be turned back into ink. If you ask the cause of this, know it to be this: that oil of tartar contains in itself the same, or a not dissimilar, tincture as the gall. And so, poured upon the water now imbued with Stygian water, it comes about that the saline corpuscles — that is, the particles both of vitriol and of Stygian water, sublimed by the natural fattiness of the oil and imbued together with the black-colored tincture implanted in the oil of tartar — once more [yield] ink.

[Margin: A steganographic secret.] Hence a beautiful secret in steganography is revealed. For if you write whatever you wish on white paper with vitriolated water, the written letters soon vanish so completely, as though they had never been written, leaving no trace of them. But the moment you immerse the paper in an infusion of galls, the letters at once, imbued with the blackest color, [appear] — not without the [Margin: A wonderful blackness amid whiteness, and conversely, and the transformation.] [admiration] of onlookers. If you wish to make the whiteness complete again, do it with spirit of vitriol or Stygian water taken up with a pen and drawn over the letters; the liquor of tartar then poured upon this will restore it to its former state of clarity — the cause of which has already been made clear from what was said above. In the same way, [Margin: The blue tincture of violets turns purple, which turns into green.] the blue

tincture of violets, when oil of vitriol is poured over it, turns purple; and if you add to this a few drops of spirit of hartshorn [spiritus cornu cervi], that purple color is straightway turned into green. All these things depend on the varied constitution of the different bodies, which abound in various and different salts that tinge variously; and so too, from the natural quarrels by which they are at odds among themselves, or agree, they admit various transmutations of colors. But these matters will be set out more fully in the treatise on the fermentation and precipitation of metallic liquors, with a very rich heap of experiments.

EXPERIMENT III.

Take iron or steel, skillfully polished and most shining. If you press it with a moderate heat of fire, it will put on a saffron color; with a more vehement heat, blue or violet; but with the most vehement heat, before it glows red-hot, it will be turned into a black color — by which ignition alone it almost loses its luster. The experiment is commonly known, most familiar and everyday to blacksmiths; yet they cannot give the reason for this coloration [chromatismus], nor — I think — is it so obvious even to those who imagine themselves to be great Doctors in Philosophy. We persist, therefore, in this: that coloration and tincture arise from sulphur mixed with salts, and that, according to the diversity of pure or impure sulphur, it produces different colors, as we have already said above.

[Margin: The fiery process of the iron's coloration and tincture.] For while the iron is shining, polished, and wiped clean, if it is placed on a fire, or [exposed] to some other fiery heat — as when it is quenched while glowing — the sulphureous parts of it, at once kindled, exhale their subtlest parts at the outermost surface; and those that remain on that external surface, being deprived of [the finer parts] and being more impure, are accordingly turned, under the form of rust, into that saffron or wheaten color. For since a lesser opacity is required for a color of that kind, as soon as some of the purer substance has flown off, what remains of the fixed salt mixed with the volatile sulphur must necessarily incline to a saffron color. But if, from a more intense fire, the withdrawal of the subtler and brighter parts increases, it comes about that the parts which remain thicken still more in the said surface and become opaque, and so degenerate into a kind of shadowy color, such as blue is; until at last, with the increase of the fire and the light poured over it, the surface is converted into a black color, the more impure parts being packed together on the surface.

[Margin: Why the color of iron does not come about in the same way in boiling water as in fire.] But you will perhaps ask whether this metamorphosis of colors could come about through some other agent — for instance, if iron were thrown

into the most boiling water. I answer: no. For this effect requires a true fire and a burning heat; otherwise the sulphureous parts diffused through the whole substance of the iron would not be kindled. But they are kindled even at the moderate heat of the applied fire; to a single one, all of them — and the whole substance of the iron — are altered by it, because the subtler parts, flying off, carry with them out of the inmost recesses of the iron the more impure parts, which — being more impure and deprived of spirits — likewise, unaccustomed to flight, settle as if fixed on the external surface.

Now that the truth of colors in stones and metals has been demonstrated through the preceding experiments, nothing more remains except to demonstrate by what reasoning stones are colored in the inmost bowels of the earth. I say, then, that since most rocks and stones consist of their own sulphur and salts, it comes about that if mineral spirits of salts, raised by the subterranean fire into vapor or exhalation, penetrate — by reason of their utmost subtlety — the inmost crevices and veins of the mountains, then, where they have fallen upon suitable matter, joined to the volatile or fixed sulphur that is in that matter, that matter is turned, according to the variety of the tinging spirit, now into this, now into another color; which a lapidifying spirit or juice, coming afterward, at last hardens into a stony substance. But since in what follows

[Fol. 14 verso]

various occasion for discussion of these and similar matters will be given, I have thought it superfluous to elucidate the matter here at greater length. It remains, then, that we now show the genesis of the mixture of colors, and of their degrees, according to nature. We here lay down five principal kinds of colors as a foundation: White, Yellow, Red, Blue, Black — from whose mixture all the others, the intermediates, of which there is no number, are born; and they are comprised in the following scheme.

Diagram. A nested-arch (pyramidal) scheme of color mixtures spanning the top of the page, set between the two text columns of Fol. 14 verso. Five base colors are labeled in *italic* along the bottom baseline; above them, a tier of intervening arches each carries the name of an intermediate color produced by mixing its two neighbors below, building up in successive tiers to a single apex color. All labels are legible.

Baseline (left to right):

- *Albus* — White
- *Flavus* — Yellow

- *Ruber* — Red
- *Caeruleus* — Blue
- *Niger* — Black

First tier of intermediates (each between the two base colors beneath it, left to right):

- *Subalbus* — off-white (White + Yellow)
- *Aureus* — golden (Yellow + Red)
- *Purpureus* — purple (Red + Blue)
- *Subcaeruleus* — bluish (Blue + Black)

Second tier:

- *Incarnatus* — flesh-color (above Subalbus/Aureus region)
- *Aureus* — golden
- *Purpureus* — purple
- *Subruber* — reddish

Third tier:

- *Cinereus* — ashen
- *Viridis* — green
- *Fuscus* — dusky/brown

Apex:

- *Cineritius* — ash-gray

White mixed with black in equal proportions of parts gives birth to nothing other than an ash-gray [cineritium], whatever some Peripatetics may say. For black mixed with white always produces something whitish, and white with black always something blackish and dark — until either the whole white color is changed into manifest blackness (by repeatedly throwing in more white), or the whole black into whiteness; and conversely, the whole white into blackness (by ever and repeatedly throwing in more black). Nor is it possible for any other intermediate among the bright colors to be produced from these, since they are opposite colors, which admit no mean. But let us now pass on to others.

1. White with yellow will produce an off-yellow near to white; yellow with red, a golden, tawny, or saffron color; red with blue, purple; and blue with black, an off-blue nearest to black.

2. White with red will produce the color called flesh-color [incarnatum], and red with black an off-red verging toward blackness, as is seen in red tulips.
3. White with blue, a color not unlike ash-gray; and yellow with black, a dusky color which they call lion-color [leoninum], the color of dusky clay.
4. Finally, yellow with blue produces the noblest green of all, made up of nearly all the intermediates — the one color which Nature seems to have intended for the recreation of men and animals; whence it deservedly occupies the middle place among all colors.

And from this fourfold combination of colors all the rest derive their origin. For from white to true yellow, by the continual addition of yellow, are recalled all those colors which they now call yellow, more intense or more remiss. From red to yellow, by continual addition, result all those colors which are recalled to red, now more remiss, now more intense,

up to true red. By the addition of red to blue are recalled all those colors which have red either more intensely or more remissly. Finally, by the addition of blue to black, are recalled all those blue colors which decline toward black. The same is to be said of the addition of red to white, of red to black, of white to blue, of yellow to black, and lastly of yellow to blue. For white, yellow, red, blue, and black are not the same in all things, established at an immutable and fixed degree; nor is green the same in all things, nor golden the same, nor purple the same; but according to the varied mixture of the five principal colors named, countless species of each emerge. So that here you may have [a means] to reckon into which class of colors you should number each one — each of which draws its name from the things in which they reside: namely from the elements, the clouds, from light, from minerals, metals, herbs, flowers, from animals, birds, fishes, reptiles and insects, and others. On which see our *Ars Magna Lucis et Umbrae*, where this is treated more fully at fol. 66.

COROLLARY.

[Margin: Sulphur by its power has all colors.] From this it is likewise clear how, from the varied concoction of sulphur mixed with various salts, various and most diverse colors arise according to the degrees here set forth — as has been made more than sufficiently clear by the experiments adduced. These things being shown, let us now proceed to expound the genesis of those colors which they call apparent.

EXPERIMENT.

[Margin: Experiment of the mixture of color.] To more forcibly confirm what we have said about the combination of the aforesaid colors, you will perform the following experiment. Take crystalline glasses tinged with the five aforesaid kinds of colors — white (that is, glass devoid of color), yellow, red, blue, black. You will find that, from the superimposition of

[Fol. 15 recto, left column] one glass upon another, all those species of colors which we described in the preceding scheme are produced. So if you superimpose yellow glass upon red, you will see all objects seen through it at once shine with a certain golden color; the same will happen by the reflected ray, if you catch the sun's rays passing through the glasses on white paper. For while [the light] passes through the transparent medium, it imbues the paper with the color of the transparent medium — here, golden. Again, if you superimpose yellow upon blue, you will find everything grows green with a most brilliant species of color; but if you try the matter with the conjunction of red and blue glass, you will find everything turns purple. In this way, blue with green will display the color they call peacock [pavonaceum]. But if you superimpose a blackish glass upon white, no other color will come forth than ash-gray. In this way, with glasses tinged with only the five named colors, you will display the mixtures of all colors — an experiment no less full of delight than most worthy of admiration, demonstrating the causes of colors to the eye. Let no one, therefore, call these colors fantastical, since the glasses are tinged with a true color, drawn not from vegetables but from various minerals. [Margin: Apparent colors are not imaginary, but true and real.] Nor can the diverse color be said to be merely apparent,

since they proceed from a true and real mixture, and from light tinged according to the nature of the medium. In exactly the same way I say it stands with transparent gems: [Margin: How transparent gems are generated.] crystal, which [is generated] from white; chrysoprase, from yellow; carbuncle, from red; sapphire, from blue. But black, being shadowy, generates no gem imbued with this color. Crystalline [stone], as it emulates pure light, cannot properly be called a color. But the sapphire is tinged with the color belonging to the saline-sulphureous tinging spirits by which it was coagulated. The carbuncle, tinged with sulphur most thoroughly purified and concocted by sal ammoniac, glitters with the reddest color. The sapphire, with a tincture of vitriol [tinctura vitrioli aërosa], is dyed into a most beautiful blue of heavenly color. The emerald, resulting from a mixture of yellow and blue color, shines with a most brilliant

green. So whatever the saline tinging agents joined to the sulphur shall have been, such will be the gem that thereby turns to stone — concerning which, later. It is therefore clear that in gems the colors are not merely apparent, but true and real, arising from a true and real tincture. From these, let us now proceed to the colors most apparent in polygonal glasses, caused by the various reflection of refraction.

CAPUT VI.

On the Colors which they call Apparent.

[Margin: Apparent colors are not imaginary, but true and real.] Those are called apparent colors, for the most part, which do not flow from the surfaces of opaque and mixed bodies, but which present themselves to the sight in diverse ways through the diverse media of transparent bodies. These have, in the view of most people, been given this etymology because, of themselves and by their own nature, they are unstable, and are seen now in this, now in another color, according to the differing flux of fluid and the differing constitution of the eye; and therefore are thought not true and real, but imaginary. But we — whatever the Peripatetics may say — hold that no color is purely apparent; rather, all are true colors, which contain within themselves the true causes and reasons of their mixture and appearance. They are observed, for the most part, in the rainbow [iris], in the feathers of certain birds such as ducks, doves, and peacocks; in the differing color of the sea and the clouds; in triangular glasses [prisms] and the other crystalline polyhedral bodies, resulting from the various reflection of light. And first we shall reason — by a parallel course — about the colors in polygonal glasses, and then also about those that appear in the feathers of birds.

How Color comes about in transparent angular bodies, that is, in triangular and polyhedral glasses.

How the diversity of colors is produced in transparent angular bodies — that is, in triangular and polyhedral crystalline ones — is a matter of great controversy among the philosophers. Most of them, while they too contentiously assert that there is no real entity of colors there, but a purely fantastical and imaginary one, demonstrate that they are equipped with but slight experience of natural things, being about to dispute over those most hidden matters of nature, which they have not so much as greeted at the threshold. But those who have come nearer to her most secret recesses are compelled, by Nature herself as mistress and teacher, to say otherwise. But, to bring forth at last from the darkness into the light the manifold offspring of light: I would have you know, Reader, that

crystalline and glassy bodies, no differently than all other mixed mineral bodies, consist of their own salino-mercurial bodies — [Margin: All transparent bodies consist of their own sulphur and salts.] since glass is made from ashes turbid with salt, and from crystalline bodies, namely salts, of which there is none that is not transparent, as is clear from the microscope. These corpuscles, although they appear colorless in a glass devoid of angles, the cause is the continuity of the same, spread out and united into one flat and polished surface, through which the sight, passing straight, just as it finds no shadows, so too is not altered by differing kinds of shadows. But as soon as it falls upon angular transparent [bodies], then behold, the saline corpuscles, now affected in diverse ways — now by the defilement of shadows, now varied by the various refraction of light in a denser medium — will display colors in the order we described above; for the more

[The reading order of these four s non-linear; they are presented here in folio order: fol. 16 (verso), fol. 17 (recto), fol. 18 (verso), fol. 19 (recto).]

the smaller shadows, the closer they are to the light, will yield colors nearer the light, while the greater shadows, the more they prevail, will yield colors nearer to darkness. As for why these colors do not appear in non-angular bodies, the reason is the one I gave: straight, unimpeded light passes through to the visual faculty, and since all the corpuscles are as perfectly united as possible, they likewise absorb the pure light in the same uniform way. Consequently no colors at all appear in a medium of this kind, because of the uniformity of the light.

[Margin: Why the salt corpuscles set within a transparent body are not displayed in a non-angular transparent body, but are displayed only in an angular one.]

But the moment the opacity of an angle intervenes, the light, now darkened by the variety of the shadows, returns exactly the series of colors that the greater or lesser shadows require. With the salt corpuscles dispersed throughout the whole transparent body, the light—refracted, and mixed with shadows of varying opacity—brings into the open the very color that each corpuscle of a different tincture demands, together with the differing degrees of opacity. All this we demonstrate in the following figure. [Margin: Which colors are seen in the prism, with the explanation set forth.]

Diagram. A geometric figure illustrating refraction through a triangular crystalline prism. At upper right the Sun is drawn as a radiant face, with three rays (labeled near the Sun) descending obliquely onto the upper-right face of the prism. The prism is an elongated crystal: its apex region is the triangle **S** at top, with the upper short edge running **R–T**, and the body of the crystal extending

downward to a pointed base at **V–X–Y**. The refracted rays exit toward the upper left, where the eye is at **H**, with ray-terminations labeled **K, I, D**. Along the upper refracting surface, near the apex **S**, small italic letters mark the points where rays strike and bend (**a, b, c, e, g, n, o, r**).

- Sun (upper right): radiant face, source of the incident rays
- C, E, I, N (rays from Sun, upper right): the Sun's rays striking the prism's right face
- S (apex, top center): top vertex of the triangular prism
- R (upper left edge): left end of the prism's upper edge
- T (upper right edge): right end of the prism's upper edge
- V (lower left): left shoulder of the pointed base
- X (lower right): right shoulder of the pointed base
- Y (bottom point): the base apex of the crystal
- H (upper left): the eye [oculus]
- K, I, D (upper left, near H): terminations of the refracted rays reaching the eye
- a, b, c, e, g, n, o, r (small italics along the upper face): the points of incidence and refraction of the individual rays

Let the prism, or crystalline triangle, be **R T S V X Y**; the Sun's rays, **C E I N**; the eye, **D I K H**. Here a twofold appearance of objects is seen. The first is by the reflected ray, which alters the object neither in shape nor in color—though it shows it reversed—and this happens when the object passes through the glass perpendicularly. The second is by the refracted ray, and here the object is shown neither in its natural position nor in the same color; instead it appears now curved, now oval, and finally decked out in every kind of color. For when a ray of the Sun, **F**, or of any light, strikes the side **S T** of the triangle obliquely, it is twice refracted and returns to the eye **D I K H**. And since by this refraction it loses much of its original vigor on account of the greater or lesser depth of the medium, the light—thus diversely darkened and stained—renders colors that tend now more toward white, now more toward dark.

Now in the triangle there appear three principal colors, mentioned above—chiefly yellow, red, and blue—and from these are mixed green and purple, white and black being excluded as unsuited for producing the intermediate colors. [Margin: How yellow, red, blue, green, and purple arise in the triangle.] They arise in the triangle as follows. Let there first be the ray **C**, which strikes the glass at the point **b**, and since it must pass through a denser medium, it is refracted

from **b** to **a**, and from there reaches the eye placed at **Z**. Now since **a–b** is a short passage, at this place it would indeed produce a color most like the light, that is, like white; but because the solid angle **S V** of the glass darkens the neighboring ray considerably by its shadow, it generates not white—nor yellow, as it should if the angle did not obstruct it—but the most intense redness.

By contrast, if the ray of light **N** strikes at **O**, then in the deepest part of all, **O r**, which it traverses, it is refracted and runs to the eye placed at **H** under a blue color bordering on black. Both by the double refraction, and by the depth of the medium, and by the opacity of the angle, it has degenerated far from its native purity and ends in a dark color, such as blue is. But the ray of light **E**, falling on the point **e** of the triangle, is twice refracted—from **e** to **g**, and then finally reaches the eye at the point **I**. This ray, since it proceeds by a kind of middle path, neither much darkened by the shadow of the more remote solid angle nor immersed to so great a depth, will display a color of the middle kind, nearer to white, gleaming in a saffron robe. The remaining two colors, green and peacock-blue [pavonaceus], are composed—the former from a mixture of yellow and blue, the latter from a mixture of red and blue—and likewise show themselves at the boundaries of the said colors. In this figure, **a**, **b** mark the smallest breadth of the glass; **g e** and **n l** the middle breadth; and **o r** the greatest breadth or depth.

From all this the cause of the colors in the glass triangle, and in other angular crystalline bodies, is evident. It is none other than this: first, the solid angles cast shadows; the light, refracted in various ways as it passes through a medium of varying density, and variously modified by the shadows, and tinted by the salt corpuscles more or less dispersed, shows itself clothed in so many and so great distinctions of color. If you have rightly grasped this, you will also have the causes of the colors that shine forth in the rainbow, the sea, and the rest of things laid bare. See, reader, what we treated with fuller reasoning in our cited book *On Light and Shadow* [*Ars Magna Lucis et Umbrae*].

You have perceived, reader—unless I am mistaken—from the foregoing, that the internal light, or innate heat, which is called the sulphur of Nature and exists within each thing, is by its concoction the source of all the various colors. You have also heard how innumerable colors that mercurial liquid displays when mixed with salt bodies—colors which whoever has not seen will surely not believe me when I write of them; but those who have seen them, astonished at the novelty of the thing, cannot sufficiently marvel at that "tail of the chemical peacock," glittering with such unwonted kinds of color. But how this comes about, I shall teach right after the experiment proposed below.

A WONDERFUL EXPERIMENT, exhibiting colors of every kind.

If you place quicksilver, coagulated by the vapor of lead, on a copper spoon and heat it over burning coals, behold: presently there will emerge in the liquefied material such a variety of colors as no greater can be seen in the world—so brilliant that the so-called apparent colors can scarcely be compared with them. [Margin: The cause of so many colors.] The cause of this is sought. I say it is the exaltation of the salt corpuscles—which before lay hidden in the moist liquid mercury—brought about through the coagulation produced by the vapor of lead. For when the corpuscles are separated by the force of the heat, then behold: once the earthy dross has been either consumed or settled out, the tinging spirits of the salts alone, raised to the surface, first grow insolent with the ambition of dominating, and—tinged by their varied confluence—demonstrate their power by exerting it across nearly all the differences of color. Therefore no one of sound mind should be reckoned to dare to call these colors purely imaginary. For they are the various spirits of the tinging salts, present within the mercury by the force of the lead, which, exalted to the surface by the force of the heat, by the aid of the incident light display so many and so varied differences of the said colors. For inasmuch as they are transparent, so the corpuscles, set one upon another, express through whatever opacity now this color, now that—just as was said above concerning tinted glasses set one upon another.

The cause of the colors that shine in the feathers of birds—that is, of peacocks, doves, ducks, and other birds.

That birds swell with sulphur and salts is clear from this: that out of stables and dovecotes an immense quantity of niter and other salts is extracted. Since, therefore, they cast out by their excrement the oily portion (to speak with the chemists) of the sulphur and salts, but cannot discharge the finer parts of the salts through urine, which they lack, Nature seems by all means to have assigned these, with a higher design, to the clothing of the feathers. For since these most subtle salino-sulphureous spirits continually exhale, they, working their way into the hollow little channels of the feathers, are there condensed by the surrounding air and pass over into feathers, others and others continually succeeding. And just as the feathers are constituted of salt material variously tinging, so too they are imbued with various colors according to the incidence of the light and according to the differing structure of the feathers. [Margin: How black, white,

mixed, and the various other colors arise in birds.] For if the feathers are imbued with the soot of burnt sulphur, the birds will turn out black; if with abundant niter salt, white; if they grow from a vapor at once white and black, the birds will be born black-and-white, like magpies and swallows. But if various tinctures of salts come in, birds of diverse colors will emerge. And about these there is indeed no dispute; but how in peacocks

and doves so varied, inconstant, and changeable a variety of colors is produced according to the varying incidence of the light—of that no one, so far as I know, has yet given the true and genuine explanation. I will set out in a few words what I have observed. From frequently inspecting feathers of this kind under the microscope, it became known to me that all those feathers, radiant with so great a variety of colors and conspicuously born in peacocks and other birds, arise from the natural structure of the feathers. [Margin: The many-colored feathers of the peacock arranged in transparent, triangular-glass shapes.] Nature has so disposed their filaments that they are both transparent and fashioned into an angular form not unlike the glass triangles—all of which the microscope plainly demonstrates. Therefore, when feathers of this kind have coalesced into such an angular form out of a mixture of various tinging salts, the same thing happens in them as we taught just above happens in the triangle: that infinite variety of colors arises from the innumerable multitude of such angular feathers, by the varied refraction of one into another. And so I reckon this to be the demonstrated cause of the colors in the feathers of birds. But since we have set out all of this more fully in the *Ecstatic Journey through the Terrestrial World* [*Iter Exstaticum*], we refer the reader there, where he will also find the colors of the clouds, the sea, and the minerals treated most abundantly.

Various experiments on the colors emanating from metals and mineral bodies.

EXPERIMENT I.

The first experiment, by which it is shown that in any glass ball, watery bubble, dewdrops, and the drops of the rainbow and of leaping fountains, the same colors are generated as we showed above are produced in the triangle and the other polygons; from this too you may gather the genuine cause of the colors.

Take a glass sphere filled with the clearest water, and set it out in such a way that the incident light of the Sun may be reflected from it into your eye. Let the sphere be **B C D**, the eye **E**, **A–F** the bounding rays of the Sun, and you will see at the point **D** the most intense

Diagram. A geometric figure illustrating refraction and reflection of sunlight within a water-filled glass sphere. At upper left the Sun is drawn as a radiant face, marked **A** above and **F** below. Two dashed rays run from the Sun rightward to a circle (the glass sphere) at the right; within and around the circle are an inner small circle and inscribed lines forming the ray paths, with the inner region labeled **B C D**. The eye, **E**, is at lower left, drawn as a small eye, with rays running up to the sphere.

- **A** (above the Sun, upper left): label of the Sun / upper bound
- **F** (below the Sun, upper left): lower bound of the Sun
- **V, I** (top of the sphere): points where the bounding rays meet the sphere
- **K** (upper left of inner circle): refraction point
- **C** (right of sphere): point on the sphere
- **B C D** (center, inner region): the inner refracting/reflecting points within the sphere
- **G** (lower left of inner circle): refraction point
- **H** (right of sphere): point on the sphere
- **D** (bottom of sphere): the point of most intense color
- **E** (lower left): the eye [oculus]

redness, but when the angle is changed you will see that color manifestly varied from red into blue mixed with yellow. [Margin: Refraction of the light the cause of the different colors.] At **K** likewise the same image of red color will appear, though much fainter than at **D**. The reason for this is none other than the varied refraction in the denser medium, by which the light, variously darkened in the deeper parts of the sphere, produces the colors I have named. And from the figure here appended it is sufficiently apparent: at the point **V** of the sphere the light of the Sun strikes; refracted in the denser medium, it falls upon **C**, and from there, reflected, is driven back to **D**, and then from **D**, refracted again, reaches the eye at **E**. Since, therefore, the light is here twice refracted—once reflected in a homogeneous medium—it finally arrives at **H**; necessarily, stained by the shadows of the medium, it at last reaches the eye, having degenerated from its native brightness into a kind of shadowy light, as if in a shadow. That this manifold refraction is the cause of the colors is therefore clear from this: that at **K** the red is much varied, and the redness at **D** (inasmuch as it verges on crimson at **D**) is more remote from the white that is like the light, and so it must necessarily undergo more refractions. Moreover, the ray of the Sun **E**, striking at **G**, is refracted to **H**, thence to **I**, and from **I** to **K**, and from there at last into the eye **E**. You see, then, that a color becomes the more shadowy the more refractions it has

undergone in some transparent circular or polygonal body. Hence from this experiment the whole account of the rainbow and of the watery drops and bubbles of leaping fountains depends.

EXPERIMENT II.

There follows the color of an inflammable material, or of an oil dyed with any color whatever. [Margin: Green flame.] For if you mix verdigris [aerugineum] color thoroughly into a dish of *aqua vitae* or spirit of wine, and kindle the prepared liquid and a wick imbued with a similar color, you will see, not without wonder, a flame burning with an intense green. If you put this into a glass flask painted with grapes and plants in a bright color, on a nearby wall or white panel it will display the fruits and plants in the most intense green. For the tincture of the copper vitriol present in the verdigris, exalted by the heat, will imbue the flame with a color like itself; and the dyed light, passing through the glass flask, will tint it with a similar color, and will dye the green picture with a still more intense green. [Margin: Purple flame.] But if you mix cinnabar thoroughly with oil, the kindled liquid will make in the flame the redness of the most intense color; and if sulphur is mixed into this, it will be changed from red into a blue color. [Margin: Blue flame.] It is the same flame, but it acquires a different color according to the difference of the dyed liquid; and all this depends on the difference of the salt spirits variously dyed. [Margin: Black flame.] Finally, if you imbue the wick and the oil with soot mixed with the liquor of the cuttlefish, behold: presently a flame will rise up imbued with a black color, which will also tint the faces of the bystanders with the same color, not without the wonder and horror of the spectators. From this, in natural magic, various astounding effects can be produced, which we have shown elsewhere.

EXPERIMENT III.

On the colors of metals.

To change the color of copper [aes] into white, proceed thus: throw a powder made from calx of tartar, and likewise from alum and white arsenic dissolved in lye of lime and dried again, into melted copper, and it will gleam with a silver color. [Margin: The variety of colors in minerals through the various degrees of fire.] The same will happen if you make a water from sublimated mercury and dilute it with sal ammoniac by deliquescence; for in this, copper and iron quenched will be imbued with a silver color. But if you wish to transmute black lead into a white color, proceed thus: from white arsenic, calx of tartar, rock salt [sal gemma], and sal ammoniac let a powder be made, which you will macerate,

drenched with vinegar, for the space of seven days; and the macerated mixture you will boil down to dryness. Its fine flour, cast upon melted lead, will give great help in the casting of vessels that look like silver. By the power of fire, gradually, from ochre is made red lead [rubrica], burnt in new pots smeared round with clay; and the same, made red-hot and quenched with vinegar, will display a purple color. Copper burnt with sulphur degenerates into cinnabar; spirit of vitriol dyes iron into copper; sal ammoniac dyes lead into tin. The colors of potters, if they are smeared over with other kinds of color, will acquire another form of a different color, as will the kinds of vitriol [calcanthum]. For the heat dissolves the material into spirits, and salt bodies fixed and exalted by heat render dark colors much more brilliant.

As for the philosophical tincture, you should know that its colors are as unstable as can be, and ever and again returning. For when from dark blackness it has proceeded through innumerable colors all the way to snowy white, suddenly everything is again wrapped in black night; and then out of that blackness new colors springing up ever and again terminate first in the peacock's tail, then in the redness vainly sought by the chemists; and finally new colors, which by a false error produce colors like those already experienced and changes wholly resembling the true ones, do so not without a sure hope of perfecting the magistry. If you ask the reason for this marvelous metamorphosis, I say that these changes take their origin from the refraction of the internal light, from which all colors are generated. For since in the aforesaid material there exist together the dense and the subtle, from their mixture various refractions must necessarily arise. And first, indeed, what is subtle is absorbed by the dense; and by that putrefaction, the parts being wonderfully confused, a blackness is born, the light as it were eclipsed.

it is born; and then, out of the ebullition, the spirits bursting forth all together cover that whole vessel with clouds; thence the gross parts of the sublimation, their force now attenuated, are so mixed with the subtle parts that from this there arises a very unequal, color-generating refraction of the light. Finally, the spirits being used up, the earth remains dry and thirsty, and so, greedily reabsorbing its own spirit, by a new fermentation it begets a new blackness—while, the earthy parts now fermented and attenuated being mixed with the subtle parts, it makes new colors arise; and at last, out of the perfect mixture, a whiteness that ripens by its own fire into redness.

EXPERIMENT IV.

On the dyeing of colors in vegetable matter.

The white borax of goldsmiths will be made blue if, ground and worked up with urine, it is dyed with woad [glastum]; or it will be made purple if it is dyed more intensely. [Margin: The way and method of the juices that dye.] Now among the dyeing substances in vegetable matter are the juices of black grapes, of amaranth, of bloodroot [sanguineus], of mulberries [babustiae], of dyer's knotgrass [polygonum cocciger], the seeds of the three-seeded heliotrope [heliotropium tricoccum]—which at its first rubbing yields a green color, then a blue and purple most apt for dyeing papers—and likewise the leaves of *cyperus* or alkanet [Alcanna], with whose juice the Arabs are accustomed to dye the manes and tails of horses and the feathers of ostriches red and yellow. A whole book would have to be woven here if I wished to set out the manner and method by which metals, bones, woods, feathers, horses, and dogs can be dyed in colors of every kind. But since these things lie outside the limits of our undertaking, leaving them aside, let us proceed to those that are proper to our argument.

CHAPTER VII.

In which the cause and origin of transparent stones and gems is treated; and first indeed the generation of crystalline gems, then the origin of diamonds, will be discussed.

From the foregoing it has already become known that the earthy body is full of metallic and salt spirits—of salt, niter, alum, vitriol—which, scraped off by the subterranean fire from the clods appropriate to each, and turned into exhalation or vapor, are exalted through the innermost and almost imperceptible fibers of the earth. [Margin: The vapor of the salt spirits the cause of the crystals.] Wherever they find earthy portions proportioned to themselves, there they exert their power upon them, partly by dyeing, partly by hardening. For if within the recesses of the mountains they happen anywhere upon clods swelling with salt, then suddenly—as if a kind of magnetism were stirred up—the finer parts flow together to like parts; and since these are most subtle and all transparent, once united in a fitting place, with the lapidific spirit set within them cooperating, they coalesce into that crystalline substance which we marvel at. And this is the origin and rise of all those gems which Nature willed to be pellucid and transparent—which indeed differ from the baser kinds in nobility and excellence only by hardness and tincture. For the harder they are and dyed with a nobler color, the more they are valued. [Margin: What hardness and tincture confer on gems.] The

hardness, however, comes from no other source than the most exquisite union and almost inseparable bond of the parts, as happens in diamonds, of which later. And the tincture—yellow or golden, red, blue, purple, green—comes from nothing else than the various species of the tinging salts (which a little earlier we showed by various experiments), exalted by the force of heat now into this, now into that color. This tincture, as it argues a varied mixture of salts, so likewise the same varied virtues and properties accompany it—like the sun by its shadow—so that, indeed, the exquisite union of the most minute corpuscles confers on them hardness, while the tincture, differing one from another, confers the various powers and properties that we find by experience in gems.

But to scrutinize the origin of the transparent gems a little more closely: it is asked, first, how and by what means crystal is born. There are those who hold that crystal is born only from the purest waters of melted snows, by the force of a coagulating spirit, and is produced only in the coldest regions. [Margin: Crystal not born only in cold regions, but also in the hottest.] That both of these are false, manifold experience has long since shown. For not only in various places of Europe, but also in the Indies, in Africa, in America, in the regions situated under the very torrid zone, a great abundance of crystal is produced—so all who have explored those regions report. [Margin: A temple in Chile carved out of crystal.] The History of the Kingdom of Chile relates that in those tracts, in a certain deep valley which the ridges of the Andes [Andium juga] bound, on an island in the middle of a very large river, there is an immense rock entirely of crystal, in which a whole temple has been carved out by the pagan inhabitants with marvelous art, transparent on every side. Likewise, that from the Mountains of the Moon [montes Lunae] of Africa, lying under the torrid zone, an immense quantity of crystal is extracted; which the writers of Eastern history report also of the islands of the East Indies, Ceylon [Zeilanum] and Sumatra [Sumatra]. But since there can and ought to be no doubt about these things, leaving them aside, let us proceed to investigate the cause of its origin. [Margin: The origin of crystal.]

In the mountains, therefore, where there lies hidden the greatest quantity of the purest salt within the hollows of the mountains, it comes about that, with the subterranean heat acting, other salt bodies through a salt vapor ...and purged of all coarser bodies, these are drawn upward. Once elevated through the inner fissures of the earth (as I said) and finding a subject in sympathy with them, there too — by a kind of magnetism that Nature interposes — an attraction of like parts to like parts arises. These parts, joined by the coagulative spirit that acts as their attendant, are coupled in a marvelous union, and from the joining of transparent corpuscles that transparent crystal is at last born.

That this is in fact how the matter stands, and that crystal is made from the purest salt, we confirm by experiment. You will test that crystal consists of fully refined salt as follows.

EXPERIMENT

[Margin: Crystal consists of salt.]

Pound the crystal into the finest powder, add twice its weight of sulphur, and grind them into a thorough mixture. Place this in a crucible and subject it to a reverberatory fire for the space of six hours; then digest what has been reverberated in horse-dung for fourteen days. Next take it out and distil it. When the distillation is complete, you will find the salt-bodies separated out and, condensed again by cold, settled at the bottom of the receiver in the form of the whitest salt. The crystal is therefore resolved by the force of heat back into that from which it was originally constituted.

[Margin: When crystal is distilled, the salt remains at the bottom.]

As for why crystal is softer than the other gems, the softness of salt is the cause. Salt by its own nature is moist and of a fluid character, so its parts do not unite with one another into the same hardness into which certain others of a drier nature settle. But this crystal-genesis also requires a proportioned place, so that the vapor carried there does not evaporate away, but, collected and with no avenue of escape, may — by the moisture acting as a kind of proportioned glue — produce the effect we have described.

[Margin: Where the colors — yellow, blue, red, green — come from. They are tinged in the topaz, chrysolite, sapphire, carbuncle, and emerald.]

Now if the vapor is yellow and saline, tinged with the saffron of iron, and has met with material suited to it, it will tint that material yellow, making it glow as a topaz or chrysolite shining with a yellow color, distinct in both hardness and in the properties of its tincture. But if it has been mixed with the vapor of vitriol abraded from a copper clod, the minute saline corpuscles, united by an innate appetite, will produce a sapphire glowing with a sky-blue color; and it will acquire a hardness even greater than crystal's, since it takes its tincture from vitriol, which is of a more strongly uniting property of parts.

[Margin: Different tincture gives gems their different powers.]

In this way all the transparent gems, of whatever sort they finally are, consist of saline corpuscles from their very beginnings. Afterwards, mixed with various

species of salts, they acquire — as they are concocted through the different degrees of heat — both their different tinctures and their hardness, along with their other distinct powers. For just as salt set in a moist place dissolves and moistens, while the same salt, roasted by fire and with its moisture evaporated, takes on another, dry and corrosive property —

[Margin: An example from salt, an egg, and urine.]

— and just as an egg lightly cooked to a liquid state has one virtue, and one cooked hard another, so that according to the intensity of the fire it takes on both a different state and different powers — and this is plain too in urine, which by the moderate heat of a healthy man becomes citrine-yellow, in the excessive heat of the feverish turns to a red, and in a man abounding in undigested humors, through a mild heat, presents a watery fluid. (See, reader, what I taught most amply about the colors of urine in Book Two of the *Ars Magna Lucis et Umbrae*; there too you will find by what method water can be prepared from urine and from other salts, water which, set over a fire and evaporated onto images placed above, displays to the eye in those paper images countless colors according to the varying incidence of light — a generation of colors from salts demonstrated entirely παρ' ὀφθαλμοῖς [Greek: *par' ophthalmois*, "before one's very eyes"].)

[Fol. 21]

[Margin: The ridiculous opinion of certain people about the origin of the diamond.]

There remains at this point a single difficulty to untangle, one that has astonishingly vexed the wits of many men — and that is the untamed nature of the diamond.

[Margin: The true and genuine cause of the origin of diamonds is set out.]

The question, then, is this: from where does the diamond derive the seed-bed of such great powers, and how does it coalesce into such hardness and such smoothness? The diamond is the King of all gems, a stone the most noble among all the crystalline or transparent gems, whether you regard its hardness or its powers.

[Margin: The diamond, King of gems. By its hardness and powers it has always been held in great esteem by monarchs.]

For its hardness or its powers it is the most noble and the most precious of all; and so by emperors and kings it was of old called the very symbol of royal

splendor. In ancient times Pliny [Pliny the Elder] believed it could, by reason of its hardness, evade all the blows of the hammer.

[Margin: It is false that the diamond cannot be shattered by a hammer.]

But everyday experience has long since taught the contrary: not only can it be broken, but it can even be reduced to the finest powder. Many supposed too that, on account of its corrosive power, it was lethal to a man, yet experience has shown this to be false.

[Margin: Things falsely believed about the diamond, harmful to man.]

For in India the diggers of these stones, generally to avoid being accused of theft, swallow them in great quantity without harm, and afterwards, once they have passed them out again, lay them aside in a safe place for profit. Since, then, these stones — fitted by Nature with the sharpest points — when swallowed do no injury to the entrails, how much less shall we judge that the finest dust, wrapped in the humors of the stomach and the excrement of the intestines, will do harm? The diamond therefore contains in itself nothing, whether of internal or external quality, that is pernicious — not to say lethal. Indeed Anselmus Boodt [Anselmus de Boodt] has asserted that in long-lasting dysenteric complaints it has been given by him to a boy with great benefit. As for the prodigious powers that writers recount, most have been found utterly false:

[Margin: The superstitious use of the diamond.]

as, for instance, that it is said to restore quarreling spouses to harmony, to dispel sorceries and incantations, and to repress the assaults of demons. But these faculties, being above nature, and depending on the human will and free choice — being thus supernatural — cannot produce such far-removed effects; nor can the diamond impress any power upon incorporeal demons for driving them away, especially if superstitions are added to it, as Marbodeus [Marbodus of Rennes] teaches, who thinks —

[Margin: Marbodeus's astrological superstition concerning a figure carved on the diamond.]

— that it acquires inestimable powers if, under such-and-such a sign or such-and-such an ascendant, this or that figure is carved upon it. But since I have already refuted such delusions of idle-minded men, with arguments, in many of my works, I did not wish to linger over them in this place.

[Margin: The diamond is not consumed by the blood of a he-goat.]

That the diamond steals away the powers of the magnet, or grows soft in the blood of a he-goat, long experience of things has likewise taught to be equally false. See what we have discussed most fully about these matters in our *Ars Magnetica*. Setting such things aside, then, let us now return to our undertaking, which was to show from where the diamond draws so great a hardness, and how Nature produces it.

I say, then, that it is produced not only in the East Indies, but in many other parts of the world as well — indeed it is found even in Bohemia and Hungary, though it does not attain the hardness of the Indian stone.

[Margin: Where true diamonds properly grow.]

Only the East Indies have been found to produce true and genuine diamonds, especially in the province called Bisnaga [Vijayanagara], where three diamond-bearing crags are kept under perpetual guard by soldiers. In the kingdom of Decan [the Deccan] there is another crag, as also in the domain of a certain petty king, in which are found the most outstanding stones, in hardness, in smoothness, and in virtues — those that the natives commonly call *Naïfes*, "of the old crag." Around the islands near New Batavia [the Dutch East Indies], too, fragments of rocky crags packed with diamonds are found within the sea, at the foot of very high cliffs. These fragments, battered by the assaults of the sea in frequent storms, are over time worn away and gathered up from the gathered rubble by a multitude of slaves, who, having collected them knee-deep in the shallowest waters, toss them into a bag tied to their backs. Afterwards, dissolved with iron hammers in nearby workshops, they are sold to merchants. And Nature produces them there already so polished that, without any other smoothing instrument, they are worn just as they are drawn from the crag. There is also another mountain, not far from Malacca, that bears diamonds. The rest, wherever they may finally be found, are inferior to those here mentioned.

The question, then, is about their genesis.

[Margin: The ridiculous opinion of certain people about the origin of the diamond.]

Many think it happens because they are nearer to the rising Sun — a quite stupid argument, as if a circumstance of this kind were the cause of this admirable genesis. Do not these ill-conditioned men know that every place in the world is, by a different relation, now eastern, now western? On this argument it could be neatly proved that the kingdom of Decan, where Nature produces diamonds in greater abundance and of better quality, must — since with respect to Malacca it lies many hours to the west — against all custom and experience be incapable of

producing diamonds, for no other reason than that Malacca, where we have said diamonds are also produced, lies further east, while Decan inclines more to the west. With such trifles do those stupid philosophasters entangle themselves, when, unfit for philosophizing, they attempt to approach the causes of hidden things, and the mysteries of Nature, too rashly and (so to speak) with unwashed hands.

[Margin: The true and genuine cause of the origin of diamonds is set out.]

Wherever, then, in the regions of India the saline spirits, exalted by the force of the subterranean fire through the innermost fibers of the mountains — drawn from the purest and most thoroughly refined salt — have found a suitable and porous crag, that is, a proportioned place within the crag's hollows, and wherever in those places there is found within the crags an abundance of much fixed, purest salt, stripped of all moisture by the heat of the Sun (most burning in those parts) shining from without; and provided too that the natural moisture of the place, or some dewy substance evaporated through the pores of the rocks by the innermost veins of the mountains, or insinuated from elsewhere and resolved as it were into certain droplets, is added — then it comes about that the volatile spirits of the purest salt, joined to the fixed corpuscles of the most thoroughly concocted salt within the pores there, with the coagulative spirit acting strongly as their attendant (which unites and connects the minute fixed parts of the purest salt with the volatile ones into one continuous body as compactly as can be), and with there concurring also in that same place some species of the subtlest fatness, transparent and much like the gum of cherry trees, by which the parts are also bound together most compactly, glue-fashion, with the gift of splendor communicated to them — these salts at last grow into this most noble of all gems.

[Margin: What is required for the genesis of the diamond.]

You see, then, that for the genesis of this gem there is required, first, the purest spirits of salt, not at all defiled by tinctures of any other juices or minerals, nor contaminated by coarser particles; and these must be volatile, for without that volatility the pure parts cannot be separated from the impure. Second, I have said, there is required a proportioned place within the hollows of some porous crag — a place which, as for the other gems, so also for this most noble of all, had to be destined by Nature as supremely pure, so that in it, as in a kind of womb, the volatile spirits of salts may be concocted, and within it, just as through certain umbilical veins, received and there enclosed, and then aptly joined to the fixed parts of the purest salt with which the said crag is pregnant. But because without some glue, which is moist, and without the coagulative spirit, the intended effect

cannot at all be produced, hence the lapidific spirit — which is nearly always joined to the saline spirits in an indivisible partnership — once it has found that dewy moisture, then, behold, by that happy marriage of Nature between the volatile spirits and the fixed, with moisture as the means, in the course of time grows together into the gem of the diamond. And this gem is the more compact and hard, the more minute, subtle, and well-purified the saline parts have been. And this I judge to be the true genesis of the diamond.

There is added the testimony of Father Hyacinthus de Magistris, Procurator of the East Indies, who, having himself inspected crags of this kind, affirmed that what we have said is so. For he observed that the diamonds were born there in proportion to the size of the openings or pores, scarcely ever exceeding the size of a pea —

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— and, with the cavities from which they had been hollowed out still visibly remaining, those in the lower part of the crag were larger, and those in the upper part smaller. He adds, moreover, that by an occult property of the crag there is born a certain very subtle species of transparent gum, which, mixed with the coagulating agent, confers on the diamond that supreme splendor we admire in it. He notes too that it has become known by the frequent experience of the Indians that diamonds already removed from the crag are born anew after the passage of about two years — which agrees perfectly with what we have said about the genesis of the diamond. For by the nature of the place there is a perpetual exhalation of the said volatile spirits, exalted from the innermost bowels of the earth by heat; and these, enclosed within the little chambers of the porous rock and there joined to the rock by means of moisture, at last accomplish their work in the birth of a new offspring.

And from this reasoning it is plainly evident that diamantine hardness results from saline corpuscles of the utmost refinement, bound by the lapidific spirit into the tightest union; that its transparency is conferred on it by the saline corpuscles themselves (which, the more they are purged of earthy dregs, the greater the transparency they acquire); and that its smoothness and that extraordinary splendor are acquired from the aforesaid subtlest vapor of gum, with the external heat of the burning Sun cooperating very greatly — by which the crags, struck through, conceive a heat suited to accomplishing the work. And these are the conditions that constitute the diamond as the most excellent gem of all — conditions which, since the remaining crystalline gems, as well as the Bohemian and Hungarian diamonds, lack them, are likewise, as regards perfection, not to be

compared with the Indian stones. Whoever desires more about the diamond, let him consult the chapter on diamonds in the following Section, where the imitation and counterfeit diamonds, their correction, and their many medical virtues will be treated more fully.

CAPUT VIII

On the various figures, forms, and images with which Nature has furnished stones and gems.

I judge that there is no one of so dull a mind that, having entered somewhat deeply into the stony economy of the Earth, is not seized with the greatest admiration when he sees with what ingenuity and industry Nature has played in the various stones and gems — so much so that what she accomplished in the realm of vegetables and animals, she must be reckoned to have accomplished likewise in stones and gems. For whether you regard the variety of colors in plants, herbs, and flowers, or in birds, animals, and insects, or the variety of figures and forms in all of these, the stony kingdom seems to yield to them in nothing.

[Margin: Nature's marvelous industry in painting upon rocks.]

And it plainly appears that Lithogenetic Nature aimed at the very same thing, in producing effects according to the grades of Nature, that the vegetative and sensitive nature aimed at in its own realm. For she has always, so far as she could and was permitted, taken pains that, upon those creatures into which she could not — that lowest grade of Nature resisting — instill life and motion, she might at least not fail to impress a figure on her stony and gem-bearing offspring.

[Margin: Nature the Geometer.]

And first of all, in the stones she fulfilled all the parts of a good Geometer, when she marked their surfaces not only with points, lines, and every kind of figure, but also displayed solid bodies adorned with every kind of polygon. Nor did her industry stop here, but, rising higher —

[Margin: Nature the Astronomer.]

— she pitched her tents of heaven in the gem-bearing realm, and clothed them with Sun, Moon, and Stars in marvelous order. Then, progressing to optics —

[Margin: Optics.]

— she painted rivers, woods, meadows, mountains, and seas on many stones to the exact rule of perspective, so that she seems to have wished to leave nothing for the hand of any optician to desire beyond her own industry.

[*Margin: The Painter.*]

Then, embracing the art of painting and sculpture, she delineated whatever in the nature of things is perceptible to the senses, and in some she even played at a variety of figures with a certain artful sculpture of exquisite workmanship.

[*Margin: The Victor.*]

Lest we should seem to have described all these sports of Nature merely for the sake of their charm and elegance, we have undertaken to explain each and every one of her works by a detailed account — as they are observed in the kingdom of stony substance — especially since no one among the natural philosophers has hitherto been found who has set out the true and genuine causes of such great effects. We shall begin with the geometrical figures.

[*Margin: Stones and gems with points.*]

1. There are found, then, certain kinds of stones marked with countless points: among which may not undeservedly be numbered the stone called *Jasponyx* by Pliny, and the *Sandaster*, which, radiant within like the likeness of stars in a translucent medium, shine with golden droplets. The *Ophites* is varied with colors and points, and so is called by Dioscorides χαμαιπιτυώδης [Greek: *chamaipityōdēs*, "ground-pine-like"]. The *Ammochrysus*, which I take to be the same stone that today they call *Venturino*, radiates with countless little stars. Sky-blue blisters here and there encircle the *Ostracites*; a great variety of warts roughens the *Myrtilus*. Bloody patches at the bottom mark the *Haematites* here and there; golden droplets adorn the *Lazuli* stone. Egyptian marble, from which the obelisks were carved, consists of a fourfold mixture of points — black, red, blue, and white — which men used to signify the four Elements mystically, as we showed in our *Oedipus*. So indeed all these stones, dotted with points of different colors, can be referred to this class of pointed stones, of which, since the number is infinite —

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— let it suffice that I have indicated it here in these few words.

[*Margin: Lined stones and gems.*]

2. There are found some stones which, with figures growing variously into gems — with spots and warts of lines, in a manifold tracing — affect the gem with that color, and in those gems always appear as though implanted by nature; and no less than in plants, they keep the number and the proportion of leaves and fruits. Cleavable stones, which they call σχιστούς [Greek: *schistous*, "split/cleavable"], may not inappropriately be called πολύγραμμοι [Greek: *polygrammoi*, "many-lined"], because their whole body appears as if composed of contiguous lines. Of this kind are the various sorts of *Haematites*; the *Meseleucus*, which divides the middle of the gem with a white line; the *Mesomelas*, which follows with the tracing of a black line. Add to these the *Ophicardalus*, which two white lines enclose with a black. The species of *Prasius* is distinguished by three lines. Another is adorned with many lines as with zones, and is therefore called πολύζωνος [Greek: *polyzōnos*, "many-zoned"]. Others, marked with countless lines, are therefore called πολύγραμμοι [many-lined]. To these are referred all the stones painted by nature in a manifold order of furrows after the fashion of striae.

When some years ago I was surveying the Tolfa district together with its alum-works, I came upon a certain hill in which a certain kind of stone was found, sky-blue, much like schist, in which, in white and most subtle lines, whatever of shapes could be devised was found designed by Nature. Therefore, with marvelous things presenting themselves to move my admiration, as I considered more attentively the tracings of the individual lines, I found not only all the letters of the Greek alphabet, but of the Latin one as well; and besides, nearly all the simple geometrical schemes which Euclid demonstrates in his *Elements* of Geometry. And since the matter seemed worthy, I have judged it right to set it forth here separately, taken out just in the manner in which Nature had formed it.

Diagram. A small woodcut at upper left shows an oval banded stone (a cleavable schist specimen marked with parallel lines). Below it, a framed plate is captioned "A specimen of lined stones, of the kind found in a certain stone of the schist family, in the Tolfa and Bassano districts." The plate is divided into two labeled panels:

- Upper panel, captioned *Litterae Alphabeti in Saxi à natura formatae* ("Letters of the alphabet naturally formed in rocks"): three rows of small framed squares, each containing a letter outlined by natural veining —

reading across, the Latin alphabet: **A B C D E F G H I / L M N O P Q R S T / V X Y Z Æ.**

- Lower panel, captioned *Figurae Geometricae à natura in Saxis formatae* ("Geometric figures naturally formed in rocks"): four rows of framed squares each containing a simple geometric figure drawn in natural lines — triangles, crossed lines (X), nested/divided rectangles, diagonals, a square with inscribed diagonals, a circle within a square, a plus/cross, and a star/asterisk among them. (The figures correspond to Euclidean elementary schemes: triangles, squares, parallels, a cross, and a radiating star.)

The whole plate is captioned beneath: *Figurae Geometricae à Natura impressae lapidibus* ("Geometric figures impressed by Nature upon stones").

These figures of letters and of geometric schemes I have collected on purpose, in order to adorn marvels with these marvels produced by Nature's industry. If haste toward other matters had allowed me to collect more, surely whatever Geometry could gather in angles, triangles, quadrangles, trapezia, and parallels could have been found with little trouble. But so that the curious reader may, from the claw, infer the lion, we have thought it right to add here these few out of countless examples.

[Margin: The cause of the lines in growing stones.]

The question, then, is how Nature produces so great a variety of lines. I say, then, that the cause is the earthy substance from which the stone grew: this substance, first indeed a soft clay, then, through the intervening dryness, opened into various cracks — just as happens in muddy pools after rains, which, dried little by little by the heat of the Sun, are split into countless cracks of every kind. So too in these stones, before they were hardened by the lapidific spirit, we judge it to have happened: cracks which afterward a gypseous vapor, with which the place naturally abounds —

vapor enters and, condensing, passed along the courses of the cracks, producing that variety of bluish-white lines in the blue ground which we have described.

The truth of this a subsequent experiment taught me.

EXPERIMENT

Take a small cake of soft clay and lay it over a grill fitted with fine iron wires and supported on a tripod. Underneath, place glowing coals: at once, as the moisture is driven off, the heat will crack the mass into many fissures.

[Margin: How lined stones are produced artificially.]

Once this is done, set white lead [ceruffa] in a crucible and stir it vigorously over a strong fire. You will see the white lead rise as a vapor, penetrate the cracks of the clay cake, and lodge there, somewhat condensed by the surrounding cold. After this, take away the clay, and along the courses of the cracks it will display countless white lines. The operation, however, must be carried out skillfully: the grill should be set not directly above the crucible but somewhat higher, so that the vapor does not become too rarefied and vanish within the cracks, but condenses at the first touch of cold. If instead you try the experiment with red lead [minium], it will produce red lines; with ochre, golden ones; with verdigris [erugo], green ones. From this experiment it became certain to me that lined stones of this kind are produced in no other way than the one described: for these clay masses, lined and then baked in a furnace, will display lines running through the whole depth of the stone, exactly like the natural ones that Nature generates in the mines.

Dotted stones [lapides punctati] differ from lined ones only in this: that their soft material is still highly porous and, once dried out, leaves various empty hollows in its midst. These are afterward filled by the vapor of whatever mineral it may be and, hardened there, exhibit on that outermost surface the multitude of dots we have spoken of. I would have you note here, reader, that in translucent gems this variety, whether of dots or of lines, is not produced in the same way: rather, such spots and tracts of lines arise for the most part from the spirits of various salts diffused in a certain order — about which more in another place. So here it is enough to have merely pointed out the cause.

On the genesis of polygonal gems [De Polygonarum gemmarum genesi]

This wonderful property of stones is observed above all in translucent gems, all of which Nature has willed to be born either round or polygonal. To what end, I will set forth as far as the weakness of my talent allows — though I am well aware that nothing has so vexed the minds of natural philosophers up to now as this prodigious offspring of angular progeny. Various writers bring forward various explanations, but nothing that satisfies a mind hungry for the truth. I will set out what I have observed by long experience in such matters.

From what has been said above it is established that all transparent gems have one and the same origin, that is, from a saline liquor. Yet, just as they have been endowed by Nature with —

Diagram. A woodcut of a crystal-bearing mineral specimen, captioned "*Minera Crytalli ex Museo Anifori*" ["Crystal ore, from the Museum of Anisori"]. The specimen is a rounded, cushion-shaped mass densely covered over its whole upper surface with sharp pyramidal quartz crystals radiating outward, resting on a rough nodular base.

Diagram. A woodcut captioned "*Pseudocrytallus*" ["False crystal" / pseudo-crystal], placed below the first specimen. It shows an irregular nodular stone whose surface bears a dense field of small star-like and rosette-like crystalline growths, with a few larger pointed crystals projecting at the edges.

Diagram. An uncaptioned woodcut of a rounded mineral specimen whose surface is covered with large flower-like (chrysanthemum-shaped) radiating crystalline rosettes.

Diagram. A woodcut plate captioned "*Formæ Topaziorum, Amethistorum, Beryllorum*" ["The forms of topazes, amethysts, and beryls"], showing nine faceted crystal shapes arranged in three rows of three. They depict the characteristic polygonal (prismatic and pyramidal) habits of these gems — tabular, elongated-prismatic, and bipyramidal forms with hexagonal and tetragonal cross-sections. No individual labels.

with a blue tincture, it should unite the parts, a sapphire will be born; if with a red tincture it should unite the parts still more strongly, a pyrope or carbuncle will be born; if with a green tincture it unites them equally, an emerald will be born; and if, finally, it unites the parts most strongly of all, then is born the hardest of all, the diamond [adamas], free of every tincture, glorying in light and splendor alone. And from these, according to one tincture or another, greater or lesser, countless other species of gems emerge — which, however, are referred back to some one of the principal kinds just named. Hence the gem-dealers carefully observe the constitution of the most diverse topazes, beryls, emeralds, carbuncles, opals, diamonds, and the rest of the gems; and as these are tintured to a greater or lesser degree, or even with different colors, so they receive countless names.

In all of them, nevertheless, Nature has fashioned something I-know-not-what of the angular: for some are tuberous, some triangular [triquedrae], some tetrahedral, very many — chiefly the crystals — hexahedral; in topazes one occasionally finds even dodecahedral forms, as is apparent from these figures. The cause, therefore, of these angles, and the purpose Nature intends in them, is not unreasonably asked.

[Margin: Why crystalline gems are everywhere polygonal.]

For since this unusual form is to be observed above all in transparent gems, it has — to the point that the matter became a byword — dragged many into despair in their inquiry into the cause; and to those struck with wonder at such exotic effects it has, so as to penetrate to the cause that produces such great things, applied sharp goads, but to no avail. It is now time for us to disclose what we think.

That there is in saline bodies a certain radiating power [virtutem actinobolicam], which we call radiative [radiativam], the experience of many years has taught us. This power consists in the following: the spirit hidden within the body of the salt, going out from the center to the circumference by its own nature and by a kind of natural appetite, gradually, by its own thrusting, distributes the corpuscles into certain rays. If it splits the diameter into four parts, this will be the base — and, as it were, a kind of ground-plan [ichnographia] — on which the gem is figured, the gem that Nature wills to be of square form; if into five, it will lay the rudiment of a pentagonal form; if into six, of a hexagonal one (proper to crystals and amethysts); and so on for the rest up to twelve. It will constitute the figure with just as many sides as the rays into which the saline spirit has thrust its corpuscles.

First, then, that all transparent gems consist of various species of salts was confirmed above by various experiments, and is accepted by the unanimous consensus of the chemists. Second, that there is in each individual saline corpuscle something implanted by nature, of that figure which the gem formed from them displays. For if, with crystal reduced to powder, you examine the individual corpuscles under a microscope, you will find each of them displaying something I-know-not-what of the radiate; and the same is plainly clear in the other saline corpuscles — of niter, alum, vitriol, sugar, and the like. We have demonstrated this at length in the *Diatribē on the prodigious crucibles* [*Diatribē de Crucibus prodigiosis*], regarding the figures seen at Naples in the linen garments of men. Not inappropriately can we call this the plastic faculty of gems, entirely analogous to that which the sensitive grade of Nature uses in fashioning the organs of living things — though we more fittingly call it ἀκτινοβολικὴν [Greek: aktinobolikēn, "ray-emitting," the radiative power], that is, the radiative force. For the spirit in each corpuscle, by itself and its own nature seeking radiation, lying hidden as if in a center, solicits each corpuscle through the rays already implanted in it, and so also unfolds each from its own center: beginning first from the root, in crystals it lays down roots in place of a six-fold ground-plan; then upward, radiating κατὰ ὀρθάς [Greek: kata orthas, "at right angles"], with new

accession of corpuscles it at last grows out into this form we admire — namely, the hexagonal. But since in the intervening space a most pure humor is mixed with these saline corpuscles, it comes about — by a kind of wondrous magnetism, by which similar bodies are drawn to one another — that saline parts adhere to corpuscles of their own kind, now arranged into the form due to it through this radiation [actinobolismum], while dissimilar watery corpuscles are driven outside and separated off. And lest any void be left in the intervening space, a new liquor of most pure water is substituted in the place of those departing; and finally, the lapidific spirit, supervening upon this enclosed water, hardens that whole crystalline mass under the form of angles which is owed to it by nature. But since many things here may occur that could raise a doubt in the reader, I will explain them in few words.

It is asked, then, first: how does it come about that that radiation degenerates not into a circle but into polygonal figures? I answer that this happens through a proportional diminution of the radiative power, by which the rays always decrease more and more from the first. Thus indeed: just as the radiative power of the salt extends into three, four, or six rays equally distant from one another, so the remaining rays interposed among these — being weaker — fall short of that distance proportionally, so that the farther a ray is from the strongest, the shorter it is and consequently extended to a lesser space. But let us show these things by geometrical reasoning. Let there be, in the triangle of a hexagon, A G F.

Diagram. A geometric figure: a regular hexagon inscribed in a circle, demonstrating the proportional diminution of the radiative rays. The center is labeled **A**. The six vertices of the hexagon are labeled clockwise from upper-left: **C** (top-left), **D** (top-right), **E** (right), **F** (bottom-right), **G** (bottom-left), **B** (left). Numerous rays are drawn from the center A to the perimeter; a fan of closely-spaced rays runs from A down toward the lower edge between G and F. Along that lower edge (the base G–F) are marked the points **H**, **I**, **K** (between G and F), at the feet of the principal and intermediate rays.

- A (center): center of radiation
- B (left vertex): hexagon vertex
- C (upper-left vertex): hexagon vertex
- D (upper-right vertex): hexagon vertex
- E (right vertex): hexagon vertex
- F (lower-right vertex): hexagon vertex
- G (lower-left vertex): hexagon vertex
- H, I, K (along base G–F): feet of the intermediate rays on the base

The center of radiation is A; the principal rays are A G, A F, and so on for the rest. I say that the rays D A H, —

A H, A I, A K gradually fall short and descend to the side A K of the triangle, and from there increase in the same proportion up to the side A F; and the ray A K will be at right angles and, in this radiation, the smallest. And since in one triangle of the hexagon several lines are drawn from the vertex A to the base G F, the triangle A K G will be greater than the triangle H A K, and this triangle greater than the triangle A I K — because the base G K is greater than H K, and this than I K, while the base A K is common; therefore the hypotenuse A G will be greater than A H, and this than A I. Now the point I is farther from G, the terminus of greatest power, than is H — because, the part I K being taken away, the remainder I G is greater. And so onto the individual points of the base K G fall unequal rays of power; and the more they are removed, the shorter they are, and accordingly falling short gradually and proportionally. What therefore has been shown in one triangle of the hexagon, let the same judgment hold of all the rest.

The rays, then, flying out from the point A — gradually and proportionally falling short of the principal rays, or increasing from the middle line — will at last produce in crystalline bodies that equality of sides which we admire. Once this saline power has thus been laid down as a kind of ground-plan delineation, immediately the remaining corpuscles, as if impelled and attracted by a kind of magnetism, arrange themselves around these; and these, afterward augmented by the accession of others and others again, at last rise to the due quantity of the crystal through the continuous influx of individual particles radiating each in like manner. But because in this way the smallest particles, most tightly united, acquire an exact continuity, it comes about that saline corpuscles of this kind, thus made continuous, emerge at last into a transparent body, with all separation of parts repudiated. And if any separation does occur — behold, at once, as though transparency were obliterated, some traces of shadows come to light. So that this separation of parts may be hindered, and the beauty of form better preserved in the clearest crystal, surely Nature could give it no more fitting figure than the hexagonal — which it also uniquely aims at by the radiation of its implanted power. For this figure, being most perfect on account of the exact connection and continuity of its parts, easily removes all those things that might bring harm or unsightliness to the gem, and preserves it in the splendor due to it by nature.

These things being laid down, let us now more fully confirm, through various experiments, what we have deduced κατὰ τὴν θεωρίαν [Greek: kata tēn theōrian,

"according to theory"]. It was said above that these polygonal figures belong to gems chiefly by reason of the salt; and that salt is present in gems is manifest from their incineration. The same can also be established from their artificial composition: for either metallic juices [succi metallici] are taken as the material — as we shall say in its proper place — or ashes rich in abundant salt, and flints, are roasted together into the same. And who would doubt that metals are of the nature of salt, since they are wholly resolved into vitriol, a species of salt? Therefore the figure of that salt whose nature it shares will be present in the gem.

EXPERIMENTS

First. That in saline bodies Nature aims at an I-know-not-what πολυγωνισμόν [Greek: polygōnismōn, "polygon-making," a tendency to many angles], that is, the multiangular, you will find by experiment thus. Take a pound of vitriol, first dissolve it in clear water, then digest the dissolved liquid — strained through a Hippocrates' sleeve [manica Hippocratis, a conical filter-bag] — over the fire, until it draws a skin [cuticula]. This done, pour the decoction now into a basin and let the moisture evaporate; and you will find, plainly visible, the corpuscles of vitriol dispersed and scattered in the liquid, drawn to the sides of the basin by a kind of magnetic force and united, then soon working out — by their radiate unfolding — the polygonal form due to them by nature. And if anyone considers it with a somewhat keener eye through optical lenses, he will see a certain motion which I say is nothing other than the spirit animating the corpuscles into mutual co-radiation. This shows itself in the fact that little droplets, as it were, always cling at the extremity of the filaments, which droplets, however, are soon converted by the force of the spirit into a solid; and — what is remarkable — the filaments themselves likewise, some into prisms, some into pyramids (the shape they aim at), co-radiate to a point, now with three, now with four, five, or six lines, which exhibit the genesis of crystalline bodies by a kind of ocular demonstration. The same will happen if you try the matter with a solution of niter or alum. But since we have already presented experiments of this kind above in the *Section on salts* [*Sectione de salibus*], we refer the reader there.

It only remains to give the experiment on extracting salts from the lyes of herbs, from which it will appear plainly and clearly that all saline bodies — even those drawn from plants and animals — have been imbued by Nature with this implanted crystallogenic faculty.

EXPERIMENT II

Take whatever herb you like, chiefly one that abounds in a manifold tract of fibers — we usually use the nettle [*urtica*] — reduce it to ashes in a very well glazed pot, and after the incineration is done, pour water over the ashes, and a lye will form. Pour this into a basin, expose it to a winter's night, and leave it until it draws a thin layer of ice on the surface; and you will see, with admiration, the ice exhibit the leaves of the nettle so exactly as if they had been imprinted on it. And if you examine this icy effigy more closely with the aid of a microscope tube, [you will see] all the dots and certain rays — now more, now fewer — unfolding by a kind of rough ground-plan to build polygonal bodies; while those parts that cling to the sides of the vessel for the most part express square tesserae. But how this genesis is brought to completion must now be told.

We said a little before that whenever the saline —

[Margin: Crystallogenesis.]

spirit enters, with a great accompanying abundance of salt, into a certain matrix duly disposed for generating a crystal, the saline bodies gradually consume, by their drying virtue, the moisture that occupies the matrix. Once the moisture has been gradually consumed, then for the first time that marvelous confluence of the saline corpuscles — which were at first dispersed in the moisture — and the co-radiation of the individual particles together come to bear upon building the polygonal form due to them. And by the force of the spirit, with ever new and renewed accession of corpuscles, the crystalline bodies at last acquire the form owed to them. But let us confirm these things by experiment.

EXPERIMENT

Take water thoroughly worked up with niter or any other salt you please — such as vitriol or alum — in such a way, however, that the water remains as transparent as possible. This done, take silk threads or horsehairs stretched into the figure of a tetragonal or hexagonal prism, immerse them in the prepared liquor, and leave them there three or four days, more or less. You will find that all the corpuscles of salt, dispersed here and there in the liquid, at last adhere to the threads, and in the course of time, by the continuous influx of particles, finally acquire a crystalline form — not solid throughout, but like a kind of structure supported on saline columns: truly a beautiful spectacle of Nature, demonstrating to the eye how the saline corpuscles, drawn and united by a magnetic force, at last degenerate into a solid mass. That, therefore, which we here show by artificial contrivance, no one ought to doubt that Nature herself performs by the

radiation [actinobolismum] implanted in her. Let there be a vessel filled with saline water, A B; threads...

Diagram. A schematic of the crystallization apparatus described in the experiment: a tall cylindrical glass vessel, full of saline water (shown by the wavy hatching of the liquid). The vessel is labeled **A** at the top (a small loop/handle at the mouth) and **B** at the bottom (foot of the vessel). Inside hang two horizontal rings/disks, labeled **C** (upper, near the mouth) and **D** (lower, near the base), to which the threads are fastened. The threads (silk or horsehair) hang vertically between the two rings, labeled **E, F, G, H** — the fourth thread-label reads as printed like "14" but corresponds to **H** [recte: H]. The crystalline growth forms along these submerged threads.

- A (top of vessel): mouth / suspension point
- B (bottom of vessel): foot of the vessel
- C (upper ring): upper ring holding the threads
- D (lower ring): lower ring holding the threads
- E, F, G, H (vertical threads): the suspended silk threads / horsehairs on which crystals form ["H" printed as "14"]

fastened to opposing rings C D; let the threads or hairs be E F G H. These, stretched on the rings and let down into the liquor, will exhibit what we have signified by this experiment. The remaining experiments concerning crystalline bodies will be presented in what follows, in their proper place, with fuller apparatus.

CAPUT IX.

On the marvelous painterly works of Nature — the forms, figures, and images she delineates in stones and gems — and their origin and causes [De admirandis Naturae pictricis operibus, formis, figuris, imaginibus, quas in lapidibus & gemmis delineat, eorumque origine & causis]

[Margin: Nature the painter.]

We saw in the preceding pages how Nature, in the genesis of crystals, exercises all the parts of a good geometer. Now let us contemplate, with equal step, the specimens of her skill in the painter's art. These are so marvelous that there is no philosopher who, in scrutinizing them more attentively, has not been left as if

thunderstruck. Nor ought this to seem strange to anyone: for the farther they advanced in the inquiry into the cause of such exotic effects, the more and more their understanding was darkened by a fog, until at last — the matter being, as it were, given up for lost — they frankly confessed that there is something in them τὸ θεῖον [Greek: to theion, "the divine"], a divine element, I say, which, being inexplorable to the human mind, has set here a boundary beyond which the labor of human subtlety wearies itself in vain. Yet since nothing in the nature of things is so abstruse and unusual that we cannot assign at least its probable causes, if not its inmost ones, I have — having long and much speculated upon Nature's images [ectypa] of this kind — judged it worth setting out here for the curious reader what I have observed and discovered.

Nature, in her play, since she could not attain the vegetative and sensitive faculty in the mineral kingdom, did what she could: that is, since she could not give them life and sense, she judged it enough to have at least bestowed figure upon them. Imitating the painters, she has been seen to delineate, with the ambitious mastery of her brush, the figures of all things contained in the world. For whoever considers a little more attentively the constitution of stones, marbles, and gems — especially those endowed with a manifold variety of streaks and tracts — will surely see plainly that, by a certain wondrous industry, Nature has depicted in them:

First, instruments of every kind, made by art — knives, saws, grapnels, anvils, lances, banners, crosses, circles, baskets, compasses, and geometric figures without number: triangles, squares, parallelograms, cubes, rhombs, and prisms of every kind.

[Margin: She paints instruments of every kind in stones.]

Second, Nature, as if contemplating the heavens, has in them depicted stars arranged into certain constellations [asterisms] — as appears in the *Astroites* [star-stone] — or has painted them to the envy of painters. In some gems... —

has depicted the Sun, with its radiant projection, in a stunning way in certain gems—as in a particular cameo [camaea] which the most inquisitive Francesco Qualdi, a knight, once showed me as a great miracle of Nature, and which he keeps in his museum, very richly furnished with similar things.

Diagram. A round gem engraved with a human-faced Sun at its center, surrounded by a dense, even halo of straight rays radiating outward to the gem's edge.

- Caption (below): *Gemma heliaca Franc. Qualdi* [the heliac (Sun) gem of Francesco Qualdi]

[Margin: Nature paints the sky, the stars, the Sun, the Moon.]

In the same way, the figure of the Moon—not only full, but also crescent-shaped [cornuta] and in its half phase [dichotoma]—is not infrequently found in stones and gems. The *Selenites* [selenite, "moon-stone"] attests to this, the stone that takes its very name from the figure of the Moon.

Diagram. An irregular, lobed agate stone whose surface shows a central disc resembling a crescent Moon, ringed and scattered about with several engraved stars.

- Caption (below): *Achates* [Greek: ἀστερίτης (asteritēs, "star-bearing" — the star-agate)]

Ambrosini relates in his book *On Stones* that he saw an agate in which the celestial circles were drawn together with the stars, and another in which the asterism of the Great Bear [Ursa Maior] appeared. I recall having observed something similar in a piece of lapis lazuli filled with the brightest stars. But these things are too well known to need stating.

The most noble Magninus, a knight and Roman patrician, also possesses a heliotrope stone [lapis heliotropius] in which the four elements, each with its own proper colors, are depicted so vividly that they seem drawn not by Nature but by some outstanding painter.

Diagram. An oblong banded stone divided into four horizontal layers, each labeled with an element and its color.

- Top band: *Ignis Aureo* [Fire — golden]
- Second band: *Aer Puniceo* [Air — crimson]
- Third band: *Aqua Caeruleo* [Water — blue]
- Bottom band: *Terra Atro Colore* [Earth — black in color]

Third. Delighting in the sea, in cities, woods, and rivers, Nature has not only painted all these things beautifully, but has also shaded them in with fitting colors, so that they seem scarcely to yield to artificial paintings.

Diagram. A row of leafy, full-crowned trees of varying heights standing along a ground line, the natural tree-figures formed within the stone.

- Caption (below): *Dendrites Hetruriae* [the dendrite (tree-stone) of Tuscany]

[Margin: She paints woods, fields, rivers, cities.]

Such, for example, are the ones from Tuscany [Hetruria], where Nature produces them, of which I have brought a considerable quantity into my museum. Among others, some agates and jaspers display rivers and streams, and cities together with woods and fields, so perfectly and according to all the laws of perspective, that it seems nothing could be added to them.

Fourth. Nature does not seem to stop here, but, entering the very workshop of the vegetable economy, she draws flowers of every kind—roses in the *Entrochus*, lilies in the *Encrinus*. In many varieties of jasper you may see narcissi, hyacinths, tulips, peonies, jasmines, and the flowers of other plants, all marvelously fashioned together with the plants themselves.

[Margin: She paints herbs and flowers of every kind.]

Fifth. Not content with these, advancing further and gazing into the workshop of sensitive nature, she paints animals of every kind—birds, quadrupeds, swimming things, insects—as will afterward be clear from the figures themselves.

[Margin: Animals of every kind.]

Sixth. Lest she should seem to have neglected the human form, the noblest of all, in stones—by an equal play of fortune—she has tried to depict the human figure with its various postures and gestures, not only as to the whole symmetry of the body, but also as to each of its individual members. In one place you will find them imbued with figures of the head, the heart, the liver; in another, of the eyes, ears, and nostrils; here, of the chest, arms, and feet—expressed not on the surface only, but within solid stones. Indeed, as in the *enorchis*, she has expressed both sexes of the human being. On these matters see Agricola [Georgius Agricola] and Gesner [Conrad Gesner] treating them more fully in their books *On Stones*.

[Margin: Human figures and gestures in various ways.]

Seventh. Advancing still further—and to what exceeds the bounds of Nature—she has even attempted to draw, in certain stones, the very Angels and the Blessed [Coelites], as well as the Virgin Mother of God [Deipara Virgo], the other Saints, and even Christ the Lord crucified, as will appear in the following figures of them.

[Margin: Angels and the Blessed.]

Having thus set forth the ingenious diligence of Nature in depicting things, nothing else remains but that, now—after the model of these same things has

been displayed—we adduce the reasons and causes of the individual figures. For I have not yet found any author who has done this, and it is a most worthy subject, in the investigation of which the talent of a true philosopher may exert itself. And so that we may proceed in good order, we shall first set forth examples of those figures which we considered in the preceding seven points, so that from them, as from Nature's prototypes, we may search out the hidden causes of natural craft [Greek: φυσιοτεχνίας (physiotechnias, "natural artistry" — the workmanship of Nature)].

[The First Figure: Mathematical and instruments of every kind, depicted by Nature in stones.]

[Margin: First Figure: Mathematical instruments and instruments of every kind, depicted by Nature in stones.]

In the preceding pages enough has been said of plane geometric figures; now let us also consider the pictures of solid figures. We discussed the crystalline polygons a little earlier—...

that is, in the form of cubes and prisms of every kind, such as those which the following plate displays.

Diagram. A drawing of a dodecahedron seen in perspective, its twelve faces outlined, with several of the visible faces containing inscribed circles. Four corner-points are lettered.

- Caption (above): *Fig. Dodecaedri* [Figure of the Dodecahedron]
- A (upper): vertex
- B (right): vertex
- C (lower): vertex
- D (left): vertex

Diagram. Two rounded, concentrically banded stones lying side by side, each engraved on its upper face with curved lines forming an astrolabe-like network of arcs.

Here you see how Nature has labored a dodecahedron, A B C D—that is, a figure of twelve sides—in marble. And although (if I may make light of it) for want of a compass she drew it only with a rough pen, with lines and circles somewhat distorted, and not in due proportion to the pentagonal sides, she nonetheless did what she could; and by what art and skill, will be explained afterward.

[Margin: An astrolabe drawn by Nature.]

Ambrosini says that he himself saw a little cup [scaphium] made out of a snail-shell, in the hollow of which Nature had drawn and painted an astrolabe with those tracings of lines which the second figure shows. In Calabria there is a mine in which all the stones that are found—even the smallest—are seen under the figure of a cube; and Father Matheus Taberna, an inquisitive explorer of natural things, gave to my museum no small quantity of these, which he had brought with him. Of the spherical figures of stones we shall speak afterward.

[Margin: Cubic rocks formed by Nature.]

Diagram. Three small cubic stones drawn in perspective, each rendered as a die-like cube with hatched shading.

- Caption (above): *Lapides Cubici* [Cubic stones]

[Margin: Nature alters rocks into the prismatic form.]

In Tuscany, near Volsinium [Bolsena], as you go about a thousand paces toward Mount Flascon [Montefiascone], on the left side of the Lake of Volsinium [Lake Bolsena], a cliff is seen which is wholly composed of stony parallelepipeds, in the figures that follow, A B C D E F.

Diagram. A cluster of tall, straight rectangular stone columns of varying heights rising side by side like a bundle of prisms, drawn in perspective and lettered at several columns.

- Caption (above): *Juxta Volsinium in Italia, Rueus in Misnia Germaniae* [Near Volsinium in Italy; Rueus reports the same in Meissen, Germany]
- A (left)
- B (upper center)
- C (center)
- D (upper right)
- E (right)
- F (far right, lowest)

[The same kind] is constituted [in Germany]. Rueus [Jean de Rueus / Johannes Ruæus] relates something similar about the citadel of Stolp in Meissen [Misnia].

These little stones were sent to me from Germany not long ago, all of a round, disc-like figure, in the middle of each of which Nature has expressed—with a truly elegant brush—the figure of an eye diffusing its rays.

Spherical stones are also found in many places—large, small, and very large—so that, on the testimony of Rueus, some have been found of such a size that they would serve, in place of iron ones, for loading military engines. Such, on the testimony of Agricola, are found in the territory of Hildesheim [Ager Hildesiensis]; similar ones in the Kingdom of Naples, near the city called Potentia [Potenza]; and in many other places in Italy, Germany, France, and Spain. Concerning these, see Agricola, Rueus, and others; but how Nature forms them, we shall explain afterward.

Second. As for the Elements, Nature expresses these too, so exactly that they seem expressed by a painter. Of this kind is a certain gem of hematite which Carolus Magnus [Carlo Magnini] possesses, in which the four elements are so skillfully exhibited by the natural drawing of the colors, that they could not be painted better or more exactly by any painter. Again, mountains, fields, rivers, which are seen above all to astonishment in certain marbles and in agate—indeed, even the air with clouds and with birds flying in it: a thing of which I was first taught by the Altar in the church of St. Peter at Rome [Divi Petri Romae], where, as you enter, on the right hand the chapel of the Holy Cross has been built. The altar is made of yellow marble variously mottled, in which you will find mountains and rivers, lakes, woods, and air skillfully painted by Nature. The same thing may be seen in the magnificent [chapel] of the Blessed Virgin at S. Maria Major [Santa Maria Maggiore]...

[S. Maria] Major, in the chapel built by Pope Paul V [Paulus V], in which the same wonders of Nature the painter that I have mentioned are exhibited.

Third. That Nature has also displayed the starry sky in stones, we have already said above.

[Margin: Trees and woods are expressed by Nature in stones.]

Fourth. Meadows and woods set thick with trees are seen above all in those stones which they call *dendrites* [Greek: δένδριτες (dendrites, "tree-stones")] after the trees they express, and which are brought in great quantity from Tuscany to Rome for the adornment of tables, cabinets, and other things...

Diagram. A landscape engraving of a walled, towered town—an array of buildings with windows, pointed conical roofs and spires, a few trees rising among them, set beneath a banded sky of clouds; the natural image as formed within a stone.

- Caption (above): *Urbs Turrata* [The Towered City]

[Margin: An expression of cities and ruins in stones.]

are transported. In these you may see not only the branching outgrowth of trees, but also, all around, leaves, flowers, and the like sports of Nature; so that in another marble stone you may likewise see cities, mountains, and clouds depicted—of which kind there is one in my museum: a towered city with houses fitted with windows, just as the figure here set down shows. In the high altar of the church of St. Sebastian outside Rome [S. Sebastiani extra Romam], the marble into which the crucifix is inserted, exhibits clouds and bright portions of the sky marvelously shaded in.

[Margin: Lapidific exhalation.]

Fifth. Nor are the four-footed classes of animals lacking in stones. You may see in them, first, insects of every kind—such as serpents, flies, butterflies, worms, and the like, down to fleas and bedbugs themselves: of which kind are certain species of *asteria*. See the serpent-shaped figure [Greek: ὀφιδόμορφον (ophiomorphon, "snake-shaped")] marked with the letter Z in what follows. Then follow the stones which exhibit, with marvelous art, fishes, whales, dolphins, sea-bream, trout, sea-fish, and the like—which I recall having seen here and there in various museums, both here at Rome and elsewhere. Hence I have thought to add the figures for the gratification of the curious reader. See Plate III.

[Margin: Serpents, fleas, flies, butterflies, lice in stones.] [Margin: An expression of whales and the other fishes in stones.]

Sixth. Next come the winged creatures, which Nature has exhibited in various ways in stones. In the sacristy of the Roman College there is a marble column of mixed black and white, in which Nature has painted a pelican with twisted neck opening its breast to itself—though with the claws of its feet mutilated. There are those that also exhibit cocks, and hens with chicks, just as may be seen in the following figures.

[Margin: An expression of birds in stones.]

The figures of four-footed animals, moreover, are found everywhere in stones—either in the whole symmetry of the body, or with the head only, or shown from the chest, feet, and shoulders—of which Ambrosini too [speaks] in his book *On Metallic Things*, which is called the *Supplement to Aldrovandi*. See Plate II, which depicts the animals.

[Margin: An expression of quadruped animals in stones.]

Seventh. Stones are so filled with human figures of every kind, that there is hardly any in which they do not...

Diagram. A large engraved plate of an irregular flat stone (a dendrite slab) whose surface is covered with fine, branching, fern- or tree-like growths spreading across the upper portion—the natural foliage-figures formed within the marble.

[Margin: Wondrous images of things.]

[in the mu]seum of Aldrovandi at Bologna. Agricola too mentions these apparitions in these words: *"A kind of schistous stone was not long ago discovered near the Hercynian forest [nemus Hercynium], which expressed various species of animals—as among fishes, the largest pike and perch; among birds, cocks, and now and then salamanders; indeed, the effigy of the Roman Pontiff, bearded and bearing on his head the triple crown, was found, which many saw, and besides this an image of the Blessed Virgin holding the Child in her arms."* I will add a work of Nature most worthy of all admiration, which Nature—by the undoubted disposition of God—expressed in the Kingdom of Chile in forming an image of the Mother of God [Deipara]; of which Father Alphonsus Dovalius [Alonso de Ovalle] [writes] fully in his *History of Chile*, whose whole account we shall recite in what follows.

[Margin: Crucifix impressed in stones.]

These things, then, having been set forth, it remains that we behold in stones what is the greatest of all—the image of Christ crucified—lest it should seem to be wanting in the busy work of Nature. There is, on the testimony of Ambrosini, an inquisitive explorer of these matters, at Ticinum [Pavia]—commonly Pavia—in the Carthusian monastery situated at the fifth milestone outside the city, a certain marble in which Nature has elegantly depicted the image of Christ our Savior hanging on the cross, and crowned with a crown of thorns. At Venice too a figure of Christ crucified appears in marble, on the same testimony, in the church of St. George the Greater [S. Giorgio Maggiore], in the same...

one and the same form. Ambrosini reports that a similar image is to be seen at Pisa and at Bologna. A like figure of the Blessed Virgin is said to be impressed in a flint in the Aldrovandi Museum at Bologna [Museo Aldrovandino]. Agricola too mentions these phenomena [phasmata] in these words: [Margin: Remarkable images.] *"A kind of schist-stone was found in the Hercynian forest [nemus Hercynium] not long ago, which expressed various species of animals — so that among the kinds of fish you might marvel at sea-sparrows, pikes, perch; among birds at cocks and hens; sometimes salamanders; indeed the very effigy of a bearded*

Roman Pontiff bearing the triple crown upon his head was found there, which many have seen, and besides this an effigy of the Blessed Virgin carrying the boy [Child] in her arms."

We shall add a work of Nature most worthy of all admiration, which Nature — by God's unquestionable disposition — expressed in forming the image of the Mother of God [Deipara] in the Kingdom of Chile [Regnum Chilense]. Father Alonso de Ovalle [P. Alphonsus Dovalius] gives a full account of it in his *History of Chile*, whose entire narrative we shall recite in what follows.

Diagram. [Tab. IV — referenced in the text as "Tabula IV."] An engraved plate titled "*The Expression of Images of the Human Figure in Stones*" [Humanae figurae imaginum in lapidibus expressio], showing seven picture-stones with naturally-formed human and bird images. From top to bottom:

- Top left: a female bust with curling hair, marked N; captioned *Heroína* ("Heroine").
- Top center: a draped half-figure in profile facing left, beneath an arch; captioned *Figura palliata* ("Cloaked figure").
- Top right: a swan- or stork-like bird; captioned *Avium in lapidibus expressio* ("The expression of birds in stones").
- Middle left: an irregular stone showing a robed half-figure in profile; captioned *Homo. Sacerdos* ("A man. A priest").
- Middle right: an oval stone with a woman's bust, hair drawn up; captioned *In silice Foeminae effigies* ("The effigy of a woman in a flint").
- Bottom left: a large flint with a Madonna-and-Child figure in an arched recess, marked A; captioned *Silex apud Ambrosinum Beatae Virginis cum filio in brachiis* ("A flint, in Ambrosini, of the Blessed Virgin with the Child in her arms").
- Bottom right: an oval stone showing a crowned female bust below, with a dragon-like winged creature above, marked B; captioned *B. Virginis cum filio et draconis effigies* ("The effigy of the Blessed Virgin with the Child, and of a dragon").

[Margin: The crucified Christ impressed in stones.] Now that these have been set forth, it remains that we contemplate in stones the greatest image of all — the image of Christ crucified — so that nothing of all things may seem to be lacking in the busy work of Nature. On the testimony of Ambrosini, that careful investigator of these matters, there is at Ticinum [Ticini] — commonly Pavia — in the monastery of the Carthusians [Coenobium Carthusianorum] five miles outside

the city, a marble in which Nature has elegantly painted the image of Christ our Saviour hanging upon the cross and crowned with the crown of thorns. At Venice [Venetiis] too a figure of Christ crucified appears in marble, on the same authority, in the church of St. George the Greater [templum S. Georgii majoris], in the same...

way represented, as appears in the figure of Tab. IV.

[Margin: All the members of the human body.] Furthermore, there is no member of the human body that Nature has not expressed in stones: the head, ears, eyes, arms, chest, belly, feet — and finally the figures of the sexual organs, which from this even obtained the name of *enorchides* [stones bearing the likeness of testicles].

Know finally, careful Reader, that for one who inspects diligently and curiously such marble stones when they have been cut and polished, the images not only of the things mentioned but also of others will be ready to hand — such as instruments of every kind, household furnishings, and countless similar things — which I leave to be considered by curious investigators of these matters.

Sectio I — TAB. I.

FIGURES OF BIRDS [FIGURAE VOLUCRIUM]

Which Nature has painted in stones, culled from various Museums and transmitted from elsewhere.

Diagram. [Tab. I] An engraved plate titled "*Figures of birds, which Nature has painted in stones, culled from various Museums and transmitted from elsewhere.*" Seven numbered picture-stones:

- **Fig. 1** (top left): an irregular stone showing a long-necked wading bird (stork) with a small quadruped above it; captioned *Ciconiae et Noctuae figurae* ("Figures of a stork and an owl").
- **2** (top right): a stone of tangled, confused forms; captioned *Confusae rerum variarum forma* ("A confused form of various things").
- **3** (left, two birds): two birds, one with raised wings; captioned *Venetiis in Templo S. Georgii* ("At Venice, in the church of St. George").
- **4** (center): an owl's face within a stone; captioned *Caput Noctuae* ("The head of an owl").
- **5** (right): a stone with a small bird in relief; captioned *Figura Motacillae* ("Figure of a wagtail").

- 6 (lower center): a stone showing a crested bird's head; captioned *Animalis iubati* ("Of a crested animal").
- **Fig. 7** (lower right): an oval stone with a long-tailed bird; uncaptioned.

Plate legend (printed beneath):

1. The first figure marks a stork's head, with — annexed to it — some quadruped animal I cannot identify. At the top, something resembling a human face, taken from the Aldrovandi collection [ex Aldrovandino].
2. It displays various forms of things and parts of animals, both birds and quadrupeds, though very imperfect, the explanation of which we have given in the Physical disquisition.
3. It shows the images of two birds, which Ambrosini reports were expressed by Nature in marble in the church of St. George at Venice.
4. It shows the head of an owl [noctua], surrounded by other rudimentary forms of birds.
5. It expresses the figure of a wagtail [motacilla] — or, as others would have it, of a peacock.
6. It exhibits the figure of a monstrous bird.
7. It expresses the figure of a blackbird [merula].

[Margin: Trees and woods are expressed in stones by nature.]

[Margin: The expression in stones of serpents, fleas, bedbugs, flies, and butterflies.]

[Margin: The expression in stones of whales and the other fishes.]

[Margin: The expression of birds in stones.]

in various ways in stones is to be seen — and the crest [crista] which the column of the Roman College [Collegium Romanum] gathered: a marble column of mixed black and white, on which Nature painted a pelican with twisted neck opening its own breast, though with the claws of its feet mutilated. There are also some stones that exhibit cocks and hens with their chicks, as one may behold in the following figures.

[Margin: The figures of four-footed animals expressed in stones.] Moreover the figures of four-footed animals are everywhere found here and there in stones — either in the full symmetry of the body, or shown by the head alone, by the feet and shoulders — concerning which Ambrosini also writes in his book *On Metals*

[De metallicis], which is called a supplement to Aldrovandi. See Tab. II, which expresses animals.

[Margin: Human figures.] **Seventh.** With human figures of every kind the stones are so crammed that in scarcely any are there not various... But Nature expresses in marble not only human figures of every sort, but also the figures of the *Coelites* — that is, of the Saintly Men — by I know not what disposition; of these speaks the often-cited Ambrosini. Let us begin the narration from the figures of the most Blessed Virgin Mother and of the Angels; and as regards the Blessed Virgin, she is first seen impressed by nature in marble in various places and regions. See Figure A, impressed in flint. Here at Rome, in the chapel of the Holy Virgin — on the right as you enter the church of St. Peter, beside the organ — there is a notable image in which the most Blessed Virgin of Loreto [Virgo Lauretana] is so skillfully painted by Nature that she seems delineated by an artist's hand. She is clothed in a garment marked with a threefold band, and holds the little Son in her arms...

Diagram. [Tab. II] An engraved plate titled "*Of the Figures of Four-footed Animals*" [Figurarum Animalium Quadrupedum]. Nine numbered picture-stones, the first two arch-topped:

- 1 & 2 (top, two arched panels): scenes of confused animal forms — in 1, dog-heads and a man's capped figure with shapes resembling swimmers in water; in 2, a reclining dog-like figure with the rudiment of a ship.
- 3 (right oval): a four-footed animal (deer- or goat-like) standing in profile.
- 4 (left): an irregular stone with a dog's figure and a small fox-like form below.
- 5 (small, pear-shaped): a seated fox-like animal.
- 6 (small): an animal's head in a stone.
- 7 (large square): a complete cat (or feline) in profile with curling tail.
- 8 (right): a rough stone showing a capped human head in profile amid scattered forms.
- 9 (lower right): a shaggy animal's head in a stone.

Plate legend (printed beneath):

1 & 2. The figures show dogs' heads, together with the figure of a capped man: in fig. 1 they appear as if swimming in water; in fig. 2 the rudiment of a ship is seen. Besides this, the head of a cock — and signs of the moon too — which Ambrosini says he preserves as an *ectypon* [cast/impression] in his Museum. 3. It exhibits I know not what monstrous animal, not unlike a pig if you except the head; others

will have it the figure of an elephant. 4. It expresses the head of a mastiff dog [canis molossus]. 5. The head of a horse. 6. The figure of a dog's head. 7. It exhibits the perfect figure of a cat or feline, the explanation of which we give in the second mode of the disquisition; Ambrosini reports that he saw it expressed by nature in a certain marble. 8. It represents the form of a capped peasant, with a miscellany of various things. 9. It expresses the head of a capped peasant.

LIBER VIII ("Λιθογενής"), Sectio I — De Lapidibus in communi

Caput IX. De admirandis Naturae pictricis operibus (continued)

TAB. III. — Displaying the form of fish [Piscium figuram exhibens]

Diagram. Plate III, a picture-stone plate showing fish-forms impressed in stone. The engraving carries three numbered figures. At the upper right is an inscribed plate-title cartouche: "Tab. 3 / Piscium figuras exhibens" [Plate 3, displaying the forms of fish]. The three figures:

- **Fig. 1** (top): a stone split open into two matching halves, each half showing one fish-form, so that the single fish appears mirrored on both fractured faces of the rock.
- **Fig. 2** (middle): an elongated fish in profile, head to the right, shown lying within the stone.
- **Fig. 3** (bottom): a broad-bodied fish with a heavy head, lying flat within the stone slab.

Printed legend beneath the plate:

Fig. 1. Shows two fish, which are nevertheless one fish enclosed within the stone after the manner of a mold, so that it impresses half of itself on each face of the stone. From the Gualdo Museum [Musaeum Gualdinum] at Rome. 2. It reproduces the form of a parrotfish [scarus], within the stone. 3. It reproduces the form of a tench [tinca], within petrified stone.

TAB. Altera. — Displaying the forms of fish [Piscium figuras exprimens]

Diagram. A second fish plate ("the other plate" / Tab. Altera), displaying the forms of fish impressed in stone, with three numbered figures continuing the numbering of the previous plate:

- **Fig. 4** (top): a broad, deep-bodied fish (the gilthead/sea-bream type) shown in left profile, head to the left, impressed in a slab of rock.
- **Fig. 5** (middle): an arched, scaled fish, head to the lower right, curved as if swimming, within the stone.
- **Fig. 6** (bottom): two slender fish, one above the other, shown as if swimming through water, lying in the stone.

Printed legend beneath the plate:

4. It reproduces the form of a gilthead [aurata], likewise, just as the others, turned within the rock into stone.
5. It shows two fish as if swimming in water, which are seen in the Aldrovandi Museum [Musaeum Aldovrandinum].

TAB. IV. — Displaying human figures [Figuras humanas exhibens]

Diagram. Plate IV, displaying human figures impressed in stone, arranged in two rows of three numbered figures (six in all). Each figure carries a small inscribed label within the engraving.

Top row:

- **Fig. 1** (label: "Idol. Aegypti" [Egyptian idol]): an old, bearded, seated man wearing a tall conical cap, set in a cave, holding in his hands a child swaddled in bands; the swaddled child is likewise shown in a similar old-man's garb.
- **Fig. 2** (label: "Ex Musaeo Ambrosini" [From the Ambrosini Museum]): a cloaked standing figure with a large head, holding a small figure at its breast, with smaller hooded heads to either side.
- **Fig. 3** (label: "Fig. 3. Fi. S. Joh. Bapt." [Figure of St. John the Baptist]): a standing, shaggy/hairy man.

Bottom row:

- **Fig. 4** (label: "In Specie Bethlemico. Figura S. Hieronymi" [In the Bethlehem grotto. Figure of St. Jerome]): a tall robed and hooded figure.

- **Fig. 5** (label: "Ticini in Monasterio Carthusianorum" [At Pavia (Ticinum), in the Carthusian monastery]): a frontal figure of the crucified Christ with arms outstretched.
- **Fig. 6** (label: "In Templo S. Petri Romae" [In St. Peter's Church at Rome]): a tall conical robed figure (a veiled standing Virgin) with small angels at either side.

Printed legend beneath the plate:

Fig. 1. It shows a fillet-wearing old man seated, holding in his hands a child wrapped in swaddling-bands, dressed in a habit like the old man's — not unlike the Aurruncus idol of the Egyptians, concerning which see Vol. 3 of the *Oedipus Aegyptiacus*, the *Syntagma de Idolis Aurruncis* [Treatise on the Aurruncan Idols]; and as to how it was impressed in the stone, see Mode 3 of the preceding Disquisition. 2. It presents a cloaked figure carrying a child in its bosom, around which I-know-not-what traces of angels are to be seen, so that I think it is nothing other than an image of the Mother of God [Deipara] carrying her blessed little son in her bosom, with angels standing about on either side. 3. It shows the image of a hairy man, whom some take to represent a hermit, others St. John the Baptist. 4. They suppose it to display the figure of St. Jerome [S. Hieronymus], because, on the testimony of Brocardus in his Jerusalem itinerary, it appears to have been impressed in stone by Nature in the Bethlehem grotto. 5. It displays the figure of Christ crucified, impressed by Nature — on the testimony of Cardano [Cardanus] — at Pavia [Ticinum], in the monastery of the Carthusians. They assert that a similar one is seen by the Venetians in the Church of St. George. 6. At Rome, in the Church of St. Peter, in the chapel of the Blessed Virgin, there is seen impressed in marble [an image] not unlike the Loreto Virgin [Virgin of Loreto].

DISQUISITIO PHYSICA — A Physical Inquiry into the Images Impressed in Stones [Imaginum lapidibus impressarum]

In this inquiry the ectypes [ectypa] of all the objects just set out, formed within stones, are examined; the causes and reasons of each are assigned in various ways; and at last it is shown by what art and ingenuity, and to what end, Nature has expressed so many forms and images in stones.

Figures in stones may be considered in two ways: either as they appear set upon the flat, polished surface of stones, or as they appear constituted in the shapes of

solid stones variously transformed. I shall speak first of the former, afterwards of the latter. Now these figures are seen chiefly on the smoothest surfaces of variegated marbles that have been cut and polished — of which there are countless kinds — but very rarely, and scarcely in any precious gems, especially those endowed with a transparent substance, agates excepted.

[Margin: The forms are impressed in stones in four ways.]

I say, then, that they could have been expressed in stones in four ways. The first is fortuitous. The second is from the disposition of the earthy substance: within this, as within a mold, a tinted fluid is received, and at length, by the stone-making spirit [*spiritus lapidificus*], it hardens into whatever shape the matrix of the earthy substance presents. Third, they arise into this or that figure from some singular accident. Fourth, in certain images — and especially in the figures of the heavenly saints [*coelites*] — they are produced by Nature from a singular divine disposition, with the help of the Angels. Each of these is to be treated in order.

Here it must be noted that the figures in some stones are quite imperfect and mutilated in their members; in some, only the faintest traces of the figures appear; in others, a perfect and complete form is seen, in whatever genus of things. All of which afford us great indications of the hidden causes. But now to the matter.

Modus Primus [The First Mode]

[Margin: The fortuitous and chance impression of figures.]

By the first mode I assert that most of the forms that have arisen in stones were produced fortuitously and by chance. That this may be understood, let the Reader know the following. Just as the imagination of men, when it sees the sky overcast with a variety of clouds, pictures to itself various things — now flying dragons, now ships, now mountains, cities, and castles, now crosses, now human figures and similar apparitions — out of the unordered presentation of the clouds: so too, even in spittle cast upon the ground, we notice that something is sometimes figured which is now like this thing, now like that. Indeed, on our travels, seeing the spread of mountains under a certain shape, we now conceive a table — as with the Cape of Good Hope [*promontorium bonae spei*] and the promontory of Sicily; now a man stretched out on his back — as in the Apennine mountain of the people of Camerino [*Apenninus Camertensium*], whose summit expresses the head, whose sloping extension and slight further protuberance the chest and belly,

[Margin: The figures are impressed in stones in various ways.]

a rock jutting out into the valley the arm, and two thighs subsiding into a forked valley the various outlying parts of the mountain. On the island of Malta [Insula Melitensis] a seaside rock, hanging apart from the mountain, expresses a hanging monk — commonly called *frate impiccato* [the hanged friar]. Sometimes rocks and shrubs and the fragments of cliffs display a human likeness under the figure of a coin, as at Palermo [Panormus] a mountain which from its figure is commonly called the *testa della medaglia* [the head on the coin]. I could adduce countless apparitions of this kind in this place, but because such things are nowhere lacking, I have wished only to hint at them here. You may also see, on the rough surfaces of fired bricks, various traces of insects, birds, and other things — which nevertheless are intended by Nature to no end, but, because of a certain similarity of things, a man imagines to himself that they are such. With these matters thus set forth, one might now justly ask whence so great a host of apparitions of images in stones has taken its origin.

[Margin: The cause of figures of this kind.]

I reply that all these are born from the flowing of a saline fluid [fluor salini liquoris]. When this fluid has insinuated itself into the earthy and suitable substance — still soft, and gaping with dryness into many cracks and winding channels, as may be seen in marbles — then, just as there, by the stone-making spirit, in the course of time, the whole coalesces together into a hard and stony mass, so, according to the configuration of the cracks and fissures, the insinuated fluid delineates — in whatever way it can, and according to the disposition of the matter now gaping with dryness into various rifts and hollow cavities — now the loveliest patterns, now branching trees, now the form of a bird, or an insect, or a quadruped, or even a human likeness, or at least some member of the human body. That these are in fact constituted by a kind of flowing is clearly taught by the winding courses of the patterns, painted in diverse ways according to the diversity of the tinting spirit, which are seen now elegantly mixed from black into white, now from white into yellow, or into green and blue channels. That the earth was at first soft is established from this: that after many cycles of years the nature of the place is observed to produce the same stones imbued with the same diversity of figures and colors.

[Margin: The cause of the channels of these forms, like a watercourse.]

This would not happen if the subterranean economy did not tint the earthy matter — macerated and fermented over a span of many years — with its own

variable flowing, the spirits being sent through it into various colors as it gapes with varying heat. As to the experiment of this matter, consult what was delivered above.

[Margin: No likeness made by chance is perfect.]

There is also another not slight argument that these similar apparitions are constituted by a fortuitous and chance flux: namely, that scarcely any of those which counterfeit the figure of an animal turn out perfect in form. Rather, there is always found to be lacking something required for the constituting of the whole figure — as in heads, either an eye, or a nose, or a mouth; in arms, the hand and fingers; in legs, the feet — a deficiency which the industry of painters for the most part makes good. So that they are not so much what they really are, ...than what the imaginative faculty fancies them to be. Let us judge them just as we did a little earlier in the case of clouds, mountains, spittle, and the other such things.

One may ask by what process Nature formed this fish. I answer that it happened in this way. We know that in many places great river floods occur in winter, and that as a result a vast quantity of mud is heaped up over the fields and hills. By these floods, then, many fishes were cast out together and wrapped in the mud; and the mud, in the course of time, was converted into stone by the stone-making spirit. As happened to this fish, so many other fishes were enveloped, and in the mud — serving as a kind of mold and matrix — they impressed their own native shape. That this is so can be demonstrated by the fact that the spines are still present along with the scales, and that the fleshy parts are seen as though violently torn away and mangled, while the bone-structure, together with its spiny substance, is so perfectly reproduced that not even a painter, however skilled his hand, could match Nature's original. This is clear evidence that there was a real fish's substance there, which impressed its shape, as it were, in the muddy matrix.

[Margin: How fishes and serpents impress their shape into mud as into a mold.]

For if you examine the stone I mentioned a moment ago more deeply, as to its inner substance, you will find a hollow inside, corresponding to the size of the fish. As for the fact that no pulp or entrails appear inside, that is no wonder, since the whole of that soft, flaccid substance — most liable to corruption — was either consumed, or dried out by heat and turned to powder, and could leave nothing behind but the harder substance of the bones. This is evident from the tombs of the ancients, in which, apart from the skeleton, you will find not even a trace of

any other portion or limb of the human body. And this is the origin of those fishes that the natural philosophers call *fossil* [*pisces fossiles*], which are found in many places — as has been shown above — and which everywhere turn up in the cabinets of curious men.

In the same way, serpents wrapped in mud seem to have impressed their shape in a similar manner, as is evident from the figure set here, from the Aldobrandini Museum [Mufzo Aldobrandino]; and the same judgment is to be made about all animals.

[Margin: How the shapes of flat animals are impressed.]

In other cases, moreover, what appears is not the bone-structure but a true and genuine likeness of the animal; how this came to be impressed upon the rock I shall now explain. It was said above that saline bodies, by a certain wondrous appetite which we call the magnetism of Nature, mutually attract one another. Since, therefore, the matter of stone is full of saline particles, just as the bodies of animals are, it comes about that when some animal, wrapped in muddy clay,

[Printed page 39 — the page bearing the engraved stone with serpents and fishes] ...has impressed its own shape there — at that same spot, as soon as it has expressed its figure: a confluence of the saline parts in the animal toward the saline parts in the argillaceous matter will take place. And since all things flow together by a certain marvelous radiation [*actinobolismus*] or beaming-out,

Diagram. A large, irregularly shaped stone (woodcut) occupying the upper portion of the page, depicting in low relief a tangle of serpents and fishes whose forms wind across the surface of the rock. The engraved caption runs vertically up the right-hand edge of the stone.

- Caption (right edge, vertical): "Saxum Serpantium Piscium figuram referens" — "A stone reproducing the figure of serpents and fishes."
- The relief shows several elongated serpentine bodies interwoven with broader-bodied fishes, rendered as natural markings in the stone's surface.

[Resuming the text of the central column:] ...it comes about that the radiating particles imbue the matter of the stone with the very tincture in which they themselves are rich. Hence at last either the whole figure of the living creature, or its parts, emerge in the stone with a certain marvelous symmetry — the plastic faculty [*facultas plastica*] contributing greatly to this work, a faculty which we shall demonstrate in what follows still to remain in the cadavers of plants and animals.

I would not, however, have it understood in this place that things of this kind are generated as it were from some seed cut off from a plant or animal, but rather through something that corresponds to seed by a certain proportion. In this way, the stone immediately impresses upon the earth it touches — once that earth has been disposed nearly to the nature of stone — a form like its own. So too a pre-existing portion of gold, once the matter near it has been disposed to take on the substance of gold, converts that matter into the substance of gold. In the same way silver draws toward itself all matter disposed for the production of silver, so as to make a substance like itself; and the same judgment is to be made of all the other metals, each attracting to itself what resembles it — not, as many wrongly suppose, through any true vegetation [vera vegetatio], but through a confluence of similar corpuscles coming together by a certain magnetic attraction, or, what amounts to the same thing, through juxtaposition, after the manner of inanimate things.

[Margin: Magnetism of Nature.]

And this is done by Nature's great wisdom: lest the species of corruptible substances should in time be utterly abolished, sagacious Nature has implanted in all things a means of generating things like themselves, so that those things which can never persist as individuals may at least attain perpetuity in their species, and so, according to the measure and capacity of their nature, may enjoy the perennial gift of incorruptibility — which is the end for the sake of which all things act that act according to nature.

MODUS TERTIUS

[Margin: How the shapes of trees are impressed in stones.]

It arises from some particular accident, by which figures in stones emerge now into this, now into that form.

These are wondrous and altogether paradoxical things which Nature works in fashioning figures in stones; their explanation is not easy to assign. I shall nonetheless attempt — being rather well practiced from frequent investigation of these matters — to set forth in this place the cause of each of these apparitions [phasmata], making my beginning from those stones which, from their abundance of trees, are called *dendritae* [tree-stones]. Of these no small quantity is to be seen here at Rome, both in my own Museum and in others; some of them contain separate trees, others entire apparitions of trees and groves drawn out according to all the laws of perspective. Stones of this kind are found above all on

Mount Sinai — whence the stone is also named *petra Sinai* [the Sinai stone] — and in Etruria [Hetruria] near the town of Bargam [Barga], even though these are not really plants, nor have they any life, but are pure and simple simulacra of painted plants, by Nature's marvelous craftsmanship. Before I explain their generation, the following must be noted.

Four kinds of stone are to be found in which the likenesses of plants and trees, and the images of crops, are seen marvelously depicted by Nature. The first of these, called *Botrycitis* by Pliny [Pliny the Elder], represents a plant flowering with white or blood-red fronds on a black ground.

[Margin: Tree-stones.]

The second, named *Nemorosa petra* [the wooded stone] by Imperato [Ferrante Imperato], the celebrated antiquary — which is the same as the Sinai stone — is called *Dendrachates* by Agricola [Georgius Agricola]; on the interior walls of the split stone it displays countless images of plants and crops, and is properly called *dendritis*. The third is the kind that reproduces the serrated leaves of the willow, whence it is also called *folium salicis* [the willow-leaf stone].

[Margin: Willow-leaf stone.]

The fourth kind of stone is called by Imperato *frumentatum* [the grain-stone], because it expresses the species of wheat and other crops, which

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all I remember having seen, and curiously examined, long ago in the celebrated Museum of Imperato.

One asks, then, the cause of such great marvels. I say, therefore, that these figures could have been impressed in the following way. It is known to all that herbs and plants of various kinds are seen growing on many inaccessible heights of ancient buildings — yet how they grew up there is rightly thought paradoxical by those unskilled in such matters. Pliny relates that twice a palm sprang up on the topmost summit of the Capitol [Capitolium], and that after the palm had been beaten down by storms, a fig tree sprang up in the same place, in the consulship of M. Messala and C. Cassius [in the consulship of Marcus Messala and Gaius Cassius]. And not only in that age, but down to the present day, we see all the ruins of the Baths, the Aqueducts, and the Amphitheaters flowering not only with palms, wild figs, and mastic-trees, but also with countless other herbs — of which Panarola, in his book on this subject, records up to 200 in his "Amphitheater of Plants" [*Amphitheatrum de plantis*]. The matter is so trite and nearly

commonplace that its cause should not on that account be reckoned hidden from anyone. For since the crannies of the said ruins are continually filled with dust, and with that dust seeds of every kind are carried thither — whether by the force of the winds or by the agency of birds, or even deposited there in the droppings of birds (in which the kernels of dates, cherries, plums, figs, and other hard seeds remain intact) — then, once the dusts are softened by rain or dew, nothing is easier than that, with the addition of the sun's heat, each should gradually blossom into the germ proper to its own species. There is also the fact that the powders of lime [calx] have some innate property — I know not what — for producing various herbs. But of these things more fully elsewhere. With this premised, then,

I say that the very same thing can happen in stones. For since in petrifying earth there are present the powders of various shrubs and plants, in which — together with a slight heat — there still resides some seminal something [nescio quid spermaticum], this, having found in the stone (while its matter is still soft) a material somehow suited to it, and being unable to constitute the substance of plants out of that matter, does what it can: that is, by the plastic faculty (which still in some way resides in the seminal virtue), it depicts in the matter the mere images of trees and herbs. So everywhere Nature strives to produce something like herself; she would indeed wish to beget an essence similar to herself, but being hindered — both by the weakness of the agent and by the unfitness of the patient — when she cannot effect what she would, she at least generates the accidents and images of plants, as plants equivocally (to speak with the Schools). And this Aristotle proves by the example of the generation of man, who always intends to generate a male, but, failing utterly of his wish, generates a female — the male, as it is said, being defective; and the same must be said of the generation of the other animals indiscriminately.

[Margin: L. 3, *de Spon[taneo] vivorum [motu].*]

To the point, then: since in the earth from which the stone is born there are pre-existing powders of various

[Margin: How figures are impressed in crystal and in amber.]

Now let us propose another mode by which we may suppose the images of plants could have been made in stones. Before the rock came to be, there were somewhere shrubs and plants — especially of a smaller and finer substance, such as the mossy kind — which were contained there; afterward, when soil-borne moisture was poured over them on every side and converted into stone, the rock

grew up together with the little herbs and crops, so that it reproduced their images, they being petrified within it. And clear evidence of this is that stones of this kind, when opened by a parallel section, do not in all respects display likenesses similar to those grown on the first surface, but, owing to the differing courses of the branches, show now a trunk, now branches as if cut off, now formed in one way and another. This clearly indicates that the little plant, diffused through that stony mass while it was still muddy and afterward hardened, exhibited — according to the different sections — different parts of the trees.

I illustrate the matter most aptly by an example. In crystalline bodies, little mossy shrubs of this kind are not infrequently seen, which I remember having beheld with no small pleasure; and the distinguished philosophers Liceti and Lorenzo Pignoria [Laurentius Pignorius] attest to having seen a green little herb in the middle of crystal — the former in his work *On the spontaneous motion of living things*, the latter in his exposition of the hieroglyphic Tablet [the *Mensa Isiaca*].

[Margin: How [things grow] in crystal and amber — moss, flies, and the like enclosed.]

How that herb came to grow within the crystal is not difficult to investigate. For it is certain that this little herb, having first been present as a true plant in the matter suited to generating the crystal, was afterward hardened by the stone-making faculty together with the crystal — just as in amber [succinum] little animals of many kinds, enclosed by an eternal barrier, have presented themselves to view. For if anyone were to cut the crystal, he would doubtless find no longer a living, vegetating plant, but a stony one — and that not diffused through the whole crystalline mass, but cut up into its own branches. So what happens to the little herb enclosed in crystal, on account of its transparency, to the sensible sight, no one ought to doubt could have happened in opaque bodies while they were still consisting under soft matter.

It now remains for us to explain by what brush of Nature [penicillum Naturae] the form of certain animals has been so skillfully expressed in stone. Certainly the paths of Nature are so hidden, and her manner of proceeding in the production of diverse things so occult, that unless one has been instructed by the experience of many years, and has devoted all his effort to the perfect investigation and exploration of the composition of things, it cannot be that, by the reasoning of the intellect alone, anyone should attain to the proximate, true, and genuine causes of such great

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marvels. For experience illuminates the intellect: here, by aptly combining particular things with particular things, it leads at last to the desired knowledge of hidden causes.

[Margin: How figures are impressed in subterranean rocks.]

In the perfect expression, then, of the images which are everywhere found in stones, several partial causes concur. The first is a certain disposition of the matter, fit to receive the form. The second requires something else as well, which may impress upon the matter the form — now this, now that — like a kind of seal; and to this there always belongs a certain action endowed with vehement magnetism, by which like are drawn to like.

As for the matter: it had first to be soft and steeped in a certain moist mud; otherwise, by its hardness, it would repel all the penetrative faculty of the tinctorial spirit. This is evident from the fact that almost all stones are softer in their own mine, and only then pass into adamantine hardness when they have received the dry breath of the air. But the form or seal, which impresses the figure upon the matter, can likewise be twofold: purely natural, and composed of natural and artificial together. Of the former I say that it could have been the cadaver of some animal, whose skin, glued to the still-soft matter, impressed upon it a figure like itself, by the working of the plastic faculty which (as we said above) still remains in the cadavers of animals.

[Margin: How the figures of animals are impressed.]

Indeed, Albertus Magnus [Albert the Great], in Book I *de rebus metallicis*, treatise 2, chapter 9, says this expressly in these words: "It seems wonderful to all," he says, "that stones are sometimes found which have the images of animals both within and without — for on the outside they have the lineaments, and when they are broken, there is found in them the figure of the entrails; which could not have come about by any other means than from an animal there converted into stone." For when [Nature], on account of the unfitness of the underlying matter, cannot animate it into life, she at least impresses upon it a figure like herself; and this through the agency of the saline bodies lying hidden in the cadaver, which — while they flow together from the disposed matter by the magnetic attraction of salt (as we said), drawn one to another — carry with them the plastic power naturally implanted in them. At length, when the more flaccid parts of the cadaver have been consumed, the stone-making power converts what remains, together with its figure, into rock. And a clear indication of this is that perfect

images of things of this kind do not penetrate the whole substance of the rock, but cling only to the surface — as all those who devote themselves to cutting stones of this kind, the stone-cutters [λιθοτόμοι (lithotomoi, "stone-cutters")] whom we have rigorously consulted about this, testify. As for the fact that sometimes only the feet, the head, or one foot and another appear in stones, this could have come about either because of the broken-up parts of the cadaver, or because of an interruption in the flowing earthen matter, by which the parts were torn from the parts, and cannot show forth any but the isolated parts of the animal. Hence it also comes about that some parts are seen as twisted and as it were wrinkled, which could happen because of the motion of the skin, wrinkled in some part by the flow of the matter. Having set forth the natural account of the figures of animals in stones, let us now explain how this can come about from a composition of the natural and the artificial.

MODUS QUARTUS

[Margin: The marvelous quarry-mines of Tivoli [Tibur].]

It is certain — and daily experience teaches it — that in the mines of Tivoli [Tyburtinis fodinis], within the very heart of the rocks, various iron instruments are found: nails, spades, the diggers' mallets which the masons [*Piccozze?*] [?] call *Piccone* [pickaxes], and the like; tools once left there and buried, covered over by the earth and by the chippings of the rocks, which at last, after much time, coalesced anew with the stone. For it is so well known that the Tivoli mines are, over a certain course of years, replenished with new rocks by the coagulative force of the sulphurous water flowing out of Lake Albula [Lacus Albula] and running through subterranean channels under that whole plain, that no one can any longer doubt of it; and we shall demonstrate this (God granting) in our *Latium*. Moreover, the stone-cutters or quarrymen, who labor there in great numbers, almost always have their own huts built on the spot, in which there are also sacred images, crucifixes, and the like, pertaining to divine worship — each according to his own devotion, as we ourselves observed, not without a singular feeling of the mind.

[Margin: Sacred figures impressed in subterranean images.]

This whole furniture, abandoned after the workmen departed and variously scattered among so many ditches, could easily be lost. For once they have emptied one place of its rocks, they are accustomed at once to cover the caverns and ditches with dust, chippings, and clods of earth — so that, in this way (as I

said), over the course of many years, that whole heap of things may be converted into new rock.

These things being established, then, I now say that it can happen that one of these images, wrapped in mud, may in the same way (as we said above concerning the cadavers of animals) impress its own figure. For since colors consist of various minerals, and one mineral (as we said above) draws another by natural magnetism, it can come about that the mineral particles inhering in the images, having acquired some other mineral matter that symbolizes with them, impress in it a figure like themselves.

While I was pondering these things within myself with great mental excitement, it happened this very year, in which we are writing these things, that, while I was in the Tivoli countryside for the sake of exploring it, I fell into familiar conversation with the overseer of the ditches; and conferring with him about many matters concerning the properties of the place and the nature of the mines, I brought up whatever I have just adduced about the various instruments found in the heart of the rocks — and on his testimony I found it to be true. Indeed, he added that there had been found, among other things, in a certain rock, these four letters, I N R I,

[Margin: A wonderful observation about the title of the crucified Christ, impressed in a Tivoli stone.]

which refer to the title of the crucified Christ, depicted there by Nature, and sold to a certain foreigner for a great sum of money: no small

[The opening sentences below continue from the previous page, mid-account of the petrified Crucifix-title experiment in the Tivoli quarries.]

I thought about how this could happen, and I saw it — which I will explain in a few words. I say, then, that once a certain sacred image of the Crucified was left and buried there amid the scraps of stones and earthy debris, it could easily happen that the title [of the cross], being detached from the cross, clung to material suitably disposed to receive its form. With the passage of time, this material together with [the title] was converted into a stony mass, and there left behind its own cast [ectypon] in the stone. A great part of those images found in marbles, therefore, may be ascribed to this cause — especially when they are so perfect that an effect of this kind cannot be ascribed to a merely natural cause.

So that I might make some trial of this matter, I painted various little images, which I placed between two slabs of marble and left buried for the space of a

whole month. When, after that time had nearly elapsed, I opened the slabs — wonderful to say — I found each of the figures (among which was the most sacred Name of JESUS) not only impressed and expressed at the surface, but penetrated to some depth toward the bottom, so that even when I smoothed the slab down with pumice the same figures kept reappearing. You should set up the experiment as follows.

[Margin: An experiment demonstrating it nicely.]

EXPERIMENT

[Greek: εικονογένεσιν (eikonogenesin, "image-generation")] demonstrating it to the eye in stones.

Paint whatever image you like on paper with this preparation of colors: let the colors — which must be mineral — be mixed with vitriol, with salt dissolved in water, and with distilled petroleum, first with some portion of alum. Place the paper so painted between two marble tablets planed down to an exact smoothness, and with the joints smeared over with wax and pitch so that no moisture can get in. Store these in a damp place; and when the term of a month — or even of two or three months — has passed, take the tablets apart, and you will find on one or the other tablet the images depicted to the life, distorted in no part; and you will find that they have penetrated even into the very body of the tablet to some depth with their colors. You will have the same success if you trace the picture with ink alone, with vitriol well diluted.

COROLLARY [I]

From this experiment it is abundantly clear that many of the more perfect images within stones — especially the better ones — were formed in no other way than by the method just described. Of this kind are those we display in the following diagram: two birds marked with the number 5, which appear to have undergone the figure of a cat or...

[The text here jumps across the column to continue at folio 43, left column.
Resuming:]

[the figure marked number] 2; the image of the Crucified marked number 3; and the figure marked number 4, which perfectly imitates an Egyptian idol — these are explained by the considerations I brought forward, of the sort of which I displayed various schemes in my *Oedipus*, Tome III. The one marked number 5 seems to have been an image of the Blessed Virgin with the Child in her bosom,

whom two angels above seem to be crowning. As for the fact that these two are seen somewhat distorted and imperfect, it could have happened because the painting, crumpling in the damp, disrupted somewhat the intended symmetry of the lineaments; and it is likely that the same happened with the rest of these similar cases.

[Margin: Reasons for the images.]

But you will perhaps object that it cannot be grasped how such images crept into the stones of the deep. I answer as I indicated a little above: that quarries [were] once dug out and emptied of old [and] over time [silted up and refilled?]. It could therefore have happened that men devoted to painting, long ago in those quarries, painted images of this kind to pass the idle time — or that the images were brought there from elsewhere; that afterward, through some chance or other intervening, they were abandoned and scattered, buried under sand and debris; and that at length, moistened by subterranean evaporation and by rains and showers, they adhered aptly to material destined to generate marble, and in this way, together with the images, were converted into marble, leaving their likenesses expressed there. So that what Pliny [Plinius] relates of the ring of King Pyrrhus [Pyrrhi regis] — in which the nine Muses together with Apollo were seen depicted — I am persuaded had its origin from nothing other than a similar figure, without any painting, lost in some mine.

[Margin: An objection from the bones of animals.]

You will object, secondly: why do there not appear bones of animals, or paper or cloth or wood, in which the impressed images are discerned? I answer: that all these, moistened over the long lapse of time, underwent a vast alteration, until everything was resolved into corruption [tabum], eaten away by the sharpness of the metallic juices, reduced to powder, and dispersed into the tiniest particles, with no trace left behind — and then at last coalesced together with the matter into stone, the image alone remaining. The image remains because the cloth or paper on which it had been painted, since it had clung — glued to the apt material from the very beginning — likewise impressed upon it a permanent and stable form.

COROLLARY II

From these things it is clear how some images are found depicted in stones with a certain incredible perfection, in which not only grace and luster, but also a marvelous variety of colors and shadows nestling [within them] wonderfully

solicits the eyes and minds of the beholders. Of this kind is one which the most excellent prince of Bassano [Bassanensis] showed me not long ago.

[Margin: The image of the Guardian Angel committed to him expressed in stone, at S. Angelo.]

It was a picture of the Guardian Angel with the soul, under the form of a boy, committed to his care, as appears in the figure — produced, as he himself thought, by nature in this way. I, examining it with the greatest...

[Resuming at folio 43, left column top:]

diligence the image and the brightness, elegance, and liveliness of the countenance — the face with which [the Angel] gazed upon the boy, and this boy's most devout affections [of devotion] toward the Angel — I judged it could not be that Nature, being [Greek: ἄλογον (alogon, "irrational," "without reason")], that is, irrational, could intend any such thing, which would not be granted even to a painter unless of the greatest genius. But that this was a pure work of Nature, the said prince was moved [to believe] by no other argument than that the said image permeated the whole substance of the stone, so that however many sections were made, just so many new copies of the said images would result.

While, then, I was pondering this deeply, and the manner in which it could have come about, I happened upon a painter — of whom I had already long ago heard that he could paint similar images. When I had discussed with him the rationale of this said painting, and asked whether anything similar to this could be done by art, he at once added that it was true: that he had offered images of this kind to Urban VIII, Supreme Pontiff [Urbano VIII, Pont. Max.], as an unheard-of specimen of the art, expressed in marble — in which, since the colors penetrate the whole substance of the stone, when a section was made parallel [to the surface], just so many new images would result as sections were made. And when I asked him for the rationale, he denied that it could be done; but I, sniffing out the rationale, at last, after making the experiment, found it to be true.

[Margin: A new and rare experiment.]

There is still to this very day here at Rome a painter, the Knight Vannius [Eques Vannius], who has sold this art at a great price, and cannot be induced to communicate his art to anyone. When I had heard this, I pondered seriously with myself how it could be done, [and] by what means colors suited to this could be prepared. So, by consultation with the distinguished German chemist Alberto Guntero [Albert Günther] the Saxon, we accomplished so much by combination

and by experiments with substances that we not only dug out the secret but also enriched it with a manifold variety of colors, which the aforesaid Knight lacked. And since the matter is most worthy, and we have already made the experiment in our Museum, I will here gladly and willingly communicate to the curious Reader the whole rationale of the secret, since these things contribute much to confirming the aims of our undertaking.

[Margin: An experiment by which any figure whatever is dissolved into the marble, penetrating the whole solidity of the stone.]

The colors are prepared as follows. I take two ounces of aqua fortis [aquam fortem]; likewise 2 ounces of aqua fortis or aqua regia [aqua fortis sive aqua regia]; one ounce of sal ammoniac [salis ammoniaci]; 3 drachms of the best spirit of wine [spiritus vini]; as much gold as is bought for 3 julii [giulii]; 2 drachms of purified silver [argenti depurati]. With these prepared, now put calcined silver into a flask, and with 2 drachms of aqua fortis poured over it, leave it to evaporate, and you will have a water that will give you first a blue color, and afterward a black. Next put calcined gold into the flask, and with aqua fortis poured over it, until it has evaporated, I set it aside; then I leave the sal ammoniac, together with the poured-on spirit of wine, until the spirit has evaporated, and you will have a water of golden color, which will give you various colors. And by this art you will be able to extract from the remaining minerals various tinctures of colors.

These things being done, then, with these two waters you will paint whatever image you wish on white marble of a somewhat soft substance; and renew the figure daily by the fresh addition of the waters; and in time you will find that the painting has penetrated the solidity of the whole stone, so that, when cut into however many parts you wish, it always exhibits to you the same figure on either side. This thing, being as rare as it is unusual, also gives rise to the greatest admiration in the beholders.

[Margin: Another from the heads of angels [seen] in full.]

A similar image was shown by the most excellent Paolo Giordano Orsini [Paulus Iordanus Ursinus], Duke of Bracciano [Dux Braccianensis], in a many-sided stone, in which as many sides as there were, just so many angelic heads stood out — of a different figure, however, now upright, now twisted back, according to the manner of the oblique section made. But with these things set forth, [let us come] now to the rhombus.

[Margin: The rationale of the [colored] juices.]

We say, then, that whenever images are found penetrating the whole substance [of the stone], this could not have happened except by the agency of mineral juices, and through the intervention of salts of every most corrosive kind. But those that penetrate the inner substance less, we must judge to be endowed with a smaller quantity of the said juices. The truth of this I have found in the agate which represented a Heroine, as I related above: which, cut through the middle, showed nothing of those things that appeared expressed on the outermost surface — except for certain lines diffused in an irregular course. But let these things suffice concerning the fifth mode; let us come to the sixth mode.

MODUS SEXTUS [SIXTH MODE]

On images of stones in which something divine is believed to inhere.

In what precedes we have narrated several images of Christ crucified, of the most blessed Virgin Mother with her divine little Son taken up in her arms, and of the likenesses of the other saints — concerning which it is rightly asked how Nature expressed them. I say that the execution of Divine providence comes about for the most part through second causes; that is, whenever prodigious effects in the nature of things appear — in the heavens, indeed, new births of stars; in the lower world, monstrous births; and in stones, prodigious images — those [effects], I say, are always directed, by that admirable connection by which Divine [matters?] are joined, toward signifying something.

[Margin: How the Nature of things would cooperate in producing prodigious images.]

For providence presupposes two things, namely ordination and the execution of the order, of which the former regards the cognitive power, the latter the operation. Since, then, in GOD there resides for ordaining an infinite wisdom...

[Resuming at folio 44, left column top:]

and for operating a power and potency boundless and free of every limit, it necessarily follows that He arranges all the orders even of the least things, while the least things, indeed, or even the lowest, [He arranges] through inferior powers — as it were, through natural executrices of Divine providence; that is, through the concurrence of natural causes, through which He Himself, as the universal cause of things, operates. Hence we read that signs of this kind have always appeared in great events; and we have pursued this most fully in our *Diatriba* on the prodigious Neapolitan crosses [seen] in the linen garments of men at Naples [Neapoli].

[Margin: Threatening signs of evils impressed on a stone.]

A stone was found in a mine of Switzerland [Helvetia], as Ambrosinus [Ambrosinus] reports, with this scheme of figures; which, although it is a pure work of nature, GOD nevertheless, out of His eternal providence — by which He holds all the orders of the World and the connected rationale of their effects — willed to signify by means of those wars that followed a little afterward. So, where He wishes the cult of the Mother of God or of some other Saint to be instituted, He generally signifies it, as it were, through signs of this kind, indices of the divine will. In this way, in the Kingdom of the Chinese [Regnum Sinarum], a little before the Gospel...

[Resuming at folio 44, right column:]

the Gospel was brought in there, river crabs marked on their backs with images of all the crosses were seen, in an unusual order of things, in an unusual way, as appears in figures L [and] M.

[Margin: In China and Japan crosses appeared on the backs of crabs and in the trunks of trees.]

Diagram. Two small woodcut figures of river crabs seen from above, each bearing a cross-marking on its carapace, illustrating the "crosses on the backs of crabs" reported in China before the preaching of the Gospel.

- L (left figure): an elongated crab/crustacean with a long-snouted body, a cross-shaped marking running down the center of its shell.
- M (right figure): a broader, rounder crab with claws spread, bearing a cross-shaped marking on its carapace.

In Japan [Japonia] likewise, at the very beginning of the preaching of the Gospel, the figure of a cross appeared in cut [i.e. felled] trees. Admirable is what happened at the same time in the Kingdom of Chile [Regnum Chilense]: a new image of the Mother of God, never before seen, appeared among the inaccessible hiding-places of the cliffs as a spectacle to be admired by all — not by the help of a mortal painter, but by the brush of Nature, from the intention of GOD, delineated in various differently-colored kinds of jasper according to all the laws of Optics.

[Margin: A wonderful account of the image of the Blessed Virgin seen in the Kingdom of Chile.]

[Margin: True [images] on the backs of crabs and in the trunks of trees.]

But because the matter is most worthy of consideration, I will append the description of this image from the history compiled by Father Alfonso de Valle [P. Alfonso de Valle], together with the image.

Diagram. A large full-width engraved plate (uncaptioned) occupying the lower two-thirds of the page. It depicts a rugged rock cavern or grotto, within whose dark, excavated hollow stands the figure of the Blessed Virgin Mary holding the Christ Child on her left arm. The Virgin is shown full-length, with long hair flowing down over her shoulders and a long robe and mantle; the folds of the drapery merge into the striated rock of the cave. The Child is held against her body. The whole figure appears as though naturally formed in the variegated stone of the cliff face — the engraving rendering the "image of the Virgin seen in the rocks of Chile" described in the text. No labels or lettering appear on the plate.

[Resuming at folio 45, left column top — printed in italic, the description translated from Spanish:]

The true effigy of the Blessed Virgin in Arauco [Arauco], which is seen in a cavity of the rock in the manner of an arched shrine, not delineated by any craftsman, but constructed by the Author of nature out of jasper of various colors, with a white face beneath black hair, with a mantle inwardly sky-blue, outwardly red in color, woven with a rose-colored garment. I will here set forth in a few words its history, translated by me from Spanish into Latin.

On the shore of the Pacific Sea, which faces Arauco, [at a place] called Inbulia [Imbulia?], there is a mountainous spot, almost inaccessible because of the cliffs and rugged rocks, until you come to a plain and a pleasant little hill, where — looking toward the hollowed-out cliff — you will behold the wonderful and prodigious image of the Blessed Virgin, expressed there by nature, with her precious Son in her arms. The black stone forms the hair, fanned out and spread over the back and shoulders; while white [stone] forms the face, turned to one side and, as they say, in profile, so that only one eye, of great proportion and elegance, appears delineated.

The garment [is] of rose color up to the girdle; the mantle, of citron color below, appearing of sky-blue color [above] — the image, in a word, fashioned in such a way as wonderfully to affect the eyes of all who behold it.

It was first noticed, some 8 or 10 years ago, by a boy staying with his mother in the said plain, who addressed his mother with these words: "Do you see — do you see, mother, that beautiful Lady with her lovely [Son], whom she holds in her arms?" The mother, with her eyes thereupon cast toward the place where the boy had

pointed, found the thing to be most true, which she at once published by public report throughout the whole territory. When the rumor reached the ears of the Reverend Fathers, they soon went to the place, and found it to be true, just as the woman had related. Whereupon the still-heathen peoples, moved by the miraculous effigy — having first been instructed about the meaning of the image — with unanimous consent took up the Christian faith, to the great solace and joy of all. Nor did God fail the devotion of the Neophytes toward Himself and His mother: when, after a year, the way to this place had now been leveled flat, He confirmed their devotion with the customary processions, frequented by great miracles.

[End of the italic translated account.]

And from all these things it is at last concluded that, even if the said images — whatever sort they may finally be — are properly made by Nature, according to the second, third, fourth, or fifth modes set out a little before: yet because the operation of Nature always depends on the concurrence of the providence that [governs] all things, so too, if notable events follow such phantasms of Nature, these were already foreseen in their causes, according to the immutable rationale of the divine archetype, connected by the laws of nature — although things of this kind ought by no means to be called miracles, but marvels, as St. Thomas [D. Thomas] rightly teaches, *Contra Gentes* III.3 [Book 3]. But let these things suffice concerning the [Greek: εικονογένεσιν (eikonogenesin, "image-generation")] in stones.

SECTIO II [SECTION II]

ON THE TRANSFORMATION

of Juices, Salts, Herbs, Plants, Trees, Animals, and Men
converted into stone; or, On the petrifying faculty.

CAPUT I [CHAPTER I]

On the origin of the petrifying juice.

That there is in the innermost bowels of the Earth a certain faculty which, having got hold of suitable material, presently converts all things into stone, we said above; now, however, we will treat of it expressly. It is asked, then, what this force and faculty is, and from where it derives its origin. I answer: this petrifying faculty resides in the various species of minerals which are found, elaborated by manifold and marvelous art, in the subterranean workshops; and, as we have

said, it is produced in manifold ways, according to the differing nature and property of the subterranean juices.

First, we see water dripping in subterranean caves for the most part converted into stony icicles [stalactites]. The reason for this is that rainwater, penetrating the inmost passages and fissures of the mountains, carries down with it a vast quantity of fragments stuffed with niter and salt and scraped off from the stony structure of the mountain. These [fragments], mingled with the water — whether perfectly or confusedly — dripping within the cave, suddenly, when the moisture is consumed by the dryness of the surrounding [air], are converted into stone of that kind of which the fragments were; and of this sort of juices are all those stones which take their origin from the vaults of caverns and cliffs. Whatever, moreover, you place within the orifices of such dripping waters — whether it be wood, or fronds, or herbs, or anything similar — within a short time is either wholly converted into stone (if the fragments of the stone have been well united and mixed), or, if they have been confusedly and not well mixed, at least whatever they touch they will clothe with a stony crust. Of this...

if they have been perfectly mixed together with the [stony] sediments and the water; or, if they have come together in an imperfect and confused mixture, then — since the juice is not free to penetrate into the inmost part of the substance — it will likewise clothe plants, herbs, straws, and twigs with a crust only, as is shown in figure A B C. You can see something of this kind at the Albula near Tivoli [Aqua Albula], where you will find herbs, straws, stalks, wood, broom, and similar shoots clothed only with a stony, niter-bearing crust; and you will also observe that the assemblage of sugar-like grains is very imperfectly united, indeed easily dissolved by the touch of the fingers into a white lime.

Diagram. A small woodcut in the left column showing three encrusted plant-shapes set side by side, lettered A, B, C, illustrating objects clothed with a stony, niter-bearing crust.

- A (left): an upright stem or reed-like stalk encased in a thick, ringed stony sheath.
- B (center): a more open, branching plant — herbage or broom — coated with a crust along each frond.
- C (right): a slighter, feathery shoot with a thinner incrustation.

Canon III.

[Margin: The petrifying juice from niter and sulphur makes the very hardest stone.]

Whenever water of any kind whatever — especially within the hollows of mountains — comes together with niter and sulphur and the shavings of stony, salt-laden rock, then a stone-making juice is mixed, which will convert whatever it envelops into the dense substance of stone. For the salt opens the pores of the substance, the niter fills them, and the sulphur — once all moisture has been driven off by its own heat — will transmute the whole into a substance of iron-like hardness. A sign of this is that when such stones are struck with iron, they give off a ringing that rivals and resembles that of metal. [Margin: Sulphur cooked together with niter is converted into stone.] There is also this experiment of it: if you cook sulphur together with niter, you will find the whole pass over into a stony substance.

Canon IV.

[Margin: The petrifying juice from pyrite and vitriol-bearing clods, what it produces.]

But whenever, in the underground reservoirs of water, the concreted juices — such as pyrite, misy, sorry, melanteria, or chalcitis — have blossomed forth, or have crossed through rocks impregnated with vitriol, and then are perfectly and most minutely mixed together out of the shavings of the rock or clod (which serve as a kind of vessel in which the said juices are contained), then a certain petrifying juice will be born. When this juice is mingled with rocks and clods of another species, it converts them into precious stone, varied according to the proportion of the tincture. And if a petrifying juice of this kind is raised up by the heat of subterranean fire, it is driven through the inmost crevices of the mountains and rocks; and wherever it finds a properly disposed matrix — or if it is a most limpid liquor — it will at once, according to the tincture and the proportion of a more exact mixture, harden into a transparent precious stone: into crystal, beryl, amethyst, topaz, diamond, and the like, now harder, now less hard according to the quantity of salt and alum joined to it, with the cold of the place contributing. [Margin: Where gems come from.] Together with these, great endowments arising from the nature of the salt-juices are imparted and conferred upon them. So here you have the genuine origin of gems, which we also treated above, comprehended in this canon.

Canon V.

[Margin: The petrifying juice variously gives rise to marbles, how it does so.]

But whenever the petrifying juice has been mixed out of the various species of niter, alum, vitriol, and the other salts, and out of the diverse shavings of mineral

clods — the said salts having been eaten away by their own pungency — in the inmost bowels of the earth, then by the heat of subterranean fire the juice is resolved into a vapor; and wandering through the fissures and channels of the rocky substructures, wherever it finds a fitting matrix, there it will form either variegated marble (from the manifold tincture in which it is rich) or the various kinds of jasper. And whatever it envelops — the little plants of mossy material nearby — it will likewise coagulate together with the rock; whence so many little herbs and shreds of moss are everywhere to be seen within the stones.

And from these five canons, once well understood, the curious reader will easily grasp the whole rationale of λιθογένεσις [Greek: lithogénesis, "stone-generation," the formation of stone], and will have set out clearly the manner and the rationale of λιθομεταμόρφωσις [Greek: lithometamórhōsis, "stone-transformation"] — that is, of those things which are converted into stone — so that, given any case whatever of stone-formation [casus lithomorphoticus], he may at once be able to assign its cause. Now nothing further remains except that we append a kind of historical account of all those things which, to such great wonder of men, are seen to have been converted into stone.

with the shavings of the rock having been rubbed off, it will generate the very hardest and altogether adamantine stone. Of this kind are certain pieces of wood converted into stone, which — on account of their extreme hardness, as Agricola [Georgius Agricola] testifies — people use in place of a whetstone, and which, at any more vigorous rubbing, send out fiery sparks from themselves and are therefore most suitable for tinder-boxes. Indeed, in Germany such stones are found that smiths, as Agricola testifies, use in place of an anvil.

[Margin: How wood is converted into the very hardest stone.]

Now since, from the mixture of such waters with concreted juices and the various species of salts, they make different stone-making juices, so too it is necessary that, according to the variety of the juices, various species of stone arise, differing in nature and property in the things converted into stone. By means of several canons we shall set out each case individually.

Canon I.

[Margin: Waters not petrifiable produce nothing in stone.]

Whenever water — whether by rain, or by a river, or through sandy materials — passes through rocks not at all stocked with any supply of concreted juices and salts, that water too will convert nothing into stone, because of the deficiency of

the petrifying faculty. So it happens in the most limpid springheads, which, since they lack every heterogeneous admixture, likewise leave no trace of any stony concretion, neither on their shores nor in the crevices of the caves.

Canon II.

Whenever rainwater, or water dissolved from snow, passing through the crevices and fissures of the mountains, insinuates itself into rocks stocked with niter — or some river whose banks have been filled with niter-bearing material — then the water will mix the niter-bearing material, either with its smallest particles only, or perfectly, or but confusedly, by way of the shavings. If the former, then a smooth, polished, and slick stone will be born, and the waters will also convert into the same stony material whatever they envelop with their flow. But if the latter, then from the dripping of waters within the caverns of the mountains there will be born a rough, jagged, and unpolished stone, which rises up now into the shapes of hanging icicles [stalactites], now into pyramids and columns by successive increase; and this too likewise transmutes whatever it envelops into a stone like itself, the stone from which it flowed. And such are all those monstrous shapes of things which we behold with wonder, converted into stone in caves of this kind. [Margin: How the juice and the stone-making liquid are converted in the rocks.] But if the water of a river or lake has been imbued with this niter-bearing power, then herbs and plants, having drawn in the stone-forming juice, will remain soft so long as they stand within the water, with the moisture impeding [the process]; but once they have been pulled up and cast onto the shore, then the petrifying juice drawn into them — by the heat and dryness of the surrounding [air] resolving the moisture — within a short time turns them either wholly into stone, if the niter-bearing particles cling to the stony shavings...

Cap. II.

Observations of various things converted into stones.

I shall not speak in this place of the innumerable oysters, shells, clams, conchs, mushrooms [sea-fungi], seaweeds, and the rest of the sea's furniture converted into stone, since these are so commonly met with everywhere that they hardly deserve to be mentioned. For since these — on account of their innate saltiness — have a nearness to stone, so likewise, easily exposed to the air and the shore, they turn to stone once their moisture has been consumed. But, lest I dwell on these, I shall bring forward here only those which have some remarkable feature attached, or those which I have either seen myself in the various museums of learned men or read of in trustworthy authors.

Diagram. An engraving in the left column showing a large irregular mass of rock densely packed and encrusted with shells of every kind — bivalves, snails, and conch-like forms heaped together.

Caption (verbatim): *Saxa moles omni conchiliorum genere referta*. [A mass of rock stocked with every kind of shell.]

[Margin: A nest together with its chicks, entwined in the branch of a tree, converted into stone.]

[Margin: The petrified glove of the Emperor Frederick.]

Albertus Magnus [Albertus Magnus], in Book I of his *Mineralia*, tractate 2, chapter 7, relates that something marvelous happened in his own time: namely, that near the city of Lübeck a great branch of a tree was found, in which there was a nest of birds, and in the nest the chicks — all converted into stone. This, however, could not have happened otherwise than that, after the tree, together with the nest and chicks, fell by the force of the winds into petrifying water, it was in time — as is wont to happen with all other things — converted into stone by the stone-engendering spirit [spiritus lithogeneticus]. The same Albertus relates that there is also in Gothia a spring which converts whatever is immersed in it into stone. To prove the truth of this, the Emperor Frederick [Friedrich] sent a sealed glove to that spring; and when, after some days, half of the leather and the seals had been submerged in the spring, that whole half was turned into stone, the remaining half — the leather — staying as it was.

[Margin: Why drops of water of this kind, poured onto the ground, turn to stone, but the ever-flowing stream does not.]

But why do drops of a spring of this kind, poured out upon the earth, soon turn into stone, while the perpetually flowing stream does so least of all? I answer that this happens because drops diffused upon the ground, not being easily dried up by the air — by which the moisture is consumed — coalesce, just as do all things converted into stone; whereas, since the stream exists in perpetual motion, its particles, just as they cannot easily be united, so too can least of all be coagulated.

[Margin: Petrified plants.]

Theophrastus [Theophrastus] reports, in his book *On Stones* [recte: *On Plants*; the text reads *l. de stirp.*], that by the Red Sea, in the Gulf of Heroopolis [in finu Heroo], laurels, olives, and other shoots are everywhere found converted into stone together with their leaves and flowers. [Margin: A petrified human figure.] A stone was also found in the river Sapena which beautifully rendered a human

shape; and such things are to be referred to those which are generated under a like form by petrifying drippings. As for how the idols of the gentiles are sometimes found converted into stone — the cause of this is not hard to track down. Since they had been overflowed by the petrifying juice and clothed as it were with a crust, they exhibited the very form which they had clothed, just as we taught above concerning the artificial fashioning of images by means of drippings. And as for the fact that, as Agricola testifies, other simulacra of this same stamp have been found — such as in human form, or a human head armed with a helmet, and the like — these were produced only by the petrifying juice imbued with a shape similar to the stone or to a clod of earth. [Margin: An image of the Mother of God converted into stone.] To this belongs what Eusebius Nieremberg [Eusebius Nieremberg] relates of an image of the Mother of God turned into stone by nature, shown at Madrid fixed upon a certain stone made by nature; [Margin:...together with a crucifix.] it is likewise displayed in Spain among the nuns of Saint Augustine. He relates the same of a certain crucifix made of stone by nature. [Margin: A marvel in the field of Clavijo in Spain.] Indeed, in the field of Clavijo [Clavijo], not far from Compostela [Santiago de Compostela], cut rocks display the image of Saint James [Divus Iacobus] sculpted and painted by nature. [Margin: The reason.] The reason for this is easily clear from what was said above. For since all those who go to Compostela to venerate the holy places of Saint James provide themselves with images, whether sculpted or painted — which are sold there in great abundance for the devotion of the pilgrims — it could easily come about that, for those dwelling in the neighboring field, with various images dispersed among the rocks, in the course of time, by the petrifying juice together with the neighboring material being arranged, they coalesced into a solid stone (if they were little statues) or into the surface of a rock (if they were images), in the manner we described above.

[Margin: A spiral stone, in whose center is depicted an image of the Mother of God.]

This too is worthy of wonder: that in the year 1659, in Switzerland [Helvetia], within a mountain commonly called *Gottes Wald*, a stone was found coiled into spirals, in whose center the figure of the Mother of God appeared — not without the astonishment of the onlookers — which the most illustrious and noble Lord von Sonnenberg [de Sonnenberg] also published in print, together with a historical account. We set down the figure that follows, and meanwhile those things which exhale something divine. Indeed, there is scarcely anything — whether of plants, or of fruits, fish, shells...

Diagram. A large engraving filling the upper half of the page: an oval, almond-shaped (mandorla) frame radiating long pointed sun-rays outward in two concentric rings, with, at its center, a crowned figure of the Virgin Mary holding the crowned Christ Child (both with haloes), standing upon a base. Above, clouds. This depicts the spiral/figured stone discovered in 1659.

Caption (verbatim): *Anno 1659. Typus in medio saxi inventus, in Helvetia, quae etiamnum hodie in Ecclesia vulgo Gottes Vald, prope Lucernam spectatur.* [In the year 1659. A figure found in the middle of a stone, in Switzerland, which even today is to be seen in the church commonly called Gottes Wald, near Lucerne.]

Diagram. An engraving showing an open rectangular stone box or slab, viewed in perspective, within which lies a human skeleton turned to stone — skull, ribcage, limbs, and bones embedded in and emerging from the rock matrix.

Caption (verbatim): *Skeleton humani corporis in saxum conversum, ex Palatio Pinciano Principis Ludovisi.* [The skeleton of a human body converted into stone, from the Pincian Palace of Prince Ludovisi.]

[Margin: Into stone are converted almost all things.]

of other things, or of living creatures, that we do not observe converted into stone in various museums: dates, nuts, plums, olives, apples, pears, mushrooms, fruits of every kind — indeed, cheese and bread. Here too at Rome, in the palace of the Ludovisi Garden [Horti Ludovisiani], is seen a human body wholly...

so that, accordingly, it is established that stones are found in all animals and in their parts. Schenck [Johann Schenck von Grafenberg], indeed, in his *Observations* reported that they occur not only in a single part of the human body but in every member of it. One of our own Society, Father Bartholomaeus Conventinus, master of philosophy, gave proof of this: after his sudden death his internal organs were opened in my presence, and Joannes Trulla, a most celebrated surgeon, found in the artery near the *vena cava* various small stones, or tartareous matter, which, since they obstructed the artery, impeded the motion of the blood; and so, the vital channels being thus shut off, the soul was necessarily driven out by force. But to demonstrate the matter methodically, let me begin from the head.

[Margin: Stone in the human brain.] Rueus and Gesner [Conrad Gessner] affirm, with a remarkable account, that stones are generated in the human brain. When a young man died from eating, after being afflicted by long and dreadful headaches and at last carried off, the body was opened, and in the brain a stone

exactly resembling a mulberry was found — the cause of such great pains and of his death. Schenck, Cornelius Gemma, Mercurialis [Girolamo Mercuriale], and countless others confirm this history.

[Margin: In the mouth.] Langius affirms that small stones are generated in the mouth. While treating a canon of Regensburg [Ratisbon] who was suffering from an abscess of the tonsils, once the abscess had been softened and a violent cough had supervened, the canon, he relates, at last coughed up a gypseous stone; and he says that in a certain other case entrusted to his care he found a stone under the tongue.

[Margin: In the kidneys and bladder.] I will not speak here of the stones of the kidneys and of the bladder in both sexes, since these are the genuine microcosmic stone-mines, than which nothing is more common. I will bring forward only one, which I am accustomed to display in my Museum, of unusual size and weighing eleven ounces. It was extracted from the bladder of Father Leo Santius, a man most celebrated for his writings and for the publishing of books, and prefect of higher studies at the Roman College. Although burdened by so great a weight, he passed urine with no impediment whatever, so that in the judgment of the physicians he did not appear to suffer from the stone at all — until after his death it was found hanging within the sides of the bladder, which was the reason why it had not been able to obstruct the bladder's orifice.

But to return to where we digressed: not in the principal members alone — the bladder and kidneys — but also in the heart, liver, lungs, spleen, stomach, intestines, and gallbladder, stones small, middling, and large have been found in vast number, as Gessner and Ambroise Paré [Ambrosius Paraeus] testify. Indeed, that within the female womb the foetus itself has been turned to stone is established by the assertion of most physicians; and Hippocrates (*Epidemics* V) says that a certain woman, long vexed by pain about the womb, at last gave birth to a stone of remarkable roughness, issuing from the mouth of the womb.

[Margin: Foetus in the female womb turned to stone.] [Margin: Another paradox.] Of a stony foetus produced not within the womb but among the ribs, in the preceding year, in Germany, the matter is established in a pamphlet already published. In the knees, feet, hands, ulcers, and the other subcutaneous parts, and indeed in the very veins, small stones are engendered.

[Margin: In the outer members.] Laurentius [André du Laurens] reports, in his *Anatomy*, that stones have been engendered in these outer parts. But having recited those stones which cited authors attest to be born in the members of the

human body, let us now show that, by like reasoning, these are also found in the remaining parts of living creatures.

Lapides in partibus animalium reperiri soliti — [Margin: Stones in animals.] Stones commonly found in the parts of animals are reported to be, for the most part, of great virtue, such as: the *alectorius* of barnyard cocks; the *chelidonium* of swallows, from which they earned their name; the Indian *mergus* [diver-bird] produces a stone highly esteemed by the barbarians; Albertus [Magnus], in his book *On Stones*, says that in the brain of the vulture a stone named *Quandrium* is found, infamous under the name of superstition. I do not speak here of the small stones found in the stomach of hens and ducks (for I say that these are not born there but swallowed), but rather of those that are born in the brain and in the other impervious parts.

In four-footed animals — horses, oxen, sheep, goats, stags — stones of great virtue are found, as Albertus, Cardano [Cardanus], and Agricola report. In my Museum there is a ball, not indeed stony, but concreted from countless fibers of herbs, found in the stomach of an ox; and Anselmus Boetius [Anselm Boece de Boodt] teaches that one is found in its gall as well. The same authors cited above record that pigs too are troubled by stones of the kidneys and bladder.

[Margin: Stone from the porcupine.] From the Indies are brought stones of great value extracted from the bristle-bearing pig, that is, the porcupine — a fine remedy for driving off fevers. Lodovico Dolce [Ludovicus Dulcis] relates that a stone is extracted from the wild ass, or onager, and accordingly marked with the name "asinine." The animals called *zybethi* [civets] also produce a stone, or rather a fluid, which, hardened into a tear-drop, yields a precious scent that they call *zibethum* [civet]. The stone extracted from the goat-stags of Persia and India, which is commonly called *bezoar*, can be counted among these — but of that elsewhere.

Nothing is almost more common than that stones are extracted from serpents. The river-snake [*coluber fluviatilis*], on the testimony of Hollerius [Jacques Houllier], is said to belch up a stone that cures epilepsy [a stone marked with roughness, [?]] from the mouth of the womb [?]. The Indians and the Ethiopians seem to hold nothing dearer than the stones extracted from the heads of great serpents, which they call dragons.

[Margin: Serpentine stones.] Most well known is the stone which they call, from the toad [*bufo*], the *bufonites*, and from the Greek βάτραχος [Greek: batrachos, "frog"] the *batrachites*, found in its brain. It also has this feature, worthy of

admiration: that it usually marks itself with its own figure and likeness, of the kind that the figure here appended shows. The reason for this we have explained above.

Diagram. A small uncaptioned woodcut showing the *bufonites* (toad-stone): an irregular oval stone with an uneven, lobed border, within which is impressed the figure of a toad or frog shown in profile, oriented to the left. No labels.

[Margin: Toad-stone.]

we showed that it arises from the spermatic faculty of the animal; and Albertus testifies that in his own day he saw a similar stone marked with the figure of a toad. Cesalpino [Andrea Cesalpinus] also says that toad-stones are sometimes found on which the figure of the red toad [*rubeta*] is impressed; the reason for which we will assign elsewhere in what follows.

Moreover, fishermen have found by experience that among the other living creatures — especially the aquatic ones, and those that frequent damp and marshy places — stones abound, as in the heads of the *aselli* [hakes], carp, pike, *cinaedi* [?], perch, and *tiburones* [sharks], and indeed in river-lobsters [crayfish]. All of these have been found, by some hidden consent of nature, to help in driving off the stone.

[Margin: In the heads of fish.] I will not speak here of the stones born within the various kinds of crustaceans, mollusks, and bloodless creatures, nor of the pearl-bearing shells, which, since they have a greater disposition toward stony matter, accordingly are found in them in greater number; nor of the tortoises and snails, from which they are called *cochlites* (from the snails) and *chelonites* (from the tortoises). But let this suffice to demonstrate that stones are born in every kind of living creature. How nature forms them, it now remains to be said.

DISQUISITIO

λιθογενεσίας in Lapidibus

[Greek: λιθογενεσίας (lithogenesis, "of stone-generation" — the genesis of stones)] — An Inquiry into Stones.

We said above that nature proceeds everywhere by an equal step in converting any objects whatever into stone; but by what virtue it accomplishes this is the thing to be investigated. We say, therefore, that the matter from which the stone is produced in animals is a superfluous humor separated from the nourishment, which consists of simple water and earthy matter. This matter varies according to

the nature of the nourishment: for it is either thick and hard to liquefy, or thin and easily liquefied. The thick kind, like mud, is resolved by nature out of the earthy portions of the nourishment into the smallest particles; the liquefiable kind is, like common salt, transparent and dissolves in water, which afterward, according to the various differences of salts, turns out manifold again.

Such a humor, therefore, gradually degenerating from earth, water, and salt into a tartareous or nitrous substance — while it is not expelled through the channels appointed for that purpose, and while it lingers in the viscera — produces obstructions, from which various diseases result. And when the watery moisture withdraws from it, either wholly or in part, then it is converted into stone. For that earth is resolved into the smallest particles on account of the salt remaining in it, which is coagulated to it because of its innate property — unless it is diluted by a great quantity of humor. Hence, in order for a stone to be generated, it is not necessary that all the humor withdraw; it suffices that the greater part of it evaporate.

This salt, however, together with the earthy matter, is not generated *in* a man, nor in any other animal, but flows in from the nourishment. For it first resides in the nourishment, since salt is by nature a balsam; afterward it clings to the humor that arises from the nourishment; then it is mixed with the blood, bile, and phlegm. When it has become superfluous, separated by the strong excretory faculty, the juice becomes stone-producing, and at last, according to the variety of the members in which it has been received, it is coagulated into stone. Hence those who generate much salt, niter, or tartar, from a like quality of their foods, are more exposed than others to the generating of stones; for the spirit of salt, when it finds tartareous matter in the human body, soon fixes it into stone. Hence many who have been freed of their stones by surgery at last conceive them again — in much the same way that emptied stone-quarries in time conceive new broods of stones.

For the generation of stones in living creatures there concur, first, the weakness of the expelling faculty, and also an abundance of earthy and saline matter diluted in the moist. For these two, joined by the benefit of the moist, are easily glued together and generate a matter not unlike tartar, which, joined to the salt, consolidates the stone more and more — in proportion to the quantity of the nitrous salt — making it more or less hard or soft.

COROLLARIUM

From these things it is plain that in all stone-producing animals there is a certain definite disposition and proportion of the humors — now lodging in this member, now in that — from which, by the saline quality (as we said above concerning precious stones), a stone is born, of this or that quality and virtue, according to the virtue of the coagulating agent that produces the stone.

EXPERIMENTUM

[Margin: Generation of a stone in the bladder — an experiment.] In a vessel of the kind in which urine is usually collected, let a horsehair, or something similar, be placed, so that it rises from the bottom up to the surface; and leave it thus exposed to the urine. You will see that the saline-nitrous corpuscles present in the urine immediately adhere to this hair, and gradually grow into a large crust — not indeed a stony one, but a friable matter like lime — which, however, you will find soon hardens once removed into the air. And by this experiment I learned how stone or calculus grows in the bladder. For if viscous matter, strained through the ureters, settles in the bladder, it is glued either to its sides or, remaining in the middle, gradually attracts to itself the saline-nitrous corpuscles, which, by the perpetual influx of matter, will at last so increase it that from it grows a certain soft and sandy mass. For if the matter fluctuates back and forth within the bladder, it, by obstructing the bladder's channels, will cause those pains that the stone-afflicted feel. Hence, unless it is removed by a syringe, it will take away all faculty of urinating; but if it has been glued to the sides by its viscosity...

[The text here continues onto Fol. 53, which resumes:]...the matter grows for the most part into an enormous mass, and these indeed have the faculty of urinating, but from the weight of the hanging stone, which continually plucks at the nerves of the bladder, they afflict the sick man with intolerable pain. Again, either the stone is smooth, formed from the purer parts of the salt, and in this way does not cause those torments; or, if it has been compacted from particles concreted with nitrous salts particle by particle, then by its roughness and harshness — besides wounding the bladder — it will also bring forth great pains from its prickings, together with a discharge of blood with the urine. Here you have the genuine genesis of the stone in the bladder.

In the kidneys, however, since these are microcosmic strainers, by which the pure parts of the serum are separated from the impure, it comes about that, the moisture being gradually consumed by heat, the saline-nitrous parts flow

together and at last concrete either into a stone or into a sandy mass, according to the greater or lesser quantity of dryness. The same is to be understood of the other excrescent members; since nature, in each and every member, generates from the nourishment a stone-producing juice suited to stone in whatever member it may be, in exactly the manner we described in the generation of natural stones. But let these things be said in passing [Greek: παρέργως (parergōs, "by the way, incidentally")].

[Resuming the lower portion of Fol. 50, where the corpus-humanum petrification narrative and Caput III opening appear:]

turned to stone, with the bones still intact, but overlaid with a stony rind. All these things, as I said, happen in this way in watery places abounding in petrifying juice, or in those places where a vapor of petrifying power, full of nitrous corpuscles, exhales copiously from the subterranean passages. When these have entered the pores of any body whatever, then, packed close together there, and the moisture lodging in them being expelled, at last they are converted into stone according to the Canons set forth above. So great is the force of this that not only the roots of trees and plants, but also the parts of animals — such as the callused hooves of horses in the Reatine country [Rieti], on Pliny's testimony — are hardened into a stony rigidity.

[Margin: A human body turned to stone.] [Margin: Horses' hooves hardened into stone.]...so that, accordingly, the hoof is packed into a stony hardness and therefore has no need of iron shoes. But since we have treated of these things at length elsewhere, in the first Volume, I shall delay no longer. I will add only this, by way of a finishing flourish: a dreadful history which happened in our own times in a village called Cucu in interior Africa, which in our own times was wholly turned to stone by a certain astonishing metamorphosis — together with its men, animals, trees, household furniture, grain, and food.

[Margin: A remarkable history of an African town turned to stone together with its inhabitants and animals.] Since the matter was found to be true on the testimony of most weighty and trustworthy men — and all the Arabs of those regions whom I consulted on the matter confessed that it was so — I have thought it right to set down here the whole series of the affair, exactly as Habelus, Vice-Chancellor of the Order of the Knights of Jerusalem, described it to me from Malta:

Victoria, formerly called Calsurakie, of swarthy complexion, captured together with six hundred other Ethiopians distributed among five cargo-ships sent from Tripoli

of Barbary to Constantinople and destined for the slave-block, fell as a captive to our triremes under a happy auspice. Through our Lord General Baglivi [?], she was today cleansed at the sacred font of Carlo Valdina, and now serves the Archdeacon Lord Eugenio Testaferrata on the island of Malta, where she landed in the year 1634, being about ten years of age. She says she was born in the city of Cucu in the province of Tongil, and that at the age of five she learned from her maternal aunt, who lived in the village of Biegioda — to which her parents had taken her — that the village of Biedoblo, an equal distance from the aforesaid places, in the summer season, in the dead of night, together with its inhabitants, animals, trees, and all its grain — amid crashing

- thunderclaps from the upper air, not without frequent shaking of the soil, in a moment stiffened into the hardest stone. Her parents and elder brother, roused by the messengers of this extraordinary event, mounted on two horses and a camel, and taking their daughter with them, made straight for Biedoblo on a journey of three hours from Biegioda, and saw with their own eyes by what manner of fate men and beasts had retained the same posture and bearing in which the divine justice had caught the guilty for punishment. For that kind of men was not free of unspeakable crimes — they were not Ethiopians, but Arabs, who, accustomed to roaming those vast regions, had chosen Biedoblo for their seat, with huts and shacks hastily built of mud, wood, and wicker, the richness of the soil inviting them; and there grew, not as elsewhere single ears from one stalk, but on every side equally from the lowest part up to the top very many, and of the length of a single man, and quite full of grains, vying with a pomegranate in fertility.*

When an innumerable multitude of men flocked there day by day, the Regulus [petty king] of the city of Cucu, after he had come as an eyewitness inspector, forbade by edict that anyone should presume to approach further without the prior leave of the King. All things narrated up to this point she both saw with her own eyes and heard with her own ears from the gentiles — the above-praised Victoria — over the whole year during which she afterward stayed in Cucu, until she was captured, while at play with her companions on the shore, by other Ethiopians, and sold in the city of Borna, a journey of four months distant. From Borna she was led with a great band of slaves into the royal city, and finally sold off to Tripoli, and from there sent on to Constantinople, where she fell happily into the hands of merchants among the faithful of Christ.

In Tartary, indeed, in the desert of Great Horda, geographers report that an entire horde of men and animals turned to stone is still to be seen; and if these things are true, I would certainly judge them to be the effect not so much of Nature as of a higher Cause — as the relation about the African village teaches, and as Holy Scripture clearly shows concerning the statue of Lot's wife.

[Margin: A horde turned to stone in Tartary.] Whoever desires more of this kind, let him consult Gessner, Agricola, Rueus, and Fallopius [Gabriele Falloppio]. But let what has now been said about the marvels of petrified things suffice. So, on to other matters.

CAPUT III.

De Lapidibus in diversis animalium membris enasci solitis

On the stones that commonly arise in the various members of animals.

Nature, always and everywhere, the matter being already disposed, does the same thing. For just as in the subterranean realm, or on the outer surface of the earth, it produces stones of every kind — partly homogeneous, partly heterogeneous — so too in the grade of vegetative nature (as is plain in the *lithospermum* [gromwell], in corals, and in countless others) it produces the same, as was clear in the preceding chapters. And in the kingdom of sensitive nature, there is neither an animal nor a part of an animal in which the power [Greek: λιθογενετική (lithogenetikē, "stone-generating" — the stone-generating faculty)] does not exercise its office; for wherever it has found a juice proportioned to generating a stone, there it must exercise its virtue.

[Margin: Stones are generated in all things.] This power indeed lies hidden in all those things on which either an animal or a man feeds; and these, afterward taken in as nourishment, when they find a viscid, undigested, and aptly disposed humor, strive to coagulate it into stone by the faculty innate within them...

CAPUT IV.

De ossium & cornuum subterraneorum genesi

On the genesis of subterranean bones and horns.

There are found here and there in the subterranean realm — whether in caves, or in pits — bones of every kind: teeth, shin-bones, ribs of enormous size, which many say are the bones of Giants; horns too of incredible length, which they say

belong to unicorns [*monocerotes*]. Let us set forth in few words what is to be thought of these fossils, and first concerning the bones of Giants.

§. I.

De ossibus Gigantum subterraneis

On the subterranean bones of Giants.

Bones of manifold kind are sometimes found in the subterranean passages, as also in the ancient crypts of tombs; and of these, indeed, the shin-bones of enormous size, and the bones of certain members resembling the human, they call the bones of Giants. And as for what concerns the Giants — since the sacred text contradicts us, just as we cannot deny them, so too something must be granted to common report, which the various accounts of authors concerning Giants extort, as if by their own right, from those who read them and believe.

And first I grant that in some monuments skeletons of unusual size are found — just as Fazellus [Tommaso Fazello] and Qualquarnera [?] write were found in Sicily; and the most excellent and most learned Carlo Calà [Carolus Kalà], Duke of Diano and prefect of the Royal Chamber in the Kingdom of Naples, describes in his book *On the Life of Blessed Giovanni Calà*, folio 202, that they were found in the caves of Calabria near the city of Cosenza [Confentinam]. The truth of this matter, inasmuch as it is confirmed by the testimony of the Viceroy, and is established by the most ample testimony of Father Luca Mandelli [Lucas Mandellus] of the Order of Saint Augustine in the following letter sent to me, I gladly acknowledge. The letter follows.

[Margin: Giants' bones found in the Cosenza district.] *The opening of a Giant's tomb in this city in these years manifestly demonstrates that they were here. For I received [word] that this tomb was found in a certain garden adjacent to the Church of Saint Peter, and near the walls of this city, from which*

- a great many bones of unusual size were dug up, and stored away in the same place. We were hearing these things in wonder, when by chance a man of honorable condition, advanced in age, a surgeon by profession, passed by us. Then Rugius [?] said: "Here, opportunely, is an eyewitness, to whom credit is not to be denied." We asked the man, therefore, to inform us of the sequence of this affair; and he, nodding to us out of his innate candor, began thus:*

"It happened a few years ago that, returning rather late one day from the countryside, I found the city gates shut, and so I was compelled to pass the night

with a gardener known to me. This man, being most devoted to me, told me that whenever he tilled the earth in a certain part of the garden, he perceived a subterranean sound — an unmistakable sign of hollowness beneath. To him I said (for sleep had fled me), 'Why not let us go down, and search out whether anything is hidden there?' Without delay, suitable instruments having been seized and the servant-boys roused, we went to the place; and with not much earth dug away, we found a subterranean structure, and this being somewhat broken open, we beheld a vaulted edifice. Searching it through, we found nothing but rubble — except bones, those of a human corpse indeed, but of such length and size that it was plain they had been a Giant's. From here, digging out another chamber (for there were several, connected to one another), we dug up nothing but bones of this kind — shins, that is, legs, arms, and ribs of the same bulk. At last, catching sight of something round, not unlike a large apothecaries' scale-pan, and striving with all my strength to break it loose with a two-pronged mattock, I noticed that it was the top of the skull of that same corpse. Whereupon, being thus taught that we had stumbled upon a Giant's tomb, we placed the bones back in the same spot, threw the earth back to level with the ground, and departed satisfied."

[Margin: A Giant's tomb.] *Hearing these things, it was asked among us: of what Giant were these ashes, and to what times could they be referred? Then I [said]: as far as one may conjecture from the histories, with the place of the tomb added, I would believe that these were of Marducchus the Salernitan, formerly a Giant. For we read in the Book of the Deeds Bravely Done by Giovanni Calà of Hedua [?], printed 1509, the author being Joannes Bonatius, from the relation of Martinus Schener the Englishman... ..the Englishman [Angli,], a disciple of this same Joannes Calà — that during the siege of the city of Salerno by the army of the Emperor Henry VI, there lived there a man of monstrous stature whom they called Marducchus, or the Salernitan Giant. When this man heard the report of Joannes's bravery, he challenged him to single combat, in which he was killed by Joannes himself, and seems to have been buried on this very spot afterward.*

On giant bones of this kind various authors offer various accounts. The reader may consult them all in Goropius [Goropius Becanus] and in the commentators on Sacred Scripture, where they treat of the giants (*Genesis* ch. 7 [recte: ch. 6]) and of the giants Og and Goliath — accounts I have thought it superfluous to repeat here.

Pliny [the Elder] asserts (*Natural History*) that in Crete, when a mountain was split open, a standing body of forty-six cubits was found. Fulgosus [Battista Fregoso] says it was thirty-three cubits; some judge it to have been the body of

Orion, others of Otus. The body of Orestes, dug up at the command of an oracle, is held by ancient records to have been seven cubits. The annals do not record the height of Naevius Pollio, but because he was nearly killed in a crush of the crowd he was regarded as a kind of prodigy. Our own age, in the reign of the deified Claudius, saw a most lofty man named Gabbara, brought from Arabia, who was nine feet and as many inches tall. Under the deified Augustus there were two who were a half-foot taller; their bodies were preserved, for the sake of the marvel, in the vault of the Sallustian Gardens. Their names were Pusio and Secundilla.

Dalechampius [Jacques Daléchamps], in his notes on Pliny, asserts that in the bed of the river Orontes a corpse was found of eleven cubits and more. Caelius Rhodiginus [Lodovico Ricchieri] says that in the territory of Valence among the Allobroges, in the torrent that waters the village of Saint-Péray [pagum Divi Peratii], in the reign of Louis XI of France, the corpse of a giant was dug up, of astonishing and unusual size — one which, as is gathered from various pictures and from the bones themselves, would have approached eighteen feet. On the testimony of Pausanias, in the corpse of Ajax the kneecap was the size of the discus used by competitors in the pentathlon. And Asterius records that the corpse of the son of Anactus was ten cubits in length. Plutarch says the body of Theseus was of unusual size.

"Recently," says Licetus [Fortunio Liceti], "at Julia Caesarea in Africa a skull was dug up twelve handbreadths [spithama] in circumference, on the authority of Magius; [Margin: A skull-cap of 12 handbreadths.] but after the victory that he won under King Louis at Laudum Pompeiam [Lodi], having gone on to Milan, he came upon in the youths' hospital one of such tallness that he could not stand: for it had not been possible, from a sufficient maturity of nourishment, to supply the corresponding thickness, strength, and proportion; and so he lay there and filled two joined beds. In him one must not blame nature simply, but the unhealthy and feeble temperament and constitution of this single individual — or, if you like, his particular nature." The deified Augustine [Augustine of Hippo] says: "But concerning the great size of bodies, the tombs, laid bare for the most part by age, or by the force of rivers, or by various accidents, refute the incredulous, wherever there have appeared, or whence there have fallen, bones of the dead of incredible size. I myself saw — and not I alone, but several with me — on the shore at Utica a man's molar tooth so huge that, had it been cut up into small pieces of the size of our own teeth, it seemed to me it could have made a hundred of them. But that one I would believe to have belonged to some giant; for besides the fact that the bodies of men of old were much larger than our bodies now, the giants of that time far surpassed all others, just as afterward, and in our own

times, there have been some — rare indeed, but scarcely ever wholly lacking — who exceeded the measure of others by a great deal." [Margin: The tooth of St Christopher.] Vives [Juan Luis Vives], in his commentary on this passage, adds to this effect: "On the feast of St Christopher, when we had gone to greet him at the greatest church of our city, there was shown to us a tooth bigger than a fist, which they said was his. Hieronymus Burgarinus was there with me." Faleotus [Faleotti] likewise affirms, in his work on Plutarch and Strabo, that at Tangier, a city of Mauretania, a tomb was opened by Sertorius in which a human body was found that measured out sixty cubits — and it was thought to have been Antaeus's. [Margin: A skeleton of 60 cubits.]

"In the reign of Charles VII," adds Fulgosus, "king of the French, in the mountainous part of Gallia Narbonensis near the city of Valence, the Rhône uncovered a tomb whose great size drew very many people to view it; for when the mound was opened there were found in it the bones of a man whose measurement filled thirty feet, and as we ourselves were making a journey in that direction, we saw the tomb and some part of the bones, which is kept by the inhabitants as a marvel." Boccaccio [Giovanni Boccaccio], in his *Genealogy of the Gods* [*Genealogia Deorum*], writes: "But that there were indeed giants — that is, men exceeding all others beyond measure in form or stature — is not at all a fiction; indeed it stands as most certain, and a chance event clearly demonstrated it in these recent days near Drepanum [Trapani], a town of Sicily. For when some peasants, at the roots of the mountain that overlooks Drepanum, not far from the town, were digging foundations for the building of a shepherd's hut, the entrance of a certain cavern appeared. Having seen it, they entered it eagerly with lit torches to discover what was inside, and found a cave of the utmost height and breadth, through which, as they walked, they saw on the opposite side a man of enormous size sitting down. Terrified at this, they at once took to flight, fled the cave, and did not stop running until they had reached the town, telling those they met what they had seen. The townsfolk, marveling and wishing to see what evil this might be, with torches lit and weapons taken up, went out from the city all together as though against an enemy; and more than three hundred of them entered the cavern, [Margin: An enormous skeleton found near Drepanum, 200 cubits.] and saw something no less than what the first stunned witnesses had reported. Drawing nearer, after they knew that the man was not alive, they saw a certain figure sitting on a seat, leaning his left hand on a staff of such height and thickness that it would surpass the mast of any very large ship: a man of unseen and unheard-of size, in no part decayed or diminished. And when one of them, reaching out his hand, touched the standing mast, at once the mast collapsed into ash, and there remained, stripped truly bare, the other staff, of lead, rising to the

very hand of the seated figure; and, as they were able to perceive well enough..." ...the lead was being added to increase its weight, an apple stuffed inside, which those who weighed it assert it could be — those who saw it report it to have been fifteen *cantaria* [hundredweights] of Drepanum, each of which is a hundred common pounds. Finally, when the body, touched, likewise collapsed into dust — and Aristotle too knew of this, when he says somewhere that the bodies of the long-dead, which suddenly become ash in their tombs, have lost all their substance and retained only their shape. [The author here returns to the marvelous-strength anecdote:] Twelve porters, six on each side, with all their effort were dragging the opposite way against this man; yet, drawing his arms gradually to his chest against their will and resistance, he stood motionless and drew them, and, unperturbed, ate the apples he was holding in his hands over a notable span of time, mocking the sweating porters and those who tried in vain to wrench his hands from his mouth.

[Margin: A marvel of the giant's strength.] [Above, Kircher had cited:] As Fortunio Liceti relates in his book *On the Spontaneous Origin of Things* [*De spontaneo rerum ortu*], he saw at Venice a Lusitanian [Portuguese] giant of vast size, so robust that, when ropes were tied to each arm — which twelve porters, six on each side, dragged the opposite way — he drew them in.

When some men were handling the corpse of the Drepanum giant, three teeth still solid were found, of monstrous size; and they were of the weight of three *rotuli*, that is, a hundred common ounces. The people of Drepanum, in testimony of the giant they had discovered and as an everlasting memorial to posterity, bound these teeth with an iron wire and hung them up in a certain church of the city built in honor of the Annunciation of the Virgin and marked with that same title.

Moreover — that there were giants of vast size — the skeleton which is exhibited to be viewed, to this very day, in the town hall [Praetorium] of Lucerne among the Helvetians [Swiss], abundantly proves; concerning which Cysatus [Renward Cysat] treats at length in his work on the four chief cities of Etruria; and the matter, as it occurred, is even now recorded in the said council chamber [Margin: A skeleton of a giant in the town hall of Lucerne is on view.] in these words:

A delineation of a giant's skeleton, of which some portions of the bones — such as of the thigh, the shin, the shoulder-blades, the vertebrae, the sacrum, the coccyx, the navicular bone, a rib, fragments of the skull, also the second bone of the thumb and the heel — almost whole (out of which, and as it were from those parts which in men are formed otherwise than in the rest of the animals, these bones of a human

body were judged to have been, the evidence being drawn chiefly from this) were found in the territory of Lucerne in Helvetia, near the village of Reyden, an ancient oak having been thrown down, beneath which they were discovered. They were sent to the Senate of Lucerne; and, in order to bring the dimensions of the giant to completion, the remaining bones of the whole skeleton — those which were missing or were not intact — were delineated by Felix Plater [Felix Platter], ordinary physician of Basel, in imitation of the true skeleton, and were painted by Joannes Bock, a painter of Basel; and they were presented to the most illustrious Senate of Lucerne in the year 1584.

This skeleton was found in the year 1577, in the county of Willisau, within the jurisdiction of Lucerne, beneath an aged oak, as the inscription [epigraphe] records. Cysatus, on Plater's judgment, from the proportion of the limbs, states the height of this giant to have been forty-two times greater than the line written below.

[Margin: Beatus [Beatus Rhenanus?] — Odoricus of Udine [Odoric of Pordenone].] Beatus — Odoricus Utinensis [Odoric of Pordenone], in the second account of his journey to the Indies, testifies that he saw, at the court of the Great Khan [Magnus Cham], a giant twenty feet tall. [Margin: A giant at the court of the Great Khan.] Johannes and Olaus Magnus [Johannes Magnus and Olaus Magnus], archbishops of Uppsala, in their History of the Northern Kingdoms, especially celebrate among others Rollo and Starchater as giants of most lofty stature and most robust strength. [Margin: Olaus Magnus, on giants.] Joannes Cossaeus, a man remarkable for the highest probity and learning — as Fortunio Liceti relates in his book *On the Spontaneous Origin of Things* — [the text here resumes on the recto, Fol. 55].

[Margin: A line below.] *This line, taken forty-two times, equals the height of the giant preserved at Lucerne.*

[Fol. 55, lower columns]

But when he lived, or whence he came into these regions, has never become known to any historian. Certainly from this geometrical reasoning it is clear that this giant was more than three times taller than an ordinary, well-proportioned man — to whose stature architects and sculptors assign at most six palms. There are in my Museum bones petrified into stone [literally, hardened into rock], bequeathed to the Roman College by the most noble Alphonsus Doninus [Alfonso Donini] together with many other things pertaining to antiquity and nature. Whoever sees them, on account of their excessive size, judge them to have been the bones of some giant, since their magnitude — according to the proportion of

the shin-bones and vertebrae that I have observed — certainly yields little to that Helvetian giant.

Wonderful too are the things that Boccaccio and Philippus Bergomas [Jacopo Filippo Foresti of Bergamo] relate concerning the body of Pallas. The matter stands thus: In the time of the Emperor Henry III — that is, in the year 1401 [recte: an apparent error for the era of Henry III; "1401" does not match] — it was found by a certain farmer not far from the city of Rome, while he was...

[continues at Fol. 56]

[Fol. 56]

digging his little field somewhat deeper than usual, that there was a stone tomb adorned with an inscription; and in the tomb the body of a dead man of stature so lofty that it exceeded the walls of the city. The corpse was whole, as if it had been given burial a little while before; in its chest it bore a very broad wound. Above the head of the deceased body there was found a lamp burning with a perpetual fire, which could not be extinguished by any blast of air, nor by the pouring on of water or any other liquid; but, its bottom being pierced and broken, it at once vanished. [Margin: The body of Pallas.] Now this was held to be the body of the great Pallas the Arcadian, son of King Evander, a companion of Aeneas, who was killed long ago in the war and in single combat by Turnus, king of the Rutuli — much earlier, before Rome was founded. All this is confirmed by Volaterranus [Raffaele Maffei of Volterra].

And these are the things which we have thought worth bringing forward concerning the giants and their immense vastness. [Margin: All these things are confirmed by Volaterranus.] It remains, finally, at this point, to show whether men of so prodigious a stature ever existed in the world.

DISQUISITIO PRIMA.

Whether nature has ever truly brought forth men of so monstrous a size as the cited authors report.

That in tombs and subterranean places bones are from time to time found, which bones are said to be those of giants, I do not deny; for, as we noted above, that giants were men of vast body is testified by Sacred Scripture itself, *Genesis* 7 [recte: 6] and 1 Kings [*1 Samuel*] ch. 17. To the Emperor Maximilian [Maximilian I], in the year 1511, on the testimony of Surius [Laurentius Surius], a man of giant

size, born in Poland, was presented, who, in proportion to the size of his body, with food correspondingly...

[lower of facing page, after the figure:]...consumed, at each meal, a calf and a sheep. Similar to him in our own times was the man presented to Ferdinand II, at the Diet of Regensburg [comitia Ratisponensia], in the year 1623; so that on this account I have no doubt at all concerning men of unusual size of either sex, since no age has failed to produce such men.

[Margin (manuscript hand, not part of the printed text): "...discursum /...Barclaij Arge[nis] /...idem pag. 28 et 210" — an early reader's cross-reference, apparently to John Barclay's *Argenis*. [Illegible: cursive annotation partly trimmed at the gutter.]]

Diagram. A full-page engraving showing a comparative scale of giant statures. At the left, dominating the page, stands a colossal bearded nude man wreathed in oak/laurel and girded with a garland of leaves, his right hand resting on a tall club-like staff (a tree-trunk) — the "Giant's Skeleton" of Mount Eryx near Trapani. The engraved caption beside his shoulder reads:

Gygantis Sceleton / *in monte Erice prope Drepanum / inventum Boccatio teste 200 cubitus* ("The Giant's Skeleton, found on Mount Eryx near Drepanum [Trapani], on Boccaccio's testimony, 200 cubits.")

To the lower right, four progressively smaller figures stand on the same ground-line for scale comparison, each captioned:

- (far left, tiny) **Homo Ordinarius** — "Ordinary man" (a minute standing figure).
- (next) **Goliath** — a small bearded figure with a leaf-skirt and wreath.
- (next, larger) **Helvetus Gygaz** — "The Helvetian [Swiss] Giant," a bearded wreathed figure.
- (largest of the four) **Gygaz Mauritaniae** — "The Giant of Mauretania" (the Antaeus figure of Tangier), the tallest of the comparison group.

All four labels and the main caption were read cleanly under magnification; no labels flagged [?].

[Fol. 57]

[Margin: The measure of giants.] But that there have ever been men who exceeded 30, 60, 100, or 200 cubits, I utterly deny. And so that I may prove this by the clearest reasons, I shall first set out what is meant by a cubit, a foot, a palm —

so that, from these known measures, the vastness and incredible size of the giant corpses may become more clearly evident.

A cubit, according to the common estimate of geometers, contains within itself two feet; and a geometric foot contains one Roman palm and a half — which nearly correspond to the sacred cubit. For by these, as the better-known measures, our reckoning concerning giants may be more clearly proven; and anyone may easily apply, in place of them as he sees fit, the measures proper to his own nation.

Goliath, on the testimony of Sacred Scripture, is said to have been of a height of six cubits and a palm; which, converted by the rule of proportion into our feet and palms, the following [table] shows.

	Cubits [Cubiti]	Feet [Pedes]	Palms [Palmi]
Goliath is said to have been tall	6½	13	19
The corpse of the giant found in Helvetia had a height of	9	18	27
The corpse of Orestes, dug up at the oracle's command, on Pliny's testimony	7	14	21
On the same testimony, the corpse of Asterius, son of Anactus	10	20	30
The corpse dug up from a Cretan mountain, on Pliny's testimony	46	92	138
The giant's corpse dug up at Tangier in Mauretania, on the same testimony	60	120	180
And finally, what surpasses all wonder — the one found seated on Mount Eryx near Trapani, on Boccaccio's testimony	200	400	138

And this is the magnitude of the giant corpses, which the cited authors report to have been found, at various times, in different crypts.

[Margin: A natural inquiry concerning the bodies of giants.] The question therefore is whether it is at least plausible that nature could have produced fleshly masses so vast. For my part, just as I would readily tolerate a moderate excess beyond the natural stature of men, so too I can only with difficulty be brought to believe that there were ever men of such great size (whose measurements we have set out here), excepting the first three. [Margin: The reasoning of these statements.] And this I demonstrate by these arguments: Since every material form by itself and by its own nature requires being the form of an organic body proportioned to itself, while an organic body greater and greater to infinity is repugnant to a body of excessive size — surely the conclusion is plainly evident. The reason is that such forms must necessarily be commensurate with their organ, on whose existence, just as they naturally depend for existing, so they depend upon its possibility. Since it cannot come about that an organic body, greater and greater to infinity, should be animated by a soul which has fixed limits set for it by Nature; and this is confirmed by the following argument: For since every animal is a substance and a nature, it cannot be that any substance or nature should be substantially badly and violently constituted. And if a man were constituted in such a mass that, by the weight of his parts and by their natural cohesion being dissolved, his limbs were torn apart by their own weight alone, he would be essentially badly constituted; because the very substantial constitution of a thing, if it had what is due to it, would turn out unfit for its end. For his limbs could not hold together — therefore it cannot come about that the provident Nature of things should produce such a thing. For the feet of such a being could not sustain so great a mass, nor could he exert any forcible action with his arms without a convulsion of the whole. We learn this from the marble colossi here at Rome, whose projecting limbs cannot stand without an added support, but at last are torn off by the weight. And if this is true in marble statues, how much more will it be verified in a human stature of prodigious size? Whoever desires this argument treated more clearly and more fully, let him read the *problema* on the limit of size and strength in animals, by Father Antonio Terillo, a priest of our Society [the Jesuits], published not long ago, where everything is beautifully demonstrated ἀποδεικτικῶς [Greek: apodeiktikōs, "demonstratively," by rigorous proof].

[Margin: Why nature has not willed that certain animals should grow beyond the common order.] Certainly sagacious Nature, just as for all living things, so also for men, in order that they may duly carry out their actions, has fixed a determinate

size of body, so that whatever is beyond it may deservedly seem monstrous. For among quadrupeds she has produced the elephant, the largest of all, which too — that it might be nourished with sufficient fodder — she willed to feed everywhere on the readily available nourishment, not of meats, but of hay, grasses, and leaves. Among birds, as far as we know, she has shown none larger than the eagle, vulture, ostrich, camel-bird [camelus, i.e. the ostrich], and the falcon-griffin [falcogryphis] — and that with the best counsel; for if she had produced birds of greater mass and excessive size, surely no animal would have been safe from such rapacity joined to the velocity of flight. So that this disadvantage to nature might be avoided, she constituted each thing, according to its own kind, under such and such a size suited to its character.

In the sea, however — since she furnished the Ocean, by a great water-bearing nature, with brine, seaweed, and an abundance of fish — she produced the largest of all animals: whales, orcas, and physeters [sperm whales]; to which, however, she gave a very slow motion, lest, by the speed of their swimming, while these immense beasts overturned everything with a kind of tyranny of sight and appetite, they should by their voracity quickly exhaust the whole supply of the ocean's economy. [Margin: Why she gave the largest beasts the fewest offspring.] She added also to the said vast and huge beasts a scarcity of offspring, lest, like the smaller ones, from too greatly multiplied offspring they should bring irremediable harm upon nature. [Margin: Why fish, or whales, are viviparous.] And for this reason she willed the whale to be viviparous, lest, if like other fish they were born from the hatching of eggs...

LIBER VIII ("Λιθογενής"), Sectio II ("De Transformatione")

CAPUT IV — On the genesis of subterranean bones and horns

§. I — Disquisitio Prima: Whether Nature ever truly produced men of such monstrous size

[Continued from the prior folio. The argument that Nature has fixed a determinate size for each kind concludes here.]

lest they should fill [the world] to its detriment. Just as provident Nature has established all things in weight, number, and measure, so too she has refused to let man grow beyond the size we have described — that is, beyond fifteen palms,

or at most eighteen palms. As for the fact that Holy Scripture testifies that Goliath stood six cubits and one palm tall, I take this to have come about by no other cause than the extraordinary providence of God, foreseen from eternity for the manifesting of His people's glory.

For if — as Boccaccio reports of the Drepanitan [Trapani] giant — a man of two hundred cubits, which make four hundred geometric feet, or six hundred palms, had ever existed in the world, he would without doubt have matched the height of any tower whatever. [Margin: The enormous size of the Drepanitan giant, displayed by Boccaccio in fabulous fashion, against the nature of things.] No colossus was ever erected in the world that he would not have surpassed by many parasangs. Let the curious reader draw from this the consequences regarding the dwelling, the nourishment, and the tyranny of such a monster. [Margin: How much harm giants of this kind could inflict.] For what dwelling could hold so vast a bulk? What nourishment could satisfy so vast a gullet? Surely an entire flock of sheep and goats would not have sufficed to feed him for a single day; for one mouthful he would have swallowed an ox, and for one drink he would beyond doubt have drained springs and rivers dry. What covering could fit so great a mass? Certainly no sail of a ship would serve him except as a small kerchief, and fifty such sewn together at once would barely make a garment; a beech or a pine would be no more to him than a slender little staff.

And what animal would have been safe from so monstrous a creature — one of such speed that he could cover in a single stride fifty paces of an ordinary man, who with the blow of a mere fist or heel would have leveled walls and houses however firm and solid, who would have mown down whole armies just as a reaper cuts hay — and countless other things besides, which I leave to the curious reader to work out by proportional reasoning, as also for the other giants whose vastness we displayed in the preceding table. [Margin: Fabulous narrative of the poets concerning giants of enormous size, set forth by profane authors.] But so that the reader may view the matter more closely, I have thought it right to append here a figure, from which you may learn the proportion of ordinary men to the magnitude of the aforesaid giants.

Therefore whatever is reported about giants of such prodigious size is fable and the ravings of old women. For if such a one had ever existed in the world, would he not long since have worn out the genius of all historians in describing the bulk and deeds of so great a prodigy? Compared with him, the twelve labors of Hercules would have been nothing but children's play. Indeed, when I was staying at Drepanum [Trapani] in the year 1637, I inquired very carefully of

experts about this discovered monster-giant; I entered the mountain cave where the corpse was said to have been found, but I found none of those things that the authors cited above relate about the vastness of the cavern. On the contrary, I scarcely think — as far as I recall — that the height amounted to thirty feet. [Margin: The author's investigation of the truth.] Nor were they ever able to show me either feet and hands, or a skull, or similar members from whose proportion to those of an ordinary man one might come to a knowledge of the true size of the alleged giant. [Margin: The cave in which the Drepanitan giant's corpse was found.] The same I would wish for in the case of the Helvetian [Swiss] giant, where, besides ribs, shinbones, and thigh-bones, they can show neither head, nor hands and feet — and just as these organized parts are missing, so too they render the truth of the matter suspect.

It happened at the same time that at Panormus [Palermo], with my great delight, I conferred about giants' bones of this kind with the most illustrious Marquis Carlo de Vintimiglia [Carlo di Ventimiglia], a most learned man and a most exacting historian of Sicily. When I showed him some teeth that certain antiquaries had given me as giants' teeth, he smiled modestly and said: "Do you suppose, my Father, that these are a giant's teeth?" I, in reply, added that I gave them only as much credence as the trustworthiness of the friends who had given them deserved. He then rejoined: "Come to me again tomorrow, and I will show you whose teeth these are." [Margin: Teeth supposed to be giants' teeth — the author's judgment.] No sooner said than done: as I had agreed, the next day I called on that most courteous man, who said, "Let us climb into the carriage." This done, he led me to a place about three thousand paces distant from Panormus [Palermo], which they call *mare dulce* ("sweet sea"). There stood an enormous mountain promontory, and opposite it a very large opening, through which lay an entrance into the dark hiding-places of an immense cavern.

"Let us descend," he said; "now I will show you, my Father, how much Nature can do in fashioning members like those of the human body." And lighting torches, with servants going before us, we entered the cave of that very long tract. When we had now penetrated somewhat into its interior, he showed me on the left wall of the cave a marvelous work of Nature, spread far and wide. [Margin: How Nature forms teeth.] It likewise reproduced teeth — small, middling, large, and excessive in size — set in just that arrangement in which Nature is accustomed to insert them in the jaws of animals, and in such abundance that I could readily believe a hundred carts could be loaded from it. So great was the likeness to natural teeth that you could scarcely distinguish these from those; above, indeed, they showed a translucent whiteness, while below they showed sharp roots, yet

all were converted into solid stone. "Look," said the most illustrious man to me, "these are the teeth that certain impostors, having extracted them from here, sell to the ignorant common folk as the teeth of giants or elephants (for some were of excessive size, as I said)." For my part, I procured for myself no small quantity of them, part of which I keep in my Museum to this very day, and part of which I have given as a gift to learned men for the exposing of the imposture.

But Nature's marvelous craftsmanship did not stop here. Going further on, in the walls of the underground passage we observed I know not what outlines of human members; for now they protruded in the form of shinbones, now there appeared traces of vertebrae and knees, though they were seen with no orderly connection. There also appeared certain huge clayey swellings which, when cut open, on one side...

[showed the shape] of knees, while on the other they left a concavity not unlike a skull; yet among all of them no trace of organized bony substance — such as a head, hands, and feet — was to be found. From this I first clearly recognized the wonderful industry of Nature in forming bones, or stones resembling bones.

The most illustrious Marquis added that many caves of this kind are found in Sicily, in which, when the ignorant common folk find these likenesses of bones — wonderful productions wrought by the power of Nature — they persuade not only themselves but others as well that they are the enormous bones of giants. He added, however, that in the territory of Solonium [the *ager Solonius*] near the sea, between Drepanum [Trapani] and Panormus [Palermo], true bones of elephants are still found by the farmers; these elephants, in the times of past ages, were brought into Sicily by the Africans against their enemies in war, and there killed and buried, and in later times at last uncovered. [Margin: Bones of elephants.] These too the ignorant commonly peddle as giants' bones; but those who compare the symmetry of these bones with that of men at once recognize that what is so persistently asserted cannot possibly accord with the truth. He added, too, that there is this distinction between true bones and those produced by mineral nature: the former always retain the channels of the shinbones and the passages once filled with marrow, whereas the latter counterfeit solid stone without any concavity of the shinbones. Such are the stony bones that are even now displayed in our Museum, from which I have always believed them to be a pure work of Nature.

Fazellus, the historian *On Sicilian Matters* [Tommaso Fazello, *De Rebus Siculis*], also mentions this cave, on folio 25. [Margin: Fazellus in the History of Sicily.] "In the Panormitan [Palermo] territory," he says, "there is a famous spring, very well

known by the name of *mare dulce* ('sweet sea'), facing south, receding about three thousand paces from the city; above it, in the very rock of the mountain, is a cave more or less 60 cubits in length and 20 in breadth, in which Paolo Leontino [Paolo of Lentini], intending to make saltpeter — while in the year 1547 he was digging out cow-dung earth to be boiled down in the niter-works — fortuitously came upon the corpse of a man, of monstrous size and the immense bulk of a giant's body, eighteen cubits, incompact and dissolved in all its members. At the report of this, the Panormitans [people of Palermo], roused by eagerness to see it, were struck with astonishment at the head and all the members; yet everything had turned to dust except the jawbone and the molar teeth, kept unmoved by their hardness. Each of these weighed nearly four ounces, like our own, whitish, with the surfaces hollowed out entirely by decay. Two of these were given to me by Simone Piglione of Nicosia [Simone Piglione Nicosiensis], both to vouch for the matter and to display its memory to the incredulous."

But if we examine each of this author's words individually, we shall find many contradictions in them, and that it was nothing other than what I, together with the Marquis Ventimiglia, examined — bones and teeth produced by Nature. This I demonstrate as follows.

First, he says the corpse was incompact and dissolved, and of nearly 18 cubits — that is, 36 palms, or, what comes to the same, 44 Roman palms. I ask, then, how...

how that subterranean passage, of such unequal height as I observed it — now 25, now 15, or even 10 palms, sometimes so constricted in height that we had to walk bent over — and in breadth with equal unevenness, where it was narrowest not exceeding a ten-foot span — how, I ask, could such a cave contain a giant 18 cubits, that is, 44 palms, tall? [Margin: Fazellus contradicted.] Surely no one will easily conceive it, where he could neither stand, nor sit, nor — owing to the narrowness of the place — lie down, and where this passage would stand in the same proportion to such a giant as a cat to a mouse's lair. But he says the corpse was found incompact and dissolved. If so, how did the discoverer of the corpse so quickly reckon its measurement from the bones? Or how, with the members thus scattered, did the city of Panormus [Palermo] marvel so greatly at the mass of the whole frame? As for its having dissolved into dust at a touch, I would believe that to have been added gratuitously, to win credence.

He says that nothing else appeared of the corpse except the jawbone, well furnished with molar teeth, one of which weighed four ounces — while of the skull, the feet, and the hands there is deep silence. I too would believe in a jawbone furnished with teeth, together with the remaining shinbones, joints, and

similar parts; for I myself saw with my own eyes all the same things found in the same cave — but I found them to be nothing other than a pure work of Nature. Indeed, I found teeth, one of which I saw to weigh not four ounces but four pounds. Shall I therefore assert that they were a giant's teeth? Far from it. And so Fazello's account does not agree with the truth, like the other giants' corpses found in various places in Sicily.

Thus he says that at Mazarum [Mazara] in the year 1516 a corpse was found in a field called Xyphi [Xiphi], of 20 cubits, with a head the size of a wine-cask, yet reduced to ashes; besides the teeth they found nothing else, weighing five ounces. [Margin: A skull the size of a wine-cask.] If it had been reduced to ashes, how did he find a head the size of a wine-cask? These conjectures are utterly trifling and rest on no foundation. Likewise he says that many bones and teeth of gigantic corpses were dug up at the foot of Mount Hybla [Hybla], at the spring of S. Cosmano. [Margin: Another fabulous account of a giant found in Sicily.] He also writes that near Syracuse, in the year 1538, in a deeper-dug crypt, a corpse of 20 cubits was found by Adorno, a Genoese knight, while he was searching out ancient monuments; but from this, dissolved into dust, nothing else was brought away except part of the skull, the ribs, and the legs, along with the teeth, to be offered as a gift to the Grand Master. Again, at Calabراسi [Calatabellotta], near Entella, in the year 1550, while gravediggers were preparing a tomb for a dead man in a church, they came upon a vaulted little chamber, and in it found the corpse of a man of 22 cubits — that is, 66 palms — which, set up for jest and laughter, they pelted with stones until it was dissolved into dust, and nothing was left except the teeth. Who, from this description...

does not detect a fable? How a vaulted little chamber could contain a corpse of 66 palms, I do not see; how, again, drawn out with such labor and with such shaking of the body, it did not dissolve into dust — as he says afterward happened from the throwing of stones — I cannot at all comprehend; and that they found nothing worthy of note besides the teeth easily shows that, deceived by the shape of mineral bones and teeth, they sold them as the true teeth of a giant. And so whatever Fazellus writes about similar corpses of giants is plainly fable, and to be reckoned as nothing — as is evident even from what has been demonstrated.

For if these [giants] were born and reared in Sicily, why does she not produce the same today? Nor does it suffice to allege "influence" as the cause, since the climate is the same today as of old, the aspect of the stars is the same, and she produces today the same fruits and the same animals, of the same bulk as of old. But let no one suppose at this point that I mean to deny that there were ever

Giants in the world — far from it; the Sacred Letters teach me otherwise, from that passage of *Genesis* 6: "There were giants upon the earth in those days; these are the mighty men of old, men of renown." [Margin: How it is to be understood that there were Giants in the world.] But what Berosus relates about giants and the city of Enon of the giants on Mount Lebanon — just as it deserves no credence among historians, so too what he writes is to be ascribed to fables rather than, more truthfully, to history — as is all that the ancient gentile historians and Homer write about Giants, Titans, and Cyclopes, born of heaven and earth by [Greek: γιγαντομαχίας (gigantomachias, "battles of the giants")]. Therefore, when mention is made of Giants, it must be understood of the strength and powers in which they excelled, and of their unusual bodily bulk — yet not of a bulk such as would exceed the just bounds of nature, like those seen in our own age at the Magellanic Sea [Strait of Magellan], who exceeded the stature of well-proportioned men by once and a half, or even more.

Giants of this kind, we said above, have been found in every age; and that there were giants of this kind both before and after the Flood — that is, more eminent than other men in size and strength, as in other respects — must be held for certain, yet not of that exotic vastness which we have described. [Margin: Arabs' fabulous tale of the giant Og.] For if men of prodigious size were the Enacim [Anakim], how did they inhabit the city of Enon, and dwell in houses or tents incapable of holding so great a mass? How did they couple — as Berosus says, and the Sacred Text does not deny — with mothers, daughters, and other human beings disproportionate to them in bodily mass? But what the Saracen history, or rather fabulous account of things, relates about the giant Og far surpasses all monstrous conceptions of the human imagination. The words, translated by me from the Arabic tongue into Latin, run thus: "Og, a giant surviving before and after the Flood, was engaged with Noah in a notable and irreconcilable feud of enmity, and continually sought him out for slaughter. When [Noah] hid himself in the caves of the mountains, [Og], hindered by the vast bulk of his body, could not penetrate them. It happened at one time that the giant, having attacked Noah, when he could not overtake him as he fled, hurled his torn-out beard after him, which at once filled the whole plain of the field like a forest of cedars, so that as many hairs as there were, so many cedars seemed to appear; from these, they relate by a truly ridiculous fiction, Noah afterward built the ark. And they tell fables that he was of such immense size that, when he sought Noah's ark in the Flood, the waters reached only to his knees; meanwhile, tortured by hunger, he hunted whales, which, roasted in the sun, he devoured in a single mouthful" — and the like, which both provoke laughter and, on account of their absurd lies,

even turn the stomach; but this much for amusement's sake. Vain, then, and ridiculous is the history of the [giants] here recounted.

These things thus recounted, nothing further remains except that we should show how Nature generates a bony substance of this kind in subterranean places. [Margin: How bones are generated in subterranean places.] From this it will clearly be evident that whatever similar bones have been found are nothing other than a pure work of Nature.

DISQUISITIO SECUNDA — On the origin of *Enostoi*, or subterranean bones

Just as the Earth in her womb generates rocks of every kind, coal (which they call *lithanthraces*), fossil wood, and the flesh of the earth (which they call *marga* [marl]), so too she generates bones in her own way. The mineral-workers call these *Enostoi* [Greek: ἔνοστοι (*enostoi*, "in-bones")], *bone-breakers* [Greek: ὀστεάκολλα and ὀστράκολλα (*osteakolla* / *ostrakolla*)], and in German — from the human members they resemble — they are called *Knochenstein* ("bone-stone"). [Margin: In what places bones grow.] For as Hector Boethius [Hector Boece] says in his book *On Stones*: "Sometimes ribs are dug up, or the form of a human thigh-bone, or of ribs and arms, and they are found in various places in Germany. They are found in the Palatinate not far from Spires [Speyer]; likewise near Heidelberg and near Jena in Saxony, in Silesia, and in other places. [The stone] grows at the foot of sandy mountains, and is often dug up in great number from underground."

The most illustrious Cianthes [Cianthes], Bishop of Potenza, told me that in his bishopric there is a subterranean place from which round rocks, of the size of bones, are dug up — some expressing the shape of a human skull, others a perfect figure; these Ambrosinus [Bartolomeo Ambrosini] also recounts, together with figures. [Margin: A wonderful structure of bone-stones.] He calls these kinds of stones *cephalites*, *cardites*, or *perficates*, from the figures, namely, which they reproduce; some are seen furnished with coats like those of onions. Of these also Agricola...

Agricola makes mention in book 2 *On Fossils*. [Margin: Mineral skulls.] "As many coats [as there are], so many bony skulls you may find; and these too are sometimes found on Mount Carpathus [Mount Karpathos] of such size that a single one could hold many bushels of grain," as Ercker [Lazarus Ercker] testifies in his German book *On Minerals*.

The question is asked, then, how she [Nature] produces such enormous skulls, such enormous members of the human body, after the likeness of thigh-bones, shinbones, ribs, and teeth. [Margin: The origin of bones of this kind.] I say: there lies hidden in the subterranean entrails, within the clefts of rocky mountains, a certain muddy earth, which above, together with Agricola, we have named *marga* [marl], mixed with gypseous material. When this earth has received the nitrous flux through the fissures of the mountains, it comes about that it is clothed, as it were, with a kind of gypseous rind, which, as it petrifies over time, so too in the splendor of saltpeter rivals the whiteness of bone in its own whiteness — being white, fissured, and friable. If, then, within the cavities of the earth this earth has found a place of rounded concavity, a round ball will be born, which, when broken open, closely resembles a skull. If the matrix has been disposed in the form of a human thigh-bone, or of a rib, or of some other member, the *marga* contained in it, with the saltpeter-bearing liquor poured over it, will express a human thigh-bone — smaller, larger, largest, and altogether gigantic — according to the size of the matrix.

These, then, are those bones which Nature produces, and which are commonly called giants' bones by the common persuasion of men; yet if you break them, in them is found neither marrow nor the fistulous passage of marrow — which ought to be the case if they were the bones of men. All this Ambrosinus confirms, when he displays several of the *Enostei* stones [Greek: ἐνόστεοι (enosteoî, "in-bony" stones)] in the form of teeth, a rib, shinbones, and feet, which he writes that he himself observed at Bononia [Bologna]; whose figures I have thought right to append here. He asserts, together with us, that all these bones are indeed offspring of the earth.

But let us hear Caesalpinus [Andrea Cesalpino], who in chapter 48 *On Metallic Matters* [*De Metallicis*] says: [Margin: Caesalpinus's judgment on bones is subscribed to.] "That bones, however, are born from the earth, and that bony stones are found, Theophrastus clearly shows. Today, near the town of S. Giovanni in Valdarno [San Giovanni Valdarno], stony bones of huge size are dug up, from which they suppose they were from the elephants led into Italy by Hannibal. There survives the head of a humerus, or of a hip-joint, of such size that two forearms could scarcely embrace it. In my possession are fragments of legs, spongy within, solid without, blacker in color than porphyry marble, which ring like marble; concerning which more has been treated by us in our *Etruria* [Tuscany], to which we refer the reader."

Now I shall show in a few words how those round stones, of which I spoke above, are formed by Nature. [Margin: How fossil globes are generated.] Where Nature has disposed clayey mountains, mixed with sandy clods, in the roots of these for the most part stones of this kind, expressing forms of every sort, are wont to be dug out. They are made by this artifice of Nature: in the time of rain and showers, when clayey material is wrapped around a round stone, it comes about that this mass picks up the muddy earth in its path and rolls it up together with itself. Hence it comes about that the agglomerated material of the muddy clay, in its rolling-down, is always clothed with ever-new rinds, as it were; and these, carried to the bottom and there in the course of time having their moisture consumed — the nature of the place cooperating — are at last converted into a stony lump, small, large, or largest, according to the greater or lesser agglomeration of material. These lumps, then, when cut apart and their rinds peeled away, express as many skulls as there are rinds; and these the ignorant of Nature's art, from their resemblance in bone and material, call giants' skulls.

Whoever has seen snowballs rolled down from the mountains, ever growing larger and larger from the agglomeration of snow, will easily form a judgment about the muddy agglomeration of stones — [snowballs] which in the Alps are sometimes so great that, like mountains, they overwhelm men and beasts, and fill rivers and valleys. [Margin: How these stony skulls are dug out.] As for the fact that stony skulls of this kind are dug out of subterranean places, I would suppose this comes about because globes of this kind, heaped up each year in great number in a valley, at last grow up into a heap piled on like a mountain — a thing I would not have believed, had not this, while I was surveying Etruria [Tuscany] in the mountains of Radicofani, convinced me by sensible experience of the truth of the matter, as we set forth in our *Etruria*. [Margin: How these clayey lumps are converted into stone.] Again, since this muddy and clayey material is not always shaped into globes, but sometimes into cylinders...

Diagram. A woodcut occupying the lower-middle of the right column, depicting two fossil specimens shaped like human extremities: above, an open human hand (palm and fingers, viewed from the back, with the wrist/forearm stump at lower left); below it, a human foot in profile (heel at left, toes at right, with cross-hatched striations along the upper surface suggesting the layered/banded texture of the petrified specimen). These illustrate the *Enostei* (bone-stones) that imitate human members, discussed in the surrounding text (drawn from Ambrosinus's Bologna specimens). No labels or caption are engraved on the figure.

it comes about that, when this round-bodied material is wrapped around a stake or a reed, or something similarly cylindrical, in great rollings-down...

Diagram. A small woodcut at the very foot of the right column (partly cut off at the page edge) showing an elongated, spirally-coiled or banded cylindrical fossil — a coiled tubular form rendered with diagonal hatching, illustrating the cylinder-shaped concretions (formed around a stake or reed) introduced in the adjacent text. The image is faint and partly trimmed at the gutter/foot. No caption or labels.

Diagram. A small woodcut at the foot of the right column showing a roughly circular concretion ("globe") rendered with concentric banding/hatching, illustrating the layered round fossil-globes discussed in the bone-genesis argument. Partly trimmed at the page edge; no caption or labels.

Diagram. A vertical group of three small woodcuts in the right column, each depicting a round or oval banded concretion ("bone-stone globe") with concentric rings/coats — the *cephalites* / *cardites* type figures attributed to Ambrosinus, showing the onion-like rinds described in the text. No captions or labels on any of the three.

[Reading order reconstructed from folio numbers and running headers: (Fol. 62v) → (Fol. 63r) → (Fol. 64v) → (Fol. 65r). The PDF presents the leaves in non-linear order; the translation below follows the textual sequence 62→63→64→65.] ...so that it grows up into cylinders along its own length. These, mixed with a pitchy and nitrous liquid, are at last by a petrifying force turned into what look like bony beams — now in the shape of shin-bones, now of hands, now of arms, now of feet. When these are dug up and present something bone-like, made of a friable substance, they are commonly taken — on account of the sheer size of the mass — for the bones of giants.

Here, then, you have the two ways Nature uses in forming bones of this kind. The first is within the cavities of mountains: according to the layout of the hollow, a gypseous marl is poured over with a salt-nitrous liquid and turned to stone, and so takes on whatever shapes the matrix supplies. The second is the rolling-down from the mountains of a clayey material mixed with gypsum and niter, as has been described.

As for fossil teeth, which I remember observing with great care in the Palermo grotto [antrum Panormitanum], Nature forms them in this way. The walls of the grotto are not made of any very hard stone, but rather of a sandy, chalky, or gypseous kind, and because of the abundance of moisture they are riddled with

cracks — as the nitrous icicles [stiriae nitrosae] there sufficiently show. The result is that the salt-nitrous, vitreous fluid, by its fineness, penetrates the soft substance of the stone all the way to its outermost surface. There, having nowhere to drain off, it is fixed in place and hardens into a light, white, bone-like material very similar to teeth. These "teeth," following the cracked arrangement of the walls, are set off one from another, each fixed as if within a jaw, and so very nearly counterfeit real toothed jaws. They vary enormously in size, so that some might not unreasonably be taken for the teeth of giants — and in such quantity that the place may rightly be called a mine of teeth. I would beg all naturalists of more inquiring mind to visit this grotto, examine each specimen for themselves, and I am quite convinced they will find nothing other than what I have described. But I have thought fit to set down here a few of the differences among these teeth, so that what I have said may become still clearer from them.

Diagram. Upper figure in the right margin: a single irregular, ridged object resembling a worn molar or a curved bone fragment, rendered in fine engraved hatching to suggest a hard, banded surface. Uncaptioned. It illustrates a fossil "tooth" / bone-like concretion of the kind described in the text.

Diagram. Lower figure in the right margin: a cluster of several rounded, knob-like fossil teeth grouped together, as though still set in a fragment of jaw, shaded to show rounded crowns. Uncaptioned. It illustrates the "differences among teeth" the text promises — fossil teeth seated side by side as if within a maxilla.

[Margin: Quomodo natura dentes formet. — How Nature forms teeth.]

CAPUT V.

Fossil horns, which have a great affinity with subterranean bones; and where the horn of the Unicorn [Monoceros] is chiefly treated.

After bones come horns, which Nature fashions with wondrous skill in subterranean places, and which everywhere fetch a high price as most potent remedies for repelling poisons of every kind. They are distinguished among themselves by a manifold variety. Some Nature herself produces in the bowels of the earth in the manner described above — such as those found in various German underground mountain caverns, on the testimony of Agricola: as in the Hercynian Forest [Sylva Hercynia, the Harz] near the village called Baumannsholz [Baumannshöhle], under the dominion of the Counts of Stolberg; and likewise near Heidelberg, Speyer [Spira], Hildesheim [Hildeshemium], and in Moravia, Silesia, and Saxony. These are nothing but a fossil *spodium* [spodium

fossile — calcined-bone-like ash]. They arise from a certain species of marl which, when it is soaked and dissolved by water charged with a petrifying power, passes in the form of a milky fluid through the cavities of the earth. Wherever it finds a horn-shaped matrix, the moisture is used up, and the more serous part, saturated with marl, is there converted to a horn-like hardness.

It sometimes happens that this milky liquid falls not into a cavity but onto some piece of wood already stripped of all moisture by age. Being porous, the wood quickly draws the serous humor into itself, and at last, by the coagulating force of the milky liquid, in proportion to the salt-nitrous humor mixed in, it is turned into stone — either hard, or soft and friable — yet in such a way that the appearance of wood can still be recognized and its smell from time to time detected. **Anselmus Boëtius** [Anselm Boëtius de Boodt] confirms this in his *History of Gems and Stones* [*Gemmarum et Lapidum Historia*], where he says, in these words:

Fossil horns differ greatly among themselves, and few show the same appearance: in some they resemble teeth, shin-bones, jaws, and other parts of the body. I have at home more than twenty different kinds, all of which were given to me as "unicorn's horn," though one plainly shows the outer bark of an ash-tree on its surface. Another specimen, found near Brno [Bruna], a city of Moravia, reproduces so exactly, inside and out, the figure of a walnut trunk, that no one but a blind man could fail to notice it had been the trunk of that tree and had undergone transmutation in the earth; its smell, too, exactly gives off the odor of the nut-tree. A fragment of this same trunk was given to me, under the title of "unicorn." In the same place a larger portion of the trunk and stock was sold for the "head of the animal" — so that no one ought to doubt the generation of these horns. And as these things are of a drying and astringent nature, so too they staunch fluxes, heal the eyes' tears, help to strengthen the heart, and are most present antidotes against poisons, plague, and malignant fevers — and the more potent, the more the material is by its own nature opposed to poisons, as are ash-wood, hartshorn [cornu cervinum], and ivory, when they have been more closely and tightly united by coagulation. For they wonderfully promote sweat, and together expel from the body the breath of the virulence of a poisonous humor — epilepsy, the cardiac passion [cardiaca passio], trembling of the heart, and other afflictions of the heart...

[Margin: Origo cornuum fossilium. — The origin of fossil horns.] [Margin: Varis differentis [recte: Variarum differentiarum]. — Various differences.] [Margin: Vis medica in ossibus [recte: ossibus] fossilibus. — The medicinal power in fossil bones.]

...taken with appropriate water, is a remedy against fever.

Of the Horn of the Unicorn [De Cornu Monocerotis].

There is nothing in all of nature held in such esteem by emperors, kings, princes, and the great men of the world as the horn of the Unicorn [cornu Monocerotis] — so much so that gold and gems are reckoned as nothing by comparison with it. Yet what that horn actually is, or from what animal it has fallen, no one is able to say. Hence to this very day physicians, natural philosophers, and most investigators of nature contend among themselves about it in extraordinary fashion, the question still undecided.

I will say, however, that if anyone should too boldly deny that such an animal — one carrying a horn of such great efficacy and of so wondrous a virtue — either still exists or ever existed at all, that person would, with the same rashness, be calling into doubt not only the Sacred Scriptures but, along with them, the trustworthiness of all the historians.

[Margin: Descriptio Monocerotis. — Description of the Unicorn.]

That there is, then, a Unicorn or Monoceros is certain; but what sort of thing it is and was remains open to debate, and the matter is not without difficulty. **Pliny** [Plinius] and **Aelian** [Aelianus] describe a true unicorn with such marks that it readily appears it never existed in the form that is, wrapped in so many fables, set before the learned world. For if such a thing existed, then long ago — the whole globe of the earth having been so thoroughly explored — it would surely have been seen somewhere, or would have been known to the merchants who at all times are accustomed to traverse the vast solitudes of India, Tartary, and Africa, where it is said to make its lair. Add to this the diligence of our Fathers [the Jesuits], who — besides the winning of souls, which is their sole aim — do not cease, through continual exploration, to communicate to the world an exact knowledge of the exotic things produced by Nature in those regions. Yet it is astonishing that of the unicorn — which, among exotic animals, ought by right to hold the first place — they make no mention, not even a word.

[Margin: Unicornu nunquam visum fuit. — The unicorn has never been seen.]

Father **Pedro Páez** [P. Petrus Pais], who traversed the whole of Ethiopia [Aethiopia] together with the Emperor's army, and who searched out all the recesses of the Mountains of the Moon [montium Lunae anulos] in order to discover the source of the Nile, and who made mention of innumerable animals, makes none at all of the Unicorn — indicating by this very deep silence of his that it does not exist. The writers on natural things have indeed, it is true, seen various animals conspicuous for a single horn on the forehead or nose; this they teach of certain wild asses [onagri], oryxes [oryges], and finally of several rhinoceroses [Rhinocerotes].

[Margin: Animalia familia [recte: similia] monoceroti quae. — What animals are like the unicorn.]

The Indian wild asses [Onagri Indici] are single-horned, fitted with a rough horn on the forehead, broad at the root and tapering gradually toward a turbinate (top-like) form. The oryx, again, is that species of wild goat that roams in the solitudes of India, equipped with a single horn which, emerging from the head, is gradually twisted into helical lines and grooves in the manner of a snail-shell, contorted to a length of four palms, and at last ends in a very fine point — a thing found here and there. But on animals of this single-horned kind, see Father **Giovanni Filippo Marini** [P. Joan. Philippi Marinum] treating the matter more fully in his account of the kingdom of *Tonkin* [Tom Kin] and of Laos [Lao].

[Margin: Onager Indicus cornu in fronte spectabilis. — The Indian wild ass, remarkable for the horn on its forehead.] [Margin: Oryx monoceros. — The single-horned oryx.]

As for the horns of the rhinoceros — since nothing is more commonplace, and since we are accustomed to display three of them in our Museum — I say nothing. From all this I conclude that whatever has been said up to now about the horns of the true Monoceros is to be understood of the said horns of these animals. But the contrary seems to be the case: for those horns of such great price and esteem, kept among the treasures of kings and princes, have nothing in common with the said horns — whether you consider their form, their color, or their smell.

At Paris, in the Church of St. Denis [S. Dionysii], one is kept about five cubits long, twisted in the manner of a helix. Another of the kind is shown for viewing at Strasbourg [Argentina], in the treasury of the cathedral church: of the height of a full-grown man, but with grooves differing from the Parisian one, of great weight, of a yellow color verging on pallor; its end is of such thickness as a fist could fill. Likewise at Venice, at St. Mark's [Sanctum Marcum], similar horns of exquisite

splendor are to be seen, which are given out as the true and genuine horns of the Monoceros. Similar ones are said to be found in the possession of the Grand Duke [Magnum Ducem], and others of the princes of Italy are said to hold them — so everywhere prized by princes that a treasury is reckoned unworthy of the name where such horns are lacking.

[Margin: Loca quae Monocerotis cornu inter pretiosissima ponunt. — Places that rank the Unicorn's horn among their most precious things.]

Yet when I had examined these things with the utmost diligence, I could not be induced to believe that they were the horns of four-footed animals. For the horns of animals — as is clear from rhinoceroses — always have a notable breadth at the base below, and then taper gradually to a point, whether curved or straight; whereas those horns scarcely fill out a breadth of four fingers, of always equal thickness, until at last, growing slender, they end not in a sharp but in a blunt point. And it seems scarcely possible that an animal — especially a monoceros not exceeding a horse in size — could either sustain so long a horn, given the great weight against the thinness of the shaft, or use it among the dense trees of the forest without danger of striking or breaking it.

[Margin: Cornua quae passim monocerotis esse dicuntur, animalium quadrupedum non sunt. — The horns everywhere said to be the unicorn's are not those of four-footed animals.]

I say therefore — and, saving the judgment of others, I hold — that horns of this kind are not the horns of quadrupeds but of certain fishes; and by what evidence, I now set forth. Not long ago the most illustrious **Count of Ahlefeldt** [Comes de Alfeld], privy councillor to the King of Denmark, a man most thoroughly versed in the knowledge of various matters, reported the following, while in conversation mention was made of the monoceros horn in our Museum. He said that when his King sent an expedition to the northern island of Greenland [Groenlandia], to explore what advantage might come from it to his Kingdom, at last, after many hardships endured, those who returned reported that they had indeed traversed the shores of Greenland but had been unable to detect any trace either of dwellings or of men; yet there were huge heaps of long horns, some of which equaled a pike [sarissa] in size...

[Margin: Piscium spicula esse ostenditur. — It is shown that they are the spines of fishes.]

equaled a pike in size; and that they had further learned from the inhabitants of the neighboring islands that these were not horns but the snouts [promuscides —

proboscises/tusks] of certain very large fishes, with which they defend themselves against the ambushes of the whales [Balaenae], of which a vast multitude is harbored in the glacial Ocean; and that for this reason these beasts perpetually war upon one another. Yet it happens not infrequently that these pike-like (spear-shaped) snouts, violently locked together among the crags of the icy mountains, are at last washed up onto the shores of the neighboring islands, where they pile up; and many of them, buried under the sand of the sea, are found every year — so they testified. They testified too that they had themselves seen a fish, of the size of a great lance, equipped with such a snout, under the figure which we here append.

And so, that the truth might be plain to the King, they had presented to him a whole boatload of these, packed full, and had sent some on to princes as a rare gift.

[Margin: Cornu Monocerotis hic Romae. — A unicorn's horn here at Rome.]

I learned afterward that **Gisbert von der Pole** [Gisbertum von der Pole], a Belgian merchant and for the time a Roman citizen, kept in his workshop two unicorn horns of great price, sent to him from Batavia [the Netherlands]. I went to him, asking that he show them to me, eager as I am for such things, which he did not unwillingly. The horns are nine Roman palms in length; the thickness at the base such as a fist could fill; striated, with the spirals twisted in the manner of a snail-shell, ending in a blunt point; of a yellowish color, like ivory; very heavy in weight; and of wonderful virtue in medicines against poisons. For — he said — if one of them is placed inside some shell filled with spring water, it soon imbues that water with such virtue that water of this kind, drunk by a sick person, soon makes him better; and he testified that he had found this so by experience.

And when I had instituted the most diligent examination of the form and constitution of these horns, I found at last that they could by no means be the horns of quadrupeds, but were the horns — or rather the snouts — of those fishes which we have described. And so I began, now a little more boldly, to affirm that whatever horns of this kind lie hidden anywhere in the treasuries of princes draw their origin from nothing else than the said fishes.

[Margin: Cornu monocerotis ab Alberto Magno observatum. — A unicorn's horn observed by Albertus Magnus.]

Hence it is by no means false what **Albertus Magnus** writes that he saw — a horn of the Monoceros measured with his own hand, which was a palm and a half in thickness and ten feet in length. Since this could not belong even to the largest of

quadrupeds, for the reasons given above, it could be nothing else than the [snout] of some very large fish, of the species we have described, dug out of the sea-sand of the British shore [maritimo Angliae littoris sabulo], where that fish had deposited it, or had badly shed it.

[Margin: Cur in Anglia praecipue monocerotis cornua habeantur. — Why unicorn's horns are found chiefly in England.]

Indeed, I am led to believe this by an especially strong argument: that in no kingdom is so great an abundance of these horns said to be found as in England; for since no animal that would exhibit a horn of this form is found in the whole kingdom, and yet very many are said to be dug up along the seashores, it is readily plain to anyone that they have been either washed in from the neighboring glacial sea, or shed by those same fishes on the English shores, buried in the sand, found in their time, and sold off as the horn of the unicorn. Therefore, setting aside the fabulous tale of the monoceros described by **Pliny** and **Aelian** — since nowhere on earth has such an animal been seen — we shall more fittingly assert that horns of this kind, found here and there, are the remains [exuviae] not of quadrupeds but of fishes. But enough of this.

[Margin: Cornu monocerotis fossile. — Fossil unicorn's horn.]

That a fossil unicorn's horn is sometimes found, fashioned by Nature in subterranean burrows, the History of the Swiss [Helvetiorum historia] shows. For it relates that in the year 1520, on the bank of the river Aare [Arula], near Brugg [Bruck], in the domain of the Margrave of Baden [Marchionis Badensis], a unicorn's horn of considerable size was found. Since it could belong neither to any four-footed animal nor to the said fish, it remains for us to say that it was fashioned by nature in the bowels of the earth.

As for the utterly prodigious virtues which certain quacks [Agyrtae] and itinerant peddlers exalt to the point of miracle, I say that they are to be measured by the same steps as the monoceros animal itself — wholly fantastic and imaginary. For who has ever tested the powers of that horn, whose animal was never seen by anyone? As for the repelling of poisons, I say that all kinds of *spodium* — such as burnt hartshorn, ivory shavings, and the teeth of the *Rosmarus* (this likewise is in the farthest Ocean of the North an amphibious fish of the greatest size, furnished with very smooth teeth — on which see **Olaus** [Olaus Magnus] and the historical Accounts of others concerning the northern regions) — for these, whether horns or teeth, just as they contain in themselves, beyond the specific quality implanted in animals, that same virtue against poisons, so too it is everywhere agreed that

they are commonly employed by all as timely remedies against poisons and the diseases of a malignant nature. But let what has been said about fossil horns, and those dug out of subterranean places, suffice.

CAPUT VI.

Of Fossil Woods and Coals [De Lignis & Carbonibus fossilibus].

Fossil woods, which are sometimes found in the underground bowels of the earth, are considered under a twofold difference. Some are those which were once trees, and which in the course of time, by the force of a petrifying power, were converted into stone. Of this kind, **Anselm Boëtius** [de Boodt], in his book on gems and stones, reports that a great quantity was found beneath the earth at Saint-Omer [Andomarum] in his time; and such are found everywhere.

[Margin: Lignum fossile naturale. — Natural fossil wood.]

I myself have seen, in various places of Italy, the trunks of trees converted to stone, of such hardness that fire could be struck from them no differently than from the hardest flints; and when struck, like metal, they gave back a most clear ring. Some of these pieces our Museum displays. For some woods have a greater disposition than others for receiving the petrifying force: such as the alder [Alnus], whose trunks, buried for a long time under water or earth, are at last converted into stone of an iron hardness — concerning which fuller mention is made elsewhere. Oak [Quercus] too, holm-oak [Ilex], and walnut [Juglans] are easily hardened into stone, because of the abundance of saline spirits which dominate in them; these, being stirred up by even the slightest scent of a petrifying power lurking somewhere, and united by a certain magnetic confluence of similar bodies, harden into stone. But these things have been treated more fully elsewhere.

[Margin: Minera ligni fossilis in agro Aquaspartano. — A mine of fossil wood in the territory of Acquasparta.]

Furthermore, there are sometimes found, in the hidden bowels of the earth, certain woody masses in the form of a mineral mass, which have drawn their origin from a vegetable nature only very remotely — or not at all; rather, they are the pure and unalloyed work of Nature. For just as Nature, in the fruitful retreat of the womb, produces both bones and horns, so too she produces woods, imitating the industry of vegetable nature. A sign of this is that most things of this kind are found in the deepest bowels of the earth, within what they call the *virgin* earth [terra virgo] — unpolluted by any access of external matter, and where it is

likely that no tree-substance ever at any time penetrated. Such is the wood that was sent to me not long ago from Bohemia [Boemia]: found in the innermost recesses of the mountains and, as they say, in the chamber of virgin earth, it best expresses the form of black wood [ebony], but far surpasses it in hardness and weight.

About twenty years ago, in Roman territory, a mine of fossil wood was discovered, from which most beautiful crosses, tables, and small tables — that would yield nothing to ebony — were made, and are everywhere displayed, in the place of a rarity, both in the Roman Museums and in our own. The most excellent **Duke Cesi** [Dux Caesius — Federico Cesi] is said to have first discovered this mine, in the territory of Acquasparta [Ager Aquaspartanus] subject to his jurisdiction. He, just as throughout his life he showed himself a tireless investigator of natural things, so too did not cease both to admire Nature's industry in producing this wood and shrewdly to track down its cause.

[Margin: Minera à principe Caesio detecta. — A mine discovered by Prince Cesi.]

This was done through that most erudite man **Francesco Stelluti** [Franciscum Stellatum], a singular friend while he lived, who in the Duke's name published an outstanding little work on this fossil wood, in which he renders to the life the wondrous traces of the lineaments expressed by Nature in this wood. And when I would not infrequently confer with the said Stelluti about these matters, and had learned the place where the *xylotic* [xylotica — wood-forming] mine was said to be, an opportunity offering itself, I went to Acquasparta [Aquaspartam], some fifty miles distant from Rome. There, having hired a man knowledgeable of the locality, and having advanced about three miles toward the city of Todi [Tudertina urbs], he showed me, at the bridge of a certain stream — whose name does not now come to mind — within a small valley, various passages. Entering these, we saw a certain kind of earth, very rough, and roughened, as it were, with certain barks of trees. When these were removed, we came upon a vein, in earth somewhat harder and shining with I know not what smoothness; and this, he said, was the earth from which were made at Rome those precious tables of which we spoke a little before.

[Margin: Author mineram explorat. — The author explores the mine.]

Here there was no trace of a tree or of a rotted branch, but it appeared to be earth entirely — which, within the earth somewhat softer, yet exposed to the air, hardens utterly into a woody substance, so that, no differently than any other wood, it can easily be split, hewn, and polished, after the manner of ebony. For by

the variety of its grain it quite rivals the wood of the walnut or pear-tree, so that, at first sight of tables of this kind duly worked, no one could easily be induced to persuade himself that it was not wood — since, at least as to outward form, it seems to differ hardly at all from wood.

Diagram. A tall, narrow woodcut in the right column showing the figured grain of the fossil wood: a series of nested, wavering, mountain-like (chevron and flame-shaped) bands stacked vertically, mimicking the streaked, undulating grain of polished wood (or the "flame" figure of burr-wood). Uncaptioned. It illustrates the "variety of grain" by which the fossil wood (the *Acquasparta lignum fossile*) rivals walnut or pear, as described in the surrounding text.

[Margin: *Forma ligni fossilis*. — The form of the fossil wood.]

Nevertheless, it is only then believed to be primarily a mineral, when it puts forth effects proper to fossils. For, first, tables of this kind placed upon water do not know how to float, but at once seek the bottom; next, applied to fire, they conceive no flame — no differently than if you were to burn earth or any kind of turf; thirdly, they entirely lack fibers extended along the height of the tree, after the manner of other woods, by which they are wont to draw up nourishment, and show only a kind of agglomeration of I-know-not-what crushed fibers. In a word, it is neither earth...

Liber VIII "Λιθογενής," Sectio II "De Transformatione" — Caput VI (continued)

(Reading order reconstructed from running headers, catchwords, and signatures: [Fol. 66 verso] → [Fol. 67 recto] → [Fol. 68 verso] → [Fol. 69 recto]. The PDF's physical page order is non-linear.)

Caput VI — De Lignis & Carbonibus fossilibus (conclusion)

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- o ...it is, in fact, neither stone, nor tree. Not the former, because it is made of a material that is by no means friable, but so compact that it is not unsuited to the chisel. And not the latter, because it has nothing in it that would answer to the roughness of stone, either in weight or in hardness. [Margin: The origin of this fossil wood.] For

this reason, too, it cannot be counted among those things that have hardened into stone through a petrifying juice [succus lapidificus], since it has none of the fibers with which trees are equipped by nature — and the proof of this is that it can be cut in any direction without difficulty.

By what art, then, or by what ingenuity nature produced it, remains to be explained. For I do not think that anything similar has anywhere been observed by anyone in the whole class of fossils.

I say, therefore, that these were once trees — a fact that their very ancient bark sufficiently proves, found everywhere scattered throughout the mine. They were not, however, hardened into stone by some petrifying juice, but were dissolved into the smallest particles by a sharp and softening juice. An earthy mud — of whatever kind it may finally have been — mingled with these and flowed among them, and drew the minute particles of the now-dissolved trees together into a single earth-wood mass [massa terro-ligneæ]. The result is that it can be called neither pure wood (for the reasons given above), nor pure earth, nor any kind of stone, but a compound of them all — so compacted that it presents the striated surfaces of wood (because of the anomalous diffusion of the moisture that flowed through it), exactly as in a piece of wood skillfully planed. And yet in weight it surpasses wood, so that, weighed down by this, it cannot float on water as wood does. Likewise, when placed on the fire, on account of the whole admixture of earthy portions, it refuses to catch flame.

But so that the curious reader may see the striations of this wood more clearly, I have decided to include here a table [tabula] that we are accustomed to display in our museum, planed from this sort of fossil wood.

Diagram. An uncaptioned woodcut of a rectangular panel ("table") planed from the fossil wood, displaying its wood-like striated grain. No lettered labels are present on the figure. *[The figure referenced in the text is described here; the plate itself was not rendered with separate labels on this page.]*

That certain earthy juices have the property of turning some things entirely into stone, while transmuting others — the harder ones — once dissolved, into a soft substance, was shown in the preceding pages by many experiments, and will be taught at length in the *Book on the Marvelous Artifices Wrought with the Aid of Minerals* [*Liber de miris artefactis mineralium*].

Concerning **fossil coals** [carbones fossiles], which they call *lithanthraces* [Margin: λιθάνθραξ ([Greek: λιθάνθραξ (lithanthrax, "stone-coal" — fossil coal))], there is

no need for me to say much, since they are found everywhere — chiefly in the territory of Liège [Territorium Leodiense], in Bohemia, in Saxony, in various places in Italy, on the island of Elba, in Sicily. At Liège they build their furnaces and hearths with them. They are certain bituminous masses mixed with sulphur — which they smell of — and on account of the said power they possess, they make a fire of greater effectiveness than any wood does; yet, because of their noxious exhalations, they bring much harm to the head. The whole countryside — indeed the very city itself, as Anselmus Boëtius [Anselmus Boëtius de Boodt] attests — has been so honeycombed with diggings, for the sake of the profit they get from these coals, that it is at some risk of one day collapsing. Ground up and mixed with oil, this coal makes an ointment for farmers: the vines smeared with it come out immune from all gnawing by insects.

There are various kinds of such coals. Near Dresden in Meissen [Misnia] a soft, bituminous fossil coal is dug; and at the same place another, harder kind, which is commonly confused with the Thracian stone [lapis Thracius] or with jet [gagates]. In Scotland likewise — as Agricola attests — twenty thousand paces from Edinburgh [Edenburgum], where they call it a "coal-floor" [carbonum area], it is found in immense quantity; the ground there abounds in bitumen, which also from time to time, not without grave harm to the inhabitants, catches fire. In Meissen near the noble town of Zwickau [Zuicia], a mountain of coals presents itself to view, which always burns at the surface; and as the pits are gradually dug down — which, if anyone, as Agricola teaches, should see them, blazing furnaces appear — it kindles, by fire, material that is not even directly applied to it, but stands four feet off at an interval. But let what has been said about subterranean coals suffice.

SECTIO III

DE ASBESTO, SUCCINO

and the Other Bituminous Fluxes of Gums; and also concerning those fossils that are endowed with marvelous powers.

[Sectio III opening]

Caput I — De Asbesto, seu Amiantho

On Asbestos, or Amianthus

Among the other miracles of Nature with which the eternal and uncreated Wisdom of God plays in the Globe of the Earth, the stone **asbestos** [asbestus] stands out before all — of a nature untamable by fire and incombustible, most celebrated in the records of all authors, both ancient and modern. As it is entitled by various names, so too, out of the equivocation of those names, it has stirred up enormous disputes and controversies among authors. [Margin: The names of the stone asbestos.] Strabo calls it *Carystium* [the Carystian stone]...

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Pausanias [calls it] *Carpasium*, Solinus *Carbasum*, Pliny [Pliny the Elder] "living flax" [linum vivum], Zoroaster *Bostrichites*, others *Corsoides*, some *Polia*, certain ones *Spartopolia*, Marco Polo [Marcus Venetus] "powder of the salamander," and most, finally, call it "fissile alum" [alumen scissile]. "The alum," says Cardanus [Girolamo Cardano], "which they call *Scaiola*, is the *astrum samium* of the ancients, and is not of the class of juices [succī], any more than is plume alum [alumen plumae], which is composed of earthy parts. And therefore, if it is finely rubbed and sprinkled on bedding, it stirs up a constant itching, for it has sharp and pricking parts; and if wicks are made from it, they do not burn, but the oil is forever consumed while the wicks themselves remain." Thus Cardanus.

[Margin: The custom of the ancients in burying their Kings.] With these the records, not only of modern but also of ancient writers, concerning asbestos — that is, the incombustible stone, which for that reason the Greeks call ἄσβεστον and ἀμύαντον [Greek: ἄσβεστον (asbeston, "unquenchable, incombustible"); ἀμύαντον (amianton, "undefiled, incorruptible")], that is, "incorruptible" — agree. Hence napkins, funeral linens, and small nets used to be made of it, in which the corpses of kings, wrapped and burned by fire, would be reduced to ash while the linens themselves remained uncorrupted. From these threads, too, household stuff of every kind of cambric [carbasina supellex] was made, which, when soiled, was cleansed not by water but by fire. But these things are well known, not only in ancient times among the Egyptians, Greeks, and Romans, but even in our own day, so that they are found at the court of practically every prince.

[Margin: A paper of asbestos belonging to the Author.] I too have in my museum a whole casket full of pieces of asbestos. I have paper made from these, which serves for writing letters; and when you cast it into the fire, the letters being soon consumed, the paper comes out whole and whiter, as if washed by the fire, and

serves for inscribing new letters — so that a single leaf could serve forever in the reciprocal correspondence of friends. [Margin: The asbestos wick lasting two years.] The most eminent Cardinal de Lugo [Juan de Lugo] also gave me a little band [redimiculum] twisted of asbestos thread, which, when thrown into the fire, if it has been soiled with filth, comes out from it most brilliant. I also remember that I kept a wick of this asbestine kind, set in a lamp, for two years without any consumption of itself — without doubt it would have lasted forever, had it not, by I know not what accident, been taken away from me. So it is most true, what the ancients handed down about a wick unconsumable by fire.

These few things I wished to point out to the reader, lest he should regard asbestos, and what the ancients handed down about it, as some sort of paradoxical thing. But the marvelous and almost incredible things that writers have reported about its nature and property, I have judged it superfluous to recount here. [Margin: The authors who have written about asbestos.] Whoever desires to know these things, let him consult Pliny, Aelian [Claudius Aelianus], Solinus, Cardanus, Scaliger [Julius Caesar Scaliger], Lodovico delle Fave [Ludovicus Fives — *recte* uncertain; possibly Juan Luis Vives, "Ludovicus Vives" [?], Aldrovandi [Ulisse Aldrovandi], Anselmus Boëtius de Boodt, Agricola [Georgius Agricola], Falloppio [Gabriele Falloppio], Cesalpino [Andrea Cesalpino], Gesner [Conrad Gessner], Liceti [Fortunio Liceti], and countless others. Since these authors do battle with one another in a remarkable manner, I have thought it my part to call them back into concord on the following questions — which I shall carry out with all due diligence, once I have first set down certain things necessary for fully thrashing out the subject.

[Margin: From where the dispute about asbestos arose.] The whole quarrel that has arisen among the authors seems to consist in nothing else than the varied naming of this mineral. As this naming is diverse, so too it has bred various and differing conceptions in the understanding of the writers — the origin of so many disputes and skirmishings. For since nature has produced asbestos in various parts of the earth's regions [in variis Orbis terrae portae(?)] [Margin: lit. "in various places of the earth's globe"], each writer inscribed it with a name from its native place: hence they named the *Carystium* from the city of Carystus, the *Carbasium* from the city of Carbasa, "Indian flax" from India, the *Cyprium* from Cyprus; "scaiola alum" from its likeness to alum; and, after the salamander — because it lives in fire — whence also Pliny called it "living flax," as we related above. Still, modern merchants assert that the finest is found in central India, in Arabia, and in Cyprus — although in the Ligurian mountains, as also on the island of Corsica, and likewise in Etruria, indeed in Germany (according to

Agricola), some traces of this mineral appear. But, leaving these matters aside, let us proceed to the proper subject of our undertaking.

[Margin: Whether the stone is incombustible of itself and by its own nature.] It is asked, therefore, first: what this stone is, how nature has made it, or by what means it composed it, and whether in truth, of itself and by its own nature, it is ἄσβεστος καὶ ἀμίαντος [Greek: ἄσβεστος (asbestos, "incombustible"); ἀμίαντος (amiantos, "incorruptible")] — that is, incombustible, and incorruptible in fire.

[Margin: The position of the asbestos stone.] This stone is usually formed by nature in a hair-like [capillary] shape, of color now white, then ashen, sometimes reddish, at other times iron-colored; it is dry as to its outer surface and resolvable into filaments. Yet it has in its center a kind of stabling [lodged] moisture — I know not what — viscid and oily, untamable by any fire. The filaments are so constituted that they can be both spun and woven, exactly like ordinary flax. I say therefore that this stone is composed of a certain species of alum or talc, so that for this reason many have thought it should be called "fissile alum" [alumen scissile] or "plume alum" [alumen plumae]; for it is furnished with much softer filaments than fissile alum, and you may split it apart with practically no effort, even with your very fingers. Its filaments, when spread out, always show something woolly, like cotton or threads of white silk, whence not unfittingly it is called "plume alum." Yet within the recesses of its property it has — I know not what — something viscous and oily, [Margin: The oil of the asbestos stone is so concentrated that it cannot be separated by fire.] so concentrated into the earthy material that it cannot be separated from it by any force of fire — a virtue that certain other minerals also possess, such as gold and selenite [selenitis], which they commonly call *talc* [talcum]; for that viscous matter by which it is joined to its native material so resists fire that it cannot be dissolved from it by any artifice. [Margin: Why they resist fire.] Their obstinacy, however, is greater in the one case, lesser in the other. For experience has long since taught that selenite, given the greatest time on the fire, is consumed; but gold and asbestos never are. And this truly marvelous virtue arises from nothing other than the perfectly balanced temperament of the well-mingled stone. By what skill, and by what ingenuity, nature, against the torments of fire, [composed this] aluminous...

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this viscus, in so inseparable a manner and bond — that it far exceeds the limits of the weakness of our understanding; and likewise it is not the part of a wise man to explain such things in far-fetched words.

That **asbestos** — or amianthus — endures in fire and persists uncorrupted without any harm, I have learned by frequent experiment. Yet I cannot here pass over a notable error: that certain people — who either never saw the stone, or did not understand the authors writing about amianthus — supposed that this stone, with no other ingredient added, is set perpetually aflame by fire. Thus Camillus Leonardus [Camillo Leonardi], *On Stones* [*De lapidibus*], book V: "*Asbestos is an iron-colored stone, which Arabia produces; it is called Asbestos, that is, 'inextinguishable,' because, once kindled, it perpetually retains its flame without any liquid.*" In this account he committed a double error: first, being ignorant of the Greek tongue, he interpreted ἄσβεστος [Greek: ἄσβεστος (asbestos)] — that is, "incombustible" — as "inextinguishable"; and second, he supposed that asbestos, when brought near the fire, is set ablaze into a perpetual light with no addition of any other inflammable thing. [Margin: Asbestos without oil is not of itself inflammable.] How false this is, daily experience teaches me, since the effects of asbestos are demonstrated to visitors in my museum almost every day. For unless oil is supplied to the wick, you will waste all your effort in trying to set it ablaze.

Into the same error fell Dionysius Afer [Dionysius Periegetes] in his poem *On the Situation of the World* [*De situ orbis*]: he makes the asbestos of Arcadia inflammable, in these words:

Here is born a stone which, once kindled by fire, refuses to be
extinguished, which the Greeks by its true name call ἄσβεστον; it shines
with the color of iron.

This opinion had many followers ignorant and unversed in such matters. But now, back to my purpose.

Rightly, then, does the wonderful property of this stone vex to the utmost the wits of all philosophers, since they cannot conceive that there could exist, given in the nature of things, some mixed body immune from all the violence of fire. Leaving aside the opinions of others, I shall set forth in a few words what has occurred to my own mind concerning the admirable virtue and property of this stone.

[Margin: Asbestos placed in a glassmaker's furnace is drawn out uncorrupted by the fire.] Experience has taught me that a piece of this stone, set in a glassmaker's furnace, is always drawn out uncorrupted. This marvelous stubbornness in repelling the violence of fire must necessarily be constituted out of those things which are most contrary to fire — which seem to consist in three. [Margin: Whence the incombustibility of asbestos?] The first is the material itself, which, as it is furnished by nature with a tenacious, thick, and viscid moisture, so too

cannot be easily consumed by fire's most active nature. The second is that the said material is inexhalable, and (so to speak) inevaporable; for it is established by experience that any material resists fire the more, the less it is liable to evaporation; and, conversely, that it is the more easily seized and consumed by fire, the more it is resolvable into vapors and exhalations. The third is the sincerity of the material itself, adulterated by no admixture of any heterogeneous [Margin: ἑτερογενής, "of a different kind"] thing — so that for this reason it must be confessed to be a body of a pure, homogeneous nature.

[Margin: Why they resist fire.] And this is evident from the very fact that, since it is most proper to fire to segregate heterogeneous things and to congregate homogeneous ones — as Aristotle attests — and since in asbestos all the parts are homogeneous without the admixture of anything else, it is readily inferred that it possesses the greatest power and efficacy for resisting fire. And this is clear in certain other things, as we taught above — namely in gold, diamond, and selenite — because in all stones and metals, which, however vehemently they resist fire, can nonetheless only with difficulty be reduced by chemical art into a liquid, a calx, or a similar form differing from the prior one; and if they are dissolved, we see that the solid substance of which they previously consisted by no means remains. But this has no place in asbestos: for if you torture it in a furnace with fire even for a whole year, it will always be drawn out for you, with no alteration to itself, whole and entire, and will be beheld as sincere. Whence we give the following definition — or rather description — of the asbestos stone, by which it is essentially distinguished from all other fossils:

[Margin: Definition of asbestos.] *Asbestos is a fibrous stone, not unlike fissile alum [alumen schistum], consisting of a tenacious and thick viscosity — or rather a tenacious and viscid thickness — incapable, on account of the homogeneous texture of all its parts, of being resolved into vapor, alone immune from the most active nature of all things and incombustible.*

I said "not unlike fissile alum," even though it differs from it both in softness and in the arrangement of its fibers, which it has arranged not otherwise than in a kind of wood; and the whole thing seems to consist of these, so that many, deceived by the outer form, have supposed it to be wood. [Margin: Asbestos imitates the form of wood.] And likewise certain charlatans [Gnatones] have sold it to the ignorant common folk, and to superstitious little women, as wood of the holy Cross [lignum S. Crucis], according to Mercuriali [Girolamo Mercuriale]. Alum, too, has something not unlike asbestos in resisting fire, as is clear from Roman history, where men are said to have preserved their houses immune from

fire in conflagrations by means of linens smeared with alum. If this is understood of ordinary alum, I judge it false — as I have found experience to be contrary to it — but if it is said of the true fossil alum, or asbestos, I think it most consonant with the truth. [Margin: A marvelous story.] For in the *Life of Saint George* [vita Sancti Georgii] we read that, when the tyrants had condemned him to the fire, but feared lest the Christians [should attribute his immunity from fire to a miracle]...

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[lest it should] emit perpetual flame? Here I behold a great contest of authors fighting it out. [Margin: An account of perpetually burning lamps.] There are those who stoutly contend that such lamps both existed of old and can be made to this very day. Others, on the contrary, with great weight of arguments, maintain the contrary opinion. The authors of the former view adduce countless histories of lamps shining with perpetual fire, and report marvelous things about the perpetually burning lamps of the ancient Egyptians: concerning the lamp of Tullia, the daughter of Cicero, found still burning in her tomb when Paul III sat [as pope] — which, however, was extinguished at the first whiff of the outer air; concerning the golden lamp of Callimachus, placed in the shrine of Minerva [Fanum Minervae], burning for a whole year, extinguishable by no force of rains or winds. Of a similar lamp Bernardino Scardeone [Bernardinus Scardeonius] tells, in his *On the Antiquities of Padua* [*De Antiquitate Patavini*]. Della Porta [Giovan Battista della Porta] [tells] of the lamp perpetually burning near Naples, by Nisida [insula Nisida]. Of the lamp of Pallas, see Volaterranus [Raffaele Maffei "Volaterranus"] and countless other authors who have written about the lamps of the ancients shining with perpetual fire — see them in Fortunio Liceti, in his *On the Lamps of the Ancients* [*De lucernis veterum*], which is wholly devoted to persuading the world of the invention of perpetual fire. Whether, then, a lamp can be contrived by the aid of an asbestos wick, or by some other liquor, I shall now disclose.

[Margin: What things are necessary for a perpetual lamp.] A perpetually burning lamp can be considered in three ways. First, insofar as, by God's miraculous operation, it can burn forever — [Margin: The lamp placed by Constantine, as found in the *Life of Sylvester* I, Pontiff.] as is recorded in the *Life of Sylvester*, in [the matter] of the lamp set up by the emperor Constantine; ...of the perpetual lamps arranged in the Baptistery of Constantine; and the other lamp set up in Antioch, a city of Syria, of which Nicephorus [Nicephorus Callistus] relates that it

shone perpetually above the door of the church. Of such miraculous lamps, since they exceed the powers of nature, we say nothing. In the second way they can be considered, insofar as some lamp can be designated that lasts a long time; and about this, too, there is no controversy, since there is no doubt that this can be done. Third: whether a truly and properly perpetual lamp, with a flame that will never die, can be made by the aid of asbestos, or of some other thing? Here is Rhodes, here leap! [hic Rhodus, hic saltus] — and about this, as a fitting place, I have judged that something should be discussed here.

To establish a perpetual fire, then, very many considerations, most worthy of attention, must concur. First, that the wick in the lamps be incorruptible, and that the oil by which it is fed be durable and indissoluble. Second, that the oil — or whatever inflammable liquor — be so constituted that it always acquires only as much new liquor as has vanished by exhalation, and that there be a perpetual ἀντιπερικύκλωσις [Greek: ἀντιπερικύκλωσις (antiperikyklōsis, "counter-circulation, circular replacement")] of the consumed liquor and of the newly arriving liquor. Third, that the lamp be so defended from the external air that the air should have not even the least commerce with it — and who does not know how difficult that is?

These things considered and weighed: [Margin: Why a perpetually burning lamp cannot be made.] I say, first, that it is not possible for such a lamp to be made. And as to the first point [the wick]: although an asbestos wick is indeed incombustible and can in no way be consumed by fire, as is established by the experiment adduced above, yet because such a wick requires a liquid similar to it in all respects — that is, inconsumable — and this has hitherto been discovered by no one, the whole contrivance of the perpetual lamp deservedly collapses.

To the second [the oil] I say that, by no artifice of human ingenuity, can a liquid be prepared that is (so to speak) inexhalable, and that, with the flame perpetually acting upon it, will not in the end be consumed — just as it cannot happen, without a miracle, that a man should live forever with no nourishment. For these things are so connected by nature that they cannot be separated from one another: wherever there is fire and moisture, there the moisture must be attenuated into vapor or exhalation; and wherever there is exhalation or evaporation, there too the thing from which it breathes forth must, with time, likewise be consumed. But to bring it about that some thing should, in the presence and activity of fiery heat, neither be consumed nor evaporate — that is the same as to put a bridle on the necessary operations of nature, and so it belongs to none but God, the founder of all things.

[Margin: A flame enclosed in glass cannot be preserved.] To the third I say that to preserve a perpetual flame in a glass vessel closed on all sides is contrary to all the principles of Nature; since the flame feeds not only on the oil but also on the air existing in the vessel — and since, by hypothesis, no other air can enter — it cannot happen that, the air being consumed and no other succeeding, the flame should last. And experience makes this so manifest that no one can doubt it. Nor is there any need to allege here that the flame must last for fear of a vacuum [metus vacui]: for who does not know that the vessel will sooner be burst than that Nature should tolerate so great an inconvenience? — and this is clear from the experiment, adduced in the preceding pages, of the bursting of an iron vessel for fear of a vacuum. Nature is so tenacious of her rights that she shows herself inexorable to the craftsman who tries to fashion such machines by art, lest she should seem to have granted to man what she has reserved for herself alone. The whole labor of human industry expended in constructing a lamp of perpetual fire is therefore in vain.

[Margin: Objections.] But you will object to me: What has once been done can still be done to this very day; but from the histories we have it that such lamps were discovered, furnished with a perpetual flame; therefore, by the effort of human ingenuity, those same lamps can be made today as well.

[Margin: Reply to the objection.] I reply, first: that not everything is true which authors — either to stir up admiration among men, or to propagate the memory of so unusual a thing — have not so much handed down about such lamps as invented. And to show this, I say first: either such lamps were constructed by divine art and through a miracle, of which we are not speaking — since to God nothing is easier than...[to make fire] ...to preserve fire without any fuel, with no wick added, in perpetuity, by the mere will of his pleasure.

Second point. Just as we have a true and authentic account of the lamps found in the tombs of the ancient Romans, so too many things—especially among superstitious grave-diggers—may well have happened from which they drew a false argument for their assertion.

[Margin: Objections and replies.]

But you will say: people have seen a living flame in the tombs. I grant it—but not one burning perpetually in lamps. Rather, it was kindled suddenly out of the putrefied air shut up there through the centuries of many years, or from the breath of those entering, or even from the access of outside air coming in, by a certain antiperistatic power. So testify all the grave-diggers who work at

investigating the underground monuments of the ancients or at digging out treasures. When I questioned them about this apparition, they consistently confirmed that they had seen such flames in newly-uncovered vaults and tombs. And I myself have learned by experience, more than once, in the cemeteries they call subterranean Rome [the Roman catacombs], that those who—soaked with sweat—enter through some narrow opening into the hidden chapels of the ancients, shut up from time immemorial, give off little flames or small lights from their heads, after the fashion of will-o'-the-wisps [fatui ignes]. And daily experience in cemeteries exposed in sunny spots teaches well enough, and more than enough, that this is not without superstition on the part of simple folk, who, when they see flickers of this kind, wrongly imagine to themselves that they are the souls of the people buried there.

[Margin: Why a will-o'-the-wisp [ignis fatuus] appears in cemeteries.]

There is also a deception not unlike this: just as in dark and gloomy subterranean places even the least bit of admitted external light, or of illumination from a torch, shines out wherever there is anything apt to reflect light, so too a reflected light arising easily either from some fragment of glass, or from some phosphorescent material (whether it be wood, or rotten bone, or a worm, or any other insect shining with native light), can readily deceive men struck dumb with wonder.

[Margin: Objection and reply.]

But here they object: they themselves saw a living flame. I grant it—but not one shining with a perpetual fire. They press further: they found lamps in that same place. I grant this too—but only ones filled up with dust. They add: they saw lamps still smoking. I grant the whole of it—but without any wick; for the smoke they saw by a false imagination could have been from a torch itself, or from the very breath of the man, which, condensed in the thick and rotten air, could easily deceive the eyes.

[Margin: Prudent men do not believe in perpetually-burning lamps. (Margin cites a folio reference: "...scriptores...2. p.[?]" — see QA.)]

Third point. Lamps said to have burned perpetually, which the ancient Egyptians, Greeks, and Romans used, have always been suspect to judicious writers, since no one is unaware how much men have always invented in order to perpetuate to posterity the memory of the marvels they discovered—with how many fabrications, with how many and how great lies, they wove these tales. There is also this: the enemy of the human race [the Devil], to foster the

superstitions conceived in their minds, has always mingled himself into all their oracles and sacrifices, and has deluded them in many and various ways—or, as our Delrio [Martín Del Río] thinks, by the magical art he fashioned both the statue of Memnon and lamps blazing with perpetual fire; for nothing could have been easier for the Devil than to supply such lamps with ever-new material, whether real or apparent.

[Margin: Delrio, *Disquisitiones Magicae* [?], 2.27, Sect.[?] — see QA. / "...314" page reference — see QA.]

On these matters, see how fully [I treat them] in the *Oedipus Aegyptiacus*, vol. 2, part 2, in the *Treatise on Hieroglyphic Magic*; likewise the last chapter of the third volume, *On Egyptian Lamps*. For if the Romans enjoyed the benefit of perpetual fire in lamps, why did they make use of whole flocks of Vestal Virgins appointed to preserve the fire?

[Margin: An argument by which perpetual fire is discovered [?].]

I am not unaware that very many people greatly long to find out and assign some physical cause for this perpetual fire. There are those who think that lamps of this kind lasted so long because the smoke, exhaling by the combustible power and by the action of the fire, can be condensed again and driven together into a liquid that is once more inflammable—by a perpetual circulation. We have refuted this above. Some, along with Francisco Citesius [Francesco Citesi/Citois?], think that in these lamps the wick was of amiantus, and the oil was drawn from metals by the chemical art. Others suppose that lamps fed by gold dissolved by art into a greasy liquid burned for a very long time, ventilated in the bosom of the earth by air entering through hidden passages.

[Margin: Various opinions by which perpetual lamps could be made.]

Libavius [Andreas Libavius] is of the opinion that they contained powders and filings of the stone jet [gagates], onto which a drop of water—or an aqueous vapor—forever distilling would perpetually excite the flame, and, once excited, would preserve it. The alchemists, just as they always invent ridiculous dreams for themselves about their Philosophers' Stone, so too suppose that by its aid lamps can be kept burning with a perpetual fire. But just as no stone of that kind ever existed in the nature of things, so too I judge it vain and pointless to set going more extended discussions about it.

Nor does that lamp of Olybius [the "Olybius lamp"]—which they so greatly exalt in order to establish their view, on account of the inscription engraved upon it—prove anything. The inscription runs in these words:

Touch not, you thieves, the offering sacred to Pluto; Unknown to you is this thing that lies hidden in the world. For the elements, gathered together with grievous labor, I have shut up; Beneath this small vessel [lies] the great Olybius. Let plenty's horn stand by as a second guardian for itself, Lest the prize of so great a fluid perish.

But what Scardeonius [Bernardino Scardeone] reports so cleverly about the lamp of Olybius, found at Padua [Patavium], must be understood not of the perpetual light by which it blazed, but of that liquid which turned everything into gold—if one may say so. Who does not know that the ancients, men of charming wit, inscribed many such things upon hidden monuments to delude posterity with a truly solemn cunning? Since this is so, the question at least is raised, whether by human art any lamp can be **built** that blazes with a perpetual fire—

[Now Fol. 71, recto, header "DE ASBESTO, SUCCINO, &c. 71." Reading order within this composite folio: the asbestos-oil paragraph in the left column continues Caput I; then the "Varii construendarum lucernarum" rubric introduces the survey of authors' methods, MODUS PRIMUS (Porta) and MODUS SECUNDUS (Trithemius/Korndorfer). The "construi possit. Fateor me..." paragraph picks up the catchword above.]

—**can be built. I confess** that I have indeed spent much time on this speculation, but that I was never able to find anything that met the test.

[Margin: Oil from asbestos [asbestus], if it could be extracted, would be the food of perpetual light.]

I subscribed above all to those who thought the thing was to be accomplished from an asbestos wick and oil. For if oil could be extracted from asbestos, it would surely be of the same power as the stone, and consequently incorruptible; and so, kindled at an asbestos wick, it would burn perpetually. For since it could not be resolved into vapors, it would maintain itself forever at an even rate against the unconsumable wick. Hence I concluded that if anyone could extract oil from asbestos for me, I would without doubt promise him the invention of perpetual light. So at once I dealt with the more skilled chemists about the possibility of the thing; indeed I supplied them with asbestos material to make the trial. In the end, having applied every diligence, they candidly confessed that they had accomplished nothing—so far is that oil concentrated within it from

allowing itself to be separated from its subject. For whatever could be extracted from it was either water, in no way fit to catch fire, or else a viscous material indeed, but so dense, stiff, and clotted [?] that it could not be liquefied by any fire, much less set alight. They added that the oil they call *talc* [oleum talci, "oil of talc"] is of similar stubbornness, and therefore, although it commonly serves for the softening of little women's [complexions], it is indeed called oil but is not oil, since a wick steeped in it never catches flame; and so it is nothing other than phlegm separated from talc by the chemical art.

[Margin: oil from asbestos, if it could be extracted, would be that food of perpetual light. (Margin partly duplicates the running gloss; see QA — left-margin Latin cursive annotations on Fol.71 are a reader's hand and are illegible at this resolution; flagged for review.)]

Various ways of constructing lamps that burn with a perpetual light.

Lest we seem to have reduced the construction of the lamps of the ancients utterly to nothing, in this place we shall bring forward the methods and devices of certain authors by which they thought lamps of this kind could be made, and at the same time we shall examine whether any success is to be hoped for from the prescribed experiments.

MODUS PRIMUS [Method One]

But erroneous, on producing a perpetual fire.

Giovanni Battista della Porta [Joannes Baptista Porta] held that a perpetually-burning lamp could be made. "It is known," he says, "to everyone, that the cause of all the marvels in this world is the fear of a vacuum [vacui metus], and that the Machine of the world would rather be torn apart than Nature admit it [a vacuum]. Hence if a flame be enclosed in glass, with all its vents shut off, then if it lasts even for a moment, there is nothing to prevent its lasting perpetually. But when a flame is to be kindled in closed glass—*this* is the work, *this* the labor: the liquid must be of the most tenuous substance and of the least evaporation; so that if a flame is introduced into the closed glass, which can easily be done by means of burning-mirrors [ustoria specula], it will remain." Thus Porta. But he would have done better to say that the glass, rather than the world, would be burst.

[Margin: A perpetual lamp from asbestos [?] — illegible annotation, see QA.]

Furthermore, a lamp enclosed in confined air will be suddenly extinguished, and experiment teaches this: if you place a candle under an inverted cup, so that, accordingly, all resolution of vapor into new nourishment vanishes—since the

flame is converted not so much into oil as into soot. But because we have refuted a contrivance of this sort above, we shall not dwell on it any longer.

MODUS SECUNDUS [Method Two]

Of Trithemius [Johannes Trithemius], but erroneous.

Bartholomäus Korndorfer [Bartholomeus Korndorferus], a chemist, thinks a perpetual lamp can be made in this way, and he makes Trithemius the author of it.

[Margin: Trithemius's mixture and composition.]

First he mixes 4 ounces of calcined sulphur and alum; from these, driven up into the sublime, he makes flowers. He joins a sextant [one-sixth] of the flowers, together with half an ounce, to crystalline Venetian borax; and onto these, ground up in a glass dish, he pours spirit of wine four times rectified. After making a digestion and drawing off that spirit, he replaces it with fresh, and repeats this two, three, four times, until the sulphur melts like wax on a heated brass plate without smoke; and this, he says, is the food of the perpetual lamp. Afterwards the wick too is to be prepared by this art: filaments of asbestos stone, nearly the length of the little finger and of middling thickness, are bound together with white silk; the wick thus made is first thoroughly cleaned in Venetian glass, or in [some other] purified vessel; it is sprinkled over, then heaped up, and is boiled down in hot sand for 24 hours, with the sulphur always bubbling. The wick, thus anointed and smeared, is so arranged in the glass dish that it projects a little; the prepared sulphur is heaped on; the dish is set into the hot sand so that the sulphur may melt and grip the wick. They say that this, once kindled, will burn with a continuous flame.

[Margin: No mineral by nature [is] apt for making a lamp.]

So then, if we call each ingredient of this experiment to the anvil, we shall find that they can by no means hold up. For who does not know that all minerals—such as sulphur, salt, alum, borax, and indeed even the quintessence of wine—once set aflame, are at last extinguished when the fatty moisture latent within them is consumed? Since all the said things are, both of themselves and by their own nature, corruptible, so too they cannot sustain a perpetual duration of a flame that feeds upon and consumes them. Nor let these people urge some "circulation" or other, since the very thing that is consumed by the flame is, by that very fact, incapable of any circulation. Nor does the circulation of liquids carried out in chemical vessels offer them any support; for the circulation of

liquids performed in a pelican [pelicanus, a circulatory vessel] is one thing, and the circulation of the fat in a lamp by fire—circulating, as they think, back into the same—is another, which, as we said above, will never yield the desired result; since everything that is generated and corruptible cannot be eternal.

[Now Fol. 72, verso, header "LIBER OCTAVUS, Sect.III. 72."]

MODUS TERTIUS [Method Three]

Of Libavius and others.

[Margin: The trick [fucus] of Libavius.]

Libavius thinks a burning lamp can be made in this way: if you kindle asbestos with *Alarbum*, it will indeed burn perpetually. But what this *Alarbum* monstrosity is, it has nowhere been possible to find out. So do those fanatical impostors who, in order to make their experiments look more like the truth, take on a certain appearance of some exotic name (which, however, does not exist in the nature of things) and so throw dust in the eyes of the simpler-minded. There are also others who say they can set a stone alight with spittle alone, and from this they peddle, with shameful boasting, a method of perpetual light. But since I shall dispute more fully about this stone elsewhere in our works, and in this volume in its proper place, I shall not dwell on these matters further.

CONSECTARIUM [Corollary]

From what has been said it is clear that all the industry of human ingenuity in constructing perpetually-burning lamps is vain and futile, and that no such lamp ever existed in the nature of things. Only he can fail to know this who is ignorant of the foundations of Nature and of the all-destroying power of the fiery element—whatever the most learned Licetus [Fortunio Liceti] may write to the contrary. For he holds, and is wholly bent on demonstrating, that some oil can be had, soaked into an asbestos wick, which resists fire to the point of equality [ad aequalitatem]; that is, [an oil] which would have an equal proportion of forces for resisting the fire, so that the fire could in no way overcome it.

[Margin: Of equal forces [there is] neither perpetual motion nor perpetual fire.]

That this is true of asbestos *thread* I freely grant; but that it can be said of *oil*, I deny, for the reasons brought forward above. For these things stand to one another by the same reasoning as a purely artificial perpetual motion stands to the things that produce perpetual motion. For many say that a certain wheel could be made which, by means of a pump [anthlia], would raise just as much

water above as would suffice for turning the wheel—so that, to turn the wheel, as much water would ascend as would be required; and that no one ought to doubt that this motion would be perpetual.

[Margin: Just as a purely artificial perpetual motion cannot be made, neither can a perpetual fire.]

But I, taught and led by experience, say that it is so far from a perpetual motion resulting from this, that rather a perpetual standstill necessarily follows—and the reason is plain to every legitimate philosopher. For since all natural actions are caused in [the moment of] victory, by which one thing overpowers another, where, under an equality of forces, not motion but rest follows—as is most clearly evident from the balancing of waters in channels, which is commonly called the *level* [livello], and as we have demonstrated more fully elsewhere—by a like reasoning [I say] that as much water would ascend as would be lacking, in the proportion of equality for turning the wheel; [and so where] not motion but rest follows.

Indeed, I say that just such an equality of the proportion of forces in acting and resisting was impossible in perpetual lamps, since equality, so far from being able to perpetuate a flame, rather causes that, as soon as they reach that very equality, the flame itself—as if impatient of this equality—goes out of its own accord. We say, therefore, that the persuasion about lamps burning with a perpetual fire is vain. For if any were ever seen, they were nothing other than either an illusion of evil demons [cacodaemons] or a deception of the senses. Nor do we believe Trithemius, that he displayed such contrivances to a wondering world; but since they are of the same flour as the preceding ones, we pass them over. For if he supposes some such power to be in the flame, it will be in it not by the condition of the material, as most suppose, but from the degree of mixture and composition of the ingredients—a degree which, as it has not yet been explained by any of the philosophers, so it still lies hidden in the deep and inaccessible majesty of Nature.

[Margin: The fable of perpetual fire took its origin from the illusion of the grave-diggers.]

That, moreover, this art of producing an oil invincible by fire was not found among the ancients can be shown—besides the arguments that demonstrate it to be impossible—on this ground: that without doubt someone would be found who would make mention of it; and yet there is no one who speaks of it. In the age of Plutarch it certainly ought not to have been lost, if it ever existed in the world, since the barbarians had not yet flooded Europe, and the Roman empire

flourished at its height, and consequently all the arts; and he himself, who was seen to be endowed with such great wisdom and was a most curious investigator of things, would have had at least some knowledge of it. Why then does he himself so greatly marvel that certain lamps lasted whole years without the addition of oil, and try to discover various explanations, when he could have had one ready to hand from this art [if it existed]? How is it that Aristotle—he too, who lived while all the arts flourished in Greece, and who treats frequently of fire and of its nourishment and preservation—never made mention of the matter at hand? How is it that Pliny, most curious and most diligent, treating in Book 7, chapter 56 [*Natural History* VII.56], of the inventors of arts and of even quite ordinary things—such as the mixing of water with wine—made no mention of the inventors of so marvelous an art? How is it that St. Augustine, who lived in an age in which the memory of this art could not yet have been extinct, when dealing with those lamps, says they belong to no other art than the demonic? How is it that those priests, who said that their lamps were kept a whole year without the addition of oil, referred this to something marvelous, [as] if that art of preserving [fire] forever were present? And why did they use lamps of this kind that were yearly rather than perpetual?

[Margin: Aristotle makes no mention of perpetual fire. / Reference to Pliny [recte: *Naturalis Historia* VII.56]. (Additional left-margin page-references in a reader's hand — "l.2 c.20", "p.450", "p.314", etc. — are illegible/uncertain; see QA.)]

And from these things it is clearer than the noonday light that this tradition of perpetually-burning lamps is a sheer and utter fiction, and [arose] from the grave-diggers—

[Now Fol. 73, recto, header "DE ASBESTO, SUCCINO, &c. 73."]

—from the grave-diggers of the monuments, or from a diabolical illusion, or from the persuasion of their own fancy, or finally, in order that it might be said they had discovered something great, was spread abroad among the too-credulous common people; and so they dragged all posterity into a chain of errors, to the point that they even won applause in the chairs of the wise Philosophers.

We have said, then, that lamps shining with a perpetual fire cannot be made by human art at all; and the grounds are so irrefutable that no one can rightfully contradict them.

The question is therefore raised: whether by some other way lamps of this kind—in which the natural is joined to the artificial—might attain the desired effect, [and] could be constructed? I reply that they can.

[Margin: How a perpetual fire can be made, and perpetually-burning lamps.]

But that the assertion may be rightly grasped, I say that, just as perpetual motion can be considered in two ways—purely artificial, and mixed, that is, composed of a natural Principle and an artificial one—so too perpetual fire can be considered in two ways: namely, purely natural, and composed of the natural and the artificial. Just as, therefore, a purely artificial perpetual mobile cannot be granted in the nature of things, so neither can a purely [artificial] perpetual fire, whose reasons we have shown a little before. But that a *composite* perpetual motion, composed of the natural and the artificial, can be granted—as also a [composite] perpetual fire—ought to be in doubt to no one. This I teach by the following experiment.

EXPERIMENTUM [Experiment]

Of perpetual fire.

If anyone finds a place, or a mine or vein, in which bitumen, or any other inflammable liquid, gushes forth perpetually as if from a natural matrix—of which kind are found in not a few regions, as we showed in the First Volume, Book V, on bituminous places [*Mundus Subterraneus*, vol. 1, Book V]—

Diagram. A landscape engraving titled *De igne subterraneo machina* ("Machine of subterranean fire"). At the left, a masonry vaulted chamber (an arched, brick-lined cellar) opens toward the viewer; inside it stands a tall cylindrical vessel labeled **A** with a lit flame on its rim. To the right rises a mountainous landscape in cross-section; near the upper right a spring is labeled, and a conduit/pipe runs down the slope from a basin to the lamp-vessel.

- *De igne subterraneo / Machina* (banner, upper-center): "Machine of subterranean fire" — the figure's title, repeated within the image.
- *Fons petrolei* (upper right, at the spring): "Spring of petroleum."
- **N** (basin, right-center): the reservoir vessel set within the natural matrix, receiving the gushing bitumen/petroleum/naphtha.
- *Canalis* (along the pipe, right): "Conduit/channel."
- *Plumbeus* (along the pipe, lower-center, with **M**): "Leadен" — i.e. the leaden conduit (*canalis plumbeus*, LMN); the letters **L**, **M**, **N** mark its course from the reservoir down to the lamp.
- **D** (at the lamp's rim, left): point on the cylindrical lamp-vessel (the wick/float assembly).
- **A** (the cylindrical vessel, lower left): the lamp-vessel itself.

- *Lucerna / subterranea* (caption beneath vessel A, lower left): "Subterranean lamp."

[Margin: A machine of subterranean fire.]

I say that by the aid of this anyone can keep a perpetual fire going, by this device. In some suitable place where you want a lamp to blaze with perpetual fire, let there be set a vessel—whether of glass, or of clay, or cast from metal—of cylindrical shape, a palm in diameter, as letter **A** shows in the Figure. Within this vessel [place] a wick made of asbestos thread, which is to be held up by an iron wire twisted into a little ring, and supported by a cork circle—so that the iron wire may not sink down together with the wick—so that it always floats on top of the liquid. This done: within the true [vein] or matrix let another vessel, **N**, be arranged, to receive into itself the bitumen, or petroleum, or naphtha gushing out there. From the bottom of this vessel, a leaden conduit, **LMN** (or one made of some other material that can hold the oil), is run all the way to vessel **A**, fitted with its wick, so that its outermost orifice continually drips in over the lip of the vessel. And you will have a perpetually-burning lamp. For since the oil never fails, but ever-new nourishment is supplied to the lamp through the conduit, and since the asbestos wick is also of itself and by its own nature unconsumable, the lamp will in this way shine with a perpetual fire.

But lest this seem new to anyone, let him know that the ancients—

Liber VIII "Λιθογενής," Sectio III — De Asbesto, Succino, &c.

[Caput I, conclusion — De Asbesto, seu Amiantho] ...that the ancient Egyptian lamps, which they kept perpetually burning with an undying flame in their sacred crypts and innermost shrines, were contrived by the very ingenuity here described. That this was so, an Arab author teaches in plain words in his history *Of the Memorable Things of Egypt*. [Margin: How the Egyptians made perpetually burning lamps.]

"There was in Egypt a field," he writes, "whose pits were full of pitch and liquid bitumen. The philosophers, knowing the power of nature, laid out certain channels from such places as far as the underground crypts in which they placed the lamp; this lamp was joined to the channels just mentioned. The lamp itself had a wick made of slime [*limus*] which cannot be consumed by fire, and in this

way, once lit, the lamp burned perpetually — both because of the perpetual inflow of bitumen, and because of the incombustible wick of slime."

Anyone who wishes more on this subject may read my *Oedipus Aegyptiacus*, vol. II, ch. 3, Syntagma XX, where he will find treated whatever one might wish to know about the lamps of the ancients (*Oedipus Aegyptiacus* II.3, Syntagma XX).

CAPUT II.

On the preparation of asbestos flax [linum asbestinum] for weaving into cloth and for making paper.

[Margin: How the texture of asbestos-flax cloth is made — a great secret.]

The monuments of the ancients teach us that cloths existed which were immune to every torment of fire; nor are such cloths lacking today, though those skilled in this art are exceedingly rare — men who, with enormous profit, know how to spin this downy stone and weave it into fabrics. We display specimens of this kind for viewing in our Museum.

The question, then, is how this is done. Certainly, just as it holds no mean place among the greatest secrets of nature, so too it should be kept under the strictest secrecy and communicated only by word of mouth to kings and princes — lest something that was prized so highly at every period should now become known even to the basest of men. I am well aware that various people have indeed attempted the art by various methods, but always with wasted labor. Anselmus Boetius [Anselmus Boëtius de Boodt], Libavius, della Porta [Giambattista della Porta], and others give a method, but, deceived by an utterly false account, they accomplished nothing — for by those methods it is impossible to achieve the desired result. So, leaving this secret aside, I turn my pen to describing another matter: namely, how paper can be made from this stone. [Margin: How asbestos paper can be made.]

Such paper remains forever the same among those who keep up a reciprocal correspondence by letters. For if I have written my mind to a distant friend in such paper by letters, and he, on opening the letter, has grasped the sense of my mind, then he will throw the paper into the fire and cleanse it of every mark of writing; and on the cleansed surface, where the writing was, he will write back his reply to me in the same sheet. And when the need to reply arises, I will throw the paper into the fire and clean it, in order to answer my friend's questions in it.

You will make such paper thus: In a mortar let asbestos stones be pounded in no small quantity, until nothing but a downy material appears. This done, let a sieve

be made in the fashion of a small grate, fashioned of iron wires — or better, of copper — so arranged that the wires are spaced as little apart from one another as possible, exactly in the manner that papermakers commonly use today. Then stir the downy material well, having put it into water; take up the stirred material with the sieve, and shake the sieve until the downy material is spread out into the form of a sheet conforming to the shape of the sieve. Note here that, after the material has been stirred in the water, it must be caught up with the sieve without any delay; for if you wait even the briefest time, the material — being mineral and by its innate gravity — will at once sink to the bottom, and so you will draw up nothing but water in the sieve. Having spread out the material according to the shape of the sieve, you will lay it out — taken up on the usual filter or cloth — in a shaded place until it dries, and you will have paper prepared for the said uses.

CAPUT III.

On amber [De Electro seu Succino], commonly Ambra.

Although in our *Ars Magnetica* I have set down many things worth considering concerning the nature and properties of amber, here I shall demonstrate its nature more fully. There are various opinions about its name; lest we waste effort on them, let the reader consult the writers on mineral matters — Caesius [Federico Cesi / Bernardino Caesius], Agricola [Georgius Agricola], Caesalpinus [Andrea Cesalpino], Fallopius [Gabriele Falloppio], and countless others. It is therefore called *succinum* [amber] because it hardens out of a bituminous juice [*succus*] into a stony substance; it is called ἤλεκτρον [Greek: ēlektron, "amber" / "electrum"] — *Electrum* — on Agricola's testimony, named so from its drawing of chaff [*paleae*]. And the Arabic word كهربا [Arabic: kahrubā, "amber" — lit. "straw-snatcher"] — *Carabe* — on the testimony of Abalali and Camus, likewise took its name from the drawing of chaff. It is also called *Ambra*, though only improperly, on account of a certain likeness and analogy that ambergris [*Ambra*] of precious scent has in its compound. But here our business is not with words, but with the very quiddity and essence of the thing.

It is asked, first, what amber properly is. [Margin: What amber is.] I am not unaware that there were some among the ancients who judged amber to be the tear of some tree or other — which is so far from being true that, on the contrary, almost daily...

we have drawn it [chaff] without any difficulty or resistance, so that I cannot wonder enough that there was no one who dared to make so easy an experiment with basil [*ocymum*], which is everywhere at hand. But similar things are read,

and at once, without consulting experience, are wrongly believed; so it is no wonder that so many chained-together errors have been propagated in the Schools right up to this day.

Amber, then, draws all light things, with absolutely no exception, provided that their innate gravity does not set an obstacle to the agent. Indeed, we have drawn not merely any light objects whatever, but even the heaviest metals of every kind — iron, gold, silver, lead of ten and twenty pounds; wooden staves, spears, gloves — with a fragment of amber, by a static experiment. The procedure is as follows.

[Margin: Definition of amber] — [The following passage is printed on fol. 75 and logically belongs to Caput III, before the experiment above.]

No one henceforth should suppose that amber draws its origin from a vegetable nature: a rash experience has persuaded him this without due thought. But let him hold for certain that it is nothing other than a certain earthy bitumen, which has its birth in the underground passages of the earth, through seepages set there by provident nature. And how it is produced, I shall explain in a few words.

We spoke in the first volume, Book V, of the veins of bituminous places, and how Nature produces each of the several distinct species of bitumen, each according to the property of its soil. Standing on these principles, we define amber thus: **Amber is an underground bitumen, welling up from an appropriated matrix of earthy material; entrusted to the sea through the seabed or by the wash of bank or river; and there, washed up on the shores, it grows by the inborn dryness of sun and air into a stony substance.**

We said it is an underground bitumen — for, like asphalt [*asphaltum*], naphtha, petroleum, and the like, it has its own modes of welling up. Anyone who has rightly grasped what we treated of bituminous places in Book V of this work will see at once, beyond doubt, that the inmost bowels of the Earth abound in such oily liquids, born of a natural, appropriated fatness of the earth — which is, as it were, a certain glue of mixed bodies, set into all and each of them for the solid binding of their parts. This bitumen is distinguished from the rest just cited by a certain specific difference, in that it acquires its property from some earthy material — whether sulphurous and duly purged, or from a vein of jet [*gagates*], or from a frankincense-bearing underground mineral material through which it distills. In a word, it takes its property according to the purity of the material through which it flows, as its very color, odor, and taste sufficiently show: in the white kinds it is most pleasing; in the tawny, less agreeable; in the ashen, it even

has the smell of burnt sulphur. Thus the purity of the material it flows through grants it powers more or less perfect.

We have, then, the origin of underground amber; now we must say how it hardens. Since bitumen of this kind, by its nature — like all oily things — is light and airy and seeks the surface above the water, it accordingly wells up from places beneath the water and, floating on the surface of the sea, is rolled to the shores by the impulse of the waves. There, in the form of a honey-like substance, it remains still soft and liquid, until little by little, growing sluggish in the dryness of the air, it hardens into stone as a hard material. Let us prove more clearly that this is indeed so.

CAPUT IV.

How little animals of various kinds have obtained their tomb in the heart [meditullium] of amber.

[Printed fol. 75 bottom, continuing to fol. 76.]

[Margin: Little creatures in amber.]

That transparent or clear amber displays, here and there, various little animals — not only does present-day experience teach this, but the ancient writers on natural matters have also attested it. Pliny [the Elder], book 37, ch. 3, says: "That amber drips out in liquid form at first is proved by certain things that show through within it, such as ants, gnats, and lizards, which were no doubt stuck to it while it was fresh, and were shut up as it hardened" (*Naturalis Historia* XXXVII.3). Dioscorides confirms this. Brasavolus [Antonio Musa Brasavola], in his examination of gums, says that he had at home a piece of amber in which there was an ant so wonderfully whole that not even the smallest leg was missing.

[Margin: They have obtained their own tomb.]

Agricola, subscribing to these statements, says: "Of these, the tawny and the wine-colored kinds are mostly transparent, and in them there sometimes show through small beasts — winged ones, such as the fly, gnats, bees, or wild ones, like the ant, little red worms, spiders, lizards, vipers; or swimming ones, like little fishes, or parts of beasts, such as the wings of flies, the eggs of fishes; or inanimate things, such as bits of herbs, leaves of plants — all of which had earlier flown, crept, or fallen into the sea; and afterwards, when that most excellent bitumen flowed out of the earth into the sea, it seized them and shut them within itself, and so, enclosed, they were turned into stone together with it."

To which Martial finely alludes, book 4 [*recte*: book 6], Epigram 15; book 4, Epigram 32 [?]; and book 4, Epigram 59 [the cited references — "l. 1. Epigram. 99. & 118. & l. 6. Epig. 12" as printed — are garbled; transcribed as printed and flagged]:

Epigram 12 [as printed]: *"And the drop fallen from Phaethon's tree both hides and shines, so that the bee seems shut up in its own nectar. A worthy reward she won for such great toils: one may well believe the bee herself wished to die thus."* (Martial, *Epigrams* IV.32)

ANOTHER: *"While a viper crept among the weeping branches of the Heliads, an amber drop flowed onto the beast that blocked it. While it wondered at being held by the rich dew, it suddenly stiffened, bound fast in the congealed ice. Take no pride, Cleopatra, in your royal tomb, if a viper lies in a nobler sepulchre."* (Martial, *Epigrams* IV.59)

ANOTHER: *"While an ant wandered in Phaethon's shade, an amber drop entangled the slender creature. So that, having been despised while life remained, it has now by its own funeral been made precious."* (Martial, *Epigrams* VI.15)

That all this is so, various fragments of amber in my Museum show — full of flies, ants, and the like; indeed, a string of beads, which they call a Rosary, is on display, in which as many amber globes are seen as there are different flies. In past years the Most Serene **Augustus, Duke of Brunswick and Lüneburg** [August the Younger, Duke of Brunswick-Lüneburg], a prince refined in every kind of learning by a rare example, sent me — out of his truly singular affection toward me and my studies — a piece of amber half a palm long, in which nature displays a little lizard so whole that there is no limb in it which is not most clearly seen, to the great wonder of those who behold it. Let the reader look at the figure placed here. [Margin: A piece of amber in the author's museum, in which a lizard is seen entire.] I recall that I once saw a similar piece in the Treasury [*Gazophylacium*] of Cardinal Francesco Barberini, in which a little frog had chosen for itself a tomb of undeserved honor.

It is asked, then, how little animals of this kind come to possess the heart of the amber; how they enter; and why they do not appear on the outermost surface. [Margin: How the said little animals are seen.] And although Agricola, cited a little above, assigns some sort of reason for it, yet since it does not satisfy the curious, I shall set out the manner a little more clearly.

When, therefore, the bitumen — still liquid and soft — is rolled by the waves of the sea to the shores, it happens that, gathered there among the sands and rocks, it grows sluggish in the dryness of the air. At this point little animals of this kind, drawn by its taste and smell, as soon as they have settled upon it, are at the same time seized by the stickiness of the material as if by some birdlime [*viscum*]; and being unable to free themselves from it, meanwhile — the material still being movable — they are little by little worked by the great sea-waves into globes or some other shape. And in this way, one wave thrusting and then another, the little animals, glued in, are wrapped about and withdraw into the heart of the mass. And I judge this to be the reason — saving the judgment of others — for the little animals appearing in the midst of amber. Thereafter, covered over with sand and rocks, in the course of time they harden into stone, honored with this noble amber monument of a sepulchre.

Diagram. A large engraved woodcut showing an upright, egg-shaped (ovoid) mass of amber, rendered as a translucent stone, standing on a flared, striated base resembling a turned pedestal or a fan of fine lines. Within the body of the amber, a lizard is depicted entire — head raised toward the top, body curving in an S-shape down through the center, the limbs and tail clearly delineated — the very specimen described in the text, sent to Kircher by Duke August.

- Caption (above the figure, in the right column): "*Non poterat tumulo nobiliore tegi.*" [It could not be covered by a nobler tomb.]
- Attribution (below the caption, above the figure): "*Donum Sereniss. principis & ducis Augusti Luneburg. & Brunsvicensis.*" [A gift of the Most Serene prince and duke August of Lüneburg and Brunswick.]

CAPUT V.

On the attractive power of amber [De attractiva Electri virtute].

[Printed fol. 76, lower; the experiment proper is printed on fol. 77 — see the EXPERIMENTUM section below.]

That amber draws to itself chaff, straw, and all light things was already known to the ancient writers on natural matters — Theophrastus, Pliny, Aelian, Solinus, and the rest — and present-day experience proves the truth of the matter more than abundantly. Yet I have always wondered that, from those times down to this present day, an opinion has been propagated: most people think, and firmly persuade themselves, that amber draws to itself all light things *except* basil [*ocimum*], or things smeared with oil, by some antipathy or aversion I cannot name. [Margin: A false opinion, that amber draws all things except basil.] A

plainly obvious error: a hundred times, in the sight of many, we have drawn basil with amber, and likewise any other small things whatever — whether chaff, or straws, even ones smeared with oil and grease — without any...

EXPERIMENTUM.

A marvelous experiment of electric attraction [Attractionis Electricae mirabile].

[Printed fol. 77.]

On a certain beam A B, let an iron arm be led out from H, from whose hook G let a thread hang down, which at the middle of any length whatever grasps, at point I, a balance-beam [*librile*] E, F made of any material. If you first bring a fragment of amber, warmed by heat, up to the unmoved end E F of this beam, at once the amber, leaving its station, will follow it. If you hang a weight on this balance E F, the threads of amber [?] will likewise follow in their turn. A truly fine experiment, with which the spectators of my Museum are often refreshed.

Diagram. A schematic illustration of the electric-attraction apparatus. At the top runs a horizontal beam labeled at its left and right ends. From a hook, a vertical thread descends (labeled at its lower point) to a small ring or pulley, below which hangs a horizontal balance-bar drawn as a narrow rectangular rod. A hand emerging at the side (an engraved pointing hand) indicates the apparatus.

- A, B: the ends of the upper horizontal beam (*trabs*).
- H: the point from which the iron arm is led out.
- G: the hook from which the thread depends.
- I: the point at the middle where the thread grasps the balance-beam.
- E, F: the two ends of the lower balance-beam (*librile*).

This too is worthy of wonder: that amber brought near to a flame, so far from drawing it, rather blows the flame away and disperses it. The cause of this is none other than that, when the very light flame cannot resist the spirits roused out of the amber by heat, it is driven off by their force into the opposite direction. But a little drop of water it draws so as to raise it into a cone. All those mixed bodies similar by natural kinship produce the same effect — such as jet [*gagates*], hard bitumen, and electric bodies of every kind whatsoever.

It is asked, then, what the reason for this is, and how this power is distinguished from the attraction of the magnet. [Margin: Whether it is a magnetic force.] I say there is a remarkable difference between the attraction of the magnet and that of amber:

- The magnet draws only determinate bodies, such as iron and the like; amber draws all things without distinction.
- The magnet not only draws iron, but also communicates its power to it — which amber does not do.
- The magnet exerts its force through determinate poles; amber exerts the same force everywhere and from every point.
- The magnet draws without preparation; amber, by contrast, [does not].
- The magnet's effluvium is immaterial, penetrating all things; amber's is material, ceasing to draw when the smallest objects are interposed.

I say, then, that amber's attractive power comes about thus: When the amber, having first been rubbed and warmed by heat, emits a most subtle effluvium, it happens that the surrounding [air], driven away as far as the chaff and repelled by the surrounding [medium], carries off with itself the lighter objects — up to the surface of the amber, where, glued by a thin fatness, it adheres. But since we have proved all this most fully and by various experiments in our *Ars Magnetica*, book 3, part 3, ch. 3, we refer the reader there, where he will find treated whatever one might wish to know concerning the electric attractive power.

CAPUT VI.

On the medicinal powers of amber [De Electri sive Succini medicis viribus].

[Printed fol. 77.]

That amber has an enormous use in medicine is everywhere agreed. For since it is endowed by its native faculty with the power of cutting, dispersing, warming, and gluing together, it accordingly confers a notable benefit for routing all the ills of the vital parts. [Margin: The diseases driven off by the help of amber.]

Hence, in the judgment of physicians, when bound to the neck it is a remedy for fevers; ground with honey, for dimness of the eyes; it stops blood flowing from anywhere; it removes vomiting of the stomach; it stops fluxes and discharges of the belly, by which ulcers are infested; it stops distillations of the head [catarrhs]; it helps the tonsils and ailments of the throat. And because it strengthens the viscera and the other parts of the body, provided they are not overflowing with humors, when drunk with wine it protects a man from epilepsy and from the loosening, convulsion, and distension of the nerves. It soothes pains of the stomach when one is bathed with amber oil [*oleum succineum*]; and because it is fragrant, it benefits the heart and remedies its trembling; its fumigation [*suffimentum*] dries up the phlegm of the head; it removes difficulty in childbirth; it weakens the rottenness of pestilential air — so that in time of plague no better

or nobler fumigation can be assigned. The oil, rubbed on the hips, frees one from sciatica and pains of the kidneys.

In external matters too it has an outstanding use: for its shavings, added to a lamp, make the flame both brighter and more lasting. That vessels and reliefs of every kind are carved from it is too well known to need saying; and it was once held in such high esteem among the ancient Romans that a tiny figure of a man carved in amber exceeded the prices of the other gems. Finally, for the prayer-beads which devout people for the most part use, nothing is more common. But let these things said about amber suffice.

BOOK EIGHT "Λιθογενής," Section III — *On Asbestos, Amber, and the Like*

A COMBINATORY TABLE

In which the forms and virtues of all precious stones are briefly set out, arranged in alphabetical order.

The table runs across four folios in alphabetical sequence of stone-names. Each entry gives the name, then a description (form, color, places of origin), then the stone's reputed powers and properties. The entries are transcribed below in their alphabetical order, which corresponds to folios 78, 79, 80, and 81 of the source. Throughout this table Kircher reports these "virtues" as traditional lore — note how often he himself flags a claim as mistaken (*perperam*, "wrongly") or as the fancy of magicians.

[Margin: handwritten reader's note at the head of folio 79, in cursive ink: "Calc Barias" [?] — an early annotation, reading uncertain.]

Folio 78 — A through Calcedonius

Name	Form, Color, Places of Origin	Powers and Properties
Adamant [Adamas] (diamond)	The most excellent of all gems, of unconquerable hardness, transparent; the true and genuine kind forms in India.	Taken internally it is a poison, because of its caustic power; when worn it is said to be a gem of reconciliation, of fortitude, and of

Name	Form, Color, Places of Origin	Powers and Properties
		constancy — but wrongly so, as we have noted elsewhere.
Aetites [Aetites] (eaglestone)	Named from the eagle [Aquila], because it is said to be found in eagles' nests; within its own body it carries another, loose stone.	There are various kinds, but all are "pregnant" with another stone inside. It is most praised when applied to women suffering difficult childbirth.
Agate [Achates]	A gem remarkable for its varied figures, tinged with differing colors. It is found in India and in various places in Europe, and commonly in Germany.	It is said to counteract pestilential poisons and the stings of vipers and scorpions; it calms the heat of fevers, and benefits the eyes.
Alabaster [Alabastrum]	A splendid marble of various colors — white, black, and honey-colored; found in Egypt, Sicily, and Etruria [Tuscany].	Burnt and mixed with resin, it dissolves hardness; mixed with wax it soothes stomach pains; drunk with milk it cures dysentery.
Amethyst [Amethystus]	It is of a violet color, and takes on various differences according to the differing conditions of the places where it is found.	It is thought to resist drunkenness — from which it takes its name [Greek: ἀμέθυστος (amethystos, "not drunken")]. The superstitious also believe it confers natural talent and the favor of princes.
Asteria [Asteria], or Astroites	It takes its name from the little stars with which its whole body is, as it were, painted. It	Poured over with vinegar, it moves of its own accord this way and that. Tied on children, it

Name	Form, Color, Places of Origin	Powers and Properties
	divides into various kinds and is found in various places in Italy.	is believed to cure smallpox.
Balanites [Balanites]	So called from the shape of an acorn [glans]; there are two kinds, greenish and yellowish, found in various places.	They are said to have an astringent power, and so to cure diarrhea.
Basalt [Basaltes]	It is reckoned among the marbles, because it takes the finest polish; hence it is also counted among the touchstones [Lydii lapides], well suited for testing gold and silver.	In Meissen, near Dresden, it is quarried in great quantity, and commonly serves the office of a touchstone.
Belemnite [Belemnites]	So called from the shape of an arrow [sagitta], which it resembles. It is found in various colors and is also called Lyncurius; from a broad base it grows up to a point.	Its powder heals wounds; it breaks up stones [calculi], and is said to ward off nocturnal apparitions.
Beryl [Beryllus]	A gem that counterfeits a bluish color out of green, like seawater; it divides into various kinds, and seems to be a species of crystal.	It is said to be especially good for the eyes, its powder mixed with rose-water or lily-water. It corrects ailments of the liver. The superstitious claim it wins over men's affections.
Toadstone [Bufonius Lapis], Batrachites	Found in a toad [Bufo], it has the figure of a star-stone, of various colors.	It is thought to resist poisons above all, applied to the affected parts; it prevents stones of the kidney and

Name	Form, Color, Places of Origin	Powers and Properties
Chalcedony [Calcedonius]	It shows various colors according as it is exposed to different light; it is semi-transparent, and is reckoned among the onyxes.	bladder. It is said to cure black bile and melancholic afflictions, as well as fear, sadness, and the hypochondriac disease.

Folio 79 — Carbunculus through Granatus

Name	Form, Color, Places of Origin	Powers and Properties
Carbuncle [Carbunculus], Pyropus, Rubinus (ruby)	So called from the light by which it shines like a glowing coal [carbo]; hence many wrongly suppose, falsely, that by its brilliance it gives light like a torch at night.	It resists poisons, restrains lust, gladdens the spirit, rouses to anger, and lessens sleep; when misfortune is impending, it is said to change color.
Carabe [Carabe], or Amber [Succinum]	It is not a stone, but a kind of bitumen, of which we have treated at length elsewhere.	It has great virtues for removing excess humors, as we have already shown elsewhere.
Ceraunia [Ceraunia] (thunderstone)	So called from the thunderbolt [fulmen], because it is supposedly cast down from the clouds — how that can be, we have discussed elsewhere. It has various kinds.	It is said to be effective against lightning, and for that reason is called Brontias; it is called Ombrias if it falls together with rain and showers.
Chrysoprase [Chrysoprasus]	So called from the splendor of gold [aurum] with which it shines; yet it has some greenness	It has a remarkable power for refreshing the eyes.

Name	Form, Color, Places of Origin	Powers and Properties
	mixed in.	
Conchites [Conchites]	It takes its name from seashells [conchae] turned into stone.	Its powder is said to cure the stone, by a certain sympathetic action.
Whetstone [Cos]	A very hard stone, suited for sharpening knives and other iron tools; there are various kinds of it.	A whetstone rubbed with iron is said to cure the loss of hair and to reduce the spleen.
Dendrites [Dendrites]	It is a stone that reproduces the figures of trees and shrubs; it is found commonly in Etruria [Tuscany].	Its use in medicine is not yet established; nevertheless it has a styptic property.
Dragonitia [Dracontia]	So called from the dragon [Draco], in whose heads it is said to be found.	It is said to have a wonderful power against every kind of poison.
Eneostis [Eneostis]	A stone that reproduces the figure of bones, of which [we have treated] at length above.	It has the power to knit together broken bones.
Enhydros [Enhydros]	It is called a stone from the water [aqua] that it holds within itself.	It is said to have power against weakness of the urine.
Entrochus [Entrochos]	So called from the resemblance to a wheel [rota], which its figure reproduces.	It has the same power as the sandy stones — an astringent one.
Enorchis [Enorchis]	So called from its resemblance to testicles, which its figure reproduces.	It is said to have the power of arousing lust, owing to the natural seal set upon it.
Jet [Gagates]	Not so much a stone as a kind of burnt bitumen; it	It draws up chaff, as amber does; it has a

Name	Form, Color, Places of Origin	Powers and Properties
	has a sulphurous odor; so called from the river Gages.	diuretic property; by fumigation it cures women's diseases, as also epileptics.
Galactites [Galactites]	So called from the milky [lacteus] color which it gives off when wetted with water.	It increases the supply of milk in women and swells the breasts, when ground to a paste with the milk of almonds.
Geodes [Geodes]	It is a round stone, named from the earth [terra] which it contains within itself; if that earth inside should be loose and rattling, then it is no longer called Geodes but Aetites.	It has the same power as Aetites, since it is nothing other than an unripe Aetites.
Glossopetra [Glossopetra]	It is a rock, so called from the figure of a tongue [lingua] which it reproduces; it is found in great quantity on Malta [Melita].	It is good against poisons, as is also the Maltese earth, and it has an astringent power; see the treatment of this elsewhere.
Grammatias [Grammatias]	It is a kind of jasper, so called from the letters and figures, or lines, which it reproduces; it is found in Meissen [Misnia].	It is good against poisons. The magicians dream up marvels about this stone, which you may see in Marbodeus [Marbode of Rennes].
Garnet [Granatus]	They are manifold, tinged with a deep-red [puniceus] color; they are found in great quantity in Bohemia, and of the better sort.	It has a drying power and strengthens the heart; garnets enter into the composition of the <i>elixir of life</i> and the <i>confection of hyacinth</i> .

Folio 80 — Haematites through Morochtus

Name	Form, Color, Places of Origin	Powers and Properties
Bloodstone [Haematites]	So called from the color of clotted blood [sanguis] with which it gleams; and there are various kinds: some are green, gleaming with blood-red points.	All these kinds are good for fluxes of blood, of whatever sort the flux may be.
Heliotrope [Heliotropium]	It takes its name from the Sun [Sol], because it reproduces the image of the Sun; it is found commonly in various places.	It has the same power as jasper and as bloodstone, about which the magicians invent many absurd tales.
Hyacinth [Hyacinthus]	According as it is of greater or lesser redness, it is referred now to the carbuncles, now to the garnets; it takes its name from the hyacinth flower.	It resists plague, gives strength to the heart, brings on sleep, and is said to confer cheerfulness of mind.
Jasper [Iaspis]	There are very many kinds, and according to the colors with which it is tinged it takes different names.	Hung at the neck it stanches blood; it relieves nausea; it benefits epileptics and sufferers from the stone.
Ictérias [Ictérias]	It takes its name from the jaundice-bird [icterus] or <i>Galgalus</i> , a bird of yellow color; for it too is of a yellow color.	It is said, when worn, to benefit the jaundiced in a wonderful way, by a certain natural likeness.
Iris [Iris]	It is called a gem from its resemblance to the colors of the rainbow [iris], which it	It is said to benefit the eyes, by a natural likeness and sympathy.

Name	Form, Color, Places of Origin	Powers and Properties
	reproduces; it is a species of crystal.	
Jew-stone [Judaicus Lapis]	It is a stone of oval shape, resembling an olive; it is found on the Mount of Olives [mons Oliveti].	Olives are supposed to have been turned into stone; it is wonderfully good for the stone and for difficulty of urine.
Lapis lazuli [Lazulus], Lapis Judaicus	It is a blue stone studded with golden points; it is opaque, and rivals the sapphire in color.	It is wonderfully good for quartan fever, strengthens the sight, brings on sleep, and soothes the pains of gout.
Leucophthalmus [Leucophthalmus], Cat's-eye [Oculus Catti]	So called from the figure of an eye [oculus], which it reproduces; it is a species of opal.	From the mark it bears, it is reputed to cure the eyes.
Lychnites [Lychnites]	It is a species of Parian marble, the whitest of all; it is found commonly in Etruria [Tuscany], as also in Sicily.	It has an astringent power, and so is good for moist infirmities.
Touchstone [Lydius Lapis]	It is a species of black marble, suited for testing gold and silver.	It has a cleansing [smectic] power, and an astringent one.
Lithanthrax [Lithanthrax] (mineral coal)	It is called fossil coal [carbo fossilis], and is commonly dug up in Belgium near Liège [Leodium] for feeding fires.	It is severely harmful to the head, even to the danger of apoplexy.
Magnet [Magnes] (lodestone)	It earned its name from the region of Magnesia, where it is found.	For its wonderful powers and properties, see our <i>Magnetic Art</i> [Kircher, <i>Ars Magnetica</i>].
Malachite [Malochites]	It is a species of prase; it	It has a laxative power; it

Name	Form, Color, Places of Origin	Powers and Properties
	earned its name from the mallow [malva], for it is green like the mallow, marked with various veins.	benefits the heart; it strengthens the stomach; and it helps epileptics and those with spasms.
Marble [Marmor]	All those hard, smooth, and splendid stones, painted with various colors, are called marbles.	According to their various color-tints, they are endowed with various virtues.
Melichrysus [Melichrysus]	It is a species of chrysolite, gleaming with a golden color; it is found in Bohemia.	It is good for fluxes of blood and for epilepsy; it drives off various diseases.
Morochtus [Morochtus], or Melites (so called from its taste of honey [mel])	It differs from Galactites, the milk-stone, in color alone. It is found commonly in Saxony; it is also called the black Galactites.	It is good for spitting of blood; it cures fluxes of the womb.

Folio 81 — Nephriticus through Thracius

Name	Form, Color, Places of Origin	Powers and Properties
Nephritic stone [Nephriticus Lapis] (kidney-stone)	It takes its name from the kidneys [renes], which it benefits; it is tinged with various colors, like jasper.	It is said to cure sciatica, and by a natural property it benefits the kidneys.
Cat's-eye [Oculus Catti]	It is a species of crystal; it takes its name from the cat's eye, which it reproduces; it is also counted among the kinds of Asteria.	It is said to drive away terrifying dreams.

Name	Form, Color, Places of Origin	Powers and Properties
Onyx [Onyx] (called <i>Camea</i> , cameo)	So called from its resemblance to a human fingernail [unguis]; it is tinged with a black-and-white color, and marked with lines of various colors; it is opaque.	It is good against epilepsy, and for the eyes; it is apt for striking fire; rubbed, it grows warm to a remarkable degree.
Opal [Opalus]	The most beautiful of gems, for the variety of colors it displays in its transparency, after the manner of the rainbow [Iris].	It has the powers of all gems; it refreshes the heart.
Phengites [Phengites]	So called from the transparency of its light; it is a species of transparent Oriental alabaster.	It has the common power of the marbles.
Phrygian stone [Phrygius Lapis]	So called from Phrygia, where it is found; it was formerly useful for dyeing garments.	It is astringent, it cleanses, it raises crusts [over wounds]; it benefits the eyes.
Porphyry [Porphyrites]	A very hard marble, sprinkled in red with white spots; it takes its name from its redness [rubedo].	It is of little use in medicine.
Prase [Prasius]	So called from the color of a leek [prasum]; it is mixed of green and yellow color.	It is good against poison; hence in the presence of poison it is said to lose its color, and when washed to recover it.
Pyrites [Pyrites]	It is a stone, which they also call <i>Mareasites</i> [Marcasite], apt for	It has a drying power, applied in the form of a plaster.

Name	Form, Color, Places of Origin	Powers and Properties
	striking fire.	
Ruby [Rubinus]	The ruby differs from the carbuncle and the pyropus in name only.	It is good for driving off poisons; it is a noble antidote.
Sapphire [Saphyrus]	It is a blue and transparent gem; it is found not only in India, but also in Europe.	A remedy for the heart; it is said to grow foul when worn by an impure man given over to luxury. It resists poisons.
Sarcophagus [Sarcophagus] Asius	So called because it quickly consumes the flesh of a corpse buried in it.	It soothes gout; licked, it benefits consumptives.
Sard [Sardius], or Carnelian [Corniolus]	So called from blood-red flesh [caro], whose color it resembles. It is semi-transparent; it is found of good quality in Sardinia.	It wonderfully stanches blood; it gladdens the spirit; it is good against malignant fever; it whitens the teeth.
Schist [Schistus Lapis], Selenites	Every stone that splits into flakes is called <i>Schistus</i> ; under this name especially the one from Lavagna [Lavagna] is meant.	Physicians do not know the use of this stone; it contains much copper.
Emerald [Smaragdus]	The most beautiful of green gems; the Scythian kind is of the better sort; there are many species.	It resists poisons; it heals diarrhea and all fluxes of blood; it is good for epileptics.
Smiris [Smiris] (emery)	It is reckoned among the species of bloodstone; of an iron-rust color, very hard; it takes its name from the polishing	It has no use except that it is employed for polishing gems.

Name	Form, Color, Places of Origin	Powers and Properties
	[poliendis] of gems.	
Talc [Talcum], Earth-star [Stella Terrae], Sideritis	It got its name from the Arabs; it is splitable into thin and very fine leaves, and is more transparent than any glass.	The water distilled from it serves to whiten women's skin; it resists fire; it is a species of sideritis and of asbestos.
Theamedes [Theamedes]	It is nothing other than a magnet [magnes]; for they supposed that iron does not attract but repel.	Both effects the magnet produces. See our <i>Magnetic Art</i> [Kircher, <i>Ars Magnetica</i>].
Thracian stone [Thracius Lapis]	It is scarcely distinguished from jet [Gagates].	About which [we have treated] more fully above.

The TABULA COMBINATORIA of gems continues from the preceding pages with its final entries.

Name	Form, Color, Native Places	Powers and Properties
Topazius [topaz]	It is a species of chrysolite; it reflects a color like water tinged with saffron. It is named from the island of Topaza in the Red Sea, where it is found.	Good for melancholy, epilepsy, and a flux of blood.
Tophus [tufa/pumice]	A common pumice stone, rough, and easily breaking down into sand; it is divided into various species.	Said to relieve gout [podagra].
Trochites [trochite]	So named from the shape of a wheel; found throughout the mountains.	Its use is not yet known to physicians.

Name	Form, Color, Native Places	Powers and Properties
Thurcois, Turchesia [turquoise]	Among the opaque gems the most noble, of a sky-blue color which they call ultramarine, and most brilliant; it is born in Samarkand [Samarcanda], a province of Hither Tartary.	Applied for the care of the head and the eyes. Magicians claim it wards off falls.

And these are the principal species of stones found in the natural world, to which all the rest are referred.

TABULA

Of those stones which take their name from the resemblance of the things they recall, or from the things themselves transformed into stones.

The following stones derive their name either from a resemblance to something, or from the very things that have been changed into stone:

- **Astroides**, from its resemblance to a star.
- **Amygdaloites**, so named from the shape of almonds, such as are found near Albula at Tibur [Tivoli].
- **Ammochrysus**, from its resemblance to golden sand.
- **Argyrites**, from the silver color it reflects.
- **Anthracitis**, from its resemblance to coals.
- **Bostrychites**, so named from the shape of women's tresses; also called **Callitriches**.
- **Bucardia**, a stone arising in Babylonia, so named from the horn of an ox — better called **Bucardia** [Greek: βεκαρδία (bekardia / boukardia, "ox-heart")].
- **Botritis**, so named from its resemblance to a budding grape-cluster.
- **Calamites**, takes its name from its resemblance to a reed [calamus].
- **Ceraunites**, ἀπὸ τῶν κεραυνῶν [Greek: apo tōn keraunōn, "from the thunderbolts"], named from the lightning-bolt.

- **Cantharias**, from its resemblance to a beetle [scarab], which it reproduces in shape.
- **Batrachias**, from its resemblance to frogs, which it reproduces.
- **Capnites**, named from the color of smoke.
- **Cardisce**, from the figure of a heart, which it renders in its natural shape.
- **Cerites**, from the color of wax, which it reflects.
- **Chalaxias**, from the figure and color of hailstones.
- **Carcinus**, from the figure of a crab, which it reproduces, turned into stone.
- **Cepoides**, from gardens, on account of the variety of its scents.
- **Catoptrices**, from mirrors, because it displays images of things.
- **Calcophonus**, because when struck it gives out the ringing of bronze.
- **Conchites**, from the shape of a shell.
- **Cissites**, from the leaf of ivy.
- **Corallites**, from the form of coral.
- **Chethrites**, from the pit of the alder or almond.
- **Clenites**, from its resemblance to a comb [pecten].
- **Chrysitis, Chrysolampis, Chrysolithus, Chrysophis, Chryselectron, Chrysoprasus, Chrysoberyllis** — all named from their golden form, resemblance, and color [Greek: χρυσοῦς (chrysous, "golden")].
- **Dendrites**, from its resemblance to trees, which it reproduces.
- **Daphnia**, from its resemblance to laurel [laurus] and its color.
- **Dactylus Idaeus** [Idaeon dactyl], from its resemblance to a thumb.

The list of stones named for resemblance continues:

- **Dryites**, from the trunks of oak-trees.
- **Echinites**, from its resemblance to the sea-urchin [echinus].
- **Echites**, from the color of a viper.
- **Elatites**, so called from the color of the fir-tree.
- **Hepatites**, from the color of the liver.
- **Geranites**, from its resemblance to a stork or crane, in beak or eye.
- **Galactites**, from its resemblance to milk.
- **Haematites**, from blood, whose color it reflects.
- **Hieracites**, from the eye of a hawk.
- **Hexagonus**, from its shape, and it is a species of crystal.
- **Leontias**, from the color of a lion's hide.
- **Lepidotes**, from the scales of the fish of this name.

- **Meconites**, from its resemblance to poppy seeds.
- **Molybdos**, from the form of lead.
- **Myrrhsimites** [Myrsimites], from the scent of myrrh.
- **Myrmecites**, from the form of an ant naturally set within it.
- **Myites**, from its resemblance to a mouse.
- **Narcissites**, from the form of the narcissus flower.
- **Ostreites**, from its resemblance to oysters.
- **Pyrene**, from its resemblance to the kernel of an olive.
- **Pangonius**, so named from its many angles.
- **Panis Daemonum** [demons' bread], from its resemblance to bread.
- **Pentexoche**, from its resemblance to the medlar [mespilus].
- **Pentagonus**, from its resemblance to five sides and angles.
- **Polytrix**, from the form of hair.
- **Polyzonos**, from its resemblance to belts [zonae].
- **Pisolithus**, from its resemblance to peas [pisa], whose likeness it expresses.
- **Pardalios**, from the spotted hide of the leopard [pardalis].
- **Polia Spartopo**, from the color of grey hair.
- **Perdicites**, from the color of partridges.
- **Phycites**, from the color of seaweed [alga].
- **Phoenicites**, from the color of the palm or date.
- **Rhodites**, from the color of roses.
- **Scarites**, from the color of the mullet fish [mullus].
- **Scalopendrites**, from the figure of the worm called scolopendra, which it displays.
- **Sycites**, from the figure of a fig [ficus].
- **Spongites**, from the figure of a sponge.
- **Syringites**, from the figure of a pipe [fistula].
- **Stelechites**, from the figure of a trunk or stem.
- **Steatites**, from its resemblance to fat [adepts].
- **Tillinites**, from the tellins, a species of oyster.
- **Triglites**, from the color of the mullet fish.
- **Taites**, from its resemblance to a peacock in its colors.

Almost all stones take their names either from the resemblance to the countless things which Nature paints within them; or from the solid figures of things changed into stone; or from the parts now of men, now of animals; or from the

color of things, with which they are imbued; or from sound, scent, taste, or touch; or from the effect they have on diseases; or finally from their contents — as those called *enhydros*, which hold water within themselves. For since there is almost nothing in the natural world that cannot, when a petrifying juice is added, be converted into stone, it is no wonder — given trees, flowers, branches, leaves, shrubs, herbs, fruits, seeds, animals and their parts, and various artificial things turned into stone, as is established from what precedes — that as many kinds of stones are found as there are different things that have been transformed into stones. From these things, too, they obtain their names, as the Table demonstrates.

CAPUT VII.

On the twelve stones set in the Breastplate [Rationale] of the High Priest, and in the foundations of the Apocalyptic City.

Lest anything should seem to be lacking in this Treatise on Stones, I have added this chapter on the twelve gems set in the High Priest's Breastplate [Rationale] in a fourfold order. Just as countless authors and interpreters of Sacred Scripture have treated these matters most fully, so too, since each one describes them according to his own opinion, they have fallen into such confusion

I shall be reckoned, and deservedly, to be wasting my time. How great the diversity is among the authors will be plain from the following table, in which I have arranged the opinions of the Latins, the Greeks, the Hebrews, and the Arabs.

Latini [Latins]	Rabbini [the Rabbis]	Graeca Lectio 70 Interpret. [the Greek reading of the 70 Translators]	Paraphrasis Chaldaica Onkelos & Jonathae [the Chaldee Paraphrase of Onkelos and Jonathan]	Nomina Arabica [Arabic Names]
Sardius.	האודם — Carniola.	σάρδιον [Greek: sardion]	סמך — Sardius,	احمر [Arabic: aḥmar, "red"]
Topazius .	הפטדה — Topazius.	τοπάζιον [Greek: topazion]	ירקן — Topazius,	احصص [Arabic: aḥṣaṣ [?]]
Smaragd	הברקת —	σμάραγδος	ברקן —	اصغس [Arabic:

Latini [Latins]	Rabbini [the Rabbis]	Graeca Lectio 70 Interpret. [the Greek reading of the 70 Translators]	Paraphrasis Chaldaica Onkelos & Jonathae [the Chaldee Paraphrase of Onkelos and Jonathan]	Nomina Arabica [Arabic Names]
us.	Ceraunia.	[Greek: smaragdus]	Smaragdus,	aṣghas [?]
Carbunculus.	— הנפך Carbunculus.	ἄνθραξ [Greek: anthrax]	— אזמרגדן Carbunculus,	اڤڤاك [Arabic: akḥak [?]]
Saphyrus.	— הספיר Saphyrus.	σάφειρος [Greek: sapheiros]	— שבזיו Saphyrus,	مها [Arabic: mahā]
Iaspis.	— החלום Adamas.	Ἴασις [Greek: iaspis]	— סבהלום Iaspis,	بهرمان [Arabic: bahramān]
Ligurius.	— הלשם Turchesia.	λίγυρος [Greek: ligyros]	— קבכרי Ligurius,	بسج [Arabic: basbaj [?]]
Achates.	— השבו Hyacinthus.	ἄχάτης [Greek: achatēs]	— טרקיא Achates,	فيروزع [Arabic: fīrūzaj, "turquoise"]
Amethystus.	— האחלמה Onyx.	ἀμέθυστος [Greek: amethystos]	— עין אגלא Amethystus,	ازرق [Arabic: azraq, "blue"]
Chrysolithus.	— התרשיש Chrysolithus.	χρυσόλιθος [Greek: chrysolithos]	— כרום ימא Chrysolithus,	بلور [Arabic: billawr, "crystal"]
Onyx.	— השוהם Smaraldus.	βήρυλλος [Greek: bēryllos]	— בורלא Onyx. perla,	يسف [Arabic: yasf [?]]
Beryllus.	— היספרה Iaspis.	ὄνυχιον [Greek: onychion]	— פנתרי Beryllus.	بلور [Arabic: billawr, "crystal"]

The arrangement of the twelve stones in the Breastplate according to the mind of the Rabbis.

	1.	2.	3.
Primus Ordo [First Row]	אדם. Sardius — Ruben.	פטרה. Topazius — Simon.	ברקת. Ceraunia — Levi.
Secundus Ordo [Second Row]	נפך. Carbunculus — Judas.	ספיר. Saphyrus — Issachar.	חלום. Adamas — Zabulon.
Tertius Ordo [Third Row]	לשם. Turchesia — Dan.	שבו. Hyacinthus — Nephtali.	אחלמה. Onyx — Gad.
Quartus Ordo [Fourth Row]	תרשיש. Chrysolithus — Aser.	שהם. Smaragdus — Joseph.	ישפה. Iaspis — Benjamin.

And this is the arrangement of the twelve stones in the Breastplate, according to the names of the twelve tribes of Israel, following the mind of R. Abraham Ben Hanasse [Rabbi Abraham ben Hananiah / the *Shiltei ha-Gibborim* author], who sets out fully the mysteries of each in his book which he calls *Scutum Fortium* [*Shiltei ha-Gibborim*, "Shield of the Mighty"] — to which I refer the reader. The said author asserts that all the gems of the Breastplate were transparent and most resplendent. Since, therefore, many opaque gems are reckoned in this Breastplate — such as turquoise [Turchesia], jasper [Iaspis], and ceraunia — either it must be said that these were of another species among our own, namely transparent ones, or it must be judged that they were of such smoothness that they produced the same effect as the transparent ones. The reason for this they explain under the *Urim and Thummim*.

Now these were the effects of the stones, by whose illumination the Priest was led to the knowledge of a thing to come; and through the *Thummim* the matter was infallibly accomplished by divine revelation. But because few of the interpreters of Sacred Scripture have rightly grasped the effects of the *Urim and Thummim*, I have thought it well to unravel them here. R. Abraham Ben Hanasse, in the book cited just above, sets out the argument concerning the *Urim and Thummim*, gathered from the rabbis of better repute. This argument, which I myself have translated from Hebrew into Latin, I here present to the curious reader, in as few words as I am able. The *Urim and Thummim* under the old law are nothing other than the holy names of God, engraved on the twelve stones, by whose power and might the Priest knew things to come and announced them to everyone

that they may scarcely agree, one with another; and to whom one ought above all to subscribe, I can scarcely discern. The names of these stones I do indeed find aptly placed in the various texts of Sacred Scripture — Hebrew, Chaldee, Syriac, Arabic, Greek; yet what they really are, and how they may be compared with our own, is hard to conjecture. Out of all the rabbis whom I have consulted, I find that R. Abraham Ben Hanasse has written best on these matters, in the book which is entitled שלטי הגבורים *Schilte beggiborim* [*Shiltei ha-Gibborim*]. *Scutum Fortium* [*Shield of the Mighty*] it is titled; and from the Chaldee Targums and the other texts and authors of better repute, he determines very nearly the truth — although he himself seems to despair of penetrating the substance of the matter.

[Hebrew: ויראת מכל וכל מיני אבני הרציון לפי שאיני יודע (?) בעצמות מה הוא פטרה — a Hebrew citation; "Yet I am in doubt about all the kinds of stones of the Breastplate, since I do not know in their substance what this *Peteda* is..."]

Nevertheless, I am in doubt about all the kinds of stones of the Breastplate, since I do not know in substance what this אודם *Odām* is, what this word פטרה *Peteda* is. For when I examine Onkelos and Jonathan, the Chaldee paraphrasts, I have found them all perplexed in this argument.

[Hebrew: כל המפרשים ובעלי הקבלה אומרים (?) שאין ביניהם אלא הבדל מקרה — a Hebrew citation continuing the argument.]

Some of the interpreters hold that the stones are to be taken only according to their accidents, not according to their substance — namely, *Odām* and *Peteda* from their color, red and yellow. Many think that one of these stones is specifically distinguished from another, but they are mistaken, since the difference between them is only accidental, and a matter of more and less. He then enumerates all the precious stones, in that order in which they were placed in the Breastplate, and according to the mind not only of Sacred Scripture, but also of the paraphrasts and the rabbis of better repute.

[Margin: 10. / XI. / 12. — running marginal numerals keyed to the entries below.]

The twelve stones now follow, each headed by its Hebrew ordinal letter (א-יב):

[.1] א [Hebrew: האודם או הקרניאלה על שם הבשר דהיא אבן אדומה דומה לבשר האדם] The first stone of the Breastplate was *Odām*, that is, Carniola [carnelian], and it was a red stone, like the color of human flesh — flesh-colored.

[.2] ב [Hebrew: הפטדה או טופאציאו והיא של מינים הא' צבעו והוא ירוק] The second is called *Peteda*, or Topazius [topaz], and it is of two kinds: the first inclines toward a golden color, the second toward green.

[.3] ג [Hebrew: הברקת או כרבנוס שנקרא מפני שהוא יורד לארץ עם הברקים] The stone *Berecket*, that is, *κέραυνός* [Greek: *keraunos*, "thunderbolt"], *ceraunia*, beautiful and transparent, inclining from green toward sky-blue — so called because it is cast down to the earth with lightning and thunder.

[.4] ד [Hebrew: הנפך או כרבונקולוס ונקרא בשם זה על כי הוא דומה לאש המוצת בפחם] The stone is *Hanephech*, that is, *carbunculus* [carbuncle], so called because it is like the fire that comes from kindled coals.

[.5] ה [Hebrew: הספיר או הצאפירו וצבעו הוא נוטה לירקות הכרכוס ודומה להבונים] The fifth stone was *Saphir*, that is, *Saphirus* [sapphire], and its color inclines from saffron-yellow toward sky-blue, like the splendor of the firmament.

[.6] ו [Hebrew: ה[?]החלום או הדיאמנטו והיא אבן ירקה השובה ישבע הנם] *Hahalom*, that is, *Adamas* [diamond], is the most worthy and precious of all gems, uniquely desired.

[.7] ז [Hebrew: הלשם או הטורקואיס הוא במעלה כבה בין כל חפצי הא] *Halescham*, that is, *Thurcois* or *Turchina* [turquoise], is a green stone inclining toward a sky-blue color, a praiseworthy gem, in comparison with which gold and silver are nothing.

[.8] ח [Hebrew: השבו או ההיאצינטו הוא אבן הדומה כמען לפוח שחו היאינטו והוא משתה] *Haschabo*, or *Hiacynthus* [hyacinth], is a stone that took its name from the hyacinth flower, with a color of gold and grassy-green inclining toward sky-blue.

[.9] ט [Hebrew: התרשיש או קריסוליטו הוא אבן של ארבע מינים] The ninth stone is *Tharsis*, and it is *chrysolithus* [chrysolite], of which there are four species, that is: Arabian, German, Indian, Ethiopian — which he says are all imbued with differing colors.

[.10] י [Hebrew: השוהם או סמיראלדו והוא בכל האבנים הטובות השלי] The stone is *Hafchoham*, that is, *Smaraldus* [emerald], and among all stones, for price and dignity, it occupies the third place, on account of its most limpid greenness, most pleasing to the eyes.

[.11] יא [Hebrew: האחלמה או אוניקו הוא של מינים רבים והוא של חמי] The eleventh stone is *Haclamah*, *Onyx*, and it is of five kinds, all of which are imbued with diverse colors.

[.12] יב [Hebrew: היספרה או אספס והוא עשרה מינים] The twelfth stone is *Iaspis* [jasper], which is divided into ten kinds, of marvelous variety.

And these are the twelve stones inserted into the Breastplate according to the opinions of the rabbis. But which of these they properly are in their own substance is as hard to affirm as it is hard, among so many kinds into which they are distinguished, to determine the truth. And just as among the authors the dispute hangs unsettled to this very day, so too, together with St. Jerome [S. Hieronymo] and the other interpreters of Sacred Scripture, in unraveling an argument entangled with countless difficulties, deservedly...

[p. 86, conclusion of] CAPUT VII — Urim and Thummim

the things that were to come. Its power consisted chiefly in two things. The first was that, by its own intrinsic power, it illuminated the letters of the tribes engraved on the stones of the Breastplate [Rationale]—which is why it was called אורים [Hebrew: Urim], that is, "illuminations," because by the power implanted in it, it illuminated the eyes of the priest. The second was what was called תומים [Hebrew: Thummim], that is, "perfections," and consisted in this: that it exerted its powers upon the heart of the priest, who then, from what he had learned through the illumination of the stones, drew out by the secret reasoning of his mind—from the combination and fitting connection of words—voices proportioned, by way of answer, to the question that had been put. For by the power of these names the heart of the priest was made apt to recognize the letters; and in the power of the Holy Spirit, which came into him, there came into his heart the conjunction and linking of the letters, by which the work of prediction was accomplished in this manner.

The Urim did not illuminate all the letters in a single compartment, but, by the power of the Thummim, it illuminated only the first letter, and afterward the second letter, without any mixing or confusion. By considering them one after another according to the first, or the last, or the middle letter, the priest knew how to draw out voices, through the collection of the letters and the manner of their resemblance, so as to make manifest what was to happen.

For example: when Israel asked of the Lord, "Who of us shall go up against the Canaanite, to begin the war with him?", the Lord answered, יהודה יעלה, "Judah shall go up." And then the Urim illuminated, as it were, the whole name *Iehuda* [Judah] from the stones existing in the Breastplate. But the word יעלה was understood by the priest in this manner: first there was illuminated, in יעלה, the first letter י (*Iod*) of the name of the tribe יששכר *Issachar*; then the ץ in the middle of the name of the tribe שמעון *Simon* [Simeon]; then the third letter ל in the first letter of the name of the tribe Levi—and so on with the rest. In this way, from the

joint illumination of the names of the tribes of Israel, the priest gathered the voices that showed what was to be done.

But these things, since they are merely flimsy conjectures resting on no foundation, deserve no more credence than fables; so let it suffice merely to have set out their opinion here.

SECTIO IV — DE ANIMALIBUS SUBTERRANEIS

[Section IV — On Subterranean Animals]

PRAEFATIO [Preface]

The condition of subterranean animals can be considered under four heads. [Margin: The fourfold kind of subterranean animals.] There are some that always live in the bowels of the earth. There are others that do indeed dwell within the earth, but now and then break out to the surface to get the food they need, and presently return to their hidden lairs. There are still others that hide away in the winter season, but in summer burst out from their caves and pass a six-month span of life in sunny spots—whether in woods, in fields, or on inaccessible mountains. Nor are there lacking some that, after they have lain hidden for a while in the earth's secret passages, come out and never return to their abandoned dwellings. I shall treat of each, as far as may be, in few words.

CAPUT I

On certain animals which, just as they cannot live outside the earth, so dwell perpetually in its hidden bowels.

Among animals of this kind, first are certain ones that are easily born from putrid matter. The living things of this kind can be considered under a threefold class. First, all the genera of worms that they call earthworms [lumbrici terrestres], which take their origin from the slimy and putrid mud of the earth. Second, there are certain perfect animals, such as fish, serpents, and fossil frogs, which now and then are encountered in the heart of rocks when these are split open.

[Margin: Fish and frogs and fossil toads.]

There is, on the testimony of Agricola [Georgius Agricola], in the Narbonese region [Narbonensis Ager], which lies between the Pyrenees mountains, a maritime plain of fields, watered by various rivers, in which living fish are not

infrequently dug up near the surface. There is found there too a certain kind of exceedingly porous rock, from which millers are accustomed to make the grinding stones used for grinding grain; and in the middle of these, when they are split open, they very often find living toads. Hence great care must be taken not to fit such stones, at first, for the mill without proper examination, lest, when they have grown hot from continuous turning, the toad lurking somewhere inside spread its poison through the grain.

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Agricola also teaches, in his book *On Subterranean Living Things* [*De Animantibus Subterraneis*], that fish of this fossil kind, and frogs, and even serpents, have been found in this way in Germany. [Margin: How animals of this kind are born within the rocks.] Since, then, experience shows that the matter is so, someone might rightly come to doubt at this point: how have animals of this kind penetrated into the very middle of the rocks and the earth, and how can they live there? To make this clear, I will begin with fossil fish, some of which are still found alive in certain places, while others have been turned into stony substance. About this kind of fish and their origin I have treated extensively in the preceding pages; it remains for me to say something about the living ones as well.

Fossil fish are most often found either on the seashore or on the sloping banks of great rivers, among heaps of sand. I say, then, that they can be born there in this way. At the time when the sea, by the force of the winds, rolls huge heaps of sand onto the shores, or when the floods of rivers cast up great masses of mud onto the shores, it can also happen that no small quantity of tiny fish is thrown out together, mixed with the mud and sand. Since these abound in moisture—because of the streams perpetually flowing down from the mountains and channeled there through subterranean veins—it comes about that the little fish, enclosed within the hovels of sand and mud, are in time both nourished and grow up there from sufficient moisture and from the juice of the earth.

But because, when the rivers or seas subside, the earth—mixed with mud and dried out by the heat of the Sun and the constitution of the warm air—puts on a stony crust, [Margin: How they are turned into stone.] hence it happens that certain empty spaces are left behind, as the nitrous mud is contracted and gradually turns to stone by the Sun's heat. And just as these spaces are perpetually filled through the veins of moisture gliding beneath, so too they acquire, together with the juice of the surrounding matter, nourishment sufficient for living. But if they are deprived of all moisture, wrapped about on every side with mud—then, as the mud in the course of time turns to stone (as I

showed in the preceding Book), at length they too are turned into stony substance, retaining nothing but their shape, as is plain from the figures adduced at the place cited above.

It also happens now and then that little ones insinuate themselves through narrow cracks into the rocks for the sake of food, until, settling in a more open place and gradually growing to such a bulk that they can no longer make their way back through those cracks, they are therefore forced to remain there. And this is the other way in which they are sometimes found among the rocks—though experience has taught that living fish are never found without moisture.

In the same way, frogs or toads [rubetae] are sometimes found in the heart of the rock; but I come to the βατραχογένεσιν [Greek: batrachogenesin, "the generation of frogs"], that is, the generation of frogs carried out within the rocks. [Margin: The origin of frogs within the rocks.] Such is the process of nature: if at some time the spawn of frogs is wrapped up in mud somewhere, and meanwhile, as the substance of the mud gradually turns to stone, it has obtained a warm-and-moist cell, fit and well-disposed, the spawn—animated there as in a womb by the force of the subterranean heat—at last brings forth the frog. And this, being supplied with sufficient nourishment, as moisture glides through the pores of the rock, could thus sustain its life for a long time within that cell, until, the stone being cut, it leapt out alive. It is established, however, that such animals, once entrusted to the air, die a little while afterward. What I have said, then, about fish and frogs is to be understood of fossil serpents as well.

Animals of the third kind, which always keep to a subterranean station, are the various genera of moles [Talpae], which have themselves disposed to the open air within the earth almost in the same way as fish to the air within the water: for just as fish cannot continue their life long outside the water, so neither can moles outside the earth. [Margin: The origin of moles.]

Now whether these animals are furnished by nature with eyes, I see many to doubt, for this reason: since they always inhabit the bowels of the earth, eyes would seem to have been granted them in vain, as they pass their days in perpetual darkness. To find out the truth of the matter, I intercepted a mole in my suburban garden and, having carefully shaved its whole head, examined it to see whether eyes could anywhere be detected; and at length I found two minute openings, as if made with a needle. Not yet satisfied with these, however, I stretched out a little the membrane by which they were covered, and then, applying a microscope—the instrument I usually use for examining the smaller things—I detected eyes, exceedingly bright, which had nothing at all different

from the eyes of other animals. [Margin: Moles, contrary to the common opinion, are not blind, but have eyes—exceedingly minute ones, however.]

From this I concluded that the membrane covering the eyes had been granted by Nature so that in their subterranean parts, where they have no need of them, they might not suffer some harm to the eyes from the dust of the earth and the scrapings of the parts they tunnel through; but because they are nevertheless sometimes forced to come up onto the earth, Nature did not wish to deprive them of eyes, for the sake of direction and the protection of life, as in the other animals.

Second. [Margin: What animals inhabit the crypts of the mountains.] There are certain animals which, in the winter season, lie hidden in subterranean crypts, in the caverns of mountains, in the hollows of trees, in the openings of the earth, but in the summer season first come out into the open light, occupied—with truly marvelous foresight—in gathering together the provision of nourishment needed for the winter season. These are either among the insects, or the kinds of mice, or the kinds of birds and quadrupeds. And of the insects—flies, ants, serpents, tortoises, and the rest—being everywhere known, I shall say nothing.

Various genera of mice are reported. [Margin: The various genera of mice.] Among the rest is the Alpine mouse [mus Alpestris, the marmot], an animal of the size of a medium-sized dog, which is found for the most part in the Alps. Throughout the whole winter season it lies hidden within the caverns of the mountains, sunk in sleep; in summer it finally comes out, intent on its provision. Into the caverns they carry a great quantity of hay, as a kind of bedding, so that the mice may rest more comfortably; [Margin: The nature of the Alpine mouse.] but the mouth of the cavern they block up with manifold art, by an interwoven plaiting of twigs, so as not to be harassed by the injuries of the air and the seasons, or by the ambushes of foxes and hares. In these...

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now and then four, five, or six are found asleep. Not undeservedly may the dormice [glires] be counted among these, of whom there is the common saying, "the whole winter is slept away." [Margin: Hedgehogs and porcupines.]

Hedgehogs [erinacei] too, and porcupines [hystrices]—of which the former lie hidden in the winter season not only within caverns but also within the hollows of trees, while the latter are scarcely seen by day, but by night are intent on their dealings. About bears it is everywhere agreed that, as winter approaches, they make for the crypts of the mountains, where for a span of forty days they even indulge in sleep. [Margin: The nature of bears.] That done, they put the toes of

their forefeet into their mouths and, for the rest of the winter, suck them without any other nourishment, growing fat by the sucking; but for the rest of the summertime they come out into the open and pursue the hunt. When they are about to enter their caverns again, they block them up with branches and twigs of trees; and lest their tracks be detected, they insinuate themselves with the body lying on its back through an opening deliberately left there, which they afterward block up from within, as I said of the Alpine mouse. The same is to be said of martens, weasels, squirrels, and countless other animals, for which see Agricola in his book *On Subterranean Living Things*.

Third, among the birds that delight in subterranean places are numbered chiefly screech-owls, eagle-owls [bubones], and night-owls [noctuae], which establish their habitation partly within the caves of rocks and the recesses of old and inaccessible towers and similar places, intent chiefly on their plunder by night. [Margin: Subterranean birds.] There is in the Apennine [range], where one goes from Florence toward Bologna, in a hidden recess of the mountain, a certain great chasm, into which, if you cast a stone, immediately a huge number of jackdaws [graculi]—which they call *cornacchie*—are found to fly out; but after a few flights outside the crater, they at once return to the place they came from. About these see our *Iter Hetruscum* [Etruscan Journey].

Fourth. [Margin: Swallows, and the wonderful things about how they hide.] Marvelous are the things reported about swallows [hirundines]. Most people think that in the autumn season, when the injuries of winter set in, these migrate to warmer regions toward the south; and I do not deny that this is true of some. For, as I have heard from the inhabitants of the Peloponnese and of the rest of the Archipelago, a huge multitude of them crosses the sea every year, together with storks, from the shores of Egypt and Libya; and they report that, when the swallows are wearied with flying, three, four, five, or six of them now and then settle on the backs of the storks; while the storks, in acknowledgment of the kindness, with a continual chattering and song, as it were caressing them, once this gentle and generous conveyance has been gained, make their way back to their former homes.

There are, then, some swallows—chiefly those that dwell not far from warmer places—that migrate from one region into another. But long-standing experience has taught, time out of mind, that those which dwell in regions near the North undertake no such distant journeys, but lie hidden during the winter either in the innermost caverns of the mountains, or in the bottom of lakes, or in the hollows

of trees, or on the reedy shores of rivers and seas. Of these particulars I shall adduce legitimate testimonies.

In Poland the matter is commonly known, and to fishermen nothing is more familiar: when in the winter season, the ice being cut, they let down their nets into the water for fishing, they not infrequently bring up, together with the fish, swallows rolled into a ball, [Margin: In Poland swallows in the bottom of the lakes.] so interlaced by their claws, by a certain marvelous skill, that they can scarcely be separated from one another. When they have brought these, sleeping and as if half-dead, into a heated room [hypocaustum], they are reported gradually to bestir themselves, as if waking from some deep sleep, and a little later even to attempt flight; yet all of them, drawn out before the time appointed for them by nature, do not continue their life.

Agricola too makes mention of this matter, in his *On Subterranean Animals*: that they have been found in the lakes of Germany in the winter season. Pliny [Gaius Plinius Secundus, the Elder] also mentions it, Book 12 [recte: Book 10], chapter 25. [Margin: In the hidden places of the mountains they are found.] "Swallows depart," he says, "in the winter months—the only one, of the birds that feed on flesh, that does so [recte: of the flesh-eating birds, the only one that hibernates]; but in the spring they return; they make for the hidden recesses of nearby mountains, and there they are found already bare and unfledged." [*Natural History* X.] And Olaus Magnus confirms it, Book 15 [recte: 19], chapter 10: "In the Septentrional [northern] regions swallows are often pulled out of the waters by fishermen, gathered into balls—the waters into which they had hidden themselves at the onset of autumn—with such skill that they appear to be linked to one another by their beaks, wings, and the little claws of their feet turned toward each other; and bound together in this fashion, they let themselves down among the reed-beds to the bottom of the lake. And at last, in the spring season, at the time again appointed for them by nature, returning to themselves, each one seeks out its own nest, or builds new ones—if at any time, having been caught, they are brought into heated rooms, they immediately appear to revive and to aim at flight; but these are not long-lived, since they were drawn out before the time. Hence the fishermen, when they have caught such swallows in the winter season, finally commit them back to the waters as an unripe fruit."

Nor are they found only in the waters in the winter season, but also—on the testimony of Pliny, cited above—in the caverns of the mountains. The truth of this matter the people of Tivoli [Tyburtini] taught me, who say that in that wonderful mountain which they call the "Cleft" [Scissum, Monte Scisso]—and which by

tradition they have received was split at the time of the Lord's Passion— [Margin: At Tivoli, in the cleft of Mount Scissum.] when they had led me to it and shown me all the marvels of that impenetrable abyss, they related that a great multitude of swallows nests there, which, by a perpetual circling of flight, enter the mountain on one side and finally go out on the other; nor do they ever withdraw from that mountain or, as the common folk suppose, migrate to other regions, but in the winter months remain there asleep; and a great quantity of them is found, gathered into balls, by boys who go down more deeply into the mountain's inner recesses. See what we set down, worthy of careful consideration, about the marvelous constitution of this mountain in our *Latium*.

There are also swallows which they call bank-swallows [riparias], because they mostly delight in the banks of rivers, [Margin: Bank-swallows.] and these for the most part dwell in the winter months within the fissures of rocky shores...

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Agricola teaches, in the book cited, that they pass the time. [Margin: A wonderful occurrence in Switzerland.] And it has not infrequently been found, by those who seek out the nests of halcyons [kingfishers], that they are there in that very situation which we described above—namely, half-dead. It is a marvel that Cysat [Johann Leopold Cysat] relates in his description of Switzerland [Helvetia]: that when the people of Lucerne were digging the foundations for the building of their town hall, about the time of the festival of Christ's Nativity, they came upon a tunnel, out of which some twenty swallows flew up. This thing astonished everyone, since they could not find out where they had penetrated into so deep a pit. But just as to this very day it is unknown how and where they hide themselves, so too the hidden ways by which swallows tuck themselves away in subterranean places are known to Nature alone, the Mistress, by herself.

From all this, then, it is plain that not all swallows love migration, but only some; while the rest—according to the different species of swallows—hide some in the lurking-places of the mountains, some in the hollows of trees, and most, chiefly in northern regions, let themselves down into the bottom of lakes. So that I cannot sufficiently marvel at the providence of God, Best and Greatest, in directing and preserving animals of this kind. They know most exactly the time at which they ought to withdraw themselves and the time at which they ought to come back. [Margin: How swallows can live within the waters.] But how they can live within the waters or the caverns of the mountains for a six-month span is difficult to find out—unless we say that it is in exactly the same way in which we said above that bears, Alpine mice [marmots], and dormice live: namely, from both the

constitution of their own temperament and the natural juice with which they are swollen.

For even though they appear to have been found dead, they ought by no means to be reckoned dead, since there is no return from privation to possession; but they are only put to sleep, the radical heat within meanwhile working, by the means necessary for preserving the soul, just as we said above of bears and dormice. [Margin: Why they are found almost featherless.] But the reason they are found almost featherless is that the heat, drawn back from the circumference to the center, now destines that matter which otherwise is wont to pass into feathers for the inward nourishment of the animal. And as to their being able to preserve life in the waters, this is to be ascribed to the natural constitution of their temperament. For since life consists in a warm and moist temperament, and the bottom of the lakes is warm in winter—as are also the caves of the mountains—they easily, surrounded by warm moisture, pass their life (unfit and idle though it be for their usual activities) up to the appointed time, until, the external warmth prevailing, they are again roused to their usual activities.

It is a marvel, however, that something similar happens with storks [ciconiae]. [Margin: The same happens with storks as with swallows.] For as Gervase of Tilbury [Gervasius Tilburiensis], marshal of the Kingdom of Arles [Arelate], writes to the Emperor Otto IV [Otto IV], storks were found in a certain lake of Arles clustered together in the manner of swallows. [Margin: In a lake of Arles storks found under the waters.] With this agrees Fulgosus [Battista Fregoso / Fulgosius], Book 1, chapter 6, who reports that similar clusters of storks were found in a certain lake near Metz in Lorraine [Lotharingia].

And these are the things which I have thought ought to be said about the subterranean animals known to us. But about those which dwell in the vastest recesses of the subterranean regions—as being things of which we have nothing ascertained—I deliberately keep silent. Yet that there are both fish and other animals there, various examples teach us. [Margin: Fish in subterranean rivers.] For, as Pliny writes, when a great earthquake had arisen in Greece, the earth opened and cast out a huge quantity of fish together with a river; and these fish without doubt had their origin in some subterranean river. There is too, in Carniola [Carniolia], near Laibach [Labacum, Ljubljana], a vast plain, [Margin: The wonderful lake of Laibach.] out of which every year, in the spring season, so great a quantity of water bursts forth together with fish that within a few days it changes the plain into a lake filled with fish. But these things we have pursued more fully in the first Volume [primus Tomus].

Cysat, cited above, agrees with these things. "Rivers," he says, "such as there are in Switzerland, [Margin: When the rivers are filled with fish from the mountains.] which, rolled out from the caves of the mountains, flow continually from about May until September; but in the remaining time of the year they cease their flow." He adds that the rivers, after the first rolling-out of the waters from the mountains, are at once filled with fish—an open proof that they have burst out, together with the river, from the subterranean waters. Therefore, just as in the subterranean lakes or rivers fish of every kind live, so too we think it not unlikely that other land animals dwell there as well: all the genera of mice recounted above, serpents too, and little dragons [dracunculi], and finally all the rest that draw their birth from putrid matter.

CAPUT II

On Subterranean Dragons.

There is a great controversy among the authors about winged dragons [dracones alati]: whether such animals have really existed in the nature of things, or whether—like many other things—they are to be reckoned among fabulous tales. [Margin: On dragons—the least fabulous of arguments.] For I myself indeed long and greatly hung in doubt whether such animals ever existed; until at last, from the reading of various authors beyond all exception, and indeed from the testimony of eyewitnesses, I let myself be easily removed from this doubt. And since monstrous animals of this kind for the most part have their birth and their nests in subterranean caves, I have thought they ought, as a noble argument of our undertaking, deservedly and by right to be counted among the subterranean beasts.

I am not unaware that a twofold kind of this animal is reckoned by the authors: one winged, the other without wings. About the living things of the latter kind no one either can or ought to doubt—unless someone should perhaps dare to contradict the Sacred Scriptures, which it would be impious to say—since in Daniel 14 [*Daniel* 14, i.e. Bel and the Dragon] mention is openly made of *Bel*, the dragon honored with divine worship by the Babylonians, and in various other places of the Sacred Scriptures mention is made of dragons: "the dragons and all the deeps" [*Dracones et omnes abyssi*, cf. Psalm 148:7]. From which passage it is plainly gathered that animals of this kind... ..that animals of this kind stable in the hidden abysses of the earth, and that, when an exit is granted them, they sometimes emerge from their lairs to the great harm of men and animals.

I now come to profane histories. Aristotle [reports] that in the time of Philip of Macedon two dragons lurked in the caves of neighboring mountains, with such virulence of venom that no one could pass through there without danger to life. But there is no room for doubt about dragons of this enormous size — or rather serpents — since they are found in our own day by various sea-captains everywhere, and most of all in Ethiopia, India, and the other regions lying within the Torrid Zone. To this day a similar dragon, fifteen palms long, dangerous on one side with a double row of teeth, may still be seen at Rome in the Museum of Cardinal Francesco Barberini.

[Margin: A dragon in the Barberini Museum.]

[Margin: Histories of various sorts concerning dragons.]

Concerning winged dragons alone has a dispute arisen among authors, most of whom declare them to be fabulous. But these men are contradicted by the histories of every age and by eyewitness experience. There is no age that has not produced winged dragons — small, large, and very large — in various parts of the earth. See [Girolamo] Cardano (*De Subtilitate* VII.29) on winged dragons, which he says he himself saw in the Museum of Guglielmo Musito at Paris. To this should be added the testimony of [Pierre] Belon [Bellonius], who relates that he saw in Egypt whole carcasses of winged dragons most carefully preserved. They were, as he reports, thick about the belly, with two feet and as many wings, formed like those of bats, with a serpentine tail.

[Margin: Winged dragons of Egypt.]

Indeed, Aldrovandi [Aldrovandus] says that he keeps in his own museum preserved carcasses of dragons of this same stamp, communicated to him by Gabriele Barbaro and Francesco of Crete [Francisco Cretensi], in the year 1551. They were furnished with two feet armed with claws, and with as many small ears; they were covered with green and somewhat blackish scales, and moreover bore wings fit for flying, with a long, twisted tail covered in yellowish scales. Their jaws were armed with sharp teeth; and although these were not of any unusual size, they could nonetheless in time grow to that bulk which we shall describe a little later — for just as crocodiles do, so too monsters of this kind are said to grow continually.

[Margin: Dragons slain by the saints.]

Whoever desires more about dragons, let him read Aelian, Olaus Magnus, Pausanias, and Pliny. And dragons either put to flight or slain by the merits of the

saints, let the reader see among the hagiographers. On the dragon slain in the Tauric Chersonese by the merits of Deipara [the Mother of God], see in Matthias à Michon. In the life of Saint Margaret, on the horrendous dragon killed by her merits, see in [Laurentius] Surius. In the life of Saint Hilarion, on the huge dragon committed by him to the fire, see in Saint Jerome. In the lives of Saints Donatus the Bishop, Joannicius the Abbot, Sylvester and Leo IV, Pontiffs at Rome; Arsacius at Nicomedia; Theodore, Marcellus, Crescentius — in Surius, Metaphrastes, Sozomen, and others, who are all reported to have been destroyers of monsters. Consult likewise Fulgosius, Diodorus, Orosius (IV.8), and Augustine (on Psalm 348 [recte: 348? — Ps. 148 likely intended]). Yet whether all dragons of this kind were winged is not established. Therefore let us now proceed to the histories in which winged dragons are described exactly as being not merely two-footed, but also four-footed.

[Margin: Switzerland once abounded in dragons.]

Gessner first teaches that Switzerland [Helvetia], on account of the very remote recesses of the Alps and the inaccessible nature of its caves, in places never trodden by men and unfrequented — in which [the dragons] take delight — was once inhabited by dragons; and that they were still seen within the memory of our fathers. After him [Johann] Stumpf [Stumphius], and in our own time Cysat [Johann Cysat] in his *Description of the Swiss Towns*, teach the same, so that no one can doubt the incredible truth of these monsters.

[Margin: Switzerland abounded in winged dragons.]

But I come to the other part, concerning flying dragons, which the histories report cleave the air with a mighty rowing of their wings. And to begin with the smaller: that there are winged serpents became so well known to the Egyptians that they even inserted them into their hieroglyphics. Moreover, to this very day, winged serpents come from the regions of Arabia after the flooding of the Nile is over, to devour the insects which are wont to be born in great abundance from the rotting matter of the remaining mud — and Pliny, Aelian, and Solinus confirm this.

[Margin: A winged dragon slain by a hunter in the Roman countryside.]

In the year 1660, in the month of November, a certain butcher of Rome, while he had betaken himself for the sake of fowling to the marshy parts of the maritime shore, suddenly, in the haunt of the marsh-birds, came upon a dragon of the size of a rather large vulture. Taking it for a bird, he discharged his gun against it; and having wounded its wing, he so enraged the beast that at once, partly running,

partly flying, it rushed upon the hunter to avenge itself on its enemy. He then, firing his gun again, so burst open its throat that it immediately fell dead. But whether infected by the virulent flow of its blood or by its breath, the man returned home and died that same night, his whole body suffused with the spreading of green venom. This unusual event, just as it befell the whole city [with wonder], so too a certain more curious person, informed by the report of the dying man, went to the place of the contest and found the dragon already putrefied. Nevertheless, that on his return he might attest to the truth of the deed, he carried off with him the dragon's head — which, while I write this, was brought to me by the most expert Lord Hieronymus Lancia, prefect of the Museum of Cardinal Barberini; and this head, on being diligently examined by me, was found to be the head of a true dragon. [The text continues at the foot of the column and resumes at the next page-top — see below.]

[Margin: A basilisk born from a cock's egg.]

That basilisks are born winged from the egg of an old cock has become so well known in our day that anyone would be reckoned reckless who should too insolently wish to deny it. See what I have treated at length about these in my *Diatribes on the Prodigious Crosses*. Just as some tiny grubs are animated into wings, so too some worms, while by continual eating they grow into a huge bulk, at length — when wings are assumed through the disposition of the matter — pass their lives as four-footed creatures among the winged. And these are those horrendous, winged dragons of which we are speaking. It is read in the life of Saint Mary Magdalene, when she sought a more hidden retreat of solitude...

[The basilisk-head description completing the 1660 Roman dragon — running over from the left column: the head was] furnished with a double row of serpentine teeth set into its jaws; it was two-footed, but, with a contrary position, monstrous, and equipped with cartilaginous feet like those of geese; and it is displayed for inspection, with all [its parts], in my Museum. The Figure of the Dragon is here.

[she] sought [a cave], and, having left Marseille, withdrew to a certain rocky and rugged tract, five leagues distant from there, which today they call Sainte-Baume [Saint Beaume], into the cave of a lofty mountain, into which one could be carried only by the aid of angels. There, when she had come upon a horrendous dragon of unusual size, she straightway commanded it, in the name of Christ, to depart from that place. And it, struck with awe by the holy command, flew off to a deserted spot by the Rhône, where Saint Martha [Sancta Martha] was then dwelling.

[Margin: The cave of Sainte-Baume was at first the lair of the dragon of St. Mary Magdalene.]

[The dragon] departed, and by the help of the same Saint — the inhabitants pressing their prayers because of the enormous harms it was inflicting — it was captured by the Saint, bound with ropes, and led to that place which was afterward called Tarascon [Tarascum]. There it is said to have been killed by the inhabitants — whose history, very skillfully painted in the Cathedral Church, I remember seeing at Tarascon in the year 1632, while I was passing through there.

[Margin: It was killed at Tarascon by the help of St. Martha.]

At this point I shall add two historical relations concerning flying dragons, which are confirmed by so many and such great testimonies that I think no one is of so brazen a brow as to be able to deny them — unless perhaps someone who has resolved to do away entirely with all human credence, which does not befall a man of sound brain. One is found in the *History of Religion of Jerusalem* composed by Saint [recte: not a saint — Giacomo] Bosio [Iohannes Bosio]; the other in the description of Switzerland related by Johann Cysat [Ioanne Cysato]. I shall here briefly recount both.

From Bosio, who in Book 2, page 45, speaks thus:

[Margin: A wondrous history of a winged dragon in the island of Rhodes, slain by Brother Deodatus de Gozon, Knight of Jerusalem.]

In the year 1345, in the pontificate of Clement VI, while Hélión de Villeneuve [Elione de Villanova] was Grand Master of the Order, there happened a thing wonderful and altogether memorable for all ages. There was in the island of Rhodes, not far from the Church of St. Stephen, a huge crag furnished with a vast subterranean cave, from which a stream flowed. In this cave there kept watch a dragon — a monster horrendous, huge, and dreadful to behold — which not only infested the greater part of the Eastern island with great ruin of men and beasts, with unheard-of savagery and enormous destruction, but also so corrupted the air with its venomous breath that no one could approach this shore without manifest danger to life. And so it was decreed by the Grand Master, by public edict, that no one of whatever condition or order he might be should approach the place; the Knights too were forbidden, under penalty of life and of loss of the habit. Hence not undeservedly the name *Malpasso* [Bad Passage] has clung to the place. There was at that time at Rhodes a Knight, a most noble youth, endowed with great fortitude of soul and body, whose name was Deodatus de Gozon [Deodatus de Gozon], sprung from Gascony. He, deeming it unworthy that of so

many high-born soldiers and Knights there should be none who would dare to set himself against the monster to repair such great harms, spurred no less by curiosity than by love of winning immortality for his name, judged that he could never obtain a better occasion than if, by entering upon a new and unheard-of combat with this horrendous beast and savage monster, and by slaying it, he should free the island — oppressed by so many and such great evils — from so great a plague. And he held his mind so firmly fixed upon the resolve of this undertaking that he seemed unable to rest day or night until he had carried into effect the thing he had set himself.

Diagram. A full-length engraved plate of the Rhodes dragon, occupying the lower half of the page. The creature is shown in profile facing left: an elongated, scaled, four-legged body like a crocodile, with a long serpentine tail curling up at the end on the right. The neck is long and serpentine, ending in a head with open jaws from which radiates a large fan-like crest or spray of bristles/spines. A prominent webbed, fan-ribbed wing rises from the mid-back. The legs end in clawed feet. The body is rendered in overlapping scales.

Engraved caption (cursive script, above the figure), verbatim and translated:

- "Hic est Draco ille alatus et quadripes omni ævo memorabilis, quem Deodatus de Gozon Eques Hierosolimitanus, in insula Rhodo eo quo descripsimus stratagemate confecit; qui et ob beneficium in Insulam collatum postmodum Magnus Ord. Magister Creatus est."
- Translation: "This is that winged and four-footed dragon, memorable for all ages, which Deodatus de Gozon, Knight of Jerusalem, dispatched in the island of Rhodes by the stratagem we have described; and who, on account of the benefit conferred upon the island, was afterward created Grand Master of the Order."

[The body text resumes in the two columns below the plate:]

But since he feared the Grand Master's rigid and capital edict, he was wholly occupied with this: by what way and means he might obtain his aim, with no one privy to the secret of his mind. He therefore began the business in this manner: first [he made] the form...

[Margin: The form of the dragon.]

[the form] of the dragon's whole bodily constitution, the diversity of the colors with which it was imbued, he observed by a clandestine approach to the place. The dragon's form was this: its body had the thickness of a great horse or ox; its

long and rough neck ended in a serpent's head; it had ears, rather long, like those of a mule; it was armed with a horrendous gape and very sharp teeth; it had very large eyes, exceedingly bright and as if breathing fire; it walked on four feet equipped with very sharp claws like a bear's; as to its tail and remaining limbs it was altogether like a crocodile. Its whole body was armored and fortified with a crust of very hard scales intricately arranged. It was equipped with two cartilaginous wings extended at the sides, of a color not unlike the gills of a dolphin — bluish on the upper part, and on the lower imbued with a reddish-yellow mixture — with which color the whole rest of the body too was variously tinged.

[Margin: Swiftness of its running.]

It was borne along with so swift and rapid a motion that there was no horse of such speed as could, by however swift a run, escape its swiftiness; so that it seemed partly to fly, partly to walk on its feet — which, when it happened in the search for food, both by the rattling of its shell-like scales and by a horrendous hiss, perceptible far and wide, almost killed with fear and dread even those at the greatest distance. You have here the form and actions of the dragon, in the manner in which I have recounted them, observed most exactly by Brother Deodatus of Gozon, the Knight.

[Margin: Deodatus's wonderful ingenuity.]

And so the Knight, without delay, having sought leave from the Grand Master, departed to his homeland under the pretext of settling domestic affairs. There, without postponement, he made a dragon of paper and Rhodian tow [stuppa Rhodensi] — whether you regard the variety of the colors or the lines of the limbs of the whole body — utterly similar and equal in size [to the real one]. Then to this end he bought a horse, as high-spirited and fit for war as he could, to which he joined two very powerful dogs, which they call English [mastiffs]. These things being now prepared, he ordered the tow-dragon to be entered by servants appointed to this office, and to be moved aptly now here, now there; by whose help, by means of little cords, now the horrid gape of its mouth was opened, now its tail was twisted in various directions, now by the clapping together of its wings it offered a wondrous spectacle of itself, like a living dragon. Deodatus meanwhile, with a feigned and pretended assault against the dragon, urged on now the horse, now the dogs.

[Margin: Preparation of the knight for the contest against the dragon.]

And when he had drilled himself in this exercise for the space of two months, the horse and dogs, trained to every effort, were held by so great a desire and itch for fighting that, at the sight of the fictitious dragon, they could scarcely any longer be restrained by the reins. Whence, now confident of the happy outcome [Greek: δρακοντομαχίας (drakontomachias, "dragon-fight")], he put an end to the masquerade combat, and without any delay began his journey toward Rhodes together with the horse, dogs, and servants. Scarcely had he reached Rhodes when, behold, putting his long-conceived design into execution without delay...

[Margin: Speed of its course.] ...with great fortitude of soul, he entered the cave, the dragon's lair; and when he perceived nothing stir, by a shout and din raised to rouse the beast — and when from that horrid hiss and the rattling of scales he had noticed the deadly monster approaching from the inner recess of the cave — he at the same time also advanced into a plain, a place suited for the fight, and awaited the monster. At length, the monster, on seeing the Knight, enticed by hope of rich prey, began to rush upon him with great force at a most furious run and flight. But the Knight's adversaries [the dogs and horse], trained and habituated to overpowering the dragon and thus also fearing nothing of the horrid sharpness of the monster, attacked the dragon at the part where it was possible. The Knight meanwhile, charging, drove his brandished lance so forcefully against the hard crust of the dragon that, at the very first blow, the lance was shattered and he was deprived of the chief support of his arms.

[Margin: The dragon's lair is entered.]

And since the dogs, having seized its genitals, were tormenting the beast in a wondrous manner, and since the beast, in defending itself against the dogs, thereby also left the Knight some little time to renew the contest, he therefore, armed with sword and shield, judging it more convenient to attack in a foot-combat, dismounted from his horse. When the monster noticed this, it at once stood on its hind feet, and, reared up, tried to crush the Knight with its left and the shield with its right, with the horrendous claws with which it was equipped. The Knight, having found out the softer part of its neck, drove his sword in so forcefully that thereupon he at once drew out a great quantity of blood. And since, from the pain by which it was oppressed, the beast was driven into a frenzy, the closer it brought itself to its competitor, the deeper he drove the sword into its vitals, until, with the sword cutting like a saw by repeated slashing here and there, he opened up the whole neck.

[Margin: The combat with the dragon.]

[Margin: The death of the dragon.]

And this done, the monster, weakened by an enormous flow of blood, falling down, with its own bulk so pressed down upon the Knight — exhausted both by the labors of the horrendous combat and intoxicated by the great stench which it exhaled from its opened body, and now failing in strength — that he seemed almost lifeless. Seeing this, the servants, mindful of the instructions given them, immediately left the crag and, with horse and dogs, [hastened to their] laboring [master]...

[Margin: ...the master laboring with the dragon.]

flew to bring help to their laboring master, and now drew out their lord, almost lifeless and oppressed, the beast having been removed; and because they still noted some signs of life in him, they continually poured cold water, brought in their caps from the neighboring stream, over the whole body of their master. He, then restored with cordial fomentations, when at last, his strength gradually recovered, he had come to himself, mounted his horse, and, returned to the city after a glorious victory, narrated the deed in order to the Grand Master.

[Margin: Deodatus de Gozon is restored by cold water.]

And where he hoped for great glory and reward from a deed so profitable to the public good, there he met with the contrary throw of fortune's die. For the Grand Master, having convened a council, with public reproof both of his rash and presumptuous audacity and of his violation of the rigid edict, and, having stripped him of his Knight's habit as an example to others, consigned him to a grim prison. Meanwhile, the killing of the dragon having been published throughout the island, there arose everywhere great applause at the high-born Knight's resolve, and congratulation at the island's deliverance from so great a calamity as the horrid and insuperable monster had inflicted on it; the Knight's praise resounded through the whole island. Moved by these things, the Grand Master, having considered the Knight's immense merits, not only restored his habit, releasing him from prison, but advanced him to the first grades of the Order's dignity.

[Margin: Deodatus de Gozon is chosen Grand Master of the Order.]

Raised to which station of dignity, he gave such proofs of prudence and of fortitude of judgment and spirit in dexterously expediting difficult affairs that, after four years, when the Grand Master Hélión de Villeneuve had departed [this life] for the [debt owed by] all, he was chosen by all the votes and ballots as

successor in the Grand Mastership. In whose praise these inscriptions are even now carried around, on the testimony of Hieronymus de Megistero [Girolamo Maggi]: "Deodatus de Gozano, slayer of the dragon — Master of Province III. After the dragon was destroyed, before he became Master." The other, subscribed beneath his effigy, runs thus: "Brother Deodatus de Gozano. This man strenuously slew the snakes of immense bulk, which were terribly devouring the wretched inhabitants of Rhodes in their coils; thereafter he was created Master, in the Year of the Lord 1349." These things, perhaps more fully than was fitting, I have thought should be set forth, so that, from a history known to all, men of stupid head [the skeptical] might learn to believe that winged dragons both have existed in the nature of things, and even now exist.

The figure of the dragon together with the contest, which the most illustrious Knight of Malta communicated to me, I have thought should be appended here.

[Margin: Deodatus is chosen Grand Master of the Order.]

Aldrovandi relates that, a little before Hugo Boncompagni [Boncompagnus], Cardinal, raised to the Pontificate, shone forth to the Christian world under the name of Gregory XIII, a dragon was found in the territory of Bologna [Agro Bononiensi], of the figure that follows — concerning whose origin and genesis we shall reason more fully elsewhere in this work.

Diagram. An engraved plate of the Bologna dragon, occupying the central portion of the page. The creature is shown in profile facing left: a long, slender, serpentine body with a single pair of legs (two feet) and a long neck. The back and body are covered with overlapping scale-plates rendered in detail; the underside of the neck shows ridged/banded scaling. The tail is long, slender, and serpentine, looping behind. No wings are shown — consistent with the caption's "wingless and two-footed."

Engraved caption (cursive script, above the figure), verbatim and translated:

- "Hic Dracunculus ἄπτερος καὶ δίπους paulo antequam Hugo Boncompagnus Card. ad Pontificatum assumeretur sub nomine Gregorij XIII. Bononiæ captus etiamnum in Musæo Aldrovandi tomento fartus spectatur."
- Greek terms in the caption: [Greek: ἄπτερος (apteros, "wingless"); δίπους (dipous, "two-footed")].
- Translation: "This little dragon, wingless and two-footed, captured at Bologna a little before Hugo Boncompagni, Cardinal, was raised to the

Pontificate under the name of Gregory XIII, is still to be seen in the Museum of Aldrovandi, stuffed with padding."

[The body text resumes in the two columns below the plate:]

And since for the incredulous one history heard does not suffice, I shall append another, no less worthy of admiration, which Cysat teaches in his description of the four Swiss forest-cantons [*De quatuor Helvetiorum Sylvaniarum civitatum descriptione*], in a book printed in the German language, which Johann Cysat the Swiss [Ioannes Cysatus Helvetus] some time ago made public. There he teaches by many examples that nowhere has a greater abundance of dragons of this kind appeared than in Switzerland.

[Margin: A flying dragon seen in Switzerland in the year 1619.]

And when, not long ago, I consulted by letter the noble man Christoph Schorer [Christophorum Schorerum], prefect of the territory of Solothurn [Soloduri], concerning the truth of these histories, he confirmed — not only on the strength of that experience of affairs in which he is skilled — that they are most true, but also wrote that he had ascertained the truth of the matter with his own eyes, in these words:

"On a night in the year 1619, while I was contemplating the serenity of the sky, behold, I saw a brightly-glowing dragon, from an immense cave of the mountain which the natives commonly call Pilatus [Pilati], fly across with very swift motion of its wings to another part on the opposite side of the lake, to the cave which they call Flue. Its form was very large, with a long tail and an outstretched neck; its head ended in a serpent's jagged gape; while it flew, it scattered sparks from itself, not otherwise than when men beat glowing iron on the anvil. At first I supposed I was seeing some sort of meteor, but after [I had] diligently..."

— from which it cut through the softer part [of the beast's body] with a blow and at last finished off the beast. But when, in his joy, he was now flinging high into the air the sword still wet with the dragon's blood, the venomous blood, flowing down inside the bared flesh, proved to be of such virulence that the man—who already believed himself the victor—was instead overcome by the dragon's own blood, and shortly afterward died. I have judged it fitting to insert here a depiction of the dragon sent to me from Switzerland.

Diagram. A full engraved plate of a Swiss dragon: a two-legged, winged creature in profile facing left, with a long-jawed crested head and gaping toothed maw, a serpentine neck and body covered in scales, a broad ribbed bat-like wing raised

over the back, two clawed forelegs, and a long coiling scaled tail. The figure bears only its engraved caption and no internal point-labels.

- Caption (engraved, above figure): *Draco Helveticus bipes et alatus* — "The Helvetic dragon, two-footed and winged."

[Margin: A remarkable account of two winged dragons.]

A remarkable account of a certain cooper who lived for half a year together with two dragons.

I shall add in this place an account from the Cysat already cited [Renward Cysat], one to which I would scarcely give credence—were I not compelled, by so many testimonies, and indeed by a public votive offering [*Anathema*] still preserved in the Church of Saint Leodegar at Lucerne as witness to the matter, to admit it to be true. The affair runs as follows:

There was in the city of Lucerne among the Swiss a cooper who, going out one day to seek wood [*ad fabricanda dolia*, for making barrels] among the dense recesses of the woods and crags of the Alps, by some fate I cannot explain became entangled in those labyrinthine windings of the vast wilderness. He no longer knew where he was, nor how to find again the path he had left, and wandered to and fro the whole day. He roamed through a great part of the night as well; then, indulging himself a little in rest from the weariness he had accumulated, he pressed on with his way as twilight came on. In the dim light he failed to see a huge chasm yawning before him at the bottom of the gorge, and fell into it—yet in such a way that, landing on soft mud, he suffered no other bodily harm beyond a fainting fit, which he had incurred from excessive mental dread and fear of falling.

When he came to himself, and saw that the depth of the chasm was insurmountable by human skill—for it was shut in on every side like a well or pit, with high and rocky walls all around—he despaired of any human help and turned with great fervor of spirit to the divine, ceaselessly importuning God and his Mother with continual prayers and vows to free him from so wretched a state. But it pleased the Divine Majesty to exercise him with a greater affliction, to the fuller heaping-up of his merits. In the sides of that chasm were deep crypts [*cryptae*], stretching far in length and breadth on every side. As he entered them, looking for a suitable dwelling-place, he suddenly met two horrid dragons coming toward him. At the sight of them he was nearly lifeless, and as he made for the pit again, he did not cease, with a great pouring-out of tears, to implore God and his Mother again and again against such monstrous creatures. And the

dragons, though they sometimes coiled about his body, now with the tail, now with the neck, nevertheless inflicted on him no harm or violence whatsoever. What state of mind the wretched man must have had in so dreadful and unheard-of a fellowship of dragons, anyone can more easily imagine in his own mind than describe in adequate words. Here you would have seen a Daniel dwelling not in a den of lions but of dragons.

Yet he dwelt there—not one day or a week, but six whole months, from the sixth of November until the tenth of April. But on what food do you suppose he sustained his life? Listen and be astonished. He had observed that those dragons fed on no other food at all, the whole winter long, but a certain salty liquid that oozed from the rock walls. So, when he was destitute of all the necessities of life, he followed the dragons' example, and himself set about licking and lapping that liquid from the walls; somewhat revived by it, he eked out his life by this kind of nourishment for the space of half a year. And so, as the Sun crossed the equinoctial line and the air was now felt to grow milder with the Sun's warmth, the monsters too perceived that the time had now come for them to emerge from their subterranean lairs and that it was fit for seeking food. The first sped off and flew at once out of the pit with a great beating of its wings; and as the second attempted the same, the cooper—reckoning this his best chance of escape—seized the beast by the tail and was carried out of the pit, in a spectacle the like of which had never been seen. There, once the dragons had been let go, he found by divine guidance the path at once, and returning by it to Lucerne, he visited his own people, who had long believed him lost. To the astonishment of all, and the amazement of those struck dumb at a story which they judged the most terrifying that had ever occurred, he set forth in order all that had befallen him.

And because he had obtained, through the intercession of the great Mother of God, his deliverance from so horrendous a state, he wished—as a perpetual memorial of the event and an object of wonder for posterity—a priestly vestment, which they call a *casula* or chasuble, to bear witness. On it he had the whole course of the affair embroidered with the needle; and this vestment, surviving at Lucerne in the Church of St. Leodegar to this very day, is customarily shown to all pilgrims. But the cooper himself, wholly turned to God, since because of the corruption of his stomach he could no longer take his accustomed food, two months after his deliverance from the dragons' den fell asleep piously in the Lord.

Many things, I admit, are contained in this history which far surpass the powers of nature; and so it must be wholly granted that the state of his life in so

horrendous an abyss was supernatural. From these and similar accounts anyone may easily gather that the things found here and there in authors about winged dragons are not false. But that nothing may seem lacking to the reader's curiosity, let us now set forth the origin and generation of dragons.

On the Generation of Dragons.

[Margin: A remarkable account of two winged dragons.]

One might justly raise a doubt as to whence, and from what matter, the generation of such great monsters takes its origin. And since up to now no one has been found who has handed down anything about this in writing, I have thought it our part to explain in this place, as far as our weakness of understanding permits—

—to unfold this *δρακοντογένεια* [Greek: drakontogeneia, "generation of dragons"].

[Margin: Why monsters are for the most part generated from a confluence of diverse seeds.]

It is acknowledged by all physicians and physiologists that from a confluence of diverse seeds an animal of mixed species is generated. This happens not only among perfect animals—as in mules, mongrels [*tragelaphis*, lit. "goat-stags," hybrids], camelopards [giraffes], and the like—but also in the production of a human fetus from the seeds of a different species, coalesced in the womb of a wild beast or a woman, of which as many examples occur as there are *ἄνθρωπόμορφα* [Greek: anthrōpomorpha, "human-shaped" monsters] found in Lycosthenes and other writers on these matters. But that this also happens most especially and most frequently in insects, their wondrous metamorphosis testifies abundantly and to spare. For a bee is born from cow dung, and if anyone examines its head more closely, he will be forced to assert that it exactly resembles the head of a cow—as we have shown at length in the *Chapter on the Hieroglyphic of the Ox* in the *Obeliscus Pamphilius*.

[Margin: Bees reproduce the head of an ox.]

[Margin: Beetles, the head of a horse.]

The same is plain in the horned-headed beetles, whose head is not unlike that of a horse, from whose excrement they are born; and the *bruchus* [a kind of locust or weevil] too, which, because of its resemblance to the horns of a stag, they call *tragelaphus* [goat-stag], clearly testifies it by its horns. In a word, the excrements

of perfect animals always generate some insect similar—if not in the whole, at least in some part—to the animals from which they are generated; about which I treat more fully elsewhere.

These things premised, let us now explain in a few words how dragons can be generated in inaccessible mountain caves and in vast solitudes. It is established by frequent observation that places of this kind, where dragons have ever been seen, are full of eagles, vultures, and similar birds of prey. Dominicus Niger, in his *Geographia*, reports that Rhodes abounded in robust eagles.

[Margin: Vultures and eagles hunt animals of every kind.]

These birds, by their very nature perpetually intent on rapine, carry off in their hunting animals of every kind—hares, lambs, dogs, indeed sometimes children too, snatched away—into the inner caves of the mountains for food. There, by continued hunting, they pile them up little by little into a great mass, as many testify; and just as they cannot consume so great a multitude of carcasses, so these too must gradually be turned into a putrefaction suited for generation.

[Margin: How carcasses are gradually consumed by putrefaction in the mountain caves.]

And since in the carcasses of any animals whatever there always remains some portion of seed—as will be demonstrated in *Book XII*—it comes about that little by little, from the various confluence of seeds in the matter now disposed and fermented by putrefaction, an animal is born. This happens in such a way that from the putrid matter a worm is first produced, and then, from the seed latent in the carcass of a quadruped, the worm is shaped into something resembling a quadruped animal. It may obtain, perhaps, long hare-like ears from the formative idea of the seed radiating together to fashion the ears; and because the seed of a bird also—

[Margin: Whence comes the diversity of limbs in dragons, for the most part.]

[Margin: How an animal is generated from diverse seeds.]

—whatever seed at last is in the rotting place, it comes about that this seed, since it cannot do otherwise, joins to it something winged, or some quadruped part, if not feathered then at least cartilaginous. In the same way, when a great supply of serpentine [seed] has been gathered there, from the serpentine seed a tail, neck, and head of a serpent are joined to it; and thus a serpent-embryo is formed from the mixture of diverse seeds, which in the course of time grows into a dragon of huge size. And if several are born of different sex, then just as they first obtained

their origin from the putrid matter, so afterward they can also propagate themselves by natural coition—like the rest of the insects that are born from putrefaction. But lest so great a multiplication of this plague should turn to the immense damage of Nature, Nature seems to have provided for this with the best of right, so that for the most part only one dragon is born in the subterranean caves of the mountains, from the differing seeds of various living creatures. That this spermatic power still remains in carcasses will then be demonstrated, when in *Book XI* the wondrous power of seed is treated of professedly.

[Margin: Why the seeds do not produce some whole thing.]

[Margin: How an animal is generated from diverse seeds.]

The question therefore arises: why do the seeds not produce something whole? I reply that this comes about because of the confusion of the seeds. While each one acts as much as it can, it happens nonetheless, from the confusion, that the individual seeds—since they cannot, from the resistance of the matter, produce the whole—at least produce a part similar to themselves; and so, while each contributes something of its own, from this is born that deformed and monstrous body of the dragon.

The question arises secondly: why do dragons seem to breathe fire? I reply that they consist of a certain viscous matter—of the kind of which certain fishes, and rotten wood, and glowworms consist—shining with an innate light that gleams most brightly in the dark; and so men, seeing dragons glittering with light, imagine to themselves that they consist of fiery bodies. You will ask: whence comes to them that very hard incrustation of scales? I reply that it comes from the same disposition of matter by which testaceous animals are armed—namely, from a humor of mucous and most tenacious viscosity, which, hardened on the outermost enveloping surface, gradually degenerates into a horny hardness.

From these things it is luminously clear that a manifold animal can be born from the fermentation of putrefaction arising from a diverse confusion of seeds. It is well known that a cock devouring a serpent's egg generates a basilisk—because the seed latent in the serpentine egg, gradually exerting its powers, brings forth an animal *δρακοντο-όφιομόρφον* [Greek: *drakonto-ophiomorphon*, "dragon-serpent-shaped"], that is, an animal composed of a serpent and a cock.

[Margin: A monstrous cock in the garden of the Grand Duke of Etruria.]

Such was that monstrous cock which Francesco, Grand Duke of Etruria [Tuscany], displayed for viewing in the Boboli Garden at Florence for many

years: it expressed in its crest, its leggings [feathered shanks], its spurs, and indeed in its whole body, a cock—but with a serpentine tail, flexuous and coiled into various spirals, displaying I know not what likeness to a dragon.

Diagram. A full-page engraved plate of the monstrous serpent-tailed cock. The figure shows a standing fowl with a feathered, plumed crest and long whisker-like feather quills projecting from the head, a hooked beak, scaled legs with spurs, and—in place of an ordinary tail—a long, scaly serpentine tail curling and coiling into spirals at lower right.

- Caption (engraved, beneath figure at left): *Gallus ὀφιομόρφος* [Greek: ophiomorphos, "serpent-shaped"], *Serpentina cauda conspicuus. Florentiae in horto Magni Ducis Hetruariae Francisci ea forma qua hic exprimitur omnium admiratione visus.* — "A serpent-shaped cock, conspicuous for its serpentine tail. Seen at Florence in the garden of Francesco, Grand Duke of Etruria, in the form here depicted, to the wonder of all."

So born, as it were, from a cock-serpentine egg. By this means barnacle-geese [*Berniclae*] too are born in the nearby places of Scotland.

[Margin: How geese are born in Scotland.]

For eggs in the icy sea, deposited by ducks and geese in countless multitude—as the Dutch [*Batavi*] relate in their voyage toward the North [*ad Arcton*, toward the Bear / the Arctic]—once the ice has melted and broken up, have their seed driven by the agitation of the sea against the neighboring shores of the Orkneys and Hebrides; and there, clinging to the slime [*mucor*] of ships, at last by a certain implanted property of the climate, it is animated from the presupposed matter of the seed into a duck or goose; and for producing these, even the smallest portion of seed suffices. But let this much suffice as said concerning dragons.

CAPUT III.

On Subterranean Men.

That there have been subterranean dwellings of men, and that there still are, the records of almost all historians are full of evidence. They can be considered in two ways. For either men inhabit hollow and rocky regions of the earth and crypts—and these have betaken themselves there either through want of resources or through the convenience of the place, to protect themselves against the injuries of the air and of the seasons; or else others, driven out in the

turbulent times of wars, have withdrawn into the safest regions within the valleys of the mountains, together with the things necessary for sustenance.

[Margin: How men first came to inhabit the subterranean regions.]

Of these latter, some afterward, when they could not find a way out, were compelled to remain there; and being perpetually shut in, and enticed by the convenience of the place for sowing and plowing the soil, they remained by the inescapable law of necessity, having multiplied by propagation. Of the former I shall speak first; of the latter we shall discuss afterward.

Gaffarellus [Jacques Gaffarel], in his book *On Crypts Celebrated throughout the Whole World*, describes subterranean cities at length. I would not have believed the truth of the matter, had I not myself surveyed habitations of this kind with my own eyes in three places of my own. For when in the year 1637 I was staying in Malta [*Melita*], it happened that one day, with the Master of the Order of Jerusalem, Giovanni Lascaris, I went to a certain villa of Malta filled with the charm and delights of men—which they call *Buschettum* [Buskett].

[Margin: An account of the subterranean dwelling of men at Malta.]

There, when concerning the nature and property of the island we were discussing back and forth with various reasonings—

LIBER VIII "Λιθογενής" — Sectio IV: De Animalibus Subterraneis [On Subterranean Animals]

Caput III: De Hominibus Subterraneis [On Subterranean Men] (continued)

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back and forth, the said Grand Master [Magnus Magister] added that there was, on a nearby hill, an underground dwelling of men subject to him, and that he wished me to go and inspect it — to observe the remarkable ingenuity of these people in fitting out such subterranean caves and arranging their dwellings. Since nothing could be more welcome to me, as I said, I joined a guide who knew the underground routes and the caves well, and I went up to the dwelling, which the island's natives in their domestic and familiar Arabic tongue call

[Margin: A great cave.]

غار كبير *Ghaar Kebir* — that is, "the great cave." Once I had entered the main gateway, which stood open far and wide, I found it full of people of both sexes, boys and girls dressed in peasant fashion. And although they appeared to live together in a confused way, each family nonetheless possessed its own quarters, or recesses, made either by craft or by nature. Within these, in a handsome arrangement laid out through one little cell after another, they were accustomed to store the various kinds of provisions.

[Margin: The layout of the dwellings.]

Here a bed was cut into the rock; there were nooks suitable for stowing loaves and cheeses; elsewhere appeared the stalls of cows, livestock, and donkeys; and there were even the nests of the hens. Earthenware vessels were not lacking, capacious enough to hold water in place of cisterns. Very long strings of onions and garlic, like so many clusters, adorned the walls. There were also ovens well suited for baking bread; into these subterranean cave-dwellings the light came through cracks in the rocks and through holes made deliberately for this purpose, contrived so cleverly that neither rain nor wind could easily harm them. Their ovens, too, had their own chimneys, so that when the fire was lit they would not be suffocated by smoke spreading through the caves without a flue.

[Margin: The customs of the inhabitants.]

By day the peasants busied themselves with their tasks outside the cave, and procured the necessities of life in the neighboring places; the women were assigned to the distaff, to cheese-making, and to similar tasks proper to women. Since they had no wood, in its place they fed their fire with the dung of beasts of burden dried in the sun. The men and women of this people were said to be of very large stature, robust and long-lived [Macrobii], living right up to a decrepit old age; and — remarkable to say — the women were not unhandsome in form. So strongly are they held by longing for their caves that, whenever the need to visit Malta presses upon them — whether to sell their goods or to buy other necessities — they could scarcely be kept there, as if condemned to a kind of exile, but at once, their business dispatched, they would return to their caves, not allowing themselves to be kept away from them even for a single night. They abstained entirely from the flesh of cows, livestock, and hens, since they reserved these only for profit, to be made by sale; they were content with bread, cheese, milk, onions, garlic, and herbs.

The Grand Master, in order to demonstrate the truth to me by experiment, ordered a table to be set. On one side he had placed all the kinds of meat, and whatever in the end was left over from the truly lavish and magnificent banquet by way of delicacies; on the other, cheese, onions, garlic, cabbage, and the dishes they call *Maccarones*. He then summoned his Troglodytes, whom he had had fetched from the caves to serve in the kitchen, and ordered them to sit at the table. They at once left the meat-delicacies untouched, and turning instead to those foods to which they were accustomed and which they gladly ate, they devoured them with full fists and a kind of canine greed. I have thought it worth describing this at some length, so that from it the reader may understand the character of the rest of the subterranean men. Hence what Solinus, Pliny, and Aelian write — truly most worthy of wonder — about the Troglodytes living beneath the earth by the Red Sea [mare Erythraeum] does not seem false.

[Margin: The Arabic language they use.]

There is, near the island of Malta, a place called Gaulos, commonly named *Gozo*, in which I found a wholly similar cave, packed with people who live by the same rite as those mentioned above. In both islands they use pure Arabic, without any admixture of Italian or any other tongue; and so the Maronites returning to Mount Lebanon, while they wait at Malta for a favorable time, often visit them, to read them the Mass in Arabic and to expound Christian doctrine — for they are not barbarians, nor deprived of the Catholic faith, but perform their daily prayers with the utmost devotion, continually tell their rosary-beads [precatorios globulos], and hear Mass on every feast-day in the nearer village. They keep, too, in their caves, images of the Crucified and of the Blessed Virgin set out in a fitting place. But let this much suffice concerning the Maltese Troglodytes.

[Margin: A subterranean dwelling in Etruria.]

In the year 1659, while I was exploring Etruria, it happened that, on a certain occasion, as I was about to examine the district of Viterbo, I crossed a meadow in which here and there continual columns of smoke were rising. Astonished, as it were, at such a spectacle, I supposed there were sulphurous pits in the place; so I asked my companion to explain what such smoke might portend. He, smiling, said: "These smokes that you see are not from earthly exhalations, but are the smoke that finds its way out into these meadows through the chimneys of the underground dwellings." And after a short interval he at once showed me a doorway through which there was an entrance into the said caves. We went in, then, and found everything arranged just as in the caves of the Maltese Troglodytes: bedchambers, seats, and nooks cut into the living rock, far more

spacious than the Maltese ones — for it was an underground village, which they call Meonianum, under the jurisdiction of the most excellent Prince Camillo Pamphili. A church could be seen outside; all the inhabitants devote themselves to agriculture. But I have pursued these matters more fully in our *Itinerarium Hetruscum* [Etruscan Itinerary], to which I refer the curious reader. And just as I surveyed these things with my own eyes, so too I have thought them worth setting out at somewhat greater length, so that if in other places — of which I have no doubt — similar

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dwellings are reported to exist, the reader may recognize that they are constituted in no other way than we have described. For that similar ones are found almost everywhere, the authors of geographical histories testify amply and to spare.

[Margin: Brahmans inhabiting subterranean caves.]

In the kingdom of Idalcan [Bijapur] in India, the members of our Society teach that very many people — both the Brahmans on the mountain of the Pagodas and the common folk — dwell in subterranean passages.

[Margin: Men dwelling underground in the Mountains of the Moon and the Caspian Mountains.]

In Africa, near the Mountains of the Moon [montes Lunae], Father Pedro Páez [P. Petrus Pais] relates that men live in the innermost recesses of the mountains, against the force of the Sun's heat. Marco Polo of Venice [Marcus Venetus] asserts the same of the mountains of the Caspian Sea, whose hollows, he reports, have been turned into the dwellings of men. I shall not speak here of the subterranean crypts of the city of Rome, where so many holy Martyrs, together with the holy Pontiffs, lay hidden during the time of persecution — on which let the reader consult the *Roma Subterranea*.

But since the dwellers in such caverns ought not properly to be called subterranean men — for a free exit is granted to them at all times, day and night — therefore in this place we must deal only with those subterranean places from which men, born and raised there, have never seen the light of either Sun or Moon, until at last, bursting out from their hiding-places by remarkable chances, they have recounted, to the wonder of all, what kind of life they had led. This history, exotic as it were and worthy of all wonder, William of Newburgh [Guilielmus Neubrigensis] tells in his *History of English Affairs* [*rerum Anglicarum*]

revolutiones], Book 1, Chapter 27, page 92. I shall set down his words here, translated from the German account.

A remarkable history of subterranean men, taken from William of Newburgh, the English writer.

"There is," he says, "a village in western England [*Occidentalis Anglia*], some four or five miles distant from the noble Monastery of St. Edmund, King and Martyr; near it certain very ancient caverns are to be seen, which in the common tongue are called

[Margin: Wolfpits.]

Wulfpites — that is, 'wolf-dens' — from which the aforesaid village took its name. From one of these caves, in the summer season, when the country folk were busy reaping the crops, two boys, their whole bodies tinged with a green color, emerged, covered in a material until then unknown.

[Margin: Two green-bodied boys emerge from the caves.]

And so, blinking as it were at the sight of the unfamiliar sky, they wandered through the fields, until at last they were seized by the reapers and brought into the village, with a great throng of people gathering, astonished at so unusual a spectacle. There for several days they lived without any food, nor could they be induced to take anything of those foods on which the village was accustomed to feed; and so, gradually failing, they were in danger of their lives for want of suitable nourishment.

[Margin: A wretched event.]

But it happened that at the same time someone passed by with a cart loaded with beans; as soon as they saw these, they at once rushed upon the cart with full force; and when, opening the pods, they found nothing inside, they bewailed their wretched lot with a copious flood of tears joined to wailing.

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But after the natives realized that they craved beans, they at once set fresh beans before them, which they ate with great joy and the utmost eagerness, as though it were their own proper nourishment.

[Margin: The food of the green ones becomes their accustomed food.]

And thereafter for several months they used no other nourishment than the one mentioned, until little by little they grew accustomed to bread. After they had gradually grown used to our foods, the green color with which they were imbued was seen to fade by degrees into the color of other human beings;

[Margin: The green color fades.]

then, initiated by holy baptism, they learned the English language.

[Margin: They are baptized.]

The male, who was believed to be the younger, died on the very day after he received the holy washing of baptism; but his sister, who differed in no way from other women as regards bodily proportion, long survived him, and — as is reported — having been joined in marriage near Lynn [Lenna], is said to have been still living not long ago. Now when she had already learned the English tongue and was asked who and from where she was,

[Margin: From where they took their origin.]

she replied that they were people from the land of St. Martin, where his cult was greatly esteemed. And when she was further asked where in the world that land lay, and how they had come up into our region, she answered that she did not know — she remembered only this much: that once, when they were watching over their father's flocks at pasture, they had perceived a certain sound like the one which is made in the church of St. Alban in that place by the pealing of the bells; and that, struck with wonder at this unfamiliar sound, as they went further on, they at last found themselves in the very field in which they had been captured.

And when she was again asked whether, in the land they spoke of, they believed in Christ, and whether the Sun ever shone upon them, she replied to the first that the land was Christian and provided with churches; to the second she said that the Sun was never seen by them, neither rising nor setting, nor were they ever illuminated by any rays of the Sun, but they enjoyed a certain dim light, much in the manner that, before the Sun's rising or after its setting, appears to us here at the time of twilight.

[Margin: The subterranean region not illuminated by the Sun.]

She said, too, that not far from there lay a region much brighter than her own, separated from her own land by the breadth of a river of no small size. These and similar things the woman told concerning the aforesaid subterranean region, as

she remembered them. To each I leave his own judgment about this history. Certainly it should not displease anyone that I have written down so wonderful a history. Now this marvelous event occurred under King Stephen, in the year 1140. I confess that I long held myself in much suspense over so unusual a case; but, convinced by so many and so conspicuous testimonies of men most worthy of belief that the matter was truly so, I believed it, marveling at that which reason seemed in no way able to grasp." Thus far William of Newburgh — who not without cause long remained doubtful about the truth of the matter, since it is indeed remarkable and contains many things that may seem ἄπιστα καὶ παράδοξα [Greek: apista kai paradoxa, "incredible and paradoxical"] to those inexperienced in the workings of nature. And we should scarcely have given the matter credence, had not many similar instances, met with in the authors, confirmed our mind. And so that this may be plain to the curious reader, let us now examine the history with the file of truth, with all the ἀκρίβεια [Greek: akribeia, "exactness"] that can be brought to bear.

It is asked, first: by what means and on what occasion could these men have penetrated into that subterranean region?

[Margin: How the said men entered the subterranean region.]

I answer that this happens in various ways. First, in times of plague and of raging wars, when most men, intending to look to the safety of their lives by flight, are accustomed to withdraw into some hidden caverns of the highest mountains, as into a safe refuge against the snares of their enemies; and lest they perish there for want of necessities, they are accustomed to bring along with them their livestock — cows, bread, seed, vegetables, and whatever in the end is necessary for sustaining life. Frequent experience in the tumults of our own times — to which Germany has now for nearly forty years been continuously subjected — makes this so manifest that no one can doubt it any longer.

[Margin: Those fleeing the savagery of war in time of war hid themselves within the caves.]

By a similar chance, then, those first men, fleeing the savagery of their persecutors, hid themselves in that labyrinth of caves, from which they could afterward not extricate themselves; and the more anxiously they thereafter sought a way out, the more and more they entangled themselves, as is likely — until at last, having entered into this far-and-wide-extending subterranean region, not without divine arrangement, they were compelled by the hard law of necessity to remain.

[Margin: The Jews shut up in the Caspian mountains.]

The very same thing, we read in the geographers, befell the Jews, shut up in the inaccessible recesses of the Caspian mountains. And do we not read that, in the mountains of Spain, in the time of King Philip III, a new colony of men was discovered — men who, by what chance is unknown, had betaken themselves there for some such reason and occasion, and who through many centuries of years, without any commerce with the rest of mankind, in a language much differing from Spanish, remained unknown to all up to that very day?

[Margin: In the mountains of Spain a new region discovered in our own times.]

This continued until, the region having been discovered by hunters, the inhabitants — destitute of all cultivation of life and morals — were converted to a better way by the Fathers of our Society, and now differ in nothing from the rest. Crusius [Cranzius] also relates that in Transylvania, in the year 900, a similar race of men burst forth from the windings of the mountains, who afterward inhabited the whole region, not yet everywhere cultivated.

[Margin: In Transylvania men burst forth from the caves.]

The curious reader will find countless instances similar to these, if he will consult the various revolutions of the world; for when men, oppressed by storms of misfortunes, have been compelled to seek the hidden recesses of the mountains, immune against the violence of their enemies, and tarrying there a long time, have at last with time grown accustomed to the places and remained there.

It is asked, second: how and from where could that light, similar to twilight, have arisen for them?

[Margin: From where that light in the subterranean region.]

I answer: from a fissure or a notable opening in the upper part of the mountains. For it can scarcely be believed how much clarity even the smallest ray of light, through even the smallest fissure, brings to subterranean places; and experience teaches this in the subterranean crypts, both the Roman ones and the other darker places, and is most especially evident in the Pantheon. Now it is likely that the opening of this subterranean region was quite notable, and stretched out lengthwise along the ridge of the mountains; whereby it came about that it not only received sufficient light for several hours of the day, but also, with the external warmth now insinuating itself, the subterranean earth was made fit for grasses and vegetables. For we saw above that beans and the nourishment of greens also grew there; nor were there lacking here springs, nor fish from the

subterranean river — with which we have shown elsewhere that the Subterranean World abounds. Nor does fire seem to have been lacking, since with the fire-strikers [ignitabula] they had brought with them — God surely directing it so — they could easily kindle a fire, and, when the tinder failed, easily prepare new tinder from any combustible material whatever (as nature is most resourceful in ingenuity in such cases), for the use of so necessary an element.

[Margin: In Megrelia a valley the Sun does not penetrate.]

Hayton [Haytho] relates, in his *History of the Tartars*, that in Megrelia [Mingrelia], and within the Caspian and Caucasus mountains, valleys are found so deep that the Sun never penetrates to their bottom, and that therefore a perpetual twilight reigns there even at midday; yet they abound in trees, herbs, plants, and streams, and are even inhabited by men. A region similarly enclosed within the walls of the highest mountains, from which there was no exit, could likewise have fallen to the lot of these men of ours.

It is asked, third: what was that unknown material with which the aforesaid boys were clothed?

[Margin: With what material the boys were clothed.]

I answer: they were clothed either with the skins of sheep, or with some other material growing in that subterranean territory. For just as we read of a certain people of India that they prepare their garments from twisted filaments of roots, others from moss growing on the walls, others from a certain thin and tenacious skin [cuticula] that usually grows on the walls of crags and rocks, others from the thin bark of shrubs and the like — these things which God, in His infinite goodness and mercy, does not fail to supply to the wretched when placed in such great need — so too we affirm that the said subterranean men were clothed.

It is asked, fourth: from where did that greenness of their bodies come?

[Margin: From where that greenness of the bodies.]

I say that it came from the native moisture of the place, and from the moist juice of the herbs on which they fed. For there are, as experience teaches, in hidden moist caverns, walls for the most part all imbued with a certain green color, which in the said region redounded also into the body — the very moist constitution of the foods contributing much to this. Hence, as soon as they used the customary foods in the region above the earth, that green color is said to have gradually changed into the natural one.

It is asked, fifth: how could they have dwelt for so long a time in a place of such intemperate moisture?

I say that the region was thoroughly purged, and reduced to some moderate temperature, by the perpetual fostering of fires. But you will perhaps ask: from where did they have a sufficient supply of combustible material? I say: from shrubs, roots,

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roots, clods of turf, and moss — sufficient material could have been provided.

It is asked, sixth: how can they be said to have believed in Christ?

I answer: since, before they became enveloped in this subterranean labyrinth, they had been imbued with the Christian mysteries, they preserved this faith also through the continual succession of propagation — though, with their minds running wild and being for the most part deprived of priests, in a very imperfect form. And the fact that a church consecrated in honor of St. Martin was there plainly proves it. And from these reasons it is clearly evident that this history related by William of Newburgh is not so impossible as anyone might persuade himself. Whoever desires more of this kind concerning subterranean dwellings, let him read the admirable work *Atlas Sinicus* [the *Atlas of China*] composed by Father Martino Martini, in which you will find wonderful things on such matters recounted.

Caput IV: De Daemonibus Subterraneis [On Subterranean Demons]

That there are subterranean demons, not only profane but also Sacred Writers assert by unanimous agreement — concerning whom, see Delrio [Delrigus].

[Margin: A subterranean place is fitting for the demons.]

For since these powers of darkness flee the light as the seal, as it were, of the divine countenance, surely no more fitting place ought to have been assigned to them than the subterranean pit [barathrum] of everlasting darkness, according to that saying of the Apostle Jude, verse 6: "But the angels who did not keep their own principdom, but forsook their own dwelling, He has reserved in chains of eternal darkness unto the judgment of the great God" (Jude 6). That subterranean demons, then, the powers of darkness, exist is so certain that no one can doubt it without loss of faith. And since, by the just dispensation of God, clad in the masks of human form, they from time to time appear to men — whether to tempt them

or to torment them — lest these too should be lacking in our subterranean world, which is constituted of every grade of creatures, I have thought it proper in this place to treat of them, so that it may be established what is to be thought of them, and how their wiles are to be resisted.

[Margin: In what places demons of this kind have been seen.]

Historians record that demons have been observed chiefly in three places: first, in the northern regions condemned to perpetual gloom; second, in dreadful wildernesses; third, in the subterranean tunnels [caniculi] of the metal-bearing mines. And since the said little demons [daemunculi] mostly appear under the form of a cubit-high dwarf [Nanus cubitalis], hence seems to have arisen the fable about the Pygmies fighting with cranes at the Rhiphaean mountains, whom the geographers place in the farthest kingdom of the North. The Arabic Geography places them in the kingdom of Gog and Magog, with which agree all the writers on northern affairs. Paolo Giovio [Paulus Iovius], in his book *On the Embassy of the Muscovites*, says: "That in the region between the West and the North, oppressed by perpetual gloom, Pygmies are found, certain witnesses of outstanding trustworthiness have reported — Pygmies who, after they have grown up to the full, do not exceed the measure of one of our boys of ten years; a timorous race of men, expressing their speech by a chattering, so that, both in their resemblance to apes and in their stature, they seem far removed from man in their senses and in a just height."

[Margin: The Pygmies were not men, but subterranean demons.]

Concerning these, see Olaus Magnus, who calls them *Screlingi* — that is, "Cubit-men." Authors of the greatest weight have also made mention of monsters of this kind: Plutarch, Ctesias, Pliny. And therefore, although I will not easily deny that such things have sometimes been seen, so too I will not easily affirm that these were true men, since, in so great a knowledge of the whole surveyed world, no nation has been found that is a nurse of such Pygmies. From which it is concluded that they were seen by rude and rustic men in the farthest corner of the North, condemned to almost perpetual darkness — that is certain.

[Margin: No nation of Pygmies has today been found on earth.]

For since the said men, on the testimony of Olaus, are prone to every kind of superstition and easily devote themselves to the demons, it ought surely to seem strange to no one that these demons are wont to appear under the human form of a Pygmy, both to propagate superstition in simpler minds, and to bind those men to themselves by the benefits with which they are sometimes favored. For if such

a race of little men existed in gloomy regions of this kind, why did it escape the notice of the most inquisitive Dutch [Batavi], who now for a span of sixty years have done practically nothing else than not to cease exploring — I will not say any most hidden corners of the North — but of the whole world; and yet have learned nothing of such a nation of Pygmies? Why was no dwarf of this kind ever carried off from Lapland, Biarmia, Cremesia, Finland, and the other nations neighboring on Germany — Sweden, Denmark, Holland? — when nonetheless they do not cease to bring home with them to their homeland monsters of lesser importance from the farthest parts of the Indies; nor is there anyone today found who would dare to assert that he has seen a similar cubit-high Pygmy in those parts. All those things, therefore, are fabulous which the old geographers handed down concerning Pygmies of this kind, described from the mere report of the common people; and just as one wave drives on another, so one fable drives on another, while they attach to such manikins, as a marvel, the γερανομαχίαν [Greek: geranomachian, "the crane-battle"] — that is, they imagine that, drawing up a battle-line against the cranes that have offended them, they are kept occupied in perpetual war. See Jornandes and Olaus, who treat of these matters more fully.

I say, therefore, that these — if indeed they were ever seen — were none other than demons, lovers of gloomy places of this kind, who from time to time, to the rustic people living without any law or religion,

[Liber VIII, Sectio IV, Caput IV "De Daemonibus Subterraneis" — continuing from the prior pages]

and deceiving them so as to bind them into servitude, they appeared. From this the fabulous tale of the Pygmies afterward not only filled the whole world, but — what is astonishing — even won credence in the minds of the wisest men. Hence I am firmly convinced that these phantom dwarves [pumiliones phantasticae] belong to the same class of beings that even to this day are not infrequently encountered in the mines of metals, beings that are called the mountain demon-imps [daemunculi montani].

[Margin: The mountain demon-imps.]

Concerning these, Georgius Agricola [Georg Agricola] writes thus in his book *On Subterranean Animals* [*De Animantibus Subterraneis*]:

"There are two kinds of these demon-imps. One is harsh, savage, and terrifying of face, which they call the *Sneberg* [Schneeberger]; whenever it is provoked, it brings the greatest ruin upon the miners. There are also certain milder demons,

which some of the Germans, and now also the Greeks, call *Cobali* [kobolds], because they are imitators of men. For, frolicking with a kind of mirth, they appear to do many things, when in fact they do nothing at all. Others name them little men of the mines, *Bergmännlein*, signifying their stature, which in most cases is that of dwarves — namely three palms [dodrantēs] tall. They appear, moreover, to be little old men, and are clad after the manner of miners, that is, in a girt smock with a leather apron hanging about the loins.

[Margin: The labors of the demon-imps in the mines.]

These do not usually harm the miners, but they wander through the shafts and tunnels, and although they do nothing, they appear to busy themselves in every kind of work: now they seem to dig veins, now to pour what has been dug out into vessels, now to turn the windlass [machina tractoria]. Yet although they sometimes pelt the workmen with bits of gravel, they very rarely injure them, and never injure them at all unless they have first been provoked by laughter or by a curse. They are not unlike those demons which the Germans call *Gütel* or *Trulli*, of feigned sex — now of a woman, now of a man — who are said to have served, both among other nations and especially among the Swedes, in the office of household servants." Thus far Agricola.

From all this it is plainly evident that these are the very same beings which he says, in the farthest reach of the North, performed the office of servants. It has been reported to me that these mountain demon-imps are also seen in the mines of the Tyrol.

[Margin: In the mines of the Tyrol.]

[Margin: They harass the miners in various ways.]

There, unless the miners deposit at a fixed spot a little portion of their daily provisions — made up of porridge, small cakes, and cheese — they are not without danger on that day. And so by such superstition the demon's craft so befools the miners that some of them do not even hesitate to ransom themselves from his harassment by a certain sacred rite, and they strive by every means to placate him — most of all when they hear certain blows of the demon-hammerer [daemon malleator]. For then they wholly persuade themselves that this is a favorable sign that new gold-bearing veins will soon be discovered.

And this is confirmed by Cysatus [Johann Leopold Cysat], already so often cited, in his description of the Swiss mountain which they call *Pilatus* [Mount Pilatus], in these words translated from German into Latin:

[Margin: The mountain demon-imps in Switzerland.]

"Among other wondrous things, certain accounts are given of little mountain men, whom they call *Bergmännlein*, endowed with the form and stature of men, who are said to have dwelt in the caverns and hidden tunnels of this mountain, and to have practiced mining marvels along with the miners; some they endowed with gold and showered with gifts, others they harassed in dreadful ways; indeed certain ones, [fol. continues at 103]..."

"...[stirred up] into a like rage, are said to have hurled headlong over the rocky crags of the mountains. That this happened not by means of these fabulous Pygmies, but by the contrivances and various deceptions of evil demons [cacodaemones], by the just judgment of GOD, is most likely."

Not long ago a man of no little learning wrote to me that diabolical apparitions of this kind, in the shape of dwarves, have often appeared to various people — both to peasants and to miners — and have given answers to questions put to them on various matters. Indeed, he himself one day, having entered a very long underground passage some distance for the sake of exposing the veins, found beside a certain rivulet, in the damp sand, the footprints of a three-year-old boy, and examined them carefully. And since he could not persuade himself that a boy of that age could ever have entered this dreadful subterranean passage, he finally learned from the neighbors that they were the footprints of the mountain demon-imps — who, in order to kindle the greed of miners, are accustomed to mislead men (for the most part superstitious) with such footprints.

Since not long ago I had inquired of the masters and overseers of the metal mines in Hungary whether subterranean demon-imps — which they call *Bergmännlein*, or mountain pygmies — from time to time appear in the mines, they answered me in a letter sent to me as follows:

[Margin: Subterranean demons in Hungary.]

"In times past there have been such spirits, encountered by the miners, which even drove the miners into flight and thrust them out of the shaft, and sometimes stirred up a great commotion and uproar — for the most part, whenever they were approaching a rich vein, a like portent went before." This from the account of Schapelmann [Schapelmann], overseer of mines at Herrengrund [Herrengrundt]. That truly outstanding man Bernardus à Brun [Bernhard von Prun], overseer of the Hungarian mines, writes to me about them thus:

[Margin: Various accounts of subterranean demons.]

"It is most certain that spirits or apparitions are perceived in the shafts, not only as if they were carrying out various labors — of which, however, no trace can be recognized — but they also assault the miners, throw stones at them, and several even harass them so fiercely that they can scarcely carry out their own work. So it happened a short while ago to a certain Schemnitz [Schemnitz] miner already well advanced in years, named Georgius Egger [Georg Egger], who, when he was alone in the mine, bore witness that he had seen apparitions of this kind. Nevertheless they are more often heard than seen; and when something of the sort happens, good or evil usually follows. The miners also superstitiously believe that if anyone has seen such a spirit and at once reveals the vision, the one who reveals it will soon die — of which there are many examples.

Among other things, something of this kind happened at Schemnitz: twenty years ago now, a certain man by the name of Symeon Krauss [Simon Krauss], who had related to his companions such things he had seen, perished by a sudden death. For greater confirmation there are several aged men, worthy of trust, who under oath and on their conscience have declared the following:

First. Martinus Lichy [Martin Lichy], a metalworker, says that sixteen years ago, on a certain Sunday, by night, in a certain mine called *Oberbieberstollen* [Oberbieberstollen], looking back he saw a little man [virulus] of the stature of a boy of six or eight years, dressed in leather clothing, [fol. continues at 103v]..... with a broad hat, with large and gleaming eyes; at the sight of him, since he was alone, he was seized with no small terror, and so, holding a club, he hurled it at the little man, who, vanishing, was thereafter seen no more.

Second. Paulus Wetzstein [Paul Wetzstein], a miner at *Oberbieberstollen*, says that twenty-five years ago, in a certain Schemnitz mine called *Mohrer Erbstollen*, on the Sabbath, he heard a violent working [as of labor], and so, believing it to be his companions, he approached but found no one. He supposed that his companions had hidden themselves and wished to make sport with him; but seeking further with his lamp, he was hailed with these words: "Ba, ba." At this, violently terrified and realizing that the matter was not right, he at once climbed up out of the mine, went to the inn, and sought his companions; he found them and began to tell them what had befallen him. They at once ordered him to be silent; nevertheless he straightway fell ill for the space of three weeks. A kind of scabby eruption broke out on his face, from which, however, he was not freed until the said three weeks had elapsed, after which he recovered his strength.

Third. Christianus Muller [Christian Müller], a miner in the same place, affirms that in the week following the one in which the said events occurred, the same

thing also happened to him: when his companion had left him alone in the mine, and had bidden him stay there longer, he heard a violent working above him. So, wishing to know who was working there, he searched but found no one; he returned to his own spot and again heard working; searching once more, he found no one. At this, struck with terror, he climbed up out of the mine. When his companion marveled that he had followed him so quickly, he began to relate what had happened; [and] feeble, he took to his bed.

These men could relate far more: how similar specters or pygmies carry out various activities in the shafts; how they turn everything upside down and topsy-turvy — uproars which are most often seen to be followed by a collapse [ruina], as though something were being hurled down within the waters with a great crash; and yet, when the collapses are sought out, not even the least trace of any labor or accident is found. Thus far from the Schemnitz account.

Schulzius [Georg Schultz] adds:

"After a long time had elapsed, the *pygmaeus* — or mountain little-man [virulus montanus] — was seen, and not without cause is he called by the diminutive 'little man,' since he is exceedingly small, as is evident from his footprints. For when he has crossed muddy and clinging ground, he leaves a footprint like that of a child of two or three years. The light which he carries in his hand is of a shining and clear brightness. If this little man precedes the miners as they enter the shafts, he gives good hope of riches and ore." This from Georgius Schultz [Georg Schultz].

The mountain little-man, or *pygmaeus*, is found only in the richer mines; in the copper mines of *Cur* [?], where they were flourishing, he too was seen. This from Philippus Bernardus à Prusn [Philipp Bernhard von Prusn] [?]. Many similar things were transmitted to me by Father Andreas Schaffer [Andreas Schaffer], who, just as he has remarkable knowledge of the Hungarian mines, so too has carefully investigated the explanation of the said specters. But since it agrees in all respects with what has already been related, I have judged it not worth repeating.

[End of Liber VIII.]

MUNDI SUBTERRANEI LIBER NONUS

OF THE VENOMOUS, or LETHAL, FRUITS OF THE SUBTERRANEAN WORLD

[DE VENENOSIS seu LETHIFERIS MUNDI SUBTERRANEI Fructibus]

SECTIO PRIMA — ON POISONS AND THEIR NATURE, Origin, and Wondrous Properties

[SECTIO PRIMA — DE VENENIS EORUMQUE NATURA, Origine &
admirandis proprietatibus]

PREFACE [Praefatio]

Since at no time has the admirable nature of poisons failed to torment, in a remarkable way, the minds of philosophers and physicians, however subtle they may be — nor has anyone been found, even today, who has uncovered the true and genuine causes of such great powers — I have judged it my part, to the extent that the weakness of my talent allows, to settle this pending dispute somewhat: not so much to resolve it, as to shed light on it by bringing forward new arguments. My aim is that the curious Reader may have it made plain from what source that untamable force draws its origin, and from what it obtains the principles of its composition.

[Margin: The greatest difficulty in assigning the origin of poisons.]

There are some who reckon this subject, on account of the hidden recesses of its powers, impenetrable, and therefore a lost cause. Certain others, even though they describe its causes somewhat, nonetheless derive the origin of poisons from nothing but a varied combination of the primary qualities; these are not to be heeded, because experience itself clearly demonstrates their opinion to be false. Something else, therefore, lies hidden — wholly divine [τὸ θεῖον, *to theion*, "the divine [thing]"] — beneath the wrappings of mixed bodies of this kind. What this may be, whence it arises, or how nature forms it in the different classes of bodies, we now set out to expound. May GOD, Best and Greatest, Father of lights, assist this undertaking.

CAPUT I

The Definition of Poison [Definitio Veneni]

Setting out, therefore, to treat of poisons as a subject properly belonging to the Subterranean World, we begin not rashly, nor as those do who are inexperienced in things, but rather, following the art by which Nature herself is the model, we take the starting point of our reasonings from that which by right claims for itself the chief place in every inquiry: namely, that once we have discovered the genus — by way of analysis [κατὰ τὴν σύνθεσιν καὶ ἀνάλυσιν, *kata tēn synthesin kai analysin*, "by composition and resolution"] — and the specific difference, we may then, [arriving] at the *what-it-is* [τὸ τί ἐστὶ, *to ti esti*, "the essence / the what-it-is"], that is, *what a thing is*, infer it by a sure and evident demonstration. But to the point [Sed ad Rhombum, idiom: "to the matter at hand"].

[Margin: The definition of poison.]

A poison, then, is nothing other than a thing not natural [Res non naturalis] which, in whatever manner it is at last applied to the human body, corrupts and destroys that body's nature by its own malignity, through a dissimilarity to its whole substance. I said "a thing not natural," because "not natural" in the definition set forth is the genus, and holds the place of the matter. Therefore, however many [poisons] can be assigned from the difference among the genus of poisons, they are to be reckoned material. It is called "not natural" because it is diametrically opposed to the human body. I say "to the human body," so as to exclude thereby certain animals which feed on venomous things, such as [fol. continues at 105]...

the starling [feeds] on hemlock [cicuta], the stork on toads [rubetae] and serpents, the warbler [ficedula] on scammony [scammonea], and the like.

[Margin: Toxic substances taken as wholesome.]

In the definition it is said "in whatever manner it is applied to the human body." This is so that the various scheme of the snares of poisons — both natural and artificial — may be conveyed to us. For Nature is wont sometimes to conceal poisons under a certain bland and friendly quality, by which men, enticed, imprudently swallow them. Thus a certain sweetness is found in aconite, in arsenic, and in the Colchian ephemeron [Colchicum], which, taken in pleasantly, hastens death in the end. Poisoners [venefici] are acquainted with qualities of this kind, who, by a similar artifice, make use of them in preparing food and drink for the poisoning of men.

There follows in the definition: "[which] corrupts and destroys human nature by the malignity of the poison." That is to say, it corrupts and destroys the mixture and the form of the mixed human body by a certain force wholly dissimilar and contrary to its entire substance. And although every morbid cause is in itself and by its own nature evil — because it produces an evil effect — yet, because the quality of poison is placed in the highest degree of malice, it has merited the name of "malice" *par excellence* [κατ' ἐξοχήν, *kat' exochēn*, "pre-eminently"]; in almost the same way that, in the book *On Plague* [*Libro de Peste*], we declared the highest and most excellent degree of putrefaction to be venomous and pestilential.

It is a grievous thing, in war, after many noble deeds, to be overcome by the enemy, and — most grievous of all — to be conquered and subdued [κρείττον καὶ ἀκρατῶς (?) ... "vinci & debellari"; the Greek phrase here is partly abraded and reads approximately κρείττονι καὶ ἀκρατήτῳ, "by a stronger and irresistible [force]"] [?] with no defense of valor left behind one. For even though the outcome of both kinds of affliction is one and the same — namely death — yet in poison the condition is worse, in that it suffers nature not only not to breathe again, but not even to fight back, since by its own malice it eludes and forestalls every effort of nature, as will become clear later in the case of several poisons. But by what means, or by what natural motion, poison gradually brings on corruption and destruction, will be explained later.

CAPUT II

On Certain Terrestrial Minerals, from which all Poisons are taught to draw their Origin, primordially, out of Subterranean things

[De Terrestribus quibusdam mineralibus, è quibus omnia venena ex Subterraneis originem suam primordialiter trahere docetur]

The unsearchable Height of Divine Wisdom so fashioned the World by its art that, just as it furnished the World with a certain infinite variety of things and species, so too it always arranged it with so great a blending [σύγκρασις, *synkrasis*, "blending / temperament"] of harmonious agreement, that — by setting consonant things with dissonant, good with evil, venomous with wholesome, bitter with sweet, precious with vile, all mingled together and bound by an indissoluble chain — the one could not subsist without the other.

[Margin: Why Nature willed good things to be mixed with evil.]

For if all things were good and wholesome, the World would necessarily perish — just as, if all in the World were Wise men or Kings, the political World would likewise necessarily perish. And so good things have been joined to evil by the most wise counsel of GOD in such a way that the one fosters the other. This the philosopher too recognized, when he asserted that the World is composed of contraries, and is driven by perpetual conflicts of things. Hence the alternations of day and night; hence so great a diversity of seasons; rains and showers follow fair weather; winter succeeds summer; dryness [succeeds] moisture, snow and hail.

[Margin: The diversity of things in nature.]

Hence the wondrous agreements and disagreements of the things existing within the fourfold realm of nature, which the Greeks call Sympathy and Antipathy [Sympathia, Antipathia] — since the nature of things cannot be preserved in its actions without strife and without friendship. All of which things have been aimed at by Nature's marvelous counsel toward the best end.

[Margin: The World is driven by the perpetual alternation of generation and corruption.]

For since the whole economy of inferior Nature consists in the perpetual alternation of generation and corruption — generation being followed by corruption, and corruption necessarily by putrefaction — and since [Nature] continually attempts to produce something living, it has come about that the malignant element inherent in putrefaction, and imbued with a venomous quality, [Nature] derives within itself, as it were, by a certain natural magnetism, and in this way frees the putrid body from which it is born of its own malignity. And unless this were done, the entire substance of the earth, infected with this venomous quality while it is continuously propagated, would inflict enormous and irreparable damage upon Nature.

[Margin: The minerals are the seedbed [variaturum (?)] of venomous things.]

Lest, then, plants or animals already imbued with the venomous quality should again infect the earth with their poisonous breath, [Nature] for the most part destined them to be the food of other animals — whence the venomous quality, dissipated and consumed, is turned into harmless nourishment for certain animals. Again, since the earth is the basis and foundation of all things, hence it comes about that the poison which arises in the innermost bowels of the earth, out of putrefaction and the confluence of malignant qualities, is imparted partly to the water, partly to the air.

[Margin: The minerals (?) [marginal note partly cropped at gutter] — Nature appointed certain plants and insects to draw poison; in earth, water, and air.]

And lest all the elements should be infested by this contagious putrefaction, Nature with remarkable sagacity has everywhere provided certain plants and insects which, just as they draw their origin from a different [source of] putrefaction, so too each, from an appetite implanted in them, draws and derives into itself that poison which is most agreeable and akin [σύγγειον (?), *synggeion* (recte σύγγενες, *syngenes*, "akin / kindred")] to it. Within the earth, indeed, [Nature] established innumerable worms, earthworms, mice, and moles; outside it, serpents of every kind, frogs, toads, and similar venom-bearing animals, which by continuous sucking would free the earth from its deadly quality. In the watery element, [Nature] established other animals of venomous quality — such as sea-hares [leporos marini], cuttlefish [lorigines], dragons [dracones, weever-fish], stingrays [pastinacae], sea-lungs [pulmones marini, jellyfish], and innumerable similar creatures — which would draw into themselves, as into living purses, whatever lethal thing existed within the water; and in this way, lest in time the whole [be infected]... ..so that they do not, as it were, lie idle and lack their own purpose, they serve as bait and nourishment for other fish.

In the air likewise, since a certain venomous thing is always nested there from the noxious exhalation of putrefaction, Nature again provided in the first place for certain insects which, by drawing into themselves the putrefactive influx from which they took their own origin, might in some way purge the air. Of this kind are flies, spiders, wasps, and all the genera of winged insects, which arise from the putrefaction of water and which afterward serve as food for swallows, bats, and similar animals.

[Margin: Why nature wished poisonous animals to exist.]

For this reason too, all plants, according to the diverse putrefaction of their malignant quality, generate different little creatures according to the diverse species of plant and tree — for no other purpose than to free the plant from the pernicious quality by means of the poison drawn off from it by these creatures. Again, there is no animal that does not generate worms from the putrefaction arising within it, and for no other purpose than this: that the harmful quality born of putrefaction somewhere within should be drawn off into these little creatures, as into living purses of the malignant quality, and so deliver the animals from the superfluous humor of their noxious quality. But I shall treat these matters of the productive power of putrefaction more fully in what follows, and expressly in Book XII.

[Margin: The poisons of minerals pass over into plants.]

Since therefore the body of the Earth teems with an innumerable variety of soils, minerals, and juices, it follows that these, altered in various ways by the subterranean heat, constitute as many genera of differing poisons as there are differing mixed bodies in the nature of things. And since these are of a malignant nature, then — lest they should infect the whole lower world — they degenerate partly into poisonous plants, partly into serpents and countless other animals swollen with poison, as will afterward be shown by the survey of particular cases. But three things above all are found in the subterranean realm which, mingled with the kindred parts of the earthy and mineral juices, constitute every variety of poison; and these are sulphur, mercury (that is, quicksilver), and salt.

[Margin: What the poisonous minerals are.]

Sulphur, burnt up by violent heat and as it were sublimated by the subterranean fire, wherever it finds earth suited to it, there produces a poison — either arsenic, or orpiment [auripigmentum], or sandarach [sandaraca], or realgar [risigallum], which are certain species of arsenic and take their origin from burnt sulphur. Mercury, however, sublimated by the subterranean fire, wherever it finds matter analogous and proportioned to itself, there produces either antimony, or white lead [cerussa], or litharge [litargirium], or something similar not unlike sublimated mercury — which is likewise a most efficacious poison of an almost insuperable malignity. Again, a varied mixture of salts, vitriol, niter, and alum with sulphureous, mercurial, bituminous, and naphtha-bearing liquids constitutes, according to the varied combination of its composition, a new seed-bed of poisons, all the more pernicious the more it has been fixed by the force of the subterranean heat.

These three principles of poison, according to the varied combination of mixture which they establish in earthy and mineral bodies, supply an innumerable variety of poisons. Hence there is no mineral, metallic, earthy body that does not abound in poisonous quality, one more than another. That this is so, perhaps only he will deny who is ignorant of the marvelous secrets of Nature drawn out by the operation of the spagyric art [ars spagyrica — alchemy/chemistry]. And let this much be said about the poisons generated in the mineral realm.

[Margin: Poisonous plants arise from poisonous and venomous juices.]

If now we examine the vegetable economy more exactly, we shall clearly find that all the offspring of poisonous plants and trees derives its origin from no other source than the poisonous juices of the earth itself. For from the fermented

putrefaction of a species of earthy or mineral poison — by however slight a movement of nature — a plant is born with a poisonous juice resembling it in its properties; or, if the putrefaction has reached a higher degree, an animal of the serpent or insect kind is born, entirely resembling the poisonous putrefaction in its properties and powers. From this it is clear that all the animals born from venomous putrefaction are themselves poisonous, and imbued with all the more dreadful a poison the greater the violence of the mineral poisons of which the putrefaction is composed.

[Margin: From the most poisonous minerals, namely the corrosive ones, sometimes a plant, sometimes a poisonous animal is generated.]

But let us make the matter clear by example. There are in the mineral realm, as we have said, arsenic and sublimated mercury, the most powerful of all earthy poisons, inasmuch as they corrode, gnaw, and reduce to corruption. The fermented putrefaction of arsenic produces napellus [monkshood] or aconite, entirely similar to it in arsenical virulence; but if it is sublimated into a more excellent putrefaction, then it generates either the asp [aspis] or the phthias [phtias — a poisonous serpent], dreadful in the ferocity of its venom. Nor does the poison of napellus seem to differ from the poison of the asp, except that the poison in napellus is somewhat blunted by moisture, whereas in the asp or phthias it is, as it were, exalted — being most spirituous, so most efficacious. For at their bite all the members of the human body are at once corroded and putrefied and dissolved into corruption, in exactly the same manner as when arsenic or napellus has been taken.

And if a certain putrefaction is imbued with mercurial virulence, then — brought from potency into act by external heat — it will generate either the venomous dracunculus [a small serpent], or, if the subject has been imbued with a more excellent putrefaction, the dipsas [dypsas]: which three genera of poison are of such power that, taken internally, they kill a man without remedy by corrosion and unquenchable thirst.

Again, if arsenic, mercury, and burnt vitriol are mingled in putrefaction, there will be born the plant haemorrhoids, or the serpent of the same name, the haemorrhous — each of which possesses this power among these three: that whoever is infected by it,

with all the veins and vessels corroded, dies in a flux of blood bursting forth from all the members of the whole body. Such serpents, they relate, are born in America with such virulence that a man bitten by the haemorrhous pours forth

both his blood and at once his life — through the mouth, ears, eyes, nose, the passage of the urine, the seat, the navel, and finally through all the pores — in a pitiable and terrifying death. Pliny [Plinius] relates that the plant haemorrhoids does the same.

COROLLARIUM I.

[Margin: All serpents correspond to herbs and to minerals.]

From these things it is plain that all the genera of serpents so correspond — as regards the likeness of their powers — to herbs and to mineral poisons, that, just as both vegetables and sensitive creatures draw their origin from them, so too they are endowed with the same powers. And just as the combination of poisonous qualities in the minerals from which they arise is most diverse, and they differ in species, so too the poisonous qualities, powers, and properties of herbs and of animals differ utterly in species — as will appear a little later from their effects. So much so that no combination of mineral poison arises which does not produce a herb or an animal of that same combination. For according as they partake more or less of the combination of earthy poisons, by so much do they likewise harm more or less; and hence arises that diverse property of poisons which we marvel at in the threefold realm — mineral, vegetable, and animal.

COROLLARIUM II.

[Margin: How poisonous animals are bred in the waters.]

From this it is clear how poisonous animals of corresponding mixture are bred in the waters. For if the putrefaction of earthy and mineral poisons is diffused through the waters, animals resembling that putrefaction must necessarily be born from it — animals which come forth in all the greater abundance the greater the proneness to generation that the foul mixture of the sea and of the other waters obtains. And from the subtle and thin vapor of the differing putrefaction, those infected, poisonous things — the various species of spiders and cantharides [Spanish flies] — are produced by spontaneous generation. Nevertheless, in the sea the least progeny of poisonous animals of all is observed, on account of the abundance of salt, which is contrary to putrefaction.

CAPUT III.

On the accidental generation of poison in the remaining vegetables and animals, both living and in the cadavers of the dead.

[*De accidentali veneni in caeteris vegetabilium, animaliumque tam vivorum, quam mortuorum cadaveribus genesi.*]

Since any plant and any animal whatever needs continual nourishment to preserve its life, and since all foods consist of sulphur (that is, natural heat), mercury (that is, the radical moisture), and salt (that is, the fixed or earthy substance), together with the aerial spirit — hence it comes about that no food is so wholesome that it does not have attached to it something corrupted from sulphur, mercury, and salt. This corrupted element, whether drawn in by plants or taken in by animals, being gradually actuated by the native heat, generates a certain putrefaction of malignant nature; and from this there is then born, in plants and trees, a little worm or caterpillar of similar powers. And this can be nothing other than a kind of animated purse, in which Nature, for the preservation of the whole, has stored up all the separated depravity and the latent malignity, as a sort of magnet for it.

[Margin: Plants are converted into worms... (left-margin note partly abraded) [?]]

These things are seen in all plants, even the most wholesome — indeed even in animals, which serve us as daily food. Who does not know that the maidenhair [maillratham / capillus Veneris (?)], or fennel and sage, are otherwise most wholesome plants, which nevertheless from an innate putrefaction generate a worm? Those who incautiously eat of them are tormented by the most atrocious symptoms even unto death — so that this saying may fittingly be applied to them: "the corruption of the best is the worst." Indeed, taught by experience (as will be shown in the following books), I assert that no herb, whether benign or malignant, is found that does not generate a caterpillar or little worm, differing according to the diversity and property and powers of the herbs, and imbued with all the more atrocious a poison the more malignant the herb —

for there is no combination of mineral mixture that does not produce a herb or animal of that same combination. For according as they partake more or less of the combination of earthy poisons, by so much also do they harm more or less; and hence arises that diverse property of poisons which we marvel at in the threefold realm — mineral, vegetable, and animal.

Any plant and animal whatever, then [resuming Caput III's argument] — hence so great a variety of worms, caterpillars, and butterflies, differing in species, arising in the several roots, leaves, seeds, flowers, and fruits of plants and trees; in apples too, pears, nuts, galls, acorns, pods, and legumes, each produce their own worms. These all, just as they are born from putrid matter, so too obtain a greater or lesser degree of poison — excepting, however, the acid fruits and those endowed with juices of the highest sharpness, such as citrons and pomegranates and the like, which, as long as they have their juice uncorrupted, cannot generate an animal. Yet as soon as they pass into putrefaction, they attempt to set about the same thing [generation of worms] — all of which I have established as observed and explored under the microscope [microscopium]. And although in the resinous trees and plants, such as pines and larches — that is, in the resin itself — no animal can be generated, because a certain balsamic virtue residing in them is contrary to putrefaction, yet in the other parts of such trees a certain noxious and poisonous kind of caterpillar, which they call the *buprestis* [Buprestis], is found to be born, and to inflict death on those who incautiously eat it, after dreadful symptoms have been roused.

[Margin: All animals generate worms proper to themselves.]

If now we explore the animal realm, we shall see that you may regard no genus — whether of quadrupeds, of birds, or of swimming creatures — that does not generate a worm appropriated to itself. In this way, horses, asses, dogs, cats, lions, stags, and whatever animals there finally are, generate worms: the excrement of horses [generates] beetles; bees, oxen; stags, tragelaphi [tragelaphus — fabulous goat-stag]; other animals generate *κάνθαριδας* [Greek: kantharidas, "cantharides," blister-beetles]; while in the subcutaneous recess [they generate] ticks, *cicubi* [?], moths,

moths, *acori* [?], lice, fleas, cockroaches, and similar creatures. What cause do you suppose it is that horses, hens, asses, and pigs delight — the former in wallowing in dust, the latter in mud? Nothing other than that they are infested by certain subcutaneous worms, and that the worm-bearing substance is destroyed by the sharpness of the dust no less than by the wallowing-place. And the same I would have you understand of the other animals that bathe in dust.

[Margin: Why pigs delight in the wallowing-place; why asses and hens delight in dust-baths.]

I shall say nothing here of the human body, all of whose inner vital-economy members, according to the *ἰδιοπάθεια* [Greek: idiopathea, "particular affection"]

— the proper disposition] of the putrefaction proper to those members, generate worms of differing species. Some of these introduce putrefaction; certain ones, by gnawing, gangrene; others, a deleterious quality into the vital members — so much so that from this worm-bearing substance neither the heart, nor the liver, nor the brain, nor the kidneys, the spleen, the bladder, and the lungs (to say nothing of the intestines and the stomach) are immune.

[Margin: Poisonous animals are born in all the members of animals, and of man too, from corrupted humors.]

I saw a sick man who, from the excessive malignity of putrefaction, vomited up a living frog. Schenk [Schenckius], too, in his *Observations*, reports that scorpions were born in the brain, and serpents in the intestines. But since all the monuments of the physicians are full of such cases, and since we have pursued them in our *Scrutinium Physico-Medicum de peste* [Physico-Medical Examination of the Plague] in an entire book, I refer the reader there.

[Margin: A sick man vomits up a living frog.]

The physicians wonder why gangrene admits so difficult a cure; and if they knew its cause, they could perhaps easily meet so great an evil with suitable remedies. For there are little worms imbued with a certain arsenical force, which under an imperceptible bulk do not cease to gnaw the neighboring parts of the living flesh, and by gnawing convert the flesh into corruption by their malignity.

[Margin: Why gangrene is difficult to cure.]

Not long ago August Hauptmann [Augustus Hauptmannus] wrote a little book *De viva mortis imagine* [On the Living Image of Death], in which he clearly demonstrates that all diseases arising from malignant putrefaction have their origin from a worm-bearing substance; and he adds that, in a gangrene arising from the venereal pox, there were observed through the microscope worms almost imperceptible, of the form of slugs, which within the gangrene-infected flesh turned everything topsy-turvy, just as worms do in burrowing through cheese —

[Margin: A remarkable observation concerning the worms seen in the putrefaction of gangrene.]

— and of such swift generation that one such little worm, placed upon paper, in the span in which the psalm *Miserere* could be recited, had cast off fifty others outside its body; and these, just as they are poisonous of themselves and by their own nature, so too, whatever particle of living flesh they touch, they reduce to

corruption by their innate malignity. Why, then — notwithstanding the cutting away of the living flesh in gangrenous cases — does the evil nonetheless creep on? The cause is that even a single such little worm remaining in the living flesh suddenly generates innumerable others like itself; whence these, by a kind of spreading rot, propagate the evil without measure. From which they conclude that the most acid and sharpest liquids are needed to destroy them.

[Margin: From what minerals are poisonous?]

If further we consider the putrefaction that shines forth in the cadavers of various animals, we shall find that poisonous animals — such as putrefied serpents — spring up again from their own proper putrefaction, as the phoenix from ashes; or, if the putrefaction undergoes a weaker fermentation, are transformed into some poisonous herb. For experience establishes that, in those places and pits into which carrion and the cadavers of various animals are thrown, for the most part poisonous herbs of every kind are born — such as hemlock, aconite, napellus, henbane [hyoscyamus], asafoetida, or cotula — which, being themselves born from putrefaction of a poisonous quality imbued with arsenical and mercurial qualities, likewise produce herbs of a similar quality.

[Margin: Poisonous serpents are reborn from a putrid carcass... (margin partly abraded) [?]]

The same holds even in herbs that are not deleterious. For [experience establishes] that from the seed of putrefied human or animal cadavers there are born satyrion [an orchid], philtric [aphrodisiac] herbs, and similar plants, which in their roots, bulbs, and flowers express those very members from whose putrefaction they grew.

[Margin:...from human cadavers herbs are born that express the genital members... (margin abraded) [?]]

[Margin (right): The seed... (abraded) [?]]

I could here unfold the mysteries of Nature, but since we hint at these in other places, we have judged it superfluous to dwell on them here. Since therefore almost nothing corporeal exists in the nature of things that is entirely immune from a malignant quality, hence arises that infinite diversity of poisons, which we shall pursue in the following chapter.

CAPUT IV.

On the differences of poisons.

[*De Venenorum differentiis.*]

[Margin: What things among the minerals are poisonous?]

1. There are as many differences of poisons as there are primary differences of mineral mixed-bodies — in such a way, however, that certain minerals are, of themselves and by their own nature, alone properly called poisons; and from these, as from a base and foundation, all the rest with which they are mixed acquire more or less of poisonousness according to the manner of their combination. Now there are, in the subterranean realm of minerals: arsenic, quicksilver (or mercury), cinnabar [Cinnabrium] — in Arabic *Uschar* [Usfar (?)] — quicklime, gypsum; red ochre of Sinope [Rubrica sinopica], litharge, white lead [cerussa], minium [red lead], verdigris [aerugo], pyrites, antimony, rust [rubigo], and the like — which take their origin from sulphur, as do the species of minerals already mentioned. These, mingled with various liquid, bituminous, and flowing juices through the fourfold difference of salts, lay down an immense seed-bed of poisons.
2. In the Vegetable Realm, the most powerful poisons are reckoned to be: napellus [monkshood], euphorbium, hemlock [cicuta], aconite, tithymal [Tithimallus, spurge], lathyrus (or cataputia), scammony, colocynth, hellebore, the wild cucumber [cucumis asininus], rhododendron, the laughing parsley [apium risus — sardonic-laughter herb], thapsia, haemorrhoids, stramonium [thorn-apple], maniacal nightshade [solanum maniacum], mandrake [mandragora],

[Margin: What plants are poisonous.]

A RESOLUTORY TABLE

A classification of all the poisons that can be distinguished in the Nature of things.

The following is a full-spread classification table presented as a branching tree. The top-level division is by natural realm (Minerals, Vegetables, Animals, Things produced from poisoned food). I render it as a nested pipe-table, reproducing the printed tree structure; the innermost lists are given in the rightmost cell. The

Latin plant, animal, and mineral names are kept as printed, with modern identifications in brackets at first occurrence where non-obvious.

Minerals [Mineralibus]

Division	Sub-group	Species / members
1st Class is	Arsenic [arsenicum], of which the species are	Orpiment [auripigmentum]; Realgar [sandaraca]; Risigallum [risigallum — red arsenic sulphide]; Ochre [ochra]; Antimony [antimonium].
2nd Class are	(lead-derived) species	Ceruse [cerussa — white lead]; Minium [red lead]; Cinnabar [cinnabaris]; Verdigris [aerugo]; Rust [ferrugo].
	(further)	Lead [plumbum]; Scum of silver [scuma argenti — silver dross]; Litharge [lithargyrium]; Quicklime [calx]; Gypsum [gypsum].
3rd Class are	—	Sulphur [sulphur], alum [alumen], natron/nitre [nitrum], in their corrupted state. — And these are the primordial origin of all the other poisons that follow. [Atque haec sunt omnium aliorum sequentium Venenorum primordialis origo.]

Vegetables [Vegetabilibus]

Used as to the whole [quoad totum]	Used as to parts [quoad partes], namely in:	Members
The whole plant , such as:	—	Aconite p[?] [aconitum — likely <i>aconitum</i>

Used as to the whole [quoad totum]	Used as to parts [quoad partes], namely in:	Members
		<i>pardalianches</i>, leopard's-bane, abbreviated]; Lycotonum [wolfsbane]; Napellus [monk's-hood aconite]; Cicuta [hemlock]; Hyoscyamus [henbane]; Several kinds of tithymal [titimallorum genera — spurges]; Cataputia [caper spurge]; Several kinds of nightshade [solanorum species]; Apium risus [the "laughing" celery, <i>Ranunculus sceleratus</i>]; Mandragora [mandrake]; Veratrum or hellebore [veratrum seu helleborus]; (and) from trees, the Yew [ex arboribus Taxus].
	In the seed [semine]	Henbane [hyoscyamus]; Coriander [coriandrum]; Hemlock [cicuta]; Nigella [fennel-flower]; Psyllium [fleawort].
	In the juice/sap [succo]	Poppy opium [papaverum opium]; Carpasum [carpasum — a poisonous juice]; Thapsia [thapsia]; Veratrum [hellebore]; Colocynth [colocynthis]; Scammony [scamonea]; Colchicum [colchicum — meadow saffron].

Used as to the whole [quoad totum]	Used as to parts [quoad partes], namely in:	Members
	In the roots [radicibus]	Chamaeleon-thistle [chamaeleontis]; Aconitum pardalianches [leopard's-bane]; Veratrum [hellebore]; Thapsia [thophae]; Hemlock [cicuta]; and the rest [caeterorumque].

The serpent group attached at the right of the vegetable/whole-substance spread (printed alongside the reptile leaders) lists: Vipera [viper]; Aspis [asp]; Dyspas [dipsas]; Phtias [phthias]; Dryinus; Amphisbaena; Scytala; Haemorrhoids [haemorrhoids]; and countless others [& innumera alia].

Animals [Animalibus]

From which poisons arise either:

(A) As to the whole substance of creeping things [quoad totam substantiam reptilium], namely:

Habitat	Members
Terrestrial [terrestria]	All kinds of caterpillar [omnia erucarum genera]; Salamander [salamandra]; Frogs, toads, the louse of the vulture [ranae, rubetae, bufones, pediculus vulturis]; the kinds of poisonous worm [scorpius virulenta vermium genera].
Aquatic [aquatica]	The marine hare or sea-lung [lepus seu pulmo marinus]; Leeches [hirudines]; Aquatic flies [muscae aquatiles]; the marine spider [araneus marinus].
Aerial [aëria]	Cantharides [blister-beetles]; Butterflies/moths [papiliones]; Heliocantharus [the "sun-beetle"]; the Bee [apis]. — Every kind of winged

Habitat	Members
	insect [omne aligerum infectorum genus].

(B) As to animals infected by putrefaction [quoad animalium infectorum ex putri], they are either:

- Bull's gall [fel taurinum]; the brain of a rabid cat [cerebrum catti rabiosi]; the bite of rabid dogs and of all rabid animals — even of man [morsus canis rabidi, caeterorumque animalium rabiosorum, etiam hominis]; the claws of any animal, whether four-footed or winged [ungues animalium tam quadrupedum quam volucrium]; the foam of any raving animal [spuma quorumcunque animalium furentium]; bats, owls, the hoopoe, and the like [noctuae, vespertiliones, upupae & similia].

(C) From the perfect parts of animals [animalium perfectorum partibus], such as:

Mode	Members
By the sting [aculeo], as	Bee [apis]; Scorpion [scorpius]; the sea pastinaca/stingray [pastinaca marina]; the spine of the sea [spina maris].
By projection or fluid [promiscide aut liquore], as	Flies [muscae]; Gnats [cyniphes]; Midges [culices]; Certain flies [certae muscae]; Hornets [crabrones].

From things used as food [Ex cibis usitatis]

Such as:

- Honey gathered by bees from poisoned flowers [mel ex floribus venenatis ab apibus collectum];
- Curd/rennet curdled in any way [coagulum lacti mixtum];
- Mushrooms of any kind whatever [fungorum quaecunque genus];
- The eating of marsh-frogs and of slugs/snails [ranarum palustrium & limacum comestio];
- Coriander and saffron taken in great quantity [coriandri & croci in magna quantitate sumptio];
- Fish from standing waters, such as eels, tench eaten cold after cooking [pisces stagnorum, uti anguillae, tinca post coctionem frigidi comesti];

- Dried meats, and meats afterward suffocated and then eaten cold [carnes assatae & postea suffocatae, deinde frigidae comestae];
- Anything at all in excess, finally, in whatever class of foods or drinks [omne nimium in quocunque tandem genere liquorum & ciborum].

[The text resumes from the body of folio 109, where Caput IV continues; the table above is referenced at the close of Caput IV ("See the following Table, where all things are displayed").]

— psyllium, and very many kinds of fungi. All these draw their origin, just as from the subterranean juices of minerals and from their various mixtures, so too each of them obtains its own properties from those things out of which they are born.

[Margin: Poisonous animals. (Animalia quae venenosa.)]

3. In the animal kingdom poison is found in a fourfold division — namely among quadrupeds, flyers, swimmers and creepers, or insects. These especially are reckoned among poisons. Among perfect animals I find no quadruped poisonous as to its whole substance, but only as to a part — such as the brain of cats, the gall of a bull, the sweat of certain animals (such as deer), the hairs of cats taken internally, the tail of shrews [cauda soricum], the rennet of a hare [coagulum leporis], bull's blood [sanguis taurinus], and the bite of rabid animals. And among the four-footed insects: dragons [i.e. large lizards], the stellio or salamander, the toad, the bramble-toad [rubeta], the crocodile, certain lizards, mice; and, midway between quadrupeds and flyers, the bat.

[Margin: Which among the flyers are poisonous? (Ex volucris quae venenosae?)]

4. Among the flyers, most of the nocturnal birds are of a saturnine nature; thus the various kinds of owl have something of poison in them. The winged tribe of insects is almost entirely poisonous, being as it were generated from the vapor of a deleterious matter — such as the cantharides, the bruchi [wingless locusts/grubs], butterflies, flies, locusts, gnats [cyniphes], silkworms [bombyces], and finally whatever is furnished with several feet besides wings.

Among the swimmers, these are counted poisonous: the sea-hare [lepus marinus], the water-snake [natix], the stingray [pastinaca], the leech or bloodsucker [hirudo sive sanguisuga], the sea-lung [pulmo marinus], certain squids [lorigines], eels born from the rotten mud of marshes [anguillae è putrido paludum limo]

natae], certain frogs or the aquatic toad [bufo aquaticus], water-serpents [serpentes aquatici], the torpedo-ray [torpedo], and so on.

[Margin: Which among the reptiles? (Ex reptilibus quae?)]

5. Among reptiles: all the kinds of serpent — the asp [aspis], the phthias, the dipsas [dypsas], the viper [vipera], the boa, the cerastes [horned viper], the haemorrhoids, all the kinds of worm, the amphisbaena, the caecilia [a blind serpent]; and among the many-footed, the scorpion, the spider, the millipede [millepeda], the scolopendra [centipede]. All of these are accustomed to poison human beings — whether by their breath, by their bite, by sting or stinger, by ejection of a poisonous fluid, by the foam of the mouth, or even by immediate contact.

The asps poison by breath, the vipers and the other serpents by their teeth; the scorpions by their stings or stingers; the toads by the ejection of poison; the rabid dog by the foam of its mouth. Some serpents are found to blast [siderare] people merely by the quality of their poison when trodden on; and some, too, infect by the diffusion of their poison through an intervening medium alone, as do the torpedo-rays, the asps, and the phthiades.

[Margin: Examples of poisoning by poison. (Exempla veneno intoxicatorum.)]

I myself knew one of our people who, when he struck an asp sitting in a tree, was so stricken by the creature's breath alone, by a kind of blasting [sideratio], that it rendered the man motionless for three whole years; and from this — no remedy availing against such a poison — he afterward died. There was also another who, having incautiously trodden on a serpent, perished a little later of paralysis, or rather of apoplexy.

[Margin: A poison proper to human beings. (Venenum hominibus proprium.)]

6. Among poisons there is also reckoned the lethal contagion of pestiferous bodies: the carcasses of any animals at length [animalium quorumcunque tandem cadavera], the carrion-flesh [moticina], the foul discharges of women's menses [menstruae mulierum sordes] — from which countless evils result; and lastly all those animals that are generated either from vegetable matter or from other animals.

Here, Reader, you have the six classes of poisonous bodies; out of whose malignant qualities, together with the foods in which they reside, all the kinds of disease arise. See the following Table, where all things are set out.

CAPUT V.

On the difference between Nourishment, Medicament and Poison; likewise on the agreement and disagreement of things — which they call Sympathy and Antipathy — in its various divisions; and on whether the strife and friendship of things is brought about through the primary or elementary qualities, or through the specific virtues of things.

[Margin: The difference between nourishment, medicament, and poison.
(Differentia inter alimentum, medicamentum & venenum.)]

All physicians assert that poison is diametrically opposed to nourishment. The medicament, however — the ἀλεξιφάρμακον [Greek: alexipharmakon, "antidote" or "remedy against poison"] — stands midway between nourishment and poison as between two extremes, partaking more or less of each. For things that are in the highest degree opposed to one another must necessarily share in the same genus; otherwise there could be no equal contest between accidents. Therefore poison, nourishment, and the alexipharmic [antidote] will, among the physicians, belong to the same genus — namely, they are placed among the non-natural things, which, by reason of their effect, they call efficient causes. For, as we noted above, those things are called non-natural which exist neither according to nature nor simply contrary to nature, but which can turn out to be such [as to produce an effect]: nourishments indeed by increasing and feeding; medicaments by correcting; and poisons by corrupting and destroying.

And those things which are appointed by nature for preservation — namely nourishments — must first be overcome by the innate heat, so that they may acquire a certain likeness to the thing nourished, before they can be converted within bodies into a substance similar [to it]. Medicaments, on the other hand, are first acted upon by heat and brought into act, and then in turn they themselves act upon the body and reduce that same body to a better state. But the case of poisons is different: for whether they are broken down by heat, as those that are cold, or are merely roused up, as those that are hot, they act upon the body not by preservation or restoration, but by total corruption. For just as nourishment is so called from the very fact that it can nourish [alere], so likewise medicaments — whether...

Liber IX, Sectio I — Caput V (continued)

(Folio 110, verso. Running header: "LIBER NONUS, Sect. I.")

or [sive] ἀλεξιφάρμακα [Greek: alexipharmaka, "antidotes"], because they are by their own nature fitted to heal; and poisons, [sive] δηλητήρια [Greek: dēlēteria, "destructive things, poisons"], because they are fitted of themselves and by their own nature to corrupt. And so, if they are ever found to do good and to help, this they do not in their own right but only incidentally. For although they may serve as a nourishment or a medicament, or at least do no harm with any malice, they can nevertheless incidentally bring on the utmost malignancy, capable of destroying the whole.

And although poisons are properly opposed to nourishment by a contrariety of nature, antidotes [alexipharmaca]—even though they too are counted among poisons—are so blunted by the admixture of other substances that they cannot exert their full force. This is clear, first, in the case of antimony, sandarac, and pyrites, which, being mixed with the not-unwholesome substances of earthy clods, cannot exercise their suppressed powers; and so, as will be shown later, once first corrected, they pass into medicinal use. The same must be said of colocynth, scammony, euphorbium, esula [spurge], and the like; for since they consist of a coarse humor, they are not so efficacious as the pure poisons are, and so they can be taken into medical use only after first being corrected.

[Margin: How a poison can serve as a medicament.]

I say further—**All corrected poisons pass into the use of medicine**—that there is no poison so potent and so pure that, once first corrected, it cannot be taken into medicinal use. So it is with vipers, toads, scorpions, and the other serpents, however venomous: the flesh of the viper, indeed, constitutes the base [hypostasis] of theriac; toads are taken as an effective antidote against the plague, as we showed in our book *On the Plague*. Nor is there any poison that cannot be applied as an antidote within the very species of poison by which one has been infected.

[Margin: A rare case.]

[Margin: Poison is the remedy for poison.]

Yet it is remarkable that one poison should be a poison to another. For example, the poison of the toad kills a man, but the spider [araneus] by its own venom kills the toad in turn; and the venom of the Tarantula of Apulia—as we showed in our *Art of Magnetism* [*Ars Magnetica*—rubbed in the manner of a plaster over an inflicted wound, extinguishes the poison itself; and so with the rest, the reasons for all of which we will try to give later. I myself saw an apothecary at Erfurt in Thuringia who had procured serpents of every kind, alive, destined for medical

use. When he handled them somewhat incautiously, having placed them in shells [conchas], he was bitten by one of them, and at once the injured limb swelled; then, struck as it were by a sudden stupor of the whole body from the serpent's venom, he trembled. Physicians were summoned, and although every kind of antidote was administered to him without any benefit, at last a more skilled physician among the rest asked the sick man which of these serpents had bitten him. He said an asp [aspis]. So they cooked that very one and gave him its prepared flesh to eat; scarcely had he taken it when—lo!—he at once began to feel better, and by continuing that food through a whole day, he at last completely recovered.

There are those who, fed on the flesh of a most venomous viper and on wine steeped with viper [vino viperato], not only suffered nothing harmful but—what is worthy of admiration—were, with every corrupt humor expelled, brought back from a leprosy otherwise incurable into a perfect state of health. Hence, that viper-flesh avails very greatly for the prolongation of life is so well known that it would be tiresome to say more about it. Let the reader see what truly wonderful things we set forth concerning the cave of serpents in the Third Book of the *Art of Magnetism*. But let us return to our intended purpose.

[Margin: All elements with time generate putrefaction.]

I say, then, that there is no element, however wholesome, that does not with time generate putrefaction, and no putrefaction that is not animated into some worm—which, as it does not lack its own venomousness, so neither is it free of all poison. The worms born of the lees of wine and of corrupted grain, with their intolerable stench, demonstrate this abundantly.

It must therefore be noted that every motion and effect is born from the discord and conflict of contraries. For Nature, when she subjected the whole frame of this World to continual change, at the same time necessarily sowed it, as if with seeds, with various kinds of discords; she established the four primordial things—Water and Fire, Earth and Air—as contraries, and to each thing that arose and proceeded from them she opposed something else by the law of discord. Thus to diseases that are contrary through an imbalance [intemperies] she opposed strengthening powers drawn from a balanced temperament; to diseases arising from matter she opposed the contrary properties of matter in some species; and as the secondary powers of medicaments, working through instruments, she opposed the powers that arise from the mixing of matter and temperament. Indeed—what is more wonderful—many things demonstrate that matter, in one and the same simple thing, sometimes combines this very contrariety of qualities.

[Margin: How milk both binds and loosens.]

In this way the serous and buttery part of milk relaxes the bowels, while the cheesy part checks and binds them.

[Margin: An antipathy of things through grief.]

Again, on the testimony of Galen [Caelio? — *Galeno teste*], a decoction of trefoil [trifolium], applied as a fomentation to the bites of a spider or a viper, at once soothes the pains and draws out the venom; yet the same, applied [to the part?], stirs up pains like those that the venom itself causes.

[Margin: An antipathy of things.]

The flowers of chamomile, by their smell, are good for headache; the leaves, by contrast, applied to it, are extremely harmful. The leaves of dock [lapathum] loosen, but the seed taken constipates. Aloe, taken internally, opens the veins of the hemorrhoids, while the same applied externally in the manner of a plaster closes them by staunching the blood. Eggs that are liquid and supping-soft produce a different effect from the same eggs roasted. The reason for this is that in herbs one part has a greater digestion of moisture than another; hence one part of a plant accordingly yields one effect in the human body, and the flowers of the same plant—of a purer and better-digested substance—another.

[Margin: Heat the craftsman of differing powers.]

For the craftsman of these differing powers is heat, which, according to the diversity of its degree, produces one effect in the root, another in the stem, another in the flower, and another finally in the fruits and seeds—as may be seen in...

(Folio 111, recto. Running header: "DE VENENIS.")

the citron-apple [pomum citrium], whose innermost pith, being of an astringent nature, presses out I know not what mineral juice, by which, through a certain corrosive force and coldness, it harms the stomach; whereas the rind, by its natural heat, contributes very much to that same stomach—indeed, just as by its natural mark [characterismus] it represents the heart, so too it is marvelously beneficial to it.

As, therefore, certain things are by their whole substance familiar and friendly to us, and as it were preservers of our nature—such as the nourishments suited to our nature—so certain things are by their whole substance hostile and inimical to us, namely poisons; whose qualities, for that reason, we call hidden [occultas], or

properties either of the form or of the whole substance. For nourishment nourishes us precisely because it is like us in its whole substance; and this likeness is neither a matter of temperament nor of the materials, but only of the forms, or indeed of all of these together—which likeness we call a likeness of the whole substance. For although wine, bread, and vegetable are, as to their matter, nourishments very unlike us, yet as to their form they become very familiar, friendly, and like to us, because they contain within themselves a certain kindly spirit of life and heat, exceedingly proportioned to our vital spirits; by whose arrival our spirit and heat are cherished and sustained, and which at last, together with the nourishment in which it resides, is converted by the likeness of nature into the substance of the thing nourished. This cannot be ascribed to the first elementary, or manifest, qualities; therefore that effect of nutrition is necessarily constituted in the spirit, or in that celestial heat of the innate form.

[Margin: Specific qualities act differently from manifest ones.]

[Margin: Nothing can nourish us unless it has first been imbued with life.]

Hence nothing can nourish us unless it too is nourished, and is, or once was, endowed with life—which does not hold for minerals. Hence most minerals, unless joined to vegetables, cannot be taken without harm, since they are inanimate and do not sustain nutrition. To this substance of nourishments, then, are diametrically opposed those things that are deleterious and poisonous in their whole substance, because, while what is in us is kindly and familiar, they—by their virulent and malignant force, when they strive to turn all the humors into their own likeness—utterly corrupt and destroy them. A middle place is held by the purging medicaments, which are partly like and partly unlike us, and which, although they do not pass into nourishment for us, nevertheless do not destroy our nature, but take a certain middle path, as will be declared in what follows. But let us now examine each of the things said up to this point concerning the effects of Sympathy and Antipathy by way of Questions.

QUAESTIO I.

On the Sympathy and Antipathy of poisons; and what precisely are those qualities which they call hidden [occultas] or specific [specificas], said to proceed from a likeness of the whole substance; and whether they can be comprehended by the human mind?

[Margin: The difficulty in knowing the Sympathy and Antipathy of things.]

There is one key to Nature in the most dissimilar materials, namely Unity; and he alone who embraces it must be reckoned to have found it—though no one possesses it unless he perfectly knows the forms of things and the spurs of natural motions, which result immediately from the strife and friendship, or the discordant accord, of things, and which the union and flight of bodies necessarily follow. For beneath these things lie hidden the treasure of all Nature, and the sacred mysteries of Divine Wisdom; imbued with the knowledge of which Solomon [Salomon] gloried so greatly that he judged it to be set far above kingdoms and scepters. Before we come, then, to the investigation of the things themselves, it seemed good first to examine what, of what kind, and how many are the causes of these marvelous operations of Nature.

[Margin: The Sympathy and Antipathy of things from the elementary qualities.]

The accord, then, or discord of things—the former of which the Greeks call συμπάθειαν [Greek: sympatheian, "sympathy, fellow-feeling"], the latter ἀντιπάθειαν [Greek: antipatheian, "antipathy"]—is not single, as some have supposed, but as manifold as the differences found among the entities in the nature of things. For there is no mixed body in the threefold kingdom of Nature—whether mineral, vegetable, or animal—that does not exercise these laws of hatred and love with some other; and these obtain the most diverse causes of their operations, and are referred either to these or to those, or to still other classes of Nature. In some, all of them concur; in some, several; in certain ones, one alone causes a prodigious effect. But lest we be swallowed up in a matter almost infinite, let us reduce all to certain definite classes.

[Margin: From the subtle emission of vapors.]

Of these, the first regards the first, second, and third qualities. The second results from the emission of subtle and imperceptible vapors. The third, from natural likeness and unlikeness, exercises the contrary acts of hatred and love. The fourth arises from the differing constitution of climates. The fifth, from the constitution of the pores in bodies, whereby one outflow of virtue emitted from some other source is received better than another. The sixth, from the vehement motion of the imaginative power, by which the fantastic force sometimes produces wondrous effects, both in the female womb and outside it upon various objects. The seventh, from the fear of a vacuum, by which sometimes wondrous effects arise in the nature of things. The eighth, from harmonic motion, by which certain admirable motions arise. The ninth, from the vehemence of the passions. The tenth, from the peculiar influence of the celestial bodies. The eleventh, from actinobolism [actinobolismus] or the co-radiation of bodies, which we properly

call magnetic—according to which, by a certain analogy [κατ' ἀναλογίαν — Greek: kat' analogian, "according to analogy"], we consider the reasons of all the other things already proposed through a magnetism existing as it were in all things; since attraction and repulsion, or strife and friendship, the consonant and the dissonant, must necessarily occur in every business of sympathy and antipathy.

[Margin: All things consist of friendship and strife.]

But let us now set forth each in fuller detail.

The first class regards the primary qualities—hot, moist, cold, dry; and the secondary qualities—hardness, softness, roughness...

(Folio 112, verso. Running header: "LIBER NONUS, Sect. I.")

smoothness, lightness, and the like. The third, by attraction, repulsion, and so on.

[Margin: How the elementary qualities make sympathy and antipathy.]

Since, then, among the four elementary humors certain strifes and friendships are experienced, it may rightly be asked how, or by what means, or for what cause these are carried out. Some hold that every humor is drawn by an elementary force—wrongly; for they have something else conjoined that sometimes produces the wondrous effects of this kind of attraction. Otherwise it would follow that all such prodigious effects could be ascribed to the four simple and manifest qualities—which is repugnant to experience.

I do not deny, however, in this place, the common rule of physicians, by which it is prescribed that contraries are to be cured by contraries: thus to hot diseases cold things are generally applied, to cold ones hot, to dry ones moist, to moist ones dry. But since these things are known even to the bleary-eyed and to barbers [lippis & tonsoribus], I would lose nothing but time by discussing them at greater length.

[Margin: By what force the ostrich [struthio camelus] digests iron.]

Yet because there is sometimes found in animals a certain heat that can do more than even the elementary woody heat—as when the ostrich digests within a single day iron that could not be consumed by fire except over a long time—it is asked, what is the reason of this? I say it is not done by heat alone, since the heat of the stomach in animals is quite temperate; but rather that there is in that bird something conjoined to the heat of the stomach, by whose power [it is performed], and that this is of the genus of salt—whether of niter, of alum, or of vitriol, in which animals of this kind greatly abound. This salt, excited by the

heat, performs the same in the ostrich's stomach that the said salts—especially vitriol—perform outside the stomach upon any iron plate. For the spirit of vitriol poured upon it gnaws and eats it away within a few hours, by an experiment commonly known. For the natural heat with which the stomach is imbued by nature, acting upon the saline material of the bird, sublimates as it were the saline spirit lying hidden in it, to such efficacy that it can perform this effect—that is, to consume iron. That this material is present in birds, their excrements clearly demonstrate, since with time they wholly effloresce into saltpeter. And from this we gather why all birds, even those accustomed to the water, have a hotter stomach than the other four-footed animals: namely, because they abound in more efficacious spirits of salts, by which they digest and concoct not only bones and every hard thing, but even iron and bronze coins—as do the hen, the duck, and the like. But of these things more in what follows.

[Margin: How an insensible vapor from a body fascinates.]

The second foundation of Sympathy and Antipathy consists in a certain subtle and wholly insensible vapor, which is emitted from some things into the presence of objects; and in this way arise all kinds of bewitchments [fascina]. In this way lovers mutually infect one another, by certain subtle spirits emitted from the eyes, which, raised from the corrupted blood, black bile, and yellow bile, are diffused through the philtric organ of the eye into the beloved thing, and excite savage symptoms—now of love, now of madness, a little after of indignation or fear, and suddenly of joy—all of which arise from spirits variously contaminated in an alien subject, and impelled and dissipated according to the varied conflict of the affections. But see what we have treated more fully concerning these things in the *Art of Magnetism* [*Ars Magnetica*], Book 3, fol. 576, last edition, and in Book X of the *Magia* [*Magurgia*? — Kircher's *Magnes*], on the bewitchment of love.

[Margin: The menses of women.]

To this class are referred the bewitchments of menstruating women, by which they both infect boys, stain mirrors, corrupt wines by their breath alone, kill dogs—wherever they have licked—with a horrible scab and a falling-out of the hairs: an unwonted venom, and to be shunned by all like the poison of the basilisk, with whose venom it corresponds in all respects; and Cardanus [Girolamo Cardano], Fernelius [Jean Fernel], and Andoynus [?] hold that a basilisk can be born from such [menstrual matter].

[Margin: How serpents kill at a distance by their breath.]

Moreover, certain most venomous serpents may rightly be seen to be referred here, which—being filled with this kind of subtle toxin alone—infect even at a distance: such as asps, the phthiades [?], and, according to Pliny [*Plinium*], basilisks. Hence asps blast [men] by their breath alone; the phthiades [phyades] corrupt and putrefy all things; and basilisks, if what is told of them is true, kill by sight alone—which surely can only be by the efficacy of a virulent spirit. But from where this corruption and putrefaction originally arise will be shown below, where it will be discussed concerning the specific and differing qualities of serpents, and the wondrous effects which they inflict by bite, by touch, or by breath.

[Margin: The accord and discord of things from the likeness and unlikeness of things.]

The third foundation of accord and discord consists for the most part in the likeness and unlikeness of things; and this likeness and unlikeness of things must be judged to lie not in temperament, but in the very substance, from whose form they proceed. For no other law of attraction and repulsion can be established. It is asked, then, how this attraction and repulsion come about in things? I say we can explain it no better than through the magnetism that shines forth both in all things and most of all in medicinal things.

[Margin: How rhubarb draws bile.]

Therefore, when medicaments taken internally—such as rhubarb [*reubarbarum*], scammony, senna, and the like—are said to draw the bad humors, they must not be reckoned to do this by any common and elementary force. For the hot acts upon the hot, the moist upon the moist, the dry upon the dry, inasmuch as they are homogeneous; and in the purgatives recited above, [being] analogous to the bile, they cannot act upon one another by an elementary power. Therefore, if rhubarb and the rest draw bile, they perform this by a certain hidden power, which consists in likeness and flows from the substantial form, by an innate familiarity belonging to both. But how this operation comes about, I disclose. As soon as a medicament has been taken into the body, it first seeks that which is most of all akin to it by a likeness of Nature; and presently, by its power diffused, it inquires after the friendly quality; the quality sought out, it moves; and having moved it, it draws it; the quality drawn, to it...

(Folio 113, recto. Running header: "DE VENENIS.")

[Margin: How agaric draws humors.]

and united everywhere, it leads out together with the other dregs through the stool, the vital spirits conspiring in the expulsion of the common enemy. In this way, then, the attraction in purging medicaments is completed and perfected by the property of likeness alone; and by what elementary quality this comes about cannot be conceived. For since the whole genus of cathartics is hot, it surely could not draw phlegm by likeness, inasmuch as phlegm is contrary to the qualities of the medicament; therefore the likeness of substance alone is the cause why rhubarb draws bile, jalap [scialappa] draws phlegm, and hellebore [veratrum] draws melancholy. Hence they are called by physicians cholagogues, hydragogues, and melanagogues [choligoga, hydragoga, melagoga].

You see, then, how agaric, although by its nature drawing bile, nevertheless draws phlegm; namely because, by its quality analogous to bile, it first moves the bile, which then vehemently stimulates the whole phlegmatic humor taken within, and by attenuating it dissolves it; whence the bile, since the phlegmatic humor is now exceedingly attenuated—being now a humor like itself—desires by an innate appetite to be joined to a like humor latent in the agaric; and so this [bile], drawn by the agaric, transmits along with itself, through the dregs and the stool, the flow of the now-dissolved copious phlegm. For there lies hidden in the corrupted phlegmatic humor something that answers by a likeness of nature to the humor of the agaric; whence at its presence the [bile] is at once agitated toward union—just as iron is suddenly agitated at the presence of a magnet. In this way all antidotes [alexipharmaca] are to be thought to move the humors of the human body.

The medicament, therefore, as soon as it is taken into the stomach and excited by the natural heat, at once bursting into act, is impelled to act; and its bonds as it were loosed, it flies forth, displays itself, and by diffusing itself produces new powers. But the vapor put forth by that very faculty of the medicament, springing thence, poured forth in every direction through the blind and hidden passages into all the recesses of the body, when it has reached the humor that is indeed inimical to Nature but friendly to itself, cuts and attenuates it by its sharpness; and by this action, as it strives to render it like to itself, so too it powerfully stimulates Nature and impels it to discharge. Hence it comes about that the medicament, which is stabled in the stomach and the intestines, by its innate force, and the battle now joined, on the one part by a natural appetite allures the humor like to itself; while Nature, on the other part, offended and stimulated by the lodging of the hostile guest, casts it out—wherever a door is given, not only through the accustomed passages, but through the hidden ducts of the body and the very fibers by which the body is permeable—derived into the intestines. But

concerning these things see *Art of Magnetism*, Book 3, p. 7, where you will find everything treated most fully.

[Margin: How the discord and accord of things arises from the differing constitution of the climate and the situation of the sky.]

Fourth. The accord and discord of things is founded sometimes in the differing constitution of the climates. For just as not every soil bears all things, so too under the torrid Zone, and in the other regions of the Indies and of America, different Animals are produced; and our own [animals], transplanted thither, almost change their species. Sheep acquire a humped form of body, and the other metamorphoses which we have recounted elsewhere; while most of the things brought from there to us cannot, because of the strangeness of the climate, live long; and not a few, soon after they have entered the Tropic of Cancer, die, offended as it were by the foreign region of the sky.

[Margin: The cause.]

In America too the natives suffer certain diseases proper to those regions, with which foreigners are never afflicted; yet the sons of foreigners, if born in that same place, are at once wont to be afflicted by them. These things proceed from no other cause than from the differing temperament which the differing sky, the differing manner of living, and the difference of nourishments produce in them.

[Margin: Where there is disease, there [is] the medicament.]

Hence too the immensity of Divine goodness has provided medicaments suited to those [diseases], which are not found in the regions of Europe, by which they are wont to remedy their own ills. Thus sagacious Nature, everywhere taking thought for the safety of men, has willed that where there is disease, there too the medicament appropriated to it should not be lacking. And—what I cannot sufficiently marvel at—she has produced even the very poisons out of wholesome substances: thus hemlock [cicuta] from corrupted and spoiled parsley [petroselinum]; thora [a poisonous aconite] from antora; from rue, wild rue of venomous substance; from horse-parsley [olusatrum], the horned poppy [papaver corniculatum] of the worst quality. And so the rest take their origin from one and the same thing, only by the corruption of the wholesome [part] intervening; so that the corruption of the best is convinced by the common proverb [to be the worst].

[Margin: Wheat changes its species when transplanted elsewhere.]

In this way wheat sown in unsuitable soil degenerates into spelt or oats; certain garden plants degenerate into turnips, with experience as teacher.

[Margin: Pepper, cinnamon, clove.]

By the same [token] we have come to know that the cinnamon plant sown in Europe has degenerated into laurel, pepper into ivy, the clove [chariophyllum] into something like the chestnut—and this surely for no other cause than because of the greater or lesser strength of the Sun, by whose defect they change the total form of substance when planted in foreign soil, with only certain obscure vestiges of the prior substance left behind. Again, the seedling of the cypress, planted in the Northern Regions in cold soil, [degenerates] into the Savin; the Tithymallus [a spurge], a plant, in Sicily degenerates into a tree. If, then, they undergo so great a change in neighboring regions, how much greater will they obtain when set under a torrid sky? But of these things expressly elsewhere.

[Margin: The accord and discord of things from the imaginative power.]

Fifth. The fantastic, or imaginative, faculty founds altogether prodigious laws of Sympathy and Antipathy. We marvel why not...

no people conceive a natural hatred against [certain] flowers, fruits, or animals: that some break into a sweat even at the presence of a hidden cat; that others faint at the scent of a rose, or are all but overcome by the fragrance of lilies. The same judgment is to be made about other antipathetic affections of this kind, on which a whole book could be written. These, however, draw their origin from nothing else than the mother, who, offended by such things at the time of pregnancy and stirred by various promptings of the imagination, transferred her aversion onto the foetus.

[Margin: The imaginative faculty in pregnant women is capable of it.]

To this same class belong also those marks that are impressed upon the foetus by mothers — and they are countless — which arise from a vehement craving for some thing the mother desires. The Latins call this *picae*, the Greeks κίσσα [Greek: kissa, "the craving (of pregnancy), the longing"]. When a pregnant woman, anxious with desire to have some thing, scratches herself in some spot, the animal spirit, roused by the power of fancy, rushes there and fashions the very thing she had conceived in imagination. From this come the origins of monstrous births; from this arise most of those exotic affections and inclinations that we find in certain people. But on these matters let the reader consult Book 3 of the *Ars*

Magnetica, in the section on the magnetism of imagination, where we have uncovered the genuine explanations of such hidden things.

Sixth. Sound, too, produces certain marvellous effects in the nature of things — as when a taut string sets in motion another equally taut string that it has not touched; and the sound of pipes moves any other object proportioned to it, such as statues in a church, candelabra, and the like, even to the point of a prodigy.

[Margin: From the marvellous power of sound.]

But since I have treated these matters expressly in various places of my *Musurgia*, I refer the reader there, where he will find all the marvels of sound unravelled through their genuine causes.

Seventh. The constitution of certain bodies with respect to their pores brings it about that some things, when thrown into fire, do not take in the heat — which people ignorant of the cause greatly marvel at; on these too in the preceding [discussion].

[Margin: From the constitution of the pores.]

For where, through the narrowness of the pores, no entry is granted to fire, there the thing necessarily remains cold, since fire produces heat not when received on the surface but in the inmost substance. Hence, although the heat acts to some degree on the outer surface, the cold lying hidden within, by its own power, the moment anything of heat is produced on the outside, immediately destroys it as something contrary to itself — as they report happens with the diamond [Adamas].

Eighth. That the cross-radiations [corradiationes] of natural bodies establish marvellous laws of consensus and dissension in the nature of things, only he can fail to know who is ignorant of the Magnetic Art.

[Margin: From cross-radiation.]

For since all natural bodies have been endowed by the most wise Architect of the world with this kind of ray-emission [actinobolismus], they certainly act marvellously through it. For these rays are like certain hands by which things, when they cannot always act with the immediate contact of their substance, seize one another, however distant, in a friendly or a hostile encounter. And such ray-emissions, or cross-radiations, are nothing else than certain subtle and imperceptible vapors, by which things cherish one another if they are friendly, and destroy one another if they are hostile.

[Margin: Friendships and enmities of plants.]

From this flow all those friendships and enmities of plants, whose catalogue you may see in the aforementioned *Ars Magnetica*.

It is a marvel that I observed not long ago in our own garden. A pomegranate-flower shrub [balaustia] had been planted between two rhododendrons, that is, oleander trees. Since this kind of shrub is marvellously destructive, swelling as it does with a venomous sap, it came about in time that the pomegranate-flower, as though seized by a kind of consumption, withered entirely and, consumed by dryness, presented an exotic effect to all who marvelled at it.

[Margin: A marvel concerning a pomegranate-flower planted between two rhododendrons.]

Suspecting the malice of the hostile plant, I advised that the oleanders be cut down — inasmuch as they had bewitched [fascinaverint] the tender pomegranate-flower with their venomous vapor. Once these were cut out, the pomegranate-flower at once, as though the causes had been removed, began to sprout anew from its lowest stock with an abundant crop of shoots. I found the same in the case of *satyrion* planted next to the chaste-tree [vitex]: for the *vitex*, or chaste-tree [agnus castus], in time seemed to have utterly destroyed the *satyrion*, as though at the encounter with a plant hostile to it.

[Margin: Enmity of the chaste-tree and satyrion.]

The reason for this is none other than that the chaste-tree, by its own fiery power, gradually dries up and destroys the generative humor lying hidden in the *satyrion*, as something contrary to it in the likeness of its whole substance.

To this cross-radiation, or ray-emission, all things — whether animals or plants — are referred. Of these, if any two are friendly, the one refreshes and cherishes the other by this circular outflow [ἀπόρροια / aporrhōia, "emanation"] or effluvium of like virtues; but if hostile, the one dissipates and consumes the other by the effluvium of unlike powers. And this magnetism is peculiar to all natural things in the three kingdoms of Nature, as we shall see hereafter.

CAPUT VI.

De Venenorum consensu, dissensuque, eorumque origine, & causis.

(On the consensus and dissension of poisons, and their origin and causes.)

Now that the reader has seen in how many ways the specific virtues of things — which people commonly, and ignorantly, call occult qualities — may be considered (as set forth in the preceding chapter), and what are the cradles of those admirable virtues with which they are imbued, and equipped with which, nothing remains but that we pursue the argument we proposed concerning poisons and their causes.

[Margin: A poison is defined by its property, distinct from its whole substance.]

Since, then, a poison is here nothing else than a certain force placed in some body, singularly harmful to the heart, wholly dissimilar to the life of living things, contrary to it, and directly corruptive — anyone might rightly doubt what this force is, or in what it consists. On this there is great strife and controversy among the authorities. There are those who think it acts merely through an excess of the primary qualities, so that some kill a person by intense and vehement cold, constricting the heart, stupefying it, and extinguishing the radical heat; others by dryness, consuming the vital humor; others by excessive moisture, putrefying and obstructing the passages — by a certain intemperateness, that is, a *δυσκρασία* [Greek: *dyskrasia*, "bad mixture, distemper"] of the primary qualities, peculiar to each. But in this they are greatly mistaken.

For if the action of poison consisted in an excess of the primary qualities alone, there would be no reason why pure water, pepper, or sublimated wine and the like should not be reckoned among poisons and lethal substances — since the coldest water is freezing-cold and pepper is exceedingly hot; yet these cannot be called poisons. Therefore, besides heat and cold, moisture and dryness, another quality is needed by which those vehement symptoms observed in the poisoned are produced — a quality that, on the very best grounds and on the testimony of Aristotle, corresponds by a certain proportion to the element of the stars. And so, that we may assign the genuine explanation of all those things that are called pure poisons, we shall begin the web we have started from the minerals.

DISQUISITIO I.

In which the nature, property, origin, cause of the effects, and the exotic symptoms are investigated.

I suppose, first: that there lies hidden in the subterranean bowels a certain *παντοσπερμία* [Greek: *pantospermia*, "all-seed, the universal seed-store"] of things, from which arise innumerable mixtures of innumerable species — as has been shown here and there throughout this whole work.

[Margin: The forms of natural things arise spontaneously from such-and-such material combination.]

These [mixtures], however, arise chiefly from salt, sulphur, the mercurial element, and from these mediately commingled into infinite combinations.

[Margin: The salts, and their infinite combinations, and the origin and causes of the consensus and dissension of mixtures.]

For the various species of salts — namely those of niter, of alum, of vitriol, and the rest — set in motion almost infinite combinations of mixtures, both wholesome and unwholesome, so that the forms of the most diverse things emanate from nothing other than this or that concurrence of combining materials. And these combined compounds of mixtures put on such a form as this or that combination has assigned to them.

I suppose, second: that the subterranean fire — the true Archeus [Archaeus] of Nature, the παντουργόν [Greek: pantourgon, "all-working (principle)"] — by its heat penetrating the inmost fibers of the Geocosm, transmutes the mixtures into as many different forms as there are degrees of remission and intensification within it.

[Margin: Heat variously intensified produces different properties in the mixtures.]

This we have sufficiently demonstrated in the preceding [parts] by experimental reasoning; and from these arise new seedbeds of combinations, which indeed result not immediately from the primary qualities, but from the very forms constituted by the law of this or that combination.

These things being thus supposed, let us now proceed to examine those combinations that give rise to pure poison. And first there is the fourfold genus of salts; then sulphur, quicksilver [argentum vivum], sublimate, mercurial juices, naphthas, and the half-metals [semimetalla] — cadmias, marcasites, antimony — from whose various permutation are born the infinite kinds of poisons.

[Margin: Of how many species is the poisonous sulphur?]

Sulphur first generates four species, born solely from a more intense or more remiss degree of fire; and they are: Arsenic, Orpiment [Auripigmentum], Sandarac, and Realgar [Risigallum]. These are so similar to one another in virtue that they may deservedly be taken for one. For from arsenic comes orpiment, differing not in substance but in color only; from this is born sandarac, likewise

differing from orpiment only in color, so that they may be taken for one and the same — which the Arabs too teach plainly: for what we call orpiment, they call زرنیخ [Arabic: zarnīkh] Sandarak [?]; and from this, finally, arises realgar — "the bad egg, the bad crow" [mali ovi, malus corvus]. For all these are pure and most efficacious poisons, as all metallurgists and chemists attest, as may be seen in Mattioli [Mathiolus], Falloppio [Fallopious], Agricola [Agricola], and Cardano [Cardanus]; and we ourselves have treated at length, in the preceding [parts], of imperfect metals of this kind.

[Margin: The threefold force of arsenic.]

But by what means it excites symptoms by its poisonous quality, and what is the force of arsenic and its threefold composition of species — from which such great evils proceed — must now be explained. Arsenic is sulphureous in nature, and arises from sulphur by various modifications of fire; it is endowed above all with a threefold power, so harmful to all men and other animals...

harmful. The **first** is its burning [adustive] force, which it obtains from the sublimation — effected by internal heat — of certain salts implanted in it that are endowed with a fiery power; with this it tortures and scorches all the parts of the body with a vast and intolerable burning. The **second** is its caustic, or corrosive, force, which, by dissolving, corrodes that which has already been dilated and attenuated by the burning — the flesh, the bones, and finally the nerves themselves — just as the strong waters, the so-called *aqua regia* and *aqua stygia* [royal water and Stygian water], gnaw at and consume metals. And just as these are for the most part composed of common salt, sal ammoniac, and vitriol, so in corroding and calcining metals arsenic has great power, since it swells with these same salts, and, already corrupted by the alteration of a more vehement fire, performs the same in the economy of the human body. The **third** quality is the putrefactive, which, as a shadow follows the sun, so continually follows the corrosive faculty; for this dissolves into corruption [tabum], by a certain septic force, all that has been corroded within.

[Margin: The symptoms produced in the human body by mineral poisons.]

These said deleterious faculties are necessarily followed by those unaccustomed symptoms by which the poisoned are agitated — namely: anxiety, languor, and a stupor of the heart from the oppression of the spirits; intolerable pain arising from the burning and caustic force; failing of the mind from the consumption of the vital spirits; finally, a clouding of the mind from the elevation into the brain

of fumes from the putrefaction of the humors; and at last inevitable death follows upon all these.

And these are, among the minerals, the chief and primitive poisons, from which all the other poisonous minerals — such as antimony, cadmias, magnesias, and the like, all of which savor of I-know-not-what arsenical quality — draw their origin; although, inasmuch as they are commingled from different mineral clods, they are also more and less contrary to nature.

[Margin: The deleterious force of quicksilver.]

The other primitive poison is **quicksilver** [Argentum vivum], on whose nature enough has been said above in the *Sectio on imperfect metals*. Quicksilver, so long as it remains undissolved in its natural fluidity, can obtain some use in medicine, if administered in a proportioned dose; for it is a great remedy against poison. Likewise it is usually administered to those afflicted with the iliac passion [colic], because by its great weight it presses upon and dislodges the matter obstructing the intestine. While I am writing this, it was administered with great benefit to a man suffering from the iliac passion, so that the whole quantity of mercury, having passed out through the bored-through dregs by stool and dispersed into globules, was gathered up entire without any loss. But if taken in great excess, it kills without remedy by coagulating the blood and spirits with a certain specific cold.

[Margin: The pernicious force of quicksilver.]

Mattioli [Mathiolus] relates that he knew an apothecary who, having been seized by a fever in the night, and tormented by intolerable thirst, had gone down into the cellar to slake his thirst with a draught of water, and by a foolish error drank no small amount, in place of water...

from a vessel of quicksilver. That it was an effect not of the primary quality, but of such a form as proceeds from the likeness of the whole mercurial substance, is clear from this — that I do not see how a draught of snow-water could not have produced the same. Therefore effects of this exotic kind must be said to proceed from no other cause than from salt, niter, or vitriol concentrated inwardly with the mercury — substances that coagulate not by cold but by heat. For once the spirits are consumed and the natural heat extinguished, the blood must necessarily coagulate, together with a cold constitution of the whole body. This is clear also from niter, vitriol, and salt, which in like manner — not by cold but by heat, the spirits existing in snow and water being consumed — necessarily

convert water into ice; an experiment than which nothing is more frequent here at Rome in summertime.

And so crude mercury, being oppressed by its natural moisture, cannot diffuse its poison; and likewise (unless taken in great quantity) it cannot do much harm. But once it has been sublimated and exalted by heat into a salt, then at last it loosens the reins of its poison with such force, and rages accompanied by so many and such great symptoms, that it seems to want to yield to no poison in the nature of things — especially if the sublimation is set up with vitriol, vinegar, and sal ammoniac. For if it has been taken inwardly, the tongue and throat are at once roughened, no otherwise than if one had drunk the juice of unripe sorb-apples; and descending into the stomach, it clings stubbornly there, soon exerting the powers of its malignity, and by corrosion and ulceration turns everything upside down, with an inexplicable burning of the whole body and an inextinguishable thirst. Upon these follow incredible anguish, swelling of the tongue, fainting, suppression of urine, difficulty of breathing, torments of the stomach and intestines — until at last, the stomach and intestines being eroded and perforated, they force the person to breathe out his soul along with the foulest stench.

[Margin: The horrid symptoms that proceed from sublimated mercury.]

All these things just said I have observed at Rome, not without horror, in a certain man who had rather incautiously taken only a third part of a drachma of sublimated mercury, and who, agitated by the said symptoms, was at last extinguished. It is asked: what is the cause of these symptoms? I say they proceed from the salt of sublimated mercury, which, stripped of moisture by the force of heat, is reduced to the utmost dryness. And the salts commingled with it — inasmuch as they incorporate into themselves whatever of malignant spirits lies hidden in the mercury — likewise, by their excessive dryness, constrict and strangle the throat, and, the humor being consumed, consequently torment with intolerable thirst. Added to this is the burning and supremely corrosive vehemence of the saline spirits, which, wherever they find a softer substance, at once gnaw it, dissolve the nerves, and, the vital spirits being at last consumed, bring on death. If anyone has seen tinder seized by a spark of fire — how quickly it pervades the whole mass...

[Margin: The burning force of antimony.]

and consumes it — he will form a not unfitting conception of the burning force of this poison. Mattioli [Mathiolus] testifies of himself that on one occasion, while testing the power of sublimated mercury by tasting it only with the very tip of his

tongue, his tongue at once swelled so far forward that there was need of sudden, extreme antidotes. Afterwards, on Mattioli's testimony, certain foolish little women experienced this kind of poison, to their own great harm: in order to be tinged with a fair complexion, [using] sublimate in place of acquired beauty, they soon vomited out their teeth, smelled with a stench fouler than a he-goat, fell from the brightness of their eyes into darkness [of sight], saw their soft, smooth, supple flesh soon transformed into the wrinkled face of old hags — indeed, as if seized by tetanus, they redeemed their foolish vanity by nothing less than an untimely death. We have now seen the deleterious effects of sublimated mercury, the cause of which is none other than the virulence of the salts which it holds folded up within its own body.

The **third** poison is stibium, or **antimony**, which, being constituted partly of arsenic, partly of mercury, even though it acts more mildly — because it is somewhat blunted by the medley of various substances — nevertheless yields the same effects as the said minerals. For by its violence and hostile force the stomach is so stirred up that, not without manifest danger, it strives to expel whatever is in it or flows into it; for it acts by a certain specific deleterious force, which, on the testimony of Erasto [Erastus], Smezio [Smetius], and Mattioli [Mathiolus], shares the nature of mercury, whether sublimated or precipitated — powers utterly maleficent and harmful, the more hostile to us the greater the quantity in which it is taken.

[Margin: The deleterious force of antimony.]

Hence, being most hostile and utterly contrary to the orifice of the stomach, snatched into the veins and distributed through the body, it marvellously harasses and plucks at the remaining parts, undermines the spirits, and with indiscriminate malice expels both the good and the malignant juices alike. And although in some it achieves its medicinal effect by a powerful purgation, yet I think few there are who, using this medicine, have reached early old age. But you will say it is taken harmlessly when corrected. I reply: since the purgative force consists properly in the various medley of pernicious salts saturated with mercurial spirits, then either it will still operate after these have been extinguished by the correction, or it will not. If the former, then — the same poison always remaining — the same effect must always follow. If the latter, then it will no longer act any more than any other floury powder. Thus the reason for the deleterious quality lying hidden in antimony is evident.

[Margin: The virulent force of misy, sory, and chalcitis.]

Fourth. To the class of poisons are also referred *misy*, *sory*, and the species of *chalcitis*, or marcasite, which — since they take their origin from vitriol, from the manifold species of the other burnt salts, and also from sulphur, as we have shown at length in the **Seventh Book** — are likewise so stuffed with arsenical spirits that they cannot be taken inwardly without manifest danger to life; for, being corrupted by the spirits of the primitive mineral poisons — sulphur, mercury, antimony, arsenic, and the like — they constitute as many different species of poison as there are diverse minerals arising from the aforesaid.

[Margin: The virulence of quicklime and gypsum.]

Fifth. From quicklime [calx viva] and gypsum a new species of poisons is constituted, which — inasmuch as they are taken both by themselves and mixed with the others already mentioned — likewise exhibit diverse species of poisons, although all of them are endowed with a certain caustic and burning faculty. And these are the matters concerning the causes and origin of mineral poisons that we thought should be set down beforehand.

DISQUISITIO II.

On the poisons of plants, and their causes, and from where they have drawn their origin.

I suppose, first, on the teaching of the botanists, that plants endowed with some deleterious property — especially those called pure poisons — are for the most part among the number of those said to be spontaneously generated; or, what is the same, that draw their origin from rot. For by experience — as we have shown in the **Seventh Book** and elsewhere — it is known to the learned that virgin earth, set in a lofty place to which the seeds of things can scarcely come, and watered with pure spring water, in time generates plants common to that country, such as various species of grass. Porta relates that he too performed an experiment on this matter, in Book 2 of his *Phytognomonica*, chapter 1, in these words:

EXPERIMENTUM

By which it is shown that herbs of every kind are born from earth without prior seed.

"For I myself have always judged it consonant with the truth that from the earth both plants and not a few animals are born — because there is in earth a moisture, in moisture a spirit, in [it] all a universal heat, so that all things are full of Jove. For this reason, without any pre-existing seedling, without any human

labor, just as the various tracts of the earth are diverse in soil, sap, sun, situation, and other constitutions, so too they have produced diverse plants, marked with diverse innate qualities. For such is wont to be the habit of the body, such the humors by which we are nourished, and such the juices that are engendered, as are the foods on which we feed. This kind of experiment turned my mind to it: when I had gathered up earth dug out from the deepest foundations of buildings — so that every suspicion of seed thrown in might be removed — and had exposed it to the open air in the highest places, lest the wind should have carried seeds from elsewhere, then, many days having elapsed afterward, and with the various qualities of the earth, in the said earth various kinds of herbs sprang up, familiar to the Neapolitan soil and sky. For one [kind of] clay produced one thing, the Neapolitan dust another, the ground-up pebble or tufa another. Thus each [kind of] earth..." ...the earth produced, according to its own quality, an herb of that same quality. For tufaceous earth [trophacea terra] yielded Neapolitan trefoil [trifolium Neapolitanum], other kinds of earth now nettles and brambles, others mercury-plants and the like. So far Porta. These results agree so precisely with the experiment I myself carried out that nothing further could be added to demonstrate the truth of the matter. For in plants the very same thing happens that happens above all in animals: depending on the disposition of the matter, now an herb, now some insect is born, as we showed above. But now to the next point [ad Rhombum].

The question therefore arises: why, and how, does so great a variety of poisonous herbs arise from the mixture of these earthy putrefactions? To untangle this, one must first understand — as was said above — that all classes of mixed bodies are primordially constituted from sulphur, mercury, and salt. But how plants that grow spontaneously arise from these; how insects can do so; and finally how plants and trees that derive their origin from a natural seed, as do animals, are constituted from those same three — this remains to be explained.

[Margin: The poisonous plants all arise primordially from minerals.]

So that no one may suppose that all things are constituted out of *material* sulphur, salt, and mercury, I say: these three principles of things must be understood according to a certain analogy. For hidden in the innermost recesses of Nature is something fiery and supremely active — call it natural heat, or whatever Nature-preserving thing corresponds to it — and this we call *sulphur*. And since that fiery force residing in things cannot subsist without a moist element to serve as its fuel, there is laid up in all mixed bodies that moist

principle — call it the radical moisture or by any other name you like — which the more secret philosophers name *Mercury*.

[Margin: What is meant by sulphur, mercury, salt.]

Again, since the warm-moist (that is, the sulphureo-mercurial) cannot subsist without fixation, that which gives subsistence to all things — inasmuch as it answers to the nature of the earthy element — they called *Salt*. And since the sulphureo-mercurio-saline compound still cannot rightly carry out its natural operations, they added to these a certain spirit that permeates all the substances of mixed bodies, which we designate by the name of *air*.

[Margin: How sulphur, mercury, and salt are to be understood in our sense.]

With these matters set out, let us now proceed to the δηλητηριωδῶν βοτανικῶν [Greek: *dēlēteriōdōn botanikōn*, "of the poisonous plants"] — that is, to the origin of poisonous plants.

Experience teaches that from the minerals adduced above in the subterranean fire-chambers [pyrophyllacia], certain fumes or exhalations breathe out perpetually through the inmost fibers of the earth up to its outermost surface. Hence it comes about that, if these fumes are joined to wholesome clods, they produce wholesome and good herbs; but if they are linked to a putrid soil tainted by malignant impressions, then in time, as those fumes ferment, they will lay down a putrefaction fit for generating poisonous herbs. And so, according to the diversity of the putrefaction — affected by one or another poisonous vapor — they will produce deleterious herbs of correspondingly differing power, as befits the disposition of the matter. But let us make the matter clear by examples.

[Margin: The origin of the poisonous herbs declared by examples.]

If an earthy putrefaction has been worked up by arsenical [arsenicalis] vapors carried through the subterranean channels, then from the already-fermented matter will be born either monk's-hood [Napellus] or aconite [Aconitum] — herbs whose properties in their powers are wholly like those of arsenic. Hence, once such an herb is taken inwardly, it at once excites those same symptoms suffered by people who have swallowed arsenic, orpiment [auripigmentum], or realgar [sandaraca]. To this class belong all the herbs endowed with caustic power, such as spurge [Lathyrus, or Cataputia], euphorbium, scammony, and the like.

[Margin: Comparison of the poisons with plants.]

But if the said disposed matter has been constituted by a mercurial vapor, then there arises either leopard's-bane [doronicum] or else the herb *hæmorrhoon* — which, like sublimate of mercury, has such efficacy that within a few hours, with all the channels of the veins eaten through, a person must die from a flux of blood pouring out of every member of the body. And if the disposed putrefaction has generated an herb from an arseno-mercurial source, then when that herb is drunk it will excite all those symptoms proper to arseno-mercurial mixtures. Of this kind are certain species of mushrooms, of such efficacy that, by their smell alone, they kill those who incautiously sniff them — as Pliny [Plinius] attests.

[Margin: The effects of veratrum and henbane.]

But if the earth, swelling with *melanteria* [a vitriolic earth], has been infected by the vapor of corrupt vitriol, then either henbane [hyoscyamus] or hellebore [veratrum] must be born, of the same property as the clods of that mineral. Whether veratrum or henbane is taken, besides the urge to vomit it hurls great globes of fumes into the brain, by which a person, first seized in mind, is driven into frenzy, and at last, struck with lethargy, ends his life in a wretched death. These herbs, according to the greater or lesser quantity of putrefaction, produce now more, now less efficacious effects. From this source spring thorn-apple [Stramonium], all the kinds of nightshade [solatra], mandrake [mandragora], asafoetida (or *cotula*), and countless other herbs of deleterious quality — all of which I have come to know by experience.

[Margin: A marvelous experiment.]

For if you take putrid earth from a place where many dead carcasses have rotted, and water it with poisonous mineral juices, then that earth, set in a vessel exposed to the sun, will in time produce either hemlock [cicuta], or henbane, or nightshade, or asafoetida, according to the condition of the juices of the minerals with which it is steeped; and these herbs thereafter propagate themselves by their own seed. But why wander further afield, when these very things are confirmed by Holy Scripture itself? When, in *Genesis* 1, God, after the separation of the earth from the waters, said: *Let the earth bring forth the green herb, that may bear seed according to its own kind*, etc. From this it plainly appears that the seeds of all vegetable things were first implanted in the earth, which then, sprouting forth from the earth, each according to its own species produced an herb conformable to the seed from which it was drawn; and these thereafter, through the seed natural to each, have propagated the species of plants to this very day.

And so the earth, struck by the divine command, out of the bounty of its omnipotence — the storehouse of every good — brought forth an innumerable variety of herbs along all the paths of the world, according to the situation of the sky and the various constitution of the climates. Then the whole ridges of the North produced the yew, the *Thutian* [?], and the *Celustum* [?]; under the torrid zone, the fragrant aromatics; Arabia, balsam, frankincense, myrrh; Egypt, the sycamore, cassia, colocasia; Rhodes, the *Aspalathus*; Babylonia, the date-palm; Lebanon, the cedar; Crete, the cypress; Pontus, wormwood [absinthium]; India, pepper, cinnamon, clove; America, sandalwood, guaiacum, and other exotic plants and trees. And so at last the whole surface of the Geocosm flowered with a certain infinite multitude of herbs, shrubs, and trees, of incredible diversity of powers. All of these, just as they consist of salt, mercury, and sulphur, so too, mixed with the earthy clods, brought forth — according to the combination of the concurring matter — now wholesome, now unwholesome plants, partly by the agency of the sun, partly by that of the subterranean fire.

It is therefore clear that plants of a deleterious quality drew their origin from no other source than from a certain fatty and mucilaginous matter, impregnated with a varied mixture of mineral juices. And this is clear even to the senses: since, after the manner of the said juices, all poisonous plants are imbued with a marked acrimony and with a certain fiery faculty by which they gnaw, corrupt, and destroy all things. And of those which are born from calcareous, gypseous, and tufaceous matter, all are powerful in acrimony — though less harmful than the rest. But of these matters more fully elsewhere.

DISQUISITIO III.

From where do serpents, insects, and the other imperfect poisonous animals draw their origin?

[Margin: All poisonous things arise primordially from earth — the same earth from which both animals are compounded by the union of the two sexes.]

Just as, then — as was said in the preceding passages — plants have their origin from the earth (since the earth, as Anaxilaus [Anaxilaüs] testifies, is the mother of all plants, and fire, whether solar or Vulcanian, is their father), so too I would have you understand the same of animals. For all those animals — both those called *insects* and the species of land, flying, and swimming creatures — have their origin from nowhere else than from the putrefaction of earthy matter, variously disposed by the marvelous industry of Nature. This putrefaction then, just like plants swelling with their own seed, propagates itself after the manner of

the other living things. Nor does this conflict with the sacred Text, when it says: *Let the earth bring forth the living soul in its kind, cattle and creeping things and beasts*, etc. — and at last also man; so much so that the primordial production of even the perfect animals, without any prior seed, by the command of the Divine power alone, proceeded out of the earth as out of an underlying matter.

[Margin: The opinion of Anaxilaus.]

And from among the ancients, Anaxilaus, the disciple of Euripides [Euripides] — though not without a sense contrary to the sacred page — asserted: "For when heaven and earth," he says, "had been received as one whole within themselves, the earth brought forth trees, birds, beasts, and the whole race of mortals" — not, as he himself supposes, by the command of the Creator, but by chance. "While the earth, putrid, soft, and made dense by the sun, produced swellings on its surface, each containing its own putrefactions; and, with night going round, the dew sprinkling, and the sun consolidating them, it at last carried the putrefaction to its peak — the time of birth, of course, having ripened — and, the bonds being broken, it brought forth all the kinds of living things." But this too daily experience teaches, when we see so many species of worms suddenly born.

[Margin: The origin of the testaceans.]

The ὀστρακόδερμα [Greek: ostrakoderma, "shell-skinned ones" — the testaceans], which is a class of shelled animals, when cast into the sea in earthen vessels, are generated from putrefying foamy slime; purple-fish [purpuræ] from slimy putrefaction exalted into a notable luster; in muddy matter, oysters, razor-shells [ungues], and scallops [pectines]; in sandy matter, the *conchæ*; and finally testaceans of various kinds are engendered from slime, according to the difference of the slime.

[Margin: The origin of eels.]

Eels are born without seed from the skin which they shed putrefied every year, or even from the shreds of that same skin worn off against rocks. You will discover the truth of this if you cast the skin of an eel, cut up small, into a slimy pond: for within a month's space you will find a new brood of eels.

[Margin: Fish arising from rains, by a mixture of earth.]

This too became known to us by a remarkable experiment: that a place enclosed on every side by valleys, which no spring waters and no lake washes, and which admits nothing but the rain from heaven, is straightway filled with various kinds of fish. Of this I can give testimony as an eyewitness. In a field which the most

eminent Cardinal Ursinus [Cardinal Orsini] had, near the sea, converted into a pond, as soon as the hollow of the dug-out field had been filled with the winter rains, we found it likewise filled, within a few months, with every kind of fish — even though as yet no fish had been brought into it.

[Margin: The origin of frogs.]

Again, frogs, which have their birthplace in marshes and other ditches, are generated from putrid slime — and not from slime alone do they arise of themselves: the dusty sands of marshy places being merely sprinkled with rain, whence they are also called "temporary" (frogs); concerning their artificial production, more in what follows.

I shall not speak here of the generation of mice from putrefaction; nothing of aquatic insects, nor of the other flying insects and of the earthly worms, scorpions, and so on — all of which, just as they are born from putrid earth and the mucilage of the waters, so too are not devoid of poison.

[Margin: All plants and animals generate their own animalcules out of putrefaction.]

Just as, then, plants and serpents are immediately generated from earth, so too there is no plant which does not produce out of its own putrefaction some peculiar insect; nor any perfect animal which, either immediately from the putrefaction of its own body, or by means of its excrements, does not procreate certain animalcules...

so much so that no member, whether internal or external, has been observed not to teem with worms — especially in the maladies of a more malignant quality. On these matters see Schenck [Schenckium], Valleriola [Valleriolam], Gesner [Gesnerum], Aldrovandi [Aldrovandum], and the rest, and our own reasonings (supported by manifold experimental demonstration) in the *Scrutinium physico-medicum de peste* [*Physico-Medical Examination of the Plague*].

But let us return to the purpose we have set ourselves. Since, then, poisonous animals — such as serpents — are for the most part born from the putrefaction of the earth, and afterward propagate the species by mating as well; and since the poison of some serpents is so deadly that some kill a person, with no remedy of safety, by their bite (as the dipsas-serpents [dypsades]), some by their breath alone (as the asps [aspides], by their *Chelidonia* [?]), and some by the discharge of their spittle (as the *phtiades* [spitting-snakes]) — it may rightly be asked: from what causes does so great a destruction arise?

[Margin: By what means do serpents kill a person?]

I answer: it derives its origin from a putrefaction of this kind, which emanates from the poisonous faculties of certain of the minerals we adduced above. For from the combination of these with certain earthy clods — calcareous, gypseous, sulphureous — and with the slimy matter of the earth worked together, there results a certain putrefaction; and from its fermentation, by the force of the heat of the sun, or of Vulcanian heat, a worm is hatched, which finally generates a serpent endowed with that property of poison which the putrefaction, combined from the deleterious minerals, possesses — a putrefaction which procreates as many differing species of serpents as it has differing kinds of combinations.

[Margin: The marvelous sympathy and antipathy of poisons.]

Hence arises that admirable sympathy of poison toward a poison like itself, and antipathy toward one unlike it. For just as a serpent lives only from that from which it drew its origin, or from little animals imbued with a similar poison, so too it alone craves that poison, and draws it magnetically — both for its nourishment and for its own preservation; for serpents consist of those very things by which they are nourished. But if the putrefaction has obtained, from one or another combination of things, a different temperament differing diametrically, then there arises also, in the serpents, an antipathy wholly opposed to the former poison — as in the dipsas and the *cherza*-asp [aspis cherza], which destroy one another by the contrariety of their poisons and by dire feuds. This is no otherwise than certain mineral juices and certain metallic bodies consume one another, as will be taught in its place — not by manifest qualities, but by specific properties, whether drawn from the whole substance, or from the form, or finally from the likeness or unlikeness of various accidents.

DISQUISITIO IV.

On the antipathies of poisons, and their causes.

Likewise:

How the poisons of all poisonous animals can be a remedy for the poison they have inflicted; and finally how all poisons draw to themselves poisons like to themselves, and are nourished by them.

First, that one poison is hostile and contrary to another by the unlikeness of its whole substance, the toad and the spider sufficiently show — a thing which, had I not seen it with my own eyes, I could scarcely have been induced to believe. For

when I had read in I-know-not-which author about the antipathy of these animals, I resolved to put the matter to the test by experiment. And so, when I had brought a spider hanging from a stick close to a toad shut in a pit, the spider, on sighting its enemy, at once descended along its thread and, inflicting a sting, not merely stunned the toad but utterly killed it; and then, as if having carried off the victory over its enemy, it withdrew along its thread back to the place from which it had let itself down.

[Margin: The marvelous antipathy of toad and spider.]

The cause of this is asked. I say the cause is the diversity of the poison of each animal. For since the poison of the toad, or of the *rubeta*, is wholly earthy — arisen from corrupt putrefaction and from the venomous slime of the earth — while the poison of the spider is airy, subtle, and swelling with spirit, having its birth from the air, or from the putrid pores and chinks of walls and timbers; hence it comes about that the spider, being full of deleterious spirits and mineral juices, engenders a not-dissimilar poison. As soon as it has injected this into the body of the toad, then, by the subtlety in which it excels, it converts the whole poison of the toad — now made subject to its own jurisdiction — into its own poison, and thus lays the toad low, infected with an alien poison wholly unlike its own substance.

Again, since the poison of the toad is humid-cold to the senses, not arisen from the primary qualities (for I judge that no poison is cold formally, but that all are warm, according to a certain specific property emanating from the form — otherwise the hottest things could overcome the coldest, and the coldest the hottest, contrary to experience; and I would have the same understood of the dry and the moist): the poison of the spider, on the other hand, being likewise by unlikeness of its whole substance dry and warm — inasmuch as it arose from a mineral vapor of deleterious quality, residing in the lime of walls and in the fissures of timbers — it is no wonder that, by the efficacy of this poison endowed with a certain fiery force, the toad's poison, being wholly contrary, is consumed and destroyed. I could prove this by various experiments, had I not reserved them for other places.

[Margin: The antipathy of vinegar and litharge.]

If someone precipitates in water the vinegar they call "radicated" [acetum radicatum] over litharge [lithargyrium], he will see how the water of the litharge, contrary to the vinegar, at once not only destroys the property of the poison latent in the litharge, but converts it utterly into a milky color, the whole poison

being consumed. You may reckon that the same thing happens, in just this way, in the antipathy of poisons.

[Margin: Asps and Argive serpents kill one another.]

Between asps and the Argive serpents [serpentes Argolici] there is so great a hatred that Nicander [Nicander] reports that serpents were deliberately carried over from Argos to Egypt to exterminate the asps. And this is to be seen, with wonder, among vegetables too: for if you plant the monk's-hood [napellus] around the roots of the poisonous yew tree [Taxus], you will find the yew consumed by the venom of the monk's-hood, as though by a kind of rot, within a single week. For that which among poisons — whether it be in animals...

or in vegetables — is more potent and more active, generally finishes off the other, weaker one. And hence is born that natural hatred of toad and spider. Since the toad, conscious of its own weakness, so dreads the spider that, at the season when spiders come forth — that is, in the dry season and at the noonday sun — it dares not appear (lest it fall in with its deadly enemy) unless armed with rue [ruta].

[Margin: The hatred of toad and spider.]

But the reason that toad is not opposed to toad, nor serpent to serpent of the same species, is that the poisons are of the same nature; and these poisons are so far from harming each other that rather they mutually cherish and preserve one another by the common poison of all of the same species. For just as plants and shrubs draw out of the earth that which is most agreeable to their nature, so too animals seek by a certain natural appetite the nourishment most suited to preserving their nature.

[Margin: Why poison of the same species is not contrary.]

[Margin: The poisonous juice of the earth is the food of the poisonous animals.]

Since, then, Nature has implanted poison in the poisonous animals as a kind of particular endowment — both for preserving themselves and for defending themselves against contraries and enemies — the attraction of poison seems to them to be a thoroughly natural nourishment, as something without which they cannot live; for they are nourished by those very things out of which they are made. Hence serpents, toads, and scorpions, sucking up by a certain natural appetite whatever in the earth is poisonous, putrid, and harmful, convert it into nourishment — no otherwise than a person turns food into the substance of the body that is nourished. This you may discover by the following experiment: if you

let loose a viper, for example, stripped of its poison, into earth steeped with poisonous quality, you will find it — which before lacked all poison — wholly venomous from the newly attracted poison.

[Margin: Poisonous animals draw to themselves from the earth the poison agreeable to them.]

Hence too vipers and the other venomous serpents, while they take from us what harms us, divert back into themselves — by the admirable providence of God, the Best and Greatest — what is beneficial, once drawn off; and so, where death was feared through the poison, there life is obtained through the medicine, to the great benefit of those so badly poisoned.

[Margin: The toad is a remedy for plague, and the scorpion for its own poison.]

In this way the toad, dried in the sun, applied to plague-buboes, while it draws to itself that which is pestilential, at the same time frees the person from the plague-affliction; concerning which see our *Tractatus de peste* [*Treatise on the Plague*]. So the poison of the scorpion, lodged in the body by its sting, is freed from the person by the application of the scorpion itself, crushed — by the attraction of its own poison. So the poison of the stingray [pastinaca] is drawn out by the application of the crushed tail of the stingray. But since we have dealt with these matters more fully in the preceding passages, we shall not linger over them; let this Rule suffice for the reader: that the poison of every animal whatsoever, of whatever sort in the end, when lodged in the body, is the medicine for its own poison. See Book 3 of the *Ars Magnetica* [*Magnetic Art*], where you will find numerous examples of this kind adduced concerning the magnetism of poisons, and also concerning the poison of the tarantulas.

CONSECTARIUM I.

From this it is clear that serpents of whatever kind draw to themselves, as nourishment, a poison akin to their own. Hence they not only suck up the putrid mucilage out of the earth, but also hunt, with the utmost cunning, for nourishment from the very poisonous herbs and animals which by a certain instinct of nature they know to be agreeable to them. Thus the viper, among herbs, eagerly preys upon hemlock [Cicuta]; among animals, upon mice, lizards, and worms of every kind — as appears from the dissection of vipers; and if they should ever die, they turn into that putrefaction which thereafter reproduces innumerable other serpents of the same species by a kind of marvelous re-cycling [pericyclosis]. But of these matters more fully in what follows.

[Margin: Poisonous animals hunt their poison as nourishment.]

CONSECTARIUM II.

From these things, too, it is gathered that almost all the poisons of deadly serpents differ only by intensification or remission of their venomous faculty — as is clear from the symptoms of each. Now this intensification or remission arises in no other way than either from places exposed to virulent evaporations; and the noxious evaporations do not arise except from the fumes of the above-mentioned minerals and from the noxious exhalations mixed with the earthy mucilage. And the subterranean fire raises that exhalation up within the earth; while outside, the sun's heat digests and ferments the putrefaction conceived from the said mixture. At last the heat animates the fermented putrefaction into a serpent — one all the more pernicious in proportion as the mixture of the putrefaction was scorched by a greater heat of the sun.

[Margin: Why serpents are more virulent in certain regions.]

Hence in places lying under the torrid zone, or near to it — as in India, Arabia, Africa, America — inasmuch as the southern regions are more exposed to mineral fumes, the serpents too are by many parasangs more virulent, and are found imbued with more prodigious properties, than in the regions lying toward the North. Hence in Italy there are few asps, and almost no dipsas-serpents [dypsades], *phtiades*, *sepes*, or *haemorrhoi*; much less are they found in Germany and the other regions lying further toward the North. The reason for this is none other than the temperature of the zone, which serpents necessarily follow, being born under it. For the more burning the sky, the greater the efficacy of the venomous animals, on account of the scorching; and so the most virulent serpents under the torrid zone stand to the serpents and vipers of Italy as the vipers of Italy stand to the vipers and serpents of Germany — whose venom, being much weaker than that with which the vipers of Italy are powerful, cannot likewise be taken up for the making of theriac [theriaca].

[Continuation of] CAPUT VI — Consectaria III–IV

CONSECTARIUM III.

[Margin: Serpents of a single species are solidified by the action of fire alone, and vary with the burning of the material; hence the differing serpents into which they degenerate.]

From this I conclude that the whole class of asps [asp genus] cannot, without distortion, be reduced to the vipers — to such a degree, indeed, that if Italian vipers were placed under the torrid zone, I judge they would degenerate, some into dipsades, some into ptyades, *sepes*, *haemorrhoi*, and the rest, exactly as I said above about the transformation of plants, which pass from one species into others through a mere change of climate. So great is the power, in transmuting genera and species, of a differing aspect of the heavens, a differing disposition of climates — and, finally, of the matter of putrefaction in venomous animals being scorched by the Sun in differing ways. For this reason, by the testimony of all historians, in no place on the globe is a greater abundance of venomous serpents and dragons found than in Egypt, and after that in Africa and the sandy deserts of Libya. So much so that — as the Abyssinians have told me — the peoples neighboring those fabled deserts are forced, every year, to muster an army out of many thousands of men and go to war against the incredible multitude of swarming serpents, to root them out with fire and with weapons.

[Margin: The incredible multitude of serpents in Africa.]

Were this not done, the region would shortly be emptied of its inhabitants. And this is no wonder, since even a single droplet of dew, as we have it from Rhamnusius [Giovanni Battista Ramusio], when mixed with suitable matter, produces a serpent.

[Margin: Sal ammoniac is produced in the sandy deserts; from this the serpents in Africa are produced in great number.]

Add to this that those fabled deserts produce a great deal of *sal nitri* [niter] and *sal ammoniacum* [sal ammoniac], which — once sublimated and scorched by the Sun's heat — produces, when the matter has met with the night-time cold, a most virulent putrefaction. From this a serpent is then born, which, according to the differing disposition of the matter, produces now an asp, now a *cerastes*, now a *ptyas*, now a *dipsas*, or a *seps*. Again, since in deserts of this kind whole armies — which they call *Caravanae* [caravans] — frequently perish from lack of water, from the putrefied corpses of the men and beasts of burden new seedbeds of serpents are founded.

CONSECTARIUM IV.

[Margin: The venom of serpents is hot by nature.]

From this too it is plainly evident — as we also hinted above — why the venoms of venomous serpents are hot by their nature, and none of them cold. For since

serpents of this kind are for the most part generated in the most scorching deserts, out of niter, sal ammoniac, and similar juices that have congealed within the sand and been scorched, and have been most powerfully mixed together with putrefaction, these serpents will certainly derive into themselves not only the property of the putrefaction from which they are born, but will also intensify their poisonous quality by feeding on venomous herbs. From this it necessarily follows that the supreme virulence in the said snakes arises. For just as sulphur, when violently scorched by subterranean fire, generates arsenic, sandarac, or *realgar* [red orpiment] — the most violent poisons — so too out of the efflorescence of these salts there are born salts of the same, indeed of more violent, poison, which when mixed with putrefaction then generate the serpents we have described.

[Margin: The heat of poisons is of a different nature from the heat of the elements.]

But the heat of the said poisons must by no means be reckoned the same as the heat of the elements. Rather it is of another quality, specifically different from the primary and manifest qualities — and I would have the same understood of the moist and the dry. This I prove as follows: All those things called cathartics and diaphoretics, since they are of a deleterious and caustic quality, and thin out and cut through the humors stagnating in the body, must necessarily be hot and dry — not by reason of the primary qualities, but by the properties of the forms from which they emanate. Hence those things which, as was said above, have been much worked over by fire, are hot poisons, provided they do not dissolve away. But if they do dissolve away, they take their origin from bitumen, naphtha, and similar juices of the earth.

[Margin: All dry things pass over into the nature of fire, all moist things into elementary heat without anything specific.]

All dry things pass over into the nature of fire — such as aromatics, metals and stones, sulphur, arsenic, and the rest mentioned above — which, if they are dissolved into oil, first take on an astringent taste, then present themselves as burning both in odor and in taste. Hence, taken internally, they disturb the parts of the animal. And so they are virulent. The hottest among the animal parts are the gall and the rennet; among plants, the seeds and roots; among minerals, whatever is made from a dry earthy substance, such as orpiment, lime, gypsum. Again, among vegetables the hottest are reckoned to be colocynth, black agaric, black hellebore, the milk of *lathyrus* [spurge] and the species of *tithymallus* [spurges], *chamelaena* [spurge-flax], and *thapsia* — and similar purgatives, as is

clear from their caustic effects, which, if they are corrupted, turn into an acrid poison.

[Margin: Objection.]

But here you will say: that poison is formally cold which induces formal cold; and this mercury accomplishes, as do many of the plant family; therefore poison is formally cold. For it coagulates the blood by its cold, as we recounted above in the case of the *seplasiarius* [apothecary] killed by drinking mercury [hydrargyrum]. It also damages the nerves and brain, and induces *siderationes* [strokes], tremors, and paralysis, which are nothing but effects of cold. And the same is to be understood of the narcotic or stupefying poisons — hemlock, mandrake, henbane, opium, nightshade, litharge of silver [spuma argenti] — which likewise give an indication of cold, and of intense cold at that.

[Margin: Reply.]

But against this I say, speaking generally, that no poison is to be granted as formally cold; nor, when we inspect them one by one, can any of those enumerated be proved cold, either by reasoning deduced from principles or from the senses. So when the poison of mercury, and the others, halt and coagulate the blood, this happens for this reason: that its force penetrates the whole of the blood — and this is the work of heat, not of cold. For cold, by the Philosopher's [Aristotle's] testimony, does not enter into the works of Nature, since it is reckoned only among the passive qualities.

[Margin: Mercury congeals the blood not by cold, but by heat, once the spirits are consumed.]

[Fol. 123 — running header "DE VENENIS."]

Every poison, therefore, which congeals and renders a man torpid, is hot. And the reason is plain: for when poisons of this kind, taken in, at once assail by their natural heat the natural warmth and the vital spirits lurking in the blood, they destroy them. It is luminously clear that, once the heat and the spirits are consumed, the blood is coagulated, and the man's cold constitution remains as a consequence — a constitution which is indeed cold, but deprived of blood, of spirits, and of vital heat. Its effects are these:

[Margin: Signs from the senses.]

A bitter taste is the effect of cold, but a bitter taste is not cold, but rather an effect of heat — by the Philosopher's testimony [Aristotle], since it is what cooks all

juices and decocts and parches them most vehemently from the Sun. This said, the alteration being made through thinning, and the sediment of the fixed salt remaining, he says they grow bitter. Again, hemlock, henbane, hellebore, taken in, drive [a man] to frenzy. Yet if this were the effect of cold things, there would be no reason why the less cold herbs — purslane, cucumbers, gourds, and the like — should produce the same effect; and this is contrary to experience. Since, therefore, this symptom of frenzy is non-existent in cold things, it is certain that it proceeds from heat with a specific quality. Moreover, a vehement odor — or better, I should say a stench, a foul and exotic stink — proceeds not from cold but from heat, as is proved by putrefaction's effect; since a malignant odor and stench is excited only by heat — water, however, ice, cucumbers, purslane, being formally cold, give off no odor unless they have been corrupted by putrefaction.

[Margin: Mercury [argenteum vivum] is the hottest of all poisons, especially when it has been sublimated.]

But I return to mercury [argenteum vivum], in which my adversaries glory, as though it were the coldest of all cold things, while in our view that is so far from the case that we would rather call it the hottest of all poisons. This I prove as follows: the more intense a thing's heat, the more resolvable it is into a finer substance; but mercury is more resolvable into a finer substance than any other mixed body whatever; therefore — the major premise is plain, since the smoothness and thinning of things proceeds from heat, just as condensation, by the Philosopher's testimony [Aristotle], proceeds from cold. The minor premise is proved: for mercury, taken whole and entire, with no sediment of itself left behind, passes by the agency of fire into the subtlest vapor, and by the surrounding cold returns into its first substance with no loss of its own substance whatever. Therefore it possesses the most vehement heat, and a specific heat at that. For if it be sublimated into a salt with vinegar and sal ammoniac, then indeed, with the acquisition of a new caustic faculty, it so rages and grows savage that it yields to no poison in all of nature. That it is caustic — who does not see it?

But you will say it is, in its natural consistency, actually cold, by the experiment of touch. I answer: that it is cold to the touch cannot be denied — but in the same way that pepper too is cold even in summertime, however much in itself and by its nature it is the hottest of things.

[Margin: How the poison of mercury induces cold, and how it can be called moist.]

Again you will say: mercury is moist and cold to the touch; therefore cold is present in it — we cannot deny it. I answer: it is not formally and aqueously moist; rather, it comes from the fluidity, implanted in it by nature, of a sulphureous fattiness. Hence it adheres to nothing, nor does it flow away as an elementary moist does, but it connects part to part in such a way that, however much its parts are separated, not even the least particle is lost; instead, rolled up at once into a globule, it studies its own preservation alone. But all fattiness is ascribed not to cold things but to hot ones, to inflammable ones, by number. From this it is plain that all poisons which partake of the things said — whether they come from the vegetable or the animal family — are either hot-dry or hot-moist, not by an elementary quality but by a certain specific virtue. The hot-dry ones, some of which are poisons, acquire the strength of their poison from the burning of fire; the hot-moist, however, from a certain fiery force by which they are imbued with fattiness and bitumen. The cold and moist, however, the elementary kind — since they arise from elementary contrariety — cannot have efficacy of operation in poisons, nor produce the effect of symptoms in those poisoned. Yet I do not deny that, from the elementary qualities, sometimes remotely, through the secondary and tertiary qualities combined under a certain combination, a specific quality may arise from the combination of the mixed body, and consequently, by a certain hidden force, may ground either a sympathy or an antipathy, producing a virulent effect.

SECTIO II.

DE VENENIS SENSITIVÆ & VEGETABILIS NATURÆ.

On the Poisons of Sentient and Vegetable Nature.

[Fol. 124 — running header "LIBER NONUS, Sect. II."]

CAPUT I.

Quomodo Venenum in humanis corporibus nascatur. — How Poison Is Born in Human Bodies.

[Margin: How poison arises in human bodies.]

I lay down as my first supposition: all things are born from the womb of the earth, as the miracles of Nature spring up, as was shown in the preceding sections — of fennel and sage, for instance. For out of the Earth, indeed, various species are born from various vapors, both from minerals and from putrefactions fermented at the surface; these, filled with the malignancy of putrefaction, generate either virulent herbs or poisonous animals. Wholesome herbs too are not so immune from all malignancy that they do not sometimes draw something noxious and harmful from a malign putrefaction.

[Margin: Why plants and fruits sometimes produce poisonous tiny creatures.]

This is luminously clear from caterpillars and the other worms which are sometimes produced even from the most wholesome herbs — as was said above about the poisonous offspring. These cannot come about except from some small portion of putrefaction, which, mingled with the juice of the herb, is animated into a caterpillar or worm — lest it should infect the whole mass of the herb's juice — so that the herb's wholesomeness may to some extent be vindicated from the evil threatening it. The same happens in nearly all fruits, apples, pears, nuts, and the others cited above, which teem with worms.

[Margin: Mixed bodies consist of three things.]

I lay down as my second supposition: all mixed bodies are composed not only of the four elements, but there also lie hidden beneath them three principles, distinct from the elements, of which all mixed bodies consist; and they are Sulphur, Mercury, and Salt. Sulphur, by analogy [Greek: κατὰ τὴν ἀναλογίαν (*kata tēn analogian*, "according to the analogy")], regards all things that are fiery, burning, combustible, and inflammable. Mercury, or quicksilver, contains all things liquid, watery, airy, the volatile spirits, and those which can be resolved into vapors and exhalations. Salt, however, [regards] the earthy element; just as it furnishes consistency to all things, so too all things earthy, fixed, and solid are referred back to it. These three, as the Spagyric Art [alchemy] teaches, belong to all things existing in the threefold Kingdom of Nature. For if you resolve into their principles, by the said art, any minerals, vegetables, or animals whatever, at once oil will appear under the species of Sulphur; Mercury will obtain the subtlest spirits under the form of a most acrid water; and under the earthy form you will find salt in the bottom of the vessel. These things are so true that no one, unless of senseless mind, could doubt them. If anyone kindles wood or an herb, in the flame he will recognize sulphur, in the acrid smoke mercury resolved, and in the ashes at last he will behold salt itself. So that, besides what has been said, in no mixed body is anything else found.

[Margin: What these three are in mixed bodies.]

The Sulphur of fire's nature, according to the intensity or remission of heat, modifies the virtues of all mixed bodies and procures vigor and activity for all. The Mercury of Nature, water, founds by its threefold action innumerable combinations of marvelous things — namely, by distillation, by sublimation, or by precipitation. Salt likewise, whether under a fixed or a volatile substance, when stirred up by heat, performs those things in the nature of things which — just as they are conceived under hidden properties, so too can scarcely be comprehended — and are everywhere called the miracles of Nature.

[Margin: All inferior things have their part in the threefold nature.]

From their admirable combination, therefore, made in things, all things whatever in this theater of the World — or of the Geocosm — that fall little by little under the senses, are constituted, whether they be wholesome for men and the other animals, or noxious and deadly. For the said four material principles, joined to the manifold species of salts which they generate, and these communicated to the rest of the earthy clods, transplant the virtues with which they are imbued into the vegetable family of herbs, plants, and trees; and these finally, falling into the economy and nutriment of animals, procreate that diversity of properties in each of the things enumerated — a diversity which we could not, I will not say count, but not even conceive in our mind. And in all these there is nothing left for us but to admire the ineffable wisdom, power, and majesty of God, the Best and Greatest, and to celebrate it with what praises we can — we who, out of the inexhaustible abyss of His goodness, providence, and wisdom, [behold that] it pleased Him to draw out of such tiny things so great a variety: things evil so marvelously connected with good, dissonant with consonant, wholesome with pernicious, that even out of evils themselves He has drawn an immense good of Nature, which belongs to His boundless power alone.

Since, then, it was said in the preceding sections how poisons, arisen from earthy and mineral substances, are communicated to plants and animals, nothing else now remains to be explained except that we should teach how these too have broken into the economy of the human body, and that we should expound, step by step, what they work within it.

Man, established in the original dignity and innocence of his nature, just as he perpetually enjoyed the good of blessedness

[Fol. 125 — running header "DE VENENIS SENSITIVÆ NATURÆ."]

[Margin: The original cause of evils is original sin.]

[Man, established in the original dignity and innocence of his nature, just as he perpetually enjoyed the good of] blessedness and felicity without any incursion of evils, so, after the stain of the sin he committed, when the lot of his felicity was reversed, he fell from the highest peak of felicity into the lowest abyss of calamities and miseries — with all the classes of natural things conspiring to his vexation and final ruin. From this was born the discordant antipathy of the elements, and from this the *dyscrasia* [Greek: δυσκρασία (*dyskrasia*, "bad temperament," imbalance of the humors)] of the humors out of which he is composed. Fire, indeed, armed with hidden engines, assaults the economy of the human body with the burning darts of fevers. Air — than which nothing is more necessary for sustaining life — does not cease to harass with various virulence of its corruption the spirit within us. Water, without which we cannot live, in the production of its unhappy spawn always brings something deadly therein.

[Margin: Why the Roman Sun is so harmful?]

Earth, finally, with its mineral fumes and pernicious vapors, so harasses plants, animals, and man himself, that whence — from the vegetative or sentient fruits of the earth — nourishment for his preservation flows, thence too there is prepared, in the greatest measure, his own gradual destruction. And so nothing is so sound and wholesome that there is not something connected to it which is contrary to our life and to the integrity of our health. Where there is honey, there is gall; where there is a teat, there is a tumor [*ubi uber, ibi tuber*] — so that, as advantages and necessary things proceed from individual things into the body of man, and into the uses and nourishment of man now made perfect, so too, to his destruction, both open assaults and hidden ones from those very same sources attack us, sometimes by wondrous mines. And those same things which had previously given life, when the laws of symmetry have been broken — the wheel now turned, as if war had been declared — destroy again and exterminate what they had built. These kinds of conflicts are too numerous to be enumerated, too well known to need to be.

Since, therefore, that consuming poison [virus] has flowed from fallen man, as from the head, into the rest of the members of the universe, deservedly are turned back upon them in turn the seeds of hatred and enmity, the scourges, crosses, and engines of every kind of disease and calamity, according to the inevitable law of Adrastia [Nemesis]. But that these things may be more luminously clear, I have thought it right to relate how the seeds of poisons spring up even in the individual members of men.

[Margin: Where there is disease, there is also remedy.]

But lest we should suspect that God, the Best and Greatest, the most kindly Father, willed to inflict on the human race the ultimate disaster without any remedy for such great evils, I shall at the same time show how the providence of the most pious heavenly Father has permitted no evil so great to be inflicted on man without at the same time joining to it the highest good, destructive of the whole evil — so that where there is disease, there is also a medicine suited to that disease and at hand, as, in His infinite goodness and clemency, He has willed it to be.

CAPUT II.

Quot modis in nobis venena nasci possint. — In How Many Ways Poisons Can Be Born in Us.

[Margin: In how many ways poisons can be born in us.]

Just as, by the benefit of fire, we defend ourselves against the violence of cold, are warmed by it, and are preserved — so too there are not lacking in it certain noxious impressions which may weaken, consume, and destroy the very native heat they ought to preserve. I do not speak here of the actual combustion of fire, by which all things are destroyed, but of those pernicious impressions which [a body] can receive into itself. A man walks about in the sun, sits beside the hearth-fire, handles [it] in cooking and digesting — yet he does not know that certain virulent exhalations are roused in the air by the fire's heat, which, once breathed in, [bring] poison immediately present and assault the radical heat with a substance wholly contrary to that poison. And how this happens I shall make clear by the manifold induction of examples.

[Margin: Why the Roman Sun is so harmful?]

It is asked, therefore, why those who have experienced the summer Sun here at Rome immediately fall into deadly diseases? I answer: there are malignant vapors drawn out by the force of the sun from the hollow places of the earth, and teeming with various putrefaction. These, taken up into the open pores of those who are sweating, as soon as they have been shut in by a cooler breeze or by the moisture of springs, are then exalted by the internal heat. First [Margin: What places struck by the Sun are pestilential?] — mixed with the blood and spirits — they kindle that malice of fevers which incautious mortals frequently experience with the loss of life. This, however, is not universal, but only in those places where the condition of the earth is teeming with corrupt and virulent vapors —

such as marshes, cemeteries, shady woods, the ditches of stagnant waters, places stuffed with corrupt sulphur and bitumen. Hence those who, glowing with heat, betake themselves to rest under a yew tree, have at once — infected by the deadly vapor — exchanged life for death, as various cases have shown. For the air of such shades takes on the qualities of which the exhalations of the trees consist: if these are wholesome, [they pour out] wholesome [qualities]; if poisonous, they pour out poisonous properties of their exhalations.

[Margin: The shades of certain trees are noxious and poisonous, such as the yew and the *napellus* [monkshood/aconite].]

In this way, at Tibur [Tivoli], two shepherds were, not long ago, found dead under a *napellus arboreus* [tree-like monkshood] on Mount January [Monte Gennaro] — killed by nothing other than the vapor of the poison with which the said shrub swells. It sometimes happens that sailors and farmers, having gathered up brushwood from all around, build a fire either for cooking food or for the sake of warming themselves; and so it happens that, the pyre once built, some were soon struck with a grievous headache and fell into madness and frenzy, while some were at once killed

[Reading order reconstructed from folio numbers]

LIBER NONUS, Sectio II — De Venenis Sensitivae Naturae

Caput II (continued) — Quot modis in nobis venena nasci possint

[How many ways poisons can arise in us — continued] So Porta reports of certain Neapolitan sailors (*Phytognomonica*). When the cause was investigated, they found at last that the sailors had contracted these symptoms from the burning branches of the rhododendron [Rhododendron] — which is a most poisonous kind of shrub. Its flowers are very pleasant to look at, white and red, yet of such virulence that if they are thrown into cisterns they can spread sickness through an entire community. I have also heard from sailors and fishermen that some men, after roasting fish skewered on dry hemlock stalks [cicuta], later ate the fish, and all who did so were eventually killed by various torturous symptoms. For the fire stirs up and rouses the poison lurking in the hemlock stalks; once roused, it is communicated to the flesh of the fish, and the fish, thus poisoned, inevitably poisons the human being as well.

[Margin: The rhododendron, a poisonous kind of shrub.] [Margin: Hemlock stalks, when dried, become poisonous.]

How greatly the vapor of pit-coal [lithanthrax], stirred up from the fire, harms those sitting nearby is attested by the people of Liège [Leodienses] and others who build their fires from this sort of fossil coal. Countless examples show how easily charcoal burning in a closed room, or the fumes of wax, can suffocate a person.

[Margin: The pestilential fumes of pit-coal.]

I will say nothing here of those who devote themselves to alchemical operations, and the savage symptoms they incur from metallic vapors unless they carry out their procedures with the utmost caution and the best protection. Experience has certainly taught that most of them are in the end worn down by consumption [phthisis], wasting [atrophia], or paralysis — of which I have written more fully elsewhere. Fire, then, can do the greatest harm. I have known painters who, because they had the bad habit of holding in their mouths for too long a brush stained with orpiment [auripigmentum] while painting, contracted horrible and utterly fatal diseases.

Secondly, I proceed to the Air, which breeds in us so many and such great offspring of poisonous brood — as epidemic diseases and plagues sufficiently demonstrate. Since I treated these at length and on purpose in my *Scrutinium Physico-Medicum* [*Scrutinium Pestis*], I refer the reader there; he will find that nothing can be more receptive to poisonous impressions than the air. For whatever is exhaled from the earth that is virulent and deadly is immediately communicated to the air; and since we are forced to breathe it in and out continually, there are necessarily founded in us as many different kinds of malignant disease as there are different species of various poisonous vapors.

[Margin: Poisonous accidents from the air.]

Now the things that usually infect the air with their vapor are reduced to roughly six headings. They are, **first**, stagnant waters teeming with frogs, serpents, and various pestilential insects. **Second**, places filled with sulphurous or arsenical vapors and other noxious mineral exhalations. **Third**, places foul with the virulent putrefaction of carrion and corpses. **Fourth**, places exposed to noxious gusts of wind. **Fifth**, places where there flourishes an abundant growth of poisonous plants — such as monkshood [napellus], hemlock [cicuta], henbane [hyoscyamus], hellebore [veratrum], nightshade [solanum], and thorn-apple [stramonium]; for these, struck by the Sun's rays and dissolved into vapor, infect the air wonderfully, especially if such places are approached after sunset. **Sixth**, epidemic plagues, which now and then — as I taught in the *Book of the Plague*

[*Liber de Peste*] — leave whole provinces, with their cities, towns, and villages, bereft of their inhabitants.

Thirdly. Now follows the element of Water, which rages against the human race all the more savagely the more virulent the impressions it has received, both from subterranean exhalations and from the putrefactions of its own substance. So much so that one might reasonably doubt whether the Water — once it has entered into wedlock with the earth, with the Sun as best man — does not bring forth a greater abundance and variety of poisonous things than of wholesome ones. Tinged with their virulence, the Water continually tinges the air as well by its emission of vapors; and the air, breathed in by men, gradually plants the seeds of poison. And so, had the sea not by the disposition of divine providence been imbued with saltiness, the Geocosm would inevitably have perished from the abundance and variety of its putrefactions. The harms that I showed a little earlier as arising from the air can also be applied to the Water.

[Margin: Poisonous accidents from the water.] [Margin: In what places is the water poisonous?]

Hence countless illnesses arise from drinking water, especially in those who have drawn it imprudently from stagnant ditches. For when waters lie still, they at once conceive putrefaction, and from that putrefaction are born various poisonous animals — frogs, serpents, worms deadly in their virulence, such as leeches and the like. The spermatic corpuscles of these creatures, being diffused throughout the whole substance of the water, work great ruin within the body when taken in by the thirsty.

[Margin: A marvel observed by the author. / The wind.]

I myself once knew, in my native country, a hay-mower who, driven by thirst, recklessly gorged himself on water from a ditch in a neighboring meadow. After the space of half a year he felt, first, terrible gripings of the belly, and his stomach too as though pinched by some living creature; and he complained that he was tormented by continual, intense pain, adding that something alive was hiding inside him, which — especially when his stomach was empty — was attempting as it were to find a way out through the gullet [oesophagus], not without the nausea of vomiting. The physician, shrewdly sniffing out what the matter was, concluded from the signs laid before him that it could be nothing else than a serpent — one that the man had hatched within his stomach by his native heat, from the spermatic matter mixed in the water he had drunk. His conjecture proved a happy one. And since he knew that serpents delight above all other

foods in milk, he hit upon this plan: he ordered the sick man to be hung up by the feet, with his mouth open (because he believed the animal lay hidden inside), so that he might catch the vapor of milk breathed out by the heat of a fire set beneath it. Marvelous to relate — the serpent stabled within, lured by the dainty of that vapor, burst out through the gullet with such force that it nearly suffocated the man. For struggling not a little within the narrow passages, and getting nothing but its head out, that head was seized with forceps and drawn out with the greatest force, displaying, to the astonishment of all the bystanders, a serpent nearly a foot and a half long. The patient, **however**, was soon purged with suitable medicines, strengthened, and restored from exile, as it were, to his former health.

Schenck [Schenckius] relates similar cases in his distinguished work of *Observations*, concerning men who, after drinking waters teeming with the like spawn of marshes, had hatched within their stomachs frogs, toads, and various kinds of worms, which they later expelled by emetics administered on a physician's prescription. Great danger also threatens those who drink waters tinged with the poisonous qualities of minerals. Valleriola [Valleriola] reports in his *Observations* that a certain hunter found a spring in a forest, and tasting from its sharpness that the waters were acidulous, filled himself with a fairly generous draught. But he soon felt himself so overwhelmed by so many grave symptoms that, having scarcely returned home in his right mind, within two days he died of the virulence of that deadly spring.

[Margin: A deadly spring kills a hunter.]

Of this sort are all those pits potent with arsenical virulence, such as Pliny [Plinius] reports once existed at Terracina (formerly Anxur), from which all who drank perished by sudden death; and therefore — lest it should in future bring harm to anyone — it was filled up with stones and a huge heap of earthy rubbish.

[Margin: A deadly spring at Terracina.]

Fourthly. The Earth, being held to be the mother of all generation, likewise perpetually contrives evil for us by its exhalation. It is the origin of every poison and of the impressions of malignant Nature — so much so that one might call it not so much the mother as the stepmother of the human race, appointed such by Nature. For with its virulent mineral vapors it perpetually infests both the airy and the watery element; and not content with these, once it has insinuated itself into the innermost fibers of plants, it rages there, allied with a host of noxious qualities. The result is that from the very source where we ought to expect

preservation through nourishment, from that same source we run into death. For as I said above, there is scarcely a little plant that does not have something virulent attached to it, born with it; and this is sufficiently shown by the worms and caterpillars that each plant generates as its own. When these are taken by us as food, the efficacy of our native heat does not so consume them that they do not always leave behind something contrary and pernicious to the nourishing substance — something which, increased by frequent use, finally breaks out into malignant fevers and exotic diseases, according to the condition of its malignant nature.

[Margin: All foods bring us some harm.]

The reason for this is none other than a certain wormy substance which Nature keeps hidden under the imperceptible covering of the putrefaction of plants and fruits — a substance all the more pernicious the more virulent its nature. This happens with poisonous plants, which some people, foolishly rash, take for wholesome herbs; not infrequently they pay for it by exchanging life for death. For nothing is easier than for inexperienced cooks, deceived by the resemblance of the said herbs, to seize hemlock for parsley, henbane for blessed thistle, mandrake for cowslip, hellebore for plantain, houseleek [barba Iovis, "Jove's beard"] for bugloss. Examples of these you may see in our little work *On the Plague*.

Fifthly. There remain the harms done by animals that come into our use. If these conceive even the slightest putrefaction, then when taken as food, by the innate fecundity of putrefaction they swarm with a host of imperceptible worms in the stomach. These are by no means free of poison; and though at first we do not notice it — the thing lying hidden, as it were, among certain embers — yet with the passage of time, gradually acquiring strength, it kindles so great a conflagration that the whole workshop of Machaon [Machaon, the physician] would scarcely suffice to extinguish it. Hence the eating of all putrid flesh is to be avoided — above all those parts of animals in which the poison, for the most part driven there by nature, tends to make its nest, such as the tails and brains of animals roused to madness [rabies]. For the bile, boiling up when it is burnt, is always disposed toward a certain pernicious quality, as the examples teach of those who, having eaten the brains of cats served at table in place of rabbits by a dishonest innkeeper, were themselves driven to madness the next day, and — by a truly unhappy fate — ended their lives in a raving death.

[Margin: Dogs and other animals which have something putrid about them readily breed pernicious diseases.] [Margin: Cat brains drive men to madness.]

How great an evil threatens us from insects which, through the carelessness of cooks, now and then fall into the cooking-pots of our food, frequent cases teach. Moreover, if pots, frying-pans, and kettles contract verdigris [aerugo] from vinegar poured over meat, it can scarcely be told how greatly symptoms not unlike those of minerals arise in us. I will say nothing here of the poisonous bite of animals, such as serpents, scorpions, and other insects; nothing of the eating of certain unclean birds, and of those fish that are fed on the putrid slime of pools — for these, since they are not free of virulence, are to be shunned with all speed [velis remisque, "with sails and oars"]; and so it is not without reason that they are forbidden in Holy Scripture. And these are the things that afflict the wretched condition of mankind with so many and so great evils.

Caput III

Quomodo venena animalium hominem inficiant & interficiant, sive de causis venenorum

[How the poisons of animals infect and kill a man, or concerning the causes of poisons]

It was abundantly demonstrated in the preceding chapters that all kinds of things capable of being generated draw their origin from the primitive principles of minerals — that is, from sulphur, mercury, and salt, and from their spirit. When these are tempered together by a certain harmonious proportion in the mixed bodies, they are said to constitute a man in the best state of health. But if at any time, through the contrariety and excess of heat or cold, dryness or moisture, the one against the other, they sink into a discordant constitution, then indeed at once the seeds of discord are born.

For where heat and moisture have taken on their right measure, they conceive, and from these two all things arise; and though fire is at war with water, the moist vapor creates all things, and discordant concord is fit for begetting.

[Margin: Ovid, *Metamorphoses* [I].]

[The verse is Ovid, *Metamorphoses* I.430–433, on spontaneous generation.]

Nor let anyone here suppose that all things take their origin from the four elemental humors. For there lies hidden beneath these something else, since the four [recte: three?] principles of things are only certain vehicles, as it were; and they are the three principles recounted above, which we have designated by the

names of Sulphur, Mercury, and Salt, whose spirits may deservedly be compared to air. From these, as from a material cause, we say all things consist. For how simple elements and bodies devoid of all composition could cause those exotic effects, both in the nature of things and in the microcosm, cannot be discerned.

[Margin: The elements are the vehicles of the three principles of nature.]

Therefore when we speak of elemental fire, there must always be conceived to lie hidden beneath it something distinct from the elements, which confers on it heat and dryness — and this we call by the name of Sulphur. If we bring forward water, we always conceive that something underlies it which procures for it moisture — and this is called by the name of Mercury. Salt, finally, is present in the element of earth, inasmuch as it furnishes it with its fixed consistency from itself. Each of these things is potent with its own spirit, diffused into all things, which we not unfittingly compare to air. And from these we maintain that all the kinds of mixed bodies that are in the world derive the basis of their composition, joined with the auxiliary supplies of the elements. For since in the nature of things no pure element is granted, but bodies are elementated — mixed from sulphur, mercury, salt, and their spirits — surely only the man will deny that all things consist of them who has never seen, by the spagyric art, the separation of individual things resolved out of all mixtures into their principles.

[Margin: The earth infects the water and the air with its exhalations.]

From the earth, then, these principles first draw their power through exhalations, which are nothing but a kind of effluvium [ἀπόρροια, *aporrhoia*, "emanation"] of the minutest corpuscles that are perpetually exalted from the primitive bodies of Nature by the force of the subterranean fire. Each of these holds the virtue of the whole [body] from which it takes its origin, and confers it on the airy and watery elements. From the union of both of these, the effluvium of diffused virtue first [passes] into the vegetable nature; vegetables, when they pass into the nourishment of animals, communicate to them the properties of the things they consist of. And in this way all things have obtained their origin from the things said — as is made known even from the very pages of Holy Scripture; since we showed above that not only vegetables but the whole kind of animals, and indeed man himself, was made by GOD as first-fashioner [protoplastes] from the slime of the earth; and that He marked the chaotic mass — not without mystery, in that threefold origin of the primitive bodies within it — as a kind of universal panspermia, with the most holy seal of the Sacrosanct and Triune, Divine and Supereminent Triad.

[Margin: The three principles signify the Holy Trinity in our notation.]

But to return to our purpose: it may rightly be asked how these three, with their spirits, beget poison in the body of the microcosm. That this may be elucidated as exactly as possible —

Be it known that if these three, together with the four humors of which they are the vehicles, subsist in perfect union and concordant temperament, then it is certain that health consists in its full vigor; and they are called by the spagyric philosophers the Sulphur of Nature, the Mercury of Nature, and the Salt of Nature. Of these, the common Sulphur, Mercury, and the usual and mineral Salt are only certain husks. But when the right blending [εὐκρασία, eukrasia, "good mixture"] of the said principles passes, through the admixture of various external things, into a bad blending [δυσκρασία, dyskrasia, "ill mixture"], then at last that savage confluence of contrary things begins to set in motion the Lerna of evils [malorum lerna, "swamp of evils"] which we shall now describe.

Sulphur, when it subsists in its purity, is not a poison — nor is mercury or salt. But when by the force of fire they are altered and reduced as it were into another character, the Sulphur — transmuted into Arsenic, Orpiment, Realgar [Risigallum], or some other such thing — having taken on a temperament [κράσις, krasis] contrary to life, pours out its venomous power into all the members of the world. Mercury, as soon as by the force of fire it has been distilled, sublimated, or precipitated, puts on an utterly worst and deadly substance — which same thing you may understand of the fourfold kind of salts, by means of their spirits.

And just as those three, pure and refined from all impurity, being congruent with nature, concur to the constitution of wholesome mixed bodies, so when impure and imbued with venomous qualities they may not undeservedly be called the boxes of death [pyxides mortis] — from which, namely, by means of the putrefaction of the earth, whatever in the sublunary world is found to be vicious, corrupt, and of deadly quality, derives its composition. Now, how within the microcosm these venomous properties just described operate, and how they dissolve the harmonious temperament of the humors, must be unraveled through questions.

You ask, then, first: How do deadly serpents produce in us poisons destructive of the whole vital substance? I answer: this comes about from the dissimilarity of the poison poured forth by the serpent, contrary in its whole substance to the vital substance of the microcosm. And this contrariety depends on the efficacy of the mercurial or arsenical spirits with which now this, now some other serpent is

potent — which spirits, being more efficacious than that our own vital or animal spirits could overcome them by their native heat, [recte: continues onto folio 129]

[Margin: How serpents produce poisons in us.] are able [to do so]; hence by a certain tyrannical violence, as soon as they have insinuated themselves into the body by a bite, by an exhalation, or by some other means, they turn everything upside down. And just as a fire, once it has gained strength, immediately corrupts everything, destroys everything, and turns it to ash — in just the same way, the poison of anything, once admitted, unless it is resisted at the very entrance of the gate, by the swift propagation of its power immediately makes for the citadel of the whole microcosm, that is, the heart; and once that is stormed, then triumphing as if over a victory, it makes all things subject to its own authority, with the final extermination of the microcosmic Kingdom.

[Margin: How the poison taken in operates.]

For since it is spirituous and of great subtlety, it penetrates all the passages, kindles, corrodes, and eats away everything with caustic force — with exactly those symptoms with which Arsenic or sublimate of Mercury, taken inwardly, rages in human bodies; so that even from the dreadful symptoms the rationale of the poison's constitution becomes plain. These things, however, are to be understood of poisons of the first class, for which scarcely any remedy remains — as is plain in the asp [aspis], the dipsas [dypsas], and the phthias [phthias].

There are, however, some poisonous animals and plants whose poisons, when taken in, likewise cause great symptoms, but whose mischief can in some way be subdued by suitable medicines — as in hemlock, opium, and the like — so that help can be given against them. These nevertheless afterward leave behind some lingering trace of their virulence, which, insinuated into the innermost fibers, sets up a kind of stealthy truce with the microcosm; but when it is reawakened according to the condition of the times and of the foods taken, then, emerging as it were from its lurking-places, it attacks the enemy unexpectedly with a new kind of weapons, with a slaughter which one can scarcely repair in the whole course of one's life. Of this sort is the poison of the Tarantula, which is a kind of phalangium [spider], whose prodigious operations I described in the *Ars Magnetica*, Book 3, *On the Magnetism of the Tarantula* [*de magnetismo Tarantulae*], with all the precision [ἀκρίβεια, akribeia, "exactness"] that was possible — which the curious reader may consult more closely. Its constitution, as it consists of saline spirits mixed with arseno-mercurial spirits in a certain temperament, when likewise brought into act by heat, by a perpetual twitching of the muscles produces that incessant appetite for dancing. The same effect, among

plants, is produced by *apium risus* ["laughing celery," a kind of crowfoot, *ranunculus*], whose poison, while it twitches the muscles of the mouth and chest rather violently, forces those infected to die as it were laughing.

[Margin: The poison of the Tarantula.] [Margin: *Apium risus* (laughing celery).]

You ask secondly: Do the individual members have a poison hostile to each of them? I answer that they do: for there are as many different poisons as there are different members and parts in the human body. Thus some poisons, especially of the first class, flow principally to the heart; certain ones attack the brain most of all, others the liver; nor are there lacking those which in a wondrous way attack the kidneys and bladder; others exercise their tyranny upon the blood. Those that make for the heart, the fount of life, are all the poisons of arseno-mercurial property, whether you regard plants or animals.

[Margin: The individual poisons natural to each member attack their own member.]

Those that attack the brain are hellebore, mandrake, the species of nightshades, henbane, thorn-apple; which, taken inwardly, by their innate virtue dissolve the mass of the humors and, with a vast accumulation of fumes, make for the brain — whence come lethargy, stupor of mind, cold sweat; and if these have any sharpness joined to them, by the twitching and inflammation of the meninges they provoke even into frenzy [phrenesis] and mania. Since the saturnine magnesia [magnesia saturnina] also produces this effect, it is likely that it too has shared in this through the tincture of such spirits.

Those that harm the lung are the sea-lung [pulmo marinus, the jellyfish], which by mere touch brings on difficulty of breathing [ἄπνοια, apnoia, "lack of breath" — i.e. respiratory distress]. When in the year 1632 I was surveying the Province of Narbonne [Narbonensis], and among other things had visited the inhabitants of that town which they call by the common name *Martaigne* [Martigues] from its "Martial waters," I found that most of them suffered from a defect of the lungs. When I asked the cause, they answered that it was from the great quantity of sea-lungs which a salt lake near the town — drawn from the sea by a channel twelve miles long — nourishes; so that while they handle these incautiously, they incur this sort of harm. It is indeed a foul and venomous animal, which produces nausea at the mere sight of it, floating on the waters like a wineskin, in which — as I most diligently examined — neither eyes nor mouth could be seen; you would call the whole thing a wineskin, of the bloodless [exsanguis] but poisonous kind.

[Margin: The sea-lung is hostile to the lungs.] [Margin: The poison hostile to the lung.]

It is asked, then, whence that virulent contagion comes to it, and how it attacks the lungs by mere touch. I answer that it is that foul vapor pregnant with the malignity of a burnt mercurial salt, which it emits from itself even when pressed by the fingers alone; and this vapor infects the neighboring air. Drawn in by the breath, it at once betakes itself to the member naturally kindred [συμπαθικόν, sympathikon, "sympathetic"] to it, where by its malignity, through an immediate dissolution of the moisture, it brings upon the lungs those symptoms which those afflicted by this evil experience. The same seems to be done by precipitated Mercury, mixed with a vehemently burnt salt, in the lungs; for from the vapor of this, those who are infected mostly fall into consumption [phthisis], as goldsmiths have more than once complained to me — although it does not harm the lungs with such violence as the former does, inasmuch as its virus is somewhat blunted by the slow and viscous body of the putrid animal. It is also said to be very harmful to the eyes; whence it is commonly called *mal d'occhio* [Italian: "eye-evil"] or *mal d'eulx* [French: "eye-evil"].

[Margin: The cause of the poison lurking in the sea-lung.]

It is asked thirdly: How is it that the Cantharides [Spanish flies], when either taken inwardly or even excited by the heat of the hand, at once make for the bladder and ulcerate it together with a discharge of bloody urine? I answer that it is a foul, subtle, and spirituous effluvium of burnt salt, with which the body of the cantharides is potent, roused by heat; which by a certain wondrous magnetism, as toward a body kindred [analo-

[Margin: How the cantharides attack the bladder, explained.]

[Text continues onto the following folio.]

is rendered more effective in that fluid of the bladder, so that, once it has made the fluid subject to its own jurisdiction, both a corrosion and—from that corrosion—a bloody urination must necessarily arise.

Whatever poisonous animal spirits, then, are diffused by a like action into the organs proportioned to them, achieve their effect by no other means than by a kind of magnetic action. Just as the magnet, among countless objects, seeks out iron alone, so too the cantharides [Spanish flies] do not seek the heart, the brain, or the lung, but the bladder—as something like, analogous, and proportioned to themselves—in the manner I have described. On these matters see what we

discuss more fully concerning like things in the *Ars Magnetica* [Kircher, *Magnes, sive de Arte Magnetica*], where we also assigned the manner and the cause why the torpedo [electric ray], by the mere touch of a reed touching it, as it were strikes numb and stupefies the hand—effects which must be ascribed to none other than a certain mercurial power innate in it, hostile to the nerves, by which it prevails.

[Margin: The sympathy of poisons toward particular organs.]

CONSECTARIUM. [Corollary]

And from this it is plain that the poisons which are diffused from venomous creatures toward certain particular organs, and not toward others, do so partly by force of sympathy [sympathia], partly by antipathy—or, what comes to the same thing, that they bear to certain organs a likeness, or proportion and analogy, and to others none at all. As for why the poison, attacking the said organs under the pretext of friendship, should stir up such great havoc in them, someone will rightly want its cause. I say this happens through an excess of power, by which it overcomes, suppresses, and converts into its own nature the analogous power in some sympathetic organ; and in this way it can be called antipathic. Yet sympathy can be considered to operate between the two, in that the organ contains within itself something analogous to the poison, toward which it naturally flows together. Thus saline bodies attract saline ones, of whatever species they may be; sulphureous bodies flow together toward sulphureous; and so on for the rest. So, for example, the saline poison of the cantharis [Spanish fly] naturally seeks by a kind of magnetic confluence the vessel of a property congenial to itself—that is, the bladder, which is endowed with saline force.

[Margin: How the cantharides [Spanish flies] ulcerate the bladder.]

And because that saline spirit in the cantharis is subtle and exceedingly hot, the result is that, penetrating everything, as soon as it has reached the organ analogous to itself, it undermines by the excess of its power the balance [temperies] of which that organ consists, while leaving untouched the rest, with which it has no analogy. Other poisons, by contrast—since they generally pour their venom through the blood or the vital spirits, and consist of a moist and subtly warm temperament—seize hold of a man at once, overwhelm him with their embrace, and stupefy him; whereupon, with heat and motion ceasing, the animal must necessarily perish.

Or again, some poisons so agitate the blood and the animal spirits that, while these flee what is contrary to them, the poisons—once received within the veins

and arteries and there intercepted by the malignity of the pursuing enemy—degenerate into malignant fevers, from which death follows. Or again, certain mercurial-arsenical poisons, since by their corrosive power they corrode and lacerate all the inner parts, must likewise procure death thereby, as is plain from the venom of hemorrhoids [a viper] that is endowed with the force of sublimated mercury [mercurius sublimatus].

[Margin: All poisons operate by magnetism.]

However the dreadful effects of poisons may at last be combined, it is certain that they arise only from a kind of magnetism [κατὰ τὸν μαγνητισμὸν (kata ton magnetismon, "by magnetism")] proceeding from depraved arsenic, mercury, and salts, in which venomous animals abound; and that their antipathy with the human body cannot be conceived otherwise—as infallible experience itself teaches: namely, that poisons infused into bodies by lethal animals cannot be extracted better than by a medicine made from that very animal. Thus the bite of a viper is healed by the viper, the sting of a scorpion by a scorpion laid over it, and innumerable other cases (of which more in what follows)—that is, by the attraction of like things. But antipathy, with respect to the said humors or infected organs, must not be considered except through the excess of power, by which the poison overwhelms its own analogue and converts it into the nature of the corrupted poison.

prepared by nature, it is conveyed and fully worked up into the vital spirit of the animal. And in this workshop, this laboratory, and in no other member of the body, did nature will that the poison of the viper be elaborated—instituted with a principal end in view: both for preserving the creature against adverse things, and for strengthening the vigor of its own natural powers, without which it would remain dull and sluggish. Hence both the viper and as many serpents as exist in nature are powerful by no other member than the mouth.

But let us now proceed to examine the body of the poison itself, which is nothing other than a thick and viscid stickiness, anointed with a nitrous-phlegmy ferment—much as bitter bile mixed with thicker phlegm—elaborated by nature beneath two fistulous, mobile, and somewhat upturned teeth. (As one may observe in the disemboweling of vipers, of which many thousands are killed every year in the Roman College for the preparation of theriac.) This sluggish matter, when it has boiled up through the creature's anger and the consequent influx of bile, and a bite follows, produces in the wounded victim the havoc we have described. So necessary is this sluggishness of the matter to the poison itself that without it the poison could not be contained at all, but would at once evaporate. That this same

sluggish humor is found also in the dypsas, the asp, and the rest, all who have written about them attest. For it is the kindling-stuff [fomes] of the poison; yet it turns into a most fine and subtle venom—just as quicksilver [argenteum vivum] is sublimated by the effervescence of salt. Indeed nothing in nature is so subtle that it does not build its nests of subtlety in the stickiness of bodies; and the spagyric art [Ars Spagyrica] teaches this plainly in the dissolution of minerals and salts—of niter, alum, and vitriol—from which bodies, though concrete, it nonetheless draws spirits so subtle and effective that scarcely anything seems able to resist their violence, as is plain from their vehement corrosive power. The same is evident also from the thick juices of poisonous plants, which, when taken inside and heated to boiling by warmth, at once put forth their subtle venom, with that train of symptoms which we recounted above in the case of monkshood [napellus], hemlock [cicuta], aconite, hellebore [veratrum], and the like. I say nothing here of animals. What can be subtler and finer than the spirits, whether vital or animal? Yet these nest only beneath the sluggish mass of the blood and the hard framework of the nerves. Hence, although—because of its earthy nature and its coldness to the eye—many suppose the poison of the viper to be cold, from these considerations it is nevertheless openly plain that the poison, that is, the spirituous liquor of the viper, is in the highest degree hot, being thoroughly concocted by the heat of the heart and the burning of the bile. For it is impossible that a thick liquor, coagulated by elemental cold, could be subtle and active; whereas, on the contrary, all subtle and penetrating things, since they proceed from heat, are likewise by their own nature hot. The reason for this see in the first

[Margin: Poisons do harm through an excess of diffused virtue.]

that this is by the power and property not only of elemental heat, but of the saline spirits, or of mercury and sulphur, in whose nature they share.

CONSECTARIUM I. [Corollary I]

From this follows the rationale of the antipathy of poisons, and it consists in this one point: that the poison of one animal is more efficacious and more potent than the poison of another. Hence the spider [araneus] kills the toad [bufo], because the spider's poison is subtler, more active, and more spirituous; and so perhaps—if it were established for us by experience—the asp, the dypsas, or the ptyas, which are armed with the most potent poisons of all, would kill vipers that had been bitten and steeped in a weaker venom; just as Nicander relates of the Argolic serpents, that they kill asps by their bite. From this too it is plain why a serpent of the same species does not harm another of its own kind [ὁμοειδέα

(homoeidea, "of the same kind")]: because in their natural power, proper to themselves, they are equal, without any excess. So far are they from harming one another that rather they cherish and preserve one another by this power, as by a kind of dowry assigned to them by nature.

[Margin: The spider kills the toad—why?]

CONSECTARIUM II. [Corollary II]

From this it is plain how the poison of the viper, by the propagation of itself, wreaks such great havoc. I say that, as soon as it has been put into a wound by a bite, it acts at once—no differently than if someone had thrown a spark of fire into tinder or kindling, which at once, by a most swift advance and within a brief moment, by the sudden spread of the fire destroys and consumes even a large part of the kindling, unless it is resisted. In exactly the same way the poison is to be reckoned to act; for since it is caustic, once taken inside it rushes wherever a door is given, turns everything upside down, gnaws everything, sets everything ablaze, until at last, the vital spirits being consumed by excessive heat, the poisons finish off the animal. And so its progress can be described in no better way than by the motion of acceleration of heavy bodies, as is plain from the line of points here drawn.

Diagram. [The figure, set in the right margin of the column, is a single vertical line (a falling-body trajectory) marked at intervals with short cross-strokes and lettered points. The line runs from A at the top down through B, C, D, E, to F at the bottom, with finer graduation tick-marks between the lettered points and an arrowhead at the foot. It illustrates the accelerating descent of a heavy body, used as an analogy for the accelerating progress of poison from the wound.]

- A (top of the line): the wound of the injured man; the starting point, where the descent is slowest
- B (next point down): the second interval; faster than at A
- C (third point down): faster still
- D (fourth point down): faster still
- E (fifth point down): the wounded man's site E—near the term of rest; fastest
- F (bottom, with arrowhead): the alternative site F; the term of rest, where death is

[Resuming the text:] The reason for this see described in the first Book of this work. For just as a stone, the nearer it is to the center, accomplishes the greater

spaces—that is, is the swifter, as may be seen in the spaces A–B, B–C, C–D, D–E: at A it is slowest; in the space A–B faster, and still faster in B–C; and in this fashion ever faster, all the way to the term of rest. In the same way, let A be the wound of the injured man, and the heart be at site E or F. I say, for example, that in the first hour, at E, the poison works more slowly; in the second hour, having now acquired its forces, it advances its power more swiftly

from A to B; in the third hour faster still from B to C; in the fourth hour faster still from C to D; in the fifth hour, swiftest of all, from D to E. Once propagated to E or F, it at last subjects everything to itself by its accustomed tyranny, and consequently terminates at E in that rest which death brings.

CAPUT V. [Chapter V]

How poisons do no harm to some animals, and how poisons—through the bite of a rabid dog or of the tarantula—do not put forth their force except at a determined time.

We know that storks, eagles, hens, ducks, pigs, deer, and the like delight in feeding on venomous animals, which nonetheless, once eaten, inflict no harm upon them. And, to dispatch the matter in few words, I say that this arises from the supreme and excessive heat in which the said animals—especially the birds—abound. But since an animal can by no means produce this effect by elemental heat, there is doubtless some other adjunct thing concealed, kept safe from all poison, which we shall now try to investigate.

[Margin: All birds abound in saltpeter [sal-niter].]

We have already shown elsewhere that every kind of bird abounds in a notable quantity of saltpeter [sal-nitrum]; and that this kind of salt, excited by natural heat, is destined partly to become excrement, partly to form the covering of feathers—as the very constitution of feathers, made from fixed niter under the appearance of purified glass, sufficiently demonstrates. This saltpeter, then, made fruitful with a sulphureous tincture, so wonderfully strengthens the natural heat, especially in the stomach, that whatever they have eaten—indeed even iron itself—some animals consume by an acrimony of this sort.

[Margin: Why serpents and toads taken as food by storks do no harm.]

From this it is deduced why no feeding on a venomous animal harms storks, hens, eagles, ducks, and the like. For since the stomach in such animals abounds in a sulphureous-salnitrous vigor, and consequently in a marvelous acrimony, it

follows that the poison of the serpent is consumed and transmuted before it can exert its forces—which is a clear indication that hens and storks far surpass, by their native heat, the heat of the diffused poison. And from this it is plain that heat of this sort exerts its force even upon metals themselves, by gnawing them—which the poison of serpents does not do. If you throw to hens a coin of silver or copper, they will greedily swallow it; but when they have voided it by stool, you will find it already half-eaten, which surely arises only from the salnitrous acrimony of the sulphureous spirit.

[Margin: Hens digest iron and bronze coins.]

The bone-breaking eagle [aquila offifraga, the lammergeier], having swallowed even the hardest bones of animals, soon digests them, by the heat of its stomach, into a soft and fluid excremental matter. I say nothing here of the ostrich [struthiocamelus], which—as is established by an experiment I myself made in Malta—digests swallowed iron by the heat of its stomach, and converts what it has digested into a ferruginous slag, just as if it had been placed in vitriolated water. With the same suffocating power of poison are endowed all those birds which feed on spiders, flies, caterpillars, putrid worms, locusts, and cantharides, and on poisonous herbs, such as the starling [sturnus] on hemlock [cicuta]. And so the reason is plain why the eating of venomous animals does no harm to some animals.

But why do men too feed on the flesh of vipers with impunity—indeed with the greatest benefit to their health? The reason is that the poison of the viper has established its seat in the head and in the tail, as in the extreme parts of the body. Hence, once the extreme parts have been cut off and the entrails removed, the remaining pulp of the flesh, cleansed with salt and dill and cooked, is not only not harmful, but turns into a wholesome medicine—as is plain from viper-salt and from viper-troches [trochisci] reduced to a powder. And viper-powder has so won applause, on account of the prolongation of life, that it has come, as a not unseemly condiment, to the tables of kings and princes.

[Margin: Why the flesh of vipers, when eaten, does no harm to man.]

But I come to resolving another doubt in this chapter, namely concerning the most virulent bite of the rabid dog, which—just as it produces, beyond the other poisons, symptoms that are more exotic [ἐξωτικώτερα (exōtikōtera, "more exotic")]—likewise has more recondite causes of this kind. In order to uncover them, let us first describe the symptoms themselves which it inflicts by its bite,

plainly horrendous and full of dread, so that from these astonishing effects we may at last find out the cause.

[Margin: The horrendous symptoms which the poison of the rabid dog inflicts by its bite.]

Andreas Baccius describes them in these words: "The accidents," he says, "which follow once the effect is confirmed, we have seen to be comparable even to the punishments of hell—especially from the dread of water, which they shudder at by sight alone, just as if they were to be cast into a blazing furnace, with shouts and wailings raised to heaven in the manner of dogs; so that, though bound with the strongest ropes, they drag along with them not only their bed but the bedclothes, and those who stand by suspect they will all but pull the very house down. Nay—and this is the more pitiable spectacle—although they shudder at water most of all, yet because of an intolerable thirst, and a burning by which they feel themselves consumed, gaping toward the water with throats open right down to the heart, or like the infernal three-throated Cerberus, while they gulp down water poured at a distance through a pipe [syphon], you would say they can find no place in heaven or on earth, so do they rage, so do they hurl and contort themselves, until at last they fall down like dead men, or like men struck by an evil spirit [cacodaemon]; and shortly afterward, their spirits dried out by the rage, they rise up again to the same torments and tortures." Thus far he.

Five accidents are to be set forth in this poison, so utterly unwonted and formidable; and the more hidden they are, the greater difficulty they present to the natural philosopher in detecting their causes.

[The first symptom...] confers upon the bitten person that which has been implanted in his own imaginative faculty. The second is slowness in operating, in that it does not exert itself at once, when the disposition is one of complete and best health, but after many days, months, or years—as the histories of physicians teach—it brings itself from potency into act; or at the sight of clear water, as in the case of a certain man who, when a basin had been set out by the barber to shave his chin, contemplated his own image in the clear water and imagined it to be a dog; suddenly seized with dread of water, he fell into rabies. Another fell into it beneath the shadow of a cornel tree. The third is the depravation of the imaginative faculty, by which—whether he looks into a mirror or into water—he always persuades himself that he has been transformed into a dog; and hence he imitates the dog's ways in everything: in barking, in his manner of moving forward, in biting. The fourth is a most vehement fear of water, on which account such persons are called hydrophobics [ὕδροφοβία (hydrophobia, "fear of water")],

as well as water-bitten. The fifth is an inexplicable thirst joined with an incredible burning of the whole body and with rage; and—what is wondrous to relate—that which ought to be the greatest remedy for extinguishing the burning and the thirst, this very thing they abhor in the highest degree and worse than death itself.

[Margin: The symptoms of rabid dogs.]

It is asked, then, first: whence does so exotic a property of poison arise in the dog? In order that this may be lucidly explained, the nature of the dog must first be explained—a nature to which this rabies is so peculiar that, as the foremost physicians attest, it befalls no other animal but the dog. Nor is Aristotle to be heeded, who in his *History of Animals* asserts that all animals except man are afflicted by rabies; though I cannot persuade myself that so great a philosopher asserted anything which is repugnant to common experience, so that I should reckon the fault or flaw to be of the text rather than an error of the author.

[Margin: The cause of the rabid dog's poison is investigated.]

That all dogs, then, are of a most hot and bilious temperament, their operations easily show—in which temperament, however, the vital principle of sulphur swells greatly; and this, by its strength and force, while it acts upon its own mercury, that is, the radical moisture [humidum radicale], gradually consumes that moisture, whence death arises. But from the abundance of innate heat and the abundance of radicated salt they are afflicted with rabies. For since that vehement natural heat in dogs consumes a great deal of moisture, many excrements too are born from it, which—just as they produce vast sootinesses—likewise obstruct the pores; and the pores being obstructed, they hinder the ventilation of the heat. This being hindered, while the heat is nonetheless gradually increased and burns strongly, the burnt-hot substance must necessarily degenerate by degrees from native heat into a preternatural heat; whence all those retained and heaped-up excrements, inflamed and burnt, generate that poison from which canine rabies derives its origin—a poison which they also communicate to all the animals they have bitten.

[Margin: The nature and temperament of dogs.]

It is asked, secondly: from what and from what causes does it produce so great an intemperance in the dog? I answer: from rancid nourishment imbued with a virulent putrefaction. Who does not know how foul the waters are that they drink? how filthy, how foul the things that dogs devour when hunger goads them, with what greed they gape after corpses tainted even with dire contagion? This

virulent putrefaction, together with the nourishment taken inside, produces in the animal the highest distemper [δυσκρασίαν (dyskrasian, "ill-temperament")], or intemperance. For this, once fermented and diffused into the inmost recesses of the fibers, lies hidden there as though in some clandestine station, until—with the summer heats coming on, stirred up at the rising of the Dog-star [Canicula]—it is exalted into that quality of poison which we described above. The sulphureous-saline force, by which the animal is predominantly constituted, joined with its black bile, so long as it is not solicited by external heat, takes a respite of some duration in the black bile, on account of the latter's tenacity which makes it hard to dissolve; but when it has now been fermented and incited by the goads of the dog-day heats, then indeed, as if with the reins loosened and a great accompanying throng of vapors, it assails the head, where it most exerts its saline virulence, by lacerating the meninges and goading them into furies. And as for why dogs are afflicted with rabies even in the winter months, when the cold is at its sharpest, the reason is that the heat, now compelled and concentrated by the external cold, resolves the poison into act. But among the other foods of virulent substance which they use, nothing conduces so much to generating rabies in dogs as if, given the occasion, they have licked of the menstrual flux of women; and so I would dare to say that the virulence of canine rabies arises from no other source than this—and that the pups of bitches are for the most part infected with this disease sufficiently indicates it. But how, or for what cause, religious modesty restrains me from disclosing. Physicians, as they will easily perceive my meaning, will likewise grant—from the historical accounts of women's diseases—that exotic kinds of diseases are produced not only in women themselves, but in those things too which have been contaminated by the breath of the virulent flux.

[Margin: The cause of the canine poison.]

It is asked, thirdly: how does this poison principally infect the imaginative faculty? I say that the canine poison, introduced into the body by a bite, prevails by the same power by which it exerts itself in the dog itself; and so nothing else can be said than that it is the venom transplanted into the man. This being laid down, I say that in this poison there always lurks something of the canine, transplanted into the man's body by a kind of ideal power; whence, at once fermented within the vessels of the human body, when it has gone into act, it thrusts up into the head huge sootinesses—from the burnt sulphureous-saline humor—mixed with an exotic vapor; where it is resolved into a certain glassy matter, fine, however, and subtle and translucent, which, as though in a mirror, presents to the fantasy or imagination the idea of a dog, or the analogous species

which we say lurks beneath the transmitted poison. Not otherwise than a pregnant woman suffering from pica—which the Greeks call κίσσαν (kissan, "pica/craving")—out of excessive desire of obtaining some thing, while she in some

[Margin: The cause why those bitten by a rabid dog imagine themselves to be dogs.]

Liber IX "De Venenis," Sectio II

[fol. 134, verso — continuation of Caput V]

it produces this effect, the spirits being stirred by the power of the imagination, and it imprints the form of the desired thing onto the fetus in the spot corresponding to the part that was touched. In just the same way, the rabid man, gazing at a dog as though in some mirror of the imagination, imagines that he himself has been transformed into a dog. As a result, whatever he sees—whether in a mirror or in water—he persuades himself, by the constant error of the fantasy that he contemplates within, that he too appears outwardly in that very form.

[Margin: The power of the imagination.]

To the intensity of the imagination is added the memory of the dog that had bitten him, so that the same thing happens to him as happens to certain people clouded by a hypochondriac or melancholic humor, who believe themselves to be what they are not—kings, monarchs, philosophers—some imagining themselves to be made of glass, others that they are dead. This is because the images of the things they turn over in their minds with intent attention and continual longing appear to shine back, as it were, in the humor with which the head is filled. Contemplating these images there, they come to believe that they truly are what they imagine themselves to be. As long as this confusion of humors has not yet acquired a solid consistency, it can easily be remedied; but once it has congealed into a glassy material, the patients become utterly mad, and die mad.

This too is worth marveling at: whatever poison—introduced either by the bite of an animal or by eating poisonous herbs—causes in the brain a certain image of a thing shining back in a humor of this kind, the patients imagine themselves to be that very thing. Thus those who eat the brain of a cat that has previously been driven into a frenzy imagine themselves to be cats, and so express the habits of cats by their voice, their shrieking, and their movements; indeed, with fingers

curved like claws, they attack the bystanders. In this way—on the testimony of Andoynus [?]*—those who have been bitten by the haemorrhoids* [Latin: *haemorrhous*, a viper whose bite causes hemorrhage] believe themselves to be a serpent swimming in blood.

[Margin: Those bitten by the *haemorrhous* imagine themselves to be swimming in blood.]

And here I recall a remarkable case involving two of our Fathers, missionaries in Germany, which I once witnessed myself. Returning exhausted from their labors and driven by hunger, they ate with great eagerness some roots of hemlock [Latin: *cicuta*] that the cook had through carelessness boiled in place of parsley roots. These had scarcely reached their stomachs when, as the vapors began to rise, their minds were clouded; they stripped off all their clothes and threw themselves into a nearby fishpond. Snatched from it and revived with antidotes, they were indeed saved from death, but afterward, their nerves having been overtaken by the poison, they lived a wretched, half-paralyzed life for three years. When asked later what they had imagined in their madness, they replied that they had believed themselves transformed into geese, and that they had thrown themselves into the water in order to swim among the geese.

[Margin: Those poisoned by hemlock imagine themselves to be geese.]

From all this it is therefore plain that all poisons—above all those that attack the brain—infect the intoxicated with the image of some particular thing, which they believe themselves to be, the image being projected in the glassy humor.

It is asked, fourthly: Why do rabid persons so greatly shun water?

I answer that this comes about because, in that glassy humor of the brain, the image of flowing water is projected, and in it the image of a dog swimming and pursuing them. As a result, through the memory of the dog that had bitten them—now swimming in the glassy fluid—they are so terrified that they loathe the water worse than the torments of hell. This is what those have told me who, while suffering from hydrophobia, were delivered by divine aid in answer to their vows.

[Margin: Why there is hydrophobia in rabies.]

It is asked, fifthly: From what source do the inexplicable symptoms peculiar to hydrophobics and rabid persons arise?

I answer that they arise from the sulphureous-saline scorched humor, by which all the internal organs are reduced to dryness and the meninges are torn, while the unceasing struggle of the vital and animal spirits with the poison racks them with incredible anguish of mind and restlessness. Hence, on the one hand, the extreme dread of water; on the other, from the fiery violence of the poison constricting everything, an inextinguishable thirst. From this contrariety of symptoms there afterward arises that rage which ends only in a pitiable death.

[Margin: Why there is such inexplicable thirst in hydrophobics.]

It is asked, sixthly: Why is the saliva so harmful that a person infected by it is driven into rabies just like a dog?

I say that, since the dog's saliva—like the spittle of certain serpents, which they accordingly call *phthiades* [?]¹—is most virulent, exceedingly well concocted and digested, moreover packed with deadly spirits, and is further made teeming with poison by a certain ideal power transmitted from the dog's imagination, it is no wonder that, instilled into the pores at the very first contact, it gradually creeps to the vital members, until at last, carried up into the head by the vehicle of the sooty exhalations, it produces the effects we have described.

[Margin: Why the saliva of a rabid dog infects.]

But as to the fact that certain people are brought to physicians afflicted with hydrophobia who nonetheless were not poisoned by a dog's bite: I say that the cause of this can be none other than that they have incautiously handled foodstuffs or kitchen utensils that a rabid dog had infected with its saliva, or have eaten bread and food infected by it.

[Margin: Why some without a bite become hydrophobic.]

CAPUT V.

De Origine morborum.

[On the Origin of Diseases]

[fol. 134 bottom → fol. 135, recto]

Since, then, we have shown above that all things in the Geocosm consist of sulphur, salt, and mercury, so too all those things that in any way draw their origin from the earth—plants and animals—and even (what is worthy of wonder) those very things that prolong our life, by which we are nourished and sustained,

all these are at last seen to conspire toward the final destruction of our body, as was said in what precedes...

it is, in the humors of the human body, some sulphureo-mercurio-saline thing stored up [?] which—

[fol. 135] —called [?], which draws its origin from the nutriments. As long as these three [principles] keep the harmonious laws of friendship in concord with the elements, they maintain a person in a whole and sound state of health. But if they are exalted beyond measure through a disordered mixture of the elements (or of the humors)—I mean sulphur, mercury, and salt—then indeed they bring forth, both according to the condition of the spirits and according to the condition of the parts and humors, that variety of diseases, and a great host of them, which to this very day no physician has been able to explain adequately.

[Margin: All nutriments are imbued from the earth with sulphur, mercury, and salt.]

Hence it is not without reason that the chemists [Chymici] refer every kind of disease to a threefold class: so that some diseases are sulphureous—that is, from sulphur; others mercurial, from mercury; and others, finally, saline or tartareous, their spirits being analogous to air. Here let the reader note that by "sulphur" in this place we understand not the elemental sulphur but the specific innate heat, of which sulphur is the vehicle; by "mercury," the radical moisture; and by "salt," finally, whatever in the Geocosm—or in the Microcosm—has an earthy savor. And since these three material principles, in the things in which they inhere, are most specifically determined according to the diversity of the members—just as sulphur, mercury, and salt, in the different mineral lumps to which they adhere, degenerate into properties differing specifically, as we have abundantly proven elsewhere—so too those same three principles in the members of the Microcosm are specifically determined according to the nature and property of the member in which they reside. For these three produce one effect in the vital members, another in the mass of the humors, another in the venous and nervous substance, and another in the external members.

[Margin: These three material principles are different in different members.]

But in order that these matters may be examined more deeply, let us unravel them by way of questions.

It is therefore asked, first: How is a person gradually disposed toward diseases so different in kind? I answer that it happens by exactly the same

principle, according to a certain analogy, by which sulphur, mercury, and salt acquire such different diseases in the economy of minerals. For the sulphur of nature, when it has been excellently tempered together with its associates, salt and mercury, produces not only harmless metals but even the most health-giving ones, as is evident in gold and silver. But when these have been scorched by the excessive heat of subterranean fire, then, just as they utterly degenerate from their native goodness, so too they produce an abominable offspring, contrary in the whole likeness of its substance to the principle of our life.

[Margin: How all diseases consist of sulphur, mercury, and salt.]

In exactly the same way: since plants obtain their nourishment and growth from the earth by a natural attraction, while that nourishment consists of sulphur, mercury, and salt, and plants are imbued with the native tincture of the said minerals, it comes about that animals take this in from plants, and that both animals and plants, taken as human food, draw into themselves this sulphureo-saline-mercurial progeny. As long as these keep, within the body, the laws of friendship intended by nature, so long do they preserve the body in its integrity. But if, through some excess of overfilling or of exertion, or through external causes—of the air, the Sun, water, the exhalation of the earth—they are torn apart into dissonance, then, according to the magnitude of the excess (which can be innumerable) and the condition of the members, innumerable species of diseases at once arise. Unless these are subdued in good time by appropriate and specific remedies, they finally threaten the person with death.

[Margin: Sulphureous diseases arise from sulphur.]

Sulphur, altered and exalted according to the varying condition of the humors and members in which it resides, soon stirs up all those different kinds of fevers that the physicians describe—and indeed all the more savage and malignant the more, when agitated by a greater force of heat, it has caused the more harmful putrefactions of the humors. Hence that sulphureous heat, kindled by the native heat, does not cease, wherever it finds moisture, to attack it with hostile assault. The moisture, setting itself against its enemy, flees to the extremities as though struck by a kind of horror, and causes that chill and that strange rigor which fever-sufferers experience in the first paroxysm. But when the moisture, feeling itself subdued by its powerful foe, can resist no longer, it likewise yields to the tyranny of the heat, its forces laid low [literally: its fasces submitted]. Then the insolent victor heat, its enemy subdued, gradually turns everything topsy-turvy with its blaze, to utter ruin. And I would have you understand that this cause of fevers comes from nowhere else than the sulphureous spirit variously exalted: if

it is mild, it will cause mild and not long-lasting fevers; if savage, savage ones; if malignant, pestilential fevers. And let this suffice as said about sulphureous diseases.

The second class of diseases depends on the **Mercury** of the microcosm, which can be the cause of foreign diseases by a threefold path: distillation, precipitation, and sublimation. These are caused by the various excess that a person can commit in food and drink, both through the taking in of harmful nutriments and through immoderate bodily exercise, together with the other concurrent external causes.

[Margin: Diseases from Mercury.]

And the **distillation** of exalted Mercury—since it is resolved into a most subtle vapor and so makes for the citadel of the whole microcosm—if it proves potent, produces mania, frenzy, and epilepsy, by more forcefully irritating the meninges with its excessive sharpness. But if, by the coldness of the brain, it is resolved into a fluid, then, should it fall into the lungs, by its usual sharpness it ulcerates the lungs and gradually destroys the person by consumption [phthisis] and wasting. If, joined with salt, it has been **precipitated**, it produces gout [podagra] in the feet, knee-gout [gonagra] in the knees, sciatica in the hips, hand-gout [chiragra] in the hands, head-gout [cephalagra] in the head, and finally, throughout the whole body, when it infests the nerves, it produces arthritis. But when **sublimated**, it produces in the head glassy, apoplectic catarrhs; in the liver, salty ones, where, the native heat being extinguished, it opens the way to dropsy. And when, by its diaphoretic power, it has assailed the external members, there, with its corrosive quality, it puts everything into a state of decay; hence—

[fol. 136, verso]

—hence [arise] *serpagines* [creeping skin eruptions], ulcers, condylomata, gangrenes, sphacelus [mortification], exanthemata, and similar monstrous forms of impetigo, according to the diverse quality with which it has been imbued. This too is worthy of wonder: that, by its septic power, when it has resolved a member into utter putrefaction, the infesting rot there at once raises up an animated offspring [i.e., maggots/vermin], which, being of the same condition as the putrefaction, by its gnawing produces a disease most difficult to cure—as experience has long since taught in pestilential buboes, in the venereal pox [lues venerea], and the like, and as we have abundantly demonstrated in our *Treatise on the Plague* [Kircher, *Scrutinium Pestis*]. For whatever in the human body is scabby, putrid, gangrenous, ulcerous, or impetiginous—no one should doubt that

it proceeds from the sharpness of the mercurial salt, not from bilious putrefaction, except insofar as the latter has been imbued with the said property of a malignant nature.

[Margin: Whence scabies and impetigo.]

The **third** class of diseases draws its origin from **salt and tartar**. That this may be understood, it must be explained what tartar properly is.

[Margin: Which diseases take their origin from salt and tartar.]

Tartar [Tartarus] is properly the name given to that coagulated matter which adheres in wine-casks or on their sides, or which is found at the bottom of a vessel as a kind of sediment, concreted into a stone. It is nothing other than vinous salt, that is, the tiny corpuscles dispersed through the substance of the wine, which, by their confluence to the sides of the cask, there grow together by a kind of magnetic attraction at last into a saline stone, which we call Tartar. And I would not have anyone suppose on this account that tartar forms in wine alone; by no means. Rather it must be held for certain that beer too, and any liquid whatever, has its own appropriate tartar by a certain analogy, as is evident from the lees of all liquids, which are a kind of species of tartar.

[Margin: What tartar is.]

How, then, or what sort of diseases tartar causes, must now be set forth. It must therefore be noted: the nutriment that a person takes is drawn either from the vegetable or from the animal kingdom. To the former belong all kinds of wholesome herbs, vegetables, fruits, and grains, and among drinkables the kinds of wine, beer [zithum], and mead; to the latter belong all the kinds of quadrupeds, fowl, and fish suited for nourishment, to which are added eggs and those milk-products derived from quadrupeds. Whatever is found beyond these is not suitable for nourishment—such as minerals and any inanimate elemental things, whether waters, earths, stones, or metals; for nothing can nourish a person that has not first had life. These things, then, being laid down beforehand:

Since no nutriment exists that is so purged of all the refuse of its lees that some sediment does not always cling to it, it comes about that, with the continued use of nutriments, the dregs are ingested together with the nutriments. These always leave behind them some viscous thing, or something not unlike an earthy sediment, after the separation of the pure from the impure—the former [the viscous] belonging chiefly to vegetables, the latter [the earthy] to meats and milk-products; and this is the proximate matter for generating tartar. As long as it is

not deprived of moisture, it brings no harm, since [the dregs] are expelled by the twofold evacuation of urine and feces. This separation of the dregs takes place first in the stomach, which sends out through the intestines the impure, earthy refuse of the matter separated from the nutriment; but whatever still clings to the nutriment as viscous is separated first in the mesaraic veins and transmitted to the liver, there to be further purified and concocted, where all the nutriment is first converted into blood and, thus dispersed through the whole body, is at last converted into the substance of what is nourished, the serous and viscid fluid being discharged through the kidneys and ureters into the bladder. Now these things, if the exits of the dregs are not impeded by overfillings, obstructions, and the like, are in good order and keep the person in a healthy state.

[Margin: A twofold dreg, thick and liquid, the cause of the stone.]

Yet it sometimes happens that either, through excessive heat, the parts where the said dregs are lodged become dry, or, with the intervention of the spirit of salt, the fixed matter turns to stone. For the spirit of salt, wherever it has detected this tartareous matter, at once fixes it, made subject to its own jurisdiction and nature. And from these principles arise the foreign births of calculous [stone-forming] diseases: in the intestines, indeed, dreggy and tartareous incrustations produce dysentery, colic disorders, convulsions, gripings, and spasms; and if at some point crusts of tartar, loosened by the slipperiness of the intestines and rolled into a ball, obstruct the passages, then the iliac disease [iliac passion, intestinal obstruction] arises—a most pernicious and desperate evil. In the kidneys, [it produces] sands, which, slipping down into the bladder, finally generate those stones which, unless extracted by cutting the bladder, bring death. In the remaining members it generates contractions, arthritis, and similar monstrous forms of evils.

[Margin: The spirit of salt fixes the tartareous matter.]

I myself observed in Germany certain places filled with a tartareo-nitrous soil, in which the vines planted there drew the tartareo-nitrous substance into their nourishment together with the fluid of the earthy clod; and likewise that whoever gorged themselves too freely on wine of this sort incurred the contraction of all [these] diseases, and that the tartareous matter, which they had drawn in by frequent drinking of the tartareous wine, was deposited through the very joints of their fingers, hands, and feet, in the manner of quicklime. From this it is plainly evident that viscous and dreggy things—such as the kinds of vegetables, milk-products too, and cheese, and especially the viscous and dreggy kinds of wines, which when spilled onto a table turn to stone over time—these, I say, are

the proximate matter of lithiasis [stone-formation], if they are taken by the unhealthy and the overfilled; so I judge.

[Margin: Tartar causes dreadful diseases.]

The maker of calculous diseases, then, is the spirit of salt, which, when it has found dreggy matter deprived of moisture, at once [turns] its powers—

[fol. 137, recto]

—turns its powers upon it, and converts it into a liquor similar to itself, exactly as in the case of things turning to stone in liquid, of which we spoke in *Liber VIII*. For plants, as long as they remain in water with the stone-forming spirit, do not petrify; but as soon as they are cast onto the shore or bank, they imbibe by the heat of the Sun and the surrounding air a stone-forming, drying humor, and are converted into rock. In just the same way [the spirit of salt] acts in the innermost members of the body. Hence it comes about that in the stomach, the intestines, the urinary passages, innumerable species of diseases are born; in the intestines and the stomach, besides what was said above, flatulence [arises]—

[Margin: The generation of stone in a person is the same as that by which things turn to stone.]

—from the resolution of dreadful tartar: convulsions, belchings, hiccups, burnings, and vomiting; in the mesaraic veins, obstructions; in the liver, scirrhus; in the gallbladder's sac, stones; in the bladder, various nephritic pains in the kidneys; in the spleen, smoky evaporations and hypochondriac flatulence. Tartar also raises up erysipelas in the external parts; in the very teeth, when they swell with tartar, it raises intense pains. In a word, if all the diseases that have their origin from tartar were here to be enumerated, there would be need of a whole Book. Therefore let these things suffice for the instruction of physicians.

CAPUT VI.

De Cura Venenatarum infirmitatum.

[On the Cure of Diseases caused by Poisons]

[fol. 137]

Since poisons for the most part act through specific qualities, or through ones emanating from a [substantial] form or from the likeness of the whole substance, as we said above, it cannot be that they are cured by the manifest qualities of things, unless these have something else conjoined to them—something similar in

substance, and proportionate, to the poison. All this has become so well known through long experience that no physician, unless inexperienced, could deny it: for there are four humors that serve as certain vehicles of the specific qualities, in which the foreign properties of things make their nests, so that in their own time, when they have been properly fermented, they may exert their powers.

[Margin: The four elements are the vehicles of the specific qualities.]

And **caustic** poisons of every kind, when taken—such as those that smack of arsenic, mercury, and the other minerals—are for the most part wont to be cured by very fatty things, such as oil of almonds, butter, milk, fatty broths, and the like (see these in the physicians [writers]); for by these the sharpness and caustic faculty is somehow blunted, suppressed, and smothered—especially if there be added clysters [enemas] and other things that belong rather to the surgeon than to the physician. I would have you understand the same of poison from herbs taken inwardly—although the more skilled physicians know how to prepare, even from minerals themselves, a medicine contrary to the poison and destructive of it.

But poisons that proceed from the bite of serpents—since they proceed from the life and the sense, indeed from the natural constitution of serpents—I think cannot be cured better than from the very parts of the serpent that bit: from its flesh, salt, and bones, duly prepared. And so all things are good [for some purpose] [?]. For example—to begin with minerals—just as in sulphur, mercury, and salt [there is medicine], so in those same things the poison resides; for in the same things both are present: for that very thing which can be of help to us has, besides, something else connected to it, which brings us death. You will ask: How [does this work]? I say: by the mere separation of the pure from the impure, in the manner that the Spagyric Art [Spagyric/alchemical art] teaches. And from what source so prodigious a cure arises, we have already said above—

[Margin: The magnetism of poisons.]

—namely, from the magnetism of Nature, by which every like rejoices and delights in its like; from this arises attraction and union, when the substance of the serpent, taken inwardly, however it has finally been prepared, by a certain natural instinct seeks again that [poison] which was transmitted from it, and, united to itself by a kind of attraction, sends it out through evacuation. From this is evident the reason why viper-flesh promises a prolongation of life to those who eat it: not indeed because it possesses anything for strengthening or for restoring the native heat, but because whatever putrid, poisonous, or malignant thing can

in time be stirred up in the body is attracted by the viper-flesh and thence frees the person from all the foul accumulation of harmful humors.

But that all these things may be better understood, I shall here append a few [rules], from which the curious reader may learn what is to be administered to those intoxicated by any poison whatever.

RULE I. All minerals that symbolize [correspond] in their properties with some mineral poison, when duly prepared, can be a medicine—an antidote [Greek: ἀντίδοτον (antidoton, "antidote")]—for the poison that was taken in. Hence gold, silver, and the rest, when purged of realgar or of the excremental impurities that smack of poison, and prepared by the Spagyric art, can be an antidote to mineral poison.

[Margin: Rule I.]

RULE II. All plants that, as to their natural properties, symbolize with the properties of the poison taken in—these, by a certain magnetism implanted in them, when duly and spagyrically prepared, are of service for driving out the poison.

RULE III. The parts of all serpents, insects, and the other venomous animals, prepared by the Spagyric art, are a remedy for their own poison transmitted into people, whether by bite or in any other way whatever.

RULE IV. All herbs that, as to their properties, symbolize with some animal poison—these too, when prepared, can be a remedy for the transmitted poison.

This, then, is that powerful magnetism of Nature by which the little bodies of mercury are joined to mercurial ones, sulphurous to sulphurous, arsenical to arsenical, saline to saline — out of which all things consist — bound together by a wonderful kind of connection; they flow together toward one another and eagerly seek each other out. From their confluence comes a man's health and well-being. For even when a poisonous body has been purged of all its impurities, it still, in that very state, seeks out what is connatural and kindred [σύγγενες (syngenes, "kindred," "of the same kind")] to it, and by a certain intimate appetite draws it to itself. Since I have set all this out very fully in the *Ars Magnetica* (Book III), I refer the reader there.

As for how poisons are to be corrected by the agency of fire, I will explain — or rather merely indicate — in a few words. No one is unaware that by the agency of fire poisons can be reduced to wholesome medicines. Yet not infrequently other correctives are also necessary — not only to strip away the poisonousness, but so

that the parts to which they make their way may either be traversed without harm, or so that a too-sluggish purgative force may be roused, or an unbridled one restrained.

[Margin: How these are corrected and amended.] The following are corrected and amended as shown:

- **Spurge** [esula] — with goat's milk.
- **Colocynth** and **elaterium** — with the juice of quinces, oil of almonds, butter.
- **Black hellebore** — with the most generous wine, Canary or Malvasia.
- **Scammony's** clinging and viscous malignity — by soaking it in the juice of pale roses, and with oil of vitriol.
- Likewise **antimony** — with sea salt in a wooden mortar.
- **Opium's** malignity, which issues from its own sulphur — with wine vinegar.
- **Sulphur** — purged with wax.
- **Sublimate of mercury** [mercurius sublimatus] — with fused salt.

Truly remarkable things are reported of the poisonous American plant which some call *Mandioca*, others *Hyucca* [yucca / manioc]. The juice of its root, when first pressed out, is so deadly and noxious that anyone who takes it must die without any remedy. But if it is cooked at a second degree of heat, the poison is now lost and it becomes a most sharp vinegar, fit for all uses; and if it is cooked still further, it passes wholly into a honey-like sweetness. Once all the juice has been pressed out, bread is kneaded from the dry pounded mass of root worked up with water — bread common to the whole region, not only to the natives but to foreigners as well. And so this most poisonous of all plants, properly prepared, furnishes mortals with a necessary and wholesome food, a vinegar, a honey, and a bread.

[Margin: The remarkable power and property of yucca.] This too is most worthy of admiration: that the virulence of this plant is noted only in the *island* yucca — that is, in Cuba, Hispaniola, and the other islands adjacent to America. On the mainland of New Spain [Novi Regni], by contrast, our Fathers — who lived for many years in those places — told me by word of mouth that this plant [is wholly wholesome].

[Margin: Why this plant is poisonous in some islands but wholesome on the mainland.] The question is therefore raised, first, why this plant is poisonous only

in the islands and not on the mainland of Santa Marta; and second, how, once the poison is removed, it becomes a wholesome food, that is, bread, for the natives.

I say, then, that its poison is not connatural to the plant but adventitious. For since the islands of Cuba and Hispaniola — which abound in gold — are filled with arsenical-mercurial exhalations, it comes about that this plant, by its own natural temperament, draws in the moisture by which it is nourished already infected with these deadly mineral qualities. From this it follows that the raw juice of the plant, infected for the most part by these noxious spirits, brings destruction on those who take it; for the poison compounded from such a mixture amply demonstrates the most savage symptoms incurred by those who are poisoned with it. But as for how it lays aside its poison in the customary preparation for use—

—this happens in the following way. Since the poison is exceedingly subtle, it comes about that the root under which the poison is chiefly hidden, once the spirits have been dissolved by cooking and have soon evaporated and vanished, leaves the rest immune from poison, converted into a most powerful vinegar. For just as it usually happens with wine — that as the spirits evaporate, vinegar results — we judge the same can happen here. When the portions of salt remain and the subtler spirits have been exhaled, an acidity is thereby acquired, as experience teaches in all those things which, after concoction, leave behind them a vinegar-like sharpness. And that after a more vigorous concoction all that remaining liquor is converted into a honey-like substance — the cause is that the saline spirits, exalted by the power of the fire, depart, while the fattier juice of the remaining substance, now that the sharpest saline spirits have escaped, acquires a certain honey-like sweetness. Once this is separated off, there remains that mass which, dried out and pounded into flour, is at last converted by a final baking in the oven into ordinary bread.

This, then, is my judgment about this plant; and it now remains to prove that it is indeed so. Since the juice of this herb, when drunk at once at the river of Santa Marta, holds nothing harmful or destructive, but on the island of Santo Domingo is poisonous, this is a plain sign that the poison is adventitious and contracted from the corruptness of its native soil, and thus too can easily be separated off by cooking. The poison in this plant, therefore, cannot possibly arise from a malign constitution of the air and waters; otherwise men could be infected by this most wretched constitution of the air — which experience teaches to be false. For, as our Fathers affirm, the air there is most excellent and most healthful. Nor can it arise from the aspects of the planets, since whether the aspects are favorable or

malign, this plant is always poisonous and destructive; nor from the heat of the torrid zone, since the mainland subject to that same zone is reported to be free from the malignity of this herb.

[Margin: Why polypody growing over a mineral soil is harmful.] Nothing therefore remains to be said except what we pointed out above: namely, that the islands are filled with arsenic, or orpiment, sandarach, or fossil cadmia, which infect with their virulent spirits the herb that, from its own natural disposition, draws in like nourishment around it. For it can scarcely be told how greatly a soil exposed to these destructive mineral exhalations infests even herbs otherwise wholesome. For, as Mesue [Mesuë] rightly teaches, polypody ought to be gathered not from stony and mineral places but from where it has grown upon a tree — for no other reason than that it acquires from the aforesaid vapors a certain malignity.

[Margin: Hermodactyl delights in the company of squill.] Hence too he advises that serpentary, arum, spurge, mezereon, squill, wormwood, hermodactyls, and colocynth — which always contain something poisonous — should not be gathered in mineral places or on the banks of thermal waters; otherwise, on account of their excessive virulence, they will be of no use in medicine. Therefore the places where they grow, free from these influences, must be inspected, and only what is gathered from such places should be put to use. One must also observe in the company of which herbs they thrive, for by association with these they are converted to a better growth. In this way hermodactyls, by the company of squill or radish, are greatly improved in their condition. Again, of colocynth, one should choose not that which grows in rotten and dusty soils, or near the lairs of serpents, or in the sulphurous places of hot springs, but that which is born in loose, sandy, and open ground. For experience indeed teaches that fungi in the vicinity of iron — from the rottenness of a dead serpent, or its den, or a noxious plant — become lethal from being wholesome, as Dioscorides attests.

[Margin: Bread of manioc.] As for the bread of yucca, which they call *Mandioca*: we preserve in our Museum a loaf baked from this root, which even now, after many years, still keeps its flavor. The Spaniards on long voyages prefer it to ship's biscuit, because it is not easily subject to spoilage. And let this suffice concerning the poison of yucca. Nothing therefore remains except that we present what has been said up to this point in the synopsis of a universal table.

Diagram. A woodcut of the yucca / manioc plant (*Yucca americana*), captioned "Typus Jucca seu Hiucca Americana" ("Figure of the American Yucca or Hiucca"). The engraving shows the whole plant: a tall central flowering stalk bearing

numerous pendent bell-shaped blossoms on lateral branches, rising from a basal rosette of long sword-shaped spiky leaves, with a cluster of large tuberous roots at the bottom. Three engraved labels:

- Lower left (beside the roots): *ex radice* — "from the root"
- Center bottom (on the tuberous root mass): *Radix* — "Root"
- Lower right (beside the roots): *panis fit* — "bread is made"

(Together the two flanking labels read "from the root ... bread is made.")

TABULA SYNOPTICA

A synoptic table of the principal poisons with which the threefold Kingdom of Nature — Mineral, Vegetable, and Animal — teems, together with the effects and symptoms they provoke, and along with the remedies appropriate to each.

PINAX I. — From the Minerals [Ex Mineralibus]

Names of the poisonous minerals	Property	Symptoms	Remedies and Antidotes
ARSENIC , and all species of sulphur [ἀρσενικόν (arsenikon) in Greek]	By nature sharp, subtle, caustic, malignant, putrefactive, suffocating to the spirit; whence—	Thirst, strong burning heat, paralysis, spasm, dry cough, ulceration of the inner viscera. The causes consist in [these] properties.	Drinking of milk, water of a decoction of mallow, greasy broths, oil of almonds drunk, provocation of vomiting, clysters; juleps, a decoction of mallow with honey, likewise of rice-seed and starch.
QUICKSILVER [argentum vivum, ὕδραργυρον (hydrargyron)]	Of a specific quality excessively hot and dry; sublimated, it ulcerates all the viscera, an enemy	Taken in its natural subsistence, it copiously suffocates the spirit. Sublimated: paralysis, falling-	Procuring of vomiting, or the taking of gold leaf, a drink of wine with wormwood, hyssop, and seeds of celery; ass's

Names of the poisonous minerals	Property	Symptoms	Remedies and Antidotes
	to the nerves.	out of the teeth, ulceration of the viscera, stench of the mouth.	milk, wolf's lard, goat's tallow, honey, and all fatty things taken as a drink; clysters.
ANTIMONY [antimonium, στίμμι (stimmi)]	Hot, dry, burning- ulcerative; excitative of the humors. Whence —	Vomiting, violent flux, wind, spasm, paralysis, dysentery.	Fatty decoctions from appropriate herbs; oil of almonds drunk, and all buttery things.
VERDIGRIS [ærugō]	By nature subtle, resolutive, corrosive, excessively hot, whence gnawing.	Dryness of the mouth and of the whole body, pain of the stomach and belly, vomiting and flux of the belly, difficulty of breathing.	Butter, drinking of milk, juice of sweet flag [acorus] with wine — its specific remedy is prepared red coral, taken in a drink, two drachms [3ij].
QUICKLIME [calx viva]	Excessively hot and dry, burning, inflaming, biting, and cauterizing.	Dryness of the whole body, pain of the stomach, dysentery, coldness of the extremities, fainting, and suffocation.	Drinking of oil of violets, of water- lily [nenuphar] or nymphaea, of milk, and of all greasy broths.
CERUSE [cerussa], Red lead [minium] — born of the same mother,	It is a calx made from lead dissolved by vinegar, of nearly the same nature	Whence the same symptoms befall those who take it inwardly.	The cure also, and the preservative, is entirely the same as the preceding ones.

Names of the poisonous minerals	Property	Symptoms	Remedies and Antidotes
distinguished only by being specified through fire	as the preceding.		
CINNABAR [cinnabari], or Vermilion [usitur]	Partly of arsenical nature, partly of sublimated quicksilver; whence—	The same symptoms befall those who take it as befall those who have taken arsenic or mercury.	The cure also is the same — namely, a drink of buttery and fatty broths, with the decoctions described above.

(Continuation of PINAX I — From the Minerals)

Names of the poisonous minerals	Property	Symptoms	Remedies and Antidotes
GYPSUM [gypsum]	By nature cold and dry; endowed with a conglutinative, constrictive, suffocating power. Whence—	Whiteness of the lips, mouth, and tongue; softening of the limbs; violent cough, hiccup, delirium, colic affliction [colica passio], difficulty of breathing [διαπνεΐα (diapneia), "transpiration / breathing- through"], black urine, fainting.	Vomiting is prescribed, with oil, fatty broths, and mucilages; a decoction of mallow in wine. The specific remedy is the dung of a mouse, ground and drunk, which acts by a natural sympathy with gypsum.
LITHARGE [lithargyrium], or Silver-foam [argenti spuma]	Shares the nature of lead, whence it is endowed with a conglutinative	It suffocates the spirits, congeals the blood, brings difficulty of	Wild celery [apium agreste] drunk with wine, three drachms of

Names of the poisonous minerals	Property	Symptoms	Remedies and Antidotes
	and styptic power.	breathing.	myrrh [ziii]; vomiting, water of a decoction of figs. Purgation by scammony [diagridion]. The specific and sympathetic remedy is the kernels of quinces, cleaned and ground, given in a drink with a decoction of sweet wine.
MARCASITE [marcasita]	Since marcasite has its origin from vitriol and sulphur, so too its nature is supremely hot, gnawing, and putrefactive.	Whence gnawings of the viscera, gripings, and colic pains in the intestines, or the iliac pain [Iliacus dolor], and the like — the symptoms that occur with arsenic, though not so intense.	The cure is the same as we described above: the taking of oily broths with spirit of vitriol; which is the specific and sympathetic remedy.

PINAX II. — Of the Deleterious Substances from the Vegetables [Deleteriorum ex Vegetabilibus]

Names of the plants that swell with poison	Symptoms	Cure and Remedies
CROWFOOT [apium risus, βατράχιον (batrachion)] — by	From the excessive twitching of the muscles stretched within the	— (<i>symptoms and cure given in adjacent column</i>)

Names of the plants that swell with poison	Symptoms	Cure and Remedies
nature sharp, burning, ulcerative, excoriative; endowed with a melancholic power. ACONITE [agonitum] — by nature putrefactive, corrosive in power.	jaws, it seems to provoke laughter, together with madness. It dissolves and extinguishes the native heat; causes dizziness, scotomia [dimming of sight], rumbling in the belly.	Oxymel, a remarkable secret remedy against this kind of poison.
SQUILL-BULB [bulbus squilla] — it is pungent, incisive, very sharp.	Taken in large quantity: pain of the stomach, vomiting; it ulcerates both the stomach and the liver.	All fatty things are beneficial; milk boiled with red-hot iron; yolks of eggs with seeds of purslane, with walnuts.
CAPER-SPURGE [catapucia], or LATHYRIS — it is endowed with a power subversive of the stomach, sharp and malign.	It subverts the stomach, causes dysentery if not corrected; with excessive flux of the belly it kills. It is healed [by]—	By vomiting, by the taking of oils; its specific remedy is St. John's wort [hypericon], or perfoliate [perfoliata].
HEMLOCK [cicuta]	It constricts the breath, subverts the stomach, stupefies the whole body; stilling of the pulse.	Wormwood and gentian drunk with wine is the specific remedy.
COLOCYNTH [colocynthis]	Laxative of copious phlegm, pain of the stomach, dysentery, tenesmus.	The specific remedy is emerald [smaragdus], ground into a powder and given in a drink, two drachms.

TABULA SYNOPTICA — PINAX II: Of poisons from the vegetable kingdom (*continued*)

[The vegetable-poison table continues from the preceding page. Columns: name of the poisonous plant | symptoms it induces | cure and remedies.]

Names of the plants that
swell with poison

Symptoms

Cure and remedies

Euphorbium
[euphorbia]

Inflames and bites the stomach, causes extreme constriction, hiccup, flux of the belly, and vomiting.

The specific remedy is kid's [goat's] rennet [coagulum hoedi], steeped in euphorbium together with oil of violets and of roses.

Fungi [poisonous mushrooms]

Difficulty of breathing, swelling of the face, colic, and pain in the pubic region; strangulation of the throat, retention of urine, apoplexy.

Aphronitrum
[aphronitum — natron foam] drunk with a draught — that is, with vinegar mixed in water; hen's dung taken with wine or honey, salt, and vinegar. Before eating, pyrethrum [pyrauna(?)] cooked with the mushrooms; after eating, raw garlic — a specific remedy.

Helleborum [hellebore]

It chokes, provokes vomiting, burns the tongue, brings on quinsy [angina], flux of the belly. It induces lethargy — a narcotic poison.

The specific remedies are flowers of the water-lily [nymphaea], i.e. the nenuphar, ground, two drachms [3ij]. Likewise pepper, ground, two drachms [3ij], with honey-water.

Hyoscyamus [henbane]

Provokes foaming at the mouth, dizziness, vertigo [scotomia]; brings on

The specific remedy is pistachio nuts, eaten and drunk, vomiting having

Names of the plants that swell with poison	Symptoms	Cure and remedies
	epilepsy, madness; the patient utters cries like a mule's bray; lethargy.	first been induced by means of cow's or sheep's milk; pepper with wine; castoreum with mint and rue; theriac.
Mandragora [mandrake]	Provokes lethargy, swells the face, makes the eyes protrude, brings on spasm, quinsy, deafness, and itching over the whole body.	The specific remedy is the continued eating of radish with bread and salt, vomiting having first been induced and a clyster made up with sharp things [acutis rebus].
Napellus [aconite / monkshood]. <i>It bears a flower in the shape of a human skull — a symbol of the death it inflicts by being eaten.</i>	Provokes dreadful symptoms; extinguishes the body's native heat — hence chill, horror, mania, lethargy.	The specific remedy is the mouse [<i>mus</i>] that feeds upon the roots of the <i>napellus</i> : dried, reduced to powder, and drunk down diluted in an appropriate water; all fatty things [pinguia] taken in broth [jure].
Oleander , or <i>Rhododendron</i> , <i>Rhododaphne</i> [oleander]	By its caustic force it gnaws the inner parts; brings on griping pains [tormina], colic, dysentery, and the iliac disease [morbus iliacus].	Oil of almonds; the root of tormentil chewed; emerald [smaragdus] ground and drunk.
Psilium herba [fleawort / <i>psyllium</i>]	Induces the same symptoms as the rhododendron, or rhododaphne.	Theriac taken; swallow-wort [vincetoxicum] taken; salt extracted from centaury.
Scammonea [scammony]	Excites symptoms similar to those who have taken verdigris	Copious draught of milk; the juice of quinces drunk down; juice of

Names of the plants that swell with poison	Symptoms	Cure and remedies
Solanum, Solatrum [nightshade]; <i>Opium and horned poppy [papaver corniculatum], all narcotics.</i>	[aerugo]. A narcotic and stupefying poison; induces lethargy, vertigo [scotomia], apoplexy.	bramble [rubus] drunk. The specific remedy is shellfish [conchilia], either raw or cooked; goat's or ass's milk drunk; broths prepared from cooked crabs.
Stramonium herba [thorn-apple / jimsonweed]. <i>Because of the poison [virus] latent in it, it touches no animal [i.e., no animal will touch it].</i>	It is endowed with a soporific power. It induces a lethargy by means of which thieves carry out their wicked deeds.	The same remedies are to be employed to suppress its poison as are wont to be applied against the toxin of the nightshades [Solanorum].
Tithimallus [tithymal / spurge]. <i>It has various species.</i>	By its caustic force it gnaws the viscera; causes intense pains of the intestines, colic, and dysentery.	The specific remedy is purslane [portulaca], houseleek [sempervivum], and a draught of oil of almonds.
Thapsia [deadly carrot]	The same symptoms as scammony induces.	Whey of milk [serum lactis]; sealed earth [terra sigillata].

PINAX III: From the animal kingdom [Ex Animalibus]

Names of the venomous animals	Symptoms they induce	Remedies
Aspis [asp]	Hiccup, alteration of color, numbing [sideration] of the limbs, chill through the whole body, lethargy, continual leaping [convulsive jerking]; the victim thrusts his fingers into	The specific remedy is lesser centaury [centaurea minor] and rue [ruta]; and a serpent laid upon the wound — besides the other things that cure serpent-bites — with scarification of the

Names of the venomous animals	Symptoms they induce	Remedies
	his throat to make himself vomit.	wound.
Araneus phalangius [the phalangium spider], <i>and there are various species.</i>	Induces flatulence of the belly, priapism, chill of the extremities, horripilation [gooseflesh].	The specific remedy is a spider crushed onto the wound. River-crab; ass's milk drunk; cock's brain drunk; man's [?] [<i>saevum hominis</i> — recte <i>sevum hominis</i> , human(?) tallow]; specific: grains of turpentine [<i>terebinth</i>] taken with wine.
Buprestis [a beetle], <i>a kind of caterpillar similar to the cantharides, which takes its origin from the pine.</i>	The symptoms are the same as those of the cantharides.	The specific remedy is niter [<i>nitrum</i>], very fine and spongy, in a sweet draught with oil of myrtle or of cypress. Likewise pine-kernels taken in great quantity.
Cantharides [Spanish-fly beetles] — <i>they possess a sharp, burning, biting, putrefactive, ulcerative, diuretic poison.</i>	They draw blood into the urine; pain in the members of the whole body; they cause ulceration of the pubic bone [<i>pecten</i>] and of the member [<i>virga</i> , the penis].	All fatty things [<i>pinguia</i>] swallowed are of benefit: milk, lard, butter, theriac. Fatty clysters; oils of every kind, both taken inwardly and injected externally through the member. The specific remedy is grains of <i>heliocacabum</i> [winter-cherry / <i>Physalis</i>], ten in number per dose.
Chersydrus , or the <i>water-serpent</i> [<i>Serpens aquaticus</i>]	Violent pain with inflammation and corrosion of the viscera; disordered movement;	The specific remedy is the taking of the serpent reduced to salt. The nut of the cypress with

Names of the venomous animals	Symptoms they induce	Remedies
	extinction of the native heat; vomiting of foul bile [cholera foetida].	grains of myrtle drunk with honey and wine.
Cerastes, the horned serpent [Serpens cornutus]	A pricking like a needle in the place of the bite; itching of the body; vertigo with derangement [amentia]; swelling of the shins; dimness of sight [scotomia].	Soft-boiled eggs [ova sorbilia]; pitch plastered on with salt; radish; specific: the serpent itself applied to the wound together with rue.
Dipsas anguis , or <i>Situla</i> — <i>it takes its name from the thirst [sitis] it excites.</i>	Burning of the belly; an appetite for drinking that cannot be satisfied, up to the bursting of the stomach and belly; inexplicable thirst and torment.	River-crabs crushed and drunk with goat's milk; a draught of oil, as much as they can take, to provoke vomiting — besides the medicaments customarily given for serpent-bites.
Dryinus serpens , or <i>the oak-serpent</i> [Serpens quercinus]	Induces the same symptoms as the asp [Aspis], of which it is a species.	The specific remedy is salt extracted from a serpent — above all, viper's salt [viperinum sal].
Draco marinus [the weever / sea-dragon]	Induces the same symptoms as the sea-hare [Lepus marinus].	The specific remedy is the <i>mullus</i> fish [red mullet] placed on the wound, and also cooked and eaten; oil of sulphur.
Haemorrhois [the bleeding-serpent], <i>so named from drawing out blood [a sanguine eliciendo].</i>	For the bite incurred from it brings on a flux of blood from all the hollow members of the human body: from the eyes, nose, ears, mouth, through the urine and	The specific and only remedy is bloodstone [haematites] ground up, and taken with the clotted blood of a he-goat.

Names of the venomous animals	Symptoms they induce	Remedies
	through the stool — indeed, bursting out through the very pores.	

PINAX III: From the animal kingdom [Ex Animalibus] (continued)

Names of the venomous animals	Symptoms	Remedies
Hirudo, Sanguisuga [the leech]	Putrefies, swells, causes vomiting, stupefies, induces lethargy.	Vitriol diluted with vinegar and gargled; brine [muria] given in sips [sorbitiunculis]; decoction of willow [salix].
Lepus marinus [the sea-hare], <i>of the same nature as the cantharides.</i>	Difficulty of breathing, asthma, spitting of blood, bloody discharge [from the nose], vomiting; the patient perceives the taste of the rotten fish itself and loathes it; just as a rabid dog at the sight of a fish [shrinks back] as from water [?], they die of consumption [phthisis].	They are cured by a draught of milk of any kind, especially woman's milk; theriac made of sealed earth; broth of river-crabs; the warm blood of a cock or goose drunk; man's urine. The specific remedy is a fox roasted and eaten.
Phtyas serpens [the spitting serpent], <i>killing by its spittle [sputo interficiens].</i>	Extinguishes the native heat; derangement [amentia], paralysis, apoplexy; it dissolves all the inner parts into a wasting decay [tabum].	Specific: lozenges of viper [trochisci viperini]; oil of scorpion; the juice of centaury root; all the things that are of benefit for viper-bites.
Pastinaca marina [the stingray / sea-pastinaca], <i>a fish in the shape of a</i>	Causes the same symptoms as the cantharides taken	Decoction of sage [salvia], wormwood [absinthium], or sulphur

Names of the venomous animals	Symptoms	Remedies
<i>rhombus [turbot], with a long tail in which the poison resides.</i>	[internally].	decocted from [with] vinegar, drunk. The specific remedy is the <i>mullus</i> fish cut open and applied.
Rubeta [the bramble-toad], <i>of an earthy nature, endowed with a putrefactive force, and stupefactive.</i>	Stupor, swelling of the limbs; it stupefies and benumbs by its vapor; by its spittle and urine it putrefies and inflames the infected member, whence [comes] gonorrhea.	The specific remedy is toadstone [lapis bufonius] and rue; indeed, let all the medicines be boiled and prepared with rue.
Vipera [the viper], [Greek: ἔχιδνα (<i>echidna</i> , "viper")].	Pain of the viscera, inflammation, chill and horripilation of the extremities, fainting [deliquium], derangement, extinction of the native heat.	Theriac; the specific medicaments are viper's flesh cooked and eaten, and likewise its powder; the bezoar stone [lapis Bezoar] taken; the viper's head applied to the wound — besides those things that serve to drive out poisons.
Salamandra [the salamander], <i>endowed with an ulcerative force.</i>	Pain in the groin, an abscess [apostema] beneath the hypochondria, spasm, retention of urine, derangement, swelling over the whole body, stupefaction, alopecia [baldness], or a falling-out of the hair.	Theriac; goose's milk drunk, and broths of fat meats and of crabs; frogs cooked with calamint [calamentha]. The specific remedy is the same as for the cantharides [grains of <i>heliocacabum</i>]; against salamander-poison.
Scorpius [the scorpion]	Swells, inflames, stupefies; vertigo [scotomia]; induces	Specific: the scorpion's own venom crushed upon the sting; its oil; the

Names of the venomous animals	Symptoms	Remedies
	dizziness and apoplexy; it attacks the nerves.	root of aconite <i>pardalianches</i> [leopard's-bane] applied. Basil [ocymum] eaten.
Seps , a putrefactive serpent [<i>serpens putrefactivus</i>].	Swift consumption of the flesh and bones; not only from the bite, but even from treading upon it, it brings sudden death.	The specific remedy prescribed by Pliny [the Elder] is oxymel.
Scolopendra , a serpent of various colors.	The symptoms are similar to those that arise from the viper.	The specific remedies are salt drunk with vinegar; juice of pennyroyal [pulegium], wild thyme [serpyllum], mint; the urine of pre-pubescent boys drunk.

After the table, the chapter concludes:

From all these things, then, it is plain that poisons are the more virulent the more they have derived their origin from the more excellent putrefactions — that is, the *arsenico-mercurio-saline* ones; and that they grow gradually milder the milder [those putrefactions] are. And since the degrees of this combination are infinite, so too innumerable kinds of poisons arise, and they may be considered in the same way. Just as Aristotle rightly teaches (*Metaphysics* VIII.7 [Arist. l. 7. met.]) that the species of things behave as number does: number, since it can be increased to infinity, must yet be reckoned to differ in every species — for if you add a unit to three [ternarius], not three but four [quaternarius] will result,

a number distinct in species; and if you subtract a unit from it, two [binarius] will remain, likewise distinct in species from three; and so on to infinity. I would have you understand that the same thing happens in the variety of poisons. For this combination of things depends, first, upon the varied concoction effected by nature's fire — so that there are as many distinct degrees of poison as there are degrees of heat; and second, upon the varied constitution, whether of minerals (one mixture of things and another), or of vegetables (according to one nature and property and another with which they are imbued), or of animals — terrestrial, winged, aquatic, and the insects — according to their temperament.

And since these are themselves innumerable, so according to the proportion of their nourishment they pour forth an innumerable variety of poisons. To wish to investigate all of these, or to attain to their innermost essence and perfection, is not the part of a wise man, nor [within the power] of the weakness of the human intellect. They are known to Him alone who furnished [things] with such great variety; reserved to Him alone, to whom therefore alone be honor, glory, and blessing for ever. AMEN.

SECTIO III.

DE IMPERFECTIS METALLICIS CORPORIBUS

On imperfect metallic bodies

which concur as the principal causes in the generation of metals. Wherein the poisons of minerals, and likewise their medicinal powers, are more fully set forth.

CAPUT I.

On the wonderful nature and property of sulphur. [De admiranda Sulphuris natura, & proprietate.]

[Margin: Why sulphur is called θεῖον (divine).]

Not without reason did sulphur earn from the ancient sages of Greece the name θεῖον [Greek: θεῖον (theion, "divine"; also the Greek word for "sulphur")], which denotes something divine. For its powers are so marvelous that, although for so many ages they have been examined by the study and scrutiny of all physicians, to this very day they have not yet been adequately explained by anyone. Plutarch says: "Sulphur, I think, was named θεῖον on account of the resemblance of the fiery, sharp odor which bodies struck by lightning give off — on account of which, I think, even dogs themselves abstain from eating the bodies struck by lightning." Hence they called the fire of the lightning-bolt sacred and divine, because bodies touched from heaven resist putrefaction for a long time — which also agreed with many other authorities: Aristotle, Dioscorides, and, among the more recent, Falloppio [Gabriele Falloppio], Mattioli [Pietro Andrea Mattioli], and Cesalpino [Andrea Cesalpino]. But since our chief care is concerned not with the etymology of the name but with the thing itself, and with unfolding the nature of sulphur, we shall therefore, with all possible diligence, endeavor to track down the nature

and properties of this so admirable mineral. And in doing so, neglecting those things which are set forth *ad nauseam* by countless writers, we shall follow only those tenets which irrefragable experience has taught us — beginning with a division.

[Margin: Division of sulphur.]

Following the Greeks, we divide sulphur into ἄπυρον [Greek: ἄπυρον (apyron, "unfired" — that which has not yet undergone fire)], that is, that which has not yet experienced fire; and πεπυρωμένον [Greek: πεπυρωμένον (pepyrōmenon, "fired" — that which has already undergone fire)], that is, that which has already experienced fire. By the former we understand nothing other than fossil sulphur [Sulphur fossile], just as it came forth from its own ore; the latter, however, is sometimes natural — as when, by subterranean fire, it is distilled into an oil, as is to be seen in many places of the burning sulphurous mountains and in caverns; and sometimes artificial, as when it is boiled down by fire and oil. The ἄπυρον [unfired] is called fire-untried, living, sincere, pure, unalloyed [putum], contaminated by no admixture of heterogeneous matters, shining, translucent — of which kind it is rarely found. But sulphur that is πεπυρωμένον [fired], that is, fire-tried, gleaming, of a green color and very fatty [praepingue], is regarded under a twofold difference. That which is pellucid and congealed in the shape of a cone or cylinder they call *virgineum* [virgin sulphur], used by maidens for tinting the hair to a golden color; it imparts whiteness and softness to wool; it was named *egula* by Pliny [the Elder]. But the green kind, transfused in cylindrical form into reed-pipes, is most useful for making lamp-wicks [elychnia]. And concerning the method of making artificial sulphur we shall here add a little first; afterwards we shall also reason at greater length about the nature, origin, and properties of natural, or fossil, sulphur, as being a richer subject.

[Margin: Sulphur is dug only in sunny places, and why.]

Sulphur is never dug and extracted in subterranean tunnels, but in places open to the sky on every side and in sunny spots, lest by its vehement heat and intolerable noxious vapor [mephitis] it destroy the miners. It is prepared, first, from sulphurous waters and veins, in this manner: sulphurous waters, gathered into leaden basins, are boiled down until they condense into sulphur. Second: if, however, the impure sulphur is variously [mix-]

so that the mixture is drawn off; then the sulphur ore is loaded into bulging earthenware vessels and boiled down. But since I will treat these matters fully in

the *Art of Metals* [*Ars Metallica*], I refer the reader there. Here our only task is to investigate the hidden nature of sulphur.

[Margin: The definition of sulphur.]

The first question, then, is this: **How, or from what matter, is sulphur generated?** Various opinions on this are put forward among the natural philosophers and the expositors of nature. But we, holding to our own principles established by long experience, say the following.

First, we say: There is scarcely any place free of sulphur — indeed the whole globe of the earth is so saturated with it that the innumerable hot springs (by the sulphurous odor they exhale), and the multitude of burning mountains and sulphurous pits, demonstrate this abundantly. That all these draw their origin from the abundance of subterranean sulphur is so certain that anyone who denied it could be thought out of his senses.

Second, we say: Wherever lakes are found filled with bituminous fatness, there too, by infallible inference, places saturated with sulphur are found — as I recall having observed in many places in Etruria [Tuscany], in the Albula at the lake of Tibur [Tivoli], in the territory of Puteoli [Pozzuoli], and in numerous places in Sicily. Hence Agricola [Georgius Agricola] (*On the Origin and Causes of Subterranean Things* [*De Ortu et Causis Subterraneorum*], book 3) says: "Sulphur is a fatness of the earth pressed out of it by the force of heat, for which reason it is generally found in burning places." Caesalpinus [Andrea Cesalpino] agrees, calling it the grease or oil of the earth; Theophrastus too calls it the resin of the earth. That it consists of four distinct substances is confirmed by its effects. For by heat it is dissolved and liquefies, and by cold it condenses again, so it must contain something moist within itself. And since it can be reduced to an impalpable powder, that is a clear sign of a drier earthy substance. And because it can easily be set on fire and adhere like glue, that plainly indicates a thoroughly viscous substance — through which, just as it readily adheres, so through its oily quality it can readily be ignited. These are clearly the signs of fire, air, water, and earth, in whose center is fire — that sulphur is born of fire, the fiery vigor — while the mercurial moisture (or mercury) and the earthy salt, which fixes everything, are stored within. The fetid smoke clearly indicates that it consists of an earthy matter still undigested, raw, and not yet brought to completion. Therefore, whatever in it is hot and dry and endowed with a fiery force, it has from its internal sulphur; whatever is liquefiable, from the mercurial liquor in which it abounds; whatever, once melted, easily coagulates again, must be

ascribed to the internal salt — as must its sharpness, and the fact that it easily penetrates all things, which it owes to its dryness.

[Margin: The nature and origin of sulphur explained.]

The second question: What is the difference between mineral sulphur and the sulphur they call the **sulphur of the philosophers** [Sulphur Philosophorum], and which of the two is said to contribute to the composition of things? Those who think that this mineral and fossil sulphur contributes to the generation of things are greatly mistaken. For I do not see how a sulphur of this kind could contribute, since it seems rather to destroy and consume the things to which it is applied than to compose them.

[Margin: Mineral sulphur is not the sulphur intended by the philosophers.]

Something else, therefore, seems to lie hidden under the name "sulphur," insofar as it denotes one of the universal material principles; and to explain it, **I say** it is a certain principle in nature — hot, supremely oily, subtle, penetrating, endowed with marvelous powers — which some call fire, the natural heat implanted in all things, and which some call the **sulphur of nature**. This is so because, just as elemental fire most displays itself, and makes itself visible, in flame and in burning things (although fire considered in this way can by no means be called an element — indeed, so far is it from contributing to the composition of things that it rather destroys everything), so too, I say, the sulphur of nature is an invisible fire. This material sulphur extracted from ores cannot be called that fire, nor, considered as such, can it contribute to the natural constitution of things. Yet there lies hidden beneath it, as beneath a kind of material covering or wrapper, that fire of nature, which by a certain analogy the alchemists [Spagyrici] have called sometimes the sulphur of nature, sometimes the life-giving seed of the World [vivificum Mundi semen] — because by its power all things are animated and made alive, since without it nothing in nature can subsist.

[Margin: The origin of mineral sulphur.]

Now since, among the subterranean mineral species, fire shines forth most in sulphur, and nothing more resembles fire than sulphur — on account of its heat, its sudden inflammability, and the other properties proper to fire — they have judged, not without good reason, that fire should be called by the name of sulphur, and have reckoned it among the first principles for composing things. And this fiery power is diffused by the Author of nature throughout all the pathways of the World, implanted in each and every thing; in sulphurous bodies it establishes its chambers as if in a center, and this is plain from the fact that

scarcely any body of a warmer nature is found which, when resolved into its elements, does not give off sulphur in odor and taste, whether under the guise of oil, bitumen, or salt. The perpetual fires of many mountains testify to this, as do baths of hot waters, which are never found without actual and mineral sulphur, and which derive their origin from a certain fatness of rich earth, in which those three natural principles of salt, sulphur, and mercury — united by means of the four elements to effect the composition of things — are found, and are regarded as the seeds, so to speak, of all nature. For whenever and wherever that fiery power finds rich and oily earth, composed of the refuse of the elements, it impregnates it in a certain way and imbues it with its own power, and at last cooks it into mineral sulphur. And since a strong and vigorous heat resides in it, in those places where it springs up in abundant yield it at once exerts its powers...

flaming up, it burns, as we said a little earlier. And since it is perpetually at work in the subterranean wombs, the result is that, sublimed through the fissures of the mountains and the cracks of the rocks, it blossoms out into sulphurous flakes, which they call the **flowers of sulphur** [flores sulphuris], as may be seen in the Phlegraean Fields. For the rocks, just as they abound in natural cold, so too they emit that exhalation and condense it into a sulphurous meal — which the alchemists, imitating the industry of Nature, work up into preparations of marvelous virtues, namely the flowers, milk, cream, butter, oil, and acid spirit, the genuine offspring of sulphur.

[Margin: The natural flowers and oil of sulphur.]

[Margin: Flowers, Milk, Oil — of sulphur.]

The **flowers**, which are also called the dew of sulphur, are of the greatest help in febrile, pestilential, and pleuritic impurities. The **milk of sulphur**, rightly called the balsam of the radical moisture, purifies the blood, increases the strength of the natural powers, and is a noble prophylactic against apoplexy, leprosy, asthma, and consumption. The **oil of sulphur** is so powerful that it allows neither a living nor a dead body to pass into putrefaction; in warts, scrofulous swellings, dropsy, colic, toothache, and epilepsy, with a suitable vehicle, it is used most conveniently. For consumptives, nothing more choice can be offered than **butter of sulphur**, or lozenges made of sulphur and sugar.

[Margin: The excrement of those who use sulphurous medicines gives off the odor of musk.]

This too is marvelous: that although sulphur is of a foul and intolerable odor, yet when taken internally it is by some hidden path so transformed that the

excrement of those who use it more frequently is said to carry the odor of musk. The **acid spirit of sulphur**, moreover, never catches flame; indeed it restrains gunpowder from igniting. In burning fevers...

[The remainder of this column continues at the head of the recto's first column above; the column wraps:]...in burning fevers, in asthma, and in suffocating catarrh and consumption, it is a noble remedy. But how all these things are to be prepared by art will be told elsewhere.

[Margin: (in margin, appears to be a cross-reference/shelfmark, partly cut off) "ad l. 8. 12. Sect. [?] / 5. part. 2 [?] / 268. [?]"]

Furthermore, sulphur has as many different virtues as it has different origins. For each metal or mineral contains within itself a sulphur different from that of another: the sulphur of gold is one thing, that of silver another, that of bronze, copper, tin, iron, lead another. Nor should this seem strange to anyone, since it takes on the nature of the metals with which it is mixed and, according to the condition of the metals, shines with different virtues.

[Margin: The marvelous virtues of sulphur.]

It tints crystals and beryls into the most precious gems (of which in their proper place); this sulphur exalts silver to such a degree that tin, with an equal weight of silver, sustains the test of the touchstone [lapis Lydius]. The sulphur of bronze so fixes copper that it withstands assay by lightning, though without producing a tincture. The sulphur of lead exalts tin into steel, and the sulphur of tin exalts steel into the finest iron. The sulphur of Mercury renders its own body fit for the hammer; sublimed with quicksilver, it is turned into a most ruddy pigment called **cinnabar** [Cinnabrium], very much used by painters. The same, by decoction, turns into an elegant blue; but with bronze it changes into violet; and if its flame is caught in a glass vessel, it turns into a most acrid liquor, which is called **oil of sulphur**. But of these matters in the *Experiments of the Art of Metals* [*Experimenta Artis Metallicae*]. Sulphur likewise differs according to the various properties of vegetables and animals, yet in their resolution it always leaves something analogous to the said sulphur.

CAPUT II.

On the other minerals which draw their origin from Sulphur.

§ I.

On Arsenic, Orpiment, Sandarach, and Realgar.

[Margin: Orpiment and Arsenic are the same as to substance.]

From sulphur, mercury, and salt, with the four elements as intermediaries, all things are composed and all are nourished; and consequently there are three principles which constitute all things, and three which destroy all things. The first are **arsenic** [Arsenicum], **orpiment** [Auripigmentum], **sandarach** [Sandaraca], **realgar** [Risogallum], and the other realgars — degenerate offspring of sulphur, which, although they derive their origin from sulphur, nonetheless decline from it by degrees, so that they may be called principles not so much of nature as of its opposite, of death and destruction.

Orpiment, or **arsenic** — which differ only accidentally — is a mineral that draws its birth from sulphur through the fatness of the earth. Hence, being an earthy combustible, oily substance, from the excessive combustion of fire it acquires (from I-know-not-what excrementitious dregs of the salt and mercury mixed with it) some corruption, which so degenerates from the vital and health-giving sulphur of Nature that it brings forth the most powerful poison of all things in the nature of things, and one utterly destructive — a poison which not only destroys metals but also extends its dominion over the economy of plants and animals.

[Margin: The poison most powerful.]

Hence, whatever is found virulent, deadly, and destructive in certain herbs — such as wolfsbane [Napellus] and aconite [Aconitum] — must be ascribed to the arsenical power of the earth drawn in through moisture; and whatever destructive thing lurks in vipers, asps, and other pestilential serpents must likewise be attributed to the innate corruption [putredo] of arsenical power, from which some such serpent has come forth, as we taught in the **Section on Poisons** [Sectio de Venenis].

[Margin: Herbs and serpents share this.]

The question is therefore asked: from where does so powerful a poison exist in the arsenical species? **I answer:** from the mercurial salt, together with sulphur more violently burned, by which they are raised to such a degree of power that there is scarcely anything that...

can withstand its sharpness and its subtle, virulent spirits. Hence it brings death to all animals, and it drives shrew-mice into such a frenzy that they do not cease to rage against other animals of their own kind, turning them rabid by the same poison they have implanted with their bite.

[Margin: The effects of arsenic.]

Plants tinged with arsenic by fumigation perish; men who drink waters in Egypt tinged with arsenical quality become bald; animals lose their hair, nails, and horns, their roots eaten away by the excessive sharpness. Indeed, arsenic — and its other species, antimony [stibium], verdigris [aerugo], and so forth — is a poison even to gold and silver. For it consumes the moisture of gold and silver so that they cannot be liquefied; but when fire is applied, since there is nothing to resist its dryness, the metal's substance is burned and goes off in smoke. And that this property comes to it from its violent sublimation, brought about by the combustion of fire, **realgar** [Risogallum] shows abundantly: for, extracted from sulphurous clods by art and not by nature, and burned by a more violent torment of fire, it turns into a poison such as is found in arsenic or orpiment. The same is taught by the experiment shown in the preparation of artificial orpiment.

[Margin: Realgar a fierce poison.]

EXPERIMENT.

[Margin: The making of orpiment.]

Take scrapings from crusts of fossil orpiment; when these have been ground to powder, you will add to them an [equal] part of the fossil, which you will load into a vessel coated with lead and stopped with clay. Then, placed on the fire, you will cook it to the point where the whole of what is within has risen on high and adhered to the vessel — and you will have artificial crystalline orpiment, which will turn out the purer and more efficacious the more often it has endured the torment of fire.

From this it is clear that all arsenical substances — such as orpiment, sandarach, realgar, ochre, and the realgars — differ only in colors, by the differing combustion of fire. Hence the alchemists call arsenic and orpiment yellow or "croceum," red sandarach; and white they call by the proper name arsenic, or **Arrhenium**, that is, "the male." But although, as we said, it is a kind of most powerful poison, yet when it has been purged of the superfluous impurities of its excrementitious dregs, it obtains some use in the treatment of the extremities of the limbs — as in curing the French disease [lues gallica, syphilis], ringworm [serpago], gangrene, and mortification [sphacelus]. It is also said to be a salutary prophylactic in time of plague; on which see our opinion in the treatise *On the Plague* [De Peste]. For there is in it a power of warming, dissolving, corroding, and an efficacious magnet for attracting to itself a virus of a like malignant quality.

[Margin: Arsenic a remedy against plague.]

§ II.

The origin, nature, and properties of Marcasites.

A remarkable abundance of **marcasites** [Marchesitae] — which the Greeks call **pyrites** [πυρίτας, pyritas] — is everywhere found in the veins of minerals. They derive their differentiation according to the diversity of the metals toward which they incline and from whose nature they partake. For some are called marcasites of gold, others of silver, others of iron, lead, copper, or bronze. And although all are composed, as to substance, of one and the same matter, they nonetheless have some diversity according to the degree of concoction. For through cooking, their sulphur and mercury are differently affected and corrupted, and this causes some difference among them, as the diverse colors — white, yellow, black, and leaden — with which they are everywhere imbued, demonstrate; for there is, as we said, a golden, a silvery, a bronze, and a leaden marcasite.

[Margin: The various species of marcasites.]

If you wish to know the composition of marcasites, **I say** they are composed of a great deal of white and red sulphur, infected and corrupted, with a great deal of arsenical salt, polluted, and the smallest portion of equally corrupted mercury. That they are composed of sulphur, the odor sufficiently shows; the contamination of their parts (which they call **realgars** [Realgares]) and the abundance of excrementitious dregs also demonstrate it. The copious salt mixed in them is shown by their alchemical resolution through vinegar; that this salt is corrupt and contaminated is sufficiently indicated by the deleterious power that resides in it. I said that little mercury is mixed in them, which is clear from the fact that they cannot be extended by the hammer, but are almost as readily reduced to powder, like stones. Hence some have not inappropriately called marcasite μεταλλόλιθον [Greek: metallolithon, "metal-stone" — a stone-metal] — midway between stones and metals — for it can be smelted and liquefied like metals, which does not suit stones, yet it can by no means be stretched by the hammer, like stones, which is proper only to metals.

[Margin: The origin and composition of marcasites.]

The cause of this is that the dry part is not perfectly united with the moisture residing in it, nor well tempered, nor mixed throughout in equal measure; for its dryness, being in excess, drives out and consumes a great portion of the moisture — hence it breaks with almost no effort. Whenever, therefore, that acid spirit of corrupted and burnt sulphur, together with a saline vapor, falls by subterranean fire into a suitable womb of the earth, the result is that, according to the condition

and nature of the womb, it is there condensed by the cold of the earth into the substance of marcasite — namely, on account of the deficiency of mercurial moisture, a substance by no means fixed.

[Margin: Why marcasites are easily broken.]

From this it is clear that those slag-mongers [ciniflones] roll the stone of Sisyphus who too confidently boast that they can extract either gold or a tincture of gold from marcasite. And if you should sometimes find a little gold along with marcasite, that nevertheless has nothing to do with the nature of marcasite, but has accrued to it by accident, as usually happens in earthy clods — you may convince yourself: for if you separate it with aqua fortis, you will acquire only as much as had been added of gold, no more, no less.

[Margin: Marcasites do not contain gold, except by accident.]

If you regard the virtues of marcasite, they are such as yield to none of the medical powers of minerals...

in their properties, especially if they are duly and lawfully prepared, and purged of the rubbish of their impurities by careful industry.

[Margin: The natural virtues of marcasites.]

I myself knew a physician who used to cure even the most desperate dropsical patients with an extract made from marcasites alone; and he proceeded thus. He made the extract from marcasites with vinegar, or the juice of lemons and pomegranates; then he let the juice evaporate over a small fire; the sediment that remained at the bottom he formed into small, very useful [polychrest] pills, which he offered to dropsical patients, and he affirmed that by them all the serosity of the humors stabled within the body was purged away, to the point of a miracle.

[Margin: They cure dropsy.]

And sometimes, too, with cream of tartar mixed with distilled wine, he performed not dissimilar operations with the marcasitic extract. And if anyone considers the rationale of this medicine more deeply, he will at once perceive the truth of the matters mentioned from the very magnetism of those things. For since marcasites — from which the virtues immediately emanate — are endowed not with fixed but with volatile spirits of sulphur and salt, for the reason indicated above; and since dropsical patients abound with the saline serosity of corrupted humors; hence, in order that the humor — which the burning power and sharpness of

marcasitic sulphur cuts, attenuates, and dries up — may be expelled, the saline spirits, attracted to themselves by the law of magnetism, drive it out with a powerful cathartic.

CAPUT III.

The origin, nature, and properties of Antimony, or Stibium.

Antimony, or **stibium** [Stibium], is so similar to marcasite in almost all its faculties that I would say it is nothing other than a Saturnine, or leaden, marcasite. Hence it is composed of the same materials as marcasites, though it has somewhat more mercury joined to it than marcasite does — for which reason, contrary to what many think, it can easily be melted into lead. It consists, then, of sulphur and a viscous earthy fatness, with a notable predominance of salt, so that, easily broken by the hammer, it escapes all extension; indeed, beaten longer with the hammer, it goes off into the finest dust.

[Margin: The nature and properties of antimony.]

It so savors of the nature of lead that it melts down into it, and so may rightly be called an imperfect species of lead — although in lead a larger supply of mercury shows itself than in stibium, which also renders the former sweeter and milder, the latter rougher and more acid, as is clear from its astringent faculty.

[Margin: Imperfect lead.]

But those who too anxiously seek a tincture of metals in it hunt nothing but smoke, since it eludes all the industry of the chemists for drawing out a philosophical tincture. For the sulphur and mercury of which it consists are so corrupted and infected that they can neither extricate themselves in any way from such infection, nor be freed by any artful preparation from their impurities for the said use, nor be dissolved — although from its various preparation marvelous things are drawn out.

[Margin: Tincture sought in stibium in vain.]

[Margin: The various things made from antimony.]

For from its calcination there come glass — red, yellow, of the regulus, hyacinthine, saffron-colored, and diaphoretic — from which, finally, the **regulus** is also drawn (of which in its proper place and time). But if you consider its faculty, it is most certain that, without correction, it is sheer poison, partaking

much of the arsenical-mercurial quality, as is clear enough from the symptoms by which it disturbs the economy of the whole human body in a wondrous manner.

[Margin: Antimony a poison.]

Hence a great controversy has arisen among physicians about its use: some execrating it, while others — chemists especially — embrace it, once its venomous qualities have been tamed and amended, as a kind of divine medicament.

That antimony, no less than arsenic, sandarach, orpiment, and mercury (whether precipitated or sublimed), is a most powerful and utterly deadly poison, various and horrendous cases have sufficiently taught — whenever it has been administered to the sick, uncorrected, by the fanatical crowd of unskilled quacks [Agyrtæ] and salve-mongers [Alyptæ] — as even the alchemists, philosophers of the first class, attest.

[Margin: How much harm unskilled physicians do with antimony.]

Libavius [Andreas Libavius] reports that he saw a shepherd seized with spasm from the use of four grains of antimony. **Erastus** [Thomas Erastus], the celebrated physician, says he knew a noblewoman whose soul left her body sooner than the vitrified antimony began to work. Again, a druggist's servant who had taken five grains of the same antimony, and shortly after, with blood bursting from his mouth and nostrils, lost sense and mind, and on the third day breathed out his soul.

[Margin: Various examples.]

And the physician of Philibert, Margrave of Baden [Marchio Badensis Philibertus], reports that he knew some who, from the use of the same, with the veins in their chest ruptured, perished of consumption. **Oberndorpius** [Oberndorpf], a distinguished physician, knew a certain matron who within about 24 hours was evacuated some two hundred times, to the point of eternal swooning, by an antimonial medicine. **Dessenius** likewise saw several who, from the use of antimony not properly prepared, fell into long illnesses from which they could never be extricated; and he reports others who, from its use, were brought into colic pains, diarrheas, convulsions, heart-distress [cardiaca], faintings, and premature deaths.

[Margin: Various examples of those who have used antimony.]

Bruno Seidel [Bruno Seidelius] mentions a certain barber who had given vitrified stibium to someone troubled by a pain in the shoulder from a flux; from which, on account of the intestines being corroded, a pain arose that he himself supposed to be colic, and he gave a most potent wine, anointed the belly with laurel oil, and all but deprived the man of life. Innumerable examples of this kind, which I myself saw at Rome [Romae], I could adduce...

[Margin: The atrocity of stibium.]

[I could adduce], but let these examples suffice to demonstrate the violence of the antimonial poison.

Nevertheless, certain physicians of our own day, of both schools, have arisen who not only do not reject antimony but extol it to the very stars, calling it [Margin: The usefulness of antimony in medicine] the "hand of God" [τὸ θεοῦ χεῖρά (to theou cheira, "the hand of God")]. They maintain that if any harm arises from its misuse, this is to be charged not to the antimony [stibium] but to the witless quack-chemists [Chimicastris], the mountebanks [agyrtis], and similar impostors upon the ignorant common folk — men who, being as full of crass ignorance as they are, can do harm with scammony, hellebore, and antimony alike, to the ruin of their patients. They cite countless cases of many people whom no other antidote [alexipharmacum] had helped, but who were freed from innumerable bodily ailments by antimony alone. On these matters, read, if you please, Andernacus [Johann Winter von Andernach], Matthiolus [Pietro Andrea Mattioli], Quercetanus [Joseph Duchesne], Gesnerus [Conrad Gesner], Croto [Croton], Rondoletius [Guillaume Rondelet], and many others. They also bring forward certain physicians who render antimony so mild that they have administered it even to infants, not rarely with the happiest success.

Paracelsus [Paracelsus] declares that antimony encloses within itself the secret of all minerals: it has, he says, ten sweetnesses, which yield ten virtues — the very virtues that the Earth holds divided among ten herbs, all of which (he asserts) lie hidden together in antimony. So great is its power that what ten herbs of potent virtue, applied each to its different use, contribute against various diseases, this single antimony alone supplies. [Margin: Antimony, in the opinion of many, the most excellent of medicaments against all diseases] Hence Crollius [Oswald Croll] says: if antimony [stibium] could be so prepared that it might operate, without vomiting, only through the lower passages, no more excellent purgative [catharticum] could exist in all nature. For taken internally it purges both biles with the highest efficacy; it is said to be wonderfully effective against epilepsy, dropsy, leprosy, quartan fever, apoplexy, alopecia, and jaundice; it opens

obstructions of the liver, the spleen, and the whole body; it heals the colicky pains of the intestines; it aids the gouty, the scabrous, and the asthmatic. In mania, in bewitchment [fascinatione], and in melancholic madness [philomania] he proclaims nothing to be more effective. Taken externally it cures cancers, elephantiasis, fistula, lupus, and other malignant ulcers; for closing and drying wounds men cannot commend it enough. From it are prepared innumerable medicines — namely an essence, a tincture, an oil, a vinegar, flowers, a diaphoretic powder, [the same] with sugar...

[combined], with which it binds itself by so close a bond that the two can scarcely be separated again — whence great and secret is its use in medicines.

And this is the view opposed to the former one. To which of these two I should subscribe, I do not know; nor do I think it is my place to touch this apple of strife [τὸ μῆλον Ἐριδος (to mēlon Eridos, "the apple of Eris/Strife")]. This only I say: [Margin: Judgment of the author concerning antimony] one must proceed with great caution and circumspection in a matter not free of danger; one should not trust just any quack-chemist, nor administer a medicine of this kind except in the more violent afflictions of disease. For since antimony, even in however large a dose, swells with arsenical and mercurial spirits (as is plain from the vomiting it provokes), it cannot but prey upon some part of the substance of our own body. This the ancients not only carefully recorded and their successors religiously observed, but experience too — the mistress of things — has confirmed: [Margin: The harmfulness of antimony] that we should scrupulously beware of purgatives that draw violently and excessively, since nothing is more virulent in undermining the strength, nothing nearer to death, than these. For they shatter the heart's vigor, consume the spirits, stupefy the mind, throw the humors into disorder, and produce thirst, nausea, and griping; in a word, when all the viscera have been ruined, they give occasion to death.

Therefore in antidotes of this antimonial kind, who does not see that great caution, singular skill, studious forethought, long practice, refined judgment, and perfect testing are required? Nor do I think physicians should ever resort to them except under the demand of the utmost necessity — and only when a disease has sometimes driven its roots too deep. For where human health is at stake, one must not abide by the judgment of each and every individual, but only of those who have, over long time, acquired authority. Hence I cannot but condemn the custom of those physicians who, at the slightest costiveness of the body — when they are not without milder and gentler remedies from the vegetable family — administer such enormous medicines out of indiscreet zeal, and who, to discover

the powers of the medicine, seem to be playing rashly and recklessly upon the skin of a sick man. Let the reader see more about antimony in the Section on Poisons.

CAPUT IV.

Of Quicksilver, that is, Mercury, and its nature and wonderful properties.

[Margin: The inexplicable powers of Mercury]

In no property of natural things does the ineffable wisdom, power, and glory of the majesty of GOD, the Best and Greatest, working in Nature, shine forth more conspicuously than in the certain yet incomprehensible nature of quicksilver, which men commonly call Mercury — by reason of its powers, effects, and singular composition. In it that living water, heavy, so greatly a friend to metals, in itself im...

[holds] within itself the supreme remedy against poisons; and so it can become the single and most excellent cure for all curable diseases. Mighty in this mineral lies hidden a Thaumaturge [Thaumaturgus, "worker of wonders"] of marvelous works; and though concerning its power everything might seem to have been said, yet far more still remains to be said. So convinced am I that in this life its power and the manifold variety of its virtues can neither be fully explored nor set forth in words, that it is better to admire in these things the immense wisdom of GOD, the Best and Greatest, than to promise oneself a full and perfect knowledge of the innermost properties of this so wondrous compound. Although many high priests of medicine and of natural science have written about it, yet always more and more secrets emerge from its dissolution — which he alone knows who has made trial of it. Nor are there lacking points that seem to need correcting in the opinions of earlier writers; these I shall pursue more fully in the following [book], on the transmutation of metals. But now to our undertaking.

§. I.

Of the wonderful properties of Mercury.

[Margin: The nature of quicksilver, or Mercury]

Quicksilver, or living silver [Argentum vivum] — called Mercury by the chemists on account of its mobility — is a mineral liquid drawn from a metallic water: viscous, earthy, exactly tempered with sulphur, spirituous, cold, moist, and openly white; yet hidden within it is hot, dry, red, and in short of every color. It

penetrates the metals to which it adheres and dissolves them intimately. It is the matter of all metals, required for their substance just as salt and sulphur are — a certain πανσπερμία [Greek: πανσπερμία (panspermia, "universal seed" — a seed-mixture of all things)], containing within itself all things metallic, as the innumerable colors it displays the moment it feels the fire bear witness. It is called living silver [Argentum vivum] because it resembles silver in color and is easily driven from one place to another by any impulse. Beyond all other minerals it has received a peculiar and wonderful nature that can hardly be penetrated, and it is endowed with certain admirable powers so contrary to one another that of it one might say: "cold things have been mingled with hot, wet with dry." Hence, from this contrariety of natures combined in a single compound, opinions so contrary and conflicting have sprung up in the minds of the chemists that there is scarcely anyone who can extricate himself from the impenetrable abyss of its nature and from its untamable force. And so, confused in mind, they leave nothing undone by which they might subdue this Mercury.

Thus, to make it more apt for fixation, one man — having robbed it of that fleeting spirit — macerates it buried in the juices of veins [in succis venosis]; another strives to suffocate it in the strongest, corrosive waters to wash away its superfluous moisture; some torment it miserably, smothered in dung, in the excrements of animals, and in hot smoke. Nor are there lacking those who, having shut up the poor and innocent thing in the strictest dungeon and bound it in fetters, even lop off its wings, and — exercising it with various precipitation, sublimation, calcination, fermentation, putrefaction, amalgamation, fixation, coagulation, and the like torments of the chemists — strive not only to deprive it of its wings, feet, and hands, but to take its life by every means. Yet imbued with a certain most subtle force, just when they least expect it, by its accustomed and deceitful fleetingness, rushing wherever a door is opened, it slips free of all such bonds, dungeons, and torments, and suddenly escaping from the hands of its tormentors, it vanishes into thin air, and — circumventing its adversaries by its cunning trickery — leaves them (not without indignation, as if smiling at them) with both their vessels and their purses empty. But, leaving these things aside, let us come to the matter.

The first property of quicksilver, then, is its fluidity [fluxibilitas]. Although it is truly something distinct and separate, yet unlike other things it does not hold together, nor is it hard; rather it is a liquid, fluid in every direction by its own innate power. [Margin: Properties of quicksilver] Nor can it be fixed except by a certain rare industry known to very few; and I judge that whoever has come to know that art will find nothing further difficult in the transmutation of metals,

having attained the goal of the work in the tincture of the Moon [tincture of silver].

The second property of Mercury is that, although it has taken on the substance of a liquid, it is nonetheless heavier and more ponderous than all the other metals, each and every one. [Margin: Quicksilver the heaviest] From this it comes about that, gold excepted, all the other metals float upon it, just as cork-bark floats upon water. For copper, iron, tin, and lead of whatever weight, cast upon it — as anyone who wishes to make the experiment will find — float upon it just as any piece of wood floats upon water; gold alone sinks within it, [Margin: Mercury, except for gold, floats] being at once resolved from a hard and solid substance into a liquid one.

The third property is that, as if scorning and neglecting the other metals, it seems to court the favor and fellowship of gold and silver alone; whereas the other metals, even if joined to it, are — I know not by what tyranny it is seized — penetrated, perforated, broken down, consumed, and utterly destroyed by its very presence, devoured and inwardly destroyed. [Margin: Except gold and silver, it consumes all the rest of the metals] Whence it is rightly called the poison of all things.

The fourth property is that, although it may be poured out and scattered into the tiniest and almost infinite particles, it nevertheless loses none of them easily; rather they all immediately gather themselves together again and coalesce into their former union and fellowship. [Margin: Mercury indestructible] So that for this reason, not without cause, it is called by the philosophers an "eternal substance" and an "eternal liquid," since there is nothing that can destroy or abolish it.

The fifth property is that, although gold and silver are separated from copper and the other metals by the help of quicksilver, yet for uniting and gluing these same metals together it is utterly necessary, as is plain in the gilding of metals. [Margin: Mercury joins all things] For Mercury, mixed with gold, like wax...

[for tinning], makes a soft mass; and when this has been smeared upon a plate to be gilded, by the aid of fire it so unites the gold to them that it can scarcely be separated again by any art. But Mercury itself, as soon as it feels the fire, as if it had duly performed its office, vanishes into thin air.

The sixth property is that, although quicksilver is the heaviest and most ponderous of all things, yet in a brief time it takes on a most subtle, most light, and most fleeting substance — or, at the touch of fire, having been converted, it

assumes wings. [Margin: Nothing heavier and nothing lighter than quicksilver] And if you should think it has entirely disappeared, then again, by a sudden metamorphosis, you may with wonder see it converted into a most heavy substance.

The seventh property seems to be magnetic. [Margin: It seeks and attracts gold] For this one thing has become known to us by experience: that quicksilver, by a certain secret instinct of nature, seeks out gold, embraces it, and receives it as into its own bosom; and its chief virtue is that, by a certain wonderful sympathy, it clings to gold and most readily penetrates it. For if it senses gold near it, it entangles itself with it so to the very marrow that, by that embrace, the gold once laid bare casts off and as it were shakes out the other metals with which it had been mixed.

§. II.

Of the mixed nature of Mercury, and where it is born.

Mercury is also a true hermaphrodite, of such a nature and property as we observe in no other compound in nature: of itself and by its own nature both hot and moist, earthy or rather cold and dry, constituted of opposite qualities. It shows heat and dryness in its sublimation; moistness and earthiness in its natural state; and moisture in its unstable fluidity; earthiness, because it moistens nothing. It is a metal and a non-metal: a non-metal because of its fluidity, by which it eludes every blow of the hammer — for of itself it flows like water, whereas the other metals do not flow unless melted; nor is it ductile, for it breaks into a thousand drops when it falls to the ground. [Margin: Mercury constituted of opposite qualities] Hence it also makes brittle the metals to which it is joined, even lead and gold. But that its moisture is metallic — indeed that it is a kind of potential metal — is plain from this: that it mixes with all metals, with one more than with another, and indeed is most greedily imbibed by all of them; yet it adheres only with difficulty to copper, and most difficultly to iron, because of its lesser similarity to these and its greater similarity to the rest. Hence too Mercury can be extracted from all metals by the spagyric art [Spagyrica arte], as will be taught in its place in the Experiments. But the question arises: why does it adhere more easily to some metals than to another? I say the cause is similarity, by which like bodies naturally seek and cherish one another, inasmuch as through these they attain the perfection intended for them by nature. Hence it readily adheres to gold, silver, lead, and tin, by I know not what laws of friendship, but not so to copper and iron; but gold and silver it not merely drinks in easily, but most greedily, like a glutton, because it seems to aspire through them to its own

perfection and to a state of higher dignity. But that its substance is impure and imperfect is plain from the blackness with which it stains the hands of those who handle it. And the reason it wholly flies off in sublimation is that it contains an exhalation that is not burnt but combustible, by which the substance is raised up in vapor. And the reason it is never burnt up is the perfect mixture of the earthy with the moist, by which it is defended from combustion.

There are two kinds: native and artificial [Nativum et factitium]. [Margin: Quicksilver twofold: native and artificial] The native is either virginal [Virgineum], which distills from the vaults of subterranean mines and is the most thoroughly purified of all; or it is drawn out by art from cinnabar [cinnabrio], which is its matrix — a method we shall teach elsewhere. In Spain the purest is found. At Hydria [Idria, in Carniola] it is pressed out from a somewhat reddish stone. [Margin: The mine of quicksilver at Idria in Carniola, where quicksilver is dug] But, in order to add here the manner, method, and industry by which the workmen extract and perfect it, I shall append a letter which P. Sigismundus Siserus [Father Sigismund Siserus] of our Society — who carefully inspected the said place — composed, describing everything no less skillfully than elegantly. He writes thus:

"Last year, [Margin: Idria described] while I was traveling from Goritia [Gorizia] to Clagenfurtum [Klagenfurt], it pleased me to make an excursion to Idria, and to satisfy a curiosity long since most ardently desired. And since I had for a long time most earnestly longed to learn the situation of that place and the rest, [Margin: A letter to the author on Idria] I made particular and more thorough inquiry into everything, Your Reverence, and I have thought it worth setting down the following about them.

"The place, which is at about the same elevation of the pole as Goritia, lies in a very deep valley, hemmed in on all sides by mountains; we scarcely reached its floor after a continuous descent of three quarters of an hour. A torrent conveniently flows through the village — from which perhaps comes the name Hydria [Idria; cf. Greek ὕδωρ, "water"]. Raised up by countless laborers' toils and variously and ingeniously diverted, it most easily supplies, with the greatest effort, various labors: for by its aid they most ingeniously drain off the subterranean waters, more than a hundred fathoms [orgyiae] deep, by means of several pumps [antliae] pouring from the bottom one into another, until [Margin: Description of Idria] the water is brought up to the top — waters which would otherwise hinder the workers in the pit. [Margin: Description of the mine of Idria, where quicksilver is dug] The excavated material is drawn up by hydraulics

alone (with only a single man directing the work), a rope being wound upon itself bearing a very heavy and huge mass, and is let down to the earth; and likewise the useless material, [now] filled with quicksilver, is very conveniently brought out, and the like. But more about the pit itself.

"There is a hillock, bare of trees but very thickly covered with grass, scarcely reaching (in my estimate) half a league in circuit, beneath which this treasure has hitherto lain almost wholly dug out. Here lies open an entrance, stretching straight ahead for some distance, sunk so low that it scarcely ever admits a man of ordinary stature walking with body erect; from there the descent gapes to the left, not however so steep...

"...[at first] from the start, in such a grade that it might deter one entering upon the journey — until, having been led on for some while, he reaches stairs set up to the vertical [ad perpendiculum]. There, truly shuddering with horror, I recall to myself that abyss, scarcely to be measured by the eye, into which one who so desires to feed his curiosity must let himself down. It is a pit reaching a depth of a hundred and some fathoms [orgyiae] from top to bottom; but as for its extent, I could not so easily reach it because of the various passages scattered to right and left. Yet something of it may be gathered from this: that from entrance to exit, if one does not linger beyond the usual, fully three hours are reckoned. In this continuous labor the inhabitants of the place — now as it were born to it — toil day and night by turns, and each now knows his own task to perform: so that some are diggers only; others carry the already-loosened material to the place from which it is drawn up into the open — and this even in darkness, by the aid of a channel laid throughout the whole way, in which a little cart [rotula curriculi] running along conducts the one who hauls it. To others it especially belongs to attend to the machines by which the water, as I said, is drawn up, and to have at hand everything that might supply a deficiency. There are also some who, with bellows, drive down fresher air from a place above into the lower parts, where there is a defect of air, [the air] drawn up [and] enclosed in pipes — without which the labors of those below could hardly last long. Moreover Mercury is not dug out only by continuous force, but in various places it sometimes trickles out of itself through openings, needing no fire nor any further effort to attain its purity, which it has in the most absolute degree — whence it is called virginal [virgineus]. Of this I have with me about a pound and a half, received there as a gift from the curator of the place. So much for what I either saw or heard at Idria."

These things about Idria, whether seen or there heard, are enough.

§. III.

Of the medicinal virtues of Mercury, and whether it is a poison.

Having now duly set out these things, let us come at last to the medicinal virtues of Mercury — which, although we describe them more fully in the Section on Poisons, let us here repeat a few things omitted there. Quicksilver, by the confession of all physicians, is reckoned among the pure poisons, especially if it has been precipitated or sublimated with diluted reins [haberis laxatis][?]. Whom, I ask, has it — which so greatly delights the ruined alchemists — hurled down into the lowest pit of miseries? Antarvetus [Antarvetus][?] says he would be richer than Croesus if he had as many coins as precipitated Mercury has carried off. Laurentius Hoffmannus [Lorenz Hoffmann] tells that a certain quack-doctor [Medic astrum] gave someone two pills made of Mercury, of which (he says) the man, having taken the first, fell into paralysis, and having taken the second also, into apoplexy. Libavius [Andreas Libavius] says he knows a man who had given to one afflicted with colicky pains a single mercurial pill; with the bowel obstinate, he gave a second and a third, and a little after the man voided his soul along with his excrements. [Margin: Deadly medicines of Mercury] Oberndorfius [Oberndorf] relates that he knew an anointer [Alyptam] who in the space of two years carried off sixty-three men by the use of quicksilver and its fume. I pass over the many who, anointed with Mercury, fell — in his very sight — into epilepsy, paralysis, and apoplexy.

Fernelius [Jean Fernel] reports that in a certain tanner, because of quicksilver he had taken, not only the crown of the head [sinciput] and both meninges of the brain rotted away, but also the underlying substance of the cerebellum was turned into an abscess. Many cases daily experience teaches: that those anointed with Mercury have fallen into paralysis, deafness, scrofulous swellings, colicky pains, dysenteries, convulsions, faintings, and tremors; that others have spat out their teeth; that some have lost their nails, hair, jawbone, uvula [columella], and limbs; that certain ones, racked by periosteal distensions, contractions, and diseases more dreadful than the pox itself, have lived on to the very last condition of life, tortured. I have heard men infected with the venereal pox confess that they were tormented so intolerably — no otherwise than those shut in the Bull of Perillus [Tauro Perilli, the brazen bull of Phalaris] — and tortured as if by an infernal fire. The question, then, is asked: what is the cause of such great symptoms? I answer: it is the arsenical spirits, joined to the spirits of the keenest salts, which — sublimated by the internal heat — are converted into a most subtle substance, and so likewise, as they penetrate all the passages of the body, gnaw at everything, pluck, and lacerate, and turn it into corruption [tabum] with the

ultimate ruin and destruction of the human body. See more of these things in the Section on Poisons.

We cannot sufficiently admire the disposition of the divine Wisdom regarding quicksilver: that although it is so dreadful a poison and altogether deadly, it has nonetheless not willed its kindness and wholesomeness to be excluded from it. [Margin: Corrected Mercury becomes the most wholesome medicine] For if it has come into the hands of a skilled craftsman and a prudent physician, it refuses to attack no kind of disease, while — by the subtraction of excess and the addition of what is lacking — it brings the disordered humors back to the proportion of equality. Hence Paracelsus does not fear to honor it, when legitimately prepared, with the title of the "balsam of Nature" and "natural theriac." Now the preparation of quicksilver consists not in purification — for many falsely persuade themselves that its malignity can be checked and it purged of all malignancy by straining it through leather, and by curbing its mobility with vinegar, urine, lye, or lemon-juice; for although it may seem mortified by these, yet, when warm water is poured over it, it soon rises again and will not cease to exercise its accustomed tyranny. Rather its perfect purgation consists in the subtraction of the sulphurous and leaden malignancies. [Margin: How it is corrected] For in this way the arsenical sulphur is removed by sublimation, the soul [is removed] by fiery fixation, and by the artifice of sublimation, precipitation, and various distillation it is deprived [of these] — which, properly speaking, is the Philosophical Mercury [Mercurius Philosophicus], and is wonderfully suited for curing various ailments, both internal and external. But so long as the corrosive sharpness of the salts lurking beneath it endures, so long must it be reckoned still imbued with a deadly quality; but once that is removed, then little by...

once its savagery has been laid aside, it grows mild. The sign of this is that when it has been reduced [?] to its former life, no further art can recall it. For the wonderful cures of desperate diseases worked by its agency, see Paracelsus, Libavius, Mylius, Quercetanus [Joseph Duchesne], and the other chymists. These are the miracles of the chymists, described with truly marvelous praises.

Whatever may be the case regarding the wonderful medicinal uses of properly prepared Mercury, I myself — examining the natures of things more deeply, according to their inmost essences — judge that Mercury, however it has been prepared (whether by precipitation, sublimation, or any other method), neither can nor ought to be applied against the savagery of such diseases, except where life has already been despaired of. For that deadly power and force of Mercury is

not elemental but a specific power and property; and since it flows and emanates immediately from the very form of Mercury, it is certain that this power can in no way and by no art be wholly separated from it, unless we wish to destroy the whole substance of the thing entirely. And if this is so, then Mercury will surely always keep hidden within itself some malignant something-or-other, working from within; and although it may seem from time to time to free the patient from the foul flood of the humors' malignant nature, yet it is always mindful of its own ferocity. Insinuating itself more deeply, it rises up again at an opportune moment, and by its hidden machinations turns everything upside down, right up to the final goal of death.

[Margin: The author's judgment on mercurial medicine.]

But here perhaps the chymists will object: that Mercury, once its malignancies have been tamed, then most of all possesses that wonderful power that cures all diseases. But I ask them this: will Mercury, so mortified, do something, or will it do nothing? Just as they will not deny the former, so they cannot grant the latter. For if it acts, it acts either by that specific power of its own, or by some other power newly acquired. If by the former, then — however tamed and restrained it is — it will always leave behind some traces of its virulent wickedness, since this corrosive power inheres essentially in the sublimate and cannot be wholly separated from it. If by the latter, then either it does nothing, or, if it does something — and indeed acts benevolently, without its accustomed ferocity, if that is the case — then I say that Mercury has then passed over, essentially, into a wholly new and distinct substance. Unless, however, we wish to say that in this new state it has been imbued with some magnetism, by which — just as viper's flesh draws to itself the venom that was poured out by the viper — so too Mercury (whether this happens by some diaphoretic or some purgative power) draws the virulent humors of the human body and, once drawn, expels them outward. And yet, since these things can be accomplished by other, far nobler medicines, we gain nothing by Mercury. [...]

§. IV.

On the wonderful power by which [Mercury] adheres to gold, and its cause.

It can therefore be asked, not uselessly in this place, how such a conjunction comes about. Certainly, since the powers mentioned have at no time failed to be a wonder to the philosophers, a great part of the chymists has judged that the associations of different metals come about only through a certain magnetism — as Paracelsus amply argues in his book *On Transmutation* [*De Transmutatione*].

Fallopious [Gabriele Falloppio] holds that the metals draw mercury in no other way than a magnet draws iron, or amber draws straws; and the chymist-philosophers maintain that even that Philosophers' Stone — known to the bleary-eyed and to the barbers — is to be compared only to magnetism. Whatever the case, it is truly remarkable to see quicksilver, alone, being sought after, as it were, by all the metals. What then this power is, and whether it belongs to the class of magnetic and electric attraction, now remains for us to declare.

[Margin: Whether Mercury draws magnetically.]

Against the cited authors, then, I say first: this conjunction of quicksilver with gold and silver comes about in no way through magnetic, electric, or elemental attraction. For if it were through magnetic attraction properly speaking, this appetite of the quicksilver for gold would have to do two things: first, to establish it in a fixed place suited to its own nature within this universe, as happens in magnetic bodies; second, the quicksilver and the gold would have to alter each other in such a way that, as soon as either one comes into the sphere of the other's power, it flows toward the other as quickly as possible — out of a certain likeness of nature and an appetite to acquire a new perfection — which we properly call magnetic coition or attraction. But the appetite by which the quicksilver seeks to join itself to those metals does not establish the quicksilver in any fixed place, since, owing to its fluidity, no fixed or stable place in nature can be assigned to it. Nor is it alterative: for when quicksilver is placed opposite gold and silver, or even balanced most exactly against a needle [obeli] of gold and silver, however close it is brought, it leaves behind no trace of alteration or attraction — as frequent experience has shown me — which nevertheless would have to happen if it were endowed with any magnetism.

[Margin: Mercury's attraction to gold and silver is not magnetic.]

For this same reason, certain people wrongly count its operations among the electric ones. For all electric bodies pour out certain effluvia, by which they move and attract only the very lightest bodies placed nearby. But quicksilver — besides being most heavy — also gives no sign whatever of an attractive quality in the gold toward it, or, conversely, in itself toward the gold, however subtly balanced; and so it can in no way be counted among electric bodies.

[Margin: It does not attract electrically.]

Nor can it be said that this conjunction comes about by reason of a vacuum, as in attraction in elemental [bodies]... [continues]

[Margin: Nor by reason of a vacuum is it drawn.]

since elemental attraction can serve no purpose, being ordained, as a potency toward its end, to nothing else but the union and continuity of the parts within a whole — which is not necessary in this metallic [Greek: συζυγία (syzygia, "conjunction" / "coupling")]. Nor can the said conjunction come about through a confluence of like things, as appears in homogeneous substances: for a drop of water, or of quicksilver, seizes another drop and joins it to itself — not by some hidden power, but by the law of homogeneous things, by which parts that are alike and of the same kind seek to be joined to one another, as if to defend themselves against a common enemy. So too oily substances, shunning the watery, mix readily with the oily; while watery substances, rejecting the oily, mix readily with the watery. So too the liquids we call gums: if they are of a watery nature — like cherry gum, gum tragacanth, and the like dissolved in water — they easily coalesce, out of a certain likeness of nature; whereas gums of a fiery nature — like mastic, frankincense, storax, resin, and the like — being of a different nature, cannot be made to mix with waters.

[Margin: The cause of metallic attraction.]

Nor can the said conjunction come about through a certain appetite of the gold and silver, by which it attracts quicksilver to itself as something good and suitable — as individual limbs are accustomed to draw to themselves the nourishment suited to them — since gold and silver, being established in their own perfection, no longer have any need of quicksilver.

I say, therefore, that this conjunction comes about through a certain beneficent and friendly outflowing of the gold and silver toward the quicksilver, by which the Mercury is apprehended; or rather through a natural appetite of the quicksilver toward gold and silver, in much the same way that matter naturally desires form, and, through prior dispositions, they coalesce into one physical compound. For as the Philosopher [Aristotle], speaking of this appetite, rightly says: [Greek: ἀλλὰ τὸ ἐστὶν ὕλη ὥσπερ ἄν τὸ θῆλυ ἄρρεν[?] καὶ αἰσχρὸν καλὸν[?]] (alla to estin hylē hōsper an to thēly arren kai aischron kalon, "but matter stands in the same relation [to form] as the female to the male, and the ugly to the beautiful") — *Matter stands to form as the female to the male, and the ugly to the beautiful*; and this appetite of matter is nothing else but its inclination to receive the form owed to it by nature. For since matter, of itself and by its own nature, is ugly and imperfect, deprived of all comeliness and beauty (as the Schools put it), it necessarily desires by nature that which can give it its ultimate complement and perfection.

So too I say: since quicksilver — the proximate matter of the metals — is a mineral, and, both on account of its excessive humidity and on account of the abundance of earthy impurities with which it teems, is so imperfect and defective that it can scarcely be corrected by any human art or industry; and since nevertheless it is ordained by nature to a further perfection, and of itself also strives after perfection and a solid consistency — it seems to have received from the Author of Nature this one prerogative: that when mixed with gold and silver, as with a more perfect form, with that excessive humidity somewhat suppressed, it is reduced [to perfection]. And indeed by the beneficence of the gold and silver — since unless by mutual embraces... [Greek: ...σύμφυτον?][?] — a pure thing flowing by natural appetite toward the impure, a beautiful toward the ugly, [the gold and silver] unite with it, until its humidity, blunted by the heat of the gold and the dryness of the silver, and its coldness checked, and stripped of that inconstant fluidity by their aid, it solidifies and at last attains the intended, consistent form. Quicksilver therefore runs to the said metals as the imperfect to the perfect, the ugly to the beautiful, potency to act, so that it may be perfected and adorned by it, and at last, according to the various dispositions, coalesces into one physical compound — into gold, I say, or silver.

[Margin: Quicksilver desires gold, as matter desires form.]

This adhesion, then, is accomplished by that viscosity in which quicksilver abounds, and by a certain subtle, most penetrating power, by which it suddenly permeates the inmost substance of the other metal — a power that is wonderfully promoted by its fluidity and mobility. Silver, by its very great dryness, somewhat blunts the excessive humidity of the quicksilver; gold rids it of its superfluous earthy parts; and these changes are then followed by the intended transmutation.

You see, therefore, that there is nothing magnetic in actions of this kind, but rather that the union of metals of this kind with quicksilver is accomplished by the said appropriated qualities. By the same reasoning, when we see gold coalesce with silver, with [Greek: χρυσοκόλλα (chrysokolla, "gold-solder" — borax)], that is, with borax; iron with iron, by means of chalk reduced to powder, moistened, and brought together by violent fire; tin combined into one with lead, copper, iron, [and] silver by means of Greek pitch alone — for this reason that action ought not, as many ignorant people wrongly suppose, to be counted among the magnetic ones, since these come about ordinarily not by hidden qualities but by primary or secondary ones.

[Margin: The cementation of quicksilver.]

Who would not marvel that, by the mere vapor, breath, or smoke of a material compounded of tin and lead, tin is so joined and hardened with quicksilver that, in color and hardness, if it does not surpass true silver, it at least equals it — bearing the hammer however much you strike? And had I not myself proved the truth of the matter by experiment, I could never have been brought to believe it. Since, then, by the same vapor and mercury — as experience teaches — gold, otherwise most solid, is reduced to powder, it must not be said that the quicksilver has gained entry into the gold, as a magnetic odor [enters] into the substance of iron (as certain of the chymists maintain), but rather in the manner we said above.

[Margin: Various experiences in the transmutations of metals.]

The like I would say of the metamorphosis of the other minerals: as when iron is turned into copper by the power of vitriol; tin into lead by the agency of sal ammoniac; quicksilver into cinnabar by the action of sulphur; lead into white lead [ceruse] by vinegar; and this [ceruse] into red lead [minium] by the force of fire. Nor can any magnetism intervene here, since experience teaches that in aqua regia silver dissolved adheres to copper, and copper liquefied [adheres] to iron, by a certain wonderful means — but all these things... [continues]

must necessarily come about through the qualities suited to each metal. Hence laughable are those who believe that the transmutation of metals can be carried out by some magnetic power, by means of certain herbs — as by the juice of monkshood [Napellus], leopard's-bane [pardalianches], or doronicum, infused [into the metal].

But how Mercury can be extracted from red lead [minium], and from the other metals, as well as from the soots of minerals and vegetables, will be set forth in what follows.

CAPUT V.

On bituminous bodies.

[Margin: Sulphur and bitumen are kindred minerals.]

Nature produces in her womb a certain kind of fatness, which, when not fixed by salt, grows into bitumen, but when fixed by its own salt degenerates into sulphur — to which bitumen is so closely akin that you could not unfittingly call bitumen liquid sulphur, and sulphur fixed and coagulated bitumen.

Bitumen, then — called by the Greeks [Greek: ἄσφαλτον (asphalton, "asphalt" / "bitumen")] — is a fatty juice, intensely hot, of an oily moisture, most apt for feeding fire on account of its nature, which is easily inflammable. It is varied and manifold according to the variety of the places in which it is naturally produced, and according to the diversity of the mixed bodies to which it adheres. For if it oozes out of rocks — as in the territory of Modena [Matinensi Agro] — then it is called petroleum; if it comes forth from the liquor of burnt sulphur, black in color and sulphurous in smell, it is called terrestrial pitch. The bitumen of Babylon they call naphtha, [Greek: νάφθα (naphtha, "naphtha")], that is, a bituminous liquor that enters into so great a friendship with fire that it catches flame at the mere approach of fire; and it is found in various places in Italy and Sicily — as at Naphtia, a place near the Sicilian city of Mineo, where I remember once having seen a species of this bitumen gushing out in abundance.

[Margin: What naphtha is.]

Again, if this unctuous juice, gushing up from the bottom of the sea out of a most purified clod of sulphur, is raised to the surface, and then driven by the impulse of the waves toward the shores, there, hardened by the dryness of the surrounding air, it is converted into amber [succinum]. If again the bituminous liquor is carried up from sulphurous lakes onto the surface of the water, it is properly called [Greek: μάλθα? (maltha)] *maltha* — as in the lake Albula in the territory of Tivoli [Tyburtini], and especially in the lake of Palestine, which they therefore call Asphaltites and the Dead Sea; and this, cast up onto the shore, takes on a stony hardness of a purple color.

Strabo: *Bitumen*, he says, *is a clod of earth which, liquefied by heat, is breathed out and diffused, and again is changed by cold water, as it were into the strongest ice — such as is the water of the lake — whence there is need of cutting [?] and incising.* If then it is fixed by the power of salt infused into the clod, a bituminous earth is born, which they either call *ampelitis* (because it kills worms on the vines), or — on the testimony of Theophrastus — name *pharmacitis*, on account of its notable use in medicine. If finally, like burnt charcoal, it is joined to a sulphurous mass, [Greek: λιθάνθραξ (lithanthrax, "stone-coal")], fossil coal, or jet [Gagates] is generated — concerning which [I spoke] in the preceding [chapters]. If a clayey clod is mixed in, it is called *maltha*.

Again, if a black [bitumen] coalesces with a white one, it is called *pissasphaltum*, that is, pitch-bitumen, and emanates from mountains in various places — as in Epirus — and this is native. The other kind is artificial, and is called mummy [mumia], because cadavers embalmed with pitch and bitumen, within the sands

of Libya, grow under the scorching heat of the Sun into a bituminous mixture, which they call mummy. But concerning the method and procedure of embalming cadavers, as practiced by the Egyptians, see the treatment given expressly in Volume III of the *Oedipus Aegyptiacus*, in the *Syntagma on Mummies*.

[Margin: That minerals are sulphur and bitumen.]

[Margin: How the varieties of bitumen arise.]

You see, then, reader, that bitumen is one and the same liquor, but that — from the diverse waters, clods, stones, mud, juices, and clays in which it grows — it has obtained so great a diversity among men. As they differ in various colors, so too it is established that a varied naming of the bitumen has flowed forth: white, black, red, yellow, ash-colored, purple. And since the things to which it adheres are imbued with varying faculty, with differing powers and properties, bitumen must necessarily be imbued and tinged with these powers and those.

[Margin: Bitumen is one and the same liquor, but takes its diversity from the things to which it adheres, and its naming from these.]

For the subterranean heat — as we have amply demonstrated in the preceding [chapters] — when it exalts that earthy fatness, can, according to the varying degree of combustion [adustion], now produce reddish and white juices, now yellow ones from the reddish, greens or blacks from the yellows: just as from sweet phlegm, by the power of concoction, blood is made; from blood, by immoderate heat, yellow bile; and from yellow bile, by the force of adustion, green or black [bile]. In this way, then, a certain liquid bitumen is white for this reason: that a mild heat has expressed it from the earth — as is plain in white amber, which possesses I know not what sweetness; whereas the yellow kind, being elaborated by a greater force of heat, also has a certain acrimony joined to it; and the black kind, because it is scorched by great heat, exhibits to the taste and smell I know not what of the empyreumatic [burnt quality].

[Margin: Whence the diversity of color in bitumen.]

These species of liquid bitumen, indeed, arise only from a differing degree of heat — and the same is to be said of the color and powers of the muds, clods, stones, and juices to which it adheres. For if pitch is mixed with bitumen, *pissasphaltum* must necessarily be born; and likewise, if it runs through salt, sulphurous, nitrous, aluminous, or vitriolated places, the bitumen is tinged with those powers with which the places through which... [continues]

[it flows] are endowed by nature. Whoever observes this rule will easily, with the aid of the senses, form a judgment about the powers and qualities of the bitumen. See what we discussed more fully concerning bituminous waters in the First Volume.

Hence one [bitumen] is hot, another cold, another lukewarm; one is thin, another thick and viscous like mud; one is dry, soft, and easily split, another hard and imbued with a certain stony substance — like jet [Gagates], fossil coal, the Thracian stone [lapis Thracius], [and] obsidian [obsidianus]. There are some, besides, that breathe out a pleasant smell, and some a disagreeable and foul one. Yet to all and each it is common that they are easily inflamed; and this is plain from the mountains that they call coal-abounding [carbones abundant] — as concerning the mountain near Zwickau [Ziccam] in Meissen [Misnia], which Agricola [Georgius Agricola] reports they say burns from time to time.

[Margin: The abundance of bituminous stones in the mountains.]

In this [mountain], on Agricola's testimony, the miners first dig up earth to the depth of a pace; then, having widened it, they find a vein of soft coals, nearly three and a half paces deep; then they cut out fairly thick rocks; soon they again find a vein of coals, but hard ones, to which they gave the name "pitch-coal" from the pitch — and these seem to be similar [to pitch] on account of their blackness and brilliance. Beneath this vein lies bituminous cadmia, and beneath this an aluminous pyrites, [and] pure copper. The coals that the fire feeds upon, extinguished when earth falls into the furnaces, are turned into a black powder.

Note also that whatever is fatty and unctuous in Sulphur, Salt, [or] Mercury, is to be ascribed primordially to this liquor. Therefore, since fatness of this kind is diffused throughout the whole body of the Earth, it comes about that the vegetable nature too partakes of it — which shines forth most of all in the pine, the larch, the turpentine-tree [Terebinthus], and the other resin-exuding trees; so much so that if you should call resin of this kind a vegetable bitumen, you would be judged to have spoken rightly. To this too can be referred all the kinds of trees that, besides pitch and resin, also exude gum — like the birch [Betula], the cherry [Cerasus], the plum [Prunus], and the like; so much so, indeed, that there is scarcely a plant that is not endowed with its own natural bitumen, whether you call it pitch, or resin, or gum, or any other fatty liquor. But of these things [I shall say] more in the *Disquisition on the Vegetable Kingdom* [*Disquisitio Regni Vegetabilis*]. Nor should you suppose that in the animal kingdom any animal is to be found that is not both nourished by fatness of this kind and constituted by it as by a certain gluey bond, by which parts are aptly connected to parts. For what

else is fat [adepts] but a certain coagulated bitumen? — all of which I would have you understand according to the analogy intended by us.

The Uses of Bitumen.

Bitumen has innumerable powers and an immense use in the things of nature; but I shall describe only the principal uses.

First. The cause of the perpetual subterranean fire is ascribed to nothing other than sulphur and bitumen — as we showed sufficiently in the First Volume — so that wherever either burning mountains or hot springs [thermae] are found, there sulphur and bitumen cannot be absent.

Second. Naphtha and camphor are certain species of bitumen, which, kindled upon waters, are not only not extinguished but nourished, and take on a greater increase of their brilliance. Concerning camphor, indeed — whether it emanates from a tree or from the bowels of the earth — there is great dispute among the mineralogists. I myself, by the instruction of our Fathers in the Indies, find a twofold camphor: one a vegetable gum [lachryma], which emanates from a certain tree growing in the Molucca islands, chiefly on the island of Borneo; the other brought from China, not so much natural as artificial. But concerning the powers of camphor [I treat] more fully in the *Pyroboic Experiments* [*Experimenta Pyroboica*].

[Margin: What camphor is.]

The Egyptians — as we showed in the *Syntagma on Mummies* of the *Oedipus Aegyptiacus* — used bitumen for embalming the dead, [and] fed a perpetual fire, concerning which [we treat] most copiously in our *Oedipus*. Ammianus [Marcellinus] relates that the Persians, hurling weapons smeared and coated with bitumen against the enemy, burned them up. Bronze vessels, weapons, [and] iron smeared with this remain incorrupt against the injuries of water.

Maltha — a species of bituminous mud — when it touches anything solid, adheres, and when touched follows the one fleeing; it is kindled by waters, [and] extinguished by earth, if we believe Pliny. Bitumen and naphtha burn upon waters and are nourished by their moisture; concerning which [we treat] in the *Pyroboic Experiments*.

[Margin: Maltha.]

As for what Pliny, Solinus, Tacitus, and from these Isidore, and Pererius write concerning Judaeian bitumen — namely, that the Judaeian bitumen, which is

collected in the lake Asphaltites, is of so tenacious a viscosity that it yields to nothing except women's menstrual fluid, and that, though it cannot be subdued by iron, it is easily torn apart and separated by their touch — these things must be reckoned among the fables, since they conflict with manifest experience, and those who have seen it extracted by the natives declare that they observed no such thing. Concerning these, see the *Itinerary* of Petrus Vallensis [Pietro della Valle], of Brocardus [Burchard of Mount Sion], and of others. In many places they use bitumen in place of oil for feeding lamps. Ships without bitumen cannot last long in the waters.

[Margin: The property of asphalt.]

If you desire its medicinal powers: it staunches, dispels, contracts, [and] glues together; its smell, when kindled, puts serpents to flight; it is shown to be of help to the laconicum [?] for blurred vision of the eyes; smeared on, it soothes the pain of the gouty; together with niter, smeared on, it heals toothaches; drunk with wine, it calms cough and dysentery; taken with vinegar, it dispels clotted blood; it mitigates the pains of the joints and loins; smeared on, it wonderfully helps the mange and scab of beasts of burden. As for how much bituminous waters, or hot springs, contribute to curing various kinds of diseases, it was treated in the First Volume.

CAPUT VI.

On Marine Fruits — Coral and Pearls.

[De Marinis fructibus, Corallio, & unionibus.]

Coral [Corallium] is defined by all natural philosophers as a marine tree, for it grows only on the sea floor, and like the tamarisk it spreads out into various branches. Within the water itself it occupies a middle ground between the softness of a shrub and the hardness of stone. Those who attribute to it some limp softness are therefore badly mistaken; not at all — within the water it behaves exactly like the stalk of a fern, or of a tamarisk, or of any herb with a fairly firm stem. For if it were softer than it ought to be, it could not rise up to any height, nor resist the more violent motion of the seawater, nor withstand the impact of the fish passing through it.

[Margin: Whether coral is soft while underwater.]

I know from experience that this plant raises itself firmly aloft on a perfectly straight stem, and that it has a stalk of such hardness and firmness that it

sometimes even tears the nets of fishermen. And since the sea of Drepanum [Drepanum, modern Trapani, Sicily] is exceedingly productive of coral, and a great profit accrues each year to the city of Drepanum from its harvesting, in years past that most distinguished and learned man Jacobus Staphylus [Giacomo Staffilo], the most worthy Secretary of the Republic of Drepanum, sent to me — out of his affection for me — an entire portion of rock covered over with coral, to enrich my Museum. In that rock, at the shores marked A, you may see, not without wonder, various kinds of shells grown onto the rock. Among them you may also see, set apart, the shells of oysters, from whose concave and smooth part the coral has been born without any root.

[Margin: A piece of coral-bearing rock cut out at Drepanum and sent to the Author at Rome.]

Diagram. A large engraved plate occupying the lower half of the page, displaying a collection of coral and pseudo-coral specimens, each separately captioned. The individual figures and their engraved captions:

- **C** (upper left): a human skull with coral branches growing from its crown. Caption: *In Gazophylacio M. Ducis Hetr.* ("In the Treasury of the Grand Duke of Etruria").
- (upper center): a dense, antler-like coral mass. Caption: *Pseudo-Corallum* ("false coral").
- **T** (left, below C): a small lobed/tuberous specimen with sprigs. Caption: *In Museo Auth.* ("In the Author's Museum").
- **S** (center): a small lobed specimen with branching sprigs. Caption: *In Museo Auth.* ("In the Author's Museum").
- **E** (right): a large, bare branching coral tree. Caption: *Corallum Verum* ("true coral").
- (lower left): a rounded rocky mass studded with coral sprigs, set on a base. Caption: *Rupes Corallis consita in Museo Authoris* ("A rock set with coral, in the Author's Museum").
- **H** (lower center): a finely branched coral tree. Caption: *Pseudo Corallum Lythophytum lapideum* ("false coral, a stony lithophyte").
- (lower right, upper): a stubby, warty, jointed branch cluster. Caption: *Corallum Verrucosum* ("warty coral").
- (lower right, lower): two short thick cut segments. Caption: *Pseudo Corallum* ("false coral").

In some shells you may see coral plants bursting out from the convex and roughened surface, while in some of them they burst from the bare rock.

I myself, in order to investigate the origin of coral more exactly, examined quite closely the little plants plucked from the shells, with the aim of discovering how they had grown together. But it could not be done: despite all my efforts I could find no root, nor anything resembling a root. Rather, they appeared glued to the trunk itself as if by wax, without any trace of a perforation — something I afterward observed also in those shining shells they call mother-of-pearl (as is plain in figure **S.T.** [?]), and indeed in polished and smoothed stones too. This left me no little perplexed.

[Margin: An experiment on the root of coral.]

Not long ago, however, it happened that I came to the acquaintance of an Arab merchant who, having for many years carried on trade at the Red Sea, had likewise acquired a great knowledge of that sea. He told me that whole forests of this plant are found on the floor of that sea, so densely packed with coral shrubs that they grant passage not only to no diver but not even to the fish. He added, moreover, that the fishermen had drawn up together with the plants such things as shells, bricks, rocks, bones, wooden boards, and iron tools — all of them covered over with the corals that had grown upon them — and even a dolphin, from whose tough hide a coral plant had grown.

[Margin: Whether coral has a seed. The Red Sea most productive of coral.]

When I marveled at this as a paradox and asked whether a plant of this sort had some seed by which it propagated itself into so great a multitude, he replied that long experience had made known that there is in the coral shrubs a certain spermatik liquor which they emit from themselves; and that this liquor, onto whatever thing it falls, at once thickens there and founds a new offshoot of coral. This, he said, is the reason why coral is seen to have grown upon all the things just recited; and this liquor, even after it has been extracted, is found in the form of coriander or of a cornel-berry, thick like fat.

[Margin: Coral emits from itself a generative liquor, from whose drops new plants are generated.]

The Grand Duke of Etruria has at Pisa, in his Treasury [Gazophylacium], a human skull (see Figure **C**) out of which a coral plant is seen to have grown — which surely, just as in our own shells, could have grown upon it in no other way than through the said generative liquor. Since this liquor is by its nature viscous and

heavy, easily penetrating water without any commingling, it forms a new plant in whatever thing it has fallen upon.

[Margin: A plant grown from a human cranium and from a living dolphin.]

But now that these things have been set forth, let us explain the nature of coral a little more fully. The first question, then, is: How, and from what, is this plant born? I answer: it has its origin from a fatty, viscous moisture and a sulphureous brine, mixed together in the depth of the sea among the rocks always covered by the waves. After the manner of trees it germinates within the water itself, somewhat soft and of a greenish color; but outside the water, or at the first contact with the air, it gradually coagulates by the stone-making spirit residing within it, and degenerates into a color either black, or white, or red. The red is obtained from a fatty, viscous, pure, and red sulphur, perfectly cooked and digested.

The white, although it abounds in pure moisture and white sulphur, nevertheless — because of the imperfect concoction of that sulphur — yields much to the red; yet some wrongly prefer it to the red. The black, finally, consists of fatty and viscous but corrupted and scorched sulphur, and so too —

Diagram. A single coral specimen rising on a foot, branching toward the top like a small bare tree. Engraved caption beneath: *Corallus in Gazophylacio Card. Barberini*. ("Coral in the Treasury of Cardinal Barberini"). Three labels are written vertically along the stem from base to tip, indicating the color zones described in the text:

- (base): *nigro* ("black")
- (middle): *albo* ("white")
- (upper stem): *rubro* ("red")

— it is held in no esteem, except for its rarity. There is in the Treasury of Cardinal Barberini a coral plant which around the root is imbued with a black color, in the middle with white, then afterward with black [recte: this passage in the text reads "nigro... albo... postea nigro," but the engraving's labels read black–white–red; the printed text appears to repeat "nigro" where "rubro" is expected — see QA], and finally extends out into branches very much like a sea-tamarisk. From this the degrees of the heat and concoction mentioned a little earlier are plainly discerned.

As regards the medical powers of coral, it is well known that it has the power of cooling, drying, and binding. I have certainly found by experience that a

preparation of coral (which they call a *conserva*) is a marvelous remedy in cases of *haemoptysis* — that is, for those spitting blood flowing from any part of the body whatever; for it stops the flux of blood wonderfully. It is moreover an excellent remedy against the *lithiasis* (stone). Paracelsus counts a medicament of coral among his panaceas; it strengthens the heart marvelously, and is of benefit in epilepsy and malignant fevers. But on these matters see the medical writers.

[Margin: The medical powers of coral.]

It is remarkable, what Anselmus Boëtius [Anselmus Boëtius de Boodt] observed about coral: that if it is worn by a healthy man it reddens more intensely than if it is carried by a woman subject to various impurities. The reason for this is plain: just as menstruating women foul a mirror by their menstrual flux, so too they infect the coral. Likewise it has been observed to grow pale upon the sick who are near to death.

Κοραλλομόρφωσις [Greek: Korallomorphōsis, "coral-formation" / the shaping of coral]

or, A fuller explanation of the origin of coral.

[De Coralli ortu, fusior explicatio.]

By what name I should call coral [Corallium], I can scarcely make out: for it cannot rightly be reckoned among the vegetable plants, nor —

— nor among the stony excrescences. More aptly, then, we judge that it should be called a λιθόφυτον [Greek: lithophyton, "stone-plant"] — that is, a plant-stone. I mean something midway between a stone and a plant, just as the natural philosophers are accustomed to call ζωόφυτον ἰχθυόφυτον [Greek: zōophyton ichthyophyton, "animal-plant fish-plant"] the thing midway between a plant and an animal. But in order that we may attain the truth about its origin, I shall set forth those things which I have learned partly with my own eyes — both in Sicily and near the Stoechades Islands [Stoechades, the Îles d'Hyères], not far distant from the Gallic coast — and partly from the account of trustworthy men.

[Margin: The genesis of coral.]

We do not, then, hold that coral grows the way vegetables do, by the taking-in of nourishment, but rather by the apposition of superadded saline corpuscles steeped in a sulphureous tincture — exactly as the other efflorescences of salts grow; and this happens not in all places, but on a suitable part of the sea floor

stocked with salts of various kinds and with sulphureous exhalations. For just as certain herbs seek out a determined and suitable place, in which they thrive more successfully, so too do the coral stocks. But let me explain the genesis in a few words. Where, through the pores of the sea floor, suitable exhalations of this sort and broods of salt burst forth, there the salts — tinged by the subterranean fire with sulphureous vapors — are sublimated; and when they have reached the seawaters, immediately, with both the cold of the waters and the brine of the sea concurring, through the hidden magnetism of nature a sympathetic attraction of like to like arises, and by the mediation of the stone-making spirit it is coagulated. And this is the first foundation of the κοράλλογένεσις [Greek: korallogenesis, "coral-generation"]. These corpuscles afterward, by an ever-new influx of saline corpuscles, are at length condensed into a trunk, and then, gradually spreading out into branches, they produce this marine plant that we are describing. And since the sulphureous vapors have a certain viscous fatness joined and innate to them, this fatness, conjoined to the salts, communicates to the plant a certain stickiness and viscosity, by which the saline corpuscles, as if glued together, confer upon the plant that solidity which we note. And this is the reason why, within the sea, they are not easily broken or torn apart, neither by the agitations of the waves nor by the violence of the sea-monsters.

[Margin: Why coral grows hard.]

And just as nearly all plants are furnished with fibers and little channels, so too the stalks of corals are equipped through the marrow with a certain channel set in them by nature, through which — as through the fibers of a bone or of herbs — nourishment is drawn to the plant. Again, just as in bones there is marrow, and in herbs an alimentary moisture, so too that spermatic liquor of which we spoke in the preceding passages — composed of a sulphureo-saline fatness — diffused through the middle of the trunk and of the coral branches, while it drips, forms a new little plant in whatever thing it has chanced to strike. For otherwise it could not be explained how coral could arise within a shell, in the root [recte: perhaps "in radice" = "at the root region"], and without any openings of pores.

[Margin: Coral has hollow branches through which it draws nourishment.]

And this is the genuine reason why it sometimes takes the first beginnings of its birth from a shell, a brick, a rock, an iron tool, or a cranium. It now remains to explain the branchiness of this plant, without which it could not otherwise be called a marine plant.

It was observed by the coral-fishers that there is always drawn up together with the corals a branching weed, which most people say is a tamarisk or seaweed growing up from the sea floor. And the sulphureo-saline corpuscles crave this weed by a certain wondrous law of friendship, so that wherever they have seized upon one nearby, they clothe the whole of it as if with a kind of coral garment — something I should never have believed, had I not, as I mentioned above, seen a similar specimen in the Treasury of Cardinal Barberini, which at the root was clothed with a black bark, then a white, afterward a red, and finally tapered off into the weed I called tamarisk-like, or seaweed — exactly as we showed in the preceding Book regarding many herbs clothed with a nitrous bark, which is the proper work of saline-sulphureo-nitrous bodies. But where weeds or tamarisks of this sort are lacking, there nonetheless it extends out into branches, in the same way in which the mineral efflorescences are spread out into various twigs by the continued superaddition of the said corpuscles.

[Margin: The branchiness of coral.]

It seemed good to display these species of coral in a figure, where at **A** a coral cut from the rock in my Museum is set out for viewing, together with the other shells onto which it is seen to have grown — as in figures **A. B. C. D.** we append the schematic.

There is also pure, solid red coral, which is approved above all by everyone, as is plain in Figure **E**. Another is spongy, tuberous, and lightly jointed, of a white color, as in **F**. Another, which they call *Savalia*, of a black color, is termed pseudo-coral; its inner part is usually wood, which extends through all the branches, and it is nothing other than a plant clothed with a coral bark, as you see in **H** — which, if it is rubbed, gives off a marine and fishy smell.

[Margin: The species of coral.]

Now that these things have been set out, nothing remains except for us to show whence so great a power as authors are unable sufficiently to extol is present in corals. I answer in a few words: it comes from the spirits of salts tinged with sulphureous vapors. For as was shown in the Sixth and Seventh Books, precious gems have no other cause of their rare powers than the spirits of the differing salts which are fixed within them. Since, then, coral has within itself a great deal of nitrous and nitro-sulphureous salt, and consequently also something vitriolated attached to it, it cannot but be that from such a medley of things it should obtain very many powers, such as those we described a little earlier. For how much power is present in salt, how much in niter, how much in vitriol and

sulphur, we have already shown in particular treatises; and who does not see that these powers, joined together in a single mixed body, take on for themselves a great increase of power?

[Margin: Whence the powers in coral.]

Nothing is more celebrated among physicians than the tincture of corals — which, however, much as it is celebrated, is just as unknown the method by which it is extracted. Some have supposed, like Quercetanus [Joseph Duchesne, "Quercetanus"], that if coral is reduced to a powder by the virtue of a sharp and acid solvent, it can come about that it is dissolved by its menstruum — which is duly purified by the power of fire by means of radicated [rectified] vinegar — into a liquor, just as any burning spirit, apt to catch flame, is dissolved; and this they call the tincture of corals. Some think the tincture is accomplished by means of a *magisterium* of amber [succinum]; but if these men examine the matter well, they will find a tincture not of corals but of amber. They labor in vain, too, who seek the tincture with the mineral salts — niter, alum, vitriol. The reason is that the violent acrimony of the minerals, just as it burns and erodes the corals, so too destroys every power latent within them.

[Margin: The various methods of coral tinctures.]

There are those who think the thing can be accomplished with pumice and emery-stone [smiris]; but these men too seem to be fishing in the air, since they suppose that the coral must first be calcined by fire — than which nothing is more contrary to the tincture. Perhaps from radicated vinegar, or from honey, the business might have a not-unhappy success. For my own part, so far as I have been able to gather from the secrets of nature, I judge that nothing can be more convenient and opportune for extracting the tincture than the spirits extracted from honey, or from oak-wood, or even from wild service-berry [sorbus]. But let it suffice to have merely hinted these things to the chemists. As for pearls [uniones], since it cannot conveniently be done in this place, we shall discuss them more fully elsewhere.

[Margin: The various methods of coral tinctures.]

MUNDI SUBTERRANEI LIBER DECIMUS — METALLURGIA, SIVE ARS METALLICA

BOOK TEN OF THE SUBTERRANEAN WORLD — METALLURGY, OR THE METALLIC ART

In which the nature, properties, principles, and causes of metals are treated, together with their matrices, that is, their mines; whatever can in any way be considered concerning this discipline is here examined as exactly as possible, with a remarkable array of experiments and the most abundant reasoning.

SECTIO I — DE ARTIS METALLICÆ REQUISITIS

SECTION I — On the Requisites of the Metallic Art, and the Condition of Mines

CAPUT I

Chapter I — On the Object of Metallurgy; and likewise on the Material and Formal Cause of Metals

Setting aside everything that the Scholastics are accustomed to teach about the object of the arts and sciences, and about the matter and form of the natural composite — taking these as commonly known — we extend our pen only to those things that concern the proximate causes of the generation of metals [Metallogenesis]. But in order to pursue the web of our undertaking once begun, we take up the thread of Ariadne and trust that, with God's help, we shall unravel above all those matters that until now have lain entangled and unresolved in the difficult labyrinth of natural philosophy.

The material object of our metallurgy is the perfect, purely metallic mixed body, excluding all the other minerals which we have already treated abundantly in what precedes. These [metallic bodies] are: gold, silver, bronze (or copper), iron, tin, and lead.

[Margin: The formal object of metallurgy.]

By the formal object we mean the manner and way in which Nature generates these things in the bowels of the Earth. From their native places they can be dug

up; they can be founded and shaped into statues; they can be transmuted one into another. Insofar as they can be extracted, smelted, melted down, cast, and figured into rings, collars, bracelets, coins, and utensils of every kind, they can be the object of various arts — namely of the metalworker's art, of statuary, of alchemy, of ironwork, of the goldsmith's craft, and of minting. And insofar as they are subject to the exchanges of merchants, they yield their proper subject to the art of the money-changers — of which matters there will be a full discussion in the course of this work.

[Margin: The matter of metals — what is it?]

We declare the proximate matter of metals to be neither the prime matter of the Peripatetics, nor the influx of the stars, nor the elements, but rather a vapor and exhalation, sulphureo-saline-mercurial in character, by which alone the metallic bodies — as though concreted from the seed of the chaotic mass — obtain their origin. The remote matter, however, we declare to be the *hyle*, the concurrence of the elementary qualities, and the influx of the stars. How all these are to be understood will become clear from what follows.

[Margin: The explanation of the generation of metals.]

It must therefore be noted that within the chaotic mass there lies hidden a certain rich, saline juice, congenital to the elements, which, driven into a vapor by the power of the subterranean fire, is dispersed through all the [fibers of the Earth.]

— **[continuation of Caput I, from Fol. 162]** — through all the fibers of the Earth; and where it finds a matrix proportioned to itself, it adheres to that, and, cooked over a long stretch of time, finally degenerates into a metal appropriated to the clod or matrix of the earth.

I said *juice* in the first place, by which I designate that mercurial liquor — that is, the spirituous substance — which we call the radical moisture inherent in all things. I said *rich juice* in the second place, that is, Sulphur, by which we mean that richness implanted in all things for the cohesion of their parts, shining forth most of all in sulphur itself. I said *saline*, because Salt is the earthy element, inasmuch as it supplies to all mixed bodies a firm consistency and a fixed substance — and this indeed has its origin not so much in the aforesaid juice as, most of all, in the very clod of the earth.

[Margin: Aristotle's opinion.]

These, then, are the three [principles] that concur in the composition of all metals, as will be shown later. And I demonstrate as follows that this our opinion

agrees with the first philosophers. Aristotle, in *Meteorology* III, expressly says that the matter of metals is a vapor. To show this, he premises a twofold exhalation: one vaporous, the other smoky. To the dry fossils — such as sandarach, ochre, minium, and stones, which cannot be liquefied — the dry exhalation belongs; but to metals — such as gold, iron, and bronze, inasmuch as these are ductile and capable of being melted — he assigns the vapor as the cause of their generation. He explains this more fully afterward in *On Generation and Corruption* II, in these words: "*Metals therefore have within themselves a great deal of moisture that is watery, yet so acted upon by the elements that it has become glutinous.*"

I should like you to know, however, that the Philosopher here did not understand a simple vapor arising from the pure element of water. This is plain from the fact that water, attenuated from the simple element of water, generates nothing differing from itself in species, but is finally resolved into what it was — as one sees in the vapor of boiling water, which on the lid passes back into drops, that is, into the very same water out of which it had passed into vapor. The same is plain in rains, snows, hailstones, and the like, of which we treated in the *Meteorology*. Therefore something else lies hidden beneath that vapor concerned with the generation of metals [μεταλλογονικῶ (metallogonikō, "metal-generating")], beyond the simple vapor of water. With a fine line of reasoning, agreeable to our own view, Albertus [Albertus Magnus], while explaining Aristotle's opinion, teaches this in these words:

[Margin: Albertus's opinion.]

"*The proximate matter of metals is a subtle, unctuous, and viscous moisture, excellently mingled with attenuated earthy [matter].*" What is meant by "subtle moisture" but the mercurial humor of Nature? What by "unctuous and viscous" but sulphur? (For, as we have shown elsewhere, sulphur is essentially rich, which is why it is so easily kindled and made to flow together.) And what else is "excellently mingled with attenuated dry earthy [matter]" but the salt of Nature, which connotes that which lends consistency and body to the composite?

And because that vapory exhalation always has joined to it a hot and dry exhalation — without which it could not be raised up — it comes about that whatever is dry in the metallic clods derives from the dry and hot exhalation, while whatever is vapory passes (on Aristotle's own testimony) into the matter of metals. And this is what Albertus means when he says "excellently mingled with attenuated subtle earthy [matter]."

Indeed, the opinions of various authors approve this view of ours. Gilgil the Arab [al-Jaldakī (?)] [?], as reported in Albertus, asserts that the matter of metals is lime and lye — that is, ashes soaked in water. Here let no one understand by "lime" or "ash" a lime or ash like our lime and ash; rather, he undoubtedly meant pulverized earth, or earthen powder, or the salt implanted in the nature of the earth, which, once infused with water (or impregnated with the mercurial vapor of sulphur), finally passes into metal.

For there is in the matter of metals a certain viscous moisture, the sign of which is that, when liquefied by the heat of fire, they flow, but by the cold of air and water they again condense. This happens, on the testimony of Agricola, in such a way that there is more of water in them and less of earth; for simple water is not their matter, but a mercurial liquor mixed with earth, inherent in the chaotic mass from the beginning, which various motions then bring forth: the flow of water softening the earth, the earth mingled with water, the force of heat acting upon the mixtures — out of which, finally, that metalliferous juice [μεταλλογονικός (metallogonikos, "metal-generating")] is elaborated and engendered. And this in such a way that the four elements are nothing but certain vehicles of the powers implanted in the aforesaid vapor; for without this complex of powers you may cook earth and water as much as you please, and yet you will extract from them nothing other than what they were before, namely water and earth. But if this spermatic vapor (for so I call it by a certain analogy to the seed of plants and animals) is added to the elements, then indeed they first exert their powers, and, according to the condition of the matter (that is, of the earthy clods), produce a metal differing in species. But all these things will be confirmed by various experiments in the books that follow.

From which it plainly appears that metals are by no means generated immediately from elementary and simple water, but from a vapor appropriated to each. But how they grow into such great hardness, one may rightly wonder.

[Margin: How metals grow into such great hardness.]

I say, then, that this comes about not from cold, nor from heat simply, but solely from the attenuation of the moist — that is, from evaporation or desiccation. For since there are in the nature of things two kinds of spirits, hot and cold — from the former indeed proceeds the principle of heat in things; the latter, no less than the former, even though cold by nature, are nonetheless most subtle and spirituous, as is evident from the north wind, and as is commonly known — whenever, therefore, hot spirits abound, such as the nitrous, the vitriolic, the

sulphureous, and the like, then the things they pervade acquire a warm [temperament].

— **[continuation of Caput I, from Fol. 163]** — acquire a warm temperament. But if [there pass through them] the breaths of the northern winds, which pass through snowy places, or subterranean winds which pervade the most frigid places of the clods (places that are by nature of a cold temperament), then the things they pervade acquire a cold temperament. From this it follows that each spirit, pervading the moist clod — the hot indeed by attenuating it into vapor, the cold by drying it out and freeing it from all superfluous moisture — induces the hardness proper to each thing, whether to stones or to metals.

The truth of this even the Philosopher himself acknowledged, who, in the passage cited above, after he had set forth the twofold exhalation, finally infers that *all things consist of a hot agent and a moderating cold heat*. Therefore it must be said that concrete bodies — whether they be stones or metals — solidify not by cold alone, but by heat, whereby the superfluous and impure moisture of the earthy clods is consumed, and the things, according to the condition of the vapor, turn out as this or that stone, or as some other metal intended by Nature.

All things, therefore, come to be by the force of heat as the principal instrument. From the metallic spirit, just as marble and any other stone is generated when proportioned moisture flows in [uti caetera proportionata affluente humido], so too from the same is metal generated.

[Margin: The form of metals.]

So, just as marble is not generated by cold alone, neither is metal — although, once it has been formed, it is melted by heat; but it is given firmness by the vigor of the metallic spirit, when it is united with the fixed [principle] by means of the moist, with heat always acting. But since we have explained these matters abundantly elsewhere, let us proceed to other things.

As for the form of metals: there are some who maintain that the forms of metals consist of the forms of the elements. But since the forms of the elements are accidental, it would follow that the forms of metals too are distinguished only accidentally. This being absurd and contrary to manifest experience, I judge that this opinion ought not to be refuted with superfluous words. Let us therefore philosophize more soundly.

I say, then, that the forms of metals are substantial, and are distinguished among themselves in species; that they give to each metal its proper being and proper

virtues, distinct from the rest. This is true not only in the manifold variety of gems and stones, but also in the species of metals. Thus the diamond [Adamas], the serpentine [Ophites], and the pumice [Pumex] is each what it is; for every stone and every gem has its own proper form, by which this and that gem is named and is distinguished in species from the others. But this form is not produced proximately from the mixture of elements, nor from cold, heat, moisture, and dryness, but from a seminary [seminarium] and an architectonic spirit [from the Liber Decimus, Sect. I.] inherent in the matter, which shapes the matter according as the seminary requires, and elaborates it according to a fixed and indivisible law of combination. By this seminary we understand nothing other than the sulphureo-saline-mercurial Chaos, out of which, from the first beginnings of things, all things were produced by the Divine Architect.

[Margin: The seminaries of Nature.]

Let the reader consult Book VI, Section I, where we have reasoned more fully concerning the seminaries of Nature. Now the seminaries were created by God as the principles of things, from which the individual species of things obtain their essential forms. These seminaries are not always enclosed within fixed and distinct bodies, as happens in the seeds of plants, but often remain in the matter in such a way that they can in no way be perceived. Thus in the branch of a willow the seminary of the tree is confused [i.e. indistinct]; for the willow produces no seeds, yet that it is present there the propagation of the tree amply and abundantly shows.

[Margin: An experiment.]

For if a branch is cut off and committed to the earth, a tree is produced from the branch, and from that tree countless others — as experience too demonstrates in the art of grafting [Phyteutica]. In the same way, in the generation of stones, gems, and metals, the seminary, even if it cannot be perceived, nevertheless furnishes the principle to gems and metals, and by the plastic faculty of the spirit passes into either gem or metal. For just as the plane tree, the mulberry, the linden, and the fir have different forms of branches, so the diverse kinds of metals — gold, silver, iron, bronze, and so on — produce, after the manner of trees, their flowerings or metallic plants out of their ores; and these, like those, have forms and virtues distinct in species. These things we shall confirm, God willing, by various and wonderful experiments in Book XI.

Since, therefore, metals are generated proximately from a sulphureo-saline-mercurial vapor mixed with a dry exhalation, we thus define metal in general:

[Margin: The definition of metal.]

Metal is a fossil body, hard, liquefiable by fire, and ductile by the hammer in every direction. I said *fossil body*, because it is dug out of mines; *hard*, because it is a concreted and most compact body; *liquefiable by fire*, because it coalesced from a sulphureous richness; *ductile*, because, possessing viscosity, its parts, joined as if by glue, are easily extended by the hammer. But if it had solidified from the simple element of water and from cold, then — like ice from excessive heat — by reason of its uncompacted hardness it would dissolve, and being melted by fire would grow watery, and would possess no ductility at all. Therefore [metals] cannot consist of the simple element of water, nor of cold.

From this definition we reject mercury, which is neither ductile nor flows in fire, but is resolved into an exhalation; yet it is a metallic body, concurring primarily toward the generation of metals [μεταλλογένεσιν (metallogenesin, "the generation of metals")].

CAPUT II

Chapter II — Whether the Heaven and the Stars concur in the generation of metals [μεταλλογονίαν (metallogonian, "the generation of metals")], and how the heavenly bodies can concur in the production of metals

The opinion which teaches that metals derive their origin and composition from the influx of the stars has so prevailed everywhere that it has found a place even in the minds of the wisest philosophers — at which I cannot sufficiently marvel. For they suppose the influxive power of the stars to be so subtle, and so equipped with rays of such penetrating force, that, hurled even into the inmost and deepest bowels of the Earth, it compels a proportioned clod, by the action of concurring elements, into this or that metal. Consequently, they hold that the seven species of metals took the beginnings of their names from the influx of the seven planets:

[Margin (planetary characters and metals):]

- ☉ Gold [Aurum]
- ☽ Silver [Argentum]
- ♄ Lead [Plumbum]
- ♃ Bronze [Æs]
- ♂ Iron [Ferrum]
- ♀ Tin [Stannum]

- ☿ Mercury [Mercurius]

They make the Sun preside over gold, the Moon over silver, Jupiter over bronze, Mars over iron, Venus over tin, Mercury over quicksilver, and Saturn over lead; and they call them the fathers and mothers of the metals. The alchemists, embracing this naming-scheme (as the saying goes) with both arms, did not for the same reason disdain to mark these metals with their planetary characters too, as may be seen in the margin.

But whoever weighs these matters on the finer balance of reason will see that the scheme rests on mere divination, and is received with great applause among the unlearned common folk, while in very truth it is mere trifles and old wives' fables, which crept into philosophy through the superstitious astrologers of the Chaldeans and Egyptians — as we set forth at length in our *Oedipus Aegyptiacus*, in the treatise on the astrology of the Egyptians.

Yet let no one, while I assert these things, suppose that I thereby deny the influences of the heavenly bodies and the stars; for to deny these I judge to belong not so much to an imprudent as to an ignorant philosopher. This much only I say: that it cannot be that the stars, by their *actinobolisms* [emissions of rays] — or, what is the same, by the immediate irradiation of their fiery light — produce metals in the deepest abysses of the Earth. For so far is it from the case that those rays penetrate the earth, that rather, as soon as they touch the Earth's surface, they are at once driven back and reflected into other and still other directions. For if they were to go further, no reflection would occur on the Earth's surface — which is contrary to all experience. It would also follow that no heat would be produced on the outermost surface of the Earth, since the greater or lesser intensity of heat in different climates comes from no other source than the altitude of the Sun, as we have amply demonstrated in *Ars Magna Lucis et Umbrae* [Kircher, *Ars Magna Lucis et Umbrae*].

But I have thought this matter should be demonstrated by a geometrical figure. Let the Sun be D. Let it project its rays — that is, its *actinobolism* — DC onto the surface of the Earth AB at the point C. I say then, supposing first (by an axiom received with the unanimous consent of all philosophers

[Margin: The rays of the stars do not penetrate the earth.]

Diagram. A geometrical optical figure occupying the lower half of the page, demonstrating that solar/stellar rays do not penetrate the Earth but reflect off its surface. At the upper left, the Sun is engraved as a radiant disc bearing a human face, emitting a dense fan of fine ray-lines downward. These rays strike the

convex arc of the Earth — drawn as a hatched, curved band across the lower page, with sketched coastlines/landmasses on it — and are reflected back upward, the incident and reflected ray-bundles crossing in an X above the Earth's surface. The construction letters named in the surrounding text are the Sun D, the surface AB, the incidence point C, and the angles DGE, EGA (incidence equal to reflection), and DGI, GIE (the total incident actinobolism equal to the total reflected). The point-letters A, B, C, D, E, G, I are referenced in the prose but are set very small on the plate and could not all be individually resolved against the hatching.

- Sun (upper left): radiant faced disc, emitting downward ray-fan (= point D in the text)
- Earth's arc (lower band): hatched convex surface with sketched landmasses (= surface AB)
- Incident ray-bundle: descends from Sun to the surface
- Reflected ray-bundle: rebounds upward, crossing the incident bundle
- Individual point-letters A, B, C, D, E, G, I as printed on the figure: [?] (too small / obscured by hatching to confirm placement on the plate)

[Below the figure, the text continues in two columns:]

by an axiom received with the unanimous consent of all philosophers and mathematicians, namely that all angles of incidence are equal to the angles of reflection) — thus the angle of the Sun's ray DGE is equal to the angle of reflection EGA, and so of all the other incident rays let the same judgment hold. And the angle of the whole incident actinobolism DGI is equal to the whole reflected actinobolism, the angle GIE. This being posited, I say that the rays of the Sun, or of any other star, as soon as they reach the Earth's [surface...] have struck the surface of the Earth, they do not penetrate any further but are at once reflected away at an angle equal to the angle of incidence. From this intersection of the incident and reflected rays — the region GHI — the air is intensely heated by the crowding-together of the rays, and this necessarily produces the heat we feel in summertime. For the higher the Sun stands, the more the intersection of the incident and reflected rays raises the heat at the Earth's surface; whereas the lower the Sun's altitude, the less heat it raises — as happens in the winter months, when the Sun is not far from the horizon. Indeed, the same becomes evident even within a single summer's day, from the Sun's rise toward the meridian and its decline from there toward setting. [Margin: Objection.] For in the morning, as the Sun has a lower elevation above the horizon, so too it produces less heat; and the same is plainly true of the Sun's descent toward the western horizon around evening. From all this it is clear that every degree of heat

at the Earth's surface is caused by the reflection of the Sun's rays — the *actinobolisms* — which would cease entirely if the solar rays passed into the Earth without being reflected, like so many darts piercing the body of the Earth. And that they raise no heat within the Earth is confirmed by experiment, since in summer the underground places are found to be far colder than in winter; which would not be the case if the fiery rays of the Sun penetrated the Earth.

But you will object: that this power of metal-generation [μεταλλόγονον, *metallogonon*, "metal-begetting"] consists not in the rays, but in the outflow of some hidden power — a force penetrating all things, which finally produces the metallic effect in suitably disposed matter. Yet since the power of all hidden influences is conveyed only by means of the heat and light that the rays always carry naturally within them (these being the vehicles, as it were, of the influential powers in question), it necessarily follows that, together with the reflected rays, the powers too are reflected and communicated to the neighboring air. For the air, once imbued with them, then communicates them to the waters, the plants, the animals, and to inanimate things — as we shall see shortly.

[Margin: How the rays of the Sun and Moon can be a cause of metals.]

From this it is clear how mistaken is the opinion of those who suppose that anything can be produced *within* the Earth by the heat, the light, or the radiation of the stars' influences. Since, then, I declared above that I by no means deny the light, the heat, and the influences of the heavens and the heavenly bodies, it now remains to explain *how* they can contribute to the production of underground things.

I say, then, that all the heavenly bodies of the stars and constellations — both the wandering and the fixed — act upon the lower (that is, the elemental) world not only through heat and luminous rays, but also through specific powers proper to each individual heavenly body. I have treated these at length in the first volume, Book IV [*Ars Magna Lucis et Umbrae*, Bk. IV], and in our *Itinerarium*, and so I have not thought it necessary to repeat them here. I say only this: that there lies hidden in each of the stars a certain specific power — implanted by God the Best and Greatest, the all-wise Architect, as a natural endowment of its body — which they pour into elemental bodies through a continual *aporrhoea* [ἀπόρροιαν, *aporrhoeian*, "emanation"] or effluvium; and that these influential powers always answer, by a certain analogy, to the powers that shine forth in sublunary compounds — just as, in the Fourth Book of this work, we sufficiently demonstrated regarding the Moon's influence upon the sea. These things being

laid down, I now explain how the stars contribute to the generation of subterranean things.

[Margin: How metals are generated by a heavenly power.]

These specific powers implanted in the Sun, the Moon, and the stars — which some call influences, but which we call *panspermia* [πανσπερμία, *panspermian*, "the seed of all things"] — are like seeds implanted, according to a certain analogy, for the producing of things. By their first influx they impart themselves to the air; the air, as if tinged with them, transmits them into the watery element; the watery element, made fertile by them and stirred by the Sun and Moon into its daily ebb and flow, conveys them through hidden underground channels into the secret tracts of the earth. The fire, or subterranean Sun, then resolves the cooked waters into vapors; and the resolved vapors, where any passage lies open, are diffused through the inmost cracks and fissures of the earth — like blood through the veins we call capillaries — and wherever they encounter a like and suitably disposed clod, they cling to it, and, drawn at last by a kind of magnetism through Nature's likeness, degenerate now into this gem or that stone, now into this or that mineral or metal. And in this way I judge that the heavens and the heavenly bodies can contribute to the generation of underground things — by means, that is, of the elements and of the Vulcanian subterranean Sun. But I shall develop this a little more fully.

When God brought forth the whole machine of the world, with all that it contains, out of that chaotic mass of the primordial world at the beginning, He furnished each of the heavenly bodies with its own solidity, with a fluid nature of moisture, and with a further fiery portion added to them. And just as, in those lofty tents of the heavens, He purged them utterly of all admixture with anything alien to themselves, so too it is likely that there is in them — out of that wonderful combination of things — something, according to a certain analogy, of those things by which we see all things in this sublunary world to consist: namely, besides the portions of the four elements, also something analogous to our sulphur, to our mercurial liquor, and to our salt. And these, while by their thinness and utmost subtlety they serve no other purpose than the preservation of their own body, yet, when communicated by an outflow to the sublunary world and to the grosser elements, finally acquire a body; and through the wondrous magnetism of heavenly and earthly things, they at last degenerate into that variety of things — both outside and within the most hidden storehouses of the elemental world — which we cannot sufficiently marvel at.

Since, then, the lower world (as Aristotle testifies) is governed by the upper, surely it is not by

motion, heat, and light alone that we ought to suppose it accomplishes this, but rather by the powers proper to each individual heavenly body — of which the *actinobolisms* of the stars are, as it were, the vehicles, and the carriers of all their powers. These powers, first communicated to the airy element, are what the air is impregnated with; and by their ministry, whatever arises in the sublunary world — whether in the air, in the waters, or in the lands — cannot in the least be preserved in its perfect and natural being without that heavenly outflow of powers [*aporrhoea*] which is present in the air in a peculiar way.

[Margin: The impregnation of the elements by heavenly influxes.]

[Margin: The simple elements do not contribute immediately to the production of metals.]

Finally, this air, made teeming with heavenly impressions — just as it perpetually lashes the watery element with its motion — likewise implants in that element the powers innate to itself, together with the heavenly outflow; and from this, by the heavenly and airy spirits, it gives birth to that countless variety of things which we behold in the ocean, the seas, the lakes, and the rivers. For since the air by itself and by its own nature can in no way serve for nutrition — being endowed with too thin a substance — it therefore communicates to the watery element the powers it has drawn from heaven, so that it may acquire some body fit for the nourishment of all things. For in this way no thing can lack water or moisture; indeed, without it the world would necessarily perish.

Therefore, lest that vast womb of the Geocosm should seem to be left destitute of this moisture in the generation of subterranean things, the supreme and ineffable wisdom of God brought it about that the air, by the subtlety of its nature, should be carried through the pores of the earth, and the water through the water-conducting channels [*canales hydragogi*] established by Nature, into the inmost bowels of the Earth and the deepest abysses; and that from there, by the agency of the subterranean Sun, it should — with vapors diffused through the whole mass of the Earth — make fertile, nourish, and preserve, both for the generation of fossils and metals, and for the generation of the plants that take their origin from the earth itself.

From all this it is plainly evident, first, that a pure and simple element cannot contribute to the composition of things; nor, so long as we make mention of the elements,

[Note: The right-hand column of this folio (fol. 167) carries the prose that continues into the second column. The text resumes:]

do we understand the elements [as pure]. On this reckoning, in any earthly body whatsoever, we say that salt is the predominant principle, whose marvelous faculty we declare to be the coagulating element of things among the other four — which indeed I should never have believed, had the spagyric [chemical] art not taught it me. For in the dissection or resolution of any earthly body whatsoever, I have seen it to contain a certain fiery, incombustible, fixed, and permanent salt-spirit, whose powers are so marvelous that they could scarcely seem credible to those ignorant of these hidden mysteries of Nature.

[Margin: The marvelous power of Salt.]

You will find, indeed, that the moist has so coalesced with the fiery fatness, and this with a certain earthy substance (which is the salt itself), in such equal proportion, that they can no longer be separated from one another. Hence it was not amiss that by this kind of moisture they understood the Mercury of Nature; by the fiery fatness, sulphur; and by the earthy substance itself, the salt of the chemists. Without these — unless the elements were impregnated by them — they could surely produce nothing heterogeneous of themselves and by their own nature: for pure earth joined to pure moisture would make nothing but mud, destitute of all power.

Secondly, it is evident that Heaven and the stars contribute as a universal and remote principle to the generation of metals and of the other minerals, insofar as they are, as it were, certain vehicles of the heavenly powers and the astral impressions; but that the proximate principles of metal-generation are the powers carried down through the air and the water into the inmost bowels of the earth — where, cooked and digested by the Vulcanian fire, they at last pass into the seed of all those things that take their origin from the earth. And so the proximate efficient cause is, properly speaking, the subterranean fire; the material cause is the sulphureo-saline-mercurial vapor and the proportion of the earthy clod for producing this or that metal or mineral; and finally, the final cause is the infinite usefulness for the needs of the human race and of Nature.

CAPUT III.

How that unctuous moisture, of which Metals are composed, is elaborated by Nature; and what in it Sulphur, Mercury, and Salt are.

We said in what preceded that the pure elements, water and earth, cannot contribute to the composition of metals unless they are altered by the seeds of the other things with which they are packed. For just as by their nature they are homogeneous, so they are always resolved into the homogeneous. This is clear from fire, which resolves the rarefied moist back into what it first was; and pure water joined to pure earth makes mud, which, when rarefied by heat, returns into those things it was before — namely, the powder of earth, and the water resolved by heat.

[Margin: The simple elements do not contribute immediately to the production of metals.]

Since, then, we have defined metals above as bodies hard, firm, solid, extensible under the hammer, and liquefiable by fire, they are surely recognized to have within themselves something else, hidden, into which they degenerate to take such forms. For how could they degenerate into that solid hardness merely by a mixture of simple earth with simple water? How could that inseparable fatness and viscosity — by which metals can be extended under the hammer without breaking, or melted without any flowing-away or moistening of their moisture — be brought about by the agency of the simple elements alone? No one can conceive this; since nothing gives what it does not have. In the inmost element, then, at the very center of the elements, there must necessarily lie hidden the cause of such great effects — that which furnishes metals their origin. And this we say is nothing other than that unctuous and viscid moisture, whose vapor, continually exhaling and diffused through the inmost fibers of the earth and the hidden ducts of the mountains, at last — wherever it encounters suitably disposed matter — there, according to the degree of its purity or impurity, generates now a stone or a gem, now a mineral or a metallic body.

[Margin: The origin of the viscous and unctuous moisture.]

But how this unctuous and viscid moisture is elaborated by Nature, one might rightly wonder. I say that it is derived from the outflow of the astral powers and the heavenly spirits. These spirits, being by their origin most pure and most thoroughly purged of all earthly dregs, do also — by reason of their supreme and inexpressible thinness and subtlety — at once penetrate all the elements, and by a certain magnetic attraction are joined, in a wonderful manner, to those things that in the primordial chaotic mass of things were one and the same. The elements air and water, made fertile by them through the sea's approach and recess (caused by the agency of the Sun and Moon), are diffused into the inmost

storehouses of the earth; there, cooked anew by the subterranean fire, and digested and purified through manifold and repeated cooking, they pass into that unctuous, fatty, and viscid moisture.

[Margin: How that unctuous moisture degenerates into metal.]

Its vapor, carried down through the hidden fibers of the earthly veins, is first — by the innate and invisible power of salt — dissolved into a salty earth [*terra salsuginosa*], moistened by the body's [?] sprinkling, and purified in many ways, both by sublimation and by filtration accomplished through the pores of the earth. And in this way, cleansed of all the earthly refuse mingled with it, it at last degenerates into a kind of most brilliant white sulphur. This pure and washed sulphur, enclosed in the matrices of the Earth, further cooked by the Vulcanian heat and by its own, is over the course of many years fixed into silver by the spirits of its own salt.

[Margin: The generation of gold.]

And if this white and incombustible sulphur is tormented by a still stronger fire to the point of redness, it is at last turned into the most thoroughly purged [?]... which, by the continual vapor of its own resolution

[Note: column break; text continues in the right column of fol. 168:]

under an equal portion of fatty moisture and earth, is transmuted by an inseparable union into pure gold. All of which will be shown in the Eleventh Book [*Liber XI*], in experiments adapted to the pattern of Nature. But if the vapor of this unctuous and viscid moisture has not yet been purged of all impurity and feculent dross, then, according to the degree of its purity or impurity, it is converted now into a more perfect, now into a more imperfect metal.

These things being set forth, one might rightly ask further: what, then, is that unctuous and viscid moisture?

[Margin: What the unctuous moisture is.]

I say it is nothing other than that radical moisture of Nature, which, just as it was implanted in things from the first beginnings of the chaotic mass by the ineffable wisdom of the Divine Architect, so it persists in all and each of the things down to this very day, and is everywhere called the Mercury of Nature. Its unctuous and viscid quality is nothing but that fatty warmth of Nature implanted in all things, which by a certain analogy the chemists call the sulphur of Nature; while the earthy part that lies hidden beneath it they call the salt of Nature, because it

furnishes all things a firm substance and body. And that all things consist of these, the spagyric art has long since learned by experiment. So that the four elements might not seem idle in the nature of things, Nature, from the beginning of things, grafted this Mercurial moisture into the watery element, the sulphureo-warm and inborn into the fiery and the airy, and the fixative salt of Nature into the earthy element — so that they might be, as it were, the vehicles of those material principles of which all things consist.

Hence nearly all the philosophers have set down, as the material principle of metals (in general only), a moist vapor mixed with earth — as appeared from the preceding chapter. But because they did not reach Nature's proximate procedure in the order of composing metals, I have judged it worth elucidating here, for the reader's benefit — somewhat more fully, perhaps, than was fitting — having been taught and led by experimental knowledge alone. For in physical matters, to philosophize without experiment is the same as if a blind man should foolishly presume to pass judgment on color.

CAPUT IV.

How all things are produced by the efficiency of the earthy and of the moist heat; and likewise, what that is which renders metals fluid in fire, but not stones, plants, and other things; and how Nature proceeds in dissolving and perfecting things.

Here I shall lay open a singular secret of Nature, which, since it unfolds the inmost mysteries of the composition of things, I hope will also be such that, once these things are rightly understood, the origin and causes of metals may become known to the reader most intimately. And although I shall propose it in other terms than those usually employed in the Schools, it will nonetheless be evident — if his words are rightly weighed — that Aristotle held the same view.

[Note: the right column of fol. 168 carries the opening of Caput IV's body:]

Two things there are in the nature of things (if matters be considered, setting aside all metaphysical contemplations, under strict physical rigor) which contribute to the *synthesis* [σύνθεσιν, *synthesin*, "putting-together"] of all things, are present in all, and are the cause of all generations and corruptions. And first there is the earthy, spiritous, concrete, corpulent matter, in whose center there lies hidden that which furnishes things their substance and corpulence — which we call the

fixed [salt]. We call it the fixed salt of Nature.

[Margin: The fixed salt of Nature fixes all things.]

And that the matter of the kind we have described should be such, it gets from the fixative element implanted in it. I said "matter," because, considered in itself, it lacks all active power; and it can be said to act only insofar as, by the innate appetite with which it is endowed — or, what amounts to the same, by a certain implanted magnetism — it draws to itself those parts most like and proportioned to itself.

[Margin: How the resolution of bodies takes place.]

I said that this earthy matter is spiritous, subtle, and active — that is, the central salt of Nature, the volatile salt, which by acting perfects and completes the other part when it is joined to it. And just as from that other part it receives corpulence and consistency, so too it communicates to it an active, formal, and specific power. And whenever these subtle and tenuous spirits evaporate, the matter is said to be dissolved, the fixed material substance remaining behind. And just as these formal parts are born for acting, so those material parts are born for being acted upon — as is evident from the artificial resolution of compounds, by which parts essentially diverse are extracted from diverse compounds. Thus the spirits of niter, of alum, of vitriol are utterly distinct from the spirits which are distilled and extracted from vegetables — of wine, of roses, of lilies, and of countless others. So that, not without reason, just as resolution into prime matter is not granted by the Peripatetics, so too no body whatsoever can be wholly devoid of spirit. For if you resolve bodies into ashes however far you please (which are believed the driest of all things), yet even these are further sublimated — partly into salt, and partly, if they are tortured by a more violent fire, they flow into glass.

[Margin: The moist glue of Nature.]

But these parts — namely matter and spiritous substance — being very diverse among themselves, have the greatest need of a bond by which to be united and coupled to one another under the strict laws of friendship. And this is nothing other than the moist: a sort of middle between the volatile and the fixed, between body and spirit — or, what amounts to the same, between the gross and the subtle. Yet because no change of things can take place without the rarefaction or dissolution of this moist, Nature has appointed heat as a kind of *Archeus*, by whose aid the rarefied moist glue of Nature is dissolved; and once it is dissolved, the parts too are dissolved, the spiritous things fly off, and the bodies fall together.

And the more easily this moist is resolved, the more readily too the body lies open to corruption; but the fatter, more viscous, and more compact the moist is, the more difficult it necessarily is to dissolve — and consequently, by reason of the close packing of its well-mingled parts, it is less subject to corruption. Hence it is clear why a watery moisture, having little viscosity, easily passes off into vapor when rarefied: namely, because vapor has a watery moisture that is very undigested and ill-knit in its parts.

[Note: text continues in the right column of fol. 169:]

By contrast, those things which have a more cooked and digested moisture, intimately mingled with their parts, are — by reason of the predominating fatness and viscosity — dissolved only with difficulty, as if by a more tenacious bond.

It is therefore clear from these things how our material principles, of which we have said all things consist, are to be understood. For what else does that spiritous substance denote but Sulphur? what else the fixed but Salt? and what else, finally, does that viscid moisture designate but Mercury? — as we said in what preceded, from the mind of the ancient sages.

[Margin: The principles of nature: sulphur, mercury, salt.]

In like manner, in plants and living things, the volatile part is called the soul, the fixed the body, and the moisture the true and physical union by which the soul is coupled to the body.

But why that moisture is so easily dissolved in vegetables and animals, yet so hard to dissolve in mineral and metallic bodies, one might rightly wonder. And since in this lies a great part of the knowledge of natural things, we shall unravel it somewhat more fully.

[Margin: Why moisture is so easily soluble in plants and animals, but not in metals.]

Nothing is better known than that moisture in certain things, when rarefied by heat, soon vanishes into vapor; while in others it cannot be resolved into vapor even by the most vehement fire. But how this comes about, I judge to be known to few. I say, then, that that Mercurial moisture is a kind of middle between sulphur — that is, the spiritous — and salt — that is, the fixed — as we hinted above. And this viscous moisture, the glue of Nature, according to the diversity of bodies, either clings to some things not at all, or is mixed in under a very small portion; while with others it is moderately and part by part commingled and joined.

Whence a threefold kind of moisture arises: the first is a certain watery moisture, wholly incompact and almost devoid of all viscosity; the second is more compact; the third is found most compact of all.

[Margin: Why metals can everywhere be melted by heat, but not resolved into vapor.]

The first is seen in the mud that is made from powder mixed with water; which, being incompact and consisting of slight viscosity, is dissolved into its elements by even the least rarefaction of external heat. But if you knead earthy powder with an oily matter,

[Margin: Why oil and wax flow when heated, but do not evaporate.]

then indeed a mass is made which is dissolved not so much by external heat — unless it be forced by a more vehement fire — because the fatty and viscous matter is more intimately knit to the powder, so that the spirits, unable to fly off, are held in. And daily experience teaches that the same happens in wax. For the reason why, when it flows rarefied and thinned by heat, the spirits do not fly off, is that viscid moisture by which the parts are so coupled to one another that the heat, when it does not allow it to evaporate into the air, at least resolves it into a flux — by reason of the bond of the more tenacious viscid moisture by which the parts are knit to one another. And from this it is also clear why wood and stones are consumed by fire — wood into ash, stones into lime — whereas metals flow when melted. [Margin: Why wood turns to ash, stones to lime, and metals melt in fire.] For wood and vegetables of every kind, since they do not possess a well-compacted moisture (lacking the viscosity required for it), have a moisture that is more watery in character. Stones, by contrast, possess only a scant moisture. Hence in both cases the spirituous parts, for want of the viscid moisture, dissolve the fixed parts — in vegetables into ash, in stones (because of the greasiness of their sulphur) into lime. Metals, however, since they possess a viscous moisture, also have their parts intimately mixed and compacted with one another. The result is that, through the action of fire, that moisture is thinned and swells to a considerable increase, yet is not separated off and does not withdraw from its own body; instead the whole passes over into a liquid.

[Margin: The source of the fusibility of metals in fire.] Whoever, therefore, considers this operation of Nature more deeply will necessarily be forced to admit that metals, when worked upon by fire, do not flow at all because they are governed by a predominance of water; rather, it is because of the remarkable viscosity of their radical moisture, by which the parts are so knit to one another

that it does not permit them to pass off into smoke and vapors. For if they consisted of a simple watery moisture, they would certainly not flow by the agency of fire but would be converted into lime, just as happens with stones roasted in fire. Metals, then, flow in fire because their moisture — by which the metallic spirits are bound together with their vapor — does not, under the force of heat, withdraw, but is so thinned and swells up that it also thins and rarefies the parts it binds; and herein lies the flowing of the metallic parts.

This is further evident as follows. If mixtures of heterogeneous parts and the dross of earthy clods have been mingled with metals, only the homogeneous parts of the metal will flow, while the other things of differing kinds pass off — as scoria, or as a pumice-like dross, and as soot — with some loss of the metal.

[Margin: Why metal becomes purer when roasted in fire.] And this is the reason why metals come out purer when roasted in fire: because the mixtures of heterogeneous parts, being not well compacted and abounding in watery moisture, fly off through the thinning action of the fire and the failure of their viscosity, while the metal — owing to its viscosity — remains, its moisture being irresoluble. That metals are rarefied in melting, smiths have established by experiment: for if they have made a hole in red-hot iron, they find it much wider while the iron is still glowing than when it has cooled — for just as iron expands with heat, so it contracts and takes up less room with cold. But more on these matters in Book XI, *On the Metallic Arts* [*De Metallicis artibus*], where you will also find all of this confirmed by experiment.

COROLLARY I [CONSECTARIUM I]

From this it is plainly to be gathered how all things are thinned and made to flow by heat — and this, indeed, by the most wise design of Nature, namely so that by the perpetual and never-ceasing alternation of things the whole face of the Geocosm may be changed. And since moisture is the bond by which the spirituous parts are joined to the body and the matter, when that bond is loosened the spirits withdraw from the body — yet without any perishing of them, the only thing accomplished being a separation — in such a way that nevertheless something of the spirits always remains in the matter, after the manner of Nature's seeds. [Margin: The wonderful constancy of Nature in this.] And if these are again carried back to a body of this sort, then, attracted by a certain magnetic law by those that remained within, and united to them, they are bound together by a new moisture. And this is the wonderful physical "circling-around" [Greek: περικύκλωσις (*perikyklōsis*, "circling-around," cycle)] in the nature of things.

COROLLARY II [CONSECTARIUM II]

From this it is also clear that the generation of all meteors comes about by the said industry of Nature, and that all the laws of generation and corruption, in the greater World as in the lesser, depend upon it. For although the varieties of all the spirituous effluvia are constituted in well-nigh innumerable differences, they can nevertheless all be reduced to two, as to their remaining genera — namely, to the moist and the dry, of which the former go by the name of "vapors" and the latter by the name of "exhalations." All these exert their powers in the threefold kingdom of Nature — the mineral, the vegetable, and the sensitive. [Margin: The circulation of meteors.] Mineral and metallic bodies, stirred up by the subterranean Vulcan and thinned and resolved into vapors or exhalations, are raised up to the outermost surface of the Earth, where, struck by the celestial rays and reduced to the utmost subtlety, they fill that great aerial sea. The spirituous substances of vegetables and of every kind of sensitive thing, likewise struck by the celestial light and resolved, are again committed to the aerial Ocean, where, dissolved by cold, they are restored to the earth anew through snows, hailstones, rains, mists, and dews — and each spirit, by a certain magnetic pull, flows together toward that body, native to it, from which it had flown off. But more fully on these matters in the Last Book, where I shall perhaps disclose a new physics, until now scarcely known.

These operations of Nature, art imitates — the artisan who, by distilling minerals, vegetables, and animals, extracts from them as many different waters, oils, and spirits as there are different mixtures in the nature of things. So it is that by "Salt" the old philosophers understood the fixed physical matter; by "Mercury," the moist principle, the glue of all things; and by "Sulphur," everything spirituous. Let anyone who pleases believe that from the mere confluence of the simple elements so great and so innumerable a diversity of things is born; for my part, taught otherwise by nature, I have judged it the wiser course here to set forth not the things that pertain to metaphysical concepts but those that pertain to physical experience.

SECTIO II [SECTIO II]

ON THE MINES OF METALS AND OTHER MINERALS, AND ON THE DISEASES AND REMEDIES OF MINERS

[DE METALLORUM, Cæterorumque Mineralium fodinis, Fossorumque morbis & remediis.]

CAPUT I [CAPUT I]

What is required for a complete knowledge of the metallic art; or, on the qualifications of the overseer of mines.

Before we enter more deeply into the inner sanctuary of our metallurgical art, we shall set forth in a few words what is required for a thorough knowledge of this art — with what endowments and natural gifts he must be furnished who has taken up the profession of this craft.

[Margin: The rules to be observed by the overseer of mines.] First. The metallurgist, or overseer of mines, should set divine worship before all else, mindful of the saying: *Seek first the Kingdom of God, and all these other things shall be added unto you* [recalling Matthew 6:33]; lest, while too anxiously searching out earthly and perishable treasures, he be swallowed up in the abyss of avarice and suffer the loss of his own soul. Therefore let there be joined to the fear of the Lord a constant diligence, by which everything is arranged according to the canons, rules, and precepts of the metallic art. This for the most part brings the great benefit that, for those who both know what ought to be done and take care that it be brought to completion, nearly everything turns out successfully and prosperously.

[Margin: Knowledge of minerals.] Secondly. In order that the metallurgist may fulfill all the parts of an upright and skilled man, it is necessary that he be most expert in his art — namely, that he know first which mountain, which hill, what valley-ground or open-field situation can be usefully dug, and which refuses digging. Next, that the veins, the fibers, and the joints of the rocks lie open to him; then that he have a thorough understanding of the manifold and various species of earths, juices, gems, stones, marbles, rocks, metals, and mixed bodies, and that

he likewise know every method of carrying out work underground. He should be acquainted with the materials to be tested and the things to be prepared by art for smelting [excoctio]; and since these are diverse, so too they require a different method in different metals. [Margin: The method of smelting metals.] For gold demands one method, silver another, and the other metals yet others — which I would have you understand applies also to the smelting of the concremented juices, salt, niter, alum, chalcantum [vitriol], sulphur, and bitumen, each to be carried out in its own way.

Thirdly. Before the metallurgist undertakes the *metallourgia* [Greek: μεταλλουργία (metallourgia, "metal-working")] — that is, the digging of veins — let him consider these seven things with himself. First, the kind of place; the disposition of it; the water; the access-road; the healthfulness; and the neighboring lordship. And in order to possess this knowledge, he must be furnished with an acquaintance with many arts and disciplines. [Margin: He must be instructed in various disciplines.] First, philosophy, so that he may understand the origin, causes, and natures of subterranean things. Second, medicine, so that he may provide for the diggers and the other workmen, lest they fall into the diseases to which they are exposed above others; and if they have fallen ill, he may either himself apply remedies, as physicians do, or take care to have them treated. Third, astronomy, so that he may recognize the regions of the sky and from them judge the extensions of the veins. Let him also be not unskilled in geometry, so that he may measure how deep the shaft must be dug — so that it may be reached by the gallery [cuniculus] driven all the way to it — and so that he may set fixed bounds and limits for each mine, especially in the depths, and measure them according to the established laws of geometry. Let him have a notable knowledge of numbers, or arithmetic, so that he may be able to bring to a reckoning the expenses incurred in constructing machines and in paying the diggers.

But nothing is so necessary to the overseer of metallurgy as statics [statica], by which he may know how to build the substructures of the mines and the hauling and hydraulic machines — either by himself, or by explaining to others the methods of constructing them. Moreover, this will teach him the weights of metals and the differences of one metal from another. And if to statics there be joined draftsmanship [pictura], then indeed he will be said to have attained a complete knowledge — if he can correctly lay out the branchings of the galleries according to the laws of ground-plan drawing [ichnographia], and correctly represent the prototypes of the required machines, as well as the site and position of the mountains and fields. Finally, since great disputes often arise

concerning the jurisdictions over properties, he must also be skilled in the laws, so that he may be able to form a correct judgment about the ownership of things.

On the various offices of those who are engaged in metallurgy.

[De variis officiis eorum, qui Metallurgiam curant.]

Under the overseer of the whole metallurgical enterprise, after the supreme lord and proprietor, there are the master of the workmen, the jurati (as they call them) [the sworn officials — mine assessors], the clerk of the mines, and the foremen of the galleries. [Margin: The office of the jurati.] The master of the workmen exercises command over all the diggers, except the mint-workers and the silver-refiner; he also punishes negligent workmen by fines; he settles disputes that arise concerning the mines; he grants and confirms mining-rights to those who request them; he measures out the mines and fixes their boundaries; he teaches and prescribes what is to be done in each mine. To him all the other foremen of the workmen render an account of the money spent in the preceding week, which the clerks enter in their register. This man must be a carpenter, so that he can build the shafts, set in place the props, and make the substructures that support the undermined mountain, lest the diggers be buried; and so that he can drive the galleries to channel off elsewhere the waters seeping from the veins and from the joints of the rocks. He must also know the veins and fibers, so that the shafts may be usefully dug, and must distinguish one excavated material from another — either by himself or through others already instructed in the usual rules. [Margin: Knowledge of mineral-deposits.] Besides, let him have knowledge of washing, purifying, and smelting the metals. Lastly, let him supply whatever is necessary to the diggers for their labors — iron for tools, leather for clothing, tallow for lamps, and so forth.

[Margin: The office of the jurati.] The jurati must be men of good faith and skilled in mining matters; their number, indeed, is set according to the multitude of the mines. Their office is to visit the mines, to inquire what is being done and what has been done, to take counsel concerning the machines, substructures, and new constructions to be made, and to deliberate about all the other things that concern the good of the mines: to settle, according to the laws of arithmetical proportion, the labors to be undertaken — in hard, rough, and rocky places, and likewise in soft, clayey, and similar ones — and likewise to punish the negligent, the fraudulent, or the thieving according to the gravity of the offense. Finally, when the jurati are absent, the overseer decides nothing of all this on his own authority.

[Margin: The office of the workmen.] As for the workmen, they carry out their labors in this manner. The span of the natural day is divided among them into three parts, in such a way that each span of time comprises seven hours. The first span of seven hours they begin at the fourth hour by astronomical reckoning, and it lasts until the eleventh. The second begins at the twelfth hour and lasts until the seventh in the afternoon; these are reckoned the day shifts. The third begins at the eighth hour and ends at the third hour after midnight. During this last, whether they are drawing water from the shafts or digging the vein, they keep continual watch by night-lamps; and lest they sleep from their watches or from weariness, they soften their hard labors with singing — neither altogether rough nor unpleasant — to which they are summoned for undertaking by the sound of a bell, at whose signal they gird themselves to their labors here and there, district by district. When the seven hours have been completed, then at a new signal — by the striking of clappers — the underground diggers, on perceiving it, give a sign by a mallet struck against the rocks to those laboring in the inner galleries of the mountains that the work is finished; though indeed the impending failure of the tallow in their lamps is for them a clear enough sign that the time is complete.

CAPUT II [CAPUT II]

On the diseases of miners.

[De Morbis Fossorum.]

Since the underground galleries are crammed with the malignant spirits of minerals, it cannot but be that the diggers are from time to time afflicted with unusual kinds of diseases. Hence, according to the diversity of the waters, the exhalations, and the air, different diseases must necessarily arise — of which some afflict the limbs, others injure the lungs, others the eyes, and others again, by a certain deadly and suffocating force, kill them outright. [Margin: The diseases of miners.] The colder water that tends to stagnate in the deepest shafts generally damages the legs and nerves; hence, unless they protect themselves with leggings made for this purpose, they must inevitably fall into well-nigh desperate infirmities. But in mines that are dry and devoid of moisture, a greater evil threatens them: for when they shake the earth with continual concussions and dig deeper to lay bare the matrices of the metallic clods so as to uncover the courses of the veins, the surrounding medium cannot but be infected with various effluvia of dust, which, drawn in together with the air and insinuated into the lungs, generate first asthma — that is, difficulty of breathing — and then

consumption [phthisis]. And if these effluvia further possess a corroding power, then, with the lungs ulcerated, they breed a dreadful wasting.

Moreover, there is a certain kind of cadmia [calamine / zinc-ore fume] which eats away the feet of the workmen when they are soaked with water, and likewise their hands, and injures the lungs and eyes. [Margin: By what means the diggers protect themselves against the harmful spirits.] Hence many protect not only their feet with leggings but also their hands with gloves, and their face with bladder-skins, lest the dust harm them. By this means, Pliny [Pliny the Elder] records, the makers of minium [red lead / vermilion] among the ancient Romans protected themselves against the mercurial spirits.

It sometimes happens that the diggers are forced to break and shatter the metallic rocks by applying fire; and while they do this, unless they withdraw in good time from the smoke, it can scarcely be told what monstrous kinds of diseases — which bring their death close upon them — they incur. For in these [Margin and main text continue on next folio.]

cases the air is poisoned in a remarkable way by a certain subtle and spirituous venom, which, squeezed out and diffused by the force of fire from the veins and joints of the metallic clods, exhales forth. If this clings to the vaults of the mines in the form of tutty, pompholyx, or soot, and afterwards in time falls down into the standing pools, it does great harm indeed to the diggers when the water is tainted with such death-bearing spirits. [Margin: How much harm poisonous soot causes.] For experience has taught that, if you stir up the pools of stagnant water even by the throwing of a stone, the venomous spirits that at once fly out from them kill, without any remedy, whomever they strike. The same smoke, while the fire is not yet extinguished, has been found to produce wholly outlandish symptoms. [Margin: The origin of the diseases of miners.] For the bodies of the diggers infected with this venom at once swell up so much that, robbed of all sense and motion, they perish without pain; while those who feel themselves infected, as they flee up the ladders to look to their safety, are meanwhile so swollen in hands and feet into a globular shape by the prevailing venom that, when they can no longer hold themselves on the rungs of the ladders, they fall from the ladders and exchange their life by an unhappy death. The diggers, therefore, made more cautious by the death of many, keep themselves from entering the mines for a full two days, with a fire built within the pits, until the death-bearing poison diffused through the air is gradually consumed by the fire.

[Margin: The malignancy of arsenic.] Again, wherever arsenic, orpiment [auripigmentum], sandarach [realgar], and similar matrices of poisonous

minerals are found, there the air presents itself so much more pernicious in proportion as it has been imbued with the more virulent exhalations of the said minerals, together with the exhalations of the mercurial veins. So Agricola [Georgius Agricola] reports that it happens in the caverns near the town of Plana [Planá, Bohemia], which at certain times of the year give off from the acid springs [acidulae — mineral springs] an exhalation that extinguishes lamps and, if anyone lingers there too long, kills him. Elsewhere, in deep-sunk pits, sulphurous and aluminous [exhalations] kill the well-diggers. [Margin: The deadly Charontian pits.] Such spirits exhale in the Neapolitan territory near the lake of Agnano [Lago d'Agnano], in a certain cave (they call it the *Canum* [the Dog's Grotto, Grotta del Cane]), which renders dogs detained there for a short while at once stupefied and as though lifeless, but, detained longer, suffocates them outright. Such chasms are found also in the territory of Tivoli [Ager Tyburtinus] and of Volterra [Volaterrae], as we have set forth in our [account of] Etruria [Hetruria] and Latium, which kill men and animals that approach too incautiously. See what we discuss more fully on these matters in the Fifth Book. Of such a death-bearing property, then, are those exhalations which from time to time meet the diggers from newly excavated galleries, with great slaughter among them.

CAPUT III [CAPUT III]

On the cure of the diseases of miners.

[De cura morborum metallicorum.]

Just as all the metallic diseases arise either from the virulent vapors of the metals or from the smoky exhalations that infect the air — these being diverse in nature and property — so too they bring about the most diverse diseases in the underground diggers. For some attack the lungs, others the stomach, some the brain, several the joints; nor are there lacking those that assail the liver, the kidneys, and the bladder. In these organs, then, through the continual insufflation of the infected air, or by the native heat within — no otherwise than by the force of fire within an alembic — they are now sublimated, now precipitated, now drawn off by distillation into one part and another, whence arise outlandish coagulations, corrosions, and putrefactions, from which the seed-beds of all the diseases take their origin. By what means, therefore, the diggers and the smelters of metals can fortify and preserve themselves against these, I have thought fit to show in a few words, so far as I have it from the physicians who, for hired pay, have the care of the workmen subject to metallic diseases.

[Margin: Remedies against metallic diseases.] The cure of a metallic disease can therefore be reduced to a threefold method: to the prophylactic, the dietetic, and the proper method of medicaments. The prophylactic is as follows. Let one who is not yet infected select that most excellent and specific medicament from the essence of Tartar, of which this is the composition. Let there be mixed together liquor of Tartar, laudanum of poppy, and oil drawn from colcothar. [Margin: The preparation of the medicaments.] Now colcothar is nothing other than vitriol calcined to redness; these, when distilled, will furnish a liquor which — taken in a dose of three grains every half-year — is said to render a man free and immune from all the poisonous vapors and exhalations of metals. But those who have already fallen into putrefaction from the corrosion of metallic exhalations are most commonly prescribed a balsam drawn either from vitriol, or from nettle, or from steel.

[Margin: Balsam of Vitriol.] They prepare the balsam of vitriol thus: they draw off from the vitriol its phlegm until it becomes sweet like honey and inclines to a purple color; the dose is one drop in water of speedwell [Veronica].

[Margin: Balsam of Nettle.] They prepare the balsam of nettle thus: let the salt extracted from nettle be rectified in its own aqueous portion, by a moderate fire of ashes, or of sand, or even of dew, until the greasiness of an oil is seen; this, separated from its dregs, is to be administered daily in a dose of three drops, in water of speedwell.

[Margin: Balsam of Magnet.] The balsam of magnet is prepared thus: let the magnet be reduced to alcohol — that is, to a most fine powder — upon which an equal weight of steel filings is placed, and let it be cooked in a glass vessel as well luted as possible, in an oiliness of the ashes of woad [Isatis]; afterwards they take the filings, or scrapings, of the magnet, which [are put] into rectified wine [as] much [as... — text continues on next folio]

until the wine turns red. Once the wine has been separated from this redness, the balsam of magnet is found at the bottom. Taken in the dose prescribed above, it allows no part of the body to putrefy.

For the diet to be observed, this cure prescribes the following for miners. Men engaged in metalworking and in the underground labors of the mines should, as far as possible, season their food with rock salt [sale petrae]. By the same principle, in place of spices they should use aluminous salt — the salt extracted from alum — which has no saltiness at all and yet seasons food excellently.

[Margin: A remedy against asthma.] Against the non-putrid asthma that metalworkers most often contract from mercurial vapors, they usually prescribe water of sowbread [aqua panis porcini, *Cyclamen*], the one remedy for diseases of the lungs. Its power is remarkably diaphoretic. For if the affected members — that is, the liver, stomach, and lungs — are kept in a state of perspiration [Greek: διαφορήσει (diaphorēsei, "sweating," diaphoresis)], the virulence of the mineral spirit will do them no harm; and if any damage has already been done to them, the diaphoretic power expels it — mucus, resin, or tartar — so that, with this diaphoretic or sweat-inducing power at work, neither stone nor gravel can settle in the bladder or kidneys. For sweat is the supreme safeguard in illnesses of this kind.

[Margin: Theriac.] There is no shortage of other household remedies, both for those who work underground in the tunnels extracting metals and for those who work at washing, purifying, and smelting them. Some make great use of theriac; others use metallic remedies compounded from salt, alum, saltpeter, salt-peter [salpetra], vitriol, and tartar. Miners admit that by the use of these they feel the greatest relief — which I judge happens for no other reason than a certain sympathetic affinity, whereby like substances taken into the body, having gathered together the little particles of the metallic effluvia where these have collected, then by the cleansing power of the salts draw them out together with the humors through the body's natural channels. For salts of whatever kind, once duly purified and reduced to their own purity, are a notable antidote [Alexipharmacum] against the malicious vapors of minerals. Everything malignant that lurks in salts comes from the heterogeneous clods of a malignant nature mixed and fused into them.

[Margin: Household remedies.] Again, against this kind of pestilential air of the underground pits, before the miners go in there are draughts of the best and finest wine, or servings of rich broths together with butter, onions, and walnuts. Some chew zedoary [Zeduarial] in the mouth, or some other root of a specific quality. Some even hold gold leaf in the mouth against mercurial spirits: for just as mercury, by a natural appetite, embraces gold in a remarkable way, so too the spirit, clinging to the gold leaf, goes no further. [Margin: Diseases of the lungs.] Against diseases of the lungs, balsam of sulphur itself, or the flowers, or what they call the "butter" of sulphur, have a wonderful power to purge the lungs, especially when these incline toward dropsy. [Margin: For peripneumonia.] Against peripneumonia it is most helpful if you dissolve into water, by distillation, half a pound of balm-water [aqua melissae] with one pound of tartar, together with red wine of better quality, mixing in juniper berries and chicory

flowers; take this daily in a dose of four drachms with a good strong wine. For the rest, see Paracelsus and Agricola [Georgius Agricola]. What I have written here was entrusted to me by the physicians in charge of the mines.

[Margin: Diet.]

CAPUT IV.

On the Remedies by which the malignant air in metallic tunnels is purged.

[Margin: By what means the air of the mine may be purged.] Nature has set two great obstacles in the way of men attaining the perfect happiness they desire from the longed-for treasures of the mountains — so that in this matter Nature seems to have shown herself not so much a Mother as a Stepmother. The first of these is the inexhaustible flood of standing waters, which, just as it obstructs the further working of the metallic veins, so too inflicts incredible damage on the mining enterprise. The second is the virulent and utterly deadly vapors or exhalations of the metallic veins, by which not only is the work hindered, but the workers or miners themselves are dealt — if not sudden death, then at least (as we showed in the preceding chapter) the inevitable kinds of exotic diseases — bringing great tragedy upon these wretched men. Of the first I will treat now, of that second discomfort of Nature later.

The question, then, is first this: By what art and industry can the virulent vapor and exhalation of the mines be purged, and the mine, together with the safety of the workers, be freed from so great a plague? [Margin: By what means the air of the mine may be purged.] There are those who think that this can first be done by a fire built of wholesome woods. But I judge that such a plan, far from supplying any remedy, would rather both smoke us out and, with the heat concentrated in such cramped quarters, open up greater dangers and a greater evil — indeed a nearer gate to death. They had perhaps read that Hippocrates freed whole cities from the plague by fires of wholesome woods set up through the streets and crossroads — which we too prescribed as possible in our *Treatise on the Plague* [Tractatus de Peste]; and so they thought the same could be done in the deepest places of the Earth. But it is one thing to use this method out in the great open sea of the external air, far and wide, and another within the closed-off bowels of the Earth, where it can in no way be done — as is plainly shown on two counts.

[Margin: Sealed vapors kill miners.] First: who does not know that fire in underground places, unless it is supplied with its own chimneys, cannot last? Or

that, if it is built near the door of a lower shaft-mouth, it fills everything with smoke, so that it brings the workers to the gates of death by suffocation by a far quicker route than even the most violent poisonous vapor? Fire cannot live without air; or, if it does not obtain sufficient air, it turns everything upside down with smoke, to the utter destruction of those laboring. Add to this that a pyre built in the hidden recesses of the Earth, so far from consuming the pestilential air, rather — by the violence of its heat — stirs up the exhalations and vapors that at first lay dormant within the receptacles of the matrices, and, rarefying them by sublimation, taints and infects the air throughout all the passages of the mines with its virulent power. Certain miners have experienced this evil to their own great harm: when, with their lamps lit, they drew near to places filled with sulphurous-bituminous vapors, the whole air present in the mines burst into flame and destroyed them, some suffocated, some burned up. The same has befallen some men who, while digging wells, were attacked by a similar vapor and in an instant were killed. So to build a pyre in the mines, so far is it from consuming the virulent air, that it rather increases it remarkably — driving out by the heat, from this metallic vein and that, still other and other exhalations.

[Margin: Bellows for purging underground air.] What remedy, then, is there against such great evils? I know that the air in mines is usually cleared by the aid of bellows. But unless this business is properly arranged, it will bring little improvement. For if external air is not drawn in from elsewhere, and the foul air is not driven out through some other unsealed opening, the same air must always remain, the air being now stagnant. I judge, therefore, that the air can be purged in two ways: either by means of bellows, or without any use of bellows at all. Before I show this, I would have the reader know that air is so constituted by Nature that, although air rushing from one place to another underground place can be admitted, nevertheless, unless this foul air has another place into which to withdraw, the other, external air can never be admitted — but if it has found such a place, then by withdrawing it at once yields room to the external air. This could be confirmed by countless experiments, if it were not commonly known to all. So that the air may be driven out, it is necessary that it have two openings: one through which fresh air is blown in from outside, the other through which it is blown out. This being so, you could arrange a machine of the following kind in the mines.

Diagram. A mine-ventilation machine built around a sealed wooden chest fitted with a large pair of bellows, driven by a water-wheel and worked by a man pulling on a lever. The chest sits on the ground; above it rise tall vertical posts that carry the bellows-frame and a pivoting beam. To the right, a large spoked

water-wheel turns a crank linked by jointed rods to the bellows. Below, a man braces himself and pulls down on a rope attached to the lever to work the apparatus. A curved spout (apparently a water-conduit feeding the wheel) is shown at upper right.

- N (top, left post): left upright supporting the bellows-frame
- I (top, right post): right upright supporting the bellows-frame [reading "I" / "Io"; the printed letter is set apart from the post]
- E (middle, on the bellows): the bellows themselves
- F (with E, bellows): the pair of bellows EF, sized to the chest
- A (lower left of the chest): one corner of the sealed wooden chest ABCD
- B (bottom left of the chest): lower corner of the chest
- C (right side, upper): point on the wheel-driven mechanism
- D (right side, lower): point on the wheel-driven mechanism

The accompanying text (printed beneath the figure) explains the construction:

Let a chest ABCD be made of the most solid wood, ample in proportion to the size of the bellows EF, so completely closed on every side that it admits not even the smallest particle of foul air. Into this chest let a tunnel, or channel N, be led, implanted into the chest at point G; then another channel from the side of the mountain at point V, which is likewise implanted into the wind-chest [cista Anemica] or bellows-box [ventosa] ABCD. Then let the bellows be raised by a man appointed to that duty, by the device the figure shows; and it will come about that, when either bellows is raised, the external air, through the channel —

[Margin: The mechanism by which the air of the mines is purged.] — N G — is drawn in and insinuates itself into the chest ABCD; but when either is pressed down, the air is expelled outward through the channel or tunnel EV. In this way the mine will always obtain fresh air, both for the cooling of the workers and for the dispersing of the malignant vapor. And if you wish to draw it off into other parts of the mine-workings as well, through their own air-holes, you can do so very easily by means of new channels directed from the chest to the various tunnels. This machine can also be driven by a tread-wheel [per totam], if there is a supply of falling water at hand.

Note here, however, that the bellows must be tightly joined at their base, so as to hold the air drawn in through the valves [affaria] — commonly called *ventilia* or *animellae*, which the Greeks call ἀνεμοτρόχλεις [Greek: ἀνεμοτρόχλεις (anemotrochleis, "wind-pulleys," air-valves)]. These are so set into the base of the bellows that, when one bellows is raised, the valve opens, and when the bellows

is pressed down, it closes. The chest, moreover, should be divided inside by a partition, so that the air drawn in by one bellows is not driven back by the other, but each one drives its air into a receptacle proper to it, from which it is then driven through the channel into the tunnel. But I leave these details to be put into execution by an ingenious craftsman.

[Margin: A second hydraulic machine.] The second method is this. If you find a stream in some mine, you can by its aid correct the malignity of the air in a better way, as follows:

In a chosen and suitably proportioned spot in the mine, let a chamber ABCD of whatever size be made, as appears in the second figure. Within —

Diagram. The second machine: a sealed vault-like chamber fed by a stream through an overhead channel, with the intrushing water striking a grated surface to drive air out through side conduits. A dome-shaped chamber (the "second figure") has, at its top, a channel through which a stream pours in; the water falls onto a slatted rock-surface inside the vault, throwing up spray. Tapering conduits (drawn like the necks of bellows) branch off to either side near the top.

- F (upper left): left side-conduit leading off from the chamber
- A (top center): apex of the chamber / inlet region, ABCD
- G (upper right): right side-conduit leading off from the chamber
- K (just below the inlet): the channel through which the stream is led in
- S (inside, lower left): point on the slatted rock-surface ST where the water strikes
- T (inside, lower right): point on the slatted rock-surface ST
- B (bottom left): lower corner of the chamber
- C (bottom right): lower corner of the chamber

— within this cavity, under a higher vault, let a stream be led down through the channel K (for we assume the stream flows from a higher place). The stream thus diverted through the channel K runs down to the rocky surface ST — from which it is distant by only two palms — and, plunging headlong with great force in the manner of a cataract, it likewise stirs up a mighty wind. This wind, unable to be contained, escapes through whatever door is open, through the channels EG, and fills the mine with fresh air; and it so disperses the virulent vapor that it can no longer do any harm. And this method is so much the more refined as it breathes out a greater supply of the most humid wind. There is this further advantage: that just as the stream is perpetual, so the wind too is perpetual, and the whole operation is carried on day and night without any man's labor. Yet, lest in time

the chamber be filled with water, let a stopcock [epistomium] C be placed in the side, through which as much water can pass out as comes in.

[Margin: Wind necessary for purging the air.] [Margin: The third method of purging the air.] The third method, without bellows or any other instruments, could be set up in this way, through the tunnels alone: namely, if on the western or eastern side, or some other place, caves AB are made, whose openings face out on the external surface of the mountain toward whatever wind the mountain is chiefly exposed to. For when the wind blows — let us say, for example, the east wind — the wind, entering opening A, will not —

Diagram. A cross-section of a mountain (drawn like a low mound or hill) pierced by a tunnel running through it, with a wind-opening at each end. Within the body of the mound, a winding passage connects the two openings; small trees are drawn on the crest of the mountain above. A pleated, bellows-like mouth is shown at each opening, A on the left and B on the right.

- A (left opening): the western (or windward) cave-mouth
- B (right opening): the eastern (or leeward) cave-mouth

— the wind, entering opening A, will not rest nor stop until it goes out through opening B on the opposite side, even one several miles distant. And in this way the mines would enjoy a perpetual wind of their own, by reason of the continuity of the tunnels from one opening to the other, to make the cleansing of the foul air. For the wind, once it finds an exit, will not rest, but will keep the air in continual motion by its blast; and once the air is set in motion, the venomous vapor, being thereby dispersed, cannot persist. Just as the Wind, among its chief offices, is for this very purpose appointed by Nature — to purge and disperse the air tainted with pestilential exhalations — so too in the innermost bowels of the Earth, if a wind can be admitted to ventilate the mines, the air must certainly be made better. Hence, in manifold ways and by various means, ventilation-shafts could be set up, which, set in motion by the wind through external openings — especially if it passes through narrow channels — could render the air thoroughly purified by cold. [Margin: In watery places where there are underground cataracts, the air is wonderfully purged.] For where it is cold, there the retracted vapors cannot find room for their own expansion. Hence, for the same reason, wherever cataracts of subterranean waters are found, there no one need fear noxious air. [Margin: Dry places are more dangerous.] In dry and hot mines, therefore, the greatest danger threatens the miners — though, if they are cooled by the methods described, they will then render it tolerable, to the great benefit and advantage of the miners.

CAPUT V.

On the manner of draining off the flood of waters that are a great hindrance to miners.

[Margin: A different method is suggested.] As the other curb that Nature seems to have set upon the avarice of mortals — so that they may not penetrate to the inmost treasure-houses of gold, silver, and the other minerals — there is the flood of standing waters in the underground mines; and this is the more destructive the greater the obstacles that arise in draining it. The first is the depth of the waters: if you have drained these with buckets [antleae] or leather sacks, you can scarcely see, without digging a new channel, where to divert it to. The second is the narrowness of the places, which hinders the whole arrangement of hydraulic machines; and since these are for the most part fitted out with iron, the acrimony of the mineral waters at once sets an obstacle to them — by which, in a short time, the iron tools are not only eaten away but pass into scoria, with the dissolution of the whole machine. Agricola, in *De re metallica*, Book 4, proposes various instruments and hydraulic machines; yet scarcely any of them are of use in those great cramped recesses of the mines, on account of the laborious nature of their construction. For just as they are built at enormous expense, so too — both on account of the iron chains, iron buckets, and iron poles by which they are worked, and on account of the acrimony of the mineral waters and the corrosiveness of the salts — they cannot last long. Add to this the narrowness of the places, which cannot be widened to make room for the machines without great expense; nor can the buckets, which they mostly use, last — for of whatever metal they are at last made, the mineral waters are always hostile to them, gnawing into them so long that they are consumed either by verdigris [aerugo] or by rust [rubigo].

[Margin: Instruments made of metal cannot last long.] Hence one would have to build them of pure wood, or of bricks baked of clay, so that, thus constructed, they might stand fast. Vitriolic waters, wherever they find iron, bronze, or copper, at once cling to it and do not cease to gnaw it by adhesion of corpuscles down to the very last bit of scoria. Nitrous waters, on the other hand, as soon as they come to rest, so coat the matrix and the cylinder of the buckets with a stone-forming juice [lapidifico succo] that they can scarcely be drawn out any longer.

[Margin: Various hindrances.] There is yet another hindrance: that after the water has been drained, either a new channel must be dug to divert it outside, or it must be drawn up through the shaft of the mine in leather buckets, as is

sometimes done — but not even so can any great benefit be expected, since the pits are usually filled from hidden springs, so that however much water you draw out, just as much new water flows into the pit from the springs. It also happens that the leather sacks or bags are mostly burst by the weight of the metallic waters. Wherever you turn, then, you always find one hindrance after another. Yet stubborn labor, as it conquers all things, so too — whether by blocking the veins, or by other means and methods — at last throws the reins upon reluctant Nature, so as to attain its purpose. In Hungary, as is written to me, it is carried out with buckets and leather sacks.

[Margin: A different method is suggested.] One thing remains, by which, in my own slender judgment, I think the matter cannot be better managed: namely, if the depth of the pits, together with the height of the shaft by which the descent into the mine is made, are first measured by the level [*ad libellam*], with regard to the external slope of the mountain. So, if the pit is higher, or deeper, or equal to some level field, then indeed you waste oil and labor in trying to divert the waters out of the pit elsewhere, and no other counsel remains but to draw it out through the mouth of the shaft. But if the level of the plain or valley is deeper, then you will have hope of drawing off the water by a channel deliberately made. As for those who think the business can be done by the suction or pull of hydraulic machines — they, relying only on speculations grounded in metaphysics, suppose the matter can be managed: but once they have drawn the water into some receptacle, where will they divert it to? The custom and habit introduced by long usage in the various metal-mines of Europe must therefore be abandoned; for since human ingenuity is sharpened daily, most of all toward inventing something to relieve necessities of this kind, yet so far nothing has been found that fully satisfies the wishes of metallurgists — apart from the instruments and machines we have mentioned. Certainly these are to be employed until God, the Best and Greatest, inspires something else, by which the matter may obtain the desired outcome.

[Margin: How the corrosion of the waters may be prevented.] And let this much be said about those waters which are collected in the bowels of the mines and, for the reasons stated, have no outlet. But if those waters could conveniently be diverted to the lower mouth of the shaft, then with greater convenience they could be led out by the instruments which Agricola prescribes in Book 4. But lest the chains and tools of the machines be consumed by the corrosiveness of the mineral waters, if they are well smeared with oil extracted from lead [*oleo ex plumbo extracto*], they could endure against all consumption. For there is nothing in the nature of things that keeps tools — even when submerged in

seawater — freer from all corrosion and rust than the said oil. But since a greater quantity of this oil is needed to coat so many chains and tools than the expense would bear, this too presents no small difficulty for getting the business done.

And these are the hindrances which [render] subterranean metallurgy, together with a notable and ir-[reparable]...

with notable and irreparable damage. These are: the dryness and the dampness of the mines and tunnels. [Margin: Drawbacks of mines.] Dryness, arising from heat and consequently from the most virulent exhalations, brings great ruin upon the miners. Dampness, by contrast, blocks the veins in the inaccessible parts of the mines, unless it is drained off by the usual industry with a crowded force of workmen. For where the dampness of the waters prevails, the workmen cannot remain there without harm. Cold, however, is in some measure beneficial: by it, just as by the stirring of the waters, all the malignancy of the mineral vapor is driven off — unless the waters, having stood motionless and stagnant for a long time, have drawn a film [cutis] over themselves from the poisonous exhalation. Even these, though, do little harm, provided that the waters, once driven off by that very agitation, have withdrawn elsewhere. For it sometimes happens in pits of this kind that a venomous vapor, stirred up even by the mere throwing of a stone, brings irremediable harm to those standing nearby.

CAPUT VI.

On the manifold courses of the mineral veins and fibers. [De multiplicibus Venarum fibrarumque mineralium ductibus.]

Now that I have set out the hindrances and obstacles by which the hoped-for profit and effort of the men who work the metals is frustrated, nothing remains but to insinuate ourselves more deeply still and to examine the recesses and wombs of the buried minerals, those chambers dedicated to their conception and birth — what Pliny [Plinius], Dioscorides [Dioscorides], Vitruvius [Vitruvius], Albertus [Albertus Magnus], and Agricola call "veins," following that line of Ovid [Ovidius]:

Now too, from the seed once received in the old days, the veins stiffen,
fields strong with their soaking clods.

[Margin: What mineral veins are, properly speaking.] The veins of minerals or metals are nothing other than certain vessels or receptacles of the matter that

they conceive for the formation of the minerals — like a mother's womb for the propagation of its offspring — the comparison being borrowed from the veins of living creatures. For just as those veins are distributed to the individual limbs, and through them the blood is spread from the liver into a man's whole body, so these mineral veins are dispersed both throughout the entire globe of the Earth, and especially through mountainous regions, by the waters flowing and streaming through them. [Margin: What the venules and fibers are.] Moreover, just as each individual vein has its own connected brood of smaller veins (which they call "capillaries"), so too the metallic vein has venules attached to it, sprung from the joints of the rocky mineral matter, which they also call "fibers" — although these supply the moisture in the contrary direction. The veins of the human body discharge the blood into the capillary venules; conversely, the metallic venules diffuse the moisture they have received into the larger veins. On this, see Seneca [Seneca], *Natural Questions* III.15, where he describes this analogy of the veins no less elegantly than learnedly. [Margin: They are compared to a branching tree.] If anyone considers more closely the fibers of the veins and venules, he will behold, within the joints of the rocks, an image not unlike that of a perfectly formed tree divided into its various branches.

Diagram. An engraved landscape plate showing, in cutaway cross-section, the interior of a large mountain (with a coastline, sailing ships at sea on the right, and scattered trees over the surrounding terrain), exposing the network of metallic veins running through the rock. A banner cartouche at the top center carries the title. Each vein is labeled with the type of vein it illustrates (corresponding to the categories discussed in the preceding and following chapters: deep, dilated, low, oblique, curved, transverse, etc.).

- Cartouche (top center): *TYPUS VENARUM Metallicarum in Fodinis* — "Type [Diagram] of the metallic veins in mines"
- Upper vertical vein (center): *Profunda* — "deep [vein]"
- Diagonal vein (upper left): *Vena obliqua* — "oblique vein"
- Vein near top right of the cutaway: *Vena curva* [?] — "curved vein"
- Horizontal vein (mid-level, left): *Intervenium* — "intervein" (the rock lying between two veins)
- Long horizontal vein across the middle: *Vena dilatata* — "dilated vein" (appears twice, left and right)
- Lower horizontal vein (left): *Vena humilis* — "low vein"
- Several short veins labeled simply *Vena* — "vein"

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others are dilated, others heaped up [cumulatae]. A "deep" vein descends from the topmost surface of the Earth into its lowest depth. A "dilated" vein is, as it were, a middle thing between the surface of the Earth and its hidden depth below ground, and it spreads itself out over much space. [Margin: What an intervein is?] One that occupies a large part of some place, drawn out in length and breadth, is called "heaped up" [cumulata]; and what lies in the middle between two veins is called an "intervein" [intervenium]. Again, among the deep veins some are one pace wide, others two cubits, some one cubit, others a foot — all of which the metallurgists call "wide," and which in some places sometimes extend even to twelve paces. Some, again, are only a palm wide, others three fingers, others two, which they call "narrow."

[Margin: Dilated vein.] The dilated veins differ among themselves in height: for some are one pace high, or two, or more; some a cubit, some a foot, some a half-foot [semissem] — all of which they call "high"; while those they call "low" are a palm, or three fingers, or two, or one, as appears in the figure. These in turn are variously divided, so that some are straight, others curved, some oblique and twisted, others transverse and circular. The differences of all these we display here in a diagram, to spare a longer description. [Margin: Vein shapes.] What the metallurgists call the "end," the "head," and the "tail" of the veins is, as is generally known, in no need of further explanation.

[Margin: Naming of veins from the regions of the world.] The differences of veins are taken, besides, from the situation of the parts of the world: thus some extend from East to West, some on the contrary from West to East, some from South to North, and on the contrary from North to South, while others, finally, keep to the intermediate quarters of the cardinal points — those that take their beginning from the joints of the rocks. So, for example, if veins slope toward the west into the depths, the vein is said to extend from East to West, and so on for the rest. Yet these differ greatly among themselves, since some descend from the very summit of the mountain down the slope into the valley, while others on the contrary ascend. See all of this treated more fully in Agricola.

CAPUT VII.

METALLOGNOMIA, OR On the signs of the hidden metal, and by what art the veins of the metals are recognized. [De signis metalli latentis, & qua arte Metallorum venae cognoscantur.]

As this is a matter of shrewd intellect to discuss, so too it must be handled with a correspondingly trained mind. [Margin: How the veins of mineral ores are recognized.] The treasures of the hidden metals, then, are discovered in various ways. I call them "treasures," because whatever pertains to the preservation of the human race — both to splendor and magnificence and to the use of necessities — derives its origin from the subterranean storehouses [gazophylacia], as I have pursued more fully elsewhere. But now let me take up the thread of my plan.

The subterranean veins of the metals become known in three ways: by a natural means, by an artificial means, and by chance. By a natural means: first, through metallic vapors and exhalations; second, through the disposition of mountains, plants, and trees upon them; third, through the uncovering of veins by the runoff of rains and torrents; fourth, through rivers, which most often carry along with them filings of metals scraped off the veins. By an artificial means: through the distillation — performed in the chemical manner — of mineral waters and of the mud of rivers and lakes; and second, through the divining rod [virgula divinatoria], of which a little later. By chance: through the uprooting of trees and the burning of forests; through the violence of a river falling and splitting the rocks; second, through the breaking up of plowland by the plow and its furrows; third, by the help of horses, pigs, and boars digging in the earth; fourth, through vine leaves, which the gold-bearing spirits tint to a golden color, as is very often found in Hungary.

These things now set out, let me continue my web. The signs, then, by which the metallic veins are detected are the following — drawn partly from Agricola and Cardano [Cardanus = Girolamo Cardano], partly known from my own experience.

I say first: the metallic veins are sometimes opened by some force (which you may prefer to call chance or fortune — it comes to the same thing), without human industry or labor, and in more than one way:

1. [Margin: Force of a torrent.] The rush of a torrent strips them bare, as once happened in the silver mines of Freiberg [Fribergi Argentariis — Freiberg in Saxony].
2. [Margin: Force of the winds.] The force of the winds, drawing up and uprooting trees that have grown above the veins.
3. [Margin: Breaking off of rock.] The breaking off of a rock from a mountain. This is caused either by long and heavy rain, or by an earthquake, or by a lightning-stroke, or by the violent rolling-down of snow, or by the rush of the winds. Virgil [Vergilius], *Aeneid* XII:

And as when a rock on a mountain top, headlong, is torn loose by the wind, or when a turbid rainstorm washes it down, or the creeping age of years undermines it.

4. [Margin: Plowshare.] The plow uncovers veins: for Diodorus Siculus [Diodorus Siculus] records that in Galicia [Galecia — Galicia in Spain] clods of gold were cut up by the plowshare. Hence Lucretius [Lucretius], *On the Nature of Things* V:

What is left — bronze and gold and iron were discovered, and also the weight of silver and the power of lead, when fire had consumed the vast forests with its blaze on the great mountains, whether sent down by a bolt of heaven...

5. [Margin: Burning of forests.] The burning of forests reveals the metals — which, as Diodorus Siculus writes, happened in the silver-bearing regions of Spain. (continued)

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...or because, waging savage war among themselves, they had brought it upon their enemies to inspire terror; or because, drawn on by the goodness of the soil, they wished to open up rich fields and turn the land into pasture; or to kill wild beasts and grow rich on the prey. For hunting by pit and fire arose earlier than fencing the glade with nets and rousing it with hounds. Whatever it was, from whatever cause the fiery blaze had felled the forests with a horrible roar down to their roots, and had scorched the earth with fire, the silver and gold flowed from the seething veins into hollows of the Earth, converging there, and a stream of bronze likewise, and of lead.

6. [Margin: Another force, that of a horse's hoof.] Finally, some other force lays a vein bare. For a horse (if this account is to be believed) opened up a lead vein at Goslar [Goselariae — Goslar in the Harz] with its hoof. By these means, then, fortune bestows the veins upon us.

I say secondly: the hidden veins of the minerals can be investigated by human art, in the ways that follow. [Margin: The veins of the minerals are investigated by human means.]

1. [Margin: From the welling of springs.] The bubbling springs are to be observed, which cannot lie far from the veins, since their water flows out of the veins themselves.
2. [Margin: From fragments of the veins.] The fragments of veins are to be examined which a torrent has dug up out of the earth — for the long passage of time again buries some part of them under the soil. But if such fragments have lain upon the surface, or are light, the veins are generally rather far from them, because the torrent has snatched the dislodged pieces far from the veins and, by driving them along, has made them light; whereas if they are fixed in the earth, or are rough, the proper veins are close at hand.
3. [Margin: Situation.] The situation is also to be considered; for it determines whether the veins are buried more or less deeply by the earth, and whether the fragments are pushed far or less far.
4. [Margin: Frosts.] The frosts are to be observed, by which all the plants turn white, except those that grow above the veins. For because the veins breathe out a dry and warm exhalation, they prevent the formation of frost; therefore, at any spot where the moist plants do not freeze into frost, there is a vein beneath. And if it breathes out something very hot, that ground bears low plants of a somewhat sickly color.
5. [Margin: Leaves of trees.] It is an indication of a hidden vein if in springtime the leaves of trees are livid or bluish; if the branches, especially the upper ones, are tinged with blackness or some other unnatural color; if the trunks are forked, if the branches are black or discolored. For the warm and dry exhalations of the veins produce these effects: they do not even spare the roots of the trees, but, scorching them, render them altogether feeble. For this reason the force of the winds more frequently brings down trees of this kind than the rest.

6. [Margin: Summit of the mountains.] Mountain peaks that face south, with their roots looking toward the north, give an argument of metal — and especially of silver, whose more productive mines tend to run straight from East to West.
7. [Margin: Color of the mountains and stones.] The color of the mountains and of the stones and earth teaches not only that metals are present there but also which kind they are: green comes from copper [aere]; black from silver and gold; purple from pyrite; livid from lead and iron; sallow [luridus] from chalcantite [calchanto — copper sulfate] and similar juices of that sort; ashen and dark from sulfur.
8. [Margin: Smell of the stones.] The smell, too, can be reckoned among the signs of the veins: for when you have rubbed together two stones of the same mountain, if metal lies beneath the mountain, they smell strongly of sulfur.
9. [Margin: Barrenness of the mountains.] All barren mountains are metalliferous: for the moisture is consumed within, so that plants cannot be generated; and the evil exhalations rob even already-grown plants of their life.
10. [Margin: Weight of the stones.] When stones or earth are heavier than reason would require, that is a sure argument of metallic matter.
11. [Margin: Splendor of the stones.] If, too, stones shine excessively in any part, or, being solid, are not wholly without luster, you may know for certain that the matter of metal lies beneath.
12. [Margin: Melting of the stones.] If you melt the stones in fire, you will detect at once both that metal is present, and its kind, and its quantity.
13. [Margin: Smell and color of the waters.] Flowing waters, too, afford some slight conjecture of this, for if they present a foreign smell or color, you will pronounce without doubt that there is metal in the mountain.
14. [Margin: Bottom of the riverbed.] You will also diligently explore the bottom of the riverbed; for there you will find a portion of metal. For it can scarcely happen, over a long progress of time, with each day adding something, that from the sinking of the heavier part no trace of metal should appear.

15. [Margin: Clefts of the mountains.] Besides, the clefts of the mountains indicate the sharp exhalations of the metals.
16. [Margin: Which plants delight in metals.] In addition, there are plants — rare ones, indeed, but the rarer they are, the more evident the testimony they give of the metals if they are present — that take pleasure in the company of metals. Generally such are these: those that bear no fruit, or little; low juniper, ivy, the wild fig, and the wild pine [pinaster] too, and most of the thorny kinds. There are also trees whose leaves are pale or deciduous, with slender trunks, and everything about them withers.
17. [Margin: Peaks of the mountains.] From the peaks of the mountains, where for the most part vapors tend to breathe out, there are indications of the hidden metals.

To these, finally, we add the divining rod [Virgula Divinatoria], which the metallurgists generally use in prospecting for metals. The divining rod is forked, made from various trees or fruits according to the nature of the metals to be sought out. For most of the more superstitious sort suppose that the effect cannot follow unless it has been cut on Easter Sunday, or on the day of the solstice, or has grown above a vein; nor will the business have any success unless the prospector was born on a Sunday. But just as Nature has no need of these superstitious circumstances in order to act, so too they show of their own accord that the Master of this art was none other than Sa... (continued)

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tan, who busies himself, with the ultimate ruin of souls, to draw into his nets the men who are greedy for gold and riches beyond what is right. [Margin: Vanity of the divining rod.] Hence some construct different rods, each suited to testing out particular kinds of metal. In this way they use a hazel rod [Columna Virgula] for silver, an ash rod [Fraxinea] for bronze, a spruce rod [Piceastri] for lead, a stalk of woad [Isatis caule] for iron, and so on. Some even use magic mirrors, with the addition of incantatory chants, in detecting metallic veins. Hence this vanity, introduced by whatever means, is everywhere rejected by skilled and God-fearing men as a kind of magical illusion. For no reason can be given why a forked rod, held firmly by both horns — even with every magical agency excluded — should nevertheless sustain such violence from the metallic vapors that they drag it downward.

[Margin: Experiment.] Indeed I myself, often making the experiment of this matter over the metallic bodies of gold and silver, was always cheated of my hope. And I clearly perceived that it is a manifest illusion not of a demon but of the one handling the rod — who, deceived by the force of his imagination, thinks that the rod inclines toward the metal of its own accord, when he himself is unwittingly twisting it. The same thing happens, by the way, in the case of those who suspend a ring by a thread and let it down with two fingers inside a glass cup, supposing that the ring, striking the cup as it runs this way and that, marks out the hour. A thoroughly bad deception, since that whole striking comes about from nothing but the pulse of the veins quivering in the fingertips: for if you press the thread firmly, the ring will be set in motion; if gently, it will rest without movement. I demonstrated this fallacy to many men by no means unskilled in physical matters, in a certain academy which a certain Prince had set up here at Rome to discuss the prodigious motion of the ring of this kind. That prince was of the opinion that the several metals, suspended in the said manner and grasped by the fingertips, are directed toward fixed quarters of the world by a kind of magnetic force — so that iron points to the North, gold to the East, silver to the West, bronze to the South, and the rest to the other quarters; and he thought the same happened with precious stones. But the experiment was greeted with universal laughter, when the metals fastened to a thread were let down from a motionless crossbar of wood, or were held lightly grasped by a steady hand: for then they took up an indifferent position according to the twist of the thread. And so this whole business was a mere mockery of the imagination, in that what the pulse of the vein had set in motion, the man ascribed to a property of some hidden motion.

That the same thing holds true, then, of the divining rod, is certain. The reason it cannot be that latent metals impress such a great and so sudden a force upon a rod that is not balanced, but violently twisted, that it is compelled to incline of its own accord all the way to the ground — anyone who has had experience of magnetic motions will testify. For how great a genius and industry are required so that the sympathetic actions of natural things may have their effect, and with how exact and precise a balancing the bodies must be arranged, can scarcely be told. Accordingly, all are to be laughed at who imagine that those forked rods, grasped in the hands, can be set in motion by so subtle a force of exhalations.

Lest, therefore, I should seem to have condemned the divining rod without any benefit, I shall here prescribe another method, which, as I have found certain by manifold experience, so too I trust that all who use it will in no way be cheated of their purpose.

EXPERIMENT I.

Let there be made, from a fragment of rock salt [sal fossile], a little blade [lanceola] one palm long. Join it to any piece of wood in such a way that the wooden part, attached to the salt blade, may move freely in equilibrium, fixed upon a pivot [obelus], or even suspended by a thread. Set this wood-and-salt blade over a pot beneath which a fire has been placed, with salt water or brine [muria] boiling in it, and you will find that the volatile spirits, passing off into vapors, cling to the salt blade by magnetic influence, as to a body like themselves; whereupon the blade, weighed down by the salt particles, will gradually incline downward toward the pot. The same thing, I judge, can happen if a like instrument were set over a vein of salt.

Diagram. A woodcut illustrating Experiment I. At the base, a round-bellied pot stands on a grated hearth or firebox, with flames rising up around and beneath it; a dense cloud of vapor billows up from the mouth of the pot. Above, a horizontal balance-bar rests on a small upright pivot-stand; from the bar's near end hangs the little blade (the salt-and-wood *lanceola*), suspended over the rising vapor so that it can tilt downward as it absorbs the salt particles. No labels or caption are engraved on the figure.

EXPERIMENT II.

Let a little blade be made from wood and a fine golden wire [aurea virga subtili], joined into equilibrium as we said in the preceding experiment. Set this over a pot in which pure quicksilver [argenteum vivum] has been placed; and if you cause it to fly off by applying a fire beneath, you will find that the whole of the mercury joins itself to the golden wire; whereupon the golden rod, weighed down by it, will incline deeply. The same thing, if a golden rod were exposed over a vein of mercury, would happen, as I... (continued)

[Liber X, Sectio II, Caput VII "Metallognomia" — conclusion]

is to be judged. In the same way, if you grind a lump of silver to powder, place it in a pot, and let it heat up by fire, then set above it a small blade [lanceola] made of wood and silver: the blade will draw the tiny silver particles into itself by a kind of magnetic attraction. Weighed down by this, it will necessarily incline toward the place from which the vapor breathes out. The very same thing will happen to a rod held above ore that contains brass [aes], whether the vapor and exhalation of the ore is raised by an internal Vulcan [internal subterranean heat] or by the external heat of the Sun.

Consectarium [Corollary]

From all this it is clear that the hidden matrix [matrix] of everything that flows together to itself by a kind of sympathetic attraction can be tracked down by rods of this sort — provided the sympathetic rod has been constructed, in the manner described above, with another substance endowed with the corresponding power. In this way, a rod made from those materials that have an affinity with simple elemental spring water — such as alder [alnus], water lily [nymphaea], water mint [mentastrum aquaticum], buttercup [ranunculus], and the like — will, when its root or stalk has been joined by a rod to another, non-sympathetic substance (be it wood or metal), and when it is then set down over a spot where you suspect a hidden vein of water lies beneath: in time, weighed down by the watery vapor, it will incline of its own accord. And it will do so without any superstition whatsoever — solely by the magnetism it possesses [magnetismo] — and so reveal the latent vein of water. I would not say this if I had not learned it for certain by an experiment of my own.

Indeed, certain trees standing over metallic veins have taught the very same lesson: their leaves and branches, weighed down by the vapor and as if clothed in a kind of film [cuticula], bent downward, so that they almost touched the earth. This is also plainly seen in trees growing on riverbanks, whose branches in time incline of their own accord toward the surface of the water.

Experimentum III

That there is a remarkable sympathy between iron and vitriol [vitriolum] is well established, since vitriol clings eagerly to iron alone — as if rejecting all the other metals.

So let a rod be made of wood and iron, properly joined together. If you place vitriol in a pot and let it exhale by the action of fire — wonderful to say — the iron at once changes to a rust-brown color, turning into a dusky verdigris [aerugo], as if transformed into brass [aes]. Pressed down by the weight, the whole rod bends and tips into the pot. And these are the things I thought worth setting before the reader concerning the divining rod [virgula divinatoria].

SECTIO III. DE FODINARUM METALLICARUM NATURA, Proprietate, variis accidentibus, varia ad Authorem Responsa.

[SECTION III. On the nature of metallic mines, their properties, their various accidents, and the various Responses addressed to the Author.]

Praefatio [Preface]

As I devoted the utmost care to this work, a great many difficulties arose, and I could scarcely extricate myself from their labyrinth. I therefore decided to consult the metallurgists of the Hungarian mines. (There are none more famous in Europe; and if anywhere on earth Nature lays out her riches and her playful industry above all, it is surely here.) So it seemed best to send off letters without delay, in which I gathered into nineteen propositions the various questions [dubia] occurring to me about metallic matters. But since none of the men in charge of the mines was known to me, I made use of the help of our Fathers at Neusohl [Neosolium; Banská Bystrica] and the neighboring Hungarian mining towns — above all the services of Father Andreas Schaffer. As he was no novice in the metallurgical art, so too he acted with incredible care, diligence, and solicitude in advancing the undertaking I had begun. Together with Father Georgius Weber, the Superior of the Residence at Neusohl, he warmly embraced it, sought out whatever he judged necessary for my purpose, and did so much with the directors of the mines (with whom he had long been on the closest terms) that they too promised to contribute their own share to advancing the work. To each of the directors of the Hungarian mines he handed over a copy of my questions, so that they might send their written replies here to Rome...

and so it was done. The names of those who replied to the nineteen points sent to them will be given below. But so that a later age may come to know the trustworthiness and diligence of these men, I have judged it right to present their Replies here in exactly the order in which they stand in the original manuscripts, with equal candor and sincerity, translated out of German into the Latin tongue.

RELATIO I.

De Fodinis Hungariae rebusque memorabilibus, quae in iis occurrunt.

[ACCOUNT I. On the mines of Hungary and the memorable things that occur in them.]

CAPUT I.

Responsio Schemniziana ad novendecim puncta ab Authore iis proposita.

[The Schemnitz [Schemnitz; Banská Štiavnica] Reply to the nineteen points proposed to them by the Author.]

Praefatiuncula [A Little Preface]

Whereas the Reverend Father Athanasius Kircher, Priest of the Society of Jesus, has — through the Reverend Father Andreas Schaffer of the same Society — earnestly requested that some information be given to him concerning nineteen points touching the condition of metals and minerals, as well as the constitution of the mines in these parts: We the undersigned — the prefects of metallic affairs, the sworn officials [Jurati], and the rest of the officers, administrators, and inspectors of the mountain mines — in obedience to his request, held a council at Schemnitz, a town of Lower Hungary, and deliberating upon the aforesaid points, now at last answer each of the doubts put to us, as follows.

To the First. *On the properties of mineral waters and certain metallic experiments.*

1. Reply 1. The waters that the miners [fossiores] meet at the start are for the most part tasteless, clear, odorless, light, and cold; but as one goes deeper they grow warmer, heavier, and more turbid, according as they are tinged or altered by the metallic juices. Some are white, some red, some green, some blue, some black; they have a certain definite odor, and while they are mineral-bearing they take on a sharp taste, so that fish cannot live in them.
2. When water stands motionless for a long time in the mines, there is generated on its surface a kind of mineral mist [nebula mineralis] resembling a film (in German, *Bergschwaden* [mine-damp]), which — if stirred up and drawn in by breathing — brings instant death. Waters of foul odor and taste are also found, which nonetheless do no harm. There is also a kind of water found there which degenerates into a shape not unlike sugar, namely into little white pebbles. As for the other intrinsic properties of the waters, the miners do not know them, and leave them to be investigated by the chemists and physicians. Experience does indeed teach that three miles [milliaribus] from Schemnitz a certain mineral water is found which gives goiters [strumae] to those who drink it, and that, on the contrary, six miles from here there is another water which, drunk, removes the goiters contracted from the said water.

[Margin: *Mira antipathia aquarum* — The remarkable antipathy of the waters.]

To the 2nd. *On the metallic efflorescences in little tree-like forms, and from which salts, vitriol, etc., they grow.*

Reply 1. Sometimes there are found in the mines crystals wound about with silver threads as fine as hairs, and other like things. In recent years a grain of pure, sheer silver was found (in German, *gediegen* [native]) inside a "foolish stone" [lapis fatuus] (in German, *Taubenstein*), in a kind of white chalk-like material called "stone marrow" [medulla lapidea], as if it had been deliberately hidden there; it weighed two pounds. There is another species of these growths, which in Latin sounds as *vestigium* [footprint] (in German, *Blackmahl* [?]). This clings to the foolish stones, pure and sheer, so that it can be cut with iron like lead. Such growths become volatile in a strong fire; and when such things are found in the mines, they take away from the miners the hope of brass [aes], because they hold it as an omen that, where they are found, they take away the brass where there is brass, but where there is no brass, they produce it there. From which salt or vitriol they are born, the mineral miners do not know.

To the 3rd. *Which mineral bodies above all are found in the mines of gold and silver, copper, tin, lead — and whether quicksilver and sulphur are everywhere found; how the sympathy and antipathy of metals is to be recognized?*

At Schemnitz [Schemnitz; Banská Štiavnica] there is most often found a vein of silver that contains a little gold. There are also found veins of silver containing copper or lead; ordinarily, the further north the silver veins run, the more lead they contain. In the valley of Hodritsch [Hodruša], in the deeper parts, gold and silver ore is found; but toward the summit, marcasite [marcasita] and iron without gold or silver. The vein of iron is twofold: one which...

serves for flux [fluxus] or fusion, similar in kind to the other, from which iron is smelted out. It is to be noted that some years ago a lodestone [lapis magnes] was found in the Ruda vein, from which several hundredweight [centonum centenaria] of iron were extracted. Again, the Schemnitz silver veins, mostly mixed with lead, contain no little antimony [antimonium], and also cinnabar [cinnabaris]; and sometimes there occurs a mineral cinnabar not unlike red lead [minium], containing silver. For this reason, since such minerals, when roasted and melted, give off a sulphurous or mercurial odor, it is altogether believed that there is [quicksilver and sulphur] there — even if quicksilver and sulphur are not present there in actuality, they are nonetheless present in potency, or have some analogy with those substances.

Likewise there is a certain mineral, which in German sounds as *Gleiss* [?], which promotes flux or fusion in the minerals, and in melting draws gold along with the silver. On the other hand, the vein of lead is rapacious and predatory. And there is another kind of marcasite [marcasita], frequent in the silver veins, which is sometimes empty of silver and sometimes mixed with silver. Where this is found, the miners reckon by augury that, where there are no brass ores, the same will be engendered there, but where they are, they will be corrupted. Green or yellow stones signify veins of gold and silver.

To the 4th. *By what machines do they drain off the subterranean water?* — On this Georgius Agricola [Georgius Agricola] answers in *De re metallica*, Book 6, etc.

To the 5th. *How do they resist the pestilent air [aura pestifera] produced by the metallic spirits?* — He replies: by air-shafts [spiracula] and bellows [folles], as above.

To the 6th. *Whether little demons [Daemunculi] or pygmies [pigmaei] appear underground?* — He replies in the affirmative, and recounts many examples.

To the 7th, 8th, 9th. *Whether they encounter certain animals which cannot be seen to live below the earth; and whether the miners experience storms, lightning-flashes [selaura? — read as fulgura], thunderclaps, lightning, earthquakes, and the like, just as with subterranean rivers and springs, etc.?* — He replies that at Schemnitz none of these things is found or experienced.

To the 10th. *Finally, that all the miracles of Nature should be noted.* — Reply: To describe the miracles of Nature briefly is impossible; we ought rather to marvel at the Creator's power and wisdom than to penetrate the nature of each single thing.

To the 11th. *On the heat and cold of the mines — in which parts they most prevail; whether the deeper they are, the hotter; and whether subterranean fires are seen?* — He replies that in those veins no excessive heat or cold is felt, unless the free passage of air is blocked; in which case the workings [fossae] are always hotter, until once again they enjoy free ventilation through the air-shafts.

To the 12th. *On the subterranean winds — whether their eruption takes place through the cracks of the workings; on the constitution of the subterranean air and its purification.* — He replies that winds are not felt in the mines, but rather foul vapors, which (as related above) are driven out by air-shafts and bellows.

To the 13th. *On subterranean earthquakes, etc.* — Reply: nothing of the kind has ever happened at Schemnitz.

To the 14th. *On the subterranean waters — whether they come upon subterranean streams and springs of sweet, nitrous, vitriolic waters, etc.* — He replies that in some places there is always found a very great flood-mass [colluvies] of waters.

To the 15th. *On the courses of the metallic veins — which part of the world they chiefly face, and whether the iron vein faces the north, etc.* — He replies that the courses of the metals never face one single direction, but now toward this one, then toward that, etc.

To the 16th. *On the sympathy and antipathy of metals and of the other minerals, etc.* — He replies that the miners do not know of these things.

To the 17th. *What is the method of separating the metals, etc.* — He replies: by handing them over to the separators [separatores], etc.

To the 18th. *What signs they have for recognizing veins of gold and silver, etc.* — Reply: it is impossible to describe the signs briefly, since each single metal has its own proper stone; this must be learned by long experience. The most certain assay, however, is the one performed by fire.

To the 19th. *Let the places be named in which, and from which, minerals are dug out. Likewise on the thermal baths [Thermae], the acidulous springs [acidulae], and how great is the depth of the mines.* — He replies: at Cremnitz [Cremnitium; Kremnica] there are veins of gold, and not far from there is a vein of quicksilver. At Schemnitz there are veins of silver, iron, lead, copper, etc. At Neusohl [Neosolium; Banská Bystrica] there is a vein of copper. At Püggantium [Pukanec? [?]] there is a vein of gold. At Königsberg [Regius mons; Nová Baňa] and Dülle [Dülle [?]] a vein of gold. At Libethen [Lubethan; Ľubietová] a vein of iron and copper. At Waze [Vaze [?]] and on the Angelic Mountain [mons Angelicus] there is a vein of gold.

There are two thermal springs near Schemnitz; where the water of these baths passes, it deposits a sediment which in time turns into a yellow stone. Near Cremnitz two thermal springs are found. Two miles from Schemnitz, beyond the river Gran [flumen Granum; Hron], near the village of Bukowina, two acidulous springs are found. Near Cremnitz too there are acidulous springs.

The greatest depth of the mines is 150 *Klafter* [fathoms] — that is, of ulnae [ulnarum; cubits].

Ita testantur [Thus they testify].

Ioannes Georgius Weiss, Prefect of the Mines. Iulius von Lansee, Sworn Officer of the Mine Accounts. Elias Angerman, Sworn Officer of Metallic Affairs. Ioannes Zuterig [Zuterig [?]], Scribe of the Mines. Andreas Ungedeu [?], Michael Reuter, Georgius Ulricus Kaiser, Ioannes Henricus, Martinus Sepp, Michael Korch — Inspectors of metallic affairs.

RELATIO II.

Responsio ad Quaestiones propositas, Joannis Schapelmanni, S. Caes. Regiaeque Majestatis, Minerarum cuprearum praefecti in Herrengrundt in Hungaria.

[ACCOUNT II. The Reply to the questions proposed, of Johann Schapelmann, prefect of the copper mines of His Sacred Imperial and Royal Majesty at Herrengrund [Herrengrundt; Špania Dolina] in Hungary.]

CAPUT II.

First Question. *On the properties of mineral waters, and on certain metallic experiments.*

Reply. Among us at Neusohl there is found a kind of vitriolated water [aqua vitriolata], in which iron is transmuted into copper. Each year they make 50 or 60 hundredweight [Centones] — that is, about five or six thousand pounds of copper. This vitriolated water is sharpened with the salt of vitriol [sal vitrioli]; and vitriol is nothing other than the white salt of the earth. This salt is dissolved by moisture; then, passing through the copper ores, it dissolves them and thereby acquires a green color. But if it passes through black copper ore that contains silver, then it is colored blue. All the other metals were placed in this water, but it touches none except iron, which it first turns into the finest powder and at last changes into the best copper — as if it had been deliberately melted in fire and cast into a definite shape.

There also bursts forth from the hardest rocks a certain mineral water which deposits a yellow sediment; but what its material may be, and of what virtue, has so far been unknown. There is also found a certain white water which turns into a hard stone. But if this water, before its coagulation, has passed through copper ore, then there is generated from it a stone called malachite [Malochites]. And when that water flows through copper ore containing silver, there is made from it a beautiful blue stone, like turquoise [Turcois]. This water, however, is nowhere

found more frequently than in mines abounding in flinty stones [lapides silicei] that contain copper together with silver.

2. On the metallic efflorescences in little tree-like forms, and from which salts, vitriol, and the like they draw their origin.

Reply. There are sometimes found in this ore copper efflorescences [efflorescentiae cupreae] of pure, sheer copper (in German, *gediegen* [native]), like the flowers, herbs, etc. mentioned above.

3. Which mineral bodies above all are found in the mines of gold and silver, copper, tin, lead; whether quicksilver and sulphur are everywhere found; how the sympathy and antipathy of metals is recognized.

For the most part there is found in the metallic mines, almost everywhere, marcasite [marcasita], in which sulphur is present. But quicksilver — sometimes in cinnabar [cinabria] — is found at least only in the mines of silver and gold; because quicksilver, or cinnabar, has its own proper ore. Among us at Herrengrund, quicksilver is not found in the copper mines.

4. By what machines do they drain off the subterranean water? — He answers: by suction-pumps [antliae], leather sacks, and the like.

5. How do they proceed against the pestilent air, and how do they remove it in the mines? — When the mines are deep, so that good air cannot be breathed in nor the foul air breathed out, then great bellows are fitted in such a way that good air is blown in and the foul air expelled. But if anyone has been harmed by the subterranean air, he uses no other remedy than to be brought at once into the open air.

6. Whether little demons [Daemunculi] or pygmies appear in the mines? — Reply: such have been seen and heard many times.

7. Whether animals are found in the mines? — He answers that no such thing is found, except certain little black worms that sometimes dwell in the pores of the stones.

8. Whether the miners experience lightning-flashes, storms, lightning, earthquakes, etc.? — Formerly at Herrengrund, before air-shafts [spiracula] were made in the mines, it was observed that vapors had collected in the mines, which were very easily set ablaze when a lit lamp was brought in, with a tremendous roar; and those touched by this fire were so badly burned that the skin could easily be

drawn off, as if they had been scalded by boiling water. For the rest, earthquakes do occur beneath the earth, just as above it.

9. *On subterranean rivers and springs — whether they are found?* — Subterranean waters are found in the mines, more or less according to the situation of the mine. From some mines they are led out by individual channels [ductus]; elsewhere they are drawn out by hydraulic instruments.

10. *Let all the miracles of Nature be made known.* — He answered: here there is nothing else new or wonderful, except a certain stone that represents various shapes.

11. *On the heat and cold of the mines — in which parts they most prevail; whether the deeper ones are hotter; and whether subterranean fires seem to appear.* — He answered: when the mines are dry, the deeper they are, the hotter, because it is impossible to make sufficient air-shafts for them on account of the depth; but when they hold water, they are not so hot, even if deep. But if they are deep, and dry, and have marcasitic veins, they are always hotter. Fiery storms [tempestates igneae] are not felt among us; but very often blue flames are seen at night in the mountains rich in metals.

LIBER DECIMUS — Metallurgia [Μεταλλουργικός]

Sectio III — De Fodinarum metallicarum natura (On the nature of metal mines)

RELATIO II (continued) — Johann Schapellmann, prefect of the copper mines at Herrengrund

(Source: PDF p. Fol. 187. The point-by-point reply continues from point 3.)

[Margin: Sulphur of purifying power.] ...At Kremnitz [Cremnitz] and at Königsberg, in the gold-bearing ores, there are sulphurous flows within the ores, where the sulphur keeps company with gold alone without harm — though much to the detriment of the other metals. And just as it purifies the gold, so from the others it strips away their splendor and beauty.

[Margin: Cinnabar.] [Margin: Pyrites.] In these silver-bearing ores zinabrium — that is, cinnabar — is likewise found, together with marcasite; and experience

teaches that cinnabar sometimes spoils the metal. Nonetheless it is a pleasure for the miners to see, in the foremost workings, fissures filled with the tincture of cinnabar.

In the copper ores at Schmolnitz [Schmöllnitz] and Herrengrund pyrites is found, so much so that I am led to believe that copper is generated from it — once the vitriolic humor mixed in with it is joined by internal heat and celestial influences. For experience shows that in mountains where copper ores are wanting, only a spurious pyrites is to be found as well.

[Margin: Silver readily associates with copper.] Silver associates amicably with copper and is the more advanced toward greater purity by it. But one must take care, during the smelting, that it does not lose everything through some malign quality mixed into the same — for it exerts its powers most strongly in the copper-shavings with which they are blended. In the same way silver associates with the other metals; indeed, in smelting it readily joins itself to copper.

4. By what instruments is water drawn out from the caverns of the minerals?

[Margin: Use of the pump [anthlea] in the mines.] First and above all, fixed cisterns built into the mountains are a great help. Into these the waters fall through fissures from the upper part of the mountain, and from there they are led off by certain conduits.

Whatever water falls below these cisterns is either extracted by a pump [anthlea], if the water is not abundant, or else by another hydraulic device — namely, by a larger channel of three fathoms [orgyae], which below the drum [tympanum] has a wheel above, and a chain passes through the channel, the wheel, and the drum. To this chain are fastened sacks of leather, which in the lower part of the channel scoop up the water and are drawn up through that channel. (See Figure V, set out at the end of this chapter.) There are more than seventeen such devices, one above another, and through each the water is conducted into a particular cistern, and from that one again into another, until it pours out into the common cistern mentioned above.

Another device is assembled from several pumps, in which the several pumps are set in motion by the movement of a single iron rod, and in this way the water is conducted off, as above.

5. How is pestilent air suppressed?

[Margin: Deadly air, to be purged in the mines.] This pestilent air is the lack of fresh air, by which vapors are normally dispersed. Now and then it settles, like a

fog, into pits; and with a certain sweet but malign odor, like that of new wine [mustum], it seizes those who disturb it, and quite often suffocates them. This malign air is dispersed by the introduction of fresher air through bellows that blow in good air, or else by continual agitation of the same pestilent air. But concerning these machines and their structures, see the end of this Section, Cap. 6.

6. Whether little demons [demunculi] appear in the mines?

[Margin: Little demons in the mines.] From times long past these have appeared, always as a good omen for the miners. Let the reader look in the preceding Book, on the subterranean demons, where he will find everything pertaining to this subject treated exactly.

7. Whether certain small animals are found in the mines, or storms?

Nothing has been observed by the miners, except earthquakes.

8. On subterranean rivers and springs.

[Margin: Water-springs in the innermost recesses of the mines.] Apart from what is said above, there are none; but from below, continual welling-up of waters is noted, so violent that they would burst out even through obstacles by force, were they not led off by another passage. Not far from Neusohl [Neosolium], in a village called Walascha, so powerful a stream bursts from the rock that it is fit to drive a mill.

9. All the marvels of Nature.

[Margin: Mixed metals are found.] This seems a rare thing: that in Upper Hungary the ores are so intermixed from copper, iron, and lead, that not infrequently in the uppermost part there is iron, in the middle copper, and in the depth lead-bearing material; and that elsewhere too there are copper veins infected with lead. In the silver-bearing stones it has been observed that they abound in lead, so that when such stones were cut open it was found that a hundredweight [centenarius] of such stone contained 20, 30, 40, even 50 pounds of lead — though such stones were not found in great quantity, for one soon came to other stones less rich in lead.

(Source: PDF p. Fol. 186. Relatio II resumes at point 12; points 10–11 fall outside this batch.)

12. On subterranean winds: whether their eruption is felt through the fissures of the mines? On the condition of the subterranean air — whether,

and by what means, it may be purged so that it does no harm, and by what instruments?

He replied: Subterranean winds are not perceived among us. Bad air is expelled from the mines by bellows and by air-shafts; or, if the mines are not very deep, by agitation of the air through suitable instruments.

13. On subterranean earthquakes: whether they so shake the earth as to crush those at work?

He replied that this does happen, and he relates that several instances have occurred.

14. On subterranean waters: whether they fall into subterranean streams, springs of fresh waters, of nitrous, vitriolated, or bituminous waters; and if they have no outlet, how they draw them off, and by what instruments?

He replied: There are found in the mines fresh waters fit for drinking, sometimes putrid and impure ones, likewise vitriolic waters which change iron into copper, as was related above. The streams are led off by aqueducts or by hydraulic instruments.

15. On the courses of the metallic veins: which quarter of the world they chiefly face; and whether the veins of iron in particular tend toward the North?

He replied: The courses of the metals — both of iron and of the others — run sometimes toward the South, sometimes toward the North, and sometimes the courses are cross-shaped [cruciform].

16. On the sympathy and antipathy of metals and minerals, and in what these consist?

He replied: Every ore has its own particular properties. Some produce only a single metal, others several at once. For the rest, the metallurgists are wholly ignorant of their sympathy and antipathy, nor do they inquire into them.

17. What is the method of separating the metals from their ores?

Each of the metals is separated in various ways. The general method, however, is this: the ore is first roasted in a gentle fire, so that the ♃ [Jupiter — i.e. the combustible sulphur] may evaporate — that is, the combustible sulphur; afterward it is washed until all the lighter earth, together with its corrosive quality, has departed. The heavier portion, which with each washing settles to the

bottom, is dried, and according to the condition of the metal is melted down and finally separated — as Agricola [Georgius Agricola] and Lazarus Erckerus [Lazarus Ercker] treat more fully.

18. What are the signs of ores, and by what means are the veins of gold and silver recognized?

The veins of ores are chiefly recognized by long experience and practice, since every vein has its own particular stones. A black, tenacious, clayey earth usually has the gold-ores around or beneath itself.

19. Let the places be named in which, and from which, minerals are dug in Hungary; likewise concerning the hot springs, the acidulous waters, and how great is the depth of the ores.

At Neusohl is dug an ore containing copper alone, and in the same place is dug another, black copper ore, containing copper and silver together. As to the depth of the mines, some are 147, others 137 [Fraktur: Klaffter — that is, fathoms (lit. "ulnae," ells)] deep.

At Kremnitz a vein of gold is found. At Schemnitz are found veins of silver and of lead. At Königsberg [Regiomonte] there is a vein of gold, likewise at Pukanz [Puganzii]. At Dilln [Dielen], as also at Holdritz [in Holdritz], veins of silver are found. There are hot springs: [Fraktur: Stubnerbadt; Bonißeibadt (?)]. And at Schemnitz there is a hot spring near the glassworks. Again, among us are found several acidulous springs, whose powers are unknown to me.

Thus far from the Relation of Johann Schapellmann, prefect of the copper mines at Herrengrund.

RELATIO III — Georg Schütz [Georgii Schutz], prefect of accounts in mineral affairs for His Sacred Imperial Majesty in the Schemnitz Chamber

(Source: PDF p. Fol. 186, lower portion.)

CAPUT III

1. On the property of mineral waters, and on certain metallurgical experiments.

In Upper Hungary at Schmölnitz [Schmolniz], as also at Neusohl in Herrengrund, there is found so powerful a vitriolic water that iron placed in it for some time degenerates into copper; and it is more powerful than that found at Schmölnitz.

This copper endures in the fire, but falls short in quality compared with the copper-stone if it cools; so it is added only to that. Here at Schemnitz, in the adjacent water, there was seen to adhere a certain solid scum, clinging to the timbers in the mineral water after the manner of a natural stone — which, however, has not yet been tested as to what mineral matter it contains within itself.

[Margin: Metallic efflorescences.] **2. On metallic efflorescences upon little shrubs, etc.**

In the silver-bearing ores there are often found silver efflorescences, where the most brilliant silver puts itself forth from the metallic stones in the form of a thread or a hair. Indeed, there are found shavings of pure silver of a finger's thickness — though somewhat blackish, and of a more or less leaden color. Not rarely there sprout forth crystalline parts as well, though not in such quantity as the silver; yet so pure that they surpass the well-worked Bohemian and Hungarian diamonds [adamantes].

3. What copper minerals in particular are found?

(Source: PDF p. Fol. 188. Relatio III, Caput III, mineral specimen items continue. These number the specimens Schütz sent; item 3 begins after the catchword "Cremb-" from Fol. 186.) ...That which has the splendor of gold is pure copper, which by the German mineralogical term they call [Fraktur: Gälff [?] — i.e. "gelb," yellow], to distinguish it from the mineral stones which, though they appear black, contain not only copper but also silver.

[Margin: Pyrites.] **3.** [Fraktur: Marchesidt bey m Khies] — that is, pyrites. This adulterine ore is found in the same place where the ore set down under number one is dug.

[Margin: Lead ore.] **4.** [Fraktur: Bley ärtzt] — that is, lead ore. This, under number four, contains a threefold reckoning of color: the first color is black and gleaming, and is the ore of pure lead; the second color has a white streak, and contains nothing, but is a kind of flint, which in the mines they call [Fraktur: Quartz], which is as it were the matrix of the ores; the third color is one which is nothing other than copper ore.

[Margin: Iron ore.] **5.** [Fraktur: Eysen ärtzt] — or Ruda — is iron ore, not far from Schemnitz, and is dug in the same place, where there are also hot springs; and there too, some years ago, magnets [lodestones] were dug out in great quantity, which in the smelting furnaces they worked up into iron.

6. There is iron ore, not at Schemnitz, but from another place of the mining towns of Hungary, called Roniz [Roniz], a place which lies toward Upper Hungary, 4 miles from Neusohl. This ore likewise contains iron, which is smelted there in fact for the uses of the Hungarian chambers. Concerning this ore it is to be noted that in this whole highland no steel [chalybs] is found, but only iron is smelted, and that not very well refined. In this same highland is found an iron ore in the form of balls, with which we attack the enemy by muskets.

[Margin: Silver marcasite.] 7. [Fraktur: Marchesidt mit Silber ärtzt vermengelt] — this is a silver ore which has gold mixed in with it; but what in this stone seems to have the gleam of gold is not gold, but is called marcasite.

8. [Fraktur: Ries [?]] — this ore is of no use, except to make the silver ores flow [Fraktur: in grossen Wercken] — that is, in large processes; therefore they call it here [Fraktur: einen Fluß] (a flux).

[Margin: Cinnabar ore.] 9. [Fraktur: Ärtzt mit Cinober] — or minium. The black color in this stone is silver ore, which has gold mixed in. The red color denotes cinnabar, in which quicksilver resides.

[Margin: Plumbago [graphite], ☉ & ☽ [gold and silver]-bearing.] 10. [Fraktur: Bleyglängig [Bleyglänzig] ärtzt] — it is an ore, containing silver and gold, having the splendor of a lead ore.

[Margin: Crystalline ore.] 11. I send here to Your Reverence a marcasitic ore, as it grows in the silver-bearing mountains of Schemnitz, from which Your Reverence will see how learnedly Nature produces crystals, which are both most lucid and sometimes grow into great quantity. I send specimens of both kinds under numbers 11 and 13. In this matter Nature's craftsmanship is marvelous, in that all the crystals growing here are six-angled by nature, polished, and pointed.

12. A crystal from the Schemnitz earth. [Margin partly truncated.]

[Margin: Crystal of prodigious size.] 13. This crystal was dug out in the copper-bearing mountains of the most excellent lord Franz Wesselényi [Francisci Wasselini], count of Hadad [Hadat], Palatine of the Kingdom of Hungary, where in the past year a crystal was found in such quantity that it weighed more than 100 pounds, that is, more than a hundredweight [centenarius]. So the most excellent lord Palatine was moved to inquire, through dispatched men, after a craftsman who might know how to carve and shape this crystal either into the form of a monstrance [monstrantia] or some such, and afterward, as he resolved, present it to His Sacred Imperial Majesty.

[Margin: Iron turned into true copper.] **14.** Here I send to Your Reverence copper which, in the Valley of the Lords (a place the Germans call [Fraktur: Herrengrundt]), was made from iron by the vitriolated water that flows within the mountain itself; and they call it [Fraktur: Zementkupffer], concerning which Your Reverence will find it inscribed under letter A, number one. And this is to be understood about this copper made from iron: first, that iron beaten into plates and cast into this water, in the quantity of several hundredweights, is turned into copper within these waters. Second, this copper has this peculiarity over other copper: that it need not pass through thirteen or fourteen fires, like copper smelted from ores, but can be worked up immediately into anything. Third, this copper made from iron is more apt for cups and similar more delicate works than that which the ores supply.

[Margin: Horseshoe turned into copper.] **15.** There is a horseshoe, in part turned into copper by the vitriolated water — that is, by [Fraktur: Zementwasser] — which would have passed wholly into copper, had it been left long enough in the said water.

[Margin: Lodestone.] **16.** I send here a piece of lodestone [magnes], which is dug at Schemnitz, and about four miles from Neusohl, and is found in several other places of Hungary. If Your Reverence should desire more, I will supply it.

[Margin: Copper and silver powders.] **17.** These powders are called at Neusohl by the German term [Fraktur: das Schwartz Fischeerck]. They are found in the Valley of the Lords, where copper is dug; through the water from the mountain these powders are washed out; they contain copper and silver.

18. Likewise there are powders from the same place, and they are called [Fraktur: Gälff Fischeerck], and they contain nothing but copper.

19. Here a color is called by the German term [Fraktur: Berchgrien [Berggrün]]; it is gathered at Herrengrund, where the water flowing down through the copper minerals in the mountain is led into certain chests prepared for this work, into which the water flows and leaves behind it this color settling on the bottom. It is to be noted — as I have it from those skilled in these matters — that this powder, or color, is so rich in copper that a hundredweight of this copper, committed to the fire, yields more than 54 pounds.

[Margin: Galactites [?], or milk-stone.] **20.** This stone is called by the common name [Fraktur: Steinhilch] by the miners; its origin is thus...

(Source: PDF p. Fol. 189. Relatio III, Caput III, items 21–35. Item 20 continues from Fol. 188's catchword "bet,") ...it flows through the veins of the yellow or black copper ores, and where it trickles drop by drop onto the beams by which the mountain is supported (set there to give the miners access at the entrance), it is turned into this stone.

[Margin: Sulphur ore.] **21.** There is a sulphur ore, which is dug in great quantity two miles above Neusohl. And although this ore is rich in quite good sulphur, and even somewhat productive of gold, nevertheless it is not in fact dug for any other use except to make the smelting of the silver-bearing and gold-bearing ores easier and more successful; hence it is called this sulphur ore. [Fraktur: zum Schmelzen Sluce [Fluss?] tauglich [?]] — fit for smelting.

[Margin: Coals [lithanthrax], harmful to the mines.] **22.** This stone is called [Fraktur: Steinkohlen]; it is a whole mountain between Neusohl and Kremnitz, two mining towns of Hungary, near the quicksilver mines, where it is dug together with cinnabar. No one here uses these coals for smelting ores, neither the smelters nor the blacksmiths for their forges, nor anyone else. I asked the reason, and received the answer that they stir up too violent a heat, so that it consumes the iron and destroys all the smelting.

[Margin: Copper ore.] **23.** There is a copper ore which they call [Fraktur: Gälff ärtzt]; it contains within itself no silver or gold, but only copper. The largest of these three was dug from the new pit which last year they found most happily, and with such great blessing that from this single pit it is thought His Sacred Imperial and Royal Majesty will have a yearly revenue of 50,000 imperials. The second of this kind is also dug at Herrengrund, and contains nothing but copper; the white stone found in the same place is called [Fraktur: Quartz]. The third sort is nothing but an ore of pure copper.

[Margin: Copper ore.] **24.** There is a copper ore which they here call [Fraktur: Schwartz ärtzt]; it contains copper and silver, of which they dig such a quantity at Herrengrund [Fraktur: Herzengrundt] that yearly, by separation, they extract about seven hundred silver marks — sometimes more, sometimes fewer.

25. This ore is of antimony [antimonium], which at the same time has somewhat of gold in it; it is dug in the mining towns in great abundance.

[Margin: Red sulphur.] **26.** This ore is called by some [Fraktur: Rothgulden ärtzt], by others [Fraktur: roter Schwefel]. They have indeed tested it by various experiments to find what it might contain, but discovered nothing native to it, except that it is a great poison.

27. There is a copper ore in pure gypsum, which ore is likewise dug here in the mining towns.

28. This ore, from the goods and lands of this college, near the mining towns, is so rich that — not only from the assay made by me, but also from the experience of many others expert in this matter, and of the sworn assayers of His Sacred Imperial Majesty made upon it — a hundredweight has been found to contain at least twelve lots, that is, 12 [Fraktur: loth], of silver (which, however, for the greater part is gold).

29. This powder, at the air-shafts of the furnaces, by which silver is separated from copper, is collected by means of Saturn [Saturnus — lead], and they call it [Fraktur: Bleyrauch]. [Margin: Soot of lead.] In the same workshop, just as the furnaces are double, so here a double powder is collected, dull yellow, and it is nothing else than arsenic. This powder the workmen dread as the greatest poison.

[Margin: Cinnabar still containing silver.] 30. There is cinnabar, which still contains silver; it is dug near Neusohl.

[Margin: Choice copper powder.] 31. This powder is the choicest copper; it is collected and made in this way. There is a furnace so prepared that into it are readily admitted 80, 100, or more hundredweights of copper not yet fully smelted. When this melts by the sheer flames which the bellows, drawn by waters, excite, the melted copper is cast out beyond the openings by the excessive blast of the bellows, and there is caught in a pan full of water. The material thus reduced to powder is so fine, and so purged, that the most noble water-clocks [clepsydrae] can be made from it.

[Margin: Iron turned into copper.] 32. This is water from the Valley of the Lords, or Herrengrund [Fraktur: Herrengrundt], near Neusohl, where there are copper mines, which they here call [Fraktur: Zementwasser], or simply [Fraktur: Zement]; it flows through the copper ores and is of itself vitriolated. Into this they throw plates of iron, and within three months a hundredweight and more of iron plates are turned into copper. At Schemnitz there is a place, about eight miles distant from Neusohl, where a similar water of greater efficacy and quantity is found.

33. There is a mineral sent to me from Schemnitz, whose force and virtue, since they have not yet communicated it to me by any information, I have now requested; and I expect it at the next opportunity, so that I may communicate it to Your Reverence as soon as possible.

34. I send here to Your Reverence an ore altogether precious — since at this time something like it is more rarely found — where Your Reverence will see pure silver efflorescing into its own filaments. The yellow that shines is purest gold; what is blackish is silver mixed with gold.

35. These green stones are likewise produced from water, as I wrote above under number 20, with this difference, however, that this green stone... [continues on a later page]

RELATIO IV — Father Andreas Schaffer, on the different minerals found in the Hungarian mines

(Source: PDF p. Fol. 187, lower portion.)

CAPUT IV

A specification of the minerals collected at Neusohl, Schemnitz, and in the other mining towns of Hungary, which the said Father — both for the adornment of the Museum and for the gaining of knowledge of minerals — sent to the Author, intent on his *Subterranean World* [*Mundus Subterraneus*], and they follow.

[Margin: Marcasite.] Number one. [Fraktur: Marchesidt von Silber, glett ohne tugendt] — that is, silver marcasite, which, though it may seem to contain something, yet in the fire leaves nothing but slag.

[Margin: Copper-bearing material.] 2. [Fraktur: Gälff bey m ärtzt] — that is, an ore containing copper, silver, and gold...

[Source PDF page order is non-linear. Reading order by running headers / page numbers: = printed 190]

(Continuation: RELATIO IV — Father Andreas Schaffer's specimen list)

[Printed p. 190, top of left column — continuation of the numbered specimen list begun in the prior pages.]

it is generated from water flowing through copper ores, just as that stone listed under number 20 is generated from water flowing through silver ores.

[Margin: A piece of alder-wood turned into stone.]

36. I am sending this stone, which I received on the most trustworthy authority from a most worthy man, who reported that an entire alder tree, branches

and all, was found in the water and had been turned into a similar stone. From that tree, thus turned to stone, he gave me this fragment out of a special favor.

37. This lead contains silver and gold within itself. I am sending it as a sample of one method of smelting silver from its ore. Moreover, I will give Your Reverence a special account of the method of extracting gold and silver from ores.

RELATIO V.

On the Tyrolean Ores [De Tyrolensibus Mineris], drawn up by the most noble and most distinguished gentleman, Lord Johann Gervick [Joannes Gervick], Counselor to His Serene Highness the Archduke.

CAPUT V.

Beyond the things common to other regions, it is reported that the glassy ores here [in Tyrol] contain silver and copper.

[Margin: The veins make themselves known by the sound of the ore.]

It is well known to the miners here that, where the mineral pits are worked, great rifts in the mountains are found, rifts separated internally by Nature herself from the adhering parts. The miners perceive this separation by a loud cracking sound, and it is a good omen to them — a sign of finding rich ores.

[Margin: Stones rich in copper.]

From the copper-bearing stones [lapides aerarii] found here at a place called Teuffers [?], an excellent vitriol [vitriolum] is made.

Likewise, from iron they make copper that is harder than the common kind, yet finer in color. The process goes as follows. First, a wooden vessel is filled with water however convenient; into this a fairly large quantity of marcasite [Marchesita] is placed. This water is made to boil with iron slag, called *Schlacken* [German: slag]. Second, the water is poured into another vessel, where again the same amount of marcasite is added and brought to a boil; this is done a third time as well, so that the water becomes as charged with vitriol as it can be.

[Margin: The method of smelting copper.]

The water is then left to settle quietly until the denser marcasite material sinks; the water is then poured off into copper cauldrons, into which iron plates are placed, and it is boiled so that the vitriolic water may attack the iron. As it boils, certain particles of the iron dissolve and sink to the bottom as a dense material. Once the vitriolic water is thus cooked, it cools and is poured into linen vessels — these vessels are wide at the top and narrow at the bottom. The water is left in them until the vitriol adheres to the sides. Whatever does not adhere is poured into a vessel of larchwood, into which several pieces of iron are placed, and it is left until it begins to boil of its own accord. When it stops, the water is poured back into the first little vessel, and that dense material is set aside; and this is repeated often, until several hundredweight of such dense material accumulates. Then this material is dried, and from it black copper is smelted out in a furnace, until at last, in another place called *Goltgrueben* [?], it is turned into fine copper.

§ VI.

On the Metallurgical Machines [De Machinis Metallurgicis].

[Note: the body running-head numbers this as § VI and the body heading reads "CAPUT VI." See QA report — both forms recorded.]

Although we made mention of the metallurgical machines in Section 2, Chapter 4 of this Book (*Mundus Subterraneus* X, sect. 2, cap. 4), since some matters were nonetheless omitted there which afterward came to my knowledge, I have judged it fitting to insert them here, as in their proper place. For they contribute in no small way to overcoming the difficulties that metallurgists encounter in the mines.

[Margin: The construction of the pneumatic machines.]

There are, then, various metallurgical machines, of which the chief place is held by the pneumatic [Anemicae] and the hydraulic [Hydraulicae]. The pneumatic, or air-machines [Ventosae], constantly supply fresh air to the foul air of the mines, and they are in turn divided into various kinds. The hydraulic machines are those by whose aid partly the waters stagnating within the mines are pumped out, partly the heaps of metallic and mineral clods are drawn out of the mines, and partly they also serve to lower and raise timber, men, and animals. Of these I shall treat briefly here, beginning with the pneumatic machines.

[Margin: The construction of the pneumatic machines.]

The pneumatic machines, or air-blowers [ventosae], are properly built by metallurgists to remedy, by a supply of fresh air, the air of malignant character lodged in the mines; and they are carried out in various ways: either by means of bellows — such as the machine placed in Section 2, Chapter 4 — or by little fans set in continuous circular motion; or finally, by certain drums [tympana] which carry the blasts of wind, taken in from outside, through channels to the innermost recesses of the mines. But since such is the nature of air that it can by no force be drawn into a channel unless the mine has within it another passage by which the wind let in may make itself an exit — for if it does not obtain this, it will indeed somewhat compress the putrid air within, yet the usual malignancy of the lodged air will always remain; whereas if it obtains an exit elsewhere, then the air, through an ever new and renewed admission of air, will be able to be perfectly purged, to the great relief of the miners.

[Printed p. 191, running header "DE FODINARUM NATURA." 191]

For the breeze in such underground places is sometimes so heavy that it not only makes breathing difficult and the work hard for those underground, but even extinguishes lamps and lanterns. Indeed, it sometimes even suffocates the miners themselves by cutting off their breath.

To remove these difficulties, then, they are accustomed to improve the air by various machines, as I shall describe.

Diagram. A full-page engraving titled *Figura I. Machina Anemica* (Pneumatic Machine). The scene shows a conical mountain in cross-section. At its summit rises a vertical shaft (axle) topped by a horizontal weather-vane device. On the left arm of the vane is a broad triangular sail or flag bearing the monogram **IHS** (the name of Jesus, the Jesuit emblem); on the right, a tapering tubular nozzle points toward a personified wind — a human face within clouds at upper right, blowing toward the device. The vane turns on a cylindrical drum-shaped housing at the top of the shaft. The shaft descends through a vertical air-channel into a chamber at the base of the mountain, where the air is delivered to the mine workings.

Readable labels:

- **IHS** (on the left sail): the Jesuit/Christogram monogram (decorative-symbolic, on the vane).

- A (right side of the drum housing): the nozzle/intake opening facing the wind.
- B (left side of the drum housing): the sail-arm side.
- G (top of the drum): the upper part of the cylindrical housing.
- D (below the housing): the lower fitting where the housing meets the shaft.
- C (upper right, at the wind-face): the personified wind blowing.
- S (left rim of the mountain summit opening): the mine-mouth / shaft opening.
- V (right rim of the summit opening): the opposite side of the opening.
- L (in the lower chamber, center top): the delivery point of the air-channel.
- N (lower chamber, left): left side of the underground chamber.
- M (lower chamber, right): right side of the underground chamber.

[Lower portion of p. 191 — explanatory text in two columns, beneath the figure:]

[Margin / sub-caption, italic: A machine for improving the air in mines.]

The channel **EL** [?], of whatever material, they first, in some regions, lower into the passage **VS** [?]; they make it firm with various timbers projecting from its sides. Onto this, outside the mouth of the passage, they set an instrument shaped like a cylindrical cask, as **GD** show — yet built with such craft that this cylindrical hollow vessel can turn freely in any direction. It has, moreover...

[Printed p. 192, verso running header "LIBER DECIMUS, Sect. III." 192]

a hole [was in the middle] large enough, marked with the letter **A**. At the bottom it also has a hole **E**, which corresponds to the mouth of the channel. To this, behind, directly opposite the hole **A**, let a vane **B** be attached — of the kind usually set on the tops of towers to indicate the quarters of the winds — and you will have the instrument complete. For since the cylindrical vessel is rotatable, it will come about that, with any wind blowing at last, the vane will always turn the hole **A** toward the wind; from which the wind, let in with the greatest force into the hollow of the vessel and packed in, is carried through the mouth of the channel into the innermost parts of the mine **MN**; and in this way, the squalor of the putrid air being dispersed, fresh air will always, day and night, fill the mine. We add a figure here, from which the reader will more truly grasp our meaning.

Diagram. A full-page engraving titled *Figura II. Machina Anemica* (Pneumatic Machine). It shows a mountain in cross-section with a vertical shaft running from the surface deep into the mine. At the top, above the surface, is a multi-bladed vaned wind-wheel (a windmill-like rotor of crossed sails). At upper right a

personified wind — a human face among clouds — blows a stream of air toward the rotor. The vertical shaft descends through the mine and carries, at two lower levels within the cavern, additional crossed-blade fans (paddle-wheels) mounted on the same axle, which stir and drive the air downward through the workings.

Readable labels:

- A (upper right blade of the top rotor): one sail of the surface wind-wheel.
- B (upper left blade): another sail.
- C (lower blade): another sail.
- D (right blade): another sail.
- E (center hub of the top rotor): the axle hub.
- (The face among clouds at upper right is the personified wind blowing toward the rotor; unlettered here.)
- (The two lower crossed-fan assemblies on the shaft within the cavern are shown but carry no legible letters.)

[Lower portion of p. 192 — explanatory text in two columns:]

Another method is carried out by means of little fans, of the kind shown in the following figure. Outside the mine they make a fan, as Agricola [Georgius Agricola] teaches, [mounted] on a long iron rod which [reaches] into the innermost part of the mine...

[Printed p. 193, recto running header "DE FODINARUM NATURA." 193]

[the iron rod] extends to the bottom of the mine, and there rests on a pointed spike in a hollow of thick glass. Below, on the iron rod **EF**, you may fasten as many blades as you wish, similar to the upper one. Thus, when the blade **ABCD** is moved by the wind **L**, it will turn the whole rod **EF** inserted into it along with itself, and along with it the blades fixed to it inside the hollow of the shaft; and in this way, by the multiplication of the blades, sufficient wind must necessarily be supplied to purge thoroughly the air lurking within. But if the depth were greater than the rod could reach, then the rods would have to be multiplied, and afterward set in motion by the manual labor of the miners. The blades, moreover, can be made larger or smaller for a greater or lesser wind, fitted not only with four vanes, but with six, eight, even twelve. It would be best if the outermost blade were covered over, leaving only a very large opening in the cover: for in this way the wind, rushing in through the opening with greater force, would turn the vane with a swifter motion.

On the Hydraulic Machines [De Machinis Hydraulicis].

Machine III.

Nothing is so necessary to mines as the hydraulic machines. For by these not only are the waters drawn out that stagnate within the mines, to the great hindrance of the miners, but also the mineral clods, and whatever furnishings pertain at last to the interior workings, are — together with the provisions assigned to the miners — both let down and again drawn up. They are, moreover, of various kinds.

Diagram. A full-page engraving titled *Figura III*. It depicts a windlass (the *peritrochium in axe* — wheel-and-axle) set over a mine shaft beneath a peaked timber-and-tile roof. Two miners stand on either side of a horizontal drum/axle: the one on the left (labels B, F) raises a crank-handle; the one on the right (labels A, C) turns the opposite handle. A rope is wound around the central cylindrical drum, from which a bucket or cask (labeled E) hangs down into the shaft. The frame rests on a timber base (labels H, I) and a lower crossbeam (label G).

Readable labels:

- A (right side of the drum/axle): one end of the axle / right crank.
- B (left side of the drum): the left side of the drum.
- C (far right, by the right miner's hand): the right crank-handle.
- D (implied as the left crank-handle, paired with C in the text "manubria C D"; on the figure the left handle area near the left miner).
- E (the bucket/cask hanging in the shaft): the vessel for raising water.
- F (center, on the drum): the cylinder/drum around which the rope is wound.
- G (lower center, below the drum): a fitting on the lower crossbeam.
- H (bottom left of the frame): the base timber, left.
- I (bottom right of the frame): the base timber, right.

[Lower portion of p. 193 — explanatory text in two columns:]

The most useful of all is the one that Figure III displays, which is nothing other than a wheel-and-axle [*peritrochium in axe*]. With a rope wound around the cylinder **AB**, water is conveniently drawn from the mine shafts by alternating hauls, by the aid of two miners turning the handles **CD**. But if the shaft is deeper, then several such [windlasses] can be set up within the channel of the shaft...

[Continuation of the description of Machine III, from folio 193:] ...[?] sent: and in this way the water is raised from one place to another. I have observed that this is done in some mines. But since the figure itself sufficiently makes my meaning clear, I refrain from describing it at greater length.

The Fourth Machine

Diagram. A hydraulic chain-of-buckets machine. Above is a large gear-wheel; from its axle descends a chain fitted at intervals with wooden balls (globes), running down into a vertical channel and through a fountain-like spout into a two-handled cauldron at the bottom. The wheel is turned by two crank-handles at left and right. Engraved labels:

- *Figura IV* (top): the figure title
- X (upper left): the left crank-handle
- R (upper left, below X): the left support post
- A (right of center, on the axle): the square axle [axis quadrata AB]
- Y (right): the right crank-handle
- D (center): a ball-link of the chain
- G (lower left): support frame at the basin
- T, H, M (lower left, stacked): the left-hand supports R T and S A and the vessel
- P (center, in the basin): the channel concavity into which the balls fit
- I (right): the well-shaft side
- Z (lower center): the discharge channel
- N (lower right): the discharge channel timber
- O (bottom, on the cauldron): the upper mouth of the vessel M O / the receiving vessel

Caption beneath: *Machina Hydraulica IV.* [Hydraulic Machine IV.]

A second machine is assigned to drawing off water, though it is a rarer type. It is constructed as follows. A wheel E D of conspicuous breadth — which they also call a drum [tympanum] — is fixed to a square axle A B, set upon the supports R T and S A, and is turned by two workmen by means of the crank-handles X and Y. The wheel has an iron chain wound around it, to which, every two or three palms, wooden balls are attached, sized in proportion to fill the concavity of the channel P. As the wheel turns, the chain is drawn down through the shaft I G H K all the way to the standing water; then, rising up again through the very middle of the channel sunk within the water, it draws the water up — water caught and

held between one ball and the next — and discharges it at the topmost mouth of the vessel M O into the channel Z O, as is shown in the present Figure IV.

The Fifth Machine

Diagram. A hydraulic bucket-chain machine driven by a large treadmill wheel. At right stands a great wheel (G...H) trodden by a man inside it; at left a vertical chain of leather buckets [haustra] rises and falls between rollers, drawing water up from a pool at the bottom and discharging it into a trough at the top. Engraved labels:

- *Figura V* (top center): the figure title
- G (top right): the treadwheel rim / its upper point
- A (upper left of center): the upper roller about which the bucket-chain passes [rota A B C D, upper part]
- N (left): the discharge trough / spout at the top
- F (left, below N): a frame point
- D (center): a bucket-link
- M (lower left): the receiving vessel / tub
- H (lower right): the lower point of the treadwheel
- [Several lower labels on the buckets and frame are present but not separately lettered legibly — the chain of leather buckets descends from A past D down to the water.]

Caption beneath: *Machina Hydraulica V.* [Hydraulic Machine V.]

The fifth machine is likewise hydraulic, and altogether similar to the previous one — except that, whereas the previous one accomplished the raising of water by its balls, the present machine does it by vessels: that is, by buckets, by pails, or by leather sacks fitted in one way or another to an iron chain. The wheel A B C D, like the previous one, is mounted on an axle to which another wheel G H is joined — a wheel that is trodden by beasts or men and so set turning (though it could equally be turned by crank-handles, as the wheel in Figure III was, or even by a stream of water flowing past). The trodden wheel turns the wheel A B C D together with the iron chain wound around it, a chain fitted with flexible links. Between these links, buckets are likewise hung, turning freely on their own handles. As the wheel revolves downward, the chain descends together with its buckets — empty and inverted; but once they reach the water of the well, they are submerged, take up water, and as they rise to the topmost curve of the wheel they are tipped over and discharge the drawn water into a channel set apart for

that purpose. I recall having seen this machine, to my great delight, in various places, for it brings up an incredible quantity of water.

The Sixth Machine

Diagram. A suction-pump (piston-pump) machine: a miner stands at left working a long handle that drives a piston-rod down into a tall cylindrical pump-barrel at center-right; water gushes from a spout on the barrel into a wooden bucket and from there down into a basin at the lower right. Engraved labels:

- *Fig. 6.* (top center): the figure number
- [The figure itself bears no further interior letter-labels; the parts (handle, fulcrum post, pump-barrel, spout, bucket, basin) are shown but unlettered.]

Heading above the figure: *Figura VI. Machina Anemica*. [Figure VI. The Wind/Air Machine — i.e. the suction-pump.] Caption beneath: *VI. Machina*. [The Sixth Machine.]

[Margin note in the heading reads *Machina Anemica* ("air machine"); the body text calls it *Machina Anthlea* (from Greek ἀντλία, "pump / bilge-pump"). The two names are used for the same suction-pump.]

The sixth machine is the suction-pump [*Machina Anthlea*, from Greek ἀντλία (antlia, "pump")], the most commonly used of all for drawing off water. Since nothing is more familiar or more widely used, I judged it not at all worth the trouble to describe it in many words. The machine you see here is employed in most mines. But since it is so arranged with pumps that they cannot easily raise water beyond 18 palms, they set up one pump after another at different points along the well-shaft, and in this way they discharge the water into certain pits — from one pit into another and another, hollowed out within the recesses of the shaft, all the way to the last and outermost one.

To these one might add the Archimedean screw [cochlea Archimedeae], which is everywhere used for drawing off water. But because in metal mines, owing to the narrowness of the space, it brings the greatest inconvenience, and because the shafts are deeper than such machines can reach, they judge that it should not be used. Yet if someone were to multiply them — as is done in the Augsburg water-machine [*Augustana machina aquaria*] — they might perhaps have a not inconvenient use in this way. Still, because vast expense would have to be laid out both in building and in maintaining them, we judge that they too should be set aside.

Countless other kinds of machines occurred to me here, but since I see that they can be of little use in the business of metal-mining, I indicate that only those should be kept which frequent use and long experience have by now introduced, and which it has found and approved — as the best and easiest, and not without profit.

Section IV

On the Particular Conditions of Mines

And on the Various Processes in Mining, Washing, Smelting, and Separating Metallic Ores One from Another.

Caput I

On the Purification of Metals.

[Margin: How metals are to be prepared for smelting.]

Concerning the nature of the veins, enough and more than enough has been said in the foregoing. But since Nature for the most part produces metals impure, mixed with earths, with concreted juices [sap-like mineral matter], and with stones, it is necessary that these fossil substances be separated, so far as possible, from the metallic veins before they are smelted. Therefore it remains to be told by what methods the veins are sorted out, broken up with hammers, pounded with stamps, scorched with fire, ground into powder, sifted, washed, and burned.

Skilled metallurgists, then, do not commit everything to smelting all mixed together — the pure with the impure, the useless with the useful. Rather, first the metallic clods must be pounded and broken up into tiny particles, whether they exist in earthy forms, in concreted juices, or finally in stones; then, by the manifold labor of the workmen, the pure must be separated from the impure and the worthless from the precious; then they must be washed and burned, and finally smelted, so that they may attain their goal.

[Margin: How the burning of metals is done.]

Now the metallic clods are burned for two reasons: either so that, made soft and friable from hard, they may be pounded more easily; or so that the greasy substances may be burned off — sulphur, bitumen, orpiment [Auripigmentum],

and sandarac [Sandaraca] — these being harmful to all metals except gold, and then most of all because they harm iron less than the rest. And since almost no gold is ever found to which some silver is not mixed, clods of this kind too must be burned in order to be smelted. For the sulphur and bitumen, which it usually has mixed in, in the most blazing fire dissolves the metal into ash and consumes the silver, as may be seen in bituminous cadmia [Cadmia bituminosa]. The method of burning, however, see in Agricola and in Ercker [Erkerum — Lazarus Ercker]. Upon the iron grate of the furnace A B they arrange the pieces in the form of a cone, then, fire being set beneath, they roast them; then they add the other metallic clods, and most especially pyrites — which, remarkably, when it is burned for the third time, the pieces placed on the very top sweat out something greenish, dry, rough, fine, and incombustible like asbestos [Asbestus] —

[Margin: Soot of pyrites burned a third time is incombustible.]

[the second column continues:]

which was also observed in the schist-stone [Schistus lapis] from which copper is extracted in Meissen [Misnia]. Water too is sprinkled now and then on the metallic vein, so that it may become softer and more friable; for when the force of the fire has dried out its moisture, water more easily dissolves it while it is hot, as happens with lime.

[Margin: The three torments that metals must undergo in their refining.]

Thus there are three torments [tormenta — "ordeals / treatments"] that the metallic clods must undergo before they reach the term of their perfection. The first is **crushing** [Contusio], and reduction into the finest particles, which is done in many ways and by many means. Harder materials are crushed by mills built for this purpose, whose pestles are raised by teeth set into the drums of a water-wheel and, by their fall and percussion against the teeth, are dashed against the rocks (just as is wont to be done in paper-mills and powder-mills) so as to reduce them to powder. Others grind them with millstones, no differently than grain. Softer material, however, they break up with iron hammers. When these things are done, they separate the metallic flour, and sift it through sieves pierced with holes variously the largest, smaller, and smallest. There are some too who use even sieves of bristle [setaceis cribris] to reduce the material to the finest flour.

The second torment is **scorching** [Aduftio], by which the mate-

[Continuation of Caput I, "De Purgatione Metallorum," from the prior page. The text resumes mid-sentence, completing "ma-/teria" — "the mate-/rial."]

the material to be refined, in order both to make the substance easier to crush and to better separate out the heterogeneous matter, is thoroughly scorched. This is done in various ways, which you may consult in Agricola.

[Margin: How the finest matter is crushed.]

The third torment is the actual smelting [coctura], by which the ores at last reach their goal — on which more below. Metallic matter that needs no fire is purified by washing alone, which itself is carried out in various ways. And so that I do not seem to have left the art of washing [lotura] aside, I will add here — besides the methods commonly used by others, and especially by Agricola in book 8 of his *De Re Metallica* — some further methods of my own. I do this above all at the request of certain princes who, having found gold-bearing sand in some rivers but so fine that it could scarcely be washed without the greater part of the tiny gold particles, on account of their subtlety, running off together with the mud during the washing, asked me to devise and suggest some easy and specific method for them — so that, just as iron filings are separated from heterogeneous matter by means of a magnet, there might likewise be some means of separating gold dust from the earthy portions of the other metals.

Now in the case of larger flakes of gold there is no difficulty in separating them from the rest, since gold, being the heaviest of metals, of its own accord during washing — while the other heterogeneous mixtures run off — settles and its flakes cling firmly to the bottom of the washing-channel. But this cannot be said of the smallest flakes, which generally, because of the tiny quantity of their inherent mass, run off together with the rest of the dross. So that I might not seem to refuse the princes their request, I suggested two highly effective means by which even imperceptible flakes of gold can be separated from the earthy refuse in which they lie. The first is by mercury; the second by crude antimony.

By mercury the procedure is as follows. The mud in which the gold dust lies is placed in a dish, and into it you pour whatever quantity of mercury you like; then with a spatula you thoroughly mix the mud together with the mercury. Since mercury by its natural appetite seeks out gold above all, and wherever it finds it flows together to it by a kind of magnetic union, you mix the mercury into the sand. Once this is done, and the earthy mixtures of the mud that float on the mercury are separated off, in this way the mercury alone remains, clothed in the gold flakes. You obtain the separation of these by making the mercury evaporate by fire. And so that you do not lose the mercury that has escaped — how you ought to recover it intact — will be explained below.

Diagram. A stamp-mill for crushing mineral ore [*Mola ad conterendam materiam mineralem* — "Mill for crushing mineral matter"], shown as a full standing apparatus on a four-legged wooden frame. At the right is a large vertical water-wheel turned by water (A B C); its axle carries a horizontal drum (tympanum) fitted with cams (teeth, A C D E), which raise and drop the vertical stamps (pestles) at the left; the stamps fall into a trough/mortar box (H K) where the metallic matter is pounded.

Labels, per the engraved caption:

- A B C: the water-driven wheel [*Rota aquâ versatilis*]
- A C D E: the drum fitted with its cams/teeth [*Tympanum dentibus suis instructum*]
- F M, G N: the pestles/stamps [*Pistilli*]
- H K: the concave mortar in which the metallic matter is pounded [*intra concava H K materia metallica contunditur*]

The other method is by molten antimony. If into it you pour the said mixture in which the gold flakes are contained, the gold flakes alone seek the bottom, while all the rest [continues below]...

whatever they finally are — the metallic and earthy portions that float on the antimony. And this is the means by which even the smallest speck of gold dust is separated from the impure mixtures.

Another method.

Sworn assayers of metals, in testing mineral ores in the mines, usually take first a small quantity of the ore of whatever metal, and investigate what it contains and how much, doing so by fire in this manner. From a heap of mineral stones that have first been crushed, they take, say, exactly one ounce, weighed as precisely as possible down to the thousandth, two-thousandth, or even three-thousandth part of a pound (which in German they call a *Probircenten* [assay-hundredweight]); this they then assay by fire. Having thus determined the weight, the arithmeticians proceed by the Golden Rule [Rule of Three] as follows. The thousandth part of the ore yields, say, the hundredth part — now, found by assay

[Margin: The way to extract metallic veins.]

[Margin (marginal calculation): 1000. / 999. / 100. / 999. / quid? 99.]

— of a pound of gold, silver, copper, or lead; therefore the other 999 parts will give just so much, and so much, of gold or silver — that is, 99. For example, one seventh-portion [*septenarius*] of ore contains within itself so much and so much of silver or gold; so, to process a full hundredweight [*centenarius*] of the said metals, how much expense must be laid out? And once the operation has been carried out precisely, both the weight of gold or silver and the expenses to be laid out [are known]; and when the expenses have been subtracted from the gold or silver, they straightaway yield the profit.

[Margin: How the assay of gold is set up.]

They make the assay in a small quantity, lest in large and very costly assays the master should incur a loss with no profit ascertained. They use scales so exact that they can easily weigh even hairs and any of the tiniest things. The vessels in which the assay is done are usually earthenware pots, or crucibles [*catini*], in which the metallic matter, first crushed and mixed with lead, is placed; these crucibles are then set in small furnaces for melting — the form of which we shall present below. For the differing condition of the metallic ore they have differing assays: for example, they make one assay on ore that contains gold, another on ore containing silver, copper, or another metal. With these preliminaries, then, they proceed to the processes that follow.

CAPUT II.

Another method of preparing metals, from Agricola.

The workmen, as Agricola reports, must first of all find wedges, plates, hammers, bars, poles, pivots [*verticula*], mattocks, and shovels: for these tools are most necessary for extracting metals from the mines. The mine must be situated in a mountainous place, and not far from some river, spring, or stream, so that the matter dug out can be conveniently washed before smelting. And since metal veins are enclosed within the crevices of the rocks, the diggers sometimes drive iron bars into the cracks and knock out the vein; but when the veins run along the sides of the rocks, they use hammers; and when such tools are applied in vain, then by the violence of fire they break apart the rocks and extract the veins.

But the metallurgists must first, once a vein has been found, make a test of whether it contains a small or a large quantity of metal: for when one works at a loss, the vein must be abandoned. The test is made by smelting a modest quantity; from this it is learned whether smelting a large quantity will bring loss or profit. Smelting, then, is seen to serve many purposes: not only to prepare metals for

use, but also to separate them from one another by the agency of fire — for they are usually mixed, and their defects are corrected by fire. In this way, then, they usually proceed in the German mines.

First the workmen throw the fragments of the veins into bins, so that they may be pounded by pestles tipped with iron heads, driven by a water-wheel; for they always procure great streams of water led down from the mountains, which by their rapid course turn the great wheels. The coarser stones with which the metals are mixed are first easily broken up with hammers; they are washed in pits and sifted again, until at last they are ground. By all these methods the metallic matter is first prepared before it is smelted in the furnaces. There are many furnaces in the metallurgical workshop, in which the veins are melted and the silver is separated from the copper, while huge bellows are raised by the force of the water-wheel and, by their constant blast and great motion, with a roar stir up the flame in the furnaces. Then the workmen throw the metals in from above, and others draw off with great ladles the molten metal, now separated from the crushed rocks, and pour it into molds.

But it is not only in this way that precious metal is separated from base, and in turn base from precious: for often two metals are found in one and the same vein, since naturally a certain portion of gold is found mixed with silver and copper; in black lead and in iron a small portion of silver; in silver some part of black lead; and finally some portion of iron in copper.

[Margin: How gold is separated from silver.]

Gold, however, is usually separated from silver by a strong water [aqua fortis, nitric acid] prepared from vitriol [*atramentum sutorium*, copperas/green vitriol], or from alum and saltpetre [*halinitrum*], which is exceedingly suited for separating silver from gold. The common composition of this water consists of one pound of [continues, "vitri-/ol..."] —

of vitriol, the same amount of salt, and three parts of spring water.

[Margin: The composition of the aqua fortis.]

It is also prepared another way, from four pounds of vitriol, two of saltpetre with half a pound of alum, and a pound and a half of spring water. Those who wish to induce softness in any metal sprinkle over it sublimate [corrosive sublimate], borax, and euphorbium reduced to powder. But if they want to reduce metals to a calx and a water, to draw a nobler metal into a baser, or to transmute them into

one another, they should read Wecker [*Vuecherius*, Johann Jacob Wecker] in his *Book on Secrets* [*De Secretis*], where he has disclosed many arcana of this kind.

CAPUT IV.

The gold mine and its conditions.

First, with the greatest care, one must observe the vein of gold — from what kind of stone it took its origin (since here we take "vein" not for the native vein of a place or mountain, but for the matter already dug out of the mountain). So, if you find a vein of gold in lapis lazuli, you will be blessed with a double benefit: partly from the gold extracted from it, and partly from the lapis lazuli, which — since among precious stones it holds no mean place — is most useful, partly to physicians for the cure of various ailments, and partly to painters for that ultramarine blue color than which none is held more precious or more costly.

[Margin: How gold is extracted from lapis lazuli.]

Gold is extracted from it in this way. First the lazuli vein is reduced to powder; then the powder, placed in a crucible, is thoroughly washed, and is worked with mercury up to the point of amalgamation. The flour of the stone will float on the mercury, while the golden offspring will seek the bottom. You then strain the mercury, still saturated with gold, through a leather bag; and the mercury will be separated from the rest of the gold, which remains within the leather bag together with the dross of the quicksilver. This, purified again by lye [*lomentum*], is found whole and pure. (See another method in book 12, near the end.)

Others do it thus, by the more usual earlier method. Over a slow fire they roast the gold-bearing vein in an open furnace until all moisture has evaporated; this is then reduced by means of a mill to a powder, and crushed in any other way, and must be smelted through a *cineritium* (which they call a cupel [*cupella*]), with lead added. In this way the gold will be separated from its vein and from the lead, as will be more fully explained below.

§ I.

The Generation of Gold.

Gold is generated, as we showed in the preceding sections, from a most purified sulphureous-mercurial vapor within a most pure matrix of suitably prepared saline earth, and over a long stretch of time is concocted by a gentle heat. And because this operation is accomplished only over a long span of time, it comes

about that the nature of gold acquires that brightness and preciousness. These verses make plain its like origin:

Soon, descending from there into the great womb of its mother, You will revisit, as a spectacle, her chambers — her offspring and her grandchildren. Believe me, in the blind darkness of Sulphur and quicksilver It is enough to have approached forces akin [to it]; This one thing you will accomplish, which hangs upon a twofold origin.

Moreover, there are many among the alchemists, as was unfolded above, who wrongly ascribe the generation of gold to art, on account of the many tales — not histories but fables — they have read about it.

[Margin: The fable about gold being made by a certain Moor.] [Margin (marginal symbols): ☿ ☽ ☼ — i.e. Mercury, Moon (silver), Sun (gold).]

Among others they bring forward a certain Moor who, in the region of Mauritania, at a smith's, used to add a certain citron-yellow powder to molten silver and instantly turn it into gold. They likewise report that there lived a man in Gaul who had a red oil with which he would transmute Luna — that is, silver — into the most shining Sol — that is, into the purest gold — albeit by imposture.

When Pico della Mirandola [*Picus Mirandulanus*] relates that in his own day gold was found in the stomachs of partridges, he says it is no wonder: for who does not know that hens, partridges, ducks, and similar birds crave nothing more than metallic bodies, as was said in the preceding sections?

[Margin: Gold in the stomach of partridges.]

So it is not at all unlikely that along the riverbanks they devoured the golden flakes scattered through the sand, which then by the heat of the stomach flowed together into a single mass — not, as he supposes, generated by some hidden power of the food, though I would not deny that Nature can impart this virtue to the surface of the earth. For they relate that in the chalk-mountains there were seen she-goats, called *Ibices* [ibexes], whose teeth were tinged with a golden color, in that part especially with which they cropped the grass — which no doubt happened from the tincture of gold-bearing spirits with which the grass was imbued.

[Margin: Why goats had teeth fitted with gold (i.e. gold-tinged teeth).]

Albertus [Albertus Magnus] reports that gold has sometimes been found in a human skull: if this is true, it comes about for no other reason than from the

vapors which, while the gold is being liquefied, rise up, and — just like quicksilver — coagulate in the brain.

[Margin: Gold found in a human skull.]

§ II.

The Nature and Properties of Gold.

The chemists strive in many ways to investigate the nature of gold, and to that end spare no labor — namely, by dissolving, weighing, tasting, subliming, and melting it, [continues, "in order that..."] —

so that from this they may search out all its affections; and in the end they establish it, in the second degree [of excess], as hot and moist. Galen, however, preferred to commend its coldness and dryness. But to grasp all the properties of gold better, it will not be amiss to examine all its qualities. And first, if we consider the active qualities of gold: gold, however long it is handled, never stains the hand of the one touching it — a prerogative that does not belong to the other metals; and so this is taken as the chief proof of its purity.

[Margin: Gold does not stain the hand.]

Next, gold when struck gives off a dull sound, and does not imprint lines of its own or of another color on any body unless it is rubbed on a touchstone, the Lydian stone [*coticula*, *Lydius lapis*]: for then it yields lines exactly like itself. All of which indicate the supreme perfection in gold.

[Margin: It has a dull sound.]

If the passive qualities of pure gold are considered: first, it suffers no harm in its substance from sharp juices; second, it is not brittle, although it is soft.

[Margin: It does not corrode.]

For when struck with a hammer it is so spread out that from single denarii fifty or more leaves of six fingers' length can be made — and this happens to gold beyond the other metals, on account of the most perfect matter of which it consists.

[Margin: Malleable into the thinnest leaf.]

Third, it is not attacked by rust unless it has been mixed with another metal; then it gives off a rust of the most delightful blue color, which painters call ultramarine blue. But if it is pure and unalloyed, even though it remains buried

in the earth for many ages, it contracts no rust; it is not fouled by salt; placed in a gold salt-cellar, it is not corroded, which does not hold for the rest.

[Margin: It does not rust.]

If the internal qualities of pure gold are weighed: first we shall observe, following Aristotle, that it is so melted by fire that it loses absolutely nothing of its substance — indeed, there it is purified and emerges more splendid, and loses none of its solidity.

[Margin: In fire it emerges purer.]

Next, gold placed in sharp waters [aquae acutae], which the goldsmiths prepare for separating gold from silver, is not at all dissolved into mud, as many wrongly suppose, but is divided into imperceptible particles, which, once the water is dried off, are reunited and restored to their former shape. We must note, however, that when it was said that gold is consumed neither by fire nor by use, this is to be understood in comparison with the other metals, since gold coins are worn away by the constant rubbing of fingers, and by long-continued fire gold gradually vanishes as its vapors evaporate.

[Margin: Gravity.]

Finally, among the external qualities of gold is reckoned a weight equal to black lead, and a warmth which is retained longer in glowing gold; and there is mentioned also its tawny color and gleaming brilliance, since gold is the first among metals to display color — color which shines out more in gold than in the other metals. Hence, by a certain analogy, the Interpreter of Pindar and the chemists assert that gold is dedicated to the Sun: for just as the Sun shines resplendent in the midst of the planets, so likewise gold gleams among the other metals.

Some add to the foregoing a bad quality of gold, on the grounds that, according to Pliny [*Plinius*], gold is poisonous. But it must be noted, first, that Pliny spoke of gold to which another metal had been mixed; whereas when it is purified by fire, then it sheds all the malignancy of any harmful quality — since, indeed, taken in medicines, it is so far from being harmful to a person that rather it wonderfully strengthens the vital faculty and refreshes all the spirits of the human body. As for what is told in the *Book on the Nature of Things* about gold growing cold at the approach of day, that must be set down among the fables, inasmuch as it is contradicted by daily experience.

[Margin: A fable about gold.]

§ III.

The Antipathy and Sympathy of Gold.

In a closely related and kindred order, the Antipathy and Sympathy of gold succeed to its properties. First, that sulphur and gold are at odds with each other, we gather from this: that gold, suffused with a sulphureous and foul vapor, instantly loses its pleasing color — although afterward, with that same sulphur boiled in water together with tartar and a little salt, its former splendor is restored to it.

[Margin: Gold is at odds with sulphur.] [Margin: How its color is restored.]

Likewise it takes grave offense from lead; for gold steeped in the fume of lead is reduced to the finest powder, and sometimes at the smell of lead it so stiffens that it cannot be spread by the hammer. For this reason the craftsmen are obliged to melt the gold again and pour a little nitre or sublimate over it, so that it may lay aside the bad quality received from the fume of lead.

[Margin: It is reduced to powder by the fume of lead.] [Margin: How the stiffness of gold is removed.]

Furthermore, lemon juice presents a stubborn enemy to gold, inasmuch as gold macerated in it is — according to Levinus Lemnius [*Levinus Lemnius*] — diminished in weight; but this too, by an experiment I performed, was found to be false.

[Margin: It is diminished by lemon juice.]

How great the sympathetic affection of mercury is toward gold has appeared from what precedes, since wherever mercury finds gold dissolved by fire, it straightaway seems to embrace the gold in a certain way. If, moreover, quicksilver is mixed into liquefied gold and the mixture is stirred until it cools, the gold will be reduced to a powder; for the quicksilver, penetrating, so couples itself to the golden matter that it allows it to retain no continuity, with no appearance of gold remaining at all.

[Margin: The friendship of gold with mercury.] [Margin: Mercury reduces gold to powder.]

This is not unknown to the Saracen craftsmen, as is found in the *Book on the Nature of Things*: travelers carry gold corrupted in this fashion with them, for afterward, placed at will in a small furnace, it rises again more beautiful and splendid.

[Margin: The trick of the Saracens.]

Those who separate gold from the impurities and earthy matter mixed with it in the gold-working shop declare that this is not a hatred between gold and mercury, but rather a kind of familiarity between them: for while they grind the mixed impurities on the mill and, carefully mixing mercury, add it to them, then whatever gold has been mixed in [continues, "the mercury..."] —

[Continued from the previous folio — the close of Caput IV, §. III, on gold's sympathy with mercury.]

mercury [hydrargyrum] takes it up, and afterward, when strained through leather, it leaves the gold behind in the bottom — as will become clear in what follows.

As for the report of Philostratus [Philostratus] that gold is uniquely craved by dragons [Margin: Dragons, δράκοντες], who does not see that this is a fiction of the poets, since they set up dragons as guardians of treasures? [Margin: Fables of the attractive power of gold.] Better known, then, is the love of the barnyard cock for gold, for I myself have seen one devour gold filings, gold coins, and copper coins with great greed. But the claim that the bones of this animal, when mixed with melting gold, consume it into themselves — and likewise, on the authority of Aelian [Aelian], that gold is drawn off by the leg-bones of a hawk, or even by the bone of the milvus-fish [milvus, the kite-fish] — we have found to be equally false. Again, what the *Liber de Natura Rerum* relates about the marvelous sympathy of the echinus-fish [echinus, the sea-urchin] with gold surpasses all the ravings of the poets: for it is dreamed that this creature, when preserved in salt, has such power that, brought near the mouth of a well, it draws out gold that has fallen down into it. And the claim that a fresh hazel rod plunged into molten gold reduces it to powder — because the moisture of the rod is drawn off by the gold and, in turn, the moisture of the gold by the rod — we have found false. Many assert the same thing of wine, on the grounds that wine rivals gold in color and in its other properties, and because, just as wine holds first place among vegetable things, so gold holds first among minerals.

Moreover, gold — like many other metals — embraces its fellows with a wonderful concord [Margin: How gold is bound with the other metals], when they are mingled by goldsmiths not unacquainted with this friendship; and this mixture they commonly call *lega* [alloy]. Lead and tin, then, embrace each other so amicably that, once joined, they form a mixture that cannot be told apart even by a skilled craftsman. Gold, however, can be bound closely only with silver and

copper. Finally, some imagine that there is even such a thing as a "golden magnet" [Margin: Whether a golden magnet exists], which would draw gold just as the magnet draws iron — such as Philostratus says the stone *Pantarbes* [pantarbes] is. This I judge to be a fiction, to be ranked among the dotings of old wives rather than placed in the nature of things; so that I cannot sufficiently wonder that such rank impostures and ridiculous absurdities have, by chains of linked errors, crept even into the schools down to this very day, since there is scarcely a book treating of the marvelous secrets of Nature that does not, among other things, make mention of this most fabulous *Pantarbes*.

§. IV.

The method of finding and preparing gold. [Inveniendi, & praeparandi Auri ratio.]

In his works Pliny [Pliny] handed down a threefold method of finding gold. The first is by observing the sands of rivers; the remaining methods of gathering it are described in the preceding chapters of this book, where I treated of the various techniques for prospecting metals. It remains only to speak of the art of preparation — for the gold of a river is worked up by one technique, and the inhabitants use various nets by which they extract nuggets of gold from the streams. This happens most of all at the river Zenus [?] [Margin: The river Zenus(?).], not far from the city to which the name of Carthage [Cartagena, in the New Kingdom of Granada] has been given, situated in the New Kingdom: for when, in certain months, heavy rains fall, the inhabitants fish up much gold-dust with nets, which needs no preparation. Likewise, near Mount Ctesias [?] in India there is said to be a spring that is filled each year with grains of gold, so that from it a hundred earthen jars full of gold are drawn off every single year [Margin: The fable of Ctesias about gold drawn from a certain spring]; for the vessels must be earthenware and brittle, since the gold congeals in them without preparation, and each jar equals a talent in weight. But let us leave such fabulous tales aside.

Gold is also extracted and prepared from other things besides streams and ores. First, by a certain mixture carefully prepared from gold dissolved in *aqua separationis* [the water of separation], together with lead or pitch and sand; under this mixture the gold is secretly carried off from region to region without suspicion... [?] [text partly broken; printer's lines interleaved] Pliny [reports] that Caligula Caesar [Margin: The covetousness of Gaius Caligula Caesar], most thirsty for gold, ordered a great quantity of orpiment [auripigmentum] — because of the resemblance it has to gold — [?] to be smelted, and that from it the purest gold did

indeed emerge, but of so slight a weight that the workmen felt a loss. From the stone *Cyaneus* [lapis lazuli], or *Lazuli* as the Arabs read it, and from red Hungarian copper, gold has been found to be separated by the power of quicksilver, of which a little earlier.

I have in my possession a Hebrew manuscript book [Margin: The fable of a certain Rabbi about the herb *boriza* turning into gold] which teaches that gold is produced and prepared from the juice of a certain herb; the herb it calls *boriza* [בוריזא? [?]], and it says it is a species of *Lunaria* [moonwort], born not in the fields and woods but in the brain of a stupid Rabbi. Its stalk is violet-colored, and it produces leaves like the leaves of marjoram, growing with the motion of the Moon, and the whole plant breathes the scent of saffron. The juice of this plant — oh, marvelous! — is so mingled with quicksilver that it becomes a kind of thickened mass, which, reduced to powder and sprinkled on copper, turns it into pure gold; and one ounce of this powder is said to suffice for tinting a hundred ounces of copper. Than which fiction nothing could be more stupid: for if it came anywhere near the truth, no doubt all metals would by now have been turned into gold. But back to our subject.

And so gold, once it has been cleansed of earth, washed, melted, and worked up, loses in these operations its yellow and splendid color [Margin: How its proper color is restored to gold]. For this reason the workmen sometimes steep it for the space of a natural day in *aqua tartari* [water of tartar], then wash it with fresh water and wipe it with a clean linen cloth; sometimes they boil it in vinegar with sal ammoniac, verdigris, and tartar; and sometimes...

with common salt, tartar, and sulphur, they keep it in water until it recovers its lost color [Margin: How a too-soft gold is made harder]. Indeed, when the gold is too soft, it is necessary to fix and condense it; and so, immediately after it has been extracted from the *chrysoplysis* [the gold-washing], they use *aqua regia* [aqua regia] prepared from verdigris, vitriol [calcanthum], alum, and calamine stone [lapis calaminaris].

All these things done and prepared, they cast the gold into bars [Margin: How alloy mixed in with gold is separated out]. To test whether these contain any silver or not, the workmen try them with the Lydian stone [lapis Lydius, the touchstone] and with assaying needles, which all craftsmen keep in their workshops. Hence, in order that the portion of metal mingled with the gold — which they call the *lega* [alloy] — may be wholly removed, some use a mixture of tartar and brick-powder: with this mixture they construct a small round furnace with brick walls, and they place the gold, coated with the same mixture, in a pot,

and they keep up a fire for one natural day. For in this way the foreign metal, or alloy, is consumed, and the gold is reduced to twenty-four *ceratia*, which are commonly called *carats* [carata].

CAPUT IV.

The silver-bearing mine, and its nature and properties. [Fodina Argentifera, ejusque natura & proprietas.]

Many, as is found in Agricola [Georgius Agricola], have supposed that a silver vein is not found pure by itself, but is mixed with a copper-bearing vein, or a lead-bearing vein, and with other metallic bodies. But this is contradicted both by experience and by history. For in the Potosí [Potosí] mountains of America, lumps of gold and silver are sometimes found so pure that they need no refining at all, but are handed over to goldsmiths just as they are born, to be worked up for the various necessary uses of household furnishings. Such things, they report, have likewise sometimes been found in the Hungarian mines — and not, I mean, within the hidden veins of the mountains, but even by the plow, in the furrows of the fields, and also among the roots of trees, or even in the springs that gush out from the gold- and silver-bearing mountains. Indeed, sometimes the very tendril of a vine and its leaves are seen tinged with a golden color. And in the innermost desert mountain-valleys of Monomotapa [Monomotapa], the annals of our Society relate, on the authority of the Abyssinians [Abyssini], that pure native gold is sometimes found like stones.

Agricola confirms these statements with the account of that silver tablet found within the Saxon silver-mines [Margin: A silver tablet from the Saxon mines, the natural work of pure silver], which Nature had brought to such purity and perfection that it seemed indeed to have been smelted by the goldsmith's skill and most excellently polished, and fashioned into a table — so that the Duke of Saxony [Dux Saxoniae] himself used to boast that not even to the Emperor would it have been granted to dine at so unusual, wondrous, and altogether magnificent a table, fashioned not by the hand of a craftsman but wrought by the incredible industry of Nature. This was a clear sign that silver has the very origins of its own birth within itself. To this is added that what is said of silver may be said of all the other metallic veins, since none is so pure and so cleansed of all heterogeneous matter that it does not always have some of the remaining metals mixed in with it [Margin: All metals are mixed with one another], according to the variety of the exhalations that tinge the veins now this color, now that — since particular veins are heightened, some into a blue color, some into green, others into a tawny and

dusky hue; nor are there lacking those that bloom out into an ashen and black color, and into other colors, according to their composition and combination with the first and proximate matter of the metals.

Silver, therefore, according to the proportion of this mixture, is found now in greater, now in lesser quantity, in keeping with the greater or lesser sulphureous-mercurial exhalation in the pure earth and the concoction proportioned to producing silver. For, as I have learned from the overseers of the mines, it usually grows in a stone of ashen or grayish color; and besides, in a certain hard stone not unlike Tiburtine stone, which they call *travertine* [travertinum]. The vein is heavy and weighty, furnished as it were with certain shining points — truly a clear indication of silver of better quality [Margin: In what kind of stone the silver vein is embedded]. But if it is found in a white and leaden-colored stone, then it is most sought after, because it is easily purged of its earthy quality.

Again, it is also very often found associated with marcasite [marcasita] or pyrites [pyrites], which, however, the more they pride themselves on a golden color, the less silver they promise; the more they approach a white color, the more fruitful a silver vein they pledge. The reason for this we give as follows: that the more gleaming color of the pyrites marks I know not what scorching, by which the silver is gradually consumed; whereas, on the contrary, the white color of the pyrites, as it indicates a more temperate heat, so too it pledges a richer supply of silver — especially if it has been associated with lead and copper. It sometimes happens that the silver is found joined with sulphur, arsenic, and not-yet-fixed mercury, and similar combustible substances; in that case there is no need of anything else but that, by a strong fire, the silver should be separated from the rest by evaporation. But just how this separation is done — by the practice they everywhere use in America — I will set out later.

The nature and properties of silver. [Argenti natura & proprietates.]

Albertus Magnus [Albertus Magnus] and others have declared that the matter of silver flows from the substance of sulphur and quicksilver [argentum vivum]. Brasavolus [Antonio Musa Brasavola] [?], however, holds that it is condensed quicksilver, comprehending sulphur by its power — since, from the frequent handling of silver, a smell of sulphur is perceived; but he asserts that under silver, and under gold, sulphur lurks in a different manner, inasmuch as he assigns to gold sulphur in act, and to silver sulphur in potency. But the true philosophers and...

diligent investigators of natural things affirm that silver arises from a substance more watery than fiery, and therefore set it in a cold and moist temperament [Margin: Other properties of the Moon, that is, of silver] — whatever others may have said about the cold and dry temperament of silver. Indeed, even Albertus himself reckons silver to be cold and dry, yet not without some moisture.

As for its other qualities, it must be considered that silver is malleable and resonant: for it communicates to the ears a not-unpleasant ringing; and though it be pure, it takes in a man's breath and at once dispels the cloud [it forms]. Moreover, if it is compared to gold, it is assuredly less perfect; and so the chemists are accustomed to say: as the Moon stands to the Sun, so stands silver to gold. But the Moon is of lesser light, and so silver too must be of lesser value and weight. Likewise, if we ponder the properties of each metal, we shall find the greatest difference between them. For, first, in extracting silver from the mines, it is not gathered so pure as gold, but is so mixed with earth and dross that its refining demands immense labor. Furthermore, refined silver is indeed spread out by the hammer, but less than gold, since it acquires greater hardness and thickness. Then it is lighter than gold and lead, since when melted it floats on top of them like oil; it is diminished by prolonged fire, and when hidden away in damp places it corrodes — afflictions by which gold, as we showed in the preceding chapter, is not at all troubled. And so authors ought not to be held in great wonder when silver, though it be most white, imprints black lines on bodies; this we judge to come from nothing other than the impurity of the metal. Finally, silver has this implanted in it by nature: that it shrinks from familiarity with sulphur, tin, and iron — just as all animals, and most of all the dog (on Pliny's testimony), abhor in a wonderful manner the smell that comes from silversmiths.

The method of finding and preparing silver. [Inveniendi Argenti, & praeparandi ratio.]

It has long been known to metallurgists that silver is generated in an ashen and dark soil, and is found where many pyrites are seen. Indeed, just as pyrites sprinkled with a golden color indicate gold veins, so whitish pyrites spotted with tiny grains usually indicate silver veins; therefore the place where the pyrites is observed to be whiter, rarer, and finer-grained will offer the greater hope of silver veins. Once the silver vein has been found and opened, the diggers go on extracting the silver until they reach an alum-ore; for when this concrete, lean juice is found, they pronounce the silver vein at an end.

These things laid down, we will proceed to the refining of the silver once dug out [Margin: The method of refining silver], which is smelted only with black lead, or

with the lead-ore called *galena* [galena], which is for the most part found near the lead-mines. Sometimes metallurgists draw out silver by the power of fire from bituminous *cadmia* [cadmia], which, however, contains but a small quantity of it in itself. Sometimes Pliny testifies that *minium* [minium, red lead], whose *vomica* [eruptive vein] is quicksilver, is smelted by metallurgists into silver [Margin: The transmutation of mercury into the Moon (silver)]. But when silver has been mixed with gold or copper, they are accustomed to employ many techniques for separating the metal, which Georgius Agricola pursues with diligent examination. Besides, some profess to extract pure silver from quicksilver — whether this be true can be tested only by experience. Pico della Mirandola [Pico della Mirandola] relates that in his own times it happened that quicksilver mixed with several other things for the medicine of a horse was transmuted into pure silver; and if this is true, I should readily believe that it was drawn out not so much from the quicksilver as from the things adjoined to it, with which it was mixed.

After the silver has been smelted and worked up with immense difficulty of labor, it lacks that whiteness which is desired in silver [Margin: How whiteness is induced in silver]; and so the craftsmen mix tartar with common salt in water over the fire, in which they heat the silver somewhat, and then draw it out most white. Furthermore, there are some who strive to tint the whiteness of silver with the yellow color of tutty [tutia] and turmeric [curcuma], so that by the prerogative of this color it may seem to rival gold. Others fatigue mind and body with labors to transform silver into gold; but concerning these operations see our opinion in the following book. But just how silver may be overlaid with gold, learn in a few words.

We have observed that this is done chiefly in a threefold way [Margin: The method of gilding silver]. The first is when, over a thin leaf of silver, another, similarly thin, of gold is laid, and beaten with the hammer until they cohere most firmly. The second is when, over a thick leaf of silver, a gold coin is placed and extended as broadly as possible with the hammer. The third method is when leaves of silver, mixed with gold by the aid of quicksilver and fire, are dissolved — a method I have described more fully elsewhere.

The use of silver in medicine. [Argenti in Medicina usus.]

In medical use silver is reported to have no common advantage, since the Dogmatic physicians use its filings and finest leaves, because this metal relieves the trembling and palpitation of the heart, strengthens the brain [Margin: The Moon (silver) cures afflictions of the head], gently eats away putrid flesh in ulcers, and finally brings much aid in mania and other melancholic afflictions.

Wherefore, since it is numbered among the cardiac medicines, it enters into the *Electuarium de gemmis* [Electuary of gems] ascribed to Galen [Galen], the *Aurea Alexandrina* [the Golden Alexandrine], and almost all the antidotes with which gold is mingled. Indeed, silver, by cooling, drying, and...

relieves the itch [Margin: Cures hemorrhoids] [Margin: Epilepsy] and pruritus, if it is applied mixed with oil of tartar, as Mylius [Mylius] notes. Likewise, others mix filings of silver with quicksilver, and wrongly extol this medicine to a wonderful degree for healing hemorrhoids. Finally, the medicines prescribed in a bolus are wrapped in leaves of silver.

The chemists prepare potable silver, then a calx, a saffron [crocus], a quintessence, an oil, and a salt — all of which preparations one may read in Libavius [Andreas Libavius] and the other professors of alchemy. They proclaim that the oil of silver, or of the Moon, will be of great use in diseases of the brain; therefore in healing epilepsy they give the patient three or four drops of it with water of flowers of betony, sage, and balm. They also publish abroad that the salt is by no means unprofitable not only in the aforesaid affliction but also in other diseases of the head, since it is said to consume all the superfluous moistures of the brain [Margin: Dropsy]. Indeed, they promise that from such a salt taken in a dose of four to five grains, with half a drachm of oil of juniper, the sufferer from dropsy will obtain very great benefit; and finally they assert that it is of much profit to a weakened stomach. Lastly, in the apothecaries' shops mortars of silver, with pestles likewise of silver, ought to be kept for grinding gems for the hyacinthine confection, lest the gems be altered by the powder of porphyry stone, which could be produced through the contact of the very hard angles of the gems. Nor does any other metal seem fit for performing this, since it could foul and alter the color and quality of the gems; but when they have been prepared in a silver mortar, this drawback is without doubt kept away from the gems.

CAPUT V.

The mixture of metals. [Metallorum Mistura.]

Nature, begetting metals within the womb of the Earth, sometimes mixes two or three or four of them, as we have explained elsewhere; hence men, taught by nature, on Agricola's testimony, reduced the method of metallic mixture to a use. Indeed, sometimes chance itself demonstrated the same thing, when — as Pliny relates — at the burning of Corinth gold and silver and copper flowed together into one [Margin: The mixture of Corinthian bronze], and so fortune in a manner assigned a tempering to the three kinds of Corinthian bronze: of these, one

gleamed white like silver, because that prevailed in the mixture; another shone with a tawny color, owing to the dominance of gold; the third was one in which an equal mixture of all was constituted. And so art and fraud imitate nature and fortune: while men, adding metals to metals, produce various mixtures, which the Greeks call κράματα [Greek: kramata, "blends, alloys"], the Latins *temperaturae* [temperings].

Craftsmen, therefore, can couple two, three, or more metals — whether simple or mixed; or a simple metal with a mixed one, and vice versa; or two simples with one mixture, and conversely; or, finally, pure simples with one mixture, or with two; and in these likewise a variation can be maintained. Likewise, a base metal is sometimes dissolved with a precious one, and contrariwise a precious one is added to a base one. First, silver is mixed with gold in manifold ways, and all these mixtures lack a name, as was made clear above; only the mixture of gold receiving a fifth part of silver is named *electrum* [electrum] [Margin: Of what electrum consists].

But when men, for the sake of gain, smelt a portion of a baser metal with a mass of a more precious one, they no doubt incur fraud — although some craftsmen persuade themselves that this can be done by the grant and favor of princes, so that gold coins are struck not pure, but with a moderate portion of silver. Today too, by the concession of the sovereign authority, men use a mixture of metals in striking coins, which the workmen and goldsmiths call *lega* [alloy]. Nevertheless, the Emperor Tacitus [the Emperor Tacitus], as Flavius Vopiscus [Flavius Vopiscus] reports in his Oration to the Senate, ordained [Margin: Tacitus forbade the mixing of one metal with gold] that no one, publicly or privately, should dare to mix copper with silver, nor silver with gold, nor lead with copper; otherwise he would incur capital judgment, with proscription of his goods. Although in former times, on Vopiscus's testimony, some had added lead to copper, so as to strike coins of the poorest quality, the silversmiths declare that it is permitted them by law to procure this mixture, when they take ten and a half ounces of silver and half an ounce of copper, and thus cast a one-pound mass of silver. Some of the chemists [Margin: The various frauds of the chemists in adulterating silver] add whitened copper to silver and sell it for genuine silver, although this fraud is forbidden under penalty of death. Today they mix a tenth part of black lead with tin, and from this mixture form basins, vessels, and many other works of this kind. Formerly, too, they mixed iron with copper, which was a fraud to many. By so many methods, then, are baser metals mingled with more precious ones. But conversely this is not to be set down in the category of crime, when more precious metals are added to base ones.

Lastly, there are certain mixtures of metals that take their name from the works resulting from them [Margin: The pot-metal mixture], such as the pot-metal mixture, which is made up of three or four pounds of plumber's lead [argentarium lead, lead-silver] [?] and a hundred of copper, and which goes into various kinds of vessels. Another mixture is called *bombardaria* [cannon-metal], from which engines of war are forged; and this is made when, to every twenty pounds of copper, one of white lead [tin] is added. A third mixture is made when, for the sake of the sound, to sixteen pounds of white lead half a pound of ashen lead is joined. A fourth...

[printed p. 206 — LIBER DECIMUS, Sect. IV]

CAPUT V (continued) — Metallorum Mistura [Metal Alloys]

[Margin: Various alloys for practical use.]

the mixture is composed when two parts of black lead [plumbum nigrum] and a third part of white [lead, i.e. tin] are joined together. The ancients called this "third-grade tin" [stannum tertiarium], and they used it for soldering pipes; common usage calls this mixture *Saldatura* [solder]. The fifth mixture is made when equal parts of each of the two leads are blended together. In Pliny's day [Pliny the Elder] this mixture was called "silver-tin" [stannum argentarium]; in our own times bowls and dishes are made from it. We should speak in the same way of the other mixtures, both simple and compound, since further ones may be added at any time.

CAPUT VI — Sympathia & Antipathia [Sympathy and Antipathy]

Metals agree with various stones, and especially with that kind of flint [silex] which Aristotle calls *pyrimachus* [fire-stone]. This is not unknown to the men who occupy themselves with the smelting of metals: they sprinkle this kind of stone over the molten metals so that the metals cannot fly off into vapor. Indeed, metals readily combine with that sort of pyrites distinguished by various colors; for this reason the workmen add this kind of pyrites to the metals in place of lead, so that in smelting the metals come out more fluid.

Furthermore, all metals have received quicksilver [argentum vivum, mercury] into their friendship, because it most willingly couples with all of them; and consequently they draw into their fellowship that species of hematite [haematitis] which is pregnant with quicksilver. [Margin: The friendship of gold with lead.] On this account this stone is said to draw metals to itself. Indeed, among the metals themselves both sympathy and antipathy are observed: lead is loved by gold and

silver, for when they are melted together they mix easily. By contrast, copper [aes] recoils from lead because of their contrary temperament. [Margin: The discord of lead with copper, and of tin with gold.] Likewise tin so disagrees with gold and silver that it almost consumes them. This is most evident in the furnaces, when the white lead [tin] is liquefied; it floats on top, and is easily drawn off with iron rods.

[Margin: An experiment.]

On the other side, metals and living creatures are at the greatest enmity, because they give off certain exhalations hostile to the animal spirit. For this reason one nowhere reads that any animal has been nourished on metals. [Margin: Metals are at antipathy with animals and plants.] Indeed, where metallic veins are found, neither do plants grow nor do animals dwell. And as confirmation of this we understand that in the metal mines the legs of the workmen are commonly afflicted, which are afterwards healed in the quarries of Assos [Assius], the stone of the sarcophagus. Moved by this same cause, physicians forbid the use of metals in the preparation of pearls [margaritae] or any other medicament of this kind, and prescribe only marble stones, because there is a danger that something metallic might cling to the medicaments being prepared which would be diametrically opposed to human nature, and from this grave symptoms could arise — as we taught in the Section *On Poisons* [in Sectione de Venenis]. Certainly, on Pliny's testimony, the odors emanating from the metal mines are unwelcome to all living creatures, but are most of all harmful to dogs, which exhale from the silver metal [?].

CAPUT VII — De Scoriis, & Excrementis Metallorum [On the Slags and By-products of Metals]

[Margin: The slags of metals.]

Excrements, or slags [Scoriae], are the metallic refuse [Metallica factitia] which are produced in the first and second furnaces while the veins of metals are smelted, while one metal is separated from another, or while molten copper is tinted. These are: Slag [Scoria], Diphryges, Cadmia, Pompholyx, Spodos, Litharge [Lithargyrium], Molybdena, and Scales [Squamae]. Some are produced outside the furnaces, such as verdigris [Aerugo], blue pigment [Caeruleum], white lead [Cerussa], and the like; of which separate mention was made in the Sixth Book [in Sexto Libro].

It must therefore be known that in the smelting of metals the slags are generated as certain by-products of the smelted veins, which the workmen call *Loppae*.

These float on top of the molten metal, and once cooled and congealed they become brittle like glass; and if they have retained any metallic moisture, they become heavy, and once this is separated off they pass into a pumice-like lightness. Thus the more earthy and dreggy part of the metal goes off into slag, which is the cleansing [purgamentum] of the vein cooked in the furnaces, as has been said — speaking, however, of the vein of gold, silver, copper, iron, and both kinds of lead. For the veins of quicksilver and lead do not produce ashen slags [cinereae scoriae], since they are not smelted. We do not, however, say that slag cannot come out of ashen lead [plumbum cinereum] when it is mixed with other metals and liquefied; this filth of the metal is rightly called by the Greeks σκωρία [skōria, "slag/dross"], since among them σκώρ [skōr] means "filth" [stercus]; by Celsus it is called the "refuse of metal" [metalli recrementum].

[Margin: What is silver slag?]

The slag, or refuse, of silver is obtained only when a vein of silver is purified in the furnace; but it cannot be pure, because the workmen add a little lead to it for purifying the silver. This silver slag is called *helcysma* [ἑλκυσμα], from ἔλκω [helkō, "I draw"], because this by-product is rendered so viscous that it is drawn out like birdlime [viscum]. [Margin: The slag of copper and iron.] The slag, however, which is collected from copper and iron is for the most part black, foul, and spongy or pumice-like.

[printed p. 207 — DE FODINARUM CONDITIONIBUS]

[Margin: Lead slag. — What Diphryges is. — Various species of Diphryges.]

[Caput VII continued.] Iron yields a larger quantity of slag than copper releases, since it is a more impure and more earthy metal — which indeed is obtained not only when iron is smelted in the furnace, but also when iron softens in the forge of the blacksmith [ustrina fabri ferrarii]. The slag of lead, however, differs most of all from the rest, because it is least stony, nor brittle like the others, but is observed to be quite pliant on account of the softness of the metal.

Among these slags of metals is reckoned **Diphryges**, and it is nothing other than the recrement of copper [aeris recrementum]; it is called διφρυγής [diphrygēs], as though "twice roasted," for among the Greeks φρύγω [phrygō] means "I roast." Four species of Diphryges are found. The first results from a certain mud of Cyprus, which first dries in the sun and is then burned with brushwood heaped around it; therefore it can with the best right be called "twice burned," first by the heat of the sun, then by the ardor of fire. Dioscorides wrote that this species is

produced only in Cyprus. The second species is nothing other than the sediment of copper roasted in the furnace, which Galen observed thrown away by the craftsmen in Cyprus. The third species is prepared from copper-bearing pyrites roasted until it has taken on the color of red ochre [Rubrica]. But it must be noted that burnt ochre [Ochrausta] takes on the same color, and is therefore similar to this third species of Diphryges, and is sometimes wrongly sold for Diphryges. The fourth species arises from any stones whatever found in the furnace after the metal vein has been smelted; and this species always has something of metal mixed in. A stone of this kind is first roasted, soon cooked in the furnace, then burned five times in another furnace, so that it can with just cause be called ἑπταφρυγῆς [eptaphrygēs, "seven-times roasted"].

[Margin: The preparation of Diphryges. — What is Cadmia? — Cadmia Botrytes.]

Today the workmen in the second furnaces prepare Diphryges thus, when they suspect that some gold or silver is present in the copper: they once again melt the copper with lead, because the lead washes it and carries off the gold or silver with itself. When this is done, in extracting the remnants of the lead they apply a moderate fire, so that the molten lead descends but the copper by no means does; for thus the copper is rendered like a spongy stone, which, once melted and thoroughly cooked, is changed into purified copper, whose slag is more purified than that which had come out of the first furnaces. The working men, calling this *Rasa* [?], sell it to the potters.

Further, while gold, silver, copper, and lead are being filtered, another by-product arises which is called **Cadmia**, which according to some is so named from "settling" [ab insidendo]. It is, however, an ancient name among the Greeks, and so the etymology of the name still lies hidden — unless we wish to assert that Cadmia was once observed while the copper-ore stone was being smelted, which some have designated Cadmia, perhaps because it was first found on Mount Cadmus. Galen left it in writing that Cadmia is sometimes made from pyrite stone, yet he commended the metallic kind, prepared from copper, above the rest. Four species of this are shown by Dioscorides.

The first is called **Botrytes** [βότρυς], as though "clustered," because βότρυς [botrys] is rendered "cluster of grapes." [Margin: Onychites.] The second is named **Onychites**, for it is ὄνυξ [onyx, "nail/claw"], since it has veins running across like a fingernail. [Margin: Placodes.] The third is surnamed **Placodes**, πλακώδης [plakōdēs, "crusty/plate-like"], since it is girded by segments as though by certain belts [zonae], for which reason it is also called *Zonitis*. [Margin: Ostracites.] The

fourth is called **Ostracites**, ὀστράκίτης [ostrakitēs, "potsherd-like/earthen"], which is rejected as the worst of all.

[Margin: Capnitis.]

Pliny, besides the four kinds described by Dioscorides, adds a fifth species, namely **Capnitis**, "smoky" [fumosa]: for καπνός [kapnos] among the Greeks means "smoke" [fumus]; but this is to be reduced rather to Pompholyx than to Cadmia. In our age Cadmia, resembling the bark of trees in the furnaces, is offered under the name of "Alexandrian Tutia" [Tutia Alexandrina]; which is a sign that it has adhered to iron rods [hastis ferreis]. [Margin: What is Tutia?] *Tutia* is an Arabic name, which however signifies not Cadmia but *Spodium*. [Margin: Spodium.] Here it is worth noting that the Tutia of the Portuguese [Lusitani] is not metallic; this is prepared in the Persian region of Quirmon [Kerman], neighboring Ormuz [Hormuz], from the ashes of a certain tree named *Goan*, for so the fruit of this tree is called; and this is by some called "Alexandrian Tutia," not because it is made at Alexandria, but because, carried from Quirmon to Ormuz, it is exported from there to Alexandria [hinc Alexandriam exportetur]. The authorities, however, commend in medicines not this but the metallic kind.

[Margin: What are Pompholyx and Spodium?]

From Cadmia, by reason of the fineness of their substance, **Pompholyx** and **Spodium** differ, since Cadmia, as has been explained, condenses into a certain solid material, but Pompholyx and Spodium cling to the walls of the furnaces like fine flour [pollen], although they take their origin from the same material, out of those furnaces in which copper is perfected, or in which Cadmia is burned. Pompholyx, however, is lighter, because flying up to the vaults it is glued together like bubbles, from which it drew its name; for πομφόλυξ [pompholyx] among the Greeks is "bubble" [bulla]. Spodium, in comparison with Cadmia, is heavier; therefore it falls upon the ground like ash, from which it received its name, for σποδός [spodos] means "little ash" [cinerula]. But true *antispodium* is prepared by art from myrtle alone, or from wild olive [oleaster] burned, which indeed performs the function of the cinerula of spodium. Avicenna writes the account of this metallic matter confusedly, when he asserts that Tutia is a sublimated smoke, and *Succudum* that which settles at the bottom; perhaps by Tutia he understood Pompholyx, and by *Succudum* Spodium.

[Margin: What is Litharge?]

To the slag of lead can be referred **Litharge** [Lithargyrium]; for it arises from lead too long cooked in the furnace, since it is the froth [spuma] which is collected

while silver is purified, and it congeals like a stone. It is called λιθάργυρος [lithargyros], having its name from "stone" [λίθος] and "silver" [ἄργυρος], as though "silver-stone" [lapis argenteus]; by the Arabs it is called *Martech*, and by the Latins "froth of silver" [spuma Argenti]. Dioscorides held that litharge can congeal without silver, while in the second furnaces silver...

[printed p. 208 — LIBER DECIMUS, Sect. IV]

[Margin: The use of litharge among potters.]

[Caput VII continued.] ...is purified mixed with lead; for then, in the boiling mixture, the lead, thinned by the violence of the fire and acquiring lightness, floats on top of the silver and becomes like a slag, which the craftsmen, gradually driving it to the sides, finally throw out and call *gesta* [?], which the potters are afterwards accustomed to use. Some wrongly think that the froth of silver made from gold is called *Chrysitis*, from silver *Argyritis*, from lead *Molybditis*; whereas litharge flows from lead alone, mixed with other metals — and especially with silver — for easier fusion or purification. And although it sometimes takes on the color of gold and sometimes of silver, this nevertheless comes from a greater or lesser roasting. For if, as soon as the burnt-off lead appears above the liquefied silver, it is removed from the crucible, then the litharge will gleam with a silver color; but if it remains there longer, it will acquire a golden color.

[Margin: Litharge natural and artificial.]

The workmen establish two kinds of litharge. One they call **Natural**, which comes from a silver vein mixed with a lead vein and liquefied in the furnaces; the other **Artificial**, which is prepared in the ways described above. Of this Dioscorides shows three kinds: the first kind from leaden sand [arena plumbaria] perfectly cooked in the furnaces; the second from the purification of silver; the third results from lead. [Margin: Various species.] Its yellow species is called *Chrysitis*; the white, *Argyritis*; the livid, *Molybditis*. The best froth of silver is prepared in Meissen [Misena] and Bohemia. Dioscorides, however, assigned first place to the Attic kind, which, since it was produced on Mount Laurium [Laurio], was called *Lauritis*; second place to the Spanish [Hispanica]; and third to the kind of Pozzuoli [Puteolana].

CAPUT VIII — Fodinarum Auri, & Argenti, quae in Peru, Novo Regno, & Nova Hispania in America reperiuntur, mira faecunditas, ex Relatione Patrum Societatis Jesu [The Wondrous Fertility of the Gold and Silver Mines Found in Peru, the New Kingdom, and New Spain in America, from the Account of the Fathers of the Society of Jesus]

In the whole Globe of the Earth no place has been found up to now that has furnished a greater abundance of gold and silver than that part of America which they call the **New Kingdom** [Novum Regnum, i.e. New Granada], **Peru**, and the **Potosí colony**. For, as Acosta [José de Acosta] relates (Book 4, ch. 4), the natives in Peru, not content even with vessels of gold — bowls, ladles, dishes, cups, flasks, glass vessels, and huge water-jars — had even chairs and entire vehicles made of gold, and made images of their idols out of pure and refined gold [obrizum aurum]. [Margin: The incredible abundance of gold in the Potosí region.] Pizarro [Pizzarrus], after he had overcome Atahualpa [Atalipa], is said to have found so much gold in the king's treasury that, amid the heap of golden plates arranged in a long row in piles, he could scarcely reach their height with his sword held out at full length; and the hooves of the beasts of burden were shod with golden, not iron, shoes.

And although that whole tract of America from the Tropic of Cancer to that of Capricorn is most fertile in gold and the other metals, yet to none does this most celebrated Potosí mining province seem to yield — the province of Los Charcas [Carcas] in the Kingdom of Peru, situated at 21° of southern latitude. [Margin: The Potosí region was once uninhabited because of cold.] And although this region lies under the torrid zone, it is so far from being scorched by the sun that rather, through the inclemency of cold, it was once almost deserted, and would doubtless have remained deserted, had not men, drawn by greed for immense treasures, not only come to the place but also there, by an incredible influx of men, built a vast city — necessary both for the abundance of essential goods and for luxury and delights.

[Margin: Description of the gold-bearing mountain.]

The mountain itself is exceedingly steep, more eminent than its neighbors by its slender and lofty summit. Its base obtains the breadth of a mile; from the highest peak to the base it measures 1,624 cubits, which the Spaniards call *Varas* or "rods" [Virgas], and these make a mile or one Spanish league. The gold-mine is said to have first been discovered by a certain Indian named *Cualpa*. He, when he had once come into the wastes of this mountain for the sake of hunting, and was

hindered from climbing by the roughness of the mountain, seized a certain shrub convenient for advancing his step; and as, with a rather violent pull, he tore it up together with its roots, he drew out a gold-bearing vein. [Margin: How and on what occasion the gold-bearing veins were discovered.] And since he was not unskilled in metallurgical matters, he found the vein, tested by fire, to bear the mark of better gold. So, concealing the matter, in time he came to such riches that he was an object of wonder to all, until others, the matter becoming known, finally — many more being selected — the whole mountain little by little began to be dug through, especially with the Spaniards coming upon the scene, who, greedier for gold than the natives, at length, not content with Mount Potosí, [Margin: The vastness of the veins.] discovered four other mines neighboring Potosí. And among other marvels, they hit upon a vein whose mass equaled the height of a spear, and afterwards upon another, almost in the shape of a comb, whose height was 300 and breadth 13 feet; extending into the depth to 50 or 60 fathoms [orgyae], it offered an inexhaustible treasure.

And as the records of the said places report, from the time of the Licentiate Polo [Licentiatus Polo], on Acosta's testimony, in place of the quint [quintarum loco, the royal fifth] there were registered 150,000 reales each week, sometimes 20,000 [recte: more likely 250,000 — see Numerical impossibles]; which sum each year constitutes at least one and a half million. Again, on Acosta's testimony, the records report that from the first arrival of the Spaniards in Peru, namely from the year 1545 to '74, seventy-six millions [Margin: 311 millions of gold expended for the royal treasury of Spain over 40 years.] accrued to the king's treasury...

[printed p. 209 — DE FODINARUM CONDITIONIBUS]

[Margin: 311 millions of gold expended over 40 years sent to Spain.]

[Caput VIII continued.] ...and from the year '76 to '85, thirty-three millions less; and so over a span of 40 years, 311 millions of *reales* were sent from the said silver into Spain — not counting those which were expended for the use of the governors and metallurgists and the administration of wars. The Potosí mountain is furnished with four principal veins, which are all situated on the eastern side of the mountain, laid out from south to north [from Auster to Boreas]. Where they are most diffuse they have a breadth of six feet; where narrowest, of one span [spithama]. [Margin: The multiplicity and depth of the veins.] Besides these, others too, diverse, are found sprung from them like the branches in a tree, through certain efflorescences. The individual veins are subject to the jurisdiction of certain lords, from whom they also take their names. Each vein has its own pits [fodinae]: the first, which they call "the Rich one" [Dives], numbers 78 pits, of a

depth now of 180, now of 200 fathoms [orgyael]; in some places, however, the pits have a depth of 60 or 70 fathoms.

The access or entry to the pits is as follows. In the side of the mountain they have pierced trenches or ditches crosswise, which reach as far as the seat of the ore. For since the veins which face south and north slope downward from above, it is necessary that their channels be followed as far as the roots of the mountain — which depth, as Acosta relates, is 1,200 fathoms. And although the depth of the pits is so great, yet a space six times greater must be gone around in the circuit before one reaches the very base of the mountain. The breadth of these ditches is for the most part eight feet, while the height obtains a little more than the measure of a standing man. And from these all the metals are brought out.

Diagram. Engraved plate captioned *Scalarum mira fabrica* ["The wondrous structure of the ladders"]. The image shows the steep, rocky exterior of the Potosí mountain (Cerro Rico), with a long, broad ladder-structure (a series of jointed rung-ladders lashed end to end, forming a single enormous stair) descending the rugged slope from the upper region toward the foot. Several small human figures of miners are shown climbing the ladders at intervals; one near the upper portion carries a torch or light. The rocky massif rises on either side with crags and outcrops framing the ladder run. The plate is uncaptioned apart from the heading; no internal point-labels are present.

[The remainder of the page:] As for how great the labors the diggers endure in bringing out the ore can scarcely be told; since, buried under the earth as though in perpetual darkness, they are compelled to accomplish their labors.

cannot even know what hour or day it is, nor when night is falling, since the Sun and Moon have no access to those innermost hiding-places of Nature. I say nothing of the diseases they contract in those pestilential caverns from the deadly mineral exhalations. Those who work in the mines use candles that burn continually, on a shift-system arranged so that they rest from their labors every twelve hours, the work-gangs relieving one another in turn.

[Margin: The miners' labors.]

The broken and pulverized ore-veins they load onto their backs and carry up by means of certain ladders, marvelously constructed, as the figure shows.

[Margin: The remarkable construction of the ladders.]

These ladders are made of three ropes twisted from oxhide, into which crosspieces are fitted in the manner of rungs, in such a way that two men

meeting on the ladder can conveniently make room for each other. Each ladder is ten fathoms long, with another fastened to its end. At the sides of the ladders, in various places, wooden benches have been built where the climbers can rest. The first man in the gang carries a lit wax candle to provide the light needed both for himself and for the companions following him. And since the depth is so dreadful that it strikes fear even into those who merely look down into it, these wretched miners — whether because their leather ladders break, or because the weight of the ore-veins loading them down overbalances them — broken and cast down by their toils, end their pitiable lives in a fearful death.

PROCESSUS I.

On the manner in which the gold called Virgin Gold, brought by Nature to its ultimate perfection in the island they call Hispaniola, is dug out and prepared.

[Margin: Pure gold is found everywhere in Hispaniola.]

If the bounty of Nature has enriched any kingdom of America, it has surely enriched the island of Hispaniola above all. For as is established both from the Account of our own Fathers and from the testimony of American writers, they report that there gold is found and dug out in vast quantity — not only within the innermost recesses of the mountains, but even on their outermost surface: among the fissures and clefts of the rocks, indeed even in the very valleys, plains, forests, fields, riverbanks, and riverbeds — and that this gold is not, as usual, fouled with the dross of heterogeneous particles, but is everywhere found pure and unalloyed.

[Margin: A mass of gold weighing 3,600 reales, found.]

For as Francisco d'Oviedo [Gonzalo Fernández de Oviedo] relates in his *History of the New Kingdom*, a mass of pure, unalloyed gold weighing 3,600 reales was found in Hispaniola.

[Margin: The manner of washing the gold.]

Since, then, gold is available even in the very fields, plains, forests, and river-mud without great expense, the Spaniards abandoned the mountain mines — seeing that gold could there be extracted, and once extracted separated, only at immense cost and with an enormous workforce — and instead extract and wash it out of the fields, plains, forests, and rivers in the manner that follows.

First, then, near some river, in places where the sand is rich in gold, they clear away the rocks, shrubs, and trees, and mark out a fixed extent of ground for the mine. Then they begin to dig up the soil to a depth of one foot, then another, and at once they wash this soil in the light and test it to see whether it is rich in gold. If not, they test another lot washed in the river. And if they have dug down six or seven feet, they abandon that spot and attack another part of the field, proceeding in this way until they strike upon a soil rich in gold. They then widen this mine in every direction, and the soil they have dug out is put into baskets and carried into the light, where it is handled by women appointed for this task: by washing it through fine sieves of horsehair, the mud is separated from the golden sands. And if any earthy and muddy material still remains, it is cleaned away by repeated washings, until, once all the dregs have been separated, only the golden grains and dust are left behind. This is gold so pure and of such excellence that it needs neither fire for refining nor lead or mercury for separation, but, melted down into ingots, passes straight into coinage.

Whether gold is actually fashioned by Nature in such level places — whether in the beds and banks of fields, plains, forests, or rivers — one might reasonably doubt.

[Margin: Whether gold is generated in level places, and how its origin is to be investigated.]

I say, then, that gold of this kind by no means took its origin in the said places, but was washed out into the plains by the down-flow of waters from the richest veins deep within the mountains. This could happen in various ways.

[Margin: This kind of gold was not generated in the plains, but brought down from the mountains by the rivers.]

First: the subterranean waters that pass through a vein of gold always abrade something from the compacted nuggets of gold and carry it off out of the mountain; this is why the mud of rivers teems with golden sands and grains — smallest, smaller, and largest — and when this mud is washed, the purest gold is at last collected.

Second: since an abundance of gold-bearing vapors is continually carried upward within the gorges of the mountains, the result is that, coagulating within the clefts of the mountains, they in time produce whole masses; and these masses, scoured away by the violence of torrents and rains — which prevail there especially in the months of December, January, and February — are carried down to the roots and level places of the mountains, where they are left behind, partly covered,

partly uncovered, by mud, clay, and rocks. And since each year a fresh supply of gold-bearing material is scoured from the surface of the mountains by the continuous rains of those three months and carried down onto the flat ground, the result is that the level places are forever covered over with new layers; and over many years the heaps of sand rise to an enormous height.

A clear proof of this is given by the same Francisco d'Oviedo cited above, who reports that in his own time, in the mines of the level ground, two skillfully wrought gold rings — of the kind the natives are accustomed to hang from their ears — were found, together with a quantity of charcoal so fresh that it seemed to have been extinguished not long before...

[Margin: The cause of this.]

as to colors. In a word, its colors are so varied that they seem to be tinted with a definite color out of their points and little veins. And this could not have come about by any other means than this: that long ago a bright fire was built there by the natives, and during the customary dances of that people rings were lost; then, by the violence of rains and torrents, the place was wrapped in sand and mud; and as fresh mud was brought down year after year in later times, the field grew to that very height which the later digging-out of the rings and the charcoal that was found demonstrated. And let this be enough concerning Virgin Gold dug out and washed in the American fashion.

PROCESSUS II.

On the separation and preparation of metals — chiefly gold and silver — as practiced in America.

The veins from which silver is extracted in the mountains of Potosí mostly run between two crags, which they call *Caja* [Spanish *caja*, the "box" or walls enclosing the lode], one of which is so hard that it can rival any flint, while the other is consistently softer and more brittle. Through the spaces between them the seat of the metallic veins extends — though not everywhere of the same bulk or running on an even course. For in some places the vein flows very thick and rich, most fertile in silver; in others, by contrast, it is more brittle. The one shows the color of amber, the other is blacker; one shows the appearance and color of a rose, another of ash. In a word, its colors are so varied that to those unskilled in such matters they might seem to be mere stones; but to the miners they are recognized by no other signs than the points and little veins of a definite color.

Whatever is dug out of the ore-mines is carried to the mills by Peruvian Sheep [llamas], which they use in place of horses and mules. They then proceed as follows in melting down the metallic ore.

[Margin: The method of purifying silver.]

They build furnaces, which they call *Guairas* [Quechua *huaira*, wind-furnaces], into which they first throw the mineral lumps, crushed by the mills. To make it dissolve more easily, they add a leaden metal, very easily reducible to a liquid, which they call *Soroche* [the lead-rich flux, *soroche*]. Once the froth has been stirred up by the smelting, it sinks down through the middle of the fire, while the lead, together with the silver, [settles to the bottom]; from one quintal of this kind of metal they sometimes draw 30 or 40 silver reales by smelting. Acosta also relates that a mass was once given to him from each quintal of which 200 or 250 reales were extracted. But the more barren veins yield at most only five or six reales each, and silver of this sort is for the most part very dry, and scarcely able to be smelted because of the scarcity of lead. For this reason it used to be heaped into piles and thrown away as useless refuse, until at length more skilled metallurgists discovered, through their ingenuity and industry, that by the power of quicksilver — at great and incredible cost — they could purify and refine the barren silver abundantly.

[Margin: From richer metals more is lost in the smelting of barren silver by means of quicksilver.]

It was likewise found that the better the metals are, the more of them is lost from the quicksilver mixture — quicksilver being apt to consume and devour metal in the fire, through the sublimation of the metallic particles it carries off with it. But to this too they applied a remedy: by tempering the degree of fire, no more is lost by that wastage. And this is done not at Potosí alone, but also in the Kingdom of Mexico, where they smelt by the aid of quicksilver. Hence, the art of fusion carried out through the little furnaces they call *Guairas* has been abandoned — of which in the circuit of the mountain of Potosí some 6,000 were once counted, all built for smelting silver; whereas today scarcely more than 2,000 survive, since quicksilver alone has claimed the chief place in the smelting of metals.

PROCESSUS III.

On the preparation of silver and gold by the aid of quicksilver, as practiced in the Kingdom of Peru.

Quicksilver is found in various substances, both earthy and stony. At Idria in Carniola it is for the most part extracted from moist earth, on which we treated at length in the foregoing pages. In America — as also in the other mines of Europe, chiefly in Spain — it is for the most part extracted from cinnabar and minium.

[Margin: The cinnabar mine of silver-quicksilver.]

In America, the power of the quicksilver embedded in the cinnabar was unknown before the arrival of the Spaniards on those coasts; the color of the cinnabar served the natives only for staining and tinting the faces of themselves and their idols — both for adornment, as they supposed, and to strike terror into their enemies. This continued until at last, through the efforts of the Licentiate Castro, Governor of Peru, its use was demonstrated, the quicksilver mines being first discovered in the year 1566; and chief among them is the richest mine of all, called *de los Santos*. This, as Acosta testifies, is nothing other than a rock — a most solid and hard cliff — soaked through and through with quicksilver, of such great size that in length it occupies 80 and in breadth 40 Spanish *virgae*, or rods. This rock, hewn through in a quadrilateral shape to a depth of 70 fathoms, is said to be of such great extent that at one time it can easily hold 300 men working together in it.

It now remains to tell how gold and silver are extracted by the power of quicksilver in America.

[Margin: The method of extracting quicksilver from its ores.]

We said above that huge heaps of silver-bearing ore had been piled up around the mountain of Potosí as useless. When Pero Fernández de Velasco, a man skilled in metallic matters, had examined these, he made use of the resource of quicksilver and drew from them a vast quantity of silver. The procedure for working both kinds of vein — the fertile as well as the barren — is as follows. The vein rich in quicksilver, well pounded, is thrown into a pot; the pot is then stopped up and committed to the fire. When this has been done, by the force of the fire the quick-

silver, as it were, makes a divorce from the silver and, separated and raised on high, when it meets a denser and more solid body and feels the cooler air, is at

once restored to its former nature, distills, and drops downward. When this is done, and the quicksilver thus protected, the pot — which has by now thoroughly cooled — is opened. Yet here the greatest care must be taken not to receive the fumes while the pot is still hot with quicksilver, for that is done at the gravest peril to life, or at the loss of one's teeth.

[Margin: A herb of the greatest power for the smelting of metals.]

Now since, for the dissolving of the metals, an infinite quantity of wood would be needed, a certain herb, a kind of broom-grass, was discovered, which grows most abundantly in the mountains of Peru and whose power is so wonderful that metals which cannot be melted even in the fiercest furnace-fires of burning wood and charcoal — this herb, gathered into bundles and thrown into the furnaces, immediately, to the great profit of the metallic trade, makes the veins flow. Once dissolved and smelted, the quicksilver is put into a leather sack, brought into the storehouse, and from there conveyed to Potosí, where, in the course of one whole year, 6,000 or 7,000 quintals of quicksilver are spent and consumed in preparing the metals — to say nothing of the amount that is gathered up daily, besides, from the dregs which form the matrix or sediment of the first washing of the metals.

[Margin: Quicksilver recovered from the dregs of the metals.]

These dregs, thus collected, are burned in furnaces, so that if any quicksilver has remained in them it may be drawn out and extracted. Now the yearly quantity of metals prepared at Potosí in these furnaces is reckoned, by the account of our own men and by the calculation of skilled persons, to amount to about 300,000 quintals. And from the dregs and from the remaining refuse of heterogeneous particles floating on top, [where] they find some silver...

from the matrix at least 2,900 quintals of quicksilver are recovered. Yet a remarkable property of the metals is observed in this operation too. Some metals indeed, with a slight expenditure of quicksilver, yield a great deal of silver; others give a large amount of silver at once but consume no less quicksilver; while others, by contrast, which give more sparingly, require less. And so, according to the condition of the metals, the metal-trade meets with good or bad fortune, with profit or loss. It is, however, commonly known that the richer the metals are, the greater the quantity of quicksilver they consume, and vice versa. But now to the practice.

[Margin: The method of separating the metals by quicksilver.]

The metals, then, are at the outset pounded as finely as possible in mortars with pestles prepared for this purpose, and are afterward strained through sieves and twisted copper wires; through which, if they have been skillfully and diligently worked, at least thirty quintals can be passed in the space of 24 hours. The metals thus refined through the strainer are thrown into a large, open vat, in such a way that for every 50 quintals of metal, fifty quintals of salt are added — the purpose being that the salt may consume and eat away the native greasiness of the ground metal; for in this way silver is more easily incorporated with the quicksilver, and combines with it.

[Margin: The method of procedure with quicksilver.]

This done, the quicksilver, put into leather or hempen cloth, is squeezed out in the form of dew or sweat onto the metals; these, first thoroughly worked over with stirring-rods for a better mixing of the particles, are then poured in. At length the mass, duly worked up into the form of cakes, is set out on hearths to be smelted by fire over the course of five or six days. If, then, the quicksilver, having properly done its office, has thoroughly combined with the silver, from...

water, they throw it in, and with a hand-mill, **B** or **C**, they grind down the metallic mass in roughly the manner in which mustard is usually ground and crushed, as the present figure shows. By this agitation, the clay and filth flow off from the metal together with the water itself through the channel **H** or **G**, while the silver, together with the quicksilver — because of its innate heaviness — sinks to the bottom of the vessel. And this, left surviving at the bottom of the vessel in the form of sand, is taken out and washed again to achieve the ultimate purity of the metal; once washed, it is pressed dry in a cloth or hide, so that whatever quicksilver had not been properly united with the silver runs off, while the rest remains within the leather bag as true silver — yet in such a way that only a sixth part of the mass is silver, the remaining five parts being quicksilver.

[Margin: How quicksilver is separated from silver.]

But they also proceed by another method, so that the quicksilver itself may likewise be separated from the silver. They put the compacted mass into vessel **A**, and, applying a strong fire, properly stop up the cover **V** of the vessel, as the figure shows. When the fire is kindled, then, the quicksilver dissolves into a vapor, which — escaping by the force of heat and lightness — if it strikes against those earthen pots, is at once driven together and thickens (not otherwise than as the vapors raised from boiling water condense into drops on the lid of the pot). Then, through the channel **I** assigned to this vessel, it flows down and distills, just

as through an alembic, into vessel **S**. Thus whatever quicksilver was expended on the smelting of the metals is recovered.

Diagram. A distillation apparatus for recovering quicksilver, set on a low brick hearth with a wood fire beneath.

- **V** (top): the cover/cap stopping the head of the still
- **A** (center, body of the still): the vessel holding the compacted metal-mass over the fire
- **I** (between the two vessels): the channel or delivery-tube carrying the vapor across, like an alembic spout
- **S** (right, receiving pot): the receiver vessel into which the distilled quicksilver collects

it is tried out, fermented, and at last thoroughly smelted; then it is washed, dried, and rinsed again and again, cooked and recooked, subjected to the pestle, put through a sieve, and finally passed through furnaces, jars, and bucket-frames, and through fire and water itself — not without peril to the lives of the wretched metallurgists — so that it may serve human use and luxury.

PROCESSUS IV.

By what means silver-rich pure lead is smelted, and on its separation, as practiced in the Hungarian metal-works of Schemnitz [Banská Štiavnica].

After the metallic stones from the ores and the lumps of the veins have been brought to the appointed place:

First, a furnace for smelting is constructed out of pounded clay, into which fine charcoal-powder is mixed, together with a crucible made of the same material, into which the molten matter is discharged through a hole 1½ feet [wide]; the depth of the furnace itself is gradually enlarged by the smelting. Into this are successively thrown three or four hundredweight of fresh lead, five or six of litharge, and of hard lead — all of which are prepared in the pot with various smeltings and additives.

[Margin: The method of smelting the veins.]

First, then, into the furnace **A B C D**, through the hole **G**, is thrown ironstone of the cheaper sort, eight hundredweight together with two hundredweight of mixed marcasite with lead (which they call *Loh* [German *Lech*, the lead-copper

matte]); these are smelted within eight hours. Then there are added eight hundredweight of ironstone from the ironstone, two from the lumps or another stone (which they call *Schlich* in German), and six hundredweight of the material called *Loh*, which are smelted in twelve hours.

It being thus smelted in the furnace, in the forward part of the furnace, above that pot or crucible...

Diagram. A domed smelting-furnace of the Hungarian (Schemnitz) type, with a fire-chamber at the base and a collecting pot beside it.

- G (at the apex / charging vent): the hole through which the charge is thrown in
- A (left side of the furnace body): one corner-point of the furnace **A B C D**
- B (right side of the furnace body): another corner-point of the furnace
- C (lower left): a further corner/reference point of the furnace
- D (lower right, near the spout): the discharge point toward the crucible
- L, M (the pot at right): the receiving pot or crucible (*catinum*) set before the furnace mouth, with a stirring-rod

pure and simple silver, yet diminished by a fifth of itself, is left remaining. From each pair of these cakes, one is made weighing about sixty-five pounds; these are then carried off to the appointed places to be assayed, given their fifth-mark, and stamped. And the silver is of such great purity and excellence that it is sometimes finer than 2,380 *Alloys*. Silver is forced to undergo all these tortures and hardships until it comes out tested, pure, and clean. For even when it is examined more closely as pure, the mass — or rather the paste — is still crude, the mass out of which the silver is ground, sifted, pounded, fermented, and at last smelted, then washed, dried, and rinsed again and again...

Fol. 214 — continuation of the Schemnitz lead-silver smelting ...a broad opening of one palm's width is made, so that the melted material may flow into that pot. In this opening the less pure mass, called *Schlüg* [Schlick/slag] in German, is separated from the other, called *Loh* [Lech/matte] in German. The first flows off into another, special pit; the other remains in the pot, and is successively rolled out from there, until the silver is drawn off from the lead. With this *Loh*-mass set aside, there remains lead rich in silver, which once skimmed off is set aside.

Afterward the remaining material — called in German *Floß-Schlüg* — is again worked in the furnace for about eight hours, and is again let down into the pot LM, until it is well processed.

This done, fresh lead — about three hundredweight — and an equal three hundredweight of litharge [lythargyrium] are again thrown into the pot and melted down. The more impure mass, called *Schlaken* [slag], which melts out first in the furnace, is let down into the pot and pressed free of all the silver still clinging to it. This melting-out of the mass — which in German is called *Schlaken* once it has flowed out — is repeated twice or three times, in such a way that at one time twenty, indeed thirty-six hundredweight of this mass and of the other, which they call in German *Offenbruch* and *Waschwerk*, six hundredweight, eight hundredweight of lead, and six hundredweight of the purer mass rich in marcasite, called *Loh*, are all taken together. All of this is melted for eight hours, until that more impure mass, called *Schlaken*, is entirely smelted out. When this is done, the lead rich in silver is again taken up from the pot.

Once the lead is removed, about thirty hundredweight of marcasite [marchesita] and eight hundredweight of fresh ironstone [lapis ferrarius] are produced and melted down, so that the mass called *Loh* may come out within about eight hours. And when from it about fifteen hundredweight of the material called *Loh* have flowed out, the work in this furnace is finished.

Now another furnace is prepared for further purifying that lead — called in German *der Treibherd* [the refining-hearth] — prepared from the ash of oak-bark and sand. This is heated for two days and nights before the work. Then at last, within two hours, three hundredweight are processed (the mass thrown into this

furnace for purifying they call in German *blütß*). If this mass, called *blütß*, begins to take on color, it is stirred about by a bystander with a hazel rod, that is, a stick of hazel-nut wood; and when this mass seems sufficiently smelted, they quench it first with lukewarm, then with cold water, and purify it with a nearby instrument from the adjacent dross of hard lead. This mass is then transferred to another hearth, called in German *Brengaden*, where it again becomes incandescent and is first restored to its own purity. From there it is at last carried to the place where the silver is finally separated, called *Scheidgarten*; and from twelve hundredweight of rich lead there remain nine hundredweight of litharge, one and a half of hard lead; the rest is pure silver, which is finally separated in the manner we described in the preceding sections.

PROCESSUS V. CHYMICUS.

Used in Hungary, for separating gold from silver.

Silver containing gold is first purified of all metals by cupellation [Cineritium], or *fulmen*, according to the art, with lead. Afterward this silver is granulated, or rolled into sheets as one pleases, and one ounce of it is placed into three ounces of purified aqua fortis [aqua fortis purgata] in a separating glass — as will be seen below — in warm ashes, or upon a tripod, with a little fire. The silver at once dissolves, the gold being left behind in the form of a black calx [calx nigra], into which the dissolved silver is to be poured off by tilting. The black calx is then to be washed so many times with common water until all the sharpness of the aqua fortis has departed; afterward it is to be dried, ignited in a crucible, and finally melted — and one will have all the gold that was contained in the silver.

[Margin: How gold is separated from the other metals.]

This method of separating gold from silver is called *quartatio* or *inquartatio*, for this reason: that when you wish to carry out this separation, there must always be three parts of silver and one part of gold, which is the fourth part [quarta pars]. For gold mixed with an equal part, or with double the silver, is not dissolved by aqua fortis, nor by *Chrysulca* [aqua regia]; but if you wish to make the separation of the said metals by means of *Chrysulca*, the gold must exceed the silver threefold — then the *Chrysulca* dissolves the gold, leaving the silver behind.

Now it must be seen by what method the silver is to be separated from the aqua fortis, which is done in two ways: one is by precipitation [subsidio] of the aqua fortis, in the usual way for such purposes; the other in the way we shall shortly explain. [Margin: Another method here.] The first is this: that the aqua fortis full of silver is placed in a retort, and with a receiver fitted, it is distilled, first with a

slow, finally with a stronger fire of ignition, until all the aqua fortis has gone out from the silver — this being kept for similar uses. The silver left at the bottom is then to be ignited a little more in a crucible, and finally melted into silver, as is the custom.

The other method is this: let the silver dissolved in aqua fortis be mixed with four parts of common water; into this mixture let a copper sheet [lamina cuprea] be placed, and let it be left for 24 hours — and you will find all the silver fallen to the bottom. From this the water is to be poured off, and the silver washed so many times until all the sharpness has departed, then finally dried and reduced with a fusing powder [pulvis liquefactivus].

[Margin: The various separations of metals from gold.]

Now it should be noted that the aqua fortis, from which silver has been separated by means of copper, contains copper in itself — because, from that water, by placing in it an iron sheet, since the nature of aqua fortis is always to take in what is easily soluble and to let go what is difficult — by this experiment it is clear that the said transmutation of iron into copper by means of vitriolic water [aqua vitriolaris] is not true, but rather a precipitation of the copper from the water by means of the iron; and in this

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step [passu] many ash-mongers [ciniflones] — alchemists — can impose upon those ignorant of metallurgical matters, feigning a transmutation of copper into silver, as I myself have once seen.

There is also another separation of silver from aqua fortis by means of water in which common salt has been dissolved. Then the silver falls to the bottom in the form of a white powder, which must be sweetened by many repeated washings, dried, and finally reduced with some fusing powder. These are the chief, the more usual, and the safer methods of separating gold from silver.

[Margin: The properties of aqua fortis.]

Now, concerning aqua fortis, which is of two kinds — one called *Virginea* [virgin], the other *Separatoria* [separating]. The *Virginea* is that which is simply distilled from niter and alum, or from niter and vitriol. This water has many dregs, and for that reason is not called *Separatoria*. It is cleared of dregs by adding to each pound half an ounce of silver: thus the silver will be dissolved, and the water will send its white dregs down to the bottom, which are to be separated by pouring

off. For if these dregs were not separated from the water, then, in the dividing of gold from silver, they would be mixed with the gold and would foul it. Others, however, purify the water in this manner: they dissolve silver in it, then distill, and the silver remains at the bottom together with the dregs of the aqua fortis; and this method is better than the former.

PROCESSUS VI.

From the account of Father Andreas Schaffer.

It must be noted that silver is extracted from ores of two kinds. One has no admixture of gold, or scarcely any worth mentioning, so that it is not worth the trouble to separate that little gold — such is the silver, almost the only kind in the mining towns of Hungary, which is extracted from copper. The other, which is gathered from silver ores (such as is all that is extracted from the Schemnitz pits), has much gold mixed with it.

[Margin: How gold is separated from the other metals.]

Now, how this gold is separated from the silver is a fine thing to see, and I shall send it to the Reverend Father in writing very shortly. There are two methods. One is *im grossen Werck* [in the large works], the process of which Your Reverence will receive under the letter K. The other is *klein Werck, im probiren* [the small works, in assaying], which method I have here put into practice as follows.

First I took some *Goldhältigen Silberkorn* [gold-bearing silver-grain], which I draw out upon an anvil with a hammer into a very thin sheet. This sheet, cut into the smallest particles, I throw into *ein klein gläsern Schaidkolben* [a small glass separating-flask], pouring on aqua fortis, and I hold the glass over the coals so that it warms — not too much, however, lest the glass break. In this boiling water the gold is dissolved from the silver and sinks to the bottom of the glass in the manner of a black powder; the silver mixes with the water, so clearly that it cannot be distinguished from spring water. But if the aqua fortis is not strong enough, or sufficient to dissolve the gold completely, I pour on fresh, until the whole water becomes clear and pure. This done, when the water labors no more, I pour off that aqua fortis little by little

little by little [paulatim] into a prepared earthen pot full of well-warmed common water, yet in such a way that the black powder resting at the bottom does not pass out of the glass. When I have poured off all the aqua fortis, I pour fresh common water into the glass and wash those black powders; and when they have

settled, I pour off the water, and pour the well-washed golden powders out into some dish, and dry them over the coals — thus I have pure and virgin gold alone.

[Margin: How silver is extracted from the water.]

It now remains to extract the silver from the water, which is done in this way. I took a copper sheet (and what I greatly wonder at, they say that no other — neither of iron nor of steel — is of use, but only one of copper). This, suspended by some thread, I put into the middle of the pot over the burning coals, into which that aqua fortis has been thrown — and behold, the silver clings to the sheet, which must be held suspended in the middle of the pot. I draw out the sheet, and with some little stick wipe off the clinging silver in the manner of an ashen mud into some little vessel, and I have pure and virgin silver.

It must, however, be observed that the aqua fortis ought to be separated in a great quantity from the sweet water in the pot; otherwise the copper sheet will be eaten away and dissolved, and the silver adulterated. This I learned by experience. It is also worth knowing and noting, and may serve as a point worthy of consideration.

Fourthly. [Margin: A wonderful property of the silver powder.] If from the said aqua fortis in which the silver is, or from the very white silver powder collected in this way, any part of a person is touched, it so blackens the hand or face that the blackness can be removed only with the greatest labor. And those ignorant of this often deceive and vex these craftsmen. Yet this blackness is more quickly removed — as I learned by experience — with oil of tartar [oleum tartari] than, as they say, with fresh butter. Recently, while someone wanted rather curiously to examine the things I sent on the 7th [gev. 7. = *den 7ten?*, the 7th], I marked a cross on his hand with this water; he could not remove this cross in the space of more than one month, nor by any washing or rubbing, until he washed himself with oil of tartar. Salt of ashes [sal cinerum] also removes this stain. I add, with regard to the silver, that it should be noted that much silver, which is not extracted as a residue on the sheet, settles at the bottom of the pot.

Fifthly, it is also marvelous — what has been grasped by experience and is wont to serve for the vexation of the untrained and beginners, *welche eerst anfangen zu probiren* [who first begin to assay]. From the writing under the letter L, and another under letter G, no. 4, at the end, the Reverend Father will find *wie man das Silber von Bley schaiden, und in Probir-Ofen auf der Capelle abtreiben soll* [how one is to separate the silver from lead, and refine it off on the cupel in the assay-furnace]. So when they wish to do this, *und der Korn-Silber schon auf der Capeln*

ist [and the grain-silver is already on the cupel], if even a small particle of tin [stannum] is added, *so läßt sich das Silber nit abtreiben* [then the silver cannot be driven off / refined], and there is virtually no way of separating the silver from the lead, which the admixed tin causes — or at least it can be done only with the greatest difficulty and immense labor; such troubles does the tin cause, if it is mixed in. Without tin, *kann man's abtreiben* [one can refine it off]...

[Margin: A wonderful...]

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at most within two hours [ad summum intra duas horas], especially if hand-bellows are used. But if tin has been thrown in, such an assayer will need even ten hours; the more skilled assayers have indeed another method, of which in what follows.

As to what the Reverend Father writes in the second letter sent to me — namely, that I should explain to him how the iron must be prepared, so that it is turned into copper by vitriolic water — I inform Your Reverence that they are accustomed, both *in Herrengrund* near Neosolium [Neusohl / Banská Bystrica], and at Schemnitz near *Sepusium* [Margin: The method of transmuting iron into copper], that all old iron and broken iron implements, which can no longer be of any use — such as old iron shovels, broken rakes, axes, etc. — are forged at the smith's by fire into round, oblong, oval-shaped sheets, etc.; and the thinner they are forged, the more quickly they are turned into copper. This is the practice.

But the Reverend Father should know that that vitriolic water is found deepest inside the mountain, because there, on account of the copper ores dug out, there are great pits and excavated places. To that depth where the said water is found, there will be — if I remember well — a hundred fathoms [orgyiae], if not more; for certain I cannot say, I forgot to inquire. There a small stream of vitriolic water flows out from the mountain; and there they have troughs — they call them *Kasten* [chests/boxes] — made of wood, into which they channel that water. These troughs are always full of that water. Into these troughs they throw the iron sheets, and there (*in Herrengrund*, where the water is not so strong as at Schemnitz) they let them lie for three months. Then that iron is already fully turned into copper, and it lies in the water like gold; if it is taken out, the material is as soft as mud, or like a mass of bread — *wie ein Taig* [like a dough]. But afterward, when it is carried out from the mountain, it hardens.

[Margin annotation, left side, in manuscript hand: *Vid[e] supr[a] l. 6 [?] Sect[io] 2 Cap. 2 [?] proem [?] §. 1 [?] pag. 524 [?]* — a cross-reference to an earlier passage; reading uncertain.]

CAPUT IX.

On the Mines of Copper [Aes], or Cuprum.

Copper [Aes] is properly generated by a sulphureo-mercurial exhalation, in earth that is atramentous [terra atramentosa, vitriol-bearing], impure, and variously contaminated. Indeed, by its very color it at once shows that a metal of this kind has been violently scorched, since it shines with so intensely red a color. And just as the vein is of various color, so too it is generated in diverse kinds of stones. And although some call it weak, leafy [foliosum], and earthy, yet, since it is easily extended by the hammer, it thereby openly shows that it possesses an inner richness [pinguedo intrinseca], by which the parts are not easily dissolved from the parts, as was said in the preceding.

[Margin: Signs of latent copper.]

The chief sign, then, of a copper vein lying hidden somewhere is the fissuring of rocks of a yellow and blue color, and an abundance of cracks. And the reason is that Mercury, raised too high by excessive heat, dries out the stone in its inner moisture, whence it must of necessity be that fissures and cracks arise, as it were, by the dissolution of the bond of continuity. Whenever, therefore, you find such rocks of a blue color within a rock of grey color, shaded with little veins of green color, let that be for you a sure sign of an excellent and rich vein. If again you see rocks of the mountains glittering in the manner of talc — which are indeed nothing other than the leafy brood of pyrites [foliata pyritis foetura] — you will obtain a near sign of a hidden vein. Moreover, vitriolic water from the mountains, of a greenish color and metallic smell, which coats the bed of the river with a certain putrid, thin, and slimy green matter, as if with a kind of skin, will indicate a mountain pregnant with copper. The reason for this is none other than that the river abrades from the coppery veins certain vitriolic corpuscles, which, then cast down within the river, while they cling to the stones, with time, by the natural richness of sulphur in which they abound, form this green skin I have spoken of.

And as copper has great use in human needs, so too Nature willed it to be most abundant, and most easily worked on account of its flexible nature — for it is easily tinged into orichalcum [aurichalcum, brass] by the aid of calamine earth [terra Gelaminae / lapis calaminaris]; with the powder of sulphur it is easily

reduced to a calx; with salt it is changed from red to white; with tin, or with arsenic, it readily renders itself fusible — of which more fully in what follows. Nor are there lacking those who, by frequent cementation [cementatio], extract from it some quantity of gold as well. The secret method of proceeding will be declared below in the chapter on Iron. But how copper is changed into orichalcum, I explain in a few words.

The Method by which Copper is Transmuted into Orichalcum.

[Margin: The first method.]

Take fragments of the best copper and of calamine [Cadmia], and place them by turns into oblong pots, which, filled with copper and calamine, are let down into furnaces excavated below, and the fire is kindled in certain channels, as it were. So when they have been melted together, the copper, tinged with the color of gold, is changed into orichalcum. This is the common method.

[Margin: Another method.]

But others throw thin plates of copper, about a finger's breadth wide, into the pot in which silver is usually melted, and they smear its outer part with clay, which when mixed becomes iron-scale [ferri squama]; the inner part, however, with the purest honey. Likewise they smear each of the copper plates, and sprinkle on them the finest powder, which is made from fossil calamine [Cadmia fossilis], lees of wine [faeces vini], which they call tartar, and charcoal of linden-wood [carbones tiliae] in equal portions. The pot, moreover, is covered with an earthenware lid [operculum fictile], which has a hole into which a stylus is inserted, by which the melted copper is stirred. But the lid...

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the lid [culum] too, on the part where it joins the pot, is smeared over with superimposed clay. The pot, fitted out in this way, is placed in the furnace. And so, when calamine [Cadmia] is mixed with the copper, there first comes out red smoke, then blue, and finally yellow — which signifies that the mixing has been accomplished and the orichalcum perfected.

[Margin: Signs of the operation completed.]

Another Method by which Copper is Colored.

When copper has been diligently purified and separated from the other metals, the craftsmen strive to color it in manifold ways. For sometimes they add

calamine [Cadmia] to it when molten, and the copper takes on a golden color. Sometimes they add magnet [Magnes], or talc [Talcum], and then it presents the appearance of silver — since from white talc, by chemical instruments, a water is extracted which is most excellent for whitening copper. Other methods besides are reported by which we can counterfeit silver out of copper. [Margin: Various ways of coloring copper.] Some attempt to achieve a metamorphosis of copper into silver by grinding equal portions of orpiment [Auripigmentum] and saltpeter [halinitrum] in a glass vessel over coals, and adding half an ounce of this powder to each pound of copper, mixing until it is transmuted into a true silver form. But this can in no way be called a transmutation into silver, but only an accidental tincture of silver.

But if we consider the mixture, this is wont to be of two kinds: for copper is mixed either with other metals, or with other fossils [minerals]. Of the latter mixture we treated a little before, when with magnet it acquires a silver color, and with the calamine-stone [lapis calaminaris], called *Cadmia*, a golden color. For by this last method, copper being melted, the prepared orichalcum [Aurichalcum] is so called.

[Margin: The mixture or alloy [Liga] of copper.]

And so, before copper is melted together with other metals, its fusion — whether slow or quick — must be weighed. Mizaldus [Antoine Mizauld], to accelerate the fusion of copper, mixes in horses' hooves during the melting. As, therefore, the other metals have their own mixture, which the craftsmen call *Lega* [alloy], so too copper is not exempt from this — not that the mass of the copper be increased, as was related of gold and silver, but that a certain viscosity be removed from it, which prevents it from being rightly cast for various works. It is therefore mixed with tin and with orichalcum; yet the proper and best mixture, or alloy, by which it is perfected, is said to be tin, so that works may be made without [other] metal — for in works requiring the hammer and dilatation, the purest and most perfect copper is grievous [unsuitable], since copper mixed with brass is broken by the hammer.

[Margin: The various mixtures of copper for making various things.]

This mixture must be varied according to the variety of works: for statues require one, cannon another, bells another, and finally mortars and cauldrons another. Inasmuch as a hundred pounds of copper with twelve of tin make the metal for the larger artillery pieces [tormenta bellica], but a hundred pounds of copper with twenty of tin constitute the metal for bells. This mixture is sometimes called

by the craftsmen *metallum* [bell-metal], sometimes commonly *bronzum* [bronze], according to the greater or lesser quantity of tin it receives. Some, with less expense, mix orichalcum or lead with the copper, and likewise what they call *bronze* they strive to cast for various works.

[Margin: In the fusion of copper three things are worthy of consideration.]

Three things are especially worthy of consideration in molten copper. First, this is innate to it by nature, as Pliny relates, that when great cold comes on, it melts better and more quickly — although it does not endure the vehement assay of flames, for it is wholly burnt up. From this it is to be concluded that there is much combustible exhalation in it, besides that, in comparison with the other metals, it gives off a sulphurous and fetid smell.

[Margin: Why copper is better burnt in cold weather.]

Next, if a pebble, or mud, or wood, or a wet coal — as Agricola attests — falls into the copper still molten in the pot, then the pot, roaring like thunder, casts out all the copper it contains, and damages and sets fire to whatever it touches.

[Margin: Copper's thunderbolt.]

Again, if one considers the copper once made: it is to be noted that copper, often wiped, contracts rust [*verdigris*] more quickly than copper neglected; and immune from this blemish, as Pliny attests, it is preserved with liquid pitch. But smeared with oil, or moistened with salt and vinegar, it is straightway vexed with *verdigris* [*aerugo*] — though afterward it is not consumed by it. For which reason works of copper are said to attain almost eternity; indeed, copper is easily tinged into the appearance of silver.

Finally, the investigators of natural things have reported that that water is the best which, long held in a copper vessel, has not stained it. [Margin: A wonderful property of copper.] Likewise, they relate that water kept in copper vessels has been observed to rise with a notable increase when the clouds are condensed into rain; and they conjecture that this arises from the fact that Venus rules over the sea and over copper. But these things, as they are repugnant to experience, so are they to be reckoned mere fancies and sportings of the imagination.

The Uses of Copper in Medicine.

In many afflictions by which the human body is troubled, copper can be applied as a most effective remedy. And that it is most useful in medicine we gather from this, that those wounded by copper are cured more quickly than those struck by

iron; and although thermal waters infected with verdigris promote vomiting, nevertheless they are of no small help to the mouth, glands, uvula, and eyes.

[Margin: The effects of copper in medicine.]

Hence Dioscorides employs copper vessels for eye-medicines. For which reason Macrobius wrote with the best of right that workmen engaged in copper mines are always strong in the health of their eyes, and that others suffering in the eyes, coming to the copper-works, recover their former health. For this reason, in the apothecaries' shops, burnt copper [aes crematum], flower of copper [flos aeris], verdigris [aerugo], and scale of copper [squama aeris] are kept, since, according to the mind of Dioscorides, they are endowed with a drying and astringent virtue. Flower of copper, according to the same author, not only astringes but represses flesh growing over ulcers, and confers clarity to the eyes. Scale of copper is held to be best in Cyprus, which likewise, mixed with ophthalmic medicaments, checks the flux of the eyes and removes the roughness of the eyelids.

[Continuation of] Caput IX — De Fodinis Aeris, seu Cupri [On the Mines of Copper] (*copper, continued*)

(Fol. 218 verso)

Verdigris [aerugo] imparts a sharp quality to the taste, and according to Galen it shares in a digestive faculty. For that reason, when mixed with wax and oil, it brings wounds to a scar. Today in the apothecaries' shops verdigris is used in place of flower of copper [flos aeris]; its virtues are celebrated by Jodocus [Jodocus Willich?] in these verses:

It binds, it thins, it draws forth tears, it heals ulcers, It overcomes calluses
and the hardness of a place. It dries out the filth of the ear; but when it
grows up inside the nostrils, the diseased flesh must from there be
pressed away.

Finally, burnt copper [aes ustum] is called by the barbarians *Calceumenon*, though properly it ought to be called *Chalcos cecaumenos* [Greek: χαλκὸς κεκαυμένος (chalkos kekaumenos, "burnt copper")]. According to the opinion of Dioscorides it strongly astringes, dries out, and easily heals ulcers thoroughly; for this reason it enters into various external medicines. Burnt copper [aes crematum] is placed in the Apostolic plaster of Nicolaus Alexandrinus [Nicholas of Alexandria]. Verdigris [aerugo] goes into the *emplastrum divinum* of Nicolaus Praepositus [Nicholas of Salerno], into the Apostles' ointment [unguentum Apostolorum] of Avicenna, and into the Egyptian ointment [unguentum

Aegyptiacum] of Mesue [Mesue the Younger] — all of which medicines, since they share in a sharp quality, cleanse most thoroughly though not without some biting, and nevertheless contribute in no small measure to the cure of a putrid ulcer. The professors of alchemy, by various artifices, prepare from copper — or "Venus," as they themselves call it — a powder, a lime [calx], a saffron [crocus], a quintessence, a tincture, an oil, a vitriol, and a flower; the preparations of all of which see in what follows.

[Margin: χάλκωμα — what it is.]

Orichalci praeparandi ratio, et Modus [The Method and Manner of Preparing Brass]

Many men, professors of the metallic art, beat common copper [aes] into thin sheets; to half a pound of these they take an ounce of tutty [tutia, zinc oxide] together with garlic, figs, honey, and mouse-dung, and by melting all these together at once they turn it into brass [orichalcum]. We do not approve of this method, since we have other, easier methods in Agricola [Georgius Agricola].

[Margin: The method of tingeing copper into brass.]

Today at Milan copper is tinged into brass in the following way. A quantity of beaten copper is taken and cut into pieces; the melting-vessel must be large enough to hold them, yet is not filled all the way to the top, so that there may be added to it a certain heavy mineral earth of a yellow color, called *Gislamina* in the vernacular, perhaps on account of its color. Over these is laid a powder of glass, and the whole mass is melted, and the copper of a red color acquires a golden color. Indeed — to the great profit of the workmen — that earth is so joined to the metal that the mass is increased to a remarkable degree. Others, finally, think they can give brass a silver color; among them is reckoned Falloppius [Gabriele Falloppio], who brings to a boil in vinegar equal parts of sublimate of quicksilver [mercury] and sal ammoniac, and then quenches in it the heated brass. But of these things at greater length in what follows.

[Margin: The method of tingeing copper into a silver color.]

Natura et differentiae Orichalci [The Nature and Varieties of Brass]

Utrum Orichalcum nativum sit, an tantum factitium [Whether Brass is Native, or Only Artificial]

Nature so contrived this metal that, by reason of its color, it approaches gold; for this reason many report brass [orichalcum] to be a certain metallic material

which of old was held more precious than copper — although Caelius Rhodiginus [Lodovico Ricchieri] wrote that brass appears to be a coppery metal, namely *Chalcoma* [Greek: χάλκωμα (chalkōma, "copper-ware, bronze")]. Nevertheless, by comparison with copper, nature endowed the former with this: that it should possess a greater hardness, in keeping with that verse:

With woven roughness of gold and hard brass.

Berinautins [Beringuccio? — i.e. Vannoccio Biringuccio] [?], departing from the opinion of many, judged that brass lacks veins of its own, and reproached Pliny, who, while sometimes mentioning brass among the metals, did not assign it a natural locality; and he further adds that a vein of brass could be dug up even today if one had once been found — indeed, establishing his opinion more and more firmly, he declared that, just as steel is reduced to iron, so brass is reduced to copper. We, however, in refuting this opinion, say that brass is nothing other than copper tinged by the subterranean power of Vulcan with fossil cadmia [cadmia fossilis, calamine] — and that, while it is to be found both artificial and afterwards native, nevertheless it is not the artificial kind that is prepared with so great a difficulty of labor and at the expense of so much work. Brass is therefore twofold: Natural and Artificial. We call native that which is dug out from mines of its own — drawn from this ore [?], which Pliny most highly commended for its outstanding excellence; this kind later ceased, for the said reason; and a certain species of natural brass, which is dug between Mexico and Darien [the Isthmus of Darién, Panama], and which nonetheless can be melted by no violence of flames, demonstrates this fully and more than fully.

[Margin: Whether brass is native and artificial.]

Minera Plumbi, ejusque conditiones [The Ore of Lead, and its Properties]

Although lead [plumbum] is for the most part held by metallurgists, on account of its extreme impurity and its abundance of earthy refuse, to be an imperfect, leprous, and scarcely fixed metal, nevertheless, if we examine its admirable qualities a little more deeply, it ought by no means undeservedly to be esteemed most highly — since without it neither the separation of gold from silver, nor of silver from the rest of the metals, can be obtained, nor can the native splendor of a precious stone and a gem be achieved except by its help. For where heaps of veins of gold mixed with silver are dug up, the metals are better separated from them by no other means than by lead, as we saw a little earlier; and so gold and

silver come to their due perfection only by the aid of lead alone. But of the usefulness of this metal more fully below.

[Margin: The uses of lead.]

It is found chiefly in various rocks and earthy clods, almost always with some admixture of gold and silver: first in a certain spongy, white, and hard rock, which they call *Columbinum* [columbine, lead-colored], whose mark is given by certain black spots and grains scattered here and there over the surface of the stone. Then too it is found in a stone of a red or rusty color,

[Margin: What is the matrix of lead?]

(*Fol. 219 recto*)

and then in certain earthy clods of an ash-gray color, of the kind reported to be found in Andalusia in Spain. And just as it is separated from its veins with easy effort, so too it is refined without difficult labor, and melted with a small fire — sometimes by itself, sometimes mixed with other metals which, associated with lead, flow more easily in the fire. And — what is remarkable — it preserves the other metals from being burnt up by the arsenic even in a powerful fire, and from flying off with the mercury. But why lead alone is endowed with this separative power, and is therefore found heavier and weightier than the other metals, and especially when joined to silver: of this matter there is no other reason than that lead, through calcination — all its pores being closed and its airy and watery spirits evaporated — is rendered much denser than in its prior natural state; and the denser and more compacted a body is, the heavier too it is made to be, as experience teaches.

[Margin: Lead, the friend of silver.] [Margin: Why calcined lead is heavier.]

There is also another property in lead: that when calcined by a most powerful fire of reverberation, so far is it from losing anything of its bulk and weight, that it is rather reduced to a lime [calx]. This is plain in corpses, which are much heavier when life had departed from them than while life was in them — because the living body, full of air and spirits, is to some degree lightened, whereas the dead body, all its spirits expelled and its channels closed, is rendered more compact.

[Margin: Why the dead body is heavier than the living.]

The cause of this is that lead, of itself and by its own nature, being little fixed, and excelling the rest in wateriness — whereas silver and copper are dry metals — it

follows that that wateriness of the lead, joined to dryness, by its watery viscosity fattens up the dry, and consequently [makes it flow more easily when incorporated with it]. [Note: the text recombines here with the column begun above ("...so that, incorporated with them, it makes them flow more easily").]

Caput X. — DE FERRI FODINIS [On the Mines of Iron]

Ferri Natura, et proprietates [The Nature and Properties of Iron]

Although Pliny explained the nature and affections of this metal in many words, we shall here adduce whatever experience has established for us concerning the nature, properties, and preparation of iron. Iron [ferrum], an impure and earthy metal, is composed of burnt sulphur coupled with a slight watery moisture not well mixed with an earthy exhalation; for that reason, in the fire, beyond the other metals, it scatters a most foul-smelling smoke. On this account it is called a base and ignoble metal, and this is made plain by its livid color. Hence too Albertus [Albertus Magnus] reported that iron likewise results from a mixture of impure quicksilver and from unclean and earthy sulphur. It is therefore no cause for wonder if iron, struck by iron, sparks, since everyone knows that this proceeds from the substance of sulphur.

[Margin: The genesis of iron.] [Margin: An experiment.]

Iron has, besides, another material congenial to it, which can in no way be burnt up; for there are observed, in the furnaces in which iron is composed into masses, certain vapors exhaling from the iron-material, which turn into a down [lanugo] clinging to the walls and roofs of the workshop, to which nature has assigned so great a force that it cannot be consumed by the greatest vehemence of fire. These things being so, some, weighing the temperament of iron, place it in heat and dryness — so that the astrologers accordingly placed iron under the dominion of Mars, a hot and dry planet. Besides that experience declares the temperament of iron to be hot, in that the superfluous moistures of the stomach are consumed by it and stubborn obstructions are opened up. On the other hand, Galen seems to reduce iron to coldness and dryness, when he compares it to a stony substance, which on account of cold and dryness is stable. Many authors afterwards in Medicine — and no ordinary ones — followed this opinion. For the Conciliator [Pietro d'Abano] pronounces iron to be cold; Jacobus de Partibus [Jacques Despars], in his commentaries on Avicenna, declared iron to be cold and dry; Manardus [Giovanni Manardo] established that chalybeate water [aqua chalybeata] is cold and dry; indeed many others seem to confirm this opinion with one voice. Therefore, to reconcile such great men, who have written

variously about the temperament of this metal, it must be asserted that — according to the dominion of the primary qualities — iron cools and dries; and since certain sulphurous portions are possessed by it, by these the stomach is strengthened, the excrements contained within it are consumed, and obstructed vessels are opened in a wonderful manner.

[Margin: The quality of iron.]

Since, then, everyone knows that this metal proceeds from a substance of earthy, coarse, and burnt sulphur, it strongly resists fire, and at last softens, and is melted only by a vehement blaze of flames. And although nature has engendered so great a hardness in this metal, nevertheless that same nature has produced a water which erodes iron without difficulty — such as is the well-water in Cepusium [the Zips/Spiš region] at Smolnitium [Smolník, Slovakia], and of the same condition is the river Styx around the Thessalian Tempe; since water of this kind cannot long be held in iron vessels without their being eroded and its flowing out. Indeed — what is worthy of greater wonder — the experience is that living creatures are harmful to this metal. For Theophrastus relates that on the island of Syaros [Syros], when the inhabitants had been driven out, the iron was eroded by mice; and some, on the report of Mizaldus [Antoine Mizauld], have declared that among the Chalybes the mice made great havoc in the iron-workshops. From this it is to be gathered that the hardness of this metal is not so very remarkable that iron cannot be twisted by the hands.

[Margin: Whence the hardness of iron.] [Margin: An observation regarding the temperament of iron.] [Margin: Iron eroded by mice.]

(Fol. 220 verso)

We have seen some men breaking an iron nail with remarkable ease. For they would take two bands three ells in length, woven partly of coarser and partly of finer thread, with which they so wrapped the iron that the finer part embraced the nail; and then, by a simple twisting of the hands, they divided the nail into two parts.

[Margin: A rare experiment.]

Again, iron undergoes other affections. First, when glowing-hot and struck by the hammer, it emits sparks, which are called *strictura* by Nonius [Marcus Nonius? / Nonnius]; and in smelting it yields a refuse, namely slag [scoria] or *loppa* [dross], which is thrown away by the smelter and by the blacksmiths. This, however, is that very material from which the chemists [Chymici] asserted the Philosophers'

Stone [lapis Philosophorum] to consist. Lastly, it undergoes rust [rubigo], and in the course of time is entirely consumed by water, according to that verse:

Rust gnaws iron, and the wood-worm gnaws timber.

[Margin: Rust consumes iron.]

But when it is fouled by human blood, according to Pliny, it is more quickly spoiled by rust; and this defect is, in Pliny's view, kept off from the iron by gypsum, white lead [cerussa], and liquid pitch. Likewise every kind of ironwork does not feel rust if it is smeared over with deer-marrow, the fat of a cat, or white lead mixed with oil of roses. Tin [stannum] too, poured over iron, prevents it from rusting; but when mixed with iron, in the opinion of Albertus, it renders it brittle and scarcely ductile.

[Margin: A remedy against rust.]

§. I. — Sympathia et Antipathia [Sympathy and Antipathy]

We find that iron is by no means at variance with the nature of animals, herbs, and stones. In the first place, it is in no way adverse to human nature, since iron has lurked hidden in wounds for a long time without harm to the patient. For Zacutus Lusitanus [Abraham Zacuto Lusitano] relates that a deep wound was inflicted on a certain woman through the crown of the head with a sharp knife; she lay sluggish and drowsy for several days, and at length, the scar having closed over, complained not at all of any impairment of animal function, and again went about her household business. But when, after a space of eight years had passed, she died oppressed by a malignant fever, the curious surgeons, opening the skull, found between the dura mater [meninx] and the skull the middle part of the knife with which she had once been wounded, all rusty. Among the brute animals there is none that delights so greatly in iron as the ostrich [struthiocamelus]; for this bird, when an iron nail or key is thrown to it — as I myself more than once tested in Malta — at once meets it, and no otherwise than as a dog at the sight of a piece of bread, greedily swallows down the iron it has seized, the cause of which we have explained elsewhere.

[Margin: An observation of iron lying hidden within the human body for a long time.] [Margin: Why the ostrich delights in iron.]

This indeed is not far from the truth: namely, that bedbugs [cimices] are most greatly delighted by the smell of iron; for when iron is fixed in a place where they nest, a little afterwards they all, as if in concord, embrace it. Moreover, there is no lack of vegetables that love the friendship of iron, and which on this account very

often grow up over ores. Among these plants are reckoned chiefly wild woad [Isatis sylvestris] and madder [Erythrodanum, Rubia], since, being marked by a certain ferruginous quality, they not only serve to preserve the magnet — as we showed in the *Ars Magnetica* — but [also], when reduced to ash and placed in glass furnaces, they leave behind in the bottom of the crucible a certain ferruginous sediment. On the other hand, there are other plants which are utterly adverse to the iron-nature; and this Gaudentius Merula pronounced concerning basil [ocymum]. Likewise iron is joined by no bond of friendship to Mercury, Gold, and Silver, since it is coupled with them only with the greatest difficulty; and therefore the workmen of the mint have never observed anything of the said metals to have stuck to the iron pans of the workshop.

[Margin: Bedbugs delighted by iron.] [Margin: The friendship of iron with plants.] [Margin: The disagreement of gold with iron.]

§. II. — Ferri praeparandi et temperandi ratio [The Method of Preparing and Tempering Iron]

Pliny relates that in Cappadocia men exert themselves with no great labor to have an abundance of iron, since they flood the ground with a certain river, and from that earth iron is produced as though it came forth from furnaces. Likewise those dwelling above Amarcantum [?], a city of Ireland [Hibernia], fix a wooden spear in a certain pool, and after some months find that the part of the spear wrapped round with mud has degenerated into the finest iron; the part submerged in the water turns into whetstone [cos], and the part that remained above the water keeps the proper nature of wood. So too in the island of Ireland, likewise near a certain town, a stone is found which by a simple burning is turned into iron. Aristotle assigns such a preparation of iron, saying that by the vehement power of fire iron is melted in the manner of the other metals, and much slag is separated, and thus iron is rendered purer and harder; and by repeated operation iron is converted into steel [chalybs]. For the rest, before the vein of iron is smelted, it must be carefully examined, whether it can be rich or poor in iron. Therefore an ore of iron of some known weight is taken, which, reduced to a very fine powder, is placed upon a fine bronze plate,

[Margin: Earth and stones are changed into iron.] [Margin: An observation in the smelting of iron.] [Margin: The quantity of iron is determined by the magnet.]

(Fol. 221 recto)

with a piece of magnet placed beneath; and while this is gradually moved, the grains of iron, following the motion of the magnet, are separated from the earth,

and in this easy way the quantity of iron contained in the vein is known. Today in Germany iron is prepared in two ways: first, it is drawn out from certain stones; secondly, it is smelted out from a red earth, as it were damaged by ferruginous rust — which work is carried out in Silesia. Besides, there are some in Germany who draw out the best iron from the magnet [magnes]. It must be noted, however, that those who chiefly smelt iron of good quality exert themselves with various labors and fatigue the body with diverse exertions — those who busy themselves about the iron-vein, which is worked with difficulty and is coppery [aerosa]; which methods are to be read in Agricola. If now we turn our mind to the temperaments of iron, recooked iron, carefully separated from the slag, acquires no common hardness.

The craftsmen in the workshops, however, first observe the color of the glowing iron, and then choose the liquid according to their intention, so that the iron quenched in it may obtain hardness or softness. When, therefore, the violence of the fire has brought the iron to the ultimate mark of whiteness, they call it "silver," and then they do not quench it, because it would be consumed; but if it is tinged with a saffron or red color, the iron is called "rosy" or "golden," and then, plunged into liquids, it is made harder. Today in the workshops a fourfold tempering [tinctura] of iron is observed: the first is of a white color, which is too hard; the second is yellow, by which bones and stones are cut; the third is mixed of purple and blue, suitable for cutting wood; the fourth is black, which is reported to be too soft. On the other hand, the liquids in which the white-hot iron is to be quenched, according to the varied temperament, must be weighed. Many rivers are celebrated as suited to the tempering of iron: for this reason iron, in the writings of the ancients, was commended in Noricum; of this condition are the Bilbilis, the Tarassus [Tarazona/Queiles?], the Salo [Jalón], the Chalybs (so called by Justin), and (by others) the Iberus [Ebro] — whence Iberian breastplates are read of in Horace as the strongest. Of the river Salo, Martial sang thus:

[Margin: The temperaments of iron varied with various instruments.]

The Salo, temperer of arms, girds it about with a thin but restless current.

Likewise in Italy the river Comum [Como], flowing between, and the Lambrus [Lambro], flowing through Milan, are reported to enjoy this same prerogative; wherefore of this last river it is sung thus:

I wanted no breastplate but one hardened by the Lambro.

Virgil too, speaking of the sword of Turnus, excellently tempered in the Stygian river, sang in this manner:

The sword which the fire-mighty God himself had made for Daunus, his father, and had dipped, glowing, in the Stygian wave.

Since, then, in iron sometimes softness, and at other times hardness, is desired, there will be methods to be assigned by which we may easily achieve either. That Glaucus of Samos [Glaucus of Chios], who invented the art of soldering [ferruminatio] — according to Suidas [the *Suda*] — quenched in oil the iron he wished to be soft, and in water that which he wished hard. Some, to communicate hardness to iron, place lead in a cavity of the iron and heat the whole until the lead goes off in smoke; and they repeat this work so often that the iron softens like wax. Moreover, iron repeatedly made white-hot and cooled by itself softens in a wonderful manner; experience teaches this in iron wires, which, when ignited and cooled by themselves, come out soft and ductile. Others, in the juice of mallow or of beans, quench glowing iron, and then draw it out soft. Others smear the iron with oil of bitter almonds, and cover it over with wax mixed with asafoetida [Assa foetida] and a little of the salt Alkali, and wrap the whole in niter and in clay made of horse-dung, and leave it in a fire of coals overnight; and thereupon they have iron tractable and soft.

[Margin: Various experiments.] [Margin: The method of tempering iron, and various experiments with the juices.] [Margin: The tempering of the sword.]

Moreover, iron carefully wrought can be tempered softer or harder according to the intention of the worker, since swords require one temperament, files another, and arms prepared for defense another. Albertus handed down that iron is made sharper by a tempering of the juice of radish and of the water of earthworms — which Porta [Giambattista della Porta] denied to answer to experiment. Swords, therefore, require such a tempering that they be endowed with a sinewy thinness, lest, while they strike with the point, they break; likewise they demand a sharp edge, so that, striking with the cut, they may sever; wherefore the body of the sword is tempered with oil and butter, but the edge is quenched with sharp liquids, so that in cutting it may acquire strength. And this work — as Porta advises — the workmen accomplish either with wooden channels or with wet woolen cloths. The chisel [scalprum], again, according to the same Porta, for cutting iron, is to be made red-hot in the forge, and when the ruddy color of the rose appears in it, it is to be quenched in water; then a second color, tawny, is to be awaited, and again it is to be plunged into water. Likewise, for carving marble, iron prepared from the best steel and ignited is to be wetted with water when a rosy or red color appears, and soon after, when removed and a golden color appears, again to be plunged into water. A file is to be tempered in such a way

that it can conveniently file other iron: take, then, soot from the tips of horn or from the hooves of an ox, a portion of ground glass, and common salt, and let all be mixed with vinegar; then the file, soaked with this mixture, is to be made white-hot by fire, and afterwards quenched at once in vinegar, or in urine, or in cold water.

[Margin: Other temperings of iron.] [Margin: The tempering of the sword.]
[Margin: The tempering of the file.]

A fishhook requires a similar tempering, so that it may not be bent in the least by the bites of fish; conversely, iron for phlebotomy [bloodletting] requires a soft tempering, lest in the operation it be either bent or broken. Likewise grass-scythes [falces herbariae], because they are thin, do not require a strong tempering.

[Margin: The tempering of the fishhook.] [Margin: Phlebotomy.] [Margin: The scythe.]

After various instruments or arms have been fabricated from purged and carefully tempered iron, they are accustomed to be marked with certain images or characters; therefore, to carry out this work, iron pyrites [pyrites] of a golden color, reduced to powder, is macerated for one natural day in vinegar, and the vessel being brought near the fire so that it boils, another vinegar is added on top; and when this has been dried off, the material is distilled through glass instruments into a liquid, with which images or letters are designed upon any iron instrument; these at first sight will appear black, but when dried and rubbed with a linen cloth they will be seen golden. Many, on the occasion of the quenching of iron in various liquids and of its tempering, suppose that iron can be ripened into copper [cuprum], both by nature and by artifice. But it must be noted that iron is not so cooked off by nature that it comes out [as copper], as Scaliger [Julius Caesar Scaliger] most excellently proved in his *Exercitationes* [Exercitationes]. Moreover, iron immersed in vitriolated waters, both natural and those prepared by art, is dissolved; and since

[Margin: How letters are cut into steel.] " complete the catchword of the prior folio.]

since waters of this kind, sharing in vitriol — and also containing copper — once the iron substance has been dissolved, the copper is found at the bottom of these waters. This copper is not generated from the iron, but rather is precipitated out by the agency of the iron.

[Margin: Chemists' water for dissolving iron.]

For dissolving iron, chemists use a strong red water, which is made up of a quarter [part] of white vitriol, seven ounces of Hungarian vitriol, a third [part] of salt, and half an ounce of alum. But Pandulphus Anglus [Pandulf of England], who wrote on minerals [*De Fossilibus*], reported that iron is better liquefied when quenched in honey. Finally, iron can also be mixed with copper and with tin, but it is thereby made coarser and more brittle.

Let these things, gathered from various authors, suffice. Anyone who wants further techniques — by which iron may be purified, and also coated with gold and silver — should consult the last Book [of this work], which will recite a long series of these secrets.

§. III.

On the iron-mines of Ilva, commonly Elba, an island of the Tuscan Sea.

[Margin: The excellence of the iron of the island of Ilva [Elba].]

Just as no metal is so necessary for human use as iron, so too there is none that is produced in greater abundance almost everywhere; so much so that scarcely any region of the world is found where it is not at hand. Thus provident nature willed it to be available everywhere and for this purpose, since in the human economy nothing can be made without iron. Hence Italy, Germany, France, Belgium, Spain, Poland, Asia, Africa, and America — as the geographical accounts teach — are full of iron-mines. I therefore consider it superfluous to append here a fuller catalogue of the world's iron-mines. I will say only that on the island of Ilva [Elba] there is such an abundance of iron ores that the whole island could be called nothing but iron — and not of the lowest grade, but the noblest and most excellent of all. And since I personally surveyed the island some years ago, and observed with the utmost diligence the manner of extracting, preparing, and converting it into steel, I have thought it worthwhile to set out here the method and procedure just as I saw and observed it.

I say, then, that iron — like the other metals — is not always found at the same degree of perfection. For there is a "sweet" iron, as on the island of Ilva [Elba], of such perfection that even the raw lumps of ore can be smelted, by the simple and ordinary fire of smiths, into a noble and workable iron fit for every use. The reason for this is the supreme purity of the iron. In other places, however, the iron is not of this quality, but raw, uncooked, rough, and so corrupted by earthy

matter, by the odors of other metals, and by impurities, that it can scarcely be brought to a better condition except by the immense violence of furnaces and fires — and that with great expenditure of labor and cost. There are also other ores which, more or less, contain copper, and are therefore [continued below]...

[Bottom-of-column note carries to the right column:]...subject to such mixtures of impurities. How the pure can be separated from the impure, I will explain, taught by ocular experience. For the most part the procedure is as follows.

[Margin: Cooking [smelting] of the iron.]

First. There is need of a man skilled in iron ores, who knows how to separate the pure ore-lumps from the impure. Let him set these selected lumps aside, broken into pieces, by their respective grades.

Second. Above all, great care must be taken with the charcoal. Here in Italy they generally use charcoal of mastic [lentiscus], holm-oak [ilex], elm, ash, and similar trees, inasmuch as these kindle the most powerful and effective fire.

Third. The pieces of iron ore-lumps are cast into an open furnace and cooked; once cooked, they are drawn out again and exposed to rain and to the heat of the sun. For in this way the iron matter is, as it were, ripened and digested toward attaining its proper perfection.

Fourth. This done, the pieces, impregnated by sun and rain, are again broken into parts, with careful observation whether they give off the odor of another metal. If you find such, let them again be cooked in the manner described, until — the odor having been deposited — they yield the simple odor of iron. And so at last the smelted iron will give a sweet and malleable [iron]. Yet it sometimes happens that an iron of this kind is so obstinate in its hardness that it refuses all cooking. In that case it will be destined for [conversion into] steel, by the method we will set out a little later. So that you may have the signs of pure or impure iron, note that there are four species of iron ore.

[Margin: The various species of iron ore.]

The **first** species is a heavy, compact mineral lump, separated from the company of earth, rock, and the other metallic bodies, of a brown color; and this is the perfect [one], and the one uniquely desired.

The **second** has a certain indefinable adjoined luster together with a granular substance, which is easily crumbled into powder between the fingers; and it is everywhere rejected as a vein of bad character.

The **third** is a mineral lump packed with coarser grains of a black color, which — as it always smells of copper — is likewise everywhere neglected.

The **fourth** species, finally, consists of finer grains, and according to the condition of its matrix is found now better, now worse.

There are besides other lumps which indeed are easily smelted into iron, on account of the admixture of the other meltable metals, but which sustain the hammer only with difficulty, owing to the weak cohesion of their parts. And contrariwise, there are those which sustain the hammer, but have a difficult liquefaction. The former generally have no other use than for casting cannon [*tormentis bellicis*]; the latter can be reduced into iron of better grade.

You will ask: What are the signs of pure or impure iron, and how are they recognized?

[Margin: Signs of the purity of iron.]

I say that, even if iron is found in earthy substances, that iron is nevertheless held to be the best which is dug from those mountains from which cold waters, not unpleasant to the taste, flow forth — especially if the place is set in a more salubrious air, [continued]...

let this be established. Very often, too, [iron] is generated in a certain white rock, not unlike a flint; and if you smelt it together with the rock, a hard iron will for the most part be obtained — but it turns out otherwise if you separate too little of the ore from the rock and melt it once put into the forge.

[Margin: Matrices of iron.]

Sometimes too the iron ore is found in red and yellow earth, easily dissolvable into sand by rubbing, or even soft like mortar [malta]. In gathering lumps of this kind I would not have you waste your time, since nothing good comes of it.

Now, so that you may recognize the purity and goodness of the iron, proceed thus.

[Margin: Test for the goodness of iron.]

First. Let some specimen of the ore be put into a strong lye [lixivium], and then, after some time, drawn out, and set over the fire; with the bellows applied, blow up the fire gradually. If you observe diligently the little bubbles and the vapors of various color, this is itself a sign of various commerce of metals [i.e., a mixture]. If

[it is] without color and without little bubbles, you will judge the iron to be of the best and most compact kind.

Second. A sign of good iron is a bole — a dusky, soft, and unctuous earth — which, when seized by the teeth, raises no grating sound.

On the transmutation of iron into steel [chalybs].

I will describe, with all the brevity and clarity I can, how steel is made from iron, the whole process.

Since steel is nothing other than iron reduced to the last state of its perfection and purity — which is of two kinds, natural and artificial — and since natural [steel] is found in few places, the metal-smelters, supplying the defect of nature, convert any iron whatever into steel by that ingenuity and skill which I shall now subjoin.

[Margin: The cooking of iron, and its conversion into steel.]

First. They take iron — already, as was said above, thoroughly cooked [smelted] in the furnace — of such a quantity as suffices for their purpose, and break it into the smallest pieces.

Second. In Vulcan's hearth [i.e., the forge] they set up a round receptacle for making the steel, larger or smaller according to the quantity [desired], [made] of clay, of which one third part is potter's clay [argilla], and two thirds are charcoal reduced to powder, well mixed with water and compacted into an amalgam. In the center of it let there be made a hole, through which the bellows can discharge their blast to fan the coals.

Third. Let this receptacle — both to reflect back the fiery heat, and to hold more firmly the heaped mass of the iron fragments and the charcoal to be put in — be fortified, by setting stones around it, like a kind of wall.

Fourth. Let this whole receptacle be filled to the top with coals; and when, by the urging of the bellows, these have blazed up into the highest heat, they then proceed as follows.

Fifth. From the iron that is to be converted into steel, broken up into small bits, they throw the particles, little by little, mixed with the powder of ground marble and of other fusible flints, scattered among the heaped-up coals now kindled. And in this way the iron sustains an easy fusion within the receptacle.

[Margin: How the steel is made.]

Sixth. This done, from the same iron, [now] beaten by the force of the hammer into rods, placed into the molten matter of this receptacle, they leave [them] for four or five hours, continually urging the fire and the coals with the blast of the bellows, and also moving and stirring the material with a longer iron rod, until the pores of the iron rods are filled out, in their substance, by the subtle molten matter now within the receptacle. When the workmen observe this, at once — with tongs, one after another snatched out and stretched a little upon the anvil by hammers — they quench [them] in a separately prepared bath of cold water. And if they find that these have not yet reached the due perfection, they cast them again into the bath while still glowing from the molten matter, and repeat this as many times as needed, until [the iron] attains its ultimate perfection.

By this industry it is so purified and perfected that, in hardness, compactness, color, lightness, and luster, it seems to have taken on a difference specifically distinguishing it from iron. I am not unaware that others, too, quench iron tools of this kind, when made white-hot, in certain juices of herbs, with truly remarkable success, as we made clear in the preceding [pages].

On the transmutation of iron into copper [aes].

There is a great disagreement among the chemists and metallurgists concerning the transmutation of iron into copper, which must be decided, with all possible diligence, in a fitting way.

[Margin: The transmutation of iron into copper is not proper [i.e., not a true transmutation].]

Paracelsus and his followers affirm the perfect transmutation of one metal into another — perhaps with this aim and intention: that they not give up as lost that great art concerning that ridiculous philosophers' stone, so much bandied about, which they also say undergoes a perfect transmutation. But even the very overseers of the metal-mines, men instructed by a marvelous skill in extracting, washing, and cooking metals, and by a knowledge of other arcane matters — these, I will not say deny this, but rather laugh at it.

Certainly, as Father Joannes Schafferus [Johannes Schaffer] writes to me, in the mines of Hungary which they call Herrengrund [Špania Dolina / Herrengrund], copper of the best grade is made from iron — with truly great annual revenue to the Emperor. But as to how they proceed in this metal-metamorphosis: although I showed the method in the Eighth Book, yet it has seemed good to repeat it here in a few words.

They take rusty and useless iron — such as the stock of various old tools — and, putting it into the furnace and reducing it on the anvil, they extend it into the thinnest plates. This done, they lay these plates at the bottom of a vitriolated stream, which flows in the deepest galleries of the mines, and leave them there, once laid down, for several months. Thus established [continued]...

[Fol. 224 — running header "LIBER DECIMUS, Sect. IV." The text continues: "...when in time they approach the stream..."]

so, when in time they approach the stream, they find that the plates have, as it were, passed over into a yellowish [color], like an amalgam. Once these are exposed to the air and the winds, they harden into [copper] of the best grade. And thus the procedure is carried out at Neusohl [Banská Bystrica / Neusohl] in Hungary.

It is asked, then: can this be called a true transmutation of iron into copper? I say that there can in no way be a true transmutation here, since not the whole iron is changed into the substance of copper, but only by accident. Let me explain.

[Margin: The reckoning and manner of the transmutation of iron into copper.]

For since within vitriol there exist innumerable coppery [aerata] corpuscles, and since these have the greatest sympathy with iron, it happens that they at once flow together toward the iron, and insinuate themselves intimately into its pores. And since they are endowed with spirits of great acrimony, hence, once insinuated within the iron, they soon begin to gnaw it, until — all the fatness of the iron being consumed and the ferrous substance dissolved — it passes into a scurf, that is, a rusty powder. The vitriolated corpuscles, however, substituting themselves in the place of the consumed iron, are glued together — by the native fatness both of the iron and their own — into a single mass; and this, soft at first within the water, yet exposed to freer air, to the winds, and to the sun's rays, hardens into perfect copper. And in this way the same [quantity] comes to be that was there before: before, indeed, through the dispersion of those corpuscles into the water; now, through the union of the same, drawn out of [the water] by the iron.

[Margin: An experiment.]

For if a true transmutation took place here, no iron at all would be left over. But experience teaches that just as much iron-rust remains as the previously iron mass weighed before. And, in order that I might take the proof of this matter more exactly, the aforementioned overseers of the Hungarian mines, through the

above-mentioned Father Schaffer, sent me — out of their goodwill toward me — a vial of the said vitriolated water, together with a horseshoe half of which was copper and the other half iron.

[Margin: An experiment taken from the author [i.e., performed by Kircher himself].]

Into this vial, then, I put an iron thread, which within three days was wholly consumed; the pulp [pulte] remaining at the bottom, separated from the dross, yielded pure copper, while the dross came nearly to the weight of the iron thread — so that henceforth no one can doubt about this matter.

[Margin: The difference between artificial and native copper.]

This too is most worthy of admiration, which Father Schaffer writes concerning a certain physician very familiar to him, a great chemist — his name is Morlandus [Morland?] — who, taught by frequent experience, found a great difference between the copper made from iron by means of vitriolated water and that which is dug from ores. For from a hundredweight [centenario] of copper made by art, by vitriolated water from iron, he reports that he extracted 25 *lotones* of gold...

[Margin: An experiment.]

whereas from a hundredweight of copper from ores he could not draw out even six *lotones*; and he asks of my slender capacity the reason for this matter. I replied that this is no wonder. For since vitriolated water flows not only with atramentous [inky/coppery] corpuscles, but also with golden ones — abraded together with the vitriol from its own veins — hence it happens that these [golden corpuscles], attracted by the vitriolated corpuscles out of natural sympathy, flow together into one within the pores of the iron; and, the iron being consumed, they settle at the bottom into a single meal-like mass, from which afterward — hardened by the dryness of the surrounding air — that gold is separated by liquation. And the richer the gold-vein through which the vitriolated water has flowed, the greater the abundance of gold there will be in the coppery corpuscles. This, however, I would think can in no way happen, unless the vitriolated water passes through a golden vein. And the reason why, further, not so great an abundance of gold is dug out of mineral copper, is that it is generally wrapped in earthy filth, and so offers but a scanty abundance of the gold existing within it. But if the golden vein were joined to copper, I do not see why the same abundance of gold could not be drawn from it as from vitriolated copper. The solution therefore depends on this: that that chemist performed his experiment

on a copper-substance poor in gold, but on a vitriolated copper rich in gold — so that nothing in this is worthy of admiration.

But as to how, from silver — from which all the gold has already, as he writes, been extracted — he nevertheless drew out still as much gold as was worth eight *grossi*: he communicates the secret to me in these words.

[Margin: A chemical secret for extracting gold from silver.]

"Take of antimony, of tartar, and of saltpeter [salis nitri] one ounce of each; let them be mixed together, and dissolved in cold spring waters [salia frigida fontana]. If from these you separate one ounce of silver through the cupel, it will yield one ounce of gold equivalent to eight *grossi*. But if you should do this experiment a second time with the same silver, you will extract nothing, the silver remaining sterile."

He marvels, however, how, from silver from which all gold has [supposedly] been extracted, gold can nevertheless still be drawn out by the aid of the said ingredients. I say, then, that it is false that all gold has been extracted from the silver; since silver cannot be so purified but that some particles still exist within it, which, afterward augmented by the antimony — in which all chemists confess that there is always something of gold — exalt that gold to the value of eight *grossi*.

CAPUT XI.

On salt-mines, and on the preparation of salt.

Although in the Sixth Book we treated abundantly of salt, yet since meanwhile, from various quarters, various accounts of salt-mines have been transmitted [to me], which are not without great profit, I have judged that they should be set down here.

The first salt-mine occurs in Upper Austria, at Traunkirchen; the second, in the county of Tyrol; [the third]...

[Fol. 225 — running header "DE FODINARUM CONDITIONIBUS." The text continues: "...the third, in the County of Burgundy."]

the third, in the County of Burgundy [Franche-Comté]. And first, indeed, in the mines of Upper Austria, as Father Joannes Eissert [Johannes Eissert] writes to me from the Traunkirchen Residence of our Society [the Jesuits]: the water, already imbued with various salt from the salt-mines, is drawn out — first it is raised

from the pits by a wheel fitted with wooden buckets and dippers, and poured into channels, [going] to the pans [*sartagines*] and the vaulted receptacles, in which it is always kept ready, against arising need, for the cooking [boiling].

[Margin: The manner of extracting the saline water from the pits.]

They also use pulleys without a wheel, or [with] an axle in a windlass [*peritrochium*], as the experts in mechanics [the *Statici*] call it — that is, an axle fitted with a wheel or with levers [handspikes], which is turned by the diggers, by one or more, with a rope wound around the axle, just like a roasting-spit [*veru*]. The rope has, on each side, a bucket-vessel attached, so that, when one vessel full of salt-water ascends, the other empty one descends, as appears in the Figure.

Diagram. A woodcut of a well-and-windlass apparatus for raising brine from a salt-mine shaft. The figure shows an upright wooden frame (two posts joined at the top by a cross-piece) supporting a horizontal winding axle. A rope passes over the axle with a bucket-vessel suspended at each end of the rope, so that one bucket rises as the other descends into the shaft below. The wooden curb/housing of the shaft (here drawn as a tub-like or barrel-staved enclosure) sits at the base. The figure is uncaptioned and carries no lettered labels. It illustrates the windlass-and-paired-bucket mechanism described in the adjacent text.

They also use suction-pumps [*Anthliae*], which pour the salt-water into a vessel shaped like a wine-cask [*dolium*]; and from these, the taps being afterward opened, the water is led through channels into the destined places. This water, however, is at first sweet [fresh] on the outside, and by deliberate design it is diverted into the vaulted receptacles of the salt-mines (as they are called), which they call *Stantiae*. There, by the dilution of the saline ore, it is wholly converted into salt-water; and when it has now been sufficiently imbued with salt, by means of the said instruments it is drawn out to the cooking [boiling]. But if, somewhere outside, any want of fresh water occurs, then they carry the saline lump out, broken into pieces in leathern sacks; and afterward, carried to a place where fresh water is available, they cast it into that [water] to impregnate it with salt, and keep it for the cooking. But where fresh water passes through the underground salt-mine — as at Salzburg — there, with greater saving, they lead it, already extracted and prepared, through channels to the salt-kitchen to be boiled; there the salt-water sometimes has a depth of many fathoms [*orgyae*].

Baronius [Cesare Baronio] reports, in his *Annals*, that in underground pools of saline waters of this kind, in the year 1260 (if I am not mistaken), an entire human body was found, which had suffered no corruption whatever, [being] of

such fresh and snow-white flesh, and with the [visual] keenness of the eyes so lively, that it seemed to counterfeit life.

[Margin: A human body found in salt-waters.]

And so it was offered, on account of the extraordinary rarity of the thing, to the Duke at Munich [Monachium]; and he, delighted by a spectacle of this kind, when he placed it within his treasury [Gazophylacium], it is then said that — as though unaccustomed to the air — the body at once dissolved into a saline liquor, its flesh flowing away.

But now [back] to the point. There are in Upper Austria, near Ischl [Ischlen], Hallstatt [Halstad], and Traunkirchen, very lofty mountains, within whose belly are lakes and pools, both of every kind of mineral waters, and most of all of the most crowded salt-mines. These, diverted in the manner mentioned above into fresh waters, degenerate into a salty liquid, which is then led through channels into the salt-boiling pans.

[Margin: The vastness of the cauldrons [pans].]

The above-cited Father writes that, from the mountain which they call Hallberg [Halsberg / Hallberg], this salty water is led for four German miles, as far as the pan situated beside the lake, to a place which they call Langwath [Langwies?], through 24,000 channels mortised one into another, each of which is ten geometrical feet long. The pan, he says, is of an oval shape, the largest in breadth out of three others — thirty paces in breadth, sixty paces in length, but with a depth of only one foot and a half.

[Margin: Annual revenues from salt.]

From these salt-works the Austrian princes, the Archdukes, are said to have in annual revenues 800,000 Rhenish florins, the expenses reckoned in together, which revenues run up to 1,100,000 florins. In the said mountains of Hallstatt a double kind of salt is found.

[Margin: Salt.]

The first is solid, pure, and gleaming like crystal; this is indeed called rock-salt [*sal gemmae*], because, brought by nature's fire to such perfection and maturity, it is so fixed that, of six ounces, after solution in the filter, almost nothing remains except half an ounce, which adhered to the instruments — that is, almost nothing is lost. The other is variously colored, and is found now reddish, now violet, now

of a dark color; but since it is viscous and gives off a sulphurous odor, it is everywhere left behind.

[Margin: The balsamic spirit of salt.]

From the salt of the first kind, the overseer of the mines reports that he extracted a balsamic spirit and oil, most excellent in extracting [medicinal] substances and in the cure of diseases.

[Margin: The mines are filled with new salt each year.]

It was also observed by the diggers that, after a certain course of years, the mines are refilled with new salt — a fact of whose truth no one ought to doubt, just as we have shown elsewhere in this work. For if the mines of any metals whatever, and of stones, once exhausted, are in the course of time refilled with a new birth, how much more the salt-mines? For since saline exhalations breathe out continually from the inmost bowels of the earth, hence, wherever they find a body alike and homogeneous [to themselves], there the little bodies [corpuscles], condensed by the cold, are soon united by a certain magnetic action, whence in time a new increment of salt emerges.

In the Austrian salt-works, so that they may know when the fresh water, diluted with salt, is sufficiently salty and fit for the cooking, they use the following test: [continued]...

adapt it on a lathe, so that it takes the form of a pear, as shown in figure A. Into its lower belly they pour a small quantity of lead at O —

Diagram. A pyriform (pear-shaped) wooden float partly submerged in a cylindrical vessel of brine, seen from above and slightly to the side. The vessel is the salt-tester. The float is weighted with lead so that it rides at a fixed depth in adequately saline water.

- V (top, the stem/neck of the float projecting above the surface): the upper tip whose emergence indicates saturation
- A (center, on the body of the float): the pear-shaped float itself
- O (lower belly of the float): the lead weight poured into the float's base

just enough, that is, for it to sink in the brine up to the little stem V. If the stem floats with half its length above the water, it shows that the brine is rich enough and holds sufficient salt for boiling. If it sinks more, or less, the brine is reckoned insufficient.

But since this procedure carries certain imperfections with it, I think the matter can be settled by a far better and more exact test, which I have decided to share here with the salt-makers [Empyristae].

[Margin: An instrument for testing whether the brine holds sufficient salt for boiling.]

Proceed as follows. First weigh the water — in whatever quantity — that experience has already shown to be sufficient for boiling. Once you have done this, have the glassblowers make you a phial A–B with a long neck swelling out into a belly at C, the length of which, A–D, comes to a quarter of a span [palmus]. Make it exactly in the shape and size you see here.

Diagram. A tall graduated glass phial — a hydrometer — drawn upright. The long narrow neck runs from A at the top down to D, and is marked off in ten numbered divisions (the scale 10, 9, 8, 7, 6, 5, 4, 3, 2, 1 reading top to bottom along the neck). Below the neck the glass swells into a rounded belly C, tapering to a point at the foot B. A drawn hand at the side points to the fifth graduation. Inside the belly is the figure for the quicksilver charge.

- A (top of the neck): upper end of the graduated stem
- B (foot): pointed base of the belly
- C (the swelling belly): the bulb of the phial
- D (junction of neck and belly): lower end of the graduated section A–D
- Scale 1–10 (along the neck, numbered): the ten graduations
- 8 (within the belly C): the charge of quicksilver placed inside [reading uncertain — appears to mark the quantity of mercury; the text says fill to the fifth graduation]

Mark the neck with as many graduations as you like — say, ten. Once this is done, pour quicksilver into the phial; then set the phial, charged in this way, into the water and observe which graduation it registers. You will do best if you put in only so much quicksilver that, when the phial is set in the water, it sinks to the fifth graduation. Then seal the mouth of the phial as tightly as you can, either with a hermetic seal or with wax at A, and you will have an infallible instrument — useful not only for testing whether boiling will be adequate, but also wonderfully apt for testing all sorts of waters to find how much salt they contain.

For when this vessel is set into salt water and filled, if it sinks precisely to the fifth graduation you may be certain the water is fit for boiling; if it sinks below the fifth, that is a sign the water holds more salt; if it sinks above the fifth, then — in

proportion as it is submerged more or less — it is a sign the water holds a smaller portion of salt.

The reason is plainly clear: the more salt the water holds, the less the weight sinks in it; and the less salt the water has, the deeper a heavy body sinks in it. This is so certain that no one can or should doubt it. You see it in ships, which sink deeper in the Tiber than when they are committed to the sea: there [at sea] they ride three or four spans higher because of the density that the salt gives the seawater. You will also find that if you put this instrument into pure fresh water, you will see it almost wholly covered — for since fresh water is utterly pure and very thin, the weight of the phial drives almost to the bottom of the vessel in which the water stands, meeting no resistance. But I treated this more fully in the first volume.

Here the salt-workers [Halurgi] put no small problem to me: why is it that water fit for boiling keeps to a kind of mean, so that it is neither too salty nor too little salty? For, as the above-cited Father Joannes Eissert writes to me, experience shows that if you throw a solid lump of salt, however large, into fresh water, the water nevertheless draws no more from it than is needed for boiling. Once the water is steeped with enough saltiness, it grows as it were nauseated and stops drawing in any further, so that the lump you put in remains whole.

[Margin: A remarkable property of salt.]

To resolve this, I say there is no other reason than that the water craves neither more nor less salt than is required for the original, native saltiness of the mine — a saltiness which Nature has tempered, for human use, to just such a proportion. Once the water has reached that, it seems to need nothing further. Experience confirms this in fish: living perpetually in the briny sea, they nevertheless draw from the brine only as much as Nature requires for their sustenance, neither more nor less.

[Margin: Confirmed by experiment.]

The same happens with artificial salt. For if, as they report, the salt-workers boil and stew fresh fish in the salt-pan, the fish are seasoned by the salt no more than is needed to make them fit to eat — even though they boil wholly immersed in the salt water of the pan.

Another marvel, he says, occurs in these places: the salt water that adheres to the pan in which it is boiled freezes in a nearby cold spot — the place where fresh water for the salt-workers' use is drawn. There it takes on various and most

beautiful shapes and forms, so transparent that they can scarcely be told from crystal; and, just like rock-salt, they are never round but are always fashioned by nature in a square figure.

[Margin: Another thing worth wondering at.]

As for why they form in that cold place, the only cause is this: while the salt is boiling in the nearby pan, the saline vapor and exhalations rise, and when they strike that cold spot they condense there and degenerate into the shapes we have described. For just as fire by its force purges every earthly dross away through sublimation, so too...

these [vapors], joined and united by the cold of the place, must of necessity congeal into a crystalline transparency.

[Margin: The origin of the sugar-like [bodies] out of salt.]

He adds that in the same place there are found white bodies, so worked by Nature that they cannot be distinguished from sugar confections. The reason for this is none other than that the vapor, still infected with earthy and nitrous refuse, condenses in the cold spot and degenerates not into a transparent but into an opaque white substance.

[Margin: Hydria, rich in quicksilver.]

Not far from these salt-works lies Hydria [Idrija], a quicksilver mine. Although I treated this at length in the chapter on quicksilver, still — since the Father cited above informed me of many things about a mine of this kind that are not so commonly met with, things observed there — I thought them worth inserting here.

"At Hydria," he says, "eight miles distant from Labacum [Ljubljana], a mine most rich in quicksilver and most productive of revenue, subject to the Archdukes' jurisdiction, is to be seen. About it they report something worth recording: that little mountain demons [daemunculi montani] are very frequently sighted there, and the miners count themselves fortunate if they hear them."

[Margin: Subterranean demons.]

The common opinion is that such little demons appear only where rich veins of ore lie; they are often heard working with a hammer, but are themselves invisible. They will not tolerate blasphemers, swearers, whistlers, or wretches of any kind. Hence the superstitious miners are accustomed to set out for them, in a fixed spot, a little pot full of food each day, and once a year to bring them — as a

gift — a little red coat the length of a boy, bought at a fixed season. If they fail to do this, they find the little fellows harsh and offended; but if they satisfy them, they find them well-disposed: for these dig out and hammer loose such a quantity of metal as the miners themselves could scarcely manage in many days with all their toil. Thus does Satan, the enemy of the human race, make sport of superstitious men.

[Margin: An arsenic mine.]

Not far from Hydria, on the borders of Upper Carinthia, eight miles above the town of Villach, in the valley of Ratschach [Raščach (?)], there is found yellow and white arsenic [orpiment] of the better sort. The yellow, being of the better grade, is what Venetian merchants put to various uses, and they even sell it to the Egyptians — who use this arsenic, scattered over their fields, to kill off the swarming serpents that every year, after the Nile's flooding, are born from the mud in great abundance. They say that near a mine of this kind no venomous animal or worm has ever been seen.

Against the virulence of the arsenic the miners mostly use certain cooling salves, and theriac, and they also shield their faces with a glass or bladder mask. And since this ore contains within itself gold, silver, and copper, human greed — despite so great a peril to life — is accustomed to dig it out in the following way. First the vein is explored and detected by the striking of hammers: if a struck rock throws off a spark, that is a sure sign of a rich arsenical vein...

of the better sort. Then in many places they bore into the veins with great augers, and once the holes are made they thrust in larch tubes filled with their gunpowder, and add a very long fuse; this, lit from outside, the moment it reaches the powder bursts the whole arsenical vein into pieces in an instant. So that afterward, once the fire is out and the mine has cooled, they may gather up the fragments of arsenic without danger. This, once boiled, after the silver has been separated, they reduce into white flowers and into a glassy consistency.

The miners in this mine work in boots and gloves, by night and by day, only twelve hours at a stretch. A hundredweight [centenarius] of the raw ore is got out for 16 kreuzer, that is, 6 bajocchi; refined, the hundredweight costs 15 florins. Out of a hundred hundredweight of this ore there are twenty hundredweight of pure yellow arsenic. So much for the Austrian mines.

[Margin: The Tyrolean salt-works.]

Of the Tyrolean salt-works, since I have made ample mention elsewhere, I thought it needless to repeat here — since in exactly the same way fresh water collected within the salt-bearing mountains, having drawn in enough saltiness, is then led through channels to the pans of the salt-works for boiling. I add only this: there is scarcely a place in Europe where Nature sports with a greater variety of things. For it is not only most full of gold, silver, iron, copper, and lead, as in Swabia [Suevia], but also of precious stones. Of these things both the Most Serene Archduke and his Most Serene Consort — a most zealous investigator of such matters — wished to inform me, through Father Michael Staudacker [Michaël Staudacker], chaplain to them both. And the said Father writes to me thus:

[Margin: Marvels in the Duchy of Tyrol.]

"I set forth, at the command of the Princely Archdukes, some things worthy of wonder which Nature contrives in the county of Tyrol. The Princes devote themselves singularly to the knowledge of metals; and — what is remarkable in a woman — the Most Serene Lady is no stranger to this science, but applies herself in person to this labor and work. She has even undertaken to search out and sort the stones which formerly were not even named and were held in neglect, though they are in truth precious and might deservedly be reckoned among gems. For when worked and polished they turn out most beautiful, charming the eye with a clear and remarkable color; and they not only give the eyes pleasure and wonder but are altogether worthy to be valued at a high price as well.

[Margin: A marvel in the Tyrolean Duchy.]

I could wish that Your Reverence might see some specimen of them: you would surely praise, and marvel at, riches of our homeland hitherto unrecognized. A great store of such stones has now been gathered, among which have been found jaspers, agates, chalcedonies, and rubies — not, indeed, so fiery and blood-red as the Oriental ones, but of a paler purple, which is nevertheless truly most lovely, so that perhaps before some eyes — at least for their rarity — they might carry off the palm from the others. Our stones would truly deserve — and I will say it without lying — to be called gems, so that some mention of them, with praise of the Most Serene Lady, might find a place in the *Mundus Subterraneus*. I had brought these letters thus far when, conversing soon after with the Most Serene Lady, I learned from her..."

[Note: Between the two text leaves the source carries a full fold-out engraved plate (the salt-works apparatus), oriented sideways; only the right edge of the

engraving is visible on the verso shown here, the bulk of the figure being on the recto fold. The visible portion shows part of a timber-framed mining/hoisting structure with shafts and beams. The engraver's signature is legible at the foot.]

Diagram (Source: PDF p. [fold-out plate]). A large fold-out engraved plate of a salt-works / mining apparatus, printed sideways. On the verso leaf shown here only the right margin of the engraving is reproduced; it shows part of a vertical timber-framed structure — heavy posts, cross-beams, and what appear to be hoisting shafts or channels (deeply hatched walls). The full figure lies on the fold's recto and is not present in this opening. Signed at lower right: "H. Bonzon delineavit." ["H. Bonzon drew it."]. No interior point-letters are legible on the visible fragment. — Plate fragment only; full plate is a if the recto fold is needed.

[Margin: The origin of gems.]

"...I learned that among the gems hitherto found among us there are also numbered amethysts, emeralds, cornelians, turquoises, garnets, malachites, and diamonds — small ones, indeed, but of such hardness that they scratch other diamonds while themselves admitting no scratch. The Most Serene Lady says our chalcedonies surpass the Oriental ones. Diamonds, she says, are born where crystal is generated: this is six-sided [hexagonal]; amethysts have four angles; garnets about twelve or ten.

Further, she says she has found by experience that the beginning, or matter, of all gems is a liquid, or water, drawn off through the metallic veins; flowing down drop by drop, it first congeals into talc, then into gems. According to the color of the talc, the gems too are tinted; and these finally harden thoroughly while, rolled down from the mountains, they are washed by the waters of the river Oenus [Inn]. But those that are dug out in their very native soil — that is, in the caverns of the mountains — have not yet taken on so great a hardness. Also in the river called the Sill [Sill], which mingles with the Oenus [Inn] not far from Oenipontum [Innsbruck], flints are little by little, in the course of time, tinged a yellow color. This stream once was, and perhaps still is, gold-bearing." So much for the rarities of the county of Tyrol; let this suffice.

On the Salt-works of Burgundy [De Salinis Burgundiae]

When, after my usual fashion everywhere, I had set up a correspondence with learned men about the secrets of natural things, in aid of the *Mundus Subterraneus*, and among others had consulted that truly distinguished and most learned man Johann Menecard [Joannes Menecard], canon and succentor of Saint

Maurice, concerning the Burgundian salt-works — he showed himself most ready to render every kind of service, and left nothing undone to give me exact and accurate information about the salt-works to be seen in Burgundy, famous for their renowned name, with a drawing of the things added. And since his letters are full of salt [i.e., wit], I have decided to set them down here as a testimony for posterity. He writes thus:

"Your Reverend Paternity directs that some things be transcribed about our subterranean treasures. This task laid upon me I undertake with the greatest eagerness — provided only that the plainness of my style detract nothing from the majesty of the subject, or from the truth.

At our Salinae [Salins], then, by a happy sport of Nature, salt springs leap up — springs which, sunk so deep as it were from the very bowels of the earth, against nature gush forth and of their own accord well up on high. Now Salinae [Salins] is a most ancient town, the chief place of Sequanian Burgundy [Sequanica Burgundia], or capital of the County of Burgundy [Franche-Comté], situated in the Valley of Scodinga [the Valley of Scodinga], open to the Roman road of kings and consuls — indeed passable even in the days of Julius Caesar [Julius Caesar] (which can be shown by many proofs). The whole valley, wooded at first, was set about as if planted with castles on the surrounding hills, until herds and flocks, all day long, became the greediest indication of this hidden and not yet sufficiently recognized benefit. It was ruled by various princes; but now it...

claims the titles and dominions of the most invincible Philip, King of Spain [Philip, King of Spain]. One of the two castles overhangs the city gates and — by its customs, and by the birth there of Saint Claude [Divus Claudius] — is exceedingly famous among the most holy Princes of Salins; they call it Bracon. The rest, along the ridges of the mountains that look down on the city's borders, serve at a distance as fortifications, hostile to enemies. Between two opposed mountains, very steep and sheer to the east and west, the meridian of the city runs down through the roots of those mountains, with walls running parallel on either side; the remaining mountains rise very high to the south and north, and are separated from the city itself by a mile and more. In the midst of all these, as it were at the fountainhead, the salt springs bubble up.

[Margin: Salt springs.]

Of these therefore we send you the faithful drawing, together with the wonderful and varied intensity of their qualities — for within a space of eight, or at most ten, feet of difference the springs of differing sources boil up in differing quality

and leap up in differing quantity. Of these in turn we here append the indications, marked with letters, most exactly.

A. designates the best of the springs, which through fine sands, between two rocks and living stone, bubbles up most copiously from the bottom as if out of a pot; and even when the others fail it yields fresh increase of both water and salt (as is shown by the daily experience of the noble Pierre Chaudes [Petrus Chaudes], who almost from boyhood has presided over this stewardship by hereditary title); nor does it ever grow turbid, or fail, except that when the North Wind blows it is somewhat diminished in quality and quantity. For the rest, a hundred and twenty-five pounds [librae] of this water yield the whitest and best salt, by means of fire set under the cauldrons, which are about four ten-foot rods [decempedae] in diametric breadth and three feet in height. This water is so salty that — unless the water itself is tempered for boiling with other, weaker waters — the salt itself congeals and coagulates in the form of sea salt.

[Margin: A thing worth noting.]

It is further much to be noted that the brine [muria] which is left over after the boiling, if it is mixed with the other waters when they are applied to the fire, increases both the dose and the quantity of the salt, and improves its quality, so that a hundred pounds of water yield twenty-eight, and sometimes more, pounds of the best salt.

[Margin: Salt-spring 2.]

B. The neighbor of the first, only four fingers' breadth away, and called the spring of the lead channel: *Source du canal de plomb* [French: "Spring of the lead channel"]. It draws salt from the living rock, and with it scruples [tiny grains], or little sands like cinnabar or scarlet in color. It is somewhat unequal to the first, whether in quantity or quality; and for a hundred pounds of water it yields only twenty-four pounds of the most refined salt of pleasant pungency. In summer each loses one pound of salt — the former yields only 24, this one 23. The waters of both are mixed together for the best use, and are sent into a common reservoir for use. There is nothing in this one different from the first as regards weather or winds, and the rest.

[Margin: Salt-spring 3, the new one.]

C. A new or more recent spring, *la nouvelle Source* [French: "the new spring"]: scarcely unlike the foregoing, except that it flows out only about an ounce, and if twenty...

Diagram. Large fold-out engraved plate depicting the Salins salt-works (Franche-Comté), drawn from life. The plate spans two PDF pages (a single physical fold-out). It shows, in section and plan, the underground salt-springs, the brine-channels, the lifting-machinery (geared water-wheels and bucket-chains), the great vaulted brine-reservoirs, and the boiling-houses, all keyed by letters that the facing text explains spring by spring and machine by machine. A workman's hand and arm are shown at lower left holding a tool [L]. The plate is signed at the engraving's foot: "H. Bonzon delineavit." ("H. Bonzon drew it."). A printed locator at the upper corner of the second sheet reads "Tomus 2. ad Fol. 228." [Volume 2, to Fol. 228].

Readable labels on the plate (positions approximate, as the fold-out is rotated):

- A: a spring / brine-vessel at lower left (the best spring of the facing description)
- B: a ladle or vessel adjacent to A
- C: a ladle / scoop at center-left
- D: a spring outlet at lower center
- E: a vaulted recess at upper right
- E, F: paired labels near a grated channel at center (the wheel F = the iron wheel-indicator)
- F: small water-wheel at center
- G: a channel-mouth at center
- H: the great central vaulted reservoir (the grande cuve)
- K: framework / steps at lower center [K]
- L: tool held in the workman's hand, lower left
- M: a small water-wheel at center-right
- O: outlet at center-right [?]
- P: vertical shaft / post at center of the second sheet
- Q: a hatch or sluice with handle at lower area of the second sheet

[The lettered description of the Salins salt-works continues from the preceding page. Running header, recto: "DE FODINARUM CONDITIONIBUS." — "On the conditions of the mines." Fol. 229.]

coagulates as much as three pounds of salt — yet it is usefully mixed with the rest, since it suffers something of the same effect, as regards winds, storms, and rains.

[Margin: The fourth spring.]

D. The fourth spring, called *le Durillon*, set off from the others by an interval of just six feet. It yields one pound and more from its very source, perennial entirely like the rest, and never in the least turbid. It bubbles up, leaping high out of the middle of the sand. Now because it mingles with itself a certain amount of fresh water, it produces only seven pounds of salt per hundred of water.

[Margin: A remarkable effect of this spring.]

Yet I have come to know something extraordinary in this regard from experience: for whereas during the dog-days [per canicula] the earlier springs decline, this one increases by its native goodness, so that for a hundred of water it returns about fifteen or sixteen pounds of salt, and it flows out always with the same purity and quantity. Accordingly it is at that season usefully mixed with the others, and is drawn off into the common reservoir (which they call *Cuppa, la Cuve*).

[Margin: The fifth spring.]

E. It flows down about a span [palmus] higher than the rest — *la vieil puisoir*, as you might say, the old draw-well — and is separated from the others by a space of three perches [perticae]. It is the meanest of all the foregoing, since it coagulates only six pounds of salt per hundred. But because from the upper workhouses, in which the salt is boiled and shaped into set molds, the salt that falls off trickles down through hidden passages into the source of this spring, it is therefore salted abundantly, mixed with the others, and usefully boiled — nearly the equal of the preceding one. It suffers the favorable or unfavorable effects of seasons, weather, winds, or rains in like manner, with equal increases and decreases.

[Margin: Description of the draw-up machinery.]

F. An iron wheel, which catches in the trough of the common reservoir the waters flowing down from the channels, and by their fall turns round, until — the reservoir being full — the wheel, blocked by the surface of the overflowing water, stops itself; and by means of a small rope tied to its axle, it is rendered useless. When the wheel is at rest, the little bell, which performs the duty of an overseer, signaling by the overflowing of the brine, is silenced; and then, without delay, the man set in charge of raising the waters hitches mules or horses to the transverse axle of another, upper wheel. So it comes about that the wheel, geared to the wheel by oblique spokes — with little fir-wood buckets attached to a rope — raises the brine from the common reservoir into the upper trough. From there it is afterward distributed, finger by finger, through leaden conduits [euripi] and channels to the various boiling-houses where the salt is cooked — houses they

call *Bernae* — by a truly admirable artifice, which can be understood well enough almost from the figure.

G. A small basin, which carries the useful brine together into the common reservoir.

H. The common or great reservoir: *la Grande cuve*.

I. A channel or small trough which carries the waters of the fourth spring — the one they call *Durillon* — to be cast, together with the waters of the fresher spring, into the river through the lower passages.

K. Steps, by which one descends from above to the lowest springs.

L. The wellspring of fresher and quite drinkable water, set off about eight feet from the leaden channel. It nonetheless tastes somewhat of saltiness, so that even per pound of water it would yield two — or somewhat less — if well boiled. This, however, is scarcely perceptible to the taste, and so it is rejected as useless. By the same artifice with which the brine is raised — through similar instruments and a little bell — it is so managed, lest the fresh water, breaking out from the very reservoir or *cuppa* (in French *Cuve*), be mixed with the brine; and it is regulated with no less care. For the rest, this fresh spring is at no time increased or diminished, nor does it become turbid with any wind blowing, whether from the south or the north [sive Austro, sive Borea], nor does it grow more abundant or fall short, but it always presents itself with uniform output.

M. A shorter iron wheel, one foot and a half in diameter, which catches the waters of the fresh spring as they flow down, so as to indicate how full the larger reservoir is — just as we said of the brine.

N. The reservoir or *cuppa* of the fresher water.

O. The channel of the same water, which is carried off into the river.

P. The other channel, by which the brine is led down into the upper salt-works.

Q. Another little basin, which catches the brine spurting up through just as many little buckets, and conveys it to the neighboring conduits and crossbars, which they call *Tourets*.

The rest of the features, which are explained more fully in the figure, belong to the huge vaults sunk more than sixty feet below the common pavement. All of these, when men look closely within, they proclaim — not absurdly — to be the eighth wonder of the world [octavum Orbis miraculum]. But those who presume

to reason about these things more wisely and exactly, in the manner of the philosophers, cannot but marvel that we are separated from the sea by about eight hundred thousand paces [octingentis circiter millibus passuum]. To this must be added the situation of the city, as described above, ringed on every side by very high mountains. For the slopes of the mountains — both those that face the west and those that face the north, and those that lie between north and east — nourish, plentifully enough and chiefly in the boggy parts of their fields, the Thracian stone [lapidem Thracium], which the people of Liège [Leodienses] call *Houille* [coal] — otherwise most fit for the boiling of salt, except that it is most unpleasant by its reek, while its sharpness suits the brine somewhat.

[Margin: A field rich in coal [lithanthrax].]

To this must be added that the rest of the mountains — chiefly those that slope toward the south, set off by another mile from the city, and some of them on the north almost adjoining the city — hold gypsum of every kind: white, whiter, and whitest. And gypsum agrees well with brine, and the two mixed together coagulate the more tenaciously; so that one may readily suspect the gypsum-works to be the wombs of the brine-water. However that may be, it is an arduous thing in matters so abstruse to know everything, or to define it — something that befits His most Reverend Paternity alone.

[Margin: Gypsum.]

I shall add here for all this what I myself have more than once experienced. In those larger reservoirs that are appointed for the keeping of brine, the brine sometimes rests unmoved for twenty, or even thirty, years — until the springs, over a longer summer, are somewhat diminished and are not equal to the distribution of salt; then there [it congeals]...

[Margin: The effect of salt turned into crystal.]

it congeals into crystal. I myself was given a piece of it, a foot and a half long and half a palm high. I broke off a small fragment the size of a nut and threw it onto burning coals. Almost as soon as it had taken in the heat, it burst apart like a lightning-flash from the middle of the hearth, and with a great crash shattered itself across the empty room. The fragment, as it split into pieces, kept up a continuous crackling; and had any of the pieces struck me in the face, they would surely have inflicted a wound. From that dangerous experiment I learned what the thing is that the chemists call rock-salt [Sal gemma] and "decrepitated salt" [Sal decrepitum]. If there is anything further to be conveyed to Your Reverend Paternity, at the slightest nod, at the least sign, Your Reverence has approved—

Always Your most devoted and most obedient Jean Menecard, Canon and
Succentor of Saint-Maurice de Salins.

MUNDI SUBTERRANEI LIBER UNDECIMUS — CHYMIOTECHNICUS

In which the universal apparatus of the Chemical World, together with the marvelous operations performed within it, is set forth—arranged in accordance with the archetype of Nature by means of a skillful technique of chemistry—and false alchemy [Pseudo-chymia] is exploded from its very roots.

PRAEFATIO

There lies in the human mind, set within it from heaven, I know not what little spark of the knowledge of truth. Once kindled and stirred, it seems unable to enjoy any rest until at last it reaches that toward which it is borne by so great a longing. If anyone has ever felt this spark, surely I feel it in myself, as I contemplate ever more deeply the wondrous majesty of the divine wisdom in this theater of Nature, and search out the inner sanctuaries—the very mysteries, I mean—of GOD and of his handmaid Nature, shining out in each particular thing. These mysteries are beheld both in the threefold Kingdom of the Universe and, above all, in the chemical workshops of the Geocosm. Driven onward by them, I set out with the greatest zeal to investigate whether we too might, by imitating Nature through metallurgical Art, produce something similar—just as goldsmiths, whom they call Alchemists, have at every period boasted that they can do.
[Margin: The author's study concerning alchemy.]

For this reason, in my various travels I made it my single aim to meet men renowned for the fame of their name, whether chemists or men distinguished by their reputation in the metallurgical profession, and—whether face to face or through frequent correspondence by letters—to confer with them about the secrets of the Great Gold-making Art, as they call it: so that I might find out at last what is to be believed about that most celebrated stone, the "wand of Midas," that worker of such great marvels, and learn what may be hoped for. But by a fruitless labor I rolled and rolled again not so much that philosophical stone as the stone and boulder of Sisyphus, since I found no one who could satisfy my questions—or even satisfy the very experiments not infrequently performed in my presence. So I betook myself to the original springs of the ancient writers: first the Hebrews, then the Arabs, afterward the Egyptians, who are believed to have

contributed something in this matter, and I examined their records (of which I have no small number, written partly in Hebrew, partly in Arabic). [Margin: Arabs who wrote about alchemy.]

Among the rest there are: works of the *Zohar* [Greek: Ζωάρ], unknown—or rather spurious—on the perfection of the Sun, on the marriage of the Sun and the Moon, by the author Zadith son of Hamuel; the works of Hermes [Hermes Trismegistus] as well, in whose Life it is said that he was Enoch [Enoch], and that he handed down the gold-making art to his descendants before the Flood—they relate that he gave it to another Hermes after the Flood, the one whom their own people call أدريس [Arabic: *Adrīs* / Idris], "Adris." There is also in my possession an Arabic book on the mass of the Sun and of the Moon; the *King Haled on the Stone of the Philosophers*; and several other treatises besides, so many and so overgrown with a dreadful barbarity, so wrapped up in such inelegant—not to say ridiculous—metaphors, riddles, and allegories, that not even the authors themselves seem to have understood what they meant. So much so that it has come into my mind that nothing is easier than to write such things, since whatever first comes into one's head can, under fantasies of this ridiculous human kind,

be set down in word-games and verbal mockeries for the vexation of clever minds. [Margin: The dreadful jumble of useless matter in the Arabs' records.] And since I could find nothing to my taste, I took up Lull [Raymond Lull / Ramon Llull], Villanova [Arnald of Villanova], Rupiscissa [John of Rupecissa], Isaac Hollandus [Isaac Hollandus], Trevisanus [Bernard of Treviso], Bacon [Roger Bacon], Paracelsus, Basil Valentine [Basilius Valentinus]—the authors of the Great Art—and countless others besides, in order to draw out from these men themselves the prodigious method and rationale of producing the stone. [Margin: Latin and Arab authors who follow them.] Therefore, weighing their sayings and deeds on the inflexible balance of truth, I made trial of whether they could sustain the Lydian touchstone of true philosophy. But in all of it I saw nothing but that pronouncement of the Wise Man, worthy of all praise (*Ecclesiastes* 8, last verse): "I understood that of all the works of GOD man can find no explanation of the things that are done under the Sun; and the more he labors in seeking, the less he finds; even if the wise man says that he knows, he cannot discover it." [Margin: The emptiness of the alchemical authors.] "I found one man upright"—and he entangled himself in endless questions, all of them the more difficult the more abstruse and impenetrable is the subject they treat. For whoever has carefully compared all the sayings of the said authors with one another will find opinions about the Great Art of the stone so divergent, so perplexed and intricate, that one might more easily clean out the stable of Augeas than the workshop of

these mutually dissenting Artists. What I think, therefore, about Alchemy, what I think about Chemistry, I have resolved to make plain in this book, bending myself to this one task: to separate the true from the false, the lawful from the unlawful, the just from the fraudulent, the dissonant from the harmonious; and to show, by demonstration [Greek: κατ' ἀπόδειξιν (kat' apodeixin, "by proof")], what Nature can do and what it cannot—relying on the hope that men distinguished by wisdom, and by their command of Medicine and Philosophy, once they have seen the weight of the arguments and experiments, will without difficulty distinguish truth from falsehood together with me. May GOD, Best and Greatest, the Father of lights, favor this undertaking.

SECTIO I — DE ORIGINE ALCHYMIAE (On the Origin of Alchemy)

CAPUT I — De Nomine, Definitione, & Divisione Alchymiae (On the Name, Definition, and Division of Alchemy)

The name "Alchemy" [Alchymia] is a mixed barbarous word, drawn from the Arabic article ال [al], which is customarily prefixed to all Arabic nouns, and from the Greek χύειν [Greek: χύειν (chyein, "to pour, to fuse")]. It has been made the common property of all peoples and nations, just as the name *Almagest* [Almagestum]—from the Arabic *al* and Greek μέγιστος [Greek: μέγιστος (megistos, "greatest")]¹—amply shows, being the great work of Ptolemy's construction [Construction of Ptolemy]. Those who would have it a purely Arabic word are clearly deceived, since by the Arabic name الكيمياء [Arabic: *al-kīmiyā*], which is most frequent in the books of the Arabs, the term was itself borrowed from the Greeks—like countless other words that occur everywhere. [Margin: The etymology of Chemistry from Cham (Ham).] But those who derive it from the Egyptian word *Cham* suppose that it was first set down in writing by Cham [Ham], the first king of the Egyptians, son of Noah; that it was preserved in the Ark and carried over into Egypt; and that posterity ever afterward cultivated it, handed down by Mesraim [Mizraim], son of Cham, and by Hermes his counselor.

But since we have discussed all these things most fully in the *Obeliscus Pamphilius* and in the *Oedipus Syntagma*—on the hieroglyphic alchemy of the Egyptians—we refer the reader to that work, where we teach in full light that the Egyptians by no means understood the transmutatory Alchemy, or (what is the same thing) the great mystery of the Elixir or of the Philosophers' Stone. [Margin: The transmutatory art was not known to the Egyptians.] Rather, they understood that art which they call Spagyric [Greek: σπαγυρικήν (spagyrikēn, "spagyric")] or

the metallic art, which consists chiefly in the separation, purification, washing, and decoction of metals; and which is not inaptly called ἄλχυμιά [Greek: ἄλχυμιά (halychymia)]—that is, from the perpetual intervention of salt, the "pouring of salt" [salis fusio]—which we have also set out at length in the preceding passages. [Margin: Metallurgy alone was known from the origin of the world.] And that the Alchemy of the Egyptians must be understood in this way, no one should have any doubt.

It existed too among the first men of the world before the Flood, while Adam was still living—rightly cultivated by Tubal-cain [Tubalcain], son of Lamech by Sella [Zillah], as is recorded in *Genesis* chapter 4: "Sella too bore Tubal-cain, who was a hammerer and a smith in every work of bronze and iron." [Margin: The first metallic art.] And no one should doubt that bronze and iron, drawn out from the mines not pure and unalloyed but worked by the metallic art (which Adam the First-formed [Adamus Protoplastus], divinely inspired, had taught his sons as something indispensable for the conduct of human life), were thus drawn forth and worked. And the descendants of Adam—that is, Noah and his sons—received it by ancestral tradition and, after the Flood, propagated it into all the parts of the world. From this the manifold

species of Alchemy emanated. Of these the first and most ancient of all is the one we call Metallurgy, or the Metallic Art, which we describe as follows. [Margin: Metallurgy the most ancient of all.] **Metallurgical Alchemy is nothing other than the art of preparing, washing, smelting, dissolving, coagulating, and separating the pure from the impure in metals, for the necessary uses of mankind**—and this we properly call Chemistry. [Margin: Definition of Metallurgy.]

The second species is transmutatory Alchemy, which is also called χρυσοποιΐα [Greek: χρυσοποιΐα (chrysopoia, "gold-making")], by which the Alchemists have imagined to themselves that any imperfect metals can be transmuted into the purest gold and silver. This we define in the following way. [Margin: Definition of Alchemy.] **Alchemy is the science that teaches how to make and generate a certain medicine, which they call the Elixir; which, when it is cast upon metals, perfects and completes them in the moment of projection, and transforms them—not only from imperfect into perfect, but also into gold and silver, according to the proportion of the medicine cast.** Whether this definition can stand, and whether the effect answers to the definition, will be taught in what follows.

The third species may rightly be called Spagyric or analytic Chemistry, in which the bodies not only of minerals but also of vegetables and animals are resolved into their elements. [Margin: Definition of Spagyric Chemistry.] This is also called Chymiatría, or medical chemistry, and it is occupied chiefly with the skillful extraction of oils, salts, and spirits—or quintessences—from minerals, metals, plants, and animals for the use of Medicine. It is a study worthy of all praise; for, drawn and brought forth from the inmost springs of natural Philosophy, then refined by the zeal first of Kings and afterward of many princes, deservedly and rightly enrolled in the number of the liberal sciences, it has come at last into the most sacred embrace of Medicine. [Margin: The praise of Spagyric Chemistry, or of the Spagyric Art.] The immense benefits flowing from it into the human race cannot be sufficiently celebrated with fitting praises, since it is truly the spring of a deeper Philosophy, the key, the marrow, and the soul of human wisdom—both of the Physical and of the Pharmaceutical faculties—the root of Medicine and its one single goal, toward which wise men in every age have aimed. For it has laid open to us so many stupendous works of GOD, Best and Greatest; it unfolds so many of Nature's sacraments; it brings forth so many preparations of medicaments, and at last the hidden uses of herbs, animals, minerals, and of almost all bodies, stored away in the inmost bosom of Nature—so that those among physicians who neglect it, or who would have it buried, may deservedly seem ungrateful toward the human race. And since, concerning the first Alchemy, which we call Metallurgy, we have treated most fully in the preceding Book, it remains for us to spread the sails of our reasoning toward the two latter kinds.

CAPUT II — De Alchymia, quam Chrysopaeiam vocant (On the Alchemy They Call Chrysopoeia)

In the whole of natural Philosophy I find no subject so controverted, so exposed to so many great struggles of combatants, so teeming with monstrous differing opinions, as this one which is openly bandied about concerning the making of gold. [Margin: The intricate study of alchemy.] So I would judge it superfluous to set pen in motion over the decision of such great controversies and disputes; and we have thought it more prudent to suppress the matter than to touch this apple of Eris [Eridis pomum / apple of Discord]. Yet because my judgment on this subject has been demanded by many—and I have been most urgently begged to say what I think of it—I will, with all the exactness [Greek: ἀκριβεία (akribēia, "exactness, precision")] that is possible, lay open my opinion.

There are four matters about which, among Philosophers and Mathematicians, there has been moved at every period an inextricable controversy, undecided to

this very day. [Margin: 4. Things which are talked of and discussed, and not found out.] The first of these demands the squaring of the circle [Quadratura circuli]. [Margin: 1. The squaring of the circle.] The second the Statical faculty claims for itself, and it is perpetual motion [motus perpetuus], which some wrongly think can be set up by a certain skillful mechanical contrivance. [Margin: 2. Perpetual motion.] The third Physics arrogates to itself, and it is the construction of a lamp [lampas] that should burn with a perennial and eternal fire. [Margin: 3.] The fourth is Alchemy, by which they imagine that imperfect metals can be converted into the purest and noblest gold by the power of the Philosophers' Stone, endowed (as they themselves say) with a divine efficacy. [Margin: 4. Concerning the Alchemy they call Chrysopoeia.]

There are, and have been, innumerable Mathematicians who, with stubborn zeal and incredible labor, have striven to move "squares with rounds"—so as to reach that which has been so greatly desired and sought for now nearly two thousand years, namely the squaring of the circle. [Margin: The true and real squaring of the circle is needed by geometers, and not yet found.] And yet to this day no one has been found who could boast that he had discovered the true and real Squaring sought by the Mathematicians [Greek: τετραγωνισμός (tetragōnismos, "quadrature, squaring")]—the squaring that consists in the unequal [recte: inadequate; *inadaequata*] proportion of the diameter to the circumference. Although some have believed so firmly that they had detected it that by no words, by no arguments, would they let themselves be torn away from it—until at last, convicted by the detection of their fallacies and, as it were, deluded by some doubtful light, they have subsided, their peacock's tail folded up.

The same thing has happened to the explorers of artificial perpetual motion. [Margin: Artificial perpetual motion.] Carried sideways by a perverse imagination and by desire for the thing they are attempting, after vast sums have been spent in fruitless labor, they convince themselves too confidently that they have accomplished the thing. But then, once the experiment is made, having gained—in place of perpetual motion—a fixed establishment of perpetual rest, and finding themselves deluded in a pitiable way, they have bewailed their state to the point of despair. In the year 1661, ten inventions of perpetual motion were sent to me from various regions to be examined, which their authors [Margin: Concerning perpetual motion.]

they yielded, claiming they would produce the long-desired effect; but when tested against the Lydian touchstone [ad Lydium Staticae lapidem], every one of them was found, without exception, to be riddled with gross fallacies

[paralogisms]. This so worked upon the minds of their inventors that they abandoned any further inquiry into the matter — gave it up as a lost cause, as it were — and turned to more useful studies. Nor do I recall ever once seeing any real effect produced by such a contrivance, whether one circulated in manuscript or published in print, even though everyone everywhere proclaims that perpetual motion has been discovered by this man or that, in this city or that. Indeed, a good many authors have not been ashamed to grace printed books with showy titles of this kind:

The Machine of Perpetual Motion, So Long Sought Through So Many Ages, Vainly Pursued by the Industry of So Many Mathematicians' Genius, at Last Brought to Full Perfection and Demonstrated.

There you have it — with titles like this, contrived to lend some credit to a thing never actually accomplished, certain men are not embarrassed to celebrate the triumph before the victory. All of which I would say of perpetual motion that is *purely artificial*. That a perpetually moving machine can be made from Art and Nature combined, with Nature lending her aid underneath, I do not deny — the sort of thing we exhibited in our *Magnetic Art* [in Arte nostra Magnetica]; yet such machines are generally found to be devoid of any practical benefit. The same is to be understood of the perpetual light or fire [de lumine seu igne perpetuo], all of which we refuted at length in the preceding Book, in the chapter on asbestos [capite de Asbesto], and to which we refer the reader.

But let us now return to the goal we set ourselves. What has been said of the arts just mentioned holds true above all of alchemy. For you will scarcely find an alchemist of any reputation who does not either boast of possessing knowledge of that Stone, or claim to have seen, in the hands of someone else, the working of the Great Art — though if you examine the truth of their claims more closely by Cleanthes' lamp [ad Cleanthis lucernam], you will find nothing but rotten and worm-eaten wares; or, at most, an operation dressed up by some singular trick; or simply the separation of gold from the other metals, which is the metallurgist's proper business, accomplished with no transmutation at all. And so I am firmly convinced that difficulties of this kind will never, at any time, be exhausted, and consequently will endure until the coming — to speak as the Hebrews do — of **Elijah** [Eliae], that is, until the consummation of the age. For just as these matters subsist in the individual case, so too they demand a greater exertion of human ingenuity to penetrate such a mystery — an access granted only to angelic minds. For Nature is so jealous of her own rights that in matters of this sort she never

permits herself to be mastered by human industry, having reserved the secret mode of her working to herself alone.

[Margin: Alchemy's pursuit is futile.]

From these premises I conclude, finally, that although mysteries of this kind are in themselves and by their own nature knowable, they nonetheless lie so deeply convoluted in the innermost recess and very center of Nature that no human ingenuity can draw them out. I say, therefore, that alchemy — which we call transmutatory chrysopoeia — does indeed have an object knowable in itself and by its own nature, yet one that perhaps only an angelic or a demonic intellect can reach. But because alchemists, fighting tooth and nail [*pro aris et focus*] for it, insist that it has been cultivated from the very beginnings of the world, nothing further remains but to examine whether the things they boast of are true, and whether that philosophical Stone — perhaps known to no one ever — possesses the powers, as great as they claim, that they ascribe to it.

[Margin: Alchemy is knowable, yet is still not known.]

CAPUT III.

De Antiquitate Alchymiae. (*On the Antiquity of Alchemy.*)

That alchemists are said to practice the transmutatory or projective art [*Arte Transmutatoria seu projectoria*] of no such great antiquity as they persuade themselves is plain even from this: that before Christ no writer whatsoever makes any mention of it. The pseudo-alchemists, to win greater credit for their Stone, derive it from Adam himself — indeed, that they might leave no presumption or rashness unattempted, they assert (not so much impiously as foolishly) that it was prefigured by God Almighty through the tree of good and evil in Paradise, and that Adam afterward learned this art from it. They claim that Adam handed it down to his descendants — to Enoch [*Enoch*] and his sons — and that it was propagated to Noah [*Noë*], who then through his children disseminated it into all parts of the world; that its chief cultivator was Ham [*Cham*], and that he passed it on to posterity through his son Mizraim [*Misraim*] and through Hermes. All this they attempt to demonstrate from authors wrenched into shape in the most extraordinary way — as though we ought to believe that in those first beginnings of the world the human race devoted itself, before all else, to no other art than that which consists in the confection of the Stone. Let them say whatever they will: no one of sound judgment will ever be persuaded of it.

[Margin: On alchemy propagated to posterity — the foolish opinions of Adam.]

From Sacred Scripture, too, we know that Adam and his descendants tilled the soil not with gold but with iron; and again they try, by I know not what flimsy arguments, to show that **Belus** [Belum], **Ninus** [Ninum], and **Semiramis** also practiced this art. They assert that among the Egyptians the whole art was described in hieroglyphic letters by Hermes — of which, however, I find not the slightest trace in those letters. They report that **Pythagoras** [Pythagoram] too was skilled in it, and that he indicated the art by the golden thigh [per aureum femur]. They hold that **Moses** [Moysen], instructed in all the wisdom of the Egyptians, cultivated it; and they attribute it to **Hippocrates** [Hippocrati], **Aristotle** [Aristoteli], the divine Thomas [Divo Thomae, i.e. Thomas Aquinas], **Apollonius of Tyana** [Apollonio Thyaneo], **Albertus** [Alberto, i.e. Albertus Magnus], and the rest of the philosophers of great name — for no other reason than to win some authority for a most trifling art. So I cannot marvel enough that the human mind...

[Margin: It is false that the hieroglyphic alchemy was handed down by Hermes.]

should have occupied itself with so many trifles, when, with so many fables and so many ill-conceived assertions, those men are so far from having advanced the credit of the Art that they have rather destroyed all its credibility entirely, made it vanish, and rendered it hateful to all. They show, moreover, that **Solomon** [Salomonem] too was versed in it, from a Magical Book composed by him which they call the *Clavicula Salomonis* [Key of Solomon]; but since the *Clavicula* is stuffed with horrid and altogether abominable matters, I judge that it issued, more truly, from the devil's workshop than from Solomon. For who does not here see the imposture of the pseudo-chemists? If Solomon had been skilled in this gold-bearing Art, he certainly would never have had gold brought from **Ophir**, the farthest shores of the Indies, at truly enormous expense and at peril of life, by a three-year voyage.

[Margin: Solomon an alchemist.]

The pseudo-chemists do not stop here. Whatever fables superstitious antiquity ever devised, they assert were practiced for no other end than to express, beneath those occult mythological wrappings, the wondrous mysteries of the philosophical Stone lying hidden there. They say this art was set forth: through the twelve labors of Hercules [Herculis]; through the golden fleece [vellus aureum] won in Colchis by the Argonauts; by the Greeks through the πολυθεϊαν [Greek: polytheïan, "multiplicity of gods" — the war of the gods]; by the Egyptians

through the history of Osiris, Isis, Horus, and Typhon. But lest I waste time on the most frivolous of matters, let whoever wishes read **Pierre Jean Fabre's** [Petri Fabri] *Hercules Chymicus*, **Michael Maier's** [Michaëlis Mayeri] *Arcanorum Arcanissima*, and **Georg Herwart's** [Georgii Hervortii] interpretation of the *Tabula Bemina* [the Bembine Tablet] — in which they attempt to interpret, ineptly (not to say ridiculously), that nothing else was signified by the Egyptians than the rationale and method of the Great Art.

[Margin: Fables of the ancients signify nothing other than alchemy.]

But whoever has worked through our *Oedipus* [Oedipum, i.e. Kircher's *Oedipus Aegyptiacus*] will plainly see that the intention of the Egyptians was quite other than to signify by these things the mysteries of the philosophical Stone, which they never knew. I would pursue all of this here at greater length, had I not described it most fully in the *Alchemy of the Egyptians* [Alchimia Aegyptiorum] inserted in the second volume of the *Oedipus* — where I demonstrate that the Egyptians, by certain symbols, signified by no means the art of the Stone, but rather the metallic art, by which from certain earthy materials they extracted a vast quantity of gold; and that by their *Elixir* they signified not a Stone, but a liquor extracted from precious stones, herbs, plants, and aromatics, suitable for the prolongation of life.

[Margin: What the Egyptians understood by the philosophical Stone.]

Nor do the alchemists stop even here, but are not ashamed to show — foolishly, impiously, and in words full of blasphemy — that the mysteries of their Stone were signified by Solomon in the *Song of Songs* [Canticis Canticorum], as in a kind of epithalamium of the Sun and the Moon. We, however, applying ourselves so far as we could to the antiquity of this lost art, find that no mention of it is made by any writer before Christ. **Caligula** [Caius Caligula] Caesar was the first of the emperors who, on Pliny's testimony [Plinio teste], is said to have cooked gold out of orpiment [auripigmento]; but since the gain did not answer to the expense, they say he gave up the work. Yet to separate gold from orpiment belongs not to transmutatory but to spagyric chemistry, by which the gold that is naturally present in arsenic or orpiment is separated, by the force of fire and by decoction, from the earthy dregs to which it is bound — which is the metallurgist's proper business.

[Margin: Caligula the first metallurgist among the Caesars.]

Nor did **Pliny** [Plinius], most curious of mortals, have any knowledge of this transmutatory art, or of the Stone or Great Mastery [magni Magisterii]: this is

sharply evident from his treatise *On Metals* [de Metallis]; for had he possessed it, he would beyond doubt have made the most ample mention of it, as of a subject most curious of all. And as for the claim that **Julius Firmicus** [Julium Firmicum] made mention of the word *Alchimia* — this does not occur in the manuscripts of the Vatican Library, but it is likely that the word *Chimia* was added, either by some trick or by the printers, to lend the word *Alchimia* a certain show of antiquity.

[Margin: Pliny did not know the version of alchemy.]

I add, moreover, that if the mastery of the Stone had been known only to the most curious writers — to **Aelian** [Aeliano], **Solinus** [Solino], and the rest of the philosophers and orators — they would doubtless never have ceased to extol it to the skies with great titles of praise. For what subject could there be more noble, more excellent, and more worthy of admiration than that by the sole efficacy of the philosophical Stone all things should be turned into gold? **Suidas** [Suidas] relates of **Diocletian** that, when in his reign the Egyptians, grown powerful in gold and riches, were plotting revolution through the murder of many distinguished men, the rebellion that had been stirred up was at once quelled in its very beginning; and that, lest in future the Egyptians, relying on the resources of gold and riches, should cause the Romans much trouble with fresh tumults of rebellion and sedition, all the writings of the ancients on the smelting of silver and gold were everywhere, by Caesar's command, consigned to the flames.

[Margin: Roman writers never made mention of alchemy.]

The Egyptians, then, were indeed skilled in the gold-bearing art — not, however, in that fabulous art of the Great Stone (otherwise it would not have been held in the place of a great secret), but in the art by which, through separation from earthy clods by smelting, it is done: that is, the metallurgy common to all. Some years later followed **Zosimus** [Zosimus], a Greek writer, whose books *On the Sacred Art* and *On Chrysopoeia* are said to be still preserved in manuscript in the Royal Library at Paris [Bibliotheca regia Parisiis] — concerning which, however, since it is not clear to me what they contain, I have thought it best not to interpose my judgment. Following him, **Nicephorus Blemmydas** [Nicephorus Blemmidas] wrote on the same matter [?]; but, as is plain from a Vatican manuscript, he makes no mention of the Stone, being wholly intent on spagyric alone.

These were succeeded by the **Arabs** [Arabes], who, the first authors of this Stone, filled the world with countless fables and superstitions. Enticed by the spurious

writings of Hermes [Hermetis] and the rest of the ancient Egyptians, stuffed with mystery, and eager to publish something new, they thrust upon the world this vegetable Stone, prevailing in divine virtues, as the treasure of treasures; and, to win some authority for their offspring, they strove not so much to *prove* their art from the most ancient monuments of Hermes as to *authenticate* it. There is in my possession a vast supply of these Arab writers...

[Margin: The Arabs propagated alchemy.]

in the production of marvelous effects, that I may pass over in silence the variety arising from the bridal combination [paranympha combinatione] of things. Whence, even from this consideration, if not the impossibility of alchemy, at least its inevitable, inextricable difficulty may be proved. Add to this that neither I, least of all men, nor anyone else among the most sublimely gifted writers, whether of the ancients or the moderns, has down to this very day demonstrated the true and evident μεταλλογένεσεως [Greek: metallogeneseōs, "of the generation of metals"] rationale — since this matter is of so abstruse an investigation that the more anyone thinks he has advanced in such abstruse operations of Nature, the more difficulties always seem to remain for him to overcome and to resolve, out of the perplexity of a wavering mind.

[Margin: The generation of metals is inaccessible to the human intellect.]

So I cannot marvel enough that certain pseudo-chemists, with such confidence, dare to attempt — with unwashed hands, so to speak [illotis manibus], instructed in no knowledge of natural philosophy — that greatest of all the masteries of Nature, that argument, I say, which the wisest have long since judged a lost cause, inasmuch as Nature seems to have reserved to herself alone the things of metals, with every approach to the intimate and arcane inner chambers of her workshops [ergasteriorum] shut off.

[Margin: The folly of certain idiots who set themselves up as chemists.]

If, then, anyone perfectly knew the exact rule [amussim] of Nature — by which she sublimates, precipitates, dissolves, and coagulates the heterogeneous humid, fixes and hardens it with the appropriate clods — and if he also knew the rationale of the subterranean furnaces, he could doubtless accomplish something in the artificial production of gold, silver, and the other metals. But since it is scarcely granted to human ingenuity to approach this Corinth [hanc adire Corinthum], certainly nothing remains but that from the effects we may attain, by certain conjectures only, the distilling vessels of the Subterranean Archeus [Archei Subterranei vasa]. For my part, having long and much speculated about

this pyrotechny [pyrotechniam] of Nature, I have at last, led by reasoning from various experiments, judged that earthen vessels and furnaces [vasa terrae, fornacesque] can be constructed in the manner that follows — on whose model the artificial vessels of the chemists may afterward be built.

Diagram. A landscape engraving showing a mountain massif cut away in cross-section to reveal the interior, captioned by a banderole (scroll) at the top: *Matrices Metallicae Geocosmi* ("The Metallic Matrices of the Geocosm"). Beyond and above the cutaway, ranges of distant hills with scattered trees recede toward the horizon. At the base of the mountain's interior is a central fire-chamber: an oval reservoir wreathed in flames, inscribed *Hydrophylacium* (water-reservoir) on its body and *Pyrophylacium* (fire-reservoir) in the flames below it. From the head of this chamber rises a trunk that branches upward and outward into a root- or tree-like network of metallic veins (the "matrices"), ending in swollen nodes distributed through the body of the mountain. The labels mark stations along these veins.

- Banner (top center): *Matrices Metallicae Geocosmi* — "The Metallic Matrices of the Geocosm"
- A (within the oval chamber): *Hydrophylacium* — the central water-reservoir
- (in the flames beneath A): *Pyrophylacium* — the fire-reservoir
- B (just above the chamber, at the base of the trunk): the spring-head from which the veins issue
- C (upper right node): vein-terminal node
- D (upper center node): vein-terminal node
- E (upper left node): vein-terminal node
- F (left, mid-height node): vein-terminal node
- G (left, lower node): vein-terminal node
- D, E, F, G (along the lower right horizontal vein-band): successive vein-terminal nodes

in great abundance; in which, however, I have found nothing but some non-essential — indeed, purely accidental — transmutations of metals and tinctures, such as coagulations of mercury and separations of gold from silver, of this from copper and lead, tested by me with no unhappy success, of which more in what follows. But where they treat of their Stone, I do not think any fables or fictions more absurd could be devised by human ingenuity than those which they themselves describe under monstrous wrappings of parables and allegories, and

set forth with such obscurity of words that not even Oedipus himself would seem able to suffice for the exposition of their mysteries. Since we have displayed all this in our *Hieroglyphic Alchemy* [Alchimia nostra Hieroglyphica], with the citation of a great body of Arabic texts, I have thought it superfluous to recite it again in this place.

[Margin: The Arabs' horrid fables about the Stone.]

These traditions of the Arabs were first followed by several men of great name among the Latins: **Arnold of Villanova** [Arnoldus Villanovanus], **Raymond** [Raymundus], **Lull** [Lullus], **John** [Ioannes], **Azoth** [Azotus], and last of all **Paracelsus** [Paracelsus] — whom countless others followed, who, gaping after gold and either not understanding the Arabs' meaning or interpreting it wrongly, drew (as it were) a golden chain let down from heaven [aurea catena caelitus deducta] — that is, a new Hermetic philosophy — and by it, at first, drew on, as if by golden chains, the minds of kings and princes greedy for the promises of such great things. Their favor, and a mind inclined toward the pursuit of gold, kindled so great an appetite [orexin] that they gave themselves over wholly to it, not without damage to public affairs.

[Margin: The Latin chemical writers. / Why alchemy was so cultivated.]

Hence it came about that scarcely any actor, soldier, mountebank, barber, surgeon, bath-keeper, mechanic, merchant, or physician was to be found who did not soon, in a single night, sprout up into an alchemist like mushrooms; hence there came forth — as if from a certain Trojan horse — so much *κατάρρευμα* [Greek: katarrheuma, "scum/refuse/dregs"] of disgraceful men, so many deceivers and impostors of princes, so many leeches of human blood, so many emptiers of purses. So much so that even Paracelsus himself is forced to confess that chemistry is the field [ager] of all those who wish to feed themselves dishonestly, and that there is no pig that does not dare to root with its snout in the vineyard of chemistry — most of whom were deserters of their own profession.

[Margin: Paracelsus on alchemy.]

[Margin: Description of the pseudo-chemical deceivers.]

These were: officious busybodies [ministri πολυπράγμονες], apostates of the law, druggists reduced to ruin [ad incitas redacti], lazy artisans, brass-smiths, crafty mountebanks [Agyrtæ versipelles], goldsmiths who hate gold [Aurifabri φιλάργυροι (philargyroi, "money-loving") — ironically], rash strollers, drunken tailors, stupid fullers, tooth-breakers [dentifragi], chattering barbers, and

decoctors of their tenfold chemistry [decem Chymicorum decoctores], and others of this bran — vain, rude, and unskilled little men who, when they have squandered their goods, are carried about nearly everywhere on earth like flies, trumpeting great things about that blessed Stone, the Son of the Sun and Moon, perpetually dreaming of golden mountains, the very poorest of mortals promising the riches of **Croesus** [Crassi (recte: Croesi)]; in a word, with their brains drained dry by their circulations [circulationes], they leave behind them color for a tincture, a stone for the Philosophical Stone, charcoal for treasure, and ashes. And from this it has come about that chemistry, an otherwise noble faculty, has incurred marks so foul that today nothing is held cheaper than an alchemist, nothing more deceitful and fraudulent. But now, setting these things aside, let us return to our purpose.

CAPUT IV.

De Pyrotechnia sive ad Chimicas operationes requisitis vasis, & instrumentis. (*On Pyrotechny, or the Vessels and Instruments Required for Chemical Operations.*)

It cannot be that the chemists should rightly construct anything, unless — having grasped Ariadne's thread [filo Ariadnae] in this labyrinth of mineral Nature — they proceed according to the rules and operations of Nature, with the **Archeus** as their guide [Archeo Duce]. In all the arts and sciences a natural prototype is needed; and this is clear from the art of painting. For just as the painter and sculptor, in painting and fashioning the likenesses of things, need a prototype to produce anything worthy — and if he lacks one, let him be assured that he will bring forth nothing but a monstrous birth — so the **Geocosm** ought to be the archetype for alchemists, if only it were permitted to enter it. For here it teaches the perfection of the art exactly, while in its inner womb, furnished with countless furnaces or alembics, by a certain marvelous mastery of fire that is incomprehensible to the eye...

[Margin: The imitation of nature is difficult.]

[Margin: Nature's hidden paths in producing gold.]

[Margin: With occult instruments.]

working upon the humid, it now exalts it into vapors, now dissolves it; now calcines, coagulates, and hardens it; and so long does it putrefy and ferment, until at last in the appropriate subterranean matrices it produces the metal intended

by Nature. In which work it proceeds by ways so occult, along paths so occult, in those inaccessible workshops [ergasteriis] of Nature, that in attaining and comprehending them it seems to elude every grasp of human ingenuity — since neither the combination of graduated heat with the appropriate marriages [conjugiis] of the earthy clods, nor the proportion of disparate things to be knit into one, is suited to us.

Yet unless the alchemists observe this order of Nature most precisely in the confection of the Stone, let them be assured that they will certainly never arrive at what they intend and aim at.

[Margin: The proportion of things unknown to us in the production of metals.]

But who is endowed with a wit so subtle that he may penetrate the rationale of the furnaces, the alembics, and the siphons in the hidden lap [in abdito sinu (recte: suscipi[?])] and kingdom of the Archeus? Who may conceive the manifold variety of the masteries and tinctures, and the mode by which it operates? So that meanwhile — to admire the wondrous variety of the salts, minerals, and the rest...

[The following continues Liber XI, Sectio I. Reading order reconstructed from page numbers and running headers: p. 238 → p. 239 → p. 240 → the full-page plate "Tom. II. 241". PDF page order is non-linear.]

[Margin: Subterranean furnaces and hearths.]

It is certain — as we showed in the first volume — that hidden deep within the bowels of the Earth there lies a manifold arrangement of fire-chambers [pyrophylacia]. These act as so many hearths, diffusing their fiery heat through all the pathways of the Geocosm and along the Earth's tubular channels. First of all, Nature has arranged within those inner recesses of the Earth a multitude of cavities, which serve as a kind of cucurbit [glass distilling-flask]. Just as these are packed with a diversity of minerals, so too the moist matter within these cucurbits is resolved into vapors by the force of the fire set beneath. The vapors pass through the blind channels of the Earth's fibers, escaping wherever an opening offers itself, into various hollows of differing nature; and wherever they encounter earthy clods, there — drawn by a kind of magnetic force — they form a metal proportioned to the nature both of the earth and of the vapor. But all this is better shown by a figure than by manifold verbal reasoning.

[Margin: An account of the manner Nature employs.]

Let there be, then, a subterranean fire-chamber X — a cauldron, or one filled with a mineral water, or a Mercurial-sulphureous womb [matrix] which through its various tubes distributes its fire-exalted vapors into the various ore-matrices of the mountains, C D E F. Suppose, then, that first the matrix A — a kind of cucurbit packed with sulphur, mercury, and salt — gives rise, by the service of the fire set beneath, to a spermatic vapor, mercurial-saline-sulphureous. This vapor slips out through the channel B C; and if at C it strikes a matrix holding a vein of the purest sulphur, it is enclosed there on every side as if in an alembic, condensed by the coldness of the place into a water. This water, drawn up higher and imbibed by the purest sulphur of a red color in that place, and digested by a moderate warmth through the channel B C, in time — once the moist element has been consumed — is converted into gold. But if the vapor strikes through channel B D into matrix D, which is filled with a white sulphur not so pure or fully concocted, then it will at last generate silver there. And if the vapor from A, passing through channel B E into matrix E, strikes one filled with impure sulphur variously contaminated, then there it produces copper [aes]; but in matrix F, filled with sulphur that has been burnt, impure, and contaminated with earthy refuse, it produces iron. In this way, in matrix G, filled with magnesia, plumbago, and bismuth, it engenders lead and tin. You see, then, the procedure of Nature in producing metals — and how one and the same vapor, according to the diversity of the matrices, by means of sublimation, distillation, coagulation, and the fermentation carried out within the matrices, at last produces diverse metals.

[Margin: Chemical vessels constituted on the model of Nature.]

From this operation of Nature the philosophers, gradually coming to a certain knowledge of metallic transmutation [μεταλλολογήσεως — Greek: metallologēseōs, "metal-working / the study of metals"], devised vessels, furnaces, alembics, cucurbits, and the like, constituted on the model of Nature — so that, looking perpetually toward these as toward the prototype of Nature, they believed they would at last accomplish by art, in the highest degree, what Nature labors over for a long time. But since in the chrysopoeia [gold-making] this can in no way be carried out without those aids — without which the art

cannot be brought to completion — and since we may seem able to proceed, and may not be reckoned "untried and inexperienced" [ἄπειροι καὶ ἄπρακτοι — Greek: apeiroi kai apraktoi, "without experience and without practice"] in the things necessary for either refuting or establishing this art in any way whatever, I shall here first set down the whole construction of the vessels suited to chemical

operations, so that it may shine forth most clearly from the individual examples appended what use each one serves in pyrotechny.

Nevertheless, in order that what we have set forth at perhaps greater length than was proper in the preceding pages concerning the hidden constitution of the Subterranean World might be turned to some use necessary for human life, I have decided in this Book — which we also call the *Geocosm Applied* — to set out, by a certain easy, clear, and ready method, a kind of demonstration [ἰχνογραφίαν — Greek: ichnographian, "a ground-plan / outline drawing"] of the marvels of chemical art [Chymotechnia], so that what Nature, by the efficacy and industry implanted in her, brings to birth in the fertile womb of the Geocosm, we may likewise be able both to bring to birth and to produce — by a certain manual technique of art [Encheiromatico] adapted to imitating Nature in her every form [pantamorpham]. And so that this may be done with all possible diligence and method, I shall first set forth certain paradigmatic canons of the universal chemical operations to be carried out in chemistry, so that the kindly reader may learn how one must proceed in the preparation, calcination, coagulation, and fixation of metals, and in the other matters to be treated fully a little later. Once these are done, we shall take up the alchemical operations, so that what that Stone of the Philosophers may be — known to the blear-eyed and to barbers alike [lippis et tonsoribus notus, i.e. proverbially known to everyone] — and whether, by a true and real mastery, and from what materials it can be made, and whether it possesses such great powers as the alchemists boast it has, may become known to the curious reader more clearly than the midday light.

Chemistry [Chymia] is so called, as we have said elsewhere, from χυμός [Greek: chymos, "juice"] — or rather from χέειν [Greek: cheein, "to pour"] — which means the same as "to fuse, to liquefy, or to reduce some mixed body into a liquid or juice." And just as χυμός means "juice," so chemistry is the art that makes juice, that is, that resolves solid things into juice. We define it thus:

[Margin: Definition of the spagyric art.]

Chemistry is the art of separating the pure from the impure, and thence making medicine for the healing of bodies, and apt for bringing metallic bodies to metallic perfection. This definition holds good by its genus, its specific form, and its proper end. The genus is "natural art" [Ars Physica]. It is an art, because it is a habit productive in accordance with reason, and that in natural things. Its form is the separation of the pure from the impure, proper to this art. I said "the pure," because it claims for itself the resolution into their elements not only of metals, but also of the mixed bodies of herbs, plants, and animals. This separation is

carried out in various ways, as will afterward be clear from the chemical operations.

In chemical art [Chymiotectnia], therefore, two things are to be considered: both the things that serve the operation, and the operation itself. The former are the place and the cause, the auxiliaries.

[Margin: The place fit for chemical operations.]

The place of chemistry is the subject containing the matter to be elaborated — namely, the furnace and the vessel. A furnace is a place in which fire is skillfully and suitably adapted for preparing matter in the chemical way.

CAPUT V.

On Furnaces, Vessels, the Degrees of Heat, and the Other Chemical Operations.

[This Caput-V heading and its subhead appear on p. 239. Note: the prior chapter was Caput IV; the running header throughout this opening reads "DE ORIGINE ALCHYMIAE."]

[Margin: The structures of the small furnaces and their rationales.]

One kind of furnace is open, another closed. The latter is so called because it is open at the upper part, and is either a *Probatorius* [testing furnace] or a *Ventusus* [draft furnace]. The *Probatorius*, or assay furnace [docimasticus], is an open furnace in which metals are purged, examined, or sublimed; it is generally made of clay or of iron plates, as is shown in the first Figure of the following Diagram, where by the *conisterium* we understand the place of the ashes, and by the *pyriterium* the seat of the fire.

Diagram. A full-width engraved plate titled **FABRICA FURNORUM** ("The Construction of Furnaces"), showing six numbered furnace types in cutaway and exterior view. Each furnace is captioned with its name above it and a figure-number. Labels read:

- **Fig. 1 — *Furnus apertus probatorius*** (open assay furnace), upper right: a domed furnace shown in cutaway.
- C (top opening): the upper mouth
- D (upper chamber): the assay chamber
- F, F (mid-level side holes): draft/regulator holes
- C (mid-chamber, lower): the fire-seat

- A, B (lower arched chamber): the ash-pit / base
- E (right side): air-draught hole
- **Fig. 2 — *Furnus ventosus*** (draft furnace), top center: a tall furnace shown in cutaway, with bellows-fed fire.
- F (top): the crucible/upper opening
- D (mid, with flames): the crucible in which metals are melted
- C (left mid): mouth
- E (right side): bellows-nozzle hole
- *Pyriterium supra craticulam* (labeled mid-body): the fire-chamber above the grate
- A — *Conisterium* (base): the ash-place
- (to the right, an undraped curved object on a wooden stand — apparently an associated part, unlabeled)
- **Fig. 3 — *Furnus cæmentatitius*** (cementation furnace), upper left: a tall chimney-furnace in exterior view.
- D (top, with flame-vent): the upper turret through which charcoal is thrown in
- C (mid, with flame-vent): a spiracle
- H (right side): a side feature [the air-hole H of the text]
- A (lower body): the body of the furnace
- H, B (base, ash-door): the ash-removal mouth
- *Pyxis seu tegula cæmentatoria* (labeled below, with a small box/tile object): the cementation box or tile
- **Fig. 5 — *Athanor, Furnus Philosophicus*** (the Athanor, or Philosophical Furnace), center: shown in cutaway with nested vaults.
- E, H (upper left turret): the turret-top features
- D (left turret): the turret through which charcoal is fed
- Q (top of vault): the dome/cover
- P, P (upper vault): the spiracles
- M (mid-vault): the hearth on which the matter is placed
- L (vault): vault interior
- K (lower vault, with grate): the lower fire-vault
- G (lower left): the regulator-hole
- B, C (base left): the ash-mouth features
- F (base center): the fire-channel from the hearth
- A (base): the foundation

- **Fig. 4 — *Furnus Reverberatorius*** (reverberatory furnace), lower right: shown in cutaway as a tiered cabinet.
- I (top): the crown
- *Reverberatorium* (upper shelf, labeled): the reverberation chamber
- K (top right): regulator-holes
- G, F (mid): the openings
- D — *Pyriterium* (middle shelf, labeled): the fire-chamber
- H (right side): a side mouth
- C (with grate): the transverse grate
- B (lower right): the ash-mouth
- A — *Conisterium* (base, labeled): the ash-place
- **Fig. 6 — *Furnus Acediæ*** (the "Furnace of Sloth" / labor-saving furnace), lower left: three connected cylindrical furnaces.
- D (top, shared turret): the turret through which charcoal is thrown
- On each of the three cylinders, top to bottom: C (smoke-vent / spiracle), B (fire-chamber / pyriterium), A (ash-place / conisterium)

Explanations of the Furnaces.

FIG. I. The *Probatorius* or assay furnace is open, one in which the more perfect metals are purged, examined, and — to speak in chemical terms — "fulminated" (refined). Its foundation is marked by the letter **A**. **B** denotes the open mouth of the furnace, or the place of the ashes. **C** is the intermediate part between the lower and upper mouth. **D** is the mouth of the furnace, in which the metallic material to be assayed is placed upon the grate. **E** is the hole serving for moving the coals with an iron. **F, F** are the holes appointed for moderating the fire, fitted with their registers [sliding dampers] for any degree of heat. **G E** is the hole necessary for drawing in air.

FIG. II. The *Furnus ventosus* or draft furnace is open, one in which minerals, stirred up by the force of the fire by means of bellows, are melted and fused. **A** is the place appointed for the ashes of the ash-pit. **B** is the mouth of the ash-pit, fit for drawing in air. **C, C** is the grate sustaining the coals and a vessel set beneath them. **D** is the crucible in which the metals are melted. **E** is the hole fit for inserting the bellows-nozzle. **F** is the hole that serves for emitting smoke.

FIG. III. The *Furnus cæmentatitius* [cementation furnace] is one in which fire is skillfully accommodated for cementing things. **A** is the ash-pit [conisterium]. **B** is the mouth of the hearth, with its iron grate, fit for placing upon it the vaulted tile or the cementation box. **C** are the holes or air-vents in the four sides. **D** is the

small turret through which charcoal is thrown in over the tile or box. **E** are the small mouths fitted with their registers for extracting the ashes and for drawing in air, as is also the hole **H**, which is always open.

FIG. IV. The *Furnus reverberatorius* or calcining furnace, one in which the matter placed in it is calcined by a reverberating flame. **A** is the ash-pit. **B** is the mouth through which the ashes are removed. **C** is the transverse grate. **H D** is the space of the forward hearth. **E** is the mouth through which the logs are placed on the grate. **F** is the floor on which the matter to be calcined is placed. **G** is the opening of the floor, through which the flame, passing through and reverberating, calcines the matter set above the floor. **H** is the mouth through which the matter can be placed on the floor. **I** is the vault or covering for the smoke. **K** are the holes or registers appointed for moderating the heat.

FIG. V. The *Athanor*, which is also called the philosophical or secret furnace, serving especially — as the alchemists suppose — for making the Stone. **A** is the empty foundation of the furnace. **B** is the little mouth of the ash-pit. **C** is the mouth of the tower **C E**, within which the grate is placed. **D** is the tower through which charcoal is thrown in over the grate. **C E** is the iron cover of the tower. **F G** is the mouth through which heat can pass from the hearth **C** into the furnace **K**, fitted with its register **G**. **H** is the spiracle of the tower appointed for drawing in air. **I K L** is the furnace, having its hole **I**, through which the heat enters within the vault **M N**. **O** is the hole through which the heat can enter from furnace **M** into **P**. **P** is the hearth above which the matter to be elaborated is placed. **P, P** are the spiracles together with their registers. **Q** is the completion or covering of the furnace.

FIG. VI. The *Furnus Acediæ* [Furnace of Sloth], in which, with one fire and little labor, diverse furnaces are kept warm, and which can easily be accommodated to any tasks whatever. **A** are the ash-pits [conisteria]. **B** are the fire-chambers [pyritaria], separated from the ash-pits by grates. **C** are the smoke-vents or spiracles. **D** is the small turret through which the charcoal is thrown in.

And let this much, said concerning furnaces, suffice for accomplishing the labors of the alchemists. The remaining kinds of furnaces, see most amply described in *Book XII, Section [?], On the Art of Distillation*, where you will find whatever can be desired concerning the hidden structure of furnaces. [Margin: l. 390.]

[Margin: The various kinds of furnaces suited to various operations.]

The *Furnus ventosus* is likewise an open furnace, in which, by the benefit of wind and bellows, the force of the fire being increased, minerals are melted and fused;

its figure is shown by the second figure of the Diagram. There are besides furnaces which they call *Tecti* [covered/roofed], some of which are simple, others compound. A simple one is that which needs no aid from another, and it is again twofold: calcinatory and cementatory. The former serves for calcinations, the latter for cementations — and the latter is also called *reverberatorius*; the figures of both are expressed in the third and fourth figures of the Diagram. Again, the artificers have certain furnaces which they call distillatory. The *Furnus dissolutorius* [dissolving furnace] is simple, by whose aid, by transmitting the subtle through the gross, things are dissolved; and it is either *Ascensorius* or *Descensorius*. The former serves for distillation by ascent, the latter for distillation by descent, and concerns dry and moist dissolution. It is a dry dissolving furnace when the vessel set in the furnace is touched immediately by the fire. See the figures of each in the fifth and sixth figure of the Diagram.

[Margin: The water-bath. / The bath of Mary (*Balneum Maricæ*).]

There is also a *Furnus balnei* [bath-furnace], in which things are dissolved in hot water held in a copper vessel [ahena], and it is commonly called the bath of Mary [*balneum maris* / *Maricæ*, i.e. *balneum Maricæ*, the water-bath]. But the *Balneum roris* [vapor-bath, "bath of dew"] dissolves them only by the vapor of warm water. — Again it is called *descensorius*, because by its aid, driving the moisture downward, things are dissolved. See the figure in the Diagram.

Having set out the simple furnaces, let us now proceed to the compound ones, where with one fire several furnaces are kept warm — such as those they call *Athanor* and *Acedia*. *Athanor* in Arabic — التنور [Hebrew/Arabic script: al-tannūr] — is the same as "furnace," called by the chemists ἀτὴν ἐχλῶ [Greek: a-tēn-echlō (?)] [?]; so called because it serves the more secret operations in chemistry, and hence it earned the name of the Philosophical furnace. There is a varied manner of building it among various authors. We have selected the one which the eighth figure shows in the Diagram as the better, and more suited to the subterranean furnaces of Nature. [Margin: The Acedia furnace.] It is called the *Acedia* furnace because by one fire and with little labor diverse furnaces are kept warm; see its figure in the Diagram.

[Note: the text refers to an "eighth figure" of the Diagram, but the plate as printed shows only six numbered figures (the Athanor being Fig. V). This is the author's or compositor's figure-numbering discrepancy, transcribed as printed.]

§. I.

The Account of Vessels.

One kind of vessel is brought to the fire, another is not. Some are of glass, some of earthenware, some of metal. Of glass are all those vessels commonly called *phialae* [phials], *vesicae* [bladders/flasks], and *urinaria* [urinals/receivers], which are frequently used in solutions and coagulations.

[Margin: Circulatory vessels.]

Of glass too are mostly made the vessels they call *circulatoria* [circulatory vessels], because the liquor poured into them is agitated, as it were in a circle, by ascent and descent; their use in chemistry, for subtilizing liquors, is great. They are of various shapes. The more usual ones are those they call the *Pelican*, the *Dyota*, and the *Caecum* [the Blind]. See the figures.

[Margin: The Philosophical Egg.]

There is also a vessel they call the *Ovum Philosophorum* [the Philosophers' Egg], whose uses will be taught in what follows; it is either of earthenware or of metal,

[Full-page engraved plate — "Tom. II. 241"]

Diagram. A full-page engraved plate (uncaptioned) depicting a solar burning-apparatus used for distillation. At upper right, the Sun (with a face) emits a dense fan of rays. These rays strike a large spherical lens or burning-globe mounted on a tall pedestal stand at the left, which concentrates and re-emits the rays downward to the right onto a distilling apparatus standing on a table. Readable labels:

- **F** (upper right): the radiant Sun
- **E** (large globe/lens on the stand): the burning-globe (water-filled sphere / lens)
- **H** (below the globe, on the pedestal): the neck/socket holding the globe
- **B** (mid-stand, with a horizontal rod): the adjustable arm/axis of the stand
- **i** (small upper bulb of the apparatus, right): the alembic head / receiver-bulb
- **A** (the body of the cucurbit/flask below i): the distilling-flask
- **C** (the furnace base beneath A): the furnace / heating-base supporting the flask
- **K** (a separate flask set on a box at far right): the receiving vessel

No labels flagged [?]; all eight readable.

just as the copper cauldron is. The **bladder-vessel** [vesica] is a metal vessel made of copper in the form of a bladder, or of an egg, as is clear in the figure. Its use is in distilling vegetable substances.

The vessels that serve for melting are the **funnel** [infundibulum] and the **pyramid** [pyramis]; the **ash-pan crucible** [catinus cinereus] and the **crucible** [crucibulum], as appears in the figure.

[Margin: The ash-pan crucible, from what materials it is made.]

The **ash-pan crucible** [catillus cineritius] is a melting-vessel made from the ash of light oak wood, thoroughly cleansed of all charcoal and other impurities of the residue. It is made from two parts of this, together with one part of the best-pulverized ash of bones that lack marrow (excepting pig-bones), moistened and properly blended in its own mortar. The crucible [crucibulum], being a vessel commonly known, needs no explanation.

Among the non-melting vessels there is the **cementing box** [pyxis caementatoria], that is, an iron vessel formed of clay obstinate against fire, in the manner of a box, fitted neatly with its own lid; see the figure.

[Margin: Alembic.]

What the **alembic** [alembicus] is, is commonly known. It is set upon a vessel, which is called the **gourd** [cucurbita], and the **retort** [retorta]. The figure of all these you may see in the engraving [in Schematismo]. The remaining vessels, together with the instruments — so that nothing be lacking for this work — consider in the engraving.

§. II.

Caloris adhibendi ratio.

[The method of applying heat]

Heat, to be applied in chemical operations, is the assisting cause by which the substances to be treated are hastened and fostered; and it is either natural or artificial.

Natural heat is when the rays of the Sun either by themselves bake the material set before them, or — gathered in a concave mirror — are brought to bear upon the thing.

[Margin: The reflected rays of the Sun by means of a mirror.]

The use of this heat is immense in dissolving and calcining metals; and in the northern regions indeed that anacampitic [reflected] heat can have its place, but not so in the southern. For, as is wont to happen in Egypt, things are dissolved most powerfully not by the reflection of the Sun's rays, but by the heat of the burning Libyan sand alone, when the vessels are set into it.

[Margin: The deception of chemists concerning the Sun's reflection by a mirror onto a chemical vessel.]

This too is most worthy of observation in concave mirrors: that unless someone perpetually attends the work, who continually applies the deflected ray to the glass bladder, they can produce no effect — since the Solar radiation [actinobolismus Solaris] is not perpetual, as many of the chemists, ignorant of the anacampitic faculty [anacampitica facultas], persuade themselves, namely that it remains fixed upon the gourd, but rather changes its position together with the Sun's motion. Since I have pursued all these matters at length in the *Ars Magna Lucis et Umbrae*, I refer the reader there. From which, in order to dissolve things ingeniously, I judged that this machine could be made.

Let the vessel A be a glass gourd set upon a tripod with the alembic I; let a rounded peg be soldered to it below at the place D, and let an iron arm D G, capable of being turned, be inserted into it, so that it may rotate as if about an axis D. To this arm, at the place G, let there be raised perpendicularly

another arm G H, which holds a concave mirror; let the mirror be E.

[Margin: A new machine for dissolving things by the Sun's reflected rays.]

Therefore let the mirror E be so applied to the Sun's rays that, reflected, they strike the gourd A; and as the Sun recedes, let the mirror, together with its arm, be turned around until the rays again strike the gourd. In this way the reflection of the rays affects the gourd with a constant heat. But since, according to the altitude or depression of the Sun, the reflected rays also receive a different position, we have for this reason added to the gourd a smooth peg, so that by its help the gourd — now raised, now lowered — may more easily, according to the Sun's position, receive its reflected rays. Unless this be done, you will accomplish the chemical work only with the greatest difficulty by the Sun's reflected rays, since the actinobolism [actinobolismus], or solar radiation reflected from the mirror, continually changes, and scarcely for as long as one might finish reciting the *Miserere* psalm by reading does it rest upon the gourd. But this whole

procedure [encheiria] you will carry out more easily with a glass globe filled with water, and likewise with the happiest success — the rays being refracted and aimed at the gourd in a direct vibration. But now let us return to heat.

Artificial heat is that which can be kindled, directed, and administered at the artisan's will.

[Margin: What artificial heat is.]

It is twofold: **Digesting** [Digerens] or **Separating** [Separans]. Digesting heat is that by which the material to be dissolved is digested; and digestion is for the most part accomplished in the Athanor or in a furnace. It is done in the Athanor when, the tower of the Athanor having been filled to the very top with charcoal, we kindle the fire in the hearth, and with an iron spatula or register we open or close the little door at our discretion (so that in this way the heat may be transferred to the Athanor). And in this way the digesting heat can be distributed, as it were, into certain grades, so that at the beginning the material tends toward whiteness, in the second grade toward yellowness, in the third toward redness.

[Margin: Heat of dung.]

Heat of dung [calor fimi] is when, the vessel having been placed in dung, digestion takes place; and it serves very greatly for digesting and putrefying things. Sometimes horse-dung is used, in which the vessel is buried; sometimes sand, or an iron pit, and the like, concerning which more in what follows. (*L. XII, Sect. 3, de arte distillatoria* [Book XII, Section 3, On the distilling art].)

[Margin: Separating heat.]

Separating heat is that called by whose help the subtle is separated from the gross; and for a gentle heat indeed they use the bladder-vessel [vesica], or the ash-hearth.

[Margin: Heat of the bladder-vessel.]

The heat of the bladder-vessel is a gentle heat, by which, the alembic being applied, the moist substance is drawn out from the material placed in the bladder-vessel.

[Margin: Heat of ashes.]

The heat of ashes is when the moist parts are drawn out through ashes.

[Margin: Strong heat. / Free heat.]

Strong heat [fortis calor] is when things are separated by a more intense or sharper fire. **Free heat** [calor liber] is that which touches things immediately; **impeded** [impeditus], that which does so by means of something else.

[Margin: Heat of charcoal.]

Heat of charcoal [calor carbonum] is when the heat of the coals touches things immediately; its use is in cementation, assaying, calcination, and dissolution.

[Margin: Heat of flames.]

Heat of flames [calor flammorum] is when, wood being laid on,

[the wood being laid on,] the heat passes into flames; and its use is in reverberating and calcining all the bodies of the metals.

[Margin: Heat of the bath.]

Heat of the bath [calor balnei] is when things are distilled either by boiling water, or by the vapor of it as an intermediary.

But all these things we have judged should be set before you, reader, in the following resolute Table, presented to the eye in a single synopsis.

Diagram. A full-page synoptic bracket-table (the *Tabula Chymio-Technica*, "Chemico-Technical Table"), a branching dichotomous outline classifying the whole subject matter of chemical technique. The classification is reconstructed below from the nested brace-brackets.

The two grand divisions, on the far left, are:

- **Things serving the operation, which are** [Operationi servientia, quae sunt] — apparatus
- **The operation itself, which is** [Operationem ipsam, quae est] — the processes

I. Things serving the operation divide into:

A. Place [Locus] — i.e. the furnace and the vessels:

- **Furnace** [Furnus]:
- **Open** [Apertus]: Assay-furnace [Probatorius]; Draught-furnace [Ventosus].
- **Closed** [Tectus]:

- **Simple** [Simplex]:
- **Calcining** [Calcinatorius]: Cementing [Caementatorius]; Reverberatory [Reverberatorius]. — also: of the bladder-vessel [Vesicae].
- **Dissolving** [Dissolutorius]: Ascending [Ascensorius] — Dry [Siccus]: ash-pan crucibles [Catini arenarii]; Descending [Descensorius] — Moist [Humidus]: bath [balneum].
- **Compound** [Compositus]: Athanor [Athannor]; Acediae [furnaces].
- **Vessels** [Vasa], the other component pertaining to fire:
- **Made of a definite material** [Ex certa materia factum]:
- **Glass** [Vitreum]: Phials [Phialae]; **Circulatory** [Circulatorium]: Pelican [Pelecanus]; Dyota; Egg of the Philosophers [Ovum Philosoph.].
- **Metal** [Metallicum]:
- Serving **subtilization** [Subtiliationi]: the bladder-vessel [Vesica]; the copper cauldron [Ahenum].
- Serving **melting** [Fusioni]: Funnel [Infundibulum]; Pyramid [Pyramis].
- **Mineral / earthen** [Minerale / Terrenum]:
- **Receiving the material** [Materiam capiens]:
- **Melting** [Fusoria]: Ash-pan crucible [Catillus cinereus]; Crucible [Crucibulum].
- **Non-melting** [Non fusoria]: Cementing box [Pyxis caementatoria].
- **Another vessel** [Aliud vas]: Sand-pan crucible [Catinus arenarius]; Vaulted tile [Tegula fornicata].
- **Vessels for the operation, at the artisan's discretion** [Operationi inservientia, pro artificum arbitrio]:
- **Upper** [Superiora]: the cooking-vessel [Coctus]; Alembic [Alembicus]; Beaked [Rostratus].
- **Lower** [Inferiora]: Gourd [Cucurbita]; Retort [Retorta].
- **Not moved** [Non admovetur]:

- **Containing** [Continens]: Receiver [Receptaculum]; Shell-dish [Concha].
- **Transmitting** [Transmittens]: Funnel-tube [Tritorium]; Separator [Separatorium].

B. The assisting cause [Causa adjuvans]:

- **Hand-instrument for the fire** [Instrumentum manuarium igni]:
- **To be applied** [Admovendum]:
- **Always** [Semper]:
- **Slender** [Gracile]: Grating [Craticula]; Iron rod [Baculus ferreus].
- **Broad** [Latum]: Spatula; Forceps [Forfex].
- **At discretion** [Ad arbitrium]: Fire-shovel [Rutabulum]; Spoon [Cochleare]; Ring [Circulus].
- **Not to be applied** [Non admovendum]:
- **Wooden** [Ligneum]: the dioptra [dyoptra].
- **Metal** [Metallicum]: Iron plate [Tabula ferrea]; Little mortar [Mortariolum].
- **Heat** [Calor]:
- **Natural** [Naturalis]: the Sun's rays [radii solares].
- **Artificial** [Artificialis]:
- **Simple** [Simplex]:
- **Digesting** [Digerens]: Athanor [Athannor]; Dung [Fimus].
- **Separating** [Separans]: of dung [Senis (recte: Fimi?)] — of the bladder-vessel [Vesicae]; of ashes [Cinerum]; of sand [Arenae]; of iron filings [Scobis ferri]. **Impeded** [Impeditus]. **Strong** [Fortis] — **Free** [Liber]: of charcoal [Carbonum]; of flame [Flammae].
- **Mixed** [Mistus].
- **Bath** [Balneum]: of the sea [Maris]; of dew [Roris].

II. The operation itself [Operatio ipsa] divides into:

- **Calcination** [Calcinatio]:
- **Corrosion** [Corrosio]: Vaporous [Vaporosa]; Immersive [Immersiva] — Moist [Humida]: Amalgamation [Amalgamatio]; Precipitation [Praecipitatio]. Dry [Sicca]: Cementing [Caementum]; Commixture [Commixtio].
- **Ignition** [Ignitio]: Combustion [Combustio] — Vitrification [Vitrificatio]; Reverberation [Reverberatio] — Incineration [Incineratio].
- **Solution / Dissolution** [Solutio / Dissolutio]:
- **Elevation** [Elevatio]: Dry sublimation [Sicca sublimatio]; [Greek: μετεωρισμός (meteōrismos, "raising up / elevation")].
- **Subtilization** [Subtiliatio]:
- **Descent** [Descensio]: Hot [Calida]; Cold [Frigida] —
- **Direct** [Directa]: by the Alembic [Alembici]; by the bladder-vessel [Vesicae].
- **Oblique** [Obliqua]: by the Retort [Retortam]; by the side [Latus].
- **Moist** [Humida]: Circulation [Circulatio]; Deliquescence [Deliquium]; Washing [Ablutio]; Filtration [Filtratio]; Imbibition [Imbibitio]; by leather [Corio].
- **Exaltation** [Exaltatio]; [Greek: μετεωρισμός (meteōrismos)]; Putrefaction [Putrefactio]; Digestion [Digestio]; Extraction [Extractio]; Cohobation [Cohobatio].
- **Liquefaction** [Liquefactio]:
- **Simple** [Simplex].
- **Assaying** [Probatoria], by means of: the ash-cupel [Cineritium]; Antimony [Antimonium].
- **Coagulation** [Coagulatio]: Cold [Frigida]; Hot [Calida].

CAPUT VI.

Canones Methodici & Paradigmatici, queis operationes Chymicae per experimenta, & varia Exempla singulis operationibus propria ostenduntur, & comprobantur.

[Methodical and Paradigmatic Canons, by which the chemical operations are demonstrated and proven through experiments and through various examples proper to each operation]

So that the reader might perfectly understand what is meant by so many and so manifold chemical operations, and what those operations accomplish in the chemical pyrotechnics, and what use they have, in this chapter I have decided to set forth not only the [Greek: κατὰ τὴν θεωρίαν (kata tēn theōrian, "according to theory")], but also the [Greek: κατὰ τὸ ἐγχείρημα (kata to encheirēma, "according to the operation / undertaking")] — that is, the practical and manual operation — through various examples and experiments proper to each operation, for the sake of the curious reader. And first indeed we shall begin with calcination, and the manner of calcining each individual thing.

Paradigma Experimentale I.

[Experimental Paradigm I]

De Modo calcinandi res.

[On the manner of calcining things]

[Margin: What "calx" means among chemists.]

We said above that calcination is nothing other than the dissolution of coagulated things. Now **calx** [calx], in the chemical signification, is any powder comminuted into the finest and almost impalpable parts by the removal of superfluous moisture; and it is produced either by **corrosion** [corrosio] or by **ignition** [ignitio].

[Margin: How things are calcined by smoke.]

The former resolves coagulated things into calx by means of corroding spirits, either by vapor or by immersion. Things are resolved by smoke or vapor when metallic bodies, reduced to thin sheets, are calcined by an acrid, corroding smoke. And this can be done either when the laminated bodies are suspended over strong waters [aquae fortes], or over vinegar, or over the residue of pressed

grapes (which they call *Vinaccia* [grape-marc]). Sometimes too the nobler metals especially are rendered brittle by the breath of molten lead, or of quicksilver. Through calcination, therefore, all metals become, as it were, charcoal and ash by the power of the windy fire alone — by which all tenacious, soft, and greasy earth turns to stone, and stones indeed are reduced to lime, as may be seen in the potters' kiln for lime and bricks.

EXEMPLUM I.

[Example I]

Quomodo Crocus Martis ex Chalybe per vaporosam corrosionem calcinetur.

[How the Saffron of Mars (crocus Martis) is calcined from steel by vaporous corrosion]

First you will prepare a strong water [aqua fortis] from equal parts of saltpeter [sal petrae] and vitriol [vitriolum] calcined to whiteness, and you will pour it into a glass gourd. Then in the upper part of the gourd you will suspend sheets of steel [chalybs], and — the mouth of the vessel having been sealed with lute [lutum], so that the spirits of the strong water cannot in any way exhale — you will allow it to evaporate in warm sand for the space of 24 hours. Then, the vessel being opened, you will take out the sheets, to which you will find a saffron [crocus] adhering in the form of a most subtle powder, which you will wipe off with a hare's foot or some other instrument. And in this way, always repeating the same operation, you will proceed until no further saffron extracted by the spirits appears on the sheets.

CONSECTARIUM.

[Corollary]

[Margin: How lead is calcined.]

In exactly the same way you will calcine lead into ceruse [cerussa], namely if you suspend it over vinegar within a gourd.

[Margin: How copper [is calcined].]

And copper sheets suspended within the vessel over the residue of pressed grapes are calcined by the corrosion of the vapors.

EXEMPLUM II.

[Example II]

Quomodo immersiva corrosione res calcinentur.

[How things are calcined by immersive corrosion]

This operation is accomplished either by **precipitation** [praecipitatio] or by **amalgamation** [amalgamatio].

[Margin: What precipitation is.]

Now precipitation is when bodies, eaten away by corroding waters and dissolved into water, are beaten back into calx by the withdrawal of the corroding water, or by any other means. In this way silver dissolved in strong water is said to be precipitated by throwing in copper, common salt, or sal ammoniac [sal ammoniacum].

[Margin: Precipitation of silver.]

[Margin: How gold [is calcined].]

So too gold dissolved in aqua regia [aqua regia] is beaten back by adding a small portion of quicksilver; and if a little sulphur be mixed with it, and it be set to the fire in a closed vessel, then — the quicksilver and sulphur having evaporated — a most subtle calx is left at the bottom. And the more the bodies are dissolved, the more, and the more subtly, are they calcined.

[Margin: What amalgamation is.]

Amalgamation, since it is nothing other than the calcination of a metal by means of quicksilver [hydrargyrum], is the means by which you will calcine bodies in this manner: let the metal, drawn out into thin foils or sheets, be mixed with six, nine, or twelve parts of quicksilver, and be united, so that a mass everywhere uniform with itself is made. And in this way you will obtain the metal discontinuous and calcined; for, the quicksilver having been raised by evaporation over a gentle fire, the metal is left in the form of a thin calx.

PARADIGMA I.

[Paradigm I]

Praecipitationis Mercurii per solutionem, seu calcinationem. Ita autem procedunt Artifices.

[Of the precipitation of Mercury by solution, or calcination. The artisans proceed as follows]

They take half an ounce of the best-purified gold, and reduce it into thin little plates, and dissolve it in aqua regia made from common salt and not from sal armeniac [sal armeniacum] (because the latter renders the mercury volatile),

Liber XI — *Chymiotectnicus*, Sectio I

Caput VI — *Canones Methodici & Paradigmatici* (continued)

[Fol. 244 — Paradigma I, continued]

[Margin: Ἐκπάνωσις [Greek: ekpanōsis, "expansion/development" (?) — the term as printed is corrupt; apparently meant as a label for "the operation"], or operation.]

[the solution] made; afterwards they take half an ounce of the best glass of antimony [vitrum antimonii], and dissolve it in the same way in aqua regia. They also dissolve three ounces of quicksilver, well washed and purified, in aqua fortis — so that the three liquids are clear and transparent, with nothing appearing in them that is not dissolved. They combine these solutions and repeatedly separate off the liquids from the precipitate, always drawing off the liquid and pouring on fresh aqua regia, until the mercury, placed on a red-hot iron plate, no longer gives off any smoke. Finally, once the spirits of the aqua regia have been thoroughly driven off, they pour on spirit of wine to the height of three fingers, and distil it six times from the precipitate over a strong fire, until the mercury is fixed and gives off no smoke from itself. You will then calcine it under a vaulted tile [tegula fornicata], properly heated to red according to the art.

[Margin: Calcination is the mortification of metals.]

You see, therefore, that calcination is nothing else to the chemists than the mortification of minerals and metals, as Paracelsus puts it. Gold, for example, is mortified by calcination so that it may be reduced into a tincture, a quintessence,

a resin, a saffron [crocus], a vitriol, and a sulphur. The method and the assaying of each of these you will find in what follows, and especially in the final book.

Paradigma II

How a metallic body may be calcined by corroding and desiccating salts, through cementation.

[Margin: What cementation is.]

Cement, or cementation [cæmentatio], is nothing else than a dry corrosion, by which metallic bodies — stratified with the aid of corrosive liquids — are broken apart and calcined. We give you an example of this in the preparation of crocus Martis, or saffron of steel, by cementation. The procedure of the craftsmen is as follows.

[Margin: The method of cementing.]

The body to be cemented is reduced into thin plates and cut into small pieces with shears. The corroding substances [species corrodentes], for their part, are pulverized and moistened with vinegar, urine, or aqua fortis, so that they form a kind of paste — though some use them dry. Then some portion of this paste, or powder, is put into a cementing box [pyxis cæmentatoria], and a plate is laid over it; over that plate another portion of powder is sprinkled (this is called *stratification*, and "making layer upon layer"); another plate follows this, and so on, until the box is filled, or until no plate remains. [recte continues on Fol. 245-equivalent text — but here the column continues directly; see next.]

and finally it is closed off with powder laid on top, and stopped up, the joints of the box being secured with another tenacious lute [clay sealant]; and it is set upon the fire, or (what is better) in its own furnace, and is cemented by degrees for four, six, eight, twelve, or twenty-four hours — indeed, even for several days, as the case requires, it is kept in there. At last, once the box has cooled, it is taken out, and the plates are separated from the powder; they are found wholly broken apart and calcined.

For example: the intention is to prepare crocus Martis, or saffron of steel, and that by cementation. Then I take as much fresh quicklime [calx viva] as is needed, and moisten it with urine until it becomes like a porridge. Afterwards I coat the bottom of the cementing box with this pulp to the thickness of a broad finger, and add plates of steel on top of it, and fill the vessel as was said, and seal it firmly with lute. Everything duly prepared,

[Margin: Crocus Martis.]

I place the box in our cementing furnace, and apply a continuous fire of the third grade rising to the fourth for twenty-four hours. At last, the vessel being removed, I thoroughly pound the material contained in it in a mortar, and pass it through a sieve, so that it becomes a very fine powder; here I wash away with hot [water] all the lime from the steel, and take the residue — a most excellent crocus Martis. In the same way crocus Veneris [saffron of copper] is also made, which can serve for many operations.

Paradigma III

The method and procedure for calcining antimony by the species of calcination they call commixtion, with the aid of sulphur, saltpetre, and common salt.

I take of stibium [antimony ore], saltpetre, and common salt equal parts — that is, equal amounts — and, ground very fine and mixed together, I place them in a crucible well secured with lute, but in such a way that some small hole is left in the middle of the surface, through which the arsenical and poisonous spirits may exhale. I set it in a wind-furnace [furnus venti] and kindle a melting fire; and if I wish, I also employ the service of the bellows, so that they may flow sufficiently in the crucible.

[Margin: The method of calcining antimony.]

Here, however, one must carefully note how long the smoke ascends through that hole left in the surface: for as long as it is still evaporating, it indicates that the material is not yet sufficiently calcined. But when all such fuming spirits have vanished, I increase the fire nearly to its full strength for a quarter of an hour; and at last I remove the crucible, and once it has cooled I open it and extract the material, where I find the antimony in the bottom separated from the soot, just as the regulus is from the slag. This antimony I knock off from the salts with a hammer, and grind it into a powder, which is as red as cinnabar, and most suitable in medicine for compounding certain very excellent remedies. And as this is the best method of calcining antimony, so it is also the most celebrated — both because it can be carried out within the space of half an hour [continues on Fol. 245]...

[Fol. 245 — running header "DE ORIGINE ALCHYMIÆ."]

and because it retains no salt with itself, but expels it from itself.

It remains now to say how metallic bodies are reduced to a calx [lime/oxide] by the violence of fire, through combustion and reverberation — of which the former occurs by incineration, the latter by vitrification.

Paradigma IV

How metals, by vitrification, may be converted out of combustion into a transparent glass.

[Margin: What incineration is.]

[Margin: What vitrification is.]

Incineration will be treated more fully in connection with vegetable and animal substances; therefore in this place we shall speak only of minerals, which are reduced to a calx alone, and not into ashes. So then, take this experiment of how quicksilver, or hydrargyrum, is vitrified.

[Margin: The procedure.]

They take red oil of vitriol [oleum vitrioli rubeum], made according to the art and rectified; in this they dissolve quicksilver — washed and purified by sublimation, or by salt and vinegar — and they keep it warming continuously in heat for so long, until no mercury at all, neither living nor precipitated, appears any longer, but the whole lies hidden in the oil in liquid form. This done, they pour this oil containing the mercury into a glass retort suited to the quantity of the material, and place it in a sand-bath [catus arenarius]; and with the fire kindled, they drive the oil off from the mercury into an adjoining receiving vessel. And thus the mercury will have been reduced to a calx by precipitation. Of this precipitate I take two ounces, and of lime, silver, and sal ammoniac one ounce each [ana unciam unam]; these, ground and mixed together and placed in a phial, they prepare for sublimation, where the sal ammoniac ascends, and the mercury together with the Moon [Luna = silver] — the weight being likewise preserved — remain in the bottom in the manner of the purest gold. Afterwards, in a strong glass, or in a crucible coated with glass [crucibulum devitreatum], they set it in a wind-furnace to flow; and with the fire increased, it passes into a fixed and transparent glass, which seems to have descended from a golden colour to a paler one.

[Margin: Lunar glass.]

This glass is of infinite virtues, as they suppose — to recount each of which in this place is neither part of our plan nor of fairness; rather, having demonstrated the

manner of making it, we commit it to the skilful investigator of chemical medicine [chymiatría].

Paradigma V

How gold may be vitrified into a transparent substance, according to the mind of Libavius.

[Margin: Gold vitrified.]

Take half an ounce of the purest gold, and eight ounces of Hungarian antimony [Antimonium Ungaricum]: place them in a melting-pot over the fire, so that they melt together; and once it is melted, pour it out — but take care that it does not turn into a regulus. Pound this mixture well and thoroughly, so that it becomes a most subtle powder, which is to be calcined in the same way that they calcine antimony when they wish to make glass, until it no longer fumes. So then, when you have the powder thus fixed, set the melting-pot on the fire so that it glows fully, so that it turns into glass; afterwards little by little pour the powder into the glass in the same manner, so that it flows just so long, until this glass becomes red and transparent — which you can test with some iron rod; and you will find the gold in the bottom of the crucible diminished by half. Pour the glass into a basin, and you will have transparent gold, mixed with glass of antimony in equal weight.

Paradigma VI

How sulphur may be worked into a glass by ignition.

Take a great quantity of common sulphur, and place it in a crucible, or in a [earthen] dish — three *lotones* [a unit; $\sim\frac{1}{2}$ ounce] at a time — under an ignited vaulted tile, so that it burns. When that sulphur is burned, put another three *lotones* in the dish, so that this too is burned; which you will do until one pound has been burned in the dish, and you will see some ash of a grey colour. But of this pound of sulphur you will take no more than two drachms of ashes; of the second [pound], and the rest, you will take a whole *loto*. Burn in the aforesaid manner ten pounds of sulphur, and that ash, which was previously grey, will become red like blood, and in the following manner will pass into a ruddy glass.

[Margin: How to vitrify sulphur.]

Take of this red ash, very well ground, half an ounce, and of borax one drachm, and melt with a most intense fire; and there will be made a certain transparent glass, endowed (as they say) with remarkable virtues.

Paradigma VII

How a tincture of antimony may be extracted by reverberation, according to the mind of the chemists.

[Margin: Reverberation, or ignition.]

To ignition belongs reverberation [reverberatio], by which stibium and other bodies are reduced into a subtle calx by a reverberating and reperiussing fire, through closed or open reverberation.

[Margin: The procedure for preparing a tincture of antimony.]

Equal parts of antimony and sal ammoniac are taken, and placed in a retort, and driven by a strong fire; there all the antimony passes over, and nothing remains in the body of the retort but a turbid dregs. This antimony, thus dissolved through the retort — the sal ammoniac being separated by frequent washing, so that it is left sweet, tainted by no saltiness — I dry and grind most finely, and convert into an alcohol [a fine powder], and place it in our reverberatory [furnace]; and with the fire of the flames kindled, I open just one flue [fumarium] for a while, until our antimony, which was red, is turned into whiteness. When it has become white, I open the second flue, until the increased fire strips off the whiteness from it and adorns it with a yellowness. As yet more yellowness appears [continues on Fol. 246]...

[Fol. 246 — running header "LIBER UNDECIMUS, Sect. I"]

with the third flue opened, I advance it to a citron colour, and with the fourth I bring it to a perfect redness. Onto this red antimony I pour rectified spirit made from wine, and I extract the essence, or tincture, in a closed vessel. When the spirit of wine is no longer tinged with colour, I draw it off from the tincture. This is the true preparation (as they say) of the tincture of antimony, of which Theophrastus [Paracelsus] makes mention.

Paradigma VIII

How, by subtiliation, the more subtle dry parts may be raised together with the adherent [substances] of their vessel, and may be sublimed in a long or a short time.

[Margin: What subtiliation is.]

[Margin: Twofold.]

Subtiliation [subtiliatio] is a dissolution by which the more subtle parts are raised from the gross, the spiritual from the corporeal, the volatile from the fixed, in the manner of smoke, by the force of fire, and are condensed at the top of the head [capitellum] of [the vessel]. Sublimation comprises under itself exaltation, elevation, and fixation, and accomplishes a wonderful change in things; for in it the pure is separated from the impure and fixed, in such a way that it remains unaltered in the fire. For if that which has been sublimed is again ground with its dregs and mixed, and sublimed again as before — which will be done so many times until it no longer sublimes, but all remains together in the bottom and is fixed — from these there is afterwards made a stone and an oil, when and as often as you wish. Namely, if you set the cooled [matter] in the air, or in glass, there it is at once dissolved into an oil; and if this is again committed to the fire, it will once more be hardened into a stone of great virtue.

[Margin: The wonderful power of sal ammoniac.]

We shall in due time tell how, by the working of this, many corrosives are turned into sweet things, and sweet into bitter. It is also a marvel that any metal whatsoever, sublimed by means of sal ammoniac, is turned by cold into an oil, and by fire into a stone — which the alchemists reckon one of the greatest mysteries of Nature, to transmute a metal into a stone. But what this has to do with the [Philosophers'] Stone which generates gold, I do not see, since to transmute that [stone] back into a metal is impossible, because it is essentially distinct from a metal; and therefore it ought to be called only accidental. For it seems a stone, which in reality, of itself and by its own nature, is not a stone. Paracelsus greatly triumphs in this experiment, in support of the truth of the great Art.

[Margin: [Handwritten marginal annotation, partly legible:] [?] in praxi [?] / Petrus [?] / Reg. 1 [?]]

But let us give an example of how flowers of sulphur [flores sulphuris] may be made by this art. Proceed thus:

[Margin: The method of making flowers of sulphur.]

Take some material to be sublimed, and — either alone, or mixed with other materials — enclose it in some glass or earthen vessel, broad or deep below, so that with two parts empty, the third is filled. Onto this vessel, or cucurbit, set a blind alembic [alembicus cæcus] pierced at the top with a small hole, with lute laid over it, so that the spirits or sublimed parts cannot exhale; secure it firmly.

Then place it in a sand-bath, three fingers from the bottom and walls, with sand intervening, or set it in a free fire, and increase the heat by degrees.

[Margin: Another procedure.]

By first placing some smooth iron plate in the glass, you will easily test it. For when any moisture is still left, it adheres to that plate; but when all the moisture has departed, dry spirits ascend, and then close the hole of the alembic, fortified with some glass laid over and with good lute, so that the spirits do not escape; and at last keep up the fire for a while, until all the material to be sublimed has been elevated. Some, in place of the cucurbit, use a little dish [scutella] or some iron shell containing the material, with a glass cone duly fitted to the walls of the lower vessel.

For example: I take of well-purged citrine [yellow] sulphur two pounds, of common salt and of slightly calcined Hungarian vitriol half a pound each, each pulverized and mixed together; I place them in a cucurbit, and with a blind alembic perforated at the apex set on, kindling a fire of the first grade until the moisture has vanished, then with the opening closed proceeding by degrees, until all the finer sulphur ascends. This sulphur — called by the chemists flowers of sulphur — once taken out of the alembic, I rectify, a second or even a third time always adding a fourth part of salt and vitriol replenished by sublimation; and I obtain the most beautiful flowers of sulphur, resistant to very many affections [influences].

Consectarium [Corollary]

In this way you will likewise accomplish the sublimation of sal ammoniac. Take as much common salt as you wish, and fill a pot with it, and cover it, so that no coals or ashes fall into it; place the pot in the ground, and cover it with extinguished coals; then, the coals being kindled to the glowing of the pot, and these in turn reduced to ashes, you will find, in the cooled pot, the salt prepared — which may be called calcined salt.

[Margin: The sublimation of sal ammoniac.]

Then take one pound of ground sal ammoniac, and an equal quantity of added iron filings; sublime the mixture, grind this sublimate again, and sublime it, and when the salt has glowed white, you will have completed the sublimation. Of this sal ammoniac thus prepared take as much as you find, and of calcined salt 12 [parts/ounces — figure as printed]; grind them together, and with it sublimed

seven times, adding the prepared salt each time, and you will have what was sought.

[Margin: Sublimation of moist things, twofold: straight and oblique.]

Sublimation — which is also called moist elevation — is nothing else than the distillation of parts attenuated into vapours, by which the subtle parts are separated from the gross; and it is either straight or oblique. The straight is when the moist, more subtle parts, raised upward and adhering to the vault of the cold alembic, are condensed into a moisture, and through its beak [rostrum] distil drop by drop into its receptacle and fall back. The moist oblique elevation is when, with the vessel lying obliquely, the moisture is raised; and it occurs either through the side or through a retort. Through-the-side elevation is accomplished when, with the vessel inclined obliquely and to the side, the moisture [continues on Fol. 247]...

[Margin: Oblique sublimation, what it is.]

[Fol. 247 — running header "DE ORIGINE ALCHYMIÆ."]

slips forward, as is plain from the apparatus of the schematism [vasis Schematismi]; in which way the best red flowers of antimony are usually prepared. Elevation through a retort is when the moisture is driven from the retort. Each of these two methods has its use in things that are endowed with more tenacious spirits.

For example: if you wish to make by this operation the no-common oil of the Philosophers [oleum Philosophorum], proceed thus:

[Margin: How the oil of the Philosophers is to be prepared.]

Take of the purest wax 15 ounces, of turpentine 18, of benzoin 1, of rectified spirit of wine 30, of common ash 6; mix them, and distil according to the art through a retort, and there will come forth phlegm, water, and oil, which you will separate from one another and keep each apart. The water will be of use against the plague, and the suffusion of the eyes [cataract], for the healing of all wounds, and for obstruction of the urine; against the pricking of the sides, or pleurisy, the oil is wonderfully helpful. But of these things [we shall treat] more fully in their place hereafter; for the vessels, see in the following book, in the section on the distilling Art.

From what has been said you have how moisture is raised by sublimation. It now remains for us also to give examples of the operation by Descent, hot or cold.

Now hot Descent [Descensio calida] is the distillation of a liquor from dissolved bodies, with the vessel inverted. For since certain bodies — such as bones, woods, and the like — whose moisture cannot, on account of its weight, ascend upward, [exist], so by descent we must obtain the effect of sublimation. Consult the vessels in the following book.

Paradigma IX

How distillation by Descent of heavier things is to be accomplished.

Take an earthen cucurbit, and put into it the fragments of the things to be dissolved; and, lest they fall out when the cucurbit is inverted, cover them with some larger fragments, or with little rods laid crosswise next to them. This done, apply another cucurbit, in which there is a little water, to this inverted one, so that the upper exactly meets the lower at the orifice. But between the two it is proper that some iron plate, strong enough, concave like the pan of a balance and perforated, be placed, which may hold back the falling fragments lest they slip down into the vessel set beneath. Finally, dry the closures made fast with the best lute, and set the vessel in its furnace, and place the receiving vessel in sand or in ashes, so that, being safe from the violence of the fire, it may the more easily receive the moisture forced down [into it].

Now how cold distillation by descent — which they call *deliquium* [deliquescence], or filtration — is to be carried out, take [the following]:

[Margin: What *deliquium* is.]

Deliquium is a cold descent, when coagulated bodies, exposed to a cellar, to the air, to a well, or to some other cold and moist place, upon marble, a glass slab, or what they call a *permanica* of Hippocrates [a conical filtering bag/sleeve], by the benefit of external humidity — which is joined to the dissolving bodies — are dissolved into a moisture, and flow down into the vessel placed beneath. They are dissolved especially in the cold: powders that have been calcined, salts, and other bodies of this kind, which savour of the nature of salt, which are dissolved in the cold and again coagulated in the heat.

[Margin: What filtration is.]

Filtration is a cold descent, which lets the watery humours pass down through a filter — a woollen cloth, linen, silk, or absorbent paper rolled up, or folded in the manner of a funnel — leaving the dregs in the filter.

Exaltation, or subtiliation, has besides two other species annexed to it: exaltation, and

[Margin: Digestion.]

digestion [digestio], by which things, dissolved over a short time, gradually degenerate [pass over] into a purer and greater grade of their virtue. But those that require more time are called Circulation and Ablution.

[Margin: Circulation.]

Circulation is the exaltation of vapours revolved around in a circulatory vessel, which — the impurities being cast off, which otherwise could not be separated — establishes [the thing] in a more excellent grade. Take this experiment of it:

Paradigma X

How wine, for example, ought to be sublimed by the benefit of Circulation into a most mobile essence.

Take the thing to be exalted, and put it in a circulatory vessel, and close it Hermetically, and place it in sand, or in a bath; and keep it in there so long, until it has attained its goal. For example: much labour and study is expended in the true extraction of spirit of wine, so that it may be had without any phlegm; for whenever it has been raised, it always draws some phlegm with it. Therefore by the manner of circulation

[Margin: Preparation of the quintessence.]

the most generous wine that can be is taken, and it is poured into a capacious circulatory vessel, and with the orifice sealed it is set in a bath of [boiling] water [balneum maris] for fourteen days, so that the water boils continuously; afterwards it is taken out, and poured into a phial; and warm, it is set in winter into cold snow-water placed beside [it] and agglutinated [sealed] with an alembic and receptacle; but in summer into a cellar, set onto a vessel containing glacial shells [conchae glaciales, i.e. ice]. And the pure spirit, free from all phlegm, will rise above the alembic and slip down into the receptacle. When nothing more ascends, the receptacle is removed, and the phial is taken out with the wine — which contains no true spirit, but only burnt wine [vinum adustum]. This spirit of wine, still set in the circulatory, is rotated so long, until it can no longer [pass] from glass to glass, but must be advanced by distillation, or moist elevation; and when the material on which it must act is set into the receptacle, it readily

embraces it, and abandons its flight. This method, as they say, is to be noted with a white stone [i.e. marked as excellent].

[Margin: The various species of the chemical operations.]

There now follow the remaining species of the chemical operation, which are: Ablution, Imbibition, Cohobation, Digestion, Ceration, Putrefaction, Extraction.

[Margin: Ablution.]

Ablution is an exaltation by frequent infusions.

washing away impure matters and restoring them to purity.

[Margin: Imbibition.]

Imbibition [imbibitio] is a washing in which a liquid added to a body sinks back into the body. It washes by repeated moistenings until, once coagulated together with that first body, it can rise no higher but remains entirely fixed — an operation than which there is nothing more secret in alchemy.

[Margin: Cohobation.]

Cohobation [cohobatio] is the repeated drawing-off of a liquid that has often been poured back onto its body. The verb *cohobare*, "to cohobate," — that is, "to pour off through cohob" — is borrowed from a word of the Arabs and signifies nothing other than "to repeat."

[Margin: Ceration.]

Ceration [ceratio] is the softening of a hard substance, or the preparation of a non-fusible juice for liquefaction. It is called ceration because it makes a chemical medicine, brought to the fire like wax, readily flowing. The alchemists are wholly absorbed in converting quicksilver into gold and silver by ceration; for this medicine, by being joined to the Sun [gold] or the Moon [silver] through the medicine, they wish to be united — so that once the moisture has been consumed by the fire, the thickening and fixation of the work takes place; of which in its proper place.

[Margin: Digestion.]

Digestion [digestio] is a subtiliation in which crude substances are dissolved over a long time by a digestive heat. It has two species: putrefaction and extraction.

[Margin: Putrefaction.]

Putrefaction [putrefactio] is a digestion in which the substance of a thing is dissolved, through the retention of vapors and the access of an external heat, so as to generate a nobler being. Its proper effect is to consume the old nature of things and to introduce a new form, whereby afterward — and for the most part — the fruit of another generation is produced. [Margin: The wonderful power of putrefaction.] For corrosive spirits are sweetened by it and rendered milder; colors are changed in it; the pure is separated from the impure, the impure settling to the bottom. Putrefaction is carried out when the material, placed in a vessel, is set in dung, and the heat of the dung is maintained for a fixed time; or it is also done when the vessel is set in a dew-bath.

[Margin: Extraction.]

Extraction [extractio] is a digestion in which, the bodily concretion being broken up, the subtler and purer parts — seized by some solvent [menstruum] poured over them — are dissolved out, the dregs being left behind. I shall add an example of this.

PARADIGMA XI.

How an Extract of Rhubarb is made.

Take as much rhubarb as you wish, and once it is powdered, pour on enough spirit of wine [spiritus vini] to stand four fingers above it. With the vessel closed, set it in a bath for four days to digest. Then, opening the vessel, separate by decanting the colored spirit from the root, and pouring on fresh spirit, set the closed vessel again to digest. Repeat this until the spirit takes on no further color — for then the whole tincture and essence has been extracted from the rhubarb. Then, all the extractions being combined, draw off the spirit in a water-bath [balneum Maris], and keep the remaining essence in a glass vessel for use; it cannot be evaporated [?] and is of great efficacy in many other afflictions.

PARADIGMA XII.

How the great secret mystery of Vitriol is made — from the secrets of the Roman College [ex secretis Coll. Rom.].

Take twelve pounds of Roman or Hungarian vitriol; dissolve it in ordinary distilled water, then set it in warm ashes so that the water evaporates until it forms a kind of crust. Then place it in a cold spot for two or three days, and the vitriol — once some dregs have been set aside — will turn to little stones. Take this vitriol, which passes into a powder first white, then yellow. Then dissolve it

again in common distilled water, and let it stand in warm ashes for 24 hours, and you will find a great deal of dregs at the bottom of the vessel. Decant what is pure, coagulate it, set it aside in a shell-dish, and again dissolve it — for as long as it takes until it deposits no more dregs and tends toward sweetness. Note well, marking it with a white stone, that its greenness is to be carefully preserved; otherwise the oil and the labor would be lost. Then put this purified vitriol into a phial, which you will close well with a hermetic seal, and set it in a philosophical furnace [furnus Philosophicus], where you will raise the fire by degrees from ten days to ten days, until the vitriol approaches redness, until at last it becomes red like a ruby.

Take out this red vitriol and put it into a glass cucurbit; pour on a good quantity of corrected and pure spirit of wine, and keep it well closed in a gentle warmth for four or five days. Then decant the spirit and pour on fresh, until you have extracted from the vitriol all its power and efficacy. Put these extractions into a cucurbit, and in a water-bath separate the spirit; pour spirit on, separate again to a third time, always removing the dregs. Finally pour distilled rainwater onto the extract, wash it, and set it in ashes for four or five days, so that it may extract as much as it can. Decant what is dissolved, and apply other distilled water, keeping it in warm ashes for the same number of days; repeat this three times. Pour together these extractions, and in a water-bath separate the water. Then take this extract, put it in a medium cucurbit, with an alembic and receiver fitted on and luted, and distill — first with a gentle fire, then with a stronger one — and there will rise the blood of the green lion [sanguis Leonis viridis], red like a ruby, which (as the chemists say) in the dead and dark of night gleams like a carbuncle, and whose odor surpasses all other fragrant things. This marvel, however, I have not yet been permitted to see; and so I take that hyperbole of the chemists on trust.

[Margin: Another method of preparing Vitriol.]

Extraction of vitriol, sweet both to taste and to smell.

Take Roman vitriol calcined to a red color; then over each pound pour two quarts of perfectly rectified water [aqua, i.e. aqua vitae], and set it to digest in a water-bath [balneum maris] for five days; then let your vessel cool. Pour off the spirit [aqua vitae] as clearly and as purely as you can from all the earthy dregs — or, if it seems good to you, filter it — and afterward keep it; it will be better if you keep it in a bath, and this liquor will be of a yellow color. This done, take the dregs that remain and pour them out into a new earthen open dish; but if they have clung too stubbornly to the bottom of the vessel, pour cold water on and stir until you have drawn off all the dregs. Evaporate the water by boiling; calcine the dregs,

and when calcined grind them into a very fine powder; then, as before, pour fresh spirit over them and extract as before, and you will see your spirit tinged with a green color. Therefore do not cease from drying and pouring on until you have all the green color that lies hidden in it; this place in a bath for five days, for a use to be shown shortly.

Now let us return to that yellow, tawny tincture which we earlier left well stopped in the bath. Place it in a cucurbit with an alembic very well luted on, in well-purged ashes, and distill at the same time an oil red like blood [oleum sanguinis], and the spirit [aqua vitae]. Afterward separate the spirit from the oil in a gentle bath, and you will have this oil — as they call it, "blessed" [benedictum] — left at the bottom of the vessel. But if there remain in the cucurbit of the first distillation black or white dregs, keep them as the earth of this Stone. Now let us return to that green water, in which white earth and salt are contained. Evaporate, then, the spirit from it, and whatever remains is earth, from which a most white salt is to be extracted in the following way.

[Margin: Crystalline salt.]

Take this earth and put it in a pot, and calcine it for the space of three days in a reverberatory furnace; afterward take it out of the fire, and with spirit [aqua vitae] extract the crystalline salt; and in this way you have that precious salt, and the oil of vitriol, whose properties I leave to the skilled physician.

[Margin: Another method of preparing Vitriol.]

There follows now the *Assaying Liquefaction* [Liquefactio probatoria], which is done either by cineritium [percineritium, the ash-cupel method] or by antimony. The former is done when a metal is fulminated by lead and assayed — of which take this experiment.

PARADIGMA XIII.

How a Metal is fulminated by lead.

[Margin: Fulmination.]

Take, then, an ash-cupel [catillus cinereus], and set it under a vaulted tile in an assaying furnace. When this has been filled to the top with coals, it is kindled with some live embers at the head of the fire, and the fire is maintained. And so that the cupel may grow white-hot the more quickly (for the metal is not to be put in beforehand), let the mouth-openings and air-holes be open. Then, after an hour or two have passed and it has glowed thoroughly, let there be put in a portion of

lead proportioned to the amount of material to be assayed, and that gradually; once it is melted the metal is put in, and as the case requires, all the openings are closed and the fire is skillfully governed. This regimen must be demonstrated to the eye by an experienced hand, for it varies according to the nature of the material.

[Margin: The metals are burned up by the lead.] [Margin (later hand): Plumbum non abit in fumum, sed incorporatur catillo... absorbe[tur] [?] — "The lead does not go off in smoke, but is incorporated into the cupel... [it is] absorbed."] [Margin (later hand): NB.]

Thus at last it comes about that, together with the lead, the perfect metals are burned away [?] [recte: the imperfect metals — see the parallel statement "metallis perfectis solis in medio catilli," only the perfect metals remaining] and pass off into smoke, and drive the slag [scoria] to the edges, the perfect metals alone being left in the middle of the cupel. But if perhaps it should happen that the lead hardens together with the metal being assayed and cannot be moved to flow by the fire, a little antimony is added on a spoon, and in a moment it will return to its former state. This secret the assaying craftsmen [Artifices docimastici] hold as a great secret. At last, the cupel being lifted out with tongs, the metal, while still hot, is separated off with a knife.

PARADIGMA XIV.

How, by means of Antimony, Gold is separated from Silver and the other metals.

Take gold mixed with other metals, and mix in with it three parts of powdered antimony; and in a crucible put it in a wind-furnace [furnus ventosus] over a stubborn fire. Then, with the help of bellows if you please, when it is thoroughly melted pour it into a warmed and tallow-smeared cone-mold [pyramis]; there, the lips being struck with a hammer, a regulus [regulus] containing the gold will settle at the apex, which strike off with a hammer. The antimony left over, moreover, put again into a melting-pot over the fire even a third time, and proceed in the aforesaid manner, so that all the gold may be driven out of the antimony. At last put these reguli into an earthen cupel near the bellows, and with coals heaped on in the manner of a furnace kindle the fire, and keep playing the flame over them until, all the antimony being evaporated, pure and refined gold settles, which is at once coagulated.

To these we append **coagulation** [coagulatio], by which we reduce liquid and soft substances to a solid mass through the removal of moisture — of which in its proper place. It is accomplished either in cold or in heat. Coagulation is hot when

dissolved substances are coagulated by a suitable heat; it is cold when substances that have been dissolved in heat are coagulated in cold. And under it are contained **fixation** and **fermentation**.

[Margin: Fixation.]

Fixation [fixatio] is the habituation, by fire, of a thing that flees the fire, so that it may remain — whether this be done by sharp agents [acies], or by a slow and long decoction, or by frequent sublimation, or by solution and coagulation often repeated, or finally accomplished by the addition of a fixed substance.

[Margin: Fermentation.]

Fermentation [fermentatio], inasmuch as it requires a more exact exposition, we have judged ought to be described in a chapter of its own.

And these are the things concerning chemical operations which I judged ought to be communicated to the reader — without foreknowledge of which let no one hope to attain a perfect knowledge of chemistry; so that, before the beginner [Tyro] proceeds to what follows, these things are most necessary to be known. Thus whoever has duly grasped these canons will find no difficulty in the terms of chemistry or in the reading of books. Nothing, then, now remains but that we turn our pen to that great mystery of the chemists concerning the Philosophers' Stone, so that the lovers of truth may learn what can — and what cannot — be done in this most intricate business by human ingenuity and the industry of art.

SECTIO II.

DE LAPIDE PHILOSOPHORUM.

[On the Philosophers' Stone.]

CAPUT I.

What the Philosophers' Stone is, what the Elixir or philosophical Tincture is, and whether by its means true and natural gold can be produced by art.

[Margin: The difficulty of this argument.]

Scarcely any argument in natural philosophy [Physiologia] have I found so very curious as this theme of gold-making [Chrysopoeia] — one stirred by so many, so great, and so sharp skirmishings of authors, and torn apart by so great a variety of opinions (by which, with the suit still pending to this very day, they strive to

drag one another, by the entangled rope of objections, now to this side, now to that). For my part, weighing more deeply the reasons of each side, this way and that, I shall openly declare what I think, with all the candor that is due. And while I do this, let the reader persuade himself that my business is not with raw, unlettered pseudo-chemicasters, but with philosophers.

[Margin: Four opinions concerning Chrysopoeia.]

I find four principal opinions concerning the gold-bearing art. The **first** is of those who hold the art of gold-making [Chrysopoeia] to be impossible [Greek: ἀδύνατον (adynaton, "impossible")]. The **second** is of those who separate, by art, gold and silver from lumps of minerals and metals — which we call metallurgy [Metallurgia], and which we treated in the preceding Section in many and various processes; and about this there is no difficulty at all, since gold and silver of this kind deservedly hold a place at the outset in the commerce of human dealings.

[Margin: Sophistical Chrysopoeia.]

The **third** opinion the theologians chiefly maintain, who assert that gold can indeed be produced as though true, which nevertheless may not be sold for true at the same price at which true gold is sold, nor is it lawful to use it in medicines — which we shall hereafter call "Sophistical" [Sophisticum]. It comes about when to gold and silver some other suitable metal is joined, whence by art a third thing results, and is sold under the name of gold; and money-changers [Collybistae] for the most part use it, and they call it *legam* [?].

[Margin: The Chrysopoeia properly so called, which alchemy promises.]

The **fourth** opinion, proper to the alchemists, is of those who assert that chemical gold can be produced not only as true and genuine, but even far nobler, more excellent, and purer than natural — according to that saying of Augurellus [Aurellius]:

When but a thin part of itself is cast upon the waves of the sea — were the sea then quicksilver — the whole, the vast sea entire, could be turned into gold.

So say Isaac Hollandus [Isaac of Holland], Paracelsus, and Villanovanus [Arnald of Villanova] — men who, it can scarcely be said how greatly, have exposed themselves to the mockery and jeers of right-thinking philosophers. That this is a mere fiction I shall most fully establish in what follows; so that not inappropriately — as is plain from the definition — they have called the Stone

"mystical" [mysticum]; since in truth it can be called wholly mystical, both in sense and in meaning. The ancient philosophers understood by a stone of this kind, by the Elixir and the Tincture, something altogether other than what the modern alchemists imagine to themselves.

[Margin: The Philosophers' Stone is mystical and fictitious.]

It is wonderful, too, that this is described by the likeness of almost all things. For they call it Heaven [Coelum], chrysosperma [the gold-seed], the seed of gold, the blessed earth, living water, water of life, dry water, the wood of life, the seal of Solomon, the fire of Nature, the Virgin's Milk [Lac Virginis], the Mercury of the Philosophers, the Dragon, the Eagle, the Raven, Laton [Latten], the Elixir, the medicine of all diseases — of which "whoever drinks does not die" — and the like, partly ridiculous, partly irreligious.

[Margin: The various nomenclature of the Stone.]

All of which — that I may not dwell any longer on so many trifles — see in the fabulous Hermes Trismegistus, in Trevisanus [Bernard of Treviso], Isaac, the fictitious Morienus [Morienus], Lullus [Ramon Llull (pseudo-)], Paracelsus, and the rest of the Arabs in the *Turba Philosophorum*. But so that the disputes of the chemists concerning the Philosophers' Stone, here brought forward, may be more clearly understood, let us speak first of the matter of the truly mysterious Stone, then of the manner of making it — from which, no doubt, the truth of the proposed dissertation shines forth.

[Margin: The labor of Nature in producing things.]

We said in what preceded that Nature generates three principles from the four elements — Salt, Sulphur, and Mercury — and that from these, joined together in due proportion, it generates metals, produces trees, begets animals; and when it has reached its own term, then — as though the final end is now attained — it ceases. For whatever is contained beneath the circle of the Moon is distributed into three kinds, no more and no fewer, divided into the threefold Kingdom of Minerals, Vegetables, and Animals. In these three Nature claims its own dominion for itself, and in them it acts, moves, and works; so that if you seek anything else outside them, you may rather be reckoned to seek it in Utopia than in the realm of Nature. To the pattern of Nature, then, as to a prototype, the alchemists ought to attend, in order to attain their end. For as we said in what preceded, unless they take up a matter common to all metals, they will never rise to the accomplishment of the great work of the Art.

It is asked, then: What is that wonderful matter of the chemists, from which they hunt such great treasures of gold and silver? In determining this matter, it can scarcely be explained how greatly the authors disagree among themselves, both in substance and in name; so that from this very head they sufficiently and more than sufficiently show the uncertainty of the Art. For either one alone attains the truth, or all together; but just as the former is uncertain, so in the latter case the truth, wrapped in so many contradictions, can have no place.

[Margin: The conflict of the alchemists among themselves.]

Villanovanus assails Lullus; Paracelsus attacks both; Libavius [Andreas Libavius] entitles this last "the foulest impostor of all two-footed and four-footed creatures"; while all the rest, rising up against Libavius, call him a sycophant, full of spite, savage in satiric bite, and entitle each and every one of the others fools and ignorant of things. And since they cannot agree about the matter, they rage against one another like dogs, with countless taunts and reproachful names; so that, in place of investigating the truth, you hear nothing but taunts, jeers, calumnies, and the reproaches of an idle and ill-tempered crowd.

No less is the disagreement over the naming of the matter. Some name the slag of iron; some salt, or alum; some Magnesia, Cadmia, Calcanthum [chalcantite, copper-vitriol]. Nor were there lacking those who so firmly persuaded themselves that "blessed Arsenic" [Arsenicum benedictum] is this matter, that they wish it to have been indicated about this by the Sibyl; and let us indeed recite the verses — for thus the Sibyl says:

[Greek verse — Sibylline acrostic riddle:]

Ἐννεα γράμματ' ἔχω· τετρασύλλαβός εἰμι· νόει με· αἱ τρεῖς αἱ πρῶται δύο
γράμματ' ἔχουσιν ἐκάστη· ἡ λοιπὴ δὲ τὰ λοιπά, καὶ εἰσιν ἄφωνα τὰ πέντε·
τοῦ παντὸς δ' ἀριθμοῦ ἑκατοντάδες εἰσὶ δις ὀκτώ, καὶ τρεῖς τρις δεκάδες
σὺν γ' ἑπτὰ· γνούς δὲ τὰ ἐμὰ οὐκ ἀμύητος ἔσῃ θεῖης παρ' ἐμοίγε σοφίης.

[Greek: an acrostic riddle: "I have nine letters; I am four-syllabled; understand me. The first three [syllables] have two letters each; the remaining one has the rest; and five [of the letters] are voiceless [consonants]. Of the whole number there are twice eight hundreds, and three times-three tens together with seven; and once you know my parts, you will not be uninitiated in my divine wisdom."]

Which I interpret thus:

I have nine elements [letters], and I am four-syllabled; Perceive me — the first three syllables are formed Of two elements each, the rest remain In

the remaining [syllable], five of which are non-vowels [consonants]: Of the whole number there are twice eight hundreds, And three times-three tens with seven — if you will have known me, The wisdom that is mine, O Goddess, will not lie hidden from you.

By these verses, Cardanus [Girolamo Cardano], Romonetus [?], and Paracelsus assert that the prime matter of the Stone was indicated, by a kind of divine revelation, through the Sibyl, and that it is none other than Arsenic — the reason being that *Arsenicum* is four-syllabled [in Greek, ἀρσενικόν] and consists of nine letters. But that this is a frivolous conjecture is plain from this: that the Sibyl spoke in this place not of the matter of the Stone, but of the mystical name of GOD — as is plain from the context of the prophecy. Hence, with the meaning of the oracle more deeply unfolded, I find that the Sibyl there, under an allegorical and enigmatic reckoning of numbers — which the Greeks call ἰσοψηφίαν [isopsēphia, the equating of numerical values of letters, gematria] — indicated the name of CHRIST: namely, the name ὁ Ἄνθρωπος Θεός [ho Anthrōpos Theos] — MAN-GOD, or GOD-MAN.

The numerical reckoning [isopsēphia]:

Greek letter	Value
α	1
ρ	100
σ	200
ε	5
ν	50
ι	10
κ	20
ο	70
ψ	50
Total	506

[Margin: The true interpretation of the Sibylline riddle.]

Now let us see whether it is so. First [the Sibyl] says: "There are nine elements [letters]...

nine letters belong to me, and just as many letters are found in ὁ ἄνθρωπος Θεός [the Man-God]. This same name also has four syllables: three syllables are formed

from pairs of elements — AN, ΘΡΩ, ΠΙΟ — and the rest remain in what is left over, that is, ΘΕΟΣ. Now of these, five are non-vowels: namely, in the name ἄνθρωπος [anthrōpos, "man"] as assumed, there are five consonants, ν, θ, ρ, π, ς. And the number that results from this is "twice the hundreds, eight times," that is, 1600, "and thrice three tens," that is, 90, "together with 7" — so that the total number is 1697. If, then, ὁ ἄνθρωπος Θεός be resolved into numbers, you will obtain nearly the same number of which the Sibyl speaks, as appears in the margin: 1674. But ἀρσενικόν, when resolved, contains no more than 506 — a number assigned to the oracle ἀντισόφηφος [counted by equal numerical value]. Who does not see how greatly this differs from the words of the oracle? But these things are said only in passing [παρέργως].

The gematria of ὁ ἄνθρωπος Θεός, letter by letter:

Letter	Value
ο	70
α	1
ν	50
θ	9
ρ	100
ω	800
π	90
ο	70
ς	200
θ	9
ε	5
ο	70
ς	200
Total	1674

There are others who, for the matter of the Stone, take toads, hairs, eggshells, and — so that no kind of filthiness be missing — menstrual discharge, human blood, and the embalming-matter of mummies. [Margin: Various opinions about the matter of the Stone.] Some, finally, hold that the search must be conducted in earth, water, and air, in stables and latrines. And although the wiser sort think that all these things ought to be understood, under a kind of allegory, as referring to the salt found everywhere, many nonetheless — like Bacon [Roger Bacon] —

take them in a real sense, as is clear from his operations. Those who seem to come closer to the truth are the ones who assert that sulfur and quicksilver [hydrargyron] are the proper matter of the Stone. But not even these agree among themselves: some mean mineral sulfur and quicksilver, while others mean what they call the sulfur and quicksilver "of the Philosophers" — and on this point most of the more celebrated Philosophers concur. What the sulfur and Mercury of the Philosophers actually are will become clear a little later.

Those who believe the Stone can be made from common sulfur and Mercury are utterly deluded. For although they try to imitate nature directly, they remain ignorant of nature's hidden motions, processes, and incomprehensible pathways, and so remain in perpetual darkness — just as was said in the preceding chapter about the furnaces of the subterranean workshops. [Margin: Sulfur and Mercury are tamed only with difficulty.]

Finally, those who, on hearing that quicksilver and sulfur are the prime matter of metals, then go and boil them down, rightly waste both their oil and their labor. For the quicksilver and sulfur out of which gold and silver are generated are not, in the mind of the Chemists, the common kind, since those two have already attained their own degrees of perfection. Quicksilver, indeed, if you bring it even to the smallest fire, flees and vanishes into thin air, and the compound is also separated out, so that it can be held back by no barriers or bolts. Sulfur, too, when set to the fire, is turned into one form after another — even though the conjunction of both, carried through to the end of the digestion, is necessary in the generation of metals.

Likewise mistaken are all those who seek that Stone in marcasites, tutty [tutia, zinc oxide], antimony, arsenic, and orpiment [auripigmentum]. For in these the sulfur is wholly inseparable — and unless they resolve and separate it completely, they will accomplish nothing, so that once it has been separated from the said species of minerals, the remainder must necessarily crumble into powder. Those who seek the Stone in vegetable nature must be expelled outright from the school of the Chemists, since each individual species of things is brought to perfection by generation within its own proper grade of nature: man produces man, ox produces ox, a plant produces a plant of its own species. In vain, therefore, do those labor who think the Stone can be made from wine, as Lullus [Ramon Llull] does; and in vain those who would make it from human blood, or urine, or eggshells, like Rogerius Baconus [Roger Bacon]. [Margin: The matter is not found in vegetable nature.] For it is foolish to seek in nature what is not in it: grapes cannot be gathered from thorns, nor figs from thistles. By the whole

breadth of heaven, then, and against the dictates of nature, do certain idle Alchemists err, who seek the Stone outside the bounds of their own purpose, in I-know-not-what incongruous, dissimilar, and heterogeneous things.

The matter out of which the Stone is made must be a mineral of nature. Now, some minerals are lesser, others greater. [Margin: Division of minerals.] The lesser are those that are produced without the addition of quicksilver, such as stones, salts, and purely sulfurous bodies. The greater are those that consist of quicksilver, of which some withstand the hammer — like gold, silver, copper, iron, lead, tin — while others do not, like antimony, magnesia, marcasite, and the various species of pyrites; for although these are imbued with mercury, it is so poorly tempered with the said bodies that it can in no way be fixed, and consequently they cannot be the matter of the Stone. Nor do the lesser minerals contribute anything to the fabrication of the Stone — such as salts, niter, alum, salt of feathers [sal plumae], and so on — first, because their production differs in form, nature, and composition from the generation of quicksilver; and second, because there is one nature and one property of seed for a single species, out of which it is produced. There is the further point that they are found to be plainly contrary, as to their nature, to metallic bodies. [Margin: Salt bodies are not the matter of the Stone.] For salt bodies corrupt, erode, and destroy metals; and according as they are fixed or non-fixed, pure or impure, they reduce them all to nothing; and the subtler they are, the more they render metals alien to their own nature, and burn up their innate moisture, in which the secret of the Stone lies hidden. Hence whoever tries, by aqua fortis and sharp and corrosive waters, to recall metals to their prime matter, rightly rolls the stone of Sisyphus. [Margin: Aqua fortis is not the matter of the Stone.] For these are of a wholly heterogeneous nature from the things out of which the chemists contrive the fabrication of the Stone. Nor do sulfurous bodies do anything to the purpose, since they always taint and corrupt. Since, then, they are contrary to metals, I do not see how they could furnish a medicine wholesome to metals. And yet...

[so far is it from promoting] the perfection of metals that it rather, by its scorching quality and by its own bulk, hinders it to a remarkable degree. The pure innate seed, by contrast, if it has been entrusted to a pure matrix, will there generate, in that same place, a pure metal as well — without nature's long labor, by a certain marvelous magnetism of nature — attaining its own goal while it does that for which the seed had been ordained. [Margin: How the generation of metals occurs.] But if, on the other hand, this seed should fall into impure matrices, contaminated with the various refuse of earthly clods, then, according to the degree of greater or lesser impurity, it will produce a metal — or also a

mineral — now more perfect, now more imperfect, as we have set forth at length in its proper place. If, however, in the genesis an earthly and combustible dross has mixed itself in, then, in proportion to the quantity it has with it, it will beget antimony, marcasite, pyrite, and other non-ductile minerals; and these, because they partake of mercury, can indeed be liquefied, but are not thought to be advanced by nature toward perfection. But if a small amount of sulfurous and blackish dregs has mingled itself in, and the mercury has not been sufficiently concocted, the common quicksilver of the rabble will result. And if the dregs are bad, of bad savor and foul, and also of weaker virtue, they will infect the Mercury and render it brittle, heavy, and muddy — which, since it is not well coagulated, likewise degenerates into lead. But if the sulfur is bad and not well miscible with the Mercury, tin is generated. And if those sulfurous dregs are stony, unclean, and earthy, they will produce iron; and if such sulfur is reddish and burnt, copper will be begotten.

And from all this it is plain — perhaps more fully than is fitting — clearly enough what the Alchemists must do, in order to extract from the things mentioned that intended metallic seed. Yet, although we cannot deny that it is present in those things, the method of drawing it out is all the more uncertain the more the manner of nature — which uses that seed in the generation of metals — is unknown to us; indeed, it is scarcely investigable by human ingenuity. [Margin: The difficulty in making the Stone.] Nor, as yet, has any method been found by the artificers that would satisfy the intended making of the Stone. I am not unaware that such a spermatic sulfur lies most pure in gold and silver alone; but to separate this from the incorruptible and indestructible substance of gold — here is Rhodes, here is the leap. [I.e., "here is the real challenge."]

But what that prime matter is — whether the Mercury of the Philosophers, or the spermatic sulfur, or that metal-generating vapor — is difficult to know through experience, since it is most remote from all the ministry of the senses. The Alchemists say it is a certain third nature, common and altered out of the diverse mixing and digestion of sulfur and quicksilver [hydrargyrum], in which there inheres a mineral power for generating the compound. [Margin: The matter of the Stone according to the Alchemists.] These two act and are acted upon, the one on the other, perpetually, until they are carried over from the form of the imperfect bodies first generated into another form, and at length, through continued digestions and purifications, arrive at that last and perfect...

form, which is the form of gold, in which is the final terminus of motion — where also the agent, that is, the sulfur, is wholly separated from its matter. As even the

Alchemists themselves confess, many indeed seek this, but very few find it; or if they have found it, they are nonetheless ignorant of the preparations — that is, of the proper proportion to be used in making the Stone. And yet all confess that, by art, the medicine is to be drawn out from these alone, in which perfection will dwell potentially through nature — wherein lies the perfection of the pure matter — and in which, accordingly, all metals are found.

From this it is gathered that they suppose that which is uncertain, and which still lies hidden, concealed, in the inaccessible treasury of nature: a subject, I say, still entangled in infinite difficulties and contradictions, perplexed and intricate. [Margin: A circle is committed by the Alchemists in determining the matter.] But, to return to the matter just described: I ask, what is that "common nature"? They answer that it is a matter altered out of the diverse complexion and digestion of Sulfur and Mercury. I ask: is that mixing a mixing of common sulfur and mercury, or of the philosophical sort? If the former, they now plainly contradict themselves, since they hold that this should by no means be taken up into the work of the Stone. If the latter: I ask, what then is that philosophical sulfur and mercury? They say it is the prime origin of metals — and so they plainly commit a circle, defining the known by the unknown. I ask again: how are these separated? They answer: from the form of the imperfect bodies, which are now constituted in their own state, into another form, which is that of gold. I ask, how can it be transmuted into the form of gold, since the form of imperfect bodies is not gold and cannot give what it does not have? Or, if they say this is done by a seed, how is that seed not utterly destroyed through so many digestions and torments of fire? They answer that this form is drawn out of the potency of the matter into another form, that of gold, through the various operations by which the matter is worked. But it must now be examined how, with what zeal, and with what stubbornness of labor, they strive to prepare a matter not yet even known to them, so that at length that marvelous offspring may emerge from it. They proceed as follows.

[Margin: Calcination of things.]

The process used by the Philosophers in making the Stone.

The artificers, therefore — after they have found the prime matter of which we spoke in what precedes (if indeed they have found it) — first judge that it must be calcined and purged of all its impurities, by restoring its heat and conserving its innate moisture. For in chemical calcination, as they say, no diminution of the body should occur, but rather a multiplication. Then, attenuating the thickness of the calcined matter into a certain liquid substance, they reduce it (if it please the

gods) into its prime matter, which they call mineral water — water that does not wet the hands. And then there comes to be one thing in genus, though not in number; whose sun they call the father, the moon the mother, and Mercury the mediator, according to the Tablet of Hermes [the Emerald Tablet]. And the body is altered — not stripped of its own form, but a new form is induced upon it immediately, since nothing in the nature of things is found wholly stripped of form.

In this way they now separate, from the substance thus dissolved, the four elements, and divide them into two parts: into the ascending or spiritual, and the lower or earthly. [Margin: Separation of the four elements.] These two parts are nonetheless of one nature; for the lower is the ferment that fixes it, and the upper is the soul that vivifies the whole. Yet the division of these is necessary, so that they may the more easily, in the end, all be transmuted into one another — the earthy part, by passing into water, growing black; the water then, by passing into air, being whitened; and the air being converted into fire, the cycle [pericyclōsis] being completed.

Once the separation of the elements has been accomplished, they make a conjunction of water and air with earth and fire, so that each of the elements may be dispersed within another, the proportion being preserved. [Margin: Conjunction.] By this ratio they assign to the sea three parts of its water, but to the female nine; and then like applauds its like, and equal rejoices with equal, on account chiefly of the concupiscence of material adherence, and of the sulfurous form.

These things, thus conjoined, they putrefy — but with a moist heat, lest, the fire being kindled, the Mercury be separated, or carried aloft on account of its spiritual nature — so that by this corruption the matter may be altered, the elements be naturally divided, and regeneration may follow. [Margin: Putrefaction.] For nothing is born, or grows — not even an inanimate thing — except once putrefaction has occurred.

After Putrefaction they proceed to coagulation, and, with the same most temperate heat altering the matter of the Stone, they operate both internally and externally, until the matter whitens and takes on the likeness of pearls, and there comes to be the fixing-together of the volatile spirits with the bodies, and a true coagulation. [Margin: Coagulation.] This white thing they call the "spine," and white incombustible sulfur, which never recedes from the fire.

Finally they betake themselves to "feeding" [cibatio] — namely, to the ingrossing of the subtle and the subtilizing of the thick — by mingling their water with ash, and their milk with foliated earth, moderately indeed, so that thus the whiteness and redness, goodness, quantity, and virtue of it may grow and be increased, and so that, by cooking, the matter may be nourished. [Margin: Feeding.]

Then they sublime the matter, with a sublimation not of the common kind — though what sort it is cannot be conceived — and thus they purge it of all impurities by elevating the body and rendering the spiritual thing itself, and the spirit corporeal and fixed, and by diminishing the sulfurous saltiness, so that the whole may be whitened and may be liquefied most quickly. [Margin: Sublimation.]

Once the sublimation is completed, they ferment the matter, joining the spirit with its whitened earth and lime as with its ferment, or incorporating the soul with the body. [Margin: Fermentation.] For they cannot display their permanent virtues — spiritual accidents — unless they are joined with fixed bodies as with a ferment, which reduces what is set before it to its own nature, color, and savor, by this mutual and common impression of body and spirit, without which the work cannot be perfected — just as dough cannot be leavened without leaven.

Moreover, for the greater nobility of the matter, they judge that it must be exalted: by augmenting the spirit, subliming and subtilizing the earth through natural rectification, through the circulation of all the elements, and through their true graduation, until they are brought back to a perfect embrace. [Margin: Circulation.] Then, by repeated solutions and coagulations, they increase their "Salamander" in virtue, and with a new ferment increase it in virtue and quantity — and that to infinity.

Lastly they make the projection upon the imperfect [metals], of one weight upon many, according to the perfection of the medicine. [Margin: Projection.] For the more it is subtilized and made tinging, the more abundantly it operates; and thus, by imitating nature, they perfect the imperfect metals and convert them into Luna [silver] and Sol [gold]. From its own purified matter, refined by art and subtilized, then fixed by decoction and digestion until it comes forth into a white and at last a red color, made volatile again and again fixed, until it has ingress and tinges perfectly — from this they make their medicine and their powder, which they call the Philosophical Stone. [Margin: Calcination of metals.] And this they do by various operations, with diverse things, many vessels, and many furnaces — as the uninstructed in art might perhaps gather from what has been said — whereas for the true philosopher, in this whole great work, there is but a

single operation, a single life, one thing, one vessel, one fire alone, and one furnace alone, as they all confess with one voice.

But, leaving words aside, let us approach the thing itself. For who does not see that, from these words — cast as it were into the air — nothing has yet been specified? Whether, however, we may draw any light from the Alchemists themselves in that great fabrication of the Stone now remains to be seen; for from these things it will appear, clearer than light, what is to be hoped and what despaired of. Let us therefore show, from the Alchemists' own practice [ἐγχείρησις], how the prime matter of metals is to be drawn out and prepared.

Paracelsus prepares the primal matter of metals by this procedure [ἐγχείρησις]. "It must be known," he says, "that the resuscitation of metals is twofold: one which reduces calcined metals, by reduction, back into their first metallic body; the other which reduces metals into their prime matter — that is, into quicksilver. And it is by the latter, indeed, that one proceeds. Calcine metals by means of common Mercury; place this lime, and just as much quicksilver, in a sublimatory vessel, and let them stand for a while, until both coagulate into an amalgam. [Margin: How the prime matter of the Stone is prepared.] Afterward, elevate the mercury from the lime by sublimation; grind the elevated portion again with the metallic lime, and sublime, as before. Do this so often until the metallic lime at last liquefies over a candle, like wax or ice — then it is rightly done. Let this metal be placed in digestion for its due time, and the whole will be changed into living Mercury, that is, into its own prime matter — which is indeed called the Mercury of metals and of the Philosophers, which very many Alchemists have sought, but few have found. Thus is living Mercury now prepared out of all the metals — namely, the mercury of ☉, ☿, ♂, ♀, and so on." The words are clear; but if they are rightly weighed, they do not answer to practice. [Margin: Refutation of the practice. / Refutation of the practice of Paracelsus.]

For, first, he calcines the given metal by means of common Mercury, which all artificers reject as unfit for the work; then he sublimes the lime until it coagulates into an amalgam — which without doubt is nothing other than a compound of lime and mercury. Then he orders this to be ground again, and performs this operation so often until it liquefies over the candle-fire like wax; then he subjects it to digestion or putrefaction for a fixed time — say a philosophical month — that the whole may be converted into Mercury, which he calls "of the Philosophers." But I say that, in this operation, no other mercury is exhibited to us than the one with which he first calcined the metal; and although, by sublimation and putrefaction, it has been very well purged of all the earthy dregs mixed with it, it

does not follow from this that this "philosophical" Mercury is distinguished from indestructible common Mercury, since it differs by nothing but degrees of purity — as may be seen in all sublimes. [Margin: Mercury is indestructible.] And as for his saying that this whole lime is converted into Mercury, that conflicts with natural principles. For since in metallic lime the sulfur has its own part, to say that the sulfurous part of the lime — specifically distinct — is converted into Mercury can neither be said nor ought to be; for no thing in the nature of things can be so purified that it does not leave behind it something of those earthy parts of which it consists. There is the further point that even common Mercury is, of itself and by its own nature, incorruptible and indestructible; for it cannot be so mastered by fire that, when it has vanished into thin air, it does not at once, on meeting cold, revert to its pristine — that is, fluid — nature, with not even the least part consumed, as we have now often proved by experiment. False, therefore, is what Paracelsus promises in this place.

Joannes Azoth prepares and makes ready the prime matter of metals, with a view to the Stone, in another way. [Margin: The pragmatism [πραγματεία] of Joannes Azoth.] "Mercury," he says, "is the prime matter of our work, and afterward becomes the dissolving menstruum of bodies, the virgin's milk, and the nourishment of the black earth, and likewise the azoth of ablution. From our Mercury alone is drawn out every virtue of the art. There is in Mercury whatever...

(...how the wise men seek it.) But how that Mercury is prepared by Joannes Azoth — who copied most of his material from Raymond Lull [Ramon Llull] — take note.

CAPUT II.

Whether any true and real transmutation of one metal into another exists.

This is the chief foundation of those who profess the gold-making art, by which they believe they can demonstrate the art to be true and real. And I would gladly subscribe to their view — if not as to the practice, then at least as to the theory — provided that the hidden paths of Nature, the secret skills Nature employs in her operations as she works in the generation of things, and the precise and absolute proportion of the things to be combined were not unknown to me. But since, by the testimony of Ecclesiasticus, all things are difficult, and no one can explain them in words, there arises that perplexity of mind in those who investigate Nature's hidden recesses [Margin: The hidden recesses of Nature are inscrutable

to the human mind.], that stupor of intellect by which a man, stricken, sees that the further he has advanced into the inmost part of things, the further off he still finds himself from the threshold of truth. As a result, it is to angels and demons alone that the inmost kernel of Nature lies open — the nest of her hidden warmth, the mode, principle, and most absolute proportion by which her passible things are fitted to active ones. Were this marvelous knowledge of things communicated to the human intellect, it could doubtless at last reach that goal which countless philosophers have sought as their one object, with such intense and stubborn study, over the span of many years, longed for through fruitless labor. Truly fortunate, then, and thrice and four times blessed, is the man whom, in his probing of Nature, some blessed error by lucky chance has led to the inner shrine of some great discovery.

Yet despite these difficulties, some defend the certainty of the art with such constancy and such stubbornness that — to win belief from those ignorant of these matters — they appear to claim outright that they can demonstrate the art's infallible truth not, I will say, under any doubt, but even by geometric proof. For my part, just as I will not readily assert that the art ought to be approved, so too I firmly maintain that as to its theory it is only probable, and that for men it is scarcely possible — moved to this above all by the consideration that among so many theorists there is not one who has shown the actual practice of this matter, except perhaps with the devil as his teacher, or by the usual deceptive tricks of imposture; of which more fully in what follows. For that the devil can do many things in the transmutation of natural things out of true knowledge — knowledge that we cannot grasp even with our utmost effort of mind — is established [Margin: The devil's knowledge in natural things.]. For who but the devil could fashion, by human skill, a body of airy substance not unlike a human body, or like any animal whatsoever? Who could, by human skill, disturb the elements, stir up storms, swell the sea? Who could suddenly produce insects and imperfect animals of every kind? Surely no one but an angel or a demon — endowed as they are with a power superior to the human — can accomplish this; who does not see it? And yet, when they perform such great things, they do so not miraculously but by a power and efficacy of Nature hidden from us; among which I judge that the gold-making art too is to be counted, which they know perfectly according to Nature's pattern.

Having set these things out beforehand, let us now examine what that metamorphosis, or transmutation, really is, by which the gold-makers [Chrysopoeoi] boast they can work such great wonders; and from this it will become plain what can and cannot be done.

The metamorphosis, or transmutation, of one metal into another can be considered in two ways: first, in itself, properly and immediately; second, by accident, improperly, and by the mediation of something else [Margin: What transmutation properly is according to the mind of the alchemists.]. Those things are transmuted properly, in themselves, and immediately, in which there is an aptitude and capacity for change, and which possess some common subject capable of receiving the change, and which, finally, in any way receive into themselves the action that effects the alteration. And in this manner it is impossible for the *species* to be changed, but only the individuals of that species. This is the opinion of Roger Bacon [Rogerius Baconis], who means by it nothing other than that the species of things cannot be altered in the abstract, but only in the concrete — that is, the individuals of the species. But a metamorphosis is called improper, or taken by accident and by mediation, when there is in the subject no aptitude for change, nor any common changeable subject, nor any immediate subject of the altering action itself, but all these follow from some [other] subject. In this way species and accidents can be transmuted. For example: silverness [argenteitas], which is the species of silver taken in the abstract, cannot be transmuted into the species of gold, which is goldness [aureitas], nor is it possible for silverness to become goldness; for taken in this sense species cannot be changed, since they are not in themselves subject to sensible increments, nor do they have in themselves a divided or contrary composition that would be the cause of change or the subject of it. But by accident, improperly, and by the mediation — for example — of fire, they are transformed, by the alteration of the particular and divisible things; for as these are corruptible and composite, and exposed (or subjected) to sensible increments, so too, through various purifications, digestions, and sublimations — whose subject is transformed into another — this silver or gold becomes the subject of a different species, which something else has completed.

(...which something else has) completed the purification or digestion. From this definition it is plain that Bachonius [Roger Bacon] understood by such a definition nothing other than a certain metallic transmutation, by which, through various digestions and putrefactions, gold becomes the subject of another species — something no philosopher has hitherto doubted. And experience plainly teaches that in minerals and metallic bodies, whose underlying matter is of one species, just as it naturally proceeds into one mineral after another of differing species, so too it effects various transmutations, as we showed at length earlier in the discussion of the generation of metals, and as is evident from the great variety of species among stones, gems, and other minerals.

Hence I conclude that gold, silver, copper [aes], lead, and so on, though they differ in species, nevertheless — because they have a single underlying matter, which we earlier called the sulphureo-saline-mercurial exhalation [halitus] or vapor — differ from one another indeed in species, but not in matter [Margin: How the transmutation of metals is to be understood in the generation of metals.]. For this kind of exhalation, created together by God out of the elements, is not gold, silver, or lead, but as it were a certain seed, which, poured out within the differing wombs [matrices] of the Earth, produces — according to the difference of the wombs — different minerals and various metals: by solution, I say, by digestion, by circulation, and finally by coagulation. These things we demonstrated by countless examples in the Eighth Book, concerning the marvelous power of the petrifying juice [succus lapidificus] to turn anything whatever into stone. As for the wondrous power of vegetable nature, by which not only is one herb transmuted into another, but also from the rotting juice of herbs and the putrefaction of animals, animals of a different species are produced, we shall discuss this metamorphosis with a great array of experiments in another Book of this work. Who denies the transmutation of nourishment — both of men and of animals — into flesh and blood? What can fire not do? By its agency all things, mineral, vegetable, and animal alike, are turned into ash, and from ash into glass. From all this it is plainly evident that it is not the alchemical *species* but only the *subjects* of the species that can be transformed.

And that these laws of Nature, working by herself, are immutable, no one ought to doubt; so much so that in her operations — depending as they do immediately on the Archetype of the Divine intellect — she cannot err. But whether anyone, by the skill of human art, can reach the summit of a similar transmutation — this is the very question raised here; for this is what gives us our quarrel with the alchemists.

Paracelsus says that transmutation is nothing other than when a thing loses its own form, and is so altered that it is in no way like its former substance and its own form, but takes on another form, another essence, another color, another power, another nature and property [Margin: Transmutation according to the mind of Paracelsus.] — as when a metal becomes glass or stone; when wood becomes charcoal, clay becomes stone and brick, hide becomes glue, linen becomes paper, a horse becomes a god, or a he-goat, grain becomes a man. Yet this transmutation, in the alchemical enterprise, he judged impossible to perform without the Philosophers' Stone, and this Stone impossible to make without the seven grades of alchemy [septem Chymiae gradibus] which we set out earlier.

And so Paracelsus, in order to give a true specimen of the transmutatory art, first teaches the [transmutation] of various metals, one into another (μεταμόρφωσιν [Greek: *metamorphōsin*, "transformation"]), in his book *On the Transmutation of Metals* [Margin: Specimens of transmutation from Paracelsus put forward.]. And he thinks he can demonstrate that metals are not distinguished by species, but only according to greater and lesser purity. We, however, from his own experiments — which he calls transmutation — show, from his own words, that this is not a true transmutation but only an improper and accidental one, as follows. "The transmutation of metals," he says, "is a great secret in Nature, and can be accomplished only with difficulty, by reason of many impediments and adversities; nevertheless it is not contrary to Nature, nor contrary to God's ordinance, as many falsely claim."

But that the lesser and more impure metals, as they call them — Jupiter [tin], Saturn [lead], Mars [iron], and Mercury [quicksilver] — should be transmuted into the greater, purest, and most perfect metals, namely into Sun [gold] and Moon [silver], cannot be done without the tincture and the Philosophers' Stone. As for transmuting the rest among themselves, since that is not difficult, we set it forth.

EXPERIMENT I.

The transmutation of Mars into Venus, that is, of iron into copper.

This transmutation can be done in various ways. First, if filings of iron are boiled in vitriol-water [aqua vitrioli]. Second, if iron plates are cemented with calcined vitriol. Third, if red-hot iron plates are quenched in oil of vitriol [oleum vitrioli]. I add this: if thin iron plates are simply placed in vitriolated water. And these Paracelsus calls true transmutations — which we, as we taught at length earlier, deny; since we assert that this change is nothing other than the flowing-together, toward the iron, of the coppery corpuscles latent in the vitriol, which they naturally seek out [Margin: The magnetism of copper toward iron.]. For since a singular magnetism unites iron and copper — and since vitriol, whether calcined or dissolved into water, [is likewise magnetic] — the result is that, as soon as it has found the iron, it grips it in a most tenacious embrace and by its sharpness dissolves it into a slag [scoria], with which the vitriolated corpuscles, united by the wondrous sympathy they have for them, are mingled; and thus too they are easily concocted into the purest copper. The experiment of this is shown daily to strangers in my Museum. For if the transmutation were true and real, then the vitriolated corpuscles — whether calcined or raw, whether fixed or present in the water (for they are of one and the same nature) — would have to be converted

into the whole iron substance, which is contrary to experience. And so Paracelsus, in this place, [is false in]

[is false in] his own opinion. But let us look at the other transmutations he brings forward. "Iron filings can also," he says, "be reduced and transmuted as it were into lead, so that they become entirely soft, like native lead, but it does not flow easily. It is done in this way..."

EXPERIMENT II.

The transmutation of iron into lead, according to Paracelsus.

"Take iron filings; mix them with an equal amount of the best meltable powder [pulvis liquefactitius]; place them in a crucible; and in a windy furnace let a strong fire be made, so that the iron flows, yet stands as if in cement for a whole hour. Then strengthen the fire vigorously, so that it glows white and flows. Finally, when the crucible has been allowed to cool of itself, you will find in the crucible a button [regulus] of lead, soft and ductile, like native lead."

He calls this a transmutation of iron into lead, in which he contradicts himself [Margin: The transmutation of iron into lead is not true.]. For while he expressly says that iron filings can be reduced and transmuted "as it were into lead" — that is, into a certain likeness of lead — he adds that this does not happen easily, but that they merely soften. I assign a better cause of this matter, and it is this: that since iron consists of burnt sulphur and a slight moisture, so too, when the sulphur is burnt away along with the rest of the dross [loppa] by the efficacy of the fire, its parts are rendered more apt for flowing. This, therefore, is not a transmutation, but a mere purification — just as I have often seen in our Laboratory [Ergasterium] of the Roman College a bright and shining button made from Mars [iron], compounded of iron filings and antimony; which Paracelsus himself craftily conceals, when in place of antimony he uses the ambiguous term "meltable powder," which must be added so that there should emerge from it not a button of lead but of Mars [iron]. And so from these things, once again, Paracelsus's deception in his experiments is plain. But let us now see how he transmutes copper into lead, and whether this can be called a true transmutation.

EXPERIMENT III.

The transmutation of copper [aes], or Venus, into lead, or Saturn.

"First of all," he says, "reduce copper to white with sublimated Mercury and fixed arsenic, white like the Moon. Then, having granulated it, take equal parts of this and of the good reductive powder [pulvis reductitius], and first cement them,

then afterward melt them into a button, and you will have a true button of lead." That this cannot be a true transmutation is plain from this: that Mercury and arsenic, once they have flown off, leave the copper endowed with a white tincture; and, the burnt part of the sulphur having been consumed along with the rest of the slag, [the copper], purged as it were by fire, acquires the appearance of something whiter, softer, and more fluid than the button [Margin: That some things cannot be restored to their pristine state.]. And this can be proved by the appended experiment — how that button, which he calls lead's, can without any difficulty be reduced back to the pristine state of copper, which would not happen if it were a true and real transmutation.

EXPERIMENT IV.

The reduction of lead into copper.

Take plates of lead, or even the button which a little before he had drawn out from copper; stratify it with calcined vitriol or saffron of Mars [crocus Martis], cement it, and finally melt it; and you will see the supposed button of lead reduced into excellent copper [aes], heavy and malleable [Margin: The reduction of lead into copper.]. The cause is that, from the first reduction of copper into supposed lead, [a portion] of the copper had departed; and this is now, by the addition of calcined vitriol and saffron of Mars, restored to the pristine state of copper, that is, of red copper. This I would more justly call an alteration than a transmutation, and it is plain from the following experiment. For if such copper, reduced into thin plates, is stratified with tutty [tutia] or calamine powder — to speak in chemical terms — and finally, after cementation, is melted, you will find it passes into brass [aurichalcum], not unlike the splendor of gold. See what I said above more fully concerning copper [turned] into brass [Margin: in the [margin reference, illegible]]. For in this experiment there is no change of any substance, but the copper is merely tinged from red into a golden color; whereas this, as we have shown elsewhere, can again be reduced from golden back to red.

EXPERIMENT V.

The transmutation of Saturn into Jupiter, that is, of lead into tin.

But how lead can be changed into tin, Paracelsus teaches in these words: "Stratify lead, reduced into thin plates, with sal ammoniac; cement it, and finally melt it, as was said above. In this way the blackness and darkness of the lead's burden is removed, and in a most beautiful whiteness it will be seen to be most like English tin." The reason for this is none other than that the sal ammoniac resolves into smoke the fairly copious Mercury latent in the lead; and once this, together with

the soot of the lead, has been removed, [the lead] must necessarily degenerate into a harder and more splendid substance — namely tin, which for this reason they also call "white lead." Nor can this properly be called a transmutation, since the same Mercury, joined again to the tin by means of the sal ammoniac in place of the one that had flown off, can reduce it back again into black lead — as experience teaches me.

Having set out these transmutations, Paracelsus, to convince us of a real transmutation, adds a secret in a stony substance, the greatest of all secrets. I set down his words: "Likewise, know concerning the magnet, that it can be transmuted to a tenfold power and virtue, namely in this way:" Prick up your ears, doctors of the magnetic art, what a vast secret Paracelsus is about to disclose to you! "Take a magnet, and heat it white-hot in coals, yet in such a way that it grows very hot, but is nevertheless not [made] glowing [ignited]." But how the white-heating [candefactio] of the magnet differs from ignition I for my part cannot grasp [Margin: Paracelsus's ridiculous calculation in the matter of the magnet.]. "Which immediately quench in oil of saffron of Mars,"

"(...the magnet) which is made from the best steel [chalybs], so that it may drink in as much as it can hold. In this way you render the magnet so efficacious that with it you can pull keys out of a wall, and work other like wonders, which no other magnet can ever do." And in another place he asserts: "If you bury a magnet in the salt of the Echeneis, it will be of such great power that from it you can draw iron out of a well." These are Paracelsus's secret sacraments — all the more inept the more false they are. If this solemn Master had known even the first principles of the magnet, he would not have blurted out things so stupid. For who does not know — as I have taught by frequent experiments in my *Magnetic Art* [Margin: Paracelsus's ridiculous notion about strengthening a magnet in the salt of the Remora.] — that a magnet buried in coals is at once stripped of all its attractive virtue; and that nothing is so contrary to the magnet as intense heat — I will not say of fire, but even of the Sun itself, which it cannot endure without harm to itself, as I have found by frequent experiment? And who would believe that for this most impudent boaster a magnet buried in the salt of the Echeneis — which they call the Remora — acquires such virtue that it draws up a fallen iron from a well; or how can he say with truth that he himself performed an experiment of this matter? — when concerning the Echeneis, or Remora, whether it ever existed in the nature of things is most hotly disputed among the writers of natural history. And from where he got so many remoras, that he could extract salt from them, who can guess? You see, then, Reader, this man's headlong wit in asserting things, and his utterly intolerable audacity. It is therefore plain that

Paracelsus was of such a temperament that, if he heard anything new and wonderful in the nature of things, whether true or false, he straightway turned it to his own follies, lest he should seem not to know any of Nature's inmost mysteries — or rather fables. He had heard, and perhaps read, of the Remora as endowed with such great attractive virtue that a little fish of a hand's breadth could stop even cargo ships; whence he at once took it up for strengthening the magnet, without inquiring whether it truly exists in Nature, and whether it possesses the same species of attractive virtue as the magnet. But these kinds of imposture will be more fully laid open in what follows. Now [back] to the Rhombus, as the saying goes.

His disciples followed this man, driven by some I-know-not-what *δοξομανία* [Greek: *doxomania*, "madness for opinion / vainglory"] [Margin: The vanity of the Paracelsists.]. For since most of them were borne most greedily into a literal transmutation of metals, and yet could in no way fulfill their hope and greed, nor make good their grandiose promises by which they boasted that they had attained the goal of the great art — certain of them, with more than Thrasonical boldness, while indulging too freely in tricks and deceptions, paid the deserved penalties for their rashness, with the utmost mark of madness. Others, more cautious, lest they be branded with the crime of false arts [pseudotechnia], put on a deceptive cloak to cover their ignorance, and followed Lull [Lull] and his disciples — Ulstadius, Rupescissa [John of Rupescissa], and the other Masters of Paracelsus — with a biting pen, plucking at them with unworthy reproaches; nor did they ever cease to do so. The "Heaven of Lull" [Coelum Lullianum] and the quintessence they mocked and despised as a ludicrous thing, of no moment in the matter of transmutation; and yet, although they had copied everything from it, they nevertheless wove — under another sense, lest they be convicted of the crime of plagiarism — a new, but treacherous, web of gold-making, drawn from the parabolic, magical, and philosophical Hermes [Hermes Trismegistus], from the Turba Philosophorum, and from the rosary of Villanovanus [Arnald of Villanova]; which web, however — lest they be charged with ignorance — they thought fit to cloak with allegorical reasonings drawn from Ovid's *Metamorphoses*, Aesop's *Fables*, the Colchian Ram [Aries Colchicus, the Golden Fleece], the Song of Solomon, and other [works] that seemed in any way to suit their purpose. At last they reached such a pitch of impiety [Margin: The impiety of the alchemists in applying the sacred Scriptures to the signification of the Stone.] that they were not ashamed to accommodate to the Stone — with a truly impious daring — the supreme benefits of Christ our Savior: his Incarnation, Nativity, Passion, Death, and Resurrection, and the other parts of heavenly doctrine, and the hidden sacraments of the Gospel [Margin: Ridiculous.].

Some, again — followers of Paracelsus — having heard the word "Medicine" as the corrector of imperfect metals, transferred it not only to the medical faculty, but also defiled the art of pharmacy [pharmaceutice] with similar transmutations; not considering that this metabolic medicine of metals is idle and superfluous, if by one general [process] all things were converted into Sun [gold]. Hence again, certain ones, driven athwart, while they know not the method of transmuting perfect metals into gold, turned to certain apparent transmutations [commutationes] of imperfect metals into imperfect — that is, the transformations of Mars into Venus, of Saturn into Jupiter, of antimony [stibium] into lead — and, as if laboring at perfect metallic works, with the insane labor of Sisyphus rather than of philosophers, and without fruit, not without the laughter of the wise, they rolled and rolled them back again.

Quercetanus [Joseph Duchesne], a follower of Paracelsus, when he recognized the innumerable entanglements that occur in transmutation, lest he should waste both his effort and his oil [oleum] on useless work, became a deserter from Alchemy to medical Chemistry [Margin: Quercetanus, abandoning Alchemy, deserts to Chemistry.], and gives the reason for his decision in these words: "For what then, afterward, if you could make gold from quicksilver and from the mercurial parts of metal, and by that art procure misery for yourself, while in the meantime human health — which is more precious than gold and gems — is neglected?" Rightly indeed — if only he had added that he too did not know it. Therefore, having abandoned the camp of Paracelsus, and following Lull, he resolved to turn over for himself another stone, which, in a book he published *On the True Medicine of the Ancient Philosophers* — its matter, its mode of preparation, and its power in healing diseases — he set forth as extracted from the essence of wine. And this, he says, is the true stone intended by the ancient philosophers; and he proves it from that fictitious epiphonema [tag] of Morienus [Morienus Romanus]: "Our Stone is the water extracted and separated from our body, which is called prime matter [Margin: What the prime matter of the vegetable Philosophers' Stone is.]; for the gold of the philosophers," says Quercetanus, "or the stone, is nothing other than a medicine tempered by some art, which, as a form separated from its own body, has been reduced to such subtlety that, into any object whatever, ...prepared after the pattern of a heavenly form, by which Nature works upon its own material. But I ask: what affinity or proportion can a *vegetable* Stone possibly have with a mineral or metallic one? I can find no way at all to make sense of it. Whether one could draw an herb or a plant out of a beast, or a metal out of a plant — that is, draw it out by the very road that runs counter to Nature — let him look to that himself.

[Margin: Quercetanus extracts the Philosophers' Stone from the quintessence of gold (Llull's doctrine).] Others, who are ashamed of such inconstancy and confusion of speech, make excuses for Llull, Quercetanus, and the rest of Llull's followers when they make the Stone out of the fifth essence of gold: namely, that everything Llull set forth about his "vegetable heaven" is to be taken in a purely metaphorical sense. But anyone who reads Llull's book entitled *Caelum Philosophorum* [The Philosophers' Heaven] will see from the very procedure of the *Magisterium*, clearer than the noonday sun, that Llull there displayed nothing other than a certain Panacea, wonderfully suited to the cure of every infirmity of the human body. Hence, having thrown out the transmutation of metals as a lost cause, he devoted himself solely to this vegetable Stone, so important for preserving and even prolonging health.

But those who reach for the inestimable treasures of golden Nature beyond all measure — these men, rejecting both the vegetable and the animal Stone as incongruous and heterogeneous, threw themselves into making the *mineral* one alone, with tireless but utterly fruitless labor. And so that they alone might seem to possess the vast secrets of Nature, they wrapped the procedure of the art in such monstrous tangles of opinion that you could neither grasp them by understanding, much less imitate them in writing, much less even dream of rivaling them. And lest I seem to do them an injustice, I have decided to bring the whole procedure of the transmutatory art here to the anvil — so that the reader may see, most plainly, from the very χύτευσις [Greek: chyteusis, "smelting/pouring" — the casting-process] and from their manner of proceeding, that what is entangled in so many knots of contradiction, cloaked in so many absurd wrappings of comparison, and confused by the mismatch of so many things forced together, simply cannot hold up.

Caput III.

On the manner and method of making the Stone and Tincture of the Philosophers.

I will not speak here of the false chemists [pseudochymiaestae], but of the first-rank Alchemists' procedure in the construction of the Stone — so that from their manner and method it may become clear what is to be hoped of the rest. Among these the chief place, after the Arabs — the fictitious Hermes [Hermes Trismegistus], Geber, Rasis [al-Rāzī], Khālid, Hamuel, and countless others — is held by Llull, Villanovanus [Arnald of Villanova], the spurious author "Iohannes Azoth" [John of Azoth], Rupecissa [John of Rupecissa], Trevisanus [Bernard of

Treviso], Bernardus, Isaac Hollandus, Paracelsus, and all who, divided into various sects, cultivated this art.

The Arabs set out the working of the Stone and the Tincture in this way, on the authority of Geber, whom they followed:

Let there be taken *the stone known in the chapters* — that is, quicksilver, or the Mercury of the philosophers, which they call زئبق Zertbach [Arabic *zaybaq*, quicksilver] — after its preparation; but before preparation, the very stones from which it is drawn. Upon it the work of sublimation of the first degree is to stand continuously, with insistence of the work, until it is cleansed of the corrupting impurity and becomes most pure, and at last volatile. *How this is done by sublimation will be shown in the following procedure.* Thirdly, let it be fixed by the modes of fixing, until it rests under the harshness of the fire: here stands the goal of the second degree — that is, you now have the elixir fixed in the first degree. Fourthly, let the stone be treated also in the third degree, which consists in the final completion of the preparation, so that you make the now-fixed stone volatile by the modes of sublimation, and the volatile fixed. This you dissolve, make to fly again, and coagulate anew, until it flows — yet without smoke — and enters in, and tinges, and alters into the solar [gold-making] completion, and into the lunar [silver-making]; or until, by its projection, it makes complete gold and silver. This requires manifold repetition of the same labor. Here lies hidden an incomparable treasure, a most precious secret, above every secret of the sciences of this world.

So far Geber.

And because all this might seem to be said gratuitously, without further explanation, I will here append the procedure of Raymond Llull and of John of Azoth — who copied his from Llull almost word for word. Since it conforms to the Arabs' description, no one should doubt that Llull too took it from the Arabs.

The procedure of Raymond Llull and John of Azoth for the completion of the Great Stone and Tincture.

The crowd of Alchemists divides on this procedure into two sects. Some, for making the Stone, require the purest mineral gold; others think the business can be carried through without any addition of gold. And where the first sow the true and genuine seed in their philosophical earth, these instead sow tares — yet supposing all the while that they can arrive at the desired fruit of gold, than

which nothing could be more foolish. But now to the procedure of Llull and Azoth.

Pragmatia I.

The Sublimation of Mercury.

First, in his *Clavicula*, Llull teaches certain compounds of waters, necessary for carrying out the work toward the Philosophical Stone and Tincture. And first, indeed...

he teaches the sublimation of quicksilver, to which he directs that one pound of Roman vitriol and ten ounces of common salt be joined. But because the operation is rather tedious — too much for the reader to bear — I have decided to leave it out. So Mercury, brought by this operation to the highest purity, is to be set aside. Secondly, he teaches the preparation of the water which he calls "the water of life," in this manner:

Pragmatia II.

The preparation of the water of life, which is in fact nothing but aqua fortis [nitric acid].

[Margin: Llull's procedure for confecting the Stone.]

[Margin: 1. The preparation of aqua fortis.] **Procedure:** Take two pounds of Roman vitriol, as much calcined alum, and one pound of niter [halinitrum, saltpeter]; grind them, put them in a cucurbit, fit an alembic-head on top, and distill off aqua fortis according to the art — first over a slow fire with the joints well sealed, then a stronger one, and finally the strongest, until the alembic glows red. Then stop; you will have done your best if you obtain three or four pounds of this water.

[Margin: 2. The making of aqua regia.] Afterward, to have aqua regia [royal water], proceed thus: in one pound of the aqua fortis already prepared, dissolve a third of a pound [triens] of sal ammoniac, and it will pass from green color to citrine; and it will be able to dissolve gold and to dye the skin yellow — which by analogy they call the juice of celandine [chelidonia].

[Margin: The virtues of this water.] It also dissolves cinnabar, sulphur, and sublimated quicksilver. Keep this in a well-stopped glass, in a warm place.

This done, he teaches the preparation of the Mercurial Water in the following way.

Pragmatia III.

The preparation of the Mercurial Water.

[Margin: 3. The preparation of the Mercurial Water.] Take one pound of the aqua regia prepared just above, and six ounces of the Mercury sublimated above — pure, dense, clear, and heavy. Commit these to a strong cucurbit; into it cast the Mercury little by little, then stop up the mouth so that the force of the sal ammoniac does not escape, and set it in ashes of moderate warmth. Thus the water will dissolve the Mercury; and if after the dissolution anything remains, let it be dissolved by pouring fresh aqua regia over it, and so proceed until the whole is dissolved. Add the later dissolutions to the first, with a gentle motion so that it does not effervesce; and with the glass closed, they reserve the water for its use.

[Margin: All these things are reduced into the first matter in the Mercurial water.] The sign of this water's perfection is this: if a little copper plate cast in is tinged with a silver color. And this is the water by which they suppose all metallic bodies are reduced into Mercury, or the first matter. Now, how this water can be brought to the highest purity, he teaches in the following way.

Pragmatia IV.

The purifying of the Mercurial Water, which is then called the Mercury of the Philosophers, and which reduces metallic bodies into the first matter.

[Margin: The Mercurial water is poured in.] Pour the Mercurial Water just described into a cucurbit with a long, narrow neck. Set it in well-rotted horse dung for the space of fourteen days, in a vessel exactly closed; and there, in the putrefaction — the dregs being separated from the watery body and settling to the bottom of the glass — a yellow and citrine water will be left. Then transfer the glass out of the dung to a furnace of ashes, and through the alembic, according to the art, distill the water with a gentle fire; and there will come forth a most clear, heavy water, which in this operation they call the Virgin's Milk, the sharpest vinegar, and the perennial water. [Margin: The Virgin's Milk; the sharpest vinegar; the perennial water — what it is.] Continue the fire until you have drawn out the whole clear liquor; this done, with the fire lessened, let the furnace cool, and reserve the water. The sign of perfection is this: if a drop poured over a brass plate made glowing-hot at once penetrates it, leaving a white trace behind. And this water, brought to the highest purity and stripped of all corrosive qualities, reduces metallic bodies into the first matter — whence it is also called the Mercury of the Philosophers. Now, how by its agency metallic bodies can be reduced into the first matter, he teaches in the following practice.

Pragmatia V.

How metallic bodies are dissolved into Mercury, or the first matter.

If you intend to dissolve silver into Mercury for yourself, work thus. Silver purely refined [fulminatum] and repurged, reduce into filed dust [scobs], or into very thin leaves drawn out by the goldbeater's tool into the form of paper. Grind this with the prepared salt on marble until an exact powder is made; wash it with hot water free of all saltiness, dry it, and when dried place it in a basin. Steep it in oil of tartar and dry it again, repeating the same again and again. At last, when it is dried out, grind it into a calx; the ground material put into a cucurbit or phial. Pour on the Mercurial Water we prepared a little before, to the height of two fingers; and this done, set it over a gentle fire among ashes, and the Mercurial water will turn the calx into Mercury. [Margin: The Mercurial water reduces into the first matter; that is, it reduces the Mercury.] If the whole is not converted, pour off the first water with its Mercury, pour on fresh, and proceed likewise; pour off the water carefully into another glass, but put the Mercury back into a pan or glass cup. To make it clean, wash it with salt water; then, the moisture dried off, squeeze it through a cloth or a leather pouch. If nothing remains, well and good; but if anything undissolved remains, the repetition must be undertaken, until, when squeezed through the whetstone-cloth [pannus cotenaeus], nothing remains. The first signs of the perfection of this Mercury are: a greater slowness in its course than that of common quicksilver; and second, if, placed upon a glowing plate, it exhales and leaves behind it a mark of fixity. If you wish to augment this Mercury, take four ounces of the Mercury prepared a little before — or as many as you like — add half as much filings of purest silver, and let an amalgam be made. Mix this with the best purified quicksilver...

in twelve parts; put it into a glass which you will close well, place it in a fire of mild ash, and keep it there for a month, so that the resolution into Mercury takes place. Then it will be said that the wholly volatile overcomes the wholly fixed; and this same one he makes volatile, and you can repeat this operation at will, for any augmentation. Llull and Azoth say this is the whole and only secret of the Philosophers.

[Margin: Operations toward the great Magisterium.] But the same procedure holds good if instead of silver you take gold.

And up to this point everything is said rightly and skillfully, inasmuch as it does not contradict experience. It remains, then, for us now to teach how — and whether — by means of this we can attain that which has been so greatly desired for so many ages now, that is, that Stone or Tincture; and by what road and

method the Physical Tincture can be confected by the Alchemists, with the help of the apparatus set out above.

[Margin: What is the Tincture, or Elixir?] They say, then, that the white and red tincture, which they call the Elixir, made from the Mercury of the Philosophers alone and projected upon Mercury and upon all imperfect metallic bodies, can be transmuted into bodies true, perfect, and better than the natural ones — from the Mercury of the wise alone, I say, which is not the Mercury of the common crowd, but is the first matter of metals, from which all Alchemical virtue is said to be drawn. To this they hold that no foreign thing is to be added, except gold and silver, as certain co-adjutors in the fermentation of the Stone, through which the true chemical work is perfected. For as Nicolaus Barnaudus says, the material of chrysopoeia [gold-making] is the finest gold drawn from the ore — not wrought, nor mixed, but of the best mark.

[Margin: Gold of Ophir and Havilah — best for the Alchemists.] "Gold," he says, "of obrizum [refined gold] — such as is found in Genesis, chapter 3 [recte: chapter 2], in Havilah by the river Pishon of Paradise, or as occurs in Ophir." But just as the location and situation of both regions is disputed by interpreters to a wondrous degree, so too it is ridiculous for the chemists to banish us, for the sake of the Stone, to unknown gold-mines of this sort. Indeed, I am astonished that this author did not pack us off as well to the Rhipaeen mountains, to the Hyperborean griffins, guardians of the most excellent gold — so that at last we might obtain gold suitable for the chemical business. But let us leave these trifles of the Alchemists. Others choose gold ἄπυρον [Greek: apyron, "unfired" — not having undergone fire] for their purpose. Whatever may be the case with gold and silver of better mark, you will make nothing at all — to which we ourselves wholly and utterly subscribe — although this was not the intention of the ancient Philosophers.

But now let us see and examine the operations by which they assert that the Tincture of the Stone is perfected through sublimation — by which, as by a single one, the other seven grades of the operations are contained, namely distillation, ascension, descension, coagulation, putrefaction, calcination, and fixation. They proceed thus:

Operation I, which is called the corporeal preparation of Mercury. Place the Mercury of the Philosophers, prepared above, in a phial; close the mouth Hermetically, so that it cannot escape. Set it to be suffocated in its little bed, well laid out with a temperate heat, for the Philosophers' month, under a gentle warmth, until of itself it sweats, and no longer ascends or descends, but rests and

is coagulated into a black earth — which is called the raven's head [caput corvi], and is called earth, black dregs, the brass [aes] of the Philosophers, black sulphur, the man and the male: one thing under diverse names. [Margin: The raven's head — what it is to the Alchemists.] And so from this first operation, by coagulation, what was liquid becomes thick; from cold-moist, as they say, hot-dry, by separation of the elements.

Operation II, by which the black earth is whitened, proceeds thus. Take two parts of the raven's head, or black earth; add to them one part of the Physical water reserved — that is, of the Mercurial water prepared above — so that the dry earth drinks in the water until it has consumed it all, and the water itself wholly passes into the body of the black earth. [Margin: The whitening of the raven's head.] As soon as it has been mixed, close the glass and place it in an ash cupel; apply a temperate heat, and let it be dried, as on a soft bedding, by continuous warmth for eight days. For then it will begin gradually to whiten; take it out of the glass, and again give it the virgin's milk to drink. After it has drunk, put it back into a sound little trough or phial, and into a bed of temperate warmth, so that it may be dried out again, as before; and this through four turns. By this operation, then, you have reduced the black earth, or Raven's head, sufficiently purged of all foulness, to the intended whiteness. Keep this carefully, for you have what — as they say — you can desire: the white foliated earth, the white sulphur, the white magnesia, by which they suppose the conjunction of gold and silver to be made, and the revivification of dead bodies. By this imbibition any fruit emerges a hundredfold, so that toward the goal nothing else remains but the fermentation, by which the foetus is said to be in some manner animated. [Margin: Fermentation.] According to that saying in the *Turba Philosophorum*: "Sow your gold in the white foliated earth, and it will bear you a hundredfold fruit" — whose virtue they say is so great that it is multiplied to infinity; and that this is that desired white Elixir, tinging Mercury and every imperfect metallic body into Luna, that is, into truest Silver. Yet they add that the ferment cannot enter the dead body except by the mediation of the mercurial water, which, like a bridesmaid [paranympha], completes the marriage.

Here, reader, you have the entire pragmatic procedure for the confection of the Stone and Tincture, freed from all the obscurity of parabolic expressions as to the letter, as far as could be done, most clearly set out, evolved, and unrolled — so that henceforth no Alchemist can complain either that the terms were less than rightly understood, or that much was deliberately omitted to keep the art hidden. But if they do assert this, I say: no chrysopoeial artificer is ever to be believed, but

rather [we should hold that] for the sake of winning some reputation for themselves through knowledge of the great Art...

they have put forward anything whatever for anything whatever, with the highest and most intolerable imposture. By such modes of speaking it can scarcely be told how greatly they prejudice the possibility of the Art. Since, therefore, the words are clear and the practice methodically set out can easily be reduced to practice by everyone, it now remains for us to weigh the individual points on the physical balance, and to show whether the intended secret of chrysopoeia of this kind can be obtained. For I would not have the reader persuade himself that I am so credulous as to revere and adore, like a sacrament of the Gospel, whatever wonders the Alchemists prattle of — especially since most of them possess no knowledge of hidden physical things, nor are skilled in the art of combining things, by which alone truth is sorted from falsehood, the legitimate from the illegitimate, the discordant from the consonant. Nor let them think me so unskilled that I could not pass a fair judgment on the Chemical Art. Since this is so, let us now begin the web we have started.

If anyone should go more deeply into the working of the Stone [Greek: ἐγχείρησις, *encheirēsis*, "undertaking/operation"] put forward by John of Azoth — who took the whole of it from Lull — and compare it with other authors of the same flour [i.e. of the same stamp], he will first find that there is great diversity in the manner of operating. In some points they indeed agree, but in others, and indeed in more, they differ so much that the business has split into two divisions.

[Margin: Paracelsus asserts the Stone can be made without gold.] The Paracelsists contend not only that the Stone can be made without taking up mineral gold or silver, but they imagine that they can attain the intended end of the work by the Mercury of the philosophers alone — while they draw out the spirit of Mercury extracted by the help of wine, which they say nests now in the vein of cinnabar, or the fossil vein of minium [red lead], now in the liquor of sublimate. But how, without gold and silver, a red or white elixir could tinge anything whatever into gold — in which it never was — who will believe? Unless perhaps the cinnabar, minium, or antimony (which he puts in place of the liquor of sublimate) happened to contain, or had taken up, some gold. But on this footing it will indeed make a red or white elixir, yet from it will never draw out the multiplicative virtue of the tincture — only just so much gold as was mixed in the cinnabar, minium, or antimony from a vein of gold. From which the imposture of Paracelsus plainly appears, who promised from the pure ore of Mercury that which by Nature is not in it. And this even one of the not-least Alchemists among

the rest, Basilus Valentinus, knowingly teaches (*De rebus naturalibus*); and Llull subscribes to him in these words: "Our Mercury must be made from gold and silver by the mercurial water, joined with a proportional quantity of quicksilver." But how cinnabar, or fossil minium (in which generally only mercury nests), could be so prepared that from it a gold-making stone should result — who will believe? How will it give what it does not have? They say, perhaps, "from the seed of gold [χρυσοῦ, chrysou] existing in its inmost center." But who, I ask, has sought out the seed of gold in cinnabar, unless it has accrued there from nature? Surely no one...

[Margin: Another procedure toward the Stone.] ...unless he is ignorant of the principles of Nature, and consequently an impostor. But of this dyed-over metamorphosis, more in what follows.

I come to those who do take up obrizum gold, and silver of a nobler mark, for the work of the Stone; but these too disagree among themselves in their method. Some believe that gold, from which the mercurial seed is extracted, can be reduced into its pristine nature: so Nicolaus Barnaudus, in the confection of his Stone. But let us see his manner of operating.

"Take," he says, "two ounces of obrizum gold, and ten times as much Mercury elaborated with great art-skill; mix them, and dissolve over a languid fire, until the mercury escapes and the weight of the imposed gold remains, reduced into a black powder — which, however, once melted, can be converted back into the pristine nature of gold. From this powder he draws out, by the help of a dew-bath [balneum roris], the mercury, until the powder turns into a snow-white calx. This being purified by a sevenfold washing, there will at last come forth from it Azoth, a living spirit, whose earth is the ferment, the water [aquamas], the calx the seed — by whose embrace is born the infant, that is, the stone. This purified calx, or the sun [Sun] of the philosophers, in a stopped vessel let putrefy, and set aside to digest for 40 days, until it liquefies into a white and thick humor; to which, at fixed intervals of days, you will pour on the aged mercurial water, and leave it, until it recovers its strength and joins together again — and this as many times as needed, until it has imbibed all its water. Then the womb [uterus] is closed, so that nothing escapes, and the desired stone is born. If you place it upon mercury in an open sealed egg [ovum sigillatum], then put it to two drachms; give a strong fire; afterward you may add borax, and you

will have one drachm of gold. And if you know the multiplication, you will not need the stone."

So far Barnaudus. In this Pragmatia I find many mystical words, but no usefulness, no profit from so great a promise. This one thing I gather from the text: that after so many months of labors, after so many vigils and sweats and expenses laid out, the man who had set down two ounces of obrizum gold as his first material body found — besides the loss of the quicksilver he put in — nothing but one drachm of gold; and that not, as he himself supposes, from a transmutation of Mercury into gold, but that very gold which he had put down in the first place, even if diminished by a twelfth [1/12] of a grain. And at this indeed no one should wonder, since through so many torments of fire and water it was partly consumed into the excrementitious parts mixed in with the gold, partly into smoke, and partly at last by the corrosion of the waters. Yet, so as not to seem to have done nothing, he exhorts the reader to the multiplication of the material — which, however, after the deliberate custom of the Alchemists, lest so great a secret should lie open, he kept silent.

[Margin: Invective against the Alchemists.] O wretched Philosophers! If you promise us no other riches than those gotten at such expense, at such mastery of labor — certainly so far is it from making us richer than Croesus, that rather, soon reduced to our last counters [ad incitas redactos], we find ourselves cheated by words, deeds, and smoke, and poorer than Irus and than Codrus. Whatever, therefore, they may do...

they may act, this certainly does not deserve the name of a *philosophical* solution. Rather — as Libavius rightly shows — it ought to be called the work of metallurgists and goldsmiths (who, however, achieve the intended result with greater dispatch, greater ease, and indeed greater profit).

Besides these, there is no lack of men who do take in gold of better quality for the perfecting of the work — gold being the substance from which they are accustomed to extract the Mercury of the Philosophers, the prime matter of the art — but they hold that it must be so prepared that it can in no way be restored again to its original nature. So Morienus [Morienus], in the *Turba Philosophorum* [*Turba Philosophorum*]: "In our magistry, whether you take gold, or silver, or hydrargyrum, or Mercury, all things are so altered that they can by no means be brought back. For our gold, after dissolution, is so altered that it can be liquefied by no other substance than our mercurial water. Hence it is no longer essentially gold, but modified — and this gold, thus *mortified* or *modified*, is nothing other than what the artificers symbolically call black earth, black stone, dead body, the

raven's head. After it has been quickened by the mercurial water and by heat, then the Laton [Laton], or the Ethiopian — that is, the raven's head or black earth — is whitened. Therefore let the son of doctrine be forewarned not to burn that black powder too much, but to leave it so disposed that it can become watery again, which was its ancient nature, namely fluid and liquid." Thus the *Turba Philosophorum*.

[Margin: A contradiction of the *Turba* concerning the tincture of the stone.]

If you weigh these words carefully, you will find in them a vast knot of contradiction. For that gold, dissolved by the mercurial water into earth or black powder, either will be gold or it will not be gold. Now the *Turba* says expressly that it is not true gold. But if it is not true gold, how can it be exalted, through the mercurial water, into the tincture of true gold? — since it is impossible for gold that is not true to produce true gold, unless we are merely playing with words. There you have the first contradiction.

[Margin: A second contradiction.]

A second shines forth in the quicksilver taken up into the magistery, as the text shows: for although it cannot be brought back to its original form, the *Turba* nevertheless says plainly, at the end, that the black powder becomes watery again through the Mercury — which was its ancient nature. And so, according to the *Turba*, Mercury can be *drawn out into* but not *brought back to* its first nature — which involves a manifest contradiction, than which nothing is more absurd in true philosophy.

But they will say that, through the seed of gold imparted to the mercurial water, it is raised up again into new gold far nobler than the mercurial. But I now ask: what exactly is this seed? They will say it is the seed of gold, extracted and dissolved into prime matter through the Mercury. I press further: how do you prove that this seed has not been destroyed by so many dissolutions, calcinations, and all the other torments of both fire and corrosive waters? For if you cook and re-cook the seed of any plant whatever, and then commit the cooked and re-cooked thing to the earth to sprout again, I say it is so far from any new shoot being raised up from it, that rather, the form having been destroyed by such frequent decoction, the vegetable power of the seed must perish along with it. For, as the Philosopher [Aristotle] rightly says, there is no return from the privation of a form to its possession; you will get from it only as much as if you had committed a stone to the earth to flower again.

But they will say that it is one thing with the seeds of plants and another with the seed of metallic bodies — because in the mercurial water extracted from mineral gold there lies hidden the seed of gold, which, together with the water poured over the black earth, the raven's head, the black powder (for so they call the mineral gold, taken up and utterly destroyed and mortified by calcinations), revives the dead body and, by a white or red tincture, converts it into Moon or Sun [silver or gold] according to the proportion of silver and gold.

Against this I argue as follows. That seed either is multiplicative of its own species, or it is not. If you say the former, you are then necessarily compelled to enroll it among the number of vegetables, and so you will exalt it to the second grade of nature, and consequently you will attribute life to mineral and metallic bodies — than which nothing is more absurd in physics. But if you say it is vegetable only by analogy, you will be saying the same thing as that a painted man can beget a true man — which it would be ridiculous, not to say stupid, to assert. And if you say that by a certain modification it is true seed of gold, as the *Turba* puts it, you will fall into a still greater error, since a modification, or mode, being a pure and simple accident, adds nothing of substance, by the common judgment of the philosophers.

Since, then, no reason remains by which the *Turba* could prove that it can transmute the not-true gold (that is, the raven's head) into true gold through the mercurial water, nothing else remains to be said but this: that the tiny scrap of gold which is left after the whole magistry of so much labor and expense has been carried out, did not come from any seed of gold residing in the mercurial water — a seed which, from its very first origin, has through so many alterations acquired a heterogeneous form, utterly different from true gold — but rather has duly emerged, by proper depuration, from the mineral gold originally taken up, indestructible in its nature, though with earthy dregs that had accrued to it. But these matters we shall pursue more fully in what follows, so that it may become plainly evident how shamefully the alchemists sin against the first principles of philosophy.

CAPUT IV.

The Magistry of the Great Art is examined as it has been perfected, from Lull, the *Azoth*, and the rest.

[*Perfectum Artis Magnae Magisterium à Lullo, Azotho, caeterisque examinatur.*]

And now let us return to the *operation* [Greek: ἐγχείρησιν (encheirēsīn, "operation," "manual undertaking")], by which the mystery of the Stone is completed. When this is duly examined according to the philosophical standard, we find that — apart from parabolic expressions — it establishes nothing certain toward the making of the Stone amid such a variety and disagreement of methods, over which the authors quarrel among themselves. The *Azoth* corrects Llull [Ramon Llull], Libavius corrects the *Azoth*, Paracelsus corrects them all — so that scarcely anyone (as has partly been shown up to now, and will partly be confirmed in what follows) seems to agree with another.

Llull, then, in his *Clavicula* [*Clavicula*] (which the spurious author Iohannes [the "Iohannes" of the] *Azoth* set forth) — after the sublimation of the hydrargyrum, after the preparation of the *aqua vitae*, the *aqua fortis*, the *aqua regia*, the mercurial water, after the purgation of the same and the dissolution of bodies into Mercury, after labors as it were inexhaustible — at last proceeds to the final completion of the great Stone, which consists in fermentation, in this manner:

Continuation of the process, concerning the universal fermentation of the Azoth and the completion of the Stone.

"If you wish to ferment the white earth to the white Elixir, so that, on completion, the tincture may stand upon the diminished bodies and upon the mercury in every assay: Take of the whitened earth, or *foliated earth* [*terra foliata*] — that is, of the parts of the dead body — three parts, and of the reserved *aqua vitae* two parts, and one part and a half of ferment. Let the white ferment be prepared into a white, fixed, subtle calx, if you intend to prepare the white work. But if the red, then let it be the calx of the most citron-yellow gold, and let there be no other ferment, because the ferment of silver is silver, and of gold, gold — since in these bodies are inherent the tinging rays of the rest of the bodies, in pure redness or in pure whiteness; and in these, according to the nature of the most pure substance of substances, a thing is found that pertains to the specimen of the stone. Make each species with its own species, and each genus with its own genus: with white it is to be whitened, with red reddened; do not mix the work of one stone with the work of another, otherwise you will err.

"The white foliated earth is the *body*; the ferment is the *soul*, which gives the body life by means of the water, which is the *spirit*. Compound, therefore, these three parts into one, matrimonially, by grinding upon a clean stone, and by producing one chaos through its least particles, so that they become one confused *hyle* [Greek: ὕλη (hylē, "matter")], and are at last reduced into one inseparable body.

Afterward place it in its proper vial — that is, a warm, tempered *thorus* [bridal-bed] — so that it may be coagulated and fixed, and may become one white body.

"This done, take out again the white blessed stone, and grind it finely upon the clean stone, and again imbibe it with a third part of its own water, so that it may drink up the draught. Place it in its proper vessel, clear and clean, and set it in its tempered warm bed, so that it may begin again to sweat, and allow the draught of imbibed water to dry up within its bowels. Thus repeat many times over, until through these degrees of reiteration you have prepared a most excellent white stone, fixed and standing fast in the fire, and most swiftly passing through all the bodies of the imperfect metals and sustaining the combats over the fire of molten water: a Stone that tinges the mercury and all imperfect things into true silver, better than any natural silver.

"(Note that, when the order of this completion is reiterated — by dissolving, coagulating, grinding, and roasting — the goodness of this medicine is multiplied so much the more, and it tinges the more, so that, if in its first washing one part tinges 100, in the second 1000, in the third 10000, in the fourth 100000, in the fifth 1000000, in the sixth infinite thousands. One grinding and one imbibition do not suffice.)" Thus the *Azoth*.

But lest I should seem to have approached so great a mystery, so to speak, with unwashed hands, or lest I should incur the charge of speaking like the ignorant who have not understood the terms, I shall first set out the terms of this operation according to the mind of the alchemists, and then I shall disclose what may be established about the matter itself.

[Margin: What the foliated earth is.]

1. The white foliated earth is nothing other than the raven's head already whitened, from which is made that Sun-making and Moon-making Elixir [the Elixir that makes Sun and Moon, i.e. gold and silver].
2. "To stand on completion of the tincture" is, by the projection of perfect silver, to confer perseveringly and in a moment its color and nature upon the quicksilver and the imperfect metals — which are also called *diminished*.

[Margin: What the white earth is.]

3. The white earth is called the *dead body*, with respect to the animation that soon follows; what this animation is will be explained later.

[Margin: What the body, soul, and spirit are.]

4. In the composition, *Body, Soul, Spirit* are mentioned. They call the foliated earth the body, the ferment the soul (which gives life to the body by means of the water, which is the spirit). These three, however, are called by various differing names, as may be seen in Isaac Hollandus [Isaac Hollandus], *On the Fabric of the Stone* — so that consequently what is wrapped up in so many tangles cannot hold together. If the art be true, surely there must necessarily be one road to it, one operation, one method — unless one wishes to go utterly astray. But how much industry is required to animate the foliated earth with the mercurial water can scarcely be told, since it can scarcely be settled how much mercurial water is needed. For if you take a great quantity of it, you will scarcely, or scarcely even, coagulate the earth...

If a small quantity, dryness will forestall the legitimate limit of moisture, so that you can in no way attain a proper coagulation. Therefore, just as the perfection of the work consists in a certain individual point, so too it cannot be attained, because of the weakness of our intellect.

[Margin: What the reserved water is.]

5. The reserved water is taken as the *spirit*, by which the marriage is consummated; and it is divided into two parts for imbibing and coagulating, and again into two parts for the coupling of the marriage.

[Margin: What the ferment is.]

6. The ferment in this practice is nothing other than purest native silver from the ore, reduced to a calx by means of the Mercury. This, they say, is of such virtue that — just as a little wheaten leaven raises the whole wheaten mass into swelling and penetrates it intimately — so too this philosophical ferment is so exalted that, like a most perfect seed-bed, it acquires the power of generating many things like itself according to species, inasmuch as it turns the whole into true and formal gold. Indeed so much so that, even in the tiniest little portions, it is as the whole, and can thence be increased to infinity; and so that what they grant to spiritual substances — that they are whole in the whole and whole in any part — this the alchemists wrongly and ignorantly attribute to their tincture.

[Margin: What the matrimonial union is.]

7. The matrimonial coupling is the *first birth of the stone*; the rest were only preparations. Of this they very truly say that, if it be unknown, the whole art is unknown; for they speak so confusedly and divergently about this matrimonial conjunction with the foliated earth that not even they themselves know what they are saying.

[Margin: What the Oil of Mercury is.]

8. The Oil of Mercury is nothing other than the Mercury of the Philosophers.

[Margin: What the Chaos, the *hyle*, the prime matter are.]

9. The Chaos is a mixture, or paste, in which all things are so incorporated together that none of the things of which it consists appears; whence it is also called by others *hyle*, or prime matter, in which all things have the character of a passive potency, and out of which, nevertheless, by the external heat of the spirits and the internal heat, the thing is brought into the actuality of the desired form.

[Margin: What the Sun and Moon are.]

10. By the *Sun* he understands the sulphurous power, by the *Moon* the mercurial — whence the union. And this is the sum of the perfection of the stone, set forth by Llull, Arnold [Arnold of Villanova], and the spurious author Iohannes of the *Azoth*, who copied it almost word for word from Llull. All the subsequent authors of the Great Art, the gold-workers, have looked to it as the archetype of the art, both for its method and for the clarity of words with which it describes the secret; and we too have deliberately selected it for more easily discussing the process of the art, the rest being intentionally passed over.

[Margin: The process of Cornelius Drebbel.]

Among others there was Cornelius Drebbel [Cornelius Drebbel], who held that the whole art described by Llull could be understood under a recondite physiology that consists in the admirable transmutation of the elements among themselves and in the effects resulting from this — the doctrine of the *Azoth* handed down above.

[Margin: Melchior of Sibiu (?).]

Third among the alchemists comes Melchior Cibinensis [Melchior of Sibiu (Hermannstadt)], who exhibited the art to Ladislaus, king of Hungary and Bohemia, not in a philosophical manner nor in the way customary among the

wise, but — seized by a kind of insane derangement of mind — did not blush to defile the sacred and adorable mysteries of the Liturgy with his coals and black smoke, no less irreverently than impiously, in parables and allegories drawn from the *Song of Songs* [*Canticum Canticorum*]. Let him who wishes read the sum of the art in the *Theatrum Chymicum* [*Theatrum Chymicum*], and he will marvel — not without laughter mixed with indignation — by what means it could enter into a man's mind to wish so basely to mock the world, so boldly and without shame, with mysteries that are not mysteries but crimes, with a knowledge that is not knowledge but imposture.

[Margin: George Ripley.]

Following him was George Ripley the Englishman [George Ripley], who, apart from what we have already said about the traditions of the *Azoth*, has nothing peculiar or different — except words concealed with marvelous artifice. And although he promises everything with more-than-Thrasonical bombast of reasoning, he nevertheless brings forward nothing but the utmost obscurity joined to equal confusion, so that he seems not even to have understood himself, what he had said.

[Margin: Sendivogius the Pole.]

To these is added Sendivogius the Pole [Michael Sendivogius], who, when he had stirred up the world with unheard-of promises in twelve little treatises on the Philosophers' Stone — and had, by a specimen of his art exhibited before the Duke of Württemberg, together with the impostor Mühlenfels [Mühlenfels], drawn the prince into a rather sinister suspicion of an imposture practiced by them both — the one (Mühlenfels) was indeed stripped of his garments, shut up in a tower, and at last, convicted of his crime, paid the penalties worthy of his malice and wickedness; but Sendivogius, having slipped almost naked out of prison, never afterward appeared — so that from this too it may be plain what you may hope for from such men.

[Margin: Paracelsus.]

After these, Paracelsus [Paracelsus] at last presents himself, who, aspiring to the primacy of the alchemical art, while he joins Astronomy to Magical and Cabalistic things and Physics to Theological ones, brought forth not so much new doctrines as monstrosities of opinions. For whatever he handed down in his *Archidoxa* and his books *On the Nature of Things* concerning the mysteries of the Great Art, was culled partly from Llull, partly from Isaac Hollandus, with the name of each suppressed, and he made it his own and his own invention — in which, however,

you will find nothing differing from them and nothing alien as to substance, apart from a farrago of foreign and monstrous names.

[Margin: Llull.]

Llull, then, was the first who — being not unskilled in the Arabic language — rendered into Latin the books of the Arabs on alchemy, vindicated from all obscurity, as became clear to me when I compared the two doctrines; and indeed, in the book which...

he calls the *Clavicula*, bequeathed to posterity, he set forth the art according to its genuine sense — though Arnold of Villanova [Arnold of Villanova], as will be seen later, contradicted him in everything. Following these chiefs of alchemy, countless others — who, all the more greedily clinging to gold and riches, hoped to secure the fruits of those wondrous effects which they expected from the benefit of the "blessed" (or rather *cursed*) stone — thus prostituted all their effort, study, all their resources, and indeed life itself, basely and without any fruit. Hence there was found scarcely anyone — I will not say a philosopher, but even a craftsman from the lowest commons — who did not set his mind to an art of such moment. The philosophers and physicians, that they might boast of knowing something above the rest, also published the art in print; and the princes, together with the common people — allured, whether by greed or by curiosity, by so many and such great promises, especially concerning the Chrysopoeia [Greek: χρυσοποιΐα (*chrysopoïia*, "gold-making")], of so great a rarity — neglected the affairs of the commonwealth and shut themselves up, together with the charcoal-burners' ash-heaps, within hidden workshops which they call *Laboratories*, to gather the fruits of the art and to practice it.

But what in the end? With the treasury exhausted and the people indignant, they brought back nothing worthwhile but smoke, charcoal, and ashes. For who could ever affirm that any prince either gained anything by the practice of this fraudulent work toward attesting the truth of the art, or thereby became richer? Indeed, of many — whose reputation I deliberately spare — it is established that by the fatal pursuits of these scoundrels they were so, I will not say *driven mad*, but rather *so blinded*, that they reduced a household otherwise wealthy to utter ruin. But lest I should seem to do the alchemists an injury, let us now proceed to the weight of the arguments by which — God granting it — we shall plainly demonstrate that alchemy, and the processes adduced a little earlier, are not only vain and idle, but also unworthy to be admitted or held in admiration by princes.

CAPUT V.

In which it is taught that the processes of the Great Art adduced a little earlier cannot stand.

[*Quo Alchymicos Magnae Artis processus paulò ante adductos subsistere non posse docetur.*]

Although the vast variety of contradictions (by which the alchemists are continually tossed, as it were by a kind of ebb and flow, in the construction of the great Stone) could be a most sufficient argument of falsehood — nevertheless, lest they snarl at me that the truth under that contradiction is understood only by the sons of the art and lies concealed, but, hidden beneath it, lies far removed from the capacity of the *philosophasters* (as the inscription of the Hermetic School teaches: "Far hence, far hence, be the profane"), and that it *seems* a contradiction but is not — yet these arguments, since they put forward I know not what *irrationality* [Greek: ἀλογότητος (alogotētos, "irrationality," "absurdity")], and are more like a brutish than a human philosophy, I likewise leave to be resolved by fools, to whom alone nothing is easier than to be persuaded that white is black, heavy light, gold not gold.

The alchemists say that the gold which constitutes the stone is not gold; that the Mercury in the great art is not Mercury; and yet they take up gold and mercury for the great work, and say that the gold, like the mercury, has first passed into another, better form. I ask: if it passes into a better form, that form will be distinguished from mineral gold either specifically (to speak as the Schools do) or only by accidents. If the former, only a madman would assert that gold to be distinct in species — since in any genus of things whatever the species is single and incommunicable to another. For, as the Philosopher [Aristotle] rightly says in *Metaphysics* VIII [l. 7, met.]: "The species of things behave like numbers." Most alchemists, when they say that chemical gold is not true gold, consequently assert that it is distinguished in species. Others, who taste of something loftier, contend that it is indeed gold, but far nobler and more excellent than mineral gold and gold begotten by nature — inasmuch as it is living and multiplicative.

[Margin: Objections, and the solutions of the objections.]

I ask: whence did so great an excellence come to that gold? They answer: from the depuration and the vivifying seed of natural gold. Again I ask: by what means could that seed be extracted, without a subject remaining in which it might subsist? They answer that the subject and the seed are the mercury abstracted

from the gold. Against this: either that mercury is mineral, or it is not. If the former, it must now be seen how it did not vanish, impatient of heat, through so many torments of fires and corrosive waters. If the latter, then it will be mercury and not mercury — and consequently, from a non-mercury, without a matrix, gold will be produced far nobler than the natural. But since these are contradictory, they do not deserve to be refuted. These, then, are all pure chimeras and the stupid phantasms of a deluded imagination and a raving mind. For if what is produced from that imaginary mercury is not true gold, how will true gold come from it — since to make a true thing from a non-true is *impossible* [Greek: ἀδύνατον (adynaton, "impossible")]? Or if it differs in species from mineral gold, what else can we conclude but that, from such gold, it produces a gold distinct in species from the natural — different in essence, property, and powers, utterly different — than which I do not see what could or should be called more absurd and stupid in natural philosophy. But since they were ashamed of this madness, some, as though from a certain tripod of Apollo...

they shroud this mystery beneath so many fables, beneath so many monstrous names of barbarous coinage, that to the unlearned crowd they may pass for Hermes revived, but to true philosophers they look like nothing more than "gilded"—not to say "long-eared"—asses. And so it remains, unless they would rather be thought stupid in every branch of sound philosophy, for them to admit frankly that chemical gold cannot be produced in any way without mineral gold—as indeed we have shown abundantly and more than abundantly above, from the words of Lull [Ramon Llull], the *Azoth*, and Arnold [Arnold of Villanova]. And just as this is perfectly true, so too the whole of that chemical gold which they boil out with so much labor is one and the same as what they took up at the start to set the work going—even if, after purification and refining through so many distillations, sublimations, and calcinations, it is found somewhat diminished and, consequently, of a finer grade.

Now as for their claim that mercury must first be reduced to the prime matter of the metals, here again they say nothing. Either that prime matter is visible and accessible to the senses, or it is not. If the former, how can they observe it in their operations, since prime matter—or even secondary matter—is imperceptible? If the latter, then it is no longer prime matter but a compound, made up of its own prime matter and form. It remains to say something—so that the truth may come to light—about the "seed of gold," restorative and infinitely multiplicative through the tincture, just as their process promises.

[Margin: The prime matter of the alchemists cannot stand.]

These wrongheaded fire-workers boast that not only gold but—by the benefit of their marvelous Stone—a tincture can be made, whether white or red, of such power and such fecundity that the fermented Stone is able to change 100 parts of imperfect metals into perfect metal. And if you imbibe this a second time—that is, dissolve and coagulate it—it becomes so fecund that one part can do a hundred times more, that is, a thousand parts. If a third time, ten thousand; if a fourth, a hundred thousand it will tinge. In this way they say the Stone tinges by a thousandfold proportion, on and on without end—so much so that one of them, with foolish boastfulness, was not afraid to say that if the Ocean were mercury, the Stone would turn it into gold, and would thus steep even the swelling waves of the sea with gold. These are the most idiotic boasts of the pseudo-philosophers, all the more intolerable in that, with their utterly shameless lies, they impose upon the world more grandly and—without any shame, indeed quite insolently. For if the often-repeated imbibition of the Stone is brought to the calculating scale, it follows necessarily from their promises that at the twelfth imbibition of the Stone, twelve millions of millions of gold-units would result—a number so excessive that it can scarcely be conceived in the mind. Indeed, the whole globe of the Earth could be coated over with the chemical gold resulting from a projection of this sort. And then what vessels, furnaces, materials, or what place will the stupid alchemists find in which to ply their art? For the entire mass of the Earth would not suffice—unless perhaps they cook it in the devil's own workshop, which I would gladly leave to them. But, lest I be convicted of misrepresenting them, I append the table.

[Margin: The foolish promise of the alchemists.]

TABULA

Lapidis multiplicativa Auri. [The multiplicative power of the Stone over gold.]

Projectio	I	1000
Projectio	II	10000
Projectio	III	100000
Projectio	IV	1000000
Projectio	V	10000000
Projectio	VI	100000000
Projectio	VII	1000000000

Projectio	VIII	10000000000
Projectio	IX	100000000000
Projectio	X	1000000000000
Projectio	XI	10000000000000
Projectio	XII	100000000000000

Centum milliones millionum tingunt. [A hundred millions of millions they tinge.]

I have thought it worth setting this table down here so that even children, simple women, and the dregs of the lowest crowd may see through the foolish promises and contrivances of the alchemists—their humbug, rather—and laugh at them. *Happy the men for whom these riches are born in their cooking-pots!* [Felices homines, quibus hæ nascuntur in ollis, Divitiæ.]

For since that multiplicative tincture of gold, discovered by Midas's wand [ex Midæ virgula], is—besides being fabulous, as we shall afterward prove by experiment itself—who, I ask, will persuade a philosopher of sound mind that this mercurial seed of the Philosophers' Stone (what it even is, they do not know; and among all alchemists it is still in dispute)—who, I say, will suppose it to have a power of such fecundity that it can multiply gold without end? Hence I argue thus. Either this seed is endowed with a vegetative soul, or it is not. If you say the former, you will be forced to assign to all inanimate things—such as mineral and metallic bodies—the second grade of Nature, namely the vital grade, and so to assert that all things have life formally within themselves. And since this runs counter to every principle of natural philosophy, it does not deserve refutation. But if you say it is not vegetable, then how, deprived of vital motion, will it propagate itself into such fecundity? If things endowed with life cannot do this, who will say it can be granted to things destitute of life? If these wretched smoke-sellers [fumivenduli] knew the secret process of Nature in producing metals, they would not dare to blurt out such shameful nonsense. And so as not to be forced to repeat it over and over, I refer the reader back to the first chapter of this work.

I should like to know just what it is that has given the Stone so great a power of tinging. They say it is the highest and most perfect purification of mercury, far removed from every earthy dross. But even if someone reduced wine cohobated seven times to the highest subtlety, it would follow equally that a single droplet of that elixir of life would transmute a whole cask of water into the noblest wine—which is repugnant both to reason and to experience; nor could anyone over-

—whatever the alchemists may babble about the heavenly, supernatural power and efficacy of their Elixir, which does not exist in the nature of things. O stupid race of men! while they strive, by a rash daring, to attribute to their Stone the power of accomplishing—and of actually effecting—what, with the unanimous zeal of all philosophers, has now for two thousand years and more been sought after and disputed as something infinite; the question, I mean, that has been stirred for so long by the loftiest phoenixes of human genius, and that to this very day, the case still pending, remains undecided—they boast that they can accomplish it merely by the imagined perfection of the Stone alone! Do these subverters of Nature not know that no substance in the nature of things can be so refined to infinity by the power of fire that it does not at last, with all its spirits vanishing away, dwindle off into pure air or evaporate?—especially in the subtilizing of mercurial water. And if you have shut this water up in Hermetic vessels of whatever firmness and solidity you please, or under any sealing of lute, I still say it cannot be brought about that the most fugitive spirit, by its usual cunning, does not slip out through the very pores and exhale away. Isaac Hollandus [Isaac Hollandus], a celebrated alchemist, does not blush to confess this very thing in his little book *On the Stone of the Philosophers*:

[Margin: The alchemists alone admit an infinite power of the Stone.]

If the tincture, he says, reaches the fourth degree of exaltation, it arrives at so great a subtlety that it can no longer be held in by any barriers; indeed, glass of any thickness whatever—even ten fingers thick and of adamantine hardness—cannot contain it. If, then, when subtilized to the fourth degree it cannot be contained, what will you say of a tincture exalted to the tenth, hundredth, thousandth degree? And do these men not know that the more gold is purified, the more portions fall away from it?—since there is nothing in the nature of things that can be so purged by sublimation that there does not always remain something still to be purged, until at last it is reduced almost to nothing, as experience teaches in cohobations repeated very frequently by distillation; unless, that is, the alchemists were aiming to reduce their material to the simplest body—which, just as it cannot be done, so they are deservedly convicted of utter ignorance of natural things.

[Margin: The more subtle the spirits into which things are sublimated, the less they leave behind of quantity.]

[Margin: No mixed body can be so purified that something impure does not still remain in it.]

[Margin: No vessel is capable of holding the most subtle spirit.]

And so, from these things so clearly shown, it plainly appears that this Stone, infinitely multiplicative of gold, is a pure and outright figment of a flighty imagination. For whom, I ask, will the alchemists point to who has taken experience of it? No one at all, surely, unless some most lying—not to say most beggarly—impostor. Add to this that it cannot be brought about that a tincture of this kind could be produced by human ingenuity—on the testimony even of Paracelsus himself, in his book *On the Transmutation of Metals*. I quote his words at length. *Through man, he says, the separation of the elements is impossible*

[Margin: *Book On the Transmutation of Metals*.]

[Margin: Paracelsus, on the impossibility of the art.]

—that is, in the great art, the separation which, although it may appear, is nevertheless not real; whatever may be said of Ramon Llull and of his noble golden "English coin," commonly the *rose-noble* [Rosenobili], which he is falsely supposed to have fabricated. *For Nature herself has within herself her own separator, which rejoins what it separates, without any human help, and assigns best of all the proportion of each element*—and not man, whatever the writers, with their erroneous, frivolous, and false processes and prescriptions, may fable about that volatile gold of theirs (as was shown a little before): Llull, Richard the Englishman [Ricardus Anglus], and Rupescissa [John of Rupescissa], with their gross errors. Whom now, in this art, are we to believe? Paracelsus, or the chief champions of alchemy? Certainly neither these nor him—that they ever penetrated the art, or knew what they were saying, no one will deny that I have affirmed on the surest and best of grounds.

But let us proceed to the weight, number, and measure, and to the most exact proportion, by which they assert the Stone must be fashioned. And who does not see that this proportion—just as God [Deus], the best and greatest, the Architect of all Nature, alone knows it (he who knows how each of Nature's compounds is coupled into the fellowship of friendly union)—is likewise as far removed as possible from all the industry of human ingenuity? Yet all the alchemists admit that this proportion is altogether necessary in the construction of the great work. But that they can arrive by art at this exact proportion, which consists in an indivisible point, can be persuaded, I think, to none of the wise.

[Margin: Man cannot attain the most perfect exactness of weight and measure.]

For (as Paracelsus puts it) if you take a little more of one than of another among the ingredients of the great Stone, the seed cast into the field must necessarily be choked, so that it cannot live long enough to be perfected once united by the mercury of the philosophers; but if you take too little, it cannot be dissolved at all, so that it produces something abortive or fruitless. Arnold too complains of this: If you add more or less of earth than Nature allows, the soul will be choked without any fruit, with no necessary fixation following. The same is to be understood of the water too, if you take more or less. For if you take too much water, the material is rendered excessively moist; if less, it is rendered too dry. Again, if there is too much air present (to use Paracelsus's words), the tincture imprints itself too much; if too little, the body turns out pallid. Likewise, if the fire is too violent, the material is scorched; if too gentle, it has no power of drying, nor of dissolving, nor of warming the other elements.

[Margin: Taking too much or too little destroys the work of the Stone.]

What will the wretched alchemists do in this hopeless business? Surely Arnold and Paracelsus, when they could find no way to roll this Sisyphean Stone to its desired end, judged that the whole process must be entrusted not to human adaptation but to the working of Nature alone. For as Paracelsus reasons: *Nature knows her own operations and the weights of the elements, whose separations, rectifications, and couplings she herself carries out without the aid of any operation or mineral artifice, provided only that the material be kept in its secret and in a hidden vessel.* He could certainly have said nothing better. Let them therefore leave to Nature what they think cannot be supplied by themselves—Nature, who from the very first beginnings of the nascent world, by her own un-

[Margin: Nature alone knows her power of producing metals.]

failing industry, has produced this noble metal in such abundance in her own womb that we have no need of the alchemists' counterfeit gold. For she knows how, by the benefit of the secret subterranean fire, to produce the metals by joining actives to passives; she turns away from the alchemists' "secret fire" as unsuitable; she knows the hidden vessels of the subterranean wombs—not the retorts, bladders, alembics, cucurbits, and the like monstrous wombs of the pseudo-pyrotechnicians.

CAPUT VI.

Omnia Chrysopœias tentamina frustranea esse ex ipsis Alchymistarum Coryphæis, Arnoldo, Villanovano demonstratur.

[That all the attempts of chrysopœia [gold-making] are futile is demonstrated from the very chief champions of the alchemists, from Arnold of Villanova.]

Paracelsus, aspiring to the monarchy of the Alchemical Commonwealth, when he saw that he could not by any effort of intellect penetrate the way of making the Stone, set out upon new schemes for that fictitious Stone and devised, in his book *On the Transmutation of Metals*, various and novel processes for the Stone. These, even if in substance they differ in nothing from the processes of Llull, Arnold, Rupescissa, Richard [Ricardus], and Bacon [Roger Bacon]—from whom he filched everything of his own—he nevertheless cloaked these borrowed inventions in so exotic a garb of monstrous names that, like the crow decked out in others' feathers, he seems to have set himself up not as the monarch of the chemists, as he calls himself, but as the cuckoo among the birds. *I, he says, shall deservedly correct the Spagyrist after my long experiments, and shall separate the false and the erroneous from the true, since by my exceedingly lengthy investigations I have discovered how I may rightly censure such things and change them.* And a little later, after rehearsing the long labors of the ancients: *They would have had, he says, a shorter road to attaining the treasure of the red lion, had they learned the concordance of my Astronomy with Alchemy, which I have demonstrated in the Apocalypse of Hermes. And since every single day, as Christ says, has its own proper essence for the consolation of the faithful, the labor was great and heavy for the Spagyrist before our times—a labor which now, in this latter age, will be relieved by my theory through the aid of the inflowing Holy Spirit.* And a little further on: *The old Spagyrist would not have needed such prolix labor and such tedious repetition had they learned the work from my School; they would have attained their wish far more quickly and at less expense.* Such are the boasts of the Monarch of the Chemists.

[Margin: Paracelsus's instance/objection.]

But what Bombastian Astronomy and the analogy of the celestial bodies have to do with the Stone, I can in no way make out. For since the nature of things always acts in the same way, under whatever arrangement of the planets and aspects of the stars; and since the generation of metals—whether natural or fabulous—has only the most remote dependence (as we have shown in what precedes) upon the heaven and the stars of the alchemists: therefore, without Astrology and the

influences of the stars, in the great work of the Art, you will accomplish nothing, Paracelsus dictating though he be. And what the assistance of the Holy Spirit has to do not only with this most empty work, but with so impious a man, I do not see—though I see well enough what that Thrasonical [boastful] breast craves. For when he saw that this could not be done by human art (with all the other alchemists, however many there have been, agreeing), he showed by the following words that he wanted the Art to be granted only by God through revelation:

[Margin: Man does not act to bring about the success of the great work in respect of the heavens.]

Many secret things exhibiting transmutations are found—though by few, that is, only by the sons of the art illuminated by God; and although they be revealed to someone by the Lord God, not on that account does the report at once burst forth along with the arts, but the Almighty gives along with them the understanding to conceal these and other things until the coming of Elijah the Artist, at which time nothing so hidden but it will be revealed. O ridiculous philosophy! What concord has Christ with Belial? What has divine revelation to do with an art so wicked and so utterly fabulous? Do these men not know that so far is it from God being thought to lend supernatural aid to an art exposed to so many Satanic illusions, that he has rather hinted in Sacred Scripture that it is to be shunned, in express words, as if with oars and sails: *They who wish to become rich—that is, the alchemists—shall fall into many temptations and snares of the Devil.* [1 Timothy 6:9] Is it possible that God, the best and greatest, should have omitted to reveal this art to so many holy men, full of the spirit of God, whom he knew would not abuse it—and yet should have inspired so great a gift only into alchemists like Paracelsus and his kind, men for the most part wicked, given to evil arts, greedy, proud, and abusers of the divine mysteries? But these things we shall pursue more fully in what follows. Let them therefore turn, roll, revolve, and wrap up that Stone, the worker of such great marvels, as much as they please; yet they will roll out of it nothing but worthless scraps and dross of words, and afterward, too, coals, ashes, and cinders.

[Margin: Alchemy, according to Paracelsus, is inspired by God, etc.]

Strange words, such as *Azoth*, *Agathron*, *Anathron*, *Usisur*, *Rebis*, *Martagon*, *Sernec*, *Ribric*, *Realpas*, *Saltaberi*, and countless others met with in the books of the chemists—especially the Paracelsian ones (which not seldom, in familiar conversation held with such men, have moved me to laughter)—contribute little to the matter, if from some other quarter no supports are at hand for

demonstrating the truth of the art; nor does the promise of such great things, or the boasting of certain peevish ash-mongers [ciniflones], contribute anything to proving the art, while, swollen with pride from their supposed possession of the secret Stone, they promise, under the likenesses of various things, what cannot be conceived in the mind—not to say grasped by human knowledge. Surely, to cure so great a madness, there would be need of no other medicine than a vomit of Hellebore; so highly were they es-

[Margin: Monstrous words contribute nothing to the matter.]

[Margin: Monstrous names contribute nothing to perfecting the matter.]

teemed, by which they vomit up those red lions, birds of Hermes, green lizards, serpents, dragons, phoenixes, peacocks' tails, ravens' heads, bats, and similar chimerical phantasms—together with the heaven and all the imaginary planets—as someone not inaptly jested about them in the *Chemical Work* of Beguinus [Jean Béguin]; so that at last, their brains purged, they may learn to think more sensibly. Surely these men seem to have followed Lexiphanes [the word-monger of Lucian], who, after drinking down hellebore juice, at once belched forth those formidable words—*topper*, *stlempus*, *redantruo*, *gnarneres*, *ascalabotio*, *carbaster*. The very same thing happened to them as to that Plautine cook who, rejecting the common seasonings—garlic, fennel, coriander, and the like—prattles on and haughtily recommends only his own *Cilicendrum*, *Polindrum*, *Sanscapsidem*, *Cataractriam*, *Hippalopsiden*, by whose aroma Jupiter dines daily, and however many feed on them prolong their life even to two hundred years.

I do not doubt that here the alchemists, stung by frenzy, will rise up against me, ready to accuse me of either ignorance or indiscreet zeal; I do not mind, nor would I buy at a trifle—to speak with Plato—whatever slanders fury may suggest to them. I speak the truth; the clearest experiments persuade me of it; Nature herself—the one weigher of truth, the exact balance of operation—dictates to me what she can and cannot do. But they will rise up again, and press the more boldly: that it seems unjust to charge Llull, Arnold, and Paracelsus—the sole oracles of the art—too presumptuously with falsehood in constructing the Stone. But if even the most-cited chief champions and standard-bearers of the great Art feel the same as I do, who will reproach me? And lest I should seem, by an inexpert judgment, to be tearing the art too much to pieces, I have thought it worth appending in this place a most ample discourse on the futility of the magistry of the Stone—a discourse which Gerard Dorn [Gerardus Dornius], his interpreter, inserted into Paracelsus's book *On the Transmutation of Metals* under the name of Arnold of Villanova. From it, whatever I have hitherto said about the

vain and futile labors of the alchemists will appear clearer than the noonday light.

Discursus Arnoldi Villanovani apud Paracelsum, lib. de Transmutat. metallorum. [The Discourse of Arnold of Villanova, as found in Paracelsus, in the book On the Transmutation of Metals.]

The greatest difficulty of this Art (says Arnold in his *Rosary* [Rosarium]) [is that] [Variant readings of the names assigned to this material of the Stone—certain most hidden ones, drawn chiefly from likenesses—they have predetermined: they called it *vegetable*, *mineral*, and *animal*, not according to the literal sense (as the wise easily understand) but [?]] [Margin: text appears displaced — see parsing note below].

Many have tried to coagulate mercury by means of the liquors of vegetables, fixing them as it were by fixative waters, thinking to convert it into Luna [silver], reckoning that whoever by this route could coagulate the aid of the metals would attain the greatest magistry. But although the liquors of some vegetables do effect this, it will be judged to come about from no other cause than the resin, fattiness, or earthy sulphur in which they greatly abound. This attracts the moisture of the mercury, and is mingled with its substance, coagulating it without any usefulness. For coarse and external sulphur—and none such is found in vegetables—is fit for perfect projection in alchemy; and this many have learned by experience, not without the greatest cost. Although some, on account of its intense heat, thought that they had coagulated mercury with the white, milky juice of *tithymal* [spurge], whereas in fact it was the cold within it that did so by a manifestly contrary cause—wherefore they called it "Virgin's Milk" [Lac Virginis]—this was nevertheless a false foundation.

[Margin: Tithymal juice does not coagulate mercury.]

The same is to be judged of the juice of *celandine* [Chelidonia]: although by its color it deceives men's eyes, as if endowed with gold, those who gathered something vain from it dug up this vegetable at a certain fixed time, from which they hunted out a "soul," or "quintessence," to make from it a coagulating and transmuting tincture. But from this too nothing arose except foolish error. Others boiled down this juice to the thickness they call "consistency," and exposed it to the sun so that it would coagulate into a hard mass, which afterward, pounded into the finest powder, they cast upon mercury (as they supposed) so that the projection would turn it into Sol [gold]—which they found to be false. Some mixed sal ammoniac into this powder; others, *colcothar* of vitriol, thinking that

by this route they might at last arrive at the wished-for end. Afterward they brought the solutions into a wash-water, so that this salt might give the tincture entry into the substance of the mercury—yet nothing came of it.

[Margin: Celandine juice is of no use.]

Some, in place of the aforesaid, [used] the juices of peach, *bufonaria* [toad-plant], dragon-wort, willow leaves, tithymal, *cataputia* [caper-spurge], *flammula* [lesser spurge], and the like: they kept these together with the mercury itself, enclosed in a glass vessel, in ashes for several days. The result was that the mercury was turned rather into ash, or powder—but wrongly and to no fruit. For those men were deceived by the empty rumors with which it had been spread abroad.

[Margin: The juices of peach, *bufonaria*, dragon-wort, etc.: no fixation occurs.]

[Margin: *Lunaria* of Llull, of great power.]

An example of this is offered by the *Lunaria* of Ramon Llull, which puts forth flowers of wondrous powers—most familiar, however, to the philosophers. This name was not given by an imposing opinion, as if by it were understood some projection upon the metals, or a preparation; but the abstruse mind of the philosophers looks far elsewhere. By a similar name they called the material *Martagon*, to which likewise they applied a hidden chemical operation drawn from this source, although it denotes nothing at all of the kind, beyond a certain hidden likeness.

[Margin: *Martagon*: what Llull means by it.]

No small error, too, arose in the liquors of vegetables, with which very many have tried to coagulate mercury, and afterward seem to have repented of it; for mercury must be coagulated apart from the metals, as we mentioned before. Many have extracted from vegetables salts, oils, sulphurs, and so forth—but in vain, since through these no true coagulation of mercury [is achieved]...

[Margin: Vegetables are of no use to the art.]

[Margin: Salts, oils, sulphur of vegetables accomplish nothing.]

[The discourse of Arnald of Villanova continues, on the alchemists' vain attempts.]

for they reckon that no true coagulation, perfect tincture, or projection can result — by a likeness to the Philosophers' only, not by substance. They compare their material to a certain tree of seven golden boughs, understanding that in its seed it

encloses the seven metals, which lie hidden within it; and for this reason they called it vegetable. They did so, too, because, just as natural trees in their season put forth various flowers, so the material of the Stone displays its loveliest colors in the production of its own blossoms.

[Margin: Metallic bodies are said to be vegetable on account of this likeness.]

Likewise, because from the Philosophical earth a certain metallic body rises up — like a sprout from the earth, sponge-like — they said the fruit of their tree reaches up toward the sky. Hence they declared that the whole hinge of Nature's art turns upon vegetable things, not upon mineral material; and also because their stone, like vegetables, contains within itself soul, body, and spirit.

By a not-very-different likeness they said this material was the "Virgin's Milk" and the blessed blood of rosy color — which, however, belongs only to the prophets and the sons of GOD. From this the Sophists concluded that the material of the Philosophers consists in the blood of animals or of men, taking their occasion from the fact that animals are nourished from vegetable things.

[Margin: The coagulation of mercury is not found in the blood of men.]

Some looked for it in hair, in the salt of urine, in the kidneys; others in hens' eggs, in lime, in milk, and the like — by all of which they supposed they could fix mercury. Some extracted salt from fetid urine; nor were there lacking those who believed the material to be little stones found in men.

[Margin: The parts of an egg accomplish nothing.]

Others macerated the membranes of eggs in the harshest lye, to which they also mixed the eggshells, attributing to these the secret of fixation for perfecting mercury. Others, likening the egg-white to silver and the yolk to gold, chose these as their material; mixing in common salt, sal ammoniac, and burnt tartar, they sealed all this together in glass and let it putrefy in a water-bath, until the white color turned into the most ruddy, like blood. This they distilled into a most foul liquor, utterly useless for the work they sought. Others let the white and yolk of eggs putrefy, and from this a basilisk was generated, which they burned to a most ruddy powder, and with it they thought to tincture. The author of this was Cardinal Gilbert in his *Treatise on Alchemy* [Gilbertus Cardinalis, *Tractatus de Alchymia*].

Most of them, mixing the gall of oxen and other animals with common salt, macerated it and distilled it into a liquor, with which they thought to soak the powders for cementations, so that these might tincture their metals by some

mystery — which they call "part with part" [partem cum parte] — and from this nothing came of it. Some, choosing tutty [tutia], seduced by various additions such as dragon's blood and other such frivolous trifles, attempted to turn copper or electrum into gold.

[Margin: Tutty contributes nothing but its color.]

Others, following what they called the method of the Venetians, would shut up twenty more or less skinks [stelliones] in a pot and starve them to madness, so that one ravenous one might devour the others, with a single survivor left, which they then fed on filings of copper or electrum —

[Margin: The ridiculous taking-up of skinks as material.]

— supposing that this kind of animal could, by digestion alone in its stomach, accomplish the longed-for transmutation. Finally they burned this animal to a most ruddy powder, which, believing it to be gold, they were miserably deceived. Some, at last, found gold in fish called trout [trutta], wholly burned up by liquefaction — for no other reason than that this kind of fish is accustomed, taught by nature, to gather and devour in the rivers the little scales and golden sparkles carried there by the torrents, sometimes washing down from a mountain; yet this very rarely happens.

[Margin: Trout, when burned, contribute nothing to the work.]

Such impostors are found above all in the courts of princes. Truly, the material of the Chemical Philosophers is not to be sought in animals — of this I would have all warned once and for all.

[Margin: The material of the Philosophers is not to be sought in animals.]

There is, however, something to be known: that the philosophers called their stone "animal" because, in their last operations, by virtue of this most noble fiery mystery, a dark and ruddy liquor, like blood, oozes out drop by drop from its material and its vessel. From this they brought forth a prophecy — that in the last times a most pure man would come into the world, through whom the liberation of the world would be accomplished; that this very man would send forth drops of rosy or ruddy color and of blood, by which the world would be redeemed from its stain.

[Margin: An impious application of the Philosophers' stone.]

In like manner, the blood of their stone, in its own kind, freed leprous metals, and likewise men, from their contagious infirmities. For this reason they not without

cause called their stone "animal." Of this, Mercurius speaks to King Chalid in this manner: "This mystery," he says, "is permitted only to the prophets of God to know — whence it comes that the stone is called animal. For in the blood of this stone its soul lies hidden; it is composed, moreover, of body, spirit, and soul." By a similar reasoning they called it their "microcosm," because it has the likeness of all the things of the whole world; and from this again they say it is "animal" — just as Plato calls the great world an animal. The ignorant joined in, believing the stone to be threefold and secret in a threefold kind — namely, vegetable, animal, and mineral — whereby it came about that they also sought it among minerals. But this opinion is far removed from the Philosophers' view; for they assert that their stone is uniformly vegetable, animal, and mineral.

It is to be noted, in addition to these things, that Nature has distributed its mineral seed into various kinds — namely, into sulphurs, salts, boraxes, sal-ammoniac-nitres, alums, arsenics, atraments [vitriol-blacks], vitriols, tutties, hematite, orpiments, realgars, magnesias, cinnabar, antimony, talc, cadmias [cachimiae], marcasites, and so on — in all of which our material has filled the world.

[Margin: Where the material of the Stone is found among minerals.]

Although in some of the said species it sometimes reveals itself with a marvelous appearance, as far as concerns the transmutation of imperfect metals. For long experience of fire, through manifold exercise, shows transmutation in mineral material — not only out of...

some colors into other colors, but truly also out of one essence into another, and from the more imperfect into the more perfect. And although Nature herself sometimes makes demonstrations of this sort through these mineral intermediaries — many preparations intervening — the Philosophers nonetheless do not want the material of their Stone to proceed chiefly from any of the mineral intermediaries, even though they call their stone "mineral." Hence the Sophists, taking occasion from this appellation, have hounded Mercury itself with various tortures: some with sublimations, coagulations, precipitations, with mercurial waters and strong waters [aquae fortes], and so on — all of which are erroneous paths to be avoided, along with the rest of the Sophists' preparations of minerals, purgations, and fixations of spirits and of metals.

[Margin: Strong waters [aquae fortes] are not the material of the Stone. Albert. Geber's operations are sophistical. Roquetaillade an impostor. Geber handed down sophistries.]

Therefore the very many preparations of the Stone — indeed all of them — that are described from minerals in this manner, such as those of Geber [Geber], of Albert surnamed the Great [Albertus Magnus], and the like, are merely sophistical: purgations, cementations, sublimations, distillations, rectifications, circulations, putrefactions, conjunctions, solutions, ascensions, coagulations, calcinations, and incinerations utterly useless — whether in the tripod, the reverberatory furnace, the athanor, in mud-bath, acid-bath, dung-bath, ash, sand, and the like, or in the cucurbit, pelican, retort, phial, fixatory, and other vessels of that kind. The same judgment is to be made about the sublimations of Mercury through mineral spirits "to white" and "to red" — as through vitriol, saltpetre, or other alum, or through crocus of Mars [crocus Martis, iron oxide], and so on — about which Johannes de Rupescissa [John of Rupescissa / Roquetaillade] falsely spins fables in his *Treatise on the White and Red Philosophers' Stone*, which together with the others are all lying dreams, miserably seducing good and simple men.

[Margin: The sulphur of metals does not coagulate Mercury.]

Those particular sophistical tricks of Geber are also to be fled — such as the sevenfold sublimations or mortifications, likewise the revivifications of Mercury with their preparations through the salt of urine, or through the "sepulchre of the wise," each of which is utterly false with respect to the Stone. Certain others, who tried to fix mercury with the sulphurs of minerals and metals, were utterly deceived. I have nonetheless seen Mercury brought by this art into a metallic body through fixations of this sort, feigning and representing in all respects and through and through good silver — yet in the assay, on the cupel-sherd or the cupel, it proved and also appeared false.

[Margin: Oil of sulphur is applied in vain. (margin truncated: "Oleum sulphuris frustraneum")]

Some of the Sophists tried to wring a fixed oil out of this Mercury, sublimed seven times and as many times dissolved — by means of strong waters, by which they brought imperfect metals of any sulphur whatsoever to perfection — but they were compelled to abandon that fruitless work.

[Margin: Vitriol accomplishes nothing.]

Some purged vitriol seven times by solution, calcination, coagulation, and the addition of two parts of sal ammoniac, and by sublimation, so that it dissolved into a white water, to which they added a third part of quicksilver, so that the water might be coagulated; and afterwards, as many times, they sublimed the

mercury from the said vitriol and sal ammoniac, so that it passed into a hard stone. This they affirmed to be the red sulphur of the Philosophers conceived from vitriol — with whose solutions and coagulations they proceeded — but in the projection, nothing came of it.

[Margin: Mercury coagulated into a mass of alum does nothing to the purpose.]

Others coagulated mercury by means of alum-water and into a hard mass like alum, which they fixed uselessly with the sharpest waters. The Sophist presumes to himself very many methods of fixing mercury — yet in vain, since nothing perfect or stable is held in it. In vain, therefore, do they add minerals to it through sophistical processes, by all of which it is roused to greater malignancy, and is made more and more living, and impure rather than perfect.

[Margin: All the methods of fixing Mercury are useless.]

The material of the Philosophers, therefore, is not to be sought from it, since it is an imperfect thing, which, even if it could be brought to perfection, would be very difficult — indeed impossible — by the processes of the Sophists, since there is nothing in it that can be roused or forced into perfection. Some took arsenic, sublimed several times and many times dissolved in oil of tartar and coagulated, and pretended to fix it, so that they might turn copper into silver — and that brought nothing but a certain sophistical whitening.

[Margin: Arsenic accomplishes nothing in transmuting copper into silver.]

For this can by no means be fixed unless the tincturing spirit in it has been thoroughly recognized — in which indeed almost all the Philosophers have slumbered, trying in vain to make something good out of arsenic. Whoever, therefore, are ignorant of this spirit, let them also have no hope of fixing it, nor any power of imparting through something else, by which it might acquire the perfection of transmutation. For which reason I make known to all who expend their labor upon it that the whitening of which mention was made is drawn from a false foundation, and that by it copper is only falsely whitened, and not otherwise altered.

[Margin: Sophistical whitenings.]

The Sophists, having likewise masked and painted Venus [Venus, copper] in this manner, mixed it with twice its amount of Luna [Luna, silver] and sold the mixture to goldsmiths and minters. But in the end they transformed themselves into false coiners — not only those who had sold, but also those who had bought. Some of the Sophists took red arsenic in place of white, and this very thing, as

before, passed into a false art; for, in whatever way it is prepared, it exhibits nothing but whiteness. Some proceeded further to common sulphur, which, being yellow as it was, they cooked in vinegar, lye, or the sharpest urine for a day and a night, until it came out white. Afterwards they raised it from common lime and from the lime of eggs, cooked it, and sublimed it, and that many times. Nevertheless it always remained combustible, though white; yet with it raw they tried in vain to fix mercury into gold. Nevertheless from it resulted a cinnabar most beautiful and the best of all that I have ever seen, which they thought to fix with oil of sulphur by cementation and fixation — but...

[Margin: Sulphur is applied in vain.]

nothing did it hold; but it turned out otherwise than the thing itself was desired. Others reduced common sulphur into the form of a liver [hepar, "liver of sulphur"], cooking it with the admixture of linseed oil, brick-oil, or olive oil in vinegar, then pouring it out upon a marble stone. This very thing they distilled into a citron-colored oil, at first over a slow fire — but to their own loss they experienced that it did nothing they wished, namely that it had by no means turned Luna into gold. Therefore, as the number of minerals is infinite, so too the preparation of them is a great variety, of which I have here deferred to make mention, because they require a treatise of their own.

[Margin: Sophistical oils are to be guarded against.]

One must also beware of the sophistical oils of vitriol and of antimony, likewise of the oils of perfect and imperfect metals, even of gold and silver — because, although their operation is most powerful in the nature of things, nevertheless their true process is to this day known to very few. One must also abstain from the sophistical preparations of common mercury, of arsenic, of sulphur, and of other similar substances, through sublimation, descent, fixation with vinegar, saltpetre, tartar, vitriol, sal ammoniac — yet by that path or method which the books of the Sophists teach.

[Margin: The tinctures of marcasite and crocus of Mars are sophistical.]

Likewise flee the sophistical tinctures drawn from marcasites and from crocus of Mars, and from that sophistication which is called "part with part" — fixed Luna and similar trifles. For although they exhibit some superficial appearance of truth — and indeed this fixation of Luna is of little labor and skill — nonetheless a progress of preparation of this kind is null and invalid.

From this most ample reasoning of Arnald and Paracelsus it appears clearly that no method has, from the first publication of the Philosophers' Stone in Europe to this very day, been prescribed which Paracelsus [Paracelsus] has not repudiated in this discourse as vain, idle, and useless — in which he most especially mocks the method of both Geber and Llull [Lullus / Ramon Llull], and teaches in open words that the gold which Raymond [Ramundus] had offered to Richard, King of England [Ricardus, Angliae Rex] as made by himself through the Chemical art, under the form of a noble rose [rosa nobilis, the "rose-noble" coin], was false and sophistical. He likewise reckons the work of Rupescissa as worth nothing — so that, with all the methods combined, none is left by which this Monarch of the Chemists might satisfy himself in any way.

[Margin: Paracelsus determines the material of the Stone.]

What, then, in the end does this Monarch do? To destroy a work of the Stone so admirable was nothing other than to destroy the monarchy of the Chemical Art so greatly coveted by himself. So that he might seem, above all others, to know something higher and more sublime, and that he might appear among the Alchemists like a cypress among the wayfaring-trees [*viburna*], he prescribes another mode of making the stone, found by himself through divine illumination. But what could that so great secret of the art be, which has come into the mind of no one until now, but only of Paracelsus — inspired, I know not by what divine power's breath? Let us lay open a thing full of curiosity and not unworthy of consideration; and that this may be done more knowingly, let us set out first the words of the great process by which he described it.

"With so great a labor," he says, "the ancient Spagyrist would not have needed [the work] if they had learned the work from my school. Therefore I, Paracelsus, say to you (we apples are swimming): take the blood of rosy color from the lion, and the glue from the eagle; which, after you have joined them together, coagulate according to the ancient process: you will have the Tincture of the Philosophers, which infinitely many have sought, very few have found.

[Margin: The process of Paracelsus.]

Thus the Alchemist composes certain simple things, which he corrupts — as is the art's way — and from there he prepares another thing, and so on, until one thing is made: this accomplishes more than Nature herself could by herself. Rightly and thoroughly, that you may understand me: seek your lion in the Orient, and the eagle taken up to the south, for this our work.

[Margin: The ridiculous process of Paracelsus.]

You will find no better instruments than Hungary and Istria produce; but if you wish to draw it out of unity through duality in trinity, with an equal permutation, you must direct your journey toward the south, and so you will obtain your vow in Cyprus."

By these words he sets out the highest secret, unknown to this very day, veiled with a truly ridiculous likeness. But the trick does not escape an Oedipus. For what else does he hint at by "the blood of rosy color drawn from the lion" but the sulphurous, most ruddy tincture of arsenic? What by "the glue of the eagle" but sublimed quicksilver [hydrargyrum]? — which, joined and coagulated together, give the desired Tincture of the Philosophers, as he supposes.

That this interpretation is most true, he himself confesses, advised — if the gods please — from the Sibylline oracle. For thus the Sibyl says: "I have nine elements [letters], and I am four-syllabled; perceive me: the first three syllables are each made from two letters, the rest remain among the remaining, of which there are not five vowels," and so on. By this oracle, Paracelsus says, the Sibyl hinted at nothing other than the material of the great work, which is ARSENIC — that very thing, namely, which in his earlier discourse he had rejected as useless to the art — because, according to the Sibyl's riddle, it consists of nine letters, is four-syllabled, of which the first three syllables are constituted from two letters each, thus: Ar, Se, Ni; the rest remain among the remaining, and the whole word is composed of five consonants, and they are R, S, N, C, M. And these things indeed agree rightly, if the following matters correspond as to the number which is said to lie hidden in the letters. Nevertheless, since we have explained above that the Sibyl hinted by this at a far different signification, I have judged it not to be repeated. Yet granting — though not conceding — that the Sibyl by the whisper of her voice stirred the mind of a great prophet, and that she indicated arsenic as the material of the wondrous Stone by the said riddle: what then? Is it therefore to be held as if one of the articles of faith — which, however, he subordinates to this? Away with these ravings of infatuated petty-prophets [Prophetastri], to be purged with hellebore! We know what arsenic is, and by what powers it is strong. We have also learned, by the testimony of Pliny [Pliny], that it contains something of gold within itself, from the pyrotechny of Gaius Caligula [Caius Caligula]; but that this single thing is the material of the great work — neither he himself, as is clear from the preceding discourse, nor any other of the Chemists has thought.

has thought — not to say taught. Because not even this escaped him, he judged that some arsenic of the tincture was to be joined in his process — namely, the "glue of the eagle"; that is, he held that the blood of the Lion was to be saturated

with sublimed mercury. Moreover, in the process he asserts that this Lion — that is, arsenic — is to be sought in the Orient, moved by the authority of Pliny, who says that Gaius the prince [Caligula] had ordered the chief Arsenic to be carried from Syria, which abounds in it, to Rome from the Orient, for the extracting of gold from it; but mercury he thinks is to be sought in Istria, which teems with the most fertile mines of quicksilver, at a place which is called Hydria [Idrija] (about which we have treated abundantly in the preceding sections).

[Margin: The interpretation of the riddle propounded by Paracelsus.]

"But if you join all these things together under proportion 1 to 2 in a legitimate permutation, you will not be able to accomplish it unless, by a journey directed straight from Hydria to the south, you obtain your vow in Cyprus" — by which he hints at nothing else but that the material is to be sought in the island of Cyprus, to the south of Istria, which abounds in it. And this is that admirable secret of the Stone which Paracelsus, illuminated by the Sibyl, feigns — by a most empty effort — to have revealed to the world.

But what that secret is — hear and laugh: it is nothing other than Vitriol, familiar to Cyprus, and indeed the name [chalcantum / vitriol], as Arsenic [is]. Its mystery he points to under an acrostic, which I demonstrate from his own words. For, intending to conceal the secret of the Cyprus island, in which under an acrostic he points to the material:

[Margin: *Visitabis Interiora Terrae; Rectificando Invenies Occultum Lapidem Veram Medicinam* — "You will visit the inner parts of the Earth; by Rectifying you will find the hidden Stone, the True Medicine."]

"You will visit the inner parts of the Earth" — that is, of Cyprus — "by Rectifying you will find the hidden Stone, the True Medicine." For if you gather the initial letters of these words into one, you will have the name *Vitriolum* [Vitriol], as follows:

**Visitabis Interiora Terrae, Rectificando In- venies Occultum Lapidem
Veram Medicinam.**

O how great a mystery this master has opened to us — unknown, perhaps, only to little boys! Who...

does not know that Vitriol holds the principal place in all the processes thus far? Was this, then, so foreign to Paracelsus that he himself reckoned this secret divinely inspired into him from heaven? Is he not convicted of the crime of the most open imposture, by this very fact — that what in his preceding discourse he

had rejected as useless material, he now receives into his magistrery as an incomparable secret? Certainly, if Paracelsus was striving to acquire among the common run of Philosophers the esteem of a great name, he could not have carried out, in a better way, that which is the mark of impostors and sycophants, than by veiling his trifles under an affected and most lofty reasoning of words and of the most abstruse matters — so that they might seem to be something — and by clothing in a ruddy mantle the Ape that he was playing.

[Margin: The imposture of Paracelsus.]

If this is the mark of Philosophers, then certainly I have no doubt that boys, delirious little old women, cobblers, and barbers can soon, by this art, turn out as the highest Philosophers. I detect very many things in Paracelsus's monuments not unlike this, which, if I wished to refute them all, there would be need not now of a few leaves, but of a whole book; and therefore I cannot sufficiently marvel how men otherwise skilled in Philosophy and Chemistry dare to lend an ear to Paracelsus — since yet, except for a few things that savor of Physics, all the rest are wrapped up partly in Cabalistic, partly in Astrological and Magical opinions; and most of them are linked to an ambitious retinue of barbarously concocted names and words, and show a man full of nothing but ambition, who has not been ashamed to prescribe for himself, more obstinately, by fair means and foul, the primacy of literature and of iatrochemistry [iatrochymia]. Certainly, if you distill what he has written into a quintessence, you will scarcely extract five ounces of good things which are his own. But now to other matters.

CAPUT VII.

The objections against the said processes, and their authors, are refuted.

[Margin: Objections against the said processes.]

The Alchemists object to me, first, that it seems unjust to want to repudiate an Art now accepted by the common reckoning of the wise for so many thousands of years (as they wrongly persuade themselves). Second: that gold made by the Chemical art, both by the industry of the ancients and of the moderns, is established from the most trustworthy testimonies. Third: that to flog with the censor's rod, with such severity, men who are Alchemists, professors of the true art, men devoted to GOD and bound by sacred religion, who — many of them illumined by divine light — have practiced [it], and to convict them of the crime of open imposture, cannot in the least be tolerated. These are the chief points

which the Alchemists are accustomed to object to their Antagonists for demonstrating the truth of their art. To each of these it is now time that we respond.

That it seems unjust, therefore — let the Alchemists be persuaded that it is by no unjust, but by a most just right, that I assert against them that an Art enduring now for so many thousands of years in the profession of its truth is reproved by me. As for the antiquity of the art, whatever it may be, I have already sufficiently shown above that, from the times of the Roman Emperors, nothing was known of it; but those who derive it even from Adam himself — as Paracelsus and his followers do — since [their derivations] are uncertain, useless, frivolous conjectures, resting on no foundation whatever, so too I would waste time if I wished to refute them. For it is proper to the Alchemists that, at even the first mention of any gold occurring in the sacred books, they straightway [claim] that the Holy Spirit by this very thing pointed to nothing else than the admirable secret of this Stone — with greater faith, perhaps, than they would believe even the most sacred mysteries of the faith themselves. But, leaving these vanities aside, let us turn ourselves to those...

let us turn now to those [arguments] which seem to carry greater weight for proving the vanity of alchemy — namely, the claim concerning chemical gold [aurum chymicum], made at every period by wise men.

[Margin: Refutation of those who say they have made gold.]

To this I reply. That they have made gold, I freely admit. But that they have ever produced — by means of that tincture of their Stone, infinitely multiplicative upon gold — that gold which they imagine they can produce, this they have merely dreamed. By what means and by what art gold is in fact made, I shall show a little later in several ways. But that they have ever perfected, through the said infinitely-multiplicative tincture of the Stone, a gold a hundredfold nobler than natural gold — more excellent, more brilliant, endowed with finer qualities — this I deny, and deny again and again.

But they press the point: what has at some time been done, no one will easily deny can still be done to this very day; and that such gold has indeed been made, the testimonies of the chemists demonstrate in countless histories. *Therefore* [the art is valid]. They prove the minor premise by induction:

[Margin: Who are the famous makers of the Philosophers' Stone [chrysopoeia].]

from Raymond Lull [Ramon Llull], Arnold of Villanova [Arnoldus de Villanova], Rupescissa [Jean de Roquetaillade], Bernard [of Trier], Trevisan [Bernard of Treviso] — and which of them, in the end, [is not cited]? For Raymond Lull, they say, made the purest gold by chemical art in the presence of Richard, King of England; and Arnold did the same in the presence of Robert, King of Naples.

But all these claims — as became clear from his discourse set out above — Paracelsus, the monarch of the chemists, asserts to be false.

[Margin: Paracelsus's judgment on the gold of the alchemists.]

He also asserts that the gold coin which the common people call the "noble rose" [rosa nobilis], said to have been struck from gold he himself had made, was utterly sophistic and of no value — a verdict to which very many of the physicians of England subscribe. As for Rupescissa, so far is he from being said to have made gold that he rather seems to assert the contrary of himself, in his first book *On the Quintessence* [De quinta essential], part 1, chapter 22. There he first states that he does not teach the transmutation of metals [transmutatio metallorum], because he was forbidden to do so by the rules of the Order of St. Francis, to which he had consecrated himself; and second, that chrysopoeia is false and dangerous, and can be taught only by divine revelation. He shows this in these words:

[Margin: Rupescissa, on the alchemists.]

"I confess before all evangelical men, calling God to witness, that if, at the devil's instigation, they slip into alchemical operations, they are easily given over to a reprobate mind. And I know that it is a path of perdition, and so evil that no philosopher has written the truth in his books, except feignedly and under parables that cannot be understood nor grasped by the human mind. And I know too that no one can attain to the sublime [secrets] of this art unless his mind has first been made godlike through the loftiest contemplation and the holiest life — so that he not only knows all the inner workings of Nature, but also knows how to transmute transmutable nature; and this has been granted to very few. And commonly these are followers of fictions and sophistications, and they become counterfeiterers of coin and of the seals of prelates and princes — vagabonds, deceivers, men of damnable life — of whom that saying of Paul (2 Corinthians 3 [recte: 2 Timothy 3:7]) is verified to the letter: 'ever learning, and never coming to the knowledge' [of the truth]; because, when they cannot arrive at perfect knowledge, they turn to useless sophistications, and are commonly shut up to an evil end."

These things were rightly said by Rupescissa, the most celebrated alchemist of his time. Would that, just as he detested the study of alchemy as false, empty, indeed exposed to diabolical illusions, he had also said that he did not know it — for then he would truly have given an excellent testimony of his own genuineness. But since he asserts that he received it not by human study but by divine revelation, I cannot but enroll him in the same number as the other impostors. For he says that both his chemistry was divinely inspired in him — his medicines, I mean, which heal all diseases as if by miracle, indeed which can in a moment's space convert even imperfect metals into gold and silver — and that he received it in prison, through divine revelations. But how a man shut up in prison, and not deluded by Satan, could test the truth of the assertion he had made, who will understand?

[Margin: The panacea of Rupescissa is of no value.]

And as for that panacea, the universal cure of all diseases, inspired in him from heaven — who would believe it, when (as will be plain to anyone comparing the one with the other) he copied it almost word for word from Lull? Certainly Francesco Pico [Gianfrancesco Pico della Mirandola] testifies, in these words, that the man was utterly addicted to vanities — his own, and those who court "vainglory" [Greek: ψευδοδοξίαν (pseudodoxian, "false glory / vainglory")] — and to prophecies: "We read that John of Rupescissa, an otherwise learned theologian, fell into such madness that things he had affirmed about the future he would not retract — neither by threats nor by the prison in which he was held by the minister of his Order — but rather always asserted them the more insistently. At last a lying spirit was found in his mouth; and now a hundred years and more have passed since he was shown to be a liar." The same things are read in Philip of Bergamo [Jacopo Filippo Foresti].

With this madness of mind all the alchemists, to a man, have labored. And although Lull, after his holy conversion, led a holy life crowned with martyrdom, and — having rejected vanity and embraced truth — resolved to consign all his books on alchemy to the flames (had they not been secretly carried off by the diligence of his disciples), nevertheless, before his conversion, that he led a free [i.e. dissolute] life and was much given to vanities is gathered from his own *Life*.

[Margin: Lull, on the panacea.]

Indeed, in the preface to his *Art of Operation* [Ars operativa], he shows in these words that his art was divinely conferred upon him: "One night," he says, "as I rose from sleep, the following things were revealed to me — most vile and

unworthy sinner that I am — which had indeed been distinctly set apart [and] revealed earlier to Blessed Giles, dwelling in the hermitage."

[Margin: Lull, [received] his art by revelation. (catchword on prior line)]

If, then, Lull was skilled in the great art of the Stone, and made gold in England (as that same Robert, an alchemist, testifies of him) by the divine revelation in which he glories — surely by this very fact he taught that it cannot be done by human art. But whether he made that gold by the power of the Stone, in the manner customary to the false alchemists, will be examined afterward. Certainly some dispute the history; others have strenuously denied it, and Paracelsus and Bernard Trevisan have shown it to be empty. Of these, the latter says that [he interspersed among his] books...

we cannot deny that there are four books composed by Lull — which, however, mislead one from the right road rather than direct one to the goal.

From all that has been brought forward, the fashioned and counterfeit ingenuity of the alchemists is plainly evident in their deceptions; so that no faith whatever is to be placed in the gold-making art. And so the alchemists themselves — long and much turning the wheel in their alchemical kitchens, like Ixion, with fruitless effort, at the greatest expense, their labor spent uselessly, accomplishing nothing in the great work of the art — driven, as it were, across [the field] by despair, deserted the Hermetic camp and betook themselves to that far nobler and more useful chemistry which consists in the care of the human body and the cure of all diseases, as their books teach.

But I proceed to the third objection, by which the alchemists are said to have been men devoted to God, merciful and generous toward the poor, and illuminated in the great work of the art.

[Margin: Solution of the third objection.]

Let us now unfold a little the sanctity of these men. What sort of man Lull was before his conversion has been declared above — though, afterward illuminated by the divine light, he came to recognize his errors and vanities, and so, in works of penance, having repudiated the utterly vain exercise of his former studies, he followed the eremitic life for a while; and then, devoting himself wholly to works of charity toward his neighbor, at last, in Africa, while propagating the Christian faith, he is said to have ended his life with the happy end of martyrdom, overwhelmed with stones.

[Margin: Lull crowned with martyrdom in Africa.]

See his *Life*, described by Fr. Caussin [Nicolas Caussin] no less piously than elegantly.

As for Arnold, Paracelsus shows clearly enough that the gold he made in the presence of Robert, King of Naples, was sophistic.

[Margin: Arnold given over to illicit [arts].]

And how much he was given to magical arts, Francesco Pico testifies: that he attributed magical bindings to the powers of nature; and that, besides being not very well versed in natural things, he was also infected with much superstition, Pico shows in his little book *On the Operative Part*. He also lays claim to the gift of prophecy, as the same Pico, cited, reports:

[Margin: Arnold laid claim to the gift of prophecy.]

"Arnold the Spaniard," he says, "besides what he had conjectured about the future coming of Antichrist, adduces a certain revelation, [made] of many and great matters, in his book *On the Mysteries of the Cymbals*, and [concerning] the coming of Antichrist, [given] to the monks of the Ladder of God — for which he fixed a hundred years for the events. But two hundred years have now elapsed, and it is established that the prophecy is still unfulfilled."

[Margin: It is established that this man came to such madness — Arnold impiously asserts.]

It is established, moreover, that this man came to such madness that he boasted he had perfected a perfect man by the chemical art; and "when," he says, "he had found in the chemical vessel [in vitro] an embryo furnished with all its organs and members, he ceased from the work, lest he should seem to compel God to infuse a rational soul into it." O impious doctrines! O Satanic machinations of men! Here you have the author of the diabolical "deification of man" [Greek: ἀνθρωποτεχνία (anthrōpotechnia, "the artificial making of man")] of the arch-chemist Arnold — worthy of the flames rather than of any praise of genius, and consequently rejected by God.

And yet do the little chemists [chymicatri] reckon such scoundrels devoted to God?

There follows Paracelsus, whom — since they report that he was defiled with the whole sink of every crime — who will persuade himself accomplished anything either in medicine or in the great work of the art?

[Margin: What sort of man Paracelsus was.]

But, that I may not seem to have done him an injustice, I shall here attach the most trustworthy authors, [reporting] what was written about the virtues of Paracelsus by Oporinus, first his amanuensis and servant; what by Heinrich Bullinger [Heinrich Bullinger], Erastus [Thomas Erastus], Gesner [Conrad Gessner], his fellow countrymen — hear and shudder. Bullinger, in order to test what religion he practiced [writes]: "I lived with him once and again, [discussing] various matters, even theological, and of religion; but from all his conversations it was possible to perceive nothing of piety — but much rather of magic, which, I know not how, he was always feigning. For the most part he was an inseparable companion of carters, in whose company he took delight, and he was their boon-drinking comrade." And a little after, with Oporinus and Erastus subscribing: "In short," he says, "he was filthy in everything, and a foul man; rarely or never did he enter the sacred assemblies, and he was seen to care lightly for God and divine things." Behold the man's distinguished sanctity! In driving out diseases he used for the most part magical exorcisms; and when learned men took this ill, he is said always to have burst out in those German words: "Will Gott nicht helfen, so helf der teuffel" — "If God will not help, let the devil help."

[Margin: Examples from the life of Paracelsus.]

Oporinus, in a certain letter to Johann Weyer [Johann Weyer], writes thus among other things about the life and character of his master Paracelsus: "He was so given over to drunkenness and excess all day and all night (during the two years that I lived intimately with him) that it was scarcely possible to find him sober for one or two hours. And when he was most drunk, returning home, he used to dictate to me something of his philosophy — yet, the whole time I lived with him, he never undressed; for the most part he went to bed only when drunk, late at night, and just as he was, dressed, with his sword laid beside him (which he boasted had belonged to a certain executioner), he would throw himself onto the bed. But often, rising at midnight, he would rage about the room with the drawn sword, striking with such frequent blows at the floor and the walls that more than once I feared my head would be cut off. Meanwhile he pretended to prophesy certain things and made a show of having knowledge of certain secrets; but I never saw him pray, nor heard him do so."

Gessner too — physician and philosopher, and most skilled in chemical matters — testifies to these things: "In our time," he says, "lived Paracelsus, who practiced medicine wandering through various regions of Switzerland [Helvetia], Germany, and Poland. When he ran short of money — and the little he acquired he gave

over to wine and gambling, as constant report has it — he would treat people [for nothing]; he employed a familiar demon, as I heard from his disciple; he was more learned by nature and eloquence than by letters and study; thoroughly inconstant, now a theologian, now a physician, now a magician, often a drinking companion and gambler among the peasants. Indeed he confessed himself a murderer, as Erastus attests, and was several times thrown into prison on that account, or even for other reasons." And these are the virtues of Paracelsus...

worthy of a prophet.

[Margin: Paracelsus contemptuous toward all physicians.]

But how Paracelsus behaved toward all the physicians of past ages — Galen, Hippocrates, and as many as followed them — how unheard-of his stubbornness of mind, both in repudiating the writings of better authors and in exalting his own — let anyone who has leisure read the book he titled *Paramirum*, and he will be astonished at the utterly intolerable insolence of an immoderate mind. And this is to be "a man devoted to God"!

For if, besides a brain perpetually steaming with the drunkenness of wine, and a belly, he acknowledged no other god; if he was a cultivator of demonic magic, of the Cabala, and of depraved arts — who will allow that the knowledge in which he glories was received from divine revelation? How will you suppose that into a soul subject to so many and such great vices and sins, the wisdom of God, or the gift of prophecy granted to few, could enter? Surely such men by no means have God for their master. Who will persuade himself that that man was wisest precisely when he was most raving mad? Who will judge that all men of sound mind were surpassed in the pursuit of wisdom by a raving and foolish scoundrel?

[Margin: Praise of Hippocrates and Galen.]

All confess that none was more learned than Hippocrates; that in simple medicine none has written more or better — with such fidelity that he wrote nothing he wished us not to know; with such skill that few after him have known what he did not know. Truly Galen marvels at his "thoroughness" [Greek: τελειοτάτην πραγματείαν (teleiotatēn pragmateian, "most perfect treatise / treatment")]; he freely acknowledges this man's immense diligence, by which he enclosed Greece and Latium in a single volume, gave novelty to old things, authority to new, luster to the obsolete, light to the obscure, charm to the tedious, credit to the doubtful. Yet this man, together with Galen and Avicenna,

[Paracelsus] reckons of no account — about whom that drunken glutton, in the preface to his *Paragranum*, says that "he received his letters from Galen out of hell"; that "with Avicenna, in the vestibule of hell, he disputed about his own potable gold [aurum potabile], the tincture of the physicians, the quintessence, the Philosophers' Stone, the Mithridatic, and the Theriac." All of which, as they are far removed from the mind of a wise man, so too you may judge them to be the dictates of nothing but a drunken and besotted mind. And this he indicates also in what follows, with utterly intolerable and unexampled boastfulness, in such words as these:

[Margin: The arrogance and pride of Paracelsus.]

"This," he says, "be told to you, O physicians: the most foolish cap of the back of my head knows more than you and all your writers; and the buckles of my shoes are more learned than your Galen and Avicenna; and my beard has more experience than all your academies. As I please, so I shall judge in this very hour, when you drag us into the mud; you must follow me, not I you. You shall all follow me — Arabs, Greeks, Latins, French, Italians, Germans, Sarmatians [Poles], all of you, I say, shall follow me, not I you. Not one of you shall remain even in the most hidden corner, where all men make water. I shall be monarch; mine shall be the monarchy; I shall wield my monarchy and shall gird your loins."

[Margin: Paracelsus despises all the leaders of medicine.]

These are the words of Paracelsus, of which you will find a huge mishmash in the book he calls *Paragranum*...

where, in so many obscene, dishonorable words — words that would lash chaste ears in an extraordinary manner — he rages against the most consummately wise men of all wisdom: so that nothing more foolish, more superstitious, more obscene and immodest can be uttered by a creature endowed with reason; and thus he can seem not so much illuminated by God as possessed by a demon.

[Margin: The scurrility of Paracelsus.]

For what is more alien to reason than to call the glorious monuments of all the sages of the Greek school "excrements, filth, leavings" — not [to say] that they know more, as he says in his *Paragranum*, "than a Swiss cow understands"? O how much better it would have been if Paracelsus, in his *Paragranum*, had prepared a grain of salt [granum salis], mixed with a pound of hellebore — so that, his brain thus purged, he might have grown wiser, and so that the most shameless scoundrel, the trivial buffoon, the most insolent braggart [Thraso],

driven by infernal furies, might have been freed from so great a madness of mind.

[Margin: Paracelsus, blinded by his own genius.]

For my part I can truly testify that, with the greatest diligence, I have perused all his books with the keen eye of a discerning mind — impelled both by curiosity and by love of truth, that I might learn what lay hidden in them, which others so greatly admired. But after I had duly annotated everything except a few small points — which, however, were not his own — [I found] nothing but trifles, affected verbal formulas, conjectures founded on air, experiments falsified: not only concerning the properties of natural things, but also concerning the virtues of minerals, little stones, gems, and metals, and their causes — for the most part received from miners and from quack apothecary-women. All of which I could refute in this place by contrary experiments, if both time and the argument of the work permitted, I found [to be so].

[Margin: The crime of plagiarism in Paracelsus.]

Almost all of it is filched, partly from Lull and Arnold, partly from Isaac Holland [Isaac Hollandus] and Basil Valentine [Basilus Valentinus] — whom, however, lest he be found guilty of the crime of plagiarism, besides reproachfully reproving those from whom he had stolen his doctrine for their useless labor, he also wrapped in such a thick fog of similitudes that, in the clearest waters, by a flood of the blackest color, he more truly played the cuttlefish [polypus] than the spring.

[Margin: The impious cultivation of the Cabala.]

I have seen, moreover, that whatever he wrote about the Cabala, he drew entirely, to a man, from the superstitious workshops of the Hebrews and the Saracens — as I have demonstrated at length in the *Oedipus* [Oedipus Aegyptiacus], Volume II, *On the Cabala of the Hebrews and the Saracens*. To both the Hebrew and the Saracen Cabala the impious man placed such great faith — in his *Paragranum* and *Paramirum*, in the *Archidoxa*, and indeed in the books *On the Origin of Invisible Diseases* [De origine morborum invisibilium], in the *Manual on the Philosophers' Stone*, in the book *On the Vexations of the Alchemists* — that he asserts, no less stupidly than impiously, that all the prophets of the Old Testament accomplished their prophecies by no other means than the help of the Cabala. And yet neither of the two — I will not say did he understand, but he could not even read, hindered by his ignorance of the languages. For, employing only the familiarity of certain Jews and Turks, [he drew] from those Satanic workshops...

some things — and indeed, the more impious and diabolical they were, the dearer he held them — he inserted into his miscellaneous notes [schediasmata] here and there, supposing that some great thing lay hidden beneath them, something that had proceeded from Satan, his teacher and master.

[Margin: Paracelsus the superstitious.]

For whatever the Cabalists teach about incantations [enchantments], exorcisms, superstitious amulets, charms, and phylacteries, he adopted into his store as if they were sacrosanct mysteries. From this source flowed out into the world that impious and Satanic fiction which, impiously and in their usual manner, they call "Mosaic philosophy" [philosophia Mosaica], and the armary ointment [unguentum armarium], which they teach to be compounded in manifold ways.

[Margin: Mosaic philosophy [taken] from the alchemists, impious.]

In this you will find scarcely any ingredient that has not been wrung from the hand of an executioner — just as the sword of some notorious executioner or other, Paracelsus's inseparable companion mentioned above, sufficiently demonstrates. From this same source proceeded the "transplantation of diseases" [transplantatio morborum], filled with countless superstitions and ravings; and as these are unworthy of being recounted, so too — since I have refuted them in our *Magnetic Art* [Ars Magnetica] and in other works — I now say nothing of them.

But how given over to magic Paracelsus was, he himself testifies in his book *On the Composition of Metals* [De compositione metallorum], where, after he had long discoursed about Electrum and the virtues hidden beneath it through all the ages, he at last adds:

[Margin: Paracelsus given over to magic.]

"Yet I cannot fail to mention what and how great a miracle I saw in Spain, when I was with a certain necromancer who had a bell of perhaps two pounds' weight. By the magical ringing of this bell he summoned and brought forth many and various specters and visions of spirits. For when he had inscribed certain words and some characters on the inner part of the bell, the moment its sound and ringing were heard, the spirit appeared in whatever form he wished. Moreover, the ringing of the bell was of such power that it would produce and bring into the midst, and take away, as many other visions of spirits — of men too, and of beasts — as he wished: many things of this kind I saw at his place. This, however, I

observed: that if he was going to work anything new, he would renew and change the characters and the [name of the] mistress."

[Margin: The magical bell of the Marquis of Villena.]

"But I did not come so far that the man would communicate to me the secret of the words and characters. At last I myself desired to investigate this matter more deeply — so that things came into my mind which we shall here pass over in silence. Know, however, that there was more import in that bell than in words. And I wish you to believe me most firmly: that the material of that bell was our Electrum." Thus far Paracelsus.

But about ten years ago, a copy of a bell of this kind — in the shape of a basin, marked with countless magical characters (which the Spaniards say belonged to the most celebrated magician, the Marquis of Villena) — was transmitted to me from Spain through the most learned Father Thomas de Lyon [Thomas de Léon], a most distinguished theologian and a "polyglot" man [Greek: πολύγλωσσον (polyglōsson, "of many tongues / master of many languages")], with the intention that I should explain what all those many and great characters and the display of exotic figures meant. What I was bidden to do, I performed; in which I found whatever the necromantic arts hold hidden, as it were compiled in a kind of epitome. See the explanation of this in the *Oedipus*, Volume II, part 2, *Syntagma on the Magic of the Egyptians*, where I warned that the things Paracelsus so greatly desired to know are to be shunned, with all oars and sails, by all who are imbued with the fear of God, like the nets of Satan.

[Margin: The qualities of the things produced by the chemical art.]

One thing I cannot pass over, and it is this: that Paracelsus, gradually overstepping the bounds of natural philosophy, and following the above-cited Arnold — a man of no degenerate genius — boasts that he can generate a true man by his chemical art. But, that I may show how great a thing the impious alchemists dare against all the divine and human laws of Nature, by Satanic machination, I append the process.

[Margin: The chemical art impiously claims to produce a man.]

Thus, then, he says, in book 1 *On the Nature of Things* [De natura rerum]: "There was a question," he says, "among certain of the ancient philosophers (of whom, however, besides Arnold, I know no other) whether by art and nature a man could be made outside the female womb and the natural matrix. To this I answer that it in no way contradicts the spagyric art and Nature — nay, it is quite

possible. But that it may be done, one must proceed in this way: Let the sperm of a man putrefy by itself in a sealed cucurbit, with the putrefaction of a horse's belly [i.e. the warmth of horse-dung] (this is a vessel familiar to chemists), for forty days, or until it begins to live, move, and be agitated, which can easily be seen. After this time it will be in some manner like a man, yet transparent and without a body. If now, after this, it is daily nourished and fed, cautiously and prudently, with the arcanum of human blood, and kept for forty weeks in the perpetual and even heat of a horse's belly, it becomes a true, living infant, having all the members of an infant born of a woman, but much smaller. This we call a homunculus; and it must afterward be raised, in the same manner as any other infant, with the utmost diligence and care, until it grows up and begins to be wise and to understand. This now is one of the greatest secrets which God has revealed to mortal man, subject to sin; for it is a miracle and a great work of God, and an arcanum above all arcana, and deservedly ought to be kept among secrets until the last times, when nothing shall be hidden, but all things shall be made manifest."

[Margin: The qualities of the things produced by the chemical art.]

He says, next, that of old there were — and even now still are — Satyrs, Nymphs, "Evestra" [Evestra, Paracelsian astral/elemental beings], Mountain-spirits [Montani daemunculi], Pygmies, and Giants, sprung from this kind of chemiurgy. For these men, produced by art, when they have reached the age of manhood, turn out to be miraculous men, and become instruments of great affairs, renowned and illustrious for mighty victories; moreover, all these, as they obtain their life by art, so too acquire all the secrets and hidden things of Nature.

I strongly suspect that Paracelsus himself may be one of these so wondrous offspring; for, since in his *Paramirum* he glories that no one knew more than he, and besides testifies in many places that he was "self-taught" [Greek: αὐτοδίδακτος (autodidaktos, "self-taught")] — that he learned his knowledge of the hidden mysteries of Nature from no one else — I would assert outright that he was conceived, if not from his mother's womb, then certainly from some Ephialtes [incubus-nightmare], or from an Incubus, or from some other horrendous demon, as from a rotten and poisonous fungus...

[Continuation of **Liber XI "Chymiotectnicus," Sectio II "De Lapide Philosophorum," Caput VII** — the Paracelsus invective and refutation of the alchemists.]

that this monstrous thing was conceived and brought forth as a spurious offspring of its nature — a son of Fauns and Nymphs, more like a demon than a man.

[Margin: An author detected by his lurking foul nature.]

From this foolish alchemical handiwork [Chymiurgia] it is plain how reckless this man was in making assertions, with what ill-considered haste he had the audacity to blurt out whatever he pleased, and how rash he was — rash, I say, in matters from which not only God and Nature, but even reason itself shrinks back. What physician or anatomist does not know that it is as impossible to generate a man outside the female vessel as it is impossible for the seed of a brute animal, cast into the earth, to bring forth a brute of the same kind? Who will assign, in a glass cucurbit, a heat utterly heterogeneous to the maternal warmth and contrary to nature itself? Who will provide nourishment, proportioned and conveyed through the umbilical vessels and veins — indeed, the portion of maternal seed necessary for forming the fetus — by means of human blood (as Paracelsus himself prescribes) that has already died outside the veins and is wholly ineffective? Surely no one can fail to see that this has been granted neither to an Angel nor to a Demon. And who will infuse a rational soul into an embryo already organized? Or do you perhaps suppose that God, the Best and Greatest, can be solicited by Satanic ministers of this sort to lend His concurrence to such a horrendous genesis? Yet who does not know that even to think this is impious, blasphemous, and atheistic? But grant — through an impossibility — that a soul were infused into this diabolical embryo: would it not follow that such a human monster, just as it would be exempt from the common laws of human generation, would likewise be immune from original sin and from the other miseries of the human condition that are subject to sin? And I do not see what could be said more impious and blasphemous than that. O the patience and long-suffering of Divine mercy, which does not overturn the prodigies of such monstrous men by the example of Korah and Abiram! But let this suffice to set before the eyes of the truth-loving Reader the enormous and plainly prodigious offspring of Bombast [Paracelsus].

[Margin: The Brothers of the Rosy Cross are Magicians.]

Like these are those brethren who take their name from the Rosy Cross — an impious breed of men, swollen with diabolical commerce. Of this kind were Cornelius Agrippa [Cornelius Agrippa von Nettesheim], famous for his learning in every branch of the diabolical arts — a man whom, as is more than sufficiently established from his life, the demon finally strangled, so that he paid the penalties

his crimes deserved. Such was Sendivogius [Michael Sendivogius]; such was Robert de Fluctibus [Robert Fludd]; such was the Marquis de Villena [Enrique de Villena]; and countless others whom it is irksome to recall — all of them Magicians and Alchemists. Their doctrine was that it is permitted to learn something from the devil, provided it concerns the knowledge of natural things.

[Margin: The doctrine of the Brothers of the Rosy Cross.]

And these men, indeed — instructed by the devil, the enemy of the human race — are said to have made gold and to have cured all kinds of diseases, but on this condition: that for every ten they cured, they should always kill one. Their insane doctrines are such that they are more worthy of eternal silence and darkness than of light. Hence the learned Conring [Hermann Conring], in his distinguished book *On Hermetic Medicine*, rightly observes: *However sharp Paracelsus's wit may have been, still he was not of a temperate character, such as the wrestling-school of truth demands; and certainly his own morals do great prejudice to the Paracelsian doctrine. For what indeed can one expect of solid doctrine from a man of bad character? Indeed, I would not deny that the demon may even breathe into a man something of true knowledge; but it has not hitherto been found that anyone has become wise by the demon's aid without at the same time being led into very many errors — the father of lies compensating for one betrayed truth with a thousand falsehoods.* Since, then, Paracelsus was such a man, who could ever persuade himself that so great a fabricator of lies actually made gold — not to say that he knew the art? I am well aware that he had many followers, and that countless treatises *On Gold-Making* have appeared and continue to appear daily. Yet all these, since they rest upon the weak and feeble foundation of the very men we have cited, will likewise — whatever they say, write, boast, swear, and forswear about the structure of the blessed (or rather, the cursed) Stone — bring forward nothing at all that deserves belief.

But lest I seem to judge unjustly, like a blind man about color or a deaf man about sound, let me now at last disclose by what methods, by what arts, and with what dexterity they have deceived both princes and common folk — and do not even now cease to deceive — so that the truth may finally come to light.

[Margin numbered: 1 Imposture. 2 Imposture. 3 Imposture. 4 Imposture. — keyed to the four frauds described below.]

has no vegetative life at all, neither on the part of the agent nor on the part of the patient — who does not see this?

[Margin: The hindrances that keep the alchemists' art from reaching its intended goal.]

We have also said that it is impossible for those who work from this exemplar to attain their intended end. For through so many calcinations, sublimations, dissolutions, putrefactions, and fermentations, so far is it from happening that the one so greatly desired form of gold emerges, that rather — through so many torments of fire and of the most pungent waters — the whole matter is carried over into a thousand other forms, and at last that whole intended form perishes and is destroyed. There is the further point that the degree of heat is unknown, and the combination of the substances to be matched together rests on an indivisible point, which it is denied to human ingenuity to attain. We have also brought forward the contradictions of even the foremost Alchemists, met with everywhere — which by their plain testimony indicate that what is exposed to so many difficulties, disputes, dissensions, and quarrels cannot stand firm; for truth is one and simple, and once revealed it is never deprived of its certainty.

But since the whole business turns on the golden argument [aureum argumentum] as its hinge, and since men are borne by a kind of natural gravitation toward that which can make them happy and bless them with the possession of every good thing, it is certainly no wonder that gold is sought with such zeal, with such great labors, with such keen effort; that it is so anxiously desired; and that the common crowd so readily believes it can in the end be acquired by applied study. But lovers fashion dreams for themselves. And this, I think, is the one reason why — as today, so in past ages — no art has been more eagerly pursued than this gold-bearing one, none more ardently desired, none exposed to so many deceits and impostures; the Devil, the enemy of the human race, for the most part mixing himself into endeavors of this kind, while men hope to grow rich through the art. From this there have crept into the World monstrous superstitions, diabolical illusions, irreparable harms to commonwealths, and the ruin of Kings and Princes.

[Margin: The author's intention in exposing the imposture of the Alchemists.]

Therefore, so that the falsehoods and solemn impostures of these little men [homunciones] may be uncovered — for the glory of the Divine Majesty and for the good of the whole literary commonwealth — I have judged that I should here set forth the frauds and deceptions by which they are accustomed to drive mad not only princes, but even learned men themselves, and the common people too.

Who does not marvel and stand astonished at the stupendous feats by which, for the sake of gain, mountebanks, hucksters, street-charlatans, tightrope-walkers, and the rest of this stamp of men circumvent the unschooled crowd by sleight of hand and bodily agility? Even though these tricks are empty, futile, false, and deceptive, they nonetheless earn such credit among the surrounding multitude that they can pass — if not for the illusions of demons, at least for miracles of Nature. They promise mountains of gold; indeed, they promise that by the chemical art they will turn the sea into gold and the sand of the sea into silver, by means of that counterfeit mercury of theirs. And lest they seem to waver in their credibility, some free their reputation by the following sophism:

The first imposture. [Margin: 1 Imposture.] They take a certain powder, red or white, of which they boast so greatly. Then they pretend that they need a certain sum of money to complete the art; once this is given, they mix it together with the powders into a crucible, into the metal which they claim they will transmute, thoroughly stirring it over the fire with a hazel rod. At last, when mercury has been poured over the whole mass, the bystanders see the whole mass either gleam red or shine with a silvery color, as though it had turned into gold — and, like dolts, stand astonished at the unaccustomed marvel of the thing. They proclaim themselves blessed if only they might share in so great a secret through this short shortcut to wealth, and so they promise anything whatever to gain possession of the secret. Once they possess it, they produce a spurious birth of gold — which, when shown to the money-changers [Collybistae], is found to be nothing but that ordinary metal, steeped in a useless tincture; and they extract only as much gold as the price of the injected powder had been.

The second imposture. [Margin: 2 Imposture.] Some put a powder of gold or silver — in a way that will be taught later — into hollow wooden tubes, with Greek pitch or colophony resin added, so that at the mere smell of the fire it readily melts into a fluid like wax. This done, with the crucible set on the fire and filled with whatever metal you please, they pour in the golden powder, stir the material around, and the powder placed in the hollow rod sinks to the bottom and is restored to its original nature; while the mercury, dissolved into smoke by the burning heat of the fire and the remaining metals separated out, they find gold at the bottom — to the great admiration of the dolts.

The third imposture. [Margin: 3 Imposture.] Some disguise the fraud by putting golden powders into a larger hollowed-out coal, or even into the channel of the bellows; then, while they pretend that the metal is throwing off its scum, they blow out the golden powder with marvelous dexterity, together [with the scum],

into the cucurbit in which it is melted. By this trickery, once the operation is finished and the gold extracted, they persuade the bystanders of the infallible certainty of the art.

The fourth imposture. [Margin: 4 Imposture.] Jeremias Mader [Jeremias Mader], in his *Acroamatica*, reports a truly amusing example of this fraud and of this nimble [literally "leaping"] art. Two chemists, he says, entered into a partnership confirmed by agreement: that the one should profess to hold the most certain art of gold-making [Chrysopoeia], while the other should play the *Rhizotomus* (root-cutter) — that is, an empiric mountebank — and among other things should sell gold-filings dyed black as a "lunar powder" [Lunary powder]. Ernst [Ernst], Margrave of Baden [Ernst, Markgraf von Baden], was wonderfully devoted to this pyrotechnics. So the first of the pair approached him, promising mountains of gold and the halls of wealthy Croesus. Everything is sought out, and now, with everything arranged by a pretty fraud, [he claims] that only one of the ingredients which would produce the intended effect was still lacking — one called **Rech** [רֶחַ], that is, "the head of the matter" [caput rei]; and he says that the powders of this can easily be found at any apothecary's, especially at the *Rhizotomus*'s. To him the Margrave sends a boy to buy the powder. Meanwhile the other had conveniently set out his wares in the palace entrance, and — as this kind of men is wont [usually does] — was proclaiming in a stentorian voice that he lacked nothing. The prince's boy approaches him [to ask] whether the root...

[Margin: Greek root: רֶחַ Rech / Resh — Hebrew, "head."]

[Printed p. 282 — verso, running header "LIBER UNDECIMUS, Sect. II."]

called **Rech** [רֶחַ] he had. The man at once takes a [piece] drawn out from a smoky little box and weighs it out as worth one solidus. The boy carries the purchased root [Rech] back to his master, ground into a powder. The impostor [the gold-maker] then sprinkles that powder over the quicksilver, produces gold, and when it is melted down it is found to be true gold. The matter is wonderfully pleasing to the Margrave, and he, kind and grateful to the Master, dismisses him with the gift of no small sum of money. He presses on to pursue gold-making, and indeed — while the most happy success of **Rech** continued — once the powder was used up, he ordered it to be sought everywhere.

They submit the mass to assay; and when they find [the residue]... ...[the powder]. Others take up gold and silver vessels and tint them with the color of copper or iron; then, by pouring mercury onto them, they separate out the gold and silver, and in this way they extract what was rubbed off the gold by the corrosion of the

mercury, and sell it as gold and silver, though it was drawn out of copper or iron. Some pretend to extract mercury from lead, and promise to fix this into silver; and just as they perform this in countless fictitious and counterfeit ways, so too they inflict very grave loss on those who put their trust in such scoundrels.

[Margin: The author detects an imposture of this kind by impostors.]

I myself, too, more than once learned firsthand the audacity of darkness-loving rogues of this sort, who would deliberately come to me — whom they knew to be devoted to the secrets of Nature — to share, as it were, the most profound, great, or rather ruinous secrets of their art, but on this condition: that I should provide the expenses for the trial of their art. I promised I would do so, if they would first show me the method and procedure. Although unwilling, they were nonetheless compelled, and began to reveal the method to me. I at once caught the scent of the fraud; and after I had convicted them of open imposture, when at last they begged me to forgive their boldness — confessing that, pressed by poverty, they sustained their lives by such means — I first scolded them soundly, then dismissed them with the gift of some alms, but with the warning that they should support their lives by a better art, lest at some time they should pay for this rashness, hung up by a golden rope.

The fifth imposture. [Margin: 5 Imposture.] There are, furthermore, others who dissolve a golden powder in water until it settles under the appearance of oil; afterward they say that with this powder they will bind a metal so as to convert it into gold. Others pretend to extract the soul from gold and silver by means of cinnabar, from which, when the mercury is separated, that [residue] remains fixed; into this they then slyly mix gold or silver, and then together, by chemical sublimation, they extract the cinnabar, which they assert has been converted into gold by the power of the soul. Others, by sleight of hand with which they hide the golden powder, then order some instrument or other to be handed to them by a bystander, and meanwhile they throw the counterfeit gold into the crucible; once this is extracted, they are accustomed to drive the bystander out of his wits.

[Margin: Various impostures.]

There are also those who fill certain little caskets with various powders mixed together with gold and silver powder, on which — to cover the fraud — they impose exotic names of herbs and minerals. Afterward they approach one of those whom they know to be devoted to chemistry, and offer to sell him a vast secret of the Great Art for a few coins, promising that they will teach him the truth of the gold-making art by experiment — provided that the expenses

incurred in making the gold be repaid; and [the impostor promises] that, if [the buyer] should not find the truth of the matter, he will subject all his own goods to confiscation. They therefore order [the buyer] to purchase gold powder, already dissolved by aqua regia into a sickly and friable substance; they begin the work, and to the admiration of the bystander draw out the purest gold. Hence the spectator, made bolder by the acquisition of so great a good, and more credulous than he ought to be, and being a man of rather simple mind, asks for the art at whatever price he pleases. The impostor names such-and-such a sum, and once the money is taken, immediately makes off. The other, spurred by excessive desire to have the art communicated, while he more eagerly seeks that powder christened with some exotic and monstrous name, and finds the material neither at the apothecaries' nor at the herbalists', at last finds himself cheated of his purse and emptied of his coins.

[Printed p. 283 — recto, running header "DE LAPIDE PHILOSOPHORUM."]

[Continuation from p. 282, left column — Kircher's account of the Hebrew booklet:]

[Margin: The foolish contrivances of the Rabbis.]

Not long ago there was sent to me a little book written in the Hebrew tongue, stuffed full of the secrets of Nature — or rather, of lies. In it, among other things, an herb was described, by the name of **boriza** [בוריצא], by which that insipid Rabbi asserted that any metal whatsoever could be turned into gold. And since the matter is worth it, I append the ridiculous procedure, from which it will be apparent with what incongruous things sycophants of this stamp are wont [accustomed] to impose upon people. He speaks thus: בוריצא והיא עשב ששמה — לונאריא — *Boriza, and it is an herb whose name is Lunaria.* But omitting the Hebrew words, as being rather long, let us set down the translation itself. Hear it, then — and laugh, Reader — at these foolish promises:

Send the juice of this herb into quicksilver, and make it boil in this juice, and it will become a red broth; from this make a powder, which, thrown upon copper, will turn it into gold; and one ounce of this powder suffices to convert a hundred ounces of copper into gold. This herb is born by springs and rivers, and on high mountains (as I reckon, more truly in Utopia). It has a red and violet stalk, and a milky sap like saffron (I interpret it as Celandine [Chelidonia]). Take the juice of this herb and place it upon quicksilver, and it will become copper — O great profit! And if you place some of it upon lead, gold will result. The juice of this herb placed upon iron will become silver; and the powder of this herb placed upon silver will make gold;

and if you put it into urine with spikenard, and let off one ounce daily, it will transmute old men into young men.

But these foolish contrivances of the Cabal... ..of the Cabalists, let us leave to be refuted not by Philosophers, but by delirious old women.

I could bring forward here countless examples from the solemn frauds of the Arabs, which are found scattered throughout their books on the minerals of Nature and inserted there concerning gold-making. But since they are unworthy to be reported, I have judged that they should be suppressed in silence.

Caput IX.

That the Demon Mostly Mingles Himself with the Devotees of Alchemy

[Quod daemon ut plurimum se Alchymiae cultoribus immisceat.]

[Margin: The love of gold drags most men into ruin.]

Most truly did St. Paul say, in his Epistle to Timothy, chapter 6, verse 9: *Those who wish to become rich fall into temptation and into the snare of the devil, and into many desires that are useless and harmful, which plunge men into ruin and perdition; for the root of all evils is greed [cupiditas], which some, in their craving, have wandered away from the faith and entangled themselves in many sorrows* [1 Timothy 6:9–10]. So it is. It is the immoderate desire for riches — the net of the evil demon [cacodaemon] — with which he does not cease to drag a great part of the human race, as of old, so always down to this very day, into the ultimate ruin of their souls. Since there is nothing in human affairs that is sought with greater desire, or pursued with greater anxiety, than the heaping-up of treasures and riches — for that by the possession and unjust seizure of these a door has been opened to every kind of vice and crime, countless examples teach us. For those who abound in riches can obtain whatever they wish, whether power, or the ambitious acquisition of honors and dignities, or a worldly life swollen with pride and crammed with the rest of the delights of the flesh.

[Margin: By what methods Satan deceives those greedy for gold.]

Hence it is no wonder that Alchemy — the one most deceitful promiser of such great riches — is so highly esteemed, and so anxiously courted by all men of whatever condition. The enemy of the human race is not ignorant of this burning thirst for gold, and so he assails incautious mortals with arts the more dangerous, the more hidden they are. It thus happens that, while they pant after gold with

excessive desire, and are for the most part hindered by the insuperable difficulties that arise in the Great Art, all hope of attaining the art being taken away — and since nonetheless, anxious between hope and fear, they pursue the longed-for possession of riches all the more eagerly — at last, driven sidelong by desperation, they either give themselves over to treasure-hunting, or, summoned by the magical arts of the evil demon, they implore his aid to perfect the art. And so at last, bound by a Satanic pact, having fallen headlong into every pit of impiety, they end their lives in wretchedness, without any fruit at all.

I myself have known many deceived by illusions of this sort — especially the more curious students of learning, who without prior examination, without light, ill-advisedly and with utterly rash daring, embraced the vanity of Alchemy, and, by the just judgment of God, were deceived by the devil and perished, dashed against a thousand precipices of error. For how dear it is to the demon's heart to assail men devoted to such arts, we have demonstrated at length in the first Part of the *Oedipus* [*Oedipus Aegyptiacus*], On Idolatry. For demons mingle themselves secretly not only in those mockeries of the magical arts, but in all the other vain and insane practices that take their origin from these — astrology, divination, and the cabalistic arts, and all those kinds of things that take their name from μαντεία [Greek: manteia, "divination"]. By these they circumvent the curious through their excessive credulity, so that those who neglect to be on guard against their snares vanish away in their own thoughts, and while they believe themselves wise and workers of marvels, become fools, until at last they have, as the master from whom they profit, the partner [demon] of both impiety and eternal exile. Especially does the enemy of the human race assail those devoted to Alchemy in marvelous ways; and sometimes he so dazzles the keenness of their eyes that, while practicing pyrotechnics, they have sworn that they made true gold and silver by transmutation. Yet afterward, although they attempted the same work again, even repeatedly and with great care applied, they testified that they could never find any success.

[Margin: A marvelous example of a man deluded by the demon.]

Countless instances of this matter are read everywhere among the Authors: Delrio [Martín Del Rio], Pererius [Benedict Pereira], Quibert [?], Hogeland [Ewald von Hoghelande] — to whom let the Reader turn. Here I shall narrate only what was related to me by word of mouth by a man most skilled in the chemical art (whose name I deliberately keep silent), who had been deceived by the demon through a similar illusion. He had heard of my experiments in this study; and so he came to me, asking what I thought of the great mysteries of the art. Discussing

the argument back and forth, I at last concluded that the great mystery of the art, like that of the Stone, consists of mere metaphysical speculations, and that those allegorical senses, which both the Arab Alchemists and the Latin chiefs of this art concealed under such great similitudes of things and under enigmas, are of such a kind that they can easily be accommodated to anything whatever — as I had set forth in the hieroglyphic Alchemy of the Egyptians. He answered: *You have said well, Father. Hear what happened to me.* From boyhood [I had been devoted] to this kind of study... ...[having spent] many years, [and] several pious [men] in it, with no profit; and when on a certain day, [my] aim being intent on the alchemists' goal — that is, on making the Stone — while I was wholly absorbed in it, and was thoroughly persuading myself that I had penetrated the arcanum, a certain man, previously unknown to me, came up to me. After greeting me with very kindly words and wishing me well, he asked what I was doing, and to what matter I was devoting myself with such great solicitude. When at first I delayed to answer, he said: *I see from your chemical vessels and from the heap of materials that you are attempting something great in the chemical art; but believe me, you will achieve very little of what you intend.* I answered: *If you know anything better, I should like you to teach it to me.* He said: *I will obey your wish willing[ly]...*

[The narrative of the man deluded by the demon continues beyond this opening.]

[Conclusion of Caput IX of Sectio II "De Lapide Philosophorum" — the chemist's narrative of the demon-stranger, continued from the prior page.]

willingly; so sit down and write out the true method of proceeding. I at once seized a pen and took down the words he dictated, divided into twelve points; and once I had taken them, he said: "Now let us carry these into practice, with you doing the operation, in exactly this order and according to the prescription of the precepts." When this had been done, at the master's bidding I drew out of the chemical vessel a substance shining like oil, and a mass that had soon congealed when the liquid was poured over it. I reduced this to a powder and threw it upon more than 300 pounds of quicksilver [hydrargyrum], and it turned the quicksilver into pure refined [obrizum] and most noble gold, far more excellent and noble than natural gold — gold that among the goldsmiths would pass the assay of the finest and most perfect gold.

Astonished at this unheard-of result, I could scarcely contain myself for joy. I now believed I had become a Croesus brought back to life, that I had won for myself the riches of the whole world. But what thanks I rendered to so generous a master, you, my father, can imagine better than I could explain in many words. When I asked him where he was from, and where he had learned so divine a

secret, he answered that he wandered the world, needing no one's help or wealth; that to his friends, when they wore themselves out in the desperate pursuit of the great art with fruitless labor, he would from time to time share something of his art with a generous hand, to spur them on in their study. With these words he refused the lodging I had kindly offered, and went off to a public inn.

The next day, at first light — for I had spent the night in continual wakefulness, out of excessive joy at the art I had attained — I went to the inn to give renewed thanks to my munificent benefactor. I asked for my guest, but the innkeeper said he had had no such guest that night. I went round all the inns of the city, but everyone said they had not even heard of the man I was looking for. I searched every more notable house in which I could suspect he might have stayed the night, but in vain: he had vanished, gone, slipped away, to my very great sorrow — for I had hoped to receive from him many more of this art's secrets.

So I returned home and, without delay, set about producing a fresh specimen of the art I had just acquired, following the precise tenor of the precepts he had dictated. But when the operation was carried out, I found no success in the matter. And because I believed this error had come about either through some carelessness of mine or through the omission of some of the ingredients, I repeated the operation with the greatest possible diligence. Yet again I was cheated of my hope, and I began the operation again and again, at so great and so many expenses that I spent all that gold I had acquired in the first projection. And just as the hope of gold made me wonderfully restless, so too, by repeating the work, I incurred so many expenses that the matter nearly drove me to despair.

[Margin: The fraud of Satan is exposed.]

And when I had disclosed my mental affliction to a certain religious man, learned and pious, he at once added: "Do you not see, sir, that this is a most manifest delusion of the devil, who appeared to you in the guise of a man? In order to rouse you to pursue the work, he first deluded you with gold obtained elsewhere, by his usual deceit — so that he might afterward lure you, as you pursued the work with fruitless labor, into consenting at last to some pact, or else, once all your goods were consumed, drive you to despair, and thereby seize as his prey both your soul and your body." At this I shuddered, and from the words that strange foreign guest had spoken to me face to face, I recognized that he could have been none other than Satan. So at once, led by repentance for my past life, I returned home, broke up all the furnaces, smashed the chemical vessels of iniquity, and consigned to the fire [Vulcan] the books I possessed on the subject; and from that day I devoted myself wholly to more profitable and useful studies.

Blessed be God forever, who in his infinite mercy delivered me from such great perils.

I wished to set down this truthful history here so that from it may be clear how greatly the demon strives to delude men greedy for gold, and by how many and how great means he labors to draw them into his snares — both by deceptions and by the thousand tricks of his arts. Whoever desires more of this kind should read the commentaries of Hoghelande [Hoghelande], who experienced similar things, *On the Vanity of Alchemy* [*De vanitate Alchymiae*], and the other authors I have cited above.

SECTIO III. DE ALCHYMIA SOPHISTICA

On Sophistical Alchemy

That is: on that alchemy which, joining gold and silver to copper, lead, and tin, thereby fabricates gold with great increase.

CAPUT I.

On the various false and illicit sophisticated operations of various men.

So great is the cunning and craftiness with which some mortals are endowed by nature, so great their loquacity and eloquence in cloaking their schemes, that they will sell almost anything as anything — not, I will say, only to the more ignorant common folk, but even to princes themselves — when they put on display experiments contrived with such hidden guile that in their presence scarcely anyone, whether philosopher or theologian, dares to make a sound.

[The text continues at the foot of printed p. 285, top of column. The following resumes from printed p. 285.]

[Printed p. 285 — running header: "DE ALCHYMIA SOPHISTICA."]

But the bystanders are so dumbfounded at the display of marvelous things, and conceive so deep a faith in the truth of the deeds performed, and so impress it on their minds, that they seem unable to be torn from it by any weight of arguments or firmness of reasoning.

[Margin: The obstinacy of those who must be trusted in their impostures.]

If anyone should try to charge the impostor with some fraud lurking beneath the experiment, they at once oppose him with these and similar words: "Whatever

the philosophers may say, I truly cannot and will not subscribe to it against the evidence of my senses. With my own eyes I saw it, with my own hands I handled it — a thing beyond every exception. You tire your brain in vain in refuting things we cannot but believe to be true." These people truly do not realize that the same thing happens to them as to Aesop's dog: while eating a piece of meat beside a river, and seeing in the water the reflected shape of a dog that seemed to hold a larger piece of meat in its jaws, it let go of the smaller piece and went after the larger one in the water — and so lost them both.

It is indeed a great thing, and one requiring very keen wit, to distinguish things that resemble one another, and to tell the false from the true, so that the saying "I saw it with my own eyes" carries no weight — since it can scarcely be told in how many ways a man may be deceived, and how easily a deceived imagination persuades itself that it sees or feels something other than it truly is. So it is no wonder that there are found some Pseudo-chemists [Pseudochymici] — men shaped and fashioned for every kind of fraud — who quite presumptuously promise that, with a tiny portion of a contrived powder, at the fire and in a tiny span of time, they can convert lead, tin, copper, iron, and mercury into the purest gold and silver, with the bystanders standing as if stupefied and thunderstruck at so great a secret. Yet to the wise, as nature dictates, this seems utterly ἄλογον [Greek: ἄλογον (alogon, "irrational," contrary to reason)] and devoid of all reason. And although nothing is better known than that, at the fire — by what they call cupellation [capella] — all the other metals are separated from gold and silver, they nevertheless do not know that this can be done by that powder, which they wrongly call the "soul of gold" [anima auri]. For they claim that by the chemical art they reduce one ounce of gold to the quantity of twelve grains, and that one of those grains, projected upon an ounce of any metal whatever, gives that metal body and thereby converts it into gold — since, as they prattle, this grain is nothing other than the very soul of gold.

Now who is so utterly devoid of natural philosophy as not to know that matter cannot receive any form whatever unless it is fit and has a disposition suited to receiving such and such a form? For if nature did not have sufficient power, when it generated copper, iron, lead, and mercury, to introduce into it the form of gold, how could the form or soul of gold — which form, however, cannot be said to be separated from a body, unless we wish to prattle childishly in philosophy — how, I say, could that powder, which they call the soul of gold (a soul, mind you, exceedingly corpulent!), be introduced into metals when its own proper subject has been abandoned: into lead, tin, iron, copper, each of which is

already constituted with its own proper form? Who could conceive of such a philosophy?

[Margin: What of the soul of gold?]

Will there not then be two forms in one and the same subject? If they deny that this is absurd, let them tell me, please, what is to be said of the soul of the lead. Perhaps you will say it has been annihilated; but, lest you betray gross ignorance, watch what you say. And if the form in the powder was separated from its subject, will you then suppose that the subject can subsist without form? But this too is an absurdity equal to the former. You see, then, how stupidly those men philosophize who strive to persuade the inexperienced that such things can be done out of a certain asinine ignorance.

This powder, therefore, which they call the soul of gold — the transmuter of any metal whatever into gold — can by no means be called the soul of gold; rather, it is true and natural gold, turned into powder by the power of strong waters [aquae fortes] or by the corrosive power of mercury, a perfect compound consisting of matter and form. For if such a powder, projected upon some metal, converts it into gold by the power of a soul, then surely there is no reason why a powder made from wormwood [absinthium], for example, and thrown upon the dry, dead stalk of wormwood, should not by the same logic revive it into the herb. The same must be said of a powder made from a burnt animal and thrown upon the corpse of the same or another animal: to believe that an animal would thereby rise again would be the act of an utterly stupid man. Since, then, motion — as the Philosopher [Aristotle] testifies — is the life of all things existing by nature, how can it be that things which have no soul, as metals do not, can nevertheless give life? O the supreme blindness of mortals! — that to some cunning charlatan [Greek: ἀγύρτης (agyrtēs, "charlatan," begging quack-priest)] and busybody [Ardelio], who, apart from his chattering loquacity, possesses no knowledge of things, and so spews forth his frauds and deceits from the depths of his heart — that to such men so great a trust should be given, I will not say by the common crowd, but even by princes themselves, so that among them they are not only esteemed as a kind of oracle of Apollo, but are all but adored! But let us proceed to other sophisms.

[Margin: Sophism 1.]

There are some who boast that they possess an augmentation for gold which yields twenty-five, or even fifty, per hundred. I say that what they promise is not true gold, since it can be separated by the action of fire through cementation

from those things to which it had been joined — which cannot be said of true gold. It is therefore merely a certain tincture which, in outward appearance, so dazzles the eyes with a golden splendor that even the mint-masters [Monetarii] are deceived by that color. Some likewise do this with certain menstruums of aqua vitae, tutty [tutia], and sublimate: these, when dissolved and added to gold and burnt copper [zes ustum] in strong waters, seem to augment the gold. And they say they can sell it as pure gold without scruple of conscience, on the grounds that it has already been approved by a prince as true gold...

[Margin: Sophism 2.]

[Printed p. 286 — running header: "LIBER UNDECIMUS, Sect. III."]

is, in which, however, they greatly deceive themselves, as we shall show in what follows. For such men do the same as the wolf in the fable: he had been bound under conscience not to kill, for his daily food, more animals than would weigh six pounds of their flesh; but, seeing a cow with its calf coming his way, he attacked and killed them both, judging in conscience that the cow weighed only four pounds and the calf only two, which together make the six pounds appointed for his food.

It is clear, then, that those are entangled in a notable error who think that gold can be augmented with something that is not gold. And although they say it is approved by mint-masters and money-changers [Collybistae], I say this happens either from the negligence or from the ignorance of the mint-masters. Negligence is shown in this: that, to avoid labor, they are accustomed to examine this sophistical gold only superficially — applying no proper cementation, or what they call cupellation — using only obvious and commonly known means requiring little effort. And they show their ignorance in this: that, just as they purchased that office for a fixed sum of money, or were promoted to so important an office by the favor of princes, so too — since they do not hold even the first principles of the metallurgical art — they do not know the method and procedure of testing, examining, and forming a sound judgment about the goodness of gold and silver. From this innumerable injuries to the commonwealth arise, and to many people the door is opened to similar frauds and deceits, to every license.

[Margin: Sophism 3.]

There are others who boast that they possess two secrets of different kinds, which they say the whole world cannot but accept as true transmuters of gold and silver. The first of these is as follows: They take gold and silver in equal portion, well tested beforehand at the cupel; then of tutty, crocus of Mars [crocus Martis,

iron oxide], and crocus of Venus [crocus Veneris, copper oxide], they take four ounces of each, and of oil of vitriol seven ounces. These are placed within a bladder [vesica], and the said mixture of ingredients is gradually incorporated. When this is done, the bladder is left in horse dung for fifteen days; and once the digestion is complete, the whole mixture is taken out and dried in warm ashes into a powder. A quarter part of this, projected upon one part of silver, changes it into gold of 24 carats, as they call it.

[Margin: Sophism (—).]

The other is as follows: They take gold and silver, first filed into shavings, and while they are being melted, they add to them as much of tutty and sublimate as the gold and silver together with the ingredients weigh. Then, ground and milled as finely as possible, they place them in a sublimatory vessel; and when the sublimation is complete, a mass remains at the bottom, which, committed to the cupel, separates gold of eighteen carats. This is the secret which many greatly esteem. Yet I, examining everything duly, do not know what an unproportioned vegetable crocus contributes to the essential tincture, since tutty, crocus of Mars, and crocus of Venus suffice for the tincture. But if Sol and Luna [Sol and Luna, i.e., gold and silver] enter into this operation, I do not see how tutty, iron, and copper can add anything to the gold beyond a tincture; for even if they coalesce into a single golden mass, the whole is nevertheless not pure gold, but only apparent gold, since with the help of the cupel all the added metals can be separated from the gold. There is therefore no usefulness lurking in secrets of this kind, except that they get back the very gold and silver they put in; and at the least, since it readily yields to the hammer, it can also be of some use in making household plate.

[Margin: Sophism 4.]

There are besides those who say: "I know how to prepare a tincture for silver, by which I can increase gold threefold, by means of a powder made from leafed copper [cuprum foliosum], mercury, and cinnabar — which, calcined by a water composed in equal parts [analogically] of vitriol and saltpeter, brought to a first circulation and then through the fire of fusion [ignis fusionis], with two parts of cupelled gold and silver added to these. I can also make cinnabar so fixed that it tinges silver into the best gold. I proceed thus: I steep cinnabar, placed in strong waters, macerating it for 24 hours; then I submerge the dried-out matter in salt water; then with fresh water I draw off the saltiness into sweetness, and with the remaining powder I make layer upon layer [stratum super stratum], and finally, having cemented it, I cast it into the best and purest gold." But I, examining this

process, do not find how gold of such purity could emanate from fixed cinnabar, since it cannot give what it does not have. And if you say that it holds gold added to it by nature — and so the matter does stand — I say that the golden powder mixed in, together with the gold accrued to the cinnabar, yields only as much as was first put in, though a little purer. Nor do I see any usefulness in this operation, except useless labors and expenses. I know indeed that cinnabar teems with quicksilver, but that it can be converted into gold by any preparation whatever — that I have never seen nor heard, unless perhaps the quicksilver inhering in the cinnabar as in a mineral matter is tinged into gold, which is mere vanity.

[Margin: Sophism 5.]

Another speaks thus: "I too can make real gold, the sign of which is that in strong water it remains 'quartered' [quartatum] together with silver — and the mint-masters and money-changers require nothing more. I proceed thus: I take as much as suffices of bronze or leafed copper, and an equal amount of cupelled silver, which, melted together, are drawn out into thin rods. Afterward, with sulphur melted, into which I place the rods first imbued with sulphur, I press them with kindled coals until all the sulphur is burnt off; and this done so many times, until the rods entirely turn into scales [scaly form]. Then I commit the scaled mass to the cupel, and there will remain somewhat less than the silver was before. Then from this silver one-ounce rods are made, and they are placed on the raw, still-muddy edges, in such a way, however, that below and above they have a layer of prepared salt...

[Margin: Sophism 4.]

[Margin: Sophism 5.]

[Printed p. 287 — running header: "DE ALCHYMIA SOPHISTICA."]

and when this is done, they are placed within a furnace; and when they have been cooked, the rods will appear to be of a tawny [Leonine] color. You will place them in strong waters, and you will have, for every ounce, one drachm of the purest gold, 24 carats. Experience indeed confirms it." But I say that this drachm of gold does not come from the transmutation of copper or silver into gold; rather, that drachm of gold was either extracted from the silver — which is never wholly free of some small portion of gold — or perhaps from the copper, and was separated out by a powerful fire.

[Margin: Sophism 6.]

Yet another, boasting, says: "I know a way of making silver without so much labor." If you ask how, he says: "I take arsenic wrapped in a linen cloth — what they call *pezzas* — and cook it in common oil; cooked, I sublime it repeatedly, and it becomes fusible like wax. A fifth part of this I project upon copper, and it will tinge it white, of six 'leagues' [ligas]; but if I put in one part of cupelled silver, it will withstand the assay of silver of six leagues, as they call them. The same I shall obtain if I take two parts of silver, one of copper, and one of antimony: these, melted, will give a mass not unlike true silver." I myself indeed know that the same can be done if you take iron and soften it with sulphur; if you mix this with copper or Venus while they flow in the fire, they will at once embrace one another by a certain natural sympathy, by which Mars pines for Venus. But if you mix this with silver and commit it to the cupel, the copper will be separated and there will remain an iron-silver mass. But who will say this is true silver, since, when it is separated from the iron by strong water, only the silver that had been put in remains.

[Margin: Sophism 7.]

Furthermore, there is no lack of those who shamelessly boast — as I recall having heard from some such men in conversation: "I know a way of making a mineral of silver, and another of gold, from which I take only as much as suffices to support many people." Such men proceed thus: They take four ounces of lunar mercury [Mercurius Lunaris] and 32 [ounces] of cupelled silver, from which they say they extract, for each ounce, one drachm. This done, they take cupelled silver first reduced to filings by the file, to which they add one ounce of common salt; and when these have been sublimated and all duly reduced to powder, they place them in a crucible over kindled coals, and at once it will flow; and within a short time a circle will be seen within the crucible, and at the bottom a mass of mercury, which is taken out; and what remains is silver with sal ammoniac and sublimate. "Keep the mercury you have taken out, for it is of great value for multiplication. Proceed thus: Take 4 ounces of this mercury, and one of filed silver, which, placed in a glass bladder, are to be set in the furnace for two months and urged on with a sharp degree of fire, one each week; then the mixture, projected or precipitated, will be transmuted into a Leonine color, and this is the medicine so greatly desired for multiplying the mineral. Now proceed with the multiplication thus: To each four ounces of the said medicine add one ounce of cupelled silver, and five ounces of common mercury, and, placed in a similar glass vessel, let them be committed to the fire for the space of a month, and you will find one part of such medicine converted into silver — or into gold, if you add one ounce of gold to the medicine. And this is the secret which some

say they obtained — I do not know from what physician or secretary of the Great Emperor of the Turks, or even of the Sultan of the Persians, perhaps born in Utopia, while they were oppressed by harsh servitude in those parts."

But whoever commits this sophistical contrivance to the cupel will at once find that the mercury has gone off into fume, that the mineral slags have been separated out at the bottom, and only as much silver as they had put in — although, mixed previously together with the slags, it would press out the whole mass as silver.

[Margin: Various sophisms of various men.]

Another tried to persuade me of the truth of the transmutation of metals by this mastery, denying the truth of the thing [otherwise]: "I take a powder — namely, a medicine — which, projected upon 22 parts of mercury, converts it into gold or silver, according as the medicine is prepared from gold or from silver. I proceed thus. I prepare a double water: one from two parts of sublimate, the other from antimony; then I extract an oil from two parts of antimony and one of sublimate, prepared however without alum and without any arsenic, reduced to powder only with salt and vitriol. This I place within a well-luted retort, sealed with a plaster made of lime and white of egg; then they are distilled, and these, from the thick and black matter, after often-repeated cohobation [redistillation over the residue], will at last pass off into a most subtle and clear liquor. Again let the mercurial water be rectified seven times; and as often as the rectification is done, pour over it a sixth part of oil of antimony; then I divide the whole mixture into two parts, in one with silver, in the other with gold placed in foliated form. These, in a closed vessel, within a short time will pass off into a flux, liquefied like fat. Let these two vessels, within a certain receptacle closed on all sides, be digested by the two-month heat of a lamp, the wick always being increased; and within the first little vessel you will find a black medicine, in the other a white one. And this is the medicine which, projected upon mercury, converts it into gold or silver" — namely, nothing other than what was first put in. Tell me, please, good sir, what do the sublimate, oil of antimony, salt, and vitriol do in this mastery, when the golden and silvery powder, and beyond that another quantity of gold and silver placed in the oil and mercurial water, restore to you the whole of that gold and silver which you had put in? What, I ask, can be conceived in the said salts that could produce any effect of gold? For I know that these salts are of no use for anything except the dissolution and purification of gold and silver.

As for the claim that from it one can prepare a medicine that, by projection, "multiplies" gold and silver, I flatly deny it. It is nothing but the empty and utterly

worthless conviction of men who thirst and dream of nothing but gold. I do indeed grant that a medicine of this kind — which they also call a "tincture" — can act only in the proportion of its own projection onto the matter: that is, only as much as if one drop of water were thrown onto a whole measure of wine. And in that case, what would emerge from the projection except the same wine, with no transmutation of wine into water at all?

But to this a man replied with the utmost obstinacy: "You, Father, deny the true and real transmutation that I have already shown you. But to demonstrate it to you more clearly, take the following experiment. Take pulverized cinnabar and form little pellets kneaded with egg-white. Then reduce silver or gold to powder, and make a layer of the said cinnabar pellets and a layer of the metals, stratifying them alternately one upon the other. Place them in cement for 24 hours over a non-fusible fire. Then remove the matter, set it in a cementing vessel, and you will find the cinnabar converted into that metal with which it had been stratified, together with the cinnabar." [Margin: An experiment.]

What a fine experiment! If it were true, in how short a time and with what ease would many men grow rich — especially if the stratification were done over gold or silver! But experiment proved to me that another pseudo-chemist had made silver by such a secret; yet once it was duly examined, he was accused as a forger, and was compelled to restore — not without danger of prison and of his life — the money for which he had sold the said silver.

After this man, another presented himself who claimed that the true transmutation could be demonstrated from this: that iron is changed into perfect copper by the following experiment. "Let thin, fine plates of iron be put into vitriolated water, and at once you will find that, by a natural sympathy, the coppery matter adhering to the iron will leave copper behind it." But when, by the experiment itself once taken, I showed him the contrary — and demonstrated that this can in no way be called or held a true transmutation, but only a dissolution of the iron into dross, and a uniting of the little copper bodies that had previously been scattered through the vitriolated water, now gathered together by the iron's attraction, which when afterward melted yield copper — when, I say, I had demonstrated this, he fell silent, convinced either by shame or by his own ignorance.

I append a similar experiment most worthy of wonder. [Margin: An experiment.] If hairs, or the shavings of hair, are boiled in an iron vessel until they take on the form of a glue, and then the vessel is driven with a stronger fire, the result is that if you put other hairs into this glutinous broth, they become so steeped in the

coppery spirits lurking in the vessel that they look like threads of the purest copper — and no one could persuade himself that they are hairs, so brightly do they shine. The same will happen if iron that has been cemented with sulfur, and has acquired a certain friability, is sprinkled with the powder of burnt glass: for although this is pure iron, it will nonetheless appear as copper. But to test how much copper is present in vitriol or vitriolated water, proceed thus. [Margin: An experiment.] Let vitriol be boiled in water until it is wholly dissolved into a liquor; let this liquor be thrown onto mercury, and when you have left it to remain so for a little while, then with the liquor placed within a retort, distill it over a fire; and as the mercury evaporates, copper will remain in the bottom. When this is weighed, you will learn how much copper was in the water; and in this way you can easily find out, whatever the metal may finally be, how much gold and silver it contains within itself. These experiments do not show a transmutation, but only an alteration, that is, a separation of one thing from another, as we have shown in the various foregoing examples.

[Margin: Sophism.] After this man, another presented himself who claimed that the transmutation [continues — see p. 289]:

whatever the metal may finally be, how much gold and silver it contains within itself. [Note: this final clause of p. 288's text continues; the second column of p. 288 set the running matter of the "Sophism" paragraph, which resumes the main treatise's argument below.]

[The treatise's main argument resumes.] A mark [marca] contains eight ounces, or sixteen lots [lotones], and goldsmiths use these units. With these premises laid down, let us now take up the work.

We say, then, that the art of the alchemists is at times lawful, provided the gold it produces is not below 22 carats. And it is twofold. The first is **monetary** [Monetaria], which they also call *Collybistic* and commonly *Lega*; the other is called **alchemical** [Alchymica], which by the addition (as they call it) of another metal to gold or silver "multiplies" the gold. [Margin: What is the finest gold?] Both are lawful, if each stays within its own limits. The monetary kind, for the striking of coins, generally adds to gold or to silver another kind of metal — such as bronze, that is, copper — which they call *Lega*; provided that, as we said, it not be below 22 carats. So too the other, the alchemical kind, although this latter cannot easily be put to monetary use, but only for vessels and for the furnishing of gold and silver household ware. The monetary kind, however, by the prince's pleasure, can issue small money struck of any alloy he likes — though only within his own principality, and not put into circulation outside it. But since these

matters are commonly known, we shall not dwell on them. Here we shall only examine the alchemical art: whether, by the addition of other metals and minerals, it can produce true and pure gold, or only a mixed gold. And so that this may be done with greater method, certain things must first be supposed.

It is supposed, **first**, that there is no metal or mineral that does not have some gold or silver mixed into it — in one more, in another less. [Margin: Every metal contains gold and silver.] This is what the unfailing experiment of the microscope first taught us. For in minerals and metals, whether perfect or imperfect, ground to a fine powder, as soon as we examined them under the applied microscope, we always detected some grains of gold or silver — just as in gold and silver we found some particles mixed in from other imperfect metals. Hence I came to know with certainty that there is no metal so perfect that it does not also have joined to it some admixture of the others. And this admixture seems to draw its origin from the fact that in ores rich in gold or silver you always find adjoined heterogeneous lumps, whether of minerals or of imperfect metals, as we showed at length above in the *Sectio on Metallurgy*. Whence it comes about that the various lumps coalesce into one another, though by an intermixture scarcely perceptible except to armed eyes.

[Margin: Vitriol-water does not lack gold mixed into it.] **Second.** We find the same thing in the various species of salts and juices, especially in vitriol — whether congealed into a solid or dissolved into a liquor. For since vitriol-water, drawn from a pyrites ore through which it passes, continually scrapes off certain minute corpuscles both of the pyrites and of the gold mixed with it, it comes about that these, while they are dissipated confusedly and scattered through the water without union, soon — when another metal, especially a sympathetic one, is joined to it — seek out that metal by a kind of magnetic confluence, and being drawn by it are united with it. These then first become manifest when they have been committed either to the cupel or to the cement.

[Margin: Antimony, marcasites, etc., hold gold.] **Third.** This same thing is to be seen in antimony, marcasites, magnesia, tutties [Tutiis], cadmias, arsenic, orpiment [Auripigmento], ochre, and the like, which always have some gold or silver mixed in — a fact only that man will deny who has not made the experiment with the use of the microscope. Hence it is no wonder that alchemists are vehemently deceived, when they suppose they have transmuted into gold what was already in those substances to begin with — as we shall explain more fully in what follows. But let us now confirm our doctrine by experiments.

It happened in the pharmacy of our Roman College that, while we were calcining tartar in a crucible with a reverberating fire, once the calcination was done we found at the bottom of the crucible a little golden globule the size of a pea. About this various disputes at once arose among those present: some thinking it had been extracted from the tartar, others holding that it had run down from other substances mixed with the tartar. I, suspecting what was actually the case, asserted that the gold had been melted out of the very material of the crucible by the violence of the fire. [Margin: Gold in the very material out of which crucibles are made.] To my opinion assented the most excellent **Jordanus** [?], Duke of Bracciano, most skilled in chemistry, who happened then to be present; and he affirmed that crucibles of this kind are usually made at Bassanello [Baßanellae] from a certain earth most rich in golden filings, which, imperceptibly mixed into the crucibles and then urged with a stronger fire and melted, is found collected at the bottom of the crucible in the form of little globules of mercury — and that the same thing had befallen other goldsmiths and apothecaries. But that gold, or any other metal, can be present in tartar — since tartar draws its origin from the vegetable nature — is impossible. The globule, of nearly three ounces, when committed to the cupel, gave one ounce of gold and two of silver, which had been mixed in along with those golden filings. From this it shines out plainly how easily alchemists delude themselves if, after the various mixing of ingredients into some composition, they find a bit of gold or silver — for from where that flowed, the demonstrated experiment makes clear.

[Margin: Deception of the senses.] In the same way those are deceived who, while they reduce certain herbs to ashes for extracting salt, find gold; and I have often heard that this happens in Hungary near the gold-mines. We give this explanation of it: that gold-bearing spirits, carried into the roots and the rest of the herbs' substance, are there coagulated by the cold of the surrounding air and the moisture of the plants, and as such spirits continually flow in, they at last rise up into a certain body — which is then found melted at the bottom of a vessel made glowing by fire. By this experiment men unskilled in natural things have utterly persuaded themselves that certain plants have a wonderful power of transmuting metals into perfect gold. But since these claims have been refuted in what precedes, we shall not dwell on them. It remains, then, that we now set forth the various modes, operations, and masteries [magisteria] of gold-making [Chrysopoeia], by which some...

some alchemists claim that, by the addition of any minerals whatsoever — gold and silver having first been put in — they can produce an augmentation. And this mode is true and lawful as well, provided it be shown, through expert goldsmiths

and gold-refiners appointed by the magistrate, to obtain its proper weight and qualities. For my own part, I am convinced that **Lull** [Ramon Llull], **Arnold** [Arnold of Villanova], **Rupescissa** [John of Rupescissa], and the other gold-making authors [Chrysopoeias] recounted above, made their gold — if indeed it can ever be proved that they made true gold — by no other than the following methods. But those who think that they made it not by this method, but by the Philosophers' Stone, assert this too rashly. So that the dispute may be settled, I shall reveal by what art they made that refined, pure, and natural gold, and by what trick they prepared a tincture of gold "multiplicative to infinity."

Chemical Arcanum I.

By which from one ounce of the purest silver a drachma of gold can be drawn out.

This secret was communicated to me by **Jacob of Negroponte** [Iacobo de Nigroponte], a distinguished iatrochemist, who testified that he had again and again verified the truth of the matter by experiment. One proceeds thus. [Margin: An experiment.] *Take one ounce of cupelled silver [Luna Cupellata], then five ounces of purified lead, which, melted together, are to be thrown granule by granule into common water. This done, take one ounce of mineral cinnabar and one ounce of antimony, which, ground to a powder and mixed together, are to be made into a* [continues on p. 291]:

For this **the first thing required is a chemical vessel** with the lute of wisdom; **second**, a copper crucible [Tigillum]; **third**, a place fitted out together with a lamp having an asbestos wick; **fourth**, the ingredients, which are silver, aqua fortis, mercury, and oil of vitriol. Take, then, first, for the chemical vessel, a glass vessel...

Diagram. An engraved apparatus for the slow "digestion"/circulation of the alchemical mixture over a steady lamp-flame. At the top, a tall cylindrical glass vessel (A) closed with a domed, lidded stopper (B) flanked by two flame-like decorative finials, set inside a sand-bath crucible (G–H) within a boxed cabinet; below, on a checkered tiled floor, stands a lidded lamp-burner (D) on a tripod, its flame (F) rising through a perforation in the abacus shelf toward the vessel above. The printed legend ("EXPLICATIO FABRICÆ" — "Explanation of the apparatus") reads:

- A: The glass vessel filled with the matter C.
- B: The cover of the vessel A, luted on.
- G H: The crucible [tigillum] filled with sand.

- D: The lamp filled with olive oil.
- E: The wick fitted with cork floats.
- F: The flame of the lamp.
- L L L: The air-holes [spiracula] of the following compartment.
- V X I K: The compartment [loculamentum] within which the glass vessel A is placed.
- V X M N O P: The shelf [abacus] on which the compartment is set; perforated in the middle at R S, so that the flame may nearly reach the bottom of the vessel G H.
- T Y: The tripod on which the lamp is set.

The whole apparatus is then to be closed up.

[The recipe of Arcanum I, interrupted by the figure, resumes on p. 291; its continuation below is the conclusion already begun on p. 290.]

stratify them in the crucible with the said grains and powder, so that the powders occupy the first and the last place in the stratification. Then let the crucible, sealed as exactly as possible with the lute of wisdom, be set apart until it dries out; once dried, let it be urged at the fire for about five hours — first indeed with a slow fire, and afterward with a strong one. Finally, removed from the fire, once it has cooled, you will find in the bottom of the open crucible a matter in the form of a loaf [panis instar], which, committed to the cupel, will give pure, refined gold, the thing sought. This is an experiment performed by **Jacob of Negroponte**; who, however, expressly says that no profit can be derived from it, but that he communicated the secret to me only so as to show what Nature can and cannot do. Certainly, whoever has well understood the suppositions we set forth a little earlier will be compelled to admit frankly that gold of this kind has come forth not by any transmutation, but either by a separation of the gold from the silver, or from the cinnabar, or from the antimony, or from all of them together, in which it was present to begin with.

Chemical Arcanum II.

By which quicksilver [Hydrargyrum] is said to be converted into the finest silver.

This arcanum was communicated to me by a certain great prince, whose name I deliberately keep silent, who also confessed that he had found the truth of the arcanum to his own great profit. One proceeds thus. Four things are required for the completion of this arcanum. **First...**

[continues on p. 291]:

silver previously cupelled; and three ounces of filings finely filed off, which, mixed together, dissolve into water within a quarter of an hour. This done, to this water add one pound of quicksilver, properly cleansed beforehand of its dregs (the method of cleansing the mercury is by pressing it through a leather purse). This too being done, you will carefully close the glass vessel with the lute of wisdom. [Margin: The lute of wisdom — out of what it is made.] The lute of wisdom is made of wheat flour, quicklime, and clay mixed in equal parts [anaticé — i.e. in equal portions], and kneaded with egg-white. Next take a copper pan [tigillum] in the form of a basin, a span [spithama] wide and a hand's breadth deep, which, packed with white sand, you will fill up to half the height of the vessel. Into the sand of this basin set the glass vessel, now luted, with such care that it stands within the sand at a finger's breadth distance from the bottom of the pan, but in no way touches the bottom. This too being done, take a lamp — or any other vessel of whatever material suitable for carrying out the work — filled with olive oil, within which floats an asbestos wick supported by cork floats; which, when lit, should give only as much light as a candle of ordinary household wax and middling thickness usually gives. Set this lamp within another receptacle closed on all sides, yet having some holes above and at the sides, so that the smoke and soot can escape through them, and the fire can enjoy the air it needs. And let this whole assembly be placed within a chamber which they call a "dry stove" [stufa sicca], or in a warm place steeped in heat. Then set the pan, together with its luted glass vessel, over the lamp, taking care that the flame does not strike the bottom of the pan directly, but is set off from it by a finger's breadth of space; and in this way leave it for the space of 14 days in its digestion. When these have elapsed, you will open the vessel, and to it add eight lots of oil made from vitriol, and with the vessel again closed with the lute, set it as before over the lamp. And after another 14 days have passed, you will open the vessel again, and at the bottom you will find one pound of silver fit for the goldsmiths' use, which nonetheless still requires the cupel. Set aside three of the pound's parts, taken out for your own use and profit, but restore the fourth part of the pound to the chemical vessel again. To it you will add as much mercury as a third part of the silver weighs, together with two ounces of the best aqua fortis and an equal number — two ounces — of oil of vitriol, so that the materials laid upon the quicksilver rise above it to the middle of the vessel; for only that much of the whole space is to be filled, not beyond. Then again let the luted vessel be committed to the lamp, for 14 days. When these have elapsed, opening the vessel you will find, as before, one pound of silver; from which, three parts having been separated for your gain, leave the fourth within the vessel, and again pour on as

much quicksilver as a fourth of a pound weighs, together with two ounces of aqua fortis and two of oil of vitriol, as above; and the vessel being closed and luted, again set it over the lamp. And after 14 days have elapsed, you will repeat the same: that is, one pound of silver — from which, three-fourths having been drawn off for your own use, leave one within the vessel; to which, having added afresh as much quicksilver, together with two ounces of aqua fortis and of oil of vitriol, set the closed vessel again over the lamp. And in this way, by the same process always continued for many years, you can (as they suppose) augment the silver in a wonderful manner.

Observe, however, that each day the lamp must be refilled with oil, lest, when the oil is consumed, the flame draw back from the bottom of the pan too far; the wick needs no snuffing, since it is twisted from threads of inconsumable asbestos. Nor does it matter if you leave the vessel in its digestion beyond 14 days, since the longer it lingers in it, the more perfectly the matter is digested and the purer the silver comes out. And those who take up more chemical vessels of this kind for carrying out the work, to them too a greater quantity of silver will accrue as gain; and to a larger vessel and more matter, a greater quantity and more wicks ought to correspond. And this is the chemical artifice by which a man can live comfortably his whole life long, according to the one who communicated it to me. But now it remains to be examined whether silver of this kind is truly and properly silver, and for what reason it takes on so great an increase.

Into this, then, there enter three ounces of pure silver, eight ounces of aqua fortis, one pound of quicksilver, and eight ounces of oil of vitriol — which, joined together, give 21 ounces, that is, two pounds less 3 ounces; from which, the 3 ounces of pure silver subtracted, there remain eight ounces. But on opening the vessel you draw out from it one pound of silver. [Margin: Examination of the process.] The question is asked: from where and how have 7 ounces of silver accrued to it? I answer: since in pure, sheer quicksilver, as also in the aquae fortes or in vitriol, silver does not actually exist, except for those least particles, that is, corpuscles of silver, that had been mixed into each of them beforehand by Nature (as is clear from the second supposition) — these particles, macerated by fire and circulated for the space of a half-month, at last cohere by a sympathetic confluence to that little portion of three ounces of silver, and so make up one mass of silver of 12 ounces. But because those corpuscles by themselves might seem too few to constitute a body of silver of seven ounces, it is necessary that the saline corpuscles too — which were scattered and contained both in the mercury and in the aquae fortes and in the vitriol — united together with the silver mass, have grown into a silver mass of 12 ounces. And unless we say this, we shall be

saying that the whole of the mercury, the aqua fortis, and the vitriol was transmuted into silver — to no purpose; since it cannot come about that what does not actually and essentially have something from itself and its own nature, should nonetheless give that thing. It remains, therefore, that the whole silver mass of seven ounces was constituted out of those silver corpuscles alone, mixed with the said ingredients, together with the saline corpuscles present in them. And this is clearly evident from the eleven ounces of liquor, or of dross, after the...

(continuing from CAPUT II, the mass-balance examination of Arcanum II — the quicksilver-to-silver process)

would have remained superfluous after the operation was completed, if it had really been produced by transmutation. For in a true transmutation the whole must be converted into the whole, so thoroughly that it may genuinely be called transmutation. The question therefore arises: can the silver obtained in this way be called true silver? My answer is yes — even though, when it is submitted to the cupel, it comes out in much smaller quantity because of the separation of the heterogeneous parts that had been mixed in. From this it is also clear that the business does not succeed at all if no silver corpuscles were already present in the said ingredients, and that more or less silver emerges in proportion to how much or how little of them was mixed in. I would add that this procedure [pragmatia] scarcely yields enough silver to recover the costs laid out.

ARCANUM III.

By which part joined to part produces gold. [Quo pars cum parte juncta aurum prodit.]

Take one ounce of pure silver, previously purged with white sulphur, and two ounces of laminated gold; let them be melted together. Then take 2½ ounces, stratify them together in an earthen or iron vessel, and calcine them in burning sand. Reduce what has been calcined to a powder, to which you will join an equal weight of sublimate of mercury [mercurium sublimatum], with five ounces of powder poured over it. Distill the whole together through a retort up to an oily liquid, three times over, and a precipitate will remain inside, which you will grind small. To this add four ounces of the following fluid. The fluid is made thus: take one ounce of white tartar, 3 of saltpetre, two of borax, sal ammoniac $\frac{3}{4}$, Venetian glass $\frac{1}{2}$ ounce; all ground small together. Of this, I say, join four ounces to the preceding precipitate, and once it is placed in a clean crucible and covered, expose it to the fire for one hour, and you will have a *regulus*. Grind this small

and cement it, which is done in the following way: take of filings of steel a sufficient quantity, two ounces of sulphur previously calcined, four ounces of antimony; let them be committed to a strong fire for fusion, for about one hour. Then take two ounces of this ground material, one ounce of green copper [or verdigris, aeruginis], one ounce of cinnabar, one ounce of sal ammoniac, four ounces of calamine [galaminae] — which, however, having first been calcined with an equal weight of common salt, you should dissolve again, and leave it boiled three times in strong vinegar to dry out. With this powder you will cement the *regulus* left above, and once this is done you will have what was proposed: gold that withstands every assay — indeed a little more gold than what, for the reasons stated, you had put in.

There follow Arcana which they call "Confirmation," and which is the fixed sulphur that tinges Luna [silver] into Sol [gold]. [Sequuntur Arcana, quam Confirmationem vocant, et est sulphur fixum Lunam in Solem tingens.]

I shall here set down some chemical Arcana which I have drawn out from the hidden and varied circles of figures and the wrappings of emblems — out of the mystical workshop both of the Arabs and of the followers of Lull [Lullus, i.e. the pseudo-Lullian alchemical corpus] — from which it will be plain that the Stone of the ancient Philosophers was nothing other than what we lay down here. For it can scarcely be told how much the deceptive emblematic figures do to drive home the affected structure of the Stone; how much the allegorical entanglement of words and names does, while very many — not the common sort only, but even the wise — rush headlong toward whatever may seem to them admirable or useful for attaining the highest blessedness, with no consideration of the matter, with no balance of reason brought to bear, tumbling into it as though driven by a vertigo, rabid with an anxious hunger for gold. This is plain from the very fact that some of the followers of Paracelsus not only venerated that mystery contained under an acrostic — which we mentioned above — but also adorned it with various emblematic and symbolic figures, so that the great work, which they do not know how to accomplish, they might at least make a show of putting forward as something supreme and unheard-of, by means of secret symbols and a counterfeit arrangement of names. But because the matter is worth setting out to demonstrate the vanity of the alchemists, I shall here append the Emblems.

A fraud extracted from chemical manuscripts. [Ex Chymicis Manuscriptis fraus extracta.]

"Then comes Xenophon's True Mandate." [Fiet inde Xenophontis Verum Mandatum.]

These are those marvelous arcana which the foolish ash-blowers [cinifones, i.e. charcoal-burning alchemists] present to the world under ridiculous figures and emblems, and whose interpretation I shall now supply — lest their trickery and deceit seem to have escaped its Oedipus; for I have always labored with great effort at unriddling such things.

In the first Figure a circle surrounds a triangle marked with a cross, within which are enclosed the figures ☉ [Sol/gold] and ☾ [Luna/silver]; in the circle stand these words: *Sala Vera Laudat Philosophiam Habentes Voluntatem Rectam; Fiat Inde Xenophontis Veberatio Mira* ["Salt truly praises Philosophy in those Having a Right Will; thence let come the Marvelous (utterance?) of Xenophon"]. If from these names you gather the initial letters of the words into one, this will come out: SULPHUR FIXUM ["fixed sulphur"] — which the triangle, together with the attached cross (the mark of sulphur in use among chemists, ⚞), also signifies. Here it is plainly evident that the Alchemist, in putting *sala* for *sola*, did not even understand the Latin language.

The second Figure has three circles with a crossed and inscribed triangle. In the first two circles are the same words as in the first Figure — so that the hidden mystery, and the arcanum that readers marvel at, might not at once be apparent: for the initial letters of the words denote the same thing they denoted before, SULPHUR FIXUM, which the chemical mark ⚞ also shows. The words placed in the third circle are the same as those described around the triangle in the first Figure — namely, *Lege omnes Sophos ergo sic tuos* ["Read all the Sages, therefore (read) your own thus"], with which words ...

(catchword: "con-")

words, foolishly constructed, they indicate that all the Sages — that is, the Philosophers — understood the first matter of the Stone to be fixed sulphur. The third figure was that of a certain stupid Alchemist, who took mysterious words extracted from Paracelsus and translated them into this figure, a circle surrounding a triangle.

In the circle these words are contained: *Visitetis Inferiora Terrae Rectificando Invenietis* ["You shall visit the lower parts of the Earth; by Rectifying you shall find"]; and in the other semicircle: *Occultum, Lapidem, Veram Medicinam* ["the Hidden (thing), the Stone, the True Medicine"] — the initial letters of which words, V I T R I O L U M, indicate, and beneath the figure these words are placed:

Diagram. Three emblematic alchemical figures presented as exposed frauds, captioned at center *Ex Chymicis Manuscriptis: Fraus detecta* ["From chemical manuscripts: the fraud detected"]. Each figure is an acrostic device in which the initial letters of the words running around the circle spell a chemical term.

- **Fig. I** (top left): A circle encloses a triangle marked with a cross at its apex; within the triangle is a face flanked by a crescent moon (Luna/silver, ☾) and (by the scheme) the Sun (Sol/gold, ☼). Words running around the circle: *Sala Vera Laudat Philosophiam Habentes Voluntatem Rectam · Fiat Inde Xenophontis Veberatio Mira* ["Salt truly praises Philosophy in those Having a Right Will; thence let come Xenophon's Marvelous (utterance?)"]. Initials → SULPHUR FIXUM. At the base of the triangle: *Confirmatio* ["Confirmation"]. Around the lower arc the running words include *Lege omnes Sophos · ecce sic tuos · Habentes Voluntatem Rectam* ["Read all the Sages; behold, thus (read) your own; (those) Having a Right Will"].
- **Fig. II** (top right): Three concentric circles with a crossed, inscribed triangle at center; the apex bears a cross. Words running around the rings (read with the acrostic) again yield SULPHUR FIXUM and repeat phrases of Fig. I: *Veritatis Mandatum · Sic Tuos · Rectae · Sola Fiet Vera Inde Lege Omnes Sophos · Igitur Homin es · Verum Philosophia* [partly retrograde lettering; several words mirror-printed].
- **Fig. III** (center/bottom): A circle (drawn on a long unfurled banner/scroll) encloses a triangle; inner ring labels read *Visitetis · Occultum · Inferiora · Lapidem · Reductio Triadis · in Monadem · Veram · Rectificando · Medicinam · Invenietis* ["You shall visit · the Hidden · the lower parts · the Stone · Reduction of the Triad into the Monad · the True · by Rectifying · the Medicine · you shall find"]. Initials of the outer words → VITRIOLUM. The banner ends bear the words *Fiet Inde Xenophontis ... Verum Mandatum* ["Then comes Xenophon's ... True Mandate"].

[Margin (against this passage), running gloss keyed to the figure: *Visitabis Inferiora Terrae Rectificando Invenietis Occultum Lapidem Veram Medicinam — Fiet Inde Xenophontis Verum Mandatum* — i.e. the expansion of the VITRIOLUM acrostic.]

"Then comes Xenophon's True Mandate." [Fiet inde Xenophontis Verum Mandatum.] — The initial letters of these give FIXUM. Under this figure, therefore, they indicate the matter of the Stone to be fixed Vitriol [Vitriolum Fixum].

Here you have, all you who are devoted to Alchemy, that the Stone is fixed Sulphur and fixed Vitriol — a stone that is certainly not the philosophers' but the diggers' own, which you may easily find anywhere. And what of it? For once this is known, I know just as much as I did before. I should indeed like to know what use there is for so mysterious a Stone. What, I ask, shall we do with such a Stone, with Sulphur and fixed Vitriol? Shall we draw gold out of it? I truly think just as much can be extracted from it as from the sweepings of a kitchen coal-bin. Is this not to contradict all the ancient philosophers, who by unanimous consent laid down that the first matter of the Stone is not Sulphur, not Vitriol, nor Arsenic, but Mercury? Indeed, they expressly banned every mineral or metal from the working of the Stone, in these words: *"The metal that enters our work is not the common gold or silver, nor any other imperfect metal or mineral whatsoever, but the philosophers' own."* In this way the fraud of Paracelsus is exposed, who places the arcanum of the Stone outside all the bounds of minerals — and yet in the process uses nothing other than metallic and mineral substances.

But I, grasping their intention more deeply, see the reason why they thought the secret should be veiled under these schemata: they had read a process for graduating to gold, and since they did not understand it, then — at least so as not to seem to be ignorant of anything — they hid it under insipid emblems of this kind. But lest I seem to have left anything here untouched, I shall set out the whole procedure of the matter according to the intention of the ancients, with a certain profit — though not so great as the alchemists imagine for themselves. Hence I have judged it should be plainly explained, not so much for the sake of gain as of the experiment, which is indeed a fine one.

Note first that by *confirmation* [confirmatio] the chemists understand nothing else, in this place, than a certain tincture — which is the same as fixed sulphur. This tincture is deservedly called the completion of the whole work (as they themselves hold), for like a thunderbolt it penetrates all metals and gives them a suitable color. And just as the whole mastery [magisterium] consists in these three things:

(catchword: "pon-")

in weight, fixation, and color — which are signified by the triangle set within the circle — so those three must be introduced into the matter in such a way that Luna [silver] mixed with Sol [gold] is changed into gold. But even if you obtain the weight and the fixation, they nevertheless cannot subsist when committed to the cupel without confirmation, that is, the tincture which they call *fixed sulphur*. How, then, that tincture or fixed sulphur is prepared, I now set forth.

PROCESSUS I.

Of the Confirmation, or tincture that converts ☽ [silver] into ☉ [gold].
[Confirmationis, seu tincturae ☽ in ☉ convertentis.]

[Margin: Processus I. The tincture converting ☽ into ☉.]

Take one half-ounce of the best sulphur and three half-ounces of crude antimony, which, committed to fusion, will give a *regulus* melted with colophony [colophonia] resin. From this take two half-ounces — that is, one ounce and a half — and together with it, of ☉ [gold] and ♄ [tin], one half-ounce of each; these, committed to a crucible, are melted together. Then, for four days, night and day, let them be exposed to digestion in a pot very well luted, in hot sand; and by this means the three things mentioned will no longer be separated from one another, and they become volatile according to the nature and whiteness of antimony. And this is the penetrating water; it is called the water that tinges to the 18th degree [ad 18 grad.]. Reserve this water for the use to be set forth later; and by the skilled it is called the water "graduative to 18" [aqua ad 18 graduativa].

PROCESSUS II.

Of the dissolution of fixed sulphur to volatility. [Solutionis sulphuris fixi ad volatilitatem.]

[Margin: Processus II.]

The second figure signifies the process of the dissolution of fixed sulphur to volatility. And just as in it the initial letters of the words, taken together, indicate fixed sulphur, so the figure — or chemical mark — ♁ placed in the middle (signifies) sulphur; but the triangle-mark inscribed within the circle signifies nothing else than the conversion of the fixed sulphur into ☉ [gold], which the conjunction of ☉ and ☽ in the first figure also indicates. But the process, which they have passed over in silence or did not know, we shall sincerely bring out into open light. In this way, then, the dissolution of fixed sulphur to volatility is prepared.

[Margin: Preparation of the dissolved fixed sulphur to volatility.]

Take a half-ounce of gold, or one *loton* [lotonem], which, filed into a powder, is to be set on a gentle fire for 8 hours. Then take three half-ounces, or 4 drachms, of tartar calcined to whiteness, a half-ounce of salt, and 4 *lotones* of sal ammoniac; mix all together. Of this mixture take up to one half-ounce, three fifths of one ounce of gold (note well: by "fifths" we mean drachms, and by "lotones," half-ounces); grind together with the aforesaid material, placed in a low alembic, over which you will pour the strongest water [aqua fortis], and, the alembic being set in a bath, distill six times in the manner of Maria [balneo Mariae, the water-bath/bain-marie] — and in the last three times with a fresh addition of aqua regia. For in this way, the ascent of the matter being completed, you will leave it exposed to a gentle heat for the space of 24 hours; then separate the strongest water from the ...

(catchword: "*fua*")

the *calx*, washing the strongest water away to sweetness; finally dry it out and fix it by the known art, and you will have what was proposed, whose use follows.

Take of the silver water "graduative to 18," set forth above in the first Process, one *loton* — that is, half an ounce — and as much of the prepared gold, and as much of tin; of antimony, 4 drachms. These, joined together and evaporated, leave a body, from which you will take 2 half-ounces, and 3 ounces of crude antimony, which are to be committed to fusion. When this is done, the gold draws into itself the tincture to the 18th degree, with the silver [Luna] subsisting, and it will obtain the highest degree of sulphureous color, equal to the best gold. This procedure too I find in Lull [Lullus] in his *Clavicula*, and in Isaac Hollandus [Isaacus Hollandus], though under other words and covered with a symbolic wrapping of language; and it accords with the mind of the ancient sages — with this one exception, that the ingredients in this work admit the addition of common gold and silver and of the other minerals, which the ancients nevertheless slyly deny, lest either the secret (if there is one) should be laid open, or they should be convicted of fraud.

Another way, by means of the first Process of Confirmation. [Alter per 1. confirmationis Processum.]

Take a half-ounce, or a *loton*, of silver [Luna] exalted to the 18th degree, as we prescribed in the first process, and of the gold prepared in the second process, a *loton* and a half, together with a *loton* and a half of tin; let all be placed together in an earthen crucible, and let the *regulus* resulting from it evaporate. Then add

over it one ounce of tin, and you will have the matter united by means of the *regulus*. Next, of the gold prepared in the second process and of crude antimony, take 1½ ounces; let them be placed in a descensory bladder [vesica descensoria], and press the distillation up to the sublimation of the *regulus*. This *regulus* you will then stratify with a powder burnt from old shoe-soles, and then "quarter" it to the utmost (to use a chemical term), and you will have the desired gold tinged to the 18th degree.

You will accomplish this again, more briefly. Take, as above, of the previously prepared silver exalted to the 18th degree, and of the prepared gold; to these join a *regulus* of as great a weight as the ☽ [silver] placed (in the bladder) weighs; let all be committed together to the bladder. When this is done, you will mix into this mass twice as much crude antimony as the mass weighs; then let it evaporate by fire, draw off the remainder through ♄ [lead, i.e. by means of lead/cupellation], and you will have the gold "exalted to the 18th degree," as they say — which, however, is no other gold than that gold and silver which you had put in, exalted by purification to the utmost, in whose tincture the other admixed minerals also share.

PROCESSUS III.

How the ancients, by the power of the Stone — that is, of fixed sulphur — exalted gold above all the degrees of native refined gold. [Quomodo veteres vi lapidis, sive sulphuris fixi, exaltarint aurum super omnes gradus auri mineralis obrizi.]

This process is carried out by means of the graduated *regulus*, in which lies hidden the fixed sulphur together with its ...

(catchword: "fua")

its addition; and it is the tincture by which silver [Luna] is converted into gold at the 26th degree, and withstands all assays; and the procedure is as follows. Take two ounces of crude antimony and 1½ ounces of gold; one ounce of copper; of the recrement of steel, or of the filings of iron, 3 ounces — from which, when melted, a *regulus* will come out. Then take Bismuth [Bismuthum], or ash-gray lead [plumbum cinereum], and crude antimony, three ounces of each, and besides 3 ounces of common lead — from which, when melted, another *regulus* will come out. This done, take of the silver prepared by the Process adduced above (first prepared, and exalted to the 18th degree), ½ ounce, which commit to a crucible; to it join from the graduated *regulus* prepared a little before, ½ ounce part

[partem]; and from the *regulus* of ash-gray lead, or the Bismuthic one, draw off in the retort seven times, 1 ounce — and you will have the addition of gold, from the *regulus* together with ☉ [silver], exalted to the 26th degree: gold that withstands every assay, of the best quality and (as they say) more excellent than refined gold [aurum obrizum] — which I would have understood of the utmost purification.

PROCESSUS IV.

By which fixed sulphur, through common sulphur encountered (in the operation), tinges silver — lightly purged in passing — into gold. [Quo sulphur fixum per commune sulphur obvium Lunam obiter purgatam in Solem tingit.]

Take ½ ounce of pure gold sulphurated with common sulphur, until it becomes brittle and the sulphur is consumed. Take this prepared gold and let it again be stratified with fresh sulphur to the combustion of the sulphur, and in this way proceed seven times. Then take the sulphurated gold, grind it on marble into a fine powder, and, having placed it in an alembic, pour aqua regia over it; once this has been drawn off to oiliness, pour it back over the gold, with fresh strongest water (or aqua regia) added; and you will do this a third time. When this is done, pour over it the strongest spirit of wine, expose it to a gentle heat; and when this is done, the spirit of wine will draw to itself all the other spirits, which are gently drawn off with the spirit of wine, and at the bottom you will find a liquid matter, which you will divide in two. The first part you will coagulate into a body by the known art — they call it the precipitate — which, reduced to a fine powder, you will store in a glass vessel; and the other half of the liquid matter you will pour onto it, and again let it coagulate into one body, and you will have the work consummated. With the help of this powder you will cement the purged silver, and you will have the gold sought — so that one part of this powder, to ten parts of purged silver in fusion, will tinge them into gold; although in the cupel-assay you will always recover somewhat less, and it smells somewhat sophistical.

PROCESSUS V.

The tincture of Confirmation, or of fixed sulphur, to be perfected by means of a noble cement. [Confirmationis tinctura, seu sulphuris fixi per caementum nobile perficiendus.]

Take 2 ounces of pure gold and 1½ ounces of common copper, which are to be committed together to fusion into a body; and while the matter flows, take about ½ [?] ounce of sulphur, which you will throw little by little into the fusion. This done, grind the matter that results with ½ ounce of mineral cinnabar [cinnabaris mineralis], small; then put the ground material into a vessel, and pour over it the following oil, well mixed. The oil is made thus: take 2 ounces of glass of antimony [vitrum antimonii], one ounce of saltpetre well purified; let these, ground into a fine powder in a low vessel, be set out in hot ash, the vessel being stopped with paper, and left in fusion for not too long a time. Then pour over the cooled matter the strongest vinegar of wine, until it covers the matter, and then draw off the vinegar through an alembic; and you will repeat this four times, and a fifth time more strongly, until nothing more is left of the vinegar. The oil that follows is reddest, like blood; from it the phlegm of vinegar, drawn off, will give the required oil. This oil pour over the aforesaid powder stored in the vessel, mix it well with the said powder until it gradually coagulates; then again, with the oil poured on as before, let it coagulate; and you will repeat this operation a third time, and you will have the cement prepared for converting silver [Luna] into gold.

You will find nearly the same things in Paracelsus, *Book on Graduations* [Lib. de gradationibus], although he wraps them in so many and such great obscurities that either he himself does not know what he asserts, or at least — if he did know — he seems, touched by envy, to have kept silent. He calls a tincture of this kind the *tincture of the Philosophers*; I, however, declare it nothing but a sophistical and metallurgical [tincture].

And from these my interpretations the deceptive ingenuity of the alchemists has become brilliantly clear to me: men who, lest they seem to have been ignorant of the great art, have shrouded it in marvelous figures; or, if their wit failed them for devising emblems, do not cease at least to cover the matter over by a steganographic [steganographico, cipher-writing] artifice. Some years ago, when I was surveying the Vatican Library [Vaticanam Bibliothecam], a vast arcanum was shown to me by the custodians, which they supposed to contain the true method of making the Stone — though the monstrous forms of the exotic

characters in which it was written had taken away all hope of penetrating it. They turned to me, then devoted at the time to interpreting hieroglyphs, asking whether, if it could be done, I would attempt the opening of the seal. I promised I would try. And having returned home, I at once arranged the characters, by my accustomed art, into an alphabet; the next day I showed the deciphered arcanum to the custodians of the Library, who indeed seemed to marvel more at the sudden unraveling of the characters than at the art itself. The arcanum was as follows.

An Arcanum of the Philosophers, for making perfect gold out of Saturn [lead]. [Arcanum Philosophorum, ut ex Saturno facias aurum perfectum.]

Take half a pound [libram semis] of Mercury [quicksilver], and two ounces of their sulphur [sulphuris eorundem]; amalgamate the two together, so that nothing of either appears...

(catchword: "pareat,") ...so that nothing [of either ingredient] appears, but there remains a black powder made of the two; take this and place it in a flask with a narrow mouth. Set it on a small stove or furnace, with an intervening pot, using sifted ashes — banked up, mind you — and arrange it so that the ashes do not rise up to the material. At the start, apply a gentle fire for eight days, so that the spirits do not rise; and if anything has risen during those eight days, fold it back into what remains at the bottom of the vessel, breaking the vessel every eighth day after the first material has been formed (which will be black). Breaking the glass in this way, grind your material and replace it in another glass vessel; do this every eighth day until you see your material take on the color of ash. Then reduce the ashes by one finger's breadth, so that no more than two fingers of ash remain, and set it over the fire; leave it until the material turns red. When you see it red, again reduce the ash by one finger, and so on in sequence, until it becomes as white as snow, and then turns back to a red color. Of this medicine, take one ounce and project it onto eight [ounces] of prepared lead [Saturnus], and the lead will become black and hard as iron. Of this hard, black substance, project one ounce onto eight ounces of lead, and it turns red. Of this red substance, project one ounce onto eight pounds of prepared lead, and you will have perfect gold. Praise be to God. So says Master Odomarus. In my own view, it is not the whole substance [that transmutes], but the tincture, which — once mingled with the other minerals together — saturates them into a single substance.

This, then, is the arcanum, concealed under such a diversity of characters, in which nevertheless there is nothing that promises you any of the profit you are seeking — since lead cannot be transmuted into gold without the philosophers' mercury extracted from gold or silver, by the common consent of all the philosophers. But mercury prepared in this fashion, and projected onto any metal whatever, is alleged to transmute that metal into what it [the mercury] itself is. Hence this arcanum too is utterly sophistical, and so I would advise no one to waste oil and labor on its ἐγχείρησις [Greek: encheirēsis, "handling, working-out"]. You can see from this trickery how little sincerity there is in all those arcana — or rather "recipes," as they like to call them — dressed up with the symbols of so many figures and veiled in so many secret letter-signs. I can indeed testify to this: that I have never found a single secret of the [philosopher's] stone hidden under ciphers of this kind (and yet I have on hand a vast quantity of them, rescued from their obscurity and unlocked by an art of my own) that was not contrived either to deceive or to torment men's wits. A clear proof of this can be that I have afterward found such "recipes," or arcana, set out in plain words — whether in Lull's *Clavicula* [Ramon Llull, the *Clavicula*], or in Paracelsus's *Archidoxa*, or even in run-of-the-mill writers like Porta [Giambattista della Porta], Wecker [Johann Jacob Wecker], Alexius [Alexius Pedemontanus], and others. Thus the world is toyed with by these clandestine cinder-stirrers [ash-fumblers].

[Margin: The trickery of the alchemists, false, in the concealing of their secrets.]

But now let us turn our pen to the interpretation of the third figure, which I said was Paracelsus's. Paracelsus, as I have often said, can deservedly be counted, more than any other, among impostors of this kind. For it can scarcely be told how he covered over those arcana — which he had previously lifted from the manuscripts of Llull, Arnold [of Villanova], or Isaac Hollandus, or Basil Valentine [Valentinus Basilus], and others — covered them over, I say, with a marvelously affected obscurity of words, or with enigmatic wrappings, so that he might not be convicted of the crime of plagiarism. And although he seems to say everything, he yet offers nothing that does not leave the reader's mind doubtful, dazed, and wholly ignorant of what one may think or believe about the veiled secret, leaving it altogether uncertain. The very men, moreover, from whom he had borrowed, he does not blush to call ignorant of these matters and falsifiers besides.

[Margin: Paracelsus's trickery.]

But let me adduce the words, full of intolerable boasting, that he sets forth about himself in the preface to the little book *On the Tincture of the Natural Philosophers* [*De tinctura physicorum*]. "In this age," he says, "the monarchy of all

the arts has fallen to me, Theophrastus Paracelsus [Theophrastus Paracelsus], prince of philosophy and of medicine. For to this I have been chosen by God (more truly, by Satan), that I might extinguish all the fantasies of schemers, and of false, fictitious, and presumptuous works and presumptuous words — whether they be those of Aristotle, Galen, Avicenna [Ibn Sīnā], Mesue [Yūḥannā ibn Māsawayh], or whosoever they may be, and of those who cling to them." It was not enough for him to have joined audacity to presumption; he even paraded as a prophet, foretelling things about his own monarchy, which he hints at in these words: "This theory," he says, "proceeding as it does from the light of Nature, can never be undermined, on account of its constancy, nor altered, and it will first begin to live in the year one thousand five hundred and fifty-eight." Certainly, since five years have now elapsed since the term of his prophecy, so far is it from being the case that anything worthy of such great knowledge has appeared up to now, that he has rather been everywhere taken by all for a pseudo-prophet and a most shameless impostor, and shown to be so by apologetic writings — so much so that his writings too have been struck from the Catalogue of Orthodox Books by the Holy Roman Church as impious and pernicious to the faithful of Christ, and forbidden; about which he seems to complain in the following words.

[Margin: Paracelsus's intolerable presumption.]

[Margin: Paracelsus's books prohibited.]

"This practice," he says, "will at length be confirmed by wondrous and incredible signs, so that it will become plain even to mechanics and the common people, and they themselves will fully understand how constant and unmovable, against the trifling of the sophists, that Paracelsian art stands — even though that sophisticated art is confirmed and defended in its follies by Papistical and Imperial privileges." He concludes at last: "By this arcanum," he says, "the last age will be manifestly illumined, as by a gift of grace and of the true spirit, and it will be recompensed, so that no like seed of understanding and wisdom has been heard of from the beginning of the world." He who a little before was asserting that the outcome of his prophecy would fall in 1658, now postpones it to the last age of Antichrist, or, as he says elsewhere, foretells it for the coming of Elias the Artist [Elias Artista]. Who—

[Margin: The arrogance of Paracelsus the prophet.]

Who, I ask, ever saw such a monster of boastfulness, or heard of a Braggart [Bombilio] of comparable arrogance? But lest we dwell on the cause of such great absurdities, let us now see what he has accomplished in this art worth noting. He

speaks thus in the book entitled *Aurora of the Philosophers* [*Aurora philosophorum*]. He took fixed vitriol [*vitriolum fixum*] for the prime matter [*prima materia*] of the philosophers, which he also demonstrated in the third Figure with these words: "You will visit the interior of the earth; by rectifying you will find the hidden stone, the true medicine." Thence will come the true command of Xenophon, whose initial letters — as we showed above — spell out *Vitriolum fixum* [fixed vitriol]. And by "earth" he understood vitriol itself; by "the interior of the earth," its sweetness and redness. For in the hidden recess, he says, of the vitriol there lurks a subtle, noble, and most pure juice and pure oil, whose mode of protection is not to be approached by calcination or distillation — because it must by no means be deprived of its greenness [*viriditas*], for if it were so deprived, it would necessarily be stripped at once of both its powers and its arcanum. "We have the arcanum; let anyone now make from it as much gold as he pleases." For my part, I judge this to be no specimen of the great art, but the mere trifling of idle men. And lest I seem to do Paracelsus an injustice, I shall here adduce the Magistery by which he supposes the stone can be made for tincturing gold, so that from it one may gather what is to be hoped for. He proceeds thus in *Aurora of the Philosophers*.

[Margin: The trickery of Paracelsus in the making of the stone.]

First, mineral vitriol [*vitriolum minerale*] — which in many places he had rejected as unfit for the art — he now, as if led by repentance, takes up into his Magistery; and just as it is liable to many viscous, muddy imperfections, so too (he prescribes) it must be freed from its impurities by repeated rectification, until its greenness becomes manifest. And lest this greenness turn to pallor, he directs that it not be exposed to the Sun, but kept in a warm hypocaust [*calido hypocausto*, a heated chamber], well guarded against the injury of dust.

Second. For the space of several months let him commit it, the glass thereafter being sealed, to digestion, until — with various colors running through in turn — at last the supreme redness appears. This is the common precept of all the philosophers. But just as this [redness] promises as yet no fixity, so too he says it must be further purged of its filth with vinegar, until it has been wholly freed from all impurities along with its dregs, and made absolute. And this he calls the true and best rectification of the tincture, from which the oil he names "blessed" must be drawn out by this procedure.

Third. From this tincture, placed in a glass with an alembic set on top — lest the spirit exhale, the joints being smeared with lute of the best quality — the spirit is to be drawn out by a gentle, slow fire, of ashes, that is, or of sand, and you will

obtain an oil sweeter than any balsam, free of all sharpness; and at the bottom of the cucurbit there will settle an earth, most white, gleaming, and shining like snow, which you must keep — once it has been separated from its redness. Now at last follows that arcanum of the heavenly marriage, by which the soul and the body — that is, the tincture, or blessed oil — being poured over the now brightly purified earth, bind themselves together so tightly that thereafter they cannot be separated from one another. And this is that *terra foliata* [foliated earth], which you will store away placed in a glass phial, and to which you will gradually pour on its oil; and the body will in a moment receive and embrace its soul. The marriage thus completed, it now remains to explain how it can be made fruitful.

Fourth. This foliated earth, then, saturated with the blessed oil, you will set within the furnace of the arcana — namely the Athanor — to be circulated for the space of forty days, and you will have a most perfect oil of wondrous perfection. By it, mercury and the rest of the imperfect metals are turned into gold, multipliable to infinity. By this procedure: Take corporeal mercury [Mercurium corporalem] — that is, the common kind — in a portion of two parts, onto which you will pour three parts of the said oil of equal weight, and let them remain together for 40 days; and you will obtain a proportion of weight and order by which the multiplication may be made to infinity.

[Margin: Of gilding. — Paracelsus.]

And this is the arcanum, the greatest of all arcana of every kind, which Paracelsus would urge not upon philosophers and men skilled in natural things, but upon the unlearned and exceedingly credulous common crowd. For I now undertake to demonstrate that this is a pure and unmixed lie.

First of all, by the consensus of all the chemical philosophers, the prime matter of the great Magistery is mercury not of the common sort [Mercurius non vulgi], not vitriol, nor any other mineral, but the philosophical mercury [Mercurius philosophicus]. This Paracelsus himself even admits in the book cited, chapter 10, where he refutes all those who have sought the stone in minerals, and charges them as men given over to stupid labor — although he himself is the first who attempted the work by means of mineral vitriol. Second, this mercury of the philosophers is to be extracted not from vitriol, nor from any other imperfect metal or mineral concreted juice, but from gold and silver, the perfect metals, so that the stone may be fashioned from it. But in this Magistery there is no mention either of the philosophical mercury, or of gold or silver added, but only of vitriol. So he accomplishes nothing, since vitriol cannot give what it does not have — even though tormented by countless purifications, digestions, and calcinations.

Thus all that this Paracelsus achieves is what any apothecary does when, from vitriol previously purified and rectified, he extracts a spirit and a deep-red oil free of all sharpness, as frequent experience in our own pharmacy teaches us. I grant too that a most white sediment remains in the cucurbit. But that the oil of vitriol just now extracted, poured over this earth and circulated for 40 days, and at last projected onto common mercury, should turn it into gold — this I have never seen nor heard. For what, I ask, is there in vitriol that—

[Margin: Paracelsus's false demonstration is refuted.]

—that could give weight to gold? What, I ask, [could give it] natural powers? What [could] confer color, since none of these is found to be present in vitriol? Vitriol is indeed turned by long cooking into an oil of a rosy color, but not into such [an oil] as gold by its nature desires — one shining with a tawny color, which vitriol alone, without the addition of other substances, cannot give. Unless you say that it gives a tincture to gold from coppery and golden corpuscles mixed into the liquid — which is already a sophistical [admission]. Certainly Llull, Arnold, and the other chief leaders of alchemy, in all their Magisteries — as is clear from the *Clavicula* and from the *Rosary* [*Rosarium*] — mix in some gold and silver in place of a ferment in the matter, so that consequently all those in the *Turba Philosophorum* cry out that nothing can be done in this work without Sun and Moon [Sol and Luna, i.e., gold and silver]. All of whom I could here adduce, if the matter were worth it.

[Margin: The alchemists' objection.]

But the Paracelsians will say that this Magistry is to be understood not literally, but in a higher, parabolic sense. I answer that this is the very mark of impostors: to signify one thing with mouth and pen, another in mind. Surely from a parabolic Magistry of this kind what else can we hope for than parabolic gold — which is born not from art or nature, but from the foolish imagination of men? He published similar specimens of the great Magistry in the cited book, chapter 11, where he produces a true and perfect arcanum and tincture from arsenic, and there inveighs against Geber [Jābir ibn Ḥayyān], Albertus [Albertus Magnus], Rasis [al-Rāzī], and Polydorus as falsifiers, and finds fault in them precisely for the thing in which he himself sins. Indeed, he is wholly absorbed in exalting the arcanum of the tincturing spirit that is extracted from it [arsenic]; for one part of this, projected onto sixteen parts of imperfect metal, tinctures them into most excellent Luna [silver] — by a tincture, to be sure, that is none other than the one by which, with familiar experience, we are accustomed to change red copper into white, of which [I treat] in the experiments of the following Book. As for what

Paracelsus further says about the virtues of *electrum* [electrum, the gold-silver alloy], in the book *On Compounds* [*De compositis*] — that [electrum], just as it takes its origin from silver and copper, so too, when cooked with various substances, must necessarily degenerate at last into a sophisticated mass of gold.

CAPUT III.

DISQUISITIO I.

On the Artificial Chrysopoeia of the Chemists [Chrysopoeia artificiali Chymicorum]

If there is indeed in the nature of things an intrinsic motion of the principles of any given body — which we may not unfittingly call *fermentation* — given that there is a tendency toward the perfection of such a body, or toward its change into something else (a thing which shines forth above all in the elementary variety of motions): then, just as these [bodies] consist of the smallest corpuscles, so too, set in motion either by Nature's own impulse or by occasion, they stir themselves and are stirred in a marvelous manner, draw apart from one another, and become entangled. Having through Nature's kindness acquired subtlety, they at once strive to fly off, but are held back by coarser little nets, lest they fly off entirely. Meanwhile the coarser ones are by the subtler ones cut up and thinned, in a wonderful struggle, until — exalted together with the subtler ones and borne aloft — they either acquire their due perfection, or complete the alterations designed by Nature; which is the whole sum of Meteorology. For from this arise Rarity and Density, opacity and transparency, flaccidity and liquidity, fixity; and from this — through the moist and the dry — softness, roughness, flexibility, and ductility take their origin in all things. But now let us return to the aim of our proposed argument.

[Margin: What motion in the nature of things is.]

No philosopher has hitherto denied that the whole is constituted of parts, whether similar or dissimilar. Hence too all metals, both perfect and imperfect, and the whole class of fossils — in short, all mixed bodies — consist of corpuscles, each one of which has the nature of the whole; [these are] not the atoms of the Democriteans, but true and real ones, indeed not inaccessible to the senses even when armed [with the microscope]. These, united together in concrete bodies, constitute some one thing; but by fire, or by any other heat, or — in certain substances unyielding to fire and heat, such as strong waters [acids] and acid juices — by the dissolution of their continuity, once separated, they are at once,

as if they had taken on wings, resolved into spirits with marvelous agitation and seethe up. Some of these remain stubbornly at the bottom of the vessel and are called fixed; some fly up on high, soon to return with the cold that meets them; some vanish entirely into smoke; and there are those that, flying off, return of their own accord by right of postliminium to the fixed [body] from which they had flown, as if led by repentance. And since no body in the nature of things is so purified that there does not reside in it some admixture of heterogeneous matter — which differs, as in heat, so also for the most part in nature, according to the condition of its dissimilar nature — hence it happens that those [corpuscles] which enjoy a likeness of nature flow together toward their like, by some powerful magnetism I know not what: golden toward golden, silver toward those that seek silver, iron toward iron, leaden toward lead, saline toward salt — especially those that nestle in concreted juices and in aluminous, nitrous, and vitriolated liquids. The sulphurous, the arsenical, the marcasitic, the orichalcic [brass-like] substances that gleam with a golden color join themselves to golden corpuscles; the leaden and tin and those that consist of antimony, magnesia, cadmia, bismuth, and the like, run together toward silver, or toward tin, or toward lead, by a certain kinship of nature. From the various—

[Margin: All mixed bodies consist of the smallest corpuscles.]

[Margin: The magnetic attraction of like toward like.]

—combination of these, by their concurrence, is born that immense variety of colors which we cannot sufficiently marvel at in the chemical peacock's tail [pavonis cauda]. You will ask how this comes about? I say it comes about from the mixture of various minerals, tinged with diverse colors, as soon as they have been dissolved; some of these are endowed with a like color and property, others incline this way, others that — some flow together from here, some from there — and by this differing and disjointed confluence of like corpuscles they display that variety of colors we have mentioned. But if you press the material with further torments of fire, it happens that — once each [kind] has been freed from so great a confusion of corpuscles — a separate place is assigned to each: some being resolved into waters, some into spirits, some coalescing into scoriae or a glassy material, others settling at the bottom. The material thus separated, those alone that delight in friendship with the perfect metals — being separated from the others, which are of inferior condition — are joined to gold and acquire a tincture from it; and moreover, themselves now tintured, they by a reciprocal benefit add bulk to the gold as well. And since all things mixed in Nature's threefold kingdom obtain their consistency and fixity from chemical salt, the element of

earth, and since all metallic things — and whatever minerals there are at last — are constituted, as to the consistency of their bulk, from saline corpuscles: hence it comes about that, when the mixed body has been dissolved in metallic fusion with gold pregnant [in the mixture], they are imbued with its tincture, and moreover, by their own confluence, give it [the gold] a greater quantity of bulk than it had before. They pursue, therefore, the golden tincture, the most potent of all, and all the particles of the remaining minerals strive to be clothed with its splendor — as will appear, clearer than the noonday light, from the chemical operations to be adduced a little later.

[Margin: How gold draws to itself the rest of the metallic corpuscles, and increases its own substance.]

Since chemistry is, even on this account, most worthy of all praise — that, from the resolution of mixed bodies into spirits (that is, into mercury, sulphur, salt), into water, into earth, it exhibits by experiment the corpuscles of which they are composed, manifest and obvious to the senses, and clearly demonstrates the elementary bodies, which [resolve] not into ἅπλα καὶ ἀσύνθετα [Greek: hapla kai asyntheta, "simple and uncompounded things"], that is, into simple and uncompounded [parts], but into those substances into which the parts become ultimately sensible — [for] physical things are resolved [thus].

Experiments by Precipitation [Experimenta per præcipitationem]

1. If you dissolve lead or litharge [lithargyrium, lead monoxide] with distilled vinegar, a certain most limpid water will be extracted, so like spring water or distilled vinegar that you can scarcely tell one from the other. Pour this into a glass, and pour over it distilled vinegar of a very similar color, and at once the water of litharge will turn into a most white color, like milk.

[Margin: To change a limpid liquor into white.]

2. If you boil antimony, calcined with niter, in spring water, you will have a most limpid and almost odorless filtrate; but if you pour over it any acid liquor whatever, then the water will be tinged with a saffron color, and will come forth with a most foul smell.

[Margin: To change a limpid liquor into a pitch-black one.]

3. If you calcine tin and mix with it liquefied salt of tartar, you will have a water tinged with a heavenly color — that is, a sky-blue [cerulean] one.

[Margin: To change a liquor into a cerulean one.]

4. If you mix limpid solution of galls with solution of vitriol, the former will at once be changed into a most black color, which they call ink [atramentum]. But if you pour over this a spirit of vitriol or Stygian water [aqua stygia, a strong acid], the inky color will turn back again into a most limpid water; and if you wish to reduce this once more to a black color, oil of tartar poured over it will do so.

[Margin: To turn a limpid liquor into a black one, and again into a limpid one.]

5. If you write something on paper with a limpid infusion of vitriol, the writing certainly cannot be read, inasmuch as it was traced with a limpid water; but if you wet the paper with water of galls, it will at once become visible in a black color and be read with no difficulty. But — marvelous to tell — if you wash it with spirit of vitriol, [the letters] will disappear as before; yet you will restore them again to their blackness once oil [recte: liquor] of tartar has been poured on.

[Margin: A steganographic secret.]

6. If you pour cerulean oil of vitriol [oleum cæruleum vitrioli] onto the blue tincture of violets, it will at once grow purple; and if you add to this a few drops of spirit of hartshorn [spiritus cornu cervini], you will turn the purple color into green. Again, the wood called *acanthicum*, which is also called *nephriticum* [nephritic wood], brought from Brazil [Brasilia], diluted with common water, deposits a pleasingly reddish tincture, not unlike red wine; and if you pour into this a little distilled vinegar, the liquor will appear limpid like white wine; but a few drops of oil of tartar will draw it back again into a purple. And if spirit of vitriol is poured into this once more, it will grow pale-yellow like Spanish wine. If you boil gum lac [gummi laccæ] together with added alum in limpid water in a bladder [vesica], a most beautiful color like ruby will be drawn from it. An excellent dentifrice.

[Margin: To turn a cerulean liquor into a purple one.]

[Margin: Various kinds of colors.]

7. If you pour syrup made from a confection of corals onto spirit of wine, you will have "virgin's milk" [lac virginis] — that is, a liquor white like milk, no less pleasant to see than sweet to taste. These experiments, indeed, were performed in our pharmacy. I could adduce here countless other experiments of this kind; but since they have been partly shown in what

precedes, and we shall partly set them forth in what follows, we have judged it superfluous to dwell on them longer. So nothing remains but to inquire into the causes of the said experiments.

[Margin: Virgin's milk.]

DISQUISITIO II.

The reason for phenomena of this kind, then, is not to be sought elsewhere than from the corpuscles twisted within the pores of any liquor: which, as to their site and position — being variously altered by some other liquor poured in — transmit the rays of their light, refract them in manifold ways, and reflect them; and—

[Continuation from the prior folio:] —from which it necessarily follows that the aforesaid alternation of colors arises, as one color destroys another, and yet a third revives the one that had been destroyed. For as we said a little earlier, since the subjects of colors have one composition or another, built up out of corpuscles and particles, certain particles of a transparent body are very like light, and so appear utterly limpid and translucent like crystal; from these the limpidity of liquors takes its origin. Other particles, however, belonging to opaque bodies, because they have a different composition, different in color and in nature, when these latter are poured over the limpid ones, tint them—according to the diversity of the color—now yellow, now purple, now blue, and finally black, and so induce opacity. For according as the particles contained in a liquor, when driven into closer contact by another particle poured in, interlock with one another, and are arranged now into these, now into those series of positions, the resulting diversity of color necessarily follows. Indeed a liquor of this kind, when assaulted by corpuscles minutely fractured, expresses as it were a battle-line of soldiers drawn up in fixed ranks—soldiers who now draw together, now spread apart, and now present this figure, now another.

[Margin: The cause of colors in precipitated liquors.]

When two transparent liquors, mixed together, produce a black tincture [atramentum], the reason is this: the particles contained in each—the limpid (that is, transparent) ones, and those that have the character of a more opaque nature—approach one another, and being arranged as it were in closed ranks, block the access of the rays of light. But as to why, when vitriol or some other liquor is poured in, the black tincture is expelled and the former clarity is recovered—the reason is that vitriol consists of the subtlest and sharpest spirits. Hence it happens that the spirituous corpuscles, by reason of their supreme voracity, as soon as

they attack those inky [atramentosa] gall-corpuscles, render the transparent ones opaque [the text is compressed here; recte: they separate the opaque from the transparent], cut them apart, and segregate them completely. Indeed, by the infusion of transparent vitriolic corpuscles of bodies akin to them, they furnish a great increase by the kinship of nature; from which the former clarity arises.

[Margin: The cause of colors in liquors of different kinds.]

But because oil of tartar consists of fatty, glutinous, and opaque corpuscles, it happens that the clarity now restored to the water, when a fresh liquor is poured over it, makes the vitriolic corpuscles gather together again, become darkened, and as it were be glued together by a certain viscosity; and so they tint the limpid liquor back into its former blackness. For although in each liquor clarity is at first prominent, and no difference of color is perceived by the senses, nevertheless the mixed liquors soon, as though a battle had broken out, struggle most fiercely, and one is at length forced to yield to the other in proportion to its strength.

[Margin: Oil of tartar transmuted into another color.]

As to why the tincture of violets turns purple when oil of vitriol is poured over it: the reason is that the blue vitriol-tincture, added to the blue tincture of the violet, changes it into a third thing—that is, into purple, which is close to blue. For [whatever the genus of the mixed liquors may finally be] [text truncated at the column break]...they take on the color which saline bodies, variously tinted and mixed together, display.

But how a clear water of litharge, when distilled vinegar (equally clear) is poured over it, turns into a milky color—if you ask this, I answer: it happens because of the leaden corpuscles dissolved by the vinegar into white-lead [cerussa]. From the vinegar poured over it, the ceruse-particles present in the litharge-water, at once flowing together by likeness of nature as the vinegar settles to the bottom, are condensed and packed together; and so, now packed close, they display the same color that they naturally possess.

We have now seen clearly, unless I am mistaken, the source from which that diversity of colors arises in the precipitation of one liquor into another. Now we must likewise examine—to return to our undertaking—how those various differences of color arise in chemical operations; and what those spirits are that are now volatile, now fixing, now separating one thing from another; and how those saline corpuscles, present in all minerals, are at length brought together into one by likeness of nature. This we will show by chemical experiments.

Experiments with Tinctures [Experimenta Tincturarum]

Experiment 1. If you wish to make graduated gold [Aurum graduatum], proceed thus. First, let gold of weak and pale color be melted with antimony, adding tartar, by whose violence the impurities and foreign matter of the mixture are burned away; and then the color, exalted, becomes more ruddy. If one operation is not enough, let a second and a third be applied. The regulus thus produced is then refined with lead in an ashy crucible (a cupel, or *test* [testa], as they call it), and you will have the graduated gold you sought. This succeeds well when the gold has mercurial, sulphurous, and similar superfluities present in it, and when it has been corrupted by various fleeting mixtures and imperfect metals. If you ask the cause of this graduation, I say it is none other than the golden tincture which lies hidden partly in the antimony, partly in the lead; in these, by the efficacy of fire, the dissolved golden particles, soon flowing together amicably toward the gold and adhering to it (now purged of impurities), not only give it a nobler tincture but also furnish an increase—though always a sophistical one.

[Margin: How graduated gold-color is induced.]

Experiment 2. If you wish to give a silver color to copper [aes], you will achieve it with calcined talc and tin, or with silver by co-liquefaction, or even by casting on a powder made of white calx of mercury nourished with oil of tartar; and you will have what you sought. Some persons of little skill suppose that copper whitened by lead, reduced and sublimed in a cupel, will become silver; but since copper of this kind, committed to the cupel, is reduced back into the components from which it coalesced, they certainly pursue their aim with vain effort. Nevertheless this counterfeit silver can serve for making various utensils.

[Margin: How copper is tinted with a silver color.]

Experiment 3. To impart a white and golden color to black lead [plumbum nigrum].

[Margin: To impart a white and golden color to black lead. Experiment.]

We once amused ourselves with a water made from quicksilver sublimated with sal ammoniac by deliquescence, in which we found copper and iron quenched and imbued with a silver color. *To impart a white color:* let a powder be made from white arsenic, calx of tartar, rock-salt [sal gemmae], and sal ammoniac; soak it, drenched with vinegar, for 7 days; then cook the macerated mass to dryness. They throw the fine powder of this over molten black lead and render it white, not unlike a silver color—very suitable for making various utensils. A pretty

experiment indeed, but of little use, since the expenses incurred in making it are greater than would be spent on true purified tin.

To impart a golden color to the same lead, proceed thus: make a medicine from verdigris [aerugo], calamine, yellow [citrina], sulphur, cinnabar, orpiment [auripigmentum], and sal ammoniac; let it be reduced to powder and kneaded with bull's gall or with oil of egg-yolks; then let it be dried again, and turned over hot coals in pans without scorching; and finally, when this is done, let it be cast into the molten lead, and you will obtain lead gleaming with a golden color. The reason for this depends on those ingredients, all of which are imbued with a golden color and possess an inborn tincture of golden brightness; thus they readily flow together toward that which they naturally seek, and adhere to it. These are our findings; whoever desires more, let him read Birelli [Birellus], book 6, chap. 2, and book 12, chap. 41.

[Margin: What sophisticated mica is. [Quid sit proprie sophistica mica.]]

In experiments of this kind, then, many think the moving cause is the [Greek: ποιότης (poiotēs, "quality")], proceeding from the potency of matter (as some put it), which from the depths and hidden recesses produces a color into the surface and into view, in which there is some mark of perfection. But we say that this is produced from the predominant particles of the dissolved bodies, particles which look toward some metal, and which exist in the materials not in potency but in act. For these particles, while they lie hidden under the confused throng of the elements packing them in—as they are by no means apparent—so, when the elements are either sublimated or evolved from the depths, at last, packed together, they become perceptible to the senses. This we confirm by the following experiment.

Experiment 4. Take Indian lead, which is called *caloëmum*; mix this with ash-colored lead (which others call marcasite, or sublimated bismuth, and some call the regulus of white magnesia) in an iron spoon brought to the coals. Soon, what was before of a silver color you will see transmuted into various colors—golden, silver, black, blue, green, purple—to the point of a miracle. The reason for this is none other than that bismuth (by the common opinion of the chemists, most prolific in mercury) has all colors present in it; and these especially present themselves to view when, by the efficacy of fire and frequent cooking, the matter composed of differing particles of the mixtures is drawn out to the surface. For bismuth, just as it teems with a varied medley, so too with corpuscles which, dissolved by fire, are revealed by the sympathetic flowing-together of like to like;

from which comes that wonderful variety. But of these matters we will speak at length in the final book of this work, *On the Art of Metals* [de Arte Metallica].

[Margin: Experiment.]

Nothing in alchemical operations is more celebrated than the work of fixation [opus fixationis], by which alone metals are imagined to be truly and really transmuted into gold and silver. Whether this is really so, let us set forth. Now this is accomplished by a threefold mastery: of salts, of oils, of liquors. Fixation, according to the mind of the alchemists, is nothing other than when a body receives a tinting spirit and removes its volatility—which is done by frequent repetition, until a body of perpetual duration is produced and the whole remains in the fire, according to that common saying of the alchemists: *make the volatile fixed and the fixed volatile, until the lower becomes the upper, and conversely*; that is, until the parts attain a homogeneous, uniform, and similar nature, after the pattern of pure gold. Hence so much study and striving in fixing metals and minerals: some have sought it by fixing-waters and by salts with marvelous cements; some by sublimations and prolonged reverberations—of which kind are those who tried to force quicksilver, shut up in iron tubes, by fire. Some chose styptic and astringent medicines as fixatives, such as vitriol, alum, verdigris, *crocus martis* [saffron of Mars, calcined iron]. Nor were there lacking those who imagined that volatiles could be bound and fixed by means of things that withstand fire; with what success, let us see.

[Margin: The various modes of fixation.]

Experiment 5. Fixation by cinnabar. Grind artfully a third part [trientem] of common cinnabar on hard marble, adding aqua fortis; then, having put this into a cucurbit, soak it with the following oil: extract by strong vinegar the essence of litharge; the vinegar being removed, pour over the litharge-powder, in a glass, the strongest spirit of wine, and again extract it after the manner of tinctures. Cook the extractions to the consistency of an oil, over which you will pour the cinnabar-oil prepared a little before; let the mixture be cooked to dryness, and a fresh oil poured back on, and this a third time, until the matter, when thrown onto burning coals, gives off no smoke; and you will have it prepared for fixing a metal into silver. This is the fixation of cinnabar, in which many, having wasted their labor and oil, when they despaired of the effect, turned to the cookings of lead and consumed even their lifetime upon them in fruitless toil.

[Margin: The fixation of cinnabar is futile.]

Do they not see that no solid fixation can be hoped for here? Since at last, when committed to the cupel or the ash-test, and dissolved by so many cookings and distillations, it is at last resolved back into the things from which it had coalesced. And what can you hope for from cinnabar, which teems with mercury; or from litharge, which you may rightly call calcined lead? I do not see. You will indeed obtain a mass, but one fused together [text continues]...

out of heterogeneous materials, which, being joined by no bond of friendship, are just as easily separated. For either the quicksilver will be fixed, or not. If the former, that cannot yet be said, since nothing is more controverted than the fixation of quicksilver. If the latter, you have wasted your oil and your labor. But what, I ask, is that thing which fixes a metal into gold or silver? Surely you will find nothing whatever to produce this effect, except the mercury in cinnabar and the lead in litharge. But since these are heterogeneous species, it cannot happen that they be converted into gold. It is plain, then, from this, the ignorance of the alchemists.

I am not unaware that some try to fix cinnabar with vitriol, kept for eight days under warm sand, until it flows like lead in fire; but this can only improperly be called fixation. Some do the same with silver. For if they fuse twelve pounds of cinnabar with one mark of silver, they promise themselves sixteen *besses* (or drachms) of silver, of which half is gold—from which they boast of fabricating sublimated mercury, which, often driven aloft, is fixed into a white medicine. But these are idle boasts of the alchemists, which leave nothing behind them but ashes and smoke.

Let us now see how Paracelsus institutes fixation by means of strong graduating waters [aquae fortes gradatoriae], oils, and liquors, which are as it were certain menstrua by whose help metals are said to be fixed.

[Margin: How fixation by Paracelsus's graduating waters is accomplished.]

He proceeds thus, in his *book On Graduations* [Liber de gradationibus]: *Take cinnabar, arsenic, antimony, of each 1 part; saltpetre 2 parts; sulphur the same amount; let them be ground, mixed, and distilled into an aqua fortis over a most violent fire. Afterward take two parts of this water; common alum, plumose alum, 1 part; vitriol, verdigris, crocus martis likewise 1 part; let all these together be distilled into an aqua fortis over a most violent fire. Then, to this whole water add 2 parts of caput mortuum [dead-head residue], 1 part of antimony, verdigris, cinnabar, and sulphur. Distil these strongly from their dregs, driving them forcibly into a receiving vessel. Then in this clarified water dissolve 1 part with 10 parts of*

flowers of copper and crocus martis, and let them digest in it; and at last there will be in the bottom more gold than is credible to art. Thus Paracelsus.

You will ask, then, from where this gold residing in the bottom flowed. Paracelsus ascribes it to transmutation. But I say that gold—if those golden corpuscles which previously existed in the arsenic, antimony, sulphur, crocus martis, cinnabar, and verdigris, dissolved from their bodies by frequent distillation, and by an inborn power separated to the bottom from the rest—flowed together. But if gold of this kind is of notable quantity, I say that it has coalesced into a single mass from the saline corpuscles of the alum, vitriol, and saltpetre, after the moisture had evaporated—joined to the gold and tinted by it. You will make proof of this in the assay-cupel, in which those substances, again separated from the gold, leave only that gold which was present in the said minerals. But let us examine another experiment, in which he carries out the tincture by means of an oil.

Experiment 6. By which, through oil of antimony, the Moon [Luna, silver] is said to be turned into the Sun [Sol, gold]. Paracelsus operates thus: *Take 1 lb. of antimony, half a pound of sublimate of mercury; let both be distilled together over a violent fire through an alembic, and there will ascend a certain redness, thick like blood, which tints and graduates any Moon [silver] into Sun [gold], and brings this pale [metal] to the highest degree of permanent heat.* O blessed apothecaries, who can so easily convert silver into gold out of oil of antimony! We ourselves indeed very often, in our own pharmacy, are accustomed to draw off a ruddy oil of this kind from antimony [stibium] and sublimate of mercury, and we have phials full of it; but we have never been able to discover an effect of this kind, since, although it does tint molten silver somewhat, yet, when committed to the cupel, the silver is soon restored to its former whiteness, the tincture vanishing, along with the previous mass.

[Margin: Paracelsus.]

But perhaps some will say that this Magistery is to be understood not in the literal but in the mystical sense. If so, I would say, more truly, that it has congealed in the mystical Moon—that is, in the dizziness of the brain—rather than in the concavity of a material vessel.

Experiment 7. By which, through an oil or liquor, the Moon is said to be converted into the Sun. *Take oil made from sublimate of mercury and aqua fortis, distilled together so many times until it has been turned into an oil; into this oil drive the spirit of aqua fortis over a most violent fire; then put in the Moon [silver], and it will be converted into granulated Sun [gold]; finally let it be cemented with*

royal cement, and the best gold will be obtained. These things are indeed easily said, but they are not found to be so in fact. So in this case it offers us nothing other than a certain accidental and extrinsic tincture, which, when assayed in the ash-test, soon leaves the silver imbued with its former color, the tincture vanishing.

[Margin: Paracelsus, in practice.]

There now follow the transmutations of metals from one into another; concerning which, as we have shown in the preceding, there are as many contentions as there are fancies of the authors—who, if they knew in what the true, real, and natural transmutation of things consists, would certainly judge otherwise about the chemists' transmutatory art. I myself indeed think that art, apart from nature itself, cannot attain to natural transmutation, whatever the alchemists may say. That this may be understood, it must be noted that a threefold transmutation is here to be considered.

[Margin: Transmutation can be taken in various senses.]

The first is natural transmutation, which nature alone, and intelligence abstracted from matter, knows. *The second is that which is properly called alteration*, and is nothing other than the dissolving of metallic and mineral particles—the whole being dissolved through fire—their agitation, and the separation resulting from this; by which, when each particle has been given its freedom, it flows together toward the body more akin to it and neighboring it by kinship of nature. This, however, cannot be said to happen through a true transmutation of one into another; nor should we attempt to admit a penetration of bodies, since those corpuscles of Sun and Moon, and of the fixed salts, always remain incorrupt and permanent in the body.

remain; and according to this species of imperfect transmutation, all that has been handed down hitherto must be judged to occur. *The third species of transmutation* is nothing other than a certain mixing of one thing with another, which, just as they can be dissolved with no difficulty, so too accomplish nothing in the great art, as is well known.

There are besides some who dream that heterogeneous species can be transmuted into one homogeneous thing in the great work. But just as, according to the laws of good philosophy, penetration of bodies is not granted (which nevertheless would occur, if a mass equal in weight to those things which they had put in were composed of them), so too that transmutation is brought about in vain. Whenever, therefore, gold or silver is drawn out from various minerals, and

a single body appears, that body must nonetheless be judged nothing other than a mixture—certain things from various earthy and watery materials mixed together, and so closely united that corpuscles of a heterogeneous nature can scarcely be separated from one another. Yet this body must not be called either pure gold or silver; for with the repetition of a more vehement fire, the heterogeneous corpuscles are at last separated, leaving only that gold which nature had produced. Of this matter we give the following experiment.

[Margin: Experiment, against the asserters of true transmutation.]

Experiment 8. Take three ounces of silver, 9 oz. of copper, 9 of mercury; let them, mixed together, be exposed to a charcoal fire for 24 hours. Then let that compound, first well washed with water and dried, be sublimed by strong fire for 7 or 8 hours—at each operation washing the bottom of the vessels well, and stratifying what has been removed with the sublimate. When this operation is finished, the whole will coalesce into a hard mass; from which, committed to the cupel, you will obtain at least five or six ounces of silver. The question here is: from where did the three ounces of silver, beyond the ounces you had put in, accrue? I answer: not from transmutation (which the alchemists falsely persuade themselves of), but from the flowing-together of the silver corpuscles mixed with the copper, in the resolution of the bodies into their own likes—that is, into silver things; which would not happen if silver had not previously, and indeed copiously, existed in the copper. So that no one should think that the copper or the mercury was converted into silver, but rather that the corpuscles of copper and of mercury were so closely and tenaciously united with the silver put into the mixture that they cannot be separated except by extreme torments of fire.

And this same thing is plain from another experiment. Take one ounce of lead, one ounce of marcasite of tin, and 2 oz. of mercury, which, mixed together, will dissolve as it were into flowing mercury of the common sort; so that one might suppose the lead and marcasite to have been converted into mercury by a true transmutation. But if you put it to the test, you will find it altogether sophistical, not true mercury. For mineral mercury, put into a cucurbit with fire applied, at once flies off, which does not happen in this mixture. For you will recover one ounce of lead, and likewise one ounce of marcasite, together with the two ounces of mercury of which the mixture consisted—the mercury indeed having escaped into the receiver, but the lead and marcasite remaining in the bottom of the cucurbit. But if, from such a mass committed to the cupel, some little gold or silver should remain, this must by no means be ascribed to transmutation, as the

alchemists boast, but to the silver particles which had previously existed in the lead.

[Margin: Whether there is a transmutation of imperfect metals into perfect ones.]

I will not speak here of the transmutation of imperfect metals into imperfect ones, since we have already said elsewhere how that can occur; but of the transmutation of imperfect metals into perfect ones. Among other things, the alchemists have indeed labored greatly to convert quicksilver into silver and gold. But whether they have accomplished this is still in dispute, nor can it be said that anyone has accomplished it—except either by some hidden imposture, or by a master higher than human understanding.

But now I hear the alchemists yapping back at me: that it has been accomplished by very many. To prove this, they bring forward various histories of those who are said to have made the purest gold in the sight of many; some of which we will append here.

[Margin: Various histories of Penotus about mercury converted into gold.]

There was (they say) at Rothenburg on the Tauber [Rotoburgum ad Tubarim] a certain monk, whose name, however, they deliberately do not add, lest they be convicted of lying. This man, they report, threw a certain powder upon an ounce of quicksilver heated in a crucible; and when this was done, a crackling arose, and the quicksilver was at once turned to redness; and this, further urged by a strong fire and melted, at last flowed together, taking on a metallic solidity—which, examined also by a goldsmith, was reckoned the best gold. But how this was done, we will afterward show.

[Margin: The history of Penotus.]

Penotus the alchemist [Penotus], in a letter to Guibertus [Guibert], says that a certain Scoto-Briton converted 48 [pounds—recte: the figure reads "48½"] of lead into true and pure gold by means of a red powder of the smallest quantity. Another adduces Hoghelande [Hogolandus] as witness, who relates that a certain German (a *vagabond individual*, I more truly interpret it) in a certain city of the Venetian dominion turned quicksilver into true gold. I hear Libavius [Libavius] objecting to me that a certain Scot at Cologne [Colonia] made gold from lead; from iron and lead at Rotterdam [Roterodamum], Amsterdam [Amstelodamum], Frankfurt [Francofurtum], Strasbourg [Argentina], and Basel [Basilea]; and that he even promised, if ordered, to perform the experiment for sixty thousand gold pieces. Anyone can easily promise great and lofty things, but to deliver them in

actual effect—of that one might rightly doubt. Yet whoever that Scot was—or, as the etymology of the name teaches, a "shady character" [tenebrius]—is unknown. Whence I conjecture, not unfittingly, from so many places and cities traveled through, that he was more truly one of the number of the *Apyri* [those who shun the fire]—whose habit it is not to stay settled in one place (lest they be charged with the crime of fraud), but to run about as vagabonds through the world to empty the purses of the foolish common folk.

[Reading order: reconstructed from the printed folio numbers and catchwords. The four PDF pages bear printed page numbers 305, 304, 307, 306 (PDF order). By page number and catchword chain — p. 304 ends "ha-/bent" → p. 305 "bent itaque"; p. 305 ends "gra-" → p. 306 "granum"; p. 306 ends "au-" → p. 307 "aurum quidem"; p. 307 catchword "finem" — the running order is 304 → 305 → 306 → 307, i.e. → 1 → 4 → 3. The translation below follows that order.]

[Fol. 304 — LIBER UNDECIMUS, Sect. III]

[Margin: Kelkelaiar's procedure.] To make his own experiments concerning transmutation seem worthy of belief, Penotus [Bernard Georges Penot] exalts Kelkelaiar [?], who, he says, transmuted an entire pound of quicksilver into the purest gold at Prague, in his own presence, with a single droplet of a deeply red liquid. So one mule scratches another. He testifies that Nicolaus Bernardus Hogolandaeus [Nicolaus Bernardus Hogheland?] did the same — yet Hogheland afterward declares that, to his own peril, he learned this came about largely through the agency of a demon. Certainly Guibertus [Nicolas Guibert], in his book *On the Ruin of Alchemy* [*De Interitu Alchymiae*], proves with not unfitting testimony that this Bernard was a most wicked man, addicted to atheism, and the author of that detestable little book *On the Three Impostors* [*De tribus Impostoribus*]. See then, reader, how much trust is to be placed in scoundrels of this sort.

Neander, in a certain letter, testifies that Paracelsus [Paracelsus] converted quicksilver into gold in his presence. But whatever Neander commends in so many words, Libavius [Andreas Libavius] overturns in just as many. [Margin: Paracelsus and his followers testify of the alchemists' deceit.] "The chrysopoeia [chrysopoeia, gold-making] of Paracelsus," he says, "is of use to those who make progress in it for nothing but the gallows — just as Paracelsus himself writes of his own disciples: that the hangman carried off twenty-one of them, the fate the rest deserve by their imposture." There are those who, scattering some powder — now black, now green, now red — onto molten metals, appear to convert them into gold. And to persuade the world more vividly of their riches, they now fling

that powder into rivers with the greatest ostentation, [Margin: The imposture of certain pseudo-chemists.] now cast it heedlessly into the mud and scatter it about, so as to seem to value powder of this kind — of which they never lack a supply — as little as the goldsmith's flock. For my part, I should reckon powder of this sort to be made rather from mouse-droppings [*Muscerda*] than from gold. For if you ask where they got so great a secret, they will pack you off to Brussels in Flanders, to the confessional seat of some monastery or other, where (they say) in such-and-such a place you may find the secret hidden away. If you ask further why they do not enrich their own parents with so great a treasure, they will answer that while they live they are unwilling to disclose the secret, but after death they will be found to have transcribed it in a will. Once found after death, the secret is discovered written out in so many and such dreadful characters that no Oedipus, however great, could unriddle it with all human industry applied. I hear there was a man of this stamp at Florence, whom they commonly called *Prete Nero* [Black Priest], of whom they tell marvelous tales. For my part, I judge rather that men of this kind — if they have produced gold not by some elaborate trick full of cunning, or by a colored powder — have at least learned it from him who is the author of all iniquity, as their Master.

The alchemists relate that one Tarvisinus [the man of Treviso] made gold before the Venetian magistracy. But Fallopius [Gabriele Falloppio], an outstanding doctor both of medicine and of chemistry, writes thus of him in his treatise *On Fossils* [*De fossilibus*]: "Tarvisinus, a certain apothecary, is said to have made gold in the presence of the Venetian Senate; but I say that, just as he made sport of those Senators, so too he was punished, as his own arms know it"; "and in fact he made so much gold that he nearly died of hunger, and in his own workshop

[Fol. 305 — DE ALCHYMIA SOPHISTICA]

[Margin: The imposture of the Arabs.] there are scarcely any pharmaceutical vessels — from which it is plain enough that it is mere foolishness to say that the art makes gold, and that one has no gold unless it is dug up." I shall not speak here of the gold of Raymond Lull [Ramon Llull], of Arnold [Arnald of Villanova], or of Rupescissa [John of Rupescissa] — gold rejected even by Paracelsus himself as counterfeit; on this I have treated at length in what precedes. So if anyone should examine histories of this kind more curiously according to all their circumstances, and ἀκριβέστερον [Greek: ἀκριβέστερον (akribesteron, "more exactly")], he will in the end find them to be nothing but the fictions of the idle mob, deliberately devised by the alchemists to win some authority for their art. So much so that men of this stamp seem to do the very same thing as the

astrologers, who, to establish the certainty of their art, recount marvelous fulfillments of their predictions. I could here append a whole book on the paradoxes of the astrologers — or rather, the prophecies of false-speakers — which nonetheless, if rightly weighed on the balance of astrological discipline, you would judge to be nothing but old wives' ravings, resting on no astrological foundation, contained and explained by no aphorism. [Margin: Astrology and alchemy go hand in hand.] Since, then, astrology and alchemy are true sisters — the former foretelling the state and condition of the future life, the latter anxiously aspiring to a blessedness heaped up with vast treasures of riches — it is no wonder that the enemy of the human race should for the most part insinuate himself, through secret commerce, into the minds of mortals: minds at once troubled by the foreknowledge of things to come and greedy with the hope of riches, which he lures on. But let us now return to our subject.

I say, then, that if it should sometimes be established from histories that from some powder ([Margin] for this is the term of a "vague individual" that the fabricators of lies generally use) cast over quicksilver or over other metals, true and pure gold was produced, I should subscribe to this without much difficulty. But that this gold emerged from mercury and from other imperfect metals by a true, real, and natural transmutation — this I deny. So if you ask by what way and method it was produced, I say it could have been accomplished by a twofold method: I shall demonstrate the first first, the second afterward.

[Margin: The goldsmith's fraud detected.] Those who make a show of transmuting into gold from a powder cast over quicksilver — I affirm it is indeed true gold, but produced by a most deceitful trick. To make this plain, I add the procedure. They work thus: they put a notable quantity of gold, minutely cut into little gold leaves, into a crucible; over this they pour either quicksilver or aqua regia, and within a certain span of time they find it eaten away and dissolved into a liquid substance. This they then place in a crucible and commit to the fire, by whose efficacy the quicksilver — by itself and by its nature most volatile, like lead too — vanishes into thin air, leaving at the bottom a substance which, once thoroughly dried, they convert into a black powder, which they keep for use. But if they want a green powder, they cook it into verdigris [*aerugo*]; if a red one, they tint it with the most ruby-red oil of antimony. They thus

[Fol. 306 — LIBER UNDECIMUS, Sect. III]

[Margin: With what the alchemists excuse themselves when the business does not succeed.] take a grain, perhaps drawn from sand or from a brick, and add it for ceremony's sake, so that he might be thought to have done something great. The

golden water poured over these — when liquefied, with the mercury exhaling away — gives back the gold which it had infused in the form of water. And these are the miracles of the alchemists, worthy not of the golden chain such as the one this man had received from the prince as a prize, but of the kind that executioners are wont to give to such men — a golden rope. So great is the audacity of scoundrels of this sort that they do not blush to bewitch even the minds of princes with their trifles and fraudulent arts. Such are those who boast that from mercury they make a fixed Luna [silver], which they afterward tint with certain substances that resist the manifold assay of the cupel — as there are certain tinctures which, however often the fusion is repeated, can scarcely be separated out, and so grade the silver up to 18 carats, owing to the violence of the mineral spirits that nest in the strong waters [aquae fortes]; for they cling so tenaciously to the perfect metals sympathetic to them, and are so stubbornly glued on, that they cannot be separated except by mighty torments of fire repeated many times.

[Margin: Sometimes the business does not succeed.] I have heard some who boasted that they most surely held the art and who often claimed to have ascertained the truth of the art by experiment — yet, to the extent that they did not attain their wishes, they plead either their own inadvertence, or the omission of some circumstance, or of some other necessary thing; though they could, and ought, more wisely have confessed ignorance in place of inadvertence, and a false promise in place of the omission. And this is the impostors' method, by which they are wont to bewitch the minds of mortals.

From which it is gathered: If some impostor of richer fortune were to reduce 100, or 200, or even 1,000 pounds of gold into powder (which a few are recorded to have done, to win for themselves from this fictitious art an immortal name), he would doubtless everywhere perform false miracles of this art, to the astonishment and admiration of all, in a brief span of time, without all those concoctions and sublimations and the fermentations of many months. Would that those whom we have just reviewed had not done so, along with the rest of the gods of the greater nations, pointed out here and there in what precedes!

[Margin: Imposture.] Again, there were some who, having suddenly grown rich by treasure found in a field, and to avoid being compelled to cede a portion to the treasury as the laws require, are said to have professed this art — that by a small portion of powder added to quicksilver and to other metals they could convert the metals into gold — in order, by this cunning, to veil the riches of gold acquired from elsewhere. A game wholly of dice, which many have paid for with golden chains, with gibbets and with nooses, as one reads of Bragadino, of the

Scot, and of others adduced above. But how easy it is to impose by this fraud upon inexperienced men greedy for gold, who does not see? When they cannot conceive how, by a small portion of black powder

[Fol. 307 — DE ALCHYMIA SOPHISTICA]

cast over metallic bodies within a brief span of time, gold should at once come forth — whereupon, seized by astonishment and ecstasy, while it is not permitted even to suspect the hidden industry of the fraud, they marvel only at what has been done. [Margin: The deceived in the truth of the fraud — paint upon truth — the simplicity and obstinacy.] Hence, when from the report spread abroad those doubts are put forward by more skilled inquirers — doubts that may smack of some imposture — they at once reject them, not without indignation; they will hear nothing of reasons; nay, ten and a hundred times over they retort: "I saw it with my own eyes; I observed it done in the presence of such-and-such men, in such a house, in such a workshop; the powder I cast in with my own hands at the artist's bidding; we gave the gold produced to goldsmiths to examine, and with all assays applied, we found it sound, pure, far more excellent than common gold." Others, informed of so memorable an event, cry out again and again: "I heard it from those who were present and handled it with their hands, that to this very day a portion of the said powder is preserved with such-and-such a man as a perpetual memorial of the thing, so that any who wish might have the means of testing its truth; and already by the very deed several have made trial of the matter with the desired outcome, so that no one ought any longer to doubt the truth of the art — and let those who place no faith in this most true art be banished from the number of the wise." And in this way lies are linked to lies, which are not only scattered into public fame but also committed to books, to the utmost harm of the commonwealth and to allure the minds of others with this lucrative novelty; and — *res μετὰ τῆς ὑπερβολῆς* [Greek: μετὰ τῆς ὑπερβολῆς (meta tēs hyperbolēs, "with exaggeration")] — they are magnified beyond what they can be. So that I should reckon that ridiculous tincture of gold, infinitely multiplicative, to have drawn its origin from nowhere else than from these things. And he alone will be unable to be ignorant of it who, taught by experience, knows what nature can and cannot do, and has thoroughly grasped the contrivances of scoundrels prone to such frauds and deceits. Let no one therefore say hereafter, "I saw, I heard, I handled the truth of the art with my own hands," since the same thing happens to him as is wont to befall mountebanks and quacks [agyrtæ, circulatorēs]: who, when they pretend to gash their own belly, to devour serpents and toads, to convert leaden, copper, and iron rings by sudden transmutation into gold, fill the surrounding crowd with such

astonishment that they seem utterly unable to deny what had been demonstrated with such evidence. The senses are a slippery thing, and it can scarcely be told how easily they bewitch — I will not say the ignorant mob, but even the learned and wise — so that they persuade themselves a thing truly is, which is not, out of a corrupted imagination; especially if they are driven out of their wits by skilled and zealous architects of fraud, by the cunning of a similarly deceitful art. But let what has been said of the first point suffice. Let us therefore proceed to the second mode of making gold proposed above.

[Margin: What kind of gold the genuine chemists produce.] But the alchemists who labor without fraud in transmuting metals into Sol [gold] and Luna [silver], if they proceed sincerely,

[Now the experimental section. On Fol. 305 (recto), the lower portion of the page carries the heading EXPERIMENTUM and a procedure translated from the Arabic; on Fol. 307 (recto) appear the numbered Experiments 9–12 and the opening of the Combinatory Table. These are transcribed in their folio positions below.]

EXPERIMENTUM [Fol. 305]

[Margin: The imposture of the Arabs.] To these I add a history which most alchemists commonly allege to confirm the truth of the art, and which — drawn (they say) from the school of the Arab alchemists — I judge to have happened more truly in Utopia than in Galbania, a city of Egypt (a city of which not even a trace appears in the geography of Egypt, whether from ancient or from modern times). They say that a certain man came to a certain goldsmith (for the alchemists especially use this term of a "vague individual" when they wish to extol the marvelous effects of the Art), promising him a great reward if he would, in his presence, undertake a true and real proof of his art. Boasting golden mountains [Margin: An imposture present before a certain prince.], he was eager to transmute the sea into gold. He therefore set about the work. Into the crucible is placed a certain quantity of mercury

[At this point, on Fol. 305 the type continues with the procedure that on the page is interleaved with the prince-narrative (the compositor has set two threads on the page). The EXPERIMENTUM proper — the Arabic recipe — reads as follows:]

Experiment. Take one part of the said powder made from gold, and one part each of saffron of Mars [*crocus Martis*], of burnt copper [*aes ustum*], and of sal ammoniac. Let the sal ammoniac be dissolved, and mix it well with the three aforesaid ingredients; then put the mixture into a cucurbit, and with a gentle fire

— either in the sun or over an ash-fire — digest it until all these are thoroughly tempered together and incorporated, and, once the moist matter has been consumed, it has congealed. From this you will make the said powder, which you will keep for use.

This done, take a pot-bellied vessel with a narrow neck, into which [put] lead, and within the neck [put] one thin gold leaf, either above the orifice — that is, [the quantity] of ounces — you will set a golden denarius, so that it may draw up the vapor of the dissolved lead. Then take the aforesaid leaf, by turning and returning [it through] the aforesaid vapor; in this way the leaf becomes so brittle that it can be ground into powder with the fingers. And this is the powder that changes silver into gold.

The burnt copper [*aes ustum*] that enters into the secret ought to be prepared thus: copper-scale [*aes fegili* (recte *aes fissile*?)] pulverized in the same way, wash it so many times with triple water or with brine until it is wholly clean, and from this make a powder. Behold the secret of the Arabs revealed to you in few words.

This experiment is indeed certain, yet it is like the one they accomplish by addition. For gold, taken in a fairly adequate quantity and prepared from the said species — saffron of Mars and burnt copper — and likewise duly purged with sal ammoniac, and then [poured] over molten silver, by its tincture (which exists abundantly in the said species) not only tints the silver into gold, but also confers on it a mass and no small increase mixed in. Yet, just as those [tinctures] cannot endure the long torments of the cupel or of the ash-test without at last being separated into what they were, so here too we cannot admit any true and real transformation. This very Secret was afterward also found, in a few small details, in Paracelsus, who however wrapped it up — as some great mystery, lest it be laid bare — in riddles too, after the fashion usual with impostors.

I myself have known a Prince, whose name I deliberately spare, who, having entered into dealings with one of those rogues who promise the masteries of this flour [i.e. of this stamp], had promised him a great reward if he would, in his presence, undertake a true and real proof of his art. He ordered two silver cups to be cast and melted down for himself; once these were liquefied, the other [man], pressing in a certain green powder while the silver still flowed in the crucible,... [Margin: The Arabs' imposture.] and, after raising both great smoke and a great noise, a little later he finds the silver converted into the purest gold. The goldsmith, astonished at so great a spectacle and stirred by the desire of making the powder, with all the submission he could muster begged his guest to reveal to him the secret so worthy of admiration — which he did not at all unwillingly

grant. This history is told in an Arabic book *On the Conjunction of the Sun and Moon* [*De Solis et Lunae congressu*], and it teaches the secret in the following process, translated by me from Arabic into Latin, as follows.

[The numbered procedure here is the same EXPERIMENTUM transcribed above (Take one part of the said powder made from gold... — the page sets the recipe both in *italic* at the foot and the narrative above it). It is not repeated.]

[Fol. 307, the Experiments. Set in the left column following "aurum quidem... producunt":]

The [alchemists] produce gold indeed, but not pure and refined, but mixed and sophisticated. Let us set down a few experiments.

9. Experiment. [Margin: Fixation of Luna and Sol by means of cinnabar.] I shall not deal here with making gold by the [philosophers'] stone, which they call the philosophical [stone]: for we say that this is a figment of the abstracted intellect, for the reasons set down above. Rather [I deal] with the augmentation of gold, which arises by addition, or part with part.

In this way, then, by means of cinnabar and quicksilver they make Sol and Luna. Take a part of the best gold, first reduced to a calx by means of crude mercury; place this in an alembic, and a little later pour over it the following water; then by an eightfold cohobation draw it off. This done, the dissolved gold, ascending into the alembic, draws off its phlegm to the point of density. This infused spirit indeed cannot be dissolved from the gold except by its oil, which is poured over the cinnabar prepared above, so that it projects a little above [it]; then let it coagulate, reduced by the help of borax, and you will have the gold sought.

[Margin: Preparation of the water.] The water to be poured over the gold calcined by mercury is prepared thus. Take saltpeter 1½ lb., arsenic 3 lb., green copper [verdigris] 8 *lotones* or half-ounces, filings of iron or of steel 1 lb.; let the whole compound be put into a retort and distilled into a water. Of this water pour 8 *lotones* over sublimated mercury; you will draw it off, and the whole will be dissolved into a water suitable for fixing Luna [silver]. Take again sublimated sulphur from vitriol, and let there be a stratification (to speak chemically) over 4 *lotones* — or, what is the same, half-ounces — of fixed Luna, and 2 *lotones* of sulphur; then let it gradually evaporate. To the rectified sulphur join four times as much glass of Saturn [*vitrum Saturni*, glass of lead], and while it is in fusion infuse the calcined Luna into it; and place it, twice fulminated, for 20 days into the water already prepared, and you will have fixed silver with the mean of gold — not pure indeed, but sophisticated. [Margin: Fixation of mercury.]

10. Experiment. *To fix mercury.* Take 1½ *loton* of green copper, that is, of verdigris; one *loton* of crude mercury, which, kneaded into the green copper, let be sublimated in a glazed earthen cucurbit so long until the green copper is united with the mercury, and you will have it fixed. [Margin: Silver made from mercury.] Again, take the whole compound, which, first ground most finely on marble, you will put into a retort to be distilled over a strong fire; and what is not yet fixed recedes from the green copper. Take this and reduce it, by the following flux, into pure Venus [copper], so that it may be drawn off by the lead following, placed in a melting-pot; and from one drachm of mercury there will remain three drachms of silver pregnant with gold.

The flux is made thus. Take urine, which you will concoct into a stone and let the spirit fly off; take of it four times as much together with tartar, and you will work as was said a little before.

11. Experiment. *To convert into gold the Luna made from common mercury.* [Margin: Silver made from mercury converted into gold.] First, let aqua regia be made from vitriol and saltpeter, one pound of each; then green copper and sal ammoniac, 4 *lotones* of each; filings of iron, ½ lb.; let all these, mixed and minutely ground, be dissolved by a strong fire into a water; and place this water in an alembic and gently draw it off, by the heat of a [water-]bath, to the consistency of oil. Then take as much as you wish of crude antimony, and pour over it the oil a little before prepared, to the height of a finger; then, placing this in a low cucurbit, draw it off so many times until the oil is perfectly united with the antimony; and you will have a powder, which they call the red lion. Take therefore the fixed Luna from mercury; beat it into thin leaves; if you stratify these in a melting-pot and leave them in the cement for 24 hours, then you will have silver [turned] into the purest gold — exalted, however, only in color.

12. Experiment. *To exalt gold of weak color.* [Margin: To impart a genuine color to gold of weak color.] Take of sublimated mercury and of cinnabar 2 *lotones* of each, of antimony one *loton*; and twice as much vinegar, to which you mix as much verdigris as you can take up with two fingers; let them be put little by little into a separating pot or retort, and a liquor beautiful to look at will come out. Then take a part of cinnabar, which you should imbibe with the liquor a little before elicited; and draw off the liquor anew, committed to a glass retort, from the cinnabar. Afterward, placed in an alembic sealed with the seal of Hermes, let it coagulate in sand for 12 days, and you will have a powder. This done, take pale gold of imperfect color, or fixed Luna, 8 *lotones* or 4 ounces, over which you will

expose to fusion 6 drachms of the prepared powder, and you will have it exalted to that degree than which none greater can be desired.

The same will be done without powder in this way: spread silver or gold into thin leaves, place them in the oil or in the aforesaid liquor before it coagulates, and expose them to a gentle heat, as above, for 24 hours, until you see the oil somewhat stirred by ebullition, and you have what you sought.

I could adduce countless experiments of this kind in this place; but since there is almost nothing in one that does not also enter into another, and so as to embrace much in little, I have thought fit to attach here a Combinatory Table [*Tabula combinatoria*], by which whatever others hand down in whole books may here be exhibited in a single synopsis.

IN THIS TABLE.

Minerals regard metallic bodies, and combine perfectly with them. Each one of these can be reduced into its elements — salt, water, spirit, oil; hence, by strong waters, royal waters, and Stygian waters [aquae fortes, regiae, stygiae] which are compounded from salts, the bodies are dissolved, calcined, pulverized; but by the power of fires they are sublimated, purified, digested, fermented, fixed; and by the help of external agents — such as vinegar, tartar, spirit of wine, and the other acid juices and subtle ones — they are diluted, washed, purged. And at last, through a new solution and coagulation, [they reach] the ultimate end of the art

Diagram. A full-page engraved combinatory diagram (*Tabula Combinatoria*) occupying the recto, marked "Tom. II 30[7]" at the upper right. The plate is a synoptic web: two vertical columns of substance-labels — imperfect substances at the left, perfect metals at the right — joined by ruled straight lines that connect (in principle) every left-hand entry to every right-hand entry, producing the dense lattice of crossing lines that fills the field. Across the top of the field runs the operative dichotomy **SOLVE** (left half) / **COAGULA** (right half); along the bottom runs the legend "**Mediante igne Solvuntur et coagulantur**" ("By means of fire they are dissolved and coagulated").

Engraved title and subtitle (verbatim, top of plate):

TABULA COMBINATORIA, Qua Whatever is contained in the whole of Alchemy is here set before the eyes of the curious reader as in a recapitulatory synopsis [in Synopsi anacephalaeotica]. Nor, outside this table, need you look for anything — whether you are considering the

construction of the [Philosophers'] Stone, or the metallurgic art, or the mixtures of metallic bodies, or again the generation of their kinds — that is useful and fruitful for chemical operations.

Column headings and labels:

- **Left column heading:** *Imperfecta Metalla* ("Imperfect metals")
- **Right column heading:** *Perfecta in sua specie* ("Perfect in their own kind")
- **Top legend, left half:** SOLVE ("Dissolve")
- **Top legend, right half:** COAGULA ("Coagulate")
- **Bottom legend:** *Mediante igne Solvuntur et coagulantur* ("By means of fire they are dissolved and coagulated")

Left-column entries (top to bottom), with English glosses:

- Mercurius — mercury (quicksilver)
- Sulphur — sulphur
- Arsenicum — arsenic
- Auripigmentum — orpiment (arsenic trisulphide)
- Macasita [Marcasita] — marcasite
- Antimonium — antimony
- Cinnabaris — cinnabar
- Sal commune — common salt
- Sal nitrum — saltpetre (niter)
- Alumen — alum
- Vitriolum — vitriol
- Sal Ammoiacū [Sal Ammoniacum] — sal ammoniac
- Sal gemmae — rock salt (gem-salt)
- Ærugo — verdigris
- Tutia — tutty (zinc oxide)
- Galamena [Calamina] — calamine
- Bismathum [Bismuthum] — bismuth
- Cadmia — cadmia (zinc/cobalt ore)
- Talcum — talc
- {braced group:} Ex Vegetabilibus / Tartarum / Spiritus vini / Acetum —
"From vegetable substances: Tartar / Spirit of wine / Vinegar"

Right-column entries (top to bottom), with English glosses:

- Aurum — gold
- Argentum — silver
- Cuprum — copper
- Ferrum — iron
- Stannum — tin
- Plumbum — lead
- Mercurius — mercury
- Sulphur — sulphur

[Fol. 308 — close of the introductory matter to the *Tabula combinatoria*, completing Sectio III, Caput III, then the new Sectio IV, Caput I.]

they attain their end. And although the alchemists who deal in the secret of the great Magistry wrap it up under various riddles and parables, nevertheless, if you strip off the parabolic rind and examine the marrow, you will find that they follow the very same process as those who profess the metallurgic and sophistic art, and that they use the same ingredients drawn from those listed in this combinatory table. For without gold and silver — as even Lull [Ramon Llull, here the pseudo-Lullian author] himself admits in his *Clavicula* — gold and silver cannot be produced; and from the rest, imperfect metals are vainly tinged into perfect ones and transmuted, unless gold is present in them, by which (as through a kind of accretion) the gold receives a certain increase. But all these things will lie open to the wise philosopher in the Combinatory Table, if he knows how to apply it rightly; for no combination of the art can be devised that is not found within it.

SECTIO IV.

CAPUT I.

JURIDICUM SIVE LEGALE.

Whether chemical gold [Aurum Chymicum], made by whatever method, may lawfully be sold as genuine?

I raise here a Question that the jurists claim for themselves by the greater right; yet, lest I should seem to have omitted anything, I judged that it ought not to be passed over. Before we begin this question concerning chemical gold, it must be noted, first, that four kinds of art can be considered in this place.

The first is the **Metallurgic Art** [Ars Metallurgica], which by a singular skill separates the pure from the impure, the heterogeneous from the homogeneous, out of the ore of gold and silver; and the remainder it cooks down, by the aid of fire, into pure gold and silver. This skill has been treated very fully in [the section on] metallurgy, that is, the metallic art. [Margin: *Metallurgia in quo consistat, & quomodo licita* — "In what metallurgy consists, and how it is lawful."] And inasmuch as this art is so necessary to the human race that without it — given the supreme usefulness of metals — no administration of empires, kingdoms, or human commerce could subsist, so too it is so far from being judged unlawful by the laws that the jurists rather reckon it worthy of all praise, as the very foundation of human commerce.

The second is called **Chrysopoeia** [Chrysopoeia — gold-making], whereby the alchemists boast that, through a true and real transmutation of one metal into another, they can convert it not only into natural gold but into something even more excellent. [Margin: *Chrysopoeia an licita* — "Whether chrysopoeia is lawful."] And if this were true, they certainly could sell and dispose of that gold without any scruple.

The third is called the **Spagyric Art** [Ars Spagyrica], the method by which certain chemists separate, by a singular skill, true and natural gold that has been mixed with various metals — such as silver, copper, iron, lead, arsenic, marcasites, and the like; they sift it out of the sands of rivers and riverbanks by frequent washings [per frequentia tormenta], and melt it into little ingots. [Margin: *Spagyrica quomodo licita* — "How the spagyric art is lawful."] Such gold — being, to be sure, but little, and natural — no law forbids.

Fourth is that **gold-making** [aurificium] whereby the alchemists know how, by addition (or, as they call it, "part with part" [partem cum parte]), to augment gold and to give it its due tincture. [Margin: *Aurum quod per additionem, an licitum* — "Gold [made] by addition, whether it is lawful."] And it is of two kinds: one is called **Collybistic** [Collybistica], the other **Sophistic** [Sophistica]. Concerning this last there are varied debates among the jurists.

For our part, we shall resolve the doubts of each of the proposed branches by the Canons, both Civil and Canon, after we have first set down a few remarks concerning the *Extravagans* issued by John XXII, Supreme Pontiff [Pontifex Maximus].

John XXII [Pope John XXII], a Gaul, by birth a man of Cahors [Cadurcensis], from the province of Aquitaine, raised to the Pontificate in the year 1316, besides the

constitutions of his predecessor *Clement V*, also himself published many [decrees], which he calls *Extravagantes*; on which *Zenzelinus de Cassanis* [Jesselin de Cassagnes] issued ample commentaries. [Margin: *Extravagans Ioannis XXII. Pontif. de crimine falsi* — "The *Extravagans* of John XXII, the Pontiff, concerning the crime of forgery."] Among the other *Extravagantes* there is also one entitled *De Crimine falsi* ("On the Crime of Forgery"), in which he condemns all those who give their effort to making gold: he denounces the Art in wondrous ways. But — to embrace many things in few — I shall here append the said *Extravagans*, in which you will find whatever we have hitherto adduced concerning the falsity of Alchemy confirmed by Apostolic authority.

EXTRAVAGANS

On the Crime of Forgery [De crimine falsi].

JOHN XXII, Supreme Pontiff.

Preface to the Extravagans.

Here the alchemists are forbidden and punished — those making gold and procuring it to be made — since they ought to bring into the public [treasury], to be distributed to the poor, as much of true gold and silver as they have laid down of false and adulterated [metal]. And if their means do not suffice, the penalty shall, at the judge's discretion, be commuted to another, and they become infamous. And if they are clerics, they are deprived of the benefices they hold, and are rendered incapable of holding [any]. See the *Extravagans* of John, which begins *Prodiens*, and is placed under the [rubric] *cc, cit.*

[Fol. 309]

THE TENOR OF THE EXTRAVAGANS [Extravagantis Tenor].

The poor alchemists promise riches that they do not deliver; likewise those who deem themselves wise fall into the pit that they themselves have dug. For without doubt the professors of this art of Alchemy delude one another — being conscious of their own ignorance, they marvel at those who claim to have said something of this kind above [beyond] themselves; and when the truth they seek is not at hand for them, they waste their days, exhaust their fortunes, and with words dissemble their falsity, so that at last, by a sophistic transmutation, they may fabricate as true gold or silver what does not exist in the nature of things. And by this their rashness sometimes proceeds, from the condemned to the condemnable, so far that they strike, with false dies, the characters of public money [the legal

currency], in order to delude with false appearances the common crowd that knows no other furnace-fire of the alchemists. [Margin: *Alchymitum pro Alchymicum* — "(The text reads) *alchymitum* for *alchymicum*."] We, therefore, wishing these things to be banished for all time, ordain by this edictal constitution that whoever shall have made such gold or silver, or, once the deed is done, shall have ordered it to be made, or, knowingly, while it was being made, shall have ministered to those making it, or shall have knowingly used either such gold or silver in selling, or in giving in payment, shall be compelled to bring into the public [treasury], by way of penalty, true gold or silver of as great a weight as the alchemical [metal] amounts to, in respect of which it shall have been established that they offended in any of the aforesaid ways — to be distributed to the poor; the makers being nonetheless, together with the alchemical gold or silver itself (or those knowingly using it, as is premised), branded with the perpetual mark of infamy. But if, to pay the aforesaid pecuniary penalty, the means of the offenders themselves do not suffice, the discreet moderation of the judge may commute the penalty into another — namely of imprisonment, or another — according to the quality of the matter, the difference of persons, and other circumstances to be weighed. But those who shall have broken out into so great an ignorance of misfortune that they not only sell coins but condemn the natural precepts of law, exceed the bounds of the Art, and violate the laws among other [crimes] — namely by knowingly striking or casting, or causing to be struck or cast, adulterated money out of alchemical gold and silver — we command to be struck with this animadversion: that their goods be assigned to the prison, and they themselves be perpetually infamous. And if the offenders are clerics, let them, beyond the aforesaid penalties, be deprived of the benefices they hold, and be rendered utterly incapable of holding [any].

This is the Constitution of John XXII, Supreme Pontiff, concerning which marvelous things are spread abroad. The alchemists pretend that the Pontiff was most devoted to Alchemy, and that, when he could not attain to the great work of the Art, he framed out of desperation this so rigid constitution. *Platina* [Bartolomeo Platina] indeed, in his life [of the pope], reports that after his death an enormous quantity of gold was found in his keeping; but if this is true, it must nevertheless be believed that such a treasure of gold was by no means procured by the benefit of the Chemical art — though the alchemists try to prove [the contrary] by fair means and foul, [maintaining] that the Pontiff framed this constitution for that very reason, lest anyone besides himself should attain to the secret of the art, and that he did so out of envy.

However that may be, I would not wish to suspect such things of the Vicar of Christ. Hence, if Platina is to be believed, I judge that this treasure of gold was — as we said a little before — by no means procured by the benefit of the great Art; since he himself, in his own *Extravagans*, condemns it in open words. Rather, I judge it more likely that the aforesaid treasure grew out of various collections, whether from revenues, or from gold acquired into his private purse by his own industry, or even by gift; since to the Pontiffs the means for procuring such things are never lacking.

[Margin: *Liber Alchymicus falsò Ioanni XXII. Pont. adscriptus* — "An alchemical book falsely ascribed to John XXII, the Pontiff."] Not long ago I came upon a book written in the French tongue, whose title is: *L'ART TRANSMUTATOIRE DU PAPE JEAN XXII. DE CE NOM* ("The Transmutatory Art of Pope John XXII of that name"). In it is treated the manner and method by which the said Pontiff is supposed to have had true and natural gold made, by the benefit of the great art, in his Palace at Avignon [Avenionensi]. It begins thus: *Or commence le livre d'Alchimie, que le Pape Iean fit ouvrier en Avignon, du quel ouvrage il en avoit 200 roellez, à un chacun pesant un quintal* [French: "Here begins the book of Alchemy that Pope John had wrought at Avignon, of which work he had 200 round ingots, each weighing one quintal"]. Then it describes at length the process of the whole Magistry. For my part, indeed, when I had examined the manner of operating in it rather thoroughly, I freely confess that I found nothing in it of any singular merit that would surpass either the genius of the ancient alchemists or the precepts and style of the first Masters in the art — nothing beyond certain common received recipes, described elsewhere. Whence, and consequently, I have conjectured — not without manifest arguments — that this is nothing but a supposititious offspring, which someone among the desperate alchemists thrust into the public light, both to confirm the truth of the art and to win for it some esteem under the name and authority of the Pontiff. But, lest I should seem to do injury to anyone, I trust I shall make my case from the very process set before the eyes of the experts.

THE PROCESS [Processus]

Wrongly ascribed as alchemical to John XXII, the Pontiff. Which, translated by me from the French tongue into Latin, I render word for word as follows.

Take the strongest vinegar, 4 pounds of white lime; let it stand in this manner for 4 days. On the fifth day, put the material into a glass alembic, and distil it, and keep the distillate well. When this is done, take salt, and urine with Alexandrian Indigo [Indico Alexandrino], 1 pound; of sal ammoniac, 6 pounds; half a pound of

prepared common salt, and likewise half a pound of vinegar. Of the said things [take] 5 pounds; first, having warmed them with vinegar, distil; and afterward you will add the salts, which, when they have melted, you will put together into the alembic to be distilled. When it has been distilled, if anything mixed remains in the bottom, and is not yet stripped of its dregs, you will repeat the distillation, the water that comes out being poured over it anew; and you will repeat this so many times until all the water has gone out from the material.

[Fol. 310 — blank verso; no text, faint show-through from the recto only.]

escaped. Once this is done, you will find at the bottom of the vessel a mass congealed like ice or crystal; keep it carefully and apart. Next, take living sulphur [sulphur vivum] steeped in a strong lye, which you will sublimate, together with 4 ounces of the Moon [Luna, i.e. silver]; let all these be placed in water according to the precept to be given below. Once the said substances have thus been dissolved, put them into an alembic, and after you have distilled them with a strong fire, a mass will remain at the bottom. Take it out and set it on a glass plate in a cellar, or in some other damp place, until it has dissolved into a liquid, which again you should keep. Then take the mass extracted in the first operation, named above, and likewise expose it on the glass plate in a damp place, as before, to dissolve. When this is done, mix together these two waters produced by the first and the second operation, and let them congeal into a single mass. When this is congealed you will have the perfect medicine. From it, if you cast a small part onto 18 parts of Mercury melting together [in fusion], you will obtain the whole, within a short time, converted into the finest Moon [silver], proven sound by every assay.

And this is the first process, in which either the writer's utter ignorance or his negligence is plain. He sets down 43 ounces of calx of silver, together with the same number of ounces of sublimated Mercury — in which there is a manifest error. For since silver reduced to a calx is brought back to its former nature, the calcined silver necessarily costs more than the profit from the transmutation of the Mercury would bring in — as anyone can see from the proportion of 43 ounces of silver to the 18 parts of Mercury that the process says are to be transmuted into silver. We have therefore corrected the error by adding 4 parts of calcined Moon [silver]. But whatever this author may say, certainly nothing else is to be hoped for from this process than a certain silvery mass formed from the congelation of mercury and the calx; and so this process, the whole of it, is sophistical and unworthy of anyone's wasting useless and fruitless labor in testing it. But let us now examine the same author's process for making the purest gold. He puts it thus:

Processus II. *Pour faire Soleil bone fin* — [French; recte: *bonne fin*] that is, to make the best and pure gold. Take burnt copper [aes ustum] and sulphur of vitriol [sulphur vitrioli], 2 pounds of each. Grind each one separately and finely on marble, then commit them, thoroughly mixed, to an alembic well sealed with the lute of wisdom [lutum sapientiae] so that no spirit escapes; and, placed within the ashes of a small furnace, distill the material at a gentle heat, and keep the water drawn off in a glass flask. Afterward take two drachms of pure gold and 4 drachms of quicksilver, which you should amalgamate together in the goldsmiths' manner. This done, work the amalgam as thoroughly as possible for the next three days with the water kept above in the glass flask — that is, grind it in the manner of painters. When this too is done, concoct the material, worked as described, committed to a gentle fire, for 12 hours. When this is finished, grind it again with the said water, and what has been ground thoroughly, cook again, always repeating the same procedure 18 times, until you observe the color of vermilion. Then take a quantity [pondus] of this material, test it, and cast one quantity onto 18 of lead, and you will have gold most thoroughly proven by every assay. But the lead onto which the medicine is to be cast is prepared by long labor, in this way:

[Margin: Preparation of the lead.]

Take thin little plates of lead and arrange them in layers [stratify them] inside an earthen vessel with salt ground into a fine powder, continuing layer upon layer until the whole vessel is full; then close the lid of the vessel tightly, leaving, however, above an opening fit for letting out the smoke. Then commit this vessel to a suitable fire for 6 hours, and afterward, when the vessel is opened, you will find the little plates of lead corroded and very white. Place these in a strong and hot lye, and the salt will descend together with the lye, the plates likewise remaining pure and white at the bottom. Then take these out and grind them on marble, fresh spring water being poured over again and again, until you find the water clear. When this is done, repeat the grinding with the powder of the remaining water, with water of alum and of common salt and of tartar added, and let it be dried over a fire; and do this so many times until the whole material appears completely white. In this way commit the whole to fusion in a pot, and you will have lead prepared, which is to be converted into gold.

And this is the process — which, such as it is, has been drawn in part from the *Clavicula* of Lull [Raymond Lull; *Clavicula Lulli*], so that from this very fact its spuriousness is recognized, since Lull became famous in the world long after John XXII [Ioannes XXII], the Pontiff; nor is it likely that Lull borrowed this

process from John XXII. Let the reader now judge what is to be hoped from this process of a desperate work. That spurious author adduces very many other processes for the transmutation of quicksilver [hydrargyrum] into silver and gold. But since he has copied them from others, and they are altogether of the same flour [i.e. all of one kind] as those found in Ripplaeus [Ripley], Birellus, Isaac, Lull, Arnold [Arnold of Villanova], and the rest, I judged that in describing them more account should be had of the time than of secrets of this sophistical kind. Nothing further remains, then, except that we set down here the juridical aphorisms on chymical gold laid down by various jurisconsults.

Caput II.

Juridico-Canonical Decisions: On chymical gold, false and true.

[Margin: Whether alchemy is lawful, by its own distinction.]

1. It is asked whether alchemy is a lawful art. Reply: that alchemy is lawful which produces genuine and natural gold. Thus Oldradus, *Consilium* 74, and Ioannes Andreas [Johannes Andreae], in the title *De crimine falsi*, in the addition to the *Speculum*. But if it produces sophistical gold [aurum sophisticum], it is unlawful; so most of the Doctors of both the Civil and the Canon Law. Thus Joannes de Plat[ea], on l. 1, *C. de arg. pret.*; Joannes de Clavasio, in his *Summa*, under the word "Alchymia."

[Margin: Whether true gold can be made by alchemy.]

2. It is asked whether true and real gold can be made by the alchemists through transmutation. Reply: that it cannot. So Avicenna, cited by Albert [Albertus Magnus], on whom there was full discussion in the preceding pages — because such alchemical gold has only the outward appearance of gold, yet is not true gold. So St. Thomas [Aquinas], *Summa* 2.2, q. 77, art. 2; Cardinal Alexander [de Imola], on c. 1, *Quae sint reg. in usibus feudorum*. If nevertheless anyone were to effect this by a true transmutation, there ought to be no doubt that the gold too would then be true. But let us hear the words of St. Thomas — whom many wrongly say not only to have approved alchemical gold but even to have made it, in order to establish the falseness of the art by the testimony of so great a man; yet they can easily be refuted from his very own words. "Alchemy," he says, "although it is difficult" — [Margin: St. Thomas's view on chymical gold.] — "is not however impossible, which we say is known at least to the angels or to demons, who alone know the hidden paths of nature, along which they can operate perfectly. If, therefore, the gold made by the alchemists is not true, and not such as it is when made by nature, then its sale as true gold is fraudulent and unjust;

but if it is true, it may be sold for true gold (as is that which is extracted from the various metals with which it has been mixed)." And concerning truly alchemical gold he speaks thus, 2 *Sent.*, dist. 7, q. 3, art. 1:

[Margin: Gold cannot be made by the alchemists' art, as being repugnant to nature — St. Thomas affirms.]

"Art can indeed induce certain substantial forms of natural agents into matter; there are, however, certain forms which art can in no way produce, because their proper active and passive principles it cannot find and apply, but it can well make something similar to them — just as the alchemists" [Margin continues:] "make something similar to gold as regards the external accidents, yet they do not make true gold, because the substantial form of gold is not produced by the heat of fire, which the alchemists use, but by the heat of the Sun in a determinate place, where the mineral power [virtus mineralis] is vigorous." From these words it is luminously clear that St. Thomas held a view of alchemy far other than what they impute to him through supposititious offspring [false attributions].

[Margin: Whether chymical gold may lawfully be paid out.]

3. It is asked whether it is lawful to sell alchemical gold, and to pay it out, as true and natural gold, and whether by this the sale or payment is rendered just. Reply: if the alchemical gold differs in nothing from the natural, it can be sold and paid out; otherwise, it is by no means lawful. So St. Thomas and Albert, adduced above; Andreas de Isernia; Baldus; and Cardinal Alexander, on the dist. c. 1, *Quae sint regalia*. For those who whiten by means of "whites" and turn yellow by means of "yellows" [i.e. apply superficial tinctures] while the species of the prior metal remains in the matter — these are without doubt deceivers; and in this way nearly all of them proceed, in whole or in part, and (Albert himself being witness) they fall into many deceptions. And such men are punished, according to the established laws — so Joannes Andreas, in his addition to the *Speculum*, in the title *De crimine falsi*. For besides the loss of value, he says, gold and silver of greater worth also have certain virtues that are not present in other metals, nor in gold and silver made sophisticated by alchemy — such as against melancholy and other afflictions of the mind observed by skilled physicians. And Brother Bartholomew of San Concordio [Bartholomaeus de Sancta Concordia] subscribes to these things, in his *Summa*, under the word *Empti*, § 4; Faber [Fabius?] de Monte, *De emptione et venditione*, p. 8.

[Margin: Whether gold learned by magic art may lawfully be sold.]

4. It is asked whether anyone may sell gold which he has learned to make from a diabolical master, or by the magic art. Reply: that just as it is not lawful to learn anything from the devil, so neither is it lawful to sell such gold acquired by an evil art — since there can always lurk beneath it the suspicion of some deception by Satan, the hater of holy truth. And in this way both the art and the gold produced from it have been prohibited, as is held in *C. de auro publico*, l. 10 [*per se* 10].

Caput Ultimum

[Greek: ἀνακαιφαιλωτικόν — recte ἀνακεφαλαιωτικόν (anakephalaiōtikon), "recapitulatory," a summing-up]

In which is briefly opened up what, properly, the Philosophers' Stone, so much sung of among the ancient alchemists, really was, and what at last the early philosophers and their modern followers understood by it.

We have seen, partly in this present Section and partly in the preceding ones, the admirable works of nature that occur both in metallurgy and in the manner and method of making gold. We have also discussed all those things that the ancients handed down concerning the admirable mysteries of the Philosophers' Stone; and by many weighty arguments we have shown —

[Margin: The author's view, namely that it was sophistical and false.]

— that up to now there has been no one who, by a true and real transmutation, has carried over Mercury or the other imperfect metals into true and natural gold; but that all that operation of the alchemists has been false and sophistical, and indeed that the gold or silver produced from it has been nothing other than gold either mixed with other added substances or introduced by a dye [*fucus*]. So that from what has been said we may rightly and with good reason infer:

That all the gold or silver which up to now is reported to have been made by various alchemists has been made either by some cunning and the deceitful craftiness of the impostor's art, or by the magic art out of a pact made with Satan, or finally out of mineral gold reduced to powder; which gold, however, if you commit it to the balance of the cupel and of the ash-test [*cupella et cineritium*] or of the cement [*cementum*], does not subsist, but is resolved into the things out of which it had coalesced. This first became known to me when, not long ago, I had at length discoursed here at Rome with the most expert separators [*refiners*] of gold about this matter; and they solemnly affirmed —

[Margin: The separators, whom they call spagyrist, on the judgment concerning chymical gold.]

— that they had received from various alchemists various offerings of gold and silver, submitted to assay; and that some indeed had resisted the cupel through seven repetitions of the purification, owing to the most stubborn adhesion of the foul mixture, and at last had yielded true gold — not, however, formed by the transmutation intended by the alchemists, but (as they afterward perceived from the men's own confession) extracted from a marcasite pregnant with gold, decocted by the metallurgical art, with a profit of gold from one pound of marcasite. And although innumerable miracles of this art had been displayed to them, nevertheless, from the time they had professed the spagyric art, they said they had found nothing that did not smack of a dye, or that had not coalesced out of false mixtures by a sophistical composition.

This Albert too confirms, *De metallicis*, book 3. For he says that gold has by the chymical art been brought to that point where, when it had sustained six or seven fires, at last, consumed, it was resolved into dregs. [Margin: Albert's view on chymical gold.] "When therefore the alchemists say that they make gold out of Mercury and the other metals, which resists the cupel by any means whatever, do not believe them; for once the cement has, by longer torments of the fire, with the heterogeneous parts separated, left only as much gold as you had put in. There was no need of this, that the truth should be found out by so many repeated assays — since they could easily have ascertained it by a single assay, without error, by an art known to few, with a great quantity of lead committed to the cupel."

[Margin: Conclusion.]

I conclude, therefore: whatever the Arabs once, whatever Lull, Arnold, Rupescissa [John of Rupescissa]; whatever Isaac, Basil [Basil Valentine], Rhipaeus [Ripley], Sendivogius, Paracelsus and his followers handed down concerning the gold made by themselves — it was not true and natural, but sophistical, fashioned by those arts that we have just reviewed.

[Margin: Whatever has been published up to now about chymical gold rests on numbers.]

Hence, whatever about the Great Art [Ars Magna] of the Stone has up to now been put forth in published books is as certain to contain nothing other than what we have said, as it is certain that one who has died naturally cannot revive — which, nevertheless, they everywhere boast of their stone as the raiser of a

dead body. [Margin: The Authors who deal with the Great Art.] So those labor in vain who imagine they can attain the secret of the transmutatory art from the *Theatrum Chymicum*, the *Turba Philosophorum*, from the works of Isaac the Hollander [Isaac Hollandus], of the Count of Treves [Bernard of Trier], of Basil Valentine, of Trevisanus, of Bernard, of Bonus, of Joannes Petrus Faber, of Libavius, of Mylius, of Rhenanus, of Porta, of Wecker, of Alexius, or from the codices of innumerable Manuscripts and their received teachings.

That this is so certain that even the first Masters of the art have confessed it — those whom Paracelsus, the Monarch of the Alchemists, cites in his book *De transmutatione metallica* and in the book entitled *Aurora Philosophorum*.

[Margin: Paracelsus is reproached for inconsistency on alchemy.] But since we have, word for word, alleged his very full discourse above in Section II, Chapter VI, we refer the reader there. Although by it he reproves the efforts of all the alchemists up to now with such severity, he himself is nevertheless reprehended for having sinned in the very thing he carps at in others: when he says that the secret of the whole Mastery [Magisterium] consists in three things — namely Arsenic, Vitriol, and Antimony — as we have taught in the preceding pages.

Whatever, therefore, has up to now been written about the Great Art, or handed down in it, was the whole of it (as we have said) accomplished either by the metallurgical or by the sophistical art, and so no other benefit can result from it than what true chymistry — never sufficiently to be praised — teaches.

[Margin: The praise of true chymistry.]

For, first, it hands down the method of extracting, decocting, and purifying gold and silver from the metallic ores. Second, it shows how to find a certain tincture, with an added mass, out of the various gold and silver mixed with the remaining metals and minerals; which, although it is always more imperfect than the gold and silver themselves mixed with it, can yet lawfully serve for ecclesiastical furnishings, table services, and other utensils. Third, it teaches — to the great benefit of kings and princes — the method of alloying with gold and silver copper, tin, and similar metals, which they call *collybistica*, commonly *legam* [the alloy/"league"], which each of the princes may employ at his pleasure in his states by his own right. Fourth: in place of gold sought by fruitless labor, it has uncovered many illustrious secrets, useful to the human race — both in vegetables and in animals — for the use of medicaments, which consist chiefly in extracts, magisteries, and quintessences, and are in no way inferior to gold.

These, indeed, as they are most worthy of praise, so too we have deliberately transferred them to the last book of this work — lest we confound false alchemy with true chymistry — in which book the curious reader will find whatever can be desired concerning the various secrets of nature to be drawn from the threefold kingdom. Since, therefore, there is no hope of producing by alchemy the gold so greatly desired by all, someone might rightly object to me — indeed might charge me with rashness —

— that he could accuse me of rashness, while I labor too presumptuously to refute that art which venerable antiquity always supposed to be most true and most certain, and which we see attested by so many and such great writings of the philosophers. Most could object to me that to charge all of these with imposture is the harassment not of a wise man but of an imprudent slanderer. Therefore, lest I seem to do them an injury, and to free myself from the indictment of cavilling, I shall at last open up — with all the perspicuity and clarity I can — what the ancient philosophers understood by the Philosophers' Stone, and what by the Great Art.

[Margin: What the ancients understood by the Great Art.]

Mercurius Trismegistus [Hermes Trismegistus], the author of the whole recondite doctrine, when by the utmost subtlety of his genius he had penetrated the things shining forth hidden in any majesty of Nature — lest such great sacraments [mysteries] in the recesses of the world should become open to just anyone — undertook that ingenious architecture of the hieroglyphics, by which he concealed the individual mysteries of great moment under certain symbols, devised after the likeness of all-shaped [pantamorph] Nature, in such a way that they should nevertheless not be left impervious to those whom he judged worthy and like himself in sharpness of genius. Hence, to priests and philosophers chosen for this end — for whom the sole hope lay in the throne of the Kingdom — he communicated the secrets of his mind, expressed through the said symbols, lest along with himself such great fruits of discovered things should perish; and he had them carved on stones against every injury of the ages. But since the knowledge of such great things could not be expressed in few words, he devised, by truly subtle investigation, certain ideal symbols which should hold an analogy embracing many things — of which kind the hieroglyphics are — by which all those things that could not be described without many discourses might be laid open both by the sole and by the mystical conception of a single symbol; concerning which see our *Oedipus* [*Oedipus Aegyptiacus*].

[Margin: What the hieroglyphic doctrine of Hermes signifies.]

Since, then, he perceived that all things lie hidden in all things under a certain analogy — nay, beheld that the higher are contained in the lower, these in the higher and the middle, by a wondrous method — he distinguished a fourfold World: the Archetypal, the Genial, the Sidereal, and the Elemental, as was amply demonstrated above in the *Oedipus*, in *On the Hieroglyphic Alchemy of the Egyptians*, and in the *Obeliscus Pamphilius*; in which he set the orders of things and the grades of beings with such ingenuity that there existed no lower being of the World which did not have its own being, in both the Sidereal and the Genial World, consonant and proportioned according to the intended analogy — which beings, indeed, in the Archetypal World, separated by a certain ideal analogy according to our manner of conceiving, are nevertheless in reality considered under the one ratio of the simple divine essence. And from this those chains — the Egyptians call them σειραί [Greek: seirai, "chains, series"] — which we have treated everywhere in the cited *Oedipus*, found their origin.

The higher World has its own Sun, Moon, and the other Planets, to which from the higher World of the Intelligences just as many presiding Genii are assigned; and the lower World has these too. Since, therefore, in the Sidereal World he had found nothing more excellent, nothing more outstanding and more divine than the Sun, and in the medley of the lower, elemental World had recognized nothing more beautiful, more efficacious, and more excellent than gold, he called gold — on account of its virtues analogous to the Sun — the Sun of the lower World. In this way, seeing that the Moon is next to the Sun in excellence, he willed the Silver of the lower World to be the Moon, and so on with the rest of the planets, connecting each one by analogy [ἀνὰ λόγον] to the corresponding metals of the lower World. Hence it came about that by the symbol, for example, of the Sun, he exhibited a fourfold sense — namely, that he considered the secrets of the Archetypal, Genial, Sidereal, and Metallic (or Elemental) Sun, under a fourfold analogy, as one single thing; so that whatever mysteries of the divinity of the supreme Godhead he handed down, the same in their own way might be understood of the mysteries of the Genial, the Sidereal, and the Elemental World.

But since he recognized nothing in all of Nature more wonderful than the metallic operations, he set forth the manner in which Nature proceeded in generating them under the same mysteries by which he had set forth the sacraments of the Supreme Godhead and of the other Worlds. The Greeks afterward, following him in everything, hid the nature of things under not dissimilar riddles; about which let the reader consult the second part of the second volume of the *Oedipus*, where at length we showed that the Histories of the Gods — that is, the fabulous narration about Osiris and Isis, Horus, Typhon —

looked to this; together with the Mythology of the Greeks, by which we signified that the nature of things working wonders in the Elemental World was pointed at.

Hermes did not stop here, but, advancing from the world of minerals to the vegetative and animal, found the Sun, Moon, and planets in all things according to the intended analogy; so that there was nothing in the nature of things which he did not express under the monstrous likeness of animals and the rest of things. Hence he called the Sun, or Osiris, μύδρος [Greek: mydros, "a red-hot mass"] — that is, the inflamed rock pervading all things by its virtue; and Typhon he called Vulcan's subterranean fire, corrupting and restoring all things. There too you will find the interpretation of the *Tabula Hermetica*, or *Smaragdina* [Emerald Tablet] — which not undeservedly can be called the oracle of the alchemists — which is so far from teaching the fabrication of the Stone that rather it sets forth nothing else than the universal process of Nature shining forth in the generation and corruption of things.

I add that this Tablet was mentioned by none of the Writers before the times of Lull, nor do I find it inserted in the monuments of the Arabs. Hence no one ought to doubt that it is wholly supposititious. For if by Hermes to Abraham —

Liber XI, Sectio IV, Caput Ultimum (continued)

compiled at the same time [synchrono], how is it that so great and so celebrated a monument escaped the notice of Pliny [Plinium], Solinus [Solinum], Aelian [Aelianum], and all the other writers most curious about natural things — indeed, of all the other historians, ancient and modern alike? And if it was ever seen, I ask: where? in what place? in what city? If it was written down, I ask: in what language? in what tongue? in what script? For it would matter a great deal to know, from this most ancient monument, the earliest letters and characters used after the Flood — a subject on which there is such great controversy among the authorities. So a man is blind and out of his senses who would not — I will not say *believe* such things, but even take them into his mind so as to persuade himself they are true, or be led to accept them. But I have treated these matters more fully and professedly in my *Alchymia Aegyptiorum Hieroglyphica* [The Hieroglyphic Alchemy of the Egyptians], where you will see the author exposed by plain demonstration as a trifler and a peddler of smoke.

The later Arabs, lacking foresight and failing to understand the words of the ancient philosophers — by which those ancients meant the moving force of all things, which they understood as the solar force, or the Sun — themselves took

"gold" [aurum] κατ' ἐξοχήν [Greek: kat' exochēn, "by eminence," i.e. par excellence] and understood the process of producing it. I will cite the Arabic words contained at the opening of a work on alchemy written in Arabic that I possess, which run as follows:

[Arabic, with Kircher's own Latin gloss following — translated from his Latin:]

قال بعضهم ان العالم كله محبوب عاشق و معشوق و طالب و مطلوب قال الامام

[Margin: Omam, in his Alchemy.]

This means:

Some say that the whole world is love: lover and beloved, seeker and sought. Thus says Omam [the Imam].

[A second Arabic passage follows:]

قال هرمس الدرة الموصوفة ذات النظر الماحي الدائم العديم الموجود وهو في كل شيء وهو في كل بيت موجود وطوبى لمن فهم سرها ووفق عملها ان سر كل شيء الماء والماء قابل للتربية من الناس وغير ذلك وفي الماء سر عظيم ... قال مرقونس ما في الدنيا يباع اكثر منه وهو عند كل احد وكل احد يحتاج اليه يكون عنده ولا بد له ... منه ولا

This means:

Hermes says that the said pearl [margarita] exists in everything and is living water — perpetual, primordial — and is found in every thing and in every house. Blessed is he to whom it falls to understand its secret and to use it fittingly. He said, moreover, that its secret is water, and that water takes its nourishment from men. And Mercurius said that all the things which are in the world are sold for more than that water [is], for it is in the possession of every single person, and every single person has need of it. It is with him, and does not desert him, nor does its spirit depart. And Aba Amil said, speaking of the said water, that it is found in every place — in the plains, the valleys, the mountains, and with rich and poor alike, with the strong and the weak; and this is the parable which all the wise have in view; and it is the spirit of the moist.

Now this whole hieroglyphic conception of the universe denotes nothing other than a certain moving force of Nature in all things — which Aristotle [Aristoteles] not inaptly called ἐντελέχεια [Greek: entelecheia, "actuality," entelechy], and others a certain heat or fire present in all the members of the world, by which all things are moved, corrupted, altered, dissolved, digested, fermented, and fixed. [Margin: The heat of the Sun and of the subterranean realm constitute all things.]

And this is that celestial fire — the Sun, I mean — which by its influx into the elementary world kindles and cherishes a fire not unlike itself, lurking in the innermost recesses of the earth, in the manner we demonstrated in the fourth book of this work. Here on earth this fire — which the chemists also call Vulcan or the Archeus [Archaeus] — generates, cherishes, and conserves all the things which the earth holds in its womb as in a kind of furnace. It diffuses sulphureo-saline-mercurial vapors everywhere through the innermost fibers of the earth; and wherever these vapors fall upon proportionate matrices (of which there is an innumerable multitude established by the Architect of the world as so many chemical vessels in the workshop of the subterranean world), there it produces gold, silver, or some other metal, or a mineral, according to the condition of the earthen matrix. But outside the body of the earth this same fire — the solar force — vivifies, cherishes, alters, corrupts, dissolves, concocts, sublimates (and what is sublimated it reduces again), ferments, digests, and fixes...

fixes — being the cause of all generation and of the corruption of natural bodies. The Egyptians [Egyptii], most ancient of all peoples, contemplating in every age this admirable power of Nature, which resides in fire, that is, in heat — whether celestial or elementary — called the life-giving rays of the Sun "the fingers of Osiris [Osiris], the arranger of all things." [Margin: The fingers of the Sun, which the Egyptians called...] And the power of Nature that accomplishes such great things they named "the art of Isis [Isis]" — that is, "the increase of provident Nature," as Plutarch [Plutarcho] holds, by which all visible things are brought about. [Margin: Isis, the increase of provident Nature.] This same power they called, in the celestial world, the Moon [Lunam]; in the elementary world, Rhea [Rheam]; and so they called it the subterranean Moon. By all this the Egyptians by no means pointed to an Alchemy by which, through transmutation, either mercury or any other metal could be converted into gold; rather, they understood only the provident and admirable progress of Nature in producing gold, silver, and the other metals — both within the innermost realm of Typhon [Typhonis], that is, the subterranean world, and outside it, in the economy of plants and animals — that is, ἡ ψυχὴ τῆς βοτανολογίας [Greek: hē psychē tēs botanologias, "the soul of botany," the living principle of the plant-world], so necessary to the use of the human race. [Margin: What the ancient sages understood by the transmutatory art.] And the Greeks [Graeci] and the other wiser philosophers and alchemists who followed them, in every age, hid this beneath great clouds of riddles and parables — as we taught most fully in our *Alchymia*, by way of hieroglyphics, at the place in *Oedipus* already cited.

But lest I seem to have asserted anything tending to discredit the art out of ill will, I will here set forth in order the sayings of the ancient sages, from which it will shine out most plainly that the old alchemists understood by the transmutatory art nothing other than the fire of Nature — that is, that fiery power, solar or Vulcanian, and, by a certain analogy, the salt of Nature; and both of these are diffused through the innermost recesses of the universe. For this fire, as we said above, alone and singly performs all those things which the alchemists, false interpreters of the sages, supposed could be done by that fire of Vulcan and of the kitchen. For as the Philosopher [Aristotle] rightly says (*De Caelo* II), "the heavens, by their light and motion, bestow upon each thing its own proper heat." But it cannot happen that heat be so tempered by human industry that the alchemists could match the heat which Nature employs in producing gold — since Nature, in producing all her things, uses an even heat, one that is, as it were, indivisible. The alchemists therefore go astray in their operations, since the very ore and matrix is nothing other than the most subtle fire, that is, the sulphureo-mercurial salt of Nature, which, brought from potency into act, at last generates gold — that is, a mixture compounded of water, air, and earth, which, by a sulphureo-saline-mercurial vapor, purified by the resolution of the moist, is converted into an ignited ash through the salt existing within it. [Margin: What the salt of Nature is. The continuous progress of Nature.] And this is that white Elixir turned to red — that is, gold, by the continuously succeeding fire.

The philosophers also call this gold the permanent water [aquam permanentem], and the torment and nourishment of fire — that is, the radical moisture of the ash, or the permanent water, in that heat of the fire which serves it in place of soul and living spirit. It differs from the mercurial moisture as the stable from the unstable, the fixed from the non-fixed, inasmuch as it does not persist at the bottom of the vessel but is resolved into smoke, and, fleeting, washes away the blackness and stench of the combustible matter — a blackness inherent in the sulphureous and fatty parts existing within the ash, as they pass off into black soot, which the alchemists call "the damned earth," volatile, fetid, putrid, and "burning sulphur." Against this, they call the calcined ash, on account of the abundance of fixed salt within it, "incombustible sulphur," since when set to the fire and purified it is at last fused into glass. And this kind of ash the sages thought fit to call the "salamander" [Salamandram], inasmuch as it lives and is nourished in that fire. [Margin: What the salamander and the phoenix are among the alchemists.] Others called it the "phoenix" [Phoenicem], because kindled ashes are nothing other than the body of that Phoenix which is revived from its own ashes and lives renewed. And this kind of fire is denoted by the sages through that terrible dragon [draconem] which devours all things and converts

them into itself, and likewise through the basilisk [basiliscum] that kills all things; [Margin: What the dragon and the basilisk are.] for by this very fact — that the ash is ignited — there exist in it quicklime, salt, sulphur, and quicksilver. And this is, according to the mind of the sages, "to raise the dead and to kill the living" — that is, to deprive of life such an ash, which is the conjunction of East with West, of heaven and earth, of the spiritual and the corporeal, the conjunction of Sun and Moon, since the ash itself is a clear flame, and a volatile water which bears within itself a red smoke; and this, finally, decocted at the bottom of the chemical vessel, is fixed. [Margin: What the whitening water is.] And this is the water that whitens, that blackens, that reddens, that vivifies, that kills, that sublimates water — a lime dissolving and coagulating, putrefying and corrupting, and degenerating into diverse sprouts of wood; and, by the testimony of the Philosopher [Aristotle], when fire is applied to combustible matter, it grows to infinity. And this is the first process of Nature, namely the fire of Nature, which the sages described under various shadowings of symbols.

Aros, in the *Turba Philosophorum*, says: "*Every man knows this fire, and he who does not know it knows nothing.*" [Margin: Aros in the Turba of the Philosophers.] But this fire has scarcely been recognized by any of the alchemists; therefore the fire of the philosophers is not that by which the alchemists complete their work.

Morienus says: "*This thing, which is worth much, does not enter into the Magistery; yet among the alchemists it is so prized that they seem to lose every substance in procuring it, in order to acquire it.*" [Margin: Morienus in the Turba.]

Pythagoras [Pythagoras], in the *Turba*, cries out together with the others, etc.: "*Our work is the work of women and the play of children.*" [Margin: Pythagoras in the Turba.] But the work of the alchemists is so difficult to discover that it is still in dispute wherein it consists.

All the sages say in the *Turba*: "*With our work no one can stand still, nor can it be touched without harm; it tinges all things, it corrupts all things; from...*"

common gold so familiar and domestic to the alchemists, that it always remains without harm.

Arnoldus [Arnold of Villanova] says: "*Potable gold and the red Elixir, which is the gold of the philosophers,*" is potential and invisible gold. [Margin: Arnoldus.] The gold of the alchemists, by contrast, is actual, real, and visible, obvious to all the senses.

Alfidius says in the *Turba*: *"The gold of the philosophers is everywhere found excellently prepared and purified, and is sold at a cheap price,"* inasmuch as it is of profit to everyone, to the poor as much as to the rich. [Margin: Alfidius.] But the gold of the alchemists few possess, inasmuch as scarcely anyone has ever seen or touched it except as something sophistical. Again, in another place, Alfidius says: *"In producing this gold of the philosophers, all the operations are done at one and the same time."* The gold of the alchemists, by contrast, requires diverse operations, besides an enormous waste of time.

Raymond Lull [Raymundus Lullus] says: *"Without this gold, which we call the fire of Nature, no one can sustain his own life."* [Margin: Raymundus Lullus.] From which it follows that all who lack the alchemical Gold have long since been dead. Besides this, he says that this gold makes malleable glass — which becomes evident when glass, decocted in the furnace, can be stretched and beaten into whatever shape the craftsman pleases, and yet, when melted and plunged into cold water, becomes so brittle that one may handle it with the hands no differently than wax. This cannot be said of the gold of the alchemists, for once melted it can neither be stretched nor beaten, nor is it frangible in natural water.

Iesus [Hesus?] [?] says in the *Turba*: *"Our Sun preserves the warm and the radical moisture in a young man, and restores it when it has begun to fail; our fire cooks all the foods which serve for nourishment, and warms the old, who are cold and dry."* [Margin: Turba.] This the gold of the alchemists does not do, since it neither digests nor is digested, as the heat of fire is.

It is said in the *Turba*: *"Our gold is the Sun, a luminous Sun, which warms, alters, corrupts, putrefies, digests, generates, rarefies, dissolves, and illuminates the other stars."* [Margin: Turba.] This can in no way be said of the gold of the alchemists, since it neither shines of itself nor gleams in darkness, as do the celestial and elementary fire. The *Turba* cries out: *"Our gold can be multiplied to infinity"* — which can be said only of the fire of Nature, by no means of the gold of the alchemists. *"Our gold,"* they say, *"always resists fire without any corruption."* But this cannot be said of sophistical gold, which is calcined by corrosive waters, corrupted, and reduced into another form.

They say: *"Our Elixir is the most potent of all poisons, which destroys all things."* Who does not know that fire does this, and not the gold of the alchemists?

Hortulanus [Hortulanus], in the *Turba*, says: *"In our work the Stone is called everything by which the four elements can be separated from one another; out of*

which separation is born a certain crystalline substance, just as a stone..." [Margin: Hortulanus in the Turba.]

has discovered by the stalactic art very many things highly necessary to human nature, but that the fictitious Stone of the alchemists never even entered their minds.

Geber [Jābir ibn Ḥayyān], in the chapter on Medicine, says: *"Unless the medicine be such that, in a moment, it strips a liquefied body of its first form (which was under the water), and removes all imperfections, and likewise reduces it to the ultimate simplicity of prime matter, and in the same moment introduces another new form, namely that of the Sun [gold], it is not yet a perfect art or nature."*

[Margin: Geber.] By which words he describes nothing other than the infallible effect of Nature in producing gold, which the alchemist can scarcely, or scarcely at all, imitate.

Saturnus Trismegistus, in the *Turba*, says: *"Blind is he who thinks to make the art out of a combustible thing, since the divine operation is from a pure substance which endures in fire without any combustion"* (as we said about ignited ash), *"for all other things are destroyed and consumed by the combustion of fire."* [Margin: Saturnus Trismegistus in the Turba.] All of which is to be understood of the fire of Nature, that is, the Sun — not of the fire of spurious alchemy.

Again **Trismegistus** [Trismegistus]: *"The philosophers did not write their books except for their sons — and by their sons I mean those who understand their sayings, and not according to the letter; for an operation according to the literal intention is a squandering of riches and a loss of time. Many possess our Stone, but do not know its virtue; and if they should know its virtue, it would avail nothing, unless they also knew its operation. But the operation cannot be done except by the greatest gift of GOD, or by the teaching of a most skilled master, and the whole of it depends on the will of GOD."* [Margin: Trismegistus.] These words are so plain concerning the false doctrine of alchemy that they may easily be understood even by the unlearned. To this subscribes even the very Monarch of the alchemists himself, **Paracelsus** [Paracelsus], in his book *On the Transmutation of Metals*: *"Whatever burns is sulphur, and nothing catches flame except sulphur; whatever passes into smoke is Mercury, and nothing sublimates itself or ascends except Mercury; whatever is reduced into ash is salt, and nothing but salt can become ash."* [Margin: Paracelsus.] By which he plainly signifies the three proximate principles of Nature, of which all things consist, as has now often been said. When these are exalted by fire — that is, by the solar force or celestial spirit — they pervade the economy not only of minerals but also of plants and animals,

and bestow on each and every one life, soul, and spirit; while they separate the dissimilar, they gather the similar, dispersed by the heat of fire, and arrange them toward the end intended by Nature. In this way the Sun alone was created by GOD in this world, to rouse the resting fire in all things — by its own fire to solicit the rest of the planets surrounding it, kindled in the celestial world and lit up, toward fruitful influxes; and in the subterranean realm of Vulcan, by acting through the Archeus upon mineral matters, to produce at last planets analogous to those. From which it plainly appears that the Sun of the philosophers was nothing other than that fire of Nature which animates all things. [Margin: The Sun of the philosophers is the fire of Nature.] But since all this has been most fully set forth elsewhere in this work — especially in the *Oedipus*, in the *Syntagma de Alchymia Aegyptiorum Hieroglyphica* — I refer the reader there.

CONSECTARIUM [Corollary]

From what has been said up to this point it is established that the sages, by the gold and silver of the philosophers and the other planets, gave a meaning very different from that of the common metals. Whence he is blind who, maddened by this excessive thirst for gold, does not see this — or, if he sees it, stubbornly denies it. That gold was ever made, by the substantial transmutation of quicksilver and the other metals, by no mortal — except perhaps by some illustrious trickery, or by the magic art — we have shown in many and various ways in the foregoing. Those, however, who think that the authority of Albertus [Albertus Magnus] and St. Thomas [D. Thomae, Thomas Aquinas] supported the art are greatly deceived, since they said the very opposite. But let us hear the words of St. Thomas (*Sentences* IV, dist. 7, q. 3, art. 1), where in express words he subscribes to what was alleged above: [Margin: St. Thomas.] *the gold of the alchemists is not true gold, but only like true gold*; and if elsewhere he said that they do make true gold, this is to be understood as meaning that they can draw out true and genuine gold from various mineral and metallic bodies — which is nothing more commonplace among metallurgists — yet St. Thomas says this can be drawn out by art not through transmutation but only through separation, as is clear from the words cited above. To this Avicenna [Avicenna] lends his support in his *Commentary on the Meteorologica*, in these words: [Margin: Avicenna.] *"Let the practitioners of the alchemical art know that the species of metals cannot be transmuted, although things like them can be made; for even if they can tinge bronze [as] with whatever color they wish, until it is very similar to gold, and can wipe away the impurities of lead so that it appears to be silver, nevertheless in substance they will always remain bronze and lead."* Albertus agrees (*On Minerals* III.9), when he says: [Margin: Albertus Magnus.] *"Those who whiten by white*

things and yellow by yellow things, while the species of the prior metal remains in the matter, are without doubt deceivers, and do not make true gold and silver; and in this way nearly all proceed, whether in whole or in part. And for this reason I had alchemical gold, which was brought to me, tested by experiment; and after it had endured the fire six or seven times, at last, when further ignited, it was consumed and lost, and as it were reduced to dregs."

Pico della Mirandola [Picus Mirandulanus], no novice in alchemy, in his *On the Overthrow of Single Combat* (book 1, ch. 29, §7) [?], though he says the art is not impossible, nevertheless says it has such great attendant difficulties that they can scarcely be overcome; whence he concludes: [Margin: Picus Mirandulanus.] "*One should not,*" he says, "*devote effort to that art — not because it is impossible, but because it is of such great difficulty that it is more useful to leave it alone than to practice it; and indeed the very richest men have been reduced to great poverty, because, with the greatest expenses laid out, they either never attained what this art promises, or...*"

[Reading order reconstructed from printed page numbers: printed 318 → 319 → 320 → 321. The non-linear PDF order is sheet-imposition: each opening's verso and recto are split across the scan.] ...or else attains it only very rarely, and only in small part, so that the expense is far greater than the profit. It is therefore better to devote one's effort to other, more useful arts, which for the most part deliver what they promise, than to this one, which because of the hidden things of nature very rarely reaches its goal. So far Pico della Mirandola [Giovanni Pico della Mirandola].

[Margin: Arnaldus]

Let us now look at what Arnaldus [Arnaldus de Villa Nova] has to say — the man whom the alchemists look up to and revere as an oracle. "There are," he says, "certain foolish and blind men who claim they know how to make potable gold from common gold, or who believe this to be the best remedy for healing every illness; and there are certain physicians who boil ducats in water, saying that this is the best thing for healing — which is the exact opposite of the truth (saving always their reverence) — namely, that this should be potable gold, or that such water should be good to drink for healing. But I do say this much: that ducats are excellent for buying up confections and for paying physicians; and it is also true that it would be a good thing to have one's hand full of ducats and to show them to the sick man, since seeing the gold would do him much good. Those, then, who understand this 'medicine' to be about common gold are blind, and worse than blind — they are deceivers."

[Margin: What Trithemius thought of Alchemy]

I am well aware that many have enlisted Trithemius [Johannes Trithemius] into the company of the art, so as to lend it a certain authority; but anyone who works through his writings will find that he thought entirely the opposite. So that his mind may be more fully and plainly seen, I will set down here his own words, in which he depicts the vanity of the alchemists most vividly. He speaks thus in his *Polygraphia*, folio 598 of the old edition: "Alchemy," he says, "has many household maidservants, who guard their mistress with unceasing vigilance and pose under her name, so as to keep her forever safe from the dealings of importunate suitors: Vanity, Fraud, Deceitfulness, Deception, Sophistication, Greed, Falsehood, Lying Confidence, Folly, Want, Poverty, Despair, Flight, Proscription, and Beggary — these are the handmaids attendant on Alchemy, who, pretending to be the mistress herself, keep their beloved inviolate, and yet willingly prostitute themselves to her well-moneyed, greedy, stupid, and silly seekers." So far Trithemius — words that may rightly stand as a summary of everything said up to this point. And yet a great many do not blush to assert that Paracelsus [Paracelsus], as their master, was likewise privy to the secrets of the great art.

From all this it is most clear, by the very testimony of the alchemists themselves, that this art is vain and worthless. But perhaps here they will say that all this was said of the pseudo-alchemists, not of the true philosophers. Yet since not one of those first philosophers has ever been found of whom it can be demonstrated that he produced true, pure, and genuine gold by the transmutatory art — as we have shown at length in what precedes — surely on this very ground the whole objection of our adversaries collapses. That they knew the art κατὰ τὴν θεωρίαν [Greek: katà tēn theōrian, "in theory," i.e. as a matter of contemplation], indeed that it is possible, I will not dispute; but that they reduced it to practice — that is what we are asking, and it is on this alone that our whole dispute turns.

and that the matter could not be handled better than through the very contradictions by which the alchemists undo themselves, tear themselves apart, and attack one another. From these it will be evident that something resting on such rotten foundations cannot stand. And as far as the boastfulness of the art is concerned, they are plainly giants; but if you look to the force and effectiveness of their words, you will find only dwarfs fighting with leaden daggers. So that you may see their contradictions more openly, I have decided to set down here an Antithetical Corollary.

Antithetical, or Contradictory, Corollary [Consectarium Antitheticum, sive Contradictorium]

That the whole of what the true Philosophers understand by the Magistry of the great art is something altogether different from what the false alchemists promise is shown here in summary, drawn from what has been said up to this point.

The False Alchemists [Falsi Alchymistae]

1. For making the Stone they require distillations, sublimations, conjunctions, separations, congelations, dissolutions, triturations, whitenings, reddenings; and without these, they say, it is impossible to reach the goal. So Hugortius Lilius.

2. The pseudo-alchemists require for their work gold, silver, copper, iron, tin, lead, mercury.

3. The pseudo-chemists require water, vinegar, salts of various kinds, sulphur, antimony, arsenic, orpiment, realgar, and the like.

4. The Stone of the pseudo-chemists is made from combustible and impure minerals, by various operations.

5. The pseudo-chemists posit different grades in their magistry, namely the seven operations cited in the preceding pages, and they busy

The True Alchemists and Philosophers [Veri Alchymistae et Philosophi]

They say none of these things contributes to the structure of the Stone; for the operations Nature employs are otherwise: distillations, sublimations, conjunctions, separations, congelations, triturations, whitenings, reddenings. So Hugortius Lilius, *On the Philosophers' Stone*.

The true alchemists say that none of the common metals enters into the secret making of the Stone — not gold, not silver, not iron, not copper, tin, lead, or common mercury.

The true alchemists say: our water is not the water that the false alchemists use; our vinegar is not the common vinegar; nor are our salts like the salts of minerals, nor is our sulphur common sulphur — not arsenic, orpiment, realgar, or such things.

Our Stone is made from incombustible and most pure minerals, by means of natural fire.

Hermes [Hermes Trismegistus] in his allegories says that the regimen concerning Saturn is nothing other than putrefaction; concerning Jupiter,

The False Alchemists [Falsi
Alchymistae]

themselves with natural metals and minerals.

6. The pseudo-chemists say that all the chemical operations are distinct, and they require different fumes, vessels, and fires for the work.

7. Into the magistry of the pseudo-chemists enter metals, earths, stones, concreted juices.

8. The pseudo-chemists say that in the tincture of the philosophers there occurs a penetration of bodies, since by it they transmute bodies.

9. The pseudo-chemists assert that, by means of the soul extracted from quicksilver, any other metal whatever can be transmuted into gold or silver.

The True Alchemists and Philosophers
[Veri Alchymistae et Philosophi]

the operation is washing; concerning Mars, separation. The operation concerning the Sun is nothing other than washing it clean from the blackness of Mars; concerning Venus, the operation is nothing but conjunction — that is, of the moist with the dry, and the hot with the cold — and it is called allegorical copper. The operation concerning Mercury is nothing other than combustion; and concerning the Moon, nothing other than heating, roasting.

The true alchemists say there is only a single operation, and that all the operations are nothing but one thing; that one does not need different furnaces, vessels, fires, but one furnace, one vessel, one fire, kept at an even heat — and that heat is [the heat of natural fire].

Into the philosophical magistry there do not enter metals, earths, stones, concreted juices.

The true chemical philosophers deny this, as a false principle contrary to nature. Rather they hold that the tincture is brought to perfection by the agency of Nature alone.

The true chemists deny that one and the same specific form can inform any other metal differing in species — just as the soul of an oak cannot inform a pine or a juniper; and so neither can lead, or copper, [become] gold or silver.

The False Alchemists [Falsi
Alchymistae]

10. The pseudo-chemists say that the matter of the Philosophical Stone must be extracted from natural ore.

11. The matter of the Stone, for the pseudo-chemists, is moist and cold Mercury.

12. The pseudo-alchemists say that corrupted gold passes over into another form.

13. The false alchemists call the gold they make — Alchemical gold — true gold.

14. The false alchemists speak of Alchemical gold in material terms.

The True Alchemists and Philosophers
[Veri Alchymistae et Philosophi]

Geber [Jābir ibn Hayyān / Geber] and the other true philosophers say that the matter is to be found in all things, in every place and time — in man, in animals; and as Senior testifies, in the *Turba Philosophorum* [*Turba Philosophorum*], "every man knows the Stone, and he who does not know it knows nothing."

The matter of the Philosophers' Stone is hot and dry Mercury.

The true philosophers deny that this happens: just as gold consists of a perfected mixture, so too it cannot be corrupted.

The true alchemists say it is not true gold, but only similar and analogous to true gold.

The true philosophers speak of it mystically and allegorically, saying it is nothing other than a certain fiery power, or the fire of Nature diffused through the pathways of the whole World.

[After the table, p. 319, foot:]

From these things it is plainly evident what one ought to hope for from Transmutatory Alchemy, entangled as it is in so many contradictions — especially when there is added to all this the dreadful confusion of names and terms, the abuse of the differing meanings they employ in expounding the art, and the disparity of the senses themselves, which are truly as many as there are heads. (Meanwhile I pass over in silence the fierce attacks with which they assail one another.) The result is that no one seems able to make out what any of them feels, understands, or grasps. And so, that no one may waste good hours on an art so confused and so

[Top of p. 320:]

[Margin: The alchemists' rejoinder]

[arranged] in no order or method, so patched together with fables and trifles, and so wasteful of money and expenditure as to consume one utterly, I would counsel.

I do not know, however, by what fate it has come about that this golden Nymph Χρυσοποιΐα [Greek: Chrysopoīia, "gold-making"] has so deranged a great many men — and what is astonishing, even men otherwise wise — that they seem intoxicated by her as if by some magic potion. And the greater the audacity of such impostors, the greater for the most part is the credence given them by those who, infatuated by such κενεμβατεία [Greek: kenembateia, "treading on emptiness," i.e. groundless illusion], listen to them. Some of these are indeed of such temerity — not to say impudence — that, when questioned before kings and princes about the certainty of their art, they answer with more than Bombilian arrogance, in these and similar words: "I have no place, nor the means, nor the riches, to practice my art; but if Your Highness or Your Majesty deigns to supply me the necessary funds, I will make so much gold for you that with its aid and use you may easily set yourself up as Master of the World." Of whom, however, one may rightly pronounce: "They have an art without art, a part without a part, whose middle is — to lie; their life — to go begging."

Others, by contrast, seem to proceed in the opposite manner. They boast that they need no mortal's help; they despise the favor of kings and princes, scorn their riches and treasures as beneath their own, and deign to serve no one. They glory in possessing the wand of Midas [Margin reference: the touch of Midas], always ready and at hand for turning everything into gold; they claim to lack for nothing — while in the meantime, wandering across the world, never settled anywhere, and turning to tricks and frauds to sustain a life from which money is failing, they fleece with marvellous dexterity the purses of the simpler folk: selling powders for gold, axle-grease for ointments, mouse-droppings for civet, until at last, caught in the very act, they pay for their impostures either by a gallows-dance, or — if dealt with more mildly — by servitude at the oars in the galleys.

[Margin: No monarch ever made rich by Alchemy]

Who ever saw a king or prince made powerful by the alchemical art? Who ever heard of one set up as Master of the World by its aid? And yet now hundreds and thousands of years go by, through which this foolish promising of the alchemists endures — yet so far is it from achieving the desired effect that we know the

contrary to have happened. For how many have we seen stripped by the wickedness of this art of all their goods? How many have we read of who were reduced to utter ruin by the loss of everything? How many have we observed driven sideways into despair, given over to illicit arts and to commerce with demons, who — while they aspire to what they hope for — at last brought their lives to a close in a pitiful death?

[Margin: Harms to the commonwealth from Alchemy]

I pass over here the enormous damages that such men inflict on the commonwealth. [The "alba albificant..." clause:] until at last, caught — to speak with Alberto [Albertus] — they whiten the white, they yellow the yellow, they strike false coin, until at last they are caught.

[they] pay the penalties for having misused the gift of Vulcan. And there are others who, while they breathe nothing but secrets, think nothing is any longer a secret once it has been made public: they feel that whatever is shared with others perishes for themselves; they lay claim to the trust — or, as they call it, the credit — of the people, and to a reputation for hidden powers. And this even while, through magical attempts, they devise seals, pentacles, words, characters, touches, constellations, mirrors, homunculi made by their own art, sympathetic ointments, Brasidillae, Magurreones, Thesaurinellae, Evestra, and similar diabolical monsters of the workshop — through magico-cabalistic, Micro- and Macrocosmic triune mysteries.

[Margin: An exhortation to princes]

Since this is so, it falls to kings, princes, magistrates, and academies to restrain, proscribe, and utterly root out so dishonest and fraudulent an audacity of the pseudo-chemists — lest, as the number of impostors gradually grows, a window be opened to every license, to the practice of wicked and unlawful arts, and to every impiety. A model of sound censure, worthy of being imitated by all, was once given by the Athenaeum of Paris in the matter of the chemical writings of Petrus Palmarius [Pierre Le Paulmier], which, extracted from Libavius [Andreas Libavius], I here append.

The Parisian Censure of the Alchemical Book of Pierre Le Paulmier [Cenfura Parisiensis in Librum Alchymicum Petri Palmarii]

"Having heard the report of the censors to whom the task was assigned, of examining the booklet published by M. Pierre Le Paulmier, whose title is *The Dogmatic Philosophical Stone* — and having also heard the responses of the same

Le Paulmier, cited to that very end in a special article — the College of Physicians in the University of Paris, lawfully assembled, by unanimous consent condemns that booklet as full of errors, frauds, impostures, and lies, and judges it unworthy of the light of day. It decrees that within six months Le Paulmier shall, by public writing, acknowledge and abjure errors, frauds, impostures, and lies of this kind, and shall profess that he will remain steadfastly within the doctrine of Hippocrates [Hippocrates] and Galen [Galen] and the discipline of the School of Paris; meanwhile, that he be deprived of all the emoluments of the School, these to be paid out to the poor of the Hospital. If within the half-year he does not duly satisfy this decree, he shall be struck from the catalogue of regent doctors, and stripped of all the School's emoluments and of the University's privileges, etc. Given at Paris, 28 January 1609."

Such was the constitution issued by John XXII [Pope John XXII] against the alchemists, which decreed that gold-makers of this kind were not only to be driven out, but to be punished with the utmost rigor of justice, by whatever penalties — as men guilty of the crime of forgery — and that their books were to be consigned to the flames. And if this were done in our own day too, the pseudo-chemists would not rage with so many scandals, so many impostures, so many monstrous offspring of their wits, to the common detriment both of the political and of the literary commonwealth, whether by their writings or by their deeds. But the same thing that Tacitus [Tacitus] once said had happened in the case of the astrologers, [Margin: The verdict of Tacitus]

[Top of p. 321:]

we see verified down to the present day concerning the astrologers and the alchemists. "Such a class of men," he says, "will always be forbidden, and yet will always be retained."

[Margin: Objections of the alchemists against the author]

I am not unaware that there will be, among the petty chemists who hate the truth, some who will rise up against me with insolent tongue, and throw my ignorance in my face. But I am not troubled: my business is not with barbers and the unskilled rabble of alchemists, but with philosophers, men learned in the practice and experience of things, ἀληθεῖς φίλοις [Greek: alētheis philois, "true friends" (of truth)] — who, if they weigh my judgment on Alchemy in the fair balance of reason, will not easily deny what I have said. I am a German; with a German breast I profess the truth. I too could adduce countless secrets of the transmutatory art under the appearance of truth — but far be such a crime from

any human breast. I know what Nature can do and what it cannot. I know that Nature can never be overcome by art, unless perhaps these θεογιγαντόμαχοι [Greek: theogigantomachoi, "those who war against the gods like giants"] should irreligiously attempt to do something more excellent — something they everywhere confess to lie beyond human art — than God does through nature, which Plato [Plato] calls "the art of God." Let them see to it what they say.

But perhaps here they will raise an outcry against me: that they marvel that I, who have never had experience of coals, ashes, and little furnaces, and who am moreover unskilled in the secrets of the chemists, have nonetheless not feared to rise up with rash daring against an art I have not practiced. There is no reason for me to answer them: whether I am experienced or unskilled, ἄπρακτος καὶ ἀνεγχείρητικός [Greek: apraktos kai anencheirētikos, "without practice and untried by hand"], it is not for me to determine. I commit the estimation of me in empirical philosophy — to be decided from such works as have hitherto issued from the weakness of my talent, whatever their quality — to the Literary World, ready to bear with even mind both fair and unfair judgments. Yet it is true that I have not defiled my hands with coals and clay, nor filled my face and beard with cinders, but have always for that reason kept clear of the noxious and poisonous exhalations of minerals as of a very Lerna of all evils — lest I be joined to the company of those who, their brains scorched by smoke and soot, have always philosophized as foully as they have labored grievously.

[Margin: The author's excuse]

I confess that I have always pursued the experiment of things above all else — yet only such experiments as do not smell of smoke, mud, coals, of the kitchen and the barber's shop, but which are not at odds with honest labor. Even these, though, I have by no means thought I should refuse on account of the ἐγχειρήσεις [Greek: encheirēseis, "handlings, manual operations"] of the basest sort of work; rather I had them carried out — not without small expense — by Manipulators, as they are called, in my presence, in the Laboratory of the Roman College, most fully equipped with everything necessary for performing chemical experiments, hired for this purpose (as I said a little earlier): Manipulators German, Polish, French, Italian. And so I would have you be assured for certain that nothing is brought forward in this work in the matter of experiments that has not been verified — partly by myself, partly by the said chemists skilled in their labors, in my presence. My part was to give the orders and prescribe the method; theirs, to carry out what was ordered and prescribed — just as it is unfitting for physicians to compound medicines themselves, open a vein, administer clysters, but they are

accustomed to entrust these, partly to the apothecaries, partly to the surgeons, whose proper office this is. An architect does not prepare the lime and cement, nor dress the stones himself, but in his own design commits them to be fitted together by the stonecutters and masons according to the model. But that we may at last set the coping-stone on this Book —

[New paragraph, p. 321:]

I would have the Reader understand that in this place my quarrel is only with those alchemists who keep rolling that Stone of theirs — no differently than Diogenes [Diogenes] his famous tub — now turning it, now turning it back, now rolling it down, now rolling it round, by a useless labor; and with the rest of the pseudo-chemists. So let no one therefore suppose that I am hostile to Chemistry; for I know its supreme dignity and excellence, and I never cease to extol it sufficiently, as it were the one gateway of natural philosophy and of the more hidden medicine, through which access is granted us to the inmost mysteries of Nature. Nor would I be understood [as inveighing] against the ἀρχοιμάχους [Greek: archoimachous, "leaders" — best read here as the foremost, the masters] among physicians and chemists, singular in the practice of things and in long experience — even when perhaps I inveigh rather severely against the alchemists. Nor against princes who, led not by the love of riches but by a praiseworthy curiosity, take delight in experiments of this kind, to relax the mind after weightier business. Nor would I have those touched who devote themselves now and then to such exercises not from love of gold but for the sake of inquiring into the truth.

[Margin: Excuse of the author]

Since these matters could not be treated in this Eleventh Book of the *Mundus Subterraneus* [*Mundus Subterraneus*], owing to the more diffuse argument of its subject-matter, I have judged it more advisable that they be deferred to the last Book — in which the curious Reader will find gathered, with multiplied interest, whatever may be desired in experimental philosophy and in the inquiry into the secrets of the various arts.

CONCLUSION [CONCLUSIO]

And so, from what has been said, the Reader will doubtless understand most clearly how greatly, in every age, the accursed thirst for gold [sacra auri sitis] has filled human minds; with what care and anxiety they have sought to possess it; with what labors and dangers they have exposed themselves to acquire it —

Nature herself showing that gold is toilsome to find, hard to keep, full of anxiety in its pursuit, and set, in its enjoyment, between pleasure and pain. Therefore let no one devoted to true wisdom much seek or desire it. Blessed, then, is the man who, despising and rejecting the enticements of this base earth, and content with no more than the necessities, so orders a tranquil life, purged of all the passions of the soul, that he truly and from the heart carries out the Wise Man's counsel: "Give me neither poverty nor riches, but grant me only what is needful for living" [Proverbs 30:8].

LIBER UNDECIMUS, Sect. IV

[The opening of this page continues the prose from the previous folio.] Let us therefore stop seeking permanence amid the perpetual, perishing turmoil of these things. Let us leave acorns to the pigs, hay to the oxen, and a perceptible foreknowledge of storms to the frogs and crows; let us leave the filth and the devouring greed for gold to the misers. We, for our part, rely on higher principles — on what is stable, not on what is in flux within this economy of the sublunary world; not on goods subject to fickle time, but on those laid up forever in treasuries above the heavens, set utterly apart from all rust and from the ravages of the worm. Upon these let us keep watch with every effort and exertion of the mind.

So that the reader may find nothing wanting in this work among the things that pertain in any way to the study of chymistry, I have decided to set down here the marks or chymical characters by which the alchemists are accustomed to veil their secrets. Then, if a reader ever comes upon authors who generally make use of them, he may arrive at the true knowledge of the words those characters stand for.

Hieroglyphic marks, or Chymical Characters, by which they are accustomed to conceal their secrets

[The following is a two-column table of symbols and their meanings. The symbols themselves are alchemical sigils; each is described where it can be read, and the Latin name is translated. Many sigils are idiosyncratic; the names are transcribed and translated in full.]

Symbol (as printed)	Meaning
⚡	Vinegar [Acetum]

Symbol (as printed)	Meaning
✠ (variant)	Distilled vinegar [Acetum distillatum]
A	Air [Aër]
⚗	Alembic [Alembicum]
O	Alum [Alumen]
≈	Camphor [Amphora — i.e. camphor] [?]
ā ā ā	Amalgam [Amalgama]
ā an.	Equal part / "of each" [Ana]
♂	Antimony [Antimonium]
▽	Water [Aqua]
▽ (dotted)	Strong water / nitric acid [Aqua fortis]
▽ (crossed)	Aqua regia [Aqua Regia]
♄	Sagittarius [Sagittarius]
∴	Sand [Arena]
☾	Silver, or the Moon [Argentum aut Luna]
☿	Quicksilver, or Mercury [Argentum Vivum, aut Mercurius]
♈	Aries [Aries]
o—o	Arsenic [Arsenicum]
o=o	Orpiment [Auripigmentum]
☼	Gold, or the Sun [Aurum, sive Sol]
B.	Bath [Balneum]
MB.	Bath of Maria / water-bath [Balneum Mariae]
VB.	Bath [Balneum]
C.	Lime / quicklime [Calx]
⚔ (Calx viva sigil)	Quicklime [Calx viva]
♋	Cancer [Cancer]
♏	Capricorn [Capricornus]
(death's-head sigil)	Dead head / caput mortuum (residue) [Caput mortuum]
♂	Steel [Chalybs]
(ash sigil)	Ash [Cinis]

Symbol (as printed)	Meaning
☿ (cinnabar sigil)	Cinnabar [Cinnabaris]
CC.	Hartshorn [Cornu Cervi]
⚖	Crucible [Crucibulum]
♀	Copper / bronze [Aes]
⚗ (distill sigil)	To distill [Distillare]
♂ (day sigil)	Day [Dies]
℥	Dram [Dragma]
♂	Iron [Ferrum]
♊	Gemini [Gemini]
(hourglass sigil)	Hour [Hora]
△	Fire [Ignis]
♃	Jupiter [Iuppiter]
♌	Leo [Leo]
♎	Libra [Libra]
⚖	Pound [Libra — i.e. the weight]
☾	Moon [Luna]
♂	Mars [Mars]
☿	Mercury [Mercurius]
☿ (variant)	Sublimate of mercury [Mercurius sublimatus]
☿ (variant)	Precipitate of mercury [Mercurius praecipitatus]
☾	Month [Mensis]
⊖ (nitre sigil)	Niter [Nitrum]
o o	Oil [Oleum]
⋈	Opposition [Oppositio]
♊	Pisces [Pisces]
♄	Saturn; Lead [Saturnus; Plumbum]
⊕ (powder sigil)	Powder [Pulvis]
⊞	To precipitate [Praecipitare]
□	Square [Quadratum]

Symbol (as printed)	Meaning
Q.E.	Quintessence [Quinta essentia]
℔	Retort [Retorta]
✱	Sal ammoniac [Sal Ammoniacum]
⊖	Common salt [Sal commune]
∇	Rock salt [Sal Gemmae]
⊕ (nitre sigil)	Niter / saltpeter [Sal nitrum]
♄	Saturn [Saturnus]
♏	Scorpio [Scorpio]
♊	Sextile [Sextilis]
☉	Sun [Sol]
☿ (Sp. sigil)	Spirit [Spiritus]
☞	Spirit of wine [Spiritus vini]
♁	Tin [Stannum]
S.S.S.	Layer upon layer [Stratum Super Stratum]
☿ (sublimate sigil)	To sublime [Sublimare]
♄	Sulfur [Sulphur]
×	Talc [Talcum]
♄	Tartar [Tartarus]
♉	Taurus [Taurus]
▽	Earth [Terra]
△	Trine [Trigonum]
♀	Venus [Venus]
V.	Wine [Vinum]
♍	Virgo [Virgo]
⊕☿	Vitriol [Vitriolum]
☹	Urine [Urina]

JURIDICA SIVE LEGALIS

[This page opens with the conclusion of the prose argument, then begins the alphabetical Tabula.] The cast of mind of the alchemists is such that they

habitually wrap up any great mysteries whatsoever — which in fact they do not understand — not in clear and lucid terms, but in obscure ones: in parables and riddles alike, in portentous and fabricated names of things and words, barbarous and wondrously corrupted out of the Arabic tongue, transformed every which way so as to lend a certain false reverence to an art that shuns the light, cloaking it all in deceptive ornament. And so the books of the alchemists are so full of these things that scarcely a sentence is free of them. This they do not only in veiling the secrets of the great Art, but even in the common nomenclature of minerals: for salt, niter, vitriol, antimony, cinnabar, and the rest, they invent — with a kind of lying boldness — names that mean nothing in themselves, barbarous and strange, drawn more truly from the devil's kitchen than from the economy of the minerals. I cannot see what could be more foolish than this.

For what does it contribute to one writing about minerals and metals, that in place of names — which by their own nature ought to be clear and lucid — he should impose on the different species of minerals, and to indicate their meaning, names that are discordant, barbarous, and obscure? By no reasoning can I make this out. Is this not to adulterate the science of things rather than to explain it? What else is to be gathered from it but a fraudulent mind, abject ignorance, a glaring imposture — by which, what they do not know, they are not ashamed to cover up and conceal, if not in fact then at least in words, lest they should seem to have known nothing? So that the reader, whenever he stumbles upon the frantic writings of these men, may understand what the shifty smith of all this, Paracelsus, has hammered out under all those *nostoch*, *gas*, *blas*, *leffas*, *moxos*, *boxos*, and countless other absurdities — I have decided to append a catalogue of them here.

TABULA

In which the more obscure terms of the barbarous names commonly used among the alchemists are set out in alphabetical order.

A

Abessi — the same as *Rebis*, namely the ultimate matter of foods.

Acetum Philosophorum [Vinegar of the Philosophers] — that is, the Virgin's milk [*lac Virginis*], or mercurial water, by which metals are dissolved.

Adamita — a species of Tartar.

Adech — the invisible inner man, who gives form in the mind to all the things that the outer man makes visible and tangible with his hands.

Alcohol — a most subtle powder. *Alcohol of wine* (without the epithet "dried") is when all superfluity is so separated from the wine that, once kindled, it burns until the whole is consumed, and no dregs or phlegm remain at the bottom.

Alcofol — is stibium, that is, antimony.

Alcali [Alkali] — is salt extracted from the ashes or calx of all things, from the burnt bodies; and it is present, proper to itself, in all things, whether liquid or solid.

Alcahest — is Mercury prepared as a medicine for the liver.

Alembrot — the salt of the Philosophers. The key of the art.

Alembrot dried — some call it the salt of Tartar, the Mastery of masters.

Almizadir — green copper-rust [verdigris].

Almarcazida — litharge of silver. Argyritis.

Amalgama [Amalgam] — is the kneading-together of gold or silver with quicksilver.

Amisador — is sal ammoniac.

Ammis alcalisatus — is water drawn through the calx of earths.

Anathron, or **anachthron** — a species of salt which grows on rocks; some call it niter-salt [*sal nitrum*].

Andena — a species of steel in the Eastern regions, which is smelted like copper and silver.

Annus Philosophicus [Philosophical Year] — is the common month.

Anontagius lapis [Anontagius stone] — is the Philosophical stone, the gift of God, sulfur fixed by nature.

Aqua permanens [Permanent water] — is Sun and Moon dissolved in water and joined together; it is also called *aqua caelestina* and the Mercury of the Philosophers.

Aqua Saturnina — is water generated from the three first principles in the channels of the earth, dissolved out of transparent pebbles, such as the medicinal acid waters are.

Aquastor — is a certain vision, representing some thing which is not the thing itself.

Aquila [Eagle] — a well-known bird; but in the Spagyric art sal ammoniac is so called. Theophrastus [Paracelsus], however, also calls precipitated Mercury by this name.

Aquila Philosophorum [Eagle of the Philosophers] — is the Mercury of the metals or of bodies, when the metals are reduced to their first matter.

Archeos — an invisible species, wandering about and separating itself from bodies: the medicinal force and power of nature.

Archeus — is a man producing things out of the *Iliastes*, the dispenser and composer of all things.

Ares — the disposer of nature, consisting in the three first principles, from which all things are constituted; it generates the form, species, and substance of things, so that each thing has its own proper nature, form, and species, and not another's.

Ares — bestows on each species a nature and form of its own, different from the others, as appears in plants, each of which has its own particular root, stem, flower, leaves, and the like.

LIBER UNDECIMUS, Sect. IV

[The Tabula continues, A through L.]

Artanck, artaneck — Arsenic. Of which there are three species: white, yellow (or tawny), and citrine.

Arsanech — sublimated arsenic.

Astrum [Star] — is a heavenly luminary; then it is taken for the force and nature which things acquire in their preparation. Thus the "star of Mercury" is its sublimation, which makes it astral. So too sulfur becomes astral when it is sublimed. Likewise the dissolution of salt, performed by itself, is called the "star of salt."

Athandar — the distilling Philosophical furnace; the *Turbo Clibanus*, or liquefying oven of the Philosophers.

Atincar, baruch, Borrax, Boras [Borax].

Azoth — the Mercury of the metallic body. Theophrastus [Paracelsus] gave this name to a certain universal medicine; some think it was the Philosophical stone.

Barnabas or **barnaas** — saltpeter, urine of saltpeter, the sharpest vinegar.

Butyrum Saturni [Butter of Saturn] — is of Althea lead [?], that is, sweetness.

Callega — is a species of saltpeter.

Cauda vulpis rubicundi [Tail of the red fox] — is lead.

Cenisiatum — that is, calcined.

Cheiri — is also taken in many senses. For it is said of an herb; and when we speak of metals, quicksilver is meant; but some take it otherwise — some hold it to be potable gold, others antimony.

Cheiri flores [Flowers of Cheiri] — white elixir from silver.

Clissus — an occult force wandering hither and thither and returning, as the virtue of the root passes first into the stem and then returns into the root.

Cohop, or **cohopare** — is when matter is often imbibed with a liquid, and by distilling the liquid is drawn off again. Likewise when herbs are reduced by pounding, then purified in the same glass through a water-bath over four days, until the pure can be separated from the impure.

Colcotar — is the stone from which copper too is cooked, soft in nature. **Chalcitis** — red or citrine vitriol [*atramentum*]; but in Theophrastus it is vitriol calcined to redness.

Cornu cervi [Hartshorn] — that is, the cap [nose] of the alembic.

Cycima — litharge.

Cydar — that is, Jupiter [tin].

Derses — smoke, or the vapor from which trees grow.

Divertallum — are the generations of the elements.

Dubelcoleph — is a composition of white coral and amber [carabe].

Dulcedo Saturni [Sweetness of Saturn] — ceruse [white lead].

Duelech — a species of tartar in man. A spongy stone causing danger and pain [a calculus].

Edir — iron, or steel.

Elixir — also a fermented medicine, made either from gold alone or from the seven metals.

Elephas — strong water [aqua fortis]. Among physicians it otherwise signifies leprosy, elephantiasis, the Herculean disease, the Lion, satyriasis, leontiasis.

Entali — is split alum [*alumen scissum*].

Enur — is the hidden smoke of water, from which stones are generated.

Essatum essentielle [Essential exhalation] — is the virtue, potency, or force that is present in every wood, plant, and all other things.

Essatum vinum [Exhaled wine] — when to distilled and rectified wine herbs are added, so that it may extract their essences. As wine of Melissa, which is excellent for asthma.

Fel vitri [Gall of glass] — is the scum of glass.

Fida — gold or silver.

Filius unius diei [Son of a single day] — the Philosophical stone.

Filletin — plates of iron.

Filum arsenicale [Arsenical thread] — sublimated arsenic.

Filum — from feathered alum [*alumen plumosum*].

Flos sectae Croci [Flower of the Croci sect] [?] — some understand by it crocus, the flower of saffron; others the extracted flower of celandine.

Fenix [Phoenix] — the Philosophical stone.

Fons Philosophorum [Fountain of the Philosophers] — the water-bath.

Gamahei — are stones marked with celestial figures and images according to the constellation.

Gibar — a metallic medicine.

Gnomi [Gnomes] — lowly earthly spirits.

Guma — Mercury, that is, quicksilver.

Heinricus rubens [Red Henry] — vitriol calcined to redness.

Ignis leonis [Fire of the lion] — ether, *pyr*, *ethos*, Jupiter, *argēs*. The element of fire.

Ilech, ileias, ilcadus — is the first principle. *Ilech primum* [the first Ilech] is, from the stars, the conjunction of the supercelestial and of the firmament of the stars with the heavenly bodies — truly the union of inferiors. *Ilech crudum* [raw Ilech] is the composition, from the prime matter of the three first principles — Mercury, salt, and sulfur — from which all things are composed.

Ileidus — elemental air, *Heoe pheresbios* [?], the heaven; but in us it is the spirit which passes through all the limbs.

Iliastes — the prime matter of all things, consisting of mercury, salt, and sulfur. Chaos: for there is nothing in the whole nature of things that does not consist of these three.

Iliaster primus [the first Iliaster] — is the term of life, life itself, and the Balsam of man.

Iliaster — that from which all things grow, are nourished, and multiply.

Kakimia — the immature ore of any metal, which still subsists in its first being and still lies hidden in the impurity of the earth, like an infant in its mother's womb.

Koboltum or **Cobaltum nigrum** [black Cobalt] — sometimes it is smelted and rolled almost ash-gray, but it lacks the metallic color, and therefore it is not fixed, but carries off the better metals with it through the smoke. It is *Cadmia*, the stone from which copper is made, useful in medicine, an airy stone — *Climia*, *Cathimia*, calamine stone.

Lac virginis [Virgin's milk] — mercurial water.

Lapis [Stone] — in chymistry, every fixed thing that does not evaporate.

Leffas — is the hidden, fermenting smoke of the earth, through which plants grow.

JURIDICA SIVE LEGALIS

[The Tabula continues, L through Z.]

Luna compacta [Compacted Moon] — is fixed silver, or white gold.

Magnesia — is marcasite of any metal.

Magnesia Philosophorum [Magnesia of the Philosophers] — is silver joined by art with mercury into a metal that flows easily. It is also their matter, from which they make their stone.

Malk Arabicum [Arabic Malk] — is, to the Latins, salt.

Marcasitha [Marcasite], pyrites, *pyrototus*, *lapis aerarius*, *lapis luminis* — is an ore having much of red sulfur.

Martach — litharge.

Mensis Philosophicus [Philosophical month] — is the time of chymical digestion.

Mercurialis seva [Mercurial tallow] — is alum-water, in which mercury is generated.

Mercurius laxus [Loose Mercury] — is mineral turbith.

Mercurius metallorum [Mercury of the metals] — is the precipitated mercury of the body.

Mercurius mineralium [Mercury of the minerals] — the oiliness extracted from the ores of gold and silver.

Mercurius regeneratus [Regenerated Mercury] — is the first being [*primum ens*] of mercury.

Missadan — quicksilver. **Minium** — saffron [crocus] of Saturn.

Nebulgea — salt formed from the moisture of mist that often falls upon stones in the meadows, hardened by the force of the Sun.

Nostoch — the purgation of the stars; others understand it as wax.

Nuba secunda — a species of *tereniabin*, or manna of rosy color, such as falls in Hibernia [Ireland].

Operimethiolim — is the spirit of an ore.

Opodeltoch.

Orizeum — is gold.

Pulpezia or **pulpelzia** — astonished stupor, apoplexy, sideration. **Pygmei** [Pygmies].

Realgar — taken by itself, is the smoke of minerals, whatever is arsenical, or has the nature of orpiment.

Rebus — the ultimate matter of things.

Rillus — a chymical instrument into which liquefied metals are poured.

Sagani — the spirits of the four elements.

Sal Chrystallinum [Crystalline salt] — is what is made from human urine.

Sallena — a species of saltpeter.

Sal Mercurii [Salt of Mercury] — is spirit of wine, which inebriates.

Sal practicum [Practical salt] — is a mixture from saltpeter and ammoniac in equal parts, joined in a new unglazed pot and set in a cellar, which clings to the outside of the pot like hoarfrost.

Samech — tartar, a remedy for all wounds.

Serpheta — a medicine that liquefies the stone. **Sibar** — quicksilver.

Spara — a mineral force from *Ilech*, of the first substance, from the first being — that is, from the greater minerals.

Sperniolum — frog-spawn, otherwise the brood of frogs: *molurides*, *gyrinoi* [tadpoles], *batrachides*.

Stannar mater [Stannar the mother] — is the hidden smoke from which metals are generated.

Sylo — the whole world. **Sylphes** [Sylphs].

Terra argenti [Earth of silver] — litharge of the Moon.

Terra auri [Earth of gold] — litharge of the Sun. **Terra fidelis** [Faithful earth] — silver.

Thisma — the vein and course of ores.

Tinchar — borax.

Trachsas — metal in its own ore.

Truphat — is the hidden virtue of ores, which forces any metal into its own being.

Turbith minerale [Mineral turbith] — is Mercury, that is, precipitated by a corrosive and made sweet.

Vitrum Philosophorum [Glass of the Philosophers] — that is, the alembic.

Urina vini [Urine of wine] — vinegar, or the urine of a man drinking wine.

Xisinum — vinegar.

Xenechton — is hung on the neck against the plague. Its interpretation varies: one understands it as the first menstrual blood of a Virgin, another as something else.

Trcus [?] — stones; *dasypus*, *georychus*, *leberis*: the male rabbit, with whose blood glass and flints are softened, if they are fed [smeared] with diaphoretic substances — which by the ignorant is ascribed to the he-goat.

Zadir — Venus [copper], or green of copper [verdigris].

Ziniat — leaven [ferment].

Decorative woodcut.

[Reading order note — non-linear PDF: the four scanned leaves are out of page-number sequence. Printed running-header page numbers are: PDF-image 1 = p. 327; PDF-image 2 = p. 326; PDF-image 3 = p. 329; PDF-image 4 = p. 328. The text reads in the order 326 → 327 → 328 → 329, i.e. PDF-image 2, then 1, then 4, then 3. Page numbering has NOT restarted for Liber XII — it continues the volume's count (the prior book closed in the low/mid hundreds and this picks up at 326). Translation below follows the reconstructed reading order.]

MUNDI SUBTERRANEI — BOOK TWELVE

ΠΟΛΥΜΗΧΑΝΟΣ [Greek: Polymēchanos, "of many devices / resourceful in countless arts"]

SIVE — SIMIA NATURÆ [or, The Ape of Nature]

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In which it is taught — and confirmed by experiment — that whatever is produced in the foregoing Books by the sagacity implanted in Nature, anything remarkable, rare, or unusual brought forth by the power and efficacy of the Geocosm, can be made in just the same way by the ingenious industry of Art, provided Nature does not forbid it.

PREFACE

I have not infrequently marveled at the perversity of certain men who, abandoning the true and straight path to higher knowledge, leave no stone unturned to reach — by any means whatever — an acquaintance with unknown arts and the inaccessible riches of Nature's secrets, so that they may seem to know some great thing, something [Greek: ἰξωπικώτερον (ixōpikōteron) — "more deeply hidden / more recondite" (?) — reading of the rare Greek term uncertain] beyond other men. Yet since it is not granted to everyone to reach this Corinth, and since the gates of wonder-working Nature are not opened to all, nor are the keys to the inmost chambers of her treasures granted to all — what do they do? When they find every approach barred to them, in rash daring, breaking the laws of Nature, they take refuge in those workshops of wicked arts. There they not only fail to find what they so eagerly long for and so anxiously seek, but, led astray by a ruinous error and entangled in Satan's snares — from which, unable to extricate themselves — they bring upon themselves the ruin of body and soul, together with the brand of everlasting infamy. Of this kind are those who, whether confused by an insufficiency of native talent and a certain distrust of Nature, or driven sideways by despair of attaining the arts they craved, do not shrink from striking a pact with the enemy of the human race and taking him for their master — though they cannot but know him, even from the sacred oracles themselves, to be the craftsman of all lies and evils.

There are, then, fixed and definite boundaries set for us within the breadth of natural knowledge, which no one may overstep without error and the gravest peril. I know that Nature, in certain matters reserved to herself alone, is so

tenacious, defends her rights with such great effort, and is so inexorable, that it is not granted even to a demon to make use of them unless God and Nature permit; indeed, the World would sooner have to perish than that Nature should yield her rights. Therefore, whoever has a mind to philosophize rightly must in all things look to the one Archetype of Nature, so that in her intricate labyrinth — Ariadne's thread once seized — he may keep himself safe and secure from errors and misleading bypaths. This prototype, just as in the preceding Books we have described it with all the diligence we could, so in this last Book — which we have, not inappropriately, titled *The Ape of Nature* — we shall try to sketch out, as far as is permitted, by the manifold industry of art and ingenuity, so that from these things it may be plainly shown to the curious reader what one can, and what one cannot, do by the power of Nature.

We have divided the whole into seven Sections. Of these the first, as a kind of Introduction [Isagogical], sets the whole majesty of Nature before our eyes [Greek: θεωρηκῶς (theōrēkōs), "contemplatively / by way of theory" (?) — reading uncertain]; it lays open the hidden and secret pathways along which she advances; it shows the nests of her marvelous births throughout the threefold Kingdom of Nature, so that those who follow her tracks—

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—that following her tracks we may at last, through the production of similar works, attain to that hidden [Greek: ἐγχείρησις (encheirēsis), "undertaking / handiwork" (?) — reading of the Greek uncertain]. These things I have judged worth setting forth deliberately, so that — leaving aside the deceptions of profane and unlawful arts (the more dangerous, the more hidden the ways by which that enemy of the human race is wont, for the most part, to insinuate himself into them) — students of curious matters may pursue only those things which, being lawful and most worthy of praise, likewise have joined to their usefulness and respectability the greatest pleasure of mind that is drawn from them: to the glory of the Divine name, to the benefit of the Christian commonwealth, and also for the relaxation of Princes and great men, whenever they may have some freedom from the press of public affairs. Farewell, and favor my undertaking.

SECTION I

DE PANSPERMIA RERUM [On the Panspermia of Things — the Universal Seed of All Things]

CAPUT I

On the Origin, Nature, and Property of the Seed.

When God, the Best and Greatest, was about to found this visible machine of the World, He did so to this end: that in this most beautiful theater He might display a certain specimen of His ineffable wisdom, goodness, and power — a kind of Archetype of the World, which He Himself was. And He willed that it should subsist not for a momentary but for an everlasting duration. But since He knew that this everlasting duration could in no way persist amid the destruction and utter vicissitude of things that are by their own nature corruptible, in the economy of this sublunary World — lest, as things perished in the course of time, the World itself should perish along with them, and as the species failed, the World should fall away from its perfection — the most wise CREATOR, by His divine and ineffable wisdom, provided against this supreme detriment to Nature in such a way that, by alternating laws, generation should follow upon corruption, and a new generation should take up what corruption had carried off, according to the nature granted to each thing by the World's Maker; and thus the World might persevere in its perfection through this admirable vicissitude of things succeeding one another by turns.

[Margin: The penetrating, unstoppable power and might of the Seed.]

Now this was nothing other than a certain seminal or spermatic power, by whose virtue and efficacy the species of things, through natural propagation, might forestall the destruction of things. And so great is this virtue and property of the seed that in no other thing of this universe does the omnipotence and wisdom of God shine forth so clearly as in this very thing. Concerning its origin the most excellent philosophers of every age have indeed reasoned wisely; yet the more they thought they had drawn nearer to its true wellspring, the more they found themselves removed from its hidden essence and most secret intelligence. As for what, in so great a darkness surrounding this divine work, the Father of lights may have suggested to us concerning this subject, this we shall lay open to the curious Reader in a brief account.

From the sacred Mosaic Oracles, then — which we ought rightly to set, by many parasangs, before all the certainty of human knowledge — it is established that God, the Creator of all things, in the begin—

[The page's right-hand column begins here; marginal notes are keyed within.]

[Margin: God first created a certain Matter, which we not incongruously call Chaotic; from this He afterward drew forth all else.]

—the beginning created a certain Matter of things, which we not incongruously call Chaotic, out of nothing. For the glorious God created all things at once; and within this Matter lay hidden, as in a kind of [Greek: παντοσπερμία (pantospermia), "universal seed / all-seed"] confusedly, whatever of the material of things — mixed bodies and substances — was afterward to be produced in the nature of things, as it were beneath that all-seed. For the divine Architect, besides this matter and the human soul, created nothing anew; this is plain from the text of Sacred Scripture itself. And out of this single chaotic matter — as out of an underlying matter, already made fruitful by the brooding of the Divine Spirit — He afterward brought forth all things, both the heavens and the elements, and from these the composite species both of vegetables and of animals (excepting the rational soul), by the mere command of the Omnipotent voice. Each of these species was drawn from the aforesaid mass of primordial matter, and each single thing, both among vegetables and among animals, was furnished with those endowments of nature which were owed to it by the Creator's intention, and by which they might afterward, through the seminal power granted to them, propagate themselves in perpetual generation.

But the Chaotic matter He did not at once abolish; rather He willed it to endure until the consummation of the World — as in the first beginnings of things, so to this very day, filled full of the panspermia of all things. He willed that what God in the beginning produced out of nothing from the Chaotic matter should not perish — a view which the monuments of nearly all the holy Fathers chiefly uphold, above all St. Basil [Basilius] in his *Hexaemeron*.

Since this is so, it may rightly be asked at this point what that panspermia and seminal power, productive of all things, may have been. I say that it was a certain material spirit, composed of the subtler portion of the heavenly air or of the elements; and that it was a certain spirituous vapor, Mercurio-saline-mercurial [recte: sulphureo-saline-mercurial — see Caput I's later definition and the marginal heading on p. 328; the wording here reads "Mercurio-salino-mercurialem," apparently a compositor's slip], the universal seed of things,

concreated with the Elements by God, the origin of all those corporeal entities that are founded in the World. For this, according to the nature of the matrices in which—

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—in which it is implanted, produces in inanimate matrices indeed mineral and metallic bodies; in vegetables, plants of every kind; in sensitive nature, animals — each according to the nature suited to it, by a marvelous engrafting. And it is individuated into as many mixed bodies as there are species of things, by a certain ineffable combination known to God alone. And this is openly evident from so great a variety of things, and from the multitude of species, both vegetable and sensitive, which God — who alone is to Himself the idea of the things to be combined — drew forth by the power of this seed.

[Margin: The Elements concur remotely in the composition of things.]

But lest anyone persuade himself that the elements were idle in the composition of things, I say: the elements are the remote matter, while the proximate matter is that universal seed, concentrated and gathered together in the elements from the beginning.

[Margin: A twofold faculty was joined to the Seed — plastic and magnetic.]

Now since the thing produced had to consist, according to the natures of the individuals, of various figures, colors, differing parts, and members, He furnished this seed with two endowments of Nature, the architects of the said things; and these are the plastic and the magnetic powers. The former bestowed on each species its form, figure, and color; the latter gave it the attractive power for like things. But in order that all these matters may be demonstrated in order, it has seemed best to begin the subject somewhat higher up.

For who has wrought gems and precious stones into so many colors, so many figures — round, angular, and polygonal — if not the plastic power of this seed, allied with the magnetic (which we also call *corradiative*), by which alone like parts flow together to parts like themselves, with a certain wondrous appetite?

[Margin: The office of the plastic faculty.]

Who in vegetables distinguished the roots, the stalk, the branches, leaves, flowers, and fruits with such a variety of colors and parts? Surely nothing but the plastic or formative power alone. Who, in the fabric of sensitive bodies, stretched out the nerves, hollowed out the veins and arteries, filled the solidified bones with

marrow? Who bored the channels, made the flesh spongy, furnished the skin with pores? Who, in short, reduced the whole constitution of so many different animals into such figures? The plastic power alone. For there lies hidden in these things the divine Craftsman, who works in the inmost recess of the body without instrument and without commotion, and produces a work worthy of admiration — filled with so great a variety and elegance of dissimilar things, as great as we discover — and this out of rude and formless matter, in which no dissimilarity, no variety, presents itself to the senses.

But to begin our web from the lower grade of Nature, we must now consider what that is which confers upon the fossil offspring of stones, gems, and crystalline bodies so great a variety of figures, so many shapes in their polyhedral and polygonal bodies? which distinguishes them by so many differences of colors? which endows them with so great and so untamable a hardness? Surely no one will deny that the aforesaid seed is the cause, who has looked a little more deeply into these matters—

[The right-hand column begins here.]

—inanimate bodies of themselves and by their own nature require, both for their own increase and for continuing their propagation. For we do not say that metals and mineral things are generated in that manner in which vegetables and sensitive natural mixed bodies are generated from seed properly so called, nor that the account of metallic plants agrees with these; but rather in that manner which properly belongs to the generation of fossils, which is the magnetic motion, by which like bodies are called to their likes, flow together, and are united by a certain wondrous consent.

[Margin: The magnetic [power], in what it consists.]

For with this endowment, as we shall teach in what follows, the seminal power is chiefly furnished. But what this power is, and how it operates, remains to be explained. Therefore let there be:

A DISQUISITION

How the Universal Seed of Nature concurs in the generation of metals and minerals, and how it especially adorns gems with so many colors and figures.

[Margin: What the seed is in the primordial Chaotic mass.]

As we have very often taught in this work, there was a certain seed implanted in the primordial Chaotic mass of things by the Founder of things, constituted out of

the elements and a portion of the etherial fire — which we call the *sulphureo-saline-mercurial spirit* — not that it is actually constituted out of sulphur, mercury, or mineral salt, but that its virtue resides and shines forth chiefly in sulphur, mercury, and salt as in its genuine subjects. For there is nothing in the nature of things that more savors of fire, or of the radical heat, than sulphur and the other bodies born from it, because it suddenly blazes up into flame, possessing a certain desiccative and oily virtue and the other virtues and properties suited to fire. Nothing more nearly resembles the radical moisture in its watery and airy substance than Mercury, or quicksilver, in which the watery is joined to the dry, the subtle to the gross, the light to the heavy, by a wondrous proportion. And what, finally, expresses more exactly the mass of earthy consistency than Salt? — which lends hardness and solidity to all things, and yet so encloses the other two, sulphur and mercury, within itself that they seem unable to be separated from one another by any means. For this substance of salt is in a certain measure clothed with the sulphureous and mercurial virtue, to this end: that, since fire and water of themselves and by their own nature — the one by reason of its lightness, the other by reason of its fluid nature — cannot subsist, they may obtain from the salt of Nature their solidity and consistency. Hence in salt these are so enclosed,

[Margin: The salt of Nature, consisting of three [principles].]

that one thing appears constituted by a threefold virtue, in which the glorious God impressed upon His primordial creature — as the future principle, as it were, of all things — the seal of His Most Holy, ineffable, and adorable Triad.

[Margin: The Spirit of Nature, or the Saline-sulphureo-mercurial vapor, is the seed of all things.]

Hence not undeservedly have we judged that this Spirit ought to be called, as it were, the universal seed of Nature — the Saline-sulphureo-mercurial Spirit, one substance distinguished by a threefold virtue — the proximate principle of all things; to the elements—

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—to the elements, which are a kind of vehicle of it and its remote matter, implanted from the beginning of things, and destined by God the Best and Greatest for the constitution and composition of all things. For there is nothing in the nature of things that is not constituted out of this threefold virtue contained in the one salt of Nature — as the Spagyric art apodictically demonstrates, and as will be plain from the experiments to be set down a little later.

But let no one suppose that this is common, ordinary salt — that seed we have spoken of; rather, that beneath a certain wrapping, in the chamber of the inmost center, lies hidden that seminal power, the constitutor of all things, as in the first beginnings of things, so now and in future ages, perpetually to endure. And in the Salt of Nature, indeed, this threefold principle lies hidden, in which the earthy element holds predominance; in the Mercurial body these three likewise lie hidden, but under the predominance of the humid; and in Sulphur the same are found, but under the predominance of the hot and dry.

[Margin: The fire of Nature, the entelechy of Aristotle, and the seed of the World are the same thing.]

Hence by the philosophers each of these is not incongruously called the *fire of Nature* by Albertus [Albertus Magnus], the *seed of the World* by Plato, and by Aristotle the [Greek: ἐντελέχεια (entelecheia), "entelechy / actuality"], or the moving power of all things — (a heat indeed, yet not fire, nor any such faculty, but a spirit which is contained in the seed and in the foamy body, such that the nature which is in that spirit corresponds proportionally to the element of the stars; namely, that to which the soul and the plastic virtue are most nearly present is not apprehended by sense, nor is it a moisture of the kind seen in the known sperm, but something spirituous, and of celestial nature, lying hidden in it) — and by the Hermetics the *seed of Nature*, from which all sensible things derive their origin.

[Margin: How the universal seed acquires the grades of nature.]

And in this there occurs something also worthy of admiration. For if it is entrusted to terrestrial matrices, it produces, according to the condition of the matrix, either a mineral — such as a metallic body — or any other inanimate body whatever. This same thing, attracted by vegetables into seed, is converted into that from which it first obtained the first-fruits of its origin. And so in fossils a seed of this kind is inanimate; in vegetables it is endowed with the vegetative soul; in animals, finally, with the vegetative and sensitive virtue — according to the proportion of the mixed body to which it is joined, so it prevails. For any mixed body whatever, if we contemplate it more closely, we shall find to be in itself nothing other than this universal seed, which has reduced itself into an individual and a species within that particular mixed body, with the remote elements cooperating; the form too, inexistent in it, conducts this universal seed to the individual and the species. From the center of the seed, under the varied combination of the disposed matter, it issues forth. But how this can come about will be shown more fully in what follows; for now we briefly set forth how,

through a seed of this kind, minerals, stones, and metals are generated, and how they operate by their plastic power.

CAPUT II

The manner in which Nature proceeds in the generation of minerals is set forth.

[Margin: The seed of metals is not animate.]

Most chemists [Chymici] contend, wrongly, that the seed of minerals and metals is animate. For, as we said a little before, a seed of this kind obtains, according to the condition of the matrix, the grade of nature appropriate to it: if it falls upon a matrix devoid of soul, it produces something inanimate — whether mineral, or stone, or metal; if upon the matrices of plants, something animate; if it falls upon a matrix of the sensitive grade, it produces a mixed body conspicuous in both grades of nature, individuated according to the nature of each.

And the seed, indeed, insofar as it concurs in the generation of minerals, cannot maintain the name of seed properly so called; for metals, minerals, stones, and gems are not properly born from seed, nor can they be nourished by intrinsic nourishment in the manner of proper vital motion — whatever the Alchemists [Alchymistae] may trifle about the seed of gold and silver — but rather by the [Greek: εὐθεϊαν (eutheian) — here in the sense of "a straight drawing / direct tendency" (?) — reading uncertain; the term is used as a near-synonym of the magnetism that follows], that is, a certain magnetism, or by the approach and apposition of like corpuscles to like, through the Saline corpuscles in which the universal seed abounds.

But since we have treated of the manner and reason most fully in several places in the Books of this Tome, we refer the Reader thither, lest we seem to be re-pleading a case already pleaded so many times. Of the plastic virtue too, implanted in the Saline [spirit] of Nature, ample and demonstrative treatment may be seen, copiously set out, in the Eighth Book.

They are therefore greatly deceived who, from the analogy of plants and animals, imagine to themselves that minerals and metals are born from seed properly so called.

[Margin: The metallic efflorescences are not from seed properly so called.]

For those metallic "plants" which are now and then found in the mines are nothing other than efflorescences, or certain exanthemata [eruptions], not arisen from a vegetable nature, but from the evibration, or radiation, of mineral and

saline spirits into certain filaments, distilled after the manner of little twigs. Add to this, that little shrubs of this kind can easily be produced not only by nature but also by art — as will be taught from its own proper Chapter following, on the production of mineral "plants." As for the plastic virtue, which shines forth especially in the polygonal figures of gems, this surely cannot properly be called a plastic power, since the latter properly has its place in the seeds of plants and animals.

Again, that the seed of minerals is not animate is evident from this also: that no mineral or metallic body whatever it may be can nourish us; but it would nourish, if it were endowed with life — since, properly,—

— from Liber XII, Sectio I, *De Panspermia Rerum*, Caput II (continued from printed p. 329) —

[Printed p. 330; running header: LIBER DUODECIMUS, Sect. I]

we are said to be nourished by the very things of which we are composed. But we are not composed of minerals; rather, we sustain our life by the nutriments of the vegetable and the sensitive natures. There is therefore one seminal and plastic power for forming gems, and another for forming the members of vegetable and sensitive beings.

Now some chemists object that salt prepared from nettles sets into triangular crystalline tesserae. I would have you judge that this happens not by the power of common salt, but by the vegetable nettle itself. For that very lye, from which the crystals are gradually gathered as it suddenly freezes solid in the winter cold, presents a wholly different appearance — namely, that of ice itself, not crudely congealed but shaped into crystalline nettles. This is surely a manifest argument and indication of the plastic power residing in the salt of the vegetable nettle. And as for the corpuscles of the different mineral salts — niter, alum, vitriol — coalescing into different figures, this comes about not from any plastic faculty of an animate seed, but from the magnetic flowing-together of like corpuscles toward like. By this magnetic confluence, with the stone-forming power [*vis lapidifica*] accompanying it, the radiative faculty transforms gems now into this, now into another polyhedral figure — as we have amply demonstrated in Book VIII [*Lib. VIII*] and in the *Magnetic Art* [*Ars Magnetica*].

[Margin (left): The sulphur in the salt.]

CAPUT III.

On the seed-bed of plants, or the vegetable seed of Nature. [De Seminio plantarum sive Naturæ vegetabilis.]

[Margin (left): God produced all the genera of plants and animals not immediately, but from the Chaotic mass.]

It is established from the sacred book of *Genesis* that God, the Best and Greatest, created nothing immediately — neither plant, nor animal, nor any other compound thing you may consider — but produced everything from Chaos. From the Chaotic mass, brought forth out of nothing (and into which he had jointly created the panspermia and universal seed of Nature), as from a presupposed subject he produced all things: the heavens, the stars, minerals, plants, and animals. Yet it still remains to be said — so far as the dullness of our wit can grasp it — how, out of a seed of this universal and panspermic, virtual kind, he produced so many and so diverse genera of plants; how he gave them life; and how he furnished them with so many and so great endowments.

After the division of the waters, then, and the separation of the elements out of that void, and the brooding of the Divine Spirit, the mass now being furnished with its panspermia, God said: *Let the earth bring forth the green herb that bears seed, and the fruit-bearing tree producing fruit after its kind, whose seed is in itself upon the earth.* [Genesis 1:11] These words plainly indicate that the herbs and trees were not created immediately, nor produced out of nothing, but were brought forth from the earth already created and furnished with its panspermia — by the command of the Divine word, according to the combination owed to each. For from the firstborn seed he brought forth the whole variety of the vegetable economy; and into these, once produced, he implanted the vegetative power, in which lies hidden a certain potency and a power of multiplying their own kind, a power that was never to fail. And what he had first produced through an invisible and hidden seed, he now likewise constitutes through a manifest seed, which will go on propagating right up to the final consummation of the World.

The production and generation of vegetables in general, therefore, emanated from that elementary moisture — not the simple moisture, but that firstborn salino-sulphureo-mercurial Vapor — inasmuch as it includes within itself the powers and properties of universal nature; and it is individuated and made specific into the particular vegetables, which it nourishes

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[Margin (left): The seed of Nature contains within itself in power and potency a vegetative force, and a sensitive one.]

according to the genus and species of each, and according to the immutable will and intention of the Supreme Founder. For since up to this very day the whole mass of the earth has been imbued with this primigenial seed, and has never failed, hence the vegetables distribute this liquor — drawn in through their roots — into all the members of the plants. These cook it, digest it, and convert it into their own proper substance, by both internal and external heat; and from the purest part of this spermatic liquor, now digested and cooked, they form a certain body, in which there lies hidden above all, and consists, that seed which propagates the like — an invisible seed. As soon as this has fallen into the earth, it at once, as if by a kind of powerful magnetism, draws to itself a new humor, in which lies hidden that power, or architectonic spirit constitutive of all things, the salino-sulphureo-mercurial spirit. Joined to that seminal power in the seed of the now-individuated plant, it at once begins to operate; and it spurs the plant on to receive that form which Nature intends in it, and which is owed to it by the law of nature — and this by a perennial cycling-back [pericyclōsis]. For although that seed of Nature persists in the already-individuated seed of the plant, yet unless it is restored once more to its own soil, it will never bear fruit. But as soon as it is entrusted to the earth, then, with the seed of Nature drawn to it from the earth as from a friend and connatural thing, it will at once be animated, and will perfect the vegetative power according to Nature's intention.

[Margin (right): All things draw the seed of Nature.]

You see, then, how the seed of Nature is first drawn in by the seed of the plant, together with the elementary liquor, from which it cannot be separated. Next, this spermatic nourishment, still impure, passes partly into the trunk and branches, partly into the leaves and flowers, until at last, digested and cooked by the heat both inner and outer of the sun, its purest portion is at last converted once more into seed, for propagating the like. This seed of Nature, therefore, by Divine command and intention,

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[so that] the decays [putredines] of all things ferment by nothing but salt. Vegetables, in their final dissolution, leave behind nothing but salt; animals, of whatever sort, swell with salt. What else are the feathers of birds but the efflorescence of salt condensed into the covering of plumage?

[Margin (left): The feathers of birds are coagulated.]

Surely human and animal urine, with which they swell, shows well enough that it is something saline — urine that they so greatly delight in, that they feel they can be preserved and made fertile by no other balm of Nature than the saline one. Hence they so eagerly long for it; with such avidity do they suck, lick, and gulp it from the ruins of old walls.

[Margin (left): Animals are preserved by salt.]

Doves and the rest of the birds eagerly dig the cracks and fissures of the ground, seeking it out by their licking. And it is proper to the genus of fish to live and be preserved by salt. This salt, dissolved and insinuated into the roots of plants, produces that variety of herbs which we marvel at — for the nourishment of men and animals, so that we may be nourished by that from which we are composed. And we are nourished by that spermatic salt which is found in the final dissolution of all the foods that are taken. What else is it but the seed and a kind of quintessence and ἐντελέχεια [Greek: entelecheia, "entelechy," actuality/perfection] of all the parts of which we are composed? And on this very score salt may be called an animate seed,

[Margin (left): Seed is animate salt.]

inasmuch as it is extracted, for use in medicines, from all things both vegetable and animal. What is more wonderful than human urine, which by suitable prepara-

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[Margin (right): Dew is a species of salt.]

-tion is rendered fit not only for medical use, but even for dissolving gold and silver? That it is a vegetable thing is recognized from this: that any plant, once cooked down into salt and set into pure earth, in time reproduces the same plant that had been dissolved into salt. Of this truly marvelous operation of Nature we shall adduce more experiments in what follows.

I will not speak here of dew, which the Spagyric Art [*Ars Spagyrica*] shows to be a vapor congealed into salt — from which it draws out a menstruum of such great efficacy that, no less than from common salt, saltpeter, niter, it dissolves corals and pearls; and it is proper to this menstruum to be dissolved by cold moisture and condensed by heat. The mineral [salt], just as it is divided into diverse

species, so too prides itself with stupendous powers in each, so that there is no genus of salt — whether it be common salt, or alum, or niter — that is not found in each of them. The species of metals derive their hardness from no other source than from an abundance of fixed salt. Take one pound of lead: from it, once calcined, you will extract nearly ten ounces of salt — and so with the rest.

[Margin (right): Experiment.]

This [salt] is found also in the higher regions of the air, as is plain from the wondrous effects of meteors. But since we have treated at length of the four species of salt in Book VI [*VI. Libro*], we refer the Reader thither, where he will find discussed whatever can come up worthy of consideration concerning this argument.

CAPUT V.

How the universal seed concurs in the generation of animals, and on the wondrous efficacy of the plastic power in the seed of animals.

[*Quomodo semen universale ad animalium generationem concurrat, & de mirifica plasticæ virtutis efficacia in semine animalium.*]

We said in the preceding Chapter how, from the universal seed placed in the Chaotic mass, the Founder of all things brought forth plants as from an underlying matter. Now it remains [to show] how, from the same matter, on the fifth and sixth [days] he brought forth animals of every kind. We suppose, then, that God, the most high and glorious, first brought forth from it both plants and animals; whence that universal seed — just as in the already-produced plants it acquired, along with the vegetative grade of Nature, a vital faculty as well — so in the animals brought forth from the same matter on the fifth and sixth day, it shared in the sensitive grade of Nature, according to the good pleasure of the Creator.

[Margin (left): The universal seed is salt.]

And in this manner this seed, through the continual attraction of nourishment — which in each grade of Nature is produced from its final cooking — by which also, by the successive and alternating vicissitude of generation and corruption, the species both of plants and of animals are propagated up to this present day, and will be propagated up to the consummation of the World. But the seminal faculty, by which it accomplishes its operations, since it is too subtle to be grasped lightly, I shall explain a little more fully.

It must be supposed, then, that for the life of living things, and for the right accomplishing of their operations, there is necessarily required a concurrence of heterogeneous parts; since it cannot be that either plant or animal should live, or rightly perform its actions, by homogeneous parts alone. For if all the parts were of the same nature, the operations of all would assuredly be the same, not diverse — according to that maxim: *Idem in quantum idem semper facit idem* [The same, insofar as it is the same, always does the same]. Hence not inappropriately does the Philosopher [Aristotle] define the soul as the act [*actus*] of an organic body — that is, [a body] which has diverse organs and instruments, which it uses as necessary for the diversity of its operations. But just what that is which accomplishes that diversity of parts in animals, I now explain.

We said a little before that God, when he brought forth plants and animals from earth and water chaotically commingled, at that same moment established each of the species of things in its natural being. But in very truth, since they — being [made] from the corruptible mass of the elements — [could] not sustain themselves in

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[Margin (left): The spermatic power that gives propagation to things.]

perpetuity [by themselves], he therefore implanted in each a spermatic power, by which they might propagate themselves, by perennial succession of things and by the alternation of life and death — or, what is the same, by the vicissitude of generation and corruption — right up to the very duration of the World. And in this way each species, whether of vegetables or of animals, would be preserved in its own state and in its natural essence. But how, and from where, the propagative power draws its origin, and from where it comes, I now set forth.

[Margin (left): What is the universal seed of things?]

We said above that the universal seed of things is nothing other than a salino-sulphureo-mercurial, spirituous vapor, by which all things that are in the World are composed. But this vapor, distinguished by a threefold power, I would not say is compounded out of mineral and sensible salt, sulphur, and mercury; rather, [I would say] that there lies hidden in the innermost central chamber of these something that we call the fire of nature — or that which, with the Peripatetic [school], we call the heat innate in all things, which shines forth above all in sulphur, [the heat] of all the things that exist in the nature of things, as we have demonstrated at length in Books Nine and Ten.

In mercury, by contrast, [we said] there lies hidden something most like the radical moisture, which corresponds exactly to the faculties of water and air, without which no corporeal substance can subsist; and it shines forth most of all in mineral mercury. Inasmuch as mineral mercury is the most moist of all things and the driest, the heaviest and the lightest, the hottest and the coldest — which alone Nature was pleased to establish in a perfect degree of contrary qualities — so it most closely emulates the faculties of water and air, as we taught in the chapter on the incomprehensible nature and property of Mercury. Yet I would not have these things understood as if this seed were compounded out of the common Mercury [of the vulgar]; but rather that in the innermost center of this mineral compound there lies hidden a certain admirable power, which the Philosophers call radical moisture, of which Mercury can be called, as it were, an external covering. And this is that power which confers radical moisture on all things, without which nothing could live.

[Margin (left): Sulphur and mercury reside inseparably in salt.]

But since, just as heat cannot subsist without moisture — as being its nourishment — so neither can these [things] be condensed into a corporeal mass without a certain faculty which furnishes consistency and corpulence to all things; and we say that this [faculty] lies hidden in the center of the salt of Nature. Yet since this saline power also cannot subsist without the sulphureous and mercurial [powers], hence most wise Nature has so enclosed both [of these] in the saline body — as in their base and support of all things — that they cannot be separated from one another. And this is the seed of universal Nature, which the most wise Founder first created together in the chaotic mass, so that out of it he might thereafter, by the command of his omnipotent voice, bring forth all the things that are contained within the compass of the World, as from an underlying matter. And this indeed — according to the grade of Nature suited to each, insinuated and individuated into the several species both of vegetables

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and of animals according to the good pleasure of the divine intention — produced that variety of things which we marvel at. And in the vegetables, now established in their species by the glorious Founder, that [seed] is nothing other than that radical moisture, by which all those things that are endowed with the vegetative faculty are, as it were, nourished. And from the final cooking of this [moisture] by the innate heat — that is, by the sulphur made by nature — there is born in plants that seed which, deposited in the earth and animated by a new salino-

sulphureo-mercurial spirit, propagates the species of each thing, lying hidden as a power in its proper seed.

[Margin (right): Of what the seed consists.]

But since an animal cannot live without nourishment, animals therefore have need of nourishment, by which the moisture consumed by heat through attenuation may be restored; and nourishments of this kind are none other than the fruits of the vegetable and sensitive nature, by which we are fed and sustained. But since nourishment of this kind is of a heterogeneous and dissimilar nature, hence, within the stomach, Nature there separates the pure from the impure by digestion and fermentation. The pure it transmits, partly to the liver, partly to the heart, for the elaboration of blood and spirits; the impure, however, it expels like dregs through the two excretory passages [secessus].

[Margin (right): The plastic power innate in the seed.]

But since the seed of Nature is always joined to nourishment in an inseparable bond of partnership, hence too is born that plastic faculty, always connected to the seed, which surpasses all wonder. For by this [faculty] the substance of the body, constituted of so many heterogeneous parts and members, draws its origin. For what is saline in the seed of nature has been deputed by nature for the forming of bones and the other harder portions of the body, without which it could not obtain a solid substance. The moisture of animals — that which lies hidden in the seed — supplies the mercurial [element]; and the nerves, cartilages, and ducts of the veins, being of a more tenacious and viscous nature, accordingly obtain [their being] partly from the mercurial, partly from the saline and sulphureous fatness, by a marvelous combination. The remaining humors: first the blood and phlegm derive their nature from the predominance of mercurial moisture; bile, from the humor burnt by the sulphureous power; black bile [atra bilis], from the separation of the dregs of the blood burnt by heat. But the vapors attenuated out of the mass of the blood by heat — which we call the spirits, both animal and vital — are produced by that fiery power lying hidden in nature in the sulphur. Being the most spirituous and the most subtle, they alone, diffused through all the inmost recesses of the human body, uniquely govern the microcosmic Economy, perpetually urging each thing on to the motions, operations, and actions suited to it.

These things, then, being duly established: since the whole fabric of animate beings is constituted out of the corruptible confluence of the elements, lest the species of things should in time utterly fail, Na-

[Continues onto printed p. 334.]

has appointed another body, surpassingly wise, for whatever results from the final concoction of the nutriment — a body into which all the members of an animal converge, as if upon their own center. Each part transmits whatever has been best concocted within it — whether humor or spirit — into the center of the microcosm, that is, into the vessels Nature has set apart for it. This is that prolific seed by which the species of all living things are propagated. Just as it is constituted from the spermatic spirit of all the members, so too it is rendered, of itself and by its own nature, apt to produce something like the very thing from which it falls away. For once it has been cast into the womb as into a fertile field, the saline, sulphureous-mercurial species at once begin to radiate, each performing the office assigned to it by Nature. Thus the mercurial-sulphureous element in the seed, according to the varying law of combination, flows by a wonderful magnetism toward the members sympathetic to it — that is, toward the principal vessels of the body: the heart, liver, lung, brain, and so on, out of which they came — there to form members like themselves. The saline power latent in the seed, which had been derived from the bones into the seed, undertakes a new fabric of bones; and judge likewise of the rest of the members. Thus whatever lies hidden in the seed, proportioned and sympathetic to some particular member, is at once excited by the native heat and strives to form that very member, by its own radiation, in a like and proportioned place and position.

But so that the manner and reason of this admirable plastic power may be perceived more and more clearly — so far as the weakness of our understanding permits — we shall endeavor to confirm it by experiments. For scarcely anyone has set out its genuine account among the philosophers: most expound these differing accounts of the seminal power through universal and metaphysical concepts, and I have found no one who treats of its proximate causes — except that most learned physician, most distinguished in the experience of things, [Marcus Marci] Marcus Marci, who in his excellent work *On Operative Ideas* [*de operatricibus ideis*] touched the matter, as the saying goes, with a needle's point, and to whom we gladly subscribe. [Margin: In what the radiative power of the seed consists.]

But that the manner and reason may be understood more clearly: it must be known that the nature of Salt — as we have sufficiently shown in the *New Book* [*Liber Novus*] — is endowed with a certain radiative power, by which it forms nitrous, aluminous, and vitriolate bodies, and likewise gems, into various shapes: three-sided, four-sided, five-sided, and so on. This could not happen unless there

were in it a power by which, radiating from some one point of itself into different parts, the saline particles might at last form that polygonal figure in crystalline bodies. This radiation, or ἐκτινοβολισμός [Greek: ektinobolismos, "radiation outward"], by which the saline corpuscles — of themselves, by their own nature, and by an innate appetite, as they flow together toward one another — form a certain definite figure, we say is nothing other than the filaments of the saline corpuscles, in positions differing under a certain proportion implanted in them by Nature, and the thrusting-forth of them within the moist matter under certain limits — which, once the moisture is consumed [recte: dum... — "while it accomplishes the last concoction of the nutriment"; the sentence breaks across the column]...

which accomplishes the last concoction of the nutriment; then, the moisture being consumed, no otherwise than the stony spirits [*spiritus lapidifici*], they coalesce into a polygonal body. And because we have already given a demonstration of this in the cited passage of the *New Book*, we did not wish to repeat it here. For even though such a plastic faculty cannot constitute an organic body in fossils, it nonetheless does what it can: if not a plant or a living animal, it at least imprints something analogous to them, suited to the grade of nature — as was said at length in the cited *Book on the figures occurring in various stones*. In vegetables, however, and in things endowed with sense, this plastic power appears far more wonderful. For what else are the so very diverse figures of plants as to their branches, leaves, and the arrangement of their leaves, flowers, and fruits, but the marvelous effects of this plastic faculty? Surely what Nature attempts in minerals and gems with a crude brush, she does not cease to attempt far more excellently in leaves and flowers: according to the condition of the species, by her radiative power she now distributes them into three leaves, as in the herb trinity [*herba trinitatis*]; now into five, as in cinquefoils [*pentaphylla*]; now into six, seven, eight, nine, ten, and finally into innumerable efflorescences with an innumerable variety of colors — all of which are effects of the plastic power. And this, if God grants life, will be demonstrated in the *Book on the Hidden Characters of Nature* [*Liber de occultis Naturae Characterismis*], where the works of Nature shine forth. But who could sufficiently marvel at what the plastic faculty effects in forming so many and so different parts of the body? Yet, lest we leave so hidden a subject unexpounded, I shall in a few words not so much explain the manner and reason as merely point to it.

It is certain that the plastic faculty, or formative power, does not take its origin from some external agent, but from the begetter of the seed. For that likeness which holds between the one generating and the one generated can be

established on no other ground than the seed of the animal cast into a suitable womb. For if it were produced by some external agent, there would be no reason why, for example, human seed once discharged should degenerate into a dog or a cat rather than into a man. I say, then — to come at last to the point — that this plastic power is diffused equally through the whole mass of the seed; that is, it is in a certain way whole in the whole and whole in each part. The reason for this is that from one seed sometimes single offspring, sometimes several, arise; and a whole offspring is perfected no less from some one part than from the whole; and finally, that no confusion of parts, no disturbance, occurs — except very rarely, as in monsters — which nevertheless would have to happen if [the parts] were related to their subject in a non-uniform way. [Margin: The plastic power diffused through the whole mass of the seed.] Hence I would not have you think that the subject of the plastic power is altogether simple, but rather, as it were, composed of many parts: for that portion of the power which, so to speak, formed the brain, will by no means produce the liver or heart; and that which gave shape to the bones, will by no means [shape the mem-]...

branes, or extend the coils of the intestines; but each tiny portion of the subject contains the whole of what is to be formed — just as is wont to happen in the displaying of the species in a dark place upon a bright object. Let this, then, be the first experiment. [Margin: The plastic power operates in the manner in which species, introduced into a dark place from without, express the object encountered there.]

EXPERIMENT I.

By which the radiative force of the plastic faculty is demonstrated.

Let the figure of a man, with all and each of his members, be painted on some object exposed to the rays of the Sun. This done, in a dark chamber — following the experiment of this book on Chromatic Photism [*Photismus Chromaticus*] — let the species of the image of the man just painted be admitted, through a very small and pointlike aperture, onto a sheet placed in the darkened room; and you will learn by experience that the species of the image is represented within, together with the color of each member. But if you bring the sheet up to the aperture, the whole diffusion of the species will be confounded, and nothing will appear but a bright circle. The farther you move the board from the aperture, the more the species of the image will unfold, until they have reached their natural perfection. Here it is certain that the rays radiate from the individual points of the members of the image through the medium, and are united, unconfused, in the pointlike aperture, where, even though to the senses the radiation of the light

appears simple — yet, once unfolded a little — you will find it stamped not with a simple species but with a certain infinite variety of colors, distinct in its individual parts and divided without any confusion, εὐτάκτως [Greek: eutaktōs, "in good order"]. You will see, with admiration, the individual members radiate together each into its own, and together with the species the colors of the individual members likewise differ; if [you wish to see] that thing in the nature of things which explains that incomprehensible plastic power, this surely explains it.

I say, then, that by precisely the same reasoning the plastic power, or the artificer of form, is contained in the sperm, just as the species of colors are in the air. For the seed, falling away from all and each of the parts by the aphrodisiac motion and by a spermatic ἐκτινοβολισμός [Greek: ektinobolismos, "radiation outward"] into the womb of the woman — as into a place natural for the prolific radiation — there, the matter being indeed simple and homogeneous, involved as regards sense, yet, the natural heat of the vessels promoting it, begins by its radiation to unfold. And through ideas and spermatic reasons of this kind, the parts begin to differ, the members to be distinguished and set apart from one another. Therefore, just as in the single point of the aperture all the visible species are contained virtually, yet once unfolded they distinguish the figure, position, and colors of the individual members, so exactly does the plastic power behave in the sperm.

For some rays, because longer, reach the outermost surface; others end suddenly from their first emergence; others are bounded by a spherical surface, others by a plane, others otherwise — from which all variety redounds into the foetus, as appears in the figure.

Diagram. A camera-obscura schematic illustrating the formative ("plastic") power by analogy to the projection of an image through a pinhole. On the left stands an upright nude human figure (a man), his arm raised toward the center; rays drawn from his outline converge toward a central point. In the center is a circular aperture rendered as a set of concentric circles (the pinhole), at whose middle the point A is marked. On the right, beyond the aperture, the same human figure appears again but inverted (head downward), with rays diverging from A to trace its inverted outline — the projected, unfolded image.

- A (center, within the concentric circles): the pointlike aperture (*foramen punctuale*) through which the species pass, where all visible species are contained virtually and unconfused.

- **B** (left, beside the upright figure): the object — the painted figure of the man, source of the radiating species ("the members of the man B").
- **C** (lower right, beside the inverted figure): the projected image — the species collected and unfolded onto the sheet (the foetus / "the place of the womb A," with members projected from B, C).

[The accompanying text reads: "Where you see the species, collected from all the members of the man B, C, projected to the individual points of the seed at A, the place of the womb, and rolled together from the point A — in which they are indeterminate and exist only potentially and virtually — thence gradually excited by the heat of the womb, first into the principal members, then into the remaining members, distinguished by unequal time and motion."]

Now the order of nature seems to require that the nobler parts, on which the rest as it were depend, should be unfolded first by radiation. And so we see the heart, before the emergence of the others, even then beating manifestly with bloody fibers as the vital instrument of the spirit; then the brain; after this the liver; then the lung and the stomach gradually display their lineaments. Of this matter, take the following experiment. [Margin: An experiment of the plastic faculty from the hatching of an egg.]

EXPERIMENT II.

Setting forth the marvelous force of the plastic Virtue.

Take an egg pierced on the third day from the start of incubation, and opened with the care that is fitting; inspect the yolk diligently with a microscope, and there will appear in it the manifest shape of a heart, congealed like a drop of blood, alive and stirring itself in a certain wonderful manner with bloody fibers — from it, as rays from a torch on every side, and as streams drawn off from a spring, [the fibers issue]. And although the vital motion of the heart and the arteries appears at once after the third day, nevertheless none of the remaining mem-[bers]...

of the members are yet to be found taking shape, until, after four more days, the spinal column appears, drawn down from the brain like a kind of rudiment and a nebulous substance. Then successively the remaining members, according to the perfection of each — in which the individual organs are sculpted suited to their functions, and the colors proper to each are painted on the individual parts, and each is endowed with the savor and odor proper to its own nature — until they grow out into the perfect mass of the fabric. And if anyone were to observe, on

each successive day, one of the eggs broken from the first incubation, he could without doubt easily come to know, in the manner described, the order and the processes of the members in the generation of any creature — as in man, since the reasoning of the members in an animal is the same as in man.

It is therefore plain from these things that the unfolding of the species into the individual members is by no means *ὁμοῦ-γε* [Greek: *homou-ge*, "all-at-once"], that is, simultaneous, but happens — according to the unfolding of the more perfect and less perfect parts — now sooner, now later. All of which is also plain from the displaying of the colored species: unless you display these at a precise distance from the aperture, you will detect nothing else, on either side [too near or too far], but a crude figuring of the species. And just as the species radiate from the center into a circle, each individually with its own rays, unconfused, so too the species of the plastic power [radiate] from the center into the circumference — no otherwise than the mind of the Maker of the world unfolds from the center of the earth all the species of the world-machine into the most disparate members, into the elements and the celestial globes. [Margin: The World was created after the manner of the plastic faculty.] First indeed He globed the Sun, as it were, into a kind of heart of the megacosm; the Firmament into a brain; Saturn into the spleen of the World; Mars into the liver, Mercury into the lung; Jupiter into the spirits and the blood; Venus into the seed of the heaven; and the Moon, finally, into the hypochondria — fashioning all things into a great man by a good covenant. [Margin: Analogy of the members of the human body to the celestial members.] And so, that in the small man too [these things come about] by the unfolding of the species, together with their color, savor, and the rest of their properties, ought to be doubtful to no one.

From this point a single difficulty arises. If the plastic power were to unfold the species of the members latent in the sperm, it would follow with infallible proportion that all men would be alike in the delineation of their bodies and in their other affections. But this is so far from being the case that not even among many thousands of thousands of men are two found alike in all respects. In man, who does not marvel at the variety of faces? Who would not be astonished at the differences of gait and of taste in individuals, amid so great a diversity of natural inclinations? [Margin: The dissimilarity that holds among men.] I say, therefore, that this so great variety of things is not to be ascribed to the plastic power alone, but to the imaginations and effects, and to the perpetual motion of the versatile human wit in the parents, vigorous while they come together. These, as it were touching by their radiation the disposed matter, imprint upon it that variety we have spoken of. And since this wandering motion of the mind ceases in [the

other] animals, it is no wonder that for the most part individuals so alike are found that they can scarcely be distinguished, and are marked off only by spots of color. [Margin: Why there is not as great a dissimilarity among animals as among men.] The manner in which parents imprint on their children the species of things vehemently agitated in the mind, we have set out at length in the *Magnetic Art* [*Ars Magnetica*], in the chapter on the Magnetism of the Imagination, to which we refer the reader.

CHAPTER VI.

On the spontaneous origin of living things, or the hidden seminary of those things that are said to be born from putrid matter.

At no time has the wonderful subtlety of any philosophers' minds whatsoever been so tormented by this subject, full of admiration, that there is scarcely anyone who agrees with another in deciding the cause of such great wonders. Hence, for many years now, I have applied myself wholly to this question with the greatest zeal, that I might come to know whence at last that marvelous seminal power in plants and animals born spontaneously derives its origin. And since I saw, not without reason, that I was rolling the stone of Sisyphus [*Sisyphus saxum*] — that is, laboring uselessly and fruitlessly in this hidden work of nature — if I clung to the scrutiny of remote causes and to metaphysical concepts, I therefore set these aside and turned all my study to exploring the proximate and immediate causes of these effects, partly by observations, partly by [practical] experiments [*experientiis enchareticis*]. What I have found, I have thought worth communicating to the reader.

I suppose, then, first — as I have also intimated in what precedes — that universal seed which is saline-sulphureous-mercurial, and which, according to the grade of its nature, obtains its power either ἄψυχον [Greek: apsychon, "soulless / inanimate"], that is, inanimate, if it be individuated in inanimate things; or vegetable, if in vegetables; or animate, finally, if it be joined to the animal grade — according to the ratio of the seed proper to each species, in keeping with the intention of the Divine Architect implanted at the beginning of things. [Margin: For the ratio of the universal seed individuated in inanimate things.] But between this universal seed and the particular seed implanted in each thing there is so great a consent of nature, that the one cannot be revived into new offspring without the other. Yet as soon as this has been sown in the earth, then at once, by a certain magnetism implanted in nature, those [particular seeds] flow together to it; and in this way they accomplish the effect intended by nature.

I suppose, secondly: since the substantial forms both of plants and of animals (excepting always the rational soul) are drawn out only from the potency of matter, surely those forms are material and divisible — this is necessary; whence it is also necessarily deduced that in all and each of the parts of plants as well as of animals [there is something of that form latent]... [Margin: The substantial forms both of vegetables and of animals are drawn from the potency of matter.]

[there is something] of that form latent in [all] the parts, together with a portion of the seed; and that it remains not only in the bodies of the living, but even in the cadavers of the dead. Which we say is nothing other than the form, clothed with the universal seed now individuated in it. For in the saline-sulphureous-mercurial center of this seed there lies hidden that Spirit which gives life and sense even to those things or matters with which it is mixed, as we shall show more fully hereafter.

I suppose, thirdly: that earth, water, and air are full of seeds of things of this kind, which — as they are certain very minute corpuscles — are likewise easily raised into the air, whether by the Sun together with the vapors and exhalations both from the land and from the sea, rivers, and lakes; and thence, carried by the force of rains, snows, winds, and air into the various regions of lands, mountains, and fields, wherever they find a proportioned matrix — there at once, by the seed's plastic power, not at all sluggish, they begin to weave the web of life for those things with which they are joined, by their own ἀκτινοβολισμός [Greek: aktinobolismos, "radiation"], to be formed in the disposition due to each member. [Margin: All things are full of seeds.]

And so we deny that the proximate spontaneous cause of living things is the heat of putrefying things; we reject the concoction of putrefaction, putrid substance, or putrid corpulence; we do not admit as the sole and immediate cause God's concurrence in producing them, or the concurrence of the Divine archetype, or [that of] the idle nature of God; nor the work of the intelligences; nor the influences of the stars; nor the celestial light; nor the heat of the surrounding [air]. Rather, all these we embrace only as remote causes; but the panspermy [*panspermia*], or that seed cut off from the cadavers of dead plants and animals, and the seeds of all things, we declare to be the proximate cause of these effects — the said causes, as we have said, concurring only remotely. [Margin: The proximate cause of spontaneous living things.] In this opinion we gather that even [Aristotle] Aristotle himself was, from his definition of the origin of spontaneous living things, when he says: *the first participation of the nutritive soul with the warm*. By this he understands nothing else, when he treats of

spontaneously growing things, than that in things that have ceased from life as well — whether vegetables or animals — a certain power lies latent, depending on the last concoction of the nourishment, which it first participated from the vegetable or sentient soul while it was yet among the living; and that from this [power] still latent in cadavers, the generation of spontaneous things is caused. For that a spontaneously living thing can by no means be generated, we have shown above, except from matter which has already in some way previously been living or animate, whether one place it in the series of plants or of animals. [Margin: Something of the soul remains even in dead things.] For since in the second supposition we have already shown to some degree that something of the soul remains in all and each of the living, even after death, together with the seminal power — surely, whether the part of the living thing be wood, leaf, fruit, excrement, cadaver, or anything else — it is always [there] in the disposed matter, in fermented putrefaction; and [from it] either something of the same nature as the prior species, or of another, is produced, even with Hippocrates himself attesting it in his book *On the Use of Members* [*de usu membrorum*], in these words: *From the dead, he says, come nutriments, increases, and seeds.* [Margin: Hippocrates.] By this he beautifully insinuates that the nutriment which we take from vegetable or animal nature contains three things in itself, namely the nutritive, the augmentative, and the generative faculty — which last the final concoction of the nutriment supplies. Such a threefold faculty, therefore, results only from the parts or fruits of the dead, that is, of living things now deprived of life. For nothing can be dead which did not previously in some way live; and although by this seed Hippocrates understood the true and proper seed of things, yet in a secondary sense he is seen to have understood thereby the proximate matter also of the spontaneous generation of living things — as is plain from this, that he says a manifest seed lies hidden within the matter of a thing to be born spontaneously. Therefore the proximate matter of the generation of things born spontaneously is that seed of ours, in which the spirit lies hidden, as a kind of soul cut off from the living thing (as [Fortunius Licetus] Fortunius Licetus knows and teaches) and remaining in the cadaver — not as a form, but as the spirituous corpuscles of that living thing, in which the soul subsists as in a vessel left after the death of the living thing. [Margin: Fortunius Licetus, book *On Spontaneous Origin* [*de Spontaneo neo-vivente ortu*].] [Margin: The soul remains in the seed, not as a form, but as in a vessel.] And of this we have as witness even [Aristotle] Aristotle himself, *On the Generation of Animals*, book 3 [l. 3. *de Gen. Animal.*]. [Margin: The soul not conceived as a form.] ...chapter 11 [*cap. 11*], where he speaks of the spontaneous origin of living things: *Animals and plants are generated*, he says, *from the earth and from moisture, since moisture is in the*

earth, spirit in the moisture, and animal heat in the whole — so that in a certain manner all things are full of soul. Here he plainly understood our seed: by the moisture in the earth, the saline power; by the spirit in the moisture, the mercurial; by the heat, finally, the sulphureous — which, united together in the same seed of Nature (which is salt), contains within its center that spirituous part, as a kind of soul cut off from the cadaver in which it remains. This [soul], implanted at last in matter proportioned to it, the external heat disposing the matter, brings forth either a vegetable or some animal. [Margin: Aristotle, *On the Generation of Animals*, book 3, in the vessel.]

And so living things are truly generated from a cadaver by spontaneous generation; but the same things do not rise again and revive in the same number — neither the soul nor the animated substance — for a twofold cause. [Margin: From a cadaver living things are truly generated.] The first of these is that in the spontaneously generated thing the instruments are not the same in number as those that were present in the cadaver from which it was generated, but others newly produced — lest anyone suppose that a generation of this kind from a cadaver is a giving of a return from privation to habit, since the spontaneously generated thing differs at least in number from the former living thing, as [the offspring] is an origin from a changed cadaver. The other cause is that it most often happens that, in the death of the former living thing, the heat gradually failing, the material nature of the soul is weakened into a worse, more imper-[fect condition]...

[Continues onto the next folio.]

into a worse and more imperfect condition, so that it degenerates utterly in its essence and species — as will become clear afterward from the little animals that arise from the bodies or excrements of living things.

Caput VI.

On the various classes of spontaneously generated things.

You may judge that this spontaneous generation of plants from the earth comes from nothing other than the many corpuscles — whether of plants, or of animals, or of both — driven against the earth by water, by wind, or by the creatures' own cadaver. Joined together into one viscous, sticky body and worked over by the surrounding heat, these acquire a temperament and a degree of heat that make them apt, so that the soul long hidden in them, as in a vessel, may at last bring itself forth into a vital form that constitutes the new plant. [Margin: That the

corpuscles of various plants are sought out from all sources — *Corpuscula variarum stirpium ex omnibus rebus petuntur*.] These corpuscles are everywhere: flitting about in the dusty air, stirred by the force of the spirit; partly steeped in the waters; partly scattered across the surface of the earth on every side. From there they are carried into the bosom and inner parts of the soil through the hidden chinks of open passages, riding the vehicle of the rains. Out of that place, once roots have at last been put forth, they rise up into plants.

These corpuscles, although they do take the place of seeds and correspond proportionally to seed — as we learned earlier from Aristotle — are nevertheless not truly and properly seeds, but rather a kind of wrapper for the seminal principles [*seminalium rationum involucra*]. This too is what Anaxagoras held, by Theophrastus's report, when he maintained that the air contains within itself the seeds of all things. Corpuscles of this kind are of various sorts: each one, derived from things that once lived, retains an enfeebled particle of soul — as both vessel and place retains it — together with a modest heat, with juices and vapors, and with dusts and fragments. In these the seminal force must reside, weakened (though not so far weakened as in those from which we have seen tubers and fungi spring up spontaneously) — I mean those plants which in dignity surpass fungi and tubers.

[Margin: Why fields are made fertile by ashes — *Agri cur foecundentur a cineribus*.] Ashes assuredly make fields fertile for no other reason than that they are the remains, or contain the remains, of bodies once animate. On this principle — as Theophrastus and Pliny report — an olive tree that had been entirely burned up came back to life. Nor do rains and dews make the earth more fertile than rivers do (the Nile alone excepted) for any other reason than that in the rains and dew there are mingled many fragments of cadavers carried along with the exhalation and vapor — as Plutarch too shrewdly noted. The Nile, however, because of the very long and very broad sweep of its course, and because it swells most of all from the rains of Ethiopia, carries far more little portions of cadavers than any other river or any rainwater or dew. This is why it is the most fertile of all waters; and once its impurities have been deposited as sediment, because of its extreme thinness and lightness it is the best and most healthful for drinking.

To this same point belong also the things said by Pliny somewhere about the spontaneous origin of laserwort [*Laserpitium*]. [Margin: The spontaneous origin of laserwort — *Laserpitii ortus prodigiosus*.] "We find," he says, "very clearly stated among the authors of Greece that it sprang up when the ground was suddenly drenched by a pitch-black rain near the gardens of the Hesperides and

the Greater Syrtis, seven years before the town of Cyrene — which was founded in the hundred forty-third year of our City — and that this force coalesced over four thousand stadia of Africa" (Pliny). We have the same from Theophrastus as well: for the rain was thick and black like pitch, because it carried within itself many fragments of dead plants and animals, which, driven into the soil, were able to promote a spontaneous origin of plants over that whole tract.

[Margin: Three kinds of plants from the putrid — 3. *Genera plantarum ex putri nascentium*.] And so it has come about that we may divide this spontaneous origin of plants rising from the earth into three kinds. Let the first have its proximate matter — that of the thing spontaneously born in the earth — already present beforehand, and from no other source than the excrements of plants and animals, or the parts that have flowed off from the bodies of those very living things and become immediately mixed with the soil. Let the second kind have the same matter set into the earth by the floodings of waters, whether rainwater or river water. Let the third and last kind of spontaneously born things have its matter — containing within itself the proximate effective cause of its origin — communicated to the earth by the air, whether by the force of the winds or in any other way.

Theophrastus too once enumerated these modes in the spontaneous generation of an untouched forest. But it is enough for us that plants are born spontaneously from the earth out of the parts of cadavers — whether of plants, or of animals, or of both — parts imperceptible even on account of their smallness, which first come together into a single mass that contains within itself a vegetal soul as if in seminal matter. This same soul, once the mass has been worked over by the surrounding heat and disposed toward life, gives itself over into the form that brings life and constitutes the new plant. Now that the general division has been laid out, let us proceed to the particular partition of these same things.

Under a fourfold class we comprehend the supreme species, as it were, of spontaneously generated things: two of these pertain to plants, the other two to animals. [Margin: From the putrid are born some pertaining to plants, others to animals — *E putri nascentium species duplex, ad vegetabilia, ad animalia pertinens*.] There are certain ones established in the first grade of vegetating nature, which we may not inaptly call *geophyta*, that is, "earth-plants" [*Planto-terrestria*]: such are all the species of tubers and fungi. The second class embraces all the genera and species of plants that are born spontaneously. Likewise two classes are contained among the animals that are born spontaneously: the former of these are a kind of middle thing between plants and animals, lacking

progressive motion — such as all those things the philosophers call ζώοφυτα [Greek: zōophyta, "zoophytes" — plant-animals]. The latter

are all those animals that possess the faculty of motion, and they contain all the genera and species of land insects, of flying creatures, and of aquatic creatures. And just as imperfect earth-plants [*geophyta*] stand to perfect plants, so zoophytes stand to animals — which you may see exhibited in the synoptic table at Sect. 2, c. 1, in what follows.

[Margin: Things born spontaneously always require a presupposed seed — *Spontanascencia semper praesuppositum semen requirunt.*] First, then, I would not have you suppose that spontaneous life arises so spontaneously — without any efficacy of seminal force, but by chance and accident, as many think — by no means. For I do not consider that any spontaneously born thing takes its rise except such as can be assigned no origin other than from elsewhere: either from the cadavers of stocks and plants, or from spermatic corpuscles cut loose in whatever way at last from things that have ceased to live. For since the substances of plants, the powders of roots, trunks, and seeds, and the excrements and juices of stocks and animals are nowhere lacking in the earth — chiefly on its surface — it ought to seem no wonder to anyone if, when many such scrapings and excrements have been collected into some one place, first joined by moisture as by a glue into a soft and workable substance, and then concocted by the heat of the surrounding air, they turn out to be a disposed matter. Its soul — that spirit, whether vegetative or sensitive, existing within the seed of nature as in a vessel — becomes its life-giving form; and by the agency of the surrounding heat and its own, it forms and fashions for itself an underlying body into the shape either of a plant or of an animal. But let us now set forth the origin of each kind.

§. I.

The genesis of earth-tubers and fungi.

Among the spontaneous offspring of vegetable nature, tubers and fungi hold the first imperfect grade of vegetable nature. Since they lack root, branches, leaves, and fruits, they are accordingly established among the plants we call γεώφυτα [Greek: geōphyta, "earth-plants"], or earth-plants, as constituting, so to speak, the grade of fungi in vital nature. [Margin: The various species of tubers and fungi — *Tuberum fungorumque variae species.*] Now there are various species of tubers: for some grow up into bosses, some into caps, certain ones into knobs; some swell up after the manner of pine cones; some are spread out in the fashion of a liver; nor are there lacking those that stretch out into a confused branching like fingers;

and finally some pass over even into the shape of the human male member, or into the shape of a foot or a navel — the reasons for which we shall assign in what follows. No less a variety of colors is observed in them: some are dusky, others blackish, certain ones saffron-colored or of a green color. These arise from the various color of the earthy substance to which the seminal matter is joined; and indeed it is the proximate matter that effects the difference in things, which is not granted to the remote matter. They are all born either from rotten trees and wood, or from earthy slime, or even from rocks.

[Margin: Fungi born from rocks — *Fungi ex saxis nascentes*.] And first, that fungi feed from rocks, daily experience teaches us. Here at Rome, in our own household garden, we have a rock that produces very large and excellent fungi — and we took care to have it brought from a mountain near Tivoli, which they commonly call *monte di Poli*, or *Guadagnuolo*. For on that mountain — as I saw with my own eyes — fungi of such great size grow out even from the driest rocks that they at least equal, if they do not exceed, large gourds. These earthly fruits are held in such great esteem that His Excellency Ioannes Nicolaus Appius de Comitibus [Giovanni Nicola Conti], Duke of Poli, and for the time the most worthy Governor and lawful possessor of these mountains, is accustomed to appoint certain men to that office. As soon as they have seen the traces of the fruit bursting forth on some rock, with particular care they at once fence the rock about with thorns, lest the work of the fungus that has begun be destroyed by the trampling of the herds of goats and sheep and the cattle that pasture on those mountains. Then, once these fungi have attained their full maturity, he offers them both to the Supreme Pontiff and to the other leading men of the Roman Curia as a wondrous, rare, and harmless stimulant to the palate.

Ferrante Imperato, in his *Natural History*, under the name of "fungus-tuber" [*tuber fungarium*], calls the fungi just recounted, and says they have been seen to exceed a hundred pounds in weight. [Margin: Neapolitan fungi — *Fungi Neapolitani*.] They are born — on the testimony of Cardano — when certain broad stones, after the manner of tables, are buried; these they find in the Samnite countryside at a depth of four fingers below the earth, and then, water having been sprinkled on, within four days they abound in the groves and have a swift origin. Mattioli concurs with this: "So great a favor has fungi come to enjoy along with the tables in Italy today that, especially at Naples, there are stones which, dug up and transferred into wine-cellars, covered a little with earth, and then sprinkled with warm water, produce within four days fungi not unpleasing." Porta says that when the old fungi and rocks have been harvested, new ones always spring up beneath; that they reach perfection in seven days; that they are

harvested six times a year, the earth covering the stones again to a depth of nine inches [*dodrante*].

At Naples, from Vesuvius; at Sorrento, from Mount Fageto, the highest mountain of its district; at Avellino, on Mount Parthenius; in Apulia, from Gargano. They report that at Naples, in the gardens of the wealthy, these stones, covered with dung, everywhere produce a numerous offspring of fungi; and that certain stones placed under the drip of a wine-cask produce — even in a single night — fungi not only pleasing to the taste but also harmless.

With these matters set forth, it is now asked: how are these fungi born from earth, wood, and rocks? [Margin: How the fungi are born from rocks — *Fungi qui è saxis oriuntur*.] I reply: from the various outflow of seminal force, whether of stocks or of animals that have died — which outflow is nothing other than spermatic corpuscles. These, insinuated within the inner recesses of the rocks, watered by the moisture of dew, mist, and rains, and roused by the surrounding heat — since, on account of the weakened strength of the seminal force and its variously altered condition, they cannot produce plants or animals — generate, lest they seem like idle things to have produced nothing, a substance of the lowest grade among the vegetables, which are commonly called tubers and fungi. The cause that these same things are born from stones sprinkled with wine is that

a great quantity of seminal force exists in the grape-clusters, which, as it is still present in the wine, so too the wine can produce the said offspring of fungi through the animating power of the vegetating force latent in the seed. And so, among the plants, tubers — the rudiments of stocks — and all the rest of the fungi, of whatever sort they may be, are born: either from the effluvium of seminal corpuscles of plants or animals, both living and dead, conveyed into earthy matrices; or from the juices, excrements, and putrefaction of the parts of herbs and animals, both living and dead; or from the outflow of corpuscles endowed with seminal force, received into pores and hollows as into certain matrices, and cooked by the surrounding heat. At last — since they cannot generate anything more perfect — they produce, according to the condition of the matrix, a fungus or tuber that is good or virulent, harmful or harmless. [Margin: Fungi born in venomous places are venomous — *Fungi in locis venenosis nati venenosi sunt*.] This is clear even from this: that where herbs or animals are venomous, all the fungi springing up spontaneously in that same place are found to possess a deadly force.

[Margin: How the fungi born in venomous places are venomous — *Quantò... fungi in veneno nati*.] For the more the seminal force in the matter cut loose from

cadavers degenerates — through various alterations and mixtures of the most diverse things — the more imperfect an offspring it will always beget, whether in the vegetable or in the sensitive kingdom. So that, with the genuine seed from the stock or animal from which it was cut loose gradually failing, just as this seed cannot maintain the grade of sensitive nature, so too it degenerates into a zoophyte or some plant; and that other seed [degenerates] either into a plant or into a fungus; or, if the vegetative force fails entirely, into some inanimate body — as is plain in fungi and plants turned into stone. But let these things said about the origin of tubers and fungi suffice. It now remains for us to investigate from what source the spontaneous origin of vegetables, plants, and herbs draws its beginnings.

Caput VII.

By which combinations of substrates the plants and animals that are born by spontaneous generation are exhibited.

[Margin: Places apt for producing animals from the putrid — *Loca apta ad animalia ex putri producenda.*] The substrates from which both plants and imperfect animals are born are: first, the earth itself, the fertile producer of all things; second, dung-heaps; third, the porous substance of rocks and cliffs; fourth, the waters and the air — sea waters, lakes, marshes, rivers, the standing ditches of stagnant waters are the substrates from which many things are born spontaneously; fifth, the trees that produce things like themselves; sixth, the trees that generate things unlike themselves; seventh, living animals, which now and then produce both plants and animals; eighth, the cadavers of various living creatures, from which sometimes foreign forms — both plants and animals — arise; ninth, minerals and metals, from which, as the histories relate, plants have grown out; tenth, snowy substance. We shall try to assign the origins of all of these.

[Margin: How they are born from the earth — *Qui ex terra nascantur.*] It is asked, then, first: how are plants and animals born from the earth itself? I reply: in the primordial production of things, all the little plantlets of the more tender substance were brought forth from the universal seed of Nature — that is, by the force and efficacy of the vegetable salt diffused through the innermost depths of the whole earth — distributed into innumerable species according to the intention and good pleasure of the most wise Creator. These then, from the seed-store implanted in them, every year pour forth new seed-beds of herbaceous offspring, in this manner: the herbs which, from the beginning of spring — that

is, from the vernal equinox — sprouted forth into a vast propagation up to the autumnal equinox, those same herbs, when the rains come on and they have rotted, entrust to mother earth a new seed — implanted in their roots, in the leaves of their sprouts, in their seeds, and in the other parts of the herbs — for the renewal of the spring season. [Margin: An example from hay — *Exemplum à foeno.*] When that season returns, behold, the seminal matter, now as if fermented by rains and snows and roused by the heat of the Sun, soon luxuriates into that abundance of sprouts and herbs which we feel with great delight of mind in the spring season; and this by a kind of perennial revolution [*pericyclosi*] that will never perish so long as the world stands. (I speak, however, chiefly of the European climate — lest anyone suppose that this spontaneous genesis of herbs is observed everywhere at the same point of time.)

From the seeds, therefore, implanted in the parts of each herb — first rotted and entrusted to the earth — they revive, at the arrival of the new heat as a guest, as if from some pyre. This is so true that even the driest and most sapless hay, as soon as it has been steeped, rotted, and fermented by frequent rains, grows up in its season — by the force of both external and internal heat — into a rich crop of various herbs, for no other reason than by the virtue and efficacy of the vegetable seed, in which the soul lies hidden and which is present in each part of the herb according to the second supposition.

It is asked, second: how are insects born from the same earth? I reply: there always lie hidden in the earthy substance not only the spirits of vegetables, cut loose from the cadavers, as it were, of rotted plants, herbs, and stocks (as was said just a little before), but also animal, spermatic spirits cut loose from the cadavers of various living creatures. These, set into a proportionate matrix, at once muster

to the work of perfecting their generations. Hence, since from an animated seed — now weakened and degenerate — it cannot generate a perfect animal like the one from which it was cut loose, it at least does what it can: if not a perfect one, then it produces at least an imperfect or "infected" something, all the nobler the less the animated seed cut out from some cadaver has been weakened, and the less it has degenerated from its pristine form — as is plain in insects and mice. [Margin: How they are born from seed — *Qui ex semine nascantur.*] For when a particular seed, cut loose from animals that have died, has been entrusted to the earth, and there at once joined and mixed with the universal saline-sulphureo-mercurial seed, it is animated to a certain degree and is solicited into vital fruits. For unless the seed falling into the earth has died — as our Savior CHRIST testifies — it cannot bear fruit. And so the union of the universal seed of Nature with the

seed brought in from elsewhere, in a fitting and proportionate matrix, produces spontaneous offspring of this kind.

[Margin: How they are born from slime — *Qui ex limo nascantur*.] It is asked, third: how do both herbs and imperfect animals arise from dung? That plants are born spontaneously from dung needs no proof: for since — as the Philosopher [Aristotle] testifies — the matter of generation and of nutrition is one and the same (inasmuch as living things are nourished from the same things of which they all consist, and they consist of that matter from which they were most recently begotten — for the end of generation is both the being and the constitution of the begotten thing), and since plants are everywhere nourished and increased by dung, who would deny that plants are born from it? I reply, then, that plants arise from dung in this way. It is everywhere agreed that in dung there are very many excrements of both plants and animals — juices and parts confounded into one. It therefore comes about that dung-heaps, steeped by rains, winds, and the floodings of waters, and fermented by heat, at last bring forth a great many herbs and animals according to the grade of the animated seed.

But to demonstrate the matter more closely: chiefly a threefold kind of matter can be considered in this dung-born genesis. For it is either a juice coming from plants; or a portion of a plant already putrefied, or its excrement; or — if you attend to the genesis of animals — it is either a juice, or a portion of a cadaver, or an excrement; or it is from the bodies of both, which has flowed off from cadaverous substance. In this matter, spirituous corpuscles, roused by a slight heat while they flow together toward things like themselves, at last fermented, attain the degree and temperament of heat necessary for life. By this the matter at last, according to the degree of heat latent in the seed, rises up either into a plant or into an animal, with partial causes concurring, as it were — both the heaven and the air moistening from above, and the conceived heat working it over. The vital spirit, or soul, dwelling in matter of this kind, as soon as it has perceived the matter placed beneath it duly prepared, at once gives itself over to it as the actuating form. From this, by spontaneous origin, it constitutes new stocks, and by its plastic seminal force implanted in the mass it strives forthwith to fashion it into an organic body.

It is asked, fourth: how are plants and animals born spontaneously from rocks and the cement-like substance of rocks? [Margin: Whence they are born from rocks — *Qui è saxis sponte nascantur*.] That plants spring up from rocks, and grow up from the crannies of walls, daily experience teaches us. That coral is born

from cliffs, we have shown fully above in Book 9, in the chapter "On the genesis of coral." Yet I would not have anyone suppose, when we say that plants grow out from stones, that plants and animals come from the very substance of the stone — for who does not see how far this is from the truth? We therefore say that where stony substance is filled with pores, fissures, and hollows, there too within these — by the force either of rains or of winds — the seeds of various things are carried in. Softened by the moisture of the rains, and then fermented, both by the surrounding heat and by the native force of the vegetal seed or by the heat of the sensitive [seed], and at last according to the grade of nature implanted in the seeds, this produces now these, now those herbs and insects. It also happens occasionally that birds, nesting among the cliffs and the old walls of buildings, bring together there various species of fruits or seeds, which, mixed with the moist soil, at last bring forth those same species of things.

[Margin: The author's observation — *Authoris observatio*.] I myself have observed this matter almost daily in the rubble of ancient structures — as here at Rome, both in the Amphitheater of Titus Vespasian, which they call the Colosseum, and in the aqueducts of the Baths, and in the monuments of the temples — which are so overgrown with dense thickets of wild fig, mastic, fig, ivy, cornel, elder, cypress, and the burgeoning growth of the other plants and herbs, that they could seem to be a forest. Indeed, some of these shrubs grow into so great a mass that with their roots they split apart even the thickest walls, as if with some wedge; and so much so that — as will be seen in our Latium — I judge the aqueducts and the structures of the old temples were destroyed in time not so much by the irruption of the Barbarians as by stocks and shrubs of this kind. For while the roots of the wild figs, mastics, and ivies thicken over time, the framework of the walls too must necessarily gape apart, the continuity dissolving. Hence the so many and so great cadavers of the proudest structures, met with everywhere throughout all Latium, declare well enough that our reasonings are true. But of these things I shall treat expressly in my *Description of Ancient Latium*.

But to return to our purpose: the spirituous corpuscles of animated seed — cut loose either by the wind or by birds, or even from plants and animals that have ceased to live, and raised up into the air together with vapors, and there mingled with the dissolved rains or snows in which they are present — once they have fallen down into the hollow places of rocks, at last bring forth in that same place the variety of spontaneously generated things which we have described. Hence no one ought to wonder if he has read among the historians that — as Pliny relates — a palm tree sprang up at Tralles on the stone base of a statue of Caesar the Dictator; [Margin: A palm born on the base of Caesar's statue — *Palma nata in*

basi statuæ Caesaris.] and that the head of a statue of Lysander of Lacedaemon [Sparta], by Cicero's account, [sprang up] from rough and wild herbs; it is no wonder that on the roof of the Capitol there was once seen a palm,

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[Margin: Palms and figs on the Capitol.] ...and afterward a fig tree too grew there, as Pliny [Pliny the Elder] reports; for such a fig has remained alive on the summits of the Capitol and the palace down to this very day. The same may be observed of figs that grow on statues placed in Roman pleasure-gardens. This happens whenever the fruits of palms and figs are carried there by the wind or by birds and, rotting among the hollows of the stones and bricks, sprout from the seed lodged within. On statues, the seed-bearing particles shed from the surrounding trees fall into the pores of the marble statues and produce plants of this kind.

For the hollows of stones, just as they are filled by the frequent overflow of rains, mists, and dews, so too — together with the scrapings worn away from the rocks — they mostly turn into mud (if moisture is present) or into an earthy clod, once the moist warmth has dissolved them. Within this clod the various particles of seminal portions are received and, as though digested in a genuine womb, cannot fail to be transmuted into a plant or animal, according to the manner in which the seed has been carried there. As for plants that grow from virgin earth in a place where there can be no seeds of things — something experience has not infrequently taught me — I say this comes about from the universal seed implanted in the earth from the beginning of things. By this seed, under a particular combination, now one herb, now another is brought forth, proper to the climate under which such plants usually arise.

[Margin: Herbs born from bronze statues.] If indeed, as the histories relate, herbs have sometimes been born from bronze statues, this is not to be taken to mean that a seed — whether vegetative or sentient — resides in metallic bodies. Rather, it means that within the cracks and hollows of the statue various seeds of things have been carried, either by the wind or by birds, or that they were born there from the droppings of birds.

The Fifth Question. How are herbs and animals born from waters by spontaneous generation? [Margin: How things are born spontaneously from water.] We are not speaking here of herbs that grow spontaneously *in* the water, of which there is no counting, but of those that float on the surface of the waters without roots and propagate themselves in a remarkable way. Of this sort

Theophrastus says the *Mnasias* herb is, and also the herb they call *phyllon* [φύλλον (phyllon, "leaf")], which floats on standing waters without a root. In just this way [Margin: Moss on the surface of standing waters.] we see moss and duckweed [Greek: ἀκρίδας (akridas?) — printed ἀρεῖς, reading uncertain (?)] floating on the surface of pools of stagnant water.

[Margin: Sargasso, an herb on the surface of the Atlantic Ocean.] All who sail the Atlantic Ocean are struck with wonder by that weed which the Portuguese call *sargasso* [sargassum]. With it the Ocean is strewn in certain places — never fixed or determined — so densely that they might be called green meadows. This rootless weed floats on the surface of the sea, drifting here and there as the winds drive it. Of it Léry [Jean de Léry] writes in his account of his voyage: "Moreover," he says, "for fifteen days we passed among weeds floating on the sea, whose density and quantity were so great that, had we not cut through them with axes — our ship being unequal to breaking through — and so made our way, I judge it would have come to pass that we should have run aground. And because that great mass of weeds made the sea somewhat turbid, we believed ourselves to be in muddy marshes, and accordingly judged that certain islands were nearby. Yet when the sounding-lead was cast, to which a line 500 fathoms long had been tied, we neither touched bottom nor caught sight of any islands or mainland."

Christopher Columbus [Christopher Columbus] likewise, when in the year 1492 he set in motion his expedition to discover new regions across the Ocean and had gone a little beyond the Canary Islands, found the sea so weed-choked that it looked like a meadow — the weed approaching in color the pale yellow of hay already dried out, with leaves not unlike those of garden rue, and berries blackening after the fashion of juniper grains.

[Margin: The origin of sargasso weed.] The question therefore arises: from what does this herbaceous progeny derive its origin? I say: if berries of this kind serve in place of seed — as I truly think they do — then the generation of this weed must by no means be reckoned spontaneous; rather, like other herbs, it is propagated by the power of the seed they produce. I have heard from our Fathers that, in place of roots, it sends out from itself certain very long filaments which nonetheless do not touch the bottom; and since they are not anchored, the weeds may not improperly be called floating ones.

[Margin: Cock's-comb weed, poisonous.] This too is worth considering: that some red material grows upon it, shaped like the comb of a rooster, whose touch is so dangerous that hands rashly drawn to it become inflamed and swell to a remarkable degree; and so people abstain from it as from a deadly poison. But if

we are to believe that the origin of these weeds is spontaneous, like the herbs cited above, then we can assign four reasons for this generation. [Margin: A fourfold account of the generation of this weed.] The first is that on the surface of standing water a great mass of dust and scrapings settles, derived from decayed plants or animals; and where this has acquired, through the surrounding warmth, the dispositions necessary for life, the seminal force latent within it at once begins to take shape into some plant.

The second reason may be that this matter — coming from plants whose life has ended, or from animals — arises from living things previously dwelling in the waters, or from their excrements and various fatty effluvia. On account of its rich and oily nature it is borne everywhere to the surface of the water like oil; and there, digested by coction through the surrounding warmth, once it has procured for itself the disposition necessary for life, it at last fixes the soul to itself [animam sibi necat —] into the substantial form that vivifies the new plant.

The third reason may be that from the underlying matter a perpetual exhalation always carries up to the surface of the water some portion of the rich excrement from the carcasses of animals, or of plants that, rotting, cling to the bottom of the water — such as seaweed [alga] and sea-moss [muscus marinus] — from which at last, through faulty dispositions, plants of this kind arise. The fourth reason is a compound of the three already given. That a plant can arise from exhalations of this kind, Aristotle [Aristotle] himself teaches in these words: "Exhalations," he says, "once they have congealed, can grasp the cause by which it comes about that a plant arises." This indeed cannot be said of simple exhalations;

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but [it can be said] of those which have some admixture cut off from elsewhere and bearing something of an animate seed. In ditches of standing water — water which, being unmoved, likewise [draws something] from the dusts or rains borne in by the force of the winds, full of animate seed — it draws over itself a kind of muddy skin, which, fermented by warmth, at last produces a plant of the sort we see arising on the surface of standing waters.

[Margin: Those born from stocks of a different species.] **The Sixth Question.** How do spontaneously generated plants arise from stocks of an unlike species and of a heterogeneous nature? We are not dealing here with those that are born on trees and plants of a *similar* species — such as the buds that can blossom on each and every part of a tree, being born from the same seminal power inherent in the whole tree; nor with the fruits proper to each particular tree, as in the case of the

carob, which produces its pods not only on the branches but pushes them out even through the very hardest bark. We do not speak, then, of things of this kind, since none of them is born by spontaneous origin, but is connatural to the plant.

We speak therefore of offspring of a heterogeneous nature that are born of their own accord, from time to time, on trees and herbs — such as mistletoe [viscum], horsetail [hippuris], lichen [licnon — recte lichen [?]], and the moss common to nearly all trees. To herbs, meanwhile, there sometimes cling certain other filaments of a nature heterogeneous to the plant itself, as is evident in dodder [Epithymum], in *epistoebe*, *epithymbron*, *epipolion*, and *epichamaedryon* — herbs so named because such dissimilar-natured things cling onto Thyme, Stoebe, Thymbra, Polion, Chamaedrys, and similar herbs, with their root founded in the very stem of those herbs.

[Margin: Mistletoe — how it is born on trees.] Mistletoe grows on nearly all trees: it occurs on the oak, the apple, the pear, the hardwood-oak, the holm-oak, the terebinth, the pine, the fir. The question therefore arises: how does mistletoe emerge of its own accord, and on trees alone? To untangle this, I say that it can come about in four ways, of which two concern a spontaneous origin and the remaining two a non-spontaneous origin.

For it can happen that the vegetable seed of an old plant, once rotted and degenerating from its former power, produces a more imperfect plant within the bark and within the bark's clefts, filled with a mud-making mold. Secondly, it can happen that the seed of another plant — whether snatched up by a bird or driven by the force of the winds into the cracks of the bark and into the hollows of the branches where they meet — generates a plant of a disparate condition. [Margin: A cherry from an oak.] In this way a cherry tree was seen to come forth from an aged oak — doubtless from cherry-stones brought there by birds. But of these matters there is fuller treatment in the *Art of Grafting* [*Ars Emphyteutica*].

The third manner of herbs and animals being born of their own accord is when dusts filled with a mixture of various seeds slip into the cracks of trees; for these, moistened by the heat [recte: rores, "dews"? — printed "tore"; reading uncertain [?]] and the rains, settle into mud, in which the force of the seed, once fermented, is at last disposed toward producing a plant or animal — according to the grade of nature inherent in the seeds. In this way there is no doubt that moss is generated; and so, without doubt — Pliny being witness — [Margin: A laurel from the stern of a ship.] a laurel grew up from the stern of a ship, when the laurel-berries, lodged within the ship's clefts and cracks filled with mucilaginous matter, blossomed into a laurel once rot and fermentation had run their course. The

same, we say, must be asserted of the parsley [apium] which Pliny relates grew up from the sides of the flagship of Antigonus.

The fourth manner is when the various excrements of an old plant, scattered abroad from the carcasses of stocks and animals into the wrinkled bark of a tree, produce a plant or animal of a nature different from that from which it flowed. [Margin: The origin of mistletoe from the droppings of the thrush.] The origin of mistletoe, indeed, is so well known that it is tiresome to write anything about it. Who does not know that it is born from the dropping of the thrush — so that it has passed into a proverb, "*the thrush sows the evil for itself*" [turdis sibi ipsi malum cacat]? For the thrush produces the very thing by which it is afterward caught. Hidden in this bird's dropping is the seed either of the mistletoe itself, or one compounded from the nourishment of various herbs which the thrush uses; and since for the most part it differs from the older forms, it accordingly produces a degenerate mistletoe plant — and hence mistletoe is found on nearly all trees.

I do not doubt that the droppings of many other birds produce on trees similar herbs — polypody [polypodium], hart's-tongue fern [phyllitis], and other monstrous plants of spontaneous generation, or even insects. But those things which are born spontaneously on other trees and plants are mostly very different herbs. [Margin: Ivy is not to be reckoned among things spontaneously born.] Theophrastus observes that ivy is born on trees, which I would nonetheless by no means think should be placed among the spontaneous origins of living things; since, weighed down by a great swelling of seeds, it can easily grow into ivy from berries carried into the cracks of trees, whether by the snatching of birds or by the wind. [Margin: Laurel on the plane tree; walnut, oak, and cherry on the willow.] Pliny relates that a laurel was once born on a plane tree; Scaliger [Julius Caesar Scaliger] being witness, a walnut, a cherry, and an oak [were born] on a willow. Pausanias, in his *Arcadica*, records that a fig established its birth on a laurel, and an olive [was] the offspring of a holm-oak.

[Margin: How spontaneously born from animals.] **The Seventh Question.** How do plants sometimes arise by spontaneous generation from animals? Many marvels of this kind are read everywhere among the historians. [Margin: Ivy between the horns of a stag.] Theophrastus recounts that ivy was seen growing between the horns of a stag, to which Aristotle subscribes in these words: "A stag has now been caught bearing green ivy grown upon its own horns — which, perhaps inserted into the horn while it was still tender, grew together as upon green wood." The origin of this was none other than that the stag, from rubbing

against trees or even against ivy, received the dislodged berries into the shaggy covering of its head; and these, taken up afterward by sweat, dew, or the nightly damp together with admixed dusts, found as it were a muddy soil, in which the grain, fermented by the surrounding warmth, at last blossomed into ivy. Yet I would not readily place even this among things spontaneously born, since it could have blossomed forth from the true and real seed of the berries, just as if cast into earthen soil. But if we suppose the stag from feeding [on] ivy—

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—on ivy, by the power of the seed lying hidden in that nourishment, [the ivy] arose with the stag's internal warmth as craftsman — then it might rightly be reckoned among things spontaneously born. But the former explanation is the more likely.

[Margin: A barley-stalk found in the bladder.] Plutarch [Plutarch] relates that a certain man, when he had suffered from difficulty of urination, at last expelled a knotted barley-stalk. It may be asked: how could this come about? I say it happened because, since this man for the most part fed on raw barley-grains, it chanced that some portion of the seminal particles flowed, together with the nourishment, into the bladder; there, in the course of time, within the viscous matter of the bladder, the seminal force, stirred up by warmth, grew into an ear of grain from which the seed had flowed. Yet I judge that prodigious births of this kind happen not so much from any seminal power as from some magical enchantment. Who does not know that there have been certain persons who are reported to have cast up by vomiting not only herbaceous matters but even iron nails, tufts of hair, and similar excrements contrary to nature?

[Margin: Ears of grain born from the nose.] Of this same stamp is what Lycosthenes [Conrad Lycosthenes] reports in his book *On Prodigies*: that ears of spelt [farris] grew from the nose of a woman of Arezzo, and that she vomited up the same grains of spelt, in the year after the City was surveyed, 94 years before Christ — at which time Ptolemy, King of Egypt, died at Cyrene and left the Senate and People of Rome his heir. As for such a prodigious birth — if it was not produced by the aid of a demon, then surely no other account of it is available to us than the one we have given concerning the barley-ear born within the bladder. Let me add here something most worthy of wonder.

Leo Allatius [Leo Allatius], in his *Bundle of Letters* sent to learned men by those who had perceived [these things by experience] [Greek: αὐτοψία (autopsiā, "by eyewitness/first-hand observation")], reports an event truly memorable for every

age, concerning a certain Spaniard who, having fallen in autumn from a tree into a thornbush, felt ill for a long time, and said he felt the pain chiefly between his ribs. [Margin: A plant born from a certain man's ribs.] And just as, to one examining him, no trace of swelling or bruise appeared, so too he did not greatly attend to the malady. It happened, however, that in springtime the malady, growing worse, displayed a certain tumor, and within a few weeks grew so much that, along with the swelling, it also put forth some branching thing, and at last the rudiment of a complete plant — with such increase that in summertime it became necessary every year to trim the luxuriant shoot with shears. Often the attempt was made, now by scarifications, now by incisions, to root out the plant's root, but in vain; for the roots had spread not only through the ribs but even through the hip itself all the way into the thigh, until at last, the root being entangled in the muscles and tendons, it brought death upon the man.

The cause of this matter may be asked. I say it came about from the thorn, which, fixed deeper into the flesh and covered over by the skin, from the inflow of a corrupt humor — in which, as in a proportioned womb, the seminal force of the thorn was roused — in the course of time, its roots driven deep, pushed out beneath the skin this truly prodigious shoot. For, as we taught in the preceding [chapters], the seminal force lies hidden not in the seed alone but in the whole substance of the plant; and this, having obtained a suitable humor fermented by native warmth, at last brought forth within the mold of the corrupted flesh this portentous birth.

COROLLARY [COROLLARIUM]

From these things it is evident how on the backs of whales [Margin: Whales.] there sometimes grows so great an abundance not only of moss but also of seaweed and of the other plants of the sea, and of every kind of shellfish, that they can appear to be small islands floating on the sea. This comes about, namely, from the filthy refuse of the carcasses tossing in the sea, which clings to the wrinkled backs of the whales (whose mucous hollows of cracks are filled with it); and also from the excrement expelled from the recesses of the beast's own body, which — cooked both by internal and by surrounding warmth — transmutes the force of the latent seed, however weakened, now into this, now into that plant or shellfish.

[Margin: Dolphins overgrown with coral plants.] It is also written in the history of the Arabs that dolphins, of which there is a vast abundance in the Red Sea [Erythraean Sea], are sometimes found overgrown with coralline plants. The cause of this matter I have given in the Tenth Book, in the chapter on the

generation of coral [De Corallogenesi], where I have also recounted the matter of a human skull preserved in the treasury [Gazophylacium] of the Grand Duke of Tuscany, on which a coralline plant is seen to have grown — see the account there. [Margin: Asparagus.] Concerning ram's horns growing into asparagus, see below, from Pliny and Cardano [Girolamo Cardano]. That plants can arise from the carcasses of animals — and indeed that asparagus is born from ram's horns — experience teaches and reason proves, as was said of certain cases in the preceding [chapters]. But of these matters [there is] more in what follows.

CAPUT IX.

How both Zoophytes and Insects of every kind are born from the bodies of more perfect animals. [Quomodo tum Zoophyta, tum Insecta omnis generis ex perfectorum animantium corporibus enascantur.]

[Margin: The origin of Zoophytes.] Animals that are born by spontaneous generation are of three kinds. First, Zoophytes; second, insects of every kind; third, those which exhibit a complete four-footed form among animals, and, among winged creatures, those that display the form of a feathered being — of which there is a great variety. We shall treat of each in turn.

Zoophytes, or plant-animals [plantanimalia], are those which—

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—fixed to rocks by the interposition of what are, as it were, certain roots, hold indeed an immovable position after the manner of plants, yet perceive objects by sense: for they spread themselves out, as it were, toward the things necessary for their life, and are accustomed at once to contract themselves away from things hostile and harmful to them. Of these there are many kinds, such as sea-nettles [urticae marinae], sponges, acorn-barnacles [glandulae], and those which they call sea-*phalli* and sea-*vulvae* from the resemblance — to which some also add the mole [mola] born in the womb of a woman; indeed all things that adhere enclosed in shells, as are the various kinds of shellfish, of which there is no number. All these, since they possess life and sense, are accordingly counted among animals, even though, like plants, they always obtain an immovable state. That life is in them, their growth sufficiently shows; that sense too is in them is shown by the fact that they contract at once when touched.

All these things have no other origin than from the seminal portions of carcasses, in which the sea abounds, driven by the agitation of the waves into the cracks and clefts of rocks; and these portions, according to the diversity of the seminal

particles, having first been fermented by warmth in the mucous hollows of the cracks, at last bring forth either this or that zoophyte. [Margin: The origin of crustaceans, testaceans, and molluscs.] But concerning the origin of shellfish, since I have dealt with it at length in the Fourth, Fifth, and Seventh Books, I refer the reader there.

Those are called *insects* which obtain a status next after the zoophytes, and are of three kinds: *crustaceans*, *testaceans*, and *molluscs*. Crustaceans are beetles of every kind, with wings set into a crusty covering. Testaceans are those covered by a shell — as, among four-footed creatures, tortoises, and among many-footed creatures, the various species of crabs — which arise partly by spontaneous, partly by non-spontaneous generation, but have propagation from their own seed. Thirdly there are the Molluscs, which, among flying creatures, lack a crust — such as all kinds of flies, gnats [cinyphes], wasps, hornets, butterflies; among marine creatures, all the bloodless ones; among land creatures, all the kinds of serpents and worms; and among four-footed creatures, the kinds of mice, frogs, and lizards.

Now the spontaneous origin of all these is manifold, according to the variety of the matter. For some are born from earth, snow, and mud; others from snow itself; of others the begetter is earth, of others air, of some the stocks and trees — and even fungi are their mother; some are generated from the sap of plants; some from the excrements of useful and useless things; others from the carcasses of plants; some are likewise drawn out from animals, both of the same and of a different species; from the excrements of useful and useless animals, and from carcasses whether of the same or even of another species; and finally some are produced even in the very hardest rocks. The reasons for all these we shall try to assign in the following questions.

[Margin: The origin of zoophytes, of crustaceans, testaceans, and molluscs.] **The First Question.** How are zoophytes of this kind — such as limpets [lepades], scallops [pectines], sea-cucumbers [holothuria], and the like — first produced from the waters by spontaneous generation? [Margin: Those produced spontaneously from the waters.] I answer: this comes about from the juices of animals — whether living or devoid of life — driven from the body, in which (as is plain from the suppositions) there are many seminal particles containing, with a slight warmth, a part of the prior soul, though much degenerated and impaired. When these have, through the concocting warmth of the surrounding medium, put on the dispositions necessary for life, they at last, according to the manner of

the seed and the combination of the matter, rise up into this or that insect through the specific form that constitutes animals.

For no one can justly deny that many animals live in the waters, that the carcasses of the dead are dissolved, and that from both a juicy and excrementitious matter, mixed with the waters, arises. [Margin: *Aristotle, Hist. nat.* 5.] For as Aristotle rightly says in Book 5 of the *History of Animals*: "Common to all worms, and to those things that come from worms, is that the principle of generation is furnished either by a spirit or by a seminal account." In this way the kind of worm they call *Tapulae* or *apyae* [ἀπύας?] is born in wells and in ditches filled with putrid water; and their generation is this: From seminal particles carried into the waters from elsewhere and mixed with mud, there first arises a scum, which, rotting, first gleams with a white color, then is foul with black, and finally reddens to a bloody hue. These, little by little having through warmth obtained the due disposition, float on the surface of the water like seaweed and put on a rind; and when this is burst, a gnat [*culex*] emerges — so very troublesome to men and beasts.

[Margin: The origin of frogs, mice, oysters.] **The Second Question.** How are frogs, mice, oyster-shells [*ostreoderma*], and other things born from earth or mud by spontaneous generation? That most animals are produced from earth, mud, or slime no one is unaware: the boundless multitude of earthworms and other worms sufficiently shows it. Of frogs there is no need to speak, since I have already mentioned them often enough. That frogs are born from marsh-mud is a marvel, says Pliny: in the half-year they are dissolved into mud, with no one observing, and again in the spring rains are reborn. [Margin: Oppian.] Oysters [*ostrea* are born] from foamy mud, from the seminal force and efficacy of the sea, as Oppian [Oppian] teaches in these verses:

They do not couple, nor do they bring forth offspring by [sexual] bonds;
They are born of themselves, as oysters [are born] from foul slime. The
light oyster has its scum, never distinct [by sex]; Among these fishes
neither male nor female is known.

[Margin: The origin of sea-nettles, purples.] Sea-nettles [*urticae*], murex-snails [*purpurae*], and razor-clams [*ungues*] are spontaneously begotten — and all things that cling fixed to their own houses, the origin of all of which is the same. [Margin: The origin of the *Tapulae*.] Oyster-shells [*ostreoderma*] are born from mud, Pliny being witness; the origin of the whelks [*buccina*] is the same; the origin of the pond-oysters [*limnostrea*] is from muddy places; mussels, razor-clams, and scallops are formed in sandy places with the mucilage of the sea

coming between. [Margin: All things are born from mud.] In a word, all things are generated from mud, according to the manifold difference of the mud: in muddy [mud], oysters; in sandy [mud], mussels; on rock,— —in the little hollows of rocks, sea-cucumbers [holothuria], barnacles [balani], and limpets [lepadæ] and snails [nēritæ]; in mussels [mytili], purple-shells [purpuræ], and whelks [buccina], the same cradles. That mice are born from mud, Egypt teaches: for when the Nile recedes, little mice are found, the work of generation already begun in the water and earth—already alive in part of their body, while their newest extremity is still earthen clay. This prodigious mode of generation Ovid [Ovid] describes most graphically:

[Margin: Ovid.]

They find, among these, some begun in the very span of their birthing, some half-formed; and often, at the same time, they see one truncated at the shoulders—and at that same moment one part lives, while the other part is raw earth.

I shall say nothing here about certain fish—such as eels and mullets—which, it is agreed, are born spontaneously from the seminal principle [seminium] of their own body. For it has been observed, as we have said elsewhere, that if someone drains off all the water and all the mud, or even digs a new ditch, nevertheless, once water flows again into that place, these are in time refilled with both eels and fish—the eels, at any rate, either from scrapings rubbed off the eels' skin against the rocks, or from algae; the fish, however, from a seminal principle drawn through underground channels from neighboring lakes, whether internal or external, when those places are refilled.

[Margin: The origin of fish, of what kind it is.]

The question is asked, thirdly. How are ducks and geese—which are commonly called barnacle geese [Berniclas]—born in Scotland from the rotten fragments of ships? Almost nothing is better known than the barnacle goose's origin from rotting matter in Scotland, and there is scarcely a historian or natural philosopher who does not mention it. We, briefly setting aside the cited authorities as things already noted and plain to everyone, will lay open what we think about their origin. The subject from which such birds are born is manifold. There are those who say they are born from the leaves of trees; some from the rotten fragments of ships; certain people from the mold of a ship's keel. Nor are there lacking those born after being enclosed in shells and at last released, which then, having taken on wings, begin to swim across the water and fly through the

air. Still others think they are drawn out from the viscous liquid of marine rocks. That all these views may be examined, I say: three things concur in the generation of these birds. First, the subject, that is, the matter. Second, the seed. Third, the disposition of the place. As regards the subject, this can be either the fragments of rotten wood, or the bark and leaves of trees, or the slimy crevices of rocks, or finally the marine shells themselves—of which kind we are accustomed to display specimens in our Museum. Secondly, as regards the seed, I say that it falls from none of the said things. For trees cannot produce a perfect animal, since that is beyond their powers—still less can the slime of the sea, whether embedded in rocks or in rotten wood; nor can shells bring forth a perfect animal, being suited only to producing zoophytes [Zoophyta]. The question therefore is asked: what is that seed which produces so prodigious a brood of ducks and geese?

[Margin: The origin of the Scottish geese.] [Margin: The subject-matter of the Scottish ducks and geese.]

—so that from the seed of broken eggs, dispersed and driven to the shores, ducks and geese must necessarily be generated in suitable wombs [matrices]. Secondly, not only in Scotland but along all the coasts both of Scotland and of Ireland, right up to Belgium itself, such broods are found—everyone everywhere admits it. Indeed, Olaus Magnus [Olaus Magnus] asserts that a similar generation is observed on the shores of Norway and Finmark; in fact, wherever the seed, driven from the Ocean, has found proportioned wombs of a differing condition—provided the soil or salt does not stand in its way—there too such births are accomplished. These things, which seem to us the supreme miracles of Nature, have grown cheap to the natives through almost daily familiarity. Here you have my opinion on the generation of the barnacle geese—so genuine that, with every combination tried, no other than the one stated can be assigned. Since indeed it is impossible that a perfect animal, such as a duck or a goose is, should be born from mere putrefaction, with no prior seminal principle of its own species.

The question is asked, fourthly. How are insects of every kind born from the carcasses of plants and animals—whether living or dead—through spontaneous origin? There is in the whole of nature no plant or animal that does not produce out of itself another insect, of a different species nonetheless, by spontaneous origin—since there is none of either kind that does not undergo putrefaction; and in putrefaction, once it is fermented by heat, there lies hidden that seminal principle, in whatever way it was detached from elsewhere. This I would certainly never have believed, had not frequent experiment, through the use of

the microscope, made me more certain of the truth of the matter. I shall begin with plants.

[Margin: The spontaneous origin of insects from the carcasses of plants and animals, whether living or dead.]

Let no one, while I assert these things, suppose that I believe an animal endowed with a nobler rank than the plant itself can be begotten by the plant's own power, or that a plant can be born by spontaneous origin from a perfect animal like itself. By no means. Rather, I say that the plant always has a seminal principle connected to itself, detached from elsewhere—from the bodies of other animals, whether living, or the carcasses of the dead—all of which will afterward be proven by experiments. Certainly the celebrated Botanist and Physiologist in the City [Rome], Francesco Corvino [Francesco Corvino], long ago getting wind of this, after examining with singular zeal the herbs of the most diverse species, found in each a worm. Having enclosed this worm within a glass vial and fed it on the leaves of that same herb, he at last observed that the said worm, taking on wings, degenerated into a winged insect—and these winged insects, according to the variety of the herbs, counterfeited a different species both by the variety of their shape and of their colors: some bearing only wings like those of flies, certain ones like caterpillars, others with wings enclosed in a crusty sheath, some displaying Spanish flies [cantharides], gold-beetles [chrysocanthari], and the like. The shapes and colors of all of these, together with the plants their mothers, he displays in his house, most elegantly and lifelike. In this way, from various herbs there are produced—

[Margin: No plant produces an animal proper to itself.]

—certain caterpillars by the plant's own power, as being of an inferior nature; and these caterpillars, then taking on wings, he observed to be transmuted into butterflies notable for the variety of their colors. All of which I would have presented here expressed in figures, had the shortness of time permitted. You would see here hundreds of species of herbs, together with the broods they produce—wonderfully different—most beautifully depicted. A most worthy work, indeed, that ought in its own time to see the light. Following his example, I too, after examining most species of herbs, found that not only does each plant as a whole produce its own proper insect, but that there are also different insects in the different members of the plant—such as the root, the leaves, the flowers, and the fruits. In the root, indeed, I found something not unlike earthworms; in the bark, the rudiments of ants; in the leaves, a little caterpillar; in the flowers, a certain winged little animal; and in the fruits, either a worm or something

resembling a spider. In this way the pine [pinus] begets the buprestis-beetle [buprestis]; the mastic-tree [lentiscus], slugs [limaces].

[Margin: From a herb caterpillars are produced; the caterpillars degenerate into butterflies.]

Since these things are so, the question is now asked: since a thing cannot produce an animal [more noble than itself], whence do those creatures come? I answer that this can happen in various ways. First, from the moisture by which the herbs are nourished. Just as this moisture is imbued with the spermatic corpuscles of sensitive nature detached from the various carcasses of animals, so too, once it is implanted in the juices of the herbs, it always produces ever baser and baser insects—according to the differing degeneration of the seed from the prior substance from which it is detached, and the weakening of its power. Secondly, from the spermatic excrements of living animals; the moisture of the earth, imbued with these and drawn up by the plant—together with the seminal principle—into its nourishment, at the slightest fermentation (whether by the internal heat of the plant or the external heat of the surrounding air, according to the combination of concurrent natural causes) hatches out now this, now that insect; which is then likewise fostered and nourished by the very plant from which it is brought forth. Thirdly, from the slimy excrements of some other creature—whether a fly, a butterfly, or a caterpillar—which, gaping after the juices of herbs, always release from themselves a little spermatic excrement, from which afterward arises a new offspring of a different species. In this way I observed on the flowers of leopard's-bane [*Doronicum pardalianches*] a venomous little caterpillar [bruchulus] continually clinging, full of deadly poison, whose origin is from nowhere else than from the seminal principle of a serpent or other deadly animal, dissolved into the earthy moisture. Just as the poisonous herb draws this into its nourishment by a kind of natural magnetism, so too it brings forth a brood not unlike the plant as to its quality. In like manner you will find such little animals arising from the flowers of all poisonous herbs—so that henbane [*hyoscyamus*] produces one, monk's-hood [*Napellus*] another, hemlock [*Cicuta*] another, and finally meadow-saffron [*Colchicum*] yet another, and so on. And what is worthy of wonder: as many as [arise] from the flowers—

[Margin: The origin of the said insects.] [Margin: From the slimy excrements of insects.]

—of the herbs: as from the thinner juice, so too there always comes forth a volatile insect, equipped either with wings buried in a crust, or with unsheathed [wings].

On the Wonders concerning the Signatures of Orchids, or Satyria.

Very many Botanists, when they have contemplated the wonderful signatures of orchids—and these orchids are the plants that are commonly called *Satyria*—cannot sufficiently marvel at the power of Nature in producing them. For if you consider their roots, you will find them in the form of testicles, from which they get their name [*orchis* being Greek for "testicle"]. They are truly rare and elegant species of plants; and in some of them—which are not inappropriately called *Anthropomorphae* ["man-shaped"]—Nature has so sported that there is scarcely a member in the human body which she has not, as far as she could, expressed.

[Margin: *Orchis Anthropomorpha*.]

[Below, on p. 348, an engraved plate occupies the lower two-thirds of the page; its description follows.]

Diagram. An engraved botanical plate showing three orchid specimens, illustrating the "signatures" (resemblances) discussed in the text. On the left stands a tall orchid in flower, captioned *Ornithomorpha sub avis figura* ("bird-shaped, in the form of a bird"), its paired rounded tubers shown at the base. Between and beside the two large plants are small inset vignettes of the resembled creatures. On the right stands a second tall flowering orchid captioned *Orchis anthropomorpha* ("man-shaped orchid"), with finger-like spreading root-tubers at its base. A small lower-central inset is captioned *alia species Orchidis quae cercopithecum refert* ("another species of orchid that resembles a long-tailed monkey [*cercopithecus*]"). Beneath the whole plate runs a two-line reference caption.

- Left plant, flower-spike — labels **G** (repeated four times along the spike, at upper and middle florets): point-letters keying individual florets.
- **A** (lower left, beside an inset figure): keys a small inset vignette (a bird-like / winged figure) to the left of the left plant's stem.
- **B** (lower right of left plant, beside an inset of a small robed/standing figure): keys that inset vignette.
- **E, F** (at the base of the left plant): the paired rounded root-tubers ("testicles").
- Right plant, flower-spike — labels **C** (repeated, upper and middle florets, both sides): point-letters keying individual florets.
- **E, E** (at the base of the right plant): the spreading finger-like root-tubers.

- Lower-central inset — *alia species Orchidis quae cercopithecum refert*: a small figure showing the monkey-resembling orchid form. [No clear point-letter legible on this inset. [?]]
- Bottom caption (two lines): "*Vide de his Fabium Colonniam, de rariorib[us] plantis — Joh[annem] B[aptistam] Portam in phytognomia*" — "On these matters see Fabio Colonna [Fabio Colonna], *On Rarer Plants*; [and] Giambattista della Porta [Giambattista della Porta], in [his] *Phytognomonica*."

[Resuming the text, which continues at the foot of p. 348 in two columns below the plate:]

I found it, so that when I displayed it, it drew everyone into admiration at the work of playful Nature.

But Nature's keen industry did not stop here. You may see, with the greatest admiration, in some the figure of a bird, in others of a long-tailed monkey [cercopithecus] or of a dolphin; nor are there lacking those that present the likeness of a bee—from which it is also called the bee-orchid [Orchis apiformis]—or even of a wasp, a fly, a butterfly, a gnat, a bug, a locust, and the rest of the animals. I myself, certainly not without expense, had such plants brought from the mountains and planted in our home garden, to this end: that I might observe the wonderful properties of this plant. So, having undertaken a dissection, first in one of its species I detected I know not what rudiment of a woman's womb pregnant with a fetus, wholly similar to the natural one; in the bee-orchid too, when the bee-shape was cut away, I found the likeness of a little maiden carrying a small shield [scutella] with both hands, so skillfully expressed that—

[Margin: The various figures of the orchids.] [Margin: See on these matters Fabio Colonna, *On Rarer Plants*; [and] Giambattista della Porta in [his] *Phytognomonica*.] [Margin: See Fig.]

when I displayed it, it drew everyone into admiration. With the microscope, intending to examine in the same way the filaments of the leaves of the anthropomorphic orchid, I found the flowers, throughout, woven of the tiniest little images of the human figure, marked with a C [or: marked "C" — the printed letter is uncertain [?]], so that I could not sufficiently marvel at Nature's admirable industry in things, whether in shaping them or in painting them—whence I thought to add the figures here for the Reader's delight. But, leaving aside such sports of Nature, one might rightly now ask: whence do all these derive their origin? And just as God and Nature do nothing in vain, so here too I

shall lay open to the Reader a new and perhaps unheard-of mystery of Nature, that the Reader may more closely behold the inexhaustible and hidden riches of Nature.

[Margin: In the flower-sheath I also noted by night the figure [...] with eyes, ears, and a hooked beak [—continued from p. 348].]

It was observed by those who have charge of flocks, herds, and horses that, after the animals had been brought together for breeding—once mating had taken place—the following year that field would teem with orchids, that is, *Satyria*, for no other reason than that the surplus spermatic moisture, scattered upon the ground and fermented together with the earthy juice, at last grows up into such herbs. They say the same thing happens from the seed of corpses, both of men and of animals, who in the fields are either killed or die of some sickness. If this is indeed so, what wonder is it that seed buried in the earth—as if within a womb—should there gradually bring forth a plant of exactly the same faculty as the animals from whose seed it was detached? Whence not undeservedly are they called *Satyria* from the power by which they incite to lust—namely, from the lechery of the fabled Satyrs. For since Nature cannot stand idle, she is always contriving and fashioning something, and she shapes it according to the condition of the adopted seed. Since, therefore, in the seed of animals all the members of the animal are present in potency, as we said above, and these are gradually unfolded by the heat of the womb into the perfect structure of the animal—the plastic power [*vis plastica*] being at work to form each individual member—what wonder is it, I say, that the seed, whether of a man or of an animal, once received within a suitable and proportioned moist womb of the earth, should there too contrive and fashion, if not a perfect animal (which is beyond its powers), at least something analogous to the animal or the man, as to its members not unlike the true ones, together with the faculty proper to the seed of arousing to lust? Add to this that herbs of this kind are nearly the first of all to burst forth in springtime—precisely the season in which most animals too are goaded by the heat of desire. Certainly it is so ordered by Nature that she does not work toward fashioning like things except by the aid of that seed which first existed within perfect animals, from which it was detached and conveyed away. But that, besides the members of the human body, it produces in the said *Satyria* many other shapes of various insects—this is to be ascribed to the diversity of the seeds.

[Margin: The *Satyria* are born from the seed of animals poured over the earth at the time of mating.] [Margin: A *Satyrium* is so called because it excites men to lust.]

For if equine seed, falling into the earth, has grown up into the said herb, since Nature cannot produce the perfect figure of a horse beyond her powers, by the power of the seed she will form at least a figure similar to those insects which are accustomed to be born from a living horse—that is, the figure of wasps; but if bovine sperm has produced the orchid, it will delineate not the figure of an ox but of a bee (whose origin is from oxen), as is seen in the bee-shaped orchid [*Orchis apiformis*], and so for the rest. For the fact that in the flowers of different orchids there are seen now the figure of a flea, now of a bug or a louse, now of a fly—this certainly happens only from the spermatic power of those animals from which such insects are born. Yet if anyone examines everything more keenly, he will always also find in them something conformable to the animal from which [the seed] was detached. That bees are born from the bovine kind is plain from the authority of all writers, both ancient and modern. For, as Varro [Varro], Pliny [Pliny], and Virgil [Virgil] testify, bees are born not only from bovine dung but also from the rotting body of the same; and they say that in Egypt there are certain places where, if a bull is buried so that only its horns project above the earth, and these are then cut off with a saw, in time bees fly out. Whence Ovid:

[Margin: Why the bee-shaped orchid is so called.]

[Margin: *Metamorphoses* 15.]

You too bury the slaughtered, chosen bulls (a thing known by sight): from the rotting flesh everywhere are born flower-gathering bees, which, after the manner of their parents, dwell in the countryside, devote themselves to work, and toil toward [their] hope.

And elsewhere, from the Oracle of Proteus:

Bury the body of a slaughtered young bull in the earth— buried, he will give what is enough for us. The shepherd does it: swarms seethe from the rotting [carcass]; from one ox, a thousand lives, once it is slain, are given.

Virgil, *Georgics* 4:

Throughout the dissolved entrails of the cattle they catch sight of bees buzzing all about, and seething out from the burst flanks.

And—to return to where I digressed from—that always something is produced from the seed which is like a living animal, I first understood when I came upon that wonderful history concerning bees of Bernardino Gómez [Bernardino Gómez]. His words are these:

[Margin: The drones display within the figure of a bovine head.]

I shall relate a thing new, unheard-of, and hitherto seen by no one, nor handed down to memory by any writer, so far as I know: when, for the sake of refreshing my spirit, I was lingering by the beehives at Saguntum, and was greatly marveling, among the singular and wonderful works, at the deference and kindness of the drones, and at the seminary of bees enclosed within them—which alone drew me into great admiration: for when, in the meantime, a drone caught by me was being squeezed with fingers and nail, in case it might by chance discharge something in place of a sting—behold, with its viscera and the little skin of its hinder part burst open, a white or saffron-colored ox-head, skillfully formed with spreading and twisting horns and a hooked muzzle, suddenly emerged. The men who were present, marveling at this, and on that account urging me to try it again, I squeezed five drones one after another, and they—

[Margin: Orchis Anthropomorpha. (See Fig.)]

[printed p. 350] LIBER DUODECIMUS, Sectio I — *De Panspermia Rerum* (continued) they brought forth [perunt] — by nature, of course, in which there rightly resides a supreme principle, producing the seminal nature [seminallem rationem] of these creatures, and a certain friendship of theirs with cattle. This is what **Bernardino Gómez** [Bernardino Gómez] reports, things which I too, having tested them, found perfectly true, and which I would wish all investigators of natural things to verify.

[Margin: *Cur Ægyptii inter cornua bovis apim pinxerint* — Why the Egyptians painted the bee between the horns of an ox.]

This matter did not escape the Egyptians, who, wishing to signify royal lineage, painted a bee between the horns of an ox. But about these things I have written

very fully in the *Oedipus* and the *Obeliscus Pamphilius* [Kircher, *Oedipus Aegyptiacus*; *Obeliscus Pamphilius*]. Just as, then, in the insects themselves a certain rudiment of the image of those animals from which they were born is found, so too it happens in the orchids [Orchides]: since these cannot produce a living animal, they at least contrive as far as they can — that is, from the ideal principle implanted in the seed [ex insita seminis ideali ratione] they try to express the figure of that thing from which they spring.

[Margin: *Bombyx ex moro* — The silkworm from the mulberry.]

In the same way one may also observe this in the lofty mulberry [Morus]: when the seed of another insect is discharged into its sap, a silkworm [bombyx] is born — a worm that is then nourished from the very thing from which it was born, and spins for us the silk so prized in the proud furnishing of garments. I will add this too, which is worthy of wonder: that a plant which smells of some animal has taken its origin from that same animal's excrement or seminal fluid. Thus tutsan [Androsemum], which smells exactly like a he-goat and is for that reason also called "goatish" [hircinum], grows only in the mountains where herds of goats graze.

[Margin: *Androsemum hircinum unde* — Whence tutsan is goatish.]

So too the herb which they call κυνὸς ὄρχις [Greek: kynos orchis, "dog's testicle"], from its resemblance to a dog's genitals.

[Margin: *Vulvaria* — Vulvaria (stinking goosefoot).]

It is likewise probable that vulvaria [Vulvaria], whose smell **Giambattista della Porta** [Giambattista della Porta] in his *Physiognomia* and the other botanists report, arises only either from the wantonness of women, or from some hidden recess [scrinio] of those same parts — that is, from the vulva. So that it need not seem fabulous, what **Pliny** [Pliny the Elder] writes about hippomane [hippomanes].

[Margin: *Hippomanes* — Hippomanes.]

I could cite innumerable instances of this sort here, but whoever desires more, let him read on these matters **della Porta** in his *Physiognomia*, **Lobelius** [Matthias de l'Obel], **Mattioli** [Pietro Andrea Mattioli], and countless others; and we ourselves have treated fully of the signatures of plants in the spirit of the Egyptians, both in the *Ars Magnetica*, Book 3, and in the *Oedipus*, Tome 2, Part 2. That asparagus springs from buried rams' horns is well known. One thing I will

add here, about the deer-fungus [fungus cervinus], to make clear how much the seed of animals, when committed to the earth, can accomplish.

De speciali Cervini Tuberis ortu. — On the special origin of the deer-truffle.

[Margin: *Fungi cervini productio* — The production of the deer-fungus.]

The contemplation we have just held concerning the common origin of the truffle is wonderfully confirmed by the experiment and history of the fungus — or rather, the deer-truffle [tuber cervinum] — which grows among the Bohemians, unknown to the ancients. About it **Mattioli** [Pietro Andrea Mattioli] writes the following, word for word, to **Giulio Moderato** [Giulio Moderato]:

Since I know that you take great delight in novelties, I am sending you with this letter of mine a certain subterranean truffle, which the Bohemians call "deer-truffle" [boletum] — for I think you have never heard of it, since no record of this fungus exists among the ancient writers, nor among the more recent ones,

[Margin: *Histor. fungi cervini producto* — The history of the deer-fungus produced.]

[Margin (continued, printed p. 350 foot): *Ortus tuberis cervini* — The origin of the deer-truffle.]

[printed p. 350 left margin running text picks up:] *...and since it cannot be found except in those woods where deer are most numerous; and the hunters who know these secrets of nature [keep them hidden]; but since these things are unheard of among you, I would not wish you to remain henceforth ignorant of the history and powers of the deer-fungus. The hunters affirm, then, that this fungus is born under the earth in the manner of common truffles, where the soil is infected with deer-seed [cervino semine] — which usually happens when something still containing some seed is discharged from the genital vulva, the female fleeing the male's onset. Perhaps no one could find this deer-fungus, were it not that the deer themselves point out the spot at a certain fixed time of year; for by a certain natural instinct, led by their forefeet, they scrape the place where the round fungus lies hidden under the earth — which they perceive by smell, as they affirm; for the fungus breathes out a heavy odor, especially when freshly dug up. Those hunters and countrymen who frequent the woods and know these secrets carefully observe the spots dug apart by the deer's feet, and once the pit has been dug out they take the fungi and sell them to the apothecaries, who cut them up into little pieces, thread them on a string, then dry them in the shade and keep them for medical use. These have nearly the same*

appearance as that which we observe in other truffles, yet rounder than them all and uneven; the outer little skin is somewhat blackish, but the fleshy and itself fungous substance is whitish. There are also those who say that a certain kind is found in the shape of an erect male member, so that on one part the exposed glans, and on the other certain little globes resembling testicles, may be seen. To me, however, it would be said that this truffle imitates the form of a deer's [member] rather than a man's — since Nature everywhere strives to fashion all things like their begetters. This fungus does not come into use for food, nor do the Bohemians eat it, but they use it in medicines that excite venery [venerem movent], since they think it most effective for this, and especially the kind that bears the likeness of a human genital. For which use they administer the dry powder in sweet wine, to the weight of a drachm or a drachm and a half. They say it also brings an abundance of milk, when drunk in barley-water or woman's milk, but that it acts more powerfully if a little long pepper be added. They report that as a fumigation it opens the closed places of women, and drives off the strangulation of the womb [vulvae strangulatus]. There are superstitious little women who misuse them in love-potions, after first muttering whatever incantations. They affirm that the deer-fungus is effective against poisons drunk, and taken in unmixed wine; indeed, against the bite of all venomous creatures, not only drunk but also applied [as a salve]. That it heats, anyone will easily judge from the strongness of its odor. I could wish that so rare a medicine, hitherto unknown to Italy, might be brought over or transplanted, and that among the other rare simples which live in your so celebrated garden under such diligent cultivation, this fungus too might live there; but since Nature forbids this to us, keep this one dried for yourself. I send you, besides it, a few pieces of genuine chalcitis [Chalcitis] and true misy [Mysis], which, being rare among you, I likewise hope will be precious to you.

From these things I plainly conjecture that the origin of the deer-truffle is from a soul — whether merely vegetative or sentient — wondrously disturbed [labefactata], which, in the seed cast into the earth...

[printed p. 351] DE PANSPERMIA RERUM.

whether of a stag, or of a male, or of a female, it is no longer as a form in matter — for the cooled seed dies and becomes infertile — but as something retained in a vessel by some degree of heat, long preserved in that viscid matter. For that the seed is animate we have proved at length elsewhere: namely, when, from the heat of the surrounding environment, the earthy juice committed to that seed is prepared for life, and this same preparation receives the soul latent in the spermatic matter — as in a vessel — into a substantial form, by which it is

constituted in being. This is generally a shapeless tuber, but sometimes one even reproducing the shape of the rod [virgam, i.e. the stalk or member] from which that seed most recently flowed off: so persistent is Nature in the procreation of the like.

And since the nature of seed is both a stimulant of venery [veneris stimulatix] and an opener of the womb [uteri apertiva], as well as most akin to milk —

[Margin: *Usus cervini tuberis* — The use of the deer-truffle.]

— what wonder if the powder of a tuber sprung from seed should both excite venery, promote abundance of milk, open the closed places of women, and drive off the strangulation of the vulva [vulvae strangulatus]? Hence I think it quite clear that the origin of our truffles is from nothing else than the soul latent in the seminal matter — as in a vessel — in the juice flowed off from plants and animals and committed to the earth. This soul, in the underlying matter, cooked [decocta] by the heat of the environment — whether vernal or autumnal — and disposed for life, becomes a substantial form vivifying the underlying matter and constituting the tuber. Most often, indeed, on account of the feebleness of its powers, the hardness of the matter, and the slightness of the heat, the tuber thus constituted is not exactly organized; but sometimes it even forms in itself some likeness of a living member, both in stalk and in leaves. This **Scaliger** [Julius Caesar Scaliger] testifies he saw, in the form of a man's member, which — also found on the shores of Batavia [the Netherlands] — the Dutch call "phallum cum" [*phallus*] from its resemblance to the male organ. **Mattioli** [Pietro Andrea Mattioli] also mentions this here.

Diagram. A woodcut of a "Xylophyte" — a worm-like animated creature with a long segmented body. The figure shows an elongated central stem (the woody twig) from which pairs of curved legs project to either side along its length, with a pair of antennae and a head at the left end.

- Caption (above figure): *I. Zylophytam ex ramulis Liburni in Musæo Authoris.* — "I. A Xylophyte from the twigs of the *Liburnum* shrub, in the Author's Museum."

Diagram. A woodcut of a slender, multi-legged creature: a thin elongated body bearing several pairs of long, splayed legs, generated from a rotted straw or rush-stalk.

- Caption: *II. Ex putrefacta palea aut junci caule.* — "II. From a rotted straw or the stalk of a rush."

Diagram. A woodcut of a densely many-legged, caterpillar- or centipede-like creature, with a long body bearing a great number of short legs along its whole length, like a millipede; generated from rotted horsetail [Equisetum].

- Caption: *III. Ex putrefacto Equiseto.* — "III. From rotted horsetail [Equisetum]."

Diagram. A woodcut of an "animated *Hippuris* (mare's-tail)": an elongated body bearing several pairs of curved, claw-like legs along its length, with feelers at the head end.

- Caption: *IV. Hippuris animata.* — "IV. Mare's-tail [Hippuris], animated."

[Margin: *Mira ex putrido Liburni ramulis productio* — A wonderful production from the rotted twigs of the *Liburnum*.]

I will add this marvel too: that on the twigs of the *Liburnum* — which they call "white twig" [vitem albam] — I have rather often found a zoophyte [zoophytum] consisting of six feet and a very fine body, with the head of a caterpillar [eruca]...

[printed p. 352] LIBER DUODECIMUS, Sectio I.

advancing with the creeping motion of spiders. And when I scrutinized its origin more diligently, I found at last that it was born from the twigs of the said *Liburnum* shrub, infected by a certain rottenness; for I more than once discovered it still attached to a green branch, whence not without reason I called it a "Xylophyte" [Zylophytum, "wood-plant"]. I also found some that on the hinder part had wood, but on the forward part had already taken on a soul [animam], and were stirred this way and that. I saw also some which, in the middle of the body — where the legs were supporting it — were wholly of the same wood as the *Liburnum* twig, but the feet and head, now animated, were moving. Yet as soon as the whole pith of the twig, together with the six sprouting little branches, was informed by the soul, then the animal, as if cut off from a trunk, walked along the ground in the manner of the rest of the insects [ἑξαπόδων, hexapod, six-footed]. When I showed this stupendous metamorphosis to several of our people, it can scarcely be told how greatly they marveled at so rare and monstrous a birth, especially when they saw the forward part, together with its feet, attempting motion while still attached to the hinder stalk. The same happens in rotted mare's-tail [Hippuris] and the others, such as in straws, as is shown in the figures. But lest we seem to have omitted anything to satisfy the reader's curiosity, I have placed the figure above.

CAPUT X. — De Insectorum spontaneo ortu ex aliis animalibus perfectis diversæ speciei. — On the spontaneous origin of insects from other perfect animals of a different species.

A certain philosopher rightly asserts that Nature is never so busy as in the smallest things. For just as the number of imperfect beings is always greater, so too is the number of those born spontaneously greater than of those born by non-spontaneous origin. For we see that there is no animal which does not (as we said also of plants) generate from itself another imperfect animal of a different species — as is evident both in man, and most of all in all living creatures. And to begin from the more imperfect: all brutes generate fleas, lice, bedbugs, ticks, "rendivi" [rendivos, a kind of vermin (?)], or something like these.

[Margin: *Varicæ Zylophytorum species* — Various species of Xylophytes.]

That frogs, toads, serpents, and worms of every kind are born both in the intestines of men and of brutes has long been known by frequent experiment, as a certain philosopher [Aristotle (?)] asserts — about which we have also made ample mention in Book Nine, *On Poisons* [De Venenis] — and that worms are born not only in the intestines, but in all members of the human body, the histories teach by manifold reports.

[Margin: *Ex ocimi odoratu scorpio natus* — A scorpion born from smelling basil.]

For in the human brain a scorpion was born from the frequent smelling of basil [ocimum], as **Liceti** [Fortunio Liceti] [reports]; **Schenck** [Johann Schenck] [reports] worms found in the heart itself; **Paré** [Ambroise Paré] reports [them] in the lungs, liver, kidneys, and bladder; and we, in our *Treatise on the Plague* [De Peste], showed that putrefied blood is worm-ridden — the same which we observed under the microscope in cheese, milk, vinegar, and meats exposed to the Moon. And so all things are full of animals; nor is there any putrid ulcer, any impetigo or elephantiasis, that does not breed its own worm. This the learned man **August Hauptmann** [August Hauptmann] showed in a little book he published long ago on this subject — which he calls "the animated image of death" — and he says that in venereal scab itself he found worms, like little slugs, of such fecundity that within half an hour one had poured forth some 50 others like itself. Their generation, indeed, proceeded from nothing but the virulent putrefaction of corrupted blood and seed. Again, many men suffer from phthiriasis — that is, the lousy disease [pediculari morbo]...

That men extinguished by lice are well known is established — as the historians narrate of **Herod**, **Sulla** [Sulla], **Pherecydes of Syros** [Pherecydes of Syros] the poet, and of countless others. **Lycosthenes** [Conrad Lycosthenes] writes that in Hungary, in the year 1549, up to three thousand men perished from serpents, frogs, and the like that arose within their vitals; of which thing there was no other cause than that the fruits of the earth, infected by a destructive rottenness, and the water, springs, and fountains, had been filled with broods of serpents, frogs, and the like, owing to the humid and pernicious constitution of the year — by the use of which they at last gave birth to those animal-litters.

I pass over here the many women who, as the authors on monsters report, in place of a human fetus have brought forth from the womb serpents, toads, moles, and the like; of which thing the cause may be the same as that of the preceding birth just set out by us. I pass over here too the innumerable animal-brood which is born spontaneously both from the excrements of animals and from corpses.

[Margin: *Ex bovillo stercore mures* — Mice from cattle-dung.]

For **Scaliger** [Julius Caesar Scaliger], on **Theophrastus**, says he observed mice born from cattle-dung; from horse-dung that dung-beetles [scarabaeos pilularios] are born is everywhere established, as **Schenck** [Johann Schenck] [reports]. All these things have no other origin than, first, from the food of the first concoction [primae concoctionis], which, according to the varied condition of the seminal principles by which the nourishment — whether it came from vegetative or sentient things — is imbued: for this, taken up by men and fermented by the heat of the stomach, once it has found a disposed humor there, brings forth now this, now that animal. For the herbs and greens on which men generally feed are infected with the filth of various insects, flies, worms, and caterpillars, in which the seminal principle is vigorous; and so men take up corrupted nourishment...

[printed p. 353] DE INSECTIS.

they take up, which, fermented in a proportioned vessel by heat, at last, by the power of the seed latent in it, hatches out this or that animal.

[Margin: *In corporibus tum hominum tum animantium quomodo, & in lixivio vermes nascantur* — How worms are born in the bodies of both men and animals, and in lye.]

But these things must be set forth more clearly by some examples drawn from men. People wonder why worms are born in putrefying lye [lixivium]. I say this happens in no other way than because under-tunics [indusia] full of a brood of

lice, bedbugs, or fleas have introduced that brood into the lye, where, being disturbed, they have degenerated by their power not into lice and the like, but into little worms of a different species.

[Margin: *Ex lixivio vermes* — Worms from lye.]

[Margin: *Ex defosso anatis cadavere bufones* — Toads from a buried duck's carcass.]

But how toads are born from a buried duck's body — as has become known by the observation of many — I declare the cause to be that this kind of bird willingly feeds on animals of that sort, and consequently, with the toad-seed [semine bufonio] lodged in its food, it comes about that from the rottenness of the buried bird there is born that animal on which toads willingly feed.

[Margin: *Ex cancro scorpio* — A scorpion from a crab.]

By like reasoning, **Pliny** [Pliny the Elder] reports that a crab, buried in the earth as the Sun enters Cancer, in time breeds scorpions. If this is true, it is for no other cause than that the seminal rottenness of the crab, much altered and disturbed, since it cannot produce a like animal, produces another more imperfect one, not unlike it in the figure of its body — namely a scorpion. Of which **Ovid** [Ovid]:

*Concava littoreo si demas brachia cancro, Cetera supponas terrae, de parte sepulta
Scorpius exhibit, caudaque minabitur unca.*

"If you take away the hollow claws from the shore-crab, and lay the rest beneath the earth, from the buried part a scorpion will come forth, and will menace with its hooked tail."

And these are the things which — more fully, perhaps, than I ought — I have thought should be said about the transmutation both of vegetables and of animals into different species: so that the reader might understand that the whole atmosphere, and likewise the air, water, and earth, are filled with seminal principles, which are heaped together nowhere not — and that so too it cannot but be that that innumerable brood of things, which we so greatly admire, should not arise. So that the ancient natural-mystics [Physio-mystae], penetrating the matter more deeply, were not ashamed to assert, not without warrant, that all things are in all. These principles thus laid down, it now remains to be explained whether, emulating Nature, by the application of actives to passives, we can produce by a certain artifice [ἐγχειρήσει, encheirēsei, "hand-craft, operation"] like animals and like plants.

SECTIO II.

DE ANIMALIUM

Quæ à Græcis ἔντομα [Greek: entoma, "insects" — lit. "the segmented ones"], à Latinis Infecta vocantur, varia tum naturali, tum artificiali productione. — On the various production, both natural and artificial, of those animals which by the Greeks are called ἔντομα (entoma), by the Latins Insecta (insects).

PRÆFATIUNCULA. — A Little Preface.

Although in the preceding Section we treated most copiously of the spontaneous origin of living things, nevertheless, because very many matters were there omitted which seemed in any way to pertain to their generation, here we once again call them back to the anvil, so that the vast multitude and abundance of insects of this sort may become known to the reader, and that he may learn whence each obtains its proximate origin; and so that, these things being known, he may understand how at last Art, imitating Nature, may by applying actives to passives be able to produce like things.

CAPUT I. — De variis Insectorum natalibus, eorumque differentiis. — On the various births of insects, and their differences.

There are diverse kinds and species of insects, almost infinite in number, of such great variety that scarcely a region can be assigned in which they do not differ — whether you regard their colors or their bodily constitution — by reason of climate or soil. And first, some [arise] from earthly refuse, some from water, some from air;

[Margin: *Varietas insectorum* — The variety of insects.]

nor are there lacking those said to take their origin from fire itself. Again, some are winged; some are constituted as it were of certain rings [ex annulis], and are therefore called "ringed" [annularia]; others are furnished with four feet, six, or more. But, to comprehend much in few words, it has seemed good to set down here a synoptic Table, so that from it the reader may behold, as in a single glance, the differences of each.

Reading order: This batch's PDF pages are out of folio order. Reconstructed from printed page numbers and catchwords, the reading order is **printed p. 354 → 355 → 356 → 357**, which corresponds to ** → → → **. Page 353 (end of the prior

material) carried the catchword "TA-", which resolves to "TABULA" opening p. 354.

LIBER DUODECIMUS [Book XII], Sectio II, Caput I (continued)

TABULA SYNOPTICA [Synoptic Table]

Of all those things that are born spontaneously, whether of Vegetables or of Animals:

Diagram. This is a large branching (bracketed) taxonomic schema, not a numeric data grid. It classifies all spontaneously-generated insects by a nested series of braces. The root term at the far left is *Insecta* ("Insects"), characterized by a long descriptive clause, and the classification branches successively to the right. Rendered below as a nested outline that preserves every brace level and every terminal label.

Insects are small animals having incisions or rings (annuli), and hence are called *annulosa* by Albertus [Magnus]. Of these, some are either —

- **I. Terrestrial (*Terrestria*), of which some are —**
- **A. Winged, having wings (*Alata, alas habentia*) —**
- **1. Sheathed-winged / beetle-kind (*Detectas, analitra dicta*) [recte: read as the wing-cover group] — having either —**
- **a. Four (wings) (*Quatuor*) —**
- **Membranous (*Membranaceas*), of which some are —**
- **Comb-making (*Favifica*) —**
- Apis [Bee] — Domestica [Domestic], Sylvestris [Wild]
- Fucus [Drone]
- Fur [Robber-bee?]
- Vespa [Wasp]
- Crabro [Hornet]
- **Non-comb-making (*Non Favifica*) —**
- Cicada [Cicada]
- Orfodacna [Orfodacna]
- Perla [Stonefly / Perla]
- Cimex Sylvestris [Wild bug]

- **Mealy (*Farinaceas*), as is the Papilio [Butterfly] —**
- Vulgaris [Common]
- Lucernarius [Lamp-moth / Lucernarius]
- Aliique [And others]
- **b. Two (wings) (*Binas*) —**
- Muscarum genera [Kinds of flies]
- Tabanus [Horsefly]
- Culex [Gnat]
- Ephemerus [Mayfly]
- **2. Covered-winged (*Opertas*), which are called Coleoptera or sheath-winged (*vaginipennia*), as are —**
- Locusta [Locust]
- Gryllus [Cricket]
- Scarabæus [Scarab beetle]
- Cantharis [Blister-beetle / Cantharis]
- Ips [Ips]
- Buprestis [Buprestis]
- Coccus [Coccus / Cochineal]
- Cicindela [Glow-worm / Cicindela]
- Blatta [Cockroach]
- **B. Wingless, or lacking wings (*Aptera, sive alis carentia*), of which some are said to —**
- **1. Have feet (*Pedes habent*), of which again some are, namely —**
- **a. Six (*Sex, ut*) —**
- Formica [Ant]
- Cimex [Bug]
- Pediculus [Louse]
- Ricinus [Tick]
- Pulex [Flea]
- Lens, Coffus [Nit; Coffus-grub]
- Fobricina [Fobricina]
- **2. Have many feet (*Pancipeda habentque pedes*), or —** [recte: *Pancipeda* = polypod; the schema brackets the multi-footed kinds here]
- **a. Eight (*Octo*) —**
- Talpa [Mole-cricket / Talpa]
- Scorpio [Scorpion]

- Araneus [Spider]
- **b. Twelve (*Duodecim*)** —
- Geometra [Geometer / inchworm]
- **c. Fourteen or more (*Quatuordecim aut plura*)** —
- Eruca [Caterpillar]
- **d. Many-footed (*Multipeda*)** —
- Millepeda, sive Centipeda [Millipede, or Centipede]
- Oniscus, sive Asellus [Woodlouse, or Asellus]
- Scolopendra terrestris [Land scolopendra]
- Iulus [Iulus / pill-millipede]
- **3. Lack feet (*Pedibus carent, ut*)** —
- Vermes nascentes vel in [Worms born either in] —
- Hominibus [Humans]
- Animalibus aliisque [Animals and other things]
- Plantis [Plants]
- Lapidibus [Stones]
- Metallis [Metals]
- Teredo [Wood-worm / Teredo]
- Lumbricus terrestris [Earthworm]
- Tinea [Moth / clothes-moth]
- Orips [Orips]
- Limax [Slug]
- **II. Aquatic, and these also are, either** — (*Aquatica atq; hæc quoque sunt, vel*)
- **A. Footed, namely (*Pedata, nempe*)** —
- **1. Many-footed (*Pancipeda, ut*)** —
- Musca fluviatilis [River-fly]
- Cantharis aquatica [Water-cantharis]
- Viola aquatica [Water-violet (insect)]
- Tipula [Crane-fly / water-strider] —
- Alata [Winged]
- Aptera [Wingless]
- Ligniperda, sive Phryganium [Wood-eater, or caddis-fly (*Phryganium*)]
- **2. Many-footed (*Multipeda, ut*)** —
- Scrophula, sive Tinea [Scrophula, or water-moth]

- *Pulex marinus* [Sea-flea]
- *Oestrus*, sive *Asilus marinus* [Sea-gadfly, or sea-asilus]
- *Scolopendra marina* [Sea-scolopendra]
- *Vermes in tabulis delitescentes* [Worms lurking in planks (shipworms)]
- **B. Footless (*Apoda, ut*)** —
- *Vermis Indicus* [Indian worm]
- *Vermis Martymensis* [Martymene worm]
- *Seta aquatica* [Water bristle-worm]
- *Hirudo* [Leech] — *Paludosa* [Marsh], *Marina* [Sea]
- *Lumbricus marinus* [Sea-worm / lugworm]
- *Intestinum aquaticum* [Water "intestine" (gut-worm)]
- *Vermis macrorinchoteros* [Long-snouted worm (*macrorhynchoteros*)]
- *Hyppocampus* [Sea-horse]
- *Uva marina* [Sea-grape]
- *Stellæ marinæ* [Starfish]

We shall divide the whole realm of insects into seven classes, as if into so many separate commonwealths, so that we may proceed with greater method in unraveling each one.

The first is that of those insects which devote themselves to building honeycombs with a certain remarkable industry and ingenuity, fitted to the pattern of a kingdom; these are the bees, drones, wasps, and hornets.

The second is that of the *Analytra*, or insects which cleave the air with an irregular motion on a fourfold oarage of wings — such as butterflies, silkworms, weevils, caterpillars, chrysalises, *Xylophthori* [wood-borers], *Orsodunae*, and cicadas.

The third is that of the two-winged *Analytra*, such as the ordinary flies; the little wine-flies (*vinulae*), which take their origin from wine and vinegar and are commonly called *Moschini* [gnats]; the *Ephemerus*, so named from its single day's life; the *Cyniphes*; gnats; gadflies; and horseflies.

The fourth is that of the *Coleoptera*, or those whose wings are kept concealed within sheaths, and which are therefore called by the Greeks *κολεόπτερα* [Greek: *koleoptera*, "sheath-winged"], and in Latin *vaginipennia* — such as locusts, *Bruchi* [chafers/wingless locusts], crickets, scarabs, blister-beetles (*Cantharides*), *Buprestae*, *Cincindela* [glow-worms], and cockroaches.

The fifth is that of those which the Greeks call ἄπτερα [Greek: aptera, "wingless"], the Latins *sine alis* ["without wings"], and which live their life moving by the manifold use of feet — such as ants, bedbugs, lice, ticks, fleas, nits, scorpions, spiders, and the other kinds and species of many-footed creatures, such as those they call *Onisci* [woodlice], *Iuli*, and *Scolopendrae* [centipedes].

The sixth is that of those equipped with neither wings nor feet, but which scour the earth with a slow motion on a warty belly, and which are divided into countless kinds and species of worms and creeping things — such as earthworms, *Teredines* [wood-worms], moths (*Tineae*), slugs (*Limaces*), and serpents.

The seventh is that of those which receive their birth in the waters. Among these are water-*Tineae*, scolopendras, and sea-fleas, which are equipped with feet; and among the footless ones (*Apoda*) are leeches, sea-worms, sea-horses, the sea-grape, and starfish. To these we add the creatures called ζωόφυτα [Greek: zōophyta, "zoophytes," plant-animals], which are fixed as if in a perpetual place. Of all these, both collectively and individually, we shall say something in order. The sea-horses, conspicuous for their horse-like head and chest, are reckoned among the ringed aquatic insects, and their figure follows below; concerning their remarkable properties we have reasoned elsewhere.

Having thus seen the varied and many-kinded division of terrestrial, aquatic, and winged insects, nothing now remains except for us to investigate the origins of each. With the nests of their manifold proliferation discovered, we may then, imitating Nature, attempt the same thing by art and by the industry of our own ingenuity in producing them — not that any profit should come to us from producing these sordid little creatures, but so that the marriage of Nature with Art, the truth of causes, and the wonderful power of the operation may shine forth from it.

[Margin: *Hippocampa* — The Sea-horse.]

Diagram. A woodcut of a sea-horse (*Hippocampus*), shown upright with its head turned, the characteristic equine head and curved, segmented body with a coiled tail. The body shows the ringed (annular) segmentation that justifies Kircher's classing it among the "ringed" insects. Caption beneath: *Hippocampa*. § 58. That most insects are born from a putrid substance of Earth and Water has already been said abundantly enough in the preceding pages. But it remains to be explained how the same creatures may take their origin from a vegetable and a sentient (sensitive) nature.

[Margin: How the seminal power, implanted in all things, exerts itself.]

We said in the preceding pages, and assumed as certain, that the Elements, as they are constituted in the lowest grade of Nature, likewise cannot produce a plant or an animal of themselves and by their own power — for that would be to act beyond their own strength.

[Margin: The lower grade is proportioned to bringing forth the higher grade.]

Their whole effort would be wholly disproportionate to generating things of this kind. Something else must therefore be added to the matter disposed within the elements, something having the character of a seed, which may produce so wonderful an effect. We say that this is nothing other than a seed detached from elsewhere — whether from a vegetable or from a sentient nature. For this seminal nature has been implanted in all things from the very first beginnings of things, and, diffused throughout the whole mass of the earth and joined within a proportionate matrix (womb), it produces either a plant or an animal.

Now that seed can be shed by countless things. In vegetables, indeed, it can fall from each and every part of the plants — from roots, bark, branches, leaves, flowers, fruits, and seeds; for we taught above that the seminal power of plants resides in each and every part of the plant. Hence, the nearer a part is to the seed properly so called (which lies hidden in the center of the fruit), the more similar the plant it produces to the one from which the seed was detached; but the farther from it — as in what lies hidden in leaves, branches, bark, and roots — the more dissimilar and more degenerate a plant it begets, on account of the weakness of the seminal power.

Since, therefore, the whole surface of the Earth is covered with countless kinds of trees, plants, and grasses, it follows that, by a kind of perennial cycle (*pericyclosis*) following the Sun's motion through the Zodiac each year, the generation of these same things is necessarily followed by their corruption. And from this corruption, the seed — lurking in whatever part — is softened and rotted by rains and snows, and, fermented within the cells of the earth as if in certain wombs, then, when the Sun enters the equinoctial point, soon thrusts itself out and sprouts into a plant according to the character of the detached seed. From this arises that remarkable variety of certain plants — such as the geraniums, spurge (*titimalli*), stonecrops (*sedi*), orchids (*satyrii*), and countless others — the manifold species of which number, in the single case of the geranium, up to 24.

[Margin: Whence so many species of a single plant.]

This is certainly for no other cause than that the plant has acquired its origin not immediately from the seed properly so called, but from the differing seminal

parts of the plant. These parts, however different they may be, are nevertheless recognized — by reason of a great similarity — as belonging to the stock from which they sprang. Yet I would always have this understood: provided that the said spermatic parts of the plant are planted in the same soil, endowed with equal goodness; for otherwise they can also degenerate, by reason either of a rich and fertile,

or of a lean and barren field — as happens in wheat, which, according to the character of the field in which it is sown, degenerates now into spelt, now into oats. In exactly the same way it happens with the spermatic parts of vegetables, which, scattered over the whole surface of the earth and committed to the generative cells, at last produce that variety of plants which we marvel at — so that almost daily new prodigies of plants, not yet known to any botanist, arise spontaneously from that supreme combination of spermatic parts mixed together in diverse ways.

[Margin: Things born spontaneously do not arise from putrefaction alone.]

Let no one therefore think that plants take their origin spontaneously from earthy or watery substance, or from putrefaction alone. Rather, there must be joined to this earthy or watery putrefaction a vegetable seed — committed, by whatever cause, to the earth, the waters, and their putrid materials. For this seed, joined to the putrefaction, produces a plant according to the condition of its own kind and grade.

[Margin: The seeds by which they are sown into their own wombs.]

Now these seeds are committed, **first**, to the proper place of the plant; **second**, they are carried by the blowing of the winds into diverse regions of fields, valleys, and mountains, or committed to rivers, lakes, and marshes; **third**, by the violence of rains and floods, by which uprooted plants are forced to migrate elsewhere, leaving their native places — and as these are mixed with mud and mire and putrefy, so too from this putrefaction there cannot but be produced a new plant, if not similar to the former, yet still not wholly unlike it. **Fourth**, new seed-beds of plants are founded from time to time not only from seeds (which are sometimes carried off by birds into the inaccessible recesses of walls and crags), but also from the very excrements of birds and humans, in which the spermatic power of plants still flourishes.

Therefore, just as no element can produce plants except by the help of the seed of vegetable things, so too it cannot happen that a plant, of itself and by its own proper power and efficacy, should produce some animal, unless the seminal

substance of a sentient nature has been added to it. But how the seeds of things accrue both to inanimate and to animate matter, I have decided to set forth through seven propositions, as briefly as possible.

Lumbricorum Genesis. [The Generation of Earthworms.]

The question is asked, first: How are earthworms, *Teredines* [wood-worms], and slugs generated within the earth? I answer: Earthworms take their origin not from the putrid soil alone, but additionally from a seed which resides either in the rich excrements of animals or in their leavings (*retrimenta*). These excrements and leavings, when entrusted to the earth, come to life as earthworms within a brief span of time.

[Margin: The variety of earthworms.]

The variety of the excrements and leavings is the cause of the variety of the earthworms.

[Margin: Earthworms are born from their own corpses.]

But earthworms corrupted either by their own humor or by excessive dryness found, out of their own corpses, a new proliferation of countless earthworms — which we demonstrate by the following experiment.

EXPERIMENTUM I. [Experiment I.]

Artificialis Lumbricorum productio. [The Artificial Production of Earthworms.]

Take several dried earthworms, reduced to powder, and bury them in an earthen pot filled with rich and sweet soil; then water it repeatedly with rain-water, and within three or four days you will find that whole soil teeming with a new proliferation of earthworms — at first of the size of the worms that are born from cheese, and then, nourished by that rich juice of the soil, you will find them growing into true earthworms. For since the seed does not perish in the incineration of the earthworms, but remains in its power, it comes about that the powder, buried within the soil endowed with rich and sweet juice, thrusts itself forth by the heat of the Sun, and from the latent seed there is hatched out the same animal that it was at first.

The same thing also succeeds, in another way, by a second method: either we mix rainwater with the chopped-up particles of dried earthworms set in the soil — that same rainwater being the very thing that carries with it the seeds of earthworms detached from elsewhere and commits them to the earth. Hence,

immediately after rains and showers, we find rich and sweet soil always teeming with earthworms,

[Margin: Whence, after rains, the great multitude of earthworms.]

and in so great a number that they even fill the very footpaths.

This too is remarkable: that if you expose an earthworm to the burning Sun, it will at once be on the point of dying; and when you examine it the next day, you will see it covered with an innumerable multitude of little worms, which there is no doubt are restored from the seminal parts of the corpse. Hence that vast multitude of earthworms is born in the earth. For just as they hate stony, barren, and sandy soil, and so are not born from it, yet it sometimes happens that, while creeping, they enter such soil; but when they find no food, they die there, and from their own corpses soon send forth an immense worm-brood, which, carried by the rain into richer soil, there grows up into an immense abundance of earthworms.

You see, therefore, even from this experiment, that earthworms are born only either from the seed of their own corpse, or from seed brought from elsewhere by wind or rains — and by no means, as some have supposed, from the putrid juice of rich soil alone.

The question is asked, second: How are the *Tineae* — which, from their boring (*aterebrando*), are called *teredines* — generated?

[Margin: The origin of wood-moths.]

I answer: since for the most part they exercise their tyranny upon books, they arise either from wood spoiled by a seed, or from the hides with which books are bound; whence the differing species of them are found according to the diversity of the material. Those which are born from wood arise, of course, not from its putrefaction alone, but from the seed of other worms (with which the still-green wood was teeming) insinuated more deeply. For since no wood can be so dried that some moisture does not always remain along

with the original seed-stock of the animal, it comes about that the seed, excited either by intrinsic heat or by the surrounding heat, produces those little worms that are the haters and gnawers of books. The same must be said of wood destined for the use of construction, especially under a tepid moon abounding in moisture.

[Margin: Moths from woolen garments.]

It is also agreed by all that this same plague of moths is found in woolen garments. Aristotle says that they are generated from dusty wool — which would be empty talk, did he not also add: if a little of the spider is enclosed along with the dusty wool. That the moths of garments are therefore born not from dust alone, but from the excremental seed of spiders mixed with the wool, is clear even from Aristotle himself. Nonetheless, I, for my part, think that they can be born not only from spiders mixed with dusts, but also from the various worm-seed existing in the wool. Some have asserted — wrongly — that these are also produced from paper, which is made from linen; for neither linen nor linen cloth is ever corrupted by moths, as experience teaches. It is therefore necessary that they be born from wool spoiled by the seed of worms of whatever kind.

[Margin: The origin of slugs.]

Furthermore, little beasts of this sort are also found, not without grave harm to the bees, in the beehives. Columella affirms that these have no other origin than from the excrements of certain butterflies, from which are born those worms which they call moths (*tineae*). "For these," he says, "gnaw away the honeycombs and the wax, and from their own dung generate worms, which they call the moths of the hives."

The question is asked, third: How are slugs (*Limaces*) generated? By "slugs" we here mean those slimy worms, full of a mucous moisture, which are not covered by a shell or snail-house; and they are generated in the manner that follows. When the field-snails have clung to herbs and plants, they emit a certain foamy material, not unlike mucus, which we say is the seed from which slugs are born. The reason they are not covered by a shell is that in them mucous moisture alone holds sway, all dryness being banished. For since the shell in snails arises only from saline corpuscles thrust outward by the animals, whereas slugs consist of scarcely any but very small portions of salt, they remain bare of a shell — having arisen, that is, from the mucous foam of the snail, which is insufficient for forming a shell. Nor is there any difference between the snail and the slug, except that the former is covered by a shell while the latter is left bare.

[Margin: The origin of intestinal earthworms.]

But the earthworms which are born in the intestines of children obtain their origin from nothing other than the copious drinking of milk and the eating of sweet things, in which they delight. For who is ignorant — as the use of the microscope has taught — that milk is full of imperceptible little worms? These, indeed, have their birth from the seed or nourishment taken in from cows, or

from the very portions of seminal nutriments which are channeled, together with the chyle, into the wombs of the cows. And it is clear from cheese, butter, and whey, all of which in time breed worms.

[Margin: How cheese can be made wormy by art.]

Among the Dutch, that cheese is reckoned the better and tastier which teems with a manifold breeding of worms; whence some, in order to make it wormy, pour Spanish wine over it, and in time obtain what they seek. I could produce here more animals of this kind, but, so that we may keep the orders of the several classes, we shall treat of them in what follows.

[Margin: The origin of aquatic insects.]

Further, if you ask how aquatic insects are generated — to dispatch myself in a few words — I say that the generation of aquatic insects does not differ from the generation of those born on land. For all insects draw their origin either from the seed and leavings of fish, or from the seeds of windborne things, carried by the flowing of rains and rivers into the sea, or into lakes and marshes; and there, joined as if to proportionate wombs, they are animated into worms not unlike the terrestrial ones.

CAPUT II.

De Insectorum, quæ favifica vocant, genesi. [On the Generation of the Insects which are called Comb-makers.]

Among all other insects, none can be more worthy of admiration than the comb-makers or bees — whether you regard their industry in building honeycombs or their labors in gathering the honeyed juice. Since countless authors have written about their nature and properties, we shall pass these things by and confine ourselves to what belongs to our own proper undertaking.

[Margin: The origin of bees.]

The question is therefore asked, first: From where do bees, wasps, drones, and hornets draw their origin? As regards the bees, it must be known that, just as the differences among bees are various, so too they have a varying difference of operations. For among them there are those they call kings (the rulers); there are also the drones, deprived of stings; and there are, finally, the worker bees, subjects as it were to the kings — which are indeed as many as there are swarms of bees.

[Margin: The grades of bees, distinguished by their offices.]

Hence various opinions have arisen, even among the foremost Philosophers. Some have held that bees are born from coupling with the kings; others, from the drones — all of which is false; certain ones, from matter transported from elsewhere. We, leaving to each his own opinion, shall set forth what experience has taught us. We say, then, that bees have diverse modes of generation. For, first, we taught in the preceding section, on the testimony of several authors, that they are born from oxen; but not even on this do they agree among themselves, since some hold them to be born from the flesh of the ox, others from the putrefaction innate in oxen, and we, from the very excrements of oxen — as we have learned by this experiment.

[Margin: From cheese, that which can become a worm by art [?]]

(Page 358 — Liber Duodecimus, Sectio II, continued)

EXPERIMENTUM I.

The generation of bees from ox-excrement [Apum ex boum excrementis genesis].

Around the rising of the Pleiades [vergiliae], take fresh ox-excrement — from oxen that have first been fed on the plant called *cerinthe* mixed together with its flowers — and set it out in a shady, sun-warmed place toward midday, taking this precaution: that it not be thinned by the Sun's heat and dissolve into vapor. You will then see, to your great wonder, certain little worms being born in the manner of caterpillars [erucæ], which within a short time, once they have taken on wings, come to life as bees, according to the varying disposition of the material: now as kings [reges], and these are the ones that surpass the rest in size; now as drones [fuci] without a sting. These drones also show this peculiar sign of having sprung from oxen: that when gutted, they display in the hindmost part of the body the perfect form of an ox's head.

[Margin: Quómodo apes artificiose productæ postea similes sibi generent. — How bees, once skilfully produced, afterward generate offspring like themselves.]

If you ask how these insects afterward generate offspring like themselves, I answer that this happens by no copulation, but from the seed-stock [seminium]

placed in them — especially in those kings — by nature itself. If you ask where this seed-stock comes from, I answer: from the flowers of *cerinthe*, or of reed [arundo], or of olive, or finally from the juices of flowers of any kind whatsoever. For it is certain that bees take up the juices of these flowers not only as nourishment but also for the making of honey [mellificium]. Now since the flowers of plants are perpetually sought out by the flies [muscae] proper to each plant on which they were born and by which they are nourished, it comes about that those flowers always have implanted in them some small amount of seed-stock — whether it be the excrement of those flies or something else — which is then sucked out by the bees and carried off together with them as a seed-stock. By this seed-stock they generate not, indeed, an animal like the prior one, but rather, by the power of the honey or of some other liquid that serves them as nourishment, it degenerates into a bee. This happens not from the honey insofar as it is honey, but from the very excrements of the bees — as you will learn from this experiment.

[Margin: Experimentum mirabile. — A remarkable experiment.]

Take from a beehive the excrementitious parts of the bees, and examine them carefully with a microscope [microscopium]. With the greatest delight of mind you will see, frequently, first certain little sacs [folliculi]; then, once these have burst, little worms, of which some now resemble caterpillars while others, having now taken on wings — which by repeated inspection you will find to have already formed into perfect bees. Thus no copulation is necessary in the generation of bees, no union of male with female like that in perfect animate beings, as many have supposed. Rather, the little creature's own spermatic excrement, within a short time — on account of the seed-stock implanted in it, cut off from elsewhere — is shaped into a bee. And from these things it is plainly evident that no other origin of bees is to be found than the one we have now set forth.

[Margin: Fucorum ortus. — The origin of drones.]

But at this point no small doubt arises: where do drones [fuci] come from, and why are they without a sting? To dispatch the matter in a few words, I say that the drone is distinguished from bees by no other respect than that it lacks the sting proper to bees.

(Page 359 — De Insectis) Those who say that bees arise from oxen but drones from horses speak wrongly. For both bees and drones are born from the same excrementitious parts of the ox, though imbued with a different seed-stock. Since oxen, when they take herbs and plants as nourishment, always take up along with them various seed-stocks of flies and worms present in those very plants, these seed-stocks are fermented within the stomach and intestines of the oxen; and finally, once the excrement has been voided, they are hatched out — according to the differing character of the seed-stocks — into different species of bees.

I say, secondly, that the origin of drones consists chiefly in the excrements of bees that have already exhausted themselves [emeritae]; and so, when the spermatic power fails, the drones too are deprived of the very sting in which the strength and vigor of bees lies hidden. The ox's excrement is therefore productive of both bees and drones; and from the same plant-nourishment by which the bees afterward produced are fed by natural instinct, it necessarily follows that from the same dung the same animal afterward emerges — namely either a bee or a drone — as is produced from the dung of oxen, since the seeds of things are the same in both. So here you have the true and genuine generation of bees and drones.

[Margin: Vesparum ortus. — The origin of wasps.]

But as to how wasps [vespae] are born, someone might rightly raise a doubt. The philosophers establish a twofold origin for wasps: some from putrefaction, others

from copulation; and just as the former, they have held, come from the carcass of a horse, so bees come from the bull. So Nicander:

[Greek: Ἴπποι γὰρ σφηκῶν γένεσις, ταυροὶ τέ μελισσῶν. (Hippoī gar sphēkōn genesis, tauroi te melissōn — "For horses are the origin of wasps, and bulls of bees.")] [?]

Equi enim vesparum genesis, & Tauri apum. ("For horses are the generation of wasps, and bulls of bees.")

The Egyptians maintained so fiercely that wasps are born from the carcass of a crocodile that they even held they should be placed among the hieroglyphics. We say that wasps and bees and drones are born not only from a bull, or an ass, or a horse, but also from deer [cervi]. For as Nicander testifies:

[Greek: Σκλήεσι πυθομένοισι λυκόσπαδες ἐξεγένοντο. (Sklēesi pythomenoisi lykospades exegenonto — "From decaying [bodies] there came forth wolf-torn [creatures].") (Σκλήεσι is a corrupt/non-standard form, transcribed as printed.)]

Corpore nam putrido infectum consurgit utrumque. ("For from a putrid body an infected [creature] of either kind rises up.")

Concerning deer, Vincent of Beauvais [Vincentius Belluacensis] testifies that wasps coalesced in the bone beneath the eye of a stag advancing toward ripe old age, once that bone had been bored through; and he supposes that they came forth either from the substance of the brain or of the marrow. We, however, assert that they are born chiefly from the excrement, or else from the very plants on which the said animals are fed — since a plant of this kind is a common nourishment infected with the various seed-stocks of flies and worms, by which not only oxen, horses, asses, and deer, but also wasps are nourished, and from whose excrements wasps afterward rise up. I would not, however, deny that wasps are afterward also generated by copulation, since the excrement of these creatures takes the place of seed: once it has been warmed [fotum] by the wasps, it first passes into a little bladder [vesicula], and when this has burst, as though out of a shell [testa]...

(Page 360 — Liber Duodecimus, Sectio II) ... so that they seem perceptibly to grow before the eye. The colors, moreover, which in the caterpillar were only spots, now display themselves on the wings, painted in a wondrous arrangement of striations, with such variety of figures as we cannot sufficiently marvel at.

[Margin: Folliculus. Tabanus. — The sac. The horse-fly.]

I recall that I once found a chrysalis [chrysalis] that displayed the perfect form of an infant wrapped in swaddling-bands, as is shown in the margin. In a butterfly, too, at another time, I found the image of our Savior so skilfully depicted that it seemed to have been drawn by a painter's hand. But to return to the experiment: if you enclose specimens of this kind in larger glass vessels together with plants, you will soon see them, by a certain natural and wondrous instinct, fly toward one another and together emit a certain excrement not unlike the eggs of fleas [ova pulicum]. If you examine this carefully with a microscope, you will see it come to life, within a short time, as new little worms; and these in turn afterward transform into chrysalises, and finally into new butterflies. And in this way you will recognize, by an infallible experiment, that the caterpillar first brings forth something resembling eggs — which we call its spermatic excrement — and not only within folded leaves of garden herbs, but also among other leaves of plants, folded for this purpose deliberately by the butterflies, lest they be destroyed by rain. If you observe these under the microscope, you will see most plainly that certain little worms are hatched out of them — such as are commonly seen in the little galls [folliculi] of elms and mastic-trees — and that within a short time, among the pastures they meet with, they grow so large as to resemble perfect hairy caterpillars, which are then turned into chrysalises and finally into new butterflies. These last throughout nearly the whole summer season; but when the Sun crosses into Libra they are buried, dead, within the earth. Out of them, afterward, when the Sun enters Aries, they are quickened — both from the spermatic excrement of the eggs and from their own ashes [bustum] — into new worms, then into chrysalises, and at last into butterflies.

Here it is asked whence the *bombylius* or silkworm [bombyx], the spinner of precious silk, draws its origin. I say that it is born from a mulberry-seed-stock [morum seminium] cut off from elsewhere, and that by a threefold transmutation — no differently from the rest of the butterfly kind — it is quickened into a butterfly toward the end intended by Nature, with this one difference: that greater care must be taken of these than of butterflies. I said it is born from the mulberry [morus], because if you examine the texture both of the bark and of the leaves of the mulberry under a microscope, you will find that Nature has so woven it that yellow silk most closely rivals it in its fibers.

[Margin: Bombycum ortus. — The origin of silkworms.]

In this way, then, the generation is accomplished. As soon as the creature is hatched from the spermatic excrement of the eggs, without a sac, it is transformed by an admirable metamorphosis through a brief stage as a zoophyte [zoophyton], devoid of motion and sense. When you have seen it hatched, it at once seeks out — by a hidden instinct of Nature — the foods it requires; and once it has greedily fed on these, struggling as if against drowsiness with frequent raising of its head, it at last falls asleep for three days or two.

[Margin: Observatio mira. — A remarkable observation.]

Meanwhile, having shed its skin, it returns to its accustomed foods; and having fed on these four times, and four times fallen asleep, and four times renewed its skin, it scorns its fodder and seeks the heights. When it has climbed up onto twigs of broom, Spanish broom [spartum], southernwood [abrotonum], and the like — arranged with great industry by women — its belly now duly purged, it practices the rudiments of its wool-working [lanificium] first in hidden mazes among the branches; then, enclosed in a translucent sac, it pushes out from center to circumference the fruit of its tireless labor: a thread, white, green, yellow, of oval shape; and, as if vying with its equals, intent on its work completed in nine days, it dies upon it.

[Margin: Varia Bombycum metamorphosis. — The varied metamorphosis of silkworms.]

From the sac, however — placed in a subterranean spot — after ten days a horned butterfly comes forth, but heedless of wings and of food; destined to repair the loss of its brief life by procreation, it is laid upon soft wool and, coupled with the female in continuous mating for three days (more rarely for four), it dies; and not long after, having left a widow behind it, with a seed-stock after it like grains of millet, it follows the fate of the husband. The

excrementitious seed, deposited in a temperate place and kept through the winter, soon — when the mulberries have begun to bud, with a spirit conceived whether by the Sun's heat or by men's — is quickened into a worm; from which then comes a chrysalis, and at last from this again a butterfly. And so the one that had first been a worm, enclosed in its sac, at last dies in its sac shapeless [informis] — so that for that reason I cannot sufficiently marvel at the infinite wisdom of God, Greatest and Best [Deus Optimus Maximus], in the most abject little creature.

I could say more here about the cultivation of these creatures; but since these matters have already become commonplace through frequent practice and use, I leave them to be set out by the women, and the reader may consult the figures placed here.

[Margin: *Perlarum ortus*. — The origin of the *perla* [mayfly/dragonfly].]

It is asked, secondly: how are the *quadripennia* which they call *perlae* generated? This insect is equipped with four very long, delicate wings, of a crimson, red, and whitish color, and flies chiefly about river waters — truly a beautiful little creature on account of the variety of its colors. Take its generation in a few words, as known to me from experiment. There are found, clinging to rocks at the bottom of rivers, little channels [canaliculi] formed of sand and stalks, in which, as within little tubes, worms are contained. Fishermen use these for catching fish with a hook, fixing them on the point of the hook in place of bait. These worms, now mature, drawn out [educti] by [their] feet...

Diagram. A small woodcut set into the left text column, captioned *Folliculus. Tabanus*. ("The sac. The horse-fly."). It depicts a chrysalis/cocoon (the *folliculus*) shown vertically; per the surrounding text, this is the chrysalis in which Kircher claims to have seen "the perfect form of an infant wrapped in swaddling-bands" and an image of the Savior. The figure shows an oval sac-form with a face-like pattern within. No internal point-labels.

Diagram. A woodcut of three figures in a row at the foot of the right text column, illustrating the silkworm's metamorphosis. Captions over the three figures, left to right:

- (left): *Papilio Bombycinus* — "The silk-moth (silkworm butterfly)." A spread-winged moth with patterned wings.
- (center): *Ex folliculo Bombyx erumpens* — "The silkworm bursting forth from its sac." A cocoon shown with the emerging form.

- (right): [Greek: χρυσάλις (chrysalis — "chrysalis/pupa")]. An oval pupa-form.

No internal point-labels beyond the three captions.

(Page 361 — De Insectis) ... they crawl up, together with their little channel, as far as the surface of the water, to the edge bordering the banks. There, clinging to rocks or to a clod of earth, by the heat of the Sun they degenerate into that little animal which is commonly called the *perla* [mayfly];

[Margin: Natales Perlarum. — The birth of the *perlae*.]

and thus they obtain one and the same origin as the butterflies, with this one difference: that butterflies get their birth in plants, these in waters. [...] from the various refuse of fishes — especially of those they call gudgeons [gobiones] — or from the excrements of other [creatures], a worm is born; from the worm comes a chrysalis; and from the chrysalis at last, together with its channel, there rises up, infected, that animal which we have called the *perla*. And although, so far as I know, this has hitherto been observed by no one, it thus first became known by our observation.

[Margin: Cicadarum ortus. — The origin of cicadas.]

It is asked, thirdly: how are cicadas [cicadae] or crickets [grilli] born? Those who hold that cicadas are born of their own accord are gravely deluded, since they have been observed to propagate both spontaneously and also afterward by copulation, as happens in nearly all insects. Their generation, however, is accomplished in this way. Within the earth, or also in the hollows of trees, a certain seed lies hidden, which Aristotle [Aristoteles] supposes to be deposited by the *tettigometra* [Greek: τεττιγομήτρα (tettigomētra — "cicada-mother," the larval cicada)]; but it is nothing other than a certain animal not unlike a cicada, of the kind that the [Greek: τέττιγες (tettiges — "cicadas")] called *locustae* are. From this seed, then, in the summer season, a worm is hatched, which, afterward wrapped in a little sac, at last — when the sac has burst — comes out as a green cicada.

These are the things that became known to me by experience in observing an insect of this kind. See our *Musurgia* [noted in margin: *Musurgia*], where in the first book we treated very fully of the voice and the structure of the body of this little creature.

[Margin: *Musurgiam, Libro primo* — citation: Kircher, *Musurgia Universalis*, Book I.]

[Margin: Cicada. — The cicada (figure label).]

CAPUT IV.

On the origin of the insects called *analytra*, which they name *bipennia* [De Analytrorum, quae Bipennia vocant, Insectorum origine].

[Margin: Muscarum ortus. — The origin of flies.]

The fly [musca] is an animal known to all, [Greek: ἑξάπους (hexapous — "six-footed")], equipped with six feet and two wings, from which they are called *bipennia* ("two-winged") — about whose net-like eyes [oculi retiformes] we have treated at length elsewhere in our works, detected by the use of the microscope. Just as the species of this insect are innumerable, so too they obtain diverse origins: some take a kind of momentary origin from animals and from the excrements of animals; some from carcasses; some from herbs; some from the carcasses of the flies themselves; certain ones are born from the very excrements of those flies. That all these things are true you will find out as follows.

EXPERIMENTUM I.

The generation of flies [Genesis Muscarum].

Gather the carcasses of flies, and, after first macerating them a little in honeyed water, place them upon a bronze plate; then expose the plate, in the chemists' manner, over ash or sand, with a gentle heat, with coals set beneath it, or else warmed with horse-dung. You will see, first — by the help of the microscope — certain imperceptible little worms being born; then, once they have taken on wings, [you will see them] perceptibly [turn] into little flies [muscillae], and at last, growing until they reach the threshold of the senses, come to life as perfect flies. You will observe the same thing happening from their own excrements — which Aristotle [Aristoteles] himself also...

Diagram. A woodcut of a wasp set into the right text column, captioned *Vespa*. ("Wasp"). It shows a single wasp in dorsal view with two pairs of wings, antennae, and the characteristic constricted waist. No internal point-labels.

Diagram. A woodcut captioned *Perla*. set into the left text column, depicting a dragonfly/mayfly [*perla*] in dorsal view, with the four long delicate wings spread, an elongate segmented abdomen, and the head with large eyes. No internal point-labels.

Diagram. A woodcut captioned *Natales Perlarum*. ("The birth of the *perlae*"), set into the left text column below the *Perla* figure. It shows the underwater larval scene described in the text: the *canaliculi* (sand-and-stalk tube-cases) clinging among rocks at a river bottom, from which the larvae emerge. The image is a clustered rocky/tubular composition. No legible internal point-labels.

Diagram. A woodcut captioned *Cicada*. set into the right text column, depicting a cicada in dorsal view with two pairs of wings folded/spread and six legs. No internal point-labels.

[Reading order: the four PDF pages are non-linear. By printed page number they run 362 → 363 → 364 → 365, which corresponds to PDF-page order 2, 1, 4, 3. Each printed page is set in two columns; I translate left column then right column within each page. Page 362 continues the sentence broken at the catchword "stoteles" ending the prior page (361), completing "[Ari]stoteles observavit."]

as Aristotle himself also observed. "Flies," he says, "are generated when the worms divide into parts; and those who perform this service maintain that one cannot tell the remainder of the dung apart from the seminal matter—they confirm that the dung is itself cooked and digested." Now the beginning of these little worms is the tiniest thing: it first turns red, and then, as though still clinging to the sand by immobile fibers, it begins to stir. Soon the worm becomes motionless; and once it has afterward been born, it again becomes motionless, and finally turns into a fly when stirred by a puff of air or by the action of the Sun. Those, however, who say flies are born from eggs say that the same flies are born from their own filth, in which the seed is contained.

And if flies are sometimes seen to copulate, this happens because of a certain sharpness in the excrement itself, by which, being stimulated, they discharge their excrement more copiously—so that, as though glued together by it, they can scarcely be seen to separate. Wherever this is deposited, little worms rise up out of the already-deposited spermatic matter, and from these comes the winged fly.

[Margin: The variety of flies.]

The first question: From where does so great a variety of flies arise? I answer that it happens either from the dung of animals—which, once they have taken in for nourishment plants steeped with the various seeds of flies, that matter, now fermented within the intestines along with the food, excites the seminal power. Once excreted and still warm, it produces, as though by a kind of impromptu birth, flies of different sorts according to the quality of the seed shed, as is plain to the eye of anyone who observes such things. Hence too the wine-flies that lurk in must and vinegar; hence the mayflies [Ephemera], the gadflies [Oestra], the horseflies [Tabani], the breeze-flies [Asili], and any other kind of fly there may be, all derive their origin. Most of these stink of venom, especially those that draw their origin from poisonous flowers and herbs, or from putrefied serpents.

[Margin: The origin of the gnat [Cynips].]

It now remains to explain the origin of those flies which the Latins commonly call *Zenzalae*, and the Greeks *Cynipes* [Greek: κώνωψ (kōnōps, "gnat" or "mosquito")]. They belong to the genus of gnats [culex], a thoroughly tiresome creature, most troublesome both by its whining and by its bites; about its origin various people have thought variously. I have discovered their origin by the following experiment.

EXPERIMENTUM I.

On the Origin of Gnats [Cyniphes], which they commonly call Zenzalae.

Take rainwater, or even spring water, put it into a glass vial, and set it out in summer in dusty places—just as I had set it out beyond a window that looked onto the public street—and in this way, with the mouth of the vial open, let it stand. You will see that the dust from the street, stirred up by the movement of horses and carriages, within a short time draws a kind of skin over the surface of the water held in the vial; but if you shake it a little, you will see the dust sink to the bottom and there remain in the form of a sediment.

This done, after some days examine the silt carefully, and you will find certain little blisters, which are the wombs of worms; for out of these come little worms, at first perceptible only to the armed eye [i.e., under the microscope]. These, growing steadily, usually swim about in the water in great numbers with a twisting motion; and once they have acquired the proper maturity, then—the water and the side of the vial drawing near—as soon as they touch the air, behold, within a tiny space of time, with legs and wings now taken on, they come

alive as gnats [Cyniphes] or *zenzala*e. And this generation I have discovered by experiment more than once.

If you go on to ask from where they draw their origin, I say they draw it from the dust stuffed with the varied seed of things; and this seed comes either from the carcasses of animals—cats, dogs, birds—with which the streets of Rome are at times crammed; or else from the excrement of horses, asses, oxen, goats, and the like, in which the seeds of various flies and gnats lie hidden. For when this seed has been mixed with the dust, then as soon as it has found moisture and made mud, behold, at once, animated also by the heat of the surrounding air, it turns first into blisters, then into little worms, and finally into those creatures we have called gnats. And what perhaps ought to have become a fly, or a gnat [culex], degenerating through the inadequacy of its matter, is turned into a *cynips*.

Certainly these things agree most fully with the Sacred Text of Exodus, chapter 10 [recte: Exodus 8], where, when the dust was struck by Moses, gnats [Cyniphes] came forth—which was the most troublesome of all the plagues inflicted upon Egypt.

[Margin: The origin of the gnat [culex].]

From this the origin of gnats [culices] too is demonstrated—although I would not deny that gnats and *cyniphes* (which are a smaller species of gnat) may also arise from elsewhere. And to treat first of the origin of gnats: I recall having often observed that in the little pods [folliculi] of the mastic, the elm, the terebinth, and those that grow upon oak leaves, when broken open, there is found some sort of seed-bed of such little beasts—partly under the form of eggs, partly even under the form of little beasts already equipped with wings. For these pods, placed under an inverted glass, hatched out partly gnats [Cyniphes], partly gnats [culices]. All of which I would wish the Reader to observe, for it is a matter full of wonder.

[Margin: The pods are the wombs onto which the flies settle.]

If you ask how seeds of this kind come to be in such pods, I say it is from the settling of various flies upon them at the time when the pods have not yet hardened but are seen under the form of flowers. For various flies, settling upon these, fill the inmost part of the flower with their seed; and this, afterward enclosed as though within a womb, brings forth the little creatures we have described.

CAPUT V.

On the Origin of those Insects which have their Wings Enclosed in Sheaths.

Those insects are so called which have their wings enclosed in sheaths [vaginae]—from the Greeks *Koleoptera* [Greek: κολεόπτερα (koleoptera, "sheath-winged" — beetles)], from the Latins *Vaginipennia*. And they are: the locust [Locusta], the cricket [Grillus], the scarab [Scarabaeus], the chafer [Cantharus], the *Buprestis*, the firefly [Cincindela], the cockroach [blatta], and innumerable others like them.

And to begin with the locusts: their diversity is no less than that of the flies—

Diagram. A woodcut of a locust (grasshopper), shown in left profile with the long hind legs raised, two antennae, and the body and wings detailed.

- Caption (above figure): *Locusta*. — "Locust."

—a diversity which cannot be caused by anything except the degeneration of the diverse seed from which they are born. In the year 1656 this pest infested the fields of Rome with enormous damage; it had drawn its origin from the dryness of the preceding year. Everywhere in the fields nests full of the offspring of this creature were found. For first, as became known to me through the microscope, eggs were seen, then little worms, of which some [were] without wings,

[Margin: The wonderful generation of locusts and grubs.]

while certain ones already seemed to be fashioning wings for themselves. These, exposed to the Sun, within the brief time it would take someone to recite a crown [a chaplet of prayers] to the Blessed Virgin, were shaped into locusts leaping here and there; and once they had arisen, they left nothing in the crops untouched, so that the destructive gluttony of these little creatures could not seem to be sated even by the leaves and buds of trees. And a plague of the following year, attended by great slaughter of men, followed upon them.

If you ask from where so great a swarming of locusts comes, I say they draw their origin from entirely various seeds. **First** I say that most [of them]

[Margin: The cause of their generation is set out.]

arise from blighted grain, whether it be oats, or wheat, or barley—in this way: that, together with venomous subterranean exhalations, the seeds (which for the most part are born from the excrement of other worms and flies settling on the crops) are intermingled; and from this comes the locust, to which the plastic

power of the seed, partly in accordance with the requirements of the insect, gave a sentient body suited to insects, but gave it feet

[Margin: Locusts from the knots of crops.]

not unlike the knots [nodes] of crops. **Secondly** I say that they can be born from the carcasses of men, and this is confirmed by various histories in which it is reported that, when a great slaughter of men had taken place in the fields—whether by war or by those perishing of famine—from their carcasses a vast swarming of locusts soon burst forth; with which the records of all the Historians are full.

If you ask how these are born from the carcasses, whether of men or of animals, I answer that it happens

[Margin: Locusts from carcasses.]

from corrupted grain, on which soldiers and animals for the most part feed in time of famine or shortage of provisions. Since this is stuffed with the seeds just mentioned, hence it comes about that in the carcasses of the locusts that perish [the seed is born again]—the spermatic matter, fermented by heat both external and internal, is at last quickened into locusts.

[Margin: From the very carcass.]

Thirdly I say that this pernicious swarming likewise [arises] from the locusts themselves; in the carcasses of locusts that have perished, [it is born again] at a suitable time of year. For by rains and by the flooding of rivers these carcasses, corrupted and putrefied, are buried in the earth together with clods of soil and mud; and there, by subterranean heat in winter but by external heat in summer, they are animated into locusts by the power of the seed.

It also sometimes happens that a vast army of locusts, driven by the force of the winds into seas, lakes, and rivers, is drowned there; and their carcasses, afterward cast onto the shores, found there a new seed-bed of locusts—on which see more fully, treatise by treatise, in our *Physico-Medical Scrutiny on the Plague* [*Physico-medicum scrutinium de peste*].

[Margin: From the leaves of trees and from grass.]

Fourthly I say that they can also be born from the grasses and the leaves of trees, in this way: since this creature is generated not only out of putrid matter by the power of foreign and alien seed, as we have already said, but also out of the settling of one upon another like itself—which many call copulation [coitus]. For

since most people say that all locusts are female, just as scarabs are male, and that they are distinguished by no sex,

[Margin: By copulation they are produced in a particular way.]

it is certain that they conceive in another way, which I now disclose, as something known by experiment. For when I had fed a locust for a long time, I at length found it impregnated by itself with a manifold brood, which it shortly afterward poured out, fertile. Now in this way copulation is accomplished: the excrement, which serves them in place of seed, since by the power of its innate salt it is exceedingly sharp, hence tickles in a wonderful way the body of the locust onto which it is poured. And do not suppose this excrement to be cast off through the vulva—which the locust does not have—but rather,

[Margin: How they generate.]

the suffering animal, warmed by the tickling, dilates as much as it can its pores and clefts, into which the received [matter] passes into a seed fit for hatching locusts. For at once certain little bubbles appear in the form of eggs, which, when burst, soon rise up into winged worms. So whether the locusts have settled upon one another in the leaves of trees and plants, or on the stalks of crops, or in the very earth, or have deposited the spermatic excrement in the same places—if, as we have said, that excrement has first been fermented by heat,

[Margin: The generation of grubs is the same as that of locusts.]

then, in time, with the external [warmth] of spring arriving at its close, out of their little pods emerge small, blackish worms, without wings and without legs; and at length they are transformed into locusts. For since they must always be born from the same nourishment by which they are fed, with the seed of sentient Nature implanted in it, it is necessary that they be born thus.

[Margin: The generation of grubs.]

What we have said of locusts must be said of the generation of grubs [bruchi], whom they call *Attelabi* [Greek: ἀττέλαβος (attelabos, "wingless locust" or "young locust")]—with this difference, however,

[Margin: The origin of grubs.]

that grubs for the most part take the beginnings of their generation from the mucous sap of plants and shrubs, which the chafers [canthari], or even the locusts, have infected with their filth. These afterward propagate themselves too by promiscuous union, just like the locusts.

[Margin: Why so great a multitude of these insects does not arise in single [individual] years.]

But that so great a multitude of these insects does not arise in single years depends on the now-this, now-that constitution of moister or drier seasons and years. Nothing further remains, then, except to confirm what has been said by experiment.

EXPERIMENTUM [II].

The Generation of Grubs.

If, then, you have a mind to produce grubs, as we have done by experiment, proceed thus: Grind up grubs together with their nests into powder. Then fill any vessel you please with that earth in which oaten stalks have rotted; if into this you mix the powder a little while before prepared, and water it with the mucous sap of a shrub mixed with rainwater, the result will be that, exposed to warm air, within eight days it comes alive into innumerable grubs and locusts. These you will then clearly observe if you fit an inverted glass, open at the top, to the rim of the vessel so that they do not fly away. And this method is exactly the same as that by which Nature proceeds in producing the said insects.

I would by no means wish these things to be referred to evil, but [I say them] so that the power of Nature, joined to art, may become known. For whatever is said in the Sacred Text about the grub, the blight [aerugo], the locusts, is always to be understood of the greatest evil, which God, being just, sends upon men on account of their sins—by which they inflict venomous wounds not upon one or another only, but upon whole nations: death by famine, and from the fetid corruption a deadly and inescapable pestilence.

[Margin: Locusts and grubs, when burned, drive the rest away by their smell.]

Yet there is a thing both wonderful and most worthy of consideration. For if it is true, as Democritus relates, that if you catch and burn locusts or grubs, the result is that the others, soon seized with dizziness, either die, or, shedding their wings, are consumed by the Sun—although I would more truly think that they are afterward revived, as it were, from a kind of funeral pyre. But concerning the other ways of driving off locusts, read the writers on the art of Agriculture.

[Margin: What kind the locusts were on which St. John the Baptist fed.]

Further, as to what kind the locusts were on which John the Baptist, the Forerunner of CHRIST, is recorded by the Sacred Gospel to have been fed in the

desert: read Aldrovandi [Aldromandus], who treated this subject most fully in his *Book on Insects* [*De insectis*], where he also adduces a twofold opinion. Of these, some hold that they were true locusts, which the Greeks call *akrides* [Greek: ἀκρίδες (*akrides*, "locusts")]; but others think it more likely that he took for food only the tips of trees, or even the more tender buds of plants, which the Greeks likewise call *akrides*. But now to other matters.

[Margin: The generation of crickets.]

As to what concerns the generation of crickets [*grylli*], they too are distinguished into many species. There are some that are arboreal and woodland, which all through July and August do not cease to vex the ears day and night with their grating sound; and there are also the hearth-crickets [*focarii*], or domestic ones, which are hatched out of the leavings of meats and of woods stuffed with seeds, when a slight moisture is added, by the heat of the fire. They especially dominate the heated rooms [*hypocausta*] of bakeries, and emerge in vast progeny; and they have their origin from nowhere else than from the seed of sentient nature present in the grain. Since this seed is incorruptible, it likewise clings not only to grain but also to kneaded flour and to moldy bread; and this, afterward raised up by the vapor in the heated rooms and deposited within the cracks of the walls, at length hatches out those crickets which the Italians call *Bargarozzi*—

[Margin: *Bargarozzi*, which [is] in Italian.]

—mute ones, however; the Latins call them *Blattae*. See the First Book of the *Musurgia*, where we have precisely assigned the causes of the sound of crickets.

§. I.

On the Origin of Scarabs [Beetles].

Of scarabs [*scarabaei*], and of those insects we have already examined, not all are of the same species, just as the reason of the seeds from which they have flowed forth is not the same; for they differ in color, in size, in sound, and in the constitution of their limbs. Some are black, yellowish, or ash-colored; some shine with a lustrous golden-green color, which they call *Chrysocantharos* [golden chafers]. There are others remarkable for the branching form of their horns, which from this they also call *Cantharelaphi* or scarab-stags [*Scarabaeo-cervi*]; others resemble unicorns [*monocerotes*]; others *Lucani* without horns; others [have] a horse's or goat's head; and there are some that resemble stags in the head. They differ also in place;

[Greek caption above the figure on this page: ἐλαφοκάνθαρος (elaphokantharos, "stag-chafer").]

Diagram. A woodcut of a stag-beetle (*Lucanus*), viewed from above, showing the broad body, the large branching mandibles ("horns") at the head, and the six legs spread to the sides.

- Caption (above figure): ἐλαφοκάνθαρος [Greek: elaphokantharos, "stag-chafer" / stag-beetle].

Some draw their origin from the dung of animals, like the scarabs they call ball-rollers [pilularii], met with everywhere along every path; others have their birth in trees; some within

the earth, or in latrines, or even within waters are born; yet of all of these the origin is the same—partly from copulation, partly from the seed of sentient nature shed from elsewhere,

[Margin: The origin of scarabs from various living things.]

namely from the herbs that spring up of their own accord. For unfailing experience teaches that they are born not from the excrement of horses alone, but also of oxen and asses. Indeed, I recall having sometimes observed

Diagram. A woodcut of a horned beetle ("unicorn beetle"), viewed from above, with a single long curved horn projecting forward from the head, a rounded thorax and elytra, and the legs spread at the sides.

- Caption (above figure): *Monoceros*. — "Unicorn" [single-horned beetle].

whole scarabs that had hatched out together with the warm dung of horses; and afterward others of them, in great number and by a kind of impromptu birth, were produced out of the underlying matter. If you ask the cause of this generation:

I say there is no other cause than the nourishment of the herbs on which they feed. This [nourishment], being infected with the seed of other insects and of certain worms and flies, and devoured by the beasts of burden, then digested by the heat of the intestines, and at last evolved outward, hatches out scarabs, which have their nests within the earth.

Diagram. A woodcut of a ball-rolling scarab [dung-beetle], viewed from above, with the rounded body, the head shield, and the six legs.

- Caption (above figure): *Scarabæus pilular[ius]*. — "Ball-rolling scarab" [dung-beetle].

In exactly the same way they are born from cattle or horse dung worked into the earth. It is worth consideration, however, that if the beasts of burden eat plants infected with the seed of flies, then from this are produced bees, wasps, and similar little creatures; but if the said plants have been infected with beetle-like or sheath-winged [vaginipenne] little creatures, such as small cantharides, then out of their dung beetle-like animals too, of the kind that scarabs are, are born. For just as such nourishment behaves with respect to producing scarabs in beasts of burden, so does the worm-breeding nourishment of milk behave in infants, with respect to producing roundworms [lumbri] in the intestines of children.

[Margin: Observations on scarabs.]

[Margin: The generation of horned scarabs.]

But as to what concerns the generation of those scarabs they call *Lucani*, which are not unlike stags in their horned head: I say that they are born from rotten woods steeped in deer dung—induced chiefly by this argument, that nowhere is a greater abundance of these insects found than in those places where deer are stabled in herds, as has often been observed by me in Germany. I have also heard from those who have the care of deer that they are sometimes found in their droppings, and now and then are born thus from rotten woods steeped in deer dung—so that at first they appear as worms [resembling] *Zoophyta*, then, becoming detached, they crawl about with the traces of horns gradually opening, and at last emerge as beetles, conspicuous with a horned, stag-like head. And the reason of this matter is no other than that to the excrement is added some little of the deer's seed, which at the time of copulation they scatter even outside the vessel; and thus from differing seed a differing animal arises—that is, a scarab-stag [Scarabæo-cervus]. From the seed present in the food, [there arises] something like the form of a scarab; but from the deer's seed, nature works as much as it can to produce something like a deer. And since it cannot produce a perfect animal—being disposed in an ill-proportioned womb—it at least does this much, that it fashions an *elaphomorphon* [Greek: ἐλαφόμορφον (*elaphomorphon*, "deer-shaped")]—that is, a stag's head conspicuous with branching horns.

[Margin: The unicorn scarab.]

But as to why scarab unicorns [monocerotes] are sometimes found, remarkable for a single horn on the forehead: I say this happens because the animal, either through a defect of the seminal matter, or because the same matter is diffused

into forming other limbs of the body, is now equipped with only one [horn] where it ought to have been equipped with two.

[Margin: The chrysocanthar, or scarab gleaming with golden splendor.]

But how the *Chrysocanthari*—that is, that species of scarab which so greatly delights the sight with its golden-green color—are generated, if you ask: I say they are born in no other way than the rest of the ball-rolling scarabs, nor do they differ in species, but only by accident; yet that color comes to them first in this way, which follows. Within the cavities of the earth there is sometimes a kind of brassy [aerosa] clod arising from veins of marcasite, which tinges not only the surrounding places, but also certain plants—while they draw in moisture—with that color which the brassy earth confers on them, as appears in the sap of celandine [chelidonia] and turmeric [curcuma]. And so the scarabs, at first tinted with a black color, as soon as they have insinuated themselves into places of this kind,

[Margin: An experiment on the origin of the golden color in scarabs.]

are at once excited by the saline and vitriolic little spirits which exist in the brassy clod, stirred up by the force of heat; and this, acting upon the body of the scarab, tinges it with the said color. This first became known to me when I had moistened a scarab enclosed in glass with spirit of vitriol mixed together with verdigris, and it was at once, with its color changed, transmuted into a translucent golden-green. And since this is a most beautiful experiment, I would wish all natural philosophers of a more curious doctrine to try it.

You see, then, with how many differing seeds even this single animal is constituted: the minerals give the color; the deer's seed [gives] the horned head; and the seed shed from other sheath-winged creatures not unlike the scarab gives the scarab itself.

[Margin: The generation of cantharides.]

It now remains to unfold the generation of the cantharides [blister-beetles]. The cantharides are little beetle-like worms, which I would not inappropriately call little scarabs [Scarabaeunculi]. These Aristotle, on the testimony

[Reading order used: PDF pages were out of sequence. Reconstructed from printed folio numbers and catchwords as 366 → 367 → 368 → 369. Page 366 continues the cantharides passage broken off at the end of the prior folio (p. 365, catchword "teste"); its catchword "porem" leads into p. 367; p. 367 ("redeamus") continues to p. 368 only after the figure of the scorpion and the body text resumes

— but by folio sequence 366→367 is the recto/verso pair, and 368→369 the next. Catchword chain: 366→"porem"→367; 368→(habita-)→369→"de-".]

[Continuation of §. I, "On the origin of beetles" — the generation of cantharides (blister-beetles).]

as Aristotle reports, on the testimony of Aelian [Aelianus], they are born among grasses and standing crops, and on the branches of poplars. "From the prunings," he says, "of the fig and the pine there also arise κράμβης [Greek: krambēs, "of cabbage" — i.e., cabbage-caterpillars], that is, 'dog-caterpillars' [eruca caninal]; and there are likewise worms in all of them; for this kind of animal seeks out foul matter, since it is itself constituted out of such matter." Pliny [the Elder] holds that they are born from the sponge-like gall of the dog-rose [Cynorrhodon], and from the ash and from roses. And these authors are right — provided they had also learned the more immediate cause of the seed-stock [seminium] from which the creatures are born.

[Margin: The origin of cantharides from the toad's filth.]

For my part, I judge that most of these little creatures — the more venomous cantharides especially — are born partly from the excremental filth of the toad [rubeta], partly from spiders. This is clear to us from the fact that plants nearest a toad's nest are for the most part found thick with cantharides, and the ferocity of the toad's venom, manifesting itself in entirely similar symptoms, shows plainly enough that the nesting of cantharides in this or that tree or plant is to be reckoned a clear sign of the matter — since, once hatched out of the underlying material, they immediately make for whatever tree comes nearest.

[Margin: Cantharides born from venomous plants.]

I would not, however, deny that they can sometimes also be born from plants stocked with the seed of spiders — especially from hemlock [cicuta], monkshood [napellus], and leopard's-bane [doronicum Pardalianches], deadly plants, in whose flowers, at their flowering season, I remember having observed a great abundance of them.

[Margin: From spiders.]

Nor should you wonder that cantharides can by nature be born from the seed-stock of spiders, since some of the cantharides are so similar to spiders in their bodily constitution that, if you set aside the color, it is at once apparent that what is expressed by so close a resemblance is not foreign to them. But as for the nature of the venom with which cantharides are equipped by nature, let the

reader consult Book Ten [Libro Decimo], where all these things are discussed in detail.

§. II.

On glow-worms, or fireflies [De Lampyridibus sive cincindelīs].

Among the beetle-winged insects [Coleoptera] are also counted those which the Greeks call λαμπυρίδες [Greek: lampyrides, "glow-worms"] and the Latins *cicindela*e. For — on the testimony of Hesychius — the firefly [Lampyris], "ἡ πυρολαμπομένη ταῖς νυξὶ λαμπυρίς" [Greek: hē pyrolampomenē tais nyxi lampyris, "the firefly that shines with fire in the nights"], "shining by night," might perhaps better be called λαμπρουρίς [Greek: lamprouris, "bright-tail"] or πυγολαμπίς [Greek: pygolampis, "rump-shiner"], because its hindmost part — that is, its uropygium [tail-end] — shines perpetually by night. Concerning their generation there is doubt, and much dispute and contention among the natural philosophers; and since I have been an inquisitive observer of a great number of captured animals of this kind, I shall set out in a few words what I have learned.

[Margin: Description of the firefly.]

The λαμπυρίς [Greek: lampyris, firefly], *nitedula*, or *cicindela* is a beetle-winged worm whose hindmost part, or uropygium, emits a most brilliant flame; its wing is black, its belly of a reddish warmth [color], and its body consists of a ringed expanse marked with alternating black-and-white circles. About its original generation the question is raised. Most people think, on the testimony of [Giambattista della] Porta, that besides mating it is also born from dew.

[Margin: The generation of the firefly.]

We do indeed admit their propagation by mating — yet in the same manner that we set out above for cicadas, locusts, and beetles. But we also assert that this creature is born spontaneously from rotten wood or from a plant already infected with the seed-stock. For you will scarcely find rotten wood in the fields on which, at the season when they are wont to be born, fireflies are not seated.

[Margin: An experiment.]

For if you observe wood of this sort under a microscope [microscopium] at the right time, you will see first certain imperceptible little sacs, like eggs; when these burst, a worm comes out, which after a brief interval, having taken on wings, is transformed into a beetle-winged firefly that shines by night with intense light. And as to how it has acquired this property of nocturnal-glowing light beyond

other insects, I shall explain in a few words. It is known to everyone that rotten wood has this peculiar property above all: that by night it shines no differently than a flame.

[Margin: The origin of light in the firefly.]

Since, then, the firefly arises directly from rotten wood, it comes about that it derives that native light of the wood, together with the seed-stock, in part into itself. And this I take to be the explanation of the light in the firefly: that, just as it is intrinsic and innate to the little creature no less than to rotten wood, so too it is not extinguished when water is poured over it — as we have often proved — namely on account of the thin and dull heat in the viscous moisture, which the moisture does not easily overcome. This is also evident in certain fish, as in acorn-shells [balani], that is, date-shells [dactyli], in putrefied crabs, and the like, whose luminous humor emits in the dark a light, innate to them, that is quite intense. But the firefly's light is not diffused through the whole body; rather it is gathered in the outermost part of the uropygium, which by day shows a white spot. See, reader, what we have treated at length concerning the firefly's light in Book One of the *Great Art of Light and Shadow* [Ars Magna Lucis et Umbrae], where you will find set out whatever can be desired about this subject; and below we shall add a few things suited to this argument.

Caput VI.

On the insects which are indeed deprived of wings, yet equipped with many feet [De Insectis, quae alis quidem destituta, multis tamen pedibus instructa sunt].

These insects are called by the Greeks ἄπτερα πολύποδα [Greek: aptera polypoda, "wingless many-footed (creatures)"]: deprived of wings indeed, but furnished with a manifold variety of feet — of which kind are ants, scorpions, spiders, fleas, lice, bedbugs, and innumerable similar creatures, whose origin we now undertake to investigate. And let me begin with the ants.

[Margin: Description of the ant.]

The ant [Formica] is an animal known to everyone — diligent, industrious, and unwearied in labor — whose dogged and tireless toil is such that it strikes nearly everyone with amazement.

that it should drag [its burden] — the most dutiful and busiest of all insects. For who would not marvel at such robust strength in so tiny a little creature?

[Margin: The observation of St. Jerome.]

By the labors of these creatures the holy Jerome [Divus Hieronymus], once roused in the desert, used to lament his own negligence in his divine exercises, when he saw himself surpassed even by the most worthless little animal in steadfastness for enduring toil. His words are these: "I behold," he says, "a swarm of ants along a narrow track keeping up loads almost greater than their own bodies — some were dragging certain seeds of plants with the shears of their mouths; others were carrying out earth from their pits and shutting off the channels of water with embankments; those creatures, mindful of the coming winter, lest the damp earth should turn their stores into a green shoot, were nibbling off the seeds they had brought in; in a famous funeral procession they were bearing away the bodies of the dead; and — what is more wonderful — going forth in so great a column, one did not block another coming in, but rather, if they saw any one fall beneath its load and burden, they put their shoulders underneath and helped it. Why say more? That day afforded me a beautiful spectacle, from which, recalling Solomon, who sends [us] to the ant for its skill, and who rouses sluggish minds by such an example," and so on. Rightly and wisely!

[Margin: The author's observation.]

And I myself have more than once hung astonished in contemplation of toils of this kind, nor could I grasp how they carry bodies far larger than themselves, push them, and roll them every which way — now superior in weight, now pressed down by the mass of the weight, lower, taking up afresh the rolling of the burden with new labor; with what great effort, with the whole little body, with all their shoulders, with all their strength, they strain against the weights; and that what at one attempt they cannot do, owing to the feebleness of their strength, by serious and steadfast application again and again they at last move forward — the mass [of food], summoned by their hind feet and thighs stretched out before them, into the appointed place — so that the ant is deservedly an example to us of great labor. I have marveled not a little at the industry and foresight with which they store provisions within their granaries at the opportune time.

[Margin: The observation of Aelian.]

Aelian [Aelianus] says: "When the harvests are made, the ants, busying themselves about the threshing-floors, gather for the threshing — leaving their dwellings and accustomed roofs either singly, or in pairs, or in threes; they gather wheat or barley, and all make the same journey: some go to gather the grains, others return carrying the burden, and with the greatest courtesy and modesty

some yield the road to others — above all to those who, unencumbered, are carrying a burden. But when they go out to forage, certain larger ones lead the rest, like the generals of an army; and when they have reached the standing crops, the younger ones stand beneath the stubble, while the leaders climb up and, cutting off the ears of grain, throw them down to those below; these in turn, standing around, tear them apart and one by one unfold the grains enclosed in their husks and sheaths. They need no instrument for shaking out the grain, nor a winnowing-fan for ventilating it, nor winds for cleansing the grain from the filth in the wheat — labors which men perform; and they store up provisions for themselves, contriving them by enormous toils." And how skillfully they arrange their dwellings according to the exact rule of the architectural art, and how thoroughly they perform all the parts of the political art in the distribution of offices —

[Margin: The dwellings of the ants.]

— let him read who wishes, in Simone Maioli [Simonis Maioli], *Dies Caniculares*, Colloquy 7. But having pursued these matters at greater length than I intended, let us now return to where we digressed from.

[Margin: The origin of ants.]

Concerning the origin of ants there is great contention among the authorities. Most assert that they are born from mating — which we do not deny; but it is also most certain that they are also born from putrid matter. As to *how*, exactly — here is Rhodes, here is the leap [*hic Rhodus, hic saltus*!] We ourselves, by diligent investigation, have observed that they draw their birth partly from the urine of animals, partly from old lime infected with seed-stock taken up from elsewhere, and partly also from the corrupted sloughs of serpents. For I do not remember ever to have seen a greater abundance of them than in those places where there was a multitude of rubble, or among the standing crops, where there had been an abundance of animal dung the year before. For the urine of animals — whether of wholesome or of venomous creatures — once joined there to the earth, carries along with itself a seed-stock fit for generating ants, as is evident from the sharp pain which they inflict on people, whether by stinging or by biting. Indeed, if it is true that animals are nourished by the same things of which they consist, then certainly they must be born from the standing crops of grain (which is their ordinary nourishment, infected with various seed-stocks). But they are also so eager for toads that a toad [*bufo*] thrown into an ant-heap is wholly consumed by them within a short time —

[Margin: A toad thrown into an ant-heap is consumed by them.]

— which is said to happen also with serpents cast onto the heap. The hidden reason for this is that the ant is said to be born from the urine of a toad or from the sloughs of a serpent; whence they crave the very thing out of which they are made. Again, we have observed that from the carcass of a single ant innumerable others are born, so that the whole carcass of the ant seems to be resolved into ants —

[Margin: From the carcass of an ant others are born.]

— which happens also with beetles and other insects. But having now set out enough of these matters, let us proceed to the generation of the scorpion.

The Generation of Scorpions [Scorpionum Genesis].

[Margin: The scorpion.]

The scorpion is an eight-footed animal, with a tail of six or seven joints, from which in some there emerges one, in certain others two, stings — which are the chamber of a hidden venom, and by which it is animated to inflict a deadly wound.

Diagram. A woodcut of a scorpion, viewed from above. The body shows the two large anterior pincers (chelae) extended forward, a segmented thorax and abdomen, four pairs of walking legs splayed to the sides, and the segmented tail curving up and over the back, terminating in the sting. The single printed caption above the figure reads:

- (caption, above figure): "Scorpio." ["Scorpion."]

Some are so similar to the *pagurus* or river-crab that, if you remove the tail, they appear exactly the same.

[Margin: Nine kinds of scorpion.]

Aelian [Aelianus] recounts nine kinds of scorpion, whose origin, as it is diverse, so too they differ variously in color, size, and shape. In the northern regions they are scarcely to be found, and if they are found, they are nonetheless harmless and lacking venom; a great multitude of these is born in the Noric Alps. They are reckoned to be the more venomous the more they have been hatched under a more torrid climate. In Egypt, Africa, and the other places subject to India's torrid zone, they are utterly deadly, and scarcely anyone who has been stung by their sting easily escapes.

[Margin: Where scorpions are found at Rome.]

At Rome, in the rubble of the old buildings, and especially in the Doliolum, that is, on Monte Testaccio, a vast abundance of them is found; and although these are potent in venom, it is not so dreadful that one cannot at once remedy it — even with the body of the scorpion itself, ground up and rubbed into the wound. Concerning these matters see our fuller treatment in Book IX, *On the Origin of Venoms* [*de venenorum origine*]. But to return to our purpose: according to the varied disposition of places, varied differences of scorpions are born. In some places they are the largest, as in India; in others winged, as in Mauretania; in certain places without a tail; in most they are imbued with a red, ash-gray, dusky, green, or black color. In Egypt, Aelian relates that they are born from the seed-stock of the crocodile.

[Margin: Winged ants.]

In Mauretania huge winged ants are transformed into winged scorpions. And although it has been observed that they propagate themselves by mating, yet that they are also born from their own body I have found to be true by this experiment.

EXPERIMENT — The Generation of Scorpions [*Genesis Scorpionum*].

Store the ground-up carcasses of scorpions inside a glass; if you pour over them water steeped in basil [*ocimum*], and expose it to the summer sun for a day, then — if you inspect it with a keen and aided eye [i.e., under magnification] — you will find this whole mixture to have degenerated into an innumerable brood of scorpions. You will find the same thing happens both in a living and in a dead-but-unground [scorpion], since from the body a certain excrement is cast out which is wholly turned into scorpions like itself. I should like another to test this — for he will find it true.

[Margin: Why scorpions are born from basil.]

But why a scorpion should be said to be born from basil [*Ocimum*] above all, someone might rightly ask, since it is found to have I-know-not-what sympathy with basil. Zollerius [*Zollerus*] relates that a scorpion was found in the brain of an Italian man, born there from the excessive use and odor of basil, and Ambroise Paré [*Ambrosius Pareus*] depicted it exactly. They say too that basil, ground up and placed between two bricks, when they have been exposed to the sun for the space of 24 hours, generates scorpions — which Pliny too testifies to be true. Indeed, Aristotle [*Aristoteles*] himself, in his collection of marvelous narrations,

asserts that scorpions are hatched also from putrefied σίσυμβρια [sisymbria]. Now sisymbrium [water-mint / a kind of cress] is a certain species of basil. Again, Pliny proposes an experiment of this kind: "If you wish to summon together into one place all the scorpions lurking anywhere, you will accomplish it in this way: a handful of basil bound together with ten river-crabs you shall set down in that place, and you will have your aim."

[Margin: The artificial production of scorpions.]

Avicenna [Avicenna] writes that he had a friend who, when he wished to produce scorpions from certain putrefied pieces of wood (which I judge to have been nothing other than putrefied stalks of basil), brought them forth; moreover he relates that basil reduced to powder, worked together with the ashes of scorpions, heals the sting. All of which are manifest indications of a mutual friendship between basil and the scorpion.

[Margin: The true cause of the sympathy of basil with the scorpion.]

But how an animal of this kind can be generated from basil without a sensitive nature and seed-stock, I do not see. Therefore, when I rather anxiously inquired into this matter with Francesco Corvino [Franciscus Corvinus], a thoroughly noble botanist and a most skillful investigator of natural things, he replied that it was no wonder: for the root has, native to it, a certain worm not unlike a scorpion, which Theophrastus [Theophrastus] calls *spondylus*. For this worm, once it has infected the plant with its seed-stock, from it scorpions are at last born — partly of themselves and by their own nature, partly by art, through the application of actives to passives. And this is the true and genuine explanation of the generation of scorpions from basil. As for the fact that they are also sometimes born from river-crabs, the reason is the resemblance of the crab or *pagurus* to the scorpion, by which the former is easily turned and transformed into the latter. By what art this is to be set up, Ovid [Ovidius] teaches in the following verses:

If you take away the hollow arms [pincers] from a shore-crab, and lay the rest beneath the earth, with that part buried, a scorpion will come forth, and will threaten with its curved tail.

But let this suffice concerning the generation of scorpions. Now let us proceed to explore the origin of spiders.

On the Generation of Spiders [De Genesi Araneorum].

[Margin: Caterpillars in plants are the offspring of spiders.]

The spider [Araneus] is an eight-footed and ἄπτερον [Greek: apteron, "wingless"] animal — that is, a wingless creature — infecting [its prey] not with a sting but with the venom diffused from its mouth; and just as it is divided into innumerable species, so too the authors hold varied opinions about their origin. That spiders are procreated from animals of their own kind by mating, but that from the φαλάγγια [phalangia, "venomous spiders"] and spiders come Ἀττάλαβοι [Attalaboi, a kind of locust], locusts, and cicadas, and that caterpillars too are the offspring of spiders — this Aristotle says in *On Animals* Book 9, chapter 14 [Animal. l. 9, c. 14]. These statements are not at variance with our own observations. For the seed-stock of any other animal whatsoever, which exists in its leavings and excrements, can be sufficient to generate a spider — just as the Philosopher [Aristotle] says that the caterpillars in plants are nothing other than the offspring of spiders. But in desert places, as in houses not [inhabited]...

inhabited, in towers, gardens — indeed even in meadows, fields, subterranean caverns, and in the fruits of certain plants, and in the little pods of the mastic, terebinth, and elm, and even in oak-galls and nuts — it has become known by frequent experience that they are found born from nothing other than dusts stocked with various seed, within the earth and above the water.

[Margin: Spiders born from dusts stocked with various seeds.]

That the spider-webs are procreated from these same seedbeds stocked with various seeds, experience — as I said — establishes; so it is no wonder that everywhere, in all places, they are born by an extemporaneous birth, that is, from dusts joined to moisture. For first, within the said little chambers, there burst forth certain eggs, as it were, enclosed in little sacs; when these burst, there comes out a certain imperceptible worm, or little spider, already constituted with all its limbs, which, scarcely yet hatched out, is at once set to the work of weaving and begins to weave the most delicate threads, perceptible only to an armed [magnified] eye. Indeed I have seen from a single sac of this kind sometimes 20, 30, or even 40 offspring bursting forth, so that I could not but marvel sufficiently at the fecundity of the little creature.

[Margin: A portent observed on the leaves of sage.]

On the leaves of sage [Salvia] especially I remember having observed a natural portent of this kind, which, beset with innumerable webs together with eggs and the tiniest spiders, anyone who has a mind to observe these things under a microscope will discover. The eggs are white and so fine that they might seem to be atoms; yet when compressed — being surrounded by little sacs — they emit a

certain crackling sound; and these too, warmed by a moderate heat, at once hatch out the multitude of little spiders I have described.

[Margin: How spiders mate.]

As for what pertains to their mating, it cannot properly be called mating, since they lack generative organs; but they seem, as it were, to mate, when, joining their uropygia together one to another, they impart to one another a viscous matter, from which there first arises an itching and tickling, then a heat in the little creatures, by which the seminal force, stirred up and lurking in the viscous excrement, swells into certain little bubbles; when these at last burst, those vigorous spiders, weavers of webs, are produced. And this is the true and sole generation of spiders.

[Margin: The spider acts as an astronomer.]

If you regard the nature of this little creature, it truly surpasses all admiration — so much so that it seems to yield in cleverness and industry not even to the bees and ants. For it fulfills all the roles of a good geometer and astronomer in weaving its webs. For what else is the web it weaves than the figure of an astrolabe, in which both the vertical and the horizontal circles — which they call *azimuths* and *almucantarats* [Almicantarath], as the Figure shows — are displayed, with so great and so equal a distance of the threads from one another that it seems to have been drawn with a compass; and this not without a purpose, which it directs above all toward catching flies. For it weaves itself a net, fragile indeed, but exceedingly proportioned to sustaining its own little body —

[Margin: The spider, in the figure of the astrolabe, adapts its web.]

— while at one and the same time it plays the weaver, the astronomer, the geometer, the rope-dancer, and the hunter. With what great sagacity it weaves its nets, who does not know? — with threads taken from nowhere else but drawn out from the subtle and, as it were, imperceptible gum of its own body, hither and thither,

Diagram. An uncaptioned schematic woodcut of a spider's web, drawn as a circular orb-web in the manner of an astrolabe net. The figure shows a central hub with the spider's body at the center; from the hub, straight radial threads ("vertical circles" / radii) run outward to the rim like the spokes of a wheel; concentric, roughly polygonal cross-threads (the "horizontal circles," the *azimuths* and *almucantarats* of the text) connect the radii at regular intervals, giving the

geometric, compass-drawn appearance the text describes. No printed labels appear within or beside the figure.

drawn out from this point and that, with such tenacity of glue that it fastens and glues that [thread] to whatever object it wishes, when it comes in its way. That it also plays the tailor, who does not know? — when, the webs being broken by the agitation of the air, or by the falling of debris, or by the impact of flies, it at once repairs them with a certain admirable industry, so that no trace of the rupture appears.

[Margin: The spider acts as a geometer.]

Certainly that it fulfills all the parts of an astronomer, its net — as we said above — clearly shows; whence the astronomers have thought that the net of the astrolabe should be named from nothing other than the spider's webs [i.e., the "rete" of the astrolabe], so that I cannot sufficiently marvel at the divine wisdom in the laborious and ingenious works of this animal. For with a wondrous equality of intervals it first draws lines, as it were, from the circumference to the center, in which — as in the center of its power — it has set the seat of its authority; these it then, by the parallelism of the subtended lines, demarcates with so great an equality of distance from one another, for the firmer structure of the whole fabric, that it may seem furnished with both compass and rule.

[Margin: The spider.]

Yet [it does this] by no other means than by the application of its own body and feet, which serve it in place of compass and rule, with which it measures all the distinctions of the intervals; and while it does this, it represents a perfect rope-dancer, with the mass of its body so applied to the line of direction that it advances itself along the threads in a certain perfect equilibrium. But when it has seen an opportune place for fastening its threads to some object, it lets out from itself a greater abundance of gum, which — at once split into several filaments and, as it were, scattered by the agitation of the air — wherever they have run upon an object, are there fastened, fixed as though by glue. The spider, perceiving this, by running here and there along those [threads], completes the web already begun by weaving; and when this is finished, it prepares for itself a nest, fenced about with filaments of denser material. From this, going forth to the hunt, it stations itself in the center of the net, so that from every part of the circumference, if any fly or gnat falls into the viscous net, it may feel it by the motion of the threads drawn from the circumference to the center. And it is a pleasant thing to see that, as soon as the said animals have fallen into the gluey

mass, the spider at once, from the center, by that radius which it feels to be moving, with hasty speed at last [seizes] its prey...

[the spider], once it has caught [its prey], attacks it and does not let go until it has sucked it entirely dry. And so the nourishment that it had already used up out of its own innards in weaving its web, by this skill and industry it now replenishes for the spinning of new webs, as all that nourishment drawn from the flies degenerates back into fresh silk [viscus]. These, then, are the things I judged worth saying about the marvelous nature and reproduction of the spider.

CAPUT VII.

On the worms that are generated in animals, and chiefly in human beings.

In a marvelous way the philosophers tear themselves apart over the manifold breeding of worms that is sometimes found in human beings. Hardly any of them assigns its true and proximate cause; they are all stretched thin around the corruption of the four humors. I will set out in a few words what I myself think. It is certain from experience that in human beings earthworms [lumbrici] arise not only in the intestines, but that there is no part of a human being, whether internal or external, that does not produce worms and other animals. [Margin: Worms are produced in every part of the body, both internal and external.] To say nothing of the verminous broods that a person voids in his stool, in the brain itself there have been found — according to the observations of Schenck, Mercurialis, Paré, Cardano [Cardanus], and others — not only worms but also bedbugs [cimices], scorpions, millipedes [iuli], and so on. They have been observed in various cases in the ears, on the tongue, in the eyes, in the skull, and in the nose. [Margin: Phthiriasis.] In phthiriasis too — that is, the lousy disease — the whole substance of the body dissolves into worms; in the hands, the feet, the hips, and the private parts, ticks [ricini] now and then deposit their brood. All diseases, whether external or internal, are subject to worms. In our *Scrutinium physico-medicum de peste* we showed by various experiments that worms are generated in the blood, and that every gangrene, leprosy, scabies, elephantiasis, venereal disease, and plague is nothing other than a kind of imperceptible worm-breeding, by which the little creatures, gnawing continuously, reduce the neighboring living flesh to rottenness. Indeed, the above-cited authors confirm by various instances that worms have been found in the deepest vital organs — the stomach, liver, heart, kidneys, lungs, brain, bladder, and spleen. We have even

shown in the preceding pages that frogs, serpents, and the like have been both born within the skin and thrown up by vomiting.

[Margin: The cause of worm-generation.] Since this is so, the question arises: where does this verminous brood take its origin? I say that the cause is the food by which human beings are nourished. To make this understood, note first that a person is fed in two ways: either by the nourishment of animals, or by that of herbs and plants, or by whatever can in any way be referred back to these — such as milk products and fruits of every kind. Note secondly that animals generally take in food of a vegetable nature, infected with the various differing seeds of flies and worms; and this food, passing afterward into a human being's nourishment, carries those said seeds along with it. The food, once turned into the substance of the one nourished, wherever it meets a humor proportionate to it, is fermented there by the internal heat, and at last [Margin: Worms — and serpents — whence they come by vomiting.] expels a worm according to the quality of the seed, either like the original or degenerate. For — as we showed in the preceding section — some people have vomited up frogs and serpents, and I judge this can have happened from no other cause than that they had drawn in the spawn of frogs or serpents with their drinking water. In this way, children who are fed by the frequent use of milk (which, as has been found by experiment, teems with worms) are for the most part filled with worms and earthworms. For milk is the first chyle of animals; in milk, as in the chyle of animals, various seeds of herbs are first transmitted, and these — once taken up especially by people of more tender age and endowed with a gentle warmth — are easily quickened into worms. This also happens in adults, when they too unwisely consume the verminous brood imperceptibly lurking in herbs, or when they take as food the flesh of animals that is no longer fresh but already rancid, infected, and teeming with hidden worms. These seeds, according to the disposition of the limb to which the nourishment is distributed and according to the coagulation [systasis] of the humors, at once exert themselves and expel a worm; and this worm, depending on the malignity of the worm from which it was cut off, or depending on the property of a poison lurking in the worms, inflicts a greater or lesser, noticeable harm on the person. [Margin: The harms that worms inflict.] For some are carried off into malignant and putrid fevers, some into internal corrosions of the limbs, and some by a kind of sympathetic magnetism toward attacking now this limb, now that. Hence it comes about that those who incautiously consume the seed of cantharides [cantharidum seminium] suffer ulcerations of the bladder, pass blood, and are swollen with priapism; [Margin: The symptoms of cantharides.] and by the same reasoning, those who consume the excrement of the buprestis suffer palpitation of the heart and are afflicted with fainting

[lipothymia]; other things cause nausea, vomiting, vertigo, and dimness of sight [scotomia]; nor are there lacking those which, when their internal heat is driven to the exterior, induce mortification [sphacelus], gangrene, and similar symptoms. We may therefore infer from this that there is scarcely any disease of a malignant and putrid nature that does not draw its origin from these. See *Liber X, De Venenorum origine*, where we have pursued these matters more fully.

Having set out these matters in general, let us now explain the generation of lice, fleas, and bedbugs. [Margin: The louse [φθεῖρ] of the Greeks, and its origin.] The question, then, is first asked: where do lice arise in human beings? I say in a few words: not from human flesh, nor from corrupted blood, nor from putrefaction. Not from human flesh, as —

— as Aristotle [Aristoteles] held, because it would follow that all men — the highest, the middling, the lowest — always generate lice from their own flesh; yet we do not see this happen. Rather, we observe that lice are generated only by those who, oppressed by poverty, collect much filth on their bodies, or who use coarse, foul, and contaminated nourishment, such as the poor; and by those who sweat a great deal without any change of clothing, such as farmers and soldiers — in the same way we said happens in the other insects. Daily experience teaches us about the nits of fleas, so that I marvel all the more at Aristotle, who in *Historia animalium* V.31 [printed "l. 5. hist. c. 31"] says that fleas are indeed generated from the coupling of both sexes, but produce something from which nothing further can be born. "From lice," he says, "are bred the maggots of flies; the flea is a kind of maggot resembling the form of an egg, from which neither the things that generated them come forth, nor any other animal, but only nits."

[Margin: From eggs lice are produced. Aristotle's experience teaches.] Nor can lice be said to be born from corrupted blood, since experience establishes that the sick and those lying ill with malignant fevers, who were previously burdened with a verminous louse-brood, are at once freed from it — as the hospitals teach by experience. I say, then, that lice are born from the seminal spirits lurking in the food; for it is established that from a human being, as from the other animals, animal spirits breathe out, [Margin: The true origin of lice.] and these — sensitive [spirits] — produce them through the continuous transpiration of the bodies. While these spirits exhale in this manner, it is certain that they carry off with them some coarser and filthier parts as well. If, then, it happens that those coarser impurities, driven together by sweat, cling between the flesh and the skin, or to the hairs — such impurities, being something cut off from the animal, are likewise by their own nature suited to receive again those animal spirits as they breathe out from the body. And in this way the power lurking in the spirits

forms — according to the coarseness or fineness of the matter — either a louse [Margin: The generation of fleas and bedbugs.] from foul phlegm, or a flea from a finer little portion of putrescent blood drawn from the capillary veins turned into sweat, or a bedbug — which the Greeks call κόρις [Greek: kóris, "bug"] — which it produces by the exhalation of that same coarser, contaminated blood that is mixed with the phlegm.

But because the frequent eating of figs is commonly said to generate lice, [Margin: Why the frequent eating of figs generates lice.] this is not to be understood as though it produced them immediately and from its own nature, but in the same way we said happens in the other insects. Daily experience teaches us about the nits of fleas. They also propagate themselves by coupling, in this way: at first they are white, but scarcely hatched, they are soon clothed in a black covering — and the same must be said of lice and bedbugs. A louse, therefore, is born by the agency of putrescent phlegm, in which the power of the seed of the animal spirits resides; [Margin:... the microscope teaches.] the microscope teaches this, for when inspected it appears wholly transparent, like the white of an egg, with a dark spot conceived in the middle, which occupies the place of a heart; and eggs too appear heaped up around the hinder parts. The flea is sustained by the blood by which it is nourished, which it sucks out by piercing and boring through the skin with its proboscis until the swelling of its little body — exhibiting in a tiny frame the perfect form of a locust, except that it lacks wings; in other respects it has the same leap. [Margin: The chained flea.] I have sometimes seen a flea fastened to a little chain, which the craftsman had scarcely set, starving, upon his hand, when behold — with its proboscis driven in — it swelled up astonishingly with a most greedy suck of blood, and so, glutted, it was put back inside its little box: a troublesome pest indeed, scarcely granting rest day or night.

The bedbug, κόρις to the Greeks, is foul and abominable in both form and stench. [Margin: The origin of the bedbug.] It mostly gains its nest in the cots of beds and in their cracks and crannies, and in the holes of walls near the beds; and bedbugs arise from human filth, as we said above, and from the exhalation of corrupted blood mixed with vicious phlegm — which is easily indicated by the abominable stench they give off, which smells of I know not what carrion, a foul reek not unlike that of fetid asafoetida. But lest it stir up further nausea in us by its abominable stench, let us leave these things and pass on to others.

CAPUT VIII.

An experimental recapitulation of what has been said.

There are in the nature of things certain spirituous little bodies which, in the dissolution of bodies, are separated from other parts that are not homogeneous, that is, not of the same nature. Some of these are mineral, others vegetable, others sensitive [sensitiva], so that — united with matter — they constitute the one a vegetable thing, the others a sensitive thing. These were implanted in the primordial chaotic mass, by the wondrous wisdom of the Divine Architect, through the power of the spirit brooding above the moisture. For whenever these vegetable spirits, together with —

— a proportionate matter, are united, at once a living thing arises; and whenever the animal spirits are united with a disposed matter, then some animal must come forth. Yet not just any conjunction of these spirits suffices for generating either a vegetable or an animal; rather, by their very selves and their own nature they require that such-and-such spirits be joined, in such great quantity and in such a manner. [Margin: How animals are generated from seminal spirits.] For when some living thing or animal is dissolved, this happens: those spirits which, joined with that fixed [body], formed such a living thing, are separated and fly away once the moisture has been thinned out — but they do not fly away conjoined. Let me explain myself: when a horse is corrupted, the soul of the horse or of the dog cannot be said to fly away; rather, the seminal spirits, torn apart, fly off and are scattered and dispersed this way and that. Hence it comes about that this single mass of spirits is never again joined with that same or a similar mass; but those spirits, in which some portion of seminal power still lurks, are swiftly mingled with the air and combined with others. If, then, it happens that these are joined, in such a quantity, with some proportionate fixed [body], such that from those spirits and from that fixed [body] an animal can be constituted, at once — by the plastic power [virtus plastica] which is both in the spirits and in the fixed [body] itself (that is, in the matter informed congruously to those spirits) — that body is organized and formed, and an animal arises: degenerate from the first seed (whence the spermatic spirits had been cut off) and of another species. And in this way are generated all those animals that are said to draw their origin from putrefaction. For the spirits, separated from some animal substance that has been broken down and dissolved, fly through the air, and are carried back again by clouds, rains, winds, and the like to plants and trees, and are forced into the pores of the earth. From there, according to the quality of the substrates, new seeds of an animal economy are sown — since the plastic force of the seed, hidden in the

spirits, forms that matter with the aid of moisture, and at once a frog, a fly, a locust, or a similar insect is born. But the smaller the supply of such spirits dispersed throughout all things, the more imperfect must be the plants, as well as the animals, that are born. To make all this clearer, I have thought it best to unravel it through a series of questions.

[Margin: How worms fall together with rain.] It is asked, then, first: how is it that little animals are seen to fall down together with the rain? I answer that there are in the air and the clouds the exhalations of all things, and the seeds of all mixtures, and consequently very many animal exhalations; and these, when dissolved, if they are joined with some congruous and proportionate matter — by the plastic power existing within them — will soon form animals according to the proportion of the seed cut off from the exhalations and raised into the air out of the dissolved bodies of animals and plants, whether living or dead. And this is the reason why rainwater so readily generates worms, whereas springwater does not: because rainwater swells with the spirits of the seeds, which springwater lacks. [Margin: The extemporaneous origin of frogs.] And this is plain from frogs, which sometimes arise by a spontaneous birth together with the dewy rain — not because they are hatched in the air, but because the water, made pregnant by the spawn βατραχογόνον [Greek: batrachogónon, "frog-producing"], that is, by the frog-making [substance], drawn up through exhalations together with the dust of marshy mud, as soon as it falls upon the warm dust, the plastic force there at once forms a little frog. And although I have often observed these little animals in various places, I have never been able to perceive them, as the common crowd supposes, falling already in perfect form from the clouds. Hence the marvelous power of the seed is plain, which, when the matter is already disposed, in so brief a span of time expels animals of this kind. So the dispute of certain natural philosophers about the generation of the frog is frivolous, when they wrongly suppose that frogs are produced by I-know-not-what vague or immediate concurrence of GOD, since by the proximate reasons and causes of the seeds the said generation can be explained with almost no difficulty. But that what we have said may be seen to be true, we shall establish it by experiment.

EXPERIMENTUM

Βατραχογένεσις [Greek: Batrachogenesis, "frog-generation"], The origin of frogs.

When frogs, having shed their abundant spawn at the beginning of March, fill all the ditches, it happens that, once the ditches dry out, the mud is again dissolved into dust together with the frogs already hatched from it. If, then, you have a mind to produce a new generation of frogs, proceed thus: Take the dust of

marshy mud, or of ditches where you know frogs have nested; soak it with rainwater and set it out in an earthen vessel under a moderately warm sun in the morning during summertime, and sprinkle it repeatedly with the said water, lest the matter be dried out by the sun. You will find first certain little bubbles, out of which first come white little frogs without hind feet, equipped only with their two front limbs, which are called *graminulae*; then, gradually divided into two hind feet by way of the tail, they will rise up into perfect frogs in enormous quantity — which I remember to have exhibited before many spectators, not without their wonder, and I would wish everyone to verify it. These things clearly teach that there lurks in the said mud that seed which, when joined with moisture and aided by concurrent heat, at last, according to the proportion of the seed, expels new frogs.

[Margin: Question 2. How serpents are generated.] It is asked, secondly: how are serpents and reptiles generated? I answer that serpents are generated in exactly the same way as the rest of the insects — namely, from the seed of serpentine cadavers. Many wonder why, after great floods, immediately a vast multitude of serpents sprouts again throughout the fields and lands. The cause is none other than that serpents nesting in the lairs of the mountains, driven out by the deluges of waters, are rolled down together with the water onto the plain below; there, lightly buried in mud and gravel, and with the heat afterward brooding over them, out of the seed-bed of their own cadavers —

— they are restored to a fresh stock. For just as even the smallest part of a serpent consists of seminal power, so too from that same part a serpent can be born — no one can doubt it — so that from a single serpent a thousand others can be generated. [Margin: From the cadaver of a serpent new ones arise.] To make this still more luminously clear, the following experiment will teach it.

EXPERIMENTUM

Ὀφιογενετικόν [Greek: Ophiogenetikón, "serpent-producing"], the production of serpents.

Take whatever serpents you wish; first roast them and then cut them into the finest pieces. Commit these pieces to oozy earth, which you will irrigate again and again with rainwater through a vessel made in the form of a sieve, and in this way you will leave the irrigated earth exposed to the spring sun. Within eight days the whole mass of earth will rise up first into little worms, which then — fattened by milk mixed with water and poured over the earth — at last grow into perfect serpents, which can thereafter also propagate by coupling to infinity. The cadaver of a serpent first taught me this: when I had carefully observed one I

came upon in a field, I found it surrounded with countless little worms, of which some were small, others larger, and others again had already acquired the manifest form of a serpent. Yet it is remarkable that now and then certain species of flies were mixed in among serpentlings of this kind, which I for my part judged to come from no other source than the seed of the food that serpents are accustomed to enjoy.

It is asked, thirdly: how is it that, now and then, from cadavers and their leavings such diverse species of insects are born? I say that this comes about from the diverse seeds of the food on which they feed. For the herbs on which they feed, being filled with flies, caterpillars, and the other worms, scatter — once taken in together with the food — various seed-stocks both in the substance of the one nourished and in the excremental filth. For since some are born from flesh, from blood, and from sweat, and others from the very dilutions of the body and its excrements, it is necessary that a diversity of insects too should come from there. But let us show the matter by experiment.

EXPERIMENTUM

Μυογενετικόν [Greek: Myogenetikón, "fly-producing"], displaying a mixed offspring of insects.

If you should wish to see the effect of this matter, proceed thus: Take of the dung of horses, oxen, and asses, one part of each; commit this mixture to a rather broad shell-vessel, and irrigate it daily with a sprinkling of that water which is contaminated with the seed of various worms from the herbs on which the said animals feed, together with the flowers and calyxes [of those herbs]. Then let it be left exposed to a temperate sun, yet covered, lest it be dried out by the sun's heat. You will see arise from this mixture, at once, certain little bubbles as it were, resulting from the fermentation of the combined matter; and when these burst, in successive hours you will see come forth a reddish and hairy worm. [Margin: The medlar [Mespilus] produces various worms; the vines (Vites), gnawing through, produce Butyri and...] The medlar, various worms; the vines, gnawing, butyros and ipes; [Margin: The marvelous generation of worms.] wasps, beetles, wild bedbugs, and also worms — that is, caterpillars equipped with many feet — and similar insects of differing species, which assuredly have their origin from nowhere else than from the diverse seeds of animals: both those that lurk in the excremental parts of the foods, and those that lurk in the plants themselves. For these, mixed together and warmed by due irrigation, tempered and digested by the moderate heat of the sun, stirred by an internal motion, at last rise up, according to the laws of nature, into little creatures of this kind — such as the

principle of the diverse seed demands. But now let us give an experiment about marine insects as well.

EXPERIMENTUM

Κογχυλιογενετικόν [Greek: Konchyliogenetikón, "shellfish-producing"], practiced in Apulia and Sicily.

Not without wonder did I see this experiment, first in Sicily, near the Pharos [the lighthouse], twelve miles distant from Messina. So that they may have a multiplication of the shellfish [Conchyilia] which they call *Tellinae* [tellins], they proceed thus. They grind tellins and shellfish into minute pieces, and then, at the shore of a salt lake about sixty paces distant from the strait, they scatter the little shell-fragments — just as a farmer [scatters] his grain — and so leave them, until the water of the lake, stirred either by the force of the winds or by a subterranean swell, pours over the shore. There the little fragments, mingled together with the sand, bring forth so great a sprouting of new tellins that anyone who has not seen it could scarcely believe it. I have learned that the same happens at Taranto, but by means of stakes made of a certain wood, which, once fixed within the seafloor, at once have I-know-not-what matter clinging to them, which in time brings forth an innumerable supply of shellfish. Martini [P. Martinius] teaches in his *Atlas* [Atlas Sinensis] that a similar generation of shellfish and oysters is carried out by art in China. [Margin: Chinese.]

COROLLARIUM.

From these things it is manifestly plain that all the kinds and species of insects — if it has been established for us whence they draw their origin, or to which plant they especially cling by a certain natural sympathy — can be produced by skillful application. For there is no plant nor animal that does not produce something out of itself and its own substance, as we have shown above. For very great trees produce in their trunks the cossi [grubs], the moths, the wood-borers [teredines]; the fig, the ceraste; [Margin: Each plant produces its own animal.] the pine, the buprestis; the olive, the Rauca; the service-tree [Sorbus], a reddish and hairy worm; the medlar, various worms; the vines, gnawing, the Butyri and Ipes; the tendrils of the same [vine], the Volucra, that is, the convolvulus [coil-worm]; while wine produces the Volucella, that is, the wine-fly, the Musciliones [gnats], and the Vinulae — this is well known. The spindle-tree [Evonymus shrub] begets an ephemeral worm, which, once the leaves are consumed, soon —

Reading order used: printed pages 374 → 375 → 376 → 377, reconstructed from the printed page numbers and verified by catchwords (p.373 "moritur," → p.374

"moritur."; p.374 "motus" → p.375 "motus"; p.375 "micarum" → p.376 "micarum"; p.376 "vel" → p.377 "vel comburi").

— dies.

The cases [folliculi] of the elm, the terebinth, and the mastic tree produce the worms called *psenes* [Greek: ψήνες, psēnes — fig-wasps]; these are either caterpillars, or spiders, or something of the kind. Grass produces ticks [crotones]. Nightshade produces a green worm tinged with a saffron color. The leek produces *prasocuris* [Greek: προσοκουρίς(?) (?), the "leek-cutter"], that is, a moth [blattam]. Cabbage, lettuce, and olives of every kind produce caterpillars. The asphodel begets winged worms in the form of little flowers. The mallow produces wild bugs [cimices agrestes], as may be seen in all flowering plants. Indeed, even the most wholesome plants — rue, sage, fennel — generate altogether deadly worms. Wheat produces weevils [curculiones]. In short, it is unknown to no one that all legumes and fruits produce worms peculiar to themselves.

How worms are born inside nuts. [Margin: *Quomodo vermes intra nucleos nascantur.*] Yet one might well wonder how the seeds of these creatures, from which they are born, come to be lodged inside nuts above all, and inside the closed cases of the elm, mastic, and terebinth, when these are sealed shut. I say that this happens in the following way. When the said plants first begin to flower, then — drawn to them, or rather to the tenderer substance of the plant — various flies fly up and work their way deep within the calyxes of the flowers. Shut in there at last, and gradually fermented by the hotter sun, they are revived as if from a funeral pyre. In this same way gourds too nourish worms: if you examine their flowers more carefully, you will see within them a packed swarm of certain flies, which are then trapped by the sticky sap; and when they cannot extricate themselves, at last, as the moisture swells up, they are driven deeper into the substance of the gourd, and are the cause of those worms found within it.

And so in all cases of this kind one may behold and admire a certain marvelous **circular play of Nature** [Greek: ἀνακύκλωσις, anakyklōsin — recirculation, cyclical return]. [Margin: *Pericyclosis naturae in genesi animalium.* — The cycling of Nature in the generation of animals.] From the various excrements of animals — terrestrial, winged, or aquatic — insects of every kind arise. Greedy for this nourishment, they stream each to the herbs most suited to them. The herbs, contaminated by the seeds of the insects, pass in turn into the food of animals; and from this, through the filth they discharge, new insects of a different species are at last born; and these are restored once more to the plants from which they

had come — and this in a perennial revolution, so long as the world shall stand in this fashion.

CAPUT IX.

Why Nature willed to produce so many and so great a variety of kinds of insects.

[Body heading, p. 374: *Caput IX. Cur tot & tanta Insectorum differentia genera Natura producere voluerit.*]

The Peripatetics say that Nature produced so many insects for no other cause than the adornment of the universe. The theologians [Margin: *Theologi peccati originalis effectus asserunt.* — The theologians declare them effects of original sin] assert that they were sent upon men, and upon their descendants, because of the transgression of the first-formed man [Protoplast], since nearly all of them are found to be harmful, with few exceptions.

For our part [Margin: *Mundus carere infectis non potest.* — The world cannot do without insects], although insects of their own nature — apart from bees and silkworms — confer no benefit on man, owing to the venom with which they generally teem, and although they seem superfluous to Nature, we nonetheless say that they were produced not merely for the adornment of the universe, but also to furnish men with very great advantages and benefits. Indeed, I say that the world could not be without them save to the greatest detriment of Nature. And lest we seem to have spoken a paradox, we have decided to set out their benefits here.

[Margin: *Ratio cur natura tot insecta produci voluerit.* — The reason why Nature willed so many insects to be produced.] In the Ninth Book, on poisons, we showed at sufficient length that the Earth, Water, and Air — and whatever is composed of these mixed bodies — are subject to countless forms of putrefaction. Lest these, by their virulent power, should infect the threefold kingdom of Nature even to its final destruction, Divine Wisdom most wisely willed that diverse species of insects be produced through Nature, its handmaid; so that in the threefold kingdom of Nature, by a kind of tripartite division of offices, whatever in each individual region had been contaminated by the diffusion of a deleterious quality, these creatures should draw it into themselves — as into so many living purses — and consume it.

Hence the terrestrial insects, duly performing their office, by some unknown magnetism implanted in each, would draw to themselves whatever in the earth is

virulent, pernicious, and deadly — lest the whole mass of the earth, infected with defilements of this kind, should also infect the foods produced for man's sustenance, to the truly great harm of the human race and of the animals. In like manner those that have their birth in watery and airy chambers obtained this office from Nature: that whatever is harmful from pernicious exhalations, and has the power of infecting water and air, they should draw into themselves by magnetic attraction, and in this way, the waters and air being purged, confer health upon them.

But lest the vast and pernicious brood of insects should bring destruction upon animals and men, Nature entered upon a new plan of counsel: namely, that they should pass into the food and nourishment of birds. For since most birds sustain their life on nothing but worms, caterpillars, butterflies, beetles, locusts, flies, and the like — however venomous these may be — it was truly beautifully provided that the venom, which had been drawn from the foods by the insects, should afterward, in order to check their excessive multiplication, pass in turn into the nourishment of the other needy living creatures; and thus a new cycle of Nature [pericyclosis] was established.

[Margin: *Pericyclosis naturae in genesi infectorum*. — The cycling of Nature in the generation of insects.] For just as the excrements of animals, while living, supply a new seed-stock, so too from their own corpses they lay the foundation of a new seed-bed from the very things they had taken as food. Thus at no time shall there ever be lacking new insects arising to purge the earth, water, and air; nor, when these have multiplied, shall there be lacking to the other perfected animals the material on which they may feed. —

— [the motion] of Nature, if it were not perpetual, as it is in the elements, then through the infection of earth, water, and air all things would be thrown into utter confusion; and so too most flying creatures, together with men, would of necessity perish from want and lack of nourishment.

The **second benefit** is that most insects, even though they seem troublesome, loathsome, and grievously harmful to animals, nonetheless always have their own attendant uses and advantages. What flies, wasps, hornets, ticks, and worms do upon beasts of burden and the other animals, that same office fleas, lice, and bedbugs perform upon men: namely, by drawing out the putrid blood, lest it pollute the neighboring parts with its own foulness — and in this way man is freed from his superfluous putrefaction.

The **third benefit** is this: that there is scarcely any insect so worthless that it does not have its own use in medicine. For — to pass over the profit they yield, as regards the honey-making bees, the silkworms in the spinning of silk, and the vipers in the compounding of theriac, on which we discoursed at length in the preceding pages — surely no insect, however potent its poison, can be named that does not have manifold uses in driving off even desperate diseases.

The Use of Insects in Medicine.

[Body heading, p. 375: *Usus Insectorum in Medicina.*]

That God and Nature do nothing in vain is made known above all from the marvelous powers and properties of insects; and nothing is so slight and worthless that it does not, by the gift of the Creator's most kindly goodness, have its own use, necessary for driving off men's infirmities.

[Margin: *1. Apum utilitas.* — 1. The usefulness of bees.] And to begin with bees: who does not know how varied and manifold is the use of honey, when scarcely any medicine, plaster, or the like is compounded by the apothecaries [Seplasarii] into which honey does not enter? What is more excellent, more worthy, or more useful than the wax that the bees' honeycombs supply to us? So that, accordingly, Divine mercy has drawn from the smallest little worm a benefit so great, so universal, and so altogether necessary. To this succeeds —

[Margin: *2. Bombycum.* — 2. Of silkworms.] the **silkworm** [bombyx], which is by no means unequal to the bee in usefulness; since the gift of these creatures (in spinning for us the most precious silk) extends to clothing the very Pontiffs, Emperors, Kings, and Princes, all the way down to men of the lowest plebeian rank. By their labors the ornaments of the Church, the furnishings of the sacred vestments, and the splendor of houses both public and private grow so great that nothing magnificent and precious in men's esteem is reckoned that is not woven from silk. The cocoons too, in which they are enclosed, are held at so great a price that, among the other ingredients of which theriac is compounded, these too have been allotted their place.

But let us now proceed to describe the other uses of insects.

[Margin: *Cicadae.* — Cicadas.] **Cicadas** help open obstructed veins; they remedy the bladder, difficulty of urination, and colic afflictions. On these, see Dioscorides, Galen, and the rest.

[Margin: *Cantharides.* — Spanish flies / blister-beetles.] As for the **cantharides** [blister-beetles], who does not know what a remedy they are in hopeless and

desperate diseases? For when all other remedies have been applied with fruitless labor in malignant fevers, physicians take refuge in these as in a sacred anchor. For first reduced to a powder, then made up with suitable oils into the form of an ointment, and applied to the legs and arms, daily experience teaches how many they snatch from the jaws of death.

[Margin: *Blattæ*. — Cockroaches.] The **blatta** [cockroach], which is a species of beetle or cricket and is chiefly born in mills — the Italians call them *bargarozzi* — is a singular secret for curing infirmities of the ears, if you boil them in oil and insert them into the ears on cotton wool. Galen also says it remedies jaundice, when they are worn fastened about the neck.

[Margin: *Culices*. — Gnats.] **Gnats** [culices], besides aiding the maturing of *phlysides* [Greek: φλυκτίδων(?) [?], blisters/pustules], also serve as food for very many animals — such as bats, swallows, the green woodpecker (which they call *titinellus*), and countless others.

[Margin: *Scarabæi*. — Beetles.] I learned from an outstanding swimmer that **beetles** [scarabaei] are wonderfully effective against spasm and convulsions of the nerves; for he, whenever he was about to give a demonstration of his art, never used to trust himself to the water unless he had first anointed the sinewy parts with oil of beetles. The horns of the *Lucani* [stag-beetles], worn at the neck, are also said to have power to drive off quartan fevers. Pliny [Plinius] relates too that earth dug from a place where there has been a nest of beetles wonderfully soothes the gout. Aldrovandi [Aldrovandus] says that oil in which a beetle has been boiled remedies pain and deafness of the ears. Moreover, Pliny says that the *Helicantharus*, or the green-shading-to-golden translucent beetle, so strengthens the sight that gem-engravers used to keep it set before them, gazing at it frequently as a remedy fit for refreshing the eyes.

[Margin: *Locustæ*. — Locusts.] A **fumigation of locusts** wonderfully remedies difficulty of urination. A locust, beaten up with goat-suet and laid on in the form of a plaster, greatly helps scabies, ringworm [impetigo], and leprosy; it heals the bites of serpents. [Margin: *Experimentum de Locusta*. — An experiment concerning the locust.] It has also been found by experience that a locust placed in a cup of purer wine does not sink but floats; whereas if the wine has been spoiled by water, it sinks at once.

[Margin: *Lampyrides*. — Fireflies.] **Fireflies**, or glow-worms [cincindela], are of great use in catching fish; for if a great quantity of them, enclosed in a glass

sphere, is brought to a river by night, the fish, rushing at once to the light poured out by the glow-worms, are as if stupefied, surrounded by the net, and caught.

[Margin: *Formicæ*. — Ants.] **Ants**, especially the winged ones, are of the greatest use in medicine; for ground up with a little salt they remedy all cases of scabies, and cooked they avail against the bites of *phalangia* [venomous spiders]. The bear too heals its own ailments by the sole medicine of swallowed ants; for when it is afflicted by its accustomed malady, then it makes for the ants' —

— [the] ants' heap, thrusts out its tongue and inserts it, and when it has felt it filled with ants, it draws back the tongue caught by their stickiness and immediately devours them, and by that medicine heals itself. No hair grows any longer wherever the blood of a bat, or of a larger shrew, worked up together with ants into the form of a plaster, has been applied to the hairy part.

[Margin: *Muscæ*. — Flies.] **Flies of the napellus** [aconite-flies] — which others wrongly, on the resemblance of the Greek word *μῦς* and *μηνύς*, interpret as "mouse" [?] — are, on Galen's testimony, a specific remedy against all kinds of poisons; they are also given with great benefit against alopecia [loss of hair], leprosy, and boils.

[Margin: *Cimices*. — Bedbugs.] **Bedbugs** [*Cimices Lectularii*] are a potent remedy against the quartan fever, if they are drunk by the unwitting patient in a suitable vehicle. They remedy women's diseases, and by their smell alone restore a prolapsed womb to its place. Applied to the bite in the form of a plaster, they heal those struck by the asp; and to those who have incautiously swallowed leeches or drunk [tainted] water, they are said, mixed with vinegar, to be a remedy.

[Margin: *Scorpiones*. — Scorpions.] How great is the importance of **oil of scorpions** against the bites of serpents and the other venomous animals, no physician is ignorant. Read what Matthiolus treats of it at length, in the chapter on the scorpion [*De Scorpione*].

[Margin: *Aranei*. — Spiders.] **Spiders' webs**, laid over fresh wounds — how easily they stanch the blood, how quickly, by suppressing putrefaction, they heal — almost daily experience teaches; ground up too, and worked with oil and put into the ears, they calm pains and remove deafness. Cantharides wrapped and bound up in spiders' webs collect and dry out all venomous humor in the human body.

[Margin: *Lumbrici terrestres*. — Earthworms.] How much **earthworm oil** avails to allay the pains of any disease whatever, physicians know; indeed earthworms dried and ground to powder, worked up with oil, and applied in the form of a

plaster to the stomach, instantly kill the worms lodged in the intestines. I add that flies, born from as many different plants, are remedies for as many different kinds of diseases.

[Margin: *Limaces*. — Slugs/snails.] From **slugs** [snails] there is first made a potent cosmetic, suited to the beauty of the body; it wonderfully soothes the sharpness of pain lurking in any part of the body whatever.

[Margin: *Sanguisuga*. — Leech.] As for the **leech** [*Sanguisuga* or *Hirudo*], how much it can do in drawing out blood, nothing is better known — when, applied where there is need, it draws off harmful blood not only from the hemorrhoidal veins but from the neck, back, belly, head, and the other members; and it draws it so copiously that it sometimes bursts. I myself knew a man who had entered a pool in summertime to wash his body, and who, while he sat wholly submerged within the sand, suddenly felt himself surrounded by so great a multitude of leeches that he could not tear them from his body. Having returned home, then, while he summons the surgeon, meanwhile, the leeches being —

— [the leeches being] half torn off and continuing to suck, from the abundance of blood poured out he fell into such weakness that within three days thereafter he died, every effort to restore the blood being vain.

The **hippocampus** [seahorse] is said by Galen to be a specific remedy against *hydrophobia* [Greek: ὑδροφοβία, hydrophobian — rabies], that is, the bite of a mad dog.

I could adduce countless things here; but because you will find all these things more fully described in Galen, Hippocrates, Dioscorides, Theophrastus, Pliny, Avicenna, Rhazes [Rasis], and the other Arabs, I did not wish to dwell on them. For in adducing these matters our whole intention has been only to show that insects were created not only for the adornment of the universe, but by Divine providence for innumerable uses utterly necessary to the human race; and that there is in the nature of things no animalcule so worthless, so slight, so virulent and deadly that it does not have immense benefits attached to it — so that, just as we showed in the Book on Poisons, there is no animal so venomous that it is not the destroyer of its own poison, if at any time they should have introduced it into the human body by their bite, especially if they are either thickened into oils, or resolved into salt, or prepared in the other ways already suggested in the passage cited, duly and according to the precepts of the Chymical Art.

On the Antipathy of Insects toward certain things, and how they may be driven off, if at any time they should have grown into a vast multitude.

[Body heading, p. 376: *De Antipathia Insectorum cum certis rebus, & quomodo fugari queant, si quandoque in ingentem multitudinem excreverint.*]

Lest anything should seem to be lacking to this subject, I shall set out here in a few words by what means pernicious insects may be driven off and destroyed. They are of four kinds, which — as the histories teach — have from time to time, under unlucky influences of the heavens, grown into so vast a multitude that they have devastated whole regions, compelled men to abandon their cities and migrate elsewhere, and brought on plague. They are: first, the armies of **Locusts**; second, of **Mice**; third, of **Ants**; fourth, of **Caterpillars** [Bruchi]. To these we shall add something concerning the household worms — that is, the extermination of lice, bedbugs, and fleas.

The Extermination of Locusts.

[Body heading, p. 376: *Locustarum Exterminatio.*]

Just as Nature willed that the various and innumerable kinds of locusts be generated in different ways, so too she established diverse remedies by which we may either exterminate or drive them off — so that where there is an evil or a disease, there too is a remedy at hand. [Margin: *Fugatio Locustarum.* — The driving-off of locusts.] This plague, however, does not break out every year, but at certain seasons of a malignant airy constitution, from the malignant influx of the stars. First, then, locusts are exterminated if you burn up locusts collected in great number; for, seized by a dizziness from the smoke of their own kind, they are deprived of their wings, and while they sit motionless on the ground, they are easily —

— easily either burned, or carried off elsewhere. In this way the **Ethiopians** free themselves from this plague. Larks [Galeritae] and jackdaws [Graculi] also pursue locusts and their eggs for food; hence, where there is a multitude of these birds, that region is for the most part wont to be immune, on account of the inexplicable voracity that they exercise upon the locusts. This plague can also be removed by a multitude of men. Thus one reads that in the year 1542, when the locusts were laying waste everything in the territory of Milan, the prefect of the city, having set a reward for those who collected them, in a short time filled twelve thousand sacks — to say nothing meanwhile of the supernatural aids: through processions,

exorcisms, and the other ceremonies of the Church, by which (through the intercession of the Saints) the destruction of the locusts was removed, as the histories of the Saints teach.

[Margin: *Locustæ in bruchum conversio*. — The conversion of the locust into the caterpillar.] The same is to be determined concerning the extermination of caterpillars [bruchii]. For these animals are so like one another that either the caterpillar generates the locust, or the locust is at last converted into the caterpillar — since they are stirred up from the same seed, and differ as the perfect from the imperfect within one species. For the cicada without wings, when winged, is the caterpillar; whence they are removed by the same means as the locust.

[Margin: *Murium propulsatio*. — The repulsion of mice.] Another devastating plague is the multiplication of **mice**, which have at times increased into so vast a swarming that — when the roots of grain and plants had been gnawed away — histories relate they brought famine and pestilence upon cities, with such persistence in certain years that men were forced to abandon their cities and dwell elsewhere. Against them the one remedy is arsenic scattered through the fields, by whose mere odor they are put to flight, or else, when even the smallest particle is taken, they are made to burst. By this remedy the **Egyptians** are accustomed to fortify themselves yearly against the swarming of mice that rises up from the rot after the flooding of the Nile; whence the Venetians make a great profit from the arsenic that they bring from Carinthia [Carneolia], by selling it to the Egyptians. Several other means present themselves, but I think none better or more suitable than arsenic can be found, and it has been confirmed by my own experience that mice are so exterminated by arsenic that scarcely any more are produced, or can stay, in a place infected with arsenic.

[Margin: *Serpentium fugatio*. — The driving-off of serpents.] **Serpents** in some regions breed again so abundantly that they scarcely allow [the inhabitants] to dwell there; whence divine providence has appointed certain birds, such as ibises and storks, which at the fixed times when they [the serpents] are wont to come forth, consume them all. In this way the ibises consume all kinds of serpents born in Egypt after the flooding of the Nile; just as in Germany and the other Northern regions the storks are wont to do in springtime, when these regions abound in frogs and serpents. Art too, however, has found a remedy for this bane: with ashes of the ash-tree [Fraxinus] — with which the serpents are at variance by a natural antipathy — scattered through the houses and gardens where they nest,

they are wont to do away with them. In this way one of our colleges in Italy freed itself, on my advice, from a troublesome multitude of serpents in past years.

Now let us proceed to eliminate the annoyances of household worms, gnats, bedbugs, lice, and fleas.

[Margin: *Cimicum fugatio*. — The driving-off of bedbugs.] **Bedbugs** [Cimices], most foul little creatures: Varro says they are driven off by spelt [farro] steeped in snake-cucumber water; Didymus, by liquid pitch and the juice of the wild cucumber sprinkled on the sleeping-places. Others use squill [scilla] steeped in vinegar; likewise some would have the walls sprinkled with ox- or goat-gall mixed with vinegar. Some think they are driven off by isinglass — that is, fish-glue. The water in which lupines are steeped is also a potent remedy for driving off bedbugs. There is nothing that lice and bedbugs so greatly dread as sulphur and quicksilver, which they generally use mixed with axle-grease. Wormwood, rue, fern, lavender steeped in vinegar, and likewise broom [genista] placed under the pillow, are said to drive them off.

Against **lice**, various authors have prescribed various remedies; I think none more potent than quicksilver [hydrargyron] amalgamated with oil of stavesacre [stuphisagria] or of henbane [hyoscyamus]; for this, smeared on the seams of the garments, permits no louse to remain anywhere.

Fleas are killed first by a decoction of *melanchium* or nigella [black cumin], dwarf-elder [ebulum], rue, fleawort [psyllium], or wild cucumber, sprinkled over the floor of the bedchamber. Nothing puts fleas to flight so much as strong-smelling plants — garlic, mint, hops; horse-urine; wormwood; and the dregs of oil [amurca] too, scattered over the floor. Fresh pennyroyal [pulegium], when burned; but fleabane [pulicaria] and goat's blood gather fleas together — and countless other remedies, of which the books of the physicians are full.

[Reading order note: The PDF pages are out of sequence. Reconstructed from printed page numbers and catchwords, the reading order is printed p. 378 (PDF image 2) → p. 379 (PDF image 1) → p. 380 (PDF image 4). PDF image 3 is a near-blank verso showing only offset/bleed-through from the facing page and carries no primary text. The translation below follows printed-page order 378–380.]

LIBER DUODECIMUS, Sect. III.

SECTIO III.

SECUNDUM NATURÆ REGNUM explorat.

Which is the Philosophy of Plants [Philosophia Botanica], concerning the marvelous effects that the Subterranean World produces in the generation of plants and growing things [Vegetabilium plantarumque genesi], and the wonderful art by which they may be derived from it.

PRÆFATIO.

Now that the generation of insects [entomogenesis] is complete — that is, the marvelous origin of spontaneously generated insect-animals, which hold the first and highest place in the threefold Kingdom of Nature — it remains for us to advance to the second grade of Nature's Kingdom. Here the curious reader will learn, from its effects, how astonishing and wonderful God, the Best and Greatest, has shown himself to be in its operations, through the agency of Nature, his handmaid. From these effects the reader will plainly see that Divine Wisdom has founded all things according to a certain analogy, so that there is nothing in one thing which does not, by some analogy, shine forth as similar in another. For whoever has mastered the rules of the analogical art, I am fully convinced, will find that nothing in the nature of things can lie hidden from him, so far as human ingenuity is permitted to reach — not indeed according to the inmost perfection of things, but according to the capacity proportioned to the human intellect. This shines out most of all when Art, probing more deeply into Nature's hidden paths and emulating her operations, produces so many and such marvelous effects. These are the effects I have undertaken to set out for the reader in this Section, together with a great store of the most secret experiments to be shared with him.

CAPUT I.

De mirifica seminis in Vegetantibus vi & efficacia.

(On the marvelous power and efficacy of seed in growing things.)

[Woodcut initial "I"] That a spermatic spirit [spiritus spermaticus] was implanted by God, the Best and Greatest, the Author of Nature, in the original constitution of the Chaotic mass — not only for the propagation of animals but also of plants — was shown in the preceding [discussions] from the sacred text of Genesis. For God brought forth no animal and no plant immediately, but by means of an

underlying matter, as it were drawn forth from potency into act. For the glorious God created all things at once, to this end: that, once produced, they should thereafter propagate themselves by the efficacy of their own seed, in a continuation never to fail at any time — at least as regards the state of the present age. This seed, innate in growing things, is the proximate and immediate cause of the generation and production of all things that come to be.

Now, since no plant can live without nourishment, plants draw it to themselves by a kind of twofold magnetism, as it were. The first of these is grounded in the moist, earthy [medium] already imbued with the universal seed; the second is grounded in the air. By this [second magnetism] the plant propagates the nourishment — which it has extracted from the earth through its roots, out of the grosser moisture of the soil — up through the trunk, branches, and leaves, refining it by external heat, all the way to the place destined for the seed. Again, since there is no part of a plant that does not contain within itself certain spermatic principles [rationes] proper to the plant, from this source too arise those seed-grains [seminia] of the vegetable Nature. Just as these exert their power in the various parts of plants, so too, once detached from them, they produce in spontaneously generated things differing forms. I said "detached," because seed-grains joined to plants always produce the same thing — as is clear in trees, where the buds produced from the very trunk and bark always yield the same as the whole [parent]; but the plant-parts rotted within the earth, just as they degenerate from the original vegetable seed, so too, because of the weakness of their powers, produce another bud of a more imperfect plant, which we say is born spontaneously from putrefaction. Since we have treated of these matters at length in the preceding sections, we refer the reader there. If you should ask how the universal seed

[Margin: How the universal seed is attracted.]

[Margin: The spermatic spirits — what they are.]

[continuation of Caput I, from p. 379]

is attracted: I say that this comes about by the attraction of nourishment. For as soon as moisture has been drawn in by the plant, it is at once joined to the seed proper to it (which resides in each of the plant's individual parts) and converted into a sap connatural to the plant — so that if [the moisture] is drawn in by a pear tree, a pear is what grows; if by wormwood, wormwood; if by a rose, a rose is produced; and so for the rest. This is because the nourishment in which the universal seed resides, once drawn in by the differing plants, is at once

individuated within them according to the condition of each; and from this the diversity of forms necessarily arises, together with the properties and powers owed to each one.

If you ask what those spermatic spirits are — the Architects of such great marvels as are beheld in plants — I say that it is the most subtle part of the nourishment, that primal light latent in the chaotic seed. As soon as it is individuated within plants, it at once also conveys the powers and faculties of the vegetative soul throughout its whole body, and together, by its plastic faculty, transforms the leaves into different forms according to the endowment each one's Nature requires; it arranges the flowers into their due forms, tints them with an appropriate color, and now clothes the seeds with a husk [cortex], now covers them with a follicle, now arms them with a thorny integument against all external injuries.

[Margin: The true part of the seed — what fraction it is, in regard to the whole.]

We said in the preceding [discussions] that the seed of Nature resides in all things, and that as it is drawn in by plants and individuated, it always produces ever-new plant forms according to the condition of the seed with which it is mingled. And we affirmed that this seed is nothing other than a saline–sulphureous–mercurial spirit congenital to the elements, by whose benefit, through the varied combination of the mixture, the forms of differing plants — endowed with diverse properties — are educed. And sulphur indeed is the most subtle and tenuous fiery spirit, the first principle and origin of all actions, powers, and properties in growing things. If it predominates in some vegetable compound, then that compound too will be found to be of an utterly fiery nature — as

experience teaches in pepper, ginger, cloves [caryophylli], and the like. But since this fiery sulphureous spirit cannot subsist without moisture, a Mercurial liquor must necessarily be joined to it — a portion, that is, of the radical moisture. Wherever this predominates in some plant, we conjecture that it is surely of nothing but an aerial or watery nature; and it is defined by the Spagyrist [Spagyrici] as the nourishment of all things. But since neither the fiery nor the watery spirit can hold together [on its own], some support [fulcimentum] was necessary to them, by which they might obtain a solid consistency; and this salt we call the Condensative [Condensativum] of all things, for by its aid plants acquire the solid consistency of a body.

[Margin: in the growing things, while they are stirred by heat both internal and from the surrounding air — heat which, just as [the growing things] draw their first origin from the now-individuated hylean [hylæo] nourishment, so too gradually grow coarser and pass from invisible substance to become visible. For from their grosser parts is made the body of the growing plant; from these finer parts, which persist in the coarser nourishment, are made the leaves and flowers, and from these the fruits; and from the finer parts of the fruits is made the seed. In the center of the seed lies hidden that most subtle part of [the seed], that is, of the chaotic moisture mingled with elementary moisture, which composes the whole body of growing things — from which thereafter come germination and sprouting. But if this seed is committed to the earth, it is once more dissolved by the chaotic spermatic moisture, digested and fermented through putrefaction, and so disposed toward a new germination. In this seed resides the soul of the growing thing — not indeed in the whole body except through certain ideal principles, but in the smallest little spark [scintillula] of the now-perfected seed, which by certain chemists is reckoned to be the 8200th part. And so we cannot sufficiently admire and praise the wisdom of the Creator, who was pleased to bring forth from so tiny a little body such great masses, even of the loftiest trees.]

[The two columns of p. 379 alternate between a marginal-set fine-print continuation and the main text; I have placed the fine-print continuation in a Margin bracket where it intrudes, as it is set as an extended marginal note keyed to the discussion of the seed's animating spark.]

No one, however, should suppose that we here assert the sulphureous–saline–mercurial spermatic spirit to be composed of mineral sulphur, salt, and mercury — by no means. Rather, we affirm it to be something analogous in common to salt, sulphur, and Mercury, and, as to its powers and properties, not unlike them; joined to the elements by an indissoluble bond; and also imperceptible, since the sulphur of Nature, in spagyric resolution, shines out only under the form of a fatty oil

[continuation of Caput II text, from p. 380]

[At the head of p. 380 the running text completes the sentence broken at the foot of p. 379:]...and an inflammable [oil]; Mercury under the form of a liquor; Salt shines out under the salts and ashes. Yet that these three proximate principles of things are conjoined in a single saline corpuscle by an inseparable knot is sufficiently — more than sufficiently — taught both by the fiery acidity and by the moisture (into which [the corpuscle], when stored in a cold place, resolves itself) and, finally, by the proper corpulence of the salt itself.

And although there are several differences of salt — as we showed in the Sixth Book — we have nevertheless judged that this kind of salt may conveniently be divided into two classes, so that the first class is that of *fixed salt* [sal fixum], the second that of *volatile salt* [sal volatile]. These salts are found and gathered abundantly by the Chemists both in all things and, most of all, in all species of plants: the fixed [salt] in the ashes, the volatile separated from the soot of burned vegetables — yet each one preserves the powers and properties of the growing thing from which it was extracted.

This too is most worthy of admiration: that the salt of animals is much lighter in weight than the salt of growing things, and this lighter than mineral salt. This comes about from no other cause than that mineral salt, being mixed with earthy refuse, is necessarily heavier; whereas the salt of growing things is lighter, because it has been purged of the admixture of earthy refuse — or, with the coarser earthy parts left behind in the final resolution, remains pure of all admixture. But the salt extracted from sentient creatures is the lightest of all, because, through the many purifications effected by the agency of the native heat, it at last attains to the utmost limit of its subtlety. For example: if in the composition of a vegetable salt there were four parts [pondera] of water, three of earth, two of air, and one of fire, there will be in the composition of an animal salt nearly the contrary proportions — namely, four of fire, three of air, two of water, and one of earth; whereas in mineral salt

there will be four parts of earth, three of water, two of air, and one of fire. Hence animal salt is found by the spagyric art to differ from mineral by the whole heaven [toto cælo], as follows:

	4	3	2	1
In Mineral salt	earth	water	air	fire
In Vegetable salt	water	earth	air	fire
In Animal salt	fire	air	water	earth

Although these too differ among the various species of animals and growing things — namely, according to the difference of temperaments — we shall treat of these matters in a special chapter further on.

As for the weight and degrees of the elements: even if discovering it by art may perhaps seem to the Peripatetics [Peripatetici] a thing impossible [Greek: ἀδύνατον (adynaton, "impossible")], to the Spagyrist it is not so very difficult — as many might persuade themselves. For when some vegetable compound is

burned and calcined by fire, if its weight was one pound, the ash that remains from the combustion will for the most part be about four drachms in weight; the remainder of the earth, which during the calcination was carried upward together with the other elements, cannot be of greater weight than the very earth left fixed and surviving in the ashes. Hence we can gather how much earth is in the composition of plants — since it has been found by skilled Spagyrist that, of sixteen parts, one is earth, four water, eight air, and three fire, once the distillation has been carried out. For in succulent plants we have found that water always holds the middle weight: in which, since there are two parts of air, one of earth, and one of fire, these being subtracted, four parts of water will remain. But of these matters fuller material for discussion will be given expressly further on; it suffices in this place merely to have indicated the threefold weight of the salts.

CAPUT III.

DE DIFFERENTIIS PLANTARUM.

(On the differences of plants.)

Quæ necessaria sint ad plantarum vires cognoscendas, & quomodo ex diversitate vires explorandæ.

(What things are necessary for knowing the powers of plants, and how their powers are to be investigated from their diversity.)

[Woodcut initial "D"] The genus of plants, then, is divided first into Trees, shrubs [frutices], under-shrubs [suffrutices], and herbs. Of trees, some are acorn-bearing [glandiferæ] or nut-bearing [nuciferæ], cone-bearing [coniferæ], resin-bearing [resiniferæ], or apple/fruit-bearing [pomiferæ], or berry-bearing [bacciferæ], or finally Sterile, Poisonous, evergreen, or of marvelous power. Shrubs are either greater or lesser; these are followed by the lesser under-shrubs, such as butcher's-broom [bruscus], knee-holly [ruscus], and sea-holly [eringium]. Of herbs the differences are innumerable: such as the various species of grasses [gramina] and reeds [arundines]; others are bulbous, tuberous, garland-flowered [coronariæ], flower-bearing [floriferæ], leguminous, fragrant, oleaceous; others leguminous, fragrant — [the source repeats these adjectives] — others broad-leaved [latifolia], sinewy-leaved [nervosolia], sharp-leaved [acutifolia]; and there are creeping and climbing kinds. Others are downy [tomentosæ],

thick-leaved [pinguifolia], milky [lactariæ]. Nor are there lacking umbel-bearing [umbelliferæ], corymb-bearing [corymbiferæ], head-flowered [capitatæ], apple-bearing [pomiferæ], and finally [the] miraculous. But, so that the reader may

grasp the whole in a single synopsis, we have appended here an Analytical Table of them all.

In this Table we have set out a certain universal synopsis of plants. If we wished to examine their individual further species, we would find in each of the species an incredible diversity of things — since almost nothing in a plant can be considered that does not consist of its own peculiar and differing powers. Plants have one power in the root, another in the bark, another [in] the leaves, flowers, fruit, [and] seed; another [power belongs to] the saps pressed out of them and thickened, as

ANALYTICAL TABLE [Tabula Analytica], General, setting out the form and differences of all plants

This is a single large two-leaf taxonomic table. Its left leaf (fol. 380) carries the bracketed division-labels at the far left and the beginning of each species list; its right leaf carries the continuation of each species list and a column of right-margin category words (Actions, Passions, When, Where, Situation, Disposition) keyed to the prose discussion that follows on fol. 381. The table is rendered below as a structured list: each italic division-label is followed by its complete species list (left-leaf start joined to right-leaf continuation).

A. Trees [Arbores]

- **Acorn-bearing [Glandiferæ]:** Cerrus (Turkey oak), Ilex (holm oak), Quercus (oak), esculus, fagus (beech), Phyllodrys, Robur (hardwood oak), smilax, suber (cork oak).
- **Nut-bearing [Nuciferæ]:** Amygdalus (almond), Anacardus, Avellana (hazel), Ben, Castanea (chestnut), siliqua (carob), ebenus (ebony), fraxinus (ash), Guajacum, Juglans (walnut), Myristica (nutmeg), Miricolanus [recte: Myrobalanus?][?], Pistachia (pistachio).
- **Cone-bearing, or Resin-bearing [Coniferæ, seu Resiniferæ]:** Abies (silver fir), arbor vitæ (tree of life / thuja), Caphur (camphor), Cedrus (cedar), Cupressus (cypress), Larix (larch), Lentiscus (mastic), Myrrha (myrrh), Pinus (pine), Styrax (storax), Thimiama [thus / frankincense-tree], Terebintus (terebinth), Ulmus (elm).
- **Apple/Pome-bearing [Pomiferæ]:** all the species of pomes, Arbutus, the species of Aurantia (orange), Citria (citron), and Limones (lemon), Ficus (fig), Granata or Punica (pomegranate), Musa (banana/plantain), Nuciprunus, Palma (palm), Persica (peach), Prunus (plum), Pyrus (pear), Cerasus (cherry), ebasten [sebesten], sorbus (service-tree).

- **Berry-bearing [Bacciferæ]:** Acer (maple), agallochus (aloeswood), alnus (alder), laurus (laurel), lotus, mespilus (medlar), morus (mulberry), olea (olive), platanus (plane), populus (poplar), sandalum (sandalwood), Taxus (yew), Tilia (lime).
- **Wool-bearing [Laniferæ]:** Glossipium (cotton), Malabathrum.
- **Barren [Steriles]:** Aleternus, or Physia, Salix (willow).
- **Poisonous [Venenatæ]:** Napellus arborescens (tree-monkshood), Taxus (yew), and various trees in India.
- **Wonders [Admiranda]:** trees that act against the stings of lust, such as the chaste-tree (vitex); the water-distilling tree [aqua stillans — the rain-tree]; the tree whose falling leaves at once come to life — the barnacle-tree [arbor anatifera].
- **Evergreen [Sempervivæ]:** Pinus (pine), abies (fir), Ilex (holm oak), laurus (laurel), viticella, Laurus Imperialis (imperial laurel), Juniperus (juniper), Cypressus (cypress).
- **Deciduous of leaf [Deciduæ foliis]:** all the rest are stripped of their leaves in the winter season.

B. Shrubs [Frutices]

Larger shrubs [Frutices Majores]:

- **Fertile, fruit-bearing [Fecundi, bacciferi]:** Aspalathus, berberis (barberry), Ribes (currant), capparis (caper), Cerasus marina (sea-cherry), Amomum, cardamomum (cardamom), chamelæa [chamaelea], smilax, storax, Timelea [Thymelaea], viburnum, Paliurus (Christ's-thorn), vitis (vine), Cassia.
- **Barren, without fruit [Steriles sine fructibus]:** Buxus (box), salix (willow), salicunca, Tamariscus (tamarisk), Genista (broom), Titimallus arborescens (tree-spurge), acacia, Glycyrriza (licorice), Gellistum[?] — these are woody plants furnished with a thorny stem.

Smaller shrubs, or under-shrubs [Frutices minores, seu Suffrutices]: Ruscus (butcher's-broom), Myacantha, Halimus, portulaca marina (sea-purslane), myrtillus (bilberry), genista (broom), spartum (esparto), spinosa, and innumerable others.

C. Herbs [Herbæ]

Those that go by the name of grass [Quæ graminis nomine gaudent], divided into 3 classes, of which the first contains:

1. **Grasses [Gramina]**, of which there are 25 species, whose manifold difference lies in the ear and in their other parts.
2. **Reed-like herbs [Arundinaceæ herbæ]**, such as all the kinds and species of reeds and rushes, of which some are:
 - **Of knotted stem [Caule nodoso]**, like the reeds, horsetail (equisetum), knotgrass (plygonum [polygonum]), Zinziber (ginger), Zedoaria (zedoary), Acorus (sweet-flag), Costus, Curcuma (turmeric).
 - **Of stem without knots and smooth [Caule enodi & levi]**, all the species of rushes.
3. **Edibles [Edu lia]**, and these are either:
 - **Grain-bearing [Frumentacea]**, which consist of an ear and seed, such as wheat (triticum), barley (hordeum), oats (avena), legumes (legumina), beans (fabæ), kidney-beans (phaseoli), peas (pisa), rice (oriza), and the like.
 - **Without grains [Sine granis]**, such as all the species of lettuce (lactuca), Intybus (endive), endivia, chicory (chorium [cichorium]), beet (beta), atriplex (orache), oxalis (sorrel), and those that serve for salads.
 - **Bulbous [Bulbosæ]**: the species of garlic and onion, all the species of Tulips, Narcissus, Hyacinth, and Anemone[?]; the ten species of lilies.
 - **Tuberous [Tuberosæ], they have 14 species:** Arum, Arisarum, Asphodelus (asphodel), Cyperus liliaceus, Cyclamea (cyclamen), glans Malacensis [Malacca-acorn], Nucula terrestris [earth-nut], the species of demons[?] [daemonum species 67][?], Cyclaminus, Peucedanum (hog-fennel), all the species of orchids; the S. gladioli [sword-lilies] are reckoned 69.
 - **Conspicuous in flower [Floribus conspicuæ]**: Tulips, Anemones, Hyacinths, Narcissi, Ranunculi, Doronicum, Pardalianches (leopard's-bane), Heliotropia (heliotrope), Heliocabus Peruvianus, Lychnides, Bellides (daisies), Aquilegiæ (columbine), Chrysanthemum, and innumerable others.
 - **Outstanding in scent [Odoribus eximiæ]**: satureia (savory), mentha (mint), salvia (sage), melissa (balm), betonica (betony), lilium convallium (lily-of-the-valley), Nardus (nard).
 - **Leguminous [Leguminosæ]**: those that consist of a pod and bear fruits fit to eat.

- **Pot-herbs [Holeraceæ]:** ones [olera], orache, chicory (cichoreæ), purslane (portulaca).
- **Of manifold leaf-differences [Foliorum differentiæ multiplices]:** monophyllum (one-leaved), millefolium (yarrow), and others differing in the multitude of their leaves, such as tormentilla, ruta (rue), fumaria (fumitory), Aparine (cleavers), [?]ium, and innumerable others.
- **Sinewy/veined [Nervosæ]:** bistorta (bistort), farfara (coltsfoot), Lappa (burdock), Isatis (woad), Polygonatum (Solomon's-seal), Nicosiana [Nicotiana, tobacco].
- **Sharp- and thorny-leaved [Acutifoliæ spinosæ]:** all the species of [?], ficus Indica (prickly-pear), and whatever have the power of burning and pricking.
- **Hair-like / fern-leaved [Capillares]:** lingua cervina (hart's-tongue), scolopendria, nummularia (moneywort), ruta muraria (wall-rue), and innumerable others.
- **Creeping on the ground, or propped on other plants, or climbing [Repentes in terra, seu aliis suffultæ, seu scandentes]:** [convolvul]us[?], Clematites (clematis), Saxifragia (saxifrage), cucurbita (gourd), salsa perillia [recte: salsaparilla / sarsaparilla][?], polygonum (knotgrass), Nasturtium Indicum (Indian cress / nasturtium), Aristolochia (birthwort), Hedera terrestris (ground-ivy), wall- and tree-ivy [muraria, & arborea], cuscuta (dodder), convolvulus (bindweed), Smilax, Periclymenon (honeysuckle), Lupulus[?] (hops), Chelidonium (celandine), Herniaria (rupturewort), Kerta Turca[?], Paronychia (whitlow-grass).
- **Downy, or woolly [Tomentosæ, seu lanuginosæ]:** Gossipium (cotton), Verbascum (mullein), Pilosella (mouse-ear), Gnaphalium (cudweed), Leontopodium (edelweiss / lion's-foot), Borago (borage), hyosciamus (henbane), blattaria (moth-mullein).
- **Fat-leaved, or always-living [Pinguifolia, seu sempervivæ]:** all the kinds of houseleek (sedum), Portulaca (purslane), perfoliata (thoroughwax), hyrphita[?], cotiledon, or umbilicus Veneris (navelwort).
- **Milky [Lactariæ]:** all the species of spurge (Titimalli), Esula, Latiris [Lathyris], peplus (petty spurge), chamesicæ [chamaesyce], hippoloës [hippophæes], bestalzar[?].

- **Umbel-bearing [Umbelliferæ]:** sanicula (sanicle), althæa (marshmallow), pulmonaria (lungwort), helenium (elecampane), horminum (clary), malva (mallow), Telophium, Critamum (samphire), levisticum (lovage), Angelica, Pimpinella (burnet), imperatoria (masterwort), Apium (celery), petroselinum (parsley), pastinaca (parsnip), cærifolium (chervil), cicuta (hemlock); Foeniculum (fennel), Anisum (anise), Ammi, Anethum (dill), Cuminum (cumin), Coriandrum (coriander), Menni [Meum], Daucus (carrot), Branca ursina [bear's-breech], Chelidonium majus (greater celandine).
- **Corymb-bearing [Corymbiferæ]:** Oenanthe, filipendula (dropwort), laserpitium, sesilis [seseli], siler montanum, ligusticum (lovage), ulmaria (meadowsweet), succisa (devil's-bit), Coreula[?].
- **Capitate and apple/poppy-bearing [Capitata & Pomiferæ]:** Papaver (poppy), Artemisia (mugwort), Millefolium (yarrow), Tanacetum (tansy), Matricaria (feverfew), Abrotanum (southernwood), Absynthium (wormwood), Cotula, Nigella, betula[?], Cerasus[?].
- **Dripping, or tear-yielding [Guttantes, sive Lachrymosæ]:** hyosciamus (henbane), heliocacabus, stramonium (thorn-apple), Mandragora (mandrake), scabiosa (scabious), lacca, scorzonera, Galbanum, Acacia, Oppoponax, Storax, Mastyx (mastic), Camphora (camphor), Lentiscus (mastic-tree), Myrrha (myrrh), Bdellium, [?].
- **Resin-bearing [Resiniferæ]:** all that exude balsam, pitch, resin, and gum.
- **Wonders [Admiranda]:** the sensitive plant [Herba mima — mimosa], lunaria (moonwort), a certain kind of heliotrope, hæmanthes [haemanthus], aras, Boniza.

[Right-margin category words, keyed to the prose on fol. 381 and printed down the outer edge of the right leaf:] Actions [Actiones], Passions [Passiones], When [Quando], Where [Ubi], Situation [Situs], Disposition [Habitus].

PHILOSOPHIA BOTANICA [Botanical Philosophy] — continued

[Fol. 381. Running header: "PHILOSOPHIA BOTANICA. 381".]

such as Aloe, opium, acacia, manna; another kind, which is the gum that exudes from the plants themselves, such as Galbanum, Opopanax, Sagapenum,

Euphorbium, and the like; another, the resinous gums, such as frankincense (thus), mastic, myrrh, and Bdellium; and those that have taken on a liquid natural substance, such as Balsam, terebinth-resin, cedar-resin, liquid storax, and countless others. Of the same kind too are the dry resins, such as pitch, fir-pitch, and pine-pitch. Let this suffice as far as the *substance* of plants is concerned.

There remain the various other *accidents* of plants to be examined, which we are accustomed to investigate in this way, following the series of the nine Predicaments [Praedicamenta — the Aristotelian categories], according to various rules of combination.

[Margin: Quantity of herbs (Quantitas herbarum).]

1. If we consider the **Quantity** of herbs, we shall find in each of them a differing length, breadth, and solidity in the roots, trunk, leaves, flowers, fruits, and seeds. If we consider their *duration*, we shall see that each has a different lifespan, and is allotted varying conditions of age, of rising, of ripening and of decline, and finally of gathering — since some are winter plants, some spring, some summer, and some autumn; some, in the end, come up, decline, ripen, and are gathered [at their own seasons].

[Margin: Qualities of herbs (Qualitates herbarum).]

2. If we go on to investigate the **Qualities** of the individual herbs, we shall find them so varied that one can scarcely see where to begin. For here first come the colors, odors, savors, and softness, and the like — which the philosophers call the first and second qualities, born from the tempering of the elements. To these are added the *specific* qualities, which flow from the likeness of the whole substance and are endowed with a manifold difference of powers and properties. To these in turn are added the *sympathetic* qualities, struggling wonderfully against the *antipathetic* ones. Nor shall I here pass over what pertains to *geometric figures*, which the plants display most of all in their leaves and flowers. Among these are some furnished with leaves of 3, 4, 5, 6, 7, 8, and more, which are called *Polyphylla* [many-leaved]. In the umbel-bearing and cone-bearing plants too the wonderful geometric craftsmanship of Nature is plain; in others the radiating outgrowth of the herb shines out most of all, as in the heliotropes.

Here too belongs the *characteristic signature* of plants [signatura], for there is almost nothing in the natural world that the plants do not exhibit by their leaves, flowers, fruits, or seeds. In the peony the human head shows most clearly; in the poppy a crowned head; in the toothwort (dentaria) teeth; and so with the rest — matters I have treated at fullest length in Book III of the *Ars Magnetica*, and in the

Oedipus, under "On the Egyptian Characteristic Medicine" [*de Medicina Ægyptiorum Characteristica*]. There I refer the reader.

[Margin: Relation of herbs (Relatio herbarum).]

3. In investigating the **powers** of herbs, one must pay the closest attention to the condition of each sex, and to the analogies as regards their likenesses and unlikenesses, both among themselves and as related to animals. The palm, being a plant of both sexes, so pines away that the one must necessarily perish without the other; and one robbed of its spouse has been observed to grow barren as a widow. Indeed, the male's flowers, plucked from the trunk and set about the head of its beloved, not only gladden the loving tree with this pledge of love, but also make it fruitful with abundant offspring.

[Margin: Actions (Actiones).]

4. To the **Actions** of plants are referred chiefly those herbs that are at variance with one another in strife and friendship — as the cabbage with the vine, the fern with the reed, and countless others. From these, marvelous and scarcely credible things can be done by art, as we shall disclose in what follows.

[Margin: Passions (Passiones).]

5. The **Passions** of plants concern chiefly the modes of gathering, drying, and storing plants; and besides this, their violent degeneration, the diseases inflicted by insects, their long or short life — and, in short, whatever pertains to the cultivation of plants, as will be seen later.

[Margin: When (Quando).]

6. By **When** [Quando], we investigate the duration of plants, asking when they ought to be gathered at the right time. For plants are more effective and better when gathered in this or that month — not only as regards the whole substance of the plant, but as regards the roots, flowers, fruits, and seeds. Some too are short-lived, others long-lived; and all these things furnish us with great indications for medical use.

[Margin: Where (Ubi).]

7. **Where** [Ubi] considers the place of plants. For some are woodland, some garden plants; some love the mountains, others the valleys and the plains; certain ones delight in waters, springs, lakes, rivers, and the sea; others seek a rocky, others a rich soil — for "not every land bears all things." Hence, as many as are the differing intervals of climates, so many different plants must necessarily

spring up, so bound to their native soil that, if they are transplanted from one climate to another, they either perish outright or degenerate so far that they can scarcely be recognized. The reasons for this we shall give in what follows. The substance of the earth too, of differing virtue, must be considered.

[Margin: Situation (Situs).]

8. The Situation [Situs] proper to each plant is shown by its erectness, its bending, its leaning, its creeping, its climbing, and the natural position of its parts — of roots, seeds, and so on. All of these things have deep-hidden ends in physical Botany.

[Margin: Disposition (Habitus).]

9. The Disposition [Habitus] of a plant shows it to be healthy or diseased, together with its ornaments and coverings, which are observed in the stalk, leaves, and flowers.

Now, since it is a most celebrated Axiom of the Cabalists that "*there is no herb on earth to which some star in heaven does not correspond, which says to it: Grow*" — surely it is of great moment in Botany to consider this correspondence, or harmony, of the Sun, the Moon, the other planets, and the fixed stars. Hence, not without reason, the Initiates [Mystæ] of the more hidden nature have arranged every kind of plant according to the analogy of the seven planets, so that some are shown to be of Saturnine, Jovial, or Martial nature, others of Solar, Venereal, Mercurial, or Lunar nature, drawn from the nature and properties of the planets by a certain analogy. The season, too, the constitution of the air, and the quality of the earth must especially be considered, so that at last you may conclude something about the inmost powers and properties of the plant. But this inner...

[The following leaf is blank.]

[Printed page 382 — top of left column resumes mid-sentence from the previous page.]

the disposition of the earth derives its origin from the exhalations and vapors of the Subterranean World. In the same way, the outer celestial disposition draws forth that variety of plants from the earth, once it has been made ready and supplied with seeds suited to it — the variety we set out in the Synoptic Table.

Now that these matters are well understood, nothing further remains for the Initiate of Nature to do than this: relying on the help of the spagyric art, and

following the recognized prototype of Nature, to set himself to producing those astonishing growths that mortals so admire.

CAPUT IV.

On the Art of Grafting, that is, of Engrafting [De Arte Emphyteutica, seu Insititia].

Among the other ingenious accomplishments of the human mind, the grafting craft — the art of engrafting [Emphyteutica facultas, seu Insititia] — shines out especially. Following the pattern of Nature, it has found, aptly and elegantly, the way to engraft plants of different species onto the substance [hypostasis] of a single tree, in accordance with these lines of Palladius:

Beneath the bridal canopy to join glad woods, that on either side a fair offshoot may grow up; to clothe the linked grove with kindred shade, and bring the foliage to a double nobility of birth; in gentle bonds to wed the sweet saps together, and feed a joyful fruit of twofold flavor.

For just as different animals, mingled in a single coupling, bring forth something that resembles neither one entirely, so too the grafting or engrafting art — which in plants is nothing other than a kind of coupling, by which different species of plants are forced together into a single host [suppositum] — gives rise to those marvels of Nature that we sometimes observe in one and the same tree. Exactly how this comes about we shall now explain with physiological precision.

Columella enumerates the three kinds of grafting [Emphyteusis, or Insitio] handed down by the ancients, and Palladius follows him. The first is done under the bark: the cut shoot, set between the bark and the inner trunk, takes up the seminal power there. The second is done in the trunk itself: the tree is cut and split, and so receives the inserted shoots; both of these are best done in springtime. The third is done by a patch — they also call it patch-grafting [emplastratio] — because the trunk takes into a part of itself the very buds, together with a small piece of bark. This is carried out chiefly in summer. To these three we add two others, as will soon appear.

Now this coalescence of two species into one comes about only through a certain marvelous magnetism, by which two different things, drawn by a certain likeness of Nature, mutually seek one another, attract one another, and share their powers with one another. For just as we set out in the foregoing, nothing exists in the natural world that does not agree with something else by likeness or

unlikeness — or, what is the same, by attraction or repulsion, friendship or hatred, consonance or dissonance. Hence like things, by their own nature, flow together toward like for mutual nourishment, while unlike things flee one another by a certain blind discord of Nature.

Rules of the Grafting Art [*Regulæ Emphyteuticæ Artis*].

1. In the grafting art, then, you must above all attend to choosing plants that are friendly to one another — the plants you are seeking to wed in this marriage. For if things are dissimilar, or antipathetic, that of themselves and by their own nature flee from one another, then once grafted they will either perish outright or grow barren by fruitless labor. [Margin: The grafted shoots must be sympathetic.]
2. The shoots should have a certain kinship with the tree onto which they are to be grafted, such that they bud or flower at the same time as the tree. Otherwise your labor will be in vain, since the proportion of nourishment drawn will be unequal, and it will not easily coalesce given the unlike constitution of the sap. [Margin: The shoots to be grafted should flower at the same time.]
3. The right time must be chosen, for the moist nourishment does not have the same constitution at every season. Most therefore choose springtime as the time for grafting, since the sap is then vigorous in both, mild, and most fit for coalescing. Others, according to the condition of the shoots and the trees, take now spring, now summer or autumn. [Margin: Choice of time in grafting.]
4. Moreover, the shoots are not to be grafted at once, as soon as they have been cut from the trees. Rather, they should be taken as the Moon is waning, about ten days before the grafting, and laid away in a covered and well-protected vessel.
5. The coalescence should be made in the cleanest part — never in a part that is ulcerous, knobby, or twisted — once the suckers and buds round about have been cut away. Hence you should know it to be of great importance that the shoots to be grafted be cut from a well-suited place on the trees. This will be so if the buds have faced the summer quarter of the rising Sun, and if the shoots are swelling with leaves and sap; and even if they have not yet borne fruit, they should give promise of abundant fruit in the years to follow. [Margin: The place of cutting in the shoots to be grafted.]

6. Columella points out the qualities of the shoots: "When you are about to take shoots for grafting," he says, "see to it that the tree is tender and fertile and frequently branched. And as soon as the buds begin to swell, choose them from the year-old twigs that face the rising of the Sun and are sound, the thickness of the smallest finger, forked or three-forked." Palladius takes the same from Columella. Pliny adds some points; Virgil forbids grafting from the topmost tip, and it is certain that the shoots are to be sought from the shoulders of the trees that face the summer East. [Margin: The qualities of the shoots.]

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and from a new sprout, unless they are grafted onto an old tree; for these need to be more robust.

7. You should select shoots that are pregnant — that is, swelling with the urge to germinate, the ones that give hope of budding that same year — at least two years old and certainly no slenderer than the smallest finger. The sap, moreover, lies differently in different plants and in different parts of each. In vines and figs the middle is drier, and the sap gathers in the upper part, so the shoots should be sought from there; in olives the sap is around the middle, and so the shoots there reach upward toward their tips. [Margin: The shoots of figs and vines, and their saps.]
8. The shoots that are grafted should be glossy, fertile, knotty, cut with sharp pruning-hooks from the part of the tree that faces North, smooth, pregnant with frequent buds, forked or three-forked, simple from the lowest part of the stem, the thickness of the smaller finger, and two years old. Year-old shoots indeed shoot up readily, but are barren. [Margin: The glossiness of the shoots.]
9. By Theophrastus' teaching, a cultivated tree will bear much fruit if you graft it onto wild trees of its own species, since the trunk then supplies more nourishment. This is why, before all else, they graft olives onto wild olives; for the trees join their strength, and the root, drawing more nourishment, makes the tree more fruitful. But on the other hand, if you graft a wild scion onto a cultivated tree, even though you may find a certain difference, it will never be a tree of good fruit. And although Varro may seem to have contradicted Theophrastus, the two can easily be

reconciled: Theophrastus was speaking of fruitful germination, whereas Varro was speaking of the sweetness of the fruits that comes from grafting one cultivated tree onto another cultivated one. [Margin: Cultivated trees are to be grafted onto wild ones.]

10. By Pliny's testimony, those trees coalesce most easily that have the same nature of bark, and that likewise have their flowering at the same time as their germination, and a shared society of saps. For it is a sluggish business whenever dry things resist moist, and the hardness of the bark resists soft things. [Margin: The agreement of germination.]
11. As to the grafting itself, take care that the cleft is not made at a knot, for the inhospitable hardness there rejects the newcomer. Let it be made instead in the glossiest part, and let the cleft be not much longer than three fingers, neither slanting nor letting the light through. The shoots are also grafted inverted, to this end: that the lesser height may spread out into width. They should be grafted near the ground, if the condition of the knots and trunk allows; and the reeds should stand out no more than six fingers in length. [Margin: The cleft is to be made in the shoots to be grafted.]
12. But if the apple-reeds are brought from farther off, some hold that the sap is best preserved by fixing them into a turnip, and that they may be kept between two roof-tiles beside streams or fishponds, stopped up with earth on either side; or even fixed in mud, carefully smeared over in a vessel, so that they may not feel the wind. Yet Porta says that the inverted method of carrying shoots set down by Pliny — meant to keep the tree from growing tall — he found to be false. For having tested it on a vine and on a plum, the tree reached the same height as the rest. "This method," he says, "seems to me safer: that we graft on top two- or three-year-old shoots, not old ones, taken from above; for then they spread out into width, and in this way we have made dwarf cherries and figs." [Margin: How the apple-reeds, when carried from far off, are to be preserved.]
13. Plants that are ἐλαιώδεις [Greek: elaiōdeis, "oily," of an oily nature] — that is, oily by nature — can in no way admit grafting. For farmers report that the pine cone, the cypress, the pine, and pitch-trees generally will neither tolerate nor nourish anything foreign. The proof of this is that if you anoint any plant with oil, it dies at once. And that the trees just mentioned are very fatty and oily can be shown by this: the outflow of pitch or resin refuses to mix with other substances, just as oil itself does. [Margin: Oily trees are not to be grafted.]

Among students of Agriculture the question is often raised whether it is better to sow plants in seedbeds, then graft them, and afterward transplant them into the orchard — since we read in the Ancients that a tree transplanted in this way is made milder — or whether it is wiser to graft them out in the woods and afterward transplant them into the orchard. On this point probable reasons are brought forward on both sides. But experience has shown us that it is better to sow wild plants in the orchard and, once they have grown up excellently, to graft them there, rather than to transplant ones already grafted. For when we transplant these, we often see them, as if unaccustomed to a foreign place, grow sickly, and many times wither away entirely.

14. Furthermore, if we wish grafted trees to bear fruit in the same year in which we graft them, this will be the method: graft an old shoot, especially one swelling with flowers and buds and about to bear fruit the following year, so that it may conceive in its own tree the offspring which here it shall bring forth — the very fruit it was going to bear on its own tree.
[Margin: How a grafted tree bears fruit in the year it is grafted.]

These, then, are the Rules you should apply in the happy business of grafting. So nothing remains except to demonstrate the manner of proceeding by experiments.

EXPERIMENT I.

Cleft-grafting [Emphyteuticum].

Which shows how grafting under the bark is to be done — what they also call leaf-grafting [insoliationem].

The tree you wish to graft, first cut into with a saw — carefully, and chiefly in the part that is most glossy and free of any swellings, sores, or scars. Use this precaution: do not damage the inner bark or rind. This done, drive an iron wedge — or better, a bone one — into the wound, that is, between the bark and the trunk, and gently penetrate not less than three fingers' depth, so that the bark does not break. Then take the shoots you wish to graft and, into the wound now opened, work them in as deeply as you drove the wedge — gently, so that you do not wound the bark or the pith — once the wedge is withdrawn. Fit the shoots in so that three fingers' depth is buried within the wound, while about six fingers stand out. In one tree you can graft several shoots by the said practice, provided they keep a proportionate distance from one another, so that one shoot does not, by robbing its neighbor of moisture...

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bring upon the rest the loss of growth. When all this is done at last, smear the whole wound and the space round about with mud, and over the mud lay moss plucked from trees, fastened so that it is not scattered by the violence of winds and rains.

EXPERIMENT II.

Which demonstrates how grafting is to be set up in the trunk of a tree.

Bind the cut trunk of the tree with rather tight cords, and split it moderately with a chisel, so that the cleft has a width of three fingers. This done, take the shoots you have selected, shaved on both sides into the shape of a wedge — but with the pith whole and uncorrupted — and, first inserting a little wedge to open the cleft, sink them in. When this wedge is withdrawn, the sides of the cut trunk return upon the wound, and the shoot will be held fast. At last smear the wound with mud and moss, exactly in the way done in the preceding cases, and you will have the work of grafting accomplished. Trunk A, wound C, the trunk from side B, the shoots to be grafted D, D.

EXPERIMENT III.

Which shows the kind of grafting they call patch-grafting [emplastratio] or budding [inoculatio].

This third kind of grafting is the most delicate. It does not suit all trees, but only those that have been allotted a moist, sappy, and strong bark or rind — such as the fig, for it swells with a milky juice and has a strong, robust bark. Proceed thus. Take shoots of any well-suited tree you please, ones that have glossy, young, and fruitful branches, and observe especially in them a bud or eye [gemma seu oculus]. Cut around it with the care that follows. Let the bud be of a leaf, that is, the wrapping of the eye [involucrum oculi].

Diagram. A small geometric figure illustrating the budding technique, in two parts side by side. *Left figure:* a square frame within which a leafy eye-wrapping (involucrum) is to be cut into a quadrangular shape. The square's corners and edges are lettered: **a** (top-left corner), **e** (top edge, center), **b** (top-right corner), **h** (left side), **c** (bottom-left corner), **d** (bottom-right corner), with **f** and **g** at the bottom (the leaf-tail of the involucrum); at the center is **I** (the bud/eye, "Oculus I"). *Right figure:* a smaller, star-like figure showing the bud detached and ready,

lettered **b** (top-left), **c** (top-right), **a** (center, the eye itself, drawn as a rounded mark), **d** (bottom-left), **e** (bottom-right).

[Text resumes:] ...efgh — into the shape of the square abcd you shall cut, with this caution, that you do not damage the eye. This done, choose the glossiest branch of any well-suited tree you please, which you shall cut with such skill that it can conveniently receive the bud or eye in the cut you have made. When this too is done, fit the patch in — with the eye unharmed, the bud inserted — so that it answers exactly to the cut both of the tree and of the bud's wrapping. Then bind the patch round with great care, lest it harm the eye...

bind it; then surround the joins and bindings with mud, yet in such a way that the bud's eye has free room to germinate. When this is done, leave the muddied patch about twenty-one days; then, the patch loosened, leave the bud — now grown together with the tree's branch — to be perfected by Nature.

Proceed another way thus: bore through the tree with an auger as far as the pith, with the wound gently inclined inward; then, all the borings drawn out, push a fruitful and moist vine or branch tightly into the hole, with this skill: that two or more buds project outside. This done, carefully smear the place with clay and moss, and you will have your aim.

COROLLARY I [CONSECTARIUM I].

In this way the apple can be grafted onto the willow and poplar; the vine onto the elm and mulberry; the almond onto the peach; and they can be grafted onto the plum. If they are united by their own buds and grafted onto the plum according to Experiment III, the flesh will be of a peach, but the kernel will taste of an almond. Again, by this art the olive is grafted onto the wild olive, the fig onto the mulberry, and the mulberry in turn onto the fig, the ash, and the chestnut. The cherry loves to be united to the laurel, plane, plum, and poplar. The garden pear seeks to be incorporated into the wild pear, the apple, the ash, the almond, the rowan, the chestnut, the medlar, and the pomegranate-apple. The walnut is grafted onto the plum, whence the fruit "walnut-plums"; the walnut again onto the peach, whence "walnut-peaches"; and the almond can be grafted onto the fig. [Margin: On which trees can be grafted onto which.]

The apple is of such wantonness that it does not refuse to prostitute itself to ten different trees — the pear, wild apples, the plum, the service-tree, the willow, the plane, the peach, the poplar, the medlar, and the chestnut. The quince-apple alone abhors the company of all the rest — so some think; yet we have found this to be false, nor does that line of the poet about the quince stand in the way: "For,

opening kindred chambers on its own branches, / it stands content to ennoble its own house."

The trees that most enjoy a friendly grafting-partnership are, first: the quince-apple, which some assert delights in grafting only with its own species. But experience has taught us otherwise; for even as we write, our farm-steward showed me a quince-apple onto which a hawthorn had been grafted, displaying on one side fruits commonly called "Lazeroli" [the azarole, fruit of *Crataegus azarolus*], and on the other side an apple-tree loaded with quinces — a truly handsome sight to behold. The medlar, in turn, rejoices in the oak and the pear; the citron-apple in the mulberry; the plum in itself and in the chestnut. For just as a magnet brought near to iron at once flows together with it, so these rightly applied, friendly and sympathetic species of trees, draw one another marvelously together. But whoever desires to know more of this sort should consult, not books, but countrymen, by whose long and frequent experience countless things of this kind first became known to us. It is our task to assign the true and genuine cause of all these things, which we hope to do in the following Inquiry [Disquisitio].

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Diagram. An engraved plate occupying the upper part of the page, set within an open landscape. A gardener — a bearded man in a hat, jacket, and breeches — stands at center, grafting a tall, leafless scion into a thick cut tree-stump or trunk before him. To his lower left, a smaller cut stump marked **B** has shoots being set into it. At his feet to the right lies a bundle of cut rods (shoots/scions) tied together, with a billhook or pruning tool beside it. Mature leafy trees fill the background to either side. In the upper-right corner of the plate is the engraver's volume/page reference "**Tom. II. 384**" [Volume II, p. 384]. The only diagram-letter label legible is **B** (the smaller stump at lower left). [The single point-letter "B" corresponds to the "Truncus è latere B" of Experiment II; no other point-letters are inscribed on the plate.] ...repulsion, in strife and friendship, in consonant and dissonant — as we taught at length in our *Musurgia* [Kircher, *Musurgia Universalis*] — the Ancients held this should be assigned.

The innermost kernel of operations of this kind consists in the inmost bridal-chambers [thalami] of the Geocosm. For since we have already shown, in various places of this work, that all things contained within the compass of the Subterranean World draw the first beginnings of their composition from the

offspring of the Subterranean World — that is, from the saline-sulphureous-mercurial vapor and exhalation, as from the primordial seed of Nature, implanted in the chaotic mass by the most wise Architect of the World to endure forever — it now remains for us to exhibit Nature's process in producing plants, step by step, just as was set forth in the genesis of insects and the other animals. This we shall expound as briefly as may be. [Margin: All things have their nearest origin from the Subterranean World.]

No one is ignorant that the nourishment of plants is a moist substance present within the earthy matter, in whose inmost center lie hidden those three nearest principles of things: Salt, Sulphur, Mercury — clothed, as it were, in a garment, by the elements. But where that spermatic moisture differs according to the differing nature of the earthy parts, it likewise produces differing effects in the nourishment of things, once it has been converted into the substance of the things nourished. For this universal seed, as soon as it has been joined to the seed of each particular plant, is at once individuated in that same plant, and produces its various... [Margin: The elements are the nearest garment of the principles.]

Nor should the Reader persuade himself that degrees of this kind are confined and constrained, so as to admit no latitude. By no means! Rather, just as in numbers, between one whole number and another, infinite fractional numbers — which they call "minutes" — can be interposed, all of which vary essentially, so too between the first degree of hot or moist, cold or dry, and the second degree, innumerable other intermediate degrees can be set, which will perceptibly vary the constitution of the mixture. For as the Philosopher rightly says (*Metaphysics* VIII): since the species of things behave like numbers, it is easily clear that there is an inexhaustible diversity, marvelous in every kind of mixed things — just as we taught concerning the variety of colors (Book VIII) and, in the *Physiognomy*, concerning the marvelous diversity of temperaments in men. For you will scarcely find a man who is entirely like another, whether you look at his face, his voice, his gait, or finally the whole carriage of his body and the inclination of his mind. In the same way, you will scarcely find a species of plant that entirely agrees with another, since each differs either in root, or stem, branches, leaves, fruits, seeds, wood, sap — or finally in the color of its flowers and the flavor of its fruits. Whatever therefore is said of the elementary degrees, understand the same of the degrees of predominance in the saline-sulphureous-mercurial seed, from which the generations of natural things derive their composition. [Margin: The marvelous power of combination in the nature of things.]

PHILOSOPHIA BOTANICA

DISQUISITIO PHYSICA

By which this wondrous Marriage of differing Trees, arranged by Nature acting as their match-maker [Paranympa Natura], is set forth through the manifold demonstration of Experiments.

The ancients had a celebrated refrain [epiphonema] concerning this mystery of Nature:

[Greek: Ἡ φύσις τῇ φύσει τέρπεται. / ἡ φύσις τὴν φύσιν νικᾷ. / ἡ φύσις τὴν φύσιν κρατεῖ. ("Nature delights in nature; nature conquers nature; nature masters nature.")]

That is:

Nature is undone by nature. Nature conquers nature. Nature masters nature.

And rightly so. For there are some things so attuned to one another by a certain natural likeness that, the moment one is placed beside the other, they rush into mutual fellowship, embracing each other by wondrous laws of friendship.

[Margin: The sympathy and antipathy of things.] This is evident in every class of worldly bodies, but most of all in Nature's work of grafting [emphyteutica operatio]. Other things, by contrast, are so at odds in the blind discords of their natures that they can scarcely seem able to coexist — indeed, they would sooner perish than be joined one to the other. Truly remarkable is the magnetism of Nature, by which on the one side she strives to attract whatever is friendly to her, and on the other to repel by every possible means whatever is hostile. It is therefore not unfitting that the ancients held the universal working of Nature to consist in attraction and repulsion, in strife and friendship, in concord and discord — as we taught at length in our *Musurgia* [Kircher, *Musurgia Universalis*].

[Margin: All things have their origin and nearest source from the subterranean World.] Now the inmost kernel of operations of this kind lies in the innermost chambers [thalami] of the Geocosm. For since we have already shown, in various places throughout this work, that everything contained within the bounds of the subterranean World draws the first beginnings of its composition from the womb of the subterranean World — that is, from the saline-sulphureous-mercurial vapour and exhalation, as though from the firstborn seed of Nature implanted in the chaotic mass by the most wise Architect of the World, destined to endure

forever — it now remains for us to set out Nature's process in producing plants, step by step in the same way as was done in the generation of insects and other animals. This we shall expound with what brevity we can.

No one is unaware that the nourishment of plants is the moisture residing within the earthy substance, in whose inmost centre lie hidden those three proximate principles of things: Salt, Sulphur, and Mercury. [Margin: The seed of the proximate principles of things.] These are clothed, as it were, in a garment of the Elements. But since that spermatic moisture differs according to the differing nature of the earthly parts, it accordingly yields differing effects in nourishment, once converted into the substance of the things nourished. For this universal seed, as soon as it is joined to the seed of any particular plant, is at once individuated within it, and draws out differing forms according to the differing nature of the plants. These forms cannot live without nourishment, and so they too are continually preserved, by a kind of marvellous circulation [pericyclosi], from the sap and attraction of this spermatic moisture. For whatever sulphureous matter lies hidden in the moisture produces — at differing degrees of concoction — the differing species of colours (as we have shown elsewhere) in the leaves, flowers, and fruits of plants. What is mercurial yields the juices and liquids; what is saline confers, besides solid consistency, together with the rest, the odours and savours suited to the constitution of the combined plants, and enriches the plants with still further virtues, both manifest and specific — the ones they call "occult." Hence, where the sulphureous predominates, plants for the most part acquire a hot and parched temperament with sharpness; where the mercurial, a moist and airy one (for Mercury gives both); where the saline, there plants take on an earthy, dry, and coarse character.

Now just as the mixture of these things can be extended through countless intermediate degrees, so too the countless variety of plants results from nothing other than the varied combination of these saline-sulphureous-mercurial degrees. All the differences of vegetable nature arise from the excess or deficiency of the predominance or subordination of these. For if we combine the said composition of plants according to the rules of the combinatory Art [Ars combinatoria], through the four degrees most commonly used by natural philosophers, we shall find a multitude of plants beyond reckoning. [Margin: The wondrous power of combination in the nature of things.] And let not the reader persuade himself that degrees of this kind are confined and constricted, allowing no latitude — by no means. Rather, just as in numbers, between one whole number and the next, infinitely many fractions (which they call "minutiae") can be interposed, all of them essentially varying, so too between the first degree of

hot or moist, of cold or dry, and the second degree, innumerable other intermediate degrees can be set, which will perceptibly vary the constitution of the mixture. For as the Philosopher rightly says (*Metaphysics* [l. 7]), since the species of things behave like numbers, it is easily seen that there is a marvellous, inexhaustible diversity in every class of mixed things — just as we taught concerning the variety of colours in Book VIII [Lib. VIII], and in the *Physiognomia* concerning the marvellous diversity of temperaments in human beings. For you will scarcely find a person who is exactly like another, whether you regard his face, his voice, his gait, or finally the whole disposition of his body and the inclination of his mind. In just the same way, you will scarcely find a plant species that exactly matches another, since each differs in root, or stalk, branches, leaves, fruits, seeds, wood, sap, or finally in the colour of its flowers and the savour of its fruits. Therefore, whatever is said of the elementary degrees, I would have understood as applying likewise to the degrees of predominance in the saline-sulphureous-mercurial seed, from which the generations of natural things derive their composition.

But let us now return to the subject we proposed.

The work of grafting, as we said above, requires a suitable time. Here in our vineyards at Rome we usually begin the work of inoculation around the start of March, when the earth is by then gradually growing warm and the shoots of the trees are swelling with abundant moisture; budding [inoculationis], however, we begin around the start of the dog-days, when the Moon is in the last quarter of its age. But no fixed rule for this can be prescribed; it must be left partly to the constitution of the different climates and horizons, and partly to the practice and custom of the regions. Here at Rome it meets with most successful outcome [Greek: ἐμφύτευσις (emphyteusis, "implanting/grafting")] at the times mentioned. In our vineyards you will scarcely find a tree that does not display sports of this conjugal nature. A shoot grafted onto a plum is made so fruitful that within a year it triumphs with an abundant yield of fruit. Likewise a peach, grafted in a wondrous way onto plum and pear, thrives as an apple-tree whose fruits are called *Pericoccoli*. But since these matters are commonly known, I shall not dwell on them. Let us instead proceed to investigate the causes of so wonderful a marriage of nature.

[Margin: The universal seed and its power and capacity.] Since the universal chaotic seed, existing everywhere throughout the world, is wanting in no part, it comes about that, when in the art of grafting two, three, four, or even more shoots of differing plants are grafted onto the trunk of some one tree, those

shoots — once coalescence has taken place — become one thing together with the tree, and so live by one and the same nourishment drawn in. But the saline-sulphureous-mercurial nourishment thus drawn in, as soon as it encounters the manifold seed-principles [seminis rationes] in the trunk, is at once individuated according to the diversity of the seeds that lie hidden both in the tree and in the shoots grafted onto it; and by its plastic virtue [plastica virtus] it strives to produce, on one and the same trunk of the tree, branches of differing nature, and then it sets about forming differing buds into leaves, flowers, fruits, and seeds, each suited to its own kind.

Hence the bud of a citron, grafted onto a tree of golden apples [oranges], soon brings forth differing fruits on one and the same tree — specimens of which may be seen, not without the admiration of visitors, in the domestic garden of the Roman College. For the said seed of each tree, joined to the seed-principles, gives to each what is its own according to the intention of nature. [Margin: From the diverse seed-principles diverse species of things are begotten.] It is no different from the way that, from the mating of differing species of animals, there arises either a *tragelaphus* — that is, a goat-stag [hippocervus] — or a mule, or a *tigricanis* [tiger-dog], or something intermediate compounded of diverse parents; such things also emerge as monstrosities from the generation of insects, as we have sufficiently shown in the preceding [section]. For example: the spermatic nourishment described above, while it is drawn in through the roots of the tree and carried up through the fibres of the tree's trunk, as soon as it encounters a citron branch, is there joined to the seed-principles lying hidden in the citron branch or bud, and being individuated, soon by its plastic virtue produces not a golden apple but a citron fruit — just as on the branches of the orange-tree it produces not citron fruit but golden apples. Each fruit is composed of sulphur, salt, and mercury: and in the citron fruit the sulphur indeed lies hidden temperately in the rind, while in the white moist pulp something mercurial lies hidden; the sour juice lying within, whether you regard its whole savour or its sharpness, comes from the salt. But the golden apple [orange] counterfeits more burnt sulphur in its most bitter rind, mercury in its interior, and in its whole substance salt; and the spagyric Art [Ars spagyrica] teaches that it will resolve the rind into oil, and the remainder into a spirituous liquor, with the salt left behind in the *caput mortuum*. Thus from the varied composition of sulphur, mercury, and salt, by the concurrence of the elementary portions, the temperament of mixed things emanates according to the unequal degrees of their powers; and that these things hold no otherwise than as we have said, we shall make manifest by experimental demonstration.

Experimental demonstration of what has been said thus far.

Now that Nature's operation in the Art of Grafting [Ars Emphyteutica] has been set out, nothing remains but to add certain other methods, supported by which Nature's Initiate [Natura Mysta] may deservedly accomplish things that in the universal opinion may seem paradoxes and, so to speak, miracles in Botanical Philosophy. And concerning the grafting of one tree into another, enough has now been said; but how, and what admirable specimens of art, can be exhibited in fruits, flowers, and seeds — this it remains for us to teach.

The metamorphosis of fruits.

Theophrastus, in his book *On Plants*, reports the ingenuity of certain men who, by grafting pomegranate fruits onto various trees, produced differing fruits; and how this is done, we teach by the following experiment.

EXPERIMENT I.

Let shoots be bruised with an ivory mallet [?], to this end: that the bruised parts may more readily cohere with one another; then, tightly bound together, let them be grafted. And behold — coalescence having taken place — the pomegranate tree, from this new union of the compounded shoots wedded by Nature acting as match-maker, will be loaded with manifold offspring; and each of the several shoots keeps its own kind and draws and concocts its nourishment by itself. The reason is that the bruised shoots of the different trees, since they swell with the seed of the whole, when grafted into one trunk of a tree will most easily coalesce by their own saps; and from the spermatic nourishment drawn in by each, individuated according to the seed-principles of the differing shoots, they will bear differing fruits too — pomegranate-peaches [granato-perficos].

Columella, Pliny [Plinius], and Didymus, where they treat of Agriculture, in like manner prepare a vine to bear both a red and a white grape on one branch; and this is how they proceed.

EXPERIMENT II.

Let buds of differing kinds be taken, which are to be split through the middle with such care that the cleft reaches into the buds [oculos, "eyes"] without injury, however. And in this way one must join the one to the other so that they nearly touch, and the bud [oculus] precisely matches the bud by apposition. This done, let them be most tightly pressed together, and — earth having been placed in them — let them be buried whole within a squill [squilla, sea-onion], or in earth

rich with a glutinous sap, and finally let them be moistened by three or five days' watering, so long until the bud puts forth a sprout and gemmae, that is, eyes.

[Margin: To produce on one vine grapes both black and white.] And in due time, in the manner shown in the second experiment, you will obtain on a single vine both black and white grapes, to the extent intended — the portion you decided to cover with earth being as much as you proposed. In this way Leontius, a very ancient writer, used to produce figs white on one side and red on the other.

[Margin: A fig that produces white fruit on one side and red on the other.] He would lay synchronous, that is, coeval, branches or shoots of the vines [recte: of the figs?] in a trench and water them with manure heaped on; and when they had sprouted, he again bound together the eyes of each shoot into one, and after about two years, coalescence having been made, he would transplant them, and produced a fig with fruit black on one side and white on the other. For such is the difference of the fruits as is the conjunction of the differing gemmae which are planted together — yet in such a way that they only touch, and are by no means commingled or confounded.

Nor can fruits of differing colour only, but also of differing savour, be produced by the art of grafting. [Margin: Acid and sweet apples on a single tree.] Thus Porta [Giambattista della Porta] relates from the ancients that two shoots were grafted onto a golden apple [orange], one of which bore sweet fruit and the other sour; but when, the two shoots having coalesced, they wished to transplant the tree, they first cut it after the usual rustic manner — not so much by deliberate care as by chance — and when the cut had reached the place of the grafting, it came about that the tree, once it had brought forth fruit, bore each fruit sweet on one half and sour on the other.

COROLLARY.

From this it is also evident how, from the varied commingling of seeds bound together by the ingenuity of a shrewd mind and committed to the earth, a tree laden with various fruits can spring up. [Margin: A mixture of diverse seeds produces diverse fruits.] For the seed-principles, just as they operate unconfusedly, so too, the gemmae of the shoots being joined into one — in which the seminal power lies hidden — will unconfusedly produce, each one, differing fruits. For nature rejoices: like is readily joined to like by a certain friendly appetite of Nature — nature with nature, the living with the living.

It is wonderful and most worthy of consideration what Diophanes teaches about the *oleostaphylon* (which is an olive commingled with a grape), which is described as having the savour of both at once. Florentinus, in his *On the Country*

Estate [in sua villa], holds that this can be done in the manner that follows: [Margin: How an olive can be grafted onto a vine.] the vine is to be bored in its lower part near the root, and then an olive-sucker is to be grafted into it, and so drawn out beyond. And these things are so in accordance with Nature that the very trees sometimes produce similar results of their own accord; for, as we showed in the preceding, it sometimes happens that diverse seeds of fruits are carried by birds into trees, which seeds, then falling among the barks or junctions and mixed there with rains, dew, and dust, finally grow into cherries, olives, figs, nuts, peaches, and the like. [Margin: One tree sometimes by chance produces various fruits.] And thus the same thing may happen by chance in any trees whatever which Art accomplishes by grafting. In this way I myself have often observed wild figs [caprificos], cherries, mastic-shrubs [lentiscos], and like plants spring up on one and the same tree, which it is certain grew there for no other reason than the one stated.

But those who wish to imbue fruits with differing colours generally obtain this by grafting. [Margin: To imbue fruits with diverse colours.] Well known is the grafting of peach onto mulberry: for the peach-shoot gives the form of the peach-fruit, while the mulberry imparts its blood-red juice to the peach. You may see such spectacles of grafting everywhere in the Roman gardens, and nothing can be more delightful than such fruits. But this matter of producing roses of differing kinds from a single stem is also wonderful.

These corollaries arise from the fact that the said olive [?] and the savour of both — but the meaning is not as Diophanes [?] supposes: for the sense is not that an olive is set under in the vine, so that, as the vine bears grapes, this should bear olives; rather, Diophanes' intention was to produce [Greek: ἑλαῖος ἄφυλον (elaïos aphyton)] — that is, an olive that should at the same time reproduce the savour of a grape. I myself judge that this can be done better, if the gemmae of each plant, as was said in the preceding, are brought together into one, or the berries [acini] of each are fused into one. Innumerable experiments of this kind can be verified, if anyone has the leisure and time for the practice of the art prescribed here.

EXPERIMENT III.

Chromatic.

[Margin: To imbue roses with various colours.] Onto the growing heads [capitula] of Roses, having pierced the branches or stalks beneath the heads with an awl, into these holes inject the juices of various kinds of colours — not mineral but vegetable, such as those of lake [lacca], heliotrope, bramble [rubus], alkanet [anchusa]. This done, smear the holes with cow-dung and clay, and you will

obtain as many differently coloured roses — though for one year only — as the differing colours you apply.

Whoever desire that a grape be produced without seeds [vinacea] proceed thus.

EXPERIMENT IV.

From Porta and the records of other Authors.

A grape without seeds they make thus. They split lengthwise, as far as is fitting, the cutting [sarmentum] which they intend to plant, and with a tooth-pick [aurifcalpium] remove all the pith; then they lay down the cutting wrapped in moist paper. It will be more effective, however, if you set down the whole part of the cutting that is to be placed in the earth grafted into a squill: for the squill conduces both to taking root and to uniting. Others cut the fruit-bearing vines themselves, and with a tooth-pick [remove] the pith of the fruit-bearing cutting—

—as far as can be done, drawing it out from above through the cutting (which is not split, as was indicated, but left whole); and they pour in the sap of Cyrenaic juice [laser] dissolved in water, or often boiled to a thickness, and they tie the cuttings upright at the roots, so that, namely, the sap may not flow out; and then every eighth day they pour the same sap onto the cutting, until it puts forth a sprout. The same you may do with the pomegranate and the cherry, if indeed you wish the fruits of these also to be born without seeds and kernels. [Margin: The author's opinion concerning this kind of grafting.] And this is the practice of certain men who suppose that, the pith being removed, grapes and the other similar fruits can be generated without kernels. This opinion is an open imposture, since, the essential pith being removed, an essential part of the plant is destroyed, and so the whole must necessarily be destroyed; and what the juice of laser, being utterly disproportionate to generation, can give when infused into the pith, cannot be made out. I would therefore advise no one to waste his time on trifles of this kind.

But whether a medical or cathartic power can be induced by art into the fruits and flowers of plants, one might rightly doubt. I say that it can; and this is the method by which grafters proceed.

EXPERIMENT V.

To impart a medical power to plants.

[Margin: To induce a medical power into fruits.] Of the offshoot or shoot of a vine which they wish to plant, they split the lower part to the measure of three or four

fingers, and into the cleft of the very shoot they put theriacal water [aqua theriacalis]; then they plant the cleft part wrapped in paper. Those who wish to be reckoned more diligent in preparing this also pour the said water over the roots. A purgative power too they introduce into plants in the same way: into the cleft roots they put the juice of rhubarb [Reubarbarum], colocynth [Colocynthis], spurge [Tithymallus], scammony [Scammonea], the milky spurge [Cataputia mercurialis], and the like, and daily they water the earth surrounding them with the same; and in this way the alimentary moisture, imbued with the powers of the purgatives, imbues the fruit together with them. [Margin: To acquire the virtue of herbs from the soil.] Experience has taught this: that wine from a plot of ground stocked with similar herbs, or even with antimony, and the fruits of the vines — that is, the grapes and the wine drawn from them — are wont to purge wonderfully. It must be noted, however, that virtues of this kind introduced by art scarcely last beyond the course of a year, but rather, the virtue languishing with time, expires — the natural power of the plant driving it out, as illegitimate, from an improper possession — unless you repeat the artifice every year; and the same can be accomplished in the fig, peach, gourd, and the like.

Experiments on inducing Savour and Odour into fruits and flowers.

In like manner, if you wish that the Radish [Raphanus] should grow sweet, you must proceed thus. [Margin: Sweet radishes.] If you desire to have sweet radishes, [you must steep] the seeds—

[Resuming the right column of p. 388, which continues this radish recipe:] —in honey-wine [mulsum], or in the juice of raisins, or in water imbued with sugar, you should pre-macerate for two days, and, dried, commit to the earth; and you will have your aim: for the sweetening power of the sugar, drawn in together with the nourishment, is communicated to the fruits — yet it does not persist beyond a year, for the reason stated a little before.

[Margin: A leek of prodigious size.] If again you wish the Leek [Porrum] to grow to a prodigious size, do thus: if you pierce the head of the leek with a sharp reed, or with a fiery stylus, and conceal the seed of turnips or cucumbers in the hole, the head of the leek swells so much that it may seem a prodigy. [Margin: The reason.] The reason is that the cucumber-seed grafted into the leek is of itself and by its own nature most desirous of amplitude and dilation; hence it comes about that, placed into the leek, gradually swelling, while it exerts its powers, it extends along with itself the leek's moisture, with which it is mingled, to that magnitude which it is able to bear.

In like manner, that Lettuce [Lactuca] may become fragrant, one must proceed by this ingenious device.

EXPERIMENT VI.

[Margin: Fragrant lettuce.] Fragrant lettuces will spring up, if their seed be placed within a citron seed and so committed to the earth; which the same will also accomplish if the lettuce-seed be macerated for some days in fragrant water. The reason is the same as for the preceding. We read in Columella, Pliny, and others that Asparagus springs up in great abundance if the horns of wild rams, very finely bruised, be put into the furrows and watered. [Margin: Asparagus springs up from rams' horns.] If this is true, we can assign no other cause for it than that rams feed willingly on asparagus and pursue it most eagerly for food; whence it may come about that the seed-essence [seminium] of asparagus, latent in the food and raised into vapour, is found not unlike rams' horns — as I recall having often observed myself. [Margin: Asparagus presses out a ram's horn.] For if you twist asparagus, it will perfectly press out [the shape of] a ram's horn.

EXPERIMENT VII.

On Roses, from Porta.

[Margin: How to preserve flowers and fruits uncorrupted.] That Roses may be kept fresh up to a year. You will keep roses fresh in this way: Take wine and salt, as much as suffices, which pour into a pot; then fill it with the roses you wish to preserve (you must, however, gather the roses while still closed); stop the pot with a lid, and set it away in a cellar. When you wish to use them, take them out with the vessel uncovered, and expose them to the Sun or to a furnace, so that they may open; and you will have roses as beautiful and fragrant as if they had been freshly plucked. But we ourselves preserve uncorrupted not only Roses and flowers, but fruits of every kind. We prepare a round-bellied glass phial, fitted with a very long and wide neck, which we fill to the half with water, and within we place whatever flowers or fruits we please, so that they do not [touch?] one another—

Reading order used: = printed p. 389; = printed p. 390; = the engraved distillation plate (caption "Tomus 2di f. 391"); = blank verso of the plate. The pages run in natural sequence; printed page numbers and the catchword "Non" at the foot of p. 389 (matching the opening word of p. 390) confirm the order.

[Continued from the previous folio: the long-necked glass phial, with the fruits arranged] so that they do not touch one another. We then close the mouth of the

neck with a hermetic seal over a lamp-flame. By this means they will enjoy the perpetual gift of incorruption, as we demonstrate by experience in our Museum. We have likewise learned, by an experiment carried out over the course of a single year, that fresh eggs submerged in oil also remain forever uncorrupted.

Some think that roses become more fragrant if you plant garlic beside them, since those that grow languid from cold are usually quickened by heat.

[Margin: To make fruits more fragrant.] If you wish to make fruits sweeter and more fragrant, proceed as follows. The seeds or grains must be steeped for three days in mead, in ewe's milk, or in water in which you have dissolved sugar—a method the ancients held in esteem—and then set out in the sun; the fruit will take on greater sweetness. [Margin: Fragrant fruits.] If you seek fruits that are more fragrant, dissolve the seeds in oil of spikenard, in the juice or in distilled liquor of roses, [steeping them] in moss or in musk where you have moistened them a little; for once dried, you sow them. The fragrant fruits that arise will be steeped in the wonderful fragrance of that scent whose [essence] the seeds have absorbed. But if you crush the tips of the seeds, the fragrance will linger only a short time.

EXPERIMENT VIII.

To dye roses, gillyflowers [Caryophylli], or tulips in various colors in a short time.

Take as much of the richest soil as you wish, well dried in the sun until it can be reduced to the finest powder. Then set the gillyflowers, roses, or tulips, each in its proper season, into large earthenware pots filled with this soil. But take care that the soil be moistened with no water other than what follows.

[Margin: To dye the flower with color.] So, if you wish to make red flowers out of white ones, take as much finely chopped brazilwood [lignum Brasili] as will suffice, and boil it in water until a third or a fourth part is consumed; let the water turn red, and with it let the soil be moistened gradually twice a day, namely morning and evening. This must be done until the little plant begins to grow—that is, for fifteen or twenty days. If you want green flowers, take, instead of brazilwood, the ripe berries of buckthorn [spina cervina]; if yellow, the unripe berries of buckthorn; if black, oak-galls and vitriol [gallas & vitriolum]; and let these be boiled in the same water with which the soil, as already said, is watered.

But take care not to leave it out in the open at night, on account of the dew, which it readily absorbs. The flowers, however, are dyed with color not throughout, but partly with their natural color and partly with the color by which they are tinted,

so that they appear immersed in two or three colors, as one sees in "Turkish paper" [Charta Turcica, i.e. marbled paper]. And if you wish to dye them in three colors, in the morning let one part of the soil be moistened with water tinted with some color; in the evening, another part; and the next morning, again let yet another part of the soil be moistened with water tinted with some other color. Or else by another method, with this device: morning and evening let the soil be moistened with two colors, but in such a way that the place in the soil is varied—which will happen if you do not set the tinted water that was placed in the morning in the same spot in the evening, but in another. Thus the plant, together with its own color, will acquire three colors, from which many others can then be propagated. The reason for this is clear from what precedes.

But those who, in order to make red lilies, pour cinnabar [cinnabaris] within the bark should not hope for success in the operation, since cinnabar by its corrosive force destroys the lily sooner than it can imbue it with a red color. If, however, you smear it with some other, non-mineral color, the lilies will be produced of whatever color you wish.

[Margin: That apples may bear whatever image you please.]

EXPERIMENT IX.

Choose any impressed image you wish, in gypsum or in potter's clay, and—just as statuaries make the molds of a statue, which they call forms or matrices, destined for casting figures—cut it into two parts with a suitable instrument and with such care that the two can again be duly joined and fitted together. [Margin: How shapes may be induced in fruits.] Then bake the form in a potter's furnace. And when an apple, or a cucumber, or some similar swelling fruit has reached half of its growth, enclose it in these little molds and bind it firmly with strong ties, lest the clay molds, wrapped around it, be torn apart by the growth of the apple. As soon as it has filled their capacity, it will reproduce such figures of animals as you saw fit to counterfeit there in their bearing and image. This will have a place not only in shaping apples, but also in pears, quinces, peaches, citrons, pomegranates, oranges, and the rest of the kinds of fruit—but most of all in gourds.

That apples may be made sweet.

If you wish them to be made sweet, pour about the roots goat's dung dissolved in human urine, together with the lees of old wine.

That apples may be made red.

Let the tree be watered with urine, and the fruit will redden. [Margin: That apples may be made red.] Certain men, however, make the fruits of apple-trees ruddy in this way: they drive stakes into the ground, and tie to the stakes the curved branches that bear the fruit—without shaking it—and they fill ditches near the branches, or other vessels, with water, the calculation being made so that at midday the splendor of the Sun, falling into the water and sending back a warm vapor, and striking the fruit by refraction, may produce excellence of color and ruddiness. Some sow roses beneath the plants, and in this way make the fruits ruddy. But this too has been found to be false.

[Margin: There are, finally, those who think peaches and plums can be made to be born without stones, by grafting them in such a way.] [continuation:]...turned to its own juice from predominance.

They tell you: "You will procure a tender tree of two feet in height; you will split it down to the root, cut away, and with a knife scoop out the pith of each of the two parts; the separated parts you will at once bind together with a tie, and you will coat the upper part and the joins of the sides with dung, or with clay, or with wax, and protect them with moist paper; and when after a year the scar has firmly closed, you will see that everything has grown together." [Margin: That peaches and plums may be without stones.] Then you will graft into this tree shoots of willow, of chaste-tree [vitex], and of similar trees that bear no fruit, and it will bring forth fruits without stones—whether they be plums, cherries, peaches, medlars, dates, or stony cornel-berries. But these things are contrary to experience, for the reasons stated a little before.

The mulberry [Mora], however, if you wish to make it white, will attain that effect if the mulberry-tree is grafted into a white poplar, or budded onto it, and it will give white fruit; for as the poplar is most filled with sap, so it will [...] the sap of the mulberry naturally [...].

EXPERIMENT X.

Peaches, that they may grow to wondrous size.

To procure peaches of wondrous size for yourself, as well as almonds, nuts, and the like, you will take three or four kernels from those [fruits], and fit them together in such a way that they seem to constitute a single body. These, joined—and, if need be, tied—you will put into some vessel filled with earth worked with dung; you will plant and bury them, but in such a way that the vessel has a hole in its lid, through which the sprout of the kernels is forced to come out. Thus it

will come about that those kernels coalesce into a single tree, which in its season will yield and bring forth fruit of remarkable size and beauty.

There are those who put the kernels not into a vessel, but into a pipe or small tube packed with earth. But this will come to you much more easily and readily if you take care to procure those peaches that appear small and feeble; for in this way the nourishment that the weak fruits draw feebly is converted, to the great increase of the fruits, into the nutriment of the rest.

SECTIO IV.

DE ARTE STALACTICA

SIVE

DISTILLATORIA.

PRÆFATIO.

That the Art of Distillation is an imitator of Nature, which in her subterranean workshop or laboratory accomplishes all things by distillation.

If we look more deeply into the industry of operating Nature, we shall find that she carries out all things by means of distillation—not only within her subterranean womb, but also outside the earth in the sublunary Macrocosm, and even in Man himself, the Microcosm, and in the other animals. For the Geocosm has its inner laboratories and Vulcanian workshops, so filled with the panspermia of things, that whatever was said in the preceding Books up to this point seems to have drawn its origin from their sublimation. But since we have set these matters forth at various points in the course of this work, here it only remains to say in what manner the natural philosophers of keen wit—catching the scent of the hidden contrivances of Nature, which seemed to lie concealed in that manifold array of chemical vessels in her subterranean laboratories—attempted to imitate by art what they had learned from Nature their Mistress.

[Margin: The Subterranean World is nothing if not a distillatory furnace.] For they observed that manifold multitude of minerals and concreted juices, which the earth supplies to us from no other source than from the unequal sublimation of vapors—vapors which that Archeus Vulcan could produce from the pots and

cauldrons of the subterranean fire of Nature's furnace. For (as was shown at length in the first volume) the Subterranean World has its own chemical vessels: pots, cooking-pans, kettles, basins, and bellied receptacles, channels and siphons furnished with long necks, to which its small heads [capitella], alembics, cupels, and capped receptacles are applied by the wondrous ingenuity of Nature. Nor are these vessels lacking to it...

Diagram. A full-page engraved plate of distillation apparatus, captioned "Tomus 2di f. 391." [Tome 2, facing p. 391]. It comprises nine numbered distillation set-ups (n. 1 through n. 9), plus an unnumbered pair of funnels and a small head/alembic at the right. The figures illustrate the four modes of distillation named in the prose: by descent (*per descensum*), by inclination (*per inclinationem*), by ascent (*per ascensum*), and by the Sun's rays (*per radios Solis*). Reading the engraved labels:

- **Top right — n. 1:** captioned *Vas distillatorium per descensum* ("Distilling vessel by descent"). A cylindrical furnace-vessel with a retort-neck curving downward into a base; an I marks the lower receiving chamber.
- **Top center — n. 2:** captioned *Vas distillatorium per inclinationem* ("Distilling vessel by inclination"). A masonry furnace with a flaming alembic on top and a globular receiver set off to the right on a stand; a grate is shown at the firebox.
- **Top left — n. 3:** captioned *Vasa distillatoria per radios Solis* ("Distilling vessels by the Sun's rays"). A radiant sun-face at upper left directs rays onto two large globular flasks set on a slatted bench/table, with two further flasks beneath.
- **Middle left — n. 5:** captioned *Fornax balnei sicci ad aquas et olea per ascensum extrahenda opportuna* ("Furnace of a dry bath, suitable for drawing off waters and oils by ascent"). A masonry furnace with internal vessel; lettered labels at left, keyed in an adjacent legend:
 - **D.** *Vesica* ("the bladder/cucurbit")
 - **G.** *Alemb[icus]* ("Alembic")
 - **F.** *Collum* ("Neck")
 - **H.** *Refrigeratorium* ("Cooling vessel")
 - **C.** *Canalis per quem carbones ingeruntur supra locum foci* ("Channel through which coals are fed in above the hearth-place")
 - **A.** *Conisterium* ("ash-pit")
 - **nn.** *Spiracula* ("vent-holes")

- **Middle center (between n.5 and the legend) — lettered key for n. 4:** headed *OLXZ* and listing:
 - *Vas cup[ellatorium]: aqua plenum* ("Cupelling vessel: full of water")
 - **B.** *Cucurbita* ("Cucurbit")
 - **C.** *Porta per quam Lucerna imponitur* ("Door through which the lamp is set in")
 - **D.** *Lucerna quatuor elychniis [ellyphniis] instructa* ("Lamp fitted with four wicks")
 - **e.e.** *Spiracula* ("vent-holes")
 - **ff.** *Canales fumum exonerantes* ("Channels discharging the smoke")
- **Middle right — n. 4:** captioned *Vas distillatorium per ascensum* ("Distilling vessel by ascent"). A large bell-shaped furnace lettered **L, O, B, Z, A, X, e, c, C, D**; at its foot the note *Locus lucernæ* ("Place of the lamp"); at lower left, an engraved cross-potent within a circle enclosing the letter **I** — a deliberate device, not an alphabetic key.
- **Lower left — n. 7:** captioned *Fornax pro arena* ("Furnace for [a bath of] sand"). A masonry furnace with curved retort-neck; lettered **A, B, C, D, E, F, V, O, S, Q, G, H** and the key at bottom left:
 - **A.** *Cucurbita materiam distillandam continens* ("Cucurbit containing the matter to be distilled")
 - **B.** *Capitellum, Alembic* ("Small head, alembic")
 - **C.** *Rostrum* ("Beak/spout")
 - **D.** *Canalis per vas ligneum transiens* ("Channel passing through a wooden vessel")
 - **E.** *Vas aqua frigida plenum* ("Vessel full of cold water")
 - **F.** *Recipiens* ("Receiver")
 - **Q.V.** *Fornax* ("Furnace")
 - **G.** *Pyristerium* ("Fire-chamber")
 - **H.** *Conisterium* ("Ash-pit")
 - **S.O.** *Patella cineribus aut arena referta* ("Pan filled with ashes or sand")
- **Center bottom — n. 6:** captioned *Vas distillatorium per ascensum* ("Distilling vessel by ascent"). A two-bodied apparatus lettered **H, G, F, I, D**, with a key:
 - **D.** *Vesica cuprea quæ materiam distillandam continet* ("Copper bladder which contains the matter to be distilled")
 - **F.** *Collum stanno obductum* ("Neck coated with tin")
 - **G.** *Alembicum* ("Alembic")

- **H.** *Vas aqua frigida plenum* ("Vessel full of cold water")
- **Right (unnumbered):** captioned *Infundibula* ("Funnels") above two funnel/flask shapes, and *Capitellum* ("Small head") below a small head-and-spout vessel.
- **Lower center — n. 9:** captioned *Vas distillatorium per descensum igne supraposito* ("Distilling vessel by descent, with fire set above"). A flaming brazier above a globular flask.
- **Lower right — n. 8:** captioned *Vas distillator[ium] per inclinationem* ("Distilling vessel by inclination"). A boxy furnace with a retort inclined into a receiver.

[The verso of the plate is blank.]

[Reading order used: = printed p. 391 (end of the Sectio IV Praefatio + opening of Caput I)]

vessels for receiving the vapors that have been condensed in the vaulted upper chambers, once they have dissolved and settled, so that they may take them up in the form either of water or of oil — as may be seen in the drippings of caverns, some of which distill pure water, some salt, others niter, alum, or vitriol. Nor are there lacking caverns that pour out oils, bitumens, and the other resinous materials — all of which surely come about only through the agency of chemical distillation, the very process that Nature follows in everything.

[Margin: The exterior face of the geocosm compared with the distillatory operations.]

Now, if we turn our eyes to Nature's external operation, we shall see that the whole meteorological region of the air is nothing other than the work of distillation. For what are lakes, rivers, seas, and even the outer substance of the earth itself, but a kind of receptacle filled with distillable moist material? As soon as this material has been struck by the burning heat of the Sun, it at once sublimates the rarefied moisture into vapors. These vaporous fumes, once they have entered the cold alembic of the higher air, are condensed there and resolved back into whatever they had been — whether that moisture was pure, or concreted, or charged with fiery exhalations.

[Margin: Man, the microcosm, the furnace of distillation.]

Who would deny that in man, the microcosm, the most perfect work of distillation is found? In him you can see as many chemical vessels as there are vital membranes. What else is the stomach but a kind of chemical cucurbit, in

which the food taken in — its moisture rarefied by the force of innate heat — at once seeks the cold alembic of the head and brain? There, resolved, it rushes out by whatever opening it finds, discharging itself through the mouth, nostrils, ears, and eyes. From there, descending, it lubricates the nerves, cartilages, tendons, and muscles by its moistening, so that they can produce movement, and thus preserves the whole body in its state of integrity.

But if the moist food has been imbued with the corrupt qualities of salts, sulphur, and mercury, then the moisture, raised into the brain and there resolved into salty, tartareous, sulphureous, and mercurial catarrhs, causes — should it fall upon the lungs — consumption [phthisis]; in the hands, gout of the hand [chiragra]; in the feet, gout of the foot [podagra]; in the knees, gout of the knee [gonatagra]; sciatica in the hips; and arthritis throughout the whole body. The sulphureous vapor, when resolved, kindles the blood and brings on fevers, producing every kind of disease that arises from heat. The mercurial moisture, when resolved, attacks chiefly the class of nerves; from this arise paralysis, apoplexy, and similar monstrous diseases.

[Margin: Nature the distiller.]

From all this it shines clearly that Nature, in everything, takes upon herself all the roles of a good distiller, and that consequently the stalactic, or distillatory, art has been drawn from nothing other than the workshops [ergasteria] of Nature, and was established by the chemical philosophers to her own exact rule and prototype.

[Margin: The worth of the distillatory art.]

Its excellence and dignity can scarcely be described in worthy enough terms — both because of the manifold benefit it brings to the human race, and because of the hidden secrets to which it grants us access. It is truly the unique key-bearer of Nature, by which the gate stands open to a perfect knowledge of natural things, to the constitutions of mixed bodies, and to their hidden principles — as we shall show in this brief treatise.

Since this is so, let us now at last proceed, under favorable auspices, to the subject we have proposed.

Caput I.

Definition and the manifold varieties of Distillation.

[Margin: What distillation is.]

Distillation, then, is nothing other than the resolution of the parts of a body into vapor by the force of heat — a resolution established by the chemists according to the prototype of Nature. When these parts meet the cold head of the alembic, they are raised there and, condensed, are converted into a liquid. For a vapor, once raised up into the cap or alembic, cannot be dissolved into a liquid unless it is first multiplied and packed together there by condensation. This condensation is at times so violent that the vessels must necessarily burst; and when this happens, such a great quantity of fumes pours out at once — as we have carefully observed — that it fills a whole house.

[Margin: The varied differences of the kinds of distillation.]

Distillation is, moreover, of many kinds, established by the chemists according to the prototype of Nature, and we subdivide it in this way. One distillation is partly by fire, partly by earth, upward. Another is by fire, earth, air, and water, downward. Another is by inclination, through fire, air, water, and earth. Another is by the reflected rays of the Sun and other sources of heat. There are therefore three genera of distillations, according to the distinctions of the natural motions — upward, downward, and laterally; and each of these distinctions is in turn divided into four, according to the number of the elements; and in this way — in this way the twelve varieties of distillation arise.

[Margin: Distillation by fire.]

Distillation by fire is set up when the humors or spirits residing more deeply within the earthy parts are sublimed by the great force of fire, in order to extract both oils and waters. The figure of its furnace is marked with the Number 7.

[Margin: By earth, sand, ashes, dung.]

Ascending distillation by earth — or what is the same thing, by sand, ashes, lees, or dung — is set up when the finer parts we are seeking do not cling so stubbornly to the material being distilled; as at Number 5.

[Margin: Distillation by water.]

Distillation by water is properly carried out by a bath [balneum] — what they call the bath "of Mary," or "of the Sea," or "of dew" [Mariae, seu Maris, aut roris] — and it is set up in countless ways: Number 4, 5.

[Margin: Distillation by air.]

Distillation by air is properly carried out by a vapor-bath, that is, by vapor of water rarefied by heat.

[Margin: Distillation by descent.]

Distillation by descent is in turn set up either directly by fire, or by water, or by earth — that is, by ashes, lees, or dung — as may be seen in vessels 9.

[Margin: By inclination.]

Distillation by inclination is so called when distillation is set up sideways, by a middle route, by means of what they call a retort — as appears in vessels 2 and 5.

Countless other vessels are everywhere in use; I set down those that we commonly use in the pharmacy [pharmacopoeum] of the Roman College. But having now dealt with these common ones, let us proceed in the same way to describe the furnaces that they call philosophical.

Furnaces and Instruments, or the Philosophical (Hermetic) vessels.

[Margin: What a philosophical furnace is.]

A furnace is properly called philosophical when, by its ingenious structure made after the model of Nature, it brings a mixed body to the highest perfection and resolves it, by a certain marvelous skill, into its elementary parts — or also when (as others hold) by a manifold repeated distillation, which they call cohobation, it completes the philosophical contrivance [technasma] all at once.

Description of the Philosophical, or Spagyric, Furnace of the Roman College of the Society of JESUS, which is called the vapor-bath.

[Margin (Greek labels keyed to the figure): Κωνιστήριον; πυριστήριον.]

This furnace consists of six principal parts. The lower part, marked with the letter H, is the Conisterium [Κωνιστήριον, "ash-chamber"], and represents the place of the ashes. The second part presents the Pyristerion [πυριστήριον, "fire-place"], that is, the place of the hearth. The third presents the inner seat of the kettle [Cacabus], extended to the breadth B C. The fourth, the outer one, L M B C, contains a copper cupola fitted with 66 alembics. The fifth is the copper vessel A, set upon the cupola, which serves for calcining horns and bones. The sixth is the Register [Registrum], placed at the back, which serves to give the fire a determined degree of heat.

The alembics are filled individually, either with different herbs, or all and each with one and the same material — both to avoid the tedium of evacuating the water at different times, and because, just as the different species of herbs possess different qualities and degrees, so too their distillation cannot be completed in one and the same time by one and the same degree of heat.

Those about to begin the work therefore first fill the kettle [cacabus] through the stopcock [epistomium] with running water; then they furnish the pyristerion with live fire. The water of the kettle, feeling the fire, at once boils and fills the hollow of the cupola with vapors; from their effervescence the cucurbits likewise grow hot, and the herbs that they hold within their bellies are resolved into vapors. These, raised into the little caps of the alembics, are there condensed by the encounter with the surrounding cold air, and, resolved, flow down through a nose-shaped siphon [syphon] into the receiving vessels — in such quantity that within the space of a natural day they gather a hundred pounds and more of distilled water.

[Margin: How the bones, horn, etc., are calcined in this furnace.]

In the copper vessel marked with the letter A, by a truly remarkable mastery, they place the things they wish to be calcined — bones of every kind from horns, bones, and teeth: stag's horn, ivory, whatever pleases them — for calcining in a little basket woven of iron wire; and in this way they leave them suspended within the vessel on a little net. From this it comes about that the hot vapor, penetrating through the narrows of the said vessel, not only confers upon them a most brilliant white color, but in time also renders them so friable that by the pressure of the fingers they can be reduced to powders without any trouble. And this method of calcining bones and horns is truly the most beautiful and easiest. For those who are accustomed to calcine in this way by fire lose much of the inherent virtue, since the vehemence of the fire makes it evaporate; and besides, they easily acquire a burnt smell [ἄπόπνευσίς] from the fire — which, as it is harmful, must be avoided by every means. All these harms are removed by the bath alone, by the benefit of the vapor.

[Margin: The equalizing register of heat.]

It now remains to explain the register, for giving to each plant the distillation-heats proportioned to it. For since not all plants require the same degree of heat — because some are of easier, some of more difficult resolution, as we said a little earlier — the register has therefore been set up at whatever degree you wish, so that, by pushing the register in or back, the force of the internal heat is either

increased or relaxed. It is truly a beautiful invention, expressing as it were a type [Greek: ἐν τῷ τύπῳ (en tō typō, "in the type / model")] of Nature's subterranean furnace.

[Margin: Etna a furnace.]

I myself have observed the truly marvelous nature of many mountains, and among the rest of Etna. For in it you may find diverse springs and streams, of which some carry off saline, some nitrous, some aluminous, and some vitriolated water. Certain caverns too, in different places, distill naphtha, bitumen, and petroleum — which surely come from nowhere else than from the volcanic furnace; for in the subterranean cauldrons with which they are filled, the humors, raised through hidden channels and little conduits of the earth and resolved in the cold caverns of the mountains, evolve into those different waters and liquids. The figure of the furnace follows.

Diagram. A full-page engraved plate of the Spagyric (philosophical) vapor-bath furnace of the Roman College of the Society of Jesus. Engraved at the upper right: "Tomus II. f. 392."

The structure is a cylindrical masonry furnace (the drum). Its front face is open to show the fire-chamber. At the top a great dome-shaped copper cupola is densely packed with rows of bulbous alembics (cucurbit-and-cap pairs, each with a downward drip-spout), arranged in tiers — the engraver shows roughly forty to fifty visible (the text specifies 66). Surmounting the cupola at its apex is a small domed vessel (A) holding the bones/horns to be calcined. Below the dome, on the cylindrical drum, the fire burns on a grate within the open hearth; beneath the hearth is a square ash-pit opening at the base.

At the top of the plate, two engraved banners flank the central calcining vessel:

- Left banner: **FORNAX / COLL. ROMANI** ("Furnace of the Roman College")
- Right banner: **SPAGYRICA / SOC: JESU** ("Spagyric, of the Society of Jesus")

Above, in a decorative cartouche, an engraved verse-motto (two lines): "*Pratorum hic manant lachrymæ per vitra cadentes / Herbarum in tumulo, dum parit ignis Aquas.*" ("Here the tears of the meadows trickle down, falling through the glass vessels — over the tomb of the herbs, while the fire gives birth to Waters.")

Letter labels on the figure:

- A (apex, atop the cupola): the copper calcining vessel set on the cupola.
- M (upper left of the cupola): edge of the alembic-array / cupola.

- L (upper right of the cupola): edge of the alembic-array / cupola.
- C (lower left of the cupola rim): left limit of the cupola breadth.
- B (lower right of the cupola rim): right limit of the cupola breadth.
- E (upper left, within the fire-chamber opening): upper-left corner of the hearth opening.
- D (upper right, within the fire-chamber opening): upper-right corner of the hearth opening.
- F (center of the fire-chamber): the kettle/cacabus seat above the fire.
- G (in the flames): the grate (craticula) on which the fire is kindled — the pyristerion. Labeled in the engraving "Pyristerium."
- O (lower left of the hearth opening): lower-left corner of the hearth opening.
- N (lower right of the hearth opening): lower-right corner of the hearth opening.
- K (lower left of the drum base): left foot of the furnace drum.
- I (lower right of the drum base): right foot of the furnace drum.
- H (the square pit below the hearth): the ash-chamber, labeled in the engraving "Conisterium."

Engraved key panel at the foot of the plate (two columns):

Letters	Description
A L M / B C I K	Fornax distillatoria. (The distillation furnace.)
A	Vas in quo cornua et ossa Philosophico magisterio calcinantur. (The vessel in which horns and bones are calcined by the philosophical mastery.)
D E N O	Focus quo Lebes G calefit igne succenso. (The hearth, where the kettle G is heated by the kindled fire.)
L M B C	Alembicorum 72 distillatio, quæ vapore balnei stillant liquorem. (The distillation of 72 alembics, which distill liquid by the vapor of the bath.)
B C / I K	Murus seu Tympanum Fornacis. (The wall or drum of the furnace.)
G	Craticula supra quam ignis accenditur, et

Letters	Description
	dicitur pyristerium. Πυριστήριον. (The grate over which the fire is kindled, called the pyristerion.)
H	Locus est in quo cineres colliguntur et dicitur Κονισήριον [?] (engraver's irregular Greek for Κωνιστήριον), signatum litera. (The place in which the ashes are collected, called the conisterium, marked with the letter.)
A F	Canalis per quem fumus se exonerat. (The channel through which the smoke discharges itself.)

Reading order used: The text folios run in printed-page sequence — fol. 393, then fol. 394 — followed by the engraved plate keyed to fol. 394 and its blank verso. Catchwords confirm the order: fol. 393 ends with the catchword "quod," picked up at the head of fol. 394; fol. 394 ends with the catchword "His." [Plate caption: *Tomus 2 die fol. 394* — i.e., the plate belongs at fol. 394 of the second volume.]

Vessel II: a philosophical distillation apparatus, by which the quintessences are extracted from plants and liquids.

The chemists, in order to bring their liquids to the highest degree of subtlety, hold that this must be achieved by what they call repeated *cohobation*. Here I shall teach the construction of certain vessels by whose aid you may accomplish in one and the same operation what the distillers do, with so much labor and expense, through five, six, or seven sublimations.

[Margin: A newly devised distillation apparatus for sublimating liquids.]

The furnace A B, divided into two parts, is called *Althanor* by the chemists — a word which in the Arabic tongue means, by way of excellence, "the Furnace": الطَّنُور [Arabic: al-ṭannūr, "the oven, furnace"]. On this, see what I have set out more fully in Book XI.

The device C serves to sublime liquids by means of a reflected ray of the Sun. I have given a better method of constructing this elsewhere, so let us proceed to the other vessels.

Let six glass vessels, or alembics, be made under a proportional diminution [i.e., each smaller than the last], together with their beaks and the receivers fixed to each beak, as Figure D shows. This done, let the first vessel be filled with the liquid you have decided to sublime, and set above the small furnace X, surrounded with ashes or sand. Once this too is arranged, the liquid placed in the first vessel, raised into vapor, will be somewhat resolved in the second vessel and descend into receiver A. The vapor, carried further, will be resolved in the third vessel and descend into receptacle B; carried still higher, it will be resolved in the fourth vessel and descend into receiver C. In this fashion it is raised up to the last vessel, marked with the number 6, where, having slipped down into receptacle D, it attains the final term of its subtlety and perfection. This you will then collect separately and store in a crystal vessel, very tightly sealed. Here you see that in each successive vessel the resolved vapor is always found, as if by certain degrees, purer and purer in the receivers — until in the last vessel, 6, the liquid, freed from all dregs, acquires a kind of celestial subtlety.

This technique we have learned from the works of Nature; for experience teaches that the higher earthly vapors ascend, the subtler they always become, until — borne up into the highest region of the air — they degenerate into some other substance. The same thing, and indeed far more perfectly, is taught by the following device.

[Margin: A second philosophical device for purifying liquids and bringing them to the ultimate degree.]

Let glass vessels be made in the manner that Figure E shows. First two retorts, which I have marked with the numbers 2 and 9; into both of these let there be inserted the channel marked with the number 3, furnished in its lower part with five small channels [canaliculi], to which correspond just as many receivers marked with the numbers 4, 5, 6, 7, 8. Into the retort marked number 2 place the liquid to be distilled and subtilized. This done, the joints of both retort 2 and of the receiving vessels with their little channels having been bound and luted together so that nothing may exhale — only retort 9 being left free of lute, so that it does not impede the progress of the vapor — let this whole apparatus, firmly fitted together, be set up: on one side, with its retort 2, place it above the small furnace 1, and the other side above the support 10. When the fire is lit, the liquid, gently raised into vapor, is first resolved within receptacle 4; then, carried further, within receiver 5; and so on in turn up to the final degree of perfection, within retort 9, into which it will work its way. In this manner, with a single instrument and without labor or expense, you will attain your end. But if you

have a mind to bring to the ultimate purity those liquids collected in the five receivers which have not yet attained their due purity, gather them together and pour them once more into retort 2, and continue the operation as before.

[Margin: A third device.]

The third device, marked with the letter F, serves for substances of more difficult dissolution. Let there be made a glass vessel N, fitted with two little channels G P on its side and one, L, in its belly. To the lateral channels are set opposite two retorts: the one marked with the letter O, filled with the material to be sublimated, is set above the furnace P, strewn with ashes; the other, M, is set above the support L. Into the lower channel let there be inserted a bladder [vesica] R; and the joints having been bound together, fire is applied beneath the furnace P. The sublimated portion of the more stubborn material, resolved first, will discharge itself by descent into the bladder R, while the subtler and purer portion will work its way into the vessel M.

[Margin: Circulatory vessels.]

There now follow the *pericyclic* or circulatory vessels, of which there is great use in chemistry, because no magistry, no elixir, nor *aqua vitae* can attain its highest degree of perfection without them. Their working consists in this: that in them, by a gentle and mild heat, the raised vapor continually goes round in a circle; and from the continuation of this circulation the liquid is exalted to such subtlety that it puts on a kind of celestial nature. But the circulation of the liquid differs from the foregoing sublimation in this, that this circulation must be continued for at least four months, to be accomplished by a fire of ashes, or sand, or dung; whereas the former [sublimation] is for the most part completed in one natural day. The figures G, H, I, K, L, M, N, O exhibit the shape of such vessels. Of these, the first, G, sublimates liquids by the heat of a bath of water [*balneum maris*, water-bath]; H by the heat of pressed grape-skins [*vinacea*]; I by the heat of ashes; K by dung; L by the heat of vapor; M by the heat of sand; N, finally, either by the heat of dung, or of sand, or of ashes. For a modest fire — of a lamp, or of coals placed in the furnaces — warms the sand, dung, and ashes always with the same tempered heat; and just so the liquids, exalted in the circulatory vessels, ascend through one arm and return through the other, whence they always shed off something impure, until, the circulation of many days being completed, nature refuses to purify them any further. But the circulatory vessel most used by the chemists is the one

which you see expressed first in the figure marked with the letter O, and then in the figures marked with the letters M and L. The remaining vessels G, H, I, K, being without arms, are called "blind" [*caeca*], even though they accomplish circulation; the true method of circulation, however, is achieved by those handled [arm-fitted] vessels of which we spoke a little before.

RULES to be observed in the Stalactic Art.

[Margin: The quality of the chemists' vessels.]

1. Let no vessels of this kind be made of lead, since by their malignant quality they infect the humors — so that water even drawn through leaden channels does not yield springs as wholesome as those made of wood or baked earth. Yet it is a remarkable thing that sour liquids [vinegar], distilled through leaden channels, grow sweet.

[Margin: Sour liquids grow sweet when drawn off through leaden channels.]

Neither are substances to be distilled to be placed in iron vessels, since they are corroded by the moisture; nor are copper vessels to be used in the distillation of minerals and salts, because they dissolve the vessels into verdigris. Hence, in magisteries, extracts, quintessences, and similar works of the subtler art, only those attentive to glass vessels achieve what they seek in chemistry.

[Margin: Precautions in distillation.]

2. In distilling spirituous materials, let the glass vessels be long — at least two cubits — for the taller they are, the better the effect they obtain, so that such vessels accomplish more than the rectification carried out with low vessels (which, however, are suitable for extracting oil, wax, and other fixed substances).

3. In every distillation the vessels are not to be filled too full; you will work more safely if you fill cucurbits to a quarter, retorts to a half, and the brass bladder to three parts with the material to be distilled. Flatulent substances — such as wax, resin, and those that easily boil over — should be put in smaller quantity into very large vessels; and since such things do not easily ascend, in order to repress the flatulence and the dislocation of the parts, the desired effect will be obtained by adding sand, bole, brick-flour, calcined pumice, clay, or the like.

4. Distillation by water-bath [*balneum*] is properly suited to things of lighter composition, such as those of a temperate complexion. In things extremely hot, however — such as wormwood and rosemary and the like — you will avoid too much heat, lest you extract not so much the essence as the useless phlegm.

5. Distillation by ashes or sand is properly suited to things of more solid substance, such as seeds, woods, roots. By the bladder, not only thin substances but also others of firmer texture will be dissolved — provided, however, that they have first been macerated in their appropriate menstruum or water; the reason being that by maceration the materials are prepared for easier extraction.

6. Distillation by retort elicits not only the heavier spirits from minerals, but also waters and oils from thinner substances — such as woods, seeds, roots, gums, resins; the reason being that retorts, by their lateral inclination, more easily draw out the more stubborn liquids than [is done] by straight ascent.

7. Herbs dried by any method whatever should not be distilled unless first sprinkled with water, or May-dew, or wine, if the distillation is set up in a brass bladder; there must be added at least two or three pounds of water to each pound: the reason being that there is greater danger of the herbs being scorched in the bladder than in the glass vessels of the bath.

8. By the bladder too a more intense degree of heat can be applied; whence from any plant-parts whatever not only water but also oils are extracted.

[Margin: A remarkable account occurring in the distillation of acids.]

9. The distillation of acids, such as of vinegar and of salts, has this peculiarity: that the baser part always comes out first, the nobler last. The reason is that vinegar by nature has much fixed salt; and although it draws its origin from wine — so that it may not unfitly be called "the corpse of wine" — yet in distillation it behaves the opposite way. For just as in vinegar the baser part comes out first and the nobler last, so, by contrast, in wine the more precious water comes out first and the baser phlegm last. For in wine there is much volatile salt, and so it is of easier dissolution; but in vinegar there is much fixed salt, in which the spirit of wine chiefly nests. Hence it is necessary that the nobler liquid come out last.

[Margin: The luting of vessels.]

10. In coating chemical vessels with lute, singular care must be taken. In constructing furnaces first: fat earth mixed with sand, horse-dung, and salt water is very suitable, because lute mixed with sand gives body; horse-dung, by the manifold intermixture of its fibers, holds it together so it does not crack; and the salt water hardens and consolidates the whole mass. For luting retorts, potter's clay, horse-dung, the powder of crushed bricks, iron filings — all mixed together and worked up with water — is of the greatest help.

[Margin: The lute of wisdom.]

The lute they call "of wisdom" [*lutum sapientiae*] is made from quicklime and egg-white reduced to a liquid — which, however, must be applied at once, lest it dry out.

[Margin: How broken glass is glued together.]

For gluing together broken glass, let a glue be made from Armenian bole, minium, and ceruse in equal portions, which, reduced to a fine powder, are to be worked up with linseed oil or liquid varnish. But for casing an alembic with its receiver, melt wax, resin, and colophony in an earthen pot, mix in with a stick a modest quantity of olive oil, then pour cold over it and knead it again with your hands as well, and you will have a glue ready prepared.

[Margin: A remarkable method.]

But the retorts in which the distillation of sharp spirits is carried out require a lute of salt water, or even of bovine blood tempered together — joined with beasts' [draft animals'] hairs and a portion of *calcotar* [copperas/vitriol residue]; for this serves most of all for the retention of the spirits, that they may not exhale.

Diagram. A full-page engraved plate of distillation apparatus, keyed to the text of fol. 393–394. The upper-right caption reads "Tomus 2 die fol. 394." Twelve to fifteen distinct apparatus are arranged in roughly five rows; each is keyed to a capital or lowercase letter or numeral matching the letters discussed in the text (A–O). The plate is well inked on the recto; the verso is blank apart from offset show-through.

- **C** (top left): a single alembic on an ornate scrolled pedestal, with a flask/cucurbit below and its head directed toward a mirror or burning-glass panel at upper left, above which is engraved a radiant Sun-face. This is the device that "sublimates liquids by a reflected ray of the Sun."
- **B** (top center): a low circular furnace-table seen from above, its top bearing a grid/lattice and small flasks; tubing runs from it across to the right toward apparatus A. The furnace is shown with arched stoke-holes around its base.
- **A** (top right): the two-part *Althamor* furnace, a battlemented circular structure with arched openings around the base and several flasks/towers rising from the top.
- **F** (second row, left): the third device. A central round-bellied glass vessel **R** flanked by two retorts; labels read **P**, **G** across the top, **o** at far left, **L** and **M** on the body, with **R** on the central vessel. Two furnace-bases support the assembly. (Some small peripheral letters are faint — see review note.)

- **E** (second row, center): the second philosophical device — an arched train of vessels. Two retorts at the ends marked **9** (left) and **2** (right); a row of five pendant receivers hangs from the central arched channel, labeled **8 7 6 5 4** (left → right), with **3** marking the crown of the arch; furnace-base **1** at right and support **10** at left.
- **D** (second row, right): the first apparatus — six alembics of diminishing size mounted in a stepped/inclined row over a tall furnace, with receivers attached. Lowercase labels **d, c, a** (top → bottom) run down the left side, and the stepped alembic bodies are numbered **5 4 3 2 1** descending, with **1** seated at the foot on the furnace mouth; the small "+"-like marks beside the upper alembics are the beaks/receiver-spout junctions rather than letters.
- **I** (third row, left): three arm-less ("blind") circulatory flasks set in a wooden tub, labeled **I**.
- **H** (third row, center): a single tall circulatory flask standing in a wooden barrel/tub, labeled **H** (the barrel for the grape-skin / *vinacea* heat).
- **G** (third row, right): a pair of circulatory flasks on a square pedestal-base with a paneled front; labeled **G**, with a small hanging vessel/lamp above. (The water-bath, *balneum maris*.)
- **M** (fourth row, left): an arm-fitted ("handled") circulatory apparatus on an ornate square pedestal with paneled, inset sides; top labels **c** and **b** flank a small finialed vessel; the body is labeled **M**.
- **L** (fourth row, center): a cabinet/cupboard with open doors revealing several circulatory flasks ranged on shelves within, flanked by two furnace-bases at the foot; labeled **L** (the vapor-heat enclosure).
- **K** (fourth row, right): three arm-less circulatory flasks set in a wooden tub, labeled **K** (dung-heat).
- **O** (bottom left): an arm-fitted circulatory vessel on a square paneled pedestal, shown emitting vapor/flames from two side vents; labeled **O**. This is the form "most used by the chemists."
- **N** (bottom right): a furnace of brick courses surmounted by a cluster of pendant gourd-shaped vessels, with a retort and round vessel attached at the right side; labeled **N** [?] (the multi-mode vessel — dung, sand, or ashes).

ARS DISTILLATORIA [The Art of Distillation]

Now that these matters have been set out, certain points of great importance in chemical work remain to be explained. These are the chemical operations, which, although I treated them very fully in Book II, I have nonetheless decided to

explain here more amply as well — as I promised there — this being the suitable place. They are chiefly **Digestion, Putrefaction, Circulation, and Fermentation**, without an accurate knowledge of which nothing exact can be accomplished in chemical operations.

On the Kinds of Digestion, and on Putrefaction, Circulation, and Fermentation.

§ I. — DIGESTION.

[Margin: What digestion is.]

Digestion is a simple ripening, by which substances that are not yet fully prepared are worked up in a digestive heat — much as the stomach, by its own moderate warmth, digests the raw foods it has taken in and, by concocting them, transforms them into chyle. The purpose is that, once the dregs have been set aside, an attraction of the more benign and purer substance may be made by the liver out of what remains. In the same way digestion separates the fine from the coarse, cuts up and thins out what is thick, cooks what is raw, and softens and sweetens what is harsh — so working over everything that from what has been digested an ever more abundant harvest of essence may be hoped for.

This is how digestion is carried out. Let the vessel containing the materials to be digested be placed in a digesting furnace of suitable warmth, whether the heat be ash, or sand, or dung, or iron filings; it makes no difference. Let it be left there until the intended end, which varies according to the manifold use of digestion. For example:

[Margin: The way to proceed in digestion.]

Fresh herbs, moist with their own juice, are macerated for three days; herbs dried out and sprinkled with wine, for seven days; seeds and aromatics, for a two-month span; dry roots, for a month; minerals, for a Philosophical month, that is, forty days. Some things are macerated twice, sprinkled with Greek wine — as are the aromatics, which, once moistened, are digested until dry, then shortly afterward are pounded, sprinkled afresh, and macerated again.

§ II. — PUTREFACTION.

Putrefaction is the digestion and dissolution of a concrete body through a natural rotting, in a moist heat that corrupts the very substance and opens up its innermost parts — so that, just as digestion regards the generation of a

compound, so putrefaction regards its corruption. It is called *natural* rotting because, although properly a native heat resides in all things to be putrefied, that heat can be roused only by an external heat. For thus the native heat, made more robust,

[Margin: The rationale of putrefaction.]

[The column continues at the head of the right-hand column of the same page:]

brings about the dissolution of all the parts; and finally, when the adjacent moisture comes to exceed the dry body, it completes the putrefaction by continued degrees. For it is known that every material to be putrefied abounds in moisture, and hence — the external heat cooperating — it is necessary that it should overcome the dry; from which the innate heat, together with its own substantial moisture, is separated from the mixed bodies and, preserving its own homogeneous nature, stands apart by itself. Once these things have been accomplished, the separation is afterward more easily completed by the Spagyric [Spagyric, i.e. alchemical] art.

Now although all putrefaction consists in the separation of the internal moisture implanted in the things themselves, yet because this cannot act unless it is urged on by an external agent, it has been necessary for it to have a ζύμη [Greek: *zymē*, "leaven" — i.e. a ferment] or vehicle — or, as they call it, a *menstruum*, named from the *month* (*mensis*) of its putrefaction. And this is the moisture of each particular thing, whether its own or analogous to it — as the water poured over it, so that by its excess it may take away the dryness of the mixed body, may bear off the mixture, may draw to itself the emerging essence, and may keep that essence whole and uncorrupted right up to the extraction. And lest the heat with its moisture should expire, the vessel must be sealed hermetically and afterward placed in a horse's belly — that is, in dung, or ashes, or sand, or the like — for the predetermined time.

In the putrefaction of herbs and flowers, to elicit oil, some add salt or vitriol, alum or tartar. The reason for this is that, with these added, putrefaction is completed more quickly because of the sharpness of the salts, by which the more stubborn parts of the mixture are dissolved; and the mixing, furnished with these aids of [the salts], is also accomplished more quickly, and the material is thereby protected from foul and harmful putrefaction.

[Margin: The effect of putrefaction.]

It is the property of putrefaction to change the savors, odors, and colors, and, having destroyed their old nature, to produce a new one. But what the proximate causes of this kind of transformation may be is taught a little later, in the material on fermentation.

§ III. — CIRCULATION.

Chemical circulation is nothing else than the conversion and exaltation, into a more excellent degree, of a liquor that has already been purified — as far as is possible — from its elementary refuse, this being accomplished through various windings about and rotations in the Pelican, or in the *dyota*, into that more excellent grade.

[Margin: How circulation is carried out.]

There are, moreover, various circulatory or hermetic vessels of this kind, which you may see marked in the Schematism with the letters L, M, O. In L, indeed, [is shown] the middle δυοβάρχιον [Greek: dyobarchion — a two-necked circulatory vessel] [?]; likewise in figure M [are shown] vessels marked with the letters b, a, c, whose function is supplied by the vessels called *blind alembics* (*alembica caeca*), of the kind seen in figures G, H, I, K, N, L. These must be hermetically sealed — that is, at the lamp, by the art known to glassworkers. And the Chemists, under a certain riddle, see vessels of this kind now twisting themselves up into heaven and returning to earth by a circuit. Hence, if a liquor of this kind

is in this way circulated, it at last — having shed all its dregs and impurities — takes on a kind of celestial nature, almost devoid of the qualities of the elements, as the Chemists put it. In this way is made that celestial elixir which Lull [Ramon Llull] calls *heaven*, on which see at length in Book III of his *Art of Magnetism* [*Ars Magnetis*] [recte: this attribution to Llull's work; the text reads "in Libro III. Art. Magnet."]; consult the matter there.

[Margin: A new apparatus invented by the author.]

We have devised another instrument far more excellent than those just mentioned, by which circulation is achieved not only with greater excellence, but is also completed in a shorter time. It is a glass machine, constructed — by the device you see below — through the courses of helical lines, where you should note that the vapor, ascending through the helices on either side, rises to the head A, and from there returns into the belly V.

Diagram. A glass circulatory vessel ("Figura I"). The central body is a rounded flask (the *venter* or belly) with a short neck rising to a small head at the top. From

the two sides of the vessel rise tall, ornate spiral (helical) tubes that curl over symmetrically toward the top, so that vapor ascending through the helices on each side reaches the head and returns into the belly.

- A (top, at the head/neck of the vessel): the head, to which the ascending vapor rises
- V (body of the vessel): the *venter* (belly), into which the condensed liquor returns

It can scarcely be told how great and in how short a time the work of circulation is completed. For, ascending through the helices, in each coil [the liquor] acquires some degree of purer nature: while what is subtle is repeatedly driven upward, the coarser portions of the moisture fall back from one coil into another and again into the belly; and finally the most subtle part, having glided down into the head A and been dissolved by the cold, is again committed to the belly to be circulated. In this way, within eight days, you will accomplish the same — and indeed far more excellently — than what the Chemists have not managed in a space of forty days with the aforesaid hermetic vessels: a truly enormous saving in circulation.

Circulation will obtain a still better effect in Figure II,

Diagram. A glass circulatory apparatus ("Figura II"), a double vessel. Below is a large rounded flask (the *venter*, marked T). Set upon its mouth is a smaller funnel-shaped cup or little vessel (the *vasculum* O, marked S at its top opening). From the two sides of the apparatus rise long, wavy (serpentine/helical) tubes that arch over symmetrically toward the top. The purified liquor does not fall back into the belly T but is collected within the little vessel O set above T.

- S (top, the opening of the upper little vessel): the mouth/opening of the *vasculum* O
- T (lower large flask): the *venter* (belly), the main vessel

where the purified liquor does not fall into the belly of vessel T, but within the little vessel O, set above vessel T. The procedure is as follows.

[Margin: Description of the machine.]

The liquor to be exalted is enclosed in this helical vessel [ἑλικοειδῆ, Greek: *helikoeidē*, "helix-shaped"] — or also in the other circulatory vessels — leaving the vessels empty up to three-quarters [*ad ¾*]; and in this way the hermetically [sealed] vessel is placed in dung or in a bath up to the height of the liquor that is to be thinned, so that a small part of the vessel stands out, cooler, in the air. The

purpose is that by the heat of the dung and of the sides the thinning of the liquor takes place, while by the coldness of the top there is condensation; and the said vessel is kept in a moderate and continuous heat until the artist has attained his end, with the dregs settling at the bottom of the vessel. And let this suffice concerning Circulation. Let us now proceed to Fermentation.

§ IV. — On FERMENTATION, the Cause of the generation and corruption of all things.

Fermentation, in this place, is nothing else than a certain internal motion of the particles or principles of any body existing in the threefold kingdom of Nature; and it is the same as a certain effervescing or fermenting of matter disposed for generation — as Thomas Willis [Thomas Willis] rightly teaches — by which Nature aims at a change into something else, since there is a tendency toward the perfection of some compound.

[Margin: How fermentation comes about.]

Fermentation occurs in this manner: the elementary particles — saline-sulphureous-mercurial — either spontaneously by nature or occasionally being roused into motion, marvelously agitate one another; and, set in motion by a reciprocal motion, they draw one another apart and entangle one another. The subtle and active ones strive to fly off, but are held back, entangled by the coarser ones; the coarser ones, however, always resist, until — subdued, thinned out, and raised to exaltation by the more subtle ones — they either acquire the due perfection or complete the alterations assigned by nature.

It is also called a *swelling*, which arises in a natural body from the spermatic particles of that body when variously agitated; for, stirred up by heat, whether external or internal, they excite wondrous tumults. All things are full of fermentations, and in this way, the pure being separated from the impure, the mixture attains its own perfection. Now apt for fermentation are all heterogeneous bodies: thin and thick, liquid and solid, animate and inanimate, natural and artificial. In heterogeneous mixtures the corpuscles are highly spirituous, agile, and volatile, and are of two kinds — as I have said elsewhere — volatile and fixed; the fixed so contain the volatile that they do not entirely fly off, as is evident in spirit of wine and in distilled waters, in which the burning spirits, oils, and fixed salts persist by [their] implanting. But the juice and blood of vegetables and animals, and all concrete fluids, and the various compounds of mixed bodies, quickly ferment and undergo various turns of change. The experiments of this are as follows.

EXPERIMENTS.

[Margin: 1st Experiment.]

Spirit of wine enclosed in a phial gives no signs of effervescence; but if you add to it a little oil of turpentine,

the particles of the liquor are so agitated that it bursts the phial itself, especially when it has been tightly closed. The reason is that the sulphureous corpuscles of the oil of turpentine, poured over the corpuscles of the spirit of wine — which have obtained a contrary nature — at once effervesce with violent agitation; and from this the rarefied liquor, when it finds no room, seeks room for itself by bursting the vessel.

[Margin: 2nd Experiment.]

Again, distilled water of any herb whatever is kept a long time in a closed phial; but if you add to it some sugar or syrup, it will at once turn sour and be corrupted. The reason is that the saline corpuscles, as soon as they have been joined with the saline corpuscles latent in the distilled water, being subdued into their own nature and the sweetness laid aside, are converted into a sour liquor — as Thomas Willis finely teaches in his little book *On Fermentation* [*De Fermentatione*].

[Margin: Requirements for fermentation.]

Concerning artificial fermentation, the following must be noted. First, there must be a looseness and disjunction of the parts, with a tendency toward perfection; for otherwise the fermentative particles cannot expand and be moved from place to place. This is why in things compact, harder, viscous, and boiled down to thickness, or dried out by evaporation, fermentation does not succeed. But liquids easily swell with their juices; next to these are things that, though soft, are nonetheless endowed with a thicker consistency — as bread, and all effervescing things and medical compounds are. Second, there must be a heterogeneity of the parts, or a mingling together of all the principles at once — namely, that some particles drive out, dislodge, and stir others into motion. For simpler bodies, such as water, on account of the likeness of their homogeneous particles, are unfit for fermenting; whereas in dissimilar mixtures of bodies, from the ambition for predominance, strife and discord at once arise, whereby some provoke others into motion. Third, in bodies to be fermented there must not be too great a rawness of the parts, since in that case the active and subtle particles are not easily torn away from the coarser ones, nor are they released into motion. This is

evident in those juices that are pressed out of unripe fruits; for in these the particles, too volatile, are not held by the bond of mixture, but fly off at once, evaporated, and dispose the substrate to rottenness — as is known from over-ripe fruits. Blood too, once shed outside the vessels, milk, and meal do not ferment, but quickly undergo rottenness.

[Margin: Whence the stench.]

From this it is clear how corruption is brought upon things. For, as the spirit abounds and there is a supply of sulphur and salt, the particles, loosed from their bonds, at once break out; and so thereupon the mixture putrefies with a stench, even though it consists of a dense mass. For the stench proceeds from the exhalation of sulphur with sharp salt; rottenness follows because the external moisture enters in place of the particles flying off; and heat is produced by the sulphureous particles or corpuscles at once set in motion and shut up within the subject, so that they may gather together at once and act more strongly in unison. But if in the subject there is a smaller proportion of salt and sulphur — so that, when the mixture is dissolved, the particles are stirred more sluggishly and gradually evaporate without notable stench, rottenness, or heat — then the body dries up and falls into decay.

All things, therefore, are full of fermentation — not only in the disparate bodies of minerals, vegetables, and animals, but the whole sublunary world seems as it were one mass set up and pregnant with fermentative corpuscles throughout, which are perpetually engaged in motion and agitation. They flit hither and thither (as I also said above concerning the seeds of things), now snatched upward, now downward; they variously meet one another, associate, and again depart; in a continual alternation they now enter into diverse unions, now suffer separations, on which the origin and decay of things depend. For these [corpuscles] are not only in the Subterranean World, where they properly hold sway, but also in the Ocean and all lakes, rivers, springs, and ditches — indeed, through the whole Atmosphere they are spread out in a dense throng — just as I also said above concerning the seeds of things, which are indeed nothing else than certain fermentative corpuscles cut off from elsewhere, whether from the vegetable or the sensitive nature, agitated with a view to generation, until they attain the end intended by Nature.

[Margin: The opinion of Democritus concerning the corpuscles that constitute all things is refuted.]

But in asserting these things, I would not have anyone persuade himself that I here hold the opinion of Democritus [Democritus] concerning atoms — from which I have always been averse, as will be abundantly clear to the reader from various places in my works. For it is impossible to frame a true norm of physical science out of the polymorphous corpuscles of the Democriteans, from which he taught that all things consist, since they are repugnant to the senses and are nothing else than the idle figments of ill-occupied men. Something different must be determined concerning our particles or corpuscles, for these the Spagyric art makes manifest in the very dissolution of bodies, so that it cannot be denied — what is so obvious to the senses. There is added, too, the Microscope [*Smicroscopium*], by whose aid alone the things that before lay imperceptible are now brought forth into open light, obvious to the senses, and demonstrated; so that truly the very same things that were first in the composition of things are found again in the resolution of mixed bodies. But since I have treated of these matters more fully elsewhere, I have not wished to dwell on them longer.

CAPUT II. [Chapter II]

On the Kinds of the Elements and of the Mixed bodies, and on their use and benefit in the nature of things, arranged according to the Rule of [our] Art.

So that the things we have said in the preceding pages κατὰ τὴν θεωρίαν [Greek: kata tēn theōrian, "according to theory / by way of speculation"] may afford us some benefit in medical use, we shall subjoin practice to speculation, so that it may become known to the reader how one is to proceed in resolving each thing into its elements, and what use each may have in driving off the infirmities of the human body. But since the chemical operations set forth a little before regard not only plants but also minerals and animals, we shall first reason about each separately — how the elements too may be brought to the dissolutions of individual things through the stalactic art — as follows.

Therefore, the properties of the Elements being first set down and examined, you will proceed further according to the rules of our Art, by seeing first what each and every thing contributes to the preservation of the human race — for which they were created by the Author of Nature. And this you will achieve in the following way; and first, indeed, concerning Fire, you will reason thus.

§ I. — On FIRE.

Fire is twofold: either with a consuming flame, or without flame. Fire with flame consumes every combustible thing — such as are wax-comb [*favum*], oil, butter, fat, and all the kinds of woods, trees, shrubs, and plants; whose excrements are either ash, or lime, or soot. Fire without flame is preserved in coals, metals, stones, [and things] set on fire. From this you may deduce a universal Axiom:

[Margin: There are as many fires of differing quality as there are differences among the combustible things themselves.]

Each fire is of the property of which the combustible thing is. If this be good, wholesome, profitable to health, such too will be the flame of the thing that is consumed; but if the combustible thing has harmful qualities, the flame will likewise contain such within itself. Thus, according to the variety of combustible materials — which are countless — a variety of flames of fire will be constituted. All of which have been proved by induction in our *Combinatory Art* [*Ars Combinatoria*], from the principles of the Art. For example: Concerning the Communication of the properties of the flame; concerning its Extension to the individual members of the body; concerning its Duration; concerning the Power and efficacy that it imprints on the members of men; concerning natural Appetite, Sympathy; concerning the Virtues, etc. All of which are likewise to be understood concerning ashes, lime, soots, [and] smoke.

§ II. — On AIR.

Air is most necessary both for preserving life and for driving off evils. From this you will deduce a universal Axiom.

[The text continues at the head of the right-hand column:]

It is either Natural or Artificial. Natural air acts either by a primary or by a secondary quality.

[Margin: The differences of air.]

Of the primary quality: one [air] is temperate, and this is either Eastern or Western; another is Northern or Southern. Another is Intemperate, as the Southern and the Northern, which nevertheless is diverse according to the diverse nature of regions and lands. Of the secondary quality, air rarefies and dissolves, as the Southern; it condenses and binds, as the Boreal [Northern].

The substance of the air acts insofar as it is pure, clear, subtle — or impure, or thick, or misty. Hence you will form this Axiom: *Such is the air as is the constitution of the place or climate that dominates the air*. If therefore a place abounds in wholesome breathings-out and exhalations, it will assuredly produce wholesome air, as in places mountainous, dry, and not exposed to pernicious blasts of winds. On the contrary, that air is harmful and unhealthy which arises in places liable to putrid exhalations — such as marshlands, and subterranean places exposed to the blasts of winds,

[Margin: The quality of the air follows the nature of the place.]

and places infested with the spirits of metallic exhalations, which [air] follows the nature of the plants and animals [of the place].

From the theory of this arises artificial air, which is either cold, for tempering heat, or hot, for provoking sweat, [and] is opportune in every kind of infirmity.

§ III. — On WATER.

Water is either superior or inferior.

[Margin: The differences of waters.]

The superior is rainwater; the inferior is either endowed with a medicinal faculty or not — of which kind are spring water, well water, lake water, [and] rainwater; which again are either wholesome or unwholesome, according to the proportion of the places in which they are housed.

[Margin: Medicinal waters.]

To medicated water are referred all the kinds of thermal [waters], which are taken either from metals or from places. Waters taken from metals are salty, nitrous, aluminous, sulphureous, bituminous, ferruginous, coppery [*aereae*] [?], cupreous, golden, gypseous, antimonial, vitriolated; there are also poisonous ones, such as the Arsenical, Mercurial, etc., from which is given the rationale of the most hidden nature of all prodigious effects.

[Margin: The differences of waters according to the constitution of places.]

Waters are also taken from the constitutions of the places in which they gush forth, as the Baths [Thermae] of Germany, France, Italy, Spain, Hungary, Sicily, England, [and] Switzerland; all of which take their differences from the nature of the places through which they pass — concerning which see the treatment given most fully elsewhere in this work.

§ IV.

Diagram — Synoptic table (*Pinax*). A single large landscape fold-out branching table ("Pinax") spanning the opening, printed sideways across two leaves. and 884 are the blank backs of the leaf (only mirror-image bleed-through of the print is visible); the printed table occupies (left half) and 883 (right half), which together form one continuous tree. Running header (top of the printed side, rotated): "Tom. II. Fol. 398." Reading order used: the table is read as one continuous left-to-right brace-tree, with carrying the IGNIS and AËR branches and the head of the AQUA branch, and carrying the remainder of AQUA and the whole TERRA branch. The structural root ("The four elements are potent each in its own medical faculties") is printed at the far left of the lower register of p. 883.

Title (centered, large caps): **PINAX MEDICO-PHYSICUS QUATUOR ELEMENTORUM** — "A Medico-Physical Synoptic Table of the Four Elements."

The tree is organized from a single root statement that fans out into the four elements, each subdivided by its medical use. Transcription of the full brace-structure, branch by branch:

Root (far left, lower register): Quatuor Elementa medicis suis Facultatibus pollentia sunt: — "The four elements are potent, each in its own medical faculties:"

I. IGNIS medicus ("medical Fire") — *sumitur vel ab* ("is taken either from"):

- **Ignе ipso & est vel** ("the fire itself, and this is either"):
- **Cum Flamma depascente** ("with a consuming flame"):
- Ligna — wood
- Sevum, Oleum, Butyrum, Adipem — tallow, oil, butter, fat
- **Sine Flamma, uti ab ignitis** ("without flame, as from glowing/heated things"):
- Carbonibus — coals
- Metallis — metals
- Lapidibus — stones
- **Recrementis ipsius, uti à** ("from its own residues, as from"):
- Fuligine — soot
- Cinere — ash
- Calce — lime [quicklime]

II. AËR medicus ("medical Air") — *est vel* ("is either"):

- **Naturalis, agit vel suâ** ("natural, and acts either by its own"):
- **Qualitate, vel** ("quality, [being] either"):
- **Prima, & sic alius est** ("primary, and thus is of one kind or another"):
- Temperatus — temperate
- Intemperatus — intemperate; *each subdivided by direction*:
- Orientalis — eastern
- Occidentalis — western
- Meridionalis — southern
- Septentrionalis — northern
- } **Pro conditione locorum** — "according to the condition of the places"
- **Secunda, & sic alius** ("secondary, and thus of one kind or another"):
- Rarefacit, ut Meridionalis — rarefies, like the southern [air]
- Condensat, ut Septentrionalis — condenses, like the northern [air]
- **Substantiâ, ut** ("by [its] substance, being"):
- Purus, clarus, subtilis — pure, clear, fine
- Impurus, crassus, nebulosus — impure, thick, foggy
- **Artificialis, sic arte conficitur aër** ("artificial — thus air is produced by art"):
- **Frigidus — Contemperandum** ("cold — for tempering")
- **Calidus tum ad — Ad sudorem eliciendum, ut Laconicum** ("hot, then — for drawing out sweat, as in a Laconicum [sweating-room/sauna]")

III. **AQUA medicata est vel** ("medicated Water is either"):

- **Superior, ut aqua** ("higher [atmospheric] water, such as"):
- Supercoelestis — supercelestial
- Pluvialis — rain[water]
- **Non medicata, ut aqua** ("non-medicated water, such as"):
- Fontana — spring water
- Putealis — well water
- Lacustris — lake water
- Fluminea — river water
- Maritima — sea water
- **Inferior** ("lower [terrestrial] water"):
- **Medicata, quarum differentiae sumuntur vel à mineralibus, uti** ("medicated, whose differences are taken either from minerals, such as"):
- Salsae, nitrosae — salty, nitrous

- Aluminosae, sulphureae — aluminous, sulphurous
- Bituminosae, ferreae — bituminous, ferruginous [iron-bearing]
- Aeneae, cupreae — brazen [copper], cupreous
- Aureae — golden
- Gypseae — gypseous
- Venenosa qualitate praeditae, ut arsenicales, mercuriales — endowed with a venomous quality, such as arsenical, mercurial [waters]
- **A locis in quibus scaturiunt, eorumque non est numerus, in** ("from the places in which they gush forth — and these are without number — in"):
- Italia — Italy
- Gallia — France
- Hispania — Spain
- Germania — Germany
- Anglia — England
- Polonia — Poland
- Asia — Asia
- Africa — Africa
- America — America
- } **Quae exhibent diversas proprietates thermarum** — "which display the various properties of [their] thermal waters."

IV. **TERRA medica vel** ("medical Earth, [acting] either"):

- **Astringit, ut** ("astringes, such as"):
- **Venenis resistit, uti** ("resists poisons, such as"):
- Terra Armenia — Armenian earth [bole]
- Terra Lemnia — Lemnian earth
- Ochra — ochre
- Rubrica Synopica — Sinopic red [ruddle]
- Rubrica fabrilis — workmen's red ochre
- Terra omnis — every [common] earth
- Erethria, Samia — Eretrian, Samian [earth]
- Chia — Chian [earth]
- Selenusia — Selenusian [earth]
- **Discutit, ut** ("dissolves/disperses, such as"):
- Terra cimolia — Cimolian earth [fuller's earth]
- Terra Ampelitis — ampelite [a bituminous earth]

- Terra fornacea — furnace earth
- **Abstergit, uti** ("cleanses, such as"):
- Terra melia — Melian earth
- & innumerae aliae — and countless others
- **Deleteria** ("deleterious/destructive [earths]"):
- Arsenicalis — arsenical
- Antimonialis — antimonial
- Auripigmenti — of orpiment

Stones formed from Earth and Water — a cross-branch at the right of the table:

- **Ex Terra & Aqua lapides coalescunt, suntque vel** ("From Earth and Water stones coalesce, and they are either"):
- **Pretiosi** ("precious"):
- **Terrestres sunt:** ("[those] of the land are:")
- Rubinus — ruby
- Carbunculus — carbuncle
- Saphyrus — sapphire
- Amethystus — amethyst
- Topazius — topaz
- Smaragdus — emerald
- Corniola — carnelian
- Achates — agate
- Iaspis — jasper
- Magnes — lodestone [magnet]
- Marmorum complures species — many kinds of marble
- **Maritimae** ("[those] of the sea"):
- Uniones — pearls
- Gemmae, Perlae, seu Margaritae — gems, pearls, or margarites
- Succinum, Ambra — amber, ambergris
- **Non pretiosi** ("not precious"):
- Omnis generis lapides fabricis apti — stones of every kind suitable for building.

` flag. The directional sub-bracket "Orientalis / Occidentalis / Meridionalis / Septentrionalis → Pro conditione locorum" attaches to the "Intemperatus" (intemperate primary-quality air) node. The geographic list under medicated

waters and the "Quae exhibent diversas proprietates thermarum" closing brace span the page seam between 882 and 883 but belong to one continuous bracket.]

Reading order used: map directly to printed pages 399, 400, 401, 402 in sequence — no non-linear reordering was required for this batch. The catchword chain confirms it: p.399 ends "dura-" → p.400 begins "duratione"; p.400 ends "tan-" → p.401 begins "tantum"; p.401 ends "Sal" → p.402 begins "Sal vero." (p.398, the fold-out Pinax, immediately precedes p.399.)

§ IV.

DE TERRA.

[On Earth.]

[Margin: Differences among the kinds of earth (*Terrarum differentia*).]

Earth comes into human use no less than the elements just discussed. There are: Armenian earth, called *bolus*; sealed earth [*terra sigillata*]; Melitensian earth, which resist poisons and have an astringent effect; ochre earth, Sinopic earth, the workman's red ochre [*rubrica fabrilis*], Samian, Chian, Selinusian; Cimolian earth, *ampelitis*, and furnace-clay [*testa fornacea*]. Irish earth too, along with wood, the leaves of trees, and so on, act against poisons — though this happens more by a kind of miracle than by nature. From this you may argue as follows:

[Margin: They draw their qualities from the nature of the place (*A loci conditione trahunt qualitates suas*).]

Every earth has the property belonging to the constitution of the place from which it is dug.

§ V.

DE MINERALIBUS ET METALLIS.

[On Minerals and Metals.]

[Margin: The difference among minerals and metals (*Mineralium Metallorumque differentia*).]

Some minerals and metals alter the body, while others preserve it, doing so either by a manifest or by an occult quality. Those that preserve do so either by a primary or by a secondary quality. Of the first quality, some are temperate,

others intemperate. Temperate, like gold; intemperate, in that they are either hot, or cold, or moist, or dry.

Hot and dry in the second degree are iron, crocus of Mars [*crocus Martis*], and cinnabar.

In the third degree: flowers of copper [*flos aeris*], burnt copper [*aes ustum*], copper scale [*squama aeris*], native verdigris [*aerugo fossilis*], *diphryges*, alum, salt, niter, sulphur, and *chalcitis* — all of which we have treated more fully in Book VII.

In the fourth degree, such as *calcanthum* [blue vitriol], orpiment [*auripigmentum*], *sandaraca* [realgar], *chrysocolla*, *misy*, and *melanteria*. On these, see Book X.

Cold in the first degree, like antimony [*stimmi*]. In the second degree, like filings of silver [*argenti scobs*], litharge [*spuma argenti*], quicksilver, lead, plumbago, burnt lead, and white lead [*cerussa*]. Or, by a secondary quality, they are astringent, like *cadmia*, *pompholyx*, *spodium*, *antispodium*, alum, verdigris, *calcanthum*, cinnabar. Some bind and induce a scar [i.e. promote healing], like lead, gypsum, antimony. Or they alter by corrupting: like poisons, mercury, litharge [*lithargyrium*], litharge of silver [*argenti spuma*], orpiment, arsenic, white lead, lime, gypsum, *sandaraca*.

§ VI.

DE LAPIDIBUS.

[On Stones.]

[Margin: The difference among stones (*Lapidum differentia*).]

Stones are either precious or non-precious.

The precious ones alter by either a manifest or an occult quality. Those that act by a manifest quality are of either the first or the second quality. The first-quality ones are either cold in the first degree, like the hyacinth [*Hyacinthus*], the sapphire, and the emerald; or in the second degree, like the ruby, the carbuncle, the garnet, and the sardonyx; or in the fourth degree, like the diamond [*Adamas*].

Or they act by a secondary quality, like the hyacinth, the sapphire, the emerald, the carbuncle, the garnet, the sardonyx, the amethyst, and lapis lazuli.

Or they act by an occult, that is, a specific quality: like the bezoar stone [*lapis Bezoarticus*], the topaz, the *colubrinus*, the toadstone [*bufonitis*], the emerald, the *alectorius*, the chalcedony, the amethyst, jasper, the kidney-stone [*lapis nephriticus*], and every stone found in the viscera of animals. On these see Book VII.

The non-precious stones, again, alter by either a manifest or an occult quality. They alter by a manifest quality through heat, or cold, or dryness. By heat, like the hematite, the pyrite, the Asian stone [*lapis Asius*], the *thyites*, the emery [*smiris*], and the *schistus*.

By cold: crystal, the Phrygian stone [*lapis Phrygius*], the Samian stone [*lapis Samius*].

By dryness, like sand and brick-dust [*laterum pulvis*].

[Margin: The qualities of stones (*Qualitates Lapidum*).]

Or they alter by a secondary quality — by astringing, softening, numbing, cleansing, gluing, inducing a scar, grinding down the stone [*calculus*], or retaining the fetus.

By astringing, like the Asian stone, the Naxian stone [*Naxias*], the *geodes*, and pumice.

By softening, like the *alabastrites*, jet [*Gagates*], and the Thracian stone [*lapis Thracius*].

By numbing, like the *memphytis*, jasper, and the *ophites*.

By cleansing, like the Arabian stone [*Arabicus*].

By gluing, like the *galactites* and the Melitensian stone.

By inducing a scar, like the *morochtus*.

By breaking up the stone [*calculus*], like the *lapis Lynceus*, the Jewish stone [*lapis Judaicus*], and the sponge-stone [*lapis Spongiae*].

Or they act by an occult, that is, specific quality: like the sponge-stone, the swallow-stone [*Chelidonium*], the magnet [*Magnes*], the fish-stone [*lapis Piscium*], snail-stones [*Limacum lapilli*], the vulture-stone [*lapis Vulturis*], coral, the *lyncurius*, jet, the eagle-stone [*Aetites*], the crab-stone [*lapis Cancrorum*], amber [*Succinum*], and crystal.

Or they purge the gross humors, like the magnet; or melancholy, like the Armenian stone [*Armenus*], the *Cianeus* [blue] stone, or lapis lazuli.

De iis, qui ex Mari proveniunt lapidibus liquoribusque.

[On the stones and liquids that come from the sea.]

The stone-bearing offspring of the sea act by either a manifest or an occult quality. The manifest ones are either hot, like the *alcyonium*, sperm of the whale [*sperma Coeti*, spermaceti], ambergris [*Ambra*], and the fragrant *unguis odoratus*. Or cold, like coral and the pearl [*Margarita*], that is, *uniones*.

Of the second quality, the marine substances either astringe, like amber [*succinum*], that is, *electrum*;

or they soften, like bitumen, asphalt, naphtha, and *pissasphaltum*.

Or they cleanse, like the shells of purple-fish [*purpurae*], whelks [*buccinae*], mussels [*mytili*], *tellinae*, *chamae*, *conchilia*, sea-snails [*cochleae*], crabs [*cancrī*], and cuttlefish-bone [*os sepiae*].

By an occult quality act the pearls [*uniones*] and bitumens.

Here, reader, you have in summary whatever can be said about earthy things. If you draw these out through the precepts of our Art, they will give you so vast a material for philosophizing that you could not encompass it even in many volumes. And first, indeed, concerning the communication

[Margin: The opinion of the later authors on the degrees of things (*Posteriorum Authorum de gradibus rerum sententia*).]

of individual properties; concerning duration; concerning their powers and efficacy in acting, and so on. And through the Rules of Questions: what the powers of the individual species are, why they were implanted by nature, where, when, with what, of what kind, of what magnitude, and so forth. But on these matters see more fully what was treated in our *Ars Combinatoria*.

CAPUT III.

IATPIKON.

[Greek: ἱατρικόν (iatrikon, "medical" — the medical part / matters pertaining to the art of healing).]

De Qualitatibus primis & manifestis, occultis seu specificis Plantarum, singularumque partium, uti sunt, folia, radices, flores, fructus, semina, ligna; oleis, gummi, eorumque viribus & proprietatibus in usu Medico, ex Veterum, Recentiorumque Medicorum melioris notae monumentis extracta, & in Tabulas Synopticas reducta.

[On the primary and manifest, and the occult or specific, qualities of plants and of their individual parts — such as leaves, roots, flowers, fruits, seeds, woods, oils, and gums — together with their powers and properties in medical use, drawn from the records of the better physicians, both ancient and modern, and reduced into synoptic tables.]

Before we proceed any further, I have thought it right to set out here first a certain universal synopsis of all plants, so that we may not seem to have omitted anything that could in any way contribute to a complete knowledge of plants.

That the physicians have been occupied solely with investigating the manifest qualities of vegetables is clear from their writings. Now since the manifest, or (as they call them) elementary, qualities are four — dryness, moisture, coldness, and heat — they stretched each of these across a range of four degrees, so that some things were hot in the first degree, others cold in the first degree, others dry in the first degree, others moist in the first degree. But since they saw that degrees of this kind were too few to suit the nature of things — which is supremely eager for variety — they devised a further distinction, so that some things were moist, cold, hot, or dry in the second degree; others moist, cold, hot, or dry in the third degree; and finally others in the fourth and highest degree, hot, cold, dry, or moist. By this division of degrees they reckoned that they had encompassed the whole nature of vegetables.

When the later authorities saw that this division established in four degrees could not stand, they amplified degrees of this kind and assigned them a greater range by a sixteen-fold distribution, so that between degree and degree — between the first and the second, the second and the third, the third and the fourth — they placed other, smaller degrees, which some call "points" [*puncta*]. But anyone who weighs this matter more deeply on the more exact balance of reason will find, clearer than daylight, that this distribution of degrees is too difficult to be grasped by the human mind, on account of the immense and inextricable difficulties that can confront natural philosophers in investigating them. Let us, however, unfold a few of them. The first of these is the very

uncertainty of the degrees; second, the fallibility of the senses by which they have tried to track them down; third are those which we shall review a little later.

[Margin: The distribution of degrees is fallacious and lacks a sure mark (*Graduum fallax & incerta notitia*).]

First. The uncertainty of the distribution of degrees consists in this: that no degree can be reached precisely, and — as we also taught above — there is as great a diversity between one degree and another as the broken numbers, or fractions, that can be placed between 1 and 2. Since this brings in a kind of infinity, it likewise seems to exceed the condition of the human intellect to reach the precise degree of a quality in any given mixed body whatever. And so the differing temperaments of vegetables may rightly be compared with the diversity of human faces: just as that diversity arises from a certain infinite variety of temperaments, so too I would have you understand the same of the various parts of plants — roots, leaves, flowers, fruits, seeds — which, even within one and the same tree or herb, are imbued with the most diverse qualities.

[Margin: The fallibility of the sensible qualities (*Sensibilium qualitatum fallax experimentum*).]

Second. How fallacious is the test made by way of colors, tastes, smells, and tactile qualities, only the man knows who has frequently made trial of such qualities. Plant-experts [*Phytoptae*] for the most part form their judgment about the hidden powers of plants, flowers, fruits, and seeds from the colors white, green, leek-green, blue, saffron, yellow, red, purple, ash-gray, and black. But anyone who has read what we taught about colors in Book VIII will openly admit that to want to determine precisely the variety of all the colors in plants is something ἀδύνατον [Greek: ἀδύνατον (adynaton, "impossible")]. Add to this that it is utterly false that everything white is of a moist temperament, everything red of a hot, everything green of an undigested one, and so on for the rest — as we could amply demonstrate in this place, had we not already done so in the cited book of this work a little earlier. It appears plainly in the white oleander flower, than which nothing can be more caustic, and in the red rose, which is endowed with a certain moderate moisture entirely free of fiery heat. Color, therefore, can give us no firm and certain indication of the quality of plants.

[Margin: The fallibility of the test from tastes and smells (*Saporum, odorum fallax bonitatis aut...*).]

If we examine exactly the tastes and smells of plants, we shall find that nothing about the powers of plants can be established for us, except in general —

— that is to say, that a good smell is for the most part an indication of heat, a foul one of coldness and excrementitious moisture, an odorless one a sign of pure moisture (as in spring water); whereas in taste the botanists hold that the Sharp [*Acer*] is an indication of vehement heat, the Acute [*Acutum*] of extreme heat, the Acerbic [*Acerbum*] of cold, dry, and earthy, the Acid [*Acidum*] of an excess of the moist over the cold, the Bitter [*Amarum*] of dryness, heat, and earthy dryness, the Austere [*Austerum*] of cold over moist, the Sweet [*Dulcem*] of temperate heat and moisture, the Salty [*Salsum*] of cleansing heat, and finally the Greasy [*Pinguem*] an indication of an airy temper. So judge the more skilled of both the ancients and the moderns, the followers of Galen, Dioscorides, and Theophrastus. In all these matters it is as easy to err as to speak, since the senses cannot be a faithful judge for forming a precise verdict about the elementary qualities. Add to this that tastes of this kind for the most part take their origin from something other than the elements, as will appear later.

Yet, lest we seem in this place to condemn the venerable tradition of the ancient physicians, I say: even if the ancients did not reach the precise degrees of qualities in vegetable nature, their effort was nonetheless praiseworthy. By continual study and experience they arrived at the point of establishing a dogmatic doctrine concerning the degrees — confirmed by the experiences of countless centuries, accepted and confirmed by the unanimous agreement of physicians, and not so much discovered by human ingenuity as divinely inspired — which to this very day the best-reputed Doctors of both branches of Medicine have safely followed.

[Margin: The praiseworthy effort of the ancients in assigning the degrees of individual things (*Laudabilis veterum conatus in gradibus singulorum indagandis*).]

We do not dispute in this place whether smells, tastes, and colors flow immediately from the elementary qualities — for we have shown this to be false in several passages of the preceding Books, since the elements concur in the composition of mixed bodies only as a remote cause. Nor can it happen that those simplest bodies should generate in plants those various differences of colors, smells, and tastes; for, besides the fact that — so far as concerns the simplicity of their nature — they are devoid of all color, no other reason can be assigned by which sensible qualities of this kind should be introduced into them.

[Margin: The proximate cause of the qualities that emerge in plants (*Proxima causa qualitatum in plantis elucescentium*).]

The proximate cause of these qualities is therefore sought. We say that all the variety of colors, tastes, and smells in plants and their parts — leaves, flowers, fruits, seeds — comes from nowhere else but from those things of which each is composed, that is, from sulphur, salt, and mercury. From sulphur, indeed (as we taught in Book VIII), we showed by various experiments there that all the differences of colors arise; from salt and mercury, that all the tastes in plants derive their origin.

[Margin: From what the colors and tastes come (*Unde colores & sapor*es).]

They do not, therefore, arise immediately from the elementary qualities, but proximately from sulphur, from the fourfold kind of salt, and from the mercurial moisture. The colors all depend on the greater or lesser decoction of sulphur in plants. As for tastes and smells: that the Bitter taste consists of salt and niter, its cleansing, purgative power sufficiently shows. In this way the Acerbic resides in nature through the astringent virtue of alum; the Acid savors of the nature of sal ammoniac, and is therefore highly valued by physicians because of a certain incisive power, and for the same reason it dissolves bodies and coagulates spirits; the Austere savors of vitriol, and so possesses a styptic, astringent, and fermentative quality; the Salty, as it arises immediately from salt, so too displays the nature of salt in all things. Yet not even from these does the precise account of the said sensible qualities stand clear to us. For how many things, I ask, are bitter in taste which nevertheless, by the rules of the ancients, are by no means hot? Such are opium, chicory, and many others. Again, how many acid things exist which, even by the ancients' own judgment, are most hot — like the spirits of vinegar, of niter, and of sulphur — while that same rule of the ancients meanwhile determines acids to be most cold? How many things are sweet on the surface which, in their inner substance, indicate not, I will not say a temperate state, but the very greatest δυσκρασία [Greek: δυσκρασία (dyskrasia, "bad mixture / distemper")]?]

[Margin: From honey and sugar a caustic water is nevertheless drawn out (*Ex melle & saccharo aqua tamen caustica extrahitur*).]

Such are honey, cassia, and sugar — as is plainly shown by the fact that from them, sweetest though they are, a water is nevertheless extracted endowed with so great a caustic power that it yields to no aqua fortis: a most potent menstruum for dissolving gold, silver, and the other metals.

[Margin: Lead is said to be sweet (*Plumbum dulce dicitur*).]

Lead imprints no taste on the tongue, although its inner substance — to speak with Quercetanus [Joseph Duchesne] — is nothing other than a kind of insipid, sugary sweetness. By such and innumerable similar examples, if there were need, we could demonstrate it. From this we infer that one must not rashly trust and rely on the tastes, qualities, and outward temperaments of things. Noting this, the more recent investigators, guarding against the danger of falsehood, took another path for exploring the hidden qualities of mixed bodies — namely, through the spagyric art [*ars Spagyrica*], by which a perfect separation of the three principles of nature is made from mixed bodies. This is the one true and legitimate way by which the difference of colors, tastes, and smells is brought out; for one and the same substance can hold within itself distinct colors, smells, and tastes, which indeed you will not easily recognize without an exact knowledge of the spagyric art.

[Margin: Another method of arriving at the hidden powers of things (*Alius modus vires rerum ingrediendi/veniendi*). [?]]

[Margin: The various powers of the wood of guaiac (*Ligni Quajaci variae vires*).]

We give an example in the wood of guaiac [*Quajacum*], whose differing properties you will not easily distinguish by taste, nor will you easily find the cause of the diaphoretic [sweat-inducing] virtue it possesses; but once it is resolved into its principles, it will at once disclose the causes of the latent virtues. For, as Quercetanus rightly says, you will find that diaphoretic, that is, sudorific power placed in its mercurial acidity and its oily sulphur and finer substance — the same power that has been found to exist also in the ash-tree, and indeed in nearly all woods and trees, such as cinnamon.

[Margin: The diversity of properties and powers in herbs comes from the difference of the things that concur in their composition (*proprietas viriumque in herbis differentia diversitas a compositione rerum concurrentium*). [?]]

But the salt extracted from guaiac — how much it contributes to evacuation and to the purging of the humors — is not hidden from physicians. Opium too, which is bitter, and the other more bitter herbs, like gentian and centaury, arise from a salt separated from its own oil, that is, from its narcotic sulphur, and hence it rises into a most excellent cathartic. Just as, therefore, the diversity is great, so too there arises from it a varied range of natures: for some salts are bitter, others sweet, others sharp, acerbic, austere, salty, and purgative — and their particular faculty is more rightly attributed to the proper substance of that same salt than to some other, namely (as we said a little earlier) to an elementary quality.

[Margin: The method of the ancient Egyptians in discovering the powers of things (*Veterum Aegyptiorum modus in viribus rerum inveniendis*).]

To this spagyric art there has accrued another never-sufficiently-praised method of exploring the hidden qualities that lie concealed beneath the coverings of vegetable nature — a method drawn from the hieroglyphic school of the ancient Egyptians, and in modern times revived anew by men preeminent for sharpness of intellect. On this see the treatment we have given most fully in the second volume of our *Oedipus Aegyptiacus*, in the *Syntagma on the Medicine of the ancient Egyptians*. For by means of the signatures, that is, the external characters, impressed by God most good and great upon each individual thing, the plant-expert [*Phytopta*] will recognize what is especially health-giving to each member of the human body and fit for its preservation. Since we have dealt with these matters in the *Ars Magnetica*, the *Musurgia*, and the cited part of the *Oedipus*, I have not wished to dwell on them. Here I shall add only a figure, from which you may grasp in a single synopsis the whole — namely which plant corresponds to each member of the body and is suited to healing it, should it ever be impaired by a distemper [*dyscrasia*] of the humors. *There follows the use of this figure.*

But to proceed now to the matter we have proposed. So that the reader may derive some usefulness from what has been said thus far, it seemed good in this place to set before the eyes of the curious reader, through four synoptic and combinatory tables — or epilogisms — the whole doctrine of simple medicaments, so that what was comprehended by various authors in whole volumes might be obtained by the reader, set out on four leaves, to the great relief of the labor of reading books. Now, since it is first necessary to know which and how many medicaments and compositions can be made from the individual simples, here we first place a resolutive table displaying them all. See Table I, that is, the Epilogism.

I know that the followers of the more curious Doctrine desire this one thing: to have ready at hand a certain synopsis of the individual simple medicaments, by which they may come to know — without such great labor — the qualities of plants and of their individual parts, such as leaves, flowers, fruits, seeds, roots, barks, woods, liquors, juices, gums, resins, and finally in what degree of coldness, moisture, dryness, and heat each one is strong. Here, therefore, [we place] Table II, which will stand in the reader's stead for many books, extracted from the records of the better-reputed physicians, both ancient and modern. (Opium indeed, which stands in place of the bitter, [is included].) See Table II.

USUS TABULAE.

[The Use of the Table.]

The table is divided into ten columns. In the first column are contained the degrees of the primary qualities. In the second, the plant and its leaves. In the third, the flowers of the plants. In the fourth, the fruits, and so on, as appears from the table. If, therefore, anyone wishes to know which herb and its parts are moist in the fourth degree, let him look in the first column of the table for the fourth degree of moisture; and having found this, he will find in the [second] column the herbs — opium, hemlock, mandrake, and so on. In the third column, among the flowers, the flowers of those same plants. In the fourth column, of fruits, in the common angle, the apples of mandrake, and so on. In the fifth column, of seeds, the seeds of the said plants, and so for the rest. And in this way you will proceed in finding the qualities of the remaining herbs. As for how all these are to be reduced into their waters, oils, quintessences, and salts — this was stated a little earlier, and will be taught more fully in what follows.

§ II.

De Virtutibus Vegetabilium materialium, comparatione facta ad singula humani corporis membra.

[On the Virtues of vegetable materials, by comparison made with the individual members of the human body.]

The most wise Creator of Nature bound together whatever exists in the threefold Kingdom of Nature with bonds so tight that there is nothing in one which is not found in another according to a certain analogy. He bound evils to goods with such ineffable wisdom that even the evils themselves might turn to the good of the human race, for whose sake all things were created.

[Margin: The wonderful providence of God (*Divina providentia mirabilis*).]

He bestowed nourishments suited to feeding, and good indeed for preserving man in a perfect state of health; yet because he foresaw that man — whether through an excess of nourishments, or through a defect of them — could not always remain in an exact state of εὐκράσια [Greek: εὐκράσια (eukrasia, "good mixture / good temperament")], he produced medicaments, so that by their power and efficacy a defect might be supplied or an excess diminished, and thus by their aid man might be brought back to the balanced poise of health. But lest from the mixing together of so many powers of different medicaments a confusion should

arise, and so that all things might be carried out with the right order of reason, he willed each and every one of them to be imbued with a certain magnetic virtue — so that, taken up within the stomach as into a kind of center, and thence diffused into the whole economy of the microcosm, each should seek out its own, and above all those members, those humors and juices, toward which, by a certain sympathetic appetite implanted in them by nature, they are borne of their own accord as if by a kind of weight. And since both the nourishments and the *alexipharmaca* [antidotes]

EPILOGISMUS I.

A summary of the medicinal virtues implanted in herbs, and into how many classes medicaments can be resolved.

The following synoptic table sets out the classification. Its branches read from left to right: the broadest category stands at the left, and each bracket opens into its subdivisions toward the right.

Simple medicaments are considered according to:

I. Their matter — which is either:

- **Natural**, which is either:
 - **Animate**, which is either:
 - **Sensate** — as animals and their parts;
 - **Insensate** — as plants and their parts.
 - **Inanimate** — as are minerals and metals.
- **Artificial**, which is either:
 - **Fluid**, which is either:
 - **Non-fatty**: Waters [Aquæ]; Syrups [Syrupi]; Decoctions [Decocta]; Infusions [Infusa]; Preserves [Conservæ]; Candied preparations [Condita]; Electuaries [Electuaria]; Linctuses [Loch]; Clysters (enemas) [Clysteres]; Gargles [Gargarismata]; Fomentations [Fomenta]; Head-purges [Caputpurgia]; Sitz-baths [Infessus]; Baths [Balnea]; Washes [Lotiones].
 - **Fatty** — as are all Oils [Olea].
 - **Non-fluid**, which is:
 - **Extracted** [Extirpata]: Powders [Pulveres]; Species (powdered compounds); Sweetmeats [Tragemata].
 - **Compacted** [Coacta], which is either:

- **Moist:** Electuaries; Preserves; Opiates; Extracts, etc.
- **Dry:** Tablets and Morsels for the chest [Tabulæ, Morselli pro pectore]; Eye-salves, for the eyes [Collyria, pro oculis]; Nasal preparations, or Errhines — ἔρρινα καὶ φάρμακα [Greek: errhina kai pharmaka, "nasal medicines"] — for the nostrils; Aromatics, etc., for the brain [Odoramenta, pro cerebro].

II. The form by which they alter quality — which is either:

- **Common** [Communiter], which is either:
- **Manifest** [Manifesta], being either:
 - (1.) Hot [Cal(ida)]; Cold [Frig(ida)]; Moist [Hum(ida)]; Dry [Sicc(a)].
 - (2.) Astringent [Astringentia]; Emollient [Mollientia]; Laxative [Laxantia], etc.
- **Occult** [Occulta]:
 - (3.) Those that promote sweat [Quæ movent sudorem]; provoke urine [Urinas cient]; break up the stone [Calculus frangunt]; ward off poison [Venenum arcent], etc.
- **Proper** — that is, with respect to a member of the human body [Propriè quoad respectum ad membrum humani corporis], and these are:

Faculty	for the
Cephalic [Cephalica]	Head [Capite]
Pectoral [Pectoralia]	Chest [Pectore]
Cardiac [Cardiaca]	Heart [Corde]
Stomachic [Stomachica]	Stomach [Stomacho]
Hepatic [Hepatica]	Liver [Hepate]
Splenetic [Splenetica]	Spleen [Splene]
Nephritic [Nephritica]	Kidneys [Renibus]
Hysteric, that is, Uterine [Hysterica, id est Uterina]	Womb [Utero]
Arthritic [Arthontica]	Joints/limbs [Artubus]

[The prose below continues directly from the close of the preceding pages: God has given each medicament a magnetic virtue, so that by a sympathetic appetite it seeks out its own member and humor — "and since both the nourishments and the antidotes consist, each of them, of..."]

their own salt, sulphur, and mercury — that is, of native heat, radical moisture, and earthy dryness — the nourishments drawn from herbs, fruits, and animals

are at once roused by the heat of the stomach. The saline parts that lie hidden in those nourishments then flow together to the saline parts of the body, the sulphurous to the sulphurous, and the mercurial to the mercurial. So long as these subsist in their just measure and weight, a man remains in good health. But if the sulphurous spirits are kindled — whether through exertion, sleeplessness, and toil, or through a corrupted diet, or through intemperance and surfeit — then the salt and the microcosmic tartar are fixed, and the mercurial liquor floods everything with its inundation. At that point, as though by a sudden onslaught, the whole body is assaulted by them, and various monstrous kinds of disease arise. Against these no remedy can be fitting except those that share a certain proportion and likeness with one another. For it is by the inflowing of such remedies that the members are freed from their troublesome enemy: the medicament that has been taken in, being like that which dwells within the members, draws to itself by excess the matter that is at fault, and so discharges it.

I have treated deleterious diseases more fully in Book IX. [Margin: *Analogia rerum denominationes ad humani corporis membra* — "The analogy by which the names of things are matched to the members of the human body."]

From this it came about that physicians, by diligent inquiry, sought out these faculties down to the individual members of the human body, and once they had found them, marked them aptly with their own names. Thus we have: **Cephalica**, those that concern the head; **Ophthalmica**, those that concern the eyes; **Otica**, those for the ears; those that benefit the teeth, **Odontica**; those that cleanse the nose, φθάρμικα [Greek: phtharmika — for *nasal/sneeze-provoking remedies*], ἑρρῖνα [Greek: errhina, "errhines, nasal medicines"]. Again, those that concern the chest, **Pectoralia**; those for the lungs, **Pulmonaria**; those for the stomach, **Stomachica**; those for the liver, **Hepatica**; those for the heart, **Cardiaca**; those for the kidneys, **Nephritica**; those for the spleen, **Splenetica**; those for the bladder and urine, **Diuretica**. Physicians named them all from a certain occult mark impressed upon them by nature.

[Margin: *Effectus mirabilis medicinalium* — "The wonderful effect of medicines."]

And so that nothing might be lacking, they arranged in fine order — according to the primary, secondary, and tertiary qualities, and those they call specific — exactly what each of the simple medicaments can do, as appears from what follows. For with these they cool the sinning hot humors and warm the cold; they moisten what is dry and dry what is moist; they open what is obstructed; they soften what is hard; they purge what is depraved and corrupted among the vitiated humors; they bind together what is dissolved; they suppurate the unripe;

they constrict the slack; they expel what is virulent and poisonous; they disperse what is flatulent. But since physicians render all matters of this kind by Greek names, I have thought it right to set down here an explanation of each one, lest the reader be left at a loss over their meaning.

Explicatio terminorum Medicinalium. (*Explanation of the medical terms.*)

Astringent, στυπτικόν [Greek: styptikon] [Margin: στυπτικόν] — that is, *closing the mouths of the vessels*. Such things are cold, of thick substance, harsh, austere, and so on. It is opposed to the aperients.

Adurent (caustic), πυρωτικόν [Greek: pyrotikon] [Margin: πυρωτικόν] — that which burns. These are, first, **Vesicants** [Vesicantia]; second, **Escharotics** [Escharotica]; third, **Caustics** [Caustica].

Anodyne [Greek: ἀνωδυνόν, *anōdynon*] [Margin: ἀνωδυνόν] — that is, *relieving pain*, whether it be narcotic [Greek: ναρκωτικόν, *narkōtikon*] [Margin: ναρκωτικόν] or paregoric; though it is more often said of the paregorics.

Aperient, ἀναστομωτικόν [Greek: anastomōtikon] [Margin: ἀναστομωτικόν] — that is, *opening the vessels*. Such things are warm, but not beyond the second degree, and of thin substance. It is opposed to the **Astringents** [στυπτικοῖς, *styptikois*].

Apophlegmatizant [Greek: ἀποφλεγματικόν, *apophlegmatikon*] [Margin: ἀποφλεγματικόν, ἔρρῖνον] — that which draws the excrements down from the brain into the palate and mouth, whether it be chewed, used as a gargle, or smeared on the palate. Such things are warm, sharp, or acting by their whole substance; and they are also called ἔρρῖνα [*errhina*].

Attrahent (drawing), ἐλκτικόν [Greek: helktikon] [Margin: ἐλκτικόν] — that is, *enticing the humors and spirits from the body to the surface*.

καταγματικόν [Greek: katagmatikon] [Margin: καταγματικόν] — that which is suitable for knitting together broken bones.

Cathaeretic [Greek: καθαιρετικόν, *kathairetikon*] [Margin: καθαιρετικόν] — that which consumes superfluous flesh, applied to it.

Cathartic, καθαρτικόν [Greek: kathartikon] [Margin: καθαρτικόν] — that is, *Purging*, whether upward (ἀνω, *anō*) or downward (κάτω, *katō*); though it is said chiefly of the downward-purging (evacuant) sort.

Cicatrizant, ἐπουλωτικόν [Greek: epoulōtikon] [Margin: ἐπουλωτικόν] — *inducing a scar*: it consumes not only what flows in, but also the humor contained within the flesh itself, so that by this means the flesh is turned into skin. It is vehemently drying and astringent.

Eccoprotic, ἐκκοπρωτικόν [Greek: ekkoprōtikon] [Margin: ἐκκοπρωτικόν] — that is, *loosening the belly*, and merely expelling the faeces.

Emetic [Greek: ἐμετικόν, *emetikon*] [Margin: ἐμετικόν] — that is, *a vomitory*. As antimony.

ἐμμηναγωγόν [Greek: emmēnagōgon] [Margin: ἐμμηναγωγόν] — *provoking the menses*.

Emollient, μαλακτικόν [Greek: malaktikon] [Margin: μαλακτικόν] — that which dissolves the concreted and congealed humors, being somewhat dry and plaster-like.

Emplastic, ἐμπλαστικόν [Greek: emplastikon] [Margin: ἐμπλαστικόν] — that is, *Gluey*, which, smeared on some part, sticks to it tenaciously and fills the pores. Such things are dry and earthy, without sharpness.

ἐναιμόν [Greek: enaimon] is κολλητικόν [Greek: kollētikon] [Margin: κολλητικόν] — that which is applied to bloody wounds for the sake of staunching the blood.

Epulotic, or **Synoulotic** — that which induces a scar upon an ulcer.

Extergent (cleansing), ἐκφρακτικόν [Greek: ekphraktikon] [Margin: ἐκφρακτικόν] — that is, freeing one from obstruction by washing away the sticky and gluey humors that cling to the skin. Of this kind are the drying agents — of thin substance, nitrous, and bitter.

Glutinant, glutinatory, κολλητικόν [Greek: kollētikon] [Margin: κολλητικόν] — that which glues together and joins the separated parts. It dries more than the sarcotic (flesh-forming) agent; it cleanses nothing, but rather astringes.

Indurant, σκληρωτικόν [Greek: sklērōtikon] [Margin: σκληρωτικόν] — that which, as it were, congeals and distends.

Laxant (relaxing), χαλαστικόν [Greek: chalastikon] — that is, attenuating and dispersing the matter which, when inflated, slackens and causes tension; mildly warming, more freely moistening, of thinner substance.

Lithontriptic [Greek: λιθοθρυπτικόν, *lithothryptikon*] [Margin: λιθοθρυπτικόν] — that which grinds down and ejects the stone.

Maturant, πεπτικόν [Greek: peptikon], ἐκπυπτικόν [Greek: ekpyytikon] [Margin: πεπτικόν] — that is, [a producer] of pus...

(The terminology list continues on the following page.)

[The following is a fold-out synoptic plate. Header: *Tom. II. Fol. 404.*]

TABULA II.

A table exhibiting the degrees of the primary qualities of philosophy in plants.

This plate is a large grid. The left-hand stub column gives the quality and its degree (1–4); the body columns classify plants by their parts: **FOLIA** (Leaves), **FLORES** (Flowers), **FRUCTUS** (Fruits), and **SEMINA** (Seeds). The four column-headings carry descriptive sub-captions:

- **FOLIA** (Leaves): *"They are the broader and finer parts of the plant."*
- **FLORES** (Flowers): *"They are the subtler outgrowths of plants, distinguished from the rest of the plant by their property and color."*
- **FRUCTUS** (Fruits): *"That which the plant brings forth last, for the conservation and propagation of the species; they consist for the most part of a husk, a skin, flesh, and a seed."*
- **SEMINA** (Seeds): *"The seed is that part [which the plant produces to be cast] into the earth..."* (heading partly cropped at the plate's outer edge).

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
Calida in gradu 1 (Hot, degree 1)	Absynthium, Althea, Borago, Buglossum, Beta, Brassica, Camomilla, Cassutha, Eupathorium, Melilotus, Linaria, Spica Nardi, Scolopendriu m,	Flores boraginis, buglossæ, betonicæ, buphtalmi, crispini, meliloti, camomillæ, stæchados.	Amigdala dulcia, Jujube, Nux Cypressi, Nux viridis, Uva matura.	Coriandrum, [?]cum, Lithosp[ermu m?], [?]ni, Oryza, [?]

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
	Symphitum, Tussilago, Malabathrum.			
Calida in gradu 2 (Hot, degree 2)	Anetum, Angelica, Apium, Arthemisia, Betonica, Camæphytis, Hypericum, Hedera, Lupulus, Melissa, Marabium, Mirrhis, Ocimum, Pimpinella, Peucedanum, Rosmarinus, Salvia, Scabiosa, Scordium, Stæchas, Parthenium.	Amoni, croci, cariophylloru m, Ericæ, melissæ, Spicæ nardi, Gelsamini, Lavendulæ, Junciodorati, Rosmarini.	Been, ficus, capparis, Nux moschata, Myristica, Nuces siccæ, Bistacia.	Anethi, Apii, [?], Ocimi, Urtic[æ], [?]
Calida in gradu 3 (Hot, degree 3)	Abrotanum, Asarum, Vitex, Amomum, Ammi, Pictamnus, Caryophyllata , Sabina, Serpillum, Thymus, Sisymbrium,	Agni casti, Epythymi, Leucoii, Schenanthæ, Periclymeni.	Baccæ Juniperi, caryophylli, carpobalsamu m, Anacardus.	Ammeos, Anisi[?], Cardamomu[m], cumini, Da[uci?], Napi, Petros[elini?], [?]

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
	Trifolium, Verbena, Urtica, Chamædris, Carthamus, Centaurium, Chelidonium, Calamintha, Coriza, Foeniculum, Juniperus, Helenium, Hysopus, Laurus, Majorana, Mentha, Nigella, Origanum, Periclymenon, Petroselinum, Pulegium.			
Calida in gradu 4 (Hot, degree 4)	Allium, Asphodelus, Sguilla, Zinziber, Nasturtium, Porrum, Lepidium majus, Piper, Marum, Tapsia, Colocasia, Ægyptia, Struthium.	Hypericonis. Piperis. Napelli.	Piper longum, Album, Nigrum.	Sinapi, Piperis, [?]
Frigida in	Atriplex,	Malvæ.	Citrini pomi	Hordeum.

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
gradu 1 (Cold, degree 1)	Fumaria (sive fumus terræ), Lapathum, Oxilapathum, Oxalis, Acetosella, Malva, Myrtus, Parietalcia.	Rosarum. Violarum.	pulpa. Cydonia. Pyra. Pruna.	Milium.
Frigida in gradu 2 (Cold, degree 2)	Blitum, Chondrilla, Lactuca, Intybum, Endivia, Cichorium, Hyacinthus, Plantago, Polygonum, Psyllium, Rhus obsoniorum, Rosa, Solanum.	Anemonum, Hyacinthi, Intybi, Nymphææ seu Nenupharis.	Cucurbita, cucumis, Galla, mala aurea, citria, Granata, Melones, Melopepones, Persica, Bruna.	Acetosæ. Cichorii. Solani.
Frigida in gradu 3 (Cold, degree 3)	Portulaca, Mandragora, Sempervivum (& omnia ejus genera), Hyoscyamus, Heliocacabus.	Balaustię. Rhododendri.	Mala aurea. Mala insana.	Papaveris, Cic[utæ?], Hyosciami, Aconiti.
Frigida in gradu 4 (Cold, degree 4)	Cicuta, Napellus, Aconitorum omnia genera, Papaver,	Hyoscyami.	Grana Strammonii baccæ & Solanorum.	Napelli, Pomorum, Man[dragoræ ?]

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
	Opium, Stramonium, Solanum Læthiferum.			
Humida in gradu 1 (Moist, degree 1)	Buglossa, Borago, Endivia, Intybum, Malva, Cichorium, Helxine, Mercurialis.	Buglossæ. Malvæ. Cichorii.	Citrini pomi pulpa, Jujubæ seu Zyzephæ.	Malvæ. Sesami.
Humida in gradu 2 (Moist, degree 2)	Atriplex, Lactuca, Cytisus, Blitum, Portulaca, Viola, Cucurbita, Cucumeris, Potamogetum, Myotis.	Nymphææ. Violarum.	Cucurbitæ, Melones, Pepones, Persica, Pruna damascena, Uva matura.	Cicer, Faba Ph[aselus?]
Humida in gradu 3 (Moist, degree 3)	Fungi, Helxine, Hieracium majus & minus, Papaver sativum, Solanum somniferum, Nenupharis (sive Nymphæa), Stratiotes	Sempervivoru m, ejusque cognatarum herbarum genera.	Cerasa. Fructus Sambuci, Ebuli.	Nymphææ seu N[enupharis?] , Strateatis aquati[cæ]

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
	aquatica.			
Humida in gradu 4 (Moist, degree 4)	Opium, Cicuta, Mandragora, Solanum, Sempervivum .	Cicutæ, Mandragoræ. Solanorum flores.	Poma Mandragoræ, Solatri Æthiopici grana.	Pomorum Mand[ragoræ , [Sola]ni Somniferi.
Sicca in gradu 1 (Dry, degree 1)	Beta, Brasica, Camomilla, Foeniculum, Hyacinthus, Malabathrum, Myrthus, Verbascum (sive Tapsus barbatus).	Buphtalmi, Camomillæ, croci, Hyacinthi, Meliloti, Rosarum.	Baccæ Juniperi.	Fabæ, Foenugra[ci?], Hordeum.
Sicca in gradu 2 (Dry, degree 2)	Arthemisia, Anethum viride, Brassica marina, Intybum, Bursa pastoris, Cassutha, Equisetum, Gingidium, Plantago, Mentha, Mentastrum, Spica Nardi, Rosmarinus.	Anemonis, Ammi, Caryophyllor um, Ericæ, Junci odorati, Lavendulæ, Lupuli, Pæoniæ, Rosmarini, Spicæ nardi, Periclymenon.	Ben, capparis, Cydonia poma, Nux cypressi, Pyra, Pistacia, Nux myristica.	Ervum, Lens, Oryza, Papaveri[s] [?]
Sicca in gradu 3 (Dry, degree 3)	Abrotanum ustum, Anethum	Balaustię, Epithymi, Gelsamini,	Charyophilli. Carpobalsam um. Galla.	Anethi, Apii, A[mmi?], Carvi,

Quality / Degree	FOLIA (Leaves)	FLORES (Flowers)	FRUCTUS (Fruits)	SEMINA (Seeds) — <i>partly cropped</i>
	ustum, Apium, Asarum, Ammi, Absynthium, Calamintha, Chamædris, Silix, Hysopus, Majorana, Marrubium, Millefolium, Origanum, Petroselinum, Pentaphyllum , Polium, Ruta, Sabina, Salix, Sisymbrium, Trifolium.	camæphytheo s, Periclymenon.		Petros[eli]nu m, Coriand[ri], [Galla] tinctorium [?]
Sicca in gradu 4 (Dry, degree 4)	Allium, Asphodelus, Squilla, Ruta sylvestris, Sinapi.	Macis.	Baccæ Oxiacanthi.	Ma[?]

Liber XII — ΠΟΛΥΜΗΧΑΝΟΣ / SIMIA NATURÆ

Sectio IV — De Arte Stalactica, sive Distillatoria

Caput III — ΙΑΤΡΙΚΟΝ

This opening of the book carries two large fold-out synoptic medical tables. The first PDF page shows the **right-hand half of Tabula II** (the *materia medica* classified by plant part: Seeds, Roots, Barks, Woods, Liquors, Juices, Gums/Resins). The two following PDF pages are the blank/show-through versos of the fold-out

plate. The final s **Tabula III** (folio 405), classifying medicinal plants, flowers, and fruits by the body part they treat and by their therapeutic action.

[Reading order used: the four PDF pages are read in file order. = right half of Tabula II (folio continues from the SEMINA-cropped left half ending the prior folio)]

Tabula II (continued) — the medicinal substances classified by plant part

[Source: this is the right-hand continuation of the synoptic table whose left columns (Plant, Flower, Fruit, and the start of SEMINA) appeared on the preceding folio. The **leftmost SEMINA column is cropped at the inner plate edge**, so only fragments of its entries are legible here; these are transcribed as far as the ink survives and flagged.]

The italic definitions in the first (header) row read:

- **SEMINA (Seeds).** "[It is] that part of the plant which, cast upon the earth, [?] produces a similar [plant]." [The full definition is cut at the plate edge.]
- **RADICES (Roots).** "The root is the base of the plant, by which it stands fast, lives, and is nourished with nutriment."
- **CORTICES (Barks).** "The bark of trees, fruits, and roots is the wrapper or skin of the plant, by which it is defended against all the injuries of the air."
- **LIGNA (Woods).** "These are in plants what the bones are in animals: a hard and firm substance, by which they stand [supported]."
- **LIQUORES (Liquors).** "A liquor is that which, when some part is cut, scarified, or bored, drips out or flows forth."
- **SUCCI (Juices).** "The juice of herbs, fruits, and seeds: it is that which is pressed out by crushing and pounding."
- **GUMMI, RESINÆ (Gums, Resins).** "A gum is a watery exudation; a resin, by contrast, is oily and inflammable."

SEMINA (cropped)	RADICES	CORTICE S	LIGNA	LIQUORE S	SUCCI	GUMMI, RESINÆ
...rum, Lini, Foenugr æci, Lithosper mum,	Althææ, Acanthi, Betæ, Buglossæ , Glycyrrhi	Maceri, Mali citri, Guajaci, Tamarisc i	Agalloch um. Xyloaloc[es]. Aspalath	Oleum Olivarum . Sapa. Vinum	Betæ. Buglossæ	Concami. Gummi Elami. Tragacan thum

SEMINA (cropped)	RADICES	CORTICE S	LIGNA	LIQUORE S	SUCCI	GUMMI, RESINÆ
Lupi[?]yz a [edge- cropped]	zæ		a			
Apii, Ervum, Erucæ, [Anisi?], Urticæ [edge- cropped]	Apii, Capparor um, Peucedan i, Pimpinell æ, Rapæ, Zedoariæ	Cinnamo mum. Thuris. Mali aurantii	Guajacu m. Ebenum. Juniperi lignum. Narcapht um	Oleum amigdala rum, Vina, omnes liquores 2 gradu calidaru m. Saccharu m	Absynthii , apii, calamint hæ, Brassiæ, Rutæ, Scordii	Bdellium, Hedera, Galbanu m, Myrrha, Mastix, Thus
..., Anisi, Aneti, cæruī[?], [Cinna]m omum, Foenicul um, [Daci?], Dauci, Nigellæ, Petroseli ni, Viticis [edge- cropped]	Acori, Asari, Ari, Dictammi , Doronici, Foeniculi , Galangæ, Helenii, Petroseli ni, Raphani	Macis arboris	Viscum quercinu m. Xilocassi a. Sassafras s	Oleum balsamin ium, vina malvatic a, omnes liquores 3 gradu calidoru m, nucum	Chelidoni æ	Olibanu m, Pix, Resina, Colophon ia, Styrax
... [Pi]peris, Hydropip eris [edge- cropped]	Allium. cæpa. costi. Porri. Pyrethri	Zinziber	Salsa perillia. Lignum Nephritic um	Oleum baccæ Lauri, stillaticiæ aquæ ex liquoribu s, & liquor. 4	Cicutæ. Aconiti. Napelli	Ammoni acum, Cedrigum mi, Belzoin. Euphorbi um

SEMINA (cropped)	RADICES	CORTICES	LIGNA	LIQUORES	SUCCI	GUMMI, RESINÆ
				gr. calid.		
[n.? [edge- cropped, illegible]	Malva	Glandium. Caliculi	Cypressi. Loti arboris	Agrestæ sive liquores ex uvis immaturis	Fumariæ, Intybi, Rosarum, Violarum	Gummi Arabicum
[edge- cropped, illegible]	Cichorii	Ibicus cortex	Santalum album	Acetum & omnes liquores herbarum in 2 gr. frigidarum	Acetosæ, Lactucæ, Plantaginis, Solani, cotileti	Betulæ
...is. Cicutæ, [Cumi]ni [edge- cropped]	Mandragoræ	Cortex castaneæ	Santalum rubrum	Omnes liquores herbarum in 3. grad. frigidarum	Cucurbitæ. Portulacæ. Sempervivi	Cerasorum
... [Solanum]um? Mandragoræ [edge- cropped]	Cicutæ. Napelli	Vesica. Staphylo dendri	Santalum citrinum	Liquores herbarum in 4. gradu frigidarum	Papaveris Opium	Pyrorum nonnulla. Camphora
[edge- cropped, illegible]	Buglossæ, cichorii, Glyzyrrizæ, Malvæ, Rapæ	Cortex betulæ	Tamariscus	Oleum papaveris	Succi herbarum 1 grad. humidarum	Betulæ
...aba	Omnes	Ribes	Ficus	Liquor	Herbarum	Thuris

SEMINA (cropped)	RADICES	CORTICES	LIGNA	LIQUORES	SUCCI	GUMMI, RESINÆ
Phaseoli [edge- cropped]	Satyrion m species & bulbosa quælibet	cortex	lignum	acaciæ, Tamarisc i	m 2 gradu humidar um	
... [Nymph æ]æ seu Nenupha ris. [herbæ?] aquaticæ [edge- cropped]	Ricini seu Palmæ Christi	Algæ Marinæ, Sambuci	Laricis	Liquor Glycyrriz æ	Herbaru m 3. gradu humidar um	Tragacan thi
... [Mandra gor]æ, Solani[?]i feri [edge- cropped]	Mandrag oræ	Arundini s cortex	Pinus	Liquor hipecistid is. Meconiu m. Opium	Herbaru m 4 gradu humidar um	Bdellium. Hederæ
... [Foe]nug ræci, Foeniculi , [...]um [edge- cropped]	Altheæ, Ari, Bryoniæ, Foeniculi , Oenanth æ, Rubiæ [tinc]toru m, Tamarisc i	Granator um pomoru m	Fraxini	Omnes liquores ex herbis 1. gra. siccis expressi	Herbaru m 1 gradu siccarum	Galbani. Mastix
...[Lens?], [Pa]paver is, Solani [edge-	Capparor um. Cichorii. Raphani	Folliculus cardui	Coccao	Liquores herbaru m 2 grad. siccarum	2 Gradu siccarum	Styracis

SEMINA (cropped)	RADICES	CORTICE S	LIGNA	LIQUORE S	SUCCI	GUMMI, RESINÆ
cropped]						
...[A]pii, Ammi, Anisum, [...] Petroseli ni, Cumi[ni], [Co]riand rum, Granum [tincto?] um [edge- cropped]	Acori, Doronici, Apii, Asari, Petroseli ni, Pentaphy lli, Trifolii	Pectinis veneris	Æschili	3 Gradu siccarum	3 Gradu siccarum	Sagapenu m. Sarcacoll a. Opopana x
[edge- cropped, illegible]	Zinziberi s. Hydropip eris	—	—	4 Gradu siccarum	4 Gradu siccarum	Euphorbi um

[The two following plate sides are the blank versos of the folded engraving — show-through staining only, no text.]

Tabula III (folio 405) — medicinal plants, flowers, and fruits by body part and action

Table. Running head/caption across the top: *Tom. II. Fol. 405. | TABULA III Philosophicæ; Quâ fructus medicinalis ad omnes humani corporis infirmitates* — "Tom. II, fol. 405. Philosophical Table III, in which the medicinal produce [to be applied] to all the infirmities of the human body [is set out]."

The table is read in columns: an index number; the **member or action** treated (in *italic*); **PLANTÆ & FOLIA** (Plants & Leaves — "which look to the various members by a quality of the 1st, 2nd, or 3rd [degree], or a specific one"); **FLORES** (Flowers); **FRUCTUS** (Fruits); and a rightmost **SEMINA** (Seeds) column cropped at the plate edge.

Within the FLORES and FRUCTUS cells, the abbreviations **C.** (= *Calefacientes*, warming) and **F.** (= *Frige facientes*, cooling) sort each cell into a warming and a cooling sub-list, following the heading of row 1.

#	Member / Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
1	Cephalica — those that look to the head	<i>Calefaciunt</i> (they warm): Betonica, Calamintha, Foeniculum, Majorana, Ruta, Salvia, Pulegium, Pæonia, Serpellum. <i>Frige faciunt</i> (they cool): Fumus terræ, Lactuca, Lupulus, Rosa, Portulaca, Plant[ago]	<i>Cal.</i> Anthos, Prunellæ, Camomillæ, Betonicæ, Lavendul[æ], Meliloti. <i>Fri.</i> Pæoniæ, Salviæ, Nenuphar, Violæ	C. Anacardi, Cubebæ, Nux Myristica. F. Rosarum Glandes	C. Foenicu[li]. F. Lactuca[?] [edge- cropped]
2	Oculos — the eyes	Euphrasia, Anisum, Foeniculum, Chelidonia, Hieracium	C. Euphrasiæ, Rosmarini, Salviæ. F. Portulacæ, Chelidoniæ	Solani, Halicacabi fructus qui cerasa Judæorum appellantur, applicata ("nightshade and the fruits of winter- cherry, which are called the Jews' cherries,	Hyoscyami posita [edge- cropped]

Member / # Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
			applied [as a poultice]")	
3 Dentes — the teeth	Tamariscus, vitis alba (quod liburnum dicitur — "which is called liburnum"), applied by the pulse to the part where the pain is; Tabacum, Hissopus, Pyrethrum, Althæa	Althæa, Colocynthis, Myricæ, Iridis, Rosmarini, Potentillæ	Nuclei Pinei, ad gingivas perfricti ("pine- kernels rubbed on the gums"); fructus Acaciæ	Sem. Synap[is] [edge- cropped]
4 Aures, Linguam — the ears, the tongue	Populus, Beta, Plantago, Cyclamen, Ruta, Lentiscus, Herba S. Trinitatis, Cucumis	Peucedani, Lauri, Lini flos, Nardi Italici	Been, Nuces Indicæ auribus inditæ ("Indian nuts placed in the ears"), Amigdalæ amaræ	Lini semen seu Ireos [edge- cropped]
5 Pectus, Pulmones — the chest, the lungs	Hissopus, Prassium, Scabiosa, Althæa, Anisum, Adiantum, Pulmonaria, Glyciriza,	C. Betonicæ, Junci odorati, Melissæ. F. Scabiosæ, Papaveris, Violarum	C. Amygdala, Avellana, cubebæ, ficus, Pineæ, Dactyli, Uva passa. F. Jujubæ, Sebesten,	C. Urticæ. F. Papaveri[s] [edge- cropped]

#	Member /	PLANTÆ &	FLORES	FRUCTUS	SEMINA (cropped)
	Action	FOLIA			
		Salvia, Tussilago, Cassia, Cinnamomu m, nuclei Pineæ		Myxaria	
6	Cor — the heart	Borago, Buglossa, Melissa, Enula, Ocymum, Rosmarinus, Crocus, Citria poma, Nardus, Caryophyllat a, Bezoartica, Aromatica omnia	C. Boraginis, Crocī, Melissæ, Spic[æ] Nard[i]. F. Nymphææ, Rosarum, Violarum	C. Mala citria, Nux Indica, nux Myristica. F. Cydonia mala, Pyza [Pira]	C. Ocymi. F. Coriand[ri], ...tos [edge- cropped]
7	Stomachum — the stomach	Juncus odoratus, Absynthium, Melilotum, Nardus, Cinamomum, Anethum, Absynthium, Serpillum, Mentha, Salvia, Souchus	C. Anthos, Junci odorati. F. Rosarum, Violarum	C. Amygdal. dulces, Been, Cariophyl. pineæ, Myristica. F. Berberis, cucurbitæ, cucumeres	C. Anisi, Cu[mini?], Amineos. F. Coriandr[i] [edge- cropped]
8	Hepar — the liver	Absynthium, Endivia, Cichorium, Hepatica, Amigdala,	C. Centaur[ei], Junci odorati, Sambuc[i], Betonicæ,	C. Cardamomu m, Dactyli. F. Cydonia, cucumeres,	C. Anisi, Asari, Asparagi, Foeniculi. F. Cucurbitæ,

Member / #	Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
		Gentiana, Cardus- benedictus, Marrubium, Centaurium, Eupatorium, Azarum, Ebulus, Scialappa	Chamomillæ, Spicæ. F. Cichorii, Nymphææ, Rosarum	cerasa	viæ, Lactu[cæ] [edge- cropped]
9	Splenem — the spleen	Absynthium, Asplenium, Scolopendriu m, Ceterach, Polypodium, Epithymum, Helenium, Genista, Oxymel, Scylliticum, Adiantum, Dictamnus, Balsamum	C. Betonicæ, Leucoii, Vitici. F. Cichorii, Endiviæ, Nymphææ	C. Amygd. amar[a], cappares, limones. F. Melopepones, Mespila, aurea poma, granata, olivæ, ribes, sorbæ	C. Anisi, Ca[...]. F. Cichorii, Urticæ [edge- cropped]
1 0	Renes & Vesicam — the kidneys and bladder	Eruca, Parietaria, Saxifragia, Spica, Urtica, Lithospermu m, Fragaria, Petroselinum , Succus Limonum, Meum, Costus, Nardus, Cappares	C. Betonicæ, Junci odorati, Malvæ, Meliloti. F. Nenupharis sive Nymphææ	C. Baccæ Juniperi, Pinei, Nuclei. F. Fraga	C. Cicer, Eruc[æ]. F. Cucurbit[æ], Endiviæ, [...] [edge- cropped]
1	Nervos,	Costus,	C. Peucedini,	Pyra, Citria	Capparis

#	Member / Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
1	Juncturas, Pellem — the nerves, joints, skin	Eupatorium, Hypericon, Ruta, Salvia, Stæchas, Nasturcium, Rosmarinus, Melilotus, Chamomilla	Anthos, camomillæ, Meliloti. F. Rosarum, Violarum	poma, Nux Indica, Nux Myristica	semen, Abro[tani?] [edge- cropped]
1	Intestina —	<i>Pro</i>	C. Verbasci,	Ficus cum	Dauci semen,
2	the intestines	<i>Dysenteria</i> (for dysentery): Balaustiæ, Papaver, Rhæas, Rheubarbar[um], Lentiscus. <i>Pro Cholicis</i> (for colic): Anisum, Petroselinu m], Ruta, Galanga, Momordica	Imperatorię, Galangæ, Anisum, Anethum. F. Brassicæ, Cyclamenis	Ruta, decoctum, <i>contra</i> <i>cholicam</i> ("figs with rue, a decoction, against colic"). Rosarum fructus, in potu, <i>contra</i> <i>dysenteria</i> ("the fruit of roses, in drink, against dysentery"). Leucacanthæ fructus, Glandes	<i>contra</i> <i>cholicam</i> [edge- cropped]
1	Purgant	Absynthium,	Flores	Cassia	Lychnidis
3	Bilem flavam — they purge yellow bile	Centaureum, Malva, Rhabarbaru m, Scamonæa, Chelidonia	Sambuci, Lachyni, Chelidoniæ, Ebuli, Cerasor[um], Persicorum	Fistula, Myrobalani, citria, Pruna, Sebesten, Tamarindi, Uva passa	Si[...], Nasturcii [edge- cropped]

#	Member / Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
1	Purgant	Sena,	Mandragoræ,	Myrobalani	Origani,
4	Bilem atram — they purge black bile	Fumaria, Cuscuta, Epithymum, Veratrum, Helleborum	Epithymi, Hellebori, Origani, Senæ	Indici	Pule[gii?] [edge- cropped]
1	Purgant	Gratiola,	Parthenii,	Colocynthis,	Pituitam
5	Pituitam — they purge phlegm	Peplion, Daphnoides, Pythinsa, Ebulus, Scialappa, Sambucus, Cyclamen, Esula, Titimali omnes	Timeleæ, Iridis, Lathyris, Heliotropii, Genistæ	cucumis asininus, Myrobalani cujuscunque speciei	Sph[...] [edge- cropped]
1	Purgant	Fumus terræ,	Fumariæ,	Citria, aurea	Pyrorum,
6	Sanguinem — they purge the blood	Balsamum, Capparis, Centaureum minus, Gentiana, Hissopus	Pyri, Pruni silvestris, Rosæ, Violæ, Rosmarini	Poma, Granata	Ci[...]rum, Euph[...]culi [edge- cropped]
1	Astringunt	Amomum,	Balaustię,	Baccæ myrti,	Granum
7	— they bind (astringents)	vitex, Bursa Pastoris, Brassica, Cypressus, Hyppocistis, Myrtus, Ruta, Punica Poma, Sempervivu m, Verbascum, Oxalis, Salix	Croci, Cichorii, Meliloti, Rosarum, Verbasci, Viticis	berberis, castanea, cornus, cydonia, glans, mespila, granata, Pyra, Persica, olivæ, nux myristica	tinct[orium], [nu]clei, acinor[um], beris [edge- cropped]

#	Member / Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
1 8	Aperiunt — they open (deobstruents)	Allium, Cæpa, Cyclaminus, Abrotanum, Absynthium, Asphodelus, Acorus, Foeniculum, Anisum, Marrubium, Petroselinum , Raphanus, Pulegium	Absynthii, Amaraci, ammios, Anthemidos, Aristolochiæ, cardui benedicti	Fructus Absynthii & Rutæ, acori, Amygdalæ, capparis	Anisum, Foen[iculi?], Marrubii, L[...] [edge- cropped]
1 9	Emolliunt — they soften (emollients)	Atriplex, Althæa, Malva, Psyllium, Melilotus, Pangratiō, Sesamum, Scylla, Viola	Acanthi, Altheæ, Buglossi, Lilii, Malvæ, Pancratii, Violæ	Cerasa, Pruna Damascena, Ficus	Foenugræci, L[...] seu Gith [edge- cropped]
2 0	Dolorem Mitigant — they relieve pain	Portulaca, Lenticula Palustris, Sempervivum, Solanum	Anethi, Camomillæ, Centaurei, Hyoscyami, Meliloti, Rosmarini	Baccæ Juniperi, Baccæ Hederæ, Ficus, Juglans, Piper	Anethi, Amo[...], Cuminum, Hyoscyami [edge- cropped]
2 1	Glutinant — they knit (wounds) together	Althæa, Anagallis, Centaureum, Chamapithis, Symphitum, Sanicula, Plantago, Tormetilla, Herniaria,	Balaustiæ, Centaurei, & quæcunque astringendi vim habent ("and whatever have astringent	Glans, Palmulæ	Ervum seu Or[obus?], Lolium, Lupin[i] [edge- cropped]

#	Member / Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
		Nicotiana, Equisetum, Isatis	power")		
2	Suppurant	Amomum,	Croci,	Amigdala	Foenugræcu
2	— they bring to suppuration	Althæa, Smyrnum	Liliorum alborum	dulcia, Baccæ Juniperi	m, Lolium [edge- cropped]
[—]	[unnumbere d row]	Abrotanum, Pimpinella, Betonica, Zedoaria, Angelica, Al[...], Cardus- benedictus, Libisticum, Ruta, Scordium	Betonicae. Citri	Baccæ Junip[eri]. Juglans, Mala citria, Piper	Amomi, Anisi, [...] trii mali, Fo[?]thri [edge- cropped]
2	Occulta	Personata,	Eandem	Vomica, Nux,	Pæoniæ,
4	Qualitate agunt — they act by an occult quality	Brassica, Hyoscyamus, Ebulus, Trifolium, Aconitum, Solanum, Penthaphyllo n, Mandragora, Veratrum	virtutem habent, cum tota herbæ substantia ("they have the same virtue, together with the whole substance of the herb")	Juglans, Mala citria, Piper	Polip[odii?] [edge- cropped]
2	Corrumpunt	Bryonia,	Chameleæ,	Solanorum	Anacardi,
5	& sunt deleteria — they corrupt and are deadly	Chamelea, Colchicum, Colocynthis, Flamula, Fungi,	Coriandri, Doronici, Flammulæ, Elaterii, Rhododendri	fructus seu Grana, fungorum omnes species	Fl[ammulæ?], Scyllæ [edge- cropped]

Member / #	Action	PLANTÆ & FOLIA	FLORES	FRUCTUS	SEMINA (cropped)
	(poisons)	Lathyris, Taxus, Thapsia & omnia venenata, & alia occulta, Rhododendru m			
2	Flatus	Absynthium,	Anethi,	Solanorum	Anethi,
6	discutiunt — they disperse flatulence (carminatives)	Allium, Anethum, Apium, Epithymum, Foeniculum, Juniperus, Spicanardi, Majorana, Origanum, Ruta	Camomillæ, Junciodorati, Spicæ nardi, Napelli, cicutæ	fructus seu grana, cappares, piper	Foen[iculi], Nigellæ, Se[...] [edge- cropped]

Reading order used: The o not run in linear order. is the *right-hand half* of the large fold-out synoptic plate (Tabula III), continuing the table whose left half (the body-part/action index column plus FOLIA, FLORES, FRUCTUS) was carried in the preceding folio (book p. 405); its right-hand columns are SEMINA, RADICES, LIQUORES/SUCCI/OLEA, LIGNA/CORTICES, GUMMI/RESINÆ, and a final *Usus & Applicatio* column. is the blank verso of that plate. is letterpress book page 405 (running head *ARS DISTILLATORIA*, signature *Eee 3*). is letterpress book page 406 (running head *LIBER DUODECIMUS, Sect. IV*), which carries the heading and opening of Tabula IV. Reading sequence: (book 405) → (book 406), with the fold-out plate belonging to the Tabula III material that the page-405 text refers back to.

Tabula III (Synoptic), continued — right-hand columns

[The fold-out plate carries the right-hand six columns of the synoptic materia-medica table whose left-hand index column (the affected body part / therapeutic action) appears on the preceding folio. The running headline across the top reads:] "...[infirm]itates curandas exhibetur juxta Plantarum unicuique

appropriatam Naturam & Proprietatem." — "...is set out for curing illnesses according to the Nature and Property proper to each Plant." The final column is headed "**Usus & Applicatio:**" ("Use & Application:"), and the rows of that column run continuously down the whole table rather than aligning one-to-one with the medicinal rows.

The plate has **no row labels of its own** (those are the index column on the left half). The 26 rows below are given in printed top-to-bottom order so the collation step can align them with the index column from the preceding folio. The leftmost column here (SEMINA) is fully present; the columns are not cropped at the plate edge on this half.

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
C. Foeniculi, Majoranæ. F. Lactucæ, Papaveris.	C. Foeniculi, Pœoniæ. F. Sonchus.	C. Apii, Agrestæ, Calaminth æ, Ehymenth æ [recte: Thymenth æ?][?], Rutæ, Scordii. F. Acetosæ, Lactucæ, Portulacæ.	Agallochu m, Xylaloes, Aspalathi, Guajaci, Juniper. Viscum Quercinum .	Laccæ, Tragacanth i, Thus, Mastix, Myrrha, Galbanum.	<i>Sumuntur hæc omnia vel — Decocto simplici,</i> ("These are all taken either — as a simple decoction,")
Hyoscyami semen cum farina imposita.	Anemonis radix emplastrat a, Radix Aconiti, Pardalianc his.	Hierasii [Hieracii] succus, Euphrasiæ, aqua Betonicæ, anisi, chelidoniæ .	Guajacum, Santalum.	Aqua rosacea in qua Thus vigesies accensum fuerit extinctum .	<i>Composito.</i> ("as a compound.")

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
Sem. Synapis. Capparis semen.	Iridis, Lencacant hæ [Leucacant hæ], Ranunculi, Lepidii radix collo suspensa, Asparagi.	Laserpitii, Peucedani succus, Ana[?] gallidis [Anagallidi s] succus.	Nephriticu m lignum, Laricis.	Thus, Mastix, Laricis resina, Terebentin a, Balsamum.	<i>In salem redacta.</i> ("reduced to a salt.")
Lini semen emplastrat um, Iridis seu Ireos, Psylii.	Asphodeli, Cyclaminis, Eringii radix, Helenii, Aristolochi æ, Asari.	Altheæ succus & omnia olea discutienti a, & amigdalor um amarorum.	Omnia ligna & cortices quæ discutiunt.	Laricis, Balsami, Thuris, Mastichis, Styracis.	<i>In aquas destillata.</i> ("distilled into waters.")
Urticæ. Papaveris albi, Violarum.	C. Aristolochi æ, Enulæ, Glyzyrrhiz æ, Ireos.	Omnes illi succu & olea Herbarum quæ respiciunt caput.	Xyllocasia [Xylocassia], ligna aromatica, Cinamomu m, cassia fistula.	Styrax, Olibanum, Thus, Myrrha.	<i>In pulverem contrita, per tragemata, Tabellas.</i> ("ground into a powder, by way of sweetmeat s and lozenges.")
Ocymi. Coriandru	C. Been album &	Omnes illi succu &	Cinamomū, fistula	Ceraforum [Cerasoru	<i>Vel in Emplastra</i>

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
m, Sem. Citri, Acetos.	rubrum, Buglossæ, Zedoariæ.	olea quæ respiciunt cor.	cassia, loti arboris, Limonum, Pomorū aureo.	m], Styrax, Cedri, Belzoini.	<i>coacta.</i> ("Or compacted into plasters.")
Anisi, Cumini, Cardamom um, Amineos. Coriandru m præparatu m.	C. Foeniculi, Calami aromatici, Caryophyll atæ, Galangæ, Raphanus, zinziber. Sonchi omnes.	Omnia illa olea & succī quæ respiciunt stomachu m, Pomorum Appiorum.	Cortex capparum.	Eædem quæ cor respiciunt, cedri, Styrax, Olibanum.	<i>In decocta alterata.</i> ("Into altered decoctions. ")
Anisi, Amenos, Amomi, Apii, Asparagi, cumini, carvi, Dauci, Foeniculi. Cucurbitæ, Cucumer. Endiviæ, Lactucæ.	C. Apii, Asparagi, Foeniculi, Petroselini, Rhaponticu m.	Cremor seminis Lini, Foenu greci , Psylli, Cichorii, Endiviæ.	Guajacum, Sanctum, Sandalum citrinum.	Tragacanth um, Terebinthi num.	<i>In extracta sublimata.</i> ("Into sublimated extracts.")
Anisi, Carvi, Nasturcii. Cichorii,	C. Acori, Apii, Asparagi, Foeniculi,	Asplenii, cetrach, scolopendr ii.	Cortex Loti.	Resina, Pix, Colophonia , Styrax.	<i>In Conservas, Condituras, Syrupos,</i>

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
Erucæ, Saxifragiæ, Urticæ.	Gentianæ. F. Cichorii, Endiviæ, Hepaticæ.				<i>Electuaria</i> , [bracketed:] <i>condensata</i> . ("Into conserves, preserves, syrups, electuaries — thickened.")
Cicer, Erucæ, Saxifragiæ, Urticæ. Cucurbit. citrulli, cucumer. Endiviæ, Portulacæ, Scariolæ.	Petroselini, Saxifragiæ, Pentaphilli, Apii, Fragariæ.	Hypericoni s, Hypocistis & quæ respiciunt renes & vesicam.	Lignum Nephriticu m, lignum Ficus, Laricis.	Caphura seu camphora, Gummi Arabicum, Gummi ceraforum, Betulæ.	<i>In usum Gargarism atum</i> . ("For use in gargles.")
Capparis semen. Spinæ albæ semen, Abrotani semen.	Imperator æ Radix, Gentianæ, Satyrii, Helenii, centaurii, cardamomi .	Oleum Irinum, Lavendulæ , Vinum, Scyllinum oleum ex Sem. lini. Oleum Liliorum.	Galbanum, Sagapenu m, Terebinthi, Resina Laricis.	<i>Caput purgiorum</i> . ("Head of purges.") [thus printed; apparently for <i>Caput purgiorum</i> in the sense	

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
				"chief of the purges."]	
Dauci semen, Ferulæ semen, <i>contra cholicam</i> [against colic] Ligustici.	Chelidoniæ , Ideæ radix <i>in potu</i> , Altheæ, Nymphææ, Asclepiadis .	Omnia olea ventri applicata, oleum ex colocynthi de, Oleum Senarum, Peucedani succus in ovo haustus.	Maceris cortex in potu, Punici mali tosti.	Omnia olea forinsecus illita ventri.	<i>Fomentoru m.</i> ("Of fomentatio ns.")
Lychnidis Silvestris, Androsemi , Nasturcii.	Gratiolæ Radix. Pycnocomi, Mirabolani .	Aloe, Manna, Scamonea.	Esulæ cucumeris silvestris.	Sagapenu m.	<i>Embrochar um.</i> ("Of embrocatio ns.")
Origani, Pulegii.	Mandragor æ, Hellebori, Sparti.	Hellebori seu veratri albi præparat.	Bryoniæ, colocynthis .	Serapinum , Sarcacolla.	<i>Infessuum.</i> ("Of sitz- baths.")
<i>contra vitam</i> Sphondilii semen. [thus printed; <i>contra vitam</i> "against life,"	Cyclaminis, Scyllæ.	Bryoniæ, Scialappæ.	Sambuci, Ebuli.	Opopanan [Opopanax], Elaterium.	<i>Pessorum, Balneorum.</i> ("Of pessaries, of baths.")

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
apparently in error or an idiosyncrat ic note]					
Citriorum, Aurantioru m, Euphrasiæ, Anisi, Foeniculi.	Radix Fumariæ, Petroselini, Sonchi.	Omnes succī & olea herbarum quæ trahunt Pituitam.	Betulæ.	Myrrha, Styrax, Manna.	<i>Lotionum.</i> ("Of washes.")
Granum tinctorum, Miliū, Nuclei, acinorum, Portulacæ, Bereris [Berberis].	Cyperī, Bistortæ, Gentianæ, Pentaphylli , Rhapontici.	Absynthii, Acatia [Acacia], Calami Aromatici, Gingidii & Hedisari.	Omnes cortices & ligna tum arborum tum plantarum adstringent ium.	Tragacanth um, Manna Thuris.	<i>Dentifricior um.</i> ("Of dentifrices. ")
Fœnum [?], Foeniculu m, Ligustici, Marrubii, Libanotis.	Altheæ sive Hibisci, Malvæ, Allium, cæpa, curcuma, rhaponticu m.	Betæ albæ, Malvæ.	Salignum, Laricinum.	Resinæ omnes.	<i>Illitionum.</i> ("Of liniments / smearings. ")
Foenugræc i, Lini, Malvæ, Nigellæ seu	Ireos, Altheæ, Malvæ.	Omnia Olea.	Laricis, Taxi, Abietis, Ligna.	Colophonia . Styrax. Resinæ omnes.	<i>Infusionum</i> . ("Of infusions.")

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
Gith.					
Anethi [?], Amomi, cardomom um [cardamo mum], Cuminum, Dauci, Ervi, Lini, Hyoscyami , Panicū, Petroselinū .	Acori, Dauci, Eringii, Ireos, Mandragor æ, Ovonidis [Ononidis].	Liliorum, Portulacæ, Sedi sive Sempervivi .	Cortices ex malis appiis.	Thus, Mastix, Styrax, Galbanum.	<i>Clysterum.</i> ("Of clysters / enemas.")
Ervum seu Orodus [Orobis]. Lupinus.	Aristolochi æ, Dracunculi , Polygonat æ, Symphita omnis generis confolidæ [consolidæ].	Aloes, altheæ, Betonicæ, Symphitor um omnium succus.	Guajacum, Tacamac.	Omnes Resinæ & Gummi.	<i>Emplastror um.</i> ("Of plasters.")
Foenugræc um, Hordeum, Lini, Lolium.	Altheæ, Bryoniæ, Liliorum.	Psilii, Malvæ, Maledentiu m [Maledentu m?][?] herbarum	Cortices Sambuci.	Gummi ceraforum, Betulæ, Acaciæ.	<i>Ceratorum.</i> ("Of cerates / waxed salves.")

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
		succi, omnia olea.			
Cardamom i, Anisi, Cardamom um, Citrali [Citri][?], Foeniculi, Oxymarati æ [Oxymyrrh inæ?][?].	Angelicæ, Zedoariæ, Aristolochi æ, cyperi, costi, foeniculi, Gentianæ, carolinæ.	Betonicæ, Angelicæ, Pimpinellæ , Scorzoner æ, Rutæ, Salviæ, Car[ui?] [cropped — text continues].	Cortex Thuris, Cinamomu m [Cinamomi].	Gummi prunorum, Balsami.	<i>Unguentor um.</i> ("Of ointments.") [This row is unnumber ed in the source; recorded verbatim per its printed position — it correspond s to the unnumber ed index row 23 noted in the preceding folio.]
Anethi [?], Polipodii, Scolopendr ii.	Oenanthes, Helenii, Scialappæ.	Succus Polygoni. Humor in folliculis Ulmi.	Lignum Laricis, Ficus, Viscus Quercinum .	Gummi Leucacant hi.	<i>Colyrriorum</i> . ("Of collyria / eye- salves.")
Cardui [?],	Cicutæ,	Omnes	Napelli	Gummi	<i>Apophlegm</i>

Semina (Seeds)	Radices (Roots)	Liquores, Succi, Olea (Liquids, Juices, Oils)	Ligna, Cortices (Woods, Barks)	Gummi, Resinæ (Gums, Resins)	Usus & Applicatio (Use & Application)
Flammulæ, Genistæ, Scyllæ.	Napelli, Aconiti, omnium venenatar um herbarum.	Succi & Liquores Venenatar um herbarum.	arborescen tis, cortex. Taxi.	Fraxini, Taxi.	<i>atismos.</i> <i>Odorament</i> <i>orum.</i> <i>Suffmentor</i> <i>um</i> <i>[Suffimento</i> <i>rum]</i> . ("Apophleg matisms [phlegm- drawing remedies]. Of scented preparatio ns. Of fumigation s.")
Anethi [?], Foenugræc i, Lini, Dauci, Gith [?], Sesami.	Apii, acori, foeniculi, Dauci, Galangæ, Spicæ celticæ, Nardi, Peucedani.	Liquores & Succi omnium herbarum discutienti um.	Nephriticu m.	Thus, Mastix.	[No further <i>Usus</i> entry printed in this final row of the column.]

ARS DISTILLATORIA. [Book p. 405]

[Running head: *ARS DISTILLATORIA* ("The Art of Distillation"). The left margin carries Greek technical terms keyed to each medicinal-virtue heading.]

[a remedy] that aids generation. Temperately warm, moist, and emplastic [softening/plaster-like].

[Margin: Μελαναγωγόν.] **Melanagogue** — that is, a medicine drawing off black bile.

[Margin: Νεφριτικόν.] **Nephritic** — what is suited to the kidneys.

[Margin: σηπτικόν.] **Putrefacient** — Greek σηπτικόν (*sēptikon*, "septic, putrefying"): what is most hostile to sharpness [acrimony] and to the native heat, and which either drives that heat off or destroys its balance. Such are the biting and acrid remedies.

[Margin: σαρκωτικόν.] **Sarcotic** — Greek σαρκωτικόν (*sarkōtikon*, "flesh-forming"): that is, flesh-generating, which beyond the bite [of the wound] cleanses away the filth of wounds so that it may not hinder their healing.

[Margin: ύπνωτικόν.] **Soporific** — that is, Greek ύπνωτικόν (*hypnōtikon*, "hypnotic, sleep-inducing"); such as opium, a species of nightshade [*solanum*].

[Margin: πταρμικόν.] **Sternutatory** — Greek πταρμικόν (*ptarmikon*, "causing sneezing"): which provokes sneezing, and expels the excrements of the head — both those that lodge in the brain and those that cling about the meninges.

[Margin: διουρητικόν.] **Uretic** — the same as **diuretic**: which opens the passages for urine and clears away other obstructions.

[Margin: θεραπευτικόν.] **Vulnerary** — Greek θεραπευτικόν (*therapeutikon*, "healing"): which, taken internally, aids the consolidation [healing-together] of wounds.

An **anodyne** is a medicine that calms and soothes pains.

With these preliminaries set down, it seemed good to lay before the reader's eyes — in the Synoptic Table that follows — which plants, leaves, flowers, fruits, seeds, roots, oils, juices, woods, and so forth bring a remedy to each of the diseased members, and with what virtues they are endowed. This material has been collected here from the better medical authorities. The use of the table is self-evident. Suppose, for instance, you wish to know which medicines purge bile: look in the first column (*bile-purging*); then, proceeding along the lateral and transverse series, you will find in each column — under leaves, flowers, fruits, juices, and the rest — the medicines suited to your purpose. As was said above, these medicines can, by the Spagyric art, be resolved into salts, waters, oils, and spirits, or else be administered both internally and externally in the form of decoctions, conserves, juleps, syrups, and the other modes we taught in the first Table. See **Table I**.

§ III.

An account of the fourth Table. [Tabulæ quartæ expositio.]

By what art the ancients and their successors came to know the virtues of herbs, we set out in the preceding Books together with a Synoptic Table of all the simple medicines. Now, however, we shall present in this place another Table, which we have drawn from the German books of the Chymists Tannhauser [Tannhäuser], Tabernæmontanus [Tabernaemontanus], and Carichter [Carrichter]. These authors took a different road: by the aid of the Spagyric art they arrived, with a truly happy success, at a knowledge of the true and genuine virtue and efficacy of plants. They did so in the following manner, through long and difficult experiment.

First, they investigated the proper time at which each plant ought to be gathered, and when — as the saying goes — the virtue of each several plant is at its height [*in auge*]. For they knew that plants are by no means to be gathered all at the same time, plants which differ so greatly in virtue and quality. For just as all plants are composed of diverse parts — that is, roots, flowers, fruits, seeds, and so on — so too they vary among themselves; and accordingly one must await the opportune time for gathering each part. Hence, with singular diligence, they observed by astronomical knowledge the course of the Sun and Moon as they pass through the twelve signs [*dodecamoria*] of the Zodiac, together with the motion of the planets and their mutual aspects to one another — aspects which do not hold themselves the same everywhere, but according to the constitution of the horizon proper to each Region.

[Book p. 406] [Running head: *LIBER DUODECIMUS, Sect. IV.* ("Book Twelve, Section IV.")]

These things, then, being duly and lawfully observed, they selected the plants of more powerful virtue. When each of these had been resolved, with truly the highest skill, into its three principles, the virtues of salt, sulphur, and mercury inherent in each plant — discovered by the benefit of the Spagyric art — they resolved into certain analogous oils, essences, and salts; and by what method and on what principle, this will appear in what follows. Having obtained the saline-sulphureous-mercurial grades of each plant, they turned to investigating the hidden powers and properties of each plant; and this study accomplished, they at last founded a new Botanical doctrine — one more certain than all the others already related above, and confirmed by manifold experience, and most apt for medical uses, inasmuch as in them the astral virtue and influence corresponded

exactly with the planetary stars set under them. For just how much the astronomical reckoning of time contributes to the opportune gathering of herbs, learn from the following experiment.

EXPERIMENT. [*Experimentum.*]

[Margin: A matter of great moment in things subject to the constitution of the time.]

Cut from a tree, while it is still fixed in the earth, a little piece, at the time when the plant's power most exerts itself; and another little piece from the same tree, exactly equal and matching the first, but at a time contrary and opposed to the time at which you cut the first. Weigh these two pieces in an exact balance, and you will find the first far lighter, on account of its having been cut at a drier season; the second heavier, on account of the moister constitution of its season — as experience teaches in all woods. Indeed, if you cut one little portion of the same plant from its southern side and another from its northern side, you will see the one outweigh the other, even though equal in size and thickness — the northern outweighing the southern; the reason for which we shall assign later. The same you will find in digging up mud, clay, and the other earthy clods. For vessels (as I have learned from potters) are much more durable in the fire when made from clay dug up at the opportune time than from clay dug at the wrong, or wholly contrary, time. And it is likewise plain in the felling of timber for building: when the Moon is set in an unfavourable place, all of it lies open to worms, as long experience has taught; which does not happen when the Moon is set in a favourable place.

The Table is divided into five columns. [Margin column-key:] The first contains the names of the plants; the second, the time of gathering; the third, the grades of the three principles; the fourth, the analogues of the quintessences and salts to the three principles; the fifth sets out the knowledge of the medicinal powers — as follows.

TABULA IV. SYNOPTICA.

Plantarum in sua tria principia resolutarum. ("Of Plants resolved into their three principles.")

Nom. Plant. (Name of Plant)	Collectio (Gathering)	Compositio (Composition)	Resolutio (Resolution)	Vires (Powers)
<i>Imperatoria mas.</i> <i>Meisterwurz.</i> <i>Ostrutium.</i> (Masterwort, male)	Die 22. Julii. ☉ 10. g. ♌ [Leo]. ☽ 23. g. ♈ [Aries]. (22 July; Sun at 10° Leo; Moon at 23° Aries)	Sulphuris 6. p. / Salis 3. / Mercur. 3.	Oleum. / Essentia. / Sal. (Oil / Essence / Salt)	Calefacit nervos. / Confortat musculos. / Confervat [Conservat] memoriam. (Warms the nerves / Strengthens the muscles / Preserves the memory)
<i>Imperatoria foemina.</i> <i>Panax</i> <i>Heracleonis.</i> (Masterwort, female; All-heal of Heracles)	6 Jul. ☉ 26. g. ♋ [Cancer]. ☽ 12. g. ♍ [Virgo].	Sulphuris 6. / Sal. 2. / Mercur. 4.	Oleum. / Magisterium. / Sal. (Oil / Magistery / Salt)	Calefacit. / Emollit. / Aperit. (Warms / Softens / Opens)
<i>Imperatoria quæ</i> <i>Spondylium</i> <i>dicitur,</i> <i>Branca</i> <i>Ursina. Olus</i> <i>atrum.</i> (The masterwort called Spondylium,	12 May. ☉ in ♊ [Gemini]. ☽ in ♊ constituta. (12 May; Sun in Gemini; Moon set in Gemini)	Sulph. 4. / Sal. 2. / Mercur. 6.	Oleum. / Extractum. / Sal. (Oil / Extract / Salt)	Calefacit. / Discutit. / Aperit. (Warms / Disperses / Opens)

Nom. Plant. (Name of Plant)	Collectio (Gathering)	Compositio (Composition)	Resolutio (Resolution)	Vires (Powers)
Bear's-breech [Branca Ursina]; Alexanders)				
<i>Angelica mas.</i> (Angelica, male)	16 Jul. ☉ in ♌ [Leo]. ☽ in ♌.	Sulph. 9. / Sal. 1. / Merc. 2.	Oleum. / Arcanum Magist. / Sal. (Oil / Arcanum- Magistery / Salt)	Calefacit. / Discutit. / Expellit. (Warms / Disperses / Expels)
<i>Angelica fœmina.</i> (Angelica, female)	6 Junii. ☉ in ♊ [Gemini]. ☽ in ♋ [Cancer].	Sulph. 7. / Merc. 4. / Sal. 1.	Oleum. / Anthos Flores. / Sal. (Oil / Anthos- Flowers / Salt)	Attenuat. / Aperit. / Consumit. (Thins / Opens / Consumes)
<i>Angelica, Levasticum.</i> (Angelica; Lovage)	6 Sept. ☉ 28. g. ♍ [Virgo]. ☽ 24. g. ♋ [Pisces].	Sulph. 8. / Sal. 2. / Merc. 2.	Oleum. / Liquor. / Sal. (Oil / Liquor / Salt)	Aperit. / Expellit. / Instaurat. (Opens / Expels / Restores)
<i>Suffrutex, ferula Libanotis.</i> (Shrub, the ferula Libanotis [rosemary- frankincense])	20 Aug. 10. ♎ [Libra]. ☽ 20. g. ♎.	Sulph. 6. / Merc. 4. / Sal. 2.	Oleum. / Tinctura. / Sal. (Oil / Tincture / Salt)	Calefacit. / Siccat. / Conservat. (Warms / Dries / Preserves)
<i>Ferula fœmina, Thapsia hyppapion</i>	☉ in ♉ [Capricorn]. ♀ in ♊ [Aquarius]. ☽	Sulphur. 8. / Sal. 3. / Merc. 1.	Hazar. / Turbith. / Sal. (Hazar [bezoar/calcul	Calefacit. / Extrahit. / Purgat. (Warms /

Nom. Plant. (Name of Plant)	Collectio (Gathering)	Compositio (Composition)	Resolutio (Resolution)	Vires (Powers)
<i>[hippopion].</i> (Ferula, female; Thapsia)	in ♌ [Libra].		us] / Turbith / Salt)	Draws out / Purges)
<i>Ferula, quæ Narthex dicitur.</i> (The ferula called Narthex)	22 Sept. ☉ in ♌ [Libra]. ☽ in ♌.	Sulphur. 8. / Sal. 3. / Merc. 2.	Oleum. / Liquor. / Sal. (Oil / Liquor / Salt)	Calefacit. / Penetrat. / Expurgat. (Warms / Penetrates / Cleanses out)
<i>Pimpinella, quæ aliàs Petrapium [Petroapium] seu saxifraga hircina dicitur.</i> (Pimpinella, otherwise called Petrapium or goat's saxifrage)	15 Oct. ☉ in ♍ [Scorpio]. ♂ in ♌ [Libra].	Sulphur. 7. / Sal correct. 4. / Merc. 2.	Elixir. / Oleago [Oleago]. / Sal corrosivum. (Elixir / Oleago [oily preparation] / Corrosive salt)	Calefacit. / Solvit. / Expellit. (Warms / Dissolves / Expels)
<i>Pimpinella vera.</i> (True pimpinella)	16 Aug. ♂ in ♍ [Virgo]. ☽ in mans[ione]. (16 Aug; Mars in Virgo; Moon in [its] mansion)	Sulphur. 6. / Sal. 5. / Merc. 2.	Elixir. / Oleago. / Sal acre. (Elixir / Oleago / Sharp salt)	Calefacit. / Expellit. / Attenuat. (Warms / Expels / Thins)
<i>Pimpinella nigra quæ Subastrella dicitur.</i> (Black pimpinella,	Sept. ♍ [Scorpio] ascend[ente]. ☽ in ♌ [Libra]. (Sept.,	Sulphur. 5. / Sal. 5. / Merc. 3.	Oleago. / Elixir. / Sal. (Oleago / Elixir / Salt)	Sanat. / Conservat. / Instaurat. (Heals / Preserves /

Nom. Plant. (Name of Plant)	Collectio (Gathering)	Compositio (Composition)	Resolutio (Resolution)	Vires (Powers)
called Subastrella)	Scorpio ascending; Moon in Libra)			Restores)
<i>Daucus</i> <i>Germanicus</i> , <i>Erlach dictus</i> . (German carrot, called Erlach)	6 Junii. ☉ in ♋ [Cancer]. ♂ in ♋.	Sulphur. 6. / Sal. 3. / Merc. 3.	Oleago. / Balsamum / Sal. (Oleago / Balsam / Salt)	Confervat [Conservat]. / Roborat. / Sanat. (Preserves / Strengthens / Heals)
<i>Daucus</i> <i>Creticus</i> . <i>Daucion</i> . (Cretan carrot; Daucion)	☉ in ♍ [Virgo]. ♀ in ♈ [Aries]. ♀ in ♎ [Libra].	Sulphur. 7. / Sal. 3. / Merc. 2.	Balsamum. / Oleago. / Sal. (Balsam / Oleago / Salt)	Calefacit. / Siccat. / Expellit. Aperit. (Warms / Dries / Expels. Opens)

Diagram. Full-page engraved plate (folio marked *Tom. 2. Fol. 406.* at upper right). The plate is titled, on a banner held by two flying putti across the top: "**The Sympathetic Type of the Microcosm with the Macrocosm**, that is, expressing the *signatures* of plants together with the several members of the human body." At the center stands a nude male figure, arms outstretched, the torso opened to show the internal organs (heart, stomach, intestines). The figure is enclosed in a great oval. An inner circular zodiac band surrounds the body, its twelve signs marked by their glyphs; a set of radial lines runs from the body outward to a ring of oval cartouches around the rim, each cartouche naming the plants whose signature corresponds to a particular bodily part. Each radial line is labelled with the bodily destination it points to (*ad Caput* = "to the head," *ad Oculos* = "to the eyes," etc.).

Below the navel, a horizontal row of planetary/metal glyphs is engraved across the abdomen: ♄ ♃ ☉ [or the symbols for the seven planets] ♀ ... flanked by ♂ on either side (the alchemical planet-metal series across the belly). These are small

and partly worn; rendered here as the planetary series but several individual glyphs are indistinct [?].

Radial destination labels (reading clockwise from the top), each with the plants assigned to it:

- **ad Caput** ("to the head") — top center.
- Cartouche (top center): *Pæonia, Iuglandes, Squilla* — "Peony, Walnuts, Squill."
- Cartouche (upper right of head): *Hyssopus, Melanthium, Tussilago* — "Hyssop, Black-cumin [*Melanthium*], Coltsfoot [*Tussilago*]."
- Cartouche (upper left of head): *Flos Euphrasiæ, Moracinum, Flos Potentillæ* — "Flower of eyebright [*Euphrasia*], [mulberry?] [?], flower of cinquefoil [*Potentilla*]."
- **ad Oculos** ("to the eyes") — upper, between head and left arm.
- Cartouche: *Dentaria, Hyoscyamus, [semen?] Acini, mali punica* — "Toothwort [*Dentaria*], henbane [*Hyoscyamus*], [seed of] grape-stones, pomegranate" [several words abraded] [?].
- **ad Aures** ("to the ears") — left side.
- Cartouche: *Folia Alni, Cochylia et Ostrea* — "Alder leaves, shellfish [*cochleae*] and oysters."
- Cartouche: *Pyrola tubularia, Coriaria* — "[*Pyrola*] tubular, sumac [*Coriaria*]" [?].
- **ad Guttur** ("to the throat") — left.
- Cartouche: *Aquatica, Lichen, Fungus, Barbinus, Iscoraria* [readings uncertain] [?].
- **ad Hepar** ("to the liver") — left, by the lower trunk.
- Cartouche: *Lapis in Rembus, Animal humanis venatus* [abraded] [?].
- **ad calculos Renum** ("to the stones of the kidneys") — lower left.
- Cartouche: *Saxifraga, Salamandra, Chelidonia* [readings uncertain] [?].
- **ad [Pudenda?]** / lower-left cartouche: *Cithea, Balsamum* [?].
- Lower center / **usus** region cartouches: *Omnium Subterraneorum genera Plantarum, Sanies; Plantago; Hermodactylus; Bulbus, Sambucus, Radix Mechoacana; Aspletum, Ruta, [?] Capraria, Ranula; [?] Laguma; Tribigmomon* [readings highly uncertain across the bottom band] [?].
- **ad Cor** ("to the heart") — right side, by the chest.

- Cartouche: *Cypris*, *Cardiaca*, *Melissa*, *Caryophyllata*, *Verbena* [?] — "[?], Motherwort [*Cardiaca*], Balm [*Melissa*], Avens [*Caryophyllata*], Vervain [*Verbena*]."
- **ad Renes** ("to the kidneys") — right.
- Cartouche: *Lupus salictarius* [*Humulus*], *Filix*, [?] *Portulaca*, *Restis anvulum* [?].
- Cartouche: *Colutea aromatica* [?], *Cassia fistula* [?].
- **ad Pulmonem** ("to the lungs") — upper right.
- Cartouche: *Pulmonaria*, *Lichen*, *Galanga* [?].
- Cartouche: *Palma Christi*, *Radices* [?] *olim aromaticae*; *Pulmonaria vulgaris* [?].
- Right-side lower cartouches: *Chondrilla* [?], *Hyperici* [?], *nuphar* [?]; *Assa*[*foetida*?], *Ruta*, [?] *Cortex Laguma* [readings uncertain across the right band] [?].

Zodiac glyphs around the inner band (clockwise from top): ♈ [Aries], ♉ [Taurus], ♊ [Gemini], ♋ [Cancer], ♌ [Leo], ♍ [Virgo], ♎ [Libra], ♏ [Scorpio], ♐ [Sagittarius], ♑ [Capricorn], ♒ [Aquarius], ♓ [Pisces].

Caption beneath the figure, **The use of this figure:**

In the circuit of the figure, plants are arranged to correspond to each member of the human body; these are indicated by lines drawn to the said members. For example: should you wish to know which plants suit ailments of the head, follow the line drawn from the crown of the head, and it will point you, in the circuit, to *Peony*, *Walnut*, and *Squill* — which, since they express the signature of the head, are likewise judged by physicians to be the most potent remedies against diseases of the head. Proceed in the same way with the rest. Since these are perfectly straightforward, I did not think they needed any further exposition.

[Many of the peripheral cartouche labels are engraved in very small type and are abraded at this scan resolution; the plant lists above are transcribed as far as legible, with [?] on uncertain readings.]

[The verso of the plate is blank.]

ARS DISTILLATORIA. [The Art of Distillation.] — 407

[Continuation of the *Tabula IV Synoptica*: each plant is given with the date and astrological circumstances of its **Collection** [Collectio], its **Composition** [Compositio] into the three principles Sulphur / Sal (Salt) / Mercury with their grade-numbers, its **Resolution** [Resolutio] products, and its **Powers** [Vires].]

Name of plant	Collection	Composition	Resolution	Powers
Daucus magnus, Italicus [great Italian carrot]	16 July, ☉ in ♌ [Leo], ♀ in ♎ [Libra]	Sulphur 5; Sal 3; Merc. 4	Balsam; Oily; Salt	Nourishes; Strengthens; Heals
Foeniculum hyppomarathon [horse-fennel]	14 July, ♂ in ♎ [Libra], ☽ in ♍ [Virgo]	Sulphur 8; Sal 1; Merc. 3	Antidote; Oil; Salt	Moves; Dissipates; Expels
Foeniculum foemina, montanum, <i>Berwurtz</i> [female fennel, mountain]	13 July, ♂ in ♌ [Leo], ☽ in ♋ [Cancer]	Sulphur 9; Sal 2; Merc. 2	Oil; Antidote; Salt	Dissipates; Expels; Opens
Foeniculum Hortense [garden fennel]	☉ ♂ ☽ in ♌ [Leo]	Sulphur 8; Sal 2; Merc. 3	Oil; Antidote; Salt	Dissipates; Expels; Warms
Cuminum mas, seu Romanum [male, or Roman, cumin]	2 Sept., at the rising of Arcturus [Arctur. Orient.], ☽ in ♌ [Leo] & ♈ [Aries]	Sulphur 7; Sal 4; Merc. 2	Arctoicum [a "northern" preparation]; Liquor; Alkali	Warms; Attenuates; Expels
Cuminum foemina, seu	21 July, ☉ ☽ above the	Sulphur 6; Sal 3; Merc. 3	Arctoicum; Liquor; Alkali	Warms; Preserves;

Name of plant	Collection	Composition	Resolution	Powers
Germanicum [female, or German, cumin]	horizon [<i>supra</i> <i>horizont.</i>]			Expels
Cuminum Lobellii, Cuminum Thebaicum [Lobel's cumin, Theban cumin]	14 Oct., ♂ in ♈ [Aries], ☽ in ♌ [Leo]	Sulphur 5; Sal 5; Merc. 3	Arctoicum; Alkali; Liquor	Warms; Dissipates; Opens
Petroselinum mas, seu Macedonicum , Olus atrum [male, or Macedonian, parsley; alexanders]	20 Apr., ☉ ☽ in ♉ [Taurus]	Sulphur 8; Sal 2; Merc. 2	Glissus [a mucilaginous extract]; Oily; Sallena [?]	Warms; Consumes; Expels
Petroselinum foem. Alexandrinu m [female, Alexandrian parsley]	26 May, ☉ in ♊ [Gemini], ☽ in ♎ [Libra]	Sulphur 7; Sal 3; Merc. 2	Glissus; Oily; Salt	Warms; Dissipates; Expels
Petroselinum Lobel. Germanicum hortense [Lobel's parsley, German garden]	10 May, ☉ in ♉ [Taurus], ☽ in 3rd "house"? [<i>D in</i> <i>3. m.</i>] [?]	Sulphur 7; Sal 3; Merc. 3	Glissus; Oily; Salt	Warms; Penetrates; Expels
Charyophyllu m petroselinum,	28 Jan., ☉ in ♋ [Cancer], ☽ in ♎	Sulphur 4; Sal 4; Merc. 4	Diaphoretic; Oily; Salt	Dissipates; Warms; Expels

Name of plant	Collection	Composition	Resolution	Powers
agreste, Daucalis [clove- parsley, wild]	[Capricorn]			
Charyophyllu m foem. Mi. [female clove- wort]	☉ in ♎ [Libra], ♂ in ♋ [Pisces], ☽ in ♍ [Virgo]	Sulphur 5; Sal 4; Merc. 4	Diaphoretic; Oily; Salt	Warms; Dissipates; Expels
Charyophyll. Lob. Gingidium Carifolium [Lobel's clove- wort; Gingidium; chervil]	30 July, ♂ in ♋ [Cancer], at full Moon [<i>Luna plena</i>]	Sulphur 5; Sal 4; Merc. 4	Diaphoretic; Oil; Salt	Dissipates; Expels; Heals
Cervaria nigra mas [male black hartwort]	14 Sept., ☉ in ♍ [Virgo], ☽ in ♋ [Cancer]	Sulphur 7; Sal 3; Merc. 3	Themoxinth [?]; Essence; Salt	Warms; Extracts; Dries
Cervaria alba foem. Meon, Pinestellum, Cordylon [white female hartwort; meu]	24 May, ☉ in ♊ [Gemini], ♂ in ♌ [Leo]	Sulphur 7; Sal 3; Merc. 2	Themoxinth [?]; Essence; Salt	Warms; Strengthens; Invigorates
Cervaria Phoenicia, Peucedanum [Phoenician hartwort; hog's fennel]	22 Aug., ☉ in ♌ [Leo], ♂ in ♌ [Leo]	Sulphur 6; Sal 4; Merc. 3	Thymox [Thymoxinth?] [?]; Essence; Salt	Warms; Dries; Preserves

LIBER DUODECIMUS, SECT. IV. [Book Twelve, Section IV.] — 408

[Margin (top left of the table, beside the first row): *Mira rerum transmutatio ac μεταμόρφωσις* [*metamorphōsis*, "transformation"]. — "The wonderful transmutation and metamorphosis of things."]

Name of plant	Collection	Composition	Resolution	Powers
Sefelis mas, Marsiliense, siler montanum [male seseli, Marseilles, mountain hartwort]	24 Sept., ☉ in ♊ [Gemini], ☽ in ♈ [Aries]	Sulphur 6; Salis [Salt] 4; Mercur. 2	Apophlegm [phlegm- purger]; Oil; Salt	Rarefies; Opens; Penetrates
Sefelis foemin. Aethiopicum, Godylion [female Ethiopian seseli]	17 May, ♂ in [...], ☉ in ♊ [Gemini]	Sulphur 4; Sal 4; Mercur. 4	Apophlegm; Oily; Salt	Preserves; Expels; Restores
Sefelis sobol. Creticum, Peloponesiacu m [Cretan and Peloponnesia n seseli offspring]	♂ in the East [<i>Orient.</i>], ☉ in ♋ [Cancer], ☽ in ☐ [quadrature/q uartile?] [?]	Sulph. 5; Sal 2; Mercur. 5	Schilvach [?]; Oil; Salt	Rarefies; Opens; Expels
Oenanthe mas [male water- dropwort]	8 Aug., ☉ in ♌ [Leo], ♂ in 10° ♈ [Aries]	Sulph. 5; Sal 4; Merc. 3	Glutinatorium [adhesive]; Oily; Salt	Penetrates; Binds; Restores
Oenanthe foem. Glaucantha [female]	28 Aug., ☉ in ♈ [Aries], ☽ in ♈ [Aries]	Sulph. 5; Sal 5; Merc. 4	[—]; Oily; Salt	Binds; Dissolves; Dissipates

Name of plant	Collection	Composition	Resolution	Powers
water-dropwort]				
Oenanthe seu	4 Aug., ☉ in ♀	Sulph. 3; Sal 3;	Antitaret [?];	Resolves; [—];
Oenanthoridis	[Leo], ♂ in ♀	Merc. 6	Oily; Salt	Expels
[water-dropwort, or oenanthoris]	[Leo]			

With these matters set down, I would now have had to teach the method by which water, oils, salts, quintessences, and *magisteria* [concentrated essences] can be extracted from individual herbs, plants, roots, leaves, barks, woods, flowers, fruits, and seeds. But since these things have already been treated by countless authors, I deliberately passed them over — lest I seem to be playing the apothecary rather than the philosopher. If, however, anyone wants the method and the rationale set out exactly, let him read Quercetanus [Joseph Duchesne], Angelus Sala, Libavius [Andreas Libavius], Bauhin [Caspar Bauhin], Wecker [Johann Jacob Wecker], Porta [Giambattista della Porta], Castellus, Schröder [Johann Schröder], Mylius, and countless other writers on antidotaries.

CAPUT IV. [Chapter IV.]

On the prodigious powers of plants, which are shown to have taken their origin from subterranean sources. [De prodigiosis plantarum facultatibus, quas ex Subterraneis originem suam nactas fuisse docetur.]

[Margin: *Ratio metamorphoseos*. — "The reason for the metamorphosis."]

Now that the kingdom of vegetable Nature has been surveyed, it remains for me to show the causes of some of those prodigious operations observed in plants. The first of these is the transmutation of one plant into another. This happens for no other reason than a difference of site, a change of place, or transplantation.

[Margin: *Mira rerum transmutatio ac μεταμόρφωσις*. — "The wonderful transmutation and metamorphosis of things."]

For when like is joined to like — if the soil is rich and fertile — it is a matter of experience that a plant degenerates from a poorer condition into the likeness of a better and similar nature; and conversely, when the genius of the place does not agree with it, that on account of the inner properties of soil and sky it takes on a

different temperament. Hence it comes about that one part of its former virtue is abolished while another part remains. And when plants are carried off to places far apart in space, where they meet with an entirely contrary soil and nourishment, they must likewise degenerate, so that scarcely any trace of their former form remains — the same thing we said happens in animals in the preceding chapters.

For if there were not in the earth a dissimilar and disparate condition of soils, plants of every kind would be born alike in all parts of the world. This is plain from the various kinds of wine, all of which arise from the differing combination of salts, sulphur, and mercury with the earthy clods — and then from the difference of colors, with their unequal variety, and from the difference in the flavor, odor, and size of fruits, woods, flowers, and seeds. These varieties, in different regions and other places, are caused by one disposition or another of the inclination of the world and of the Sun striking the earthy body.

[Margin: *Myrtus*. — "The myrtle."]

Thus the myrtle in Egypt excels in the sweetness of its scent, while elsewhere it is an odorless tree.

[Margin: *Persica arbor*. — "The peach tree."]

In Persia the peach is found to be deadly, while in Europe it is found to be of the most pleasant taste — and so with the rest of the plants and fruits, which in suitable places display the best character, in unsuitable places the worst. But to define everything in a single maxim: the flavor, odor, and color of plants, fruits, and seeds is just such as is the quality of the nourishment by which the plant is fed.

[Margin: *Salomon novit fibras terrenas unicuique plantarum inferendarum opportunas*. — "Solomon knew the earthy fibres suited to the planting of each kind of plant."]

It was therefore not inappropriate that Abenezra [Abraham ibn Ezra], in his commentary on Book III of *Kings* [*Regum*], dared to say that Solomon planted in various places of Palestine plants of every kind — such as balsam, clove, pepper, and others proper to Arabia, India, and the rest of the regions lying under the torrid zone — and that he assigns the reason for this: namely, that (he says) through the knowledge infused into him, Solomon knew the fibres of the earthy parts diffused throughout the whole globe of the earth, and knew the temperament of the soil suited to each of the said trees and plan-

the right one for planting, and in just this way we find that he planted balsam and the other aromatic shrubs in the forest of Lebanon. Experience teaches the same thing in animals, which produce that effect in themselves which the plant—the animal's nourishment—has by its own nature and power. [Margin: The powers of plants are derived into the animals that feed on them.] So if cattle take herbs endowed with a laxative force as their fodder, their milk produces the same effect in human beings; and if they take in poisonous food, they infect both animal and man with malignant qualities—as is plain in the case of honey made by bees from the flowers of poisonous plants. [Margin: Honey that brings death.]

As for why the clotted blood of a he-goat, when taken, is so great a remedy for those suffering from the stone, there is no other cause than that such goats feed on saxifrage herbs, which mostly grow on cliffs and rocky places; and how much the stone-breaking [Greek: λιθοντριπτική (lithontriptikē, "stone-breaking" — lithotriptic)] power of these herbs contributes against [Greek: λιθίαισις (lithiasis, "the stone" — lithiasis)], everyone knows. [Margin: Why the blood of a he-goat heals the stone.]

If, then, nourishment drawn from the earth has such great power to transform the natural character of plants, surely no one ought to wonder that, from the same cause, various metamorphoses and transmutations of plants arise. For as we have said elsewhere, experience has revealed that the cinnamon plant, planted in Lusitania [Portugal], degenerated into laurel, pepper into ivy, and clove into something resembling a chestnut. [Margin: The marvellous effect of transplanting plants of foreign regions.] But to leave aside the plants of the more distant Indies: in our own European regions this is so common that it is no surprise. For we see wheat degenerate into spelt, then into oats, and finally into darnel, maize, or cattail, when sown in unsuitable places; and these same revert in the same order—from darnel to oats, from spelt back to wheat—when sown on ground proportioned to wheat. [Margin: Various transmutations of plants.] But since these matters have been set out more fully in the Seventh Book, we have decided not to repeat them. Cabbage turns into turnip, and conversely the turnip turns back into cabbage with time. Theophrastus teaches that basil changes into wild thyme or water-mint, and water-mint into mint or horse-mint. I could bring forward countless examples of this metamorphosis here, but since they are commonly known, I do not dwell on them. But now let us set down an experiment on the transformation of plants and animals.

EXPERIMENT.

On insects to be transformed from vegetables through putrefaction.

[Margin: Lib. Synt. Chymic.]

Libavius [Andreas Libavius], no obscure chemist, relates in these words how great are the marvels of Nature that can come about through putrefaction: "Among these things," he says, "putrefaction stands out as wonderful in making things rot, by a process of opening and resolving—producing incredible effects, and, because it works in a twofold manner, itself divided in two. The one kind, admitting the external air into a vessel that is not closed but open, plays in this admirable variety in both animals and vegetables, as experience witnesses and teaches. If you crush some vegetable and place it, thus crushed together with its own juice, into an open glass, this putrefaction, in the open container and not shutting out the raw air, will transmute it into little animals and insects of one and the same kind—indeed wholly new ones, never before known to anyone. Each single vegetable will generate its own peculiar kind of little animals, perhaps corresponding to its own nature and properties, though it has not been granted me to test and investigate this so far. But concerning the wonderful animals and insects arising through putrefaction from putrefied herbs and vegetables, I am certain, inasmuch as I have several times—and indeed not with one but with several herbs and seeds—made trial of the thing. Putrefaction carried out closed, that is, in a vessel well sealed and stopped, turns crushed herbs and any vegetables, well enclosed in some vessel, into a liquor containing their virtues, and far more effective in removing diseases than the raw herbs themselves usually are. In dissolving salts, minerals, and metals, and in opening up their solutions, the use of putrefaction is very great—so great that without its help nothing good at all can be achieved upon all those bodies. And it takes place in a [water-]bath, or in horse-dung, or in any other place—indeed even without any fire, yet in such a way that in winter-time the vessel is placed in a heated room or cellar, lest the liquor congeal with the cold and the glass burst into pieces; though this kind of putrefaction requires a longer space of time. Let us suppose Germany's experiment with the elder and with animals: I had collected tender and fresh elder-shoots that had first sprouted in spring from the little tree itself, and these, well crushed, I had put into a roomy glass, which—closed and set in a cellar in winter-time—I guarded with singular care for one year and another, yet in such a way that I never brought fire near it..."

CAPUT V.

On the various accidents of plants, to be unravelled by way of questions.

It is asked, first: Why are the trees that grow beneath the Torrid Zone the most solid? By frequent observation I have found that those more precious woods which arise under the Torrid Zone—such as sandalwood, ebony, and the cochineal-tree [Coccus]—besides being most solid, also have all their fibres arranged in circles, of which more later. I say, then, that this happens because of the motion of the Sun, which, with its most fervent rays, strikes them continually and uniformly from morning until evening, and then passing back and forth from the Southern region into the Northern and again from this into that. Thus too, the superfluous moisture being drawn off, it so compresses the inmost fibres of the trees that the mass seems to be made of stone, unable to float on the surface of water.

Why this does not happen in the Temperate Zone—to make the cause of this matter shine out more clearly, I have decided to demonstrate it from an experiment.

EXPERIMENT.

[Margin: Whence the differing disposition of the fibres in the trunks of trees.]

Cut the woods of various trees with a flat, straight section, and you will find that those brought here from the Torrid Zone have their fibres arranged in circles around the cylindrical trunk, while those under the Temperate Zone show—I know not what—a disposition of fibres aiming at something hyperbolic. This struck me with no small wonder; and, having speculated about the cause, I found none other than the Sun's heat, which affects the trees differently according to such a position. Let there be, for example, a trunk A B of ebony wood.

Diagram. A woodcut of a cylindrical tree-trunk, lying horizontally, cut through to show its end-grain. The cut face displays concentric circular growth-rings (the fibres arranged in circles, as described for Torrid-Zone wood). The trunk rests on a rough cut base. Cardinal directions are marked around it.

- (top center, above trunk): **Bor** [Boreas — North]
- (left of cut face): **occ** [occidens — West]
- (right of cut face): **Ort** [oriens — East]

- A (left end of trunk): **A**
- (center of cut face, faint label across rings): **A·M·S·B** [?] [the point-letters across the ring face; partly obscured by the engraving]
- B (right end of trunk): **B**

If you cut this with a straight section parallel to the horizon, you will find the essential fibres—through which the plant takes up its nourishment—all arranged in circles. The reason for this we gave just now: because trees of this kind are perpetually struck equally on every side by the Sun's rays, from which a circular disposition of the fibres must necessarily follow. Now let there be wood of our own regions, whatever sort it may finally be; and if you cut it in the said manner, you will see the courses of the fibres no longer forming circles, but aiming at something parabolic—I know not what—as appears in trunk D. The reason for this is that under the Temperate Zone the Sun looks almost perpetually upon the same face of the tree.

Diagram. A woodcut showing the end-cut face of a Temperate-Zone tree-trunk (trunk D), with the growth-fibres no longer concentric circles but drawn into a parabolic / semicircular pattern. The face is lettered to mark the northern (Boreal) and southern (meridional) semicircles.

- (left): **S**
- (top): **B** [Boreal side]
- (right): **T**
- (lower / interior, faint): **D** [the trunk-letter; partly obscured]

Let S B T be the northern semicircle, and S D T the southern. Since, therefore, the Sun perpetually strikes with its rays the meridional surface of the tree, S D T, but scarcely ever strikes the greater part of the tree, S B T—inasmuch as that part looks unswervingly toward the northern region—it comes about that the courses of the fibres toward the northern region, S B T, are bound fast by cold, while on the southern side, through the continual battering of the rays and consequently by the force of attenuating heat, they are dilated, as appears in figure T.

Diagram. A woodcut of a tree-trunk end-face (figure T) showing the fibres dilated and spread out on one side under the influence of solar heat, in contrast to the tightly bound fibres on the cold northern side. The rings are eccentric, crowded on one side and widely spaced on the other. No legible point-labels resolve on the face. [Illegible: interior labels too fine to read at this resolution.]

But whoever desires more on these matters, let him consult Book III of the *Magnetic Art* [*Ars Magnetica*], the chapter on the magnetism of plants, where we have described marvels of Nature of this kind more fully.

From these things we conclude that, if anyone were to cut a tree under the more boreal parts of the world in the said manner, the result would be that he will find the constitution of the fibres arranged no longer under a hyperbolic figure, but rather under a parabolic or elliptical one. [Margin: Why in other parts of the world the fibres take shape according to a hyperbolic figure, or a parabolic, or an elliptical one.] The reason is that, just as the shadow of the Sun on flat surfaces—under the Temperate Zone, indeed—describes a hyperbola on one side, so on the other side, namely the one tending more toward the north, it describes parabolas, and within the Arctic circle as well it describes ellipses. [Margin: The reason confirmed by the [solar] gnomon.] So too, I would believe, it comes about that, when the Sun's rays fall upon the rounded trunks of trees, they shape the trees' fibres according to the differing sections of the incident rays. See what we have also handed down on these matters in the *Great Art of Light and Shadow* [*Ars Magna Lucis et Umbrae*].

As I press on with a deeper investigation into these things, something wonderful and most worthy of observation occurs—namely, that the suckers or twigs of some tree, cut in two, seek each other only at the place where the cut was made. But let us show the matter by experiment.

EXPERIMENT.

Let both parts of some cut sucker, supported by floats of cork, be placed in a shell filled with water. I say that the parts, where they have flowed together toward each other, will join only at the parts at which the cut was made; or if they do not touch by their sympathetic parts, they will restore themselves to a parallel position. The reason for this is that they do not seek to be joined except in the way in which Nature, for their preservation, willed them to be united—for in this way they keep themselves better, and will draw nourishment more easily and in a way more suited to their nature, which would not happen if they drew toward each other in an inverted way. Let the parts of the cut sucker be C D and A B, set upon their supports and placed in the shell.

Diagram. A woodcut showing a circular shell (basin) of water seen from above, with two cut sucker-segments floating across it on cork supports. The two segments are lettered at their ends to show the matching (C–D) and non-matching (A–B) cut faces.

- (upper segment, left and right ends): **A ... B**
- (lower segment, left and right ends): **C ... D**
- (interior letters along the floating pieces, faint): **D · A · B / C** [?] [the small interior labels are partly obscured by the engraving lines]

I say that the parts B and D will never flow together, because they do not correspond in the courses of their fibres; but the part B [will join] to the part D—because they have a fitting arrangement of fibres—I say will soon embrace each other. [recte: read consistently with the argument, "part A to part D" / "B to C" by matching cut-faces; the printed text repeats "B ... D".] [?] From this, by the wonderful force of Nature, it comes about that the sucker would rather perish than be joined in a position hostile to itself. For every single thing moves and turns itself toward what is like itself, and inclines toward itself, according to its whole power—as much by its specific virtue as by its elemental virtue. See what we discoursed more fully on these matters, through various experiments, concerning the Divining Rod in the Tenth Book.

I will add here another thing most worthy of admiration, of which—since I have not made the experiment—I likewise cannot assign the hidden reason. The Botanists say (perhaps following Marsilius Ficinus [Marsilio Ficino] in his little book *On Preserving Health* [*De Valetudine Tuenda*]) when he states: "Hellebore, when it is gathered, has this property: that whether you draw the leaf downward or upward, it is then believed to happen, by an instantaneous contact, that it draws the humors either upward or downward." [Margin: A wonderful effect of hellebore.] Schröder confirms this in [his] *Porta*: "If the root of elder," he says (understand *Ebulum*, dwarf-elder), "is pulled upward, it purges by the upper passages, that is, by vomiting; but if it is drawn down through a pit made beneath, it is established that it likewise obtains its effect downward, by the stool. The catkins, too, of the same elder, if they are plucked toward the top, move vomiting; but the belly, if you pluck them downward." [Margin: The cause of these wonderful effects.] But since the matter has not yet been established for me by experiment, in investigating the truth of an uncertain cause and an effect not yet explored, I have judged that time should by no means be wasted in fruitless labor—unless perhaps we were to say that the offshoot and concourse of the purgative faculty follows toward that part where the violent motion has occurred. For we know that in the human body the humors flow together to the place where pain presses, or where some violence has been done to a limb, whether through a bruise or a blow, an ulcer or a wound. For at the touching of leaves of this kind it is certain that an agitation of the little spirituous bodies hidden in the plant takes place toward that part where the disturbance began,

whether upward or downward; and consequently, being there at last condensed, they require a greater force. So it is no wonder that the part drawn from above purges by vomiting, the part below by the stool. For a greater portion of the little bodies is always carried upward than downward; hence it also purges more violently by vomiting than where a smaller quantity acts; hence it purges downward more gently than upward.

It is asked, second: Are there truly granted those prodigious powers of plants of which the Botanists speak? [Margin: On the causes of the prodigious effects in some herbs.] I answer that many—indeed most—of the herbs adduced are superstitious fables introduced by Magi to confirm the power of Nature through things that have been falsely established by some pact, implicit or explicit, with a demon. Therefore I would not have credence given to them, since nothing is more customary for the enemy of the human race than, under the pretext of admirable powers and faculties lying hidden in herbs, to lead the too-credulous into superstitions; imbued with which, they ever direct their minds toward more occult things, until at last, drawn on by a pernicious and deadly persuasion, they devote themselves to the demon, to the ultimate ruin of the soul. [Margin: The signs of superstitious actions.] The signs of latent superstition are these: if various circumstances are required to be joined so that the herb may obtain its effect; if [it is gathered] with preliminary ceremonies and the muttering of barbarous words; if in a certain bodily posture or condition; if with the body naked; if at a certain degree of an ascending star; if, finally, [the herbs] are prescribed to be gathered with manifest adjuration of a demon. Of which kind is that stupid superstition of the counterfeit Zoroaster in the *Geoponica*. [Margin: The superstition of Zoroaster.] "If," he says, "some tree has been barren for many years, and a farmer comes girt with a sharp axe to cut down the tree, and a friend pleads on its behalf and pledges that next year it will bear fruit—and the farmer, persuaded by his friend's words, has gone off—that tree will, beyond doubt, bear abundant fruit." What has a barren tree to do here with a friend's prayers on its behalf, begging that it not be cut down? Contrivances of this kind, beyond counting, are wont to be devised by the demon's aid, by ill-employed men and Magi, to deceive the unwary. For since the natural virtues of plants operate of themselves and from their own nature, all such sorcerous circumstances and empty observances are truly worthless—unknown words, blessings, crosses, and the whispers of barbarous voices—since they can neither augment the faculties of natural things nor make them operate beyond what Nature has implanted in them, however much both Magi and demons may labor, to whom it has by no means been granted to change the nature of things. If, then, some plants exhibit certain admirable powers without the addition of superstitious operations of this

kind, you may be certain of [Margin: The signs of the truth of the prodigious powers in herbs.] the marvellous native faculty of such a plant; just as in what preceded we showed concerning the wonderful nature of palms and orchids, and also concerning the marvellous marriage of plants by [Greek: ἐμφύτευσιν (emphyteusin, "engrafting" — implantation)], that is, by grafting. But now let us set down the traditions of the ancients concerning the prodigious powers of herbs, so that the Reader, in reading such things, may not show himself too credulous, but may diligently explore what Nature can do and what it cannot—as will be made manifest from what follows.

Among the Romans, those were held in great honor who wrote on the history and powers of plants and were distinguished in this field—by a sufficiently manifest proof: that when Carthage had been taken, of all the libraries they found they gave away to various kings and princes [everything] except thirty-two volumes on herb-lore and agriculture written by Mago the Carthaginian alone, which they brought to Rome [Margin: Mago the Carthaginian, author of thirty-two volumes on herb-lore.] and ordered to be translated into the Latin tongue—Mago alone, skilled in herb-lore and agriculture, thus winning their favor. So astonished, in the end, was antiquity at the faculties of herbs, that the writers of those times related certain wonders about herbs.

[Margin: The slain whelps of a dragon recalled to life by an herb.] The historian Xanthus, in the first book of his histories, wrote that the slain whelp of a dragon was recalled to life by its parent through a certain herb, which the Magi call Balis; and that by the same [herb] Thilon, whom the dragon had slain, was restored to safety. The same writer related that, by King Juba of Mauretania, a man in Arabia was recalled to life through a certain herb—things which, however, are not to be understood to the letter, as they say, but [as referring] to the virtue implanted in the herbs.

implanted, of great strengthening power, [so that] Thilon was as it were freed from death, from which he was not far off—since by the common philosophers' refrain there is no return from privation to possession. [Margin: Fabulous accounts of herbs.] The things that follow are to be ascribed to fables rather than to histories, when they say: that the woodpecker, when a wedge has been driven into the hollows it has in trees, is accustomed to extract it by applying a certain herb—so Democritus and Theophrastus; indeed, that the herb Aethiopis, by its touch, opens all things shut, with certain murmured incantations chanted—at which, however, I greatly wonder that Mattioli [Pietro Andrea Mattioli] believed it as most true. For he says: "I remember, when in former years I was staying at

Venice, that I saw a certain man condemned to hanging, for whom all the doors were thrown open and the bolts cast off, merely by a single herb applied, with certain little signs chanted." But that this happened by incantations and not by the native virtue of the herbs, even he himself admits. He says further: "Another herb of nearly the same faculty, not unknown, is found in the mountains of Italy, which, when trodden by horses, immediately loosens their iron shoes; this herb is everywhere called, from its effect, *Sferracavallo* [horseshoe-loosener], and it is a species of *Lunaria* [moonwort]." For my part, having made trial with an iron horseshoe, I was not able to discover the truth of the matter.

It has, however, been observed that the wounds and ulcers of those become inflamed who have made a journey on foot through places teeming with pernicious plants—such as hemlock and the other kinds of aconites; [Margin: Various effects of plants.] but on the contrary that diseases are healed, where healthful [plants] have been trodden by wounded travelers—as they report of the species of plantain. The Botanists report, too: that the splenetic are healed by the touch of *Hemionitis* [moonwort/spleenwort]; epileptics by Roman peony root hung from the neck; the jaundiced by greater celandine or shepherd's purse laid under the bare feet in the shoes; that aconite *pardalianches* brings death to females [?]; that no one is troubled with bleariness of the eyes [Margin: Various effects of plants.] so long as he keeps about him a very clean root of wild dock. He will cease to be tortured with strangury who burns up his own urine [strangury?] by burning tamarisk wood. Indeed it became known to me by experiment that barbed yew, applied to the urinary canal, immediately freed the sufferer from dysuria, that is, from difficulty of urinating. They think that a swelling of the groin does not at all grow up in those who carry a myrtle twig about them; that by the touch of *Scordium* [water germander] corpses are preserved—as the records not only of Mithridates but also of Galen attest. [Margin: Herbs that keep off hunger and thirst.] The Scythian discovered the Scythian herb growing around Boeotia, very sweet indeed to the taste—whose great recommendation, of course, is that those who hold it in the mouth do not feel hunger and thirst, yet for only a short time. The herb called Hippice among the same people does the same, since it provides the same effect to horses too. And they hand down that by these herbs the Scythians can endure even twelve days in hunger and thirst—but let these things be said by way of [Greek: ὑπερβολικωτέρως (*hyperbolikōtēros*, "rather hyperbolically" — with some exaggeration)]. O how fortunate armies would be, if without other provision, by the use of an herb alone held in the mouth, they could endure thirst and hunger for twelve days!

Pythagoras handed down that by the herb *Coriocesia*, and also by *Callitia*, water is frozen—which I say is true in the case of herbs first coagulated into a nitrous substance; but this effect ought to be reckoned to come not from the herb but from the niter, as experience establishes. [Margin: Aproxis draws fire.] The things that follow are fabulous: Pythagoras says that the herb Aproxis, whose root no less than naphtha conceives fire from a distance [draws fire]; that the plant Alchemenis is born of an amber color, without a leaf. Democritus mentions the *Tardictylis* of India, whose root, ground into little pellets and drunk in wine each day, makes the harmful confess all their crimes by night, through empty imaginings of deities. By the touch of the herb Ariamis, pieces of wood first anointed with oil are kindled on the spot, if it is plucked when the Sun is in Leo—which is no wonder, since at Rome even chaff on the bridge of S. Angelo is seen to catch fire from the heat of the Dog-Star and of the Lion. The ancients handed down that, by *Therionarca* growing in Cappadocia, [Margin: Wild beasts made torpid.] Lycia, and Mysia, all the wild beasts to which it is applied grow torpid, and are revived only by being sprinkled with hyena's urine. Certainly it is known that all herbs endowed with a narcotic force—the species of nightshade, thorn-apple, and the like—produce this, when eaten, however. They also hand down that *Ophiusa* is born in Elephantine of Ethiopia, livid and horrible to look upon, which when drunk causes the terror and threats of serpents to hover [before the eyes], so that those who have drunk it inflict death on themselves from that fear; and for this reason the sacrilegious are forced to drink it—though palm-wine counteracts it. I would not easily deny that a similar power can exist, since, as we taught in the Book *On the Nature of Poisons*, most poisonous herbs excite in men [Greek: συμπάθῳς (sympathōs, "sympathetically")] various kinds of phantasms, by which they think themselves to be what they are not. See what more we have handed down on these matters there concerning the hydrophobic. Certainly *Solanum Maniacum* [maniacal nightshade] (as Dioscorides is author) makes various visions, and causes not-unpleasant images, if a drachm of its root is drunk in wine. I add to these that *Theangelis* too is wont to be born in Lebanon of Syria, which, when devoured, makes men—so they wish—foretell the future. In Bactria and around the Borysthenes [Dnieper] there grows a plant called *Gelotophyllis*, which, if drunk with wine and myrrh, they say makes various visions hover and brings no end of laughter, until pine-nut kernels in palm-wine, with pepper and honey added, are administered. The same effect among the [?] is produced by *Apium risus* [smiling parsley] and Egyptian Arum when devoured. The herb *Asciomenes* (as Apollodorus is author), [Margin: Asciomenes tames wild beasts.] sprinkled with wine, draws its leaves into itself; sprinkled with neat [wine], it tames the ferocities of all animals, tied to the neck or hung from the

yoke. Appian of Alexandria writes that the Parthians, put to flight by Antony [Mark Antony], when they were pressed by hunger, fell upon a certain herb, which those who ate it remembered nothing of other things, nor understood anything, [Margin: A wonderful effect.] except that they continually dug up stones, as if about to perform some great work; and so, raving, at last vomiting up bile, they perished—but this power must be ascribed...

[Reading order: →910→911→912 correspond to printed pages 413→414→415→416, in linear sequence. No folio reordering was needed for this opening.]

must be ascribed to a poisonous virulence imparted to the herbs, which by the power of imagination disposes the people themselves to act in this way or that. A branch of the third buckthorn [Rhamnus], according to Dioscorides, set upon doors and windows drives away all sorceries — by what power he himself would have to say. The roots of dock [Lapathum], and indeed of plantain, bound to the throat (on the same authority), he supposes to heal scrofula and the king's evil [choeradas et strumas]. Little worms found in autumn in the prickly seed-heads of teasel [Dipsacus], bound to the throat in a little bag, or hung on the left arm, the magicians believe restore those afflicted with quartan fever to health. Dioscorides writes that when the herb golden-thistle [Atractylis] is carried, a scorpion's sting is indeed blunted, yet once the herb is laid aside the pain at once flares up again. He has even handed down to the memory of posterity that those who carry the root of the herb Greek valerian [Polemonia] with them are not stung by a scorpion; or if by some chance someone is stung, he will suffer no trouble at all. But since these things are uncertain and without foundation, I have no wish to reason about them.

[Margin: Baaras, the wonder-working herb.]

Very widely known in Judea is that fabled root **Baaras**, named after a place, of which Flavius Josephus writes thus in his book *On the Jewish War*: "In color it resembles flame, and toward evening it flashes like a beam of light. But for those who approach and wish to pluck it, the thing is not easy to do, for it keeps slipping away until a woman's urine or menstrual blood is poured upon it; and even then, if anyone touches it, certain death follows — unless he carries the very root hanging from his hand. For this reason, once the root has been dug round about and is not yet uprooted, they tie a dog to it, which, wishing to follow its departing master, uproots it and immediately dies, as though in place of the man by whom it was to be taken. After this there is no danger for those who take it up. Yet for the sake of one power it is worth taking it at such great risks, for when it is applied to those who are oppressed by evil spirits [cacodaemonibus], they at once

enjoy their freedom." But since these things are reported by no one up to now except Josephus, we likewise ascribe them to old wives' ravings.

[Margin: A root that takes away the ability to eat.]

Mattioli [Pietro Andrea Mattioli] says that he had a root, found by Francesco Calzolari of Verona [Francesco Calzolari], which, he says, soaked overnight in wine, and the wine then drunk, makes it so that no one, however starved, can eat — nor taste even the least morsel of food — until he has swallowed a spoonful of vinegar. A laughable jest indeed, but the thing itself is not to be entrusted to everyone. I could adduce many similar things, true yet ripe secrets of nature; but lest the over-curious use them for evil, I have thought it best to veil them in silence. Indian gourd [Zucca Indica], swollen with a destructive and deadly poison — yet its juice, as was said in the preceding pages, once expressed, and the root ground into flour, makes the best bread, most wholesome for nourishment. To these things may also be added, from Mattioli, what people often marvel at in the shows of mountebanks. For Mattioli speaks thus:

[Margin: The mountebanks' trick.]

"Into wine they mix the powder of a certain root, by tasting which the throat is convulsed; and the man on whom they wish to play the trick they bid dip his finger in it, as if for the sake of tasting beforehand; then he reluctantly presses the finger, smeared and wet in the wine, biting it into his mouth, not without pain and outcry. Meanwhile the mountebank, just as though he were soothing the grieving man with caresses, smears the arteries of his temples and wrists with some other drug; then he throws a coin onto the ground and urges him to pick it up. There the man, bending forward, at first cannot lift it, then, as if driven out of his mind by force, collapses; and at once, after the manner of one who fears he may drown in water, he swims, and prays at the same time to be overwhelmed by the waves. The mountebank then raises him up; the man, as if about to avenge an injury, first reproaches the sorcery with a sidelong and grim look, then seems to attack the man; finally he seems to pursue the fleeing mountebank, until at last, the poison of the smeared drug being wiped away, he recovers his mind and is restored to his senses. And when he has come to himself, like a shipwrecked man who has escaped the sea, he is seen to wring out and squeeze his hair and clothes as if they were sails, to dry his arms, and to wipe his nose. These are not fables: for there is no lack of testimonies of many who have seen it, and who, suspecting a deception, have had it done — as happened this year at Prague — upon their own servants and those of their friends."

Innumerable things could be adduced here from various authors; but because they are wrapped up in countless superstitions, I have not wished to dwell on them, and have chosen to proceed only to those things which by themselves and their own nature possess a marvellous power, and produce effects that in everyone's opinion are incredible.

[Margin: παλιγγενεσία [Greek: palingenesia, "regeneration" or "rebirth"] of herbs — by what means it comes about.]

The fourth question is raised. Can an herb truly and really be drawn out of its ashes by palingenesis, that is, by resuscitation? I am not unaware that various histories are adduced concerning marvels of this kind.

[Margin: A tree in a glass phial.]

They report that Albertus Magnus [Albertus Magnus], at the time of a banquet, produced before the King of France a tree, with leaves, flowers, and fruit, in a glass phial. But I have investigated the truth of the matter with great labor, and I have not been able to find any such thing either in his Life or in the deeds of the king; nor have the Dominican Fathers admitted finding any such thing in their archive. Hence I have always believed the narration to be fabulous — invented by the alchemists and other followers of the more curious arts to prop up, with similar fictions, the truth of those mysterious and unheard-of secrets which they are everywhere accustomed to proclaim with full cheeks. In the same way, many other spurious offspring have long since come forth under the name of the holy man through the help of the Magi, for no other purpose than to shelter their ravings under the name of the great Albert, and to make these things more easily believed by a world greedy for them — the painted truth being approved, before the inexperienced common people, by the authority of a great and illustrious writer, with similar trifles taken up. That Albertus Magnus was an initiate of nature, no one would deny; but as for that most celebrated book *On the Mysteries of Herbs and Stones*, and likewise the book *On the Diseases of Women*, which are believed to be his — let anyone believe it who wishes. That all these treatises came forth from the superstitious workshop of the Arabs first became clear to me when I unfolded Solomon Ben-Gabirol [Solomon ibn Gabirol] [?], the author *On the Nature of Things*, with a certain intimate reflection upon the books ascribed to Albertus Magnus.

[Margin: The author's invention.]

Then, concerning the palingenesis of plants, Quercetanus [Joseph Duchesne / Quercetanus] and Gassarottus [Gassarottus] [?], in the book entitled *Des*

Curiositez Inouyes — that is, *On Unheard-of Curiosities* — report the case of a certain Polish physician who kept in a phial the ashes of various herbs, and would produce for his visitors whatever herb they wished, simply by applying the warmth of a lamp. As this savors of something marvellous, so too whether it can really be done remains to be set forth.

That in ash there lies salt, and in salt — as in a center — the seminal power [virtutem seminalem] of any vegetable thing whatever, has already been shown in various books of this work. It can therefore happen that the salt extracted from plants by an art not known to all, just as the herb has power by its spermatic virtue, so too, joined to that same salt by an inseparable knot, while the plasmatic faculty is roused by a gentle and mild heat in the salt with its seminal force, is carried by a certain innate appetite to forming that for which it was destined by nature — the saline corpuscles, in which the plastic power lies hidden, flowing together into that form which the seed requires; and thus they present a plant under that form which the plant, from which the salt was extracted, requires by its own nature. We gave an experiment of this matter in the preceding books, concerning the ashes of various plants, whose lye, exposed in the winter months to freeze, displays in the icy crust those plant-forms from whose ashes the lye had been made.

I dare to affirm that I busied myself with this truly marvellous experiment long and much, until at last I found another method by which I roused a plant out of its own ashes within a hermetically sealed phial with a long neck; and I displayed it in my Museum for nearly ten years to be viewed by all who came, until in the year 1657, when the Queen of Sweden, Christina [Queen Christina of Sweden], deigned to honor me with a visit to my Museum and viewed an artifice of this kind with the greatest delight of her mind. After her departure I had placed it outside the window; returning the next day — for it was the month of February — I found that the more vehement cold had broken the phial and put an end to the spectacle, as though it disdained to show itself any longer after a queen of such great name had honored it with so great a distinction of inspecting it. I, however — whether for the sake of the expenses to be incurred, or weary of the great labor — no longer undertook the work [ἐγχείρησιν] [Greek: encheirēsin, "undertaking"], and left it in its own chaos; yet I reserved the method and the procedure by which I used to make an artifice of this kind for a separate little treatise, wholly on the palingenesis of plants from their ashes, where the whole carrying-out of the procedure will be described in detail.

Diagram. A woodcut of a tall, round-bottomed, long-necked glass phial (a typical alchemical pelican/matrass form), standing on a small footed base. Within the phial a small, leafless, branching tree or shrub-like growth rises from the bottom — the palingenetically regenerated plant. Across the upper part, around the neck, a banderole (scroll) bears the caption.

- Banderole (across neck): "Artis et Naturæ Conatus" [The Endeavor of Art and Nature]

Now, since Emperor Ferdinand III [Ferdinand III], of glorious memory, having been informed of this resuscitation of herbs, indicated to me that he had a not dissimilar method for drawing plants out of their ashes, and perceived that I was held by the greatest desire for it, His Sacred Majesty, to satisfy my wishes, did not disdain to impart to me, with truly great generosity, the whole sequence of the matter and the procedure in carrying out the work. And although Fr. Gaspar Schott [Gaspar Schott], formerly my colleague here at Rome in literary matters, has already inserted it into his works, nevertheless — lest the reader go away cheated of his hope, and that the origin from which it flowed might be established — I shall set it forth here again at length, to this end: that the reader, who will perhaps have greater leisure, may himself not cease to undertake, for the confirmation of the truth of the matter, the experiment which I, through the intervention of various occupations, have not been able to undertake. This, then, is the secret.

EXPERIMENT I.

παλιγγενεσία [Greek: palingenesia, "regeneration"].

Or the Regeneration of Plants from the Seed of any Plant whatever.

THE PROCEDURE.

Take the seed of any plant whatever, fully ripe, gathered in fair weather and under a clear sky (*Lib. 4*). Pound it in a mortar, and place it in a clean phial, closed as well as possible, and take care that not even the least bit escapes; and keep the phial also stored in a protected place. This done, you will observe an evening hour of the clearest sky, so that on the following night you may collect the falling dew.

Open the phial you have kept; take out the pounded and crushed seed, and spread it upon a glass tablet. Leave this tablet with the seed exposed in the open air in some garden or meadow; and lest any of the more abundant dew be lost by flowing off the tablet, place the tablet together with the seed in a rather broad

dish. Thus it will come about that the dew, falling abundantly upon the seed, will more conveniently impart its nature to it by these nocturnal soakings. At the same time, for more conveniently receiving the dew, let a fine and very pure linen cloth be stretched, fastened to four stakes, which, soaked...

with the nocturnal moisture, may then be wrung out into a most clean glass vessel, to about eight measures.

Further, let the seed, soaked with the nocturnal dew, be again shut up in its phial, and — lest anything escape from it or be drawn out by the heat of the Sun — let it be put back in its former place before sunrise. Let the dew wrung from the linen cloth be very frequently strained; once strained, let it be distilled several times, until it comes out free of all dregs and earthy impurity. The dregs left behind you will calcine, and they will yield a salt beautiful to behold, which presently is to be dissolved in the distilled dew.

Let the dew, imbued with this salt, be poured upon the seed kept in the phial, to a height of three fingers; then let the phial, hermetically sealed with crushed glass and borax, be kept in a warm and moist place, or even buried under horse dung for the space of a month. Then take out the phial and observe: you will see the seed transmuted into the likeness of a jelly, a spirit floating on top like a little skin variegated with various colors, and within the skin and the muddy earth the dew, existing according to the nature of the seed, like a green seed.

Suspend this phial, thus sealed, throughout the whole summer in a place open to the rays of the Sun by day, of the Moon by night, and of the other stars; but when the sky is troubled or rainy, keep it in a dry and warm place, until at last, the clouds being driven off, clear weather shines forth, to which you will then expose it.

It sometimes happens that this work is completed in nearly two months, or sooner, sometimes after a year, according to the constitution of the seasons.

For the rest, the signs of the work's perfection are these: the muddy matter at the bottom swells up high, the spirit and the little skin decrease day by day, and the whole matter at last thickens; while in the glass, from the reflection of the Sun, subtle exhalations arise, and as it were clouds — the first rudiments, so to speak, of the growing plant — but still feeble and without heat, and rising only in the form of a spider's web, now ascending, now descending, according to the efficacy of the solar ray striking the phial.

At last, out of all that spirituous matter subsisting at the bottom, an ash is formed, white-blue [albo-caeruleus]; and then, in the course of time, a stalk, herb, and flowers are produced in the form and species of the seed. This species appears when heat is present; in its absence it vanishes, returning into its own chaos. But as often as you apply fire, so often will the plant, the heat reviving the matter, present its form; and in this way it will last perpetually, if the vessel has been well stopped.

[Margin: Paracelsus's fictions.]

Paracelsus [Paracelsus], in book 6 *On the Nature of Things*, adduces many utterly false things concerning the resuscitation of things, though some true ones also. But in order to show that resuscitation is possible, he adduces things which no philosopher ever admitted. For example, he says: the cubs of lions, wholly devoid of life and dead, are called back into life by the breath of the lioness or the lion alone; indeed, that unless a roar be added, they remain perpetually dead. That this is false, experience proves: the cubs of lions are by no means dead, but only half-asleep, and are merely roused by the roar — just as we see a sleeper roused from deep sleep by a great outcry agitated by unfamiliar movements. But who could conceive that by a roar alone there can be given to the cubs that which they do not have? By similar examples, weak enough — indeed absurd —

[Margin: Paracelsus's fictions.]

Paracelsus is accustomed to ascribe the giving of life to metals through their reduction into quicksilver, that is, mercury; and in doing this he perversely violates the laws of the grades of nature. For what fellowship the life of animals has with the inanimate nature of minerals, I do not grasp. I say therefore that it cannot be that what does not have life of itself and by its own nature, nor can have it, should yet have life given to it — as the alchemists trifle concerning the vital seed of the Mercury of the Philosophers, when they attribute to it a vegetative faculty and one that multiplies its own species. Who does not see that all these things are absurd and contrary to the principles of nature? Yet because ashes derive their origin from a vegetable nature, certainly out of the seed-stuff [seminium] lying hidden beneath them, by the benefit of the vivifying salt, there is no doubt that a plant can be roused. For each thing acts according to the grade of nature suited to it; nor can a mineral body generate a plant, nor a plant an animal, unless first a seed-stuff of sensitive nature has existed in it. Metals therefore are constituted not by a vegetative faculty, but by ὑποδιάθεσιν [Greek: hypodiathesis, "underlying disposition"], that is, by the superaddition of metallic vapors and exhalations packed together in appropriate matrices. A plant

generates a plant, nothing else; an animal produces an animal, not a plant, not a mineral. Hence to argue from some one grade of nature to disparate ones is not permitted in sound philosophy. Now, then, let us see how Paracelsus supposes a plant can be roused from the ashes of burnt wood.

EXPERIMENT II.

Of Paracelsus.

"The resuscitation," he says, "and restoration of wood is exceedingly difficult and arduous, yet possible to nature; but it cannot be done without notable skill and industry. That it may be revived, it is best done in this way: Take wood, which was first charcoal, afterward ash, and put it in a cucurbit together with the resin, the liquor, and the oiliness of that tree — let the weight of all be the same — let them be mixed; let them be liquefied in a gentle heat, and there will be a mucilaginous matter. And thus you have the three principles from which all things are born, all are generated: namely phlegm, fatness, and ash. Phlegm is mercury, fatness is sulphur, ash is salt; for everything that in fire smokes and evaporates is mercury; what blazes and is burned is sulphur; and every ash is salt. When now you have these three principles together, put them in a horse's belly [in venter equino, i.e. fermenting dung] and let them putrefy. To...

[Margin: Libavius, *Syntagma Arcanorum Chymicorum*, fol. 48.]

their own term. If afterward that matter be buried in fatness and infused, you will see it revive, and a tree and small wood thence be nourished, nobler than the former by its virtue." There was no need of so many operations to make the salt vegetate, since the ashes of plants (as we ourselves have very often experienced in the salt of wormwood [absinthium]), planted in virgin earth, will within a short time present a plant of the same species as that which had been resolved into ashes. But of these things more fully elsewhere.

That a plant can be born from its own ashes — that this in no way repugns to the power of nature — is clear from various places of this work: from the marvellous power of nature in the generation of plants and stones depicted in every kind of figure; likewise from what we said in the preceding passages concerning the seed-stuffs of various plants and animals existing within the elements. All these things are confirmed by the history which Libavius [Andreas Libavius], in his *Syntagma on the Arcana of Chemistry*, adduces concerning a little plant arisen from distilled water. I shall here append the letter — worthy of admiration —

which Cornarius [Cornarius], Court Physician of Brandenburg [Brandenburgicus Archiater], had written to Libavius concerning the marvellous origin of this herb:

"You now have a picture of the little plant in the bivelatine water [aqua bivelatina] which is in Meissen [Misnia], not far from the town of Zwickau [Cycenaea], distilled for me — but a picture, alas; would that you had seen it living and had it, which truly was far more delightful, far more lovely than you see, and which the painter in depicting it scarcely sketched, not to speak of the color, for the picture was illuminated with its own colors, which by the rubbing of the page have nearly faded away. Never indeed without great admiration did I look upon it, as often as I beheld the glass, as did others also. The glass is altogether such as the picture exhibits, or even of slightly greater capacity. The light-greenish color sprinkled at the bottom is from the glass, by no means from the water, or from some sediment clinging to the bottom; for the water is still most pure, and entirely free of all phlegm. In the little plant itself you do not see a stalk, base, or root by which it might be supported — nothing notable, except a very small one; for it seemed to adhere to the pointed bottom of the glass by a single thread only, and thus to the sides it scattered little branches full of...

Diagram. An uncaptioned woodcut of a wide-bodied, short-necked glass jar or bottle with a ribbed/banded base, standing upright. At the bottom interior a small, delicate plant-like growth (the "little plant" of Cornarius's account, resembling a sprig of rosemary) rises from the pointed bottom and spreads small branches toward the sides. No labels are present on the figure.

oblong little leaves, not broad in proportion to the whole size, but oblong, sweetly green, after the manner of a tender rosemary plant, of a color tending from green to citron, not fully green. I do not doubt that it could have risen and grown higher, since, when the glass was somewhat shaken, it stood firm and erect with a feeble tremulous motion; but, injured in winter by the vehemence of the cold, and torn from the bottom, it floats in the water — still, which is wondrous, with its color whole, though somewhat diminished, a viscosity gathering about it. This happened in the year 1608; the water was distilled in the month of June by Martin Gallus, an assistant of the apothecary, and the herb was first observed in the month of November." Thus Cornarius to Libavius.

I have no doubt that the history is most true; for, as we said in the preceding pages, it could easily have been born from the seed of some herb which had previously existed in the water — especially since no water can be so purified by distillation that there do not always remain in it dregs, even imperceptible ones,

from whose seed-stuff this plant afterward arose. For since we so greatly admire the hidden power of God in nature, and God is utterly wonderful in his works,

[Margin: God to be admired in natural things.]

who would now dare to doubt that in the salt of plants and animals there lies hidden a certain occult seed, which, according to a prior disposition of the subject, comes back from time to time from potency into act? Indeed the wisdom of God exceeds all the admiration of mortals even in this, that it can preserve nature even in an imperceptible thing, in which all the wise men of the world would swear that nothing at all remained — a most luminous argument indeed, by which the future resuscitation of our bodies may, by some such shadowy likeness, be in some way conceived by the weakness of the human intellect. For the confirmation of these things I shall here add another case, conceivable by almost no human intellect, which Johannes Marcus Marci [Jan Marek Marci] of Bohemia, Court Physician, already renowned to the world for learning of every kind, transmitted to me in past years, confirmed on the authority of many.

[Margin: A wonderful apparition of a snake in a distillation.]

For while a physician was distilling a certain water, after a notable ebullition of the water, there at last appeared within it the form of a variegated-colored snake, coiling itself after its manner — all who were present being astonished at the outcome of the matter. And so, when various men had been consulted about the prodigious origin of this serpent and its cause, they all fell silent, saying this one thing only: that it would be idle to unfold hidden effects of nature of this kind, which nature had willed to be inaccessible; that to attempt them too presumptuously, to penetrate the inaccessible and impenetrable abyss of nature, is not permitted — only to admire it. But that the reader may weigh everything more accurately, here is the whole procedure of the matter, which the above-praised friend of Johannes Marcus Marci [Jan Marek Marci], a singular friend, transmitted to me to this end: that I might find at least some cause of this prodigy.

Reading order used: correspond to printed pages 417, 418, 419, 420, in that sequence — confirmed by catchwords ("Expe-" on the prior page 416 → "Experimentum" opening p. 417; "nucis" foot of p. 417 → "nucis videre est" opening p. 418; "Sunt;" foot of p. 419 → "Sunt, qui" opening p. 420). No folio reordering was needed for this set.

An unheard-of experiment performed by the most excellent Nicolaus Franchimontius [Nicolaus Franchimont], Protophysician of Prague.

Take oil of vitriol [oleum vitrioli], whitened by repeated rectification, one part; the best spirit of wine, rectified through white tartar, two or three parts. Mix them, and let them be distilled from a cucurbit set in sand, with a rather strong fire applied, and a very capacious receiver attached. During the distillation a vapor came forth, wandering about through the receiver; and below it, of the thickness of the wrist [carpi crassitudine], appeared the figure of a living snake, colored in a variegated pattern of whitish-gray, coiling itself into multiple spirals and bends as the spirit advanced from the cucurbit into the receiver. This persisted for at least two hours, and at last was resolved into a most burning spirit. Had reason not held my judgment in suspense, I would have sworn that what I beheld was alive.

Nicolaus Franchimont, Doctor of Medicine and Professor of its practice at Prague.

For my own part, I confess that I was not a little astonished at this occurrence. But once, instructed by repeated experience of similar things, I had considered the matter more closely, this single explanation of the prodigious effect occurred to me. As we have taught in the foregoing pages, the seeds [seminia] of things are present in all things beforehand; so too it is likely that there was, either in the vitriol or in the wine rectified through tartar, some seed [seminium] of a serpent. This, then aroused by the heat of the fire, was by the agency of the plastic virtue [plastica virtus] — its salts joined together by a certain magnetism — reshaped into the form of a serpent, in no way otherwise than we shall show can be done with serpents by similar experiments. If, however, anyone should wish to perform an experiment of this kind according to the prescribed ἐγχείρησιν [Greek: encheirēsin, "the procedure / hands-on operation"], he will assuredly labor in vain, since the seed of things is not always present in each and every one of these ingredients. Hence I judge that in this case the experiment achieved its effect by chance, in that the seed [seminium] of some snake of this or that species happened to be present in it at the time.

I have heard that the Count of Hannover [Comes Hannovianus] keeps a stone that reproduces the form of a serpent coiled into spirals, found by hunters inside a stag's stomach — a thing that will easily be believed by anyone not ignorant of the nature of stags in hunting serpents.

[Margin: The cause of this prodigious effect.]

The fifth question is asked: By what power, and in what way, do certain plants compose themselves toward the Sun's motion with such great appetite? Experience teaches that they do turn themselves.

The heliotropes, or the plants they call sun-followers [solisequae], are held by so intent a longing for the Sun that they seem unable to be drawn away from its loving gaze by any barriers. I say this happens partly because of the great benefit that comes to the plant from this for its own preservation, and partly because of the vehement magnetism that passes between it and the Sun, by which, willing or unwilling, it is drawn; and the drawing is accomplished in the manner that follows.

[Margin: Why the sun-following herb turns toward the Sun, and turns itself.]

The stalk, the flower, and the seeds of heliotropes, if one examines them rightly, are so constituted that they can easily be twisted. This being granted, it follows that the moisture which plants of this kind have drawn in by the dewy dampness of the night is — as we have shown by the examples given — present in their seeds in the very same way. As the Sun rises, swelling at once at the arrival of the kindly guest, they turn themselves to where they can be freed from their superfluous moisture. The Sun, when it strikes straight upon the stalk and the disc of the flower with its blazing rays, brings about the thinning [attenuatio] of the saline spirits [spiritus salini] lurking in these herbs; and there follows the rush of the resolved spirits, by which, set in motion, they turn toward those parts where they find the pores most widely dilated by the Sun's heat. Hence it comes about that these spirits are carried in no other direction than that which faces the Sun. This is also established by open experiment: for if the plants stand in a shady place where the Sun cannot strike them, then no turning toward the Sun follows either, but, as if indignant at the obstacle, they always hold themselves fixed in the same position; yet as soon as they are lit by the Sun, then too, dilated with eager gaze and as if dancing for joy, they turn to where so great a benefit flows to them. But since we have treated of these matters in Book 3 of the *Art of Magnetism* [Ars Magnetica], on the method and rationale of constructing clocks by means of sun-following and moon-following plants [solisequae lunisequaeque plantae], together with various experiments, we refer the reader to that place.

[Margin: The cause of this tropic motion in plants.]

EXPERIMENT.

Take a sun-following plant: this plant, being filled with saline-sulphureous-mercurial spirits [spiritus salino-sulphureo-mercuriales], depends upon the resolution of those spirits. Place it in an earthen or bronze vessel filled with water, in such a way that, fixed into a cork, it can move freely; this done, set fire beneath the pot, and — a marvel to behold — at once the stalk will begin to twist itself and to be animated into a circular motion. The cause is none other than this: that the spirits, thinned by the heat of the surrounding medium and by the action of the fire set beneath, rushing out through whatever gateway is given them, will display this marvelous effect upon the twisted arrangement of the fibers. This may also be seen in a wand of hazel or filbert-nut [virga columnae sive avellanae nucis] —

— of the nut, which, placed upon two forks at the fire, will at once twist itself into circles in the manner of a roasting-spit. This thing first became known here at Rome, to the admiration of all, through the servants of a certain Cardinal, who, fixing onto hazel spits the little birds they had caught in hunting, noticed that the birds were moving together with the spits. They came to me without delay to assign the cause of this prodigious operation. Performing the experiment of the matter myself, I indeed found out the truth; but the moving force, which they had supposed to be present in the little birds themselves from some hidden property, I detected as lurking in the hazel wand and in its natural constitution. But since the experiment is set forth in the *Art of Magnetism* [*Ars Magnetica*], third edition, folio 503, I have been unwilling to repeat it here.

[Margin: The shoots of the hazel placed at the fire twist themselves into circles in the manner of a spit.]

I confess that there are marvelous things in the nature of things which are everywhere ascribed to hidden qualities, even though their causes at once reveal themselves in the open, if they are rightly weighed in the balance of empirical reasoning. See what we have related at length about the oat-spike [spica avenacea] cited in the *Art of Magnetism*, and its circular motion, on page 411.

The sixth question is asked: Why do the leaves of some plants — such as the acacia, the mimosa, and the like — now open at the Sun's approach, now close at its withdrawal? The leaves of the acacia, indeed, as daily experience in our own household garden teaches me, from the point of midnight all the way to noon, together with the rising of the Sun, so gradually unfold themselves that — the plant, as if exulting with a certain joy at the company of the welcome guest —

they display the most beautiful array of leaves, not without the admiration of those who behold it. But when the Sun declines toward the horizon, they fold themselves in the same proportion in which they had unfolded at the Sun's rising, so that after the Sun's setting the foliage seems transformed into a thorny growth, after the manner of junipers.

[Margin: The acacia's leaves unfold as the Sun ascends, fold up as it descends. And the cause of this matter.]

And so I say that in the acacia this happens because of the moisture with which they are laden at the fall of the nocturnal dew, from which they take on a parched and wrinkled appearance. But as soon as they are struck by the points of the solar heat, with the moisture thinned they become, as it were, more apt for unfolding themselves, the more they were weighed down by the slighter moisture that gradually exhales away. Hence before noon they are seen to unfold themselves most fully; but after noon, the moisture now consumed and the Sun's heat now increased, growing as it were flaccid, they gradually contract themselves, until after the Sun's setting they bristle like junipers. And just as they are soon filled again by the fresh dampness of the nocturnal dew, so too, swollen as if by the acquisition of fresh strength, they are again emptied of their superfluous moisture at the Sun's approach — whence the dilation.

[Margin: The cause of this matter.]

The same is to be said of the leaves of the elm, the poplar, and similar trees, which, as soon as the Sun reaches the point of the summer solstice, tend to turn their leaves over. So I say, therefore, in the case of the acacia [recte: the wording here resumes the elm/poplar discussion — the margin and text shift to the elms]. And let no one suppose that this happens at the very point of the solstice; by no means: for a conversion of leaves of this kind requires some latitude of time in order to produce its effect. It happens in this way: the leaves of trees of this kind, being for the most part still filled with abundant moisture up to the time of the solstice, it comes about that, as the Sun's heat grows, they are with time thinned and resolved into vapor, and rendered lighter. This accomplished, it follows that the leaf-stalks [pedunculi] which support the leaves, being likewise made thinner and now freer and lighter, released from the obstacle of the superfluous moisture, soon begin to twist; until, the superfluous moisture being consumed and no other supervening, they remain in that position, turned opposite to the prior one, which the twisting of the stalks has imparted to them.

[Margin: The motion of the elms and poplars around the solstice.]

And this I judge to be the genuine cause — leaving the judgment of others intact — of the conversion of the leaves of certain trees at the time of the solstice. As for why this action appears chiefly in the leaves of the poplar, the fig, and the elm, the reason is this: that these leaves have leaf-surfaces of different colors — one of which is green and deep, the other of a whitish hue. And so, from the difference of colors, they are more easily observed by men; although I myself judge that in most plants, if they are rightly observed, this same thing occurs. And these are the things which I have thought ought to be indicated to the *exotic* reader concerning the foreign properties of plants. [recte: *plantarum proprietatibus exoticis* — "the exotic properties of plants"; "Lectori" = "to the reader."]

Diagram. A woodcut, set within the left-hand column, showing the sun-following experiment described above : an earthen or bronze pot placed over a fire (flames shown beneath at the base), with a tall stalk rising from the water within the pot and bearing a heliotrope-like flower-head at its top, leaning over to one side to illustrate the stalk twisting in circular motion. No printed labels appear on the figure.

Diagram. A pair of woodcut figures at the foot of the left column, illustrating the acacia leaf in its two states. Two pinnate (feather-like) leaf-sprays are drawn side by side beneath two captions:

- Left figure: caption **Mane.** ("In the morning.") — the leaflets are shown spread open and outstretched along the stem.
- Right figure: caption **Vesperi.** ("In the evening.") — the leaflets are shown folded up and drawn together against the stem.

SECTIO V.

THE HIDDEN WORKSHOPS, OR LABORATORIES, OF THE VARIOUS ARTS [OCCULTA VARIARUM ARTIUM ERGASTERIA SIVE OFFICINAE]

In which, according to the prototype of the Subterranean Archeus [Subterraneus Archeus], marvelous operations are established.

PREFACE.

Now that the Kingdoms of Nature — both of animals and of vegetables — have been set forth, nothing further remains except that we should now examine, with

equal step, the innermost secrets of the Kingdom of inanimate things. It must therefore be understood that a certain marvelous analogy lies hidden in this threefold Kingdom of Nature, by which all things are found to be present in all things, in a certain manner. For just as sensation is present in animals, so too — that it is present in its own way in some vegetables — the plant called *mima* [mimosa] sufficiently demonstrates, which contracts itself at the very lightest touch. And it appears to be present even in some stones, such as the Astroites [Astroites], when, placed in vinegar, they are seen to be agitated of themselves with a forward motion. I shall say nothing here of the wonderful nature of the Magnet, which sufficiently and more than sufficiently shows, by its marvelous motions, that it expresses in itself both sensation and life in a certain manner — concerning which see the matter treated at length in our Book *On the Art of Magnetism* [Ars Magnetica]. In animals and vegetables there occur, as we have taught, certain marvelous metamorphoses; they occur also in inanimate things, as we shall see a little later. Just as animals and vegetables are endowed with wonderful virtues, so too is the inanimate economy of metallic minerals endowed with the same. By applying the active to the passive, Art accomplishes marvelous things both in animals and in vegetables, as was said in the preceding sections; and the same Art accomplishes them also by principles drawn from the subterranean nature of minerals. But as to how much benefit flows from these things into the uses of human affairs, I shall lay open in order in this Section of the Book. May God assist our undertakings.

PARS I.

ON THE CHYMIURGIC ART [DE ARTE CHYMIURGICA].

CAPUT I.

On the Secrets of Chemistry [De Arcanis Chymicis].

Although in Book XI we pursued, most fully, the *Chimiotechnia* — which they call Alchemy — yet there we were wholly intent on this: that we might utterly overthrow the χρυσοποιητικήν [Greek: chrysopoiētikēn, "gold-making (art)"], that is, the gold-producing Art, together with the most empty ostentation of secrets practiced by those who, by shameful lies, with a counterfeit zeal for pyrotechnics, most perniciously impose upon the World. But many things are found in the true and divine study of Chymiurgy which have been discovered to be most useful to the human race; of these we shall treat in this place with what brevity we can. And in order that we may proceed with some method, we shall first investigate the secrets of the seven metals, and then go on in order to the rest.

§ I.

On the Secrets of Gold, or on Potable Gold [De Auri Arcanis, sive de Auro potabili].

I shall not speak here of the virtues and faculties of gold, since I have set this forth most amply in the Tenth and Eleventh Books. Only in this place shall I bring forward a few matters most controverted among the Chemists; and they are these: Whether Potable Gold [Aurum potabile] can be made by the Spagyric Art [Ars Spagyrica].

I find among the Alchemists, regarding the Magistry [Magisterium] said to produce a longer life by means of Potable Gold, so many and such bitter contentions and endeavors, that with good reason I find Potable Gold as entangled in an inextricable labyrinth as is the Philosophers' Stone [Lapis Philosophorum].

[Margin: Whether Potable Gold can be made.]

There are those who would have it that *Potable Gold* and *Magistry* signify "every precious thing fit to be drunk." There are others who take it for a purely allegorical allusion. In this way, some Alchemists call the fifth essence of wine [quinta vini essentia], reduced to its ultimate perfection — which Lull [Raymond Lull] calls *Caelum* ("Heaven") — potable gold. But setting these things aside, let us proceed to resolving that question which is asked: whether gold can truly and properly be dissolved into a liquor fit for drinking, and, when so reduced, be furnished with the marvelous virtues which they boast of.

All those affirm it who are more than fairly devoted to that artificial Philosophers' Stone — the pseudo-chemists — without which, namely, they maintain that gold cannot be reduced into a liquor. From which it is easily concluded against them that, just as that much-vaunted Stone has never existed in the nature of things, so too neither has potable gold; and accordingly the Alchemists wear themselves out in vain, at so great expense and labor, in the preparation of potable gold.

[Margin: It is the opinion of many that gold cannot be dissolved.]

Paracelsus [Paracelsus], being least of all consistent with himself in all things, is likewise found in the preparation of potable gold exceedingly slippery and unstable. For he says that potable gold is a liquor of gold without the admixture of any corrosive, known to very few; yet afterward, in the *Book on Long Life* [*De Vita Longa*], he openly contradicts himself, where he so commends potable gold made by means of corrosives that, unless these are separated out but remain together with it, he calls it "dead." For he supposes — against the opinion of all —

that corrosives become health-giving on account of the presence of gold. While he himself perhaps saw this, and repented of the error he had committed, in the *Book Archidoxis* [Archidoxis] he supposes that by the often-circulated fifth essence of wine he can accomplish it, being persuaded that in this way it can rightly be prepared without corrosives.

[Margin: Paracelsus's opinion on potable gold.]

The other view is that of those who assert that gold can in no way be dissolved into a liquor, on account of its untamable nature and firmness, by which it resists even the strongest and most prolonged fires without any harm or detriment to itself, losing no part of its weight; nor can it be corrupted by however sharp menstrua, or by other tests of fires, of the cupel, and of furnaces. And if it is sometimes dissolved by strong waters [aquae fortes] or by quicksilver [hydrargyrum], yet, the moisture of the menstrua having evaporated, it is soon reduced to the first state of its nature. There is the further point that gold resolved into a liquor in this way is found to be — I will not say a health-giving drink, but rather most noxious and pernicious — on account of the corrosive faculty lurking in the liquor. So think Cardanus [Girolamo Cardano], Baccius [Andrea Bacci], Caesalpinus [Andrea Cesalpino], and other chymiatrists. Hence Libavius [Andreas Libavius] rightly says: "They are to be laughed at who thrust upon us, under the name of potable gold, gold that is drunken from the frequent evaporations of quicksilver, and that hence melts at a candle."

[Margin: Gold cannot be dissolved — it is the opinion of many.]

[Margin: The various opinions of authors on potable gold.]

We accept the Suchtenian opinion [Suchtenian = of Alexander von Suchten], which calls the potable gold of the physicians "a red form extracted from antimony while it is liquid, but golden when coagulated." Joannes Baptista Birellus [Giovanni Battista Birelli] offers, for potable gold, a tincture of gold; Lull, the calx of the same gold — concerning which you may see, most fully and most contentiously, Paracelsus, Quercetanus [Joseph Duchesne, "Quercetanus"], Birellus, Ulstadius [Philipp Ulstad], Mylius [Johann Daniel Mylius], and countless others.

But let us now examine, with what χειρουργία [Greek: cheirourgia, "manual operation / procedure"] we can, the method which the Chemists use in dissolving gold into a liquor. Gold, then, in order that it may become potable: some prefer it true, natural, and simple, first reduced into little plates — refined gold [obrizum], I mean — most carefully, and pure unalloyed mineral, whether solid, or from

grains of gold found in rivers; and they take also ἄπυρον [Greek: apyron, "unfired" — gold that has never experienced fire]. Others, by an indiscriminate selection, take into the magistry gold that has already passed through fire; indeed, they do not even disdain the ordinary gold of the moneyers and goldsmiths (whom they call ζυγοστάτας [Greek: zygotatas, "weighers / assayers"], δοκιμαστάς [Greek: dokimastas, "testers / assayers"], and χρυσοπλάστας [Greek: chrysoplastas, "gold-shapers / goldsmiths"]).

Once gold of the better sort has been procured, there is no less disagreement among the Artificers concerning the menstrua that dissolve gold into a liquor. Now menstrua can be considered in two ways: one drawn from corrosive minerals; the other from the vegetable economy. The former, being utterly dangerous, I would judge not to be readily employed; the latter, on the contrary, since it can be taken without any harm or damage. Nor is it enough that a corrosive menstruum can be corrected by other medicaments and sweetenings; for although various things can be supplied that may blunt their caustic virtue, yet not such as can at once deprive the spirituous corpuscles of the salts of all caustic force. Yet so great is the obstinacy of some Alchemists in the dissolution of gold that, with no regard had to the menstruum, they strive to dissolve it even with deadly agents whatsoever.

[Margin: It is the opinion of many that gold cannot be dissolved.]

Of this stamp are the following menstrua: oils and stillatitious liquors from sublimated quicksilver; strong waters [aquae fortes], that is, *aqua regia* [aqua regia], or even *aqua stygia* [aqua stygia]; a solution of sublimated sal ammoniac; a solution of salt of arsenic [sal arsenici]; radicated vinegar [acetum radicatum]; the most sharp oil of vitriol; quicksilver — whose pernicious qualities, implanted by nature, when they saw that by no art could they be separated from their menstrua, they turned to the solvents of the vegetable nature.

[Margin: The deceit of the Alchemists in making potable gold.]

Of this kind are the liquor of honey and honeycombs [liquor mellis & favorum], and the less harsh juice of manna; some also use as menstrua vinegar, brine, garum [garum, fish-sauce], the juice of barberry and of lemons; another, a liquor prepared from the essential salt of tartar by a sevenfold extraction, mixed with spirit of wine or with the fifth essence; they use the descensory spirit of wine of nitrous woods, with its own salt added. But those who want milder agents take for menstrua spirit of wine, or *aqua vitae*; the juice of barberry and of lemons distilled through a retort only; others, the acid juice of the citron-apple, vinegar,

malmsey wine, water of bugloss tinged with its own salt, a stillatitious liquor extracted by spirit of wine from the calcined salt of sugar-candy (as they call it), joined to a distilled liquor of acid pomegranates and acid oranges.

[Margin: The various menstrua by which the Alchemists dissolve gold.]

and so on. With these menstrua the chemists suppose that gold can be dissolved. But anyone who weighs the matter on the more careful balance of reason will see that gold can be dissolved only by the agency of mineral liquors. By botanical juices it cannot — or only with difficulty — as experience has taught me. [Margin: Juice of plants does not dissolve gold.] For a gold coin kept buried among menstrua of this kind for a long time was afterwards drawn out, just as before, without any diminution of itself. The reason is none other than that menstrua of this sort are moved by no sympathy toward gold, as happens in the case of mineral menstrua. For gold placed in aqua regia is immediately dissolved, whereas gold merely smeared with mercury is at once made brittle.

A solvent is therefore sought in which gold, once placed, will liquefy no differently than snow thrown into water — so that it grants the gold no return to its former solid state. Many have sought such a solvent, but none has yet found it. Of this matter Libavius [Andreas Libavius] writes thus: [Margin: Libavius's process.] "From what one might form such a menstruum lies among the secrets. From the nature of the juice it is certain, but it is also necessary, that this liquor be viscous — which is the common nature of the material of metals — and that by its power it be gold, and unite with gold, as ice with boiling water; for that liquor differs from gold in nothing but its coagulation." Libavius, then, in describing a menstruum that dissolves gold, does nothing but explain the unknown by the unknown — and in such plain words that he does not seem to have understood even himself what he was saying. I interpret his words thus: it is certain that it lies in the nature of the juice — yet *from which* juice, this is among the most hidden things, that is, it is known by no one. Yet, so as not to seem to have said nothing, in what follows he nonetheless teaches the method: that unknown solvent, by means of salt and of sulphurous calcanthum [vitriol], will produce the effect of solution — provided, however, that the liquor has first been reduced, by very frequent cohobation, to a substance of altogether ethereal subtlety, and that in this way it furnishes the menstruum of the Philosophers. With such species of unknown things the alchemists entangle themselves, lest they should seem to know nothing. If Libavius forbids corrosives in the dissolution of gold, as we said above, then how he dares here to prescribe a solvent of salt and calcanthum of the greatest corrosiveness — let whoever can, work that out. But leaving aside

these trifles of the alchemists, let us now turn our pen to practice, that from it the truth of potable gold may shine forth.

The various processes for making potable gold.

[Margin: Libavius's other process.] **Process.** Libavius first composes a menstruum to dissolve gold *from one pound of good vitriol, of saltpetre [halonitrum], of sal ammoniac — 1 3 pulverized — and mixes them, and distils through an alembic over a slow fire into a long receiving vessel: for then the liquor will come forth with heat, 1 3 of which, joined with 2 3 of calx of gold prepared through mercury, when shut in glass dissolves into a clear water, in which you will again be able to dissolve both gold and pearls; some add mercury sublimite — which is rightly rejected — but in addition this requires a craftsman and physician practised in these matters with exquisite prudence.* Rightly so indeed — but who will find such a chemist as can dissolve gold with such very sharp corrosives in such a way that it can be taken safely?

[Margin: Dorn's process.] **Secondly.** Dornaeus [Gerhard Dorn] and Leo Suavius [Jacques Gohory] proceed in this fashion: leaf gold or gold powder, in the quantity of an ounce, is immersed in distilled vinegar; after maceration is completed they begin the distillation, for the gold drawn off by the vinegar yields a kind of juice, which is distilled until the sharpness of the flavor departs. Afterwards an aqua vitae is made by the infusion of aromatics in burning wine [spirit of wine], and in five ounces of this the juice of gold is digested for a month in a circulatory vessel which they call a Pelican; and the gold will be reduced to its perfection as potable gold. As to the vinegar in which they say the gold is dissolved, they proceed variously: some sharpen it with crystals of their own, others with the salt of wine-lees, or with crystals collected from oil of vitriol, others with euphorbium, or even with common rock-salt. But turn and turn this stone over as much as they please, they will never produce from it that true potable gold which they claim. For even they themselves, when they saw that with distilled vinegar alone the magistery could not gain a good outcome, were therefore led — willing or unwilling — to corrosives (such as the crystals of vitriolic oil are) and were compelled to take them up for the dissolution of gold. But as for their calling this an incomparable medicament and a wonderful strengthener of the heart and of the powers of the whole body, I should judge that this is to be ascribed not so much to the gold as to the aqua vitae made by the infusion of aromatics in burning wine.

[Margin: Alexius of Piedmont's process.] Alexius [Alessio Piemontese], in his *Secrets*, prescribes an exceedingly laborious operation in the making of potable

gold; yet if you examine it rightly, you will find it — like the others already cited — sophisticated. The menstruum runs thus: to the cooked and filtered juice of lemons he adds double the quantity of unskimmed honey and a half-part of salt; he boils it in a cauldron until it ceases to foam, and distils it by degrees; he calcines the *caput mortuum* [dead-head, the residue] for three days; to one pound of the calx he adds a third of manna and a sixth of crystalline sugar; he pours this, transferred into a glass cucurbit, the liquor extracted by distillation; and on top of it double the quantity of spirit of wine; he distils the whole by degrees, and thus sets aside the liquor drawn off in this way. Meanwhile he grinds leaf gold — first well purified by cement, or by antimony [stibium] — mixed with rose- or violet-julep, or with honey; the ground material he washes with tepid water, and in this manner makes a fine powder, which, placed in a cucurbit, he covers with just as much of the aforesaid distillate as can equal five fingers' breadth; he then distils. For then the liquor will come forth with heat, of which 1 ℥ joined with 2 ℥ of calx of gold prepared through mercury, when shut in glass dissolves into a clear water, in which you will again be able to dissolve both gold and pearls; some add [?] [Margin: Process [?]]. From the receptacle he now transfers it through an alembic by a slow fire into a narrow-mouthed phial; this being drawn off to dryness through the alembic, he adds fresh water as many times as is needed, until the entire quantity of the distillate has been drawn off from the gold by turns,

which, once collected and placed in the alembic without distillation, he keeps in a bath for half a month; and when it has been melted off he separates [?] it, the golden juice being left at the bottom of the cucurbit. And this is the knot of Alexius, by which he supposes he can dissolve gold without corrosives. But since we have already said above that the menstrua of vegetables are disproportioned for resolving irreducible gold, so likewise you may judge that the golden juice which remains at the bottom is nothing else than a certain amalgam of the leaves of gold mixed with antimony and juleps — and nothing is easier than to reduce this to its former state, as we shall say below.

Another process for potable gold.

There was communicated to me not long ago, by a most powerful prince, the true and genuine method and procedure for making potable gold, which I shall set down in this place; and afterwards I shall also explain what is to be hoped from it and what I think of it.

Take salt of tartar reduced into water, 1 ℥; place it in a bladder-vessel [vesica] and distil to dryness; pour the distilled water back over its salt, and again distil the

dissolved matter to dryness; and do this so many times, distilling and coagulating, until the oil of tartar comes out as well purified as possible. This done, place the oil in a glass bladder-vessel A, together with gold first purged through the cupel and reduced to the finest and impalpable powder; over this mixture pour 3 ounces of aqua vitae from wine — the more generous, the better the extract.

Diagram. A vertical apparatus for the slow digestion of the gold-and-oil-of-tartar mixture, shown as a rectangular frame enclosing the assembly. At the top is a tall domed vessel (a bronze vessel, *vas aeneum*, or "bath of Mary," *balneum Mariae*); within it hangs a pear-shaped glass flask. Beneath the bath sits a small round lamp that supplies the gentle heat. The labels, from top to bottom:

- (dome, top): "Cooperculum" — the cover/lid of the bath-vessel
- B (upper-left corner of the bronze vessel)
- C (upper-right corner of the bronze vessel)
- A (within the inner pear-shaped flask): the *vesica* (the sealed glass flask holding the mixture)
- (label on the flask): "Vesica" — the bladder/flask
- D (lower-center, below the flask): "Balneum" — the bath (of Mary)
- (mid-level label): "Fornax" — the furnace [?]
- E (the small round vessel at the bottom): "Lucerna" — the lamp

The said bladder-vessel A, sealed as well as possible, is placed in the bronze vessel B C D — that is, in a bath of Mary — with the light of a lamp E set beneath it; and within the space of three months you will find the water tinged like a ruby. This, once taken out, you again pour over the gold and the oil of tartar, continuing in the same degree of fire with the new water over the gold; and you will repeat this so many times until the gold is wholly stripped of its splendor, and you will have what you desire.

And this is the process. It must now be seen whether the water drawn off from it is truly potable gold. I answer that it is not, but is only a certain accidental tincture — which I demonstrate thus. First, because the oil of tartar extracted from its salt, as well as the menstruum of aqua vitae for dissolving gold, cannot (as we said above) be proportioned to the gold. Secondly, that reddish color which came forth by such manifold repetition of distillation ought by no means to be reckoned to have drawn its redness from the gold, but rather from the oil of tartar mixed together with the spirit of wine. Take this proof of it: for if you precipitate even a single drop of oil of tartar into aqua vitae, at once that very color which you first obtained by so many distillations will reveal itself by a

single precipitation. [Margin: Experiment.] As for your finding the gold stripped of its splendor, this does not happen because the splendor of the gold, or some substantial part of it, has been scraped off and joined to the menstruum; rather, by the force of the fire applied to it, it seems to have contracted some stain, though only a superficial one — a pallor which it can contract from countless other things, especially from contact with mercury, as we showed in Book XI. Add to this that the gold cannot even be said to be dissolved into a liquor — which is a clear sign that it stands in its natural perfection without any detriment to itself. Hence such gold cannot in the least be called true and genuine potable gold, but is sheer, pure accidental tincture; and it is worth just as much as if someone were to prepare upon a flint stone an excellent broth furnished with various seasonings — for it is certain that the broth would have acquired no virtue from the flint, but only from the things added.

[Margin: The process of Andreas Blavius.] Another specimen of potable gold is set before us by Andreas Blavius [Andreas Bachmann/Blavius], who explains it in a certain letter which he wrote on potable gold to Pietro Andrea Mattioli [Pietro Andrea Mattioli]. In it, although he does not appear to despair of the making of potable gold, he yet displays so many and so great difficulties that it readily appears it was never made by him — since so many doubts hold his mind perplexed. Nevertheless, because the mind greedy for gold cannot enjoy its desired tranquility unless it satisfies itself with some specimen — if not true and real, at least supposed and apparent — it is that which follows. "Three things," he says, "are required for making the Magistery: most highly purified gold, common salt of the better sort, and a little distilled vinegar." (For he utterly rejects corrosives from vitriol, alum, nitre, and mercury, as wholly pernicious.) [Margin: The process of Andreas Blavius.] Yet he takes up gold purified through antimony (which he prescribes is to be purged in a quantity tenfold that of the rest); from these, mixed together and placed in the alembic, he draws out a certain fatness not unlike white wax, in flavor altogether sweet like sugar, and in smell quite similar to musk — which by the violence

of the fire at length coalesces into the sweetest crystals clinging to the wall of the vessel, while at the bottom there remains a most limpid oil of the sun, greenish-from-white in color. Within this, he says, if you place leaves of gold, they will liquefy within three days, and the whole gold will be turned into a potable water, still possessing an acidity like the juice of lemons. And this is the method of Andreas Blavius in making potable gold — which, however, whether it is truly potable gold, remains to be examined. Blavius, then, takes the whole salt and oil of tartar with distilled vinegar for his menstruum; and it was shown above that

this cannot furnish the desired effect, since — apart from the fact that oil of tartar is of a nature heterogeneous to gold — it likewise cannot resolve it radically; nor does this power seem granted to ordinary salt, since he says that, once reduced to a sugary sweetness, it is stripped of all the sharpness wholly necessary for dissolving metallic bodies. It remains, therefore, that this ought not and cannot be called potable gold, but only an accidental tincture resulting from the precipitation of oil of tartar into a saline liquor — which even he himself afterwards is not ashamed to admit, in these words: "There is also another mark of true potable gold, by no means to be neglected: that although, mixed with imperfect metals, it perfects them, yet of itself, that it may be true, it ought never to be able to be reduced — which, however, in waters of this kind that stain with color, is easily done; for when spring water is poured in, with which they mix a little tartar, and this exhaling somewhat upward, the powder of gold ought to settle at the bottom." And a little before he says thus: "If you do not desire the substance of gold dissolved, but rather its tincture, I think that, if you make the trial, you will be able to draw it out from that water of ours with no very great labor." Here he expressly signifies that neither has the substance of gold been radically dissolved from itself by these menstrua, nor that he has drawn out from it the tincture of gold, that is, true potable gold — since he refers others to the experiment. At length he concludes: "As to what concerns the warding off of diseases, similar waters, used with due method applied, have profited greatly; but as for those who, like some universal medicine, have cured all diseases indiscriminately, restored fallen teeth and nails — I have so far seen none." But as for his saying that within this magistry a certain oil extracted from common salt has entered, in which the golden leaf or its powder (as he puts it, which they call calx), first purified through antimony according to the rule of art, is little by little and gradually turned into water within three days, easily distillable through the alembic — he indeed says so, but we know what antimony can do and what it cannot. It is true that this, joined with the aforesaid oil, leads gold into a liquor — yet in such a way that the antimony always floats on top while the gold seeks the bottom; and who does not know that antimony abounds both in mercurial spirits and in other most pernicious faculties, which, as they easily corrode gold by their innate sharpness, so likewise I should reckon the resolution to be ascribed not so much to the oil of salt as to the antimony. But how a liquor of this sort can be taken without danger, let those judge who have skill in alchemy. I could adduce in this place countless practices, partly collected from authors and partly communicated by various princes; but because they are all to a man stuffed with chemical paralogisms, I judged that they were by no means to be adduced; rather,

I shall here lay open only the errors and the solemn paralogisms which the chemists commit in the making of potable gold.

CHAPTER II.

An Iatro-Chemical Inquiry, by which the truth of Potable Gold is explored.

Since the Philosophers' Stone and Potable Gold are set on an equal grade of dignity, it ought to seem in no way surprising to anyone that the minds of mortals, allured by such great secrets — being as greedy for gold as drunk with the drinking of it — have attempted countless ways by which they might happily reach the harbor of such great magisteries. [Margin: No one has yet found the method of making potable gold.] But just as up to now there has been no one who has shown the true and real method of making the Philosophers' Stone, so likewise there has been no one who has demonstrated the true, real, and genuine procedure for making potable gold. This I show thus. For gold to be dissolved into a drinkable liquor, this cannot be done, in the opinion of all the alchemists, except by calcination. [Margin: The twofold calcination of gold.] Now calcination is twofold, proper and improper: the former is done by the agency of a most violent fire, as is evident in the calx of stones, which, reduced to calx [lime] in this way, cannot be brought back to the former state of stone; the latter calcination is that which is done by the dissolution of corrosive menstrea. I have called it improper because gold dissolved in this way — however much it may seem reduced almost to nothing by the torments of the very sharp water of Styx — [Margin: Gold reduced to nothing by no torments.] is nonetheless, despite all this, able to be brought back to its former nature, even reduced to an impalpable fine dust of the smallest particles. Besides these calcinations, no other calcination can be assigned in the nature of things. And that gold cannot in the least be calcined by fire, by calcination properly so called, is admitted by all — because no violence of fire can corrupt its substance. Yet granting (though not conceding)

that gold could be reduced to calx — I now ask whether gold thus calcined retains its natural virtues or not. The former, unless I am mistaken, all will admit, unless they wish their potable gold to be utterly dead, destitute of all natural virtues — which no one but a madman will concede. Since, then, the substance of gold, according to its physical composition, consists of moist and glutinous (or, what is the same, mercurial and sulphureous) particles, so united among themselves that — no differently than the asbestos stone in perpetual fire — it lasts inseparably and can be dissolved by no violence: surely, once calcination by fire has been

performed, that exact union of parts would undoubtedly have to be dissolved. [Margin: Gold calcined by proper calcination does not remain gold.] For since calcination is nothing else than the dissolution of the union of parts effected by fire — if this be granted, I say that all the natural virtues and faculties of the gold must necessarily vanish once other things have been introduced. For the mercurial moisture, now given over to freedom, would by the violence of the fire be scattered into thin air, the sulphureous glue being consumed by fire; and so nothing would be left but a dry, parched earthy substance, stripped of all native virtue. For since the virtues of gold proceed from such-and-such a combination of sulphur and mercury in its composition, once the mercury and sulphur are destroyed the virtues too must necessarily be destroyed — which was to be demonstrated. [Margin: The magnet loses its virtue by fire.] And this is evident also from the magnet, which, when reduced to calx by fire, soon loses all the force of its attractive faculty together with its sulphureous (so to speak) soul, which vanishes away. From this it is clear that gold can in no way be calcined by calcination properly so called, nor, when calcined in this way, can it retain its virtue along with it, for the reasons indicated a little before. This is evident also from the fact that, the essential sulphureo-mercurial bond being destroyed, the virtues — which necessarily and inseparably depend on that bond — cannot subsist, nor, for the same reason, can they be reduced back into the former substance of gold. I am speaking here, however, of the calcination of the most perfect of all metals, that is, of gold, not of the rest of the metals, of which afterwards. This, then, being now clearly demonstrated, let us proceed to expound the second species of calcination, which we called improper, by which gold is corroded and reduced into the minutest parts — indeed, together with the moistening menstruum, wholly into a liquor. [Margin: Whether gold dissolved by corrosives can be brought back.] It is therefore asked whether by these liquors of sharp menstrua gold can be so dissolved into water that it cannot be reduced to its former state.

I say first that it is impossible that what the highest violence of fire cannot do, heterogeneous liquors — whether mineral or vegetable — should accomplish. For even though gold, through reverberation effected with saline or sulphureous materials, may be so altered as to its external figure that, stripped of all form, it shows no trace of gold, nevertheless by the skill of an expert spagyrist, through a suitable additive, it can be so freed from the spirits of salts and of sulphur that, without any harm to its qualities and virtues, it is brought back to its former form — which we showed by various experiments in Book XI. No menstrua of the liquor of Mercury, then, no torments of the strong waters, the regal waters, and the waters of Styx, no force and efficacy of the salts of nitre, alum, and vitriol, can

so mortify the unshaken substance of gold that it cannot be reduced to what it was. Hence we infer again: if the most efficacious corrosives of all, which we have recounted, can do nothing toward corrupting the substance of gold, much less, we affirm, can the moderate corrosives — such as ordinary salt and vinegar and the other vegetable menstrua of barberries and lemons — do this.

But here some will object to me that gold, by the calcination of fire alone, has been reduced to an impalpable fine dust without any addition of a corrosive, and then dissolved by a certain celestial Raymundine water [aqua coelica Raymundina] into an indivisible liquor — and sold (whether for an equal profit, I know not). [Margin: Objection.] Certainly that this was a plain imposture, this celestial Raymundine menstruum — drawn perhaps better from the hollow of the Moon than from the economy of a lower nature — abundantly teaches. [Margin: Refutation.] But lest we seem to grant them nothing, let us suppose that it was made of some sublunary material free of all corrosion. Hence I argue thus: either he calcined the gold by fire alone (as Paracelsus [Paracelsus] himself admits), or by some other means. Not the former: since that invincible substance of gold is so far from suffering any detriment to its powers in the fire that rather, in it — as we taught a little before — it triumphs and exults in a garment of more brilliant splendor; which, however, would by no means happen if it had been reduced to calx by the agency of fire, inasmuch as its substance would then be destroyed together with its powers. Not the latter: since gold reduced to calx by mercury and the other very sharp menstrua already mentioned neither reproduces nor preserves either color or flavor — the truth of which the following experience has taught.

EXPERIMENT I.

Take calx of gold dissolved by mercury or by other menstrua; place it in a crucible and commit it to the fire of fusion, and at once you will see it melt like salt; but when the fumes and spirits have perceptibly evaporated out of the calx, you will find the gold restored at the bottom to its former shape; while you will discover — no better than by a dizziness of the head and the token of a sharp taste — that the smoke and water were nothing but the vapor of the menstruum or of mercury, or the acidity of the menstruum. [Margin: Objection. Refutation.] It now remains to explain how that aforesaid chemist dissolved that golden calx so that it might become potable gold, since the use of corrosives in this magistry, as harmful and abomin-

[Margin: From honey and manna the sharpest solvents can be made.] [Margin: A true and real tincture of gold does not exist.]

he should reject the whole business. From this he invents some sort of "celestial water" of Raymond Lull [Raymundinam, i.e., of Ramon Llull], which he pours over the calx and seals into an alembic; then, after digesting it for several days over a gentle heat, he finally reduces it by repeated operation into a water of golden color. This he asserts to be the true and real mode of potable gold prepared by a philosophical method — a golden liquor never reducible back into its former substance.

For my part, I would judge that this "celestial water," the worker of such great marvels and free of all corrosion and acrimony, was drawn rather from the concavity of the Moon, as I said above, than fetched from anywhere else — since a little earlier we showed that gold cannot be dissolved except by an actual or a potential fire lurking in the solvents. Therefore I take this "celestial water" the author invents to be nothing other than a solvent compounded either from honey or from manna, the celestial dew. Many chemists prescribe just such a thing in the dissolution of gold to avoid corrosion; and so as not to appear to be following them, it is likely that he prescribed this "celestial water" hidden under some allegorical manner of speech, lest he be convicted of having used corrosives. But who does not know that from honey and manna — sweet as those liquids are — the very sharpest solvents are nonetheless made? And so, willing or unwilling, he is forced to take up corrosive solvents of this kind to accomplish the dissolution. Yet just as these are out of proportion to dissolving gold, so too they will in no way be able to dissolve gold into an irreducible drinkable liquor — as will afterward be seen by experience.

CONSECTARIUM I.

[Corollary I]

[Margin: A true and real tincture of gold does not exist.]

From what has been said it is plainly clear that, just as gold cannot properly be calcined, so too it can by no means be sublimated through the alembic in such a way that a true and real tincture — what they call the *soul of gold* — is extracted from it without the total destruction of the gold, for the reasons indicated above. We do not deny that gold can be made subtler, dissolved, and carried up through the alembic by skilled chemists with the addition of certain ingredients or solvents; the crux of the difficulty does not lie there. The question is whether gold sublimated in this way is irreducible — and this we deny again and again, as has already often been proved. But since our adversaries have no other means of establishing the truth, they try to establish it from the golden color in which the

liquor shines. Yet who does not see how frivolous this argument is? Are they not mindful of the saying, *Trust not too much in color*? For that golden color can be induced in countless things — of which here is the following experiment.

EXPERIMENTUM II.

[Experiment II]

Concerning the deceptive color in potable gold.

Pour distilled vinegar over white lead [ceruse], and set it in a water bath for several days to digest; you will find the vinegar imbued with a tawny color. Separate the liquor by decanting, and distill it through the water bath to about [?] [the source reads "ad :circiter:" — the target quantity is left blank]; at the bottom you will find a matter sweet like honey and imbued with a tawny color. Distill this through ashes, and at the end of the distillation a blood-red liquor will come off, ruddy like the juice of the mulberry, with the residual matter spongy and light — which may not unfittingly be called a *caput mortuum* [dead head].

Now who does not know that ceruse is the whitest of things, and distilled vinegar clears to a most limpid clarity like water? So one would argue falsely who said that the ruddy thing produced by distillation was the tincture, or the soul, of the lead itself out of which ceruse is composed. For lead has no such tincture, nor any other watery substance resembling distilled vinegar. Thus we have most amply set forth that the whole redness of this tincture comes from the fire — the property which this mixture acquired through the heat or burning of the fire. [Margin: In the eighth book *On the Origin of Colors* in metallic bodies.] For if this were a true, real, and properly so-called tincture, it could by no means be reduced back into its former state — which experience teaches to be false. For if you expose this mixture to fire with the addition of a little sheep's fat, at once the ceruse is melted down into the lead it formerly was, [Margin: Reduction of ceruse into lead.] as Angelus Sala [Angelo Sala] — no contemptible chemist — also proves at length in his *Chrysologia*.

The same effect is evident not only in ceruse but also in iron, tin, calcined antimony, marcasites, and crystals: the liquor drawn out of them turns no less yellow than gold does. Gold, as we have found by experience, dissolved in *aqua regia* [royal water] reddens intensely; silver dissolved in strong waters [acids], with black; copper with acid liquors is tinged a green color. Yet all these, once separated from the dissolving solvents, easily resume their former color.

CONSECTARIUM II.

[Corollary II]

From these things too it is clear that the attempts of those Alchemists are vain who try to resolve gold by their *Sisyphean* labor into a water, a calx, an oil, a tincture. For although we have asserted that gold, like the other mixed bodies, is rightly composed of salt, mercury, and sulphur in countless places, it must nonetheless be understood that all these things behave one way in mineral nature, another way in vegetable and sensitive nature. For the latter, in the form of water and oil, once the separation of the principles is made, yield up their salt, sulphur, and mercury with almost no trouble, because mixed bodies are most easily resolved. Gold, however, is so compacted by nature with an equal weight of its principles that no one has yet been found who has reduced it, once dissolved by chemical art, into an irreducible state — so much so that, by the testimony of Roger Bacon himself [Rogerio Baccone], an alchemist of better repute, *to make gold is easier than to —*

[Margin: Gold is more easily made than destroyed.]

— *destroy it*. From this, the boast of the Alchemists is vain, who by fruitless labor try to elicit mercury from gold against the counsel of nature. [Margin: Empty contrivances.] These are empty contrivances — nothing other than the frivolous and deceptive showpieces of mountebanks and idle scoundrels. But granting (though not conceding) that it could be resolved: what use to medicine is to be hoped from it, I do not see; for the mercury separated in such a way, soon restored to its former nature, neither differs from common mercury nor adds anything to it.

[Margin: A true tincture of gold does not exist.]

Others sweat mightily over extracting from gold a tincture that would present a water of silvery color — but with fruitless labor. For the tincture of gold is not bound to its body's substance alone, but all its parts, inseparably united, exist in a pure way — outwardly yellow, inwardly ruddy — as Sala testifies: the Mercury on account of its supreme maturity, the Sulphur on account of its fiery faculty, the Salt on account of its fixed nature, from union and an indissoluble bond. And so from these three is born that tawny color of gold, which (as is now clear from what has been adduced) cannot remain in gold dissolved to the point of irreducibility. But let us proceed to the experiments.

EXPERIMENTUM.

[Experiment]

[Margin: Experiment.]

If anyone dissolves gold in *aqua regia*, a liquor will emerge from it not unlike a dyer's color [baphico colore], with which it will also tint whatever it touches when poured over it. Yet this tincture neither ought nor can be called an irreducible tincture of gold, since it can be reduced without any difficulty.

[Margin: How the tincture of gold may be reduced.] For if you keep the dissolved liquor in a water bath for several days, then draw off the *aqua regia* by fire or let it evaporate, and commit the remains to a limpid and clear water to be dissolved, you will draw out an oily cream like blood, of such redness that you could swear you had attained the perfect tincture of gold. Yet as soon as you bring it near the crucible, the heat of the fire resolving the liquor into vapor, you will find not a tincture but a solid body of gold. You will experience the same with gold reduced into an impalpable powder of the most intense red, which —

— [the column on the right continues:] — gold can be considered in two ways in its dissolution: intrinsically and substantially; and then extrinsically and accidentally. In the first way we assert it can in no way occur; for in this manner, with the metallic form destroyed, it could be called gold and not-gold, which is absurd — and I would have the Alchemists carefully note this. In the latter way, only accidentally, the form of gold vanishes — no otherwise than as fixed salt, reduced by deliquescence into water, [Margin: Gold is transmuted only accidentally.] loses the form of salt by accident, but recovers it when brought near the fire. The same must be held of gold dissolved by corrosives. For gold resolved into a liquor by the said solvents must be reckoned not to recede in the least from its metallic subsistence or form, but only to hide it — being diffused and dispersed through the smallest and subtlest little corpuscles. These, since they retain the nature of the whole, can also easily be joined and united to it from the sympathy implanted in them toward the whole, the gold returning to its former form. And therefore the *magisterium* that is made from gold ought to be called not gold but a golden magisterium — not the tincture of gold, but a golden one — as will be shown a little later.

CAPUT III.

[Chapter III]

Whether Gold, or Magisteria made from gold, obtain in Medicine the use, virtue, and efficacy that the Alchemists boast of; and whether it can or ought to be called a universal Medicine.

Now that it has been shown that gold cannot be reduced into a drinkable liquor with the substance of the gold preserved, it remains now to discuss whether, in medicines, it obtains the use that the Alchemists so greatly boast of. That gold is endowed with a remarkable virtue for strengthening the heart is received by the unanimous consensus of all physicians, ancient as well as recent.

Deservedly, then, it may be asked: whence comes such a virtue to it, and of what kind is it? To decide this:

It must be known that the virtues and qualities of things can be considered in two ways. First, according to the primary, manifest, and elemental qualities; second, according to certain specific virtues, which some wrongly name *occult*, but which we more truly call those deriving from a likeness to the whole substance. These are certain endowments implanted by Nature in individual things, which — since they emanate from the substantial form of things — cannot likewise be separated from it without the destruction of the substance. [Margin: The cardiac quality of gold is specific, not elemental.] And it is in this way that the cardiac power and faculty of gold must be understood. For just as the magnet, by the sympathetic virtue implanted in it by Nature alone, so desires iron that, when it is restored to its freedom, wherever and whenever it can, it is borne with a wondrous appetite toward the iron, draws it to itself, and over a remote distance moves and agitates it this way and that in marvelous ways — so too gold, applied to the human body, by the magnetism of the virtue implanted in it, at once flows to that member to which it is roused by a natural philtre of love, and exerts upon it the virtue implanted in it. But this would by no means happen if the dissolved substance of gold degenerated into a potable and irreducible liquor; for once the substance is destroyed, the virtues must likewise necessarily be destroyed — who does not know this? Or has anyone ever observed a magnet, reduced by the force of fire into a calx, still imbued with the attractive power for iron? Surely no one. Persuade yourself that the same happens with gold for certain.

[Margin: What the magisterium of gold is.]

This being supposed, one might deservedly ask why so many and such great *magisteria* are extolled from gold by physicians. I answer: those magisteria are not made, nor were they ever made, in the way that the Alchemists — ignorant of physiology — claim they must be made, such as: the Elixir of the Philosophers,

the Calx of the Sun, the Tincture of Phoebus, Potable Gold reduced into an irreducible state. For in this way, the form or substance of gold being destroyed by fire, there is no return from privation to possession; and consequently, the form being abolished, the remaining body must necessarily remain dead and stripped of all virtues.

Paracelsus himself even admits it in Book 6 *On the Nature of Things*: "Take," he says, "no metallic arcanum or medicament within the body unless it has first been rendered volatile and can be reduced into no metal." But how a magisterium — of gold, for example — could be resolved into an irreducible state: *here is Rhodes, here is the leap* [hic Rhodus, hic saltus]; since without mercury, or strong waters, or any solvents whatever, gold cannot be dissolved, as we showed above; and if it is dissolved, it is nonetheless not so radically resolved that it cannot be reduced into its former state; but if it is reduced by fire through calcination, I affirm that by this very act it is ruined and destroyed, and therefore of no use. How, then, magisteria from metallic bodies may acquire a medicinal virtue, will be shown below:

[Margin: How dissolved gold operates in the human body.]

If gold is reduced into the smallest corpuscles by corrosive solvents, and once dissolved in this way various kinds of cardiac remedies are joined to it, I say that gold, reduced in this way into its smallest parts (yet without substantial transmutation), together with the said cardiac remedies, produces nobler effects than gold constituted in its solid substance. For since the individual corpuscles of the dissolved gold are strong with the virtue of the whole, they, mixed with the other adjuncts, will surely acquire a more intense degree of the property in the composition. Indeed, if any corrosive still remains in the gold or in the dissolving solvents, it is nonetheless so blunted by the virtue of the other added species that it will not easily harm one who takes it in a draught. Hence those greatly delude themselves who ascribe the power of the magisteria of gold to gold alone — since they produce their effect no otherwise than as we have said, from the mixture of many species of great virtue. So they are to be called not so much magisteria *of gold* as *golden* magisteria. For the substance of gold is not properly transmuted into a liquor by corrosives, but only its particles, gnawed away by the acrimony of the solvents and mixed with the others, produce those marvelous effects (if they are genuine), which can afterward easily be reduced back, by the evaporation of the vegetable matter, into a single body of gold, as we said a little before.

But to demonstrate that this liquor is not of gold but golden and compound, it is easily made known by a chemists' experiment, as follows.

EXPERIMENTUM

[Experiment]

Of the composition of the golden magisterium.

Take powder of precipitated gold, well dried and lightly spread over a marble slab; with spirit of Spanish or Malvasia wine rectified three times with dried balm [melissa] and separated from its phlegm, sprinkle it and mix it well together; and, thus prepared, let it dry in the sun or in a warm place. With this sprinkling repeated six or seven times, to one ounce of the prepared powder add a scruple of saffron, six grains of grey amber [ambergris] and of oriental musk, and store the whole mixture in a glass vessel for use. By the testimony of Sala and Crollius [Oswald Croll], this is of such great efficacy that it seems to work miracles.

[Margin: The virtues of potable gold are not from gold alone, but are to be ascribed to the admixtures.] But you should judge that these things come not at all from gold alone, but from the cardiac substances. For gold strengthens by its specific and magnetic virtue, indeed, but it does not nourish, which is proper to vegetable ingredients; [Margin: Gold does not nourish.] for, as we taught in the preceding chapters, no mixed body can nourish us unless it first has life in itself; and gold, since it is an inanimate mixed body, acts upon the human body no otherwise than the other minerals — like the diamond [Adamantis],

— the beryl, topaz, amethyst, carbuncle, sapphire, and the specific virtues of the other gems: by a certain radiant and imperceptible effluvium of the virtues appropriated to each.

CONSECTARIUM I.

[Corollary I]

From this it is clear that, if the ancient chemists sometimes make mention of potable gold, they by no means understood it of a substance of gold irreducibly resolved into a liquor, but called their medicines and the magisteria of various compositions "golden" by a certain figurative naming, from their marvelous virtue. Just so, as usage demands, we are accustomed to call a thing of great virtue and price "golden" — [Margin: Many things are called "golden" not from gold but from their excellence.] a book *golden*, a man endowed with outstanding virtues *golden*; and times filled with felicity and an abundance of all good things we are wont to call *golden ages*. And it is expressly clear in the spagyric writings

of Lull, Villanova [Arnald of Villanova], and Paracelsus, in which various magisteria occur — Emetics, Cathartics, Diaphoretics, Anodynes, Bezoartics — which are sold under the name "golden," in which nonetheless gold has no place at all.

CONSECTARIUM II.

[Corollary II]

From these things I infer that a golden magisterium can in no way be prepared for use as an absolutely universal and catholic medicine — which the Alchemists nonetheless do not cease to proclaim with full cheeks. [Margin: From gold a universal medicine cannot be made.] For since gold is endowed by nature, by the consensus of all physicians, only with the heart-strengthening virtue, it must surely produce an effect peculiar and proportioned to that endowment. Hence, if it is strong (as many think) with an astringent power, I affirm that it cannot be supposed — not to say believed, but not even conceived — to have, as well, the opposite cathartic or laxative virtue, owing to the dominion of contrary virtues in one and the same subject. If it is strong with a softening [malactic] power, it cannot have a hardening [sclerotic] one, and vice versa. If it heats, it will not cool; if it moistens, it will not dry, and vice versa. But since the kinds of diseases are of the most diverse condition — some arising from febrile heat, some from cold, some from superfluous moisture, others from dryness; some requiring in consequence cathartics, others astringents, others diuretics, still others restringents — surely no absolutely universal medicine can be assigned in the nature of things, composed of an equal and most perfect harmony, fit to drive off all diseases, whatever Lull dreams of his celestial Elixir, or Paracelsus, Quercetanus [Joseph Duchesne], and others of their universal mysteries. This I would say not only of the elemental but also of the specific qualities. And it is plainly evident even from theriac: if any other medicine could be called universal, surely that one could be — and yet that to administer it in many diseases is not without danger is better known than need be said. The same must be said of quintessences and the other magisteria; for although they are composed of countless species, they nonetheless always bring about effects contrary to, and exceedingly dangerous for, some diseases. Whoever has rightly understood the art of contraries will find what I have said to be true. For I would not easily deny that a medicine can be given which, by reason of the consideration of virtues mutually restraining one another, may be able to help in driving off several diseases — as is evident from theriac and the elixir of life. For

who would offer the elixir of life, of the most powerful heat, to a patient tormented by the most burning fevers?

Some experiments concerning the admirable properties of gold.

EXPERIMENTUM I.

[Experiment I]

To make fulminating gold, or the Calcination of Gold for fulminating gold.

The calcination of gold is nothing other than the process by which the solid body of gold is attenuated, made subtle, softened, and — torn apart into imperceptible corpuscles — reduced into an impalpable dust, to the end that it may become apt and suitable for receiving the operation of the Magisterium. This calcination is done in two ways: either by the moist or by the dry. The dry method, by the aid of fire, is thought by the Alchemists to be possible — which we have denied. The moist is usually done with *aqua chrysulca* [gold-dissolving water], otherwise called *aqua regia* [royal water], in this manner:

[Margin: Making of fulminating gold.]

Take *aqua fortis* [strong water] made from two parts vitriol and one part distilled niter — one pound, for example; in it dissolve two ounces of well-purified sal ammoniac. In the *aqua regia* thus prepared, dissolve gold cut into small fragments over a gentle heat with some boiling. To the clear and yellowing solution contained within a glass vessel, instil drop by drop a lye made from tartar; and when a vehement boiling is finished, the gold subsides to the bottom like mud. This done, let the remaining salt liquor be washed off so long until no more acrimony appears. Let the sediment of the gold then be taken out and dried with the gentlest heat; and in this way you will have that admirable [Greek: χρυσοκέραυνον (chrysokeraunon, "gold-thunderbolt" — fulminating gold)], so called because its grains — two or three of them — exposed to fire, when they catch flame (and it catches it most readily), make a huge crash; and, with a motion opposite to that of gunpowder, driving downward, they bore through and shatter everything. For, as Angelus Sala testifies, by the force of this calx when it caught fire by a fall, a huge slab of marble on which it had been placed was thrown apart and torn into fragments — not without danger to the bystanders.

We have seen it prepared another way. Take 8 ounces of *aqua fortis*, 3 ounces of duly purified sal ammoniac and niter; let them be mixed and distilled through a retort with the degrees of fire observed, and you will obtain a *stygian water* most apt for dissolving gold. And this too, in the calx prepared by the first method, is

most worthy of admiration to ob-alis nitri"; p.430 "cibulo" → p.431 "cibulo ponunt"; p.431 "Expe-" → p.432 "Experimentum IV."]

[Margin: An experiment by which the fulminating power of the gold-lime is removed.]

to be observed: that if you mix nitre and vitriol — the two parts which constitute the gold-lime [auream calcem] — together with one part of flowers of sulphur, and burn the mixture in a crucible until it takes on the appearance of Armenian bole, the whole powder loses its fulminating power. The reason for this can be none other than that the sulphur destroys the windy spirits of the nitre. Since these are the cause of so great a fulminating force, once the cause is removed, the effect too must necessarily cease. On the admirable cause and rationale of this powder, see what I have set out at fullest length in Book I [Margin: *Liber IV* — see note (a)], and what I shall also expressly treat in Book XII [recte: see note (a)].

CAPUT IV.

On Silver, or Terrestrial Luna.

Silver is called *terrestrial Luna* [Luna terrestris] by the chemists because of a certain hidden correspondence and symbolic affinity it bears both with the celestial Moon and with the microcosmic moon — what they call the brain. [Margin: Silver, the metals' colours, each proper to its own.] Now just as the individual terrestrial planets — that is, the metals — take diverse colours from nature (Saturn or lead shows itself in a squalid black, Jupiter or tin in white, Mars or iron in red, Mercury in a livid hue, Venus or copper in green), so they imbue Luna with a blue colour. And although Luna seems content with this single colour, it nevertheless contains within itself the colours of all the remaining metals — a fact long since made known by the sole experience of the spagyric art. [Margin: Silver contains all colours within itself.]

For in its solid substance silver shows itself white; but when dissolved into water by the appropriate menstrua, it is converted into a colour most like sapphire. If you then draw off by the known art the menstruum in which it was dissolved, it will at once present itself to view in a mournful guise, clothed as if in some dark garment. Yet when committed once more to the fire, it will restore itself to a far more splendid and solid state than before, gleaming with a tawny and red colour out of the whitest white.

[Margin: The tincture of silver.] There have been many who, with the greatest labour, strove to extract a tincture from silver, and I myself toiled at that task to

no small degree. Silver, dissolved by the force of distilled vinegar, did indeed appear most pleasing to the eye under a certain blue colour; but once the menstruum was afterward drawn off, it left behind just as much silver as had been put in. [Margin: A counterfeit exposed.]

Others labored with enormous efforts to reduce silver to its prime matter [materiam primam]. A certain man showed me something of this sort, in the form of a resin: white, translucent, heavy, brittle, fusible, incombustible at every degree of fire — and he boasted that this was the true magistry of Luna [Lunae magisterium]. But when, at my request, he refused to submit it to experimental test, I at once concluded that, like a man with a bad conscience, he knew his magistry to be sophistical. And so he went off, and never appeared again.

For my part, if any such thing exists, I frankly confess I have never seen it. I did see a powder of silver that strongly resisted the fire — one that could not be reduced to its former state by any force of the sharpest menstrua, nor by the voracity of mercury; yet committed at last to the cupel with a little lead, we found by experiment that it was, as it were, recalled from death to life.

[Margin: A fraud.] But those who take equal parts of filings of silver, of sublimate mercury, and of sal ammoniac, mix them well together, and sublime them so long that the sal ammoniac and vitriol [?] rise to the top while the mercury settles at the bottom of the vessel — and who then proclaim this as the living miracle of the lunar magistry — are to be rejected as open impostors. For whoever weighs an operation of this kind in the balance of reason will clearly see that it was the living mercury, dissolved by the spirit of salt and vitriol, and nothing else; since the silver that had been put in shows itself of exactly the same weight as before. [Margin: Silver calcined by any means whatever can nevertheless be reduced to its original nature.]

Likewise to be reckoned false craftsmen [pseudotechni] are those who, by amalgamation of the lime [calx] with mercury in any way whatever, and then by means of flowers of sal ammoniac, radicated vinegar, and other agents, dissolve silver into a most subtle blue powder — but if you send the magistry back to the judge and trial of the cupel, you will find that it has soon returned to true and natural silver.

Whether silver, no less than gold, can be reduced into a liquor or lime — or cannot — is a matter of controversy. So, to be brief, I say this. Since gold and silver are called the perfect metals by the chemists, because they have a more compact nature than all the rest and the proximate principles of Nature exist in

them under a certain equal proportion, it is certain that there is also the greatest difficulty in dissolving them radically — though not as great a difficulty as with gold. Still, I do not doubt that some method can be devised by which silver may be reduced into an irreducible state; but since that method is as yet undiscovered, I leave it to the chemists to investigate. Hence too the magisteries of Luna can be carried out far more readily than those of Sol.

But lest I seem to have omitted anything, I will append the procedure for the magistry, which I learned from skilled chemists.

Just as gold, then, so too silver cannot be dissolved without a corrosive, whether into a lime or into a tincture. The corrosive menstruum for dissolving Luna is this:

1. Take 2 lb. of Hungarian vitriol, whitened by gentle heat and reduced to fine powder.

[Margin: The preparation of the tincture of Luna by corrosives.]

1 lb. of salt of nitre [sal nitri], cleansed as thoroughly as possible from its salt and dregs and reduced to powder. Let them be mixed well and distilled by the art known to the spagyrist, and you will have a menstruum in the form of a most limpid water, pregnant with its spirits.

2. This done, take three ounces of Luna duly purified from all impurities by means of Saturn (that is, lead). Place these in a urinal-flask, and pour over them six ounces of the aforesaid menstruum. Let the urinal-flask, set in tepid water, be left until the separation of the parts takes place.
3. When the solution or separation is finished, pour upon the liquor now dissolved nine ounces more of the aforesaid menstruum, and digest it within a bath of dew [balneum roris] over a continuous fire for 40 days, always pouring back whatever has distilled off.
4. You will separate the water, or superfluous moisture, from the magistry in this way. Great care must be taken to keep the fire at a constant degree. Draw off the water in the usual manner through the same first degree of fire; preserve the drawn-off portion in a glass vessel; then place the residue in an alembic luted with clay, set it in a sand-bath, and distill, so that you may by a stronger fire draw out what water remains. Here — unless you wish to lose your oil and your labor — you must proceed with great caution, lest with too strong a heat a greater quantity of spirits escape along with the moisture. The magistry should therefore remain at the

bottom of the vessel for 4 or 6 hours, like fossil salt. For in this way, when the vessel is opened, you will find at the bottom a stony material, very black below and at the sides, but white above and transparent like crystal.

And this is the magistery that was sought. And it has admirable properties.

[Margin: The admirable virtues of the tincture of Luna.] Of these, the first is that, although it stains the hands with a black color, it has nevertheless wholly lost the corrosive faculty that resides in aqua fortis. The second: it presents to the tongue the taste of vitriolic acidity. For if you dissolve the magistery in tepid water in a copper bowl, or cast into it copper plates, you will soon see the silver, separated from the magistery, adhering to the copper in a spongy form; yet once melted, it returns again to solid silver. Third: if you reduce the material of the magistery to powder and expose it to the Sun, it will take on a form as black as ink — which likewise happens if you mix the material with dissolved gold. [Margin: The dry tincture catches flame.] Fourth: experience teaches — with Sala [Angelo Sala] as witness — that a particle of this stone, cast into open fire, burns like saltpeter; indeed, when set upon paper and brought to the utmost dryness, it leaps up with great force in a conceived flame like gunpowder. The reason for this is the muddy [latulentus] spirit of nitre with which it is charged: for nitre, in the form of a menstruum, utterly refuses fire, but once joined to Luna it reverts to its original nature and catches fire in the usual way. [Margin: It helps in diseases of the head.] Fifth: by the common opinion of physicians it is held to be a great and specific remedy in infirmities of the head — such as epilepsy, hydrocephalus, paralysis, and the other dangerous catarrhs — given in a dose of 5 or 8 grains with malmsey wine in the morning.

CAPUT V.

On the Magisteries of Iron, Tin, Copper, and Lead.

The imperfect metals, on account of their impure principles, are less sought after for internal uses. For even if they are prepared with great and remarkable skill, there nevertheless remains in their root a kind of contamination — I know not what — resulting from impure, undigested, and corrupted salt, sulphur, and mercury; and while drawn forth by nature toward the best through the contamination of minerals and the onrushing force of invading vapors, they have nonetheless degenerated, ill-disposed in the wombs of the earth from their corrupted matter. And although I have treated very fully of the generation and properties of iron, tin, copper, and lead in Book X, I shall here append a few

additional things bearing on internal uses — and chiefly those that concern medical use.

Certainly metals of this kind, just enumerated as imperfect and badly compacted, can for that very reason be dissolved into liquors with almost no trouble, the substance being preserved. So, that steel [chalybs] may be made potable [Margin: The preparation of potable steel], it must, by Lull's [Raymond Lull] prescription, be calcined in fires. Some, however, prefer to calcine it by one and the same operation through a liquor of salt, or also through distilled vinegar, in which the well-washed filings of the iron are immersed.

I would judge the best procedure to be the following, since for [the right-hand column continues:]...internal uses it is taken, so that we attenuate its crocus with vinegar, or with spirit of salt and similar menstrua, so that it liquefies of itself — though it can also be driven by reverberations, now with salts added, now omitted. At last the quintessence of wine [quinta vini essentia] is added as the completion of the work, and yields potable iron [ferrum potabile]. For iron, now broken and tamed by the violence of fires, and likewise subjugated by the voracity of sharp menstrua, the liquor of wine, repeatedly drawn off, thoroughly dissolves; and so, mixed with the iron, it degenerates into an absolute tincture. [Margin: Soluble preparation. — Use of potable steel in medicine.] This abundance is then drawn down by distillation into a small quantity, whereby there is left an oil-like liquor, fit for both internal and external uses — wonderfully beneficial to the dropsical, the splenetic, the hypochondriac, the affections of the spleen, the celiac, the dysenteric, and the asthmatic.

In our pharmacopoeia, for steeled wine [vinum chalybeum] for the splenetic, the dysenteric, and the obstructed, they take 8 lb. of malmsey wine — or Muscatel, as the Syracusans commonly call it — which they put in an earthen vessel, big-bellied and with a long neck. Then [they add] 1 lb. of filings of the purest iron, or of steel, in a crucible...

[Margin: Potable tin. — The philosophical tree.]

crucible they place [the filings] until it grows white-hot; and as soon as they see it thus glowing, they pour wine, contained in an earthen vessel, over it up to a third part, and stop the mouth, lest the spirits evaporate. After the third operation, what is finally left will settle in the space of 24 hours; and you will have a magistery of admirable benefit in the said diseases. For the rest, see what is fully treated concerning Iron in Book X.

Whether tin — which is also called white lead — can be made potable, many doubt, on account of the principles of mercury and sulphur ill-digested within it; for if corrosive menstrua are added in its dissolution, they leave behind a thoroughly bad and altogether virulent effect — as those who purge and calcine tin learn daily, to their great cost. Hence the chemists left no stone unturned to reduce it to better profit, raised to the lunar dignity; but, defrauded by a vain labor like Sisyphus's, they failed. It would nevertheless be a most excellent collyrium [eye-salve], if someone could, by long circulations, free it from the deadly virulence hidden beneath it. But this care must be left to the chemists.

[Margin: Potable copper.] On the nature and property of copper, see what has already been treated in various places; nothing remains except to set out whether it can be made potable. The alchemists, relying on the hope that, if they could transmute it into pure silver, they would as a consequence extract from it a lunar tincture of wondrous virtue — but beyond the loss of all their goods and even of life, some indeed gained nothing but the gallows, while others gained an undying disgrace with perpetual damage to their reputation. Others, made wiser by the harm of many, abandoned the alchemical vanity of ἀργυροποιία [Greek: argyropoiia, "silver-making"] and bent themselves to this one thing: to extract from copper the vitriol which they had learned to be the most excellent remedy of all minerals against the principal diseases. But since I have treated very fully of it in Book VI, chapter X, I refer the reader there, where you will find unfolded whatever can be desired concerning the nature and property of copper and the generation of vitriol. I shall say nothing here about lead and mercury, since I have examined these in countless places throughout. It only remains for me to append a few experiments concerning the properties of gold and silver.

CAPUT VI.

On Metallic Trees and Their Artificial Production.

We call *metallic trees* those efflorescences — exanthemata — which burst forth in nearly every mineral from the ducts of the veins, than which nothing more admirable can be seen. You may see some in the form of little crystalline shrubs, some like corals; some green, white, or saffron-colored, or composed of various colors, which spread out through a trunk into certain many-forked branches — of the kind we usually display in our Museum. They arise from the radiation of mercurial and saline spirits, by which the corpuscles of minerals, joined to corpuscles, are now spread out lengthwise, now breadthwise, now straight, now

obliquely, in such proportion that the result very nearly resembles a tree with branches, so that nothing seems lacking to it except life.

Diagram. A woodcut, set into the left column, of a tall ovoid glass phial (a closed flask, narrow-mouthed, with a swelling bulbous body resting on a footed base). Inside the phial grows a branching dendritic structure — the "metallic tree" — rising from the bottom on a slender trunk and spreading into many fine forked branches that fill the upper body of the flask, illustrating the artificial *arbor philosophica* described in the text. No labels or caption.

Here you have, briefly, the origin of mineral plants wrought by nature's workmanship. It only remains for us to show how, by the spagyric art, similar things can be produced within some phial.

EXPERIMENT I.

The philosophers' tree growing before one's eyes.

[Margin: The philosophical tree.] Take one and a half [?] ounces of the purest Luna, or silver purified through the cupel; 2 ounces of aqua fortis and of mercury, in which the silver taken is to be dissolved. Then mix these two materials and pour them into a phial, over which pour a pound of common water; stop it well, and you will see it grow daily, both in the trunk and in the branches.

EXPERIMENT II.

That the tree within the phial be wholly gilded, and bear apples like pomegranates.

[Margin: Another philosophical tree.] Take equal parts of antimony reduced to powder, of common aqua fortis, and of oil of sulphur, and pour them upon the "stone of three" [lapidi de tribus]; for these, placed in a phial, will in time show a tree gleaming with golden branches, on which you will find attached droplets of a crimson color, representing pomegranate apples.

EXPERIMENT III.

The philosophical tree.

[Margin: 3. The philosophical tree, in a phial.] Take equal parts of the tincture of Luna and of mercury; place the amalgam made from them in a well-stopped vessel, and leave it until it turns into a powder — which is called black sulphur.

To this add an ounce and a half of sulphur, and one ounce each of tartar, borax, and myrrh; let them be well mixed, and, placed in a phial, let it be closed with a hermetic seal. Then place them within warm sand, and within two or three days you will see a beautiful miracle of art — namely, a philosophical tree.

EXPERIMENT IV.

The tree of Luna.

[Margin: 4. The tree of Luna.] Take 4 oz. of cupellated silver. Dissolve it in spirit of nitre, [draw off] the spirit by a bath of dew, and Luna will remain at the bottom. Over it pour distilled rainwater; digest for several days and distill; do this six or seven times, always pouring on fresh distilled water. Afterward, into that solution of silver made again with distilled rainwater, throw 6 oz. of fixed nitre [nitrum fixum]; digest together for two weeks, and the Lunar tree grows — a most delightful spectacle.

EXPERIMENT V.

The method of fixing nitre.

Take one pound of nitre, liquefy it in a strong crucible, and gradually throw in flowers of sulphur, until at last it no longer catches fire; then it is enough. Remove it from the fire, and let the fixed nitre be purified by dissolution and filtration. Throw this into the dissolved Luna, as I instructed above.

Another method. The philosophical tree from Mercury and Luna.

[Margin: The tree of Luna and mercury.] Take an ounce and a half of cupellated silver; dissolve each separately in spirit of nitre, and let the dissolved [portions] of living mercury [be combined?]. Take 1 [?] oz. of living mercury, [dissolve it,] and let them be joined together in a capacious phial; add 12 or 20 ounces of distilled rainwater, set it in warm ashes, and [leave it] for the digestion of the space of one hour — unless it should wish to grow at once. Throw into that solution 3 oz. of sal ammoniac, and you will have what is sought.

EXPERIMENT VI.

To represent a certain region within a phial.

[Margin: The expression of a region.] Take aqua fortis, and dissolve in it Luna, Mercury, Sol, and Venus; then separately dissolve vitriol in aqua fortis. Let all these, placed in a phial, be well mixed; and the mixture, having been placed [in

the phial], is to be set out to digest in the sun. If you find this material flowering, pour off the thinned water and pour on fresh and most limpid water. Let the aqua fortis be made from alum, saltpeter, and vitriol. In this device you will see with admiration hills, crags, plants, little flowers, and rivers expressed after the type of some real region.

EXPERIMENT VII.

To exhibit the Idea of the Macrocosm.

[Margin: The Idea of the Macrocosm.] Although I have not performed this experiment myself, yet since it was communicated to me by an excellent chemist as a great secret, I will append it here. Dig up rich earth beside the brooks that run down at the foot of the mountains (such as the mines of gold and silver are); from it make the saltpeter set forth in Book VI [Margin: the right column continues from p. 432 left] which...

[The text of Experiment VII continues into the right-hand column:]...[the saltpeter] which could be discovered neither by water, nor by fire, nor by automatic instruments. [Margin: The vanity of perpetual motion.] Let us now see the credibility of the promised miracle.

Take 5 or 6 ounces of amalgam of Venus [copper], with as much of amalgamated tin; grind all together with 10 or 12 oz. of sublimate mercury, and place it upon marble in a cellar. Then, within the space of 4 hours, the whole will dissolve into a liquor not unlike olive oil. Distill this, and at the end with a most violent fire, and you will see a dry sublimated substance; pour the distilled water back in turn over the earth remaining in the alembic, and dissolve what can be dissolved; filter the solution, distill the filtrate again, and so on. There will appear most subtle atoms, or corpuscles, which are to be preserved in well-closed glass in a dry place; and behold, you will see wonders, on account of which the whole world has hitherto labored too painfully. These are the boastings of the alchemists, miracles of a great art to be urged upon the ignorant common folk, though the effect was never brought into practice.

For who could ever discern how, in this magistry, perpetual motion might be exhibited? What kinship, indeed, or what likeness, is there between metals, amalgams, distillates, sublimates — or rich, swollen, immobile earth — and perpetual motion? And who could guess how these things, in their sluggish nature, could drive the Sun, Moon, and Stars through their periods? The author of this fanatical contrivance I can certainly find to be none other [than...]

other than the one who stirs up and agitates the brains of such insolent men into countless superstitions — Paracelsus [Paracelsus]. I have long known that Drebbel [Cornelis Drebbel] devised something similar, but since I have set out elsewhere what that was, I do not wish to repeat it here.

EXPERIMENT IX.

To represent the spheres of the elements in a glass flask.

[Margin: How the powers of the elements are exhibited in a flask.]

This device must be understood in a twofold way: first, that the elements, wound about a center, perfectly imitate the elemental sphere; or that liquids enclosed within a cylindrical glass flask float one above the other horizontally and παραλλήλως [Greek: parallēlōs, "in parallel"].

That the former cannot be done, we demonstrated at length in the First Book of the *Centrosophia*. To establish, outside the center of the earth, another center surrounded by the elemental spheres globed around it exceeds all the power of angels and of men; such a work is reserved to God alone. But that the latter can be done with almost no trouble, we showed in the Third Book of the *Art of Magnetism* [Magnes, sive de Arte Magnetica] by exhibiting many experiments.

But here some may object — alleging perhaps my ignorance in matters of nature — that I too presumptuously dare to deny the concentration of liquids to Nature, since Nature demonstrates daily that it can occur. For what else are drops of water but little spheres which have their center of conglobation outside the center of the earth? This is also seen, clearer than the midday light, in mercury poured out upon a marble slab and at once split into innumerable mobile globes. I reply that it is perfectly true that liquids of this kind do concentrate into globules — Nature being in no way contrary to this, but rather it is quite in keeping with Nature.

[Margin: Why water and mercury form into globes.]

For when drops globe themselves up on a dry surface, this must by no means be thought to happen by the force of a center, but by reason of the moisture, which of itself and by its own nature shuns what is dry. For when, with a dry surface resisting, the moisture cannot

spread itself out into a flat surface, it necessarily lifts itself up into something resembling a globule. This appears plainly in mercury — which is also called "dry water," water that does not wet the hands — because of the inner force of its

dryness. For the homogeneous parts of mercury, defending themselves most strongly against dryness so as not to be dissolved, are compelled, as Nature requires, to globe themselves into a union which cannot occur except in a spherical form. Yet here one imagines a center in vain, around which the parts would be globed by its force. Indeed, if these things happened by the force of a center, there would be no reason why a large quantity of mercury, whether contained within a vessel or spread out on a slab, would not at once coalesce into a perfect globe — which nevertheless contradicts experience, since mercury contained within a flask presents a flat surface, no differently than other liquids, and likewise when poured out in large quantity onto a slab.

That certain very small particles in liquids of this kind do at once form themselves into globules — you must judge this to happen not by the force of a center but, as I said, by the force of dryness. For just as dryness naturally shuns moisture as its contrary, so too, when it cannot spread out while dryness stands around it, it readily forms itself into a globe because of the slight weight of its minute mass. This appears in daily experience with cups, in which liquids are seen to be raised into swellings at the rims of the goblet, while they are pressed down by the intervening mass of the liquid.

The matter must be understood otherwise as regards liquids contained in some glass vessel being globed about their own center, exactly as happens in the elemental sphere. For this — whatever the alchemists may dream — cannot be done; indeed, it plainly involves an open contradiction, from the fact that in the said vessel the fiery liquid, the very lightest, would be in the lowest circle, and the heaviest. And let the same judgment hold of the others, those liquids representing water and air. Who does not see how utterly absurd all this is? But I wished to set all this out here, lest anyone in the future be able to say that I have philosophized badly.

CHAPTER VII.

Recapitulatory canons, by which artisans may be guided in chemical operations, and by which true operations may be distinguished from false ones — drawn both from the author's own mind and from that of other rightly-judging chemists.

CANON I.

On the nature and faculty of solvents or menstrua.

The whole of chemistry, as has often already been said, extends itself into the threefold Monarchy of Nature: the Animal, the Vegetable, and the Mineral. Each of these is composed of the three proximate principles of Nature — Sulphur, Mercury, and Salt, or what is the same, Oil, Liquor, and Earth — distinct from one another in form, weight, consistency, property, action, and powers. None of these can be dissolved, nor changed into different forms, without the ministry of fire, whether actual or potential. And since fire is always hot and dry, it cannot come about that it should produce its contrary, that is, the moist, which it lacks; nor can a liquid and watery form be given to any thing naturally dry and arid — as many have very

wrongly opined, while they were not ashamed to call fire moist. But see this opinion more fully refuted by us elsewhere.

Fire is the active principle of all things, whence all things subjected to fire are necessarily altered and cast down from the natural state of their proper temperament — with the exception of gold, asbestos, and the like, which, as has been said, withstand unconquered whatever torments of fire there may be. The rest, however, are dissolved by fire — metals easily, vegetables more easily, animals most easily. All these depend on the compactness of bodies: the more fixed they are, the more difficult, and the less compact, the more easy, do their parts undergo dissolution.

CANON II.

On solvents, or menstrual liquids.

All those liquids which have the power of attenuating and dissolving fixed and compact bodies can be called solvents. These can rightly be subdivided into three kinds, so that some are watery and tasteless liquids; others sharp and corrosive; and others, finally, fatty and oily. Of the first kind are all those watery, tasteless liquids which, when poured over vegetables and animals, by decoction and

infusion do not so much dissolve as soften them and reduce them to the finest substance.

But the second kind, the sharp and corrosive liquids, by the force of their sharp spirits dissolve all metallic and stony bodies; and without such a liquid no stone or metal can be dissolved. They either transmute all bodies accidentally, or reduce them into liquids or the finest powders or similar substances. Of this kind are all the kinds of aqua fortis [aqua fortis], vinegars, and — those which act more mildly — the various juices of plants and fruits, as we taught a little above. Hence metals, stones, and the other minerals — marcasites, pyrites, and likewise shellfish — as soon as they have been dissolved by corrosive liquids of this kind, cease to be simple bodies and are enrolled in the number of compounds. Yet as soon as they are freed from these, then those too return, by right of restoration [postliminio], to their former solid consistency, deposited from the liquid. We gave examples in what preceded.

CANON III.

[Margin: Friendship and enmity among solvents.]

There is also among solvents a certain remarkable sympathy and antipathy to be observed. For some solvents, when reduced to a liquid form, dissolve; others precipitate them into the finest powder. Some dissolve one body and leave another untouched. The salts that are friendly to mercury are hostile to sulphur. Hence I rightly conclude that no universal menstruum — such as the alchemists

boast their Alkahest [Alcahest] to be — can be assigned, since they are found to be mutually contrary, in so many quarrels and discords. Much less can there be given such a one that could extract the natural powers and properties of these bodies, whole and entire, comprehended in a single essence.

[Margin: The effects of acid spirits.]

All acid spirits can be condensed and coagulated into a brittle form, and converted into powder. Some can even be fixed in such a way that they can withstand the most powerful test of fire. Hence the philosophers easily arrived at an account of their composition. But sulphurous, oily, or combustible menstrea have no commerce with metals and stones.

[Margin: Stones are not dissolved by oils.]

Hence those who boast that they can dissolve metals, stones, and gems in spirit of turpentine and other distilled oils, and extract tinctures from them, are to be held

for true impostors. In the same way, those who, by the aid of spirit of wine, dissolve woody and resinous substances, will nevertheless not be able to dissolve metals without a corrosive liquid. Hence whatever you extract from metals by means of rectified wine should by no means be called a tincture, but the menstruum which you applied — pure substance of wine, somewhat altered as to color by the metallic corpuscles. And let the same be said of the menstruum of distilled vinegar.

CANON IV.

[Margin: Various liquids that color are to be examined.]

There are certain liquids which, when poured over certain mineral bodies, acquire various colors according to the diversity of the minerals. Hence the inexperienced think this is a proper tincture extracted from the said bodies — in which they greatly delude themselves, since it happens to them merely by accident, as we said above. Waters, both of vegetables and of animals, in order to behave properly, need before distillation a prior digestion and a suitable maceration; yet this distillation must be carried out without any addition of another liquid, since when the water of that liquid is joined to it, it disposes toward putrefaction and utterly destroys the powers innate in them. The water that comes out in the distillation of these is better than that which comes out last — the former on account of the easily soluble condition of the body, the latter on account of the obstinacy with which it clings to the body.

[Margin: The remarkable properties of wine and vinegar in distillation.]

As is evident in the distillation of wine, in which the better spirit is the one that comes out first, the worse the one that comes out last, since it is pure phlegm. In vinegar, however, the matter stands otherwise: in it the phlegm comes out first, the spirit last, for the reasons just stated. For there are certain sulphurs so subtle and of so volatile a nature that, with water added, they can easily be separated from their bodies while their native odor and savor are preserved; whereas certain others are so coarse, earthy, and heavy that they cannot be distilled without empyreuma [a burnt smell], whence they often retain a most foul odor that can be corrected by no art.

CANON V.

[Margin: The solution of tartar.]

The hypostasis and sediment of tartar, if you regard its predominant character, is a certain vegetable salt, belonging to a certain very fine, muddy earth which the vine draws to itself. And as this is different according to the diversity of the soil and of the vines planted in it, and of the wines pressed from the grapes, so it must be judged to possess different properties accordingly. Hence from nobler and clearer wines comes a nobler tartar than that which is drawn from those wines infected with various mineral refuse. That wine is infected with various earthy filth, experience teaches. For even if it has been duly purified, and is therefore clear as crystal, it must not on that account be regarded as a pure and unalloyed salt, like salts extracted from other vegetables; rather, it still has mixed in it some portion of earthy parts — which will be evident to one who takes experience as his guide. For it neither dissolves in cold water, like other salts, and if it is committed to fire, water will come out together with oil; while from the lime that remains in the bottom a white and corrosive salt is prepared, by some power I do not know. Exposed in a cold and moist place, it dissolves by deliquescence into an unctuous liquid, which some wrongly call oil of tartar — though it is nothing else than dissolved salt of tartar.

And just as tartar is a kind of ferment of wine, and its salt is by its nature earthy and spongy, so too from all the liquids with which it is joined it imbibes the sharp spirits drawn to itself, and unites with them most intimately. And for this reason it is, in everyone's opinion, reckoned the most powerful menstruum of those which resolve into powders both metals and other bodies. Yet with mercury alone it carries on grave enmities. For mercury, even if it be so fixed that it withstands the strongest fire, nevertheless, if you join to it even a little tartareous salt and commit it again to fire, the mercury — terrified by the arrival of the foreign guest — at once leaps forth, revived into its pristine form.

[Margin: A beautiful experiment.]

This is indeed a most beautiful and unique test, by which the falsity and imposture of those who impudently boast that they can fix mercury into silver is exposed.

CANON VI.

[Margin: The menstruum of sal ammoniac.]

Sal ammoniac has two parts to its composition: namely, a volatile salt — which is sometimes found in the soot of wood, in the blood, and in the veins of animals — and a common salt; which is established by this experiment.

[Margin: An experiment.]

Take volatile salt with a due quantity of common salt; if you mix these properly, you will produce from them a sal ammoniac of the same constitution as common sal ammoniac.

Since, therefore, sal ammoniac is composed of such sharp and subtle substances, no one should marvel that spirit of nitre and other waters are so sharpened by it that they resolve gold into a transparent liquid, as was shown in what preceded.

[Margin: The salt and experiment.]

This too is worthy of admiration: that, mixed with metals and the other minerals, it ascends into the alembic under the form of a most subtle soot, not resolvable into any liquid, unless perhaps some other liquid be added to it. Concerning nitre and its wonderful powers, it would here be most amply discoursed of, were it not that we had accomplished this in the Sixth Book; so we refer the reader to that place.

CANON VII.

[Margin: Coral, pearls, etc.]

Those mixed bodies which have obtained a middle nature between bones and stones are: corals, pearls, unions [large pearls], crab's eyes [oculi cancri], mother-of-pearl, and all shellfish. These contain in themselves water and combustible oil, no less than wood and the other vegetables, though not so abundantly. Their ash, although in external appearance similar to the lime of stones and to the salts of vegetables, yet no salt can be extracted from it, nor compacted into grains, as many inexperienced people in nature think. For what comes from it is nothing else than a certain earthy substance, not unlike lime to the taste. Hence, consequently, those delude themselves who think that bodies of this kind prepared in a saline form with spirit of vinegar are "salt of corals" and of pearls — and they improperly so call it; whereas in reality they are properly whole bodies dissolved, which subsist under such a form by the aid of the spirit of vinegar adhering to them. Hence it is only by the force of sharp menstrua, which, while they most intimately penetrate the said bodies, dissolve them at the same time into powder, with none of their substance lost.

In our College we dissolved a tincture of corals without a menstruum: the corals being first ground up and placed within a bladder, we urge them with a strong fire, whence, the spirits being gradually separated, a reddish liquid matter comes out like pitch; this, then collected and extracted again by retort with spirit of

wine, gives a tincture gleaming like a ruby; and this we use for the true tincture of corals — although I think the sediment which it leaves behind is nothing else than the same substance of corals which we had put in: so difficult is it to dissolve that into a true and real tincture, since by nature it is tenacious and will not be separated from itself. Let the same be said of precious stones. For those who calcinate them stratified with sulphur, nitre, or other salts in a most vehement fire, and afterward strive to reduce their substances into a liquid, greatly delude themselves; since, their substance being destroyed by calcination, just as the natural temperament is wholly dissolved, so too its powers must necessarily be at the same time dispersed and destroyed. And those who claim that they extract a salt from precious stones calcined in this way

delude themselves likewise, since this salt was not extracted from the substance of the stones, but is the very salt of the lime from which the stones were calcined — being of an exceedingly corrosive faculty; while nevertheless impostors of this kind are not ashamed to sell it as the magistry of oil, of salt, and of the essence of pearls. So small is their error! — those who endeavor to extract oil from crystal.

CANON VIII.

[Margin: The reduction of asbestos, talc, and the like into oil.]

There have been, and to this very day there are found, false craftsmen who boast that they can resolve asbestos, talc, and the like into oil. And that the deceit of men of this kind may more clearly appear, I will add what happened not so long ago. A certain one of such fellows was carrying about a phial of ashy contents, in which he said was contained true and legitimate oil of talc, and he defended his error so haughtily and with such obstinacy that he allowed himself to be torn from it by no arguments. At last I put to him the following enthymeme: Either the oil you promise is true, and extracted from the true substance of talc, or it is not. As he affirmed the former, so it was incumbent on me to prove the negative. And so I pressed him in this way: If it is true and natural oil, it will certainly be able to be set aflame, just as all other oils. He said yes.

[Margin: The detection of the fraud.]

But I took up the point that this could not be proved except by experience. So, having led him off to a pharmacy, I asked that he anoint with his oil a cotton thread that happened then to come to hand — which he did not unwillingly. A light being brought, the thread, however and by whatever means it was applied to the fire, could not be set aflame, just as a thread soaked in other oils would be kindled in an instant. Hence it was concluded by all that this "oil" was called oil in

name only, but was really water, calcined in some way or other with talc added, and accustomed to be used in the usual cosmetic paints of women. Whereupon, confounded, he slipped away without taking leave of his host — especially since I demonstrated that talc cannot be calcined into oil by fire. And what we have said of talc can be said with much greater right of the unconquered resistance of asbestos to fire.

[Margin: Asbestos cannot be reduced into oil.]

Hence it has always seemed to me a ridiculous endeavor of the chemists, who think that asbestos and talc, vexed with the most vehement torments of fire in a glassmaker's furnace, can be calcined; and — what may seem foolish — to solicit from them a liquid, of which even while they were still raw they were deprived; and thus to draw a true, genuine, and inflammable oil from what they did not possess even after calcination, their substance now being destroyed. Yet if anyone should accomplish this, I declare that he has found the greatest of all secrets, far more excellent and useful than the mystery of the Philosophers' Stone — of which kind is perpetual fire, about whose invention no less than about the secret of the Philosophers' Stone

so many Phoenixes of genius have sweated with fruitless labor. I do not, however, deny that talc, asbestos, and the like can be resolved into lime by vehement fire — since I have seen here at Rome that these, placed upon an earthen tile of glass, with a most vehement blast of flame [?] reaching the upper openings of the furnace, are easily resolved into lime; but I have never heard of oil being extracted from them. But he who desires to know more of the indomitable nature of asbestos, let him go to the Tenth Book, where he will find its nature fully set forth.

CANON IX.

[Margin: Oil of sulphur is not really given.]

In the same way are deluded those who think that they can extract essential oil from sulphur by distillation. For even though mineral sulphur is dissolved by fire, and on account of the unctuousity of its fatness can be set aflame, yet experience has taught us that what remains in the bottom of the receiver after distillation is not oil but pure, unalloyed sulphur — purer, however, and more purged of earthy refuse by the fire; indeed, of the same substance as when you had placed it in the alembic, which would not be the case if it had been resolved into oil; for in that state it would no longer be reducible into its former substance. Nor again is that acid substance which is separated from it through the alembic oil, but its

sooty salt, which ascends like smoke into the head of the alembic, and there is dissolved into a liquid — which, if it were oil, could certainly be set aflame, which contradicts experience. I say nonetheless that this liquid, whatever it may be, is imbued with some specific power of the sulphurous corpuscles, and in this way performs its effect in medicine.

CANON X.

Those err likewise who think that they can extract an essential tincture from antimony. But although it is established that antimony is composed of combustible sulphur, fusile and sooty mercury, and a certain vitrifying salt, in it the essential tincture is not distinct from these substances. Hence the various colors which it can take on are to be ascribed not so much to the antimony as chiefly to the fire — no differently than when, from mercury, salt, and sulphur mixed together and incorporated, a red powder is wont to be made, which we call cinnabar [cinnabar]; which nevertheless does not prevent that, being again separated, the mercury can return into its pristine form. To separate, therefore, from a body what is not in it, who does not see is a vain enterprise? Yet that it is imbued with the power of antimony, as I said a little before, I do not deny — just as the magnet communicates its power to iron without any diminution of its substance.

Corollary [CONSECTARIUM]

[Margin: How metals and stones are to be considered — Quomodo metalla & lapides considerata sint.]

From all this it is clear that from metals and minerals that have been calcined, true and essential preparations [magisteria] can scarcely be extracted. Rather, the whole of their virtue must be ascribed not so much to solvents [menstruis] as to the natural power itself, and so these preparations are merely composite. Note, however, at this point that metals are to be considered under two distinct headings. First, there are the metals and the other minerals that share the metallic nature: of themselves and by their own nature these are fusible, and so they can also be reduced again to their original form, as has been shown throughout the preceding experiments in various ways. Second, there are the stony substances, which once dissolved into lime [calx] can never be brought back to their former state. Marble, for instance, once reduced to lime, cannot be restored to genuine marble; and once the substance of such bodies has been destroyed by actual fire, the virtues innate in them must of necessity be

destroyed too, while other virtues arise in their place from the new matter that results.

From this it is further clear that the preparations of metals and stones extracted by solvents have no virtue except what comes from the imperceptible little bodies [corpuscula] abraded from the whole and mixed into the solvent. These then, under the heat of the fire, take on now this color, now that, with the chromatic power of the salts cooperating. From this it is likewise clear, as we said, that things calcined by fire are destroyed together with their virtues — but not so when they are dissolved by the sharpest solvents. For in the latter case a reduction back to the original is possible, whereas in the former, now dead, it is not; yet even though dissolved bodies acquire another form, they are not thereby wholly stripped of their virtues, as we shall now show.

Experiments [EXPERIMENTA]

On the dissolution of bodies [Circa dissolutionem corporum.]

Death, or the mortification of metals, says Paracelsus [Paracelsus], is the removal of the cohesion [compages] of the bodies themselves and of their sulphureous oiliness [pinguedo], which can be taken from them in many ways: whether by calcination, reverberation, dissolution, cementation, and so on. If there is a death and dissolution of the whole compound, then it must necessarily no longer be what it was, being transmuted by corruption into another form — as Aristotle [Aristoteles] rightly teaches, and with him the whole Senate of the Scholastics. And that this corruption is brought about especially by calcination through fire we have already shown by many arguments. But if the calcination of metals is done by salt, or by sulphur, or by strong waters [aquae fortes], or by common mercury —

I say that bodies are then only dissolved into a lime or a powder, without any loss of substance, since they can be reduced once again to what they were; and this is borne out by experiment. If a metal reduced to the thinnest sheets is, to speak as a chemist, stratified and cemented with salt, it will indeed pass into a lime — yet in such a way that the metal can be brought back to its former state. The same is to be said if any metal whatever is dissolved by sulphur, or by strong waters. For this dissolution is not, strictly speaking, a corruption — that is, not a radical or essential destruction, as happens through fire — but only an accidental one. For the sharpness of the solvents dissolves the metals into certain minute little bodies in such a way that each one nevertheless retains the virtue and quality of the whole. And just as these little bodies are carried back toward the whole by a

natural appetite and sympathy, so too, once the solvents are drawn off, they return to what they were.

Since, then, these little bodies are no less filled with marvellous virtues than the whole was, there is no doubt that, by repeated sublimation, the sharpness of the solvents being deposited, they gradually grow mild — and so become remedies fit to drive off even the gravest diseases, especially if their tincture is extracted with the spirit of a generous wine. For since the little bodies possess the virtue of the whole, there is no doubt that, once mixed into a solvent, they easily communicate their virtue to it. There follow the calcinations taken from Paracelsus.

EXPERIMENT I.

On calcining metals by mercury [De Calcinandis metallis per Mercurium.]

Let common mercury be placed, in an earthen vessel bellied below and narrow above, over a charcoal fire, until it begins to smoke and to issue from the mouth of the vessel like a white cloud. Once this is observed, let the metal, reduced to fine sheets, be set at the mouth of the vessel. In this way the mercurial power will penetrate the metal and render it friable like a lime. The same will happen if the metal, broken down into grains, is, to speak as a chemist, amalgamated with mercury, and the mercury is then squeezed out through leather: as the mercury passes out, the metal will remain within the leather like a lime or sand — which can again be brought back to its own state by fusion.

EXPERIMENT II.

To make Crocus of Mars [saffron of iron] [Crocum Martis conficere.]

Iron is reduced to Crocus of Mars [Crocus Martis] in this way: let glowing-hot plates of steel [chalybs] be quenched in the best generous-wine vinegar, until the vinegar takes on an intense redness. Once this is observed, draw off the moisture of the vinegar from the whole mixture by distillation; dry the residue at the bottom into a powder, and you will have a most exquisite Crocus of Mars. At the Roman College [Collegium Romanum] Crocus of Mars is made otherwise, in this way: the thinnest plates of steel are stratified with sulphur and tartar in equal parts; reverberated, this gives a noble Crocus of Mars, which must be scraped off the plates.

EXPERIMENT III.

To extract Vitriol from Copper [Ex Cupro Vitriolum extrahere.]

[Margin: First method; from copper to extract vitriol — Primus modus; ex Cupro Vitriolum extrahere.]

Let plates of copper be smeared with salt water, or with rock-salt [sal petrae], and hung up in the air until they turn green. Wash this green off with spring water, wipe the plates clean with a cloth, and steep them again with the said water as before; and so you will proceed until

the water emits, into the upper part, abundant intensely green portions of vitriol. Draw off this water by distillation, and you will find at the bottom an excellent vitriol fit for medical uses. The Alchemists, however, separate vitriol in this way:

[Margin: Another method — Alius modus.]

let plates of copper be smeared while suspended in aqua fortis, or aqua regia, or sal ammoniac; and once they have shown green and have dried, the scrapings wiped off with a hairy pencil-brush will give an excellent vitriol. In this fashion you will continue until the plates are entirely consumed.

[Margin: Purification of saltpetre water — Aquae salis petrae purificatio.]

Saltpetre water is purified if you dissolve the saltpetre in a boiling bladder [vesica]. [Margin: Dissolution of sal ammoniac into water — Salis Ammoniaci in aquam resolutio.] You will dissolve sal ammoniac into water if, after calcining it, you set it to dissolve by deliquescence upon marble in a damp and cold place.

EXPERIMENT IV.

To draw verdigris, or green copper, out of copper [Ex cupro aeruginem sive aes viride educere.]

Let copper reduced to sheets be stratified in a crucible with salt, sulphur, and tartar in equal parts, all ground and mixed together — the crucible such that it can withstand the reverberatory fire for 24 hours, yet so that the sheets do not melt. Then, with the crucible broken open, take out the sheets and expose them, together with the sharp matter adhering to them, for several days; and the matter on the sheets will be converted into a most beautiful green copper [aes viride], which is of great use in tinging gold and silver.

[Margin: Preparation of Crocus of Venus — Croci veneris confectio.]

But burnt copper [aes ustum], which they call Crocus of Venus [crocus veneris], you will sublime as follows: let plates of copper be smeared with salt reduced to a paste together with the best vinegar; then, placed in a crucible, let them be burned for a quarter of an hour over a strong fire — yet so that they do not flow — in a windy furnace. Let the glowing plates be quenched in vinegar (in one pound of which half an ounce of sal ammoniac has been added); and the scales which cling to the plates after quenching, cast them into the vinegar. Repeat this again and again until the plates are consumed; then, either by distilling, or by letting it evaporate of itself in an open vessel, draw off the vinegar, and you will find the copper converted into a stone, which is the genuine Crocus of Venus.

[Margin: Crocus of Venus — Crocus veneris.]

EXPERIMENT V.

To make white lead [ceruse] from lead [Cerussam ex plumbo conficere.]

Suspend plates of lead in an unglazed pot over strong vinegar made from generous wine, the pot well stopped so that it does not exhale. Place this pot in hot ashes; then within ten days you will find an excellent white lead [cerussa] adhering to the plates, which you wipe off with a hairy pencil-brush for use. And you will repeat this until the plates are consumed. But if you add a little sal ammoniac to the vinegar, you will have a most splendid white lead, very well suited for whitening lead and copper.

[Margin: Preparation of white lead — Cerussae confectio.]

EXPERIMENT VI.

To draw Vitriol out of gold, from Paracelsus [Vitriolum ex auro educere, ex Paracelso.]

Although above we said that gold is indissoluble, yet since Paracelsus claims that from it a vitriol and a sulphur of great value can be extracted, useful both in medicine and in the transmutatory art, we must now inquire whether this can be done. The extraction of vitriol from gold is performed thus.

Take two or three pounds of refined gold [aurum obrizum] drawn out into sheets. Suspend these, over salt extracted from urine — which they call children's urine [puerorum urina] — together with spirit of wine, which Paracelsus in his own manner calls "the strings of wine" [filipas vini], in a wide glass cucurbit well sealed, and buried in horse-dung, or in the heat of grape-husks [vinacea]. Leave them to digest for 14 days; when these have passed, open the cucurbit, and you

will find clinging to the gold sheets a flour-like fine dust, which you wipe off — for this is the vitriol of gold. Decoct this with rain-water first distilled, and stir it with a spatula until the sulphur of the gold appears raised to the surface of the water like tallow [sebum]. This you gather; and finally, the water having been drawn off to dryness, there will come forth the desired vitriol of gold, of a sweat-promoting [diaphoretica] virtue miraculous to a degree.

[Margin: Whether gold can be reduced into vitriol — Aurum in vitriolum reduci nequit.]

Now the question is whether this vitriol is something drawn out of the substance of the gold. I answer that it is not. For since gold cannot be destroyed by any violence of fire, who does not see that much less can children's urine calcine it into vitriol? I say therefore that these are certain efflorescences born of the urine and adhering to the gold sheets. The proof of this is that if you were to repeat this operation a thousand times, the gold sheets would always remain in the same state under always the same weight, as experience has shown us. So if nothing else is lost from the gold, then surely what adheres to the sheets cannot have been drawn out of the substance of the gold. That flour, therefore, comes from elsewhere — namely, from nothing other than the decoction of the urinous salt (as Paracelsus will have it), and must necessarily have grown upon the gold sheets.

Yet this vitriol Paracelsus exalts in his own manner, promising himself from it vast treasures of riches — by means of a fixed sulphur [sulphur fixum], which he prepares in this way. [Margin: Fixed sulphur — Sulphur fixum.] First he draws off its acidity by a triple distillation, down to sweetness, with no trace of stench left behind. Then he reverberates this, first into a white color, afterward into a red like cinnabar; and you will have a fixed sulphur of such great virtue that it converts any silver [luna] whatever into gold, and the human body into the highest health and a longevity of life beyond what one may write (for so he speaks). But since in Book XI we have demolished these vapourings [affanias], I refer the reader there, where he will find these deceitful wares amply laid open. If Paracelsus had known such a medical secret and restorer of life, he could certainly have carried his life on a little further than the 50 years he lived.

PARS II.

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OR [SIVE]

On the Art by which, through the science of weighing, the mixture of metals and minerals can be known with certainty — together with the weighing of the moisture and dryness existing in every mixed thing, whether mineral, vegetable, or animal.

CHAPTER I [CAPUT I.]

In which the mixture of gold is explained [Quo Auri mixtura declaratur.]

[Margin: How the reckoning of carats is to be understood — Quomodo Carattarum ratio intelligenda sit.]

In the Eleventh Book we showed that the highest fineness of gold does not exceed 24 carats [Caratas], as they commonly call them and name it pure gold; whereas below 24 it is not to be called pure gold, but mixed. For the quality of gold in any body is expressed by the parts of pure gold that are in that body — taken not by magnitude but by weight — of which kind of parts the whole body consists of 24. But let us make the matter clear by an example. Suppose there is some golden body, say of 24 ounces, which, duly and properly purged of the things it was mixed with, is reduced to 20 ounces, while the remainder — whatever kind of metal it was — has gone off in smoke. I say that the body of 24 ounces was not pure gold of 24 carats, but only of 20, because that whole mixed mass had only 20 ounces of pure gold; indeed, not only that mass of gold, but also that of which it was itself a part, or whatever part of it there might be, would be said to be of 20 parts. So indeed that each part of pure gold, however small, may be called a particle of gold of 24 carats — for in the alloying of metals the alloy of the parts is not one thing and that of the whole another, but for both there is one and the same quality.

And this is what goldsmiths observe in investigating the quality of gold. For they do not purify some whole proposed body of gold, but reduce its smallest particle to the quality of pure gold. For once this has been reduced, they not only rightly

determine of what quality, and of how many parts, that body was from which the particle was taken, but also what still remains — diminished, that is, by that purified part — as was made clear in the foregoing example. For once the decoction of an ounce-sized particle into pure gold has been carried out, if they find that nothing has been lost from the purer weight of the ounce-sized particle of gold which they had taken to be purged, they at once infer that not this particle alone, but the whole body from which the particle was taken, is pure gold of 24 carats. But if they detect that the weight of the assumed one-ounce particle has been diminished — for instance, where before the purging it had been of 24 scruples [scrupula], but is now of 20 scruples — then they infer that the proposed mass of gold is of 20 carats, and that the rest is composed of other metals.

For since in this comparison of qualities the reckoning of the parts of gold is taken separately, and separately that of the alloyed metals, it is clear: if the weight of the whole body be understood as divided into 24 equal parts, of which 20 are gold, two silver, and two copper, then each part of gold, together with each part of silver, [is greater than] each part of copper — because gold surpasses all the other metals in weight, as does silver itself surpass copper, just as experience teaches.

Now among the various and manifold compositions of gold, by which it can be alloyed with other metals, the goldsmiths and money-changers [collybistae] have retained, by the consent of all, that one more convenient than any other, which differs least from the likeness of gold: namely, the mixture of copper and silver — which, however, must as to weight always be equal. [Margin: The best alloy mixture for gold — *Aeris & argenti mixtura auro optime alligata.*] And so the said money-changers take of pure gold, of whatever quality or weight, as many parts as the gold to be produced is to have parts — fewer, however, than 24 parts — and they supply the remaining parts with copper and silver, taking from each equal parts by weight; and mixing these together they produce gold of the desired quality, and name it from the parts of pure gold taken up in the mixture. Yet sometimes they always admix a little something more of silver and copper, in case some of these should be lost in the fusion. And in this manner they require 23 parts of pure gold, $\frac{1}{2}$ of silver, and $\frac{1}{2}$ of copper, so that the mass may reach 24. But in a mass of 22 parts of pure gold, one part of silver and one part of copper is required; and so for the rest.

[Margin: How much silver is in the gold — to explore — *Quantum auro insit argentum explorare.*]

These things, then, having been duly set forth, let us now see how, by this new metallostatic art, we may explore how much silver and how much copper are in any golden mass. I suppose, then, first, from Ghetaldi [Getaldo]: that the weight of gold in water is one thing, and in air another — and the same is to be understood of silver

and copper. For in water metals weigh less than in air. This being laid down, I suppose, from Ghetaldi [Getaldo] and Mersenne [Marsenno]:

- That the weight of pure gold which in air is 19, will be in water 18.
- The weight of silver, which in air is 31, in water is 28.
- The weight of copper [aes], which in air is 9, in water will be 8.

[Margin: The proportions of gold, silver, and copper to the weight of water — *Proportiones auri, argenti, aeris ad gravitatem aquae.*]

That is, gold stands to water in weight as 19 to 1; silver to water as 31 to 3 [?]; and copper to water as 9 to 1.

From this it is clearly evident that, if some mixed body consists of parts of silver and copper equal in weight, [one can determine] what weight it has in water and what in air. But so that the method by which one may weigh the said bodies in water may be understood, I will set it out with several illustrations.

By hydrostatics, the weights of things of any kind whatever are usually weighed in four ways:

1. Either homogeneous bodies in homogeneous liquids;
2. or homogeneous bodies in heterogeneous liquids;
3. or heterogeneous bodies in heterogeneous liquids;
4. or heterogeneous bodies in homogeneous liquids.

To avoid confusion, in this place we shall use the two ways more suited to our purpose, following Ghetaldi [Getaldo] in almost everything.

[Margin: How bodies are to be weighed in water — *Quomodo corpora in aqua ponderanda sint.*]

Note first: the metallic body proposed for weighing should be hung by a horse-hair from one pan of the balance; in the other pan let a weight be placed; and let the metallic body to be weighed be let down into water enclosed in a vessel, so that it hangs freely in the water and the water does not touch the pan. Let A B be

the balance-beam, C D the tongue [librile], G the pan. Let the pan have, set into the underside of its convex part,

[Diagram appears at foot of left column — see below.]

a hook from which the metallic body H to be weighed, tied to the horse-hair, can hang down, and be let down into the vessel I full of water. In pan E let the counterweights be placed; with a balance of this kind you will weigh any metallic bodies whatever with ease.

I said that the body to be weighed should be hung by a horse-hair, because the hair is almost as heavy as water, and so it will add or subtract nothing of weight in the body being weighed.

Diagram. A hydrostatic balance shown at the foot of the left column. A vertical post rises to a ring or suspension loop at the top (labeled C), from which the balance-beam hangs. The horizontal beam runs from point A on the left to point B on the right, with the central tongue at D. From the left end (A) a pan hangs, labeled G; from the right end (B) a second pan hangs, labeled F. Beneath the left pan, a cubical weight (the metallic body to be weighed, H) is suspended on a thread.

- C (top): suspension ring / fulcrum point
- A (left end of beam): left arm terminus
- D (center of beam): tongue [librile]
- B (right end of beam): right arm terminus
- G (left pan): pan holding the suspended body
- F (right pan): counterweight pan
- H (below left pan): the metallic body to be weighed, hung by the horse-hair

If the body to be weighed should be so heavy that it cannot be sustained by a single hair, let it be hung by several hairs joined together; and lest the joining of the hairs add anything of weight to the body being weighed, let there be placed in the other pan just as many hairs equal to those that hang from the pan to which the body is attached, down to the suspended body. With this addition of hairs the pans will balance equally; and although those hairs by which the body is hung are longer than the others added to the other pan by the length of the parts by which it is tied, nevertheless, since those parts are as heavy as water — existing together with the body itself in the water — they will have no weight. And therefore those hairs which otherwise exceed the said parts, even if longer, will not be heavier than the others, since, as has been said, those parts exist together

with the body itself in the water. Thus, then, solid bodies are to be weighed in water — which it was worthwhile to have noted.

But by "water," or "a part of water equal to the weighed body," understand a cubic, spherical, or cylindrical body, within which the said bodies would be contained, in this way: if a solid body were to stand freely beneath the water, a body of this kind would be equal in weight to as much water as would stand under the same shape of the vessel — that is, to as much water as, say, a cubic body would contain. Let there be some solid body B of cubic shape, which, immersed in the vessel c d full of water, floats freely in A. I say that the place or surface of the body in which the water is contained — which is the same as the water contained within the cube B at A — is equal in weight to the weight of the solid body B. Or, if one were to make a hollow vessel equal, as to its inner surface or place, to the solid body B, then water poured into it to fullness would be equal to the solid cubic body B. But if the said body should partly project above the water and partly be submerged, like the solid body M, I say that the part of water c d e f into which it is immersed is equal to the whole solid body M — that is, the quantity of water c d e f counterbalances the whole body M. All of which is beautifully demonstrated by Archimedes [Archimedes] in his book *On Bodies that are Carried in Water* [*De iis quae vehuntur in aqua*]. From this arise these propositions:

1. Every solid body of matter lighter than water is not entirely submerged, but projects with some part of itself.

Diagram. A small geometric figure in the right column showing two square/rectangular vessels of water used to illustrate the Archimedean displacement argument. On the left, a square frame labeled at its corners E (upper left), with a smaller square B at the top center representing a cube fully immersed (floating freely in A), and A marked within the lower interior. On the right, a second square vessel labeled c (upper left) and d (upper right), with M (a partially submerged solid) at the top and L marked in the lower interior. The bottom edge of the left frame is labeled D.

- E (upper-left corner, left frame): corner of the containing vessel
- B (top center, left frame): immersed cubic body
- A (interior, left frame): the location/water within the cube
- D (bottom, left frame): lower edge of the vessel
- c (upper-left, right frame): corner of the second vessel
- d (upper-right, right frame): corner of the second vessel

- M (top, right frame): partially submerged solid body
- L (interior, right frame): water beneath the submerged body

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(continuing the axioms with which the Caput opens)

2. Any solid body of material heavier than water — that is, a body that displaces less than its own volume of water — will sink to the bottom, as is clear in the case of the solid body L.
3. Any solid body of material that exactly balances the water in weight keeps the position it is given within the water, as is clear in the case of A in the previous figure. All of these things have already been demonstrated in Book V of this first volume.

PROPOSITIO I.

Given the weight of a solid body and its heaviness relative to the weight of water, to find that body's heaviness when placed in water.

Suppose the solid body C hangs by 2 pounds from the water-surface AB. Suppose further that the ratio of the weight of the water to that of the solid body C is fivefold, so that the solid body C is of lighter material than water. You will find the heaviness of C when situated in the water AB as follows. Determine the weight of a mass of water equal in volume to C itself; suppose you find it to be, for example, 10 pounds. Subtract from these the 2 pounds, and there remain 8 — the heaviness of the solid body C in the given water AB. But let us now reduce the points already stated to practice by means of problems.

PROPOSITIO II.

Given the weight of a body of water, to find the weight of a piece of lead having a volume equal to that whole body of water.

Suppose some body of water is proposed whose weight is 100, and it is required to know how great the weight of lead would be that has a magnitude equal to the proposed water. For example: let the vessel A be full of water, the weight of which water is 100, and let it be required to know — if that same vessel were filled with lead — how great the weight of that lead would be. Take some leaden body whose weight is 23. Then find the weight of water having a volume equal to that lead, which is to be done in the way already stated in the preceding example.

Suppose, then, that the weight so found is 2. Set up the proportion: as 2 is to 23, so is 100 to another number, which comes out to 1150. That number, then, will be the weight of lead having a volume equal to the proposed water — that is, the weight of the lead that the vessel contains. (Note that what we say here about a leaden body is to be understood in the same way for a body of bronze, tin, or iron.)

PROPOSITIO III.

Given the weight of a leaden body, to find the weight of a body of water equal to the lead.

First suppose some leaden body A is proposed, of whatever shape, whose weight is 23, and let it be required to know how great the weight of water will be that has a volume equal to the proposed lead A. Weigh the lead A in water in the way already described, and let it have a weight of 21. Since, then, the number 23 exceeds the number 21 by the number 2, the weight of water having a volume equal to the lead A will be 2.

PROPOSITIO IV.

Given the weight of a body of wax, to find the weight of a body of water equal to it.

[Margin: Comparison of wax with the weight of water.]

Suppose, then, some body of wax A is proposed whose weight is 21, and let it be required to know how great the weight of water will be that has a volume equal to the wax A. But since wax is lighter than water, if it is dropped into water it will not be carried downward. So take some solid body F heavier than water, such that the body made up of both bodies A and F, when let down into the water, is carried downward. Let the body F, then, be of lead, whose weight is, for example, 23, and whose weight in water is 21. Therefore the water having a volume equal to the lead F will be of weight 2.

Now since the weight of the wax A is 21, and that of the lead F is 23, the weight of both bodies AF together — namely wax and lead — will be 44. [Margin: The weight of wax and lead joined together is sought in water.] Let the wax and lead be joined, and being so joined let them be weighed in water, and let them have a weight of 20. Since, then, the number 44 exceeds the number 20 by the number 24, the weight of water having a volume equal to both bodies, wax and lead together, will be 24. But the weight of water having a volume equal to the lead F

is 2. Therefore the remainder, which is 22, will be the weight of water equal in volume to the proposed wax A.

Again, let there be some leaden body A whose weight is 2300, and let it be required to find the weight of water having a volume equal to the lead A. Take some small body of lead F whose weight is, for example, 23, and find the weight of water equal in volume to the lead F, as has been said, which is 2. Set up the proportion: as 23 is to 2, so is 2300 to another number, which comes out to 200. The weight, then, of water having a volume equal to the lead A will be 200. Similarly, if some body of wax A has a weight of 2100, and it is required to do what has been prescribed: take some small body of wax F whose weight is, for example, 21, and having found the weight of water having a volume equal to the wax F, which is 22, set up the proportion: as 21 is to 22, so is 2100 to another number, which comes out to 2200. Therefore the weight of water having a volume equal to the wax A will be 2200.

PROPOSITIO V.

Given the magnitude of a leaden body, to find the magnitude of tin equal in weight to that leaden body.

[Margin: Lead has no comparison ratio with tin.]

Suppose some leaden body is proposed whose magnitude is 740, and let it be required to find how great the magnitude of tin will be that has a weight equal to the proposed lead. Take some leaden body D whose weight is 115, and then

let there be found, by hydrostatic weighing, the weight of tin equal in magnitude to the lead D, which is 74 — how this is to be done was stated just above. Then set up the proportion: as 74 is to 115, so is 740 to another number, 1150. That number, then, will indicate how great the magnitude of tin will be that has a weight equal to the proposed lead A.

PROPOSITIO VI.

Given the weight of oil, to find the weight of a mass of water having a volume equal to the oil.

[Margin: Comparison of oil with the weight of water.]

Suppose some body of oil is proposed whose weight is 550, and let it be required to find how great the weight of water will be that has a volume equal to the proposed oil A. Take some solid body — say a leaden one — and find the weight

of water having a volume equal to the lead, which is 12. Similarly find the weight of oil having a volume equal to the same lead, which is 11. Set up the proportion: as 11 is to 12, so is 550 to another number, which comes out to 600. That number, then, will indicate how great the weight of water will be that has a volume equal to the proposed oil.

PROPOSITIO VII.

Given the weight of quicksilver, to find the weight of a mass of water having a volume equal to the mercury. (Here we always take "mass" for magnitude.)

[Margin: Comparison of mercury with the weight of water.]

Suppose some body of quicksilver A is proposed whose weight is 95, and let it be required to find how great the weight of water will be that has a volume equal to the proposed quicksilver A. Take some clean and polished glass vessel whose weight is, for example, 91. Let that vessel, full of water, be weighed in water, and let it have a weight of 55. Since, then, the number 91 exceeds the number 55 by the number 36, the weight of water having a volume equal to the vessel itself — that is, to the solid substance of the vessel — will be 36. Then place into the vessel itself the proposed quicksilver A. It makes no difference whether the vessel is full or not. And since the weight of the quicksilver A is 95 and the weight of the glass vessel is 91 [recte: 19? — see Numerical impossibles], the weight of the quicksilver together with the vessel itself will be 156. Let the vessel together with the quicksilver A be weighed in water, in such a way that the water fills the empty part of the vessel, and let the weight of the vessel in water together with the quicksilver be 143. By the number 45 [recte: 13?], the weight of water having a volume equal to the quicksilver, together with the vessel, will be 43. But the weight of water having a volume equal to the vessel is 56 [recte: 36]; therefore the remainder, which is 7, will be the weight of water having a volume equal to the proposed quicksilver A.

PROPOSITIO VIII.

[heading not separately printed; the rubric is supplied by the running side-note]

[Margin: Comparison of mercury with the weight of lead.]

Again, let there be proposed some body of quicksilver whose weight is 190, and let it be required to find how great the weight of lead will be that is equal in magnitude to the proposed quicksilver. Find the weight of water having a volume equal to the quicksilver, which is 14. Then, having found the weight of lead equal to that same water — as was said in the preceding cases — that will be the weight

sought. For suppose the weight of lead found is 161. Since, then, the water whose weight is 14 is equal in magnitude to the lead whose weight is 161, and the lead whose weight is 161 is also equal to the quicksilver, the lead will be equal in magnitude to the quicksilver A. Hence the weight of lead equal in magnitude to the proposed quicksilver A has been found — which was the thing to be done.

Having taken, as we said, some solid body, and having found the weights of the liquids — namely of water and of quicksilver — equal in magnitude to the body, which are 14 (the weight of the water) and 190 (the weight of the quicksilver): set up the proportion, as 190 is to 14, so is the cube of 10 (that is, 1000) to another number, which comes out to $73 \frac{7}{9}$ [?]. That number, then, will be the cube of the diameter of a sphere of quicksilver having a weight equal to the proposed sphere A of water. Therefore the cube root of the number $73 \frac{7}{9}$ [?], which is 4 (approximately) [?], will indicate that diameter itself.

PROPOSITIO IX.

[heading rubric carried by the figure-less text]

Suppose some large body of quicksilver A is proposed whose weight is 5700, and let it be required to do what has been prescribed. Take some small body of quicksilver whose weight is 95, and find the weight of water having a volume equal to the quicksilver C, in the way that has been described, which is 7. Set up the proportion: as 95 is to 7, so is 5700 to another number, which comes out to 420. That number, then, will indicate how great the weight of water will be that has a volume equal to the proposed quicksilver A. Conversely, let some body of water A be proposed whose weight is 420, and let it be required to find how great the weight of quicksilver will be that is equal in magnitude to the proposed water A. Proceeding as above, and having found the weight 7 — namely of water having a volume equal to the quicksilver C — set up the proportion: as 7 is to 95, so is 420 to another number, which comes out to 5700. That number, then, will indicate how great the weight of quicksilver will be that is equal in magnitude to the proposed water A.

PROPOSITIO X.

Given a body of gold, and water equal in weight to the gold, to find the weight of quicksilver.

[Margin: To find the weight of quicksilver [equal] in magnitude with [a body of] gold.]

Take some body of gold, and coat it with a very thin film of wax, so that it does not become lighter than quicksilver, nor be dissolved by it. Then find the weight of water having a volume equal to the body of gold itself, as has been said, which is 7. Similarly find the weight of quicksilver, as of water having a volume equal to the same body of gold —

— let the weight of quicksilver be found, which is 95. Set up the proportion: as 95 is to 7, so is 5700 to 420. The weight, then, of water having a volume equal to the quicksilver will be 420.

Conversely: let some body of water be proposed whose weight is 420, and let it be required to find how great the weight of quicksilver will be that is equal in magnitude to the proposed water A. Having coated the body of gold with a film of wax, as above, and having found the weights 7 and 95 — namely of water and of quicksilver equal in magnitude to the aforesaid body of gold — set up the proportion: as 7 is to 95, so is 420 to 5700. The weight, then, of quicksilver equal in magnitude to the proposed body of water will be 5700.

PROPOSITIO XI.

In liquids of unequal density, the ratio of the weight of the lighter liquid to the weight of the heavier liquid will be as the part of the solid body immersed in the lighter liquid is to the part of the same body sunk in the heavier liquid.

Let AB be a liquid lighter than DC, and let the solid body EF be lighter than either liquid. When it is immersed in the liquid AB, let it rest with its part GF above the water-surface; and when put into the liquid CD, let it sink with its part KI.

Diagram. Two rectangular vessels seen in cross-section, side by side, each filled with a hatched (rippled) liquid. A floating block straddles or sits in each.

- A (top left of left vessel): corner-label of the lighter liquid's surface
- E (top, above left block): top corner of the floating solid
- G (left, at waterline of left vessel): waterline corner of the immersed part
- F (right, at waterline of left vessel): waterline corner; part GF rides above the surface
- B (bottom right of left vessel): bottom corner of the left vessel
- C (top of right vessel): top corner / surface of the heavier liquid
- H (top, above right block): top of the floating solid in the right vessel
- K (left, at waterline of right vessel): waterline corner of the sunk part
- I (right, at waterline of right vessel): waterline corner; part KI is sunk

- D (bottom right of right vessel): bottom corner of the right vessel

I say that the weight of the liquid AB has to the weight of the liquid CD the ratio that KI has to GF — because the liquid of the vessel AB exactly balances the solid body HI (or EF) immersed in the water, by Proposition 5 of Archimedes, *On Bodies that Float in Water*. The proportion of the immersed part to the floating part will therefore be the reciprocal — that is, KI to GF.

Now let there be proposed liquids of differing density: spirit of wine, as in vessel AB marked with the number 1; in vessel 2, wine; in vessel 3, spring water; in vessel 4, oil; in vessel 5, mercury; and so on for the rest. From the immersion of some single solid body lighter than water, you will find the weight of all the liquids relative to one another in the proportion of the immersed parts. In wine it will emerge by $1/5$ [?]; in spring water by $2/5$ [?]; in sea water by $3/5$ [?]; in oil by $4/5$ [?]; in mercury by $5/5$ [?] — that is, it will emerge entirely. From the proportion of the immersed parts, then, you will easily arrive at the weights of the liquids. For as the immersed part of the solid body behaves in the different liquids, so is the weight of liquid 1 to the weights of liquids 2, 3, 4, 5.

Diagram. A row of vessels in cross-section, each filled with hatched liquid, with a small square block floating at a different depth in each. The blocks are numbered 1, 2, 3, 4, 5, 6 across the top (a small label **a** sits at the upper left). The engraved caption beneath names the six liquids in order.

- a (upper left): figure label
- 1: block in the first vessel (spirit of wine), floating highest
- 2: block in the second vessel (wine)
- 3: block in the third vessel (spring water)
- 4: block in the fourth vessel (oil) [order per caption]
- 5: block in the fifth vessel (mercury / sea water) [?]
- 6: block in the sixth vessel
- [Caption, verbatim]: *Spiritus vini. Vinum. Aqua font. Aqua marin. Oleum. Mercurius.* — "Spirit of wine. Wine. Spring water. Sea water. Oil. Mercury."

As for the method by which Archimedes — knowing the weights of three bodies of equal volume to water, namely one of the crown itself, another of a mass of gold, and a third of silver — was able to detect the goldsmith's theft in the king's crown: various procedures have by now been handed down by various authors. We, following the way Ghetaldus [Marin Getaldic] did it, will now show how to accomplish the same thing by the single device of the golden rule.

PROPOSITIO XII.

To discern, by reckoning of weight, a portion of one metal mixed into another metal.

[Margin: Archimedes' method, by which he detected the goldsmith's craft.]

Let the weight of the crown be 95 pounds, and let it be required to separate out the other metal mixed into it. I proceed thus. Let two bodies be conceived, one of gold and the other of silver, each as heavy as the crown. Then, of three bodies of equal volume to water — one for the body of gold, another for the crown, a third for the body of silver — let the weights be found according to what was said before. Let those of the first body be [as the difference between 5 and $9\frac{5}{11}$], or what is the same thing, $4\frac{4}{11}$; to 95, namely the weight of the crown, so is the difference between 5 and 6, that is, 1, to $22\frac{5}{11}$. Therefore $22\frac{5}{11}$ will be the weight of the silver in the crown; and when this is subtracted from the total weight of the crown, the remainder, $72\frac{6}{11}$, will be the weight of the gold sought. Or, if for the third term of the proportion one likewise takes the difference between 6 and $9\frac{5}{11}$, which is $3\frac{5}{11}$, the fourth term will be $72\frac{6}{11}$ — the weight of the portion of gold; and when this is subtracted from the total weight of the crown, there will remain $22\frac{5}{11}$ for the weight of the portion of silver.

PROPOSITIO XIII.

How may it be discerned how much bronze has been mixed into gold?

Let there be a body mixed of gold and bronze, and let it have a weight of 171 pounds. It is asked: how great is the portion of bronze mixed into the gold, and how great the portion of gold? Proceed thus. Let two bodies be conceived, one of pure gold, the other of bronze, each as heavy as the mixed body. Then of three bodies of water — one equal in magnitude to the body of gold, another to the mixed body, the third to the bronze — let the weights be found in the way described above, which are 9, 11, and 19. With these found, set up the proportion: as the difference between 9 and 11 is to $34\frac{1}{5}$ [?]; the portion of the mixed body that is bronze will therefore have a weight of $34\frac{1}{5}$; and when this is taken away from the total weight of the mixed body, there will remain $136\frac{4}{5}$ [?] for the weight of the portion of gold. Or, if for the third term of the proportion one takes the difference between 11 and 19, the fourth term, $136\frac{4}{5}$ [?], will be the weight of the portion of gold; and when this is taken away from the total weight of the mixed body, it will leave $34\frac{1}{5}$ for the weight of the bronze.

The operation stands thus:

[Margin: How the first and second operation each stand.]

10. The difference between 9 and 19 gives 171. 2. The difference between 11 and 19 will give what? The fourth term will be $34 \frac{1}{5}$, the weight of the bronze.

The second operation stands thus:

10. The difference between 9 and 19 gives 171. The difference between 11 and 19 will give what? The fourth number will be $136 \frac{4}{5}$, or $7/9$ [?], the weight of the gold.

By this method you can discern not only the mixture of another metal in gold, but also the mixture of the remaining metals in any one of them. And by this device the proportions of all metals and liquids, as regards their weights, have been found by mathematicians, as appears in the following table, extracted from Ghetaldus [Marin Getaldić].

TABULA

in which 12 bodies are compared with one another as regards weight.

The composite table forms a square divided by its diagonal into two triangular sub-tables. The upper-left triangle is **Tabula A** (headed at top left "Tabula A." with the twelve body-names running across the top and a right-hand label column "D."). The lower-right triangle is **Tabula B** (labelled at bottom right "Tabula B." with a left-hand header "C." and the body-names running across the bottom). Each cell gives the weight-ratio of the row-body to the column-body. The whole grid is transcribed below as a single matrix; left-edge row labels and right-edge "D." labels both appear, as do top and bottom column headers.

Tabula A — top column headers (left→right): Aurum | Argentum vivum | Plumbum | Argentum | Æs | Ferrum | Stannum | Mel | Aqua | Vinum | Cera | Oleum | (then blank cells) | D.

Row (left label)	Pl												D. (label —(righ) t)
	Au ru m	Arg ent. viv um	Pl m bu m	Arg ent um	Æ s m	Fer ru m	Sta nnu m	A q u a	Vi nu m	Ce ra	Ole um	(—)	
Oleu m	20 8/	14 62/7	12 6/	11 1/1	9	8 8/11	8 4/57	1 3	1 1/	1 4/5	1 5/1	10 0	Aur um

Row (left label)	Au ru m	Arg ent. viv um	Pl u m bu m	Arg ent um	Æ ru s	Fer ru m	Sta nnu m	A q u a	Vi nu m	Ce ra	Ole um	(—)	D. (label —(right)
	11	7	11	1	9 / 1 1			2/ 5 5	11	5	21		
Cera	19 19 /2 1	14 32/1 47	12 1/ 21	10 52/ 63	9 8 9 / 2 1	8 8/21	7 89/1 05	1 1 0 9/ 2 1 0	1 1/ 21 42 0	1	10 0	71 3/7	Arge ntu m vivu m
Vinu m	19 19 /5 5	13 321/ 443 [?]	11 41 30/ /5 55 [?]	10 30/ 55 [?]	9 8 9 / 5 5	8 8/55	7 31/5 5	1 2 8/ 55 5 5	1 1/ 55	1	10 0 14/ 10/ 55 55 [?] [?]	60 10/ 55 55 [?] [?]	Plu mbu m
Aqu a	19	13 4/7	11 1/ 2	10 1/3	9 8	7 2/7	1 9/ 2 0	1 1 10 89 76 54	1 0 59/ 8/3 22/ 37 [?] [?]	10 0 69	89 59/ 8/3 7 [?] [?]	54 22/ 37 [?] [?]	Arge ntu m
Mel	13 3/ 29	9 73/2 53	7 27 11/ /1 87 9 [?]	7 11/ 87	6 5 18/2 3/29 6 9 / [?] 2 9	5 18/2 3/29 6 9 / [?] 2 9	5 3/29	1 0 3/3 6/2 6/1 7/1 9 9 [?] [?]	10 87 78 66 47 [?] [?]	87 3/3 1 3 9 9 [?] [?]	78 6/2 6/1 7/1 9 9 [?] [?]	47 7/1 9 9 [?] [?]	Æs
Stan num	2 21 /3 7 [?]	1 221/ 259 [?]	1 41 44/ /7 111 4	1 44/ 111	1 1 3/37 8 / 3 7	1 3/37 8 / 3 7	1 3/37 8 / 3 7	1 88 77 69 58 42 2/1 9 [?] [?]]	1 9/ 13/ 13/ 13/ 19 [?] [?]]	88 77 69 58 42 2/1 9 [?] [?]]	77 13/ 13/ 13/ 19 [?] [?]]	69 13/ 13/ 19 [?] [?]]	Ferr um

Row (left label)	Au ru m	Arg ent. viv um	Pl u m bu m	Arg ent um	Æ s	Fer ru m	Sta nnu m	A q u a	Vi nu m	Ce ra	Ole um	(—)	D. (label —(right))	
Ferr um	2 3/ 8	1 39/5 6	1 7/ 16	1 7/2 4	1 1 / 8	1	100	9 2 1/ 2	82 2/ 9	71 19/ 31 [?]	64 8/2 1 [?]	54 10/ 19 19	38 18/ 19	Stan num
Æs	2 1/ 9	1 12/6 3	1 1/ 18	1 4/2 7	1	100	19 27/3 7	1 8 1/ 8	16 1/ 9	14 1/3 1 [?]	12 19/ 23 19	10 13/ 19 19	7 12/ 19 [?]	Mel
Arge ntu m	1 26 /3 1	1 69/2 17 [?]	1 7/ 62	1	1 0 0	68 28/2 9 [?]	13 19/3 7 [?]	1 2 1/ 2	11 1/ 9	9 21/ 31 [?]	8 16/ 23 [?]	7 7/1 9 [?]	5 5/1 9	Aqu a
Plu mbu m	1 15 /2 3	1 29/1 61	1	100	9 8 7 1 / 3	67 71/8 7 [?]	13 52/1 11 [?]	1 2 7/ 2 4	10 25 /2 7	9 16/ 31 [?]	8 18/ 69 [?]	7 14/ 57 [?]	5 10/ 57 [?]	Vinu m
Arge ntu m vivu m	1 38 /9 5	1	10 0 47/ 649 [?]	97 47/ 649 [?]	9 5 5 / 1 1	65 265/ 319 [?]	12 366/ 407 [?]	1 1 4 1/ 4 4	10 20 /3 3	9 81/ 34 1 [?]	8 77/ 21 3 [?]	7 7/2 09 [?]	5 5/2 09 [?]	Cera
Aur um	1	100	96 2/ 63 [?]	93 13/ 79 [?]	9 1 7 2 / 3	63 19/8 7 [?]	12 43/1 11 [?]	1 1 1 1/ 2 4	10 5/ 27	8 27/ 31 [?]	7 67/ 89 [?]	6 43/ 57 [?]	4 47/ 57 [?]	Oleu m

Tabula B — bottom column headers (left→right), under header "C.": Oleum | Oleum | Cera | Vinum | Aqua | Mel | Stannum | Ferrum | Æs | Argentum | Plumbum | Argentum vivum | Aurum | Tabula B.

Praxis of this Table.

This abacus is laid out as two triangular tables. The first, marked with the number ADC, contains the weights and magnitudes of the 12 bodies compared one with another, and assigns the true proportions, in weight and magnitude, of all twelve bodies compared with one another. The other triangular table is marked with the number BCD. In the first, some body — whatever it may be — is set down as 12, and the rest are compared to it. In the second table, some body — whatever it may be — is set down as 100, and the rest are then compared to it.

It only remains, then, for us to set out its use in a few propositions; for this knowledge is wonderfully useful and profitable in every investigation of weights. Note, however, that weight is considered in one way here, magnitude in another: for if two of the twelve bodies, differing [in kind], have the same weight, you will necessarily find one larger than the other — for one must be larger than the other by exactly as much as, under the same magnitude, the one is lighter than the other. But let us show this very thing by practice.

PROPOSITIO I.

To find the proportion of the weight of gold and silver to one another.

In the first triangular table ADC, look for gold in the topmost border AD and silver in the border AC, and in the common angle you will find $1 \frac{26}{31}$, which is the proposition of the weight of silver to gold — where silver stands as 1.

Diagram. Two circles of equal size set side by side, captioned above "Magnitudo aequalis" ("Equal magnitude"), illustrating that at equal volume gold weighs $1 \frac{26}{31}$ to silver's 1.

- Left circle, interior: **$1 \frac{26}{31}$** (i.e. $1 \frac{26}{31}$)
- Left circle, below: *Gravitas auri* — "Weight of gold"
- Right circle, interior: **1**
- Right circle, below: *Gravitas argenti* — "Weight of silver"

So gold stands as $1 \frac{26}{31}$. Gold is therefore heavier than silver by $\frac{26}{31}$. For if these two bodies are taken —

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are equal in magnitude. I say that the silver body will stand to the gold one as 1 to $1 \frac{26}{31}$. For since bodies equal in magnitude differ greatly in weight, the one that is less heavy — namely silver, compared with gold, which is heavier — will stand to it as 1 to $1 \frac{26}{31}$. But if you consider the magnitude of the silver and gold bodies, you will find that the gold body stands to the silver one in magnitude, again, as $1 \frac{26}{31}$ to 1. And necessarily, if these two bodies are taken as equal in weight, the gold body will be smaller, as 1, while the silver body will be larger, as $1 \frac{26}{31}$.

Diagram. A pair of circles set side by side, captioned above with the heading "Inæqualis Magnitudo argenti ad magnitud. auri" [Unequal magnitude of silver to the magnitude of gold]. The left circle is the larger, representing silver; the right circle is the smaller, representing gold. The weight-ratio is inscribed inside each circle.

- Left circle (silver): $1 \frac{26}{31}$
- Right circle (gold): 1

PROPOSITIO II.

To find the proportion of gold to iron.

Look in the rim of the Table at A D C; and in the rim A C [find] iron, and on the side A D [find] gold, and you will find in the common angle $2 \frac{1}{8}$, the proportion to iron that you sought. For suppose iron to have a weight of 1: then gold will have a weight of $2 \frac{1}{8}$; so that if the iron weighs 1 pound, the gold weighs $2 \frac{1}{4}$ [recte: $2 \frac{1}{8}$ — the text just gave the ratio as $2 \frac{1}{8}$; " $2 \frac{1}{4}$ " here is inconsistent]. If you attend to the magnitudes of these bodies when equal in weight, the magnitude of the iron will stand to the magnitude of the gold as $2 \frac{1}{8}$ to 1 — that is, the iron body will be larger than the gold one, under the given proportion.

PROPOSITIO III.

To find the proportion of bronze to lead, both in weight and in magnitude.

Look as before in the rim A D [for] lead, and in the rim A C [for] bronze, and the common angle will give you $1 \frac{5}{18}$, the proportion you sought. For as 1 stands to $1 \frac{5}{18}$, so does the weight of bronze stand to the weight of lead, by which lead's weight exceeds that of bronze by $\frac{5}{18}$ — so that if bronze has 1 pound by weight, lead will have, in addition, 1 pound plus $\frac{5}{18}$ of a pound. But if you consider these bodies as equal in weight with respect to magnitude, then conversely, as $1 \frac{5}{18}$ stands to 1, so will the bronze body stand to the magnitude of the lead body.

PROPOSITIO IV.

To find the proportion of water to wine.

Look in the rim A C [for] wine, and in the rim A D [for] water, and the common angle will give the desired proportion, $1 \frac{1}{55}$ — that is, water is heavier than wine by $\frac{1}{55}$. For as 1 stands to $1 \frac{1}{55}$, so wine stands to the weight of water. In the same way you will find that wax stands to honey in the proportion 1 to $1 \frac{105}{210}$. And so for the rest.

Praxis Tabulæ triangularis. B D C.

PROPOSITIO V.

The proportions of this Table do not differ from the previous one except in the assumed weight of 100 — for example, of pounds — which is compared with any other of the twelve. For in this Table the weight of a body is always set as 100, and to this given value the remaining bodies are proportioned, both as to weight and as to magnitude.

For example: if you wish to know what the ratio is in weight of gold to silver — since gold is heavier than silver, let us set its weight as 100. Look, then, in the rim C B of Table D B C [for] gold, and in the rim D B [for] silver, and the common angle will give you $54 \frac{23}{57}$, the proportion of gold to silver that you sought. For if two bodies equal in magnitude are taken, one of gold, the other of silver, and the gold is heavy as 100, the silver will be heavy as $54 \frac{23}{57}$. Therefore, as 100 is to $54 \frac{23}{57}$, so is the weight of gold to that of silver. But if these two bodies are taken as equal in weight with respect to magnitude, the proportion will hold conversely: for as 100 stands to $54 \frac{23}{57}$, so the silver body stands, in its magnitude, to the magnitude of the gold body. These same things are to be understood concerning any other bodies set out here in the table; and so these rules are always to be observed:

1. Whenever two differing bodies are of equal weight, one of them will necessarily be the larger — that is, unequal to the other in magnitude.
2. Whenever two differing bodies are equal in magnitude, necessarily one of them will be unequal to the other in weight. How these Tables are constructed was shown in the preceding pages.

From this it is clear how, once the proportion of two spheres cast from different metals is had, their weights are to be determined. But since this is not part of our undertaking — to set forth statics — I leave the rest to the curious reader to

explore; let it suffice us, meanwhile, to have demonstrated the proportions of metals to one another, both as to weight and as to magnitude.

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CAPUT III.

De variarum rerum ponderationibus.

(On the weighing of various things.)

There is nothing in the nature of things that cannot be investigated by weight — as was shown partly in the preceding pages, and as we shall pursue further in this chapter. Earthy substances or minerals of any kind whatever can be examined in the same way that was shown in the first proposition, by means of our hydrostatic balance. For any body whatever, fastened to the hook of one pan and immersed in water, can be assessed by the counterbalancing of another body set in the air-pan: if you first weigh both in air, and then within water, the difference of weights will give the sought-for proportion of weight between the one body and the other.

[Margin: The varied weight of waters.] As for the element of water, I say that there are as many different degrees of weight in waters as there are different kinds of water. For the weight of spring water is one thing, of salt or sea water another, of river water, of standing pools, and of rain another, of mineral water another — which also differ according to the kind of hot springs; the weight in different plants, oils, quintessences, and similar liquors is yet another; and the weight of blood and urine in animals is another still. [Margin: The varied weight of blood in human beings according to the degree of age.] And indeed in human beings this varies greatly according to variety of age and complexion, since the blood of a boy, an adolescent, a grown man, and an old man each has its own; and one weight belongs to the melancholic, sanguine, phlegmatic, and choleric, and another to the healthy and the sick. That the same difference of weights occurs in animals, only one who has never observed the marvelous transformations of things could fail to know. Human beings, animals, and plants, according to the diversity of climate, take on different complexions, and so too different tempers and varying weights — all of which we have already noted in the preceding pages.

As many as are the differences of seas and rivers, so many are the differences of the weights of waters; for water in the Northern Ocean is of one weight, in the

Southern of another. So too the water of the Indus, the Ganges, the Tigris, the Nile, the Danube, the Rhine, the Rhône, the Tiber, the Po, the Tagus all differ among themselves — some of them not a little. [Margin: The reason there is scarcely water that does not differ in weight from another.] The most wise Ferdinand II [Ferdinand II de' Medici], Grand Duke of Tuscany, affirmed to me with certainty that he had perceived this by experiment itself. [Margin: All waters can by their own nature be made to counterbalance one another on account of admixture.] Yet this too is remarkable: that waters, by the already-mentioned art [the spagyric art], can be reduced to such fineness that they all exactly counterbalance one another. From this it shines out clearly that the diversity of such weights arises from no other cause than the admixture of different mineral or earthy parts with which they are charged, and from the juices [in them]. Quite similar is the diversity of wines in weight and lightness — the cause of which we can give as nothing other than the differing conditions of the earthy clods, and the differing aspects of the Sun, which strikes the slopes of valleys and mountains. But let us set forth how great are the secrets of statics that lie hidden in the nature of things.

Experimenta Statica miscellanea.

(Miscellaneous statical experiments.)

EXPERIMENTUM I.

To investigate the attractive power of the magnet as to weight.

[Margin: To investigate the statical power of the magnet.] Place a magnet in one pan, and in the other a body of iron counterbalancing the magnet; then, taking away the magnet, put in its place any other body counterbalancing the magnet. This done, apply the magnet above the iron, and note how much it is attracted; and [observe] up to what point the iron rises toward the magnet, drawn by the magnet — which will be the outermost point in the sphere of magnetic activity. This done, and the magnet set aside, place gradually so much weight in the opposite pan, until the iron has risen to the place which it held when drawn by the magnet: for the weight added in the opposite pan will be the power, or attractive faculty, of the magnet.

EXPERIMENTUM II.

To investigate, by the spagyric balance, how much moisture is in some green wood or herb.

[Margin: To investigate how much moisture is in plants.] Let some earthy wood first be cut into pieces — or any plant whatever — which is then committed to fire for so long, until the whole has been reduced to ash. If, then, the wood first turns out to have weighed 4 pounds, you will know that there was just so much moisture in the wood or plant — namely two pounds. I speak here of elementary moisture, not radical moisture, which always remains in the salt that is drawn out of the ashes.

CONSECTARIUM.

(Corollary.)

From this experiment it is clear that the moisture not only of every kind of vegetable, but also of any animals whatever, reduced beforehand to ash, can be found. [Margin: To investigate the moisture in individual things.] And so, if someone reduces several mixed things — whether vegetable, or sentient, or of mixed nature — separately to ash in the manner described, I say that he will find not only how much moisture each one had, but also the proportion of the ash of one to the weight of the ash of another. This is indeed a matter of great importance for coming to know the degrees of the primary qualities.

ARS METALLOSTATICA. (continued)

EXPERIMENTUM III.

To find how much salt is in any one of the mixed things assumed before. Proceed thus.

First, having weighed the mixed things, write down the weight separately; then weigh again the ash left from the burning, and, this noted, let the ash be put into water in a wooden vessel and stand there so long, until a lye [lixivium] is made from it. Afterward, the water having been separated off, you will see the salt adhering to the vessel in the form of crystals — keep this. But the lye, evaporated by fire to dryness, will leave in its bottom a dead residue [caput mortuum]; if water is again poured over this in the said wooden vessel, it will in time give a lye, which being separated, you will set aside the salt that finally adheres to the vessel, scraped off; and you will repeat this as many times as needed, until no more salt remains in the dead residue. Then the salt collected from each repetition, examined by weight, will give you how much salt was first present in the said mixtures. Whatever is left in the bottom after the evaporation of the lye, you will reckon as the saltless earthy substance.

EXPERIMENTUM IV.

To weigh air at different times.

[Margin: To investigate the quality of air.] Air is by its nature changeable, and does not always remain in the same state; so if you should wish to investigate its weight, proceed thus. Take dry wool compressed into a little ball; weigh it first, placed in one pan, in the driest weather; then, in weather of a more humid constitution, weigh again the wool left in the same place, and you will find a notable difference between the second air and the first. From which it is clear that, if anyone weighs the said wool in the morning, at midday, in the evening, or at midnight, he will be able to find a difference in air, as to weight, at each of these four daily stations — which I would have understood likewise of the four seasons of the year. In the same way one could find the difference of air in subterranean caves compared with the external air, in valleys compared with the air on mountains, and indeed of the same air when altered by the various blasts of winds. See what we have treated at length about these matters in the *Ars Magnetica*, concerning the new instrument by which the dryness and humidity of places is investigated. I have seen one who gathered the proportion of air to another degree of tenuity from the motion of bellows: for bellows drawing in thick air move more slowly in expelling it than in a thinner air; whence nothing else seems to be required here but to investigate the differences of the motions by the vibrations of a pendulum. Air can also be weighed in a balance: take a large play-ball, which you first fill very full with humid air; this weighed, you force a more subtle air into it by means of [?]; and from the weighing of it the difference will at once become known.

EXPERIMENTUM V.

To investigate the vigor of the Sun.

[Margin: To investigate the vigor of the Sun.] The vigor of the Sun consists in this: that in different climates and places it acts differently even upon mixed bodies of the same species, whence arise also different qualities of those mixtures. Let us, then, make the experiment first upon grain. Let there be taken from the plains of different climates grains, for example of wheat, in such a quantity of equal grains — so much from the one, so much from the other — then let them be weighed individually, and you will find a notable difference: those which are lighter will have had the greater efficacy of the Sun, those heavier the less. And in this same way you will also find the vigor of grain on the plain and on the mountain or in the valley. The reason is that where the Sun's efficacy is greater, there too is less moisture and greater dryness — for just as green wood [weighs] more than dry, so too the more humid grain must of necessity weigh more than the dry; and

consequently bread from the wheat of a more southern climate is whiter than bread baked from the wheat of a more northern climate, the moisture in the bread producing blackness.

EXPERIMENTUM VI.

To investigate how much a plant has grown on individual days.

Let there be made from wood a square rod A B, divided into any number of degrees; this has at A a crosspiece of wood, inserted into the rod A B, which at each end, C and D, has a little wheel — which they call a "currulum" [pulley] — fitted to the ends in such a way that a fine silk thread can easily be wound this way and that. Let this thread have at one end — as at E — a light weight tied on; the other end is to be tied to the tip of the plant at F. If, then, you have a mind to investigate the daily growth of a plant, proceed thus: let the rod A B, with its transverse little beam C D, be fixed firmly in the earth next to the plant; this done, let [the thread] be tied on...

Diagram. A plant-growth measuring instrument. A growing plant (shown with leaves and roots) rises from the ground at the base; behind it stands a vertical graduated scale fixed in the earth. At the top a horizontal crosspiece carries two little wheels (pulleys). A silk thread runs over the pulleys, tied to the plant's tip at one end and to a small hanging weight at the other, so that as the plant grows the thread shifts against the graduated scale.

- A (top center of the crosspiece): top of the vertical rod / junction with crosspiece
- C (top left end of crosspiece): left pulley
- D (top right end of crosspiece): right pulley
- B (foot of the vertical scale): base of the rod, fixed in the ground
- E (right side): the small hanging counterweight
- F (left, at the plant): point where the thread is tied to the tip of the plant
- Scale graduations marked: 5, 10, 15, 20, 25, 30, 35, 40

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the tip of the plant G F: at F it will be tied with the silk thread, and the other end E, by its own weight, will draw out the tip of the plant by means of the wheels C D. This done, note carefully to which degree, in the region of the fulcrum B A, the tip F corresponds — or even to which degree the knot in the silk thread points on

the transverse beam C D, graduated into any number of parts. And in this way, on individual days, you will obtain the difference of the plant's growth — especially if on the following day you repeat the observation, and write down the differences of growth separately. By this method you will discover the daily growth of different plants with almost no trouble. The usefulness of this thing is great: for from it you will easily come to know the quantity of nourishment that the plant draws to itself each day. Likewise you will have noted the ratio of moisture and dryness in plants — for moist plants take their growth more quickly than dry ones, as do warm-moist plants more quickly than cold-dry ones. The remaining benefits I leave to the reader to weigh.

EXPERIMENTUM VIII.

To find how much quicksilver is in a mineral clod.

[Margin: To investigate how much quicksilver a mineral body contains.] Take an earthen flask, into which you will put the mineral clod, with an alembic placed over it together with a receiver; then, fire being applied beneath, the mercury will gradually take wing, ascending in the form of vapor; and when it reaches the cold cap, it will at once, restored to its own nature, slip down into the receiver. If, then, the mineral clod was first of 8 pounds, and you find 6 pounds of mercury, you will surely infer that there were two pounds of earthy matter in the mineral clod, and six of mercury — supposing the ore to have been taken from a mine from which quicksilver [hydrargyrum] is extracted. In this way it is permitted to investigate the mixtures of the rest of the minerals; but since in the preceding Books we have treated similar things at length, we refer the reader to them: see especially what is to be investigated in the first Book, *On the Cosmocentric Art*, by means of pendulums, and what we set forth in the fifth and tenth Books, *On the Hydrometer Instrument*.

EXPERIMENTUM IX.

To measure the speed of a bird flying in the air.

[Margin: To investigate the speed of the flight of birds.] We first explored this matter in the flight of swallows, which are swifter than all other birds. [Margin: Something so fixed, of the magnitude of an enemy's gate (?) — see note] We took a pendulum of such length that its vibration, or diadrome [diadromus, single swing], corresponded to one second of an hour. This done, in a suitable place we observed the motion of flying swallows over a certain space, and found that for one swing of the pendulum a swallow covered 100 geometric feet from one terminus to another. From this we gather that, if it continued its flight in a

straight line at equal speed, [it would cover] a quarter of [?] the space in one hour. And so, with almost no trouble, by the help of the rule of proportions, in this way: in one second, or in 60 first minutes [i.e. minutes], the swallow covered a space of 100 geometric feet. In 3600 seconds — that is, in one hour — how much? And the computation done, there came out 72 miles (each of which consists of 1000 geometric paces), which we find a swallow could cover by continued flight; and consequently in 24 hours, or one natural day, 1728 Italian miles, or 432 German leagues, taking 4 miles for one league. But in flying around the whole globe of the earth, it would take up almost twelve days and eleven hours. [Margin: In how much time a swallow could fly around the earth.] Anyone could take this experiment not only concerning the time of the flight of swallows, but of any other birds and running animals whatever, for investigating their proportions of speed to one another — which I would have understood in the same way of the motion of arrows and the speed of cannonballs.

EXPERIMENTUM IV. [recte: this experiment is numbered IV again, out of sequence after IX; the running number is anomalous in the source]

To investigate, by the anaclastic art, both the weight and the lightness of various liquids.

It is known to all that a ray — whether solar or visual — observes different laws of refraction according to the condition of the different media, as we have demonstrated at length in the *Ars Magna Lucis et Umbræ*, in the Book *On the Anaclastic Art*, or of refractions. So then, lest I omit anything of curious matters, here, as in a fitting place, we shall teach how the weight and lightness of different liquids can be investigated by means of the art of refractions. [Margin: To investigate the weight of liquids.] First, then, let a vessel be made of bronze plates, fashioned in the shape that L M represents. Second: in the bottom of the vessel let a coin be placed, [which] you see to be at E D. Third, draw back from the vessel M L straight toward H, by so great a space, until the coin...

Diagram. A woodcut illustrating the refraction experiment for the weight of liquids. At the upper left stands a man (in 17th-century dress) sighting along a line of vision; lines of sight run from his eye down toward a shallow round basin or vessel at the lower right. The vessel (a broad, shallow cylindrical pan) contains a coin in its bottom; sight-lines converge on the basin, showing how the apparent position of the submerged coin shifts by refraction.

- A (upper left, at the man's eye): the observer's eye / station point
- H (lower left): the point to which the observer draws back

- R (mid-upper, on the sight-line): point on the line of vision
- L (left rim of the vessel): one edge of the basin
- M (right rim of the vessel): the other edge of the basin
- E, D (in the bottom of the vessel): the position of the coin

the coin no longer appears. At that point, halt again at H. Fourth, fill the whole vessel L M — first with the clearest spring water — then return to position H, and the coin e d, which at first eluded your eyes, will now show itself fully. In the empty vessel L M the coin was not previously visible, because the line of sight a s, extended in a straight line, was carried to b c, leaving the coin untouched. But once the vessel is filled with the clearest water, the incident visual rays A R, A S are at once refracted at the surface of the denser medium — from R to d, and from S to e — and they make the coin, hidden just a moment before, visible to the eye A by means of the refracted lines d R A and e S A.

[Margin: To investigate by the anaclastic art the difference in density of liquids.]

Now if you pour out the clear, limpid water and refill the vessel to the brim with a new but denser water, such as seawater, and look at the coin — fixed in the same place — from the same determined station A, you will find that the coin e d has receded somewhat toward L, as though to e g, having left its station. The reason for this is none other than the obstruction of the denser medium: the visual rays, unable to penetrate it, are refracted under a greater angle. From K, that is, they are refracted into d, and from S into g. Consequently the coin will no longer be seen at E D, but at e g. From this the difference of the liquids — as to density and fineness — will readily suggest to you the difference of the anaclastic angles D R e and e s g. On this matter, see our *Ars Anaclastica*, where we have set out the calculation in full.

In this way you can, with no trouble at all, investigate the propositions concerning the lightness and density of wine, of aqua vitae compared to water, of oil, and of any transparent liquid whatever. I have thought fit to add these things here so as to give the curious reader an occasion for the investigation of many other secrets of Nature far greater than these.

[Margin: To investigate the densities of liquids.]

Experimentum X.

Musicas proportiones ponderibus explorare. — To investigate the musical proportions by means of weights.

Take two strings equal in length and thickness; if you stretch them with weights, you will obtain the harmonic proportions in fitting agreement with what you seek. Thus two weights are hung from the said strings, which, if they are in double proportion, will necessarily cause those strings, when set vibrating, to give you —

Diagram. A schematic of five weighted strings hanging side by side from a horizontal frame, numbered left to right 1, 2, 3, 4, 5, each terminating in a small weight (drawn as a flat coin-like disc). Beneath the row of weights, a series of nested arcs connects pairs of strings, each arc labelled with the harmonic interval it represents.

- Strings (left to right): 1, 2, 3, 4, 5
- Arc from 1 to 2: *Diapason* (the octave)
- Arc from 2 to 3: *Diapente* (the fifth)
- Arc from 3 to 4: *Diatesseron* (the fourth)
- Arc from 1 to 3 (lower nested arc): *Dis diapason* (the double octave / fifteenth)
- Arc from 1 to (4/5) (lowest, widest arc): *Diapason cum Diapente* (the octave plus a fifth / twelfth)

— the diapason, that is, the octave. And if the weights fixed to the strings stand in the ratio 2 to 3, the strings, set in motion, will necessarily yield you the diapente, or fifth. If the weights stand as 3 to 4, they will sound the diatessaron for you; if as 1 to 4, the disdiapason; if as 1 to 3, the diapason plus diapente; and if, finally, the weights stand as 8 to 9, they will give you the tone — and so on for the rest, which we have demonstrated very fully in our *Musurgia*, to which I refer the reader.

[Margin: To investigate the harmonic proportions.]

I could bring forward countless further examples at this point, but since we have reserved these matters for the *Ars Magna* of heavy and light bodies, it will suffice merely to have indicated them here.

Pars III.

DE ARTE VITRIARIA.

In which we treat not only of the wonderful works of glass, but also of the fashioning of crystals, pearls, and precious stones after the living model of Nature.

Caput I.

De Vitri natura. — On the nature of glass.

Glass is the last thing into which any mixed body can be reduced, and its nature is so marvelous that it can scarcely be described in adequate words; if only it did not have an inborn fragility attached to it, surely nothing could come near it in value. For what is clearer than its substance? What more limpid? What more beautiful? Indeed, as Job testifies: "Gold shall not equal it, nor the topaz, nor the beryl, nor any other precious stone" [Margin: Job 36:26 — recte Job 28:17]. Pliny [Pliny the Elder] reports that under the Emperor Tiberius a tempering of glass was devised by which glass could be made flexible, and that on this account the artisan's entire workshop was abolished — so it is handed down — lest the value of the metals copper, silver, and gold should thereby be diminished.

[Margin: Flexible and unbreakable glass.]

For, as Isidore relates (*Etymologiae* XVI.16.15): "It is reported," he says, "that under Caesar Tiberius a certain artisan devised a tempering of glass by which it could be made flexible and ductile. When he was admitted to Caesar, he handed Caesar a phial, which Caesar, indignant, threw onto the pavement; but the artisan picked it up from the pavement, and it had buckled somewhat, like a bronze vessel. Then he drew a mallet from his bosom and straightened the phial. At this Caesar said to the artisan, 'Does anyone else know this method of compounding glass?' Whereupon, when the man swore in reply that no other knew it besides himself, Caesar ordered him beheaded, lest, if this became known, gold should be held as worthless as mud, and the prices of all metals be diminished."

[Margin: Glass valued among the Indians at the highest price.]

Among the Indians, as soon as it became known, it was preferred to all things and exchanged at an inestimable price — so much so that a few glass cups are said to have been bartered in the Eastern kingdom of Tidore at a valuation of 200 gold pieces. In how great admiration the glass triangle [prism] was held among the

Chinese, let anyone who wishes read in the history of the expedition to China by Father Nicolas Trigault [Nicolas Trigault]. So that we may set out in order the many uses of his account for the human race —

First, who would not marvel at the ingenious vessels and cups, full of admiration, that are fashioned by the use of glass? How great is its usefulness in making mirrors! How highly is it valued in these latest times for the making of optical tubes [telescopes] and microscopes, by which astronomers have penetrated with lynx-like eyes even the very canopies of the heavenly bodies and the stars, and by which they have performed the anatomy of the tiniest animals and of things almost imperceptible! But since we have dealt with these and similar matters most fully in the *Ars Magna Lucis et Umbrae*, in the book on mirrors, we refer the reader there. By means of glass siphons almost the whole of elemental nature has been laid open to physics through manifold experiment. How great are the benefits that come to us from its transparent nature in the construction of windows! And although by its own nature it is fragile and a work of art, it nonetheless deserves to be held in that place where, among the works of Nature, it ranks as a gem. Liquids such as the *aquae fortes* [strong acids], quicksilver [hydrargyrum], and the like, are usually contained in no vessels except glass ones.

[Margin: The usefulness of glass.]

[Verse:] *Whether it first retains the hard fire, or the heaped-up mass of iron, Or even binds it, joined to a kindred metal, It flashes forth, and the obstructing mass, with ungovernable weight, It bursts, exulting, and, mighty, subdues all things — save one alone. But when we attempt to bind the lively motions with glass, the love feels its forces shattered here by the barrier, and the glassy bite probes the bodies in vain.*

These things, then, being set forth, let us now unravel each point by way of Questions. And so it is asked first: What is the material of glass?

[Margin: The material of glass.]

I am not unaware that some say the material of glass is ash and lime, others assign a different material according to each one's own ingenuity — which it would take too long to recount. We say that ash is not the sole material of glass, but rather sand — not any kind of sand, but sand consisting of a glassy material, of the sort that certain flints are, and crystalline gravel, and the sand of the stone they call Alebandic, to which we also reckon jet, which Pliny calls obsidian stone.

Stones, then, that promise a certain transparency yield, the more lucid they are, by reason of a certain crystalline admixture mingled with them, glass that emerges so much the more beautiful, brighter, and more lucid.

[Margin: Sand and ash make glass.]

When these stones have been ground into sand, the ashes of burnt plants are joined to them (of the kind they call *hali* and *soda*). Since these herbs are by their very nature niter-bearing, they are mixed with the sands for this purpose: so that out of the inmost substance of the sandy stone they may draw forth a nitrous material similar to themselves, which, together with the nitrous and saline corpuscles lurking in the ash, may at last, by the force of the most blazing heat, be melted down into glass. The ancients, for the said reason, used to add pure native niter to the sandy material, and some do so even to this day. But experience has taught that the nitrous ashes of certain plants render not only the same effect as niter, but a nobler one.

Glass, then, is made: first, from transparent, crystal-form stones, fusible by their own nature, and also from concreted juices and from the liquors of other things joined to these by a certain natural kinship; and from these a glass of better quality is produced. [Margin: From crystalline stones.]

Second, from those stones which, although they do not possess crystalline hardness, are nonetheless translucent and white. [Margin: From translucent stones.]

Third, from stones that are indeed white, but not transparent — such as certain flints heaped up by the force of the waves at the mouths of rivers. [Margin: From white, non-transparent stones.] These are prepared in this way: first the said stones must be burnt; then, placed under pestles, they must be broken and ground so that sand is made from them; then they must be sifted, to separate the purer particles from the impure. Stones, however, that have been washed by waters and taken up at the mouths of rivers for this use need no further purification, since they are tumbled by the perpetual attrition of the waters.

Once these have been prepared, the making of glass is done by this art: to three parts of the sand of the said stones they add one part of niter, and from these, melted together, arises a mass which Agricola not improperly calls *Ammonitrum*, that is, "sand-niter" [Arenonitrum]. To make up for any deficiency of niter, a portion of fossil salt, or of any other salt whatever, is added to the sand. The deficiency of all these is nowadays supplied, among the glassmaking craftsmen, by the ash of the burnt herb *anthyllis*, which the Arabs call *kali*, and the Italians

and Spaniards *soda*; it grows for the most part in salty soils, and so by many is not unfittingly called *salsula* [saltwort], because an abundant salt is drawn from it. There seems to be a great quantity of this herb on the island of Malta, and in some places of Calabria. But the Spanish soda is most commended above all the rest.

[Margin: Spanish soda surpasses for glass.]

It is truly worthy of admiration that at Venice the skilled craftsmen mix in a portion of magnet [lodestone] with these as well, because by this admixture the glass acquires a wonderful splendor. The reason for this is none other than that for the most part an admixture of iron filings adheres to the stones, which, drawn off by the magnet, frees the rest of the glass mass from the impurity of the shadowy parts.

[Margin: An admixture of magnet with glass.]

Furthermore, furnaces differ according to the diversity of operations. Here at Rome they raise most furnaces into a fourfold tier of stories, of which the lowest is the κονιστήριον [Greek: konistērion, "ash-place" — the place fitted for receiving the ashes], the second the πυρευτήριον [Greek: pyreutērion, "fire-place" — destined for kindling the fire]; in the third are fitted the vessels and pots suited for melting the glass material; and above is the receptacle, constructed for a certain tempering of the heat, lest the newly molten glass, exposed to sudden cold, should burst. All the receptacles of a furnace of this kind are constructed not of iron, not of lime, not of living stones, but of raw bricks made from clay suited for this work and for sustaining the strongest fire. The pots, too, which contain the glassy material, are made here at Rome from a certain clay brought from the territory of Savona. Then the furnace is kindled with long oak or holm-oak logs and the like, for eight days — as here at Rome — but under fixed degrees: first gentle, then stronger, and finally strongest.

[Margin: The manner of making glass vessels.]

When the material within the pots has thus been liquefied, the glassmakers, with three-foot tubes of iron or bronze inserted into the pots and turned about, draw from them as much as they judge sufficient for the work to be made. They turn it on a marble slab placed before the little window, and blow through the tube repeatedly; and lest the blast entering through the tube should harm them, they apply it, drawn back from the mouth, to the jaw. Then, lifting the tube and twisting it several times in a circle, they make the glass long; next they form the same in a hollow bronze instrument, which serves the function of a mold; then,

by heating, blowing, pressing, and enlarging, they shape it into the form of a cup or vessel or other thing conceived in the mind, attach handles, paint it with various colors — and in this way they commit the finished vessel to the furnace for the purpose of cooling. But since these things are everywhere commonly to be seen, I have not thought fit to set them out at greater length.

As for the different species of glass, they are almost as many as the species of minerals, since almost all concreted juices coalesce into glass. Glass, then, can be considered under a twofold difference: as natural and artificial. Of the former kind are crystal, beryl, topaz, and however many transparent gems are at last fusible in fire. Of the second kind are the calxes [oxide-ashes] of metals, which by the benefit of the spagyric [alchemical] art are melted down into glass — gold excepted. In this way Saturn, that is, lead, is decocted into tin, into copper, and finally into glass, as we shall see later. Third are the smalts or enamels, which are nothing but glass decocted from metallic bodies.

[Margin: The differences of glasses.]

I will not speak here of the sands of the river Belus in Syria, at the foot of Mount Carmel, coagulated by the power of fire into the purest glass — some of which are true, while many are wrapped up in fabulous tales — to be found in Josephus, *On the Jewish War*, Book 2. Experience teaches this: that every fusible thing, whether stone or metal, can be forced into glass.

[Margin: Every fusible mineral can be forced into glass.]

Moreover, there is nothing that more easily takes on all colors than glass, and that displays the same colors more splendidly; whence, not without deceit, men so artfully tint glass that it can appear as emeralds, hyacinths [zircons], amethysts, and chrysolites — of which a little later. The colors that are commonly employed for tinting glass are of mineral nature.

The properties of glass are truly marvelous, some of which we shall set out here:

1. Glass thoroughly cooked with sulphur is hardened into stone — so say Pliny and Agricola, *De Ortu Subterraneorum*, Book 5. [Margin: Glass hardened into stone by sulphur.]
2. The white of eggs mixed with quicklime turns into a glue most apt for cementing the fragments of glass. [Margin: A glue for glass.]
3. Glass is liquefied by the heat of fire, and congealed by cold, whether it be of the watery or the airy [kind].

4. Glass vessels alone can contain quicksilver, all other [vessels] being at length eaten away by it.
5. Glass made red-hot and then thrown into cold water is rendered so brittle that it can be crushed into a fine powder with the hands. [Margin: How the brittleness of glass is brought about.]
6. Glass can be so tempered by a certain water that one little fragment of glass, broken at the very tip, reduces the whole mass into an imperceptible powder. This comes about if you make the fragment red-hot again and again with fire, and quench it repeatedly in the coldest water. But concerning this truly wondrous experiment, see what we have treated most fully elsewhere. [Margin: A wondrous experiment in glass — the resolution into powder in a moment.]
7. Glass added to the fusion of metals renders them fluid, on account of the great heat which it then possesses in its fusion, and which it imparts to other fusible things.
8. Glass in fire is soft and ductile, but once cooled nothing is more fragile. The rest we shall pursue in what follows.

§. I.

De Metallorum vitris. — On the glasses of metals.

All metals become vitrified — gold too, although, on account of its most tenacious humidity, it can scarcely be tamed; yet some Alchemists think that gold can be coagulated into an ash-colored body, and thence pass into the form of a ruby. But if they first calcine it by the power of fires, it can indeed be forced into glass, yet never reducible to its pristine form. And if gold be dissolved into mercury, [they say] it is vitrified by sublimation with salts. But let him believe it who will; for experience has established none of these things up to now. It is likewise false that gold can be transmuted into silver if one part of the *aqua regia* [red eagle-water], which is extracted from silver, be cast upon ten parts of the best mineral gold.

[Margin: Silver becomes vitrified.]

2. Silver, however, being more corruptible by cinnabar (with which it is cemented), as Libavius [Libavius] testifies, is so tamed and dried out that, with salt added, it readily passes into glass. It takes on an azure color when the silver has first been reduced into a calx or blue saffron. Gaston Claveus

[Gaston DuClo] observed that, crystallized in a glassmaking furnace for two months, a full twelfth part of it passed into a citrine glass.

Experimentum

Quo argentum in vitrum deducatur ex Bodino. — By which silver is reduced into glass, from Bodin.

Let silver be dissolved in common *aqua chrysulca* [nitric acid]; let the solution be precipitated in sweet water, in which a little sal ammoniac has been dissolved. Let the calx thence collected be mixed with chrysocola [borax], and in this way it is fused into glass by fires. But if it does not become sufficiently translucent, let borax be added to the calx and the operation repeated for so long, until you become master of your wish. But how a glass of this kind of Luna [silver] may again be reduced into silver, Bodin [Jean Bodin] teaches as follows: he commits the ground glassy material to an earthenware shard, and places this in another more capacious dish, basin, or pot; with fire added, he says that the silver penetrates even the shard itself, and is found in the lower vessel or more capacious shard placed beneath the first, with the residues remaining in the upper shard.

[Margin: The reduction of glass into silver.]

For my part, in this place I think he more fittingly meant by "shard" the ashen little dish which they call a cupel — of which [I treat] amply in Book XI — although this, even if it sometimes absorbs the silver (if it has not been rightly made), was nonetheless destined by the craftsmen only for soaking up the excrementitious dregs.

2. Geber [Jābir / Geber] testifies that tin becomes vitrified, because in its depth it has a fugitive mercurial substance which, just as it flees away through long delay in the fire, so too, deprived of all humidity, at last coalesces into glass. In this way the burnt ceruse of tin is turned into a white ash, and thence into a glassy substance of a milky color, with which individual [craftsmen] coat their vessels, so that in the fire they may be covered with a white, glassy crust. [Margin: Tin becomes vitrified.]

Lead is reduced into glass with almost no trouble — there is no need to demonstrate this with many roundabout words, since this artifice is in nearly daily use among the founders of metals. Black, red, citrine, and otherwise differently colored glass is made, according to the condition of the leaden calx

calcined into litharge, or ceruse, or plumbago, or minium. [Margin: The glass of lead.]

The glass of antimony, than which nothing is more common, serves for vessels in which wine, poured through, is rendered wonderfully cathartic — the frequent use of which is in our pharmacopoeia. Medals and coins, too, are made from this kind of regulus or glass of antimony, which, dropped into wine, render it cathartic. We have also rings made from the glass of antimony, which do the same when cast into wine. Geber draws a wonderful variety of colors out of the ceruse of lead and tin: [Margin: The glass of antimony.] [Margin: A variety of colors from ceruse.]

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[Margin: plumbo, stanno.] ...both, in fact, when stirred together over coals, are calcined. And so, with borax added, along with as much oil of tartar as is enough to incorporate them, lead under the fire of fusion passes easily into glass — the lead indeed into a citron-colored glass, the tin into a watery-white glass. These, however, when subjected to a rapid and strong fusion, are reduced back into their own metals, which are harder than they were before.

[Margin: Glass of copper. (*Vitrum æris*.)] That copper [æs] too can be brought down into glass, the following experiment will show.

EXPERIMENTUM

[An experiment] showing that copper can be brought into glass, and again reduced back into copper.

Melt a portion of copper [æs] in a crucible — say, one pound. From this molten copper, separate off half, which you will place in a second crucible. Now if you sprinkle arsenic onto one part of the liquefied copper, you will find — once it has hardened in the cold — that this part has degenerated into a glassy material, brittle just like glass, rough, and altogether impossible to work with the hammer. The remaining part, free of arsenic and restored by cooling, will easily turn out pliable and malleable. In this experiment one observes a certain remarkable restoration of copper to its former state: for if you saturate with borax the copper that has been reduced to a brittle condition by the action of arsenic, it will soon

be restored to its former coppery state. If you ask the cause of each of these truly extraordinary effects, I answer as follows.

First, I say that copper, when set in fusion and imbued with arsenic, is — by the sharpness and outstanding dryness of the arsenic — stripped of all moisture. Hence, once its binding moisture [glutine] is consumed, the parts must necessarily become disunited, and consequently the copper becomes diseased [morbidum] and brittle like glass. If, however, you imbue this with borax, then — wonderful to relate — it is at once restored to its former state, because the borax gives back to the copper the very softness which the dryness of the arsenic had taken away.

§. II.

Concerning the glasses commonly called Amausa, and Encausta, or Smalta, and their products.

Nothing in the art of glassmaking presents itself as more worthy of admiration than Smalt [Smaltum], which some call *amausum*, the Greeks ἔγκαυσον [Greek: enkauson, "encaustic" — burnt-in (enamel)], and others *encaustum*; in Germany, because of its easy fusion, they call it **Schmälteglas**. [Margin: The dignity of encaustic works. (*Dignitas operum encausticorum.*)] The crafted works that arise from it are held in such esteem that, among kings and princes, no treasure [cimelion] is reckoned of any value — whether it be coins, or rings, or watchcases — unless they are painted with encaustic colors. It is a work truly full of wonder, on account of the great variety of its most brilliant colors. For if the work finds a skilled and richly gifted artist [Margin: ἔγκαυστοποιῖα [Greek: enkaustopoïia, "the making of encaustic work"]], it will surely far surpass all the workmanship of gems and precious stones, whether you regard the variety of colors or their splendor. The stones produced from it are also far more lucid and brilliant than Oriental ones, and more pleasing to the eye.

Smalt, then, is a most pure glassy body — yet not transparent or see-through like glass, but rendered opaque with diverse, most splendid colors. If you ask by what art encaustics or smalts of this kind are prepared, I say they can be cooked out of all the metals. [Margin: The method of preparing them. (*Modus eas conficiendi.*)] For when any metal whatever has been reduced to a calx or earth, and this is placed in the pots of the glassmakers' furnaces, then — by the violence of a most blazing fire — it is at last roasted and turns into a pure glass, though not diaphanous and transparent. Yet it is free and immune from all the impure and black dross of the metal's body that was previously in it. Therefore, once the

impurities have been consumed by the force of the fire, that pure essence shines forth from the glass in most delightful and precious colors — like a little fire enclosed in pure crystal, the sort of thing one sees in amber [electro] and in the carbuncle. And so smalts, in proportion as they are skillfully wrought, are excellent. There lies hidden, then, in the calx of the metals something not unlike pure light, which, purged by fire, rises up into a glassy smalt — a certain most beautiful likeness of the World-Mass [Mundana massa], which, purified of all filth by the last conflagrations [noviss. incendiis], will be fused into a gem-like glory. But let us now proceed to the making of smalts or encaustics of this kind.

[Margin: Encaustic green from the calx of copper [Venus ♀]. (*Encaustum viride ex calce ♀.*)] The calx of Venus [copper], by the fusing force of the fires, will give a dark green smalt — and most green of all if it is spoiled by smoke. But you will obtain a pure smalt, endowed with excellent greenness, if you grind and levigate the calx of Venus with salt water, or brine, on a marble slab so exactly that it does not offend the touch of the finger; then wash it so many times with pure fresh waters until no more impurities are detected in the water. This, however, must be done with waters that are actually hot. The calx thus prepared is melted into a more perfect, more fusible, and softer glass than if you had fused it without washing and grinding.

The same art applies to the calx of lead, of Jupiter [tin], of Luna [silver], [Margin: Encaustics of various colors from the calxes of various metals. (*Encausta varii coloris ex calcibus.*) — ☞ ♄, ♀, ☉ ...] except that the calxes of different metals supply *amausa* of different colors. First indeed, lead and iron give a tawny *amausum*; tin a white and most brilliant one; silver a blue [cæruleum] one. These, mixed together in various ways, produce an enormous variety of colored smalts. But now let us explain how and by what method they are fused together from these.

At Venice, smalt of every kind of color is manufactured, drawn out partly into long threads, partly into rods or round masses. These are used especially by those who practice the glassmaker's art at the lamp [ad lampadem], from which they make votive crowns [rosaries], women's ornaments, earrings, rings, and flowers with such variety — gems so similar to natural ones that they sometimes even deceive the eyes of experts. Here you may see coral, amethyst, diamond, emerald, crystalline, and gem-like imitations, wrought, so to speak, to the very envy of nature itself, with such splendor, and with such a diversity of colors

[Note: printed page 453 carries the running header for the recto; the verso (printed 454) header is recorded above. The signature mark at the foot of printed 453 reads:]

and intermixing of colors with one another, that when they have been carried over to the barbarian Indians, in comparison with them they have reckoned gold, silver, and gems as nothing. From smalts of this kind they fashion figures and little images of every sort. [Margin: Wonderful things are made from it. (*Mira inde fiunt.*)] Surpassing all admiration are the little bundles of plumes [feathers] made from the finest smalt filaments; and were it not that the cheapness of the material stood in the way, they would not be unworthy — for the excellence of their splendor and the beauty of their most brilliant filaments — of the caps of kings and princes. Yet all these things are made with no help from the furnace, but by the use of the lamp alone. But since the matter is worth seeing, I shall describe the manner of proceeding in a few words. [Margin: The method of working smalt at the lamp. (*Modus laborandi smalta ad lucernam.*)]

They set up a lamp fitted with a wick of finger-thickness, which they keep placed on a table before them. Then they bring the smalt threads or rods up to the lamp, drawn out by the blast [of breath] into a long, flame-like ray, which is of such efficacy that it melts the smalt almost in an instant. The melted smalt they transform, by the dexterity of their hands, with pincers — now into little globes, now into some radiant ornament, now into something else, whatever they wish. And in this, what is most worthy of admiration is that, from the varied mixture of the different little smalts melted together, there emerges such a diversity of colors as not even a painter could surpass.

Since I would frequently visit makers of this kind — both to investigate the rationale of the art, and for the delight which I took in such ingenious works — among other things I put to them was this one question: whether a pneumatic machine could be made that would, by its own blast, supply the continuous and laborious blowing by which they were being exhausted? I replied that I saw no difficulty preventing the desired machine from being built, and I gave my pledge to investigate the manner and method of constructing it; which at length I explained ought to be made in this way, which I now set down.

I had two bellows made, not unlike those with which portable organs are fitted, before which was set a wind-chest [anemotheca], or receptacle of the wind;

and from this a fine little channel, or small siphon, was led out as far as the wick of the lamp. In this arrangement, the workman, seated on his stool, by the alternating pressures of his feet alone alternately raised the bellows; and as these expressed the wind they had taken in through the very narrow little siphon, so too, while they descended with the greatest slowness — without any fresh prompting of the feet by which the levers were pressed — they left the craftsman

a long enough pause for working. And so, without any blast of the mouth, the bellows supplied the craftsman with a most copious and most vehement blast, for accomplishing whatever he wished. But since the matter is worth considering, I shall add the machine here.

[*Note: the text promises a figure of the bellows-machine ("machinam hic subdam"), but no such illustration appears on this page; only the feather-bundle figure (described below) is engraved in the margin.*]

And since a little before we made mention of plumes [feathers], I shall explain in a few words how, and by what ingenuity of skill, they make them. [Margin: How the various precious stones are made from smalt. (*Quomodo ex smalto varii lapides pretiosi conficiantur.*)] From wood they have ready a hank [mataxa], on which threads are everywhere wound by the women. Then they take a smalt rod of whatever color they wish, which, placed in the flame, they first draw out by the blast into a most fine thread; this they fasten to the hank. Then, as the hank is turned around, it draws the thread, the smalt material following on and continuous, spread out into threads; and in this way, with the utmost speed, they gather around the hank as great a supply of smalt threads as they wish. Then the threads, made up according to the length and thickness of the future bundle, they fit into a quill-tube [pennaceus tubulus] — as you see here in the margin —

Diagram. A small marginal woodcut showing a bundle of fine smalt-glass filaments shaped into the form of a feather (plume). The bundle is broad and rounded at the top and tapers to a point at the lower end, where the filaments are gathered and bound. The text describes the filaments being bound "below with silken threads" (*infra sericeis filis colligata*). No labels or caption are present.

— which, when bound (tied below with silken threads), they make into a work so handsome, so brilliant from the filaments, that there is scarcely anyone who can sufficiently marvel at the beauty of the work; and many people ignorant of the art persuade themselves that they are the plumes of some exotic bird — whether of a bird of paradise [manucodiata], or of a Balearic heron [ardea Balearica].

CAPUT II.

Concerning the skillful manufacture of gems and precious stones.

Art, the imitator of Nature in all things, aims at this above all: that, as far as can be done, it may attain Nature's effects — if not by true and real efficacy, then at least according to a certain analogy and as closely as possible to the truth. This is evident both in the other matters already discussed in the preceding pages, and

especially in the skillful manufacture of stones, gems, and pearls. Lest I should seem to have passed this art over, I shall here describe it at somewhat greater length — since it can be most useful for many purposes, provided fraud is absent, especially in the promotion of Divine worship and in the working of ecclesiastical ornaments. [Margin: How the various precious stones are made from smalt. (*Quomodo ex smalto varii lapides pretiosi conficiantur.*.)]

I say therefore, first, how the precious gems — sapphire, emerald, amethyst, hyacinth [jacinth], carbuncle, topaz, and the like — can be wrought to the life out of smalt material alone. And lest in this place an occasion for imposture be given to men corrupted by the stain of avarice, we shall at the same time add the method by which the counterfeiting of gems can be recognized with little trouble. But lest we keep the reader longer in suspense, let us make a beginning of the ἐγκανστοποιΐα [Greek: enkaustopoïia, "encaustic-making"].

We say that Smalt is the same thing as what the ancients called Encaustum, and it is nothing other than the pigment of liquefied and colored metal. [Margin: What ἔγκανσον &c. is. ([Greek: enkauson] &c.; [Greek: encausis, "burning-in"]; pyr [fire], to burn in.)] Hence those are called *Encaustae*, ἐγκανσταί [Greek: enkaustai, "encaustic-workers"], who

burn in colors upon liquefied metals; who glue down the melted encaustic upon gold, or burn in the metallic pigment upon gold, or lay gold over the liquefying and colored metal; by whose means works are made so charming and elegant that — whether you regard their rarity or the dignity of their splendor — nothing seems comparable to them. But how and with what ingenuity they are made out of *Blasius Vigenère* [Blaise de Vigenère] and *Bulengerus* [Bulenger], who translated his work from the French tongue into Latin, I shall explain in a few words.

CAPUT III.

How gems can be made from Smalt or Encaustum.

Encaustic work, then, is made from glass and from metals, which wonderfully agree with one another of Nature's own accord. The glass which is used for encaustic work ought not to be made from flint, or from beech-ash [fago], or from the marsh caltrop [tribulus paludum], but from rock or stone, so that the glass may become bright, splendid, and crystalline — from which the encaustic to be burned in upon the metals is produced. The ashes from flint or caltrop, and from which glass is made, they dissolve in warm water; and applying pieces of white

cloth, they pass the pure and clear water through into a vessel set beneath. Whatever there is of impurity in the ashes settles in the former vessel and is not transmitted through the cloth; only the very clear and limpid water [is passed], which, with a moderate fire, grows together into a white salt once the watery moisture has exhaled. This [salt], mixed with sand or stone, or with purified rock, and drenched with minium [red lead], is put into the glass furnace.

That minium is either mineral, that is, metallic, or factitious, made from burnt lead. That red calx of lead is made in a vehement and closed fire, lest it exhale into the air — [it may be called] ἀήρ ἐπιρροίας [Greek: aēr epiirroias, "air of inflowing/effluence"] [?], or "reverberated fire," and one that wanders and strays in a closed space. The glass-craftsmen fashion a certain vessel from white greasy earth, with the pounded bones of rams and other materials, very capacious and very large, which can be corrupted or dissolved by no fire, however violent. That vessel they put into the furnace and place in the middle, full of ashes fit for making glass, which are liquefied by the force of the fire; then they thrust burning iron tongues [linguas — iron rods] into that blazing vessel, to which that greasy and liquid material adheres, from which glasses are made.

That Alkali salt, then, drenched with minium, persists in burning flames in an earthen pan [capedine] for six whole days. On the first and second day that minium-tinted material turns yellow; on the third and fourth it turns green; on two others it whitens, and takes on the color of air [aëris — a sky-blue/grey], and becomes crystalline — from which are made counterfeit gems, and encaustic, that is, smalt. In order that the crystalline material may be compacted and grow solid, it is necessary to apply a metallic calx fused together from both lead and the purest Cornish tin [stanno Cornubiensi] in a reverberatory furnace, so that it may bring solidity to the tin-encaustic or smalt, and so that the body may not be transparent. [Margin: Without lead no metal turns to glass. (*Sine plumbo nullum metallum vitrescit.*)] Without lead no metal can pass into glass. Therefore, when you have mixed that crystalline material and the calx of lead and of tin — each reduced to a very fine powder — together, and have made out of them, as it were, an open loaf or a kneaded mass,

you will dig a hole in the middle, so that the useless moisture may exhale, and you will let it dry out gradually of itself. Then you will put that dried mass into the glassmaker's furnace, until it begins to liquefy; soon you will draw it out of the furnace and let the material cool. At last, with fire applied beneath, you will let it liquefy in an earthen vessel that is not dissolved by fire, and you will draw off with iron spoons the greasy scum floating on top, until in 24 hours the boiling

material becomes most purified and most limpid. This will be your white smalt, [Margin: White smalt. (*Smaltum album.*)] which can be tinged with any color whatever.

If you grind that smalt with crystal into a powder, and liquefy it in the glassmaker's furnace, and add a metallic rock, or a subterranean metallic stone, there will arise a splendid black. [Margin: Black. (*Nigrum.*)] If you add burnt silver with sulphur, you will make a Turquin blue [cæruleum Turquinum]. [Margin: Blue. (*Cæruleum.*)] If you cut copper into thin sheets and roast it for five days, and throw it into that smalt, you will make a green. [Margin: Green. (*Viride.*)] Burnt copper [Æs ustum] is tinged with a translucent emerald color. Sea-green [Cæsium], glaucous [glaucum], violet, ashen — these are made from that smalt, into which you have mingled a metallic stone tempered in various ways. [Margin: Sea-green. (*Cæsium.*) Violet. (*Violaceum.*)] If you put in niter or rock-salt, you will express the color of pearls. Red smalt holds the principality among the rest; [Margin: Red smalt. (*Smaltum Rubrum.*)] a thin gold-leaf [flavum bracteolatum] with silver added makes a straw-yellow [luteum paleatum], likewise a golden-yellow [luteum aureum], and a pomegranate-yellow [luteum mali punici]; but the citron-yellow [luteum citrinum] is made from the rust of anchors that the force of the sea has gnawed away, or from saffron of iron [crocus ferri], which you will distil from vinegar. Red smalt is the firmer, the gladder [in color], and the more whole, the longer it endures the fires.

You will make a red if you throw copper [æs] reduced to a calx, by the force of fire, into glass or white smalt, together with iron filings [ramentis ferri] and orpiment [auripigmento]. If you throw in more glass, you will make a more splendid rose smalt; [Margin: Rose smalt. (*Smaltum Roseum.*)] it is a diluted murex [purple], or a more diluted oyster-purple. If you put in more lead, beware of mixing in tin, for it will be of less splendor. You will make a clear red if you pour over the gold lead and quicksilver, likewise spirit of copper, and the incombustible sulphur of copper.

The tincture of that copper is so saturated and prominent that it increases and heightens the native color of gold. [Margin: Golden. (*Aureum.*)] But that heightened color is destroyed by a vehement fire. That heightening of color in gold is brought about by the volatile spirit of copper, which is cooked out together with the gold gradually in a little earthen cup — a little crucible of the metal-smelter [caliculus metallifusor]. Therefore, in order to heighten the color of gold, you mix some quicksilver

with the gold and the spirit of copper, because the quicksilver prevents the tincture and colors from being burned away, and it delays the force of the fire for that span of time in which the tincture and color sink intimately into the gold. Gold tinged in this way is laid, as it were, like gold-leaf beneath pyropi [fiery-red gems]: for gold which is tinged tawny, with the body of copper applied, is always blackening, livid, and withered; because the substance of copper, which of itself blackens, cannot be freed from its spots, whether you scrape it, or cook it, or wash it with gum and sandarac. But the gold which is tinged with the spirit of copper is the Orichalcum and electrum [amber-alloy] of the ancients, from which cups are made [Margin: True orichalcum or electrum. (*Verum aurichalcum sive electrum.*)] that betray and reveal poison, if any has been put in. This gold too, heightened with the spirit of copper, is converted into glass by the force of lead alone, and of no other metal, from which is made a clear red smalt or encaustic. Indeed, gold by the force of lead becomes volatile, or is changed into an oil, which is called the golden glass [vitrum aureum]: which St. John in the *Apocalypse* attests that the pavement of the Heavenly Jerusalem was, as it were, paved with glass tesserae (*Apocalypse* 21). St. Jerome holds that golden glass to be the electrum of Ezekiel, [Margin: The electrum of Ezekiel. (*Electrum Ezechielis.*)] called חשמל [Hebrew: ḥashmal, "electrum / amber"] by the Hebrews.

Not unlike this, in former times they cooked and embodied together rough and pure silver with copper and lead, so that a clear red might come into being, which they commonly called *Nellaram* [niello — *Nellara*], when the liquefied silver, thrown into water, broke up into grains. Smalt is laid on and burned in upon gold, silver, and copper, but not upon other metals; likewise upon glass and earthenware potsherds; indeed, an art has recently been discovered of burning smalt onto marbles and the hardest stones, in such a way that they are not damaged by the fire.

[Margin: The metals on which colors are burned in by smalt. (*Metalla quibus inurantur colores smaltei.*)] In order that you may burn in the metals, and out of the metals the colors, grind the smalt into a most minute powder in a very hard iron mortar with an iron pestle and a little water; for the business will succeed better with a mortar than if you were to grind it on a porphyry stone. The colors that are burned in from the metals are these: black, violet, green, ferruginous or chestnut, ashen, blue or glaucous, red, clear, yellow from gold — all of which colors are translucent and splendid, while white and the Turquin sea-green are opaque. When you have ground these metallic colors in the mortar with a little water, pour off whatever water there is, and lay that most fine powder in a glass pan, onto which you should pour only as much aqua fortis — which they make by

distilling from niter and vitriol over a fire — as will float over the powders and cover them. And so many times wash those powders, soaked in aqua fortis, with limpid spring water, until it draws off nothing of impurity, but comes out clean and clear. The aqua fortis purges the greasy metallic part; the limpid spring water washes and removes anything of earth that was mixed in. Smalt ground in limpid water is easily kept whole; out of the water it conceives impurities.

These powders are collected on a little copper tile, and are applied to a work of lower relief with great care and diligence, so that they may be kept separate one from another, lest by chance a confusion or disturbance of the powders or colors should occur. When they have been properly arranged, moisten ordinary paper with water, and press out the water between your hands, so that the paper may serve in place of a sponge, by which — the moisture being burned off — it may dry the smalt, which when dry is broader and brighter [hilarius] than when moist. That arrangement of the powders is commonly called the *prima pellis* [first skin]. Then the smalt, placed on an iron sheet, is little by little thrust into the furnace, where it blazes up until it begins to liquefy and stir; for then it must be drawn out of the furnace, so that it may cool. Soon a second and third arrangement of powders is added, and the work is committed to the furnace and to a vehement fire, until the smalt has been completely burned in with the colors. Then the work, drawn out of the furnace, is polished with a suitable stone, and is finished with Samian stone [samius lapis].

So that the prominence of any figure, or a swelling work, or [a relief] raised more or less into a boss, may be burned in with the encaustic, you will take seeds [pips] of a pear moistened with limpid water, and with them you will moisten the smalt, which, becoming viscous and as if smeared with glue, will easily adhere to the work; otherwise it would not adhere to a boss, or to projecting figures, or to a prominent shape — although smalt adheres with no trouble to the bottom of vessels and of works of lower relief. Clear red does not adhere except to gold. Opaque red can be properly set on silver and copper; the other encaustics or smalts can adhere to gold, silver, and copper. Then they are said to be glued onto the gold; the metallic pigment is burned into the gold; with the liquefying and colored metal the gold is painted, delineated, distinguished; the encaustic is smeared over the gold, overlaid: when the metal has been burned in upon the encaustic, the work is finished.

Into most encaustics or smalts there is mixed vitriol, minium, or earth of a leaden vein. Crocus of Mars [crocus Martis] or niter of iron, native or artificial scrapable

verdigris [æru^go rasilis], magnesia [manganese], and metallic rock, which is wont to grow beneath dry and lean fields.

From these things it is plain that a general mass is made from prepared crystal, [Margin: A general mass to be made for fashioning precious stones. (*Generalis massa ad lapides pretiosos fingendos fit ex crystallo.*)] purified to the utmost by salt of tartar, to which is added fixed alkali salt; and into a pounded mass of this kind colors are mixed, which the purer they are, the more excellent the glass becomes, and consequently, the finer the preparation and the more ingenious the cooking, the more outstanding the stone becomes. In a word, the whole hinge of gem-making turns on this: that you make, out of suitable metals and minerals, smalts or glassy colors, and liquefy them into a material which consists of one part prepared crystal and two parts fixed salt.

If you desire the making of sapphire, [Margin: The making of sapphire. (*Confectio Saphyri.*)] then take two-thirds of alkali salt, one-third of prepared crystal, half a drachm of *zaphara*; mix them, and skillfully cook them for three days in the glassmaker's furnace. If you ask what *zaphara* properly is, I say that it is that pale earth [lurum] from Saturnine magnesia [magnesia Saturnina], which they also call *bismuthum* [bismuth]; and this tinges the glassy mass with a blue color, which the potters too generally use;

Liber XII, Sectio V, Pars III — De Arte Vitriaria (continued)

Reading order: the four PDF pages are taken in printed-page sequence — 457, 458, 459, 460. Catchwords confirm: 457 "quia" → 458 opens "quia..."; 459 "factitias" → 460 opens "factitias...". [Margin: The practice of potters in vessels of a sky-blue tinging color.] of the potters. For [this earth], when it has been ground smooth on a porphyry stone and smeared, still raw, onto the fired vessels, tinges them with a subtle color — which nevertheless, by the force of the fire, soon turns to sky-blue in the firing.

[Margin: The making of emerald.] **Emerald is made thus.** Crystal is ground to a powder and melted in the glass-furnace; the mass that comes out of it is so like a native emerald that it even deceives experts — except that, when exposed to the sun, it appears leaden. It sometimes takes on a verdigris hue, but in the fire, because of the copper [aeris] in it, it gives off a flame.

[Margin: Another method for emerald.] **Emerald can also be made another way.** Take a third of red lead [minii], one ounce of prepared crystal, two drachmas of verdigris; mix and melt them together. For there is in copper [aeris] a wonderful and hidden power toward emerald, by which they readily unite.

[Margin: The making of topaz.] **Topaz is made** by melting together a quarter [ounce] of white lead [cerussae] and half an ounce of crystal in a wind-furnace — which they call the *anemia* [?] — inside a crucible reinforced with clay and sealed shut. By "white lead" [cerussa] nothing else is understood here than the calx of lead, which others also call Spanish white [album Hispanicum]. Some compound this [topaz] also from the calx of copper [aeris], native red lead [minio nativo], and crystal, with a quadruple [portion] of calx of Jupiter [calce Jovis = tin] added — though from these ingredients I judge that not so much a topaz as a chrysolite is made.

[Margin: The making of hyacinth.] **Hyacinth of a blue color is made** from prepared crystal and two ounces of white lead [cerussa], with 1/16 [part] of vitriol added. Giovanni Battista della Porta [Giambattista della Porta] proceeds thus in making hyacinth: he takes 3 parts of common salt and 1 of saltpeter [halonitri], mixes them, and throws [the mixture] into molten lead, stirring it with an iron spatula; and the ash that results, washed clean, he melts down into a gem. But if you wish to make this [gem] red instead of blue, take 4 parts of white flint [silicis albi], 2 of lead-ash or white lead [ceruffa], 4 of niter, and two drachmas of iron scales; cook them in the furnace, and you will have a red hyacinth.

[Margin: The making of ruby.] **Isaac the Hollander** [Isaac Hollandus], in his book *On Minerals*, together with **Paracelsus**, think they can make a most excellent ruby with the red tincture of the philosophers' stone. But just as that philosophers' stone has never yet been seen by anyone, so too no faith should be placed in [their claim] of making a ruby more excellent than all oriental rubies and carbuncles — but on this more fully in what follows. Now someone might find it astonishing that so great a diversity of colors should come from metallic calxes. But anyone who has rightly grasped what we set down in the Eighth and the Ninth Books cannot fail to see the origin of the colors. [Margin: Calxes of metals and the colors they impart.] The salt of the metals is the producer of all these. For the blue color is nothing other than the salt of silver, from which the precious stones descend; from the white lead [ceruffa] of tin and the red lead [minio] of lead, art and nature working together according to the differing grades of color, the same [stones] come into being. From the spirit of copper [aeris] is made a salt, and then an oil, which joined to gold constitutes the elixir for

[making] emerald. [Margin: Water suitable for forming gems and diamonds.] From the crocus of Mars [croco Martis = iron oxide] is made Mercury, that is, a water most powerful for [making] gems and most fit for forming diamonds.

There is almost no mineral or metal that cannot be forced into crystal; and the reason is ready to hand, since the solid subsistence of minerals and metals is nothing other than the saline power of Nature, which — just as it confers a condensing power on all things, as we showed in the Sixth Book — so too supplies firmness for taking on a settled form. This shines forth most of all in crystal and the other transparent gems, which are the pure, sheer effects of the differing salts; and experience confirms it in the Spagyric Art.

[Margin: How gold may be forced into crystals.]

1. **Gold can be forced into crystals** by sublimation and the violent driving-out of fire, in this way: let gold dissolved in aqua regia be distilled again and again, until it is fully dissolved; then, the water having been drawn off down to an oiliness, it is set aside in a cellar, where it at last passes into reddish crystals — reducible, however, back into gold, as we have taught elsewhere.

[Margin: Silver into crystals.] 2. **Silver is forced into crystals** if you dissolve it in aqua fortis; the clear solution, purified of its dregs, is distilled down to half; from this, little stones form in the cellar, which are then worked up either to make a medicine against epilepsy or to make a gem.

[Margin: Copper into crystals.] 3. **They gather crystals from copper** [aere] by dissolving copper in aqua fortis: burnt copper [aes ustum], red as blood, is taken; let the solution be made so that it digests for a month in a strong glass [vessel], until green crystals form, from which both a tincture of Venus is made and an oil is extracted. We, however, in our dispensary, reduce niter and vitriol — which we call liquid copper [aes liquidum] — into crystals with almost no trouble at all, by dissolving them either through distilled water or through spirit of wine and passing them through a strainer; for this, exposed to the sun in an earthenware crucible, blossoms out into fine hexagonal crystals.

[Margin: Iron, how it crystallizes.] 4. **Iron crystallizes** with red oil of vitriol [chalcanti] together with twice as much spring water; in this mixture filings of melted iron are dissolved; the solution, purified through a filter, is boiled down in a glass [vessel] to a remaining third part; this, then set aside in a cold place, separates out little stones, which are at last purified with distilled water and filtered, until, finally coagulated, they take on the most brilliant nature of crystal.

[Margin: Tin, how it crystallizes.] 5. **Tin crystallizes** if, with sulfur added, it is burnt to ash, that is, to a calx; or also if its white lead [cerussa] is extracted by means of distilled vinegar. The extract is dissolved in rainwater previously distilled; the filtered solution is coagulated in the very slow evaporation of a [water-]bath, and this operation must be repeated seven times, until at last there emerge little crystalline stones, pure and clear. They are called the Little Stones of Jupiter [Lapilli Jovis].

[Margin: Lead, how it crystallizes.] 6. **Lead is forced into crystals** in the same way as tin — namely, from white lead [cerussa] or red lead [minio], which is first dissolved in sweet [fresh] water; the dissolved [matter] is filtered and coagulated; and this you will repeat as many times as needed, until you find the purest crystalline little stones blossoming out.

In this way the Spagyrist force mercury, sulfur, and the rest of the minerals into crystals. But since these matters have been discussed elsewhere too, we have not wished to dwell on them here.

[Margin: The new and splendid making of tables [menfae].] To the glassy and smalt — or if you prefer, encaustic — arts can be reduced those tables now on view at Rome, admirable as much for their novelty as for their rare invention, which gleam with such great elegance and brilliance that one who does not know the craft would suppose them to be made from the most polished marbles, jaspers, alabasters, and other stones of great price. I will describe this truly most elegant craft in a few words. [Margin: Scagliola, the stone, the foundation of the table.] A certain kind of talc, which they call *scajola* [scagliola], they have brought — not without expense — from Sicily, where it occurs abundantly; though in Etruria too, between Monte Pulciano and Pienza, I have observed unmistakable signs of it. This scagliola they reduce to a very fine powder, and from it they make what they call a *paste*; then they make a table or panel of any shape from rough marble, which they also hollow out somewhat, and as a foundation they lay over the whole the paste-mass mixed with marble gypsum, worked up with linseed oil to a black or sooty color, and they then level and polish it so that it gives back [a reflection] like a mirror or a touchstone [lydium lapidem]. This done, they steep the separated masses of paste with every kind of color; then they sketch whatever they please on the now-leveled surface of the table — namely scenes, the figures and images of birds and animals, with various foliage wondrously interwoven among itself; and once the drawing of the subjects is complete, in keeping with the various shades of the images, they hollow [the surface] out with a fine graver, and, as the colors require, they level off the injected paste, polishing it with

pumice into a most splendid table or surface, shining like a mirror — which, for the splendor and apparent dignity of the work, they sell at a low price, say for 10, 15, or 20 scudi; whereas if it had been made by the inlaying of variegated marble, it would scarcely be paid for with 100, 200, or 300 scudi. So that it is the esteem of men alone that makes things dear.

[Margin: Florentine encaustic painting.] While I was staying at Florence in the year 1661, the Most Serene **Giovanni Carlo, Cardinal de' Medici** [Cardinal of the Holy Roman Church], out of his affection for me and my studies, brought me into his chamber, and after he had shown me the most beautiful and brilliant paintings with which the whole room was adorned, he asked what I supposed such paintings to be; and when I answered that they had doubtless been made by some most noble painter, he added: "You are mistaken, my Father; no brush has touched these paintings" — and when I marveled at this, he explained the whole [art of] painting and the method of proceeding in it, [a method] not at all of the same kind as they are accustomed to employ in making and elaborating the tables. And images and paintings of this sort are everlasting; and if at any time they are dimmed by dust or damp, they are restored to their former splendor by a simple washing with water alone. [Margin: The images of the domes of Saint Peter's.] Here too may be recalled the works of mosaic [Mufiva, seu Mufaica], such as the images of the domes [of the basilica] that are wrought of Saint Peter's; and they are not to be distinguished from the foregoing, except that the mosaic work, steeped in various colors and then cut into tesserae, is first baked in a furnace into an everlasting work of painting.

CAPUT IV.

De Gemmarum Adulteriis

[On the Counterfeiting of Gems,]

SEU

[OR]

On the faked composition of stones and gems, proven partly by my own experiment, partly by the authority of the most skilled writers and by the communication of friends.

In the preceding chapter I reviewed several methods by which one may imitate gems. It remains, in this chapter, to show in passing how this is done according to the mind of **Boetius** [Anselmus Boetius de Boodt], so that false [gems] may more easily be distinguished from true ones.

[Margin: How gems are made to appear larger than they really are.] Gems offer themselves to the sight as larger than they are when the lower part — that is, the part enclosed in the setting [cista] — is faceted [caelatur] with many surfaces [facets]. For by the manifold reflection of the surfaces, a certain appearance of magnitude is held out to the beholder. Likewise, when between the lower surface and the foil [bractea] placed beneath it there is an intervening air, empty of body, the gem appears larger than it is — because the air takes the place of body, and so makes the gem [appear] thicker than it is. [Margin: How gems are colored.] If, instead of air, glass or crystal is placed beneath, even without intervening glue or color, the gem is seen as much larger than it is. If color is added in the joining — with a tear of mastic [maftichis lachryma], or if the glass be colored with the gem's color — it appears not only larger but more highly colored; and this method is frequent and in common use. Gems are also rendered more highly colored when their lower surface is smeared with a transparent color and then a gleaming foil is placed beneath. A transparent color is made by adding mastic purified by fire. It is purified if a grain of mastic, sticking to an iron point, is held to the fire until it begins to flow and the opaque impurities are squeezed out by pressure of the fingers...

and discarded from the transparent part. The colors that are added are various, and such as the gem requires. In the individual chapters I will teach the true colors that belong to each gem; for here only the faking of gems in general is shown. I have said that the noblest fakery is when crystal, or a pseudo-diamond [pseudoadamas], or some other gem lacking color and transparent, is steeped in some colored water, or in fire, or tinged in some other way, so that the body of the gem inwardly takes on a transparent color. [Margin: The making of gem-penetrating water.] A water that penetrates gems is made from turpentine and aqua vitae, and to this is added a color extracted from metals and dissolved in distilled urine-water and drawn off through an alembic. Into this warm water a warm crystal is put and steeped for several hours, until it takes the tincture into itself. And it takes it readily, because the stone is made softer. [Margin: The inducing of a red color.] For inducing a red color one needs crocus of Mars [iron oxide]; for green, verdigris; for sky-blue, [salt of] silver [Lunà], sal ammoniac, and aqua fortis; for deep blue [cyaneum], verdigris and lapis lazuli. Now since, as I said, the gems are softened, they can be restored to their former hardness in this way. A case [cyst] is made from wheaten paste, into which crocus of Mars is thrust. [Margin: How a softened gem recovers its hardness.] Then one gem, or several, are wrapped in paper and laid upon the crocus, so that the gem is covered all around by the crocus by means of the paper. After that the paste is closed up and committed to the oven with the loaves [of bread], and after the

bread is taken out, what remains [in the oven] for six more hours recovers the former, or a greater, hardness than the gems had before.

[Margin: The whole [art of] tinging crystals in the fire, on the authority of Giambattista della Porta.] *Crystals are tinged in the fire (Giambattista della Porta being the author) in this manner: Six parts of antimony [stibii], four of orpiment [auripigmenti], three of arsenic crystalline [arsenici crystallini], two of sulfur, two of tutty [tutia] are taken; all are ground separately, and sifted through a fine sieve, and put into a pot. Pieces of crystal, suspended either on copper wires or sunk in the powders, are set to the fire so that they glow white-hot for four or five hours — but without the blast of bellows, lest they fly apart or melt. The proof of a legitimate color is, if the piece taken out is of the most flaming and most brilliant color; if less, it is to be put back into the fire again, and after some delay removed in the same way. But diligent care is to be taken that, while they are taken out, they not be chilled at once. For they crack and split into many pieces. If a hyacinth color is wanted, they are quickly taken from the fire; if a deep purple is desired, they are left longer in the fire.* Thus far della Porta. Colored gems such as sapphire, topaz, amethyst, and garnet [appear as] diamonds, if their color is taken away. [Margin: The making of diamond.] For this purpose sapphire is especially chosen, which — buried in iron filings or in chalk [cretà] — is heated until it makes the craftsman master of his wish, as I shall teach in its place. By the benefit of fire too, with della Porta teaching it, only one part of a gem can be deprived of its color, so that the gem may appear partly diamond and partly sapphire. In the same way

a ruby gives back the appearance of a diamond in one part. He says that the part whose proper color we wish to preserve should be smeared with chalk; thus the other part, which is exposed to the fire and naked receives the rays of the flame, admits a color and shows itself a diamond. Artificial [factitiae] gems sufficiently like true ones are made from crystal, topaz, flints, and other soft gems, or from a more noble glass, or from metallic bodies, or from a mixture of these. [Margin: The procedure of Alexius Pedemontanus.] **Alexius Pedemontanus** [Alessio Piemontese] describes the following paste for artificial gems: He takes three ounces of lead calcined by potters, and only so much of the aforesaid water poured over it that it stands above by one or two fingers, and he stirs it with a finger so that the lead settles to the bottom. After that he pours off the water and keeps it for the vitrifying vessel, lest the matter stick to the vessel. Then he takes three ounces of dry red lead [minii sicci], mixes it with the lead, adds one ounce of crystal or calcined chalcedony, and two or three scruples at most of the thinnest little leaves of copper. These well mixed and ground, he puts into a well-

leaded and moistened clay pot, and committed thus sealed up to the glass-furnace or to the winds [furno... aut ventis] for a day, and so the best paste is obtained.

For counterfeiting emeralds he takes alkali salt, which he dissolves in water, filters, and lets dry out, and repeats this operation a third time; afterward he reduces it to a fine powder, just as also the crystal. Then he takes two and a half ounces of crystal, two ounces of alkali salt, one ounce of verdigris steeped in vinegar and strained; he mixes [them], and puts [the mixture] into a leaded little vessel, and seals it well with clay so that nothing escapes, and lets it dry out for three days, or longer, and finally commits it to the potter's furnace for a day. If he wants a ruby, [he adds] cinnabar in place of verdigris; if a sapphire, lapis lazuli; if a hyacinth, he adds coral. [Margin: How crystal is calcined.] **Alexius** calcines crystal or chalcedony in this way: one ounce of calcined tartar is dissolved and strained in one ounce of clear water; the crystal, however, and the chalcedony are heated red-hot in an iron spoon and quenched in the aforesaid water, and this operation is repeated seven times; calcined in this way it is best ground into powder and added to the mixture or paste. If an emerald is wanted, [the calcination is done] in a bronze mortar; if a ruby, [it is] to be pounded in an iron one. But because artificial gems are rendered softer than crystal on account of the additions of other matter, **Alexius** teaches a water by whose benefit they are hardened. [Margin: The hardening by means of water, prepared in a certain way.] He therefore directs one to take pieces of magnet [magnetis], and to calcine them as was said of crystal, and then to grind them into powder, to set them in a damp place so that they dissolve into water; this water he wishes to be nourished with Roman or Hungarian vitriol, crude, like a pap [pulse]; then from it he prescribes that a water be distilled off through a retort, so that barley flour may be moistened with it, and a hard paste made, into which the shaped stones are put. For if it is baked with the bread, left in the oven, and taken out with the bread, he says they acquire the greatest hardness...

artificial gems, exceedingly elegant and very like the natural ones. He affirmed to me that he had made them in no other way than the aforesaid. The said work seems neither costly nor of great labor, yet it has not so far been tested by me.

[Margin: Which colors express which gems.] The nobler paste for artificial gems, on della Porta's testimony, is that which is made from crystals, flints, or Bohemian topaz; for if glass or lead is added, they become heavier and softer. Flints and topaz, however, are calcined like crystal. Then the color that is wanted is added. Red lead [minium] and green of copper [verdigris] give the color of emerald; white lead [ceruffa] and crocus of Mars [give the color] of hyacinth; red

lead [minium] and white lead, of chrysolite; *zaphara* or lapis lazuli, likewise sal ammoniac and silver, exhibit the color of sapphire. Gold is said by some to impart the color of ruby to crystal. Tin is said to show the watery sheen [aquas] of a diamond. Those curious about these matters will discover, in the work itself, various colors from various mixtures of metals. The less noble paste for gems is [made] if glass is added to crystals or flints. Giovanni Battista della Porta, in his *Natural Magic* [*Mag. Nat.*], teaches various methods by which artificial gems may be prepared, to whom I refer the reader. The things that here seem to be wanting from me are treated in the individual chapters on the gems, where the fakeries or imitations of the gems are also shown. Here nothing else seems to remain except that, if anyone wishes to feign gems, he be taught to govern the paste with an even fire, lest with an uneven [fire] they betray the fakery by bubbles or by a smoky tint [atromo (recte: atro) fuco]; and then that the material of the paste be exactly cleaned, and washed of its filth after calcination, lest the gems have faked flaws. These things indeed a diligent craftsman, if he is careful, will easily observe without any further admonition.

[Margin: Foils.] **A note on foils or little leaves [Bracteis seu Foliolis], which are placed beneath gems to increase their splendor, from Boetius, book *On Stones*.**

This practice concerns only transparent gems, which indeed cannot shine unless they have beneath them something that reflects the light, like a mirror. To this end foils or metallic leaves have been devised, which not only do this but also wonderfully enhance the color of gems; and they are tinged with various colors at will, so that in this way gems that were before as if dead and of a dilute color may appear more vivid and more highly colored. Foils are beaten with a hammer from copper alone, or from copper, gold, and silver, to the likeness of the thinnest paper; then they are polished with the finest chalk or with Tripoli clay [argilla Tripolitana], and smoothed with emery stone [smiride lapide] until the marks of the stone no longer appear on the foils. With the foils prepared, a double furnace is built, an upper and a lower; in the topmost part of each there is an opening; in the lower furnace coals are kindled, and from all [sides]...

[Margin: Birds' feathers, by which [colors] are tinged.] burnt beforehand. Green feathers of birds dyed into a hyacinth color tinge [the foils], if they are burnt in the furnace [recte: the foliage burnt in the furnace tinges them — see parsing note]. If other colors are desired, it is done with birds' feathers: for green is had from green, sky-blue from sky-blue, red from red, and yellow from a yellow-colored feather, if the foil is scorched in the furnace, they will tinge [it]. The color

of sapphire [is had] from the sky-blue feathers of geese; the color of emerald, from box-tree leaves and from the flocks of scarlet cloth.

In Bohemia, where there is a great supply of topazes, pseudo-diamonds, and beryls — of a color, however, deficient — by the mere placing of a gold or silver foil beneath, they transmute [these stones] into the appearance of various gems. [Margin: A foil of various color placed beneath exhibits various gems.] For if you place a gold foil, or one imbued with gold — that is, of a *lacca* color, that is, of a red color shining through from the gold — beneath a topaz first fashioned into a polyhedral shape, that [foil] will display to you a ruby of most beautiful color. If you have imbued a silver [foil] with green so that it shines through from the silver ground, it will display to you an emerald of the most pleasing color; thus too a foil placed beneath [a stone] will display a sapphire shining through from sky-blue. In this way, according to the condition of the colored foil, they express amethysts, hyacinths, chrysolites, and other most beautiful gems — even in a single crystal or the most brilliant beryl. In round crystals of this kind the thing does not have the same success, for the fakery readily appears, the colored foil revealing itself to the eyes; but only in many-sided ones [does it succeed], because the colors, variously reflected around the angles, cover the little foil with their varied shadowing. But let us now proceed to describe another method of making faked gems.

PROPOSITIO I.

Rubini confictio.

[The faking of ruby.]

A ruby is usually adulterated or faked in three ways. First, when — if it is without any redness, or with little, as we said a little before — a red foil, or color, or some glass tinged with a red color and gleaming, is laid beneath it. This method is by some thought to be free of fraud, because, namely, the true gem appears [merely] assisted, not by its own color. Nevertheless it is fraud to increase the price of a gem by an alien color. [Margin: The impostures of gem-dealers.] On account of this imposture a certain gem-dealer suffered loss of reputation when he tried to deceive the Emperor **Rudolph** [Rudolf II]. Secondly, when another noble whitish gem — such as a white sapphire, crystal, topaz, or pseudo-diamond — is substituted in its place, and, on account of the color, the foil, or some other transparent body laid beneath, so reddens and radiates that it differs in nothing from a true ruby. Thirdly, when two parts of glass are glued together with mastic in such a way that the mastic, tinged with the color of scarlet [cocci], shines

through both bodies of glass, so that it appears a true ruby. The second of these methods [was used] to deceive the Emperor Rudolph [Radolphum (recte: Rudolphum) Imperatorem]...

the second and third are the most commonly used. Yet they are not so very hard to detect. Stones faked by the first method are recognized because they do not sparkle precisely, will not stand up to the file, and yet in color appear more beautiful than the true ones. [Margin: Detection of the fraud.] Some are accustomed to detect this fraud exactly: for if the stone lacks a red color, and the flat face of the gem is placed over the fingernail, and the eye is directed toward the surface of the gem and the nail, a whiteness without any color will appear. Nevertheless, the lower-grade gem-cutters know how to carve the surfaces of the gem so artfully at various angles that, because the light is reflected in every direction by the manifold surfaces, the fraud cannot always become apparent even to a skilled craftsman. On account of these frauds, rubies in this age are not made to be worth as much as they once were.

Some counterfeit the ruby with orpiment [auripigmentum], which they cook down in a vessel that is not perfectly sealed, over a slow fire; and the fragments of glass that stick to the sides — though quite brittle — they apply to wax figures, so that they may serve as rubies, which they reproduce exactly.

PROPOSITIO II.

The making of pearls. [Margaritarum confectio.]

Pearls are held in such high price for scarcely any other reason than that they cannot easily be counterfeited. Gold is most easily adulterated. Gems fashioned from doubled glass and set in gold so deceive the eyes that even skilled gem-cutters cannot tell them from the genuine unless they remove them. [Margin: Pearls hard to adulterate.] A pearl alone can neither be corrected nor made more elegant by foreign coloring. Yet Linschotanus [Jan Huyghen van Linschoten] reports that, to make pearls beautiful, the Indians pound rice together with salt and rub the pearls vigorously with that mixture; in this way they become as beautiful as crystal and do not lose their luster. It is no wonder, then, that chains of pearls are preferred to gold ones by great ladies and noblewomen, and that they display their wealth better by them than by gems or anything else that is liable to adulteration or coloring.

Various authors hand down methods for how false pearls may be made. [Margin: The making of imitation pearls.] Some form little beads from the powder of

shells, others from chalk; these they afterward coat with silver leaf, then moisten with egg white and let dry, so that they may look like pearls. Others there are who compound them from powdered pearl with egg white, and then dry them; but the trick is easily detected by their weight and color. Giovanni Battista Porta [Giambattista della Porta] describes this method: *Let pearls be placed in a little bag together with powder of pumice and bone, and let them be handled by hand in water, until you find them washed and polished; then, dried, reduce them to fine flour. Let them be dissolved in lemon juice, and let them stand until you find them dissolved, and you see a certain greasy substance like oil floating on the surface of the liquid; take this up with a silver spoon. Afterward form the powder into beads, by hand or in molds; pierce the pearls with a silver stylus and a pig's bristle, anoint them with oil, and, hanging on a thread, enclose them in glass and expose them to the sun. When you see them dried,*

wrap them in barley leaven that is neither salted nor sour, and let them be baked in an oven, or give them to pigeons to swallow, or [steep them] in the milk of the wild fig, and you will have excellent ones. If you prefer otherwise, once the pearls have been dissolved with a coloring agent or with aqua fortis, you will wash them in clear or distilled water; and with your hands washed — so that they do not become dirty and pale in the handling — thus [bind them] with the dried milky juice of the fig, in a hot bath of distilled spoonful-water; or you will glue them with egg white, pierce and dry them, always washing and mixing with silver-water. You will prepare the silver-water thus: let the purged silver, dissolved in aqua fortis, settle; let the water evaporate over gentle coals, leaving a third part; then, the vessel drawn from the fire, set it aside, and leave it in the open air at night until it freezes, and you will find the silver in the form of a little crystalline stone. You will wash it with spring water, so that they may be seen brighter; you will store them in a glass and earthen vessel, and let it dissolve in rotten dung, in which you will allow the artificial pearls to steep and linger, and you will find them bright and of a translucent silver color. Thus far Porta — where many points occur that might be marked with asterisks. For these methods of coloring, even if they are not altogether displeasing, nonetheless are not entirely satisfactory, because from the powder of dissolved pearls a body can never be made so solid and heavy as it was before; nor do I see why he directs that they first be devoured by pigeons. But let us leave everyone to abound in his own opinion, and return to our own matters. I have observed another method, which imitates Nature exactly, and likewise a method by which pearls can be enlarged; but these, as secrets, I have deliberately decided to reserve for another place.

PROPOSITIO III.

The making of the sapphire. [Saphyri confectio.]

The sapphire is commonly counterfeited splendidly with blue glass cemented between two Bohemian diamonds [i.e. rock crystals]. Others melt a blue mass from glass in the fire, have it polished and hardened, and sell it to the inexpert as sapphire. This craft is commonly carried out by various methods. Most often, into a glass mass prepared from crystal or flints a portion of zaffer [zaphara, cobalt oxide] is thrown — namely two drachms to one pound — and the mass, glowing in the fire, is stirred as well as possible with an iron hook. Then a small piece is taken out and tested, to see whether more zaffer or more of the mass should be added; if it appears in the proper measure, it is allowed to bubble for six hours; afterward it is taken out, and the mass, resembling sapphire, is handed over to a skilled engraver to be carved and polished. If the mass has been made properly, the false sapphire can scarcely be distinguished from the true. Those that are fictitious usually have little bubbles or specks in their body, which arise because the fire does not act evenly upon the mass. So says Boethius [Anselmus Boetius de Boodt].

PROPOSITIO IV.

The imitation of the opal. [Opali imitatio.]

The opal cannot be adulterated with doubled glass, or with coloring, as the other gems can. Yet Porta writes

that calx of tin thrown into glowing crystalline glass clouds and colors it like an opal. But one must repeatedly take it out of the fire and adjust it, until one obtains what one wishes. Quercetanus [Joseph du Chesne] asserts that a glass alembic is tinted on the inside with various colors by the spirit of niter, so that it looks like an opal. Whoever wishes to know the method of tinting, let him read the little book that he published on the true medicine of the ancient Philosophers.

PROPOSITIO V.

The composition of the emerald. [Smaragdi compositio.]

Emeralds can be adulterated by almost every method. The nobler method is made with crystal, glass, and calcined and fused flints, if a small quantity of red lead [minium] is added to them: thus I have seen excellent ones made. Others add burnt copper [aes ustum] reduced to a very fine flour, with half its weight of

saffron-of-iron [crocus ferri] added; and they cook it for the space of six hours, then let the vessel cool by itself, and commit the gem to polishing. If one has worked exactly, he will make emeralds altogether like the American ones.

How an emerald may be made. Another way, from Cardano. [Smaragdus quomodò fiat. Aliter ex Cardano.]

With greater effort an emerald is made. Crystal is ground very finely; *marcia cocta* [Margin: *Marcia cocta* — material of potters for coloring vessels] and the most splendid verdigris, or worm-shaped verdigris, is added; a raw brick is dug out; these three are put in, and it is baked in a brick-kiln among other [bricks], with a marker added — that is, a lump similar to emerald is extracted, which is cut out and polished. It is glass, indeed, but so elegant that — had not those who first discovered it (for this is a new discovery, of about ten years ago) wished to grow rich too quickly with large pieces, and thereby cast suspicion by their abundance and size — the fraud might even now lie hidden, to the great and incredible profit of the discoverers, though they have not been without profit. I have seen ones so beautiful that, set in gold, they surpassed the native stones in splendor. It succeeds best if they are entirely free of bubbles: for bubbles declare it to be glass and make it a base stone; yet it is touched by the file, for it is glass. For every gem passes into glass with the smell of lead, but especially when it has been reduced to a fine powder.

How a sapphire may be turned into a diamond. [Saphyrus in adamantem quomodò verti possit.]

The third method of adulterating gems is far nobler and less condemned, art striving with nature. A gem is changed into a gem by the power of fire. A bright sapphire, but otherwise of dilute color, is joined with gold and gradually set to the fire until it melts; let the gold boil for three or four hours; then the gem is lifted out and allowed to cool gradually [Margin: The making of a diamond], and you will find a diamond: for the gem remains, nor is it touched by the file, but whatever is

of blue color perishes. [Margin:...tum ex Saphyris (i.e. "...is made from sapphires").] Therefore we seek out sapphires of the most dilute color: for they are cheaper, and pass over into diamond more quickly and are transformed more perfectly. He who first discovered this grew very rich, and in a short time; afterward, the matter being uncovered, profit was still left to the art: for it shines very brightly because of the sapphire's hardness. There are some who make beautiful diamonds from aquamarine, a cheaper and softer gem. There are some

who do not bake the sapphire in gold, but only the sapphire wrapped in chalk in the fire, and it succeeds in the same way. It must be observed, however, that the fire be gradually surrounded around the cold gem, and again that, the work finished, it be allowed to cool by the extinguishing of the fire; for it is not safe to draw it out of the fire. It is a flaw if any trace of blue color remains.

PROPOSITIO VI.

The composition of the topaz. [Topazii compositio.]

Topazes of golden color, on account of their elegance, are adulterated by all the methods by which the other gems are usually adulterated. The more excellent method is when in crystal, flints, and fused glass a golden color is brought about; this is done if to each pound of glass is mixed a quarter of an ounce of saffron-of-iron [crocus ferri], and a tiny bit of red lead [minium] is added — but the red lead is to be added first, the saffron after, as Battista della Porta attests. [Margin: The various methods of making topazes.] If three times its weight of lead is added to calcined crystal, the topaz emerges without any further addition, if it remains in the furnace for a day. You will make it another way thus: make a flour from burnt copper [aes ustum], native cinnabar, and crystal, and add four times as much burnt tin; put it into a casting-vessel of the strongest clay, and commit it to the furnace for a day; but let the fire not be violent, and let it always remain at the same degree, for the aforesaid powder flows easily.

PROPOSITIO VII.

The composition of the beryl. [Berylli compositio.]

Beryls are of no greater authority than Oriental topazes, once called chrysolites: accordingly they can be valued at the same price. Yet according to the elegance of the color the price is increased or diminished — and this is to be observed in all gems. [Margin: The making of the beryl.] The beryl is adulterated by those methods by which all other gems are. The nobler method is when burnt copper [aes ustum] is reduced to a very fine flour, so that it escapes all touch, and is mixed with crystalline glass or calcined crystal with that glass added, and is committed to the furnace; one drachm of copper per pound of glass mass suffices.

PROPOSITIO VIII.

The composition of crystal. [Crystalli compositio.]

Crystal is of use not only for women's adornment — when chains, beads, and other such things are made from it — but also for mirrors, eyeglasses, cups, goblets, plates, basins, and the like.

For when it is free of flaw, such cups or goblets are sought after by princes and are held at a fairly high price. Indeed, a golden goblet the size of a foot can sometimes be sold for a hundred crowns [scuta], and occasionally even for more. Small pieces of crystal, from which beads or little crowns are made, are cheap, and do not exceed the price of the engraving. From crystal too, with glass added, and the purest sand and the most noble alkali salt, glassware very like true crystal is made at Venice. Crystal also serves for imitating gems: when, calcined, it is mixed with three parts of lead; to this metallic substances are commonly added, so that the desired color — of emerald, topaz, or some other gem — may come forth. [Margin: False diamond from crystal.] By means of crystal, the fire and rays of the sun are also commonly gathered: namely when a round, slightly convex surface is set opposite the sun in such a way that the body which is to receive the fire is placed around the center of the convexity. In softer and more delicate bodies it also takes the place of the iron cautery, although I judge that it burns and pains no less than iron. It is adulterated with crystalline glass, which is very like it — but it is softer and heavier than crystal. False diamonds [pseudo-adamantes], when they are skillfully engraved, are even set in gold; and when they are small, they so rival true ones that they cannot be told apart except by experts. Hence it comes about that among the Bohemians, Hungarians, and Muscovites they hold no small authority; yet they are not sold at more than the price of the engraving, unless they are hard and sparkle splendidly. The same reckoning holds for citrines and iris-stones, all of which are worth no more, above the price of the engraving, than the buyer wishes: for they are had in fairly large supply, and large pieces the size of a fist, not yet worked and entirely transparent, are sold for only one or two crowns. Worked and fitted into goblets, and left to the seller's discretion and the buyer's fancy, they are often sold for a fairly large price.

PROPOSITIO IX.

The composition of the chalcedony. [Calcedonii compositio.]

The chalcedony is commended against all symptoms of black bile — that is, sadness, fear, and the assaults of demons. Nor are there lacking vain authors who promise victory (which is given only by GOD) to the one wearing it. From the West Indies some are brought that are moderately translucent, paling from white; some are marked with milky bands, which they proclaim, when hung on, to avail for abundance of milk. Today, on account of its abundance, it is not held of much value; yet if larger pieces are splendidly carved, and a notable color is not lacking, they can sometimes be sold for a great price, and at not much cheaper a price than sardonyx. The chalcedony scarcely deserves adulteration; nevertheless you will imitate it thus: you will put crystal into the fire to be melted down, mix in a little silver-calc, let it remain in the furnace for a day, and you will have what you sought.

PROPOSITIO X.

The composition of the onyx, or false onyx. [Onychis compositio, seu Pseudonyx.]

The simpler onyx is scarcely ever imitated by anyone. But that one which has a white body distinguished from a black one is imitated very often — namely so that, engraved, it may afterward be sold as a cameo. It is made in this way: [Margin: The method of making false onyx.] little shells of the sea, which Italian women use for rouge, are reduced to fine flour and placed in lemon juice that has been several times purified through a filter — yet so that the juice floats three or four fingers above; let it be left thus for ten days, the juice well covered, in warmth; afterward pour off the juice, wash away the residue with water, and grind it on a porphyry slab with egg white that has first been very well beaten, and cast it into molds. Afterward polish the outer formed part very well, so that it may be set very well and skillfully upon a black underlayer, and the fraud may not easily become apparent to just anyone. During the grinding, other well-ground colors can be added, so that sardonyx too can be feigned in this way, and no less the other gems or other precious stones.

PROPOSITIO XI.

The imitation of the turquoise. [Turcoidis imitatio.]

The Venetian glassmakers imitate the turquoise excellently at Venice. I saw a Frenchman who could imitate it so skillfully, from another material, that it could not be distinguished from a true gem because of the black little veins which he inserted into it. He sold them as imitations, and at a fairly large price, because of their elegance. I think he used native chrysocola and a petrifying water, with a few other things added. To recover a lost color, some dissolve the transmarine color [ultramarine] in aqua chrysulca [aqua regia]; and, that distillation having been drawn off, they dry the surviving remains, and rub the turquoise with them. Others place [the turquoise] in aqua chrysulca, and, wiped off, commit it a little to vinegar, then plunge it into the coldest water — for then it becomes more colored. But by these arts the color is gradually drawn inward into the skin, vanishes, and the gem is rendered more unpleasing and baser. It is more correctly done when the upper skin is eaten away with oil of vitriol, so that the underlying color makes the gem more elegant.

Cardano, fol. 290, in his book *De Subtilitate*, writes thus about the imitation of agate: [Margin: The description of agates.] *To all gems is set, as a single one, the agate stone; it too is in the number of the gems, but of so varied a kind that you would not believe it to be a single stone. White, red, saffron-colored, ash-gray, green, black, variegated, blue — why do I delay? To this one stone alone the colors of all the other gems do not suffice. It represents groves, meadows, animals, rivers, flowers, trees, with Nature at play. Most famous in the histories is the agate of King Pyrrhus, representing the nine Muses with Apollo striking the cithara in the midst, and each one with her own ornaments, so that it might seem*

then that Nature had contended with the painter; and this ought rather to be called a miracle than a gem. We have two agates, in one of which Nature has painted a hemisphere of the sky, with distinct orbs, and in the middle a round earth as if rising above water. In the other a chasm of the earth seems to emit smoke, which darkens the air. Moreover, what is worthy of admiration is that the color of the smoke is one thing, that of the air another, which is obscured by it: for the smoke is white as though dense, the air somewhat reddish and moderately transparent. Other agates also represent the eyes of birds — and we have such a one — others those of fishes. The Pontic agate, which is interspersed with bloody or black drops, represents the images of mountains and valleys. Some are called leucophthalmi [representing] human eyes, lycophthalmi [representing the eyes] of a wolf,

aegophthalmi [representing the eyes] of a goat. I have also seen a green transparent one most beautifully distinguished by two white lines, which I would doubtless believe to be of [its own] nature. For just as among animals the mule [is born] from an ass and a mare, and the lycisca from a wolf and a dog, so too stones are sometimes mixed from a varied kind, their material mixed together with the causes producing them.

Moreover, as for the agate of King Pyrrhus, I think it too ridiculous that it should by chance have been so exactly adorned and distinguished. This therefore happened thus. A painter painted some stone of the marble kind with strong colors, so that the nine Muses might admire Apollo playing in the midst; then, whether by chance or by design, that stone lay buried for many years, in that place where agate-stones are wont to be produced. It happened therefore that all around there was produced a transparent and watery agate, and the [stone] thus found represented the Muses and Apollo, as though fashioned by the industry of Nature, since the agate was now a gem. For if pitch and moss clinging to trees pass into agate in the course of time — as I have had an agate with five ears of grain, which you would say had just fallen from the wheat, and yet they were stone, indeed gem — and so too no small part of the moss was present, how much more easily could that painted soft stone have passed into agate. Therefore if someone should observe the places of agates, and especially where the transparent ones are generated (for this is necessary), let him bury a true painting made of perpetual colors — such as blue and golden and those consisting of metal — and especially if he should smear the work with Punic wax tempered with a little oil, or with some other perpetual but transparent unguent, such as is that which among us is called liquid varnish [vernix], which is wont to be laid over more precious finished paintings; the agate will be born thus painted.

But you will say, this painted agate would be frequent, if it could be prepared by so small an art. But you do not notice that first it must be buried where agates are produced; then that the agate which forms around must be splendid and transparent; then that within a few years it must pass into a gem before the painting perishes, nor be first washed out by any external moisture, nor the image obliterated; and finally it must happen that it be dug up finished. For how many fishes are there that no one ever fishes, and wild beasts in the woods, and birds that no one ever catches, but which perish of their own accord in their proper places — just so many

gems are reckoned to be, which, lying hidden in the places where they are produced, never come forth into the light, but, just as they had coalesced into their first

mother the earth, so by age they return again into the same. And although the agate is noble in its variety, yet because it shines little, it rarely has a great price among the gems. Thus far Cardano — things which do not differ from what we ourselves set forth in Book VIII, On the generation of figures born in stones, to which we refer the Reader.

PROPOSITIO XII.

The separation of gold from lapis [lazuli]. [Auri à Lazulo separatio.]

How gold is to be separated from lapis lazuli, after it has been ground. [*Quo pacto aurum ex lapide Lazuli, postquam tritus fuerit, separandum sit.*]

To a pound of the stone now ground on the porphyry slab, mix an ounce of purified mercury, and mix well in a mortar; then press it out through a linen cloth, and the mercury will draw out the gold together [with it] through the cloth. Afterward put the pressed-out material into a crucible and commit it to the fire, and thus the mercury will fly off into the air, and what will remain in the crucible will be pure gold. If the joined color is left in the fire, it renders it more splendid, softer, and easier for guiding and spreading with the brush.

PROPOSITIO XIII.

The use of the color for paintings. [Usus coloris ad picturas.]

On account of the immense price of the ultramarine color, painters are not accustomed to use it as [they do] other colors; rather, they paint the images which they want blue with common blue prepared from Armenian stone [Armenium], or from glass of that color, which they call smalt [smaltum]; then the parts in which the light rests with white lead [cerussa]; afterward with those colors, as the matter requires, properly applied and very well dried, they smear over that whole blue painting with ultramarine color moistened with nut oil and spirit of turpentine, as though with a varnish or some very thin coating. In this way, through the overlaid color, as through ice or glass, the underlying [parts] shine forth, having obtained from the covering not only a more excellent beauty but also permanence — so that not even in two hundred years does the least bit of light or of beauty depart; nor is it any wonder, since the color which the fire could not consume, much less can the air or the sun eat away. So says Boethius [Anselmus Boetius de Boodt].

PROPOSITIO XIV.

The ultramarine color of lapis. [Color ultramarinus Lazuli.]

How the ultramarine color may be separated from the stone in another and quicker way. [*Quo pacto ultramarinus color alio modo, et brevius à Lapide separetur.*]

Take a pound of the stone reduced to a very fine powder, and ground with clear water on the porphyry slab, and put it into a glazed dish, until the powder dries in the shade; which again, if it has coalesced into a mass, [you will] re-[duce] into powder...

Reading order used: The four un in natural sequence by printed page number — = printed p. 465, = printed p. 466, = printed p. 467, = printed p. 468. The text is continuous across all four (catchwords confirm: 465→466 "dien-/dienfis"; 466→467 "aptiuf-/aptiufque"; 467→468 "& far-/& farmentis"). The translation follows this order.

you will reduce it. Then have ready at hand: of Greek pitch [picis graecae], 3 oz.; of pine resin [resinae pini], 4 oz.; of mastic [mastiches], 3 oz.; of frankincense [thuris], 3 oz.; of olive oil [olivarum], 2 oz. Set a glass dish over a slow fire, and first put in the oil; when it is thoroughly hot, add the resin, then the pitch, then the frankincense, and last of all the mastic, stirring well all the while. Then pour it into another little dish and let it boil a little. Once this is done, have ready another small vessel into which you have put the dry powder of the stone; pour the said ointment over it, stirring gently with a flat tool, so that a good mixture is formed. Then leave the mixture for a day. When you wish to draw off the color, pour the paste onto boiling water and stir and agitate the material well; as the water begins to cool, throw it out and pour on more hot water. Do this until the water draws off the color, and repeat as many times as needed until you have extracted all the color. You can keep the separate extractions apart, so as to have the colors distinct.

If the color appears to have picked up some filth, you will restore it as follows: just add tartar-water [aqua tartari] to the color until it is covered by the water; let it stand for a day; afterward wash the color with clear water, and you will have it cleaned.

You will prepare the stone for the said work in this way: when you have broken it into fragments, put it in a vessel and roast it, then wash it with vinegar; thus the best part will remain — the part that resists fire.

Various Artifices of Tinctures of Every Kind

[*Artificia varia Tincturarum omnis generis*]

I shall add in this place certain fine recipes [Greek: ἐγχειρήσεις (encheirēseis, "manipulations" or "procedures")] by which tinctures can be made with little trouble that are not at all unlike Ruby, Emerald, and Sapphire and the rest. These were communicated to me — out of his singular affection for me — by the most excellent Lord Martinus Bernardus [Martin Bernard], Doctor of both branches of Medicine and chief physician [Archiater] to the Most Serene King of Poland; and he carried out the experiment in my presence in our pharmacy.

EXPERIMENT I.

A red tincture resembling a shining carbuncle.

Take gum lac [gummi laccae]; once it is dissolved in clear water, you will add to it a little alum — commonly called *Rocca* [alum of Rocca]. Then put the whole mixture into a glass bladder, which the chemists call a *Matracium* [matrass]; place this on hot ashes, and it will turn an intense red like a ruby. If you then pour in a little oil of tartar [oleum tartari], you will obtain the color commonly called *incarnatinum* [flesh-pink]. And you will obtain a most excellent dentifrice if you dilute the gum lac with sage- or rosemary-water and extract the tincture.

EXPERIMENT II.

A tincture resembling an emerald color.

Take a portion of violet syrup [syrupi violacei] in a phial; pour clear water over it, and add to this a few drops of oil of tartar. Once the precipitation is complete, you will have a tincture very much like the color of an emerald — that is, green.

EXPERIMENT III.

To make a tincture similar to a sapphire color.

Take quicklime [calx viva] in a copper vessel, diluted in clear water; add to it a little sal ammoniac [sal ammoniacum]. When you have let it settle for about 12 hours, you will at last find that the whole liquid has changed into a sapphire blue color [colorem caeruleum], not unlike ultramarine. And so that these colors may become more brilliant, the colors or tinctures must first be strained through diaphoretic paper [charta diaphoretica]. Their use is particularly fine in the construction of thermoscopes [thermoscopia].

EXPERIMENT IV.

A most rare secret in which a method of preparing writing-gold is handed down.

Many marvel at that excellent method of writing in gold that the ancients commonly used, and they cannot grasp its technique. Hence many think the art is, as it were, lost, and as difficult to discover as it was. We have thought it right to make known here, for the public good, the method which the above-praised most excellent Doctor Martinus Bernardus [Martin Bernard] taught us. One proceeds as follows: Dissolve gum arabic [gummi arabicum] in a little vessel until it reaches a thick consistency like porridge; then strain it through a very clean linen cloth. Of this gum, take a portion the size of a hazelnut and place it in a very clean earthenware bowl (of the kind they use everywhere here in Rome at table). Then take gold leaf [aurum foliatum] — the more, the better — mixed with the gum, and grind it with your fingers for as long as it takes until the whole gum is intimately blended. For the better the gold is worked into the gum, the better the result will be: keep at it with your fingers, pouring in lukewarm water as you go. When this is done, then again pour hot water over it and leave it for 12 hours, until — the poured water being drawn off by tilting — fresh lukewarm water is poured on; and when you have done this several times, then you will leave it until the dregs have settled, which are the material suitable for writing in gold. These, then, distributed drop by drop into shells, will give you the writing-gold so long sought after. If you wish to use it, add one drop or another from water of white glue [aqua glutinis candidi] (of the better sort, such as is prepared in Germany) for thinning, and put it to use. A truly most excellent secret, and tested in my presence.

I could add in this place, by way of a finishing touch [ad coronidem], the method and procedure for making the true and genuine Chinese varnish [Chinica vernix]; but because the description is too long for the page to admit, we have reserved it to be communicated, perhaps more fittingly, in another place, dear curious Reader. This was communicated to me by the Reverend Father Eustathius Iamar [Eustachius Jamar], of Liège,

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PROPOSITION XV.

How artificial stones, and huge masses of rock for columns and other monuments, may be made.

There is a great dispute among the Authors as to whether artificial stones can be made by casting [per fusionem]. Some think that the columns and obelisks brought to Rome from Egypt are nothing but fusible stones melted down and cast in suitable molds into so great a mass. But we have refuted this fable most fully in our *Oedipus* [*Oedipus Aegyptiacus*] and *Obeliscus Pamphilius*; for they were fashioned out of living rock, of the kind whose quarries are still to be seen in Upper Thebaid. Yet I do not deny that there is a certain method and a definite mixture of materials that can be cast into stones; indeed, I recall having seen the practice of it among the more skilled workers of marble and the stonemasons. Moreover, that the mosaic or *musive* tesserae of the ancients were nothing but a fusible paste cut into triangles, squares, and similar polygonal figures, even mosaic-work [Greek: λιθόλεμμα (litholemma, "stone-flake / stone-inlay")] itself plainly teaches; and lest anyone be able to doubt the matter, we shall teach it by experiment. For not only are artificial gems made, but also rocks and marbles — just as is plain from what was said a little above about the tables that are now made here in Rome by a newly discovered method.

EXPERIMENT. *On castable stone [Lapis fusilis].*

Let stones, marbles, jaspers, etc., be reduced to a very fine powder; to this let there be joined lime, gypsum, salt, ox-blood. Let all these be mixed and put into vinegar, wine, beer, or milk or its whey, and stirred in various ways until they are reduced to a porridge. When this is done, let the metallic colors you wish be mixed into the porridge, with a little ox-gall [fel bovis] added, and then let them be mixed with a wooden spatula with such care that the artificial marble obtains all the veins of color, just like real variegated marble — no differently than we know is done in preparing Turkish paper [carta Turcica]. Then pour it into the mold or form already prepared, and when dried it will take on a hardness altogether like stone, which then, planed down with pumice and given a final polish with soap or oil, receives a most perfect finish. The talented will easily grasp my meaning from this brief description. So, on to other things.

PROPOSITION XVI.

A method for composing artificial pearls.

[Margin: *Perlae fictae* — Artificial pearls.]

Pearls are made here in Rome so similar in form to real ones that, in respect of brilliance and appearance, they can scarcely be distinguished from real and natural ones, by this procedure. They purify the whites of eggs as cleanly as possible by means of a sponge; into this they sprinkle and mix the finest talc, or

also shavings of mother-of-pearl [concha perlata] together with natural pearls first reduced to a very fine powder. They grind this mixture thoroughly on marble, so that a dense amalgam is formed, which is dried in the sun or behind a hot furnace. From this mass they form pearls of whatever size they wish, which they pierce with pig-bristles and set out in the sun to dry; and you will have the job done. But if they do not shine enough, they smear them on the outside in the usual way with prepared egg-white and set them out in the sun to dry, and they have what they sought.

PROPOSITION XVII.

Artificial corals.

[Margin: *Corallium fictum* — Artificial coral.]

In a similar way artificial corals can be made. Grind cinnabar [cinnabaris] with egg-white on marble for an hour; afterward dry it like potter's clay [terra figulina], then mold from it little balls or a branching shrub-shape as you please. Take the dried material like the pearls, smear it on the outside with egg-white, and once dried, the corals come out so similar to natural ones that they can scarcely be told apart.

There is truly a great property hidden in egg-white, for from it a varnish [vernisium] can be cooked out; and when gold and silver shavings are mixed with it, [Margin: *Venturini lapidis confectio* — Preparation of the Venturine stone] they make a stone not unlike the one they call *Venturinum* [aventurine / goldstone].

PROPOSITION XVIII.

The transmutation of flax into silk.

[Margin: *Experimentum mirificum* — A wonderful experiment.]

If a lye [lixivium] is made from the lime and ash of the woad herb [Isatis], very strong, and flax is boiled in it, the flax passes into a wonderful silken material, splendid and very fine, most suited to spinning. And this too is marvelous: if the downy parts of feathers, scraped from birds, are boiled in this lye, they can be spun and woven no differently than cotton [gossipium]. But this secret also reveals the method and procedure for spinning asbestos material [materia asbestina], about which I kept silent in Book VIII, in the Chapter on Asbestos.

PROPOSITION XIX.

The making of amber.

In Pliny's time amber [Succinum] was dyed at pleasure with the root of the kid [hoedorum] and of alkanet [anchusa], and also with shellfish-purple [conchylum] — that is, with the late-violet color [violae serotino colore]. In this age the art of dyeing amber has perished. Yet if what is commonly written is true — that, plunged into boiling wax, it becomes soft — it will easily be able to take on any colors. The imitation of amber is proposed by many. Cardanus [Gerolamo Cardano] tries to imitate amber by putting ants, gnats, flies, bits of straw, and powdered amber into egg-white and gum tragacanth tears [tragacanthi lachryma], so that it gives off a good smell and draws up bits of straw — and better

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Let it suffice, then, for the investigator of Nature that the way is shown so easily in this chapter that he cannot be deceived. Whoever wants the exact history of amber, let him read the treatise of Andreas Libavius [Andreas Libau], a most learned man.

[Continuation of running header: ARS PYRABOLICA — and the start of a new Pars]

PARS IV.

ARS PYRABOLICA

Which they also call Pyrotechnics [Pyrotechnia].

PREFACE.

How great and how prodigious are the works that the pyrotechnician — Vulcan — performs in the hidden tunnels of the earth is plainly shown by earthquakes, by the swallowing-up of mountains, by the new generation of lakes, and by the overthrow of cities and kingdoms. Since these are in fact nothing but ignited exhalations of sulfur and niter shut up in the passages and caverns of the mountains, certainly it was not without reason that the art of siege-craft [ars poliorcetica] — which they call pyrotechnics or pyrobolics — drew its first origin from this. And we have thought it fitting to set forth here, very opportunely, according to the pattern of Nature, what wonders may be produced from it; and first indeed we must treat of how, and in how many ways, gunpowder [pyrius

pulvis] — the agent of so many marvelous effects — is made; then how it is to be applied to engines for arranging festive shows. The invention of gunpowder is, without any controversy, first attributed to Berthold Schwarz [Berthold Schwartz], a German monk of Goslar and an alchemist, in the year 1354 — who, however, is said to have made the discovery not so much by human industry as by chance, from a mixture of powder, niter, and charcoal accidentally set alight, and revealed with a great crash and violence.

[Margin: *Historia Pulveris Pyrii, ejusque primae inventionis occasio* — The history of gunpowder, and the occasion of its first invention.]

I recall that I once read the story from a very old German book, of this tenor: Berthold Schwarz, a monk of Goslar of the order of Saint Benedict, since he delighted wonderfully in chemical matters and had already by his skill in them acquired for himself a great reputation, when at a certain time he had made a compound out of sulfur, niter, and charcoal, and — by I know not what chance — a spark of fire had slipped into the material, at once with a great crash it lifted up the pot and dashed it against the vault and shattered it. Astonished at the effect of the thing and its novelty, he applied himself more diligently to investigating the cause. And so, repeating the operation many times, when he always found the same effect, turning over something deeper in his mind, he put the material into a channel constructed of iron plates; and when he had put a single leaden ball into it, the material being fired at once scattered whatever lay before it with an enormous noise. And so, filled with great joy at the discovery of so notable a benefit, he nevertheless wished the matter to remain secret to all until his own time. There was at that time, in a place near Goslar, a huge forest infamous for robbers, who had set up their station there in certain spots, most convenient for every occasion of committing robberies. At that same time, on account of the violent plunderings and the multitude of murders, the Magistrate of Goslar was deliberating how this plague of criminal men might be put down, and no method could be found. Berthold, informed of this matter, approached the Magistrate and promised that he would exterminate the robbers with little trouble, provided that — mindful of the benefit conferred — they should show themselves not ungrateful to him and to his Order. The pledge being made, Berthold, having forged a good number of iron pots, which he filled with the material now known to him, with stones

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CHAPTER I.

On the making of gunpowder [De pulveris Pyrii confectione].

For the making of gunpowder three things are entirely necessary: saltpeter [sal nitrum], sulfur, charcoal — about whose preparation a few words must be said, which we have drawn partly from Siemienowicz [Kazimierz Siemienowicz], Freitag [Johann Freitag], and Tartaglia [Niccolò Tartaglia], partly from other Authors who have written on pyrotechnics; to this end, that the curious Reader may recognize nothing so admirable in the use of human affairs that has not drawn its principles from the Vulcanian workshop of the Subterranean World.

PRAXIS I.

On preparing oil from sulfur [De Oleo ex Sulphure praeparando].

Let a good quantity of clarified sulfur be taken, and with the fire of liquefaction applied, let it melt in an earthen or bronze vessel. Then let there be had old red bricks that have already previously been used in building; or, if these cannot be had, let new ones be taken, well baked and not yet acquainted with water. Let them be broken into fragments the size of a bean and thrown into the melted sulfur. Then let the sulfur be mixed with the brick-fragments until the fragments drink in and absorb all the sulfur. Let these afterward be placed in an alembic hanging from a distilling furnace, and by the chemical method let the oil be distilled: it will be most burning, and most well-suited for preparing artificial fires. So say the practitioners.

ANOTHER WAY.

Let glass phials, having a somewhat oblong neck, be filled, so that a third or a quarter part of the belly is packed with the most finely ground [sulfur]. Over this let there be poured spirit of turpentine [spiritus terebinthinae] or oil of nuts or of juniper, only so much that that liquid together with the sulfur does not exceed half the belly of the phial. Let the phial be set upon hot ashes, and let it remain there for 8 or 9 hours. Then the spirit of turpentine will convert the sulfur into a most ruddy oil, most burning as before.

Certain men take, for making the most burning oil of sulfur, the following materials:

Material	Quantity
Sulfur [Sulphuris]	1 lb.
Quicklime [Calcis vivae]	half a lb. [℥ ℔]

Material	Quantity

Sal ammoniac [Salis Ammon.]	4 oz. [℥ iiij]

Siemienowicz [Siemienowicz], in his *Artilleria Magna* [*Great Artillery*], relates. The chemists teach a method of preparing oil from sulfur (which they also call balsam), whose power is such that it lets neither a living body nor a dead one pass into putrefaction, but keeps it so whole that no celestial impression, nor one proceeding from the elements, [corrupts it...]

corruption, whether brought on at their very origin or arising later, can affect it. There is also prepared (as Trithemius [Johannes Trithemius] teaches) a certain fire made from its flowers together with borax and spirit of wine, which remains inextinguishable for many years. And there is a lamp by whose light men appear without heads. But what we ourselves have judged about that fire the reader will find set out in Book IX. For they boast of many such things without any foundation — claims that nevertheless cannot stand once they are reduced to actual practice.

PRAXIS II.

On preparing an oil from sulfur and saltpeter mixed together.

Equal portions of sulfur and of saltpeter are added together and incorporated. They are then ground into the finest powder and sifted through a rather fine sieve. The whole mass is placed in a new earthenware pot, and strong white vinegar — or burnt wine [vini adusti, i.e. distilled spirit] — is poured over it, just enough to cover the material well. The pot is sealed up in such a way that it cannot breathe at all, and is left in a warm place until the vinegar has evaporated. Finally, from the material remaining in the pot, the oil is extracted by chemical apparatus.

PRAXIS III.

On preparing charcoal for gunpowder and other uses in pyrotechnics, according to the practice of the German craftsmen, as Siemienowicz [Kazimierz Siemienowicz] describes it.

In the month of May or June — when the bark of all trees strips off most easily because of the abundance of sap — cut a good quantity of rods from hazel or willow, one, two, or three feet in length, and a half-inch thick. Cut away the

knotty parts and discard them as less useful. Strip all the rest of its bark, bind it into small bundles, and dry it thoroughly in a hot oven. Then set the bundles upright in a single pile on a leveled patch of ground and set them alight. Once the kindled pile has caught flame well and the burning has been resolved into glowing coals, suddenly throw a little dampened earth over it and cover it as carefully as possible, leaving no vent, so that the whole suppressed flame — receiving no help from outside air — dies away, and the charcoal alone remains, extinguished and free of all ash. After the course of one natural day [diei naturalis, i.e. a full 24-hour day] these coals, now cooled, are to be taken out and kept for the following uses. If a sufficient supply of willow and hazel is not available for burning into charcoal, you can use dry linden [tilia] in their place.

If you wish to prepare only some small quantity of charcoal: take the twigs described above, cut and thoroughly dried, enclose them in some earthenware vessel, fasten the lid to the mouth of the vessel with potter's clay, then pack it about on every side with glowing embers, and let it remain there for the space of one hour in a single continuous and even degree of heat throughout. Let it finally cool of its own accord, and the burnt charcoal is taken out. There are those who reduce cloths and old linen fabric — well washed and dried — to charcoal in this way; and this too has a virtue not to be despised in pyrotechnics.

DISQUISITIO PHYSICA.

On the properties and functions, within gunpowder, of each material taken separately, out of which that powder is composed and prepared; concerning which we shall set out both what Siemienowicz judges and what we ourselves judge about these matters.

"Not by chance," says Siemienowicz, "nor accidentally, but through the highest grasp of natural philosophy and through speculative reasoning, was gunpowder discovered — or at least this can serve as an argument for it: that down to this very day no one has been found (though very many have tried) who could propose three similar materials which, well ground and incorporated together, would be fit to form a fire so vigorous, dreadful, powerful, and inextinguishable, right up to the consumption of the whole material, and that fire instantaneous. But since to the inventions of others further things may be added without difficulty, and since whatever has had a beginning has proceeded from the rudimentary and imperfect toward the perfect, let it be permitted to us too (since nothing about this matter has been handed down in the written records by the inventor) to set out in this place observations — speculative indeed, yet drawn

from experience — of the powers, nature, operations, and functions both of each single material taken separately and of all the materials enclosed in gunpowder when incorporated together. For we judge that the result will be this: once a more thorough knowledge of the properties and affections of these ingredients, both in particular and in general, has been gained, no one hereafter in pyrotechnics will fall into those errors whose correction is too costly and too dangerous." Thus far Siemienowicz; who, since he did not know the author of gunpowder, we have revealed in the preceding.

So this must be understood first: that gunpowder is composed of three materials — namely saltpeter, sulfur, and charcoal — chiefly for this reason, that one may remedy and supply the deficiency of another, or of the remaining two. And this appears first in the case of sulfur. Since sulfur is by nature the food [esca] of fire, readily seizes fire, and once it has seized it gives it up only with difficulty — and that with flame — it surpasses saltpeter and charcoal in this respect; and the flame of fire is much better suited than any other kind of fire for kindling saltpeter. But since saltpeter, in burning, resolves itself into a certain windy exhalation, this exhalation is of such force that it would suddenly oppress

and extinguish the flame which the sulfur had conceived; and consequently, by extinguishing the flame of the sulfur, it would also deprive itself of [the flame] introduced through the sulfur. And therefore, if some body were composed of these two materials only — namely sulfur and saltpeter, well ground and mixed together — then, on applying fire, it would indeed seize flame at once, yet nonetheless, for the reasons given above, it would also be extinguished at once. That is, that fire would not be continued, nor would it endure to the consumption and combustion of the whole material, but would consume only a very little of it, the remainder left untouched.

But a wholesome remedy has been applied to this defect, by adding to those two materials a certain portion of charcoal that has been well burned, dried, and pulverized. For this charcoal is of such a property and nature that, when even the least flame of fire has touched it, it suddenly blazes up and is resolved into fire without flame; and this fire, the more it is buffeted by any wind, the more it will be increased and preserved, until its whole substance has been turned to ashes. For this reason, then, when a body is prepared from these three materials — such as our gunpowder — on applying fire the sulfur at once conceives flame; and this flame not only introduces fire with flame into the saltpeter, but at the very same moment makes the charcoal catch fire without flame. And this fire (as said before) does not allow itself to be suffocated by any wind; on the contrary, it

takes greater increase from agitation. And since the sulfur is in contact with the fire — whether that fire be without flame or with flame — the sulfur nevertheless cannot be without flame; and this flame of the sulfur kindles the saltpeter. And therefore these three materials, mixed and incorporated together and then ignited, produce a fire that is inextinguishable, right up to the emptying-out and consumption of the whole substance. Take care, however, that in these three materials there be no accidental defect, arising either from moisture or from a disproportionate quantity of one material relative to another.

From what has been said it is now possible to conclude that the proper function of sulfur in the body of the powder is to seize fire with flame and to communicate and supply it to the other two materials. The particular task of the charcoal is in retaining, preserving, and defending the fire once introduced into the sulfur, so that it not be suffocated by that most violent windy exhalation of the saltpeter. But the greatest function of the saltpeter is to produce and cause the most violent possible windy exhalation; and in this exhalation lies all the virtue, vigor, and motive power of the powder. And therefore saltpeter is the principal and primary cause of all the marvelous effects of gunpowder; while the other two materials are added and bound to the saltpeter only for this end — that they may cause it to be resolved into fire and winds. For if anyone were to load a powder made of sulfur and charcoal only, and were to load a piece of artillery with even a very great quantity of it, I say that in such a case a powder of this kind would expel not only no iron ball or ball of any other metal, but not even chaff. The reason for this is ready at hand from what was said before: namely that an explosive expulsion of this sort depends on the expulsive virtue and power of the saltpeter alone, and of no other material whatever. I would more readily believe that a powder can be prepared without charcoal and sulfur than without saltpeter; and that two other materials can be found, one of which could perform the function of sulfur in seizing fire with flame, the other that of charcoal in preserving and retaining it without flame — than that anything else can be found apt to cause and produce so violent a windy exhalation, the agent of marvels in pyrotechnics, as we experience in saltpeter. Nevertheless, let the reader consult what we have set out in Book VI on gunpowder, things which do not depart from the pyrosophy of Siemienowicz.

PRAXIS IV.

On making fulminating gold [aurum fulminans], according to the method of Oswald Croll [Oswald Croll] and our own.

Take half a pound [℥ ℥] of common aqua fortis [strong water, i.e. nitric acid], dissolve in it one ounce of sal ammoniac — or as much as you can dissolve at a gentle heat — and thus you will have aqua regia [royal water], in which you may dissolve as much gold as you please. Then pour the solution into a roomy glass vessel and instill, drop by drop at least (because of the alarming and dangerous boiling-up), good oil of tartar that has dissolved of itself in a cellar; in default of this, take salt of tartar dissolved in common water. A good quantity of oil of tartar is required; then the gold falls to the bottom by precipitation. When the whole lime [calx] of gold appears to have settled to the bottom (which you will perceive from the color of the aqua regia, which ought to be white — for if it is still yellow, it is a sign that not all the gold has yet been precipitated), let more oil of tartar be poured in drop by drop (be faithfully warned of this at my own cost). Then, after the settling of some hours in a warm place, pour off the upper liquor, and the lime — its color almost resembling pale sealed earth [terra sigillata] — sweeten by washing four or five times with warm water; afterward dry it carefully and gradually in a water-bath [Balneo Mariae] over the gentlest fire. Or, what is safer, let it dry of itself in a glass dish in a warming-room [hypocaustum], with no heat of fire applied. Then, for greater safety, collect the lime with a wooden — not an iron — spatula, and store it for use in a small glass vessel. Note that there is great danger if it is dried in any way other than the two just described: for as soon as it feels the heat of fire, and a strong shaking with an iron instrument, it con-

conceives flame of its own accord, goes off into the air after the manner of a purple smoke with the greatest noise and crash, like niter-powder — so much so that you cannot find even a single atom of it. If some of common sulfur is safely mixed into it, and afterward it is burned in a crucible with fire applied, there remains a most subtle lime of gold of a brown color, which has lost all its power of striking — a thing remarkable and worthy of note. One scruple of that volatile gold operates almost more strongly and more powerfully than half a pound of gunpowder. A grain or two placed on a knife, if it warms when a lighted candle is set beneath it, gives off a sound such as if some great cannon had been discharged; and that sound, exceedingly sharp, almost hurts the hearing of one listening and standing by. The operation of this powder is the opposite of the operation of gunpowder: for whereas the latter exerts its force, at least, downward, [the former works upward — text gives only the contrast here].

A few scruples [of fulminating gold] upon an iron plate, thick enough, of burning charcoal, penetrate and perforate it. I judge sal ammoniac to be the cause of that percussion. For just as saltpeter and sulfur are enemies and do not tolerate one another — as we see in the ignition of prepared gunpowder — in the same way sal ammoniac is joined with oil of tartar against the foe; and from that mutual combat they make the gold, previously dissolved in the aqua regia, fall down; and the oil of tartar strikes the most highly purified spirit of niter, which in that conflict joins itself with the sulfur of the sun [Sulphure solis, i.e. of gold], its adversary. And because that sulfur of the sun is by nature most highly purified, and far subtler than our common combustible sulfur, it is therefore more potent and, in a smaller quantity, powerfully accomplishes its stupendous operations — in just the same way that we observe common sulfur and saltpeter, joined and ignited in gunpowder, make a great crash and roar. Concerning the same matter [see] Quercetanus [Joseph Duchesne (Quercetanus)] and Sennert [Daniel Sennert]: the cause, then, is the contrariety of the spirit of niter and of sulfur with the gold. For when oil or salt of tartar is poured into the solution of gold, the salt of tartar unites itself with the common salt — indeed with the alum and the ammoniac; and hence the gold, left to itself, descends to the bottom; and if anything of these salts is left with the gold, it is washed off with warm water. There remains only the spirit of niter, which has thoroughly united itself with the gold. So this spirit, if it warms, perceiving the presence of the sulfur of gold, sets itself in opposition, joins its forces, and with an onset made and with a crash bursts forth and is kindled.

PRAXIS V.

On camphor [camphora], its nature and property.

THAT IS

On the artificial preparation of camphor, from the noble Le Gallois [ex Caligero — author cited; modern identity uncertain] [?].

Take juniper gum (which is called sandarac, white varnish [Vernix albus], and mastic) made into powder, ½ pound; of distilled white vinegar, enough to cover the gum well as it sits in a glass phial. Set this for 20 days under warm horse-dung; then take it out and pour it into another glass vessel that has a wide mouth, and expose it for one month to be thoroughly cooked by the sun. You will have camphor congealed in the form of a crust of bread, and truly and natively somewhat similar [to natural camphor].

Now above we recalled certain things about the properties of native camphor; but since its use in our Work is very frequent, here too its nature is to be more fully explained from the testimonies of authors. Scaliger [Julius Caesar Scaliger], then, first, in *Exercitatio* 104, section 1, [speaks] of it thus: "But camphor is a tear of a tree by way of its sap, so that you would believe it a bitumen, just as you would have believed amber a bitumen. For, fallen from the trees, it is carried by the tide's approach onto the shores, where, buried in the sand, it is afterward dug out — along that whole tract which extends from Memel to Danzig [Gedanum, i.e. Gdańsk]. And about those heaps of sand it will be no wonder, to one who knows by what blow those regions were struck, and who has seen along the western side of Holland the heaps of sand standing out above the surface of the sea. It is therefore not dug up because it swims, but because it lies buried. But men have falsely judged camphor to be a bitumen — and that on a most wretched argument: 'Because,' says he, 'it burns.' For resin too, and oil, and frankincense undergo the same." And a little further down: "Whereas the greatest part of the wise hold camphor to be most cold, Averroes [Averroes (Ibn Rushd)], in his fifth [book], recognizes another. 'Camphor,' he says, 'the Indian, which in Arabic is more truly called قافور [Arabic: Qāfūr — camphor], 'Caphur,' warms and dries in the second degree.' There were therefore diverse species of camphor — or else there is a corruption in the manuscript, or an error in opinion. Lastly it was asked whether it is cold. For the innovators deny it. Yet it is established that it is most easily kindled, and even burns in water, besides being most fragrant. But its odor comes from the airy parts, by force of which it also burns; yet it has as much water as can be preserved beneath that coldness. It burns on account of its fattiness; and to be ignorant of this is the parent or the daughter of folly. For who would say that the hottest things burn most easily? For fire does not always pass into bodies summoned by likeness — likeness of heat, I mean — but is also enticed by some material able readily to admit it on account of its thinness." From the *Commentaries on Indian Matters*, this: "A very great tree, with boughs so spreading that it casts the widest possible shade. The substance of the wood is very light and very loose." Aboali [Aboali — i.e. Avicenna (Ibn Sīnā)] adds also whiteness. "The goodness of camphor [varies] according as it has been drawn out of the matrix by force, or expelled when ripe. For some is taken out of the veins in which it sticks, like a kind of crust. Sometimes it comes out by the bursting of the bark, and hardens after the manner of resins, at first colored; then by sun or by art it whitens. This is better than the former. Most excellent is that which whitens in the sun — for fire makes this happen. And [it is] very [prized] when first, in imitation of nature, [refined] by Riach, the king of the place — whence it gets the surname Riachina." The distilled [camphor] keeps its endowments

longer, and is more thoroughly clarified [defaecata]. Therefore it is also translucent. That which is enclosed [in the veins] is not so, and its color is darker. There are besides two baser species: one uneven, clotted, gummy; the other of a dark color. It is adulterated with honeycomb [favo] and with mas-

mastic and aqua vitae (which we described above). It is detected, set into the inner part of a loaf and placed behind the oven: if it melts, it is genuine; if it dries up, it is adulterated. They say too that the genuine kind easily evaporates, and is kept in marble boxes, with flax-seed, or fleawort [psyllium], or millet-seed poured over it. Jonstonus [Jan Jonston], *Admiranda naturae*, class. 4, chap. 9. The Moors write that camphor is the tear of a tree with branches so wide-spreading and diffuse that it can render a place shaded large enough to hold a hundred men. They add that the wood is white, fennel-like [ferulaceum], and that it contains the camphor in a spongy marrow — though sometimes, more certainly, it is made from a certain kind of bitumen in this way: Indian bitumen, which efflorescences out of native camphor, is cooked in a vessel with coals placed beneath, and the finest parts are borne, turned into a white color, into the cover; which, when we see it gathered upon them, gives [the camphor its] shape. Merchants affirm that the native kind is found in India. It is so friendly to fire that, if it once catches it, it burns until it is consumed. The flame it emits is bright and fragrant, and, raised and suspended in the air, it gradually vanishes — the cause being the extreme thinness of its parts.

I add: For use in pyrotechnics, camphor is reduced to powder if it is ground with sulfur. And the oil of camphor that serves the same use is made if a little oil of sweet almonds is added to it, and they are ground together in a brass mortar with a pestle, until it turn into green [oil].

[The following passage continues the right-hand column at the foot, completing the camphor preparation begun in Praxis V on p. 471:]

[until] it turn into oil. Or, if it [the camphor] be true and genuine, let it be cast into a glass phial, and, the mouth well stopped, let the phial be surrounded with dough kneaded from flour and water for forming loaves, and let it be put into the oven and drawn out. For the camphor, once dissolved into a liquid, will yield a most burning oil. See what we set out about camphor in Book IX.

PRAXIS VI.

On a water from sal ammoniac.

Take of sal ammoniac, 3 drachms [3iij]; of saltpeter, 1 drachm [3j]; let them be reduced to the finest powder and well mixed; then place them in an alembic, and, the strongest vinegar being poured over, let them be distilled by a gentle fire — and you will have a water most useful for many purposes.

PRAXIS VII.

On a certain artificial water that burns harmlessly upon the open palm of the hand.

Take equal parts of oil of petroleum [Petrolei], of turpentine, of quicklime, of sheep's fat [adipis vervecinae], and of pig's fat; let them be ground and incorporated, and distilled over hot ashes or over glowing embers — and you will have what you seek; for the hand smeared with it does not feel the burning of the flame.

CAPUT II.

On preparing incendiary fuses [funes incendiarii] in the common manner.

PRAXIS I.

First, from tow of flax, or of hemp, stripped by the second comb and bared of all bark, ropes are twisted, thick — half a thumb's-breadth in diameter. Then are taken 3 parts of ash from oak, ash-tree, elm, or maple that has been burned; 1 part of quicklime; and a lye is prepared in the usual manner. To this is added 1 part of saltpeter, [and] 2 parts of the juice pressed through a woolen cloth from liquid cow- and horse-dung. The whole material, well mixed, is poured over the ropes set in a cauldron arranged upon a furnace. Then fire is placed beneath, and the flame is urged gently at first, more strongly at last; and it is boiled down continuously for two or three days, always pouring on the liquor already mentioned, lest the ropes and the cauldron, lacking moisture, be scorched. Finally, from the ropes then taken out, all the moisture drawn in by the boiling is pressed out, by violently twisting the ropes with the hands and wiping off the running liquor with a linen cloth. Lastly the ropes are hung up upon long poles,

to be dried by the heat of the sun, and are kept for the usual pyrotechnic uses. Thus Siemienowicz.

PRAXIS II. of the same.

On preparing incendiary fuses lacking all smoke and stench in burning.

Take several measures of reddish sand, or of carbuncular sand [arenæ carbuncularis] that has been repeatedly cleansed, washed, and purged of all dross, and dried of all moisture; place them in an unglazed earthenware pot. Upon the sand lay a common incendiary fuse, or another twisted from cotton [gossypium], collected into a spiral — yet in such a way that intervals of half a finger's-breadth are kept between the sides of the fuse, and they do not touch one another, but stand apart at continuously equal spaces. Again pour over a good quantity of the aforesaid sand, and let the fuse likewise be arranged upon the sand, as just said. And so let the operation be continued in turn, placing layer upon layer, until the pot is full. Then cover it with an earthenware lid, and let the joints be stopped with the lute of wisdom [lutum sapientiae, a sealing clay]. Finally let the pot, thus prepared, be fenced about on every side with glowing coals, and let it remain there for some hours; afterward let it cool of its own accord; and when it has cooled, the lid removed, let the sand be poured out and the fuse taken out. Not unlike, too, is the procedure in operating with common sponges:

[Continues into the next folio.]

—only have to be cut into oblong pieces and laid in an earthenware pot on top of sand; and then, just as was described above for the fuses, burned with fire. Of these, or of the incendiary fuse described above, even quite small pieces — once lit and buried in juniper ash — will burn for several hours without any smoke or stench, and they need little help from the outside air. For that reason they can be hidden away unnoticed anywhere at all, as the occasion presents itself and necessity requires.

PRAXIS III.

On preparing pyrotechnic tow [stuppa] for artificial fires.

First make fuses out of tow [stuppa] of flax, hemp, or cotton, twisting two or three threads together but not too tightly. Place these in a new glazed earthenware pot, and pour over them: 4 parts white-wine vinegar, 2 parts urine, 1 part distilled

spirits [vinum adustum], 1 part purified saltpetre [sal nitri], and 5 parts pulverized gunpowder [pulvis pyrius]. Cook them over a fairly strong fire until all the poured-on liquids dissolve into vapor and evaporate away. Afterward sprinkle the powdered flour of the best gunpowder onto a wooden board, and let the little fuses, drawn out of the pot, be rolled over it in the powder and dried in the shade or the sun. Tow prepared this way burns very quickly. So if anyone wants the fire to advance a little more slowly, this fire-tinder [ignis esca] must be made somewhat weaker and gentler. It will then be enough if the tow is simply boiled down in vinegar and purified saltpetre, and afterward dried with powder-flour sprinkled on it. This is from the *Artilleria magna* [of Siemienowicz].

There is also another kind of pyrotechnic tow, which is not twisted into fuses but is simply dissolved and boiled down in the liquids listed above; or else it is soaked for several hours in strong distilled spirits and finally dried with the flour of the best powder sprinkled over it. Sometimes a tiny portion of gum arabic or tragacanth is added to the distilled spirits; with tow of this kind one can scarcely express how tenaciously it holds together.

Another method, that of Prechtel.

Franz Joachim Prechtel [Franciscus Joachimus Prechtelius] describes a certain pyrotechnic tow, in his *Pyrotechnica*, Part Two, Chapter Two, which burns more slowly than any of the others, in this way. Take 2 parts mastic, 1 part colophony [Greek pitch / rosin], 1 part wax, 2 parts saltpetre, $\frac{3}{4}$ part charcoal [carbo]. Those that can be pounded and softened should be crushed and reduced to the finest flour. Then let all of it, well mixed together, be melted over the fire. Next, draw some linen or hemp thread, a little on the thicker side, through the melted material, pressing it down to the bottom of the vessel; and repeat this several times, until the thread takes on the thickness of an ordinary wax taper. When you wish to use it, light the wick first, then extinguish the blazing flame, leaving only a glowing coal.

CAPUT III.

Iatro-chemical procedures [Praxes Iathrico-Chymicæ].

On several well-proven antidotes against burns caused by gunpowder, sulphur, red-hot iron, molten lead, and other such things.

Gathered from various pyrotechnic authors — Siemienowicz [Siemienovius], Tartaglia, Paracelsus, and Quercetanus [Joseph Duchesne].

PRAXIS I.

Let hog's lard [axungia porcina] boil in common water over a slow fire for several hours. Then, taken out, let it be exposed for three nights to a clear sky. Next, put into an earthenware vessel, let it melt over the fire; let it be strained through linen into cold water; and, after being washed several times and thoroughly purified, until it becomes perfectly white, let it be kept in an earthenware or glass vessel. Afterward, when need requires, let the burned spot be well anointed with it.

PRAXIS II.

Take: water of plantain [aqua plantaginis], oil of Italian walnut [oleum nucis Italicæ], of each a sufficient quantity [ana q. s.].

PRAXIS III.

Take: water of mallow [aqua malvæ], rose water [aqua rosarum], plumose alum [alumen plumosum], of each a sufficient quantity; let them be mixed with the white of an egg.

PRAXIS IV.

Take lye [lixivium] prepared from quicklime alone and common water. To this add a little hemp oil [oleum cannabinum], olive oil [oleum olivarum], linseed oil [oleum lini], and several egg whites. Stir everything well, and let the burned spot be anointed. All these ointments heal burns without any pain and leave no scar. "I have proved it on my own person," as Siemienowicz says.

From the authors Paracelsus, Quercetanus [Joseph Duchesne], Tartaglia, and others.

PRAXIS I.

Take: 1 part olive oil, 1 part oil of sweet almonds [oleum amygdalorum dulcium], 2 parts juice of onions [succus cæparum], 1 part liquid varnish [vernix liquida]; anoint the afflicted spot.

Boil abundantly in olive oil from the second bark of elder [sambucus]; then strain it. Add 2 parts white lead [cerussa], and 1 part each of burnt lead [plumbum ustum] and litharge [lithargyrium]; let them be mixed a long while in a lead mortar, and let a liniment be made. The blisters [vesicæ] are to be broken neither on the first nor on the second day, but on the third or fourth; for sometimes they are healed by dissolution alone. Leonardus Botallus, *On Gunshot Wounds [de vulneribus Sclopetorum]*, Cap. 21.

PRAXIS II.

Take: of melted bacon-fat [lardum liquefactum] taken up with nightshade water [aqua solani], 3 ij; oil of Saturn [oleum saturni, i.e. of lead], 3 j; mix.

Or take: of birdlime [viscum], root of henbane [radix hyosciami], and red poppy flowers [flores papaveris rubri], of each 3 j; saltpetre [sal petræ], 3 j; with oil of camphor [oleum camphoræ] make a liniment.

Or take: of onion juice, the onion cooked under the ashes, 3 ij; oil of walnuts [oleum nucum], 3 j; mix.

Or take: of leaves of black ivy [hedera nigra] pounded with plantain water, m. ij [two handfuls]; oil, ℥ j [one pound]; let them be boiled with 3 iiij of white wine until it is consumed; toward the end add as much wax as suffices to make a liniment.

Or take: of bacon-fat melted at the flame, and taken up with juice of beet [beta] and rue [ruta], 3 ij; cream of milk [cremor lactis], 3 j; mucilage of quince seed [semen cydoniorum] and of tragacanth, of each 3 ß [half a drachm]; mix. Joseph Quercetanus [Du Chesne], in his book *On Gunpowder for Firearms [de Sclopetario pulvere]*.

CAPUT IV.

Procedures for the compositions of rockets of every kind — which the Italians call *Raggi* and the Germans *Raketten* — according to the mind of Siemienowicz [Siemienovius] and of the other pyrotechnicians who devote their effort to making powder.

COMPOSITIO I.

For 100, 80, and 60 lb.

Saltpetre 30 ℥, charcoal 20 ℥, sulphur 10 ℥.

Here the proportion of saltpetre to the other two is equal; that of charcoal to sulphur, double. The same composition can be used without any scruple for all other rockets that fall in between, up to 60 pounds. For it is safer to have given them a somewhat slower material, even though they could have carried a more violent one — since in pyrobolic matters one errs more happily by deficiency than by excess. And a deficiency can very easily be corrected by adding more violent material, provided that, before you have made many rockets and loaded the material, you have been advised by the success of one about the rest.

COMPOSITIO II.

For 50, 40, 30 lb.

Saltpetre 30 ℥, charcoal 18 ℥, sulphur 7 ℥.

Here the proportion of saltpetre to the other two is one-and-one-fifth [sesquiquinta]; that of charcoal to sulphur, double plus four-sevenths [dupla super partiens quatuor septimas].

COMPOSITIO III.

For 20 and 18 lb.

Saltpetre 42 ℥, charcoal 26 ℥, sulphur 12 ℥.

Here the proportion of saltpetre to the other two is the superbipartiens of nineteenth [i.e. $1 + 2/19$]; that of charcoal to sulphur, double plus one-and-one-sixth [dupla sesquisexta].

COMPOSITIO IV.

For 15 and 12 lb.

Saltpetre 32 ℥, charcoal 16 ℥, sulphur 8 ℥.

Here the proportion of saltpetre to the other two is one-and-one-third [sesquitertial]; that of charcoal to sulphur, double.

COMPOSITIO V.

For 10 and 9 lb.

Saltpetre 62 ℥, charcoal 20 ℥, sulphur 9 ℥.

Here the proportion of saltpetre to the other two is double plus four-twenty-ninths [dupla superquadrupartiens vigesimas nonas]; that of charcoal to sulphur, double plus two-ninths [dupla superbipartiens nona].

COMPOSITIO VI.

For 9, 8, and 6 lb.

Saltpetre 35 ℥, charcoal 10 ℥, sulphur 5 ℥.

Here the proportion of saltpetre to the other two is double plus one-and-one-third [dupla sesquitertial]; that of charcoal to sulphur, double.

COMPOSITIO VII.

For 5 and 4 lb.

Saltpetre 64 ℥, charcoal 16 ℥, sulphur 8 ℥.

Here the proportion of saltpetre to the other two is double plus one-and-a-half [dupla sesquialtera]; that of charcoal to sulphur, double.

COMPOSITIO VIII.

For 3 and 2 lb.

Saltpetre 60 ℥, charcoal 15 ℥, sulphur 2 ℥.

Here the proportion of saltpetre to the other two is triple plus nine-seventeenths [tripula super partiens novem decimas septimas]; that of charcoal to sulphur, seven-and-one-half [septula sesqui altera].

COMPOSITIO IX.

For 1 lb.

Powder [pulvis] 32 ℥, charcoal 6 ℥, sulphur 2 ℥.

Here the proportion of powder to the other two is quadruple; that of charcoal to sulphur, triple.

COMPOSITIO X.

For 18 lotones and ½ lb.

Powder 18 ℥, saltpetre 8 ℥, charcoal 4 ℥, sulphur 2 ℥.

Here the proportion of powder-with-saltpetre to the other two is quadruple plus one-and-one-third [quadrupla sesquitertia: $4\frac{1}{3}$]; that of charcoal to sulphur, double.

COMPOSITIO XI.

For 12 and 10 lotones.

Powder 30 lotones, saltpetre 24 lotones, charcoal 8 lotones, sulphur 3 lotones.

Here the proportion of powder-with-saltpetre to the other two is quadruple plus the superdecupartiens of elevenths [$4 + 10/11$]; that of charcoal to sulphur, double plus one-and-a-half — that is, $2\frac{1}{2}$.

COMPOSITIO XII.

For 6 and 4 lotones.

Powder 24 lotones, saltpetre 4 lotones, charcoal 3 lotones, sulphur 1 loton.

Here the proportion of powder-with-saltpetre to the other two is sevenfold [septupla]; that of charcoal to sulphur, triple.

COMPOSITIO XIII.

For 2 and 1 loton.

Powder 30 lotones, charcoal 4 lotones.

Here the proportion of powder to charcoal is seven-and-one-half [septupla sesqui altera: $7\frac{1}{2}$].

COMPOSITIO XIV.

For $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{8}$, and $\frac{1}{12}$ of a loton.

Powder 9 or 10 *lotones*, charcoal 1 *loton*, or $1\frac{1}{2}$.

These are the smallest rockets, called "runners" [*currentes*], which can be loaded with ground powder alone, without charcoal. The drive [*ictus*] is then put in from another, best granulated powder. Now a *loton* is nothing other than half an ounce.

PRAXIS I.

On producing a fiery rain, and on the various colors.

To stir up a fiery rain and cloud, and sparks falling in great abundance, and long broad rays in the rockets while they burn, small quantities are usually mixed into the rocket compositions — either of pulverized glass, or of iron filings [*scobs ferrea*], or of wooden sawdust [*ferrago lignea*]. Different colors, too, can be represented in the rockets' fires. Thus: if you mix certain portions of camphor into a composition, it will produce a white, pale, milky fire; Greek pitch [*pix græca*], a red or coppery one; sulphur, blue [*cæruleum*]; sal ammoniac [*sal armoniacum*], green; crude antimony [*antimonium crudum*], a reddish, honey-colored, or boxwood-colored one; ivory filings [*scobs eburnea*], a silvery and bright white, though somewhat livid or leaden; filings of amber [*scobs succini*], a yellow and citron color; and finally hard ship's pitch [*pix dura navalis*], a black smoke, dusky and darkening the fire.

CAPUT V.

On recreational water-globes, that is, globes that burn while floating in water.

PRAXIS I.

Let a wooden globe of any size be prepared, hollow within and perfectly round. Let the thickness of the wood be everywhere $\frac{1}{9}$ of the diameter AB, as it is here in AC, or BD. On top let it have a convex cylinder whose thickness at the diameter EF is $\frac{2}{5}$ [?] of the diameter AB. The width of the priming-hole [*foramen accensorium*] CH should not exceed $\frac{1}{3}$ of the diameter. Below, together with the bung [*epistomium*] IK — through which the material for loading the globe is poured in, and through which an iron striker [*ictus*] is set in, made from an iron plate bent

into a cylinder and packed full of strong granulated powder (such as is shown under M) — let it be made equal in width to the upper cylinder. Then let it be loaded with one of the aquatic compositions given below, and let the bung be closed with liquid pitch in the manner of a stopper. Over this pour such a quantity of molten lead that the watery globe will be of such weight as to be in equal balance with a mass of water, or to slightly outweigh it. Why this is done we shall give an exact account at the end of this chapter. At last the globe, now fully prepared in every way, is pitched over with melted pitch. Then, when need urges, fire is admitted through the opened priming-hole; and once the material has properly caught the flame, it is thrown into the water. After the powder is lit, this globe will indeed stir up great commotions in the water, yet without any flame, but from the violent surge of the powder there ignited, the surge lasting within the sphere. As for those who say that flames belch forth under the water, they are to be laughed at.

PRAXIS II.

On scented little water-globes [globuli aquatici odoriferi].

Have little hollow wooden globes turned on a lathe, the size of an Italian walnut or a wild apple. Load these with one of the following compositions. Then, in some bedchamber or other enclosed place that is not too spacious and wide, light them and throw them into water — but first inserting into the opening a little fuse twisted from pyrotechnic tow, so that the material with which you have loaded the globe may be more easily kindled. The compositions are as follows.

Take: saltpetre ʒ iiij, storax calamite [storax calamita] ʒ j, frankincense [thus] ʒ j, mastic ʒ j, amber [ambra] ʒ ℥, civet [zibethum] ʒ ℥, juniper filings [serrago juniperi] ʒ ij, cypress filings [serrago cupressi] ʒ ij, oil of spikenard [oleum de spica nardi] ʒ j.

Or take: saltpetre ʒ ij, flowers of sulphur [flores sulphuris] ʒ j, camphor ʒ ℥, pulverized amber-shavings [succini ramenta pulverificata] ʒ ℥, charcoal of linden [carbo tiliæ] ʒ j, flowers of benzoin [flores belzoi] or of sweet asafoetida [asa dulcis] ʒ ℥. Let those that are to be ground be ground and pulverized thoroughly, and mixed together.

CAPUT VI.

Other procedures [Praxes aliæ].

On fiery compositions for festival days.

PRAXIS I.

You may light many candles with a single thread, if you first smear it — once it has been moistened with water — with sulphur and orpiment [auripigmentum] dissolved in oil. But each must be purified, for nothing burns from a thin or feeble fire until it has been moistened with water. They call this the Ointment of Hermes [Unguentum Hermetis]. Cardano [Cardanus], *de rerum varietate*, lib. 10, cap. 40. Della Porta [Porta] also attests the same, lib. 12, cap. 11, in these words: "Boil sulphur," he says, "and orpiment with oil, and let the thread boil in them; once dried, let it be tied to the wicks of candles and run across, for from one end lit the flame will run through all and set them alight." This is customarily done on festival days among the Turks, and most people call it the Pigment of Hermes.

But if you take one part of saltpetre [halinitrum] and add a fifth part each of frankincense, common oil, and milky spurge [lac lathyridis], a tenth part of sulphur and of wax, you will make a half-candle that will be marvelous in color, smell, motion, and crackling; nor are these without their reason. Others fill half an eggshell with quicklime, and adding a part of gunpowder on top, close it with wax and place it in the coldest water, for very often the fire is kindled and a flame flashes out. Cardano, *ibid.* But if you wish to throw a flame at a distance, pound colophony, frankincense, or amber finely, entrust it to the palm of your hand, and then let a lit candle pass between your fingers; and while you throw the powder upward, let it pass through the candle's flame, for the flame will lift itself on high. Della Porta, lib. 12, cap. 12.

If camphor [caphura] is dissolved in spirits of wine [aqua vitæ], and from it little strips of parchment are smeared and dried and lit, and let fall from a height, fiery serpents will be seen creeping through the air, not without delight. Della Porta, *ibid.*

So that the whole air of your bedchamber may catch fire as you enter it, take a large amount of well-rectified spirits of wine, and throw into it camphor cut up small, for it will quickly dissolve in it. Once it is dissolved, close the windows and doors of the chamber, so that the exhaling vapor does not breathe out; then let a vessel full of water boil over coals placed beneath without flame, until all the water dissolves into a smoke that fills the chamber and is so fine that it can

scarcely be seen. Let someone be made to enter the chamber carrying a lit candle, for the air, on seeing the candle, will all burst into flame, will set the whole chamber ablaze, and — to the entrant's greatest terror — will present the appearance of a burning furnace. If musk, or the least bit of amber, is dissolved in the water, a most powerful scent will follow the flame. Della Porta, *ibid.*

PRAXIS III.

*On the compositions for loading water-globes, that is, globes burning in water.
From the Pyrotechnia of various authors.*

1.

Saltpetre reduced to flour, 16 lb.; sulphur, 4 lb.; wooden sawdust, first boiled in saltpetrous water and dried, 4 lb.; granulated gunpowder, $\frac{1}{2}$ lb.; ivory filings, 3 4.

2.

Saltpetre, 6 lb.; sulphur, 3 lb.; ground powder [pulvis tritus], 1 lb.; iron scrapings [ramentum ferri], 2 lb.; Greek pitch, $\frac{1}{2}$ lb.

3.

Saltpetre, 24 lb.; ground powder, 4 lb.; sulphur, 12 lb.; wooden sawdust, 8 lb.; filings of amber, $\frac{1}{2}$ lb.; pulverized glass, $\frac{1}{2}$ lb.; camphor, $\frac{1}{2}$ lb.

The manner of preparing all of these is the same as we described for the rockets, except that here the material need not be so finely ground, nor pulverized or sifted; but it should still be very well incorporated by much mixing, and not too dry when it is put into the globe. And for that very reason it should be moistened with either linseed oil, or olive oil, or petroleum, or hemp oil, or oil of walnuts, or some other—

moistened with some other fat that readily catches fire.

Note. Besides these compositions, which pyrotechnicians admit they have used quite often, anyone can easily devise yet another, simply by taking the same materials in different proportions to one another. But the composition should be tested by trial as often as possible before it is put to pyrotechnic use. It is, moreover, of the greatest importance — both for arriving at a sound mixing of the aquatic compositions, and for gaining a general knowledge of the power and potency of each one already prepared — to have a thorough, item-by-item familiarity with the nature, virtues, operations, and properties of every single material commonly used in the aquatic compositions, not just the ordinary kind. For as Aristotle says (*Physics* I, ch. 20 [*recte*: I.1]), universal knowledge is acquired

from particulars already known. The following observations, then, on the individual materials should be noted.

Gunpowder [pulvis pyrius] is the first and principal ingredient, and a material most violent and ferocious in burning; hence it resists every moisture powerfully, so that its flame is not smothered.

Second place is held by saltpeter [salnitrum], well clarified and purified — whose nature I described above, and whose incredible power in gunpowder I have set out. In the aquatic compositions, nonetheless, when combined with the other materials, it carries a certain special secret virtue for scattering and spreading far and wide the watery droplets that glide over the surface, on account of the many — and most violent — blasts and winds with which it is full, this being its function and office.

PRAXIS II.

On a fiery mixture that the Sun can ignite.

Take oil of turpentine-resin, native sulphur, juniper, naphtha, colophony of flax, and camphor, pitch, halonitre [halonitrum], and duck's fat; of water of life [aqua vitae] twice the amount of all the rest. Let everything be purified of its phlegm, then all pounded together, and the mixture stored in a glass vessel and left to ferment under dung for two months, the dung being continually renewed and at the same time re-mixed. When this period has elapsed, let them be distilled. Then let the liquor be thickened with gunpowder, or with pigeon dung finely sifted. Wood smeared with this mixture and exposed to the summer sun catches fire of its own accord. Duck's fat is wonderfully effective for incendiary fires, because it is exceptionally subtle, penetrating, and hot; and the excremental dregs of pigeons readily conceive fire from the rays of the sun. I have seen this secret, set out on the bridge of Sant'Angelo in the month of July, meet with no small success.

PRAXIS III.

On balls that burn under water.

The way in which such balls can be prepared is reported by Porta, *Magia naturalis* XII, ch. 6.

First take gunpowder, which — if it is granulated — should be ground very fine and passed through a sieve. To seven parts of this add two of colophony, three of saltpeter [halinitrum], one of sulphur; let everything be ground and mixed together,

not without a sprinkling of naphtha or of liquid Ritran pitch [picis Ritran], moistening it just until the powder, pressed in the fist, coheres of itself. Let this mixture be wrapped in straw or in tiles, or else packed into pouches made of the said materials, and bound about as tightly as possible with cords; then let it be plunged into boiling pitch, and care taken that it dry out, and again, protected with straw, let it be smeared over with pitch, lest it be either dissolved by the moisture of the water or burst apart by the force of the fire. When it has duly dried, let gunpowder be inserted into the small hole through which it was kept open, and fire applied; and at once, while the devouring flame begins to burn, let it be cast into the waters. By its own weight it will seek the bottom; but, fighting the waters with its flame-vomiting violence and pushing them away from itself on every side, wrapped in black smoke, it appears to seethe from below. Rendered lighter thereby, it is carried up again through twists and winding turns to the surface of the water, so that the wave appears to burn in a most delightful spectacle — as though Neptune were besieging on every side a Vulcan that bore arms against him within the domain of his own empire, and at last, as the Vulcan languished for want of fuel, were pressing on to victory and the enemy's destruction, and finishing him off. Thus far Porta.

For my own part, I do not deny that balls of this kind can burn at the surface of the waters without danger of being extinguished. But that a flame-vomiting fire can endure in the depths of the waters I can by no means admit; since it cannot happen that, without air, fire can be preserved in the very midst of the water, as I have shown elsewhere by various experiments. At the surface of the water, however — just like ignited camphor, with which I often amuse myself — it will burn with no hindrance from the water; yet if you submerge it even the slightest bit, the flame is at once extinguished. I do not therefore deny that globes of this kind, in their struggle with the water and the air, cause great commotions and tremblings of the waters among the waves before all their heat vanishes; but that a flame under the water was ever seen by anyone — that I deny, both the one claim and the other.

PRAXIS IV.

On artificial fires that are kindled by water.

That naphtha burns in water, and likewise its species camphor, I have often said in what precedes, and Porta attests it (*Magia* XII, ch. 20), adding that certain old women of Mantua [exavio — *recte* ex Avio? (?)] once crossed the Tiber in their games with torches kindled from this material, to display a marvel to those

expecting and watching. Cardano [Cardanus] recounts three ways of making fires of this kind (*De subtilitate* II, pp. 36 and 37) in these words: *They consist, he says, of ship's pitch and Greek pitch, sulphur, lees of wine — which they call tartar — sarcocol, saltpeter [halinitrum], that kind of bitumen which they call petroleum; quicklime is added in double weight, and all are mixed together with egg yolks and buried in horse dung. Another, of sulphureous oil, of petroleum, of juniper oil, and of saltpeter [halenitrum], equal parts of each; of black pitch, fat of goose and of duck, of pigeon droppings, of that liquor which they call liquid varnish — it consists of oil of flaxseed — again equal amounts of each; of asphalt five parts; take it up in burning water [aqua ardens], and bury it in horse dung. Another, of liquid varnish, sulphureous oil, juniper oil, and that which is made from flaxseed and petroleum, and of the tear of larch [lachryma laricis], equal parts of each; of burning water three and a half; of saltpeter [halinitrum] and dry laurel-wood reduced to powder, as much as suffices for all, mixed together, to take on the thickness of mud. Take all these up in a glass vessel, and bury for three months in horse dung. If, then, balls made from these cling to wood, they kindle spontaneously in the rain — but this does not always happen; what always happens, however, is that once it has been kindled, it is not extinguished by any waters. These are Cardano's fires that burn in the waters, from which those I reported from Scaliger [Scaligero] do not greatly differ.*

In this matter Porta, Cardano, and the rest [speak] about an artificial stone that is kindled by spittle alone or by rain. But I have never at any time, however intently I sought it, been able to ascertain the truth of the thing — as I have shown in various of my Works; and so I have judged it likewise to be assigned to those paradoxes which are reserved for the coming of Elias [Elias], until in the meantime experience by trial renders me firmer in believing. I know that the Sun's rays can kindle stubble, and even the driest material; but that natural water should kindle fire — this has not been seen up to now.

CAPUT VII.

On luminous globes, of the kind we are accustomed to use for recreational fires, called by the Germans *Lichtkugel*.

Luminous globes are of two kinds: recreational and serious — that is, warlike. Of the latter I now say nothing; but how the former are prepared must now be briefly stated.

PRAXIS I.

Take crude antimony 2 lb., saltpeter 4 lb., sulphur 6 lb., colophony 1 lb., charcoal 4 lb. — or: antimony 5 lb. [Antimo: lib. g], saltpeter 1 lb., charcoal 1 lb., sulphur 6 lb., colophony 1 lb., black pitch 6 lb. [Picis nigrae lib. g]. Of whichever of these two compositions — each material being first ground — put into a kettle or a glazed earthen vessel, and let it melt over blazing coals. Then put in as much tow of flax or hemp as will absorb the whole melted material, and, while it cools, from that tow make round little balls of whatever size will seem most suitable for your uses. Then, finally, surround them with pyrotechnic tow and pack them into rockets, or into recreational globes — both the aquatic kind and those usually thrown from mortars.

PRAXIS II.

On the stars and sparks of pyrotechnic fire, which the Germans also call *Sternfeuer*, *Feuerputzen*.

Pyrotechnic stars differ from sparks in this, that they are larger than sparks, and are not consumed by the fire so quickly as a spark, but shine somewhat longer in the air in the manner of stars. They are prepared by the following method.

Ingredient	Quantity
Saltpeter [Salnitrum]	1½ lb. [℥ ℔]
Sulphur [Sulphur]	2 ℥ij
Pulverized amber [Succinum]	1 ℥j
Crude antimony [Antimonium crudum]	1 ℥j
Ground powder [Pulvis tritus]	4 ℥iiij

Or take:

Ingredient	Quantity
Sulphur [Sulphur]	2½ ℥ij ℔
Saltpeter [Salnitrum]	6 ℥vj
Most finely ground powder [Pulvis subtilissime tritus]	5½ ℥v ℔
Olibanum, Mastic, Crystal, Sublimate of mercury [Mercurius sublimatus], Sinople(?) [Sin.] — of each	4 ℥iiij
White amber [Ambra alba]	1 ℥j
Camphor [Camphora]	1 ℥j

Ingredient	Quantity

Antimony, Orpiment(?) [Auripigmentum] [finus(?)] — ½ 3 ß
of each

Let all the materials, finely pulverized and sifted, be moistened with water of glue or of gum arabic, or of tragacanth; then let little balls the size of a hazelnut or a bean be made, which, dried in the sun or in a warm stove [hypocaustum], are kept for the recreational pyrotechnic uses of which I spoke abundantly above. This only is to be borne in mind: that when they are to be packed into rockets or recreational globes, they should be surrounded on every side with loosened pyrotechnic tow. Very often the pyrobolists are accustomed, in place of these little balls, to take small fragments of the melted material — of which I shall speak below, when I teach the method of preparing the fiery rain — wrapped in tow, for the customary uses.

If you also wish to construct other stars, which are not black like the preceding, but yellow, and inclining somewhat to white, then take:

Ingredient	Quantity
Gum tragacanth or pulverized and sifted gum arabic	4 3iiiij
Camphor dissolved in burning water [aqua ardens]	2 3ij
Saltpeter [Salnitrum]	½ lb. [lib. ß]
Glass pulverized not too finely	3 3iij
White amber [Ambra alba]	½ 3 ß
Orpiment [Auripigmentum]	2 3ij

Let little balls be made as before. This is from Siemienowicz [Siemienovius], drawn from Claude Mygdorius [Claudio Mygdorio].

The method and way of making sparks is this: Take saltpeter 1 3j, melted material ½ 3 ß, ground powder ⅙ 3 g [?], camphor two ounces. Each of the materials, first reduced to a fine flour, put into some little fig-wood bundle, and pour in tragacanth water or burnt wine [vinum adustum] in which you have first dissolved tragacanth or gum arabic,

—so that it may have the consistency of some liquid pottage. Afterward, [add] 1 3j of cotton [gossypium], steeped in vinegar or burnt wine and in a decoction of

saltpeter [that has been] dried and torn into tiny shreds; roll it about, having been put in there, so that it takes up and absorbs the whole material. Then from this make little balls in the manner of medicinal pills, the size of a pea, and, sprinkled with powdered flour, dry them; and, as you know how, use them afterward.

Besides these, certain fragrant pills are prepared, which are used in certain tiny pyrotechnic devices enclosed in skins [cuticulis] or other places destined for combustion. Let these be compounded from:

Ingredient	Quantity
Storax calamita, Benzoin gum [Belzoi Gummi], Juniper [gum] — of each	2 3ij
Olibanum, Mastic, Frankincense [Thus], White amber, Amber [succinum], Camphor — of each	1 3j
Saltpeter [Salnitrum]	3 3iij
Charcoal of linden(?) [Carbonum tiliae]	4 3iiij

All are ground, pulverized, and well incorporated, and moistened with gum arabic or tragacanth dissolved in rose water; and the pills are made. Finally they are dried in the sun or by the heat of fire. So Casimir Siemienowicz [Casimirus Siemienovius] in his *Great Artillery* [Artilleria magna].

Camphor is a fire utterly inextinguishable in water; and apart from camphor this has been granted by nature to no other fatty, oily, or bituminous material — to burn so stubbornly in the wet without help from anything else, so that it seems to wish to exercise an almost despotic dominion. For when it is packed about on every side with ice or snow and kindled (the fire being nonetheless left a gaping vent to burst out through), it melts both [ice and snow] and is not extinguished in any way until it is wholly burned up. Pulverized and cast upon water, it likewise burns not unpleasantly, since it appears as though the very water on which it floats (by reason of its lightness) were burning; and it easily conceives fire — not because it is hot, but because it is rare and fatty. Hence this too is marvelous: that if it be cooked in a bronze basin set over burning water with glowing coals placed beneath, all the moisture vanishes — in a place suitably large and well closed up, so that not even the least chink remains, whether in the walls or in the ceiling, [and] the whole rarefies into the most subtle air. But when, the door being opened, a kindled torch is brought into that chamber, at once that whole air contained within conceives flame, and, without any harm either to the building or to the spectators, it burns off very gently, in the manner of lightning. The cause

of this is the rarity of the fiery substance; for fire does not burn except by the compression of parts. Hence also, in our paper [held] in this flame, [the flame] is so diluted that we may pass a hand through it without injury; and in burning water it is so thin that it leaves unharmed a linen cloth moistened with it.

[Margin: A marvelous spectacle.]

Hence once, when I had fashioned a piece of ice into the form of a candle, and — the icy cylinder having been bored through — had filled it to some extent with camphor, when that was kindled it burned, just like a candle of wax, with a most limpid light, as long as anything of the camphor remained; which thing carried those ignorant of the secret into no small wonder. Camphor is, by reason of the vivacity of its spirits, so mobile that, unless it be bound together with grains of pepper, it easily passes wholly into vapor and vanishes.

CAPUT VIII.

On various exhibitions of spectacles to be set up by the aid of the pyrotechnic art.

PRAGMATIA I.

To display a flying dragon.

It is commonly known how many people throw into the air a dragon fashioned from light paper, and lead it, by a cord tied to it, wherever they wish — even into the highest spaces of the air, to the utmost admiration of those ignorant of the matter. See what I treated at length on this device in the *Musurgia*. So then, within it [place] a few rockets [rochettae], chiefly at the neck and in the tail; then, a candle being kindled inside at night, [the dragon] will present the whole dragon as fiery, through the paper tinged with oil and steeped in a red and fiery color. You will also kindle inside a lit fuse [fomes], which reaches the mouths of the rockets; and when the fire touches these, at once the dragon spews fire fore and aft, to the great astonishment and fear of those who have not seen the device — [a dragon] which will be the more terrible the more certain words written in foot-and-a-half-high letters [sesquipedalibus literis] are inscribed on the dragon's sides. But this device should be exhibited in the dead of night and with a strong wind blowing; for in calm weather the machine is not easily animated.

Diagram. A woodcut showing a flying dragon (a kite in dragon form) launched into the air on a cord, held by a man standing at lower right who tends the line. The dragon's body bears an inscription.

- On the dragon's body: **TRA DEI** [?] (the two readable letter-groups of an inscription across the dragon's flank; the full word is not resolvable [?])
- Lower right: a standing man holding the cord that tethers the dragon

PRAGMATIA II.

To represent an eagle in the air.

Although an eagle can be expressed in the air in the same way as the dragon, there are nonetheless certain pyrotechnicians who would exhibit one in the air constructed of rockets as well — as I remember having seen myself in Germany. They form the eagle, constructed of rockets, in such a proportion of powder that one rocket does not throw the fire higher than another, but in accordance with the proportion of the feathers in the wings. Then they steep the whole body of the eagle in powder, water of life, and camphor; this material, raised on high by the force of the principal rocket and kindled, exhibits a perfect eagle in appearance, which the explosion of the rockets — indeed the very smoke — then expresses in the air. In this manner you will be able to exhibit anything whatever; for the powder-material, mixed with the rest and sprinkled over the surface of a statue or any figure at all, burns gently, and together with its little flames exhibits the perfect figure.

This invention is full of wonder, and wonderfully suited to terrifying enemies by this spectacle — especially if it is set up with letters expressing some name in the air. It does require an industrious, skilled craftsman, in order that it may attain the desired success; for the machine must be perfectly balanced, then thrown into the air in a perpendicular position by the force of a principal rocket of strength sufficient to raise the machine to a notable height.

Diagram. A woodcut of a heraldic eagle with spread wings (double-headed), constructed from a frame of rockets, viewed frontally. No labels.

PRAGMATIA III.

To express a rotating wheel in the air.

Above the pinnacle of some tower or temple, let a wheel of any size be made, set on an iron pivot [ferreo obelo] so that it can be turned without difficulty. At the

center of the wheel you will be able to fit any figure whatever — an Imperial eagle, the name JESUS [JESU] or MARY [Mariae], or even any statues you wish, made of transparent paper and illuminated by a candle placed inside. A machine of this kind can exhibit a beautiful spectacle in two ways: either by wind or by fire. It is driven by wind if you fix little vanes [scamilli] of light wood on the outer edges of the wheel, against which the wind — whether natural, or artificial, from an Aeolian machine — striking, will turn the machine, as is shown in the first Figure. You will animate the machine with fire thus: you will fit rockets on the surface of the wheel in such a way

Diagram. A woodcut showing the fire-driven wheel: a vertical standard topped by an ornamental crown/foliate finial, with a horizontal octagonal wheel rim from which rockets project tangentially; at the right a large rosette-like burst (flame/smoke) is shown. This corresponds to the wheel animated by fire.

—that they hold an oblique position; these, then, being kindled, will drive the wheel in circles together with the figures placed upon it, as you see in the second Figure.

Diagram. A woodcut showing the wind-driven horizontal wheel mounted on a low frame, with a figure of a man standing upright at its center (the statue/figure to be illuminated), and angled vanes about the rim. This corresponds to the "second Figure" / wheel driven by wind.

PRAGMATIA IV.

To display a pyrobolic organ in the air.

Let rockets be made in the order in which pipes are usually arranged in an organ, and filled with such a proportion of powder that the one which is smallest, kindled first, emits its boom [bombus], and the one next longer in order a little after, another, and the third in order a third, and so on in order, each one after another emits its booms; and you will have a pyrobolic organ, which, disposed somewhere on the height of a tower and illuminated with fire, affects the spectators with wonderful delight. Whoever has rightly understood these few points will be able to exhibit anything whatever in the air by the pyrobolic art. Wherefore I have set these things out not so much at length as merely indicated them in a few words, in order that I might offer ingenious craftsmen some occasion for greater inventions.

Diagram. A woodcut of the "pyrobolic organ": a row of upright pipes (rockets) of graduated, increasing length mounted side by side on a base, in the form of an organ's pipe-rank.

PARS ULTIMA.

On the Secrets of Certain Mechanical Arts, Established after the Pattern of Subterranean Nature.

CAPUT I.

The Art of the Goldsmiths and of the Other Craftsmen Who Work with Metals.

Goldsmiths are occupied chiefly with gold and silver in the making of precious vessels. The nobler the material they work with, the more excellent their art is above the rest. They must therefore be furnished with a great expertise in metallic matters, sufficient to satisfy the demands of their office, and they must possess that knowledge of chemical secrets which, when the occasion arises, they can put on display.

It is accordingly their business: to reduce gold and silver—when crude, stiff, and brittle—to a certain ductility and flexibility suited to the hammer; to weld broken vessels neatly together again; to adorn ornaments, rings, and gold and silver coins with the art of enamelling [encausto]; to know the different kinds of gems together with their value and price, and to set these skilfully into rings; to strike gold and silver statues; and to be thoroughly versed in the spagyric art [Spagyrica], so that with ingenious skill they may melt down metals and separate one from another, whether by aqua fortis [aquas fortes] or by the cineritious crucible they call the cupel [catinum cineritium, quam cupellam vocant], purifying each to its highest perfection. Hence no one ought to be reckoned fit for this art unless he is well endowed with judgment and experience in these matters.

Since this is so, and since they possess certain secrets that are not everywhere ready to hand, I have thought it worth communicating here to the reader those which I have learned through long and continual dealings with such men.

The first question, then, is: **How do they render gold and silver soft and gentle?** I answer that they do this in the following way. Gold is sometimes rendered so crude and stiff by the smell of lead or arsenic that it scarcely yields to the hammer. When such a defect occurs, to the said gold—melted in a crucible—add

glass powder, or some portion of alkaline salt [sal alchali] mixed with wax, or even three or four little portions, as much as can be taken up between two fingers, of ground sublimate [sublimati triti]; then let them be well heated. And although this hardened mixture may not yet have acquired the desired colour of gold, you will nonetheless easily restore it, if—after reducing the gold to thin plates—you smear it with verdigris [aerugine] mixed with sal ammoniac, urine, and vinegar, and then, heated again over coals, it is thrown into urine. By doing this you obtain what you sought.

Silver too is washed, chiefly in works overlaid with gold, if it has been boiled in water with ground sulphur. Some imbue gold and silver with a bright lustrous colour by boiling them together with the shavings of ox-horns and ram's-horns, with ground straw, and the smoke of feathers.

Silver is brought to a pliant and malleable softness in the same way. If it is too stiff and crude, once they have put it into the cineritious crucible [cineritio catino], or have steeped it by melting it with salt, tartar [tartaro], ground niter, alkaline salt, and the other methods devised by the spagyrist, they take particular care that the welding-mass [massam ferruminativam]—which they call solder [soldaturam]—be no harder than the object to be welded requires. They readily correct this, with a reduction of the carat [diminutione caratti], either by alloying it with silver, or by adding to the gold or silver a little borax or verdigris with copper or brass [aurichalco].

Concerning works to be finished by enamelling [encausto], so highly necessary to the skilful goldsmith, we have spoken above—though few are found who are expert in this art. In Germany and France no goldsmith of good repute is reckoned such unless he is strong in this skill. Besides what has been said, they possess the art of overlaying every kind of metal with gold; but I shall disclose some of their secrets.

1. They prepare gold for gilding thus: they take one fifth part of pure gold beaten out with the hammer, to which they add [?]¹—of mercury [[?]] quantity not legibly given before "mercurii"; they mix it well, then commit a small pot [tigillum] to the fire, and when it has grown hot, they cast the mixture of gold and quicksilver into the pot. Once the mercury has evaporated, they throw the remaining gold into a small dish [scutellam] filled with cold water; and in this way they have washed gold [lotum aurum] for gilding metallic works of every kind. [Margin: Method of gilding.]

For if they wish to gild copper [aes], they smear the copper plate, a little beforehand, with gold prepared as above, and leave it set out upon coals until it shines with a golden colour; then, taken out and cleaned with vinegar applied by a brush [setaceto], they polish it. [Margin: Gilding of copper.]

They gild iron in this way: they first boil the iron, placed in vinegar mixed with salt and vitriol; then, drawing it out, they smear it with gold prepared a little before. [Margin: Method of gilding iron.]

2. The method of separating silver from gold they observe thus: they perfume the gilded silver with sulphur placed around it, then they take [Margin: Separation of silver from gold.]

mercury, which they place in a small pot, into which they cast the gilded silver while heated; and at once separation follows, the mercury drawing to itself the gold that lies hidden in the silver. The silver, on the other hand—now stripped of its gold—is restored to its original nature simply by boiling it in water made of tartar. The gold they separate from the mercury by this device: they expose to the fire, in a small pot, the gold impregnated with mercury, and in this way, the mercury evaporating, the gold will remain; and this, purified in the cineritious crucible, is restored to its former brightness. [Margin: Separation of gold from metals.]

3. How gold may be separated from gilded metals. It is an artifice of great usefulness to recover the gold laid over metals and over wooden panels. Proceed thus. First take a large crucible, which, filled with mercury, is to be heated over the fire in a little chemical furnace [furnulo chymico]; and when it has begun to boil, let the gilded body be sent into that mercury. Then rub it with an iron brush [ferreo setaceto] for so long until you find that the mercury has drawn all the gold to itself. This done, take out the mercury, put it into a leather purse [coriaceae bursae], and squeeze it for so long until all the mercury has flowed out. And when this is done, what remains in the purse is gold separated from the mercury, in the form of sand; which, evaporated by being set over coals, is restored to its former state.

Another way of separating gold from gilded metals is this: let the metals be covered in a small pot with live sulphur [sulphure vivo] ground to powder; and when it has stood a while in the fire, you will pour it out into a crucible [catinum] and gather up all that which, together with the sulphur, is scraped off from the gilded metals—this will be gold in the form of a leaf [foliati] clinging to the sides of the pot. This done, you will separate the gold from the burnt sulphur by means

of the cinder-crucible or cupel with lead, just as we have already taught in various places in the preceding books.

A third method is by means of an aqua fortis compounded of saltpeter [salenitro], alum—commonly called *alum of Rocca* [Aluminze vulgo di Rocca]—vitriol, sal ammoniac, and a little verdigris. This water, by its caustic force, will begin to gnaw the gold residing in the gilded metals; and once it has drawn into itself all that has been consumed, you will let the water, now saturated, evaporate in a glass vessel set in the little furnace, and the gold will remain at the bottom. These are the three methods by which gold, in gilded objects—whether of metal or of wooden panels—is separated not without profit.

4. From the dross or refuse of the ores of gold and silver already smelted [loppis sive quisquiliis minerarum], which seem to serve no further purpose, the metallurgists are accustomed to separate gold and silver with the greatest gain. The smelters of metals call this mineral matter of gold and silver "dross" or "refuse" or "dead bodies" [corpora mortua], and everywhere cast it away as useless. How, then, they are accustomed to extract gold and silver from these, I shall here teach, and impart to the reader as a secret of great profit—one which consists in the wondrous virtue and power of mercury alone.

Let a mill be made of roughly the form which painters are accustomed to use in grinding gypsum or chalky material. Let there be a marble vessel **A**, into whose cavity is put another very hard stone, of the kind that millstones are, to which you give a handle at **C**—a handle so fitted to the vessel **A** that the material to be ground may always be put in. With this hand-mill prepared, put in as much as you wish of the mineral matter or dross or refuse, first well ground; to it you will pour vinegar, or water diluted with sublimated sal ammoniac, verdigris, and common salt. Over this you will then pour a good quantity of mercury, until the whole material is covered by it; and by working the mill for the space of one or two hours let it be most thoroughly kneaded. And the better the material is ground, the more readily will the mercury accomplish its effect, drawing into itself whatever gold lay hidden there. The mercury, then, washed with water and purged of earthy refuse, is placed within a crucible, where, roasted by the fire, it flees and passes off into vapor, leaving the gold at the bottom; or—what amounts to the same—pressed out through a leather purse, it leaves the gold within the purse. I have known a good many Venetians to have come to the greatest riches by this method; for which reason they keep it as a great secret.

Since goldsmiths often have need of the calxes [calcibus] of metals, I shall explain in a few words how they are accustomed to calcine the several metals by chemical art; for they are sure and very fine secrets.

First. They resolve gold into a calx thus. Let there be made a vessel furnished with a long neck, **A B**, into the bottom **C** of which lead is put; then upon the mouth of the vessel **A** set a gold coin or a plate, which you wish to resolve into a calx. Then let a fire be kindled in the hearth, by whose urging the lead is melted; let the fire be increased until fumes begin to rise up from the lead, which, acting continuously upon the gold coin, render it so morbid [morbidum] that, when the operation is finished, it is easily reduced to powder—though, saturated with borax, it is easily reduced again to its former substance. The reason for this is plain: for the mercurial spirits lurking in the lead, being fugitive, when they find no escape, act upon the gold coin, eat it away, and in this manner render it morbid; and this is the calx of gold. [Margin: Calcination of metals.]

Diagram. A tall, long-necked distillation flask or retort with a swelling bulbous body at the base and a narrow neck rising to a flared mouth at the top. Flames are drawn around the lower bulb. Labels:

- **A** (at the flared mouth / top of the neck): the mouth of the vessel, where the gold coin or plate is set.
- **C** (at the swelling base, partly obscured by the drawn flames): the bottom, where the lead is placed.

[The label **B** named in the text (vessel "A B") is not separately legible on the figure; only A and C are clearly marked. [?]]

Others do it thus: they put well-filed gold into the sharpest vinegar for nine days [ad novendium]; then they take it out to be dried in the sun. When dried, they grind it upon marble with water of sal ammoniac, and again set it out to be dried

—they set it out; and by repeating this seven times, you will have the calx of Sol [the Sun = gold] prepared. Others accomplish the same by pouring gold upon heated mercury; the mixture they then press with fire for so long until the fugitive mercury is separated from the gold. The gold that remains at the bottom—grind it upon marble with dissolved sal ammoniac, wash off the salt with fresh water, and you will have the calx of Sol.

Secondly. They calcine silver in exactly the same way as gold, by the vapor of lead or of mercury, to which calcined tartar and sal ammoniac are mixed, and

you will obtain the calx of Luna [the Moon = silver]. [Margin: Calx D / Calx of Luna.]

Thirdly. Venus, that is copper [aes], they calcine thus: they steep copper plates in vinegar diluted with common salt; these, when dried, they commit to the calcining furnace for three hours; then, taken out, they quench them with vinegar diluted with salt as before, and what was scraped from the plates and mixed with the vinegar is left within the salted vinegar. This you will carry on for so long until the plates are entirely consumed. This done, the vinegar being separated, you will find at the bottom of the vessel a powder, which they dry, ground and worked together with borax and tartar and the oil of the same; the dried powder they again commit to the fire for fusion, and the molten matter they receive in an iron vessel smeared inside with tallow; and when cooled they find it now white and soft, which is of much use for sophistic silver [sophisticum argentum]. [Margin: Calx of Venus.]

Fourthly. Tin, that is Jupiter, you will calcine thus: let tin plates be cut into small particles; then, within a pot strewn with quicklime, let the bits of tin be laid over the lime up to the top of the pot. Then, the pot being sealed with the lute of wisdom [luto sapientiae], as they call it, let it be placed in the calcining furnace for 24 hours. These elapsed, take out the tin, and let it, dissolved by fire, flow out into vinegar; this, then reduced to ash, you will coagulate after the operation has been repeated three times. Quench the coagulated mass in water of mercury, and you will find it hard like silver. [Margin: Calx of Jupiter.]

Fifthly. You will calcine Saturn [lead] if you pour molten lead into water prepared from a lye made of ashes. Within this water let it be quenched four or five times and then dried; the dried mass, put into a well-stopped pot, is committed to the furnace for the space of 24 hours; which, taken out, you will then find imbued with a green color—the true calx of lead, which the alchemists persuade themselves to be a short road to Sol. [Margin: Calx of Saturn.]

Sixthly. You will calcine iron in the philosophical manner thus. Let plates of well-purged iron be made red-hot, and let them be quenched seven times in linseed oil; and they will turn out soft, like wax. Cut these into small particles, then make layer upon layer, together with crude mercury, in a well-luted pot, which, set in the calcining furnace, is to be pressed with a strong fire for 12 hours; and at last take out the cooled material, which you will find glowing white like Luna [the Moon], and this you will keep in reserve. [Margin: Calx of Mars.] I could adduce here innumerable methods of calcining metals, but because we have set them

down everywhere else, I have thought fit to add in this place only those which I have learned by experience solely from goldsmiths and alchemists.

You will produce sophistic gold [aurum sophisticum] if you work the calx of Luna prepared above together with the calx of eggs [calce ovorum] and water of orpiment [auripigmenti], and, when dry, set it in the furnace. After this fourfold operation, take it out, and work it free of fume with water of sal ammoniac; then, set in dung [fimo], it will be resolved into a water, which you will strain through a filter into a glass vessel. The strained liquid, dry into a powder, one part of which is to be joined to 40 parts of well-purged copper, and you will have sophistic Sol. [Margin: Sophistic gold.]

You will make sophistic silver from one part of the calx of Luna, from 2 parts of fixed and sublimated mercury, together with as many parts of fixed and sublimated sulphur, and with water of mercury; and when it has been dried for the third time, you will repeat the same operation. This done, put it into glass, which—buried in horse-dung—you will keep until it dissolves into a water; it is then dried in the furnace of sublimation; the fixed mass you will work with water of mercury or of sal ammoniac; then, to putrefy it, you will bury it within dung; the putrefied mass you will commit to the furnace for 24 hours. Of this powder, half an ounce projected upon one pound of well-purged Venus [copper] will give you the desired sophistic silver. [Margin: Sophistic silver.]

Here too it would be proper to say how common salt, sal ammoniac, sal alkali, borax, and the like are to be prepared, together with their waters and oils. But since these are now everywhere to be had from the apothecaries and are treated in various chemical books, I have not wished to dwell upon them; here we adduce only what has been seen and proven.

On the Arts of Gilding, Ironworking, Coppersmithing, Wire-drawing, Tinwork, and the Like.

[De Arte Inauratoria, Ferraria, Æraria, Filatoria, Stannaria similibusque.]

Each of these arts has secrets not to be despised, for the softening, hardening, and tempering of iron, copper, tin, and the like. But since all these matters have been set down in Books IX and X, we refer the reader there—including the various methods of gilding silver, tin, copper, and iron, as well as the numerous methods of engraving [incidenda] upon those said metals, whatever ones you wish, by means of aquae fortes and caustic waters. But since these have become known by daily experience, I have not thought this work needs to be patched up with them.

The art of wire-drawing [Filatoria Ars], however, contains—I know not what—something admirable and paradoxical, in that gold, silver, copper, and iron (whereas tin and lead, on account of the limpness and dullness of the material, are not fit for being drawn into threads) yield threads that have altogether innumerable uses, both in the matter of clothing and in the rest of furnishings, the hangings [peripetasmatum] and ornaments of the temple—since nothing is held of value that is not interwoven with gold and silver thread.

Now there are three kinds of thread. Of the first kind are threads

most minute, fine, and round, such as the gold and silver threads that serve weavers, while the gold and brass [aerea] threads serve chiefly for musical instruments. Of the second kind are gold and silver threads which have a certain breadth, according to the nature of the things to be woven—now narrower, now broader. These threads indeed are not drawn through holes like the former, but the gold and silver are beaten into plates, yet so that they are not unlike very thin paper; these plates, then—just as here at Rome the women do—they cut lengthwise to whatever breadth they wish, and consign to the weavers and embroiderers [acupictoribus]. Of the third kind is gold reduced by the work of hammers into a very thin substance, which, kept within little books of paper, serves for the gilding of objects.

But let us now expound in a few words the practice of the wire-drawing art. Gold, silver, copper, and iron are first drawn out into oblong, fine, rounded rods; these are then drawn ever through narrower and narrower holes, by the aid of suitable machines, into thread of whatever thickness, so that they are sometimes drawn through thirty different holes, ever smaller and smaller, until they come to such fineness that they match the thickness of the finest hair. By experience I have found that half an ounce of silver, after being constricted through the most varied holes, is extended at the last hole to such a length that it equals 600 geometric feet [600 pedes geometricos]. From which arises the following problem.

PROBLEM.

Given the weight of a metal and the size of the hole through which it is to be drawn, to find into how great a length it can be extended.

First take a thread of any number of feet, drawn through the given hole, which you will first most carefully weigh. Let it be, for example, a thread of ten feet, and let it weigh one grain [granum]. In this way you will arrive at knowledge of the extension of any other body drawn through the hole. Say: *10 feet weigh 1 grain; how many grains will a thread of 100 feet weigh?* And the weight sought will

result. But having the weight of the metal, if you wish to know its length, say: *1 grain gives a thread 10 feet long; to how many feet will a scruple, an ounce, a pound be extended?*—and you will have what you sought. You will operate no differently with the rest of the metals.

For example: I wish to know into how great a length one pound can be extended. Let it be: as one grain is to a thread of 10 feet, so 6912 grains, which make one pound, to another. There will result a length sought of 69120 feet; that is, 14 miles [milliaria]. This again being posited, if you wish to know into how great a length 125 pounds of silver can be extended, say: *1 pound gives a length of about 14 miles; how much will 125 give?* And there will result 1750 miles, and so of the rest.

Hence it follows, first, if anyone wishes to know how many pounds of silver ought to be extended to make up a thread that would encircle the whole terrestrial globe: now it is established that the terrestrial circumference is 21600 Italian miles. Say, then: *14 miles give 1 pound of silver; how much silver will 21600 miles give?* And there will result 154 pounds and $\frac{2}{7}$ [154 librae è $\frac{2}{7}$ — fraction read as $\frac{2}{7}$ from the tile; printed as "è $\frac{4}{4}$ "-form, i.e. $\frac{2}{7}$]. So many pounds of silver, then, are required to make a thread that would encircle the whole terrestrial mass; the third part of which, 52 pounds, will give a chord equal to the entire diameter.

But if you desire to know into how great a length a thread could be extended which, when coiled up, would be as heavy as the whole mass of the earth: we suppose, according to what has been demonstrated by Archimedes, that the terrestrial mass, if it were solid, weighs 659236344266528723850720 00 pounds [659236344266528723850720000]. Say, then: *1 pound gives 14 miles; how many miles will 659236344266528723850720000 pounds give?*—or, into how great a length will it give?—and there will result the miles of the length sought, which thread, equal in weight to the terrestrial mass, would in length far exceed the circumference of the whole mundane mass.

It is plain, therefore, that what we have said of the silver thread can be said of all the other metallic threads. For if you wish to investigate the said matters in a gold thread, take a gold thread of any number of feet long—for example, 5—and let this thread weigh 2 grains. Say: *two grains give 5 feet; into how many feet will 20 grains in a mass of gold be extended?*—and, the operation performed, there will result 100 feet, and so of the rest.

Note first that we here take one scruple for 24 grains, and one ounce for 24 scruples, 12 ounces for one pound; so that one ounce has 576 grains, and one pound has 6912 grains.

Note secondly that the material of the metals is partly quicksilver, partly sulphur. Whatever metals, therefore, have more of mercury will yield deeper [graviores] sounds; those that have more of sulphur, sharper [acutiores] sounds. And so the chemists hold. But I, for my part, would ascribe the depth and sharpness of sounds to the elementary qualities as well: so that that body which has more communion with earth and the moist sounds deeper, while that which has more with earth and fire sounds sharper. For a moist body mixed with earth—besides that it condenses and binds together—from the close packing of its parts also renders it heavy and weighty; whence a deep sound too must necessarily follow. But a dry, earthy body—besides that it dilates and extends the body, from the variety of its parts—renders it light and porous, which lightness a sharp sound necessarily follows; though these things can easily be reconciled with chemical principles.

Gold is not only drawn out into thread to an infinite extent, but is also beaten into surfaces so thin that they affirm 1600 leaves [folia] to come out of one ounce of gold; and although

DE ARTIUM MECHANICARUM ARCANIS. [On the Secrets of the Mechanical Arts]

Gold is the heaviest of all metals; yet its leaves are of such fineness that they can scarcely be made to sink beneath water. Moreover, 1600 leaves laid out flat cover a surface of nearly 400 square feet. From this anyone could easily reckon how much gold would be required to gild the vault of some church, and how much would be needed to gild the whole mass of the Earth, were it a perfect sphere.

But let me return to my subject. As for the brilliance of the gold and silver leaves, they certainly appear so exactly worked that they seem to be pure, unmixed gold and silver to anyone who does not know either the deception [fraudem] or the craftsman's skill—when in fact a large proportion of brass [aeris] goes into them, with very great profit. They proceed as follows. From brass they draw out a rod about four feet long [quadripalmarem] by the continuous beating of a hammer, then wrap it round with a leaf of gold or silver, very finely worked and soldered onto the outer face, so that the whole appears either gold or silver. This rod, so soldered, they place inside a flame-spouting furnace, where they leave it until it is close to the point of fusion. Then they take it out and beat it with a hematite stone, using the hammer as well, hammering and flattening it until it is thoroughly incorporated into the brass. Once this is done, it is fired again and

beaten into thin plates suitable for drawing out [into wire]; and by this technique the gold and silver threads acquire much greater brilliance than if they were made of pure gold and silver. But since I have dealt thoroughly with the powers and properties of strings in the Sixth Book of the *Musurgia* [Kircher, *Musurgia Universalis* VI], I refer the reader there, where I have worked out the weights of strings made of gold, silver, iron, and brass according to the laws of harmonic art, together with a great many other secrets worth considering.

To these I will add a secret for softening horn [quo cornua mollefiat]. The first method is this. Take urine that has been fermented for four weeks in a well-covered pot. Into it put one pound of quicklime, half a pound of the ash they call *soda* — or else ash from tartar — 8 pounds of tartar and as much salt; let everything be thoroughly mixed and set over a fire to boil. Then strain it twice and keep it carefully. When you wish to soften horns, place them in this lye for eight days, and you will have horn as soft as dough. Others achieve the same with ash made from burnt poppy stalks and the lye made from it, in which they put the horns to be boiled down. The second method teaches how to soften them so that they can be cast in molds, and they proceed thus. Take one pound of the soda that glassmakers use, one pound of quicklime, and one measure of water; let everything be boiled to half its volume. Then take filings of horn of any kind, and let them steep in the prepared water for two days. Next knead the whole mass like dough with your hands first smeared with oil, and once kneaded, press it into the mold of whatever form you wish; and when it has hardened you will have the horn image you sought. The third method is this. Take juice of white horehound [marrubio albo], ivy, radish, and greater celandine, together with strong vinegar; mix everything together, and let the horns be placed in it to steep for seven days inside horse dung. Then proceed as I taught in the preceding method.

CAPUT II.

De Arcanis Miscellaneis. [On Miscellaneous Secrets]

So that I may not seem to have omitted any of the curious matters in this Work, I shall treat here a few things that I hope will not be unwelcome to the curious reader. But, to delay no longer, I shall set out the whole matter in a number of propositions.

PROPOSITIO I.

To transmute air into water.

Michael Sendivogius [Michael Sendivogius], in his *Lumen Chymicum* [*The Chemical Light*], sets out the matter thus: *Make a copper instrument of the form you see here. Inside this machine, joined together and soldered from three parts, place a sponge at the bottom; and above the sponge place two pounds of marble that has been calcined for a whole natural day inside a glassmaker's furnace, to which you will mix one pound of red marble crushed into the smallest fragments. Then, after [air] has been drawn in through the lower little channel — for the hotter the heated chamber [hypocaustum] in which the instrument is placed, and the colder the air outside the chamber's window (for the channel E D must terminate outside the window of the heated chamber —*

Diagram. An alchemical/hydraulic apparatus shown in the lower right of the page, drawn vertically. At the top is a gourd- or retort-shaped vessel with a long curved neck rising to the right; the body of this upper vessel is partly filled (the fluid line is engraved across it). Below it a second, rounded vessel sits on a small foot, connected to the upper vessel by a short central channel. The lettering keys it to the surrounding text (the "instrument" of Sendivogius for condensing air into water).

- D (tip of the upper vessel's curved neck): D — the outer terminus of the channel
- E (upper neck, below D): E — the upper part of channel E D
- A (body of the upper vessel): A — the upper chamber holding marble and sponge
- L (junction / mouth of the lower vessel): L — the connecting channel into the receiving vessel
- M (lower receiving vessel): M — the vessel placed underneath to collect the water

— the more abundant a supply of water you will obtain through the opening of the channel E D, which at D is extremely narrow,

shaped like a needle [adinstar acus], having an orifice. Through this orifice, then, the cold air insinuating itself will quickly be resolved into water, which, filtered through the marble and the sponge, will flow down through the little channel B into the vessel set below, M — in such abundance that it would suffice for people and horses to drink in time of need. So says Sendivogius, who, in the manner customary to boastful alchemists, certainly promises far more than reason and

experience dictate. He adds that water of this kind is of such marvelous virtue that he has no doubt one may at last reach the great goal of the Art by the benefit of this water. But for my part, I find no special virtue in water of this kind, other than that which in winter clings to the windows of a heated chamber — resolved partly by the virtue of the external cold and partly by the warmth within. Since this is plain water, imbued with no metallic or celestial impressions, I therefore judge it to be a foolish fantasy of the alchemists to seek in it what is not there — the fantasy by which they dream that there is nothing that cannot contribute to the great secret of the [Philosophers'] Stone. I do not deny that some water can be collected this way; but what the calcined marble and the sponge contribute to the matter, I do not see — since they are more of a hindrance than a help to the gathering of the waters, in that they absorb the descending water rather than letting it flow on further. But I see well enough what he was aiming at with all this. Since he saw that the instrument was too simple, indeed common, he seems to have invented this useless addition gratuitously, in order to confer on his secret contrivance some authority among the ignorant. I am not unaware that various hydraulic vessels can be made — of the kind that I too display in my own Museum: vessels of every sort, aeolipiles, hydrolcia [water-drawers], absorbents — which are moistened within by the attraction of cold air, or by the mere touch of a warm hand. But one that would yield, from resolved air, the quantity of water he claims, I have never seen. It seems to do only as much as a breath does, which, when breathed out onto a window cold on the outside, is immediately condensed into moisture. Therefore the fact that in heated rooms the windows run with water in winter is not due immediately to the inner air itself, but to the varied and continuous breathing of people: when it strikes the cold glass of the window, it is at once resolved into moisture — as experience shows with mirrors and glass that are breathed upon. Add to this that an entire cask of external air resolved by heat can scarcely supply an ounce of water, as I have shown elsewhere by various experiments; for unless vapor is present, air by itself holds little or no water, as I taught in the art of distillation.

PROPOSITIO II.

On Mercurial Machines. [De Machinis Mercurialibus]

It is asked whether mercury can be set into motion by artificial machines. I say that this can be done by many a method and procedure. But let me explain a few.

First. If you wish a ring to move by itself, do as follows. Make a ring hollow on the inside, of any material — gold, silver, brass, iron, glass, or earthenware — and into its cavity put a little quicksilver, for example to the halfway point, so that

half the ring is filled with mercury. This done, close the orifice as firmly as possible, so that the mercury cannot escape. Then heat the ring; and when the mercury begins to evaporate, you will see, to your astonishment, the ring make certain wondrous leaps and move this way and that, exactly as though it were animated and driven by some hidden demon lurking within.

Second. How a cart or carriage animated by quicksilver can move forward of its own accord with the greatest force. Make a little carriage of wood, fashioned with its wheels and horses — of the kind commonly made in Germany, cheap — and into this carriage fit a small tube made of brass or iron, partly filled with quicksilver. Then close the little channel so tightly that no entry is allowed to the air and no exit for the mercury to slip out. Set this on some flat, smooth table, then heat the channel with a candle; and behold, the little carriage will run back and forth across the whole flat surface on its mobile wheels, not without the astonishment of onlookers. By this same device one may put on, for the delight of spectators, men walking and birds swimming through the air — yet bound by an iron thread to a ring — and countless other spectacles.

If, however, anyone should wish to display either a human figure or a globe moving upward by a perpendicular, he will proceed thus. First make a triangular prism constructed from three iron wires *a b*, *e f*, *d c*, of the form shown here. Let it have on its lower base *b c* a shell filled with burning coals, on which is set a sphere fashioned in the form of a worldly or imperial globe, cast of brass, iron, or potter's earthenware. Fill this to about a third with mercury and stop the mouth as tightly as possible — but you will do better if you make [the opening] somewhere on the side of the globe. This done,

Diagram. The figure runs vertically down the right margin of the page. At the top a cloud-like mass with a hanging chain illustrates the suspended figures ("men walking, birds swimming through the air, bound by an iron thread"). Below, a tall triangular framework of iron wires rises on a square base-plate; at its foot sits a shell-shaped dish of burning coals (flames engraved), and above the flames a spherical globe surmounted by a cross (the *globus mundi* / imperial-orb form). The mercury-filled globe rises and falls within the wire framework as it heats and cools.

- A (left upper corner of the base / framework): A — a vertex of the triangular wire prism
- D (right upper corner): D — a vertex of the triangular wire prism
- B (left front corner of the base-plate): B — the lower base, corner *b*
- C (right front corner of the base-plate): C — the lower base, corner *c*

- F (on the globe, by the cross): F — the cross-surmounted globe (imperial orb) filled with mercury

you will set the whole machine on a table — yet in such a way that it is held up from above, either by a hook or by a hand drawn down out of the clouds, since the iron wires, being extremely fine, cannot stand up by themselves. And you will see the enclosed mercury, even at the first heating, begin to stir up its usual tumults; then it will gradually begin to rise within the iron wires (which serve as a kind of bar to keep the globe from being flung outward) all the way to the top of the prism. Then, as the vapor cools, it will begin to descend in the same proportion of motion by which it had ascended; and when it reaches the place near the coals, there, stirred up again, it will be seen to hang as if suspended. A machine truly full of wonder — yet whose explanation no one will easily grasp unless he thoroughly knows the property of mercury. It will produce a still greater effect if you pour water mixed with niter [aquam nitro subjectam] over the mercury. I could bring forward here a great many machines of this kind, but in order to leave the curious reader room to think out more, I have judged it best to set down here these few only.

CONCLUSIO OPERIS. [Conclusion of the Work]

Having struggled out at last from the dreadful and dread-filled darkness of the Subterranean World — through the hidden inner recesses of Nature's and the Ocean's storehouses, through unseen paths never until now attempted by anyone — with God as our Guide and Director, we have come into the harbor long since desired and longed for, amid the great anxiety of a troubled mind, having performed countless labors and Herculean ventures. I have done what I promised, and have carried it out so far as the weakness and powerlessness of my mind permitted. I have demonstrated the admirable order, arrangement, and purpose of the inner Fabric of the Geocosm, the kernel of all Nature being unfolded; and in all these things, both as a whole and one by one, the reader will note, unless I am mistaken, the unspeakable providence of Divine goodness, and how — amid so great and so incomprehensible an apparatus of the most disparate things — their multitude, variety, and richness have been set forth, both for the manifestation of the glory of His majesty and for the preservation of the salvation of the human race. Now at last, my hand withdrawn from the picture and my eyes lifted to heaven, nothing remains but that to the supreme and glorious εὐεργέτης [Greek: εὐεργέτης (euergetēs, "benefactor")] of Nature we render — if not the thanks we owe, then at least the thanks we can — and that we confess before all the living to Him who has dealt His mercy with us. *For it is good*

to hide the secret of a king, but to reveal and confess the works of God is an honorable thing [cf. Tobit 12:7]. And so, to the supreme King of the ages, immortal and invisible, to the holy and undivided Trinity, to the Father and the Holy Spirit, to the one God — from whom, in whom, and through whom all things exist, and without whom we can not only not do, but not even think, anything good — be all honor and glory.

Then to you, Savior of the human race, the God-man [Greek: θεάνθρωπος (theanthrōpos, "God-man")] JESUS CHRIST, the Power and Wisdom of God [σοφία θεοῦ καὶ δύναμις — cf. Greek: σοφία (sophia, "wisdom"); δύναμις (dynamis, "power")], who have deigned to bring these labors of mine, such as they are, to the best end — who, that I might complete a work far beyond my own strength, have conferred a copious gift of grace upon your little servant. You, as eternal Truth, uncreated Wisdom, and the Word of the eternal Father, have likewise illumined my darkened soul with your light, visited it with grace, lifted up my mind, roused my affection, supplied your aid. To you also, eternal Love the SPIRIT, supreme Giver of graces [Greek: πανταδότης (pantadotēs, "giver of all")], who, brooding over the dark abyss of my intellect, have made fruitful a mind condemned to barrenness with the love of heavenly things, have animated it into bearing fruit, have inspired it though it did not yet will, that I might will it — have helped the efforts of my good will, that I might be able and might act — you who in your own [servants] work the being-able, the willing, and the accomplishing. To you, finally, dispenser of the divine gifts, the VIRGIN MOTHER OF GOD [DEIPARA], I give thanks entirely [Greek: πανταχῶς (pantachōs, "in every way")]: by whose kindness, merits, and intercession — not in this Work alone, but in all the others published hitherto by my slight self — I have wished it to be manifest by these words that I have, in a marvelous manner, obtained from you, most merciful Mother, this grace: that I might accomplish something. Last of all, to the most holy ANGEL of my guardianship, divinely appointed to me, who was always present with hidden promptings, who stood by me with his light in doubtful, arduous, and most difficult matters, and gave me the occasion that what I willed I might also accomplish. Praise therefore be to God the Father of lights, without whose protection — as deservedly all human wisdom is folly — so too all the efforts of human genius give out, fruitless and vain, like worthless slag tossed about in the threshing-floor.

Omnia ad maiorem DEI gloriam Virginisque MARIÆ. [All for the greater glory of GOD and of the Virgin MARY.]

[Centered, large type:] *F I N I S.*

INDEX RERUM & VERBORUM TOMI SECUNDI.

[Index of Things and Words of the Second Volume]

The page number is the index reference; the letters *a* and *b* indicate the first and second columns.

A.

[The index is printed in two columns; transcribed below as a two-column reference table, left column then right column. Entries reproduce the headword, a brief sense-tag, and the page references with *a/b* column markers as printed. Some headwords carry an ornamental swash initial.]

Headword	Reference
Absynthium ubi nascatur [Wormwood, where it is born]	119.a.
Acacia folia cur mane aperiantur, vesperà claudantur [Acacia, why its leaves open in the morning and close in the evening]	418.a,b.
Acetum acerrimum quid [Vinegar, what the sharpest is]	261.b.
— ejus in distillatione mira proprietates [its marvelous property in distillation]	334.b.
Achates quid [Agate, what it is]	28.a.
— quomodo conficiatur [how it is made]	463.b.
Aconiti Symptomata, cura & remedia [Aconite, symptoms, treatment and remedies]	141
Actinobolismus inest salinis corporibus [Ray-emission is present in saline bodies]	25.a.
— omnibus [in all]	114.b.
Adamas unde oriatur [Diamond, whence it arises]	20.b.

Headword	Reference
— gemmarum rex [king of gems]	ibid.
— à malleo conteri potest [can be crushed by a hammer]	ibid.
— ubi crescat [where it grows]	21.a,b.
— ad ejus genesin quæ requirantur [what is required for its generation]	21.b.
Adamantis scops non est lethifera [The diamond's scops is not deadly]	20.b.
— ejus superstitiosus usus [its superstitious use]	ibid.
— durities unde [whence its hardness]	20.b. 22.a.
— effictio [its imitation]	459.a. 462.a,b. 463.a.
Aër qui purget à noxiis impressionibus [Air, what purges it of harmful impressions]	106.a.
— venenosis impressionibus opportunus est [is liable to poisonous impressions]	126.a.
— subterraneus follibus purgatur [subterranean air is purged by bellows]	175.b. 176.a,b.
— quotuplex [how many kinds]	398.b.
— quomodo ponderetur [how it is weighed]	447.a.
Æs Corinthium quid [Corinthian brass, what it is]	205.a.
— quomodo in Orichalcum transmutetur [how it is transmuted into orichalc]	216.b.
— quomodo coloretur [how it is colored]	217.a.
— cur tempore frigido melius comburatur [why it burns better in cold weather]	217.b.
— ustum quomodo vocetur [burnt, how it is called]	218.a.
— tingendi modus in orichalcum &	218.b. 300.b.

Headword	Reference
argenteum colorem [method of dyeing into orichalc and silver color]	
— an potabile fieri possit [whether it can be made potable]	431.b.
— quomodo vitrescat [how it vitrifies]	452.a.
— qui crystallescat [how it crystallizes]	457.b.
Æris scoria [Slag of brass]	206.b.
— latentis indicia [signs of hidden brass]	216.a.
— mistura variæ ad varia conficienda [various mixtures for making various things]	217.a.
— fulmen [lightning(?) of brass]	217.b.
— mira proprietas [marvelous property]	ibid.
— in medicina effectus [its effects in medicine]	ibid.
— artificialis & nativi differentia [difference of artificial and native]	224.b.
— & argenti mixtura [mixture with silver]	439.b.
— quantum auro commixtum explorare [how much is mixed with gold, to test]	443.b.
— calx [its calx]	82.a.
Æruginis proprietas, symptomata, remedia [Verdigris, property, symptoms, remedies]	140, 218.a.
Ægyptii cur inter cornua bovis apim pinxerint [Why the Egyptians painted Apis between the horns of an ox]	250.a.
— quem modum in viribus rerum inveniendi habuerint [what method they had in discovering the powers of things]	402.a.
Agaricus quomodo humores trahat [Agaric, how it draws humors]	113.a.

Headword	Reference
Ager cur foecundetur à cineribus [Field, why it is made fertile by ashes]	338.a.
Albertus Magnus natura mysta [Albertus Magnus, a mystic of nature]	412.b.
Alcaest quid [Alkahest, what it is]	424.a,b.
Alchymia cur tantopere culta [Alchemy, why so greatly cultivated]	236.a.
— proprie dicta Chrysopeiam promittit [properly so called, promises chrysopoeia (gold-making)]	250.a.
— secundum Paracelsum à Deo inspirata [according to Paracelsus, inspired by God]	270.b.
— quare ab Authore confutata [why refuted by the Author]	280.b. 281.a.
— Sophisticaque [and its sophistical form]	284, & seq.
— an licita [whether lawful]	311.a.
— quæ damna Reipubl. conferat [what harms it brings to the commonwealth]	320.a.
Alchymiaë nomen [The name of Alchemy]	222.a.
— definitio [definition]	232.a.
— studium intricatum [its intricate study]	ibid.
— antiquitas [its antiquity]	ibid. & seq.
— monstruosa verba [monstrous terms]	270.b.
— vanitas [its vanity]	224.a. 304.b.
— lucro nullus monarcha dives factus est [no monarch was made rich by its profit]	320.a.
— censura Parisiensis [the Paris censure]	320.b.
— Joannis XXII. P.M. censura [the	209.a.

Headword	Reference
censure of Pope John XXII]	
Alchymistarum doli [The tricks of the alchemists]	280 & seq.
— à Dæmone deceptio [their deception by the Demon]	282 & seq.
— in auro potabili conficiendo fucus [the fraud in making potable gold]	410.b.
— in eosdem invectiva [invective against them]	263.b.
Alcool quid [Alcohol, what it is]	173.b.
Alembicus quid [Alembic, what it is]	241.a.
Alexii in auro solvendo processus [Alexius's process for dissolving gold]	423.b.
— in confectione gemmarum [in the making of gems]	459.b.
Alimentum quid conferat [Nourishment, what it contributes]	109.a.
Alteratio rerum in fibris terrae [Alteration of things in the fibers of the earth]	9.b.
Althanor quid [Athanor, what it is]	393.a.
Alumen plumae quid [Feather alum, what it is]	243.b.
Amalgama quid [Amalgam, what it is]	243.b.
Amianthus. Vide Asbestum. [Amianthus. See Asbestos.]	—
Ammochrysus lapis [The amnochrysus stone]	57.b.
Analogia membrorum corporis humani ad corporum coelestium membra [Analogy of the members of the human body to the members of the celestial bodies]	326.a,b.
Anates delectantur animalium	132.a.

Headword	Reference
venenatorum pastu [Ducks delight in feeding on venomous animals]	
— Scoticae qui nascantur [Scottish ducks, how they are born]	97.b. 246.a.
Andreae Blavii auri potabilis specimen [Andreas Blavius's specimen of potable gold]	422.b.
Androsaemum hircinum unde [Goatish androsaemum, whence]	350.a.
Anguillae unde oriantur [Eels, whence they arise]	119.b. 346.a.
Anima manet in semine [The soul remains in the seed]	337.b.
Animalia maxima cur pauca prolis [The largest animals, why few of offspring]	57.b.
— subterrestria quadruplicia [subterranean animals are of four kinds]	86.
— cryptis montium inhabitant [inhabit the caverns of mountains]	97.b. & seq.
— venenata cur [why venomous]	100.
— appropriatos vermiculos generant [generate appropriate little worms]	309.b.
— venenosa ex corruptis humoribus nascuntur [venomous ones are born from corrupt humors]	108.a.
— quae venenosa [which are venomous]	109.a.
— venenata ex terra venenum sugunt [venomous ones suck venom from the earth]	121.
— eorum ortus spontaneus [their spontaneous origin]	327.a.
— generantur ex cadaveribus [are generated from corpses]	337.b.

Headword	Reference
— ex putri [from rotten matter]	340.a.
— qui ex terra [which from the earth]	ibid.
— quomodo ex fimo [how from dung]	341.a.
— & saxis [and from rocks]	341.b.
— ex aquis [from waters]	342.a.
— spontaneo ortu nata sunt triplicia [those born by spontaneous origin are of three kinds]	344.a.
— qui nascantur ex spiritibus spermaticis [which are born from spermatic spirits]	372.a.
Anseres Scotici qui nascantur [Scottish geese, how they are born]	246.a.
Antimonii vis deleteria [Antimony, its deleterious power]	117.a.
— proprietates, symptomata, remedia [property, symptoms, remedies]	140, 49. & seq.
— calcinandi modus [method of calcining]	244.b.
— tinctura [tincture]	245.b.
— tinctura essentialis non datur [an essential tincture does not exist]	436.b.
Antipathia rerum mira [The marvelous antipathy of things]	110.b.
— difficilis cognitu [difficult to know]	111.b.
— bufonis & aranei [of the toad and the spider]	120.b.
— aceti & lithargyrii [of vinegar and litharge]	ibid.
— aspidum & serpentum [of asps and serpents]	ibid.
— quid sit [what it is]	111.a.
— plumbi cum aere & stanni cum auro & argento [of lead with brass, and of tin]	206.a.

Headword	Reference
with gold and silver]	
— auri cum ferro [of gold with iron]	220.b.
— insectorum cum certis rebus [of insects with certain things]	276.b. & seq.
— solventium [of solvents]	434.a.
Apes caput bovinum referunt [Bees resemble an ox's head]	96.a. 349.b.
— favis construendis insudant [toil at constructing honeycombs]	355.a.
— ad quid utiles [for what they are useful]	375.a.
Apum ortus [The origin of bees]	357.a.
— in officiis distincti gradus [distinct ranks in their duties]	357.b.
— ex boum excrementis genesis [generation from oxen's excrement]	358.a.
Apium risus quid [Smallage's "laughter," what it is]	129.a.
— ejus symptomata, cura & remedia [its symptoms, treatment and remedies]	141.
Aproxis herba [The aproxis herb]	412.b.
Aqua potabilis non est petrifica [Drinking water is not petrifying]	46.b.
— quae venenosa [which is venomous]	126.b.
— permanens quid [permanent water, what it is]	315.a.
— dealbans quid [whitening water, what it is]	315.b.
— quotuplex [how many kinds]	398.b.
— ad adamantes formandos idonea [suitable for forming diamonds]	457.a.
— fortis compositio [composition of aqua fortis]	200.a.

Headword	Reference
— conditiones [its conditions]	215.b.
— vitae praeparatio [preparation of aqua vitae]	261.a.
— regia [aqua regia]	ibid.
— mercurialis [mercurial water]	ibid.
— perennis [perennial water]	261.b.
— mercurialis vires [the powers of mercurial water]	ibid.
— salis petrae purificatio [purification of saltpeter]	438.a.
— gemmas penetrantis confectio [making of gem-penetrating water]	459.a.
Aquilae animalium venenatorum pastu gaudent [Eagles delight in feeding on venomous animals]	122.a.
— quomodo in aere pyrotechnica artis ope repraesententur [how they may be represented in the air by the art of pyrotechnics]	480.a.
Arabes de Alchymia scripserunt [The Arabs wrote on Alchemy]	231, 236.a.
Araneus bufonem occidit, & cur [The spider kills the toad, and why]	321.b.
— qui generetur [how it is generated]	368.b. 369.
— astronomum & geometram agit [plays the astronomer and geometer]	396.b.
— ad quid utilis [for what it is useful]	376.a.
— ejus symptomata & remedia [its symptoms and remedies]	143.
— coitus [its coupling]	369.a.
Arbor quomodo inserenda [Tree, how it is to be grafted]	382.b. & seq.
— quid faciendum ut fructus differentes proferat [what is to be done so that it	386. & seq.

Headword	Reference
brings forth different fruits]	
— una [a single one]	

Index of Subjects and Words of the Second Volume (continued)

This opening continues the alphabetical subject index of Tomus II, running from mid-letter A through the start of letter M. Each printed page carries two columns; the table below follows printed column order (left printed-column fully, then right printed-column) across the four pages, in the alphabetical sequence confirmed by the catchwords ("Calcis," "Draco-," "tur," "dit").

References preserve the page number and the column marker "a" (left) / "b" (right) of each cited page, with "ibid." (same place), "& seq."/"& seqq." (and following), and conjoined cross-references kept verbatim as printed. The English bracket after each lemma is a sense-gloss of the Latin headword.

Letter A (concluded)

Lemma [sense-gloss]	Reference(s)
<i>casu subinde alias producit</i> [by chance it sometimes produces others]	387, b.
<i>in phiala nata</i> [born in a flask]	413, b.
<i>philosophica quotidie crescens</i> [the philosophical one growing daily]	431, b.
<i>Lunae</i> [of the Moon]	432, a.
<i>Luna mercurialis</i> [the mercurial Moon]	ibid.
Arbores quae sub Zona torrida nascuntur, cur solidissimae [Trees that grow in the torrid zone, why most solid]	409, a.
<i>metallicae quae</i> [which are metallic]	431, b.
Arcana Chymica [Chemical secrets]	290 & seq.
<i>Artium mechanicarum</i> [of the mechanical arts]	481 & seq.

Lemma [sense-gloss]	Reference(s)
Argentum libenter sociatur cupro [Silver readily combines with copper]	187, a.
<i>quomodo ex aqua extrahatur</i> [how it is extracted from water]	215, b.
<i>ex ejus scoria aurum extrahendi modus</i> [the method of extracting gold from its slag]	224, b.
<i>quomodo ab auro separetur</i> [how it is separated from gold]	249, b.
<i>qui in aurum convertatur</i> [how it is converted into gold]	307, a.
<i>omnes colores in se continet</i> [it contains all colors within itself]	429, a.
<i>quocunque modo calcinatum in pristinam formam reduci potest</i> [calcined in whatever way, it can be reduced to its former form]	429, b.
<i>an in liquorem solutum reduci queat</i> [whether, dissolved into a liquid, it can be reduced]	ibid.
<i>quomodo vitrescat</i> [how it turns to glass]	352, b.
<i>qui crystallescat</i> [how it crystallizes]	457, b.
<i>quomodo dulce reddatur</i> [how it is made sweet]	481, b.
Argenti natura & proprietas [The nature and property of silver]	203 & seq.
<i>inveniendi & praeparandi ratio</i> [the method of finding and preparing it]	204, a, b.
<i>adulterandi variae fraudes</i> [various frauds for adulterating it]	205, b.
<i>in medicina usus</i> [its use in medicine]	204, b.
<i>sympathia & antipathia</i> [sympathy and antipathy]	206.

Lemma [sense-gloss]	Reference(s)
<i>scoria quae</i> [what its slag is]	206, b.
<i>purgandi modus</i> [the method of purging it]	211, a.
<i>pulveris mira proprietas</i> [the wondrous property of its powder]	215, b.
<i>praecipitatio quid</i> [what its precipitation is]	243, b.
<i>quantum auro insit explorare</i> [to investigate how much is present in gold]	439, b.
<i>calx</i> [its lime/calx]	483, a.
Argentum vivum quid operetur [What quicksilver effects]	116, a.
<i>sanguinem congelat</i> [it congeals the blood]	122, b.
<i>omnium venenorum calidissimum est</i> [it is the hottest of all poisons]	122, a.
<i>quomodo frigus inducat, & qui humidum dicatur</i> [how it induces cold, and why it is called moist]	123, b.
<i>idem cum mercurio & hydrargyro</i> [the same as mercury and hydrargyrum]	150, 151.
<i>est duplex</i> [it is twofold]	152, b.
<i>ex mineris extrahendi modus</i> [the method of extracting it from ores]	211, b.
<i>eius proprietas, symptomata, remedia</i> [its property, symptoms, remedies]	140, 150 & seq.
<i>qui calcinetur</i> [how it is calcined]	383, a, b. <i>Vide Hydrargyrum & Mercurium</i> [See Hydrargyrum and Mercury].
Arnoldus illicitis artibus deditus [Arnoldus, given to illicit arts] [Arnald of Villanova]	277, a.
<i>prophetiae donum affectavit</i> [he	ibid.

Lemma [sense-gloss]	Reference(s)
affected the gift of prophecy]	
<i>hominem se fecisse arte chymica impie asserit</i> [he impiously asserts that he made a man by chemical art]	ibid.
ars magna quid veteribus [what the great art was to the ancients]	313 & seq.
<i>Aurifabrorum circa quid occupata</i> [with what the goldsmiths' art is occupied]	481, a.
Arsenici vis [The power of arsenic]	115, b. 337, a.
<i>proprietas, symptomata, remedia</i> [property, symptoms, remedies]	140, 147, b. 148, a, b.
<i>malignitas</i> [its malignity]	173, b.
<i>fodina</i> [its mine]	227, a.
Asbestus quid [What asbestos is]	66.
<i>an sit combustibilis</i> [whether it is combustible]	67, b. & seq.
<i>ubi reperiatur</i> [where it is found]	ibid.
<i>ligni formam exprimit</i> [it expresses the form of wood]	68, b.
<i>an ex eo oleum extrahi possit</i> [whether oil can be extracted from it]	71, a. 436, a.
Asbesti denominationes [The names of asbestos]	66, b.
<i>charta</i> [its paper]	67, a. 74, a.
<i>redimiculum, elychnium</i> [its band, its wick]	ibid.
<i>compositio</i> [its composition]	b.
<i>definitio</i> [its definition]	68, b.
Asciomenes feras domat [Asciomenes tames wild beasts]	412, b.
Aspalathus ubi nascatur [Where aspalathus grows]	119, a.

Lemma [sense-gloss]	Reference(s)
Asparagi in cornu arietis nati [Asparagus born in a ram's horn]	344, b. 388, b.
Aspidis symptomata & remedia [The asp's symptoms and remedies]	143.
Asthma quomodo curetur [How asthma is cured]	174, a.
Attractionis metallica causa [The cause of metallic attraction]	155, a.
Avis velocitas qui expendatur [How a bird's speed is measured]	448, a.
Aurum ab argento qui separetur [How gold is separated from silver]	119, b. 214, b.
<i>in stomacho perdicum repertum</i> [found in the stomach of partridges]	200, b.
<i>in cranio hominis</i> [in a man's skull]	ibid.
<i>in Hispaniola passim purum est</i> [in Hispaniola it is everywhere pure]	210, a.
<i>qui vitrificetur</i> [how it is vitrified]	245, a.
<i>optimum quodnam</i> [which is the best]	262, a. 289, a.
<i>omnibus fere metallis inest</i> [it is present in almost all metals]	289, a, b.
<i>ex Saturno qui conficiatur</i> [how it is made from Saturn (lead)]	295, b.
<i>quomodo alia metalla tingat</i> [how it tinges other metals]	299, a.
<i>graduatum qui fiat</i> [how it is made graduated]	300, b.
<i>debilis coloris quomodo exaltetur</i> [how one of weak color is heightened]	307, b.
<i>per additionem an licitum</i> [whether it is licit by addition]	308, a.
<i>an verum & reale arte fieri possit</i> [whether true and real gold can be made by art]	311, a.

Lemma [sense-gloss]	Reference(s)
<i>Alchymicum an licite vendi possit</i> [whether alchemical gold can be lawfully sold]	311, b.
<i>ab Alchymistis confectum, quale?</i> [that made by alchemists, of what kind?]	312 & seqq.
<i>philosophorum quid</i> [what the gold of the philosophers is]	315 & seq.
<i>potabile an detur</i> [whether potable gold exists]	419, b. & seq.
<i>an dissolvi possit</i> [whether it can be dissolved]	420, a, b.
<i>semper in suum statum est reducibile</i> [it is always reducible to its own state]	423, b.
<i>facilius conficitur quam destruitur</i> [it is more easily made than destroyed]	426, a.
<i>accidentaliter tantum transmutari potest</i> [it can be transmuted only accidentally]	426, b.
<i>non nutrit</i> [it does not nourish]	427, b.
<i>ex eo medicamentum universale fieri non potest</i> [a universal medicine cannot be made from it]	428, a.
<i>qui crystalliscat</i> [how it crystallizes]	457, b.
<i>quomodo ex loppis sive quisquiliis extrahatur</i> [how it is extracted from dross or refuse]	482, a, b.
<i>scriptorium qui conficiatur</i> [how writing-gold (ink) is made]	465, b.
<i>quomodo dulce reddatur</i> [how it is made sweet]	481, a.
<i>sophisticum qui praeparetur</i> [how sophisticated (counterfeit) gold is prepared]	483, b.

Lemma [sense-gloss]	Reference(s)
<i>quomodo in fila ducatur</i> [how it is drawn into threads]	485, b.
Aurigenesis [The generation of gold]	168, a.
<i>natura & proprietas</i> [nature and property]	200 & seq.
<i>antipathia & sympathia</i> [antipathy and sympathy]	201, b. & seq.
<i>incredibilis copia in Potosina regione</i> [an incredible quantity in the Potosí region]	208, a.
<i>eruendi modus</i> [the method of digging it out]	210, a.
<i>semen non datur</i> [no seed of it exists]	268, a.
<i>amor homines in interitum rapit</i> [love of it carries men to destruction]	283, a.
<i>anima</i> [its soul]	284, a, b.
<i>calcinatio</i> [its calcination]	243, b. 423, a. 482, b.
<i>tinctura vera non datur</i> [no true tincture of it exists]	426, a.
<i>liquida substantia qui in pristinum statum reducatur</i> [how its liquid substance is reduced to its former state]	ibid.
<i>qualitas specifica est</i> [it is a specific quality]	427, a.
<i>magisterium quid sit</i> [what its magistery is]	ibid.
<i>in liquorem dissoluti vires</i> [the powers of it dissolved into a liquid]	427, b.
<i>potabilis virtutes</i> [the virtues of potable (gold)]	427, b.
<i>fulminantis confectio</i> [the preparation of fulminating (gold)]	428, b. 470, b.
<i>bonitas qualis</i> [of what quality its]	439, a.

Lemma [sense-gloss]	Reference(s)
goodness is]	
<i>à Lazulo separatio</i> [its separation from lapis lazuli]	200, a. 464, b.
<i>à metallis</i> [from metals]	215, a. 249, b. 482, a, b.
Aurifabri circa quid occupati [With what goldsmiths are occupied]	481, a.

Letter B

Lemma [sense-gloss]	Reference(s)
Baaras herba mirifica [Baaras, the marvelous herb]	413, a.
Balenae viviparae & cur [Whales are viviparous, and why]	57, b.
<i>musco & alga obsitae</i> [overgrown with moss and seaweed]	344, b.
Balis herba [Balis, the herb]	411, b.
Balneum maris quid [What a sea-bath (bain-marie) is]	240, a.
<i>roris quid</i> [what a dew-bath is]	ibid.
<i>vaporosum quid</i> [what a vapor-bath is]	392, a.
Bargarozzi Italis quid [What "bargarozzi" is to the Italians]	364, b.
Blattae ad quid utiles [Cockroaches, for what they are useful]	375, b.
Balsamum ubi nascatur [Where balsam grows]	119, a.
<i>vitrioli</i> [vitriol-balsam]	173, b.
<i>urticae</i> [nettle-balsam]	ibid.
<i>magnetis</i> [magnet-balsam]	ibid.
<i>sulphuris</i> [sulphur-balsam]	174, b.
Basiliscus ex ovo Galli natus [The basilisk, born from a cock's egg]	90, b.
<i>Alchymistis quid</i> [what it is to the alchemists]	315, b.
Berniclae qui nascantur [How barnacle-geese	346, a.

Lemma [sense-gloss]	Reference(s)
are born]	
Beryllus qui componatur [How the beryl is composed]	462, b.
Bismuthum quid [What bismuth is]	301, a.
Bitumen quid [What bitumen is]	156, a.
<i>à diversitate rerum denominatur</i> [it is named from the diversity of things]	156, b.
<i>varia ejus genera</i> [its various kinds]	156, b. 157, a.
<i>utilitates</i> [its uses]	157, a, b.
Bombyx ex moro qui nascatur [How the silkworm is born from the mulberry]	350, a.
<i>quale insectum</i> [what kind of insect it is]	355, a.
<i>unde</i> [whence it comes]	360, a.
<i>ejus metamorphosis</i> [its metamorphosis]	ibid.
<i>ad quid utilis</i> [for what it is useful]	375, a.
Borax Aurificum candidus quomodo caeruleus reddatur [How goldsmiths' white borax is made blue]	19, a.
Boriza herba [Boriza, the herb]	202, b. 282, b.
Botanici apud Romanos magno honore habiti [Botanists held in great honor among the Romans]	411, b.
Botytes quid [What botytes is]	207, a.
Brachmanes subterraneas cryptas inhabitant [The Brahmins inhabit subterranean crypts]	99, a.
Bruchi unde [Whence caterpillars come]	363, b. 364, a.
Bufo pestis remedium [The toad, a remedy for plague]	121, a.
<i>qui ex defosso anatis corpore nascatur</i> [how it is born from the buried body of a duck]	353, a.
<i>à formicis consumitur</i> [it is consumed by ants]	367, b.
Bulbi symptomata, cura & remedia [The symptoms, treatment and remedy of bulbs]	141.

Lemma [sense-gloss]	Reference(s)
Buprestis [Buprestis (the blister-beetle)]	143.

Letter C

Lemma [sense-gloss]	Reference(s)
Cabalistarum axioma [The axiom of the Cabalists]	381, b.
Cadmia quid [What cadmia is]	207, a.
Caementatio quid [What cementation is]	244, a.
Calcecumenon quid [What calcecumenon is]	218, a.
Calcedonius qui componatur [How chalcedony is composed]	463, a.
Calcinatio quid [What calcination is]	243, a. 244, a. 254, a. 424, a.
<i>auri duplex</i> [the twofold calcination of gold]	423, a.
Calculus omnibus in rebus generatur [Stone is generated in all things]	50, b.
<i>in omnibus membris humani corporis</i> [in all the members of the human body]	51, a, b.
C. Caligula primus metallurgus [Gaius Caligula, the first metallurgist]	235, a.
Calor multarum virtutum artifex [Heat, the craftsman of many powers]	110, b. 115, b.
<i>artificialis quis</i> [what artificial heat is]	241, b.
<i>fimi, separans, vesicae, cinerum, fortis, liber, carbonum, flammaram</i> [the heat of dung, of separation, of the bladder, of ashes, the strong, the free, of coals, of flames]	ibid.
<i>balnei</i> [of the bath]	242, a.
<i>Solis coelestis & subterranei omnia</i>	314, b.

Lemma [sense-gloss]	Reference(s)
<i>constituit</i> [the heat of the celestial and subterranean Sun constitutes all things]	
Caliditatis gradus difficulter indagari potest [The degree of heat can be investigated only with difficulty]	400 & seq.
Calx plumbea quomodo in minium vertatur ejusque causa [How lead-calx is turned into red-lead, and its cause]	12, b.
<i>quid Chymicis</i> [what it is to the chemists]	243, a.
<i>ejus virulentia</i> [its virulence]	117, b.

Letter C (continued)

Lemma [sense-gloss]	Reference(s)
Calcis vivae proprietas, symptomata, remedia [The property, symptoms, remedies of quicklime]	140.
Camphora quid [What camphor is]	157, b. 471, a, b.
Canis natura [The nature of the dog]	133, a.
<i>rabidi veneni causa</i> [the cause of the rabid dog's poison]	ibid. & b.
Cantharides qui possint [What cantharides (Spanish flies) can do]	129, b.
<i>quomodo vesicam exulcerent</i> [how they ulcerate the bladder]	130, b.
<i>unde</i> [whence they come]	365, b. 366, a.
<i>earum symptomata & remedia</i> [their symptoms and remedies]	143, 370, b. 375, b.
Capnitis quid [What capnitis is]	207, b.
Caput corvi quid [What "crow's head" is]	262, b.
<i>quomodo dealbetur</i> [how it is whitened]	ibid.

Lemma [sense-gloss]	Reference(s)
Caseus qui verminascere possit [How cheese can breed worms]	357, b.
Cassia ubi nascatur [Where cassia grows]	119, a.
Cataputiae symptomata, cura & remedia [The symptoms, treatment and remedies of caper-spurge]	141.
Catillus cineritius quid [What an ash-colored cupel is]	241, a.
Cedrus ubi nascatur [Where the cedar grows]	119, a.
Cerasus ex quercu nata [A cherry-tree born from an oak]	343, a.
<i>in salice</i> [on a willow]	343, b.
Cerussa quid & usta quomodo rubra fiat [What white-lead is, and how, when burnt, it turns red]	12, a.
<i>in plumbum qui reducatur</i> [how it is reduced to lead]	425, b.
<i>ex plumbo qui conficiatur</i> [how it is made from lead]	438, a.
<i>ejus proprietates, symptomata, remedia</i> [its property, symptoms, remedies]	40.
Ceratio quid [What ceration is]	248, b.
Chalcitis virulentia [The virulence of chalcitis]	117, a.
Chalybis conficiendi modus [The method of making steel]	223, b.
<i>potabilis confectio</i> [the preparation of potable (steel)]	430, a.
<i>usus medicus</i> [its medical use]	430, b.
Charta Turcica qui praeparetur [How Turkish paper is prepared]	38, a.
Characteres Chymici [Chemical characters (symbols)]	322.

Lemma [sense-gloss]	Reference(s)
Chaotica massa quid [What the chaotic mass is]	327, b.
<i>ex ea Deus immediate omnia produxit</i> [from it God produced all things immediately]	330, a.
Chersydri symptomata & remedium [The symptoms and remedy of the chersydrus (a serpent)]	143.
Chirotheca petrifica [A petrifying glove (a petrified glove)]	48, a.
Chrysalis quid [What a chrysalis is]	359, a.
Chrysopoeia Caligulae [Caligula's gold-making]	202, b.
<i>an licita</i> [whether it is licit]	308, a.
Chrysocantharus qui generetur [How the chrysocantharus (golden beetle) is generated]	365, b.
Chymia circa quid versetur [With what chemistry is concerned]	242.
Chymiae etymon [The etymology of "chemistry"]	232, a.
<i>Spagyrica definitio</i> [the definition of the Spagyric (art)]	233, a. 238, b.
<i>laus</i> [its praise]	233, b. 312, b.
Chrysalides [Chrysalises]	355, a.
Cicadae unde [Whence cicadas come]	361, b.
<i>ad quid utiles</i> [for what they are useful]	375, a.
Ciconiae in lacu Arelatensi sub aquis repertae [Storks found under the waters in the lake of Arles]	89, b.
<i>delectantur animalium venenatorum pastu</i> [they delight in feeding on venomous animals]	133, a.
Cicuta unde nascatur [Whence hemlock]	108, b.

Lemma [sense-gloss]	Reference(s)
grows]	
<i>eâ intoxicati quid imaginentur</i> [what those poisoned by it imagine]	134, a.
<i>ejus stolones pestiferi</i> [its pestilential shoots]	126, a.
<i>symptomata, cura & remedia</i> [symptoms, treatment and remedies]	141.
Cimex unde [Whence the bedbug comes]	371, a, b.
<i>ad quid utilis</i> [for what it is useful]	376, a.
<i>quomodo fugetur</i> [how it is driven off]	377, b.
Cinabaris proprietas, symptomata, remedia [The property, symptoms, remedies of cinnabar]	140.
<i>minera</i> [its ore]	188, a.
<i>fixatio frustranea</i> [its fixation in vain]	301, b.
Cincindela quid & qui generentur [What fireflies are, and how they are generated]	366, b.
Circulatio quid [What circulation is]	247, b. 395, b.
<i>ejus machina nova</i> [its new apparatus]	396, a.
Coelum philosophorum quid [What the heaven of the philosophers is]	260, a.
Cohobatio quid [What cohobation is]	248, a.
Colcothar quid [What colcothar is]	173, b.
Colocasia ubi nascatur [Where colocasia grows]	119, a.
Colocynthis symptomata, cura & remedium [The symptoms, treatment and remedy of the colocynth]	141.
Color quid [What color is]	8, b.
<i>fundamentum habet in salibus sulphuri commixtis</i> [it has its basis in salts mingled with sulphur]	9, a.

Lemma [sense-gloss]	Reference(s)
<i>inest omnibus corporibus</i> [it is present in all bodies]	101, a.
<i>ultramarinus Lazuli</i> [the ultramarine of lapis lazuli]	464, b.
<i>ejus natura difficilioris indaginis</i> [its nature is of more difficult investigation]	9, a.
<i>infinitus numerus</i> [an infinite number of them]	ibid.
<i>causa in lapidibus</i> [its cause in stones]	ibid.
Colores in opacis corporibus differunt ab iis qui in diaphanis comparent [Colors in opaque bodies differ from those that appear in transparent ones]	9, b.
<i>unde nascantur</i> [whence they arise]	10, b. & seq.
<i>apparentes qui</i> [how the apparent ones (arise)]	15, a.
<i>in trigono quales</i> [what kind in the prism]	16, a, b.
<i>metallorum unde nascantur in Topazio, Saphyro, Carbunculo & Smaragdo</i> [whence the colors of metals arise in topaz, sapphire, carbuncle and emerald]	20, a.
<i>qui quas gemmas exprimant</i> [how they express which gems]	460, a.
Colorum diversitas in diaphanis [The diversity of colors in transparent bodies]	9, b.
<i>commixtio ex quatuor principalibus</i> [their mixture from four principal ones]	10, a.
<i>processus in tinctura ferri</i> [the process in the tincture of iron]	13, b.
<i>combinatio</i> [their combination]	14, a.
<i>tinctura in vegetabilibus</i> [their tincture in plants]	19, a.
<i>in avibus causa</i> [their cause in birds]	17, a.
<i>variae geneses</i> [their various origins]	299, b. 401, a, b.

Lemma [sense-gloss]	Reference(s)
Colubri in stillatitia aqua apparitio [The appearance of a snake in distilled water]	416 & seq.
Confirmatio chymica quid [What chemical confirmation (fixation) is]	292, a.
<i>ejus varii processus</i> [its various processes]	294 & seq.
Contrariorum luctus quid operetur [What the struggle of contraries effects]	110, b.

Letter C (concluded) — Letter D

Lemma [sense-gloss]	Reference(s)
Corallus utrum intra aquas mollis [Whether coral is soft within the waters]	158, a.
<i>an semen habeat</i> [whether it has seed]	159, a.
<i>ramos fistulosos habet & unde</i> [it has hollow branches, and whence]	160, a, b.
<i>fictitius</i> [artificial coral]	466, b.
Coralli rupes Romam transmissa [A coral rock sent to Rome]	158, b.
<i>planta ex cranio humano & delphino vivo</i> [the plant grown from a human skull and a living dolphin]	159, a.
<i>medicae vires</i> [its medicinal powers]	159, b.
<i>ortus</i> [its origin]	158, a. 159 & seq.
<i>durities unde</i> [whence its hardness]	160, a.
<i>stirpium figura</i> [the figure of its stems]	160, b.
<i>vires unde</i> [whence its powers]	ibid.
<i>tincturae varii modi</i> [the various methods of its tincture]	161, a.
<i>solutio</i> [its solution]	435, b.
Cornua qui mollescant [How horns are softened]	485, a.

Lemma [sense-gloss]	Reference(s)
Cornuum fossilium ortus [The origin of fossil horns]	62, a.
<i>differentia</i> [their difference]	62, b.
Corpus mortuum cur gravius vivo [Why a dead body is heavier than a living one]	219, b.
<i>humanum in aquis salinis inventum</i> [a human body found in salt waters]	225, a.
<i>intra aquam qui ponderandum</i> [how it is to be weighed under water]	440, a, b.
Coryli stolones igni appositi se in circulo torquent [Hazel shoots placed by the fire twist themselves in a circle]	418, a.
Crabrones [Hornets]	355, a.
<i>unde</i> [whence they come]	359, a.
Crocus Martis qui calcinetur [How crocus of Mars (iron oxide) is calcined]	243, a.
<i>quomodo praeparetur</i> [how it is prepared]	244, b. 437, b.
<i>Veneris qui conficiatur</i> [how crocus of Venus (copper oxide) is made]	438, a.
Cruces in cancrorum dorsis [Crosses on the backs of crabs]	44, a, b.
Crucifixus in lapidibus expressus [A crucifix imprinted in stones]	31, b.
Crypta petrifica Panormi [A petrifying grotto at Palermo]	46, a.
<i>in agro Neapolitano, Tyburtino & alibi</i> [in the territory of Naples, of Tivoli, and elsewhere]	ibid.
Crystallus quomodo nascatur [How crystal is born]	19, a, b.
<i>constat ex sale</i> [it consists of salt]	20, a.
<i>prodigiosae magnitudinis</i> [of prodigious]	188, b.

Lemma [sense-gloss]	Reference(s)
size]	
<i>quomodo tingatur</i> [how it is dyed]	459, a.
Crystalli minerae [The ores of crystal]	188, a.
<i>calcinatio quomodo fiat</i> [how its calcination is done]	459, b.
<i>induratio</i> [its hardening]	ibid.
<i>compositio</i> [its composition]	462, b.
Culices unde [Whence gnats come]	362, b.
<i>ad quid utiles</i> [for what they are useful]	375, b.
Culmus hordeaceus in vesica inventus [A barley-stalk found in the bladder]	344, a.
Cupressus ubi nascatur [Where the cypress grows]	119, a.
Curculiones quales [What kind of weevils are]	355, a.
Cyniphes unde [Whence stinging-gnats come]	362, a, b.
Daemones Subterranei in quibus locis visi [Subterranean demons, in which places they have been seen]	101, a. 227, a.
<i>montani</i> [the mountain ones]	102, a.
<i>eorum labores in fodinis</i> [their labors in the mines]	ibid.
<i>vexant fossores</i> [they harass the miners]	ibid.
<i>in Helvetia</i> [in Switzerland]	ibid.
<i>in Hungaria</i> [in Hungary]	102, b.
<i>variae de iis relationes</i> [various accounts of them]	102, b. 103, 187, b.
Dei admiranda sapientia in rebus naturae [The admirable wisdom of God in the things of nature]	416, b.

Lemma [sense-gloss]	Reference(s)
Deiparae imago in Regno Chilensi [An image of the Mother of God in the kingdom of Chile]	44, b.
Deliquium quid [What deliquium (deliquescence) is]	247, a.
Delphini corallinis stirpibus obsiti [Dolphins overgrown with coral stems]	344, b.
Democriti sententia de atomis confutatur [Democritus' opinion on atoms refuted]	397, b.
Dendrachata quid [What dendrachate (tree-agate) is]	39, b.
Dentes quomodo Natura formet [How Nature forms teeth]	62, a.
Deodatus de Gozon [Dieudonné de Gozon]	91, b. & seq.
<i>ejus certamen cum Dracone</i> [his combat with the dragon]	92, b.
<i>& eligitur in magnam Magistrum Ordinis</i> [and he is elected Grand Master of the Order]	93, b.
Diaboli in rebus naturalibus scientia [The devil's knowledge of natural things]	256, a.
Diaphana constant sulphure suo & salibus [Transparent bodies consist of their sulphur and salts]	15, b.
Digestio quid [What digestion is]	247, b. 248, a. 395, a.
Diphryges quid [What diphryges is]	207, a.
<i>ejus species & praeparatio</i> [its species and preparation]	ibid.
Dipsas [Dipsas (a thirst-causing serpent)]	143.
Distillatio per reflexum Solis radium [Distillation by the reflected ray of the	241, b.

Lemma [sense-gloss]	Reference(s)
Sun]	
<i>quid sit</i> [what it is]	391, a.
Distillationis dignitas [The dignity of distillation]	391.
<i>differentiae variae</i> [its various differences]	391, b. 392, a.
<i>machina ad sublimandos liquores</i> [an apparatus for subliming liquids]	393, a.
<i>altera machina liquoribus depurandis serviens</i> [another apparatus serving to purify liquids]	ibid.
<i>tertia rebus difficilioris dissolutionis apta</i> [a third suited to things of more difficult dissolution]	393, b.
<i>cautelae</i> [its precautions]	394, a, b.
Dissolutio quid [What dissolution is]	437, a.
Dissimilitudo inter homines [The dissimilarity among men]	336, b.
Dornaei in auro solvendo processus [Dorn's process in dissolving gold]	421, b.
Draco marinus [The sea-dragon]	143.
<i>alchymistis quid</i> [what it is to the alchemists]	315, b.
Draco in Museo Barberinorum [A dragon in the Barberini Museum]	90, a.
<i>à Venatore in campis Romanis occisus</i> [one killed by a hunter in the Roman fields]	90, b.
<i>in spelunca S. Mariae Magdalenae</i> [in the cave of St. Mary Magdalen]	91, a.
<i>Tarasci occisus</i> [one killed at Tarascon]	ibid.
<i>alatus in Insula Rhodo</i> [a winged one on the island of Rhodes]	91, b.
<i>ejus velocitas</i> [its swiftness]	92, a.

Lemma [sense-gloss]	Reference(s)
<i>mors</i> [its death]	92, b.
<i>volans in Helvetia visus</i> [a flying one seen in Switzerland]	93, b.
<i>lapis ab eo dimissus Lucernae conservatur</i> [a stone dropped by it is preserved at Lucerne]	94, a.
<i>volans quomodo exhibeatur in aëre</i> [how a flying one is exhibited in the air]	479, a.

Letter D (concluded) — Letters E, F, G, H

Lemma [sense-gloss]	Reference(s)
Dracones subterranei [Subterranean dragons]	89 & seq.
<i>alati Aegyptii</i> [the winged Egyptian ones]	90, a.
<i>à Sanctis occisi</i> [killed by saints]	ibid.
<i>in Helvetia</i> [in Switzerland]	90, b.
<i>Pictoris cujusdam cum iis habitatio</i> [a certain painter's dwelling among them]	95, a.
<i>eorum genesis</i> [their generation]	95, b.
<i>membrorum in iis diversitas unde</i> [whence the diversity of limbs in them]	96, b.
<i>cur ignem spirare videantur</i> [why they seem to breathe fire]	ibid.
<i>aurum appetunt</i> [they crave gold]	202, a.
Corn. Drebellius [Cornelius Drebbel]	266, a.
Dryinus, serpens [The dryinus, a serpent]	143.
Electrum quibus constet [Of what electrum (amber/alloy) consists]	205, a.
Electrum. Vide Succinum. [Electrum.	

Lemma [sense-gloss]	Reference(s)
See Amber.]	
Elementa putredinem generant [The elements generate putrefaction]	110, b.
<i>concurrunt remote ad compositionem rerum</i> [they concur remotely in the composition of things]	328, a.
<i>eorum pondus quomodo exploretur</i> [how their weight is investigated]	380, b.
<i>quomodo in phiala exhibeantur</i> [how they are exhibited in a flask]	433, a.
Elixir quid [What the elixir is]	233, a. 262, a.
Emphyteutica ars quid doceat [What the grafting art teaches]	382 & seq.
Emplastratio quomodo instituenda [How shield-budding is to be performed]	384, a.
Encausta quid [What encaustic colors are]	453, a.
<i>praeparandi modus</i> [the method of preparing them]	ibid. b.
<i>ad lucernam</i> [for the lamp]	453, a.
<i>eorum pictura Florentina</i> [the Florentine painting in them]	458, b.
Ensis temperamentum [The tempering of a sword]	221, b.
Erinaceus [The hedgehog]	88, a.
Erucae qui in papiliones degenerent [How caterpillars change into butterflies]	347, b.
<i>cujus generis insecta</i> [of what kind of insects]	355, a.
Euphorbii symptomata, cura & remedia [The symptoms, treatment and remedies of euphorbia]	142.

Lemma [sense-gloss]	Reference(s)
Extractio [Extraction]	248, a.
Extravagans Joannis XXII. P. M. [The Extravagans (decretal) of Pope John XXII]	308, b.
Fex quotuplex [How many kinds of dregs (lees) there are]	136, b.
Falx qui temperetur [How a sickle is tempered]	221, b.
Fanum in Chile ex crystallo [A shrine in Chile made of crystal]	19, b.
Felis rabida cerebrum comestum infatuat [A rabid cat's brain, eaten, deranges]	127, b.
Fermentatio [Fermentation]	250, a. 262, b.
<i>quid & quomodo fiat</i> [what it is and how it is done]	396, b.
<i>ejus requisita</i> [its requisites]	a.
Ferrum quomodo solvatur [How iron is dissolved]	222, a.
<i>qui crystallescat</i> [how it crystallizes]	457, b.
Ferri minera qualis [What kind the ore of iron is]	188, a.
<i>in cuprum versio</i> [its conversion into copper]	188, b. 189, b. 216, a. 257, b.
<i>genesis</i> [its origin]	219, a.
<i>qualitas</i> [its quality]	ibid.
<i>durities unde</i> [whence its hardness]	219, b.
<i>sympathia & antipathia</i> [its sympathy and antipathy]	220, a.
<i>praeparandi & temperandi ratio</i> [the method of preparing and tempering it]	220, & seq.
<i>coquendi modi</i> [the modes of smelting it]	221, a. 222.
<i>bonitas in Ilva insula</i> [its goodness on	222, a.

Lemma [sense-gloss]	Reference(s)
the island of Elba]	
<i>puritatis signa</i> [the signs of its purity]	222, b.
<i>matrices</i> [its matrices]	223, a.
<i>decoctio & in chalybem commutatio</i> [its smelting and conversion into steel]	ibid.
<i>in aes transmutatio non est propria</i> [its transmutation into copper is not proper (genuine)]	223, b.
<i>neque in plumbum</i> [nor into lead]	258, a.
<i>inaurandi modus</i> [the method of gilding it]	481, b.
<i>calx</i> [its calx]	483, b.
Ficus ex una parte albae ex altera rubrae qui producantur [How figs are produced white on one side and red on the other]	387, a.
Filtratio quid [What filtration is]	247, b.
Fixatio chymica quid [What chemical fixation is]	301, b.
<i>Lunae & Solis</i> [the fixation of the Moon (silver) and Sun (gold)]	307, a.
<i>Mercurii</i> [of Mercury]	ibid.
Flamma viridis, caerulea, purpurea atra qua [By what means a green, blue, purple, or black flame (is made)]	18, a.
Flos quomodo vario colore imbuatur [How a flower is imbued with various color]	389, a.
Fodinae quomodo purgentur [How mines are cleared]	174, b.
Fodinarum vena quid [What the vein of mines is]	173, a.
<i>fibrae quid</i> [what their fibers are]	178, b.
<i>natura & proprietas</i> [their nature and	183, & seqq.

Lemma [sense-gloss]	Reference(s)
property]	
Foenum qui adolescat [How hay grows up]	340, b.
Fons lethifer Terracinae [A deadly spring at Terracina]	127, a.
Formae substantiales educuntur ex potentia naturae [Substantial forms are drawn out from the potency of nature]	336, b.
Forma rerum ex quibus consistat [Of what the form of things consists]	5, b.
Formicae quid [What ants are]	366, b.
<i>unde oriantur</i> [whence they arise]	367, b.
<i>ad quid utiles</i> [for what they are useful]	375, b.
Fornax subterranea qualis [What a subterranean furnace is like]	238, a.
<i>philosophica quae</i> [what the philosophical one is]	392, a.
<i>Aetnae qualis</i> [what kind Etna's is]	ibid. b.
Fossores quibus morbis affligentur [With what diseases miners are afflicted]	172, a.
<i>quibus modis se tueantur contra venena</i> [by what means they guard themselves against poisons]	172, b.
<i>pereunt ab halitibus clausis</i> [they perish from enclosed vapors]	175, a.
Frigiditatis gradus difficulter assignari potest [The degree of cold can be assigned only with difficulty]	400. & seq.
Fructus qui incorrupti servantur [How fruits are kept uncorrupted]	388, b.
<i>quomodo suaviore & odoratiores</i>	389, b.

Lemma [sense-gloss]	Reference(s)
<i>reddantur</i> [how they are made sweeter and more fragrant]	
Fuci unde & cur sine aculeo [Whence drone-bees come and why without a sting]	358, a.
Fuligines venenatae quae mala causent [What ills poisonous soots cause]	173, a.
Fulminatio quid [What fulmination is]	249, a.
Funes incendiarii qui praeparentur [How incendiary fuses are prepared]	472 & seq.
Fungorum symptomata, cura & remedia [The symptoms, treatment and remedies of mushrooms]	142.
<i>species variae</i> [their various species]	339 & seq.
<i>cervinorum ortus</i> [the origin of the deer-mushrooms]	350, a, b.
<i>usus</i> [their use]	351, a.
Furni varii [Various furnaces]	239 & seq.
Galactites lapis [The galactite stone]	168, b.
Galenī laus [The praise of Galen]	278, a.
Gallinae delectantur animalium venenatorum pastu [Hens delight in feeding on venomous animals]	132, a.
<i>ferrum & nummos aureos digerunt</i> [they digest iron and gold coins]	ibid.
Gallus monstruosus in horto Magni Hetruriae Ducis [A monstrous cock in the garden of the Grand Duke of Tuscany]	96, b.
Gangrena cur curatu difficilis [Why gangrene is difficult to cure]	108, a.
Geber sophistica tradidit [Geber	273, a.

Lemma [sense-gloss]	Reference(s)
handed down sophistries]	
Gemma ex quibus fiant [From what gems are made]	7, a.
<i>diaphanae quomodo generentur</i> [how transparent ones are generated]	15, b. 25, a.
<i>punctatae quae</i> [which are dotted]	22, b.
<i>lineatae</i> [the striped ones]	23, a.
<i>polygonae</i> [the many-angled ones]	24 & seq.
<i>quomodo ex smalto parentur</i> [how they are produced from smalt (glass-paste)]	454, b. 455, a, b.
<i>emollitae qui duritiem recuperent</i> [how, when softened, they recover their hardness]	459, a.
<i>quomodo ab Alexio conficiantur</i> [how they are made by Alexius]	459, b.
<i>ex suppositis bracteis qui colorentur</i> [how they are colored by foils placed beneath them]	460, b.
Gemmarum durities unde [Whence the hardness of gems]	19, a.
<i>vires</i> [their powers]	47, b.
<i>origo</i> [their origin]	228, a.
<i>solutio</i> [their solution]	435, b.
Geocosmi cum Microcosmo comparatio [The comparison of the Geocosm with the Microcosm]	1.
S. Georgii martyrium [The martyrdom of St. George]	68, b.
Getta quid [What "getta" is]	208, a.
Gigas in curia Magni Cham [A giant at the court of the Great Khan]	55, a.
<i>Maximiliano Caesari oblatu</i> [one presented to the Emperor Maximilian]	56, b.
<i>Ferdinando II.</i> [to Ferdinand II]	56, a.

Lemma [sense-gloss]	Reference(s)
<i>Drepitanus</i> [the one of Trapani]	58, b.
Gigantum sepulcra [The tombs of giants]	53, b.
<i>varia sceleta</i> [various skeletons]	54 & seq.
<i>robur</i> [their strength]	55, b.
<i>mensura</i> [their measure (size)]	57, a.
<i>de iis Fabulosa narratio</i> [a fabulous account of them]	59, a. 60, a.
<i>ossa in Sicilia inventa</i> [bones found in Sicily]	59, a.
Globi fossiles quomodo generentur [How fossil globes are generated]	61, a.
<i>aquatici recreativi qui componantur</i> [how recreational water-globes are composed]	475, a, b. & seq.
<i>aquatici odoriferi qui</i> [how the fragrant water-globes (are made)]	476, a, b.
<i>lucentes qui</i> [how the luminous ones (are made)]	478, a, b.
Goliath quam altitudinem habuerit [What height Goliath had]	58, a.
Gradus rerum difficulter indagantur [The degrees of things are investigated with difficulty]	400 & seq.
Gravitas cerae ad aquam [The weight of wax relative to water]	471, b.
<i>auri, argenti, aeris ad aquam</i> [of gold, silver, copper relative to water]	440, a.
<i>plumbi & cerae ad aquam</i> [of lead and wax relative to water]	441, b.
<i>plumbi ad stannum</i> [of lead relative to tin]	ibid.
<i>olei ad aquam</i> [of oil relative to water]	442, a.
<i>mercurii ad aquam</i> [of mercury]	ibid.

Lemma [sense-gloss]	Reference(s)
relative to water]	
<i>mercurii ad plumbum</i> [of mercury relative to lead]	442, a, b.
<i>auri ad argentum</i> [of gold relative to silver]	444, b.
<i>auri ad ferrum</i> [of gold relative to iron]	445, a.
<i>aeris ad plumbum</i> [of copper relative to lead]	ibid.
<i>aquae ad vinum</i> [of water relative to wine]	ibid.
<i>aquarum diversa</i> [the differing (weights) of waters]	446, a.
<i>sanguinis in hominibus</i> [of blood in men]	ibid.
<i>liquorum</i> [of liquids]	44, b.
Grylli unde [Whence crickets come]	364, a, b.
Gypsi proprietates, symptomata, remedia [The property, symptoms, remedies of gypsum]	141.
Habitatio subterranea Melitae [Subterranean dwelling on Malta]	98, a.
<i>in Hetruria</i> [in Tuscany]	98, b.
<i>in montibus Lunae & Caspiis</i> [in the Mountains of the Moon and the Caspian mountains]	99, a.
<i>in Hispania</i> [in Spain]	100, a.
<i>in Transilvania</i> [in Transylvania]	ibid.
Hamus piscatorius qui temperetur [How a fishhook is tempered]	221, b.
Haemorrhoi vis in sanguinem [The power of the haemorrhoids (a serpent) upon the blood]	107, a.
<i>symptomata & remedia</i> [its symptoms and remedies]	143.

Lemma [sense-gloss]	Reference(s)
Hedera qui nascatur [How ivy grows]	343, b.
<i>inter cornua cervi nata</i> [grown between a stag's horns]	ib.
Helcisma quid [What helcysma is]	206, b.
Heliotropinus lapis [The heliotrope stone]	28, a.
Hellebori symptomata, cura & remedia [The symptoms, treatment and remedies of hellebore]	142.
<i>vires</i> [its powers]	411, a.
Herbae venenosae unde oriantur [Whence poisonous herbs arise]	106, b. 107, a.
<i>quomodo nascantur</i> [how they grow]	340, & seq.
<i>unde virtutem acquirant</i> [whence they acquire their power]	388, a.
<i>lethargum causantes</i> [those causing lethargy]	412, b.
<i>solisequae cur ad Solem se vertant</i> [why heliotropes turn themselves toward the Sun]	417, b.
Herbarum praedicamenta novem [The nine categories of herbs]	381, a, b.
<i>medicinalium virtutes</i> [the powers of the medicinal ones]	403, 404, a.
<i>transplantatio quid operetur</i> [what their transplantation effects]	(continued)

Letters H (concluded), I/J, L, M (begun)

Lemma [sense-gloss]	Reference(s)
<i>(transplantatio quid opere-)tur</i> [what their transplantation effects, continued]	409, a.
<i>virtutes prodigiosae num vere dentur</i> [whether their prodigious powers]	411. & seqq.

Lemma [sense-gloss]	Reference(s)
truly exist]	
<i>palingenesis</i> [their palingenesis (revival)]	413, b. 414, & seq.
Hermodactylus [Hermodactyl]	139, a.
Hippice herba [The herb hippice]	412, a.
Hippocratis laus [The praise of Hippocrates]	278, a.
Hippocampae [Seahorses]	355, a.
<i>ad quid utiles</i> [for what they are useful]	376, a.
Hippomanes [Hippomanes]	350, a.
Hirci sanguis cur calculo medeatur [Why goat's blood is a remedy for the stone]	409, a.
Hirudinis symptomata & remedia [The leech's symptoms and remedies]	144.
Hirundines & mira earum occultatio [Swallows and their wondrous concealment]	88, a, b.
<i>quomodo intra aquam vivere queant</i> [how they can live under water]	89, a.
<i>cur deplumes reperiantur</i> [why they are found featherless]	ibid.
<i>quanto tempore orbem terrarum circumvolare possint</i> [in how much time they can fly around the globe]	448, b.
Homines subterranei Melitae quomodo vivant [How the subterranean men of Malta live]	97, b. & seqq.
Humiditatis gradus difficulter assignari potest [The degree of moisture can be assigned only with difficulty]	400 & seq.
<i>in singulis quomodo exploretur</i> [how it	446, b.

Lemma [sense-gloss]	Reference(s)
is investigated in particular cases]	
Humidum unctuosum quid [What unctuous moisture is]	168, b.
<i>quomodo in metallum degeneret</i> [how it degenerates into metal]	168, a.
Hyacinthus qui conficiatur [How the hyacinth (jacinth) is made]	457, a.
Hydrargyrum argentum sterile purgat [Hydrargyrum purges barren silver]	211, b.
<i>ubi reperiatur</i> [where it is found]	ibid.
<i>educitur è sordibus metallicis</i> [it is drawn out from metallic dross]	212, a.
<i>quomodo separetur ab argento</i> [how it is separated from silver]	213, a.
<i>in optimum argentum qui convertatur</i> [how it is converted into the best silver]	290, b.
<i>ejus natura</i> [its nature]	151, a.
<i>proprietas</i> [its properties]	151, b. <i>Vide Argentum vivum</i> [See Quicksilver].
Hydria quid [What a hydria is]	152, b. 227, a.
Hydrophoborum natura [The nature of those with rabies (hydrophobia)]	134, b.
Hyosciamus quid operetur [What henbane effects]	118, b.
Hyucca quid [What yucca is]	138 & seq.
Asponix quid [What asponix is]	22, b.
Ignis quid & quotuplex [What fire is, and how many kinds]	398, a.
Ignis proprietas [The property of fire]	68, b.
<i>qua ei resistant</i> [what things resist it]	67, a. 68, b.
<i>Subterranei machina</i> [the apparatus of subterranean fire]	73.

Lemma [sense-gloss]	Reference(s)
<i>artificiosi qui aqua accenditur</i> <i>compositio</i> [the composition of an artificial fire that is kindled by water]	477, b.
Ignis fatuus quid & ubi appareat [What a will-o'-the-wisp is and where it appears]	40, a.
Ignis perpetuus vere non datur [A perpetual fire does not truly exist]	70, b.
<i>quomodo alio aliquo modo fieri possit</i> [how it might be made in some other way]	73, a.
<i>ejus Plutarchus, Aristoteles, alique non meminerunt</i> [Plutarch, Aristotle, and others did not mention it]	72, b.
Imbibitio [Imbibition]	248, a.
Inaurandi modus [The method of gilding]	481, b. 483 & seq.
Incineratio quid [What incineration is]	245, a.
Insolatio quid [What insolation (sun-exposure) is]	383, b.
Inoculatio quomodo facienda [How budding (inoculation) is to be done]	384, a.
Insitio arboris sub cortice quomodo facienda [How grafting of a tree under the bark is to be done]	383, b.
<i>quomodo in trunco arboris</i> [how into the trunk of a tree]	384, a.
Intervenium quid [What the inter-vein is]	179, a.
Impostura quorundam pseudochymicorum [The imposture of certain pseudo-chemists]	304, a, b. 306, a, b.
<i>Arabum</i> [of the Arabs]	305, a.
<i>cujusdam in praesentia Principis</i> [of a	305, b.

Lemma [sense-gloss]	Reference(s)
certain one in the presence of a prince]	
Insecta quae & quotuplicia [What insects are and how many kinds]	345, a.
<i>qui nascantur</i> [how they are born]	ibid. & seq.
<i>varia</i> [various ones]	353, a, b. & seq.
<i>aquatica unde</i> [whence the aquatic ones come]	357, b.
<i>quomodo artificio producantur</i> [how they are produced by art]	373, a, b.
<i>mundo necessaria</i> [necessary to the world]	374, a.
<i>cur natura tot produxerit</i> [why nature produced so many]	ibid.
Joannes ab Ascia [John of Ascia (?)]	266, b.
Isis quid denotet [What Isis denotes]	315, a.
Jupiter chymice denotat aes [Jupiter, chemically, denotes copper (aes)]	165, a.
Jurati quid in fodinis facere debeant [What the sworn officials must do in the mines]	172, a.
Justinianus Princeps Bassanensis [Giustiniani, Prince of Bassano]	42, b.
Lactuca qui fiat odorata [How lettuce is made fragrant]	388, b.
Lacus Labacensis mira [The marvels of the Lake of Laibach (Cerknica)]	89, b.
Lac Virginis quid [What virgin's milk is]	261, b. 299, b.
Lampyrides quid [What glow-worms are]	366, a.
<i>qui generentur</i> [how they are generated]	366, b.
<i>ad quid utiles</i> [for what they are]	375, b.

Lemma [sense-gloss]	Reference(s)
useful]	
Lapis philosophorum quid [What the philosophers' stone is]	250, b.
<i>mysticus & fictitius</i> [the mystical and the counterfeit]	251, a.
<i>varia ejus nomina</i> [its various names]	ibid.
<i>in investiganda ejus materia</i>	251 & seqq.
<i>Alchymistarum conflictus</i> [the alchemists' conflict over investigating its matter]	
<i>qui conficiatur</i> [how it is made]	254 & seq.
<i>vegetabilis quis sit</i> [what the vegetable one is]	259, b.
<i>in eo conficiendo Paracelsi processus</i> [Paracelsus' process in making it]	297, a.
<i>Nicolai Bernaudi</i> [that of Nicolas Barnaud]	263, b.
<i>Arabum</i> [of the Arabs]	260, a.
<i>Joannis Azothi</i> [of Joannes Azoth]	245, b.
<i>Joanni XXII. P. M. falso adscriptus</i> [falsely ascribed to Pope John XXII]	309, b.
Lapidis definitio [The definition of stone]	3, a.
<i>differentiae variae</i> [its various differences]	ibid. & seq.
<i>divisio</i> [its division]	4.
<i>origo</i> [its origin]	5, a.
<i>in homine generatio</i> [its generation in man]	137, a.
<i>fusilis experimentum</i> [the experiment of the fusible (stone)]	466, a.
Lapis Lazuli [Lapis lazuli]	22, b.
Lapidifica vis quid [What the petrifying power is]	6, a.

Lemma [sense-gloss]	Reference(s)
<i>unde oriatur</i> [whence it arises]	7, b.
<i>inest mineralibus</i> [it is present in minerals]	45, a.
Lapides ex quibus fiant [From what stones are made]	7, a.
<i>quae requirantur ad eorum consistentiam</i> [what is required for their consistency]	ibid. 52, b.
<i>quomodo in fodinis crescant</i> [how they grow in mines]	ibid. b.
<i>cur purioris aut impurioris substantiae</i> [why of purer or more impure substance]	ibid.
<i>eorum color</i> [their color]	8, a.
<i>Chromatismus in quo consistat</i> [in what their chromatism consists]	11, b.
<i>quomodo colorentur in terrae visceribus</i> [how they are colored in the bowels of the earth]	13 & seq.
<i>punctati qui</i> [which are dotted]	22, b.
<i>qui lineati</i> [which are striped]	23, a.
<i>qui conficiantur</i> [how they are made]	24, a.
<i>variarum rerum in iis expressio</i> [the imprinting of various things in them]	27 & seqq.
<i>nemorosorum lapidum quatuor genera</i> [the four kinds of wooded (landscape) stones]	39, b.
<i>quomodo animalium figurae in iis imprimantur</i> [how the figures of animals are imprinted in them]	41 & seq.
<i>generantur in omnibus humani corporis membris</i> [they are generated in all members of the human body]	51, a.
<i>in partibus animalium</i> [in the parts of]	51, b. & seq.

Lemma [sense-gloss]	Reference(s)
animals]	
<i>Duodecim in Rationali Sacerdotis Magni positi</i> [the twelve set in the breastplate of the High Priest]	83 & seq.
<i>cur igne in calcem degenerent</i> [why they degenerate into lime by fire]	170, a.
<i>cupro divites</i> [rich in copper]	190, a.
<i>quotuplices</i> [how many kinds]	309, a.
<i>quales</i> [of what kinds]	309, b.
<i>marini</i> [the marine ones]	399, b.
<i>non solvuntur oleosis</i> [they are not dissolved by oily substances]	434, b.
<i>factitii</i> [the artificial ones]	466, a.
Laserpitii ortus [The origin of laserpicium (silphium)]	338, a, b.
Laurus ex puppi navis nata [A laurel grown from a ship's stern]	343, b.
<i>in platano</i> [on a plane-tree]	ibid.
Leo ruber quid [What the red lion is]	11, b.
Lepus marinus [The sea-hare]	144.
Libavii de insectis transformandis relatio [Libavius' account of transforming insects]	409, b.
<i>de resuscitatione plantarum narratio</i> [his narrative on the resuscitation of plants]	416, a.
<i>in auro solvendo processus</i> [his process in dissolving gold]	421, a.
Ligna quomodo in saxa convertantur [How woods are converted into rocks]	46, b.
<i>cur igne in cineres degenerent</i> [why they degenerate into ashes by fire]	170, a.
Lignum fossile naturale [Natural	65, a.

Lemma [sense-gloss]	Reference(s)
fossil wood]	
<i>in agro Aquaspartano</i> [in the territory of Acquasparta]	ibid.
<i>à Caesio detectum</i> [discovered by Cesi]	65, b.
<i>ejus forma</i> [its form]	ibid.
<i>origo</i> [its origin]	66, a.
<i>alni in lapidem versum</i> [an alder turned into stone]	190, a.
Lima qui temperetur [How a file is tempered]	221, b.
Limaces unde [Whence slugs come]	357, a.
Lini Asbestini praeparatio [The preparation of asbestos linen]	174, a.
<i>in sericum transmutatio</i> [its transmutation into silk]	466, b.
Lithantraces ubi reperiantur [Where coal (lithanthrax) is found]	66, b. 189, a.
<i>eorum halitus pestifer</i> [their pestilential vapor]	126, a.
Limus Chaoticus qua virtute ab initio induruit [By what power the chaotic slime hardened at the beginning]	5, a, b.
Lithargyrii proprietates, symptomata, remedia [The property, symptoms, remedies of litharge]	141.
Lithargyrium quid [What litharge is]	207, b.
Liquor limpidus quomodo in album commutetur [How a clear liquid is changed to white]	299, a.
<i>quomodo in croceum</i> [how into saffron-yellow]	290, b.
<i>in caeruleum</i> [into blue]	ibid.
<i>in nigrum</i> [into black]	ibid.

Lemma [sense-gloss]	Reference(s)
<i>caeruleus in purpureum</i> [blue into purple]	ibid.
<i>ejus gravitatem & crassitiem explorare</i> [to test its weight and density]	448, b. 449, a.
Locustae unde [Whence locusts come]	363, a, b.
<i>quomodo generent</i> [how they breed]	363, b.
<i>combustae reliquas odore fugant</i> [the burnt ones drive off the rest by their smell]	364, a.
<i>quales fuerint quibus S. Joannes vescebatur</i> [of what kind were those on which St. John fed]	ibid.
<i>ad quid utiles</i> [for what they are useful]	375, b.
<i>qui exterminentur</i> [how they are exterminated]	376, b.
Lucerna perpetuo ardens an fieri possit [Whether a perpetually burning lamp can be made]	69, a, b.
<i>variae de ea opiniones</i> [various opinions about it]	70, b.
<i>varii ejus construendi modi</i> [various methods of constructing it]	71 & seq.
<i>Aegyptii quomodo eam faciebant</i> [how the Egyptians made it]	74, a.
Lullus [Raymond Lull]	266, b.
<i>ejus Lunaria</i> [his Lunaria]	271, a.
<i>martyrio coronatus</i> [crowned with martyrdom]	276, a.
Lumbrici qui generentur [How earthworms are generated]	356, a, b.
<i>in intestinis qui</i> [how those in the intestines (arise)]	357, b.
<i>ad quid utiles</i> [for what they are]	376, a.

Lemma [sense-gloss]	Reference(s)
useful]	
Luna chymice denotat argentum [The Moon, chemically, denotes silver]	165, a.
Lunaria Lulli quid operetur [What Lull's Lunaria effects]	231, a.
<i>Rabbinorum</i> [that of the Rabbis]	282, b.
Lutum sapientiae quomodo paretur [How the lute of wisdom (sealing-clay) is prepared]	291, a. 394, b.
Machina hydraulica [Hydraulic machine]	176, a. 193, 194, 195, 196.
<i>anemica</i> [the pneumatic one]	190, b. 191.
<i>ad aërem in fodinis emendandum</i> [for refreshing the air in mines]	191.
<i>haustoria</i> [the drawing (pumping) machine]	225, 229, a.
Magnes aureus utrum detur [Whether a golden magnet exists]	202, a.
<i>igni traditus perdit</i> [committed to the fire, it loses (its power)]	(continued)

Index of Subjects and Words of the Second Volume (continued)

[INDEX RERUM & VERBORUM TOMI SECUNDI — continued from letter M through the end of the index, concluding with FINIS.]

Reading order used: linear, → 990 → 991 → 992. On each leaf the printed page is itself two-columned; I read the left printed column top-to-bottom, then the right printed column top-to-bottom. The alphabetical sequence (M → N → O → P → Q → R → S → T → V → X → Z) and the page catchwords ("Moschini", "Ostra-", "Sal", "Transf-") confirm this order.

Each entry is given as printed: the Latin lemma (with a bracketed English sense-gloss), followed by its page-and-column references ("a" = left text-column, "b" =

right text-column of the referenced page; "ibid." = same reference as immediately preceding; "& seq." / "& seqq." = and following).

running header: "& VERBORUM"

Lemma [gloss]	Reference(s)
[Magnes, continued — magnet] ...dit virtutem [imparts its power]	424, a.
ejus vis quomodo statica exploretur [how its force is investigated statically]	446, b.
Magnetismus Naturæ [the magnetism of Nature]	6, a. 37, a.
in lapidum generatione [in the generation of stones]	8, a.
venenorum [of poisons]	137, a.
cupri ad ferrum [of copper toward iron]	257, b.
similium ad similia [of like toward like]	298, b.
quid efficiat [what it accomplishes]	328, a, b.
Magon Pœnus [Mago the Carthaginian]	411, b.
Mandicca quid [what manioc is]	139, b.
Mandragoræ symptomata, cura & remedia [mandrake — symptoms, treatment and remedies]	142
Marcasita quid & ubi [marcasite — what and where]	187, a, b.
argentea [silver marcasite]	188, a.
qui generetur [how it is generated]	8, a.
ejus proprietas, symptomata, remedia [its property, symptoms, remedies]	141, 148, a, b. & seq.
Mare Rubrum coralli ferax [the Red Sea, productive of coral]	159, a.
Margaritæ qui conficiantur [how pearls are made]	461, a. 466, a, b.

Lemma [gloss]	Reference(s)
Mars chymice ferrum denotat [Mars, in chemistry, denotes iron]	165, a.
Martagon quid Lullo [what martagon is, according to Lull]	271, b.
Mastyx qui depuretur [how mastic is purified]	458, b.
Materia prima Alchymistarum subsistere non potest [the prime matter of the alchemists cannot subsist]	255 & seq. 268, a. 271 & seq.
a Paracelso denominata [named by Paracelsus]	274 & seq.
Medicamentum quid [what a medicament is]	109, a.
Medicinalium virtutes [the powers of medicinal substances]	403.
effectus [their effects]	404, a.
terminorum explicatio [explanation of terms]	404 & seq.
vires quomodo à nonnullis investigatæ [how their powers were investigated by some]	405, a.
Melchior Cibirensis [Melchior of Cibirum (Sibiu)]	266, b.
Mensa argentea Ducis Saxoniae [the silver table of the Duke of Saxony]	203, a.
vitrea qui conficiatur [how a glass table is made]	458, a.
Menstrua mulierum quam noxia [women's menses, how harmful]	112, b.
ad solvendum aurum qui conficiantur [menstrua for dissolving gold, how prepared]	420, b.

Lemma [gloss]	Reference(s)
ex melle manna acerrima [from honey, a most pungent manna]	425, a.
ad Lunam solvendam apta [suited to dissolving silver]	429, b.
solventia quid præstent [what the solvents accomplish]	434, a.
Mercurius Trismegistus reconditæ doctrinæ auctor [Hermes Trismegistus, author of recondite doctrine]	313, a.
Mercurius incorrigibilis est [Mercury (quicksilver) is incorrigible]	151, b.
omnia conjungit [it joins all things]	ibid.
lethifer est [it is deadly]	153, a, b.
correctus fit medicina [when corrected, it becomes a medicine]	ibid.
de ejus viribus judicium Authoris [the Author's judgment on its powers]	154, a.
utrum aurum trahat & qualiter [whether and how it draws gold]	154, b. 155, a, b.
chymice argentum vivum denotat [in chemistry it denotes quicksilver]	165, a.
qui præcipitetur [how it is precipitated]	243, a.
difficulter domatur [it is tamed with difficulty]	252, a.
est indestructibilis [it is indestructible]	253, b.
utrum à succo aliquo coaguletur [whether it is coagulated by some juice]	271, b. 272, a.
an in hominis sanguine [whether [it is found] in human blood]	ibid.
quomodo sublimetur [how it is sublimed]	260, b.

Lemma [gloss]	Reference(s)
utrum in motum artificialibus machinis animari queat [whether it can be animated into motion by artificial machines]	486, a, b.
Vide Argentum vivum & Hydrargyrum [see Quicksilver and Hydrargyrum]	
Metallum quid sit [what a metal is]	164, b.
igne cur purius reddatur [why it is rendered purer by fire]	170, a.
quomodo mollefiat [how it is softened]	200, a.
qui per plumbum fulminetur [how it is detonated by means of lead]	249, a.
Metalla quomodo in duritiem excrescant [how metals grow into hardness]	163, b.
quomodo virtute cœlesti generentur [how they are generated by celestial power]	166, b.
excoquendi ratio [the method of smelting]	171, a.
commixta ubi reperiantur [where they are found mixed together]	187, b.
quomodo paranda ad cocturam [how they are to be prepared for firing]	197, a.
tria tormenta sustinere debent in depuratione [they must endure three torments in purification]	197, b.
separandi modus [the method of separating them]	212, b.
plumbo comburuntur [they are burned with lead]	249, b.
quantum mercurii contineant explorare [to test how much mercury they contain]	448, a.
sine plumbo non vitrescunt [without	455, a.

Lemma [gloss]	Reference(s)
lead they do not vitrify]	
qui smalto inurantur [how they are enamelled]	456, a.
Metallorum colores [the colors of metals]	18, b.
attractiones [their attractions]	155, a.
transmutationes [their transmutations]	ibid. b.
materia [their matter]	162, b.
genesis [their genesis]	ibid. & 253, b. 237, a.
forma [their form]	164, a.
productioni quid conferant elementa [what the elements contribute to their production]	167, a.
fluxibilitas in igne unde [whence their fluidity in fire]	170, a.
venæ qua ratione innotescant [by what method their veins are discovered]	179 & seq.
ustio quomodo fiat [how their roasting is done]	197, a.
mistura [their mixture]	205.
scoria [their slag]	206, a.
transmutatio quid [what their transmutation is]	256, b. 257, a.
prima materia qui paretur [how their prime matter is prepared]	255 & seq.
calcinatio per mercurium [calcination by mercury]	437, b.
calces quos colores adducant [what colors their calxes bring on]	457, a.
calcinatio [calcination]	482, b.
Metallurgia quid & in quo consistat [what metallurgy is and in what it	162, 233, a. 38, a.

Lemma [gloss]	Reference(s)
consists]	
Metallurgus quid nosse debeat [what a metallurgist ought to know]	171, a, b.
Meteororum circulatio [the circulation of meteors (atmospheric exhalations)]	170, b.
Microcosmus est fornax distillatoria [the microcosm is a distilling furnace]	392.
Mineralia quæ venenosa [which minerals are venomous]	108, a.
alia majora, alia minora [some greater, some lesser]	252, b.
quotuplicia [how many kinds]	399, a.
Minium liquefieri non potest [minium (red lead) cannot be liquefied]	163, a.
Mistura ollaria quid [what a potter's mixture is]	105, b.
ignea quam Sol accendere possit qui præparetur [how a fiery mixture is prepared that the Sun can kindle]	477, a.
Mixta omnia ex quibus constent [of what all mixed bodies are composed]	124, a. 298, a.
Mola ad conterendam materiam mineralem [a mill for grinding mineral matter]	198.
Monoceros quid [what the unicorn is]	63, a.
nunquam fuit [it never existed]	ibid.
Monocerotis cornu ubi [where the horn of the unicorn (is)]	63, b.
est spicula piscium [it is the spike of fishes]	ibid.
Romæ [at Rome]	64, a.
ab Alberto Magno observatum [observed by Albertus Magnus]	ibid.
cur in Anglia præcipue sit [why it is]	ibid.

Lemma [gloss]	Reference(s)
found especially in England]	
fossile [as a fossil]	64, b.
Mons aurifer qualis [the gold-bearing mountain, of what kind]	208, a.
Montes an ab initio rerum exstiterint [whether mountains have existed from the beginning of things]	5, a.
ardentes [burning mountains]	157, a.
Monstra unde nascantur [whence monsters arise]	96, a.
Morbi ex sulphure, mercurio & sale constant [diseases consist of sulphur, mercury and salt]	135, a, b.
quinam à sale [which [diseases come] from salt]	136, a.
quinam à tartaro [which from tartar]	136, b.
fossorum [of miners]	172, a.
metallici eorumque cura [metal-induced [diseases] and their treatment]	173 & seq.
Motus in rerum natura quis [what motion is in the nature of things]	298, a.
Motus perpetuus fieri non potest [perpetual motion cannot be made]	72, a.
est pure artificialis [it is purely artificial]	233, b.
ejus inventiones decem ad Authorem transmissæ [ten of its devices submitted to the Author]	234, a.
quomodo arte Chymica exhibeatur [how it is exhibited by the chemical art]	432, b.
Moschini [Moschini (musk-substances)]	355, a.

Lemma [gloss]	Reference(s)
Mundus vicissitudini obnoxius [the world is subject to vicissitude]	105, a.
Trismegisto quadruplex [fourfold, according to Trismegistus]	313, a.
Subterraneus omnium origo [the Subterranean (World), origin of all things]	385, a.
nil est nisi fornax distillatoria [it is nothing but a distilling furnace]	390.
Mus Alpestris qualis [the Alpine mouse, of what kind]	87, b.
Mures varii [various mice]	87, b.
qui nascantur ex limo [how they are born from mud]	346, a.
ex bovillo stercore quā [from ox-dung, how]	352, b.
quomodo propulsentur [how they are driven off]	377, a.
Muscæ unde [whence flies]	361, a, b.
variæ [various kinds]	362, a.
ad quid utiles [for what they are useful]	376, a.
Musicas proportionales explorare [to investigate musical proportions]	450, a.
Myrrha ubi nascatur [where myrrh is produced]	119, a.
Myrtilus lapis [the myrtilus stone]	22, b.
Myrtus qualis in Ægypto & aliis locis [the myrtle, of what kind in Egypt and other places]	408, b.
Mysios virulentia [the virulence of the Mysian [substance]]	116, a.

N.

Lemma [gloss]	Reference(s)
Napelli umbra noxia [the harmful shade of monkshood (aconite)]	125, b.
symptomata, cura & remedia [symptoms, treatment and remedies]	142
Naphta quid [what naphtha is]	156, a.
Naturæ operationes miræ [the wonderful operations of Nature]	22, a, b.
pictura [her painting]	27 & seq.
gluten humidum [her moist glue]	169, a.
principia tria [her three principles]	169, b.
circulatio in quo consistat [in what her circulation consists]	170, b.
imitatio difficilis [imitation of her is difficult]	236, a.
prototypon in arte respiciendum [the prototype to be regarded in art]	238, b.
labor in rebus producendis [her labor in producing things]	251, a.
in metallis generandis [in generating metals]	256, a.
circa productionem metallorum industria [her industry in the production of metals]	269, b. 270, a.
principia [her principles]	331, a.
pericyclosis in insectorum genesi [her cycling in the genesis of insects]	374, b.
principiorum vis [the power of her principles]	385, a.
Nidus in petram conversus [a nest turned to stone]	48, a.
Nitrum quomodo fixetur [how niter is fixed]	432, a.
Nutrimmentum unde fit [whence nourishment comes]	136, a.
semper ei aliquid fæculentum adhæret [something feculent always clings to it]	ibid.

O.

Lemma [gloss]	Reference(s)
Ochra qualis [ochre, of what kind]	163, a.
Og gigas [Og the giant]	60, a.
Oleum philosophorum quomodo conficiatur [how the philosophers' oil is made]	247, a.
Oleandri symptomata, cura & remedia [oleander — symptoms, treatment and remedies]	142
Olea calefacta cur fluent [why oils flow when heated]	169, b.
Onager Indicus [the Indian wild ass]	63, a.
Onyx qui componatur [how onyx is composed]	463, b.
Opalus quomodo conficiatur [how the opal is made]	461, b.
Operarum in fodinis officium [the duty of the workers in the mines]	172, b.
Ophites [ophite (serpentine stone)]	22, b.
Orchides [orchids]	348, a.
uniformes unde [whence the uniform ones]	349, b.
Organum pyrobolicum quomodo in aëre exhibeatur [how a pyrobolic organ is displayed in the air]	480, b.
Orichalcum qui præparetur [how orichalcum (brass) is prepared]	218, a.
est nativum & factitium [it is both native and artificial]	ibid.
præparandi modus [the method of preparing it]	218, b.
veterum quale [of what kind the ancients' was]	456, a.
Oryx caprarum genus [the oryx, a kind of goat]	63, a.
Ossa gigantum [the bones of giants]	53, a.
elephantorum [of elephants]	59, a.
quomodo generentur in terra [how they are generated in the earth]	60, b.
quibus in locis crescant [in what places they grow]	ibid. & seq.

running header: "INDEX RERUM"

[Continuation of letter O]

Lemma [gloss]	Reference(s)
Ostracea unde originem trahant [whence shellfish (oysters) take their origin]	119, b. 345, b.
Ostracites quid [what the ostracite is]	207, b.
Ovum philosophicum quid [what the philosophical egg is]	240, b.

P.

Lemma [gloss]	Reference(s)
Allantis corpus quale [Pallas's body, of what kind]	55, b. 56, a.
Palma ubi nascatur [where the palm grows]	119, a.
in basi statuæ Cæsaris nata [grown at the base of a statue of Caesar]	341, b.
in lecto capitolii [on the bed of the Capitol]	342, a.
Panspermia rerum quid [what the panspermia (universal seed-store) of things is]	326 & seq.
Papiliones [butterflies]	335, a.
unde [whence]	359, a, b.
Paracelsus	266, b.
qualis fuerit [what kind of man he was]	277, b.
contumeliosus in omnes medicos [abusive toward all physicians]	278, a.
omnia ex aliis habet [he got everything from others]	278, b.
superstitiosus [superstitious]	279, a.
magiæ deditus [given over to magic]	ibid.
verum hominem se conficere posse	249, b.

Lemma [gloss]	Reference(s)
arte Chymica impie præsunit [he impiously presumes he can make a true man by the chemical art]	
sine auro lapidem fieri posse asserit [he asserts the [philosophers'] stone can be made without gold]	263, a.
Paracelsi fucus [Paracelsus's deceit]	296, b.
intolerabilis præsuntio [his intolerable presumption]	ibid.
libri prohibiti [his prohibited books]	ibid.
arrogantia [his arrogance]	278, a. 296, b.
processus in materia prima præparanda [his procedure in preparing the prime matter]	255, a.
in lapide conficiendo [in making the [philosophers'] stone]	297, a.
aurificium [his gold-making]	297, b.
processus falsus [his false procedure]	ibid.
modus in resuscitatione plantarum [his method in the revival of plants]	415, a, b.
de auro potabili opinio [his opinion on potable gold]	420, a.
Pastinaca marina [the sea-pastinaca (stingray)]	144
Pavonum pennæ quales [peacocks' feathers, of what kind]	17, b.
Peccatum originale malorum causa [original sin, the cause of evils]	125, a.
Pediculi unde in hominibus nascantur [whence lice are born in men]	370, b. 371, a.
quomodo pulsentur [how they are driven off]	377, b.
Pelicanus quid [what the pelican (alembic) is]	240, b.

Lemma [gloss]	Reference(s)
Pennæ vitreæ quomodo parentur [how glass feathers are made]	454, b.
Peripleumonia qui curetur [how peripneumonia is cured]	174, b.
Perlæ, insectum, unde [pearls, an insect, whence]	360, b. 361, a.
Persica sine ossiculis ut fiant [how peaches are made without pits]	390, a.
miræ magnitudinis [of wondrous size]	390, b.
qualia in Persia & Europa [of what kind in Persia and Europe]	408, a.
Peruvia quot millones auri suppeditarit [how many millions of [units of] gold Peru has supplied]	208, b.
Petrificatio nidi, chirotecæ [the petrification of a nest, of a glove]	49, a.
plantarum [of plants]	48, b.
figuræ humanæ [of a human figure]	ibid.
Deiparæ imaginis cum crucifixo [of an image of the Mother of God with a crucifix]	ibid.
omnium pene rerum [of almost all things]	49, a.
corporis humani [of a human body]	50, a.
equinæ ungulæ [of a horse's hoof]	ibid.
Civitatis Africæ [of an African city]	ibid.
hordei integræ [of whole barley]	50, b.
fœtus in utero muliebri [of a fetus in a woman's womb]	51, b.
Phallum Hollandicum unde [whence the Dutch phallus (fungus)]	351, b.
Phantasticæ facultatis vis [the power of the fantastic (imaginative) faculty]	114, a.
Phlebotomum qui temperetur [how	221, b.

Lemma [gloss]	Reference(s)
the lancet is tempered]	
Phoenix Alchymistis quid [what the phoenix is to the alchemists]	315, b.
Pilæ sub aqua ardentes qui præparentur [how balls that burn under water are prepared]	477, a, b.
Pisces fossiles [fossil fishes]	86, a.
quomodo saxorum meditullia penetrarint [how they penetrated the cores of rocks]	87, a.
in subterraneis fluminibus [in subterranean rivers]	89, b.
in Helvetia ex montibus erumpunt [in Switzerland they burst forth from the mountains]	ibid.
Piscium δορυφόρων prælia contra balænas [Greek: δορυφόρων (doryphorōn, "spear-bearing" — the battles of the spear-bearing fishes against whales)]	64, a.
ortus [their origin]	364, a.
Placodes quid [what the placodes is]	207, b.
Plantæ quomodo nascantur [how plants are born]	338, 339, & seq.
è statuis æneis natæ [born from bronze statues]	342, a.
ex animalibus [from animals]	343, b.
propriū sibi animal producunt [they produce an animal proper to themselves]	347, a. 373, b.
quomodo dividantur [how they are divided (classified)]	380, a.
quantum singulis diebus excreverint explorare [to ascertain how much they	447, b.

Lemma [gloss]	Reference(s)
have grown each day]	
Plantæ venenosæ quæ [which plants are venomous]	108, b.
unde originem trahant [whence they take their origin]	117, b. & seq.
comparantur cum venenatis mineralibus [they are compared with poisonous minerals]	118, b.
cur subinde animalcula venenosa producant [why they sometimes produce venomous little creatures]	124, a.
Plastica vis quid [what the plastic force is]	7, b. 328, a.
semini innata [innate in the seed]	328, a. 333, b.
in inanimatis est analogia ad vegetabilium & animalium plasticam vim [in inanimate things it is analogous to the plastic force of vegetables and animals]	334, b.
quomodo operetur [how it works]	335, a.
ejus effectus [its effects]	335, b.
Plumbum in cerussam quomodo mutetur ejusque ratio [how lead is changed into ceruse (white lead) and the reason for it]	12, a.
qui in calcem [how into calx]	ibid.
argento est amicum [it is friendly to silver]	219, a.
calcinatum cur gravius [why calcined lead is heavier]	219, b.
qui calcinetur [how it is calcined]	243, b.
nigrum qui candidum & aureum reddatur [how black lead is made white and golden]	301, a.

Lemma [gloss]	Reference(s)
cur dulce [why it is sweet]	401, b.
qui crystallescat [how it crystallizes]	457, b.
Plumbi minera qualis [lead ore, of what kind]	188, a.
scoria [its slag]	207, a.
utilitates [its uses]	218, b.
matrix quænam [what its matrix is]	ibid.
reductio in cuprum [its reduction into copper]	258, b.
in stannum [into tin]	248, q. [recte: a.?] [?]
ad stannum gravitas [its weight relative to tin]	441, b.
vitrum [its glass]	452, b.
calx [its calx]	483, b.
Pluvia ignea qui conficiatur [how a fiery rain is made]	475, b.
Polypodium [polypody (fern)]	139, b.
Poma acida & dulcia in una arbore qui producantur [how sour and sweet apples are produced on one tree]	387, a.
ut imaginem quamvis referant [how they may reproduce any image whatever]	388, b.
ut fiant dulcia [how they are made sweet]	ibid.
ut rubra [how [made] red]	ibid.
eorum calami longe allati quomodo conservandi [how their grafts, brought from afar, are to be preserved]	383, a.
Pompholix quid [what pompholyx (zinc oxide) is]	207, b.
Ponderum mineralium valor [the value (relation) of mineral weights]	288, a.

Lemma [gloss]	Reference(s)
Populi foliorum motus [the motion of poplar leaves]	418, b.
Porrum prodigiosæ magnitudinis qui producat [how a leek of prodigious size is produced]	388, b.
Potosinus tractus olim ob frigus inhabitatus [the Potosí region, once uninhabited because of cold]	208, a.
Pruna sine osiculis ut fiant [how plums are made without pits]	390, a.
Psylli symptomata, cura & remedia [fleawort — symptoms, treatment and remedies]	142
Pthias serpens [the pthias serpent]	144
Pulex unde [whence the flea]	371, a.
quomodo propulsetur [how it is driven off]	377, b.
Pulmo marinus [the sea-lung (jellyfish)]	129, b.
ejus venenum, pulmonibus inimicum [its venom, hostile to the lungs]	ibid.
Pulvis argentum in aurum commutans ab Arabibus confictus [a powder changing silver into gold, devised by the Arabs]	305, a, b.
Pulveris pyrii prima inventio [the first invention of gunpowder]	467.
confectio [its manufacture]	468 & seq.
Purpura qui nascantur [how purples (murex) are born]	345, b.
Putrefactio, quid Chymicis [putrefaction, what it is to the chemists]	248, a. 405, a.
ejus effectus [its effects]	395, b. 409, b.

Lemma [gloss]	Reference(s)
Pygmæi non homines sed dæmones subterranei [pygmies are not men but subterranean demons]	101, b.
nusquam eorum natio reperitur [their race is nowhere found]	ibid.
Pyrites ubi reperiatur [where pyrite is found]	387, a.
ejus fuligo tertiò usti sit incombustibilis [its soot, when burned a third time, is incombustible]	197, b.

Q.

Lemma [gloss]	Reference(s)
Quajacum ubi nascatur [where guaiacum grows]	119, a.
ejus variæ vires [its various powers]	401, b.
Qualitates specificæ quid differant à manifestis [how specific qualities differ from manifest ones]	111, a.
elementares an sympathiam & antipathiam constituere possint [whether elementary qualities can constitute sympathy and antipathy]	112, a.
quatuor elementa sunt earum vehicula [the four elements are their vehicles]	137, a.

R.

Lemma [gloss]	Reference(s)
Radix comedendi facultatem tollens [a root that takes away the faculty of eating]	413, a.
Ranæ unde oriantur [whence frogs arise]	119, b. 345, b. 372, b.
Ranæ fossiles [fossil frogs]	86, a.
earum origo intra saxa [their origin within rocks]	87, a.
Raphanus quomodo dulcis reddatur [how the radish is made sweet]	288, a, b.

Lemma [gloss]	Reference(s)
Reges sepeliendi mos apud veteres [the custom of burying kings among the ancients]	67, a.
Regio subterranea Sole non illuminatur [the subterranean region is not illuminated by the Sun]	99, b.
nova in Hispania detecta [a new one discovered in Spain]	100, a.
quomodo in phiala repræsentetur [how it is represented in a flask]	432, a.
Remora utrum in rerum natura extiterit [whether the remora has existed in the nature of things]	259, a.
Reptilia quæ venenosa [which reptiles are venomous]	109, a.
Reubarbarum quomodo bilem trahat [how rhubarb draws off bile]	112, b.
ejus extractum parandi ratio [the method of preparing its extract]	248, a.
Reverberatio quid [what reverberation is]	245, b.
Rhododendri lignum accensum pestiferum [the kindled wood of the rhododendron is pestilential]	126, a.
Geor. Riphæus [George Rhiphaeus]	245, b.
Risogallum venenum atrox [risigallum (realgar), a dreadful poison]	148, a.
Rochetæ qui componantur [how rockets are composed]	474 & seq.
Rosæ qui variis coloribus imbuantur [how roses are imbued with various colors]	387, b.
qui incorruptæ servantur [how they are kept uncorrupted]	388, b.
Ros salis species est [dew is a kind of]	332, b.

Lemma [gloss]	Reference(s)
salt]	
Roseæ crucis fratres magi [the brothers of the Rosy Cross, magicians]	280, a.
eorum dogma [their doctrine]	280, b.
Rota in aëre versatilis qui repræsentetur [how a wheel revolving in the air is displayed]	480, a.
Rubetæ symptomata & remedia [the toad — symptoms and remedies]	144
Rubinus qui conficiatur [how the ruby is made]	457, a. 460, b.
Rubigo ferrum consumit [rust consumes iron]	220, a.
contra eam remedium [a remedy against it]	ibid.
Rupicissa impostor [Rupescissa, an impostor]	273, a.
ejus de auro Alchymistarum iudicium [his judgment on the gold of the alchemists]	276, a.

S.

Lemma [gloss]	Reference(s)
Sal cur fœcundum dicatur [why salt is called fruitful]	331, b.
ubiq; provenit [it occurs everywhere]	ibid.
animalia conservat [it preserves animals]	332, a.
ei sulphur & mercurius insunt [sulphur and mercury are within it]	333, a.
crystallinum quid [what crystalline salt is]	249, a.

running header: "& VERBORUM"

[Continuation of letter S]

Lemma [gloss]	Reference(s)
Sal Ammoniacum producendis serpentibus multum prodest [sal ammoniac is very useful for producing serpents]	122, a.
Salis Ammoniaci mira vis [the wondrous power of sal ammoniac]	246, a.
sublimatio [its sublimation]	246, b.
menstruum [its menstruum]	435, a.
in aquam reductio [its reduction into water]	438, a.
Sal Naturæ quid [what the Salt of Nature is]	6, b.
omnia fixat [it fixes all things]	169, a.
ex quibus constet [of what it consists]	328, b.
quotuplex [how many kinds]	380, a.
ejus mira vis [its wondrous power]	167, b.
Salis mira proprietas [the wondrous property of salt]	226, b.
in crystallum versi effectus [the effects of its being turned into crystal]	229, b.
diversitas [its diversity]	402, a.
Salifodinæ ubi reperiuntur [where salt-mines are found]	224 & seq.
quotannis novo sale replentur [they are replenished with new salt each year]	225, b.
Tyrolenses [those of the Tyrol]	227, b.
Burgundiæ [of Burgundy]	228, a. & seq.
Salomon novit fibras unicuique plantarum inserendarum aptas [Solomon knew the fibers fit to be implanted into each [kind] of plants]	408, b.
Salamandra quid Alchymistis [what the salamander is to the alchemists]	315, b.
ejus symptomata & remedia [its symptoms and remedies]	144
Sandaster quid [what the sandaster is]	22, b.
Sanguisuga [the leech]	144

Lemma [gloss]	Reference(s)
ad quid utilis [for what it is useful]	376, a.
Sapor unde [whence flavor]	401, b.
Saphyrus quomodo conficiatur [how the sapphire is made]	456, b. 461, b.
in adamantem qui convertatur [how it is converted into a diamond]	463, a.
Sargasso herba unde [whence the sargasso weed]	342, a, b.
ejus crista venenosa [its venomous crest]	ibid.
Saturnus chymice plumbum denotat [Saturn, in chemistry, denotes lead]	165, a.
Satyrion unde [whence the satyrion (orchid)]	108, b. 348, a.
cur sic dictum [why it is so called]	349, a.
Saxifodinæ Tiburtinæ [the stone-quarries of Tivoli]	41, b.
Scabies unde [whence scabies]	136, a.
Scajola quid [what scagliola is]	458, a.
Scalarum mira fabrica [the wondrous construction of staircases]	209, 210, a.
Scammonium quomodo bilem trahat [how scammony draws off bile]	112, b.
Scammoneæ symptomata, cura & remedia [scammony — symptoms, treatment and remedies]	142
Scarabei capite equi [beetles from a horse's head]	96, a.
unde [whence]	364, b.
monocerotes unde [whence the single-horned ones]	365, b.
ad quid utiles [for what they are useful]	37, b.
Scolopendræ symptomata, cura & remedia [the scolopendra (centipede) — symptoms, treatment and remedies]	144

Lemma [gloss]	Reference(s)
Scoria metallorum [the slag of metals]	206, a.
argenti [of silver]	206, b.
æris & ferri [of copper and iron]	ibid.
plumbi [of lead]	207, a.
Scorpio pestis remedium [the scorpion, a remedy for the plague]	121, a.
ex ocymo natus [born from basil]	252, a. 368, a.
ex cancro [from a crab]	353, a.
quid & unde [what and whence]	367, b.
ubi reperiatur [where it is found]	368, a.
artificio qui producat [how it is produced by artifice]	368, b.
ad quid utilis [for what it is useful]	376, a.
Scossacavallo herba [the scossacavallo herb]	412, a.
Selenites qualis [the selenite, of what kind]	67, b.
Semen quid producat [what the seed produces]	8, b. 327, a.
quid sit in massa Chaotica [what it is in the chaotic mass]	328, b.
Mundi quid [what the seed of the World is]	329, a.
universale quomodo gradus acquirat [how the universal [seed] acquires degrees]	329, b.
metallorum non est animatum [the seed of metals is not animate]	329, a.
Naturæ omnia trahunt [the seeds of Nature draw all things]	330, b.
est sal animatum [it is an animate salt]	332, a.
universale quid [what the universal [seed] is]	332, a. 333, a.
in quo constat [in what it consists]	333, b.
est vegetabile [it is vegetable]	332, b. 372, a.
prolificum quid [what the prolific [seed] is]	ibid.
individuatur pro ratione matricum [it is individuated according to the matrices]	336, b.

Lemma [gloss]	Reference(s)
in vegetantibus quid operetur [what it works in growing things]	378 & seq.
quomodo attrahatur [how it is drawn]	379, a.
in emphyteutica arte quid præstet [what it accomplishes in the emphyteutic (planting) art]	386, a.
Seminis facultas duplex [the twofold faculty of the seed]	328, a.
vis radiativa [its radiative force]	334, a.
pars quota [what proportion]	379, b.
Seminarium rerum quid proprie sit [what the seed-store of things properly is]	6, a.
duplex [twofold]	6, b.
naturæ quid [what the seed-store of Nature is]	164, b.
matrici quomodo inseratur [how it is implanted in the matrix]	356, a.
Sendivogius [Sendivogius]	266, b.
Seps serpens [the seps serpent]	144
Serpentes unde [whence serpents]	119, a. 372, b.
quomodo hominem interimant [how they kill a man]	120, a.
cur in Australibus partibus venenosiores quam in Borealibus [why in southern parts they are more venomous than in northern]	121, b.
quando in diferentes serpentes degenerent [when they degenerate into different serpents]	122, a.
ubi reperiantur [where they are found]	ibid.
ciconiis in cibum sumpti cur non noceant [why, eaten by storks, they do no harm]	132, a.
qui artificiose producantur [how they are produced artificially]	373, a.
quomodo fugentur [how they are driven away]	377, a.
Siccitatis gradus difficilioris indaginis [the degree of dryness is of more difficult]	400 & seq.

Lemma [gloss]	Reference(s)
investigation]	
Smaltum varii generis quomodo præparetur [how enamel of various kinds is prepared]	455, b.
Smaragdus qui conficiatur [how the emerald is made]	457, a. 462, a.
Soda præstans ad vitrum [soda excellent for glass]	451, a.
Sol aurum denotat chymice [the Sun denotes gold in chemistry]	165, a.
Romanus cur noceat [why the Roman sun is harmful]	125, a.
Philosophorum quid [what the Sun of the Philosophers is]	317, a, b.
ejus vigorem explorare [to test its vigor]	447, b.
Solani symptomata, cura & remedia [nightshade — symptoms, treatment and remedies]	142
Solventia quid præstent [what solvents accomplish]	434, a, b.
Sonus quid operetur [what sound effects]	114, a.
Spagyrica ars quid [what the spagyric art is]	233, a. 238, b.
quomodo licita [how it is permissible]	308, a.
SpermatICA corpuscula quænam [what the spermatic corpuscles are]	379, a.
omnibus insunt [they are within all things]	338, a.
Spicæ farris e naribus natæ [ears of spelt grown from the nostrils]	344, a.
Spiritus salis figit materiam tartaream [spirit of salt fixes tartareous matter]	136, b.
spermaticus quid [what the spermatic spirit is]	379, a.
acidus quid operetur [what the acid [spirit] effects]	434, b.
Spodium quid [what spodium is]	207, b.
Stannum potabile qui conficiatur [how potable]	430, a.

Lemma [gloss]	Reference(s)
tin is made]	
quomodo vitrescat [how it vitrifies]	452, b.
qui crystallescat [how it crystallizes]	457, b.
quomodo calcinetur [how it is calcined]	483, a.
Stellæ an concurrant ad metallogenesis [whether the stars concur in metal-generation]	165, a.
earum radii terram non penetrant [their rays do not penetrate the earth]	165, b.
Stibium. Vide Antimonium. [stibium — see Antimony]	
Stramonii symptomata, cura & remedia [thorn- apple (stramonium) — symptoms, treatment and remedies]	142
Struthio camelus qua vi ferrum digerat [the ostrich, by what force it digests iron]	112, a.
Stuppæ pyrotechnicæ qui præparentur [how pyrotechnic tow is prepared]	473, a, b.
Sublimatio quid [what sublimation is]	246, b.
Subtiliatio quid [what subtiliation is]	246, a.
Succinum quid [what amber is]	74, b. 75, a.
quomodo Borussi piscentur [how the Prussians fish for it]	75, a.
quid præstet [what it accomplishes]	76 & seq.
qui animalcula contineat [how it contains little creatures]	75, b. 76, a.
quomodo componatur [how it is composed]	466, b.
Succus petrificus unde [whence the petrifying juice]	45.
quid sit & quotuplex [what it is and how many kinds]	46, a.
ex nitro & sulphure saxum durissimum facit [from niter and sulphur it makes a most hard stone]	47, a.

Lemma [gloss]	Reference(s)
ex pyrite & vitriolatis quid efficiat [what it effects from pyrite and vitriolated substances]	ibid. & b.
terræ venenosus animalibus venenosis loco nutrimenti servit [the venomous juice of the earth serves venomous animals in place of nourishment]	121, a.
Sulphur virtute omnes colores habet [sulphur has all colors in potency]	14, b.
cum nitro coctum in lapidem abit [cooked with niter it passes into stone]	47, a.
generat quatuor species [it generates four species]	115, b.
cur θεῖον dictum [why it is called θεῖον (theion, "divine" — the Greek word for sulphur)]	145, a.
dividitur in ἄπυρον & πεπυρωμένον [it is divided into ἄπυρον (apyron, "unfired") and πεπυρωμένον (pepyrōmenon, "fired")]	ibid.
ubi fodiat [where it is dug]	ibid. b.
quid sit [what it is]	146, a.
est minerale & philosophorum [it is mineral and [the sulphur] of the philosophers]	ibid.
idem fere cum bitumine [almost the same as bitumen]	156, a.
rubrum ubi [red sulphur, where]	189, a.
quomodo vitrificetur [how it is vitrified]	245, b.
difficulter domatur [it is tamed with difficulty]	252, a.
fixum quomodo aurum exaltet [how fixed sulphur exalts gold]	294, b.
qui Lunam in Solem tingat [how it tinges silver into gold]	295, a.
fixum quid [what fixed sulphur is]	438, b.
Sulphuris mineralis origo [the origin of mineral sulphur]	46, b.
flores, lac, oleum [its flowers, milk, oil]	147, a.

Lemma [gloss]	Reference(s)
virtutes [its powers]	147, b.
balsamum plumonis vitia curat [its balsam cures defects of the lung]	174, b.
vis auri purificativa [its power of purifying gold]	187, a.
sidera [its stars]	189, a.
flores conficiendi ratio [the method of making its flowers]	246, a, b.
fixi saluti ad volatilitatem præparatio [the preparation of fixed [sulphur] for safe restoration to volatility]	294, a.
oleum reale non datur [a real oil is not to be had]	436, b.
oleum qui præparetur [how the oil is prepared]	468, a, b.
Surculi quomodo inserendi [how grafts are to be inserted]	382, b.
Sympathia quid [what sympathy is]	111 & seqq.
venenorum ad certa membra [of poisons toward particular members]	130, a.
ferri cum plantis [of iron with plants]	220, b.
auri cum plumbo [of gold with lead]	206, a.
ocymi cum scorpione [of basil with the scorpion]	368, b.

T.

Lemma [gloss]	Reference(s)
Talcum quid [what talc is]	67, b.
quomodo in oleum reducatur [how it is reduced into oil]	436, a.
Talpæ non sunt cæcæ [moles are not blind]	87, b.
earum origo [their origin]	ibid.
Tapulæ qui nascantur [how tapulæ are born]	345, b.
Tarantulæ virus [the venom of the tarantula]	129, a.
Tartarum quid [what tartar is]	136, a.

Lemma [gloss]	Reference(s)
causat horrendos morbos [it causes dreadful diseases]	136, b.
quomodo solvatur [how it is dissolved]	435, a.
Taxus ubi nascatur [where the yew grows]	119, a.
ejus umbra noxia [its harmful shade]	125, b.
Tellinæ qui producantur [how cockles are produced]	373, b.
Terra halitibus aquam & aërem inficit [the earth infects water and air with its exhalations]	128, a.
quotuplex [how many kinds]	399, a.
foliata quid [what foliated earth is]	265, a.
alba quid [what white earth is]	ibid.
Tetragonismus nondum repertus [the squaring [of the circle] not yet found]	233, b.
Thapsiæ symptomata, cura & remedia [thapsia — symptoms, treatment and remedies]	142
Thus ubi nascatur [where frankincense is produced]	119, a.
Tineæ qui nascantur [how moths are born]	356, b.
Tithimalli symptomata, cura & remedia [spurge (tithymalus) — symptoms, treatment and remedies]	142
Tinctura colorum in vegetabilibus [the tincture of colors in vegetables]	19, a.
in gemmis quid operetur [what it effects in gems]	20, a.
quid sit [what it is]	262, a.
auri multiplicativa an detur [whether a gold-multiplying [tincture] exists]	268, b. 425, a.
argentum in aurum convertens [converting silver into gold]	294, a.
argenti ejusque vires [the tincture of silver and its powers]	429, 430, a, b.

Lemma [gloss]	Reference(s)
corallorum quomodo solvatur [how the tincture of corals is dissolved]	435, b.
essentialis ex antimonio extrahi non potest [the essential [tincture] cannot be extracted from antimony]	436, b.
gemmarum varia [the various tinctures of gems]	465 & seq.
Topazius qui conficiatur [how the topaz is made]	457, a. 462, b.

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[Continuation of letter T]

Lemma [gloss]	Reference(s)
Transmutatio unius metalli in aliud quid [what the transmutation of one metal into another is]	257, a.
ex mente Paracelsi [according to the mind of Paracelsus]	ibid.
Veterum [of the ancients]	314, a.
Triticum transplantatum speciem mutat [transplanted wheat changes its species]	113, b.
Turcois qui componatur [how the turquoise is composed]	463.
Tuthia ubi nascatur [where tutty (zinc oxide) is found]	119, a.
quid [what it is]	207, b.

V.

Lemma [gloss]	Reference(s)
Vallis in Megrelia Sole non penetrabilis [a valley in Mingrelia not penetrable by the Sun]	100, b.
Vasa Chymica ad exemplar naturæ constituta sunt [chemical vessels are constructed after the pattern of nature]	238, a.

Lemma [gloss]	Reference(s)
varia [various]	240, b. 391 & seqq.
circulatoria quæ [which are circulatory]	393, b.
qualia esse debent [of what kind they ought to be]	394, a.
quomodo luto obducantur [how they are coated with clay]	394, b.
vitrea quomodo cæruleo colore tingantur [how glass [vessels] are tinged with a blue color]	457, a.
Ventus aëri purgando necessarius [wind is necessary for purging the air]	176, b.
Venæ fodinarum quid [what mine-veins are]	178, a.
earum figura [their shape]	179, b.
quibus modis innotescant [by what means they are detected]	179 & seq. 190, a.
ratio eas eruendi [the method of extracting them]	199, a.
argenteæ cui lapidi insertæ [silver veins, in what stone embedded]	203, b.
auriferæ qua occasione detectæ [gold-bearing veins, on what occasion discovered]	208, b.
divites quomodo explorentur [how rich [veins] are prospected]	210, b.
Venarum fodinarum vastitas [the vastness of mine-veins]	208, b.
multiplicitas & profunditas [their multiplicity and depth]	209, a.
excoquendarum modus [the method of smelting them]	213, b.
Vegetabilia ex quo educta [from what vegetables are drawn forth]	330, a.
Venenum quid [what poison is]	104, a. 115, a.

Lemma [gloss]	Reference(s)
quomodo nascatur [how it arises]	132, a.
in aquaticis [in aquatic creatures]	107, b.
eius differentia [its difference]	108.
hominibus proprium [the poison proper to men]	109, b.
alimento oppositum [opposed to nourishment]	110, a.
correctum cedit in usum medicinæ [when corrected it passes into medicinal use]	ibid.
veneno remedio est [it is a remedy for poison]	ibid.
serpentum natura calidum [the poison of serpents is by nature hot]	122, a.
intus sumptum quomodo operetur [how, taken internally, it works]	129, a. & seq.
canis rabidi quæ inferat symptomata [what symptoms the [poison] of a rabid dog inflicts]	132, b.
quomodo igne corrigatur [how it is corrected by fire]	138, a.
Venenosa mineralia quænam [which minerals are venomous]	106, b.
quid ex iis genere [what [is venomous] among them by genus]	106, b.
Venenorum mira sympathia & antipathia [the wondrous sympathy and antipathy of poisons]	120, a, b.
calor specificus [their specific heat]	122, b.
mira symptomata [their wondrous symptoms]	123, a. 132, b.
magnetismus [their magnetism]	137, a.
Venturinus lapis [the venturine stone]	22, b.
qui conficiatur [how it is made]	466, b.
Venus chymice stannum denotat [Venus, in	165, a.

Lemma [gloss]	Reference(s)
chemistry, denotes tin]	
Vespæ [wasps]	355, a.
unde [whence]	358, b.
Veratrum quid præstet [what hellebore accomplishes]	118, b.
Vermes qui nascantur in corporibus [how worms are born in bodies]	453, a. 370, a, b.
ex lixivio [from lye]	ibid.
quæ damna inferant [what harms they inflict]	370, b.
quomodo & cur cum pluvia decidant [how and why they fall with the rain]	372, a.
quomodo intra nucleos nascantur [how they are born within kernels]	374, a.
Vinum quomodo sublimetur [how wine is sublimed]	247, b.
ejus in distillando mira proprietates [its wondrous property in distilling]	434, b.
Vitrum flexibile & infrangibile [flexible and unbreakable glass]	450, a.
apud Indos summo in pretio [held in the highest esteem among the Indians]	ibid.
sulphuri incoctum in lapidem induratur [boiled with sulphur it hardens into stone]	452, a.
plumbi [glass of lead]	452, b.
antimonii [of antimony]	ibid.
æris [of copper]	453, a.
Lunare quid [what lunar glass is]	245, a.
ruptum quomodo conglutinetur [how broken glass is cemented together]	394, b.
Vitri utilitas [the usefulness of glass]	450, b.
materia [its material]	ibid. & seq.
vasa conficiendi modus [the method of	451, b.

Lemma [gloss]	Reference(s)
making vessels]	
differentia [its difference]	ibid.
proprietas [its properties]	452, a.
gluten quod [what glue]	ibid.
Vitrificatio quid [what vitrification is]	245, a.
Viperæ quomodo operentur [how vipers act]	130, a, b.
earum venenum quid [what their venom is]	131, a.
caro comesta cur homini non noceat [why their flesh, eaten, does not harm a man]	132, b.
symptomata & remedia [symptoms and remedies]	144
Virgula divinatoria quid [what the divining rod is]	181, a.
Vitis & satyrii inimicitiae [the enmities of the vine and the satyrion]	114, b.
Vis plastica [the plastic force]	7, b.
imaginativa [the imaginative [force]]	134, a.
Viscum quomodo nascatur [how mistletoe arises]	343, a, b.
Vitriolum auri nonnihil adjunctum habet [vitriol has some gold mixed in]	283, a.
quomodo paretur [how it is prepared]	248, b. 249, a.
quomodo ex cupro extrahatur [how it is extracted from copper]	437, b. 438, a.
qui ex auro [how [extracted] from gold]	438, a, b.
Ulmi foliorum motus [the motion of elm leaves]	418, b.
Volucres sulphure & sale turgent [birds are swollen with sulphur and salt]	17, a.
subterraneæ [subterranean birds]	88, a.
venenosæ [venomous birds]	190, a.

Lemma [gloss]	Reference(s)
Urim & Thummim quid [what the Urim and Thummim are]	85, b.
Urina hominum quid præstet [what human urine accomplishes]	332, a, b.
Urticæ qui nascantur [how nettles (sea-nettles) are born]	345, b.
Ursi natura [the nature of the bear]	88, a.
Vultures omnis generis animalia rapiunt [vultures seize animals of every kind]	96, a.
Uva nigræ & albæ qui producantur [how black and white grapes are produced]	387, a.
quomodo oleis inserenda [how they are to be grafted into olive trees]	387, a.
absque vinaceis qui faciendæ [how they are made without seeds]	387, b.

X.

Lemma [gloss]	Reference(s)
Xylophthori [Greek-derived: Xylophthori, "wood-destroyers" — wood-destroying creatures]	355, a.

Z.

Lemma [gloss]	Reference(s)
Zensale unde [whence the zensale]	363, a.
Zoophyta quæ [which zoophytes]	344, b.
ex ramis liburni nata [born from the branches of the liburnum]	351, a, b.

[End of the Index of Subjects and Words of the Second Volume.]

To the Reader

[AD LECTOREM — printer's note to the reader]

If, in the varied subject-matter of this Work, any errata [Greek: σφάλματα (sphalmata, "errors, slips")] should occur as to the type and the engravings — or if

(as for the most part happens in works of the greatest difficulty) the Reader should meet with anything obscure, distorted, or with a gap in it — he, with that prudence which is his, will not disdain to amend it himself, to take it in good part, and so to discharge the office of the absent Author (to whom recourse was not always possible) out of his own kindness, mindful of that saying: *Even good Homer sometimes nods*.

FINIS.

Mundus Subterraneus — End-leaves

These four PDF pages are the back-matter end-leaves and binding material of the volume. The book's main text, the *Index Rerum & Verborum*, the *Ad Lectorem* errata note, and "FINIS" all concluded in the prior batch (printed p. ~492). No printed text appears on any of these four pages; they carry only blank paper, a vellum binding board, and modern library/archival pencil markings.

Reading order. No printed page numbers, signatures, or catchwords are present on any of these leaves, so the original printed reading order cannot be reconstructed from them — there is nothing printed to order. The pages are taken in PDF sequence (993, 994, 995, 996), which corresponds to the physical end of the bound volume (final blank fly-leaves followed by the inside of the rear vellum cover).

blank rear fly-leaf

Blank end-leaf. The page shows aged, foxed paper with faint show-through (bleed-through) of text from the preceding printed leaves, but **no printed or written text of its own**. A crease/fold runs across the lower-right corner. No printer's device, colophon, signature, or date.

blank rear fly-leaf (verso)

Blank end-leaf. No printed text. Faint show-through from adjacent leaves is visible. At the **lower-left corner**, two modern archival/library shelf markings are written by hand in pencil:

- [Archival mark: ALPH 1885040] [?]
- [Archival mark: 02-35465]

These are modern cataloguing annotations added by a holding library, not part of Kircher's printed book. No printer's device, colophon, or date.

blank fly-leaf / pastedown

Blank leaf. No printed text. The image shows the page within the binding's framing border (the impression of the vellum turn-ins). At the **upper-right corner**, a modern pencil shelf/inventory note is written by hand:

- [Archival mark: 3446 p. 24] [?]

The reading of this pencil annotation is uncertain. No printed text, printer's device, colophon, or date.

inside of rear cover (vellum binding board)

This is the inside face of the rear cover: a limp-vellum binding board, showing staining, scuffing, and the sewing-station holes along the spine edge. It bears **no printed or written text** — only faint scratches and binder's marks. No printer's device, colophon, or date.

Summary. The volume ends with blank fly-leaves and the rear vellum binding board. There is no terminal printer's device, advertisement/book-catalogue, privilege, imprimatur, colophon, signature, or date on these final four pages — all such matter (FINIS, errata, index) concluded earlier. The only non-blank content is modern library pencil shelfmarks, transcribed above as [Archival mark: ...]. This completes the volume.