THE HISTORY OF RENAISSANCE CARTOGRAPHY: INTERPRETIVE ESSAYS

3 · Images of Renaissance Cosmography, 1450–1650

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Cosmography as a Renaissance Project

Graphic images are powerful tools for making visible the idea of an ordered creation comprising heavens and earth that Greek philosophers called *Κοσμος*.[1] In the Renaissance images played an important role in remapping medieval natural philosophy. Renaissance cosmography might be regarded as a "mode," or a historically specific set of social and technical relations that determine representational practices.[2] The social and technical relations of Renaissance cosmography converged around a growing apprehension of terrestrial, celestial, and representational space as absolute and capable of intellectual mastery.[3] Drawing on medieval precedents, the practices through which such understanding and mastery were probed evolved significantly between 1450 and 1650.

Pomponius Mela's first-century A.D. Latin treatise on world geography, *Cosmographia; sive, De situ orbis,* printed in Milan in 1471, introduced cosmography into Western scholarship.[4] Jacopo Angeli's choice of *Cosmographia* as the title for his 1406 Latin translation of Claudius Ptolemy's *Γεωγραφιχὴ ὑφήγησις* (Guide to geography) ensured the significance, if not the clarity, of the term.[5] Angeli's choice was logical: Ptolemy's text explained how the Aristotelian cosmos—both corruptible, elemental *mundus* and incorruptible, ethereal *caelo*—could be mathematically coordinated. Angeli was also responding to Ptolemy's definition of geography: as both mathematical mapping and a description of lands, seas, and places on the earth's surface. Humanist elaboration and dissemination of Jacopo Angeli's work repositioned cosmography during the fifteenth century. But his linguistic fusion of geographical mapping and cosmography introduced a continuing tension within Renaissance cosmography, apparent in its graphic presentation.[6]

If Ptolemy's *Geography* thus opens the story of Renaissance cosmography, Isaac Newton's *Philosophiae naturalis principia mathematica* (1687), which finally dissolved the cosmic system described in Ptolemy's *Almagest,* signals its closure.[7] In the intervening years cos-

Abbreviations used in this chapter include: Adler for the Adler Planetarium & Astronomy Museum, Webster Institute for the History of Astronomy, Chicago; Beinecke for the Beinecke Rare Book and Manuscript Library, Yale University, New Haven; and MnU for Special Collections and Rare Books, Wilson Library, University of Minnesota, Minneapolis.

1. For a discussion of the origins and meanings of *kosmos,* see M. R. Wright, *Cosmology in Antiquity* (London: Routledge, 1995). Plato's *Timaeus* represented the fullest account of the origins of the ancient Greek cosmos.

2. Matthew H. Edney, "Cartography without 'Progress': Reinterpreting the Nature and Historical Development of Mapmaking," *Cartographica* 30, nos. 2 and 3 (1993): 54–68, and David Turnbull, "Cartography and Science in Early Modern Europe: Mapping the Construction of Knowledge Spaces," *Imago Mundi* 48 (1996): 5–24.

3. W. P. D. Wightman, "Science and the Renaissance," *History of Science* 3 (1964): 1–19.

4. The earliest illustrated publication of the text was Erhard Ratdolt's 1482 Venice printing with a woodcut world map.

5. On the complex evolution of meanings of cosmography in Italian scholarship, see Marica Milanesi, "Geography and Cosmography in Italy from XV to XVII Century," *Memorie della Società Astronomica Italiana* 65 (1994): 443–68.

6. Milanesi, "Geography and Cosmography"; Antoine De Smet, "Les géographes de la Renaissance et la cosmographie," in *L'univers à la Renaissance: Microcosme et macrocosme* (Brussels: Presses Universitaires de Bruxelles; Paris: Presses Universitaires de France 1970), 13–29; Frank Lestringant, "The Crisis of Cosmography at the End of the Renaissance," in *Humanism in Crisis: The Decline of the French Renaissance,* ed. Philippe Desan (Ann Arbor: University of Michigan Press, 1991), 153–79; idem, *Mapping the Renaissance World: The Geographical Imagination in the Age of Discovery,* trans. David Fausett (Cambridge: Polity; Berkeley: University of California Press, 1994); Jean-Marc Besse, *Les grandeurs de la terre: Aspects du savoir géographique à la Renaissance* (Lyons: ENS, 2003), 33–63; and Francesca Fiorani, *The Marvel of Maps: Art, Cartography and Politics in Renaissance Italy* (New Haven: Yale University Press, 2005).

7. Ptolemy's *Almagest* contained limited discussion of cosmology, confined to offering reasons for the earth's immobility in the first chapter. However, Ptolemy's *Planetary Hypotheses* had far greater influence on medieval and Renaissance cosmological science in its treatment of the question of the distances between the planets. For a comprehensive discussion of the cosmological thought that lay behind cosmographic writing and mapping, see Edward Grant, *Planets, Stars, and Orbs: The Medieval Cosmos, 1200–1687* (Cambridge: Cambridge University Press, 1994). Organization of the hierarchy of representation—cosmography, geography, and chorography—is a sixteenth-century idea initiated by Peter Apian and only loosely based on the Ptolemaic corpus of writings. See Peter van der Krogt, *Globi Neerlandici: The Production of Globes in the Low Countries* (Utrecht: HES, 1993), 33–35, and the comments in Monique Pelletier, "Les géographes et l'histoire, de la Renaissance au siècle des Lumières," in *Apologie pour la géographie: Mélanges offerts à Alice Saunier-Seïté,* ed. Jean-Robert Pitte (Paris: Société de Géographie, 1997), 145–56.

mography was matter for humanists and scholastics, navigators and chartmakers, painters and architects, princes and mechanicals. It flourished as a field of enquiry and speculation in an age that predated modern distinctions between art and science, and in which the pictorial image attained greater social presence: technically through print and ideologically through religious iconoclasm.[8] Softening disciplinary boundaries today perhaps encourages a sympathetic understanding of the achievements and failures of Renaissance cosmography.

Definitions, Meanings, and Uses of a Changing Cosmography

In his 1570 *Mathematicall Praeface to the Elements of Geometrie of Euclid,* written when cosmography's star was at its zenith, the Englishman John Dee defined it as "the whole and perfect description of the heauenly, and also elementall parte of the world, and their homologall application, and mutuall collation necessarie." It "matcheth Heauen, and the Earth, in one frame, and aptly applieth parts Correspondent."[9] It is "homologall application," or formal and structural correspondence, between celestial and elemental spheres that defined cosmography's fundamental hypothesis. Unity of celestial and terrestrial spheres was a geometrical-mathematical thesis founded on the coincidence of their principal circles (which is why Dee includes cosmography in his list of mathematical practices). This underpins the modern dictionary definition of cosmography as "the science which describes and maps the general features of the universe (both the heavens and the earth)." But "the meaning of cosmography, geography, chorography, and topography fluctuated from author to author: their oscillations affect even Ptolemy's revered text."[10] Thus a secondary meaning of cosmography is "a description or representation of the universe or of the earth in its general features."[11] In his detailed study of the Western cosmological tradition, Brague defines cosmography as follows: "the drawing or description (*graphein*) of the world as it appears at a given moment, with regard to its structure, its possible division into levels, regions, and so on. This description may, indeed should, take into account the static or dynamic relationships between the various elements that make up the world: distances, proportions, etc., as well as influences, reactions, and so forth. It implies the attempt to uncover the laws that govern those relationships. It is therefore a generalized geography that, thumbing its nose at etymology, does not deal only with the earth, but with all the visible universe."[12] The dual usage is present in Peter Apian's *Cosmographicus liber,* where cosmography refers to mathematical description of both cosmos and earth through their relation as established by spherical projection and relates to the four elements that compose the sublunary sphere. But cosmography also deals specifically with the terrestrial globe understood mathematically through lines of latitude and longitude—the key cartographic innovation of the early Renaissance—which permit accurate location of places on a spherical earth. The distinction is illustrated in Apian's woodcut illustrations of cosmography (fig. 3.1): the left image shows earth and cosmos as separately seen by a disembodied eye, indicating projection of the circles; the right image shows a self-standing earthly globe whose geography of lands and seas is contained within a graticule of cosmographic circles and meridian lines. The secondary meaning of cosmography is apparent in the common designation of printed world maps (and occasionally chorographic maps, too) as "cosmographies," suggesting their composition according to mathematical principles. In this chapter I concentrate principally on representations of cosmography's primary meaning, but make occasional reference to world maps where mathematical geography is explicit.[13]

Cosmography's methods combined description with measured demonstration of the homologies of heavens and earth, using both mathematically accurate mappings and written narratives. The geometric elegance of the armillary sphere or the world system diagram obscured long-recognized empirical imperfections such as the ec-

8. For a discussion of this point, see Wightman, "Science and the Renaissance." Grant discusses the distinct roles of natural philosophy or cosmology and astronomy, which he claims endured throughout the period of the Renaissance. Cosmology, Grant argues, sought "to describe the nature of the heavens and the causes of its various motions . . . to explain the nature of the celestial substance, that is, to determine whether it is incorruptible and indivisible; whether it is equally perfect throughout its extent, or differentially so; whether its properties are similar to matter in the terrestrial region; what causes it to move, and so on" (Grant, *Planets,* 37). By contrast, astronomy concerned the prediction and determination of planetary and stellar positions, and its principal instruments were geometry and mathematics. Cosmologists were rarely competent in technical astronomy, and their remit included the earth as the corruptible planetary sphere. On the intimacy of connections between scientific inquiry and art in the Galilean controversy of the early seventeenth century, see Eileen Reeves, *Painting the Heavens: Art and Science in the Age of Galileo* (Princeton: Princeton University Press, 1997).

9. John Dee, *The Mathematicall Praeface to the Elements of Geometrie of Euclid of Megara (1570),* intro. Allen G. Debus (New York: Science History Publications, 1975), biii.

10. Fiorani, *Marvel of Maps,* 98. My discussion here draws significantly upon Fiorani's work.

11. Current definitions taken from the *Oxford English Dictionary,* 2d ed., 20 vols. (Oxford: Clarendon, 1989).

12. Rémi Brague, *The Wisdom of the World: The Human Experience of the Universe in Western Thought,* trans. Teresa Lavender Fagan (Chicago: University of Chicago Press, 2003), 3.

13. Fiorani, *Marvel of Maps,* 100: "Apian's definitions were still very popular at the end of the sixteenth century and authors and mapmakers such as Sebastian Münster, Giacomo Gastaldi, Girolamo Ruscelli, and Egnazio Danti adopted them almost verbatim."

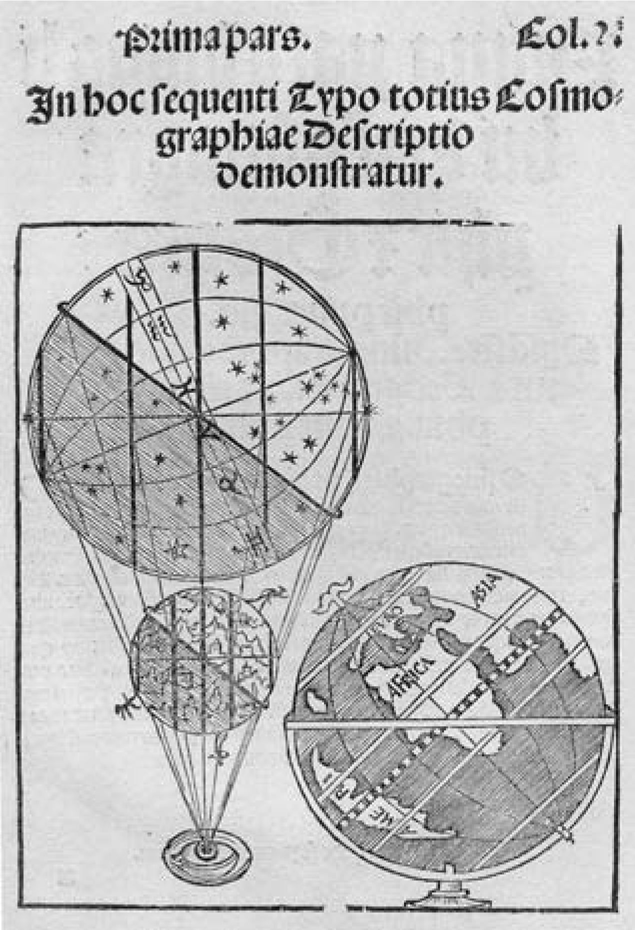

FIG. 3.1. PETER APIAN'S COSMOGRAPHY.
Size of the original: ca. 20.3 × 15.2 cm. Peter Apian, *Cosmographicus liber* (Landshut, 1524), fol. 2. Photograph courtesy of MnU.

centricities of celestial rotation and the uneven distribution of earth and water.[14] Such disruptions remained the subject of scholastic debate, illustrated in diagrams appended to natural philosophies.[15] As oceanic navigation, celestial observation, and circulation of standardized data increased cosmography's empirical content, the inadequacy of simple descriptors became increasingly apparent. Fifteenth-century humanists challenged the scholastic defense of natural philosophy's "right to explain natural phenomena according to the laws of nature without recourse to theological arguments," blurring boundaries between reason and faith as distinct epistemologies of the material and super-celestial worlds, respectively.[16] Cosmography was opened to theological contention in an age of reformation when "philosophical arguments were increasingly used to confirm religious doctrines, above all the immortality of the soul."[17] Dee wrote at a time of growing expectation that articulation of the world machine be demonstrated experientially and described in both its ornamental unity and the marvelous detail that navigation was making increasingly apparent to Europeans.[18] The diverging demands of description and demonstration, faith and reason, authority and experience, unity and diversity challenged and eventually marginalized cosmography as a respectable endeavor in early modern Europe, to be replaced by distinct sciences of geography and astronomy. Cosmography's principles of a unitary creation and a providential order survived, however, through the seventeenth century, largely within the rhetorical *dispositio* of decorative globes and maps, in pious publications and emblemata, in the arts, and in imaginative literature.[19] Understanding the philosophical,

14. Grant, *Planets,* appendix I, "Catalogue of Questions on Medieval Cosmology 1200–1687," 681–741, lists four hundred such questions from sixty-seven treatises by fifty-two authors across the five centuries, of whom he places twenty-three in the Renaissance. The questions are collected into four groups corresponding to the regions covered: the world as a whole; the celestial region; celestial and terrestrial regions; and the terrestrial or sublunar region. They are further grouped into nineteen topics. A flavor of the questions is given by the following, with one selected from each group: "Whether there is eternal motion"; "Whether or not celestial bodies act on the sublunar world"; "Whether fire exists in the vicinity of the Moon"; and "How can the generation of mountains be reconciled with the spherical figure of the earth?" On the specific problem of the irregular distribution of earth and water, see Grant, *Planets,* 630–37.

15. For example, illustrations from printings of Albert Magnus, *De meteoris* (Venice, 1494–95; Venice, 1498), show the elemental sphere, with cycles and ecliptic, employing conventional symbols for earth, water, air, and fire. These symbols also had conventional color coding, discussed by a number of Renaissance thinkers including Leon Battista Alberti, Leonardo da Vinci, and Girolamo Cardano. Fire was red or golden-yellow, air white or blue-gray, water green, and earth black or ash. The images differ in placing the sphere of earth within that of water. The eccentric location in the Venice edition of 1494–95 was a response to the delicate problem of coordinating the nonsymmetrical geographical distribution of lands and seas with the theoretical simplicity of concentric elemental spheres. The Venice edition of 1498 shows concentric placement. The two traditions, of eccentric and concentric mappings of the spheres, recur in fifteenth- and sixteenth-century illustrations of the geocentric cosmos.

16. Jill Kraye, "The Philosophy of the Italian Renaissance," in *Routledge History of Renaissance Philosophy,* vol. 4, *The Renaissance and Seventeenth-Century Rationalism,* ed. G. H. R. Parkinson (London: Routledge, 1993), 16–69, esp. 16.

17. Kraye, "Philosophy of the Italian Renaissance," 37.

18. Stephen Greenblatt, *Marvelous Possessions: The Wonder of the New World* (Oxford: Clarendon, 1991).

19. In classical rhetoric, *dispositio* is the structuring and arrangement of an argument. On the meaning and significance of rhetoric in humanism and Renaissance writing, see Brian Vickers, "Rhetoric and Poetics," in *The Cambridge History of Renaissance Philosophy,* ed. Charles B. Schmitt et al. (Cambridge: Cambridge University Press, 1988), 715–45. Giuseppe Rosaccio, a late sixteenth-century mapmaker and writer of popular cosmographies, makes an explicit connection between cosmography and the rhetorical *ars memoria:* "The study and knowledge of this most noble science gives to every man the faculty of being able to speak from memory, as if reading a book, the whole discourse of the earth." Giuseppe Rosaccio, *Il mondo e sue parti cioe*

social, and technical relations of Renaissance cosmography helps us grasp these changing representational practices.

THEOLOGICAL AND PHILOSOPHICAL RELATIONS

In promising accurate description through latitude and longitude coordinates founded on "mutuall collation" of astronomical and terrestrial geometry, Ptolemy's texts brought the world map within the scope of philosophical debates surrounding Aristotelian natural philosophy that "in all essentials" his work presupposed.[20] The *Geography*'s reception also has to be placed in the context of a renaissance of Greek scholarship in the Latin West, stimulated by the Council of Florence and Byzantine scholars after 1453, as well as the context of Hebrew learning diffusing from Spain after 1492. The *Geography* found a mid-fifteenth-century audience within such humanist circles as Georg von Peuerbach's in Nuremberg or Leon Battista Alberti's and Marsilio Ficino's in Florence. There, both scholastic Aristotelianism and Thomas Aquinas's duality of faith and reason were subjected to demands that natural philosophy be reconciled with Christian doctrine and that vulgar Latin and sterile logic be leavened by classical rhetoric. Aristotle's *Physics, On the Heavens, On Generation and Corruption,* and *Meteorology,* available in Europe since about 1200, remained cosmology's foundational texts. More familiar were popular commentaries on this corpus, such as Albert Magnus's *De caelo et mundo* and above all Johannes de Sacrobosco's *Sphaera,* the dominant text for teaching natural philosophy over four centuries after 1250.[21] Consistent with the *Physics,* Sacrobosco described a geocentric world machine filled with matter: elemental in the sublunar spheres where linear motion prevailed and ethereal in celestial realms characterized by uniform circular motion. The eternal nature of Aristotle's cosmos and his argument in *On the Soul* for the materiality and mortality of the soul had long raised questions for Christians. To these Plato's *Timaeus,* translated in full, alongside other Platonic and Neoplatonic texts by Ficino between 1463 and 1484, offered a response. Plato's account of creation seemed consonant with Genesis, while Neoplatonic ascent of the soul through the spheres to harmony with the divine implied the soul's immortality.[22] Platonism became popular among Protestant and Catholic reformers in the early sixteenth century and long remained so among the former. Protestant concentration on salvation by faith, its emphasis on textual exegesis of the biblical scheme of redemption, and the belief, significantly enriched by oceanic discovery, that divine providence was revealed also in nature reinforced the theological significance of cosmological questions and thus of cosmography during the sixteenth and seventeenth centuries.

The most radical challenge to Aristotle's cosmology came from the first-century B.C. Roman poet Lucretius. His *De rerum natura* posited a universe composed of atoms as the fundamental units of matter, without origin or end but constantly mutating in form. Revived interest in Lucretius is apparent from the late fifteenth century, for example, in the Medicean court. It provided a foundation for Neostoic cosmology in the following century, closely connected to studies of Seneca's *Quaestiones naturales*

Europa, Affrica, Asia, et America (Verona: Francesco dalle Donne and Scipione Vargano, 1596), preface. For a more detailed discussion of Rosaccio, see note 88. The common use of the theater metaphor in both memory art and cosmography is discussed by Ann Blair in *The Theater of Nature: Jean Bodin and Renaissance Science* (Princeton: Princeton University Press, 1997), 153–79, although she does not suggest that the cosmographic map or atlas was ever used mnemonically.

20. Norriss S. Hetherington, ed., *Encyclopedia of Cosmology: Historical, Philosophical, and Scientific Foundations of Modern Cosmology* (New York: Garland, 1993), 71.

21. On the importance of Sacrobosco in the age of print, see J. A. Bennett and Domenico Bertolani Meli, *Astronomy Books in the Whipple Museum, 1478–1600* (Cambridge: Whipple Museum of the History of Science, 1994). See Grant, *Planets,* 14–16, on the significance of Aristotle's *De caelo* for natural philosophy. On Renaissance natural philosophy more generally, see the essays by William A. Wallace, "Traditional Natural Philosophy," Alfonso Ingegno, "The New Philosophy of Nature," and Brian B. Copenhaver, "Astrology and Magic," in *The Cambridge History of Renaissance Philosophy,* ed. Charles B. Schmitt et al. (Cambridge: Cambridge University Press, 1988), 201–35 (esp. 225–31), 236–63, and 264–300, respectively; Kraye, "Philosophy of the Italian Renaissance"; Stuart Brown, "Renaissance Philosophy Outside Italy," in *Routledge History of Renaissance Philosophy,* vol. 4, *The Renaissance and Seventeenth-Century Rationalism,* ed. G. H. R. Parkinson (London: Routledge, 1993), 70–103; and various entries in Hetherington, *Encyclopedia.* The classic study of the medieval world system, from which Edward Grant's work proceeds, is Pierre Duhem, *Le système du monde: Histoire des doctrines cosmologiques de Platon à Copernic,* 10 vols. (Paris: A. Hermann, 1913–59); vol. 10 is devoted to the fifteenth and early sixteenth centuries. See also Lynn Thorndike, *A History of Magic and Experimental Science,* 8 vols. (New York: Columbia University Press, 1934–58), esp. vols. 4–7, for various references to natural philosophers' writings. Some of the key texts are translated and reproduced in Maria Boas Hall, ed., *Nature and Nature's Laws: Documents of the Scientific Revolution* (New York: Walker, 1970). On the implications of the theory of the spheres for globemaking in the period under discussion here, see Elly Dekker, "The Phenomena: An Introduction to Globes and Spheres," in *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum,* by Elly Dekker et al. (Oxford: Oxford University Press and the National Maritime Museum, 1999), 3–12, esp. 4–8.

22. On Ficino's work and the significance of the *corpus hermeticum,* see Copenhaver, "Astrology and Magic," 280 ff. See also Thorndike, *History of Magic,* 4:562–73; *Marsilio Ficino e il ritorno di Platone: Mostra di manoscritti stampe e documenti, 17 maggio–16 giugno 1984, catalogo* (Florence: Le Lettere, 1984); Eugenio Garin, *Astrology in the Renaissance: The Zodiac of Life,* trans. Carolyn Jackson and June Allen (London: Routledge and Kegan Paul, 1976); Paul Oskar Kristeller, "Renaissance Platonism," in *Facets of the Renaissance,* ed. William H. Werkmeister (Los Angeles: University of Southern California Press, 1959), 87–107; and Frances Amelia Yates, *Giordano Bruno and the Hermetic Tradition* (London: Routledge and Kegan Paul, 1964).

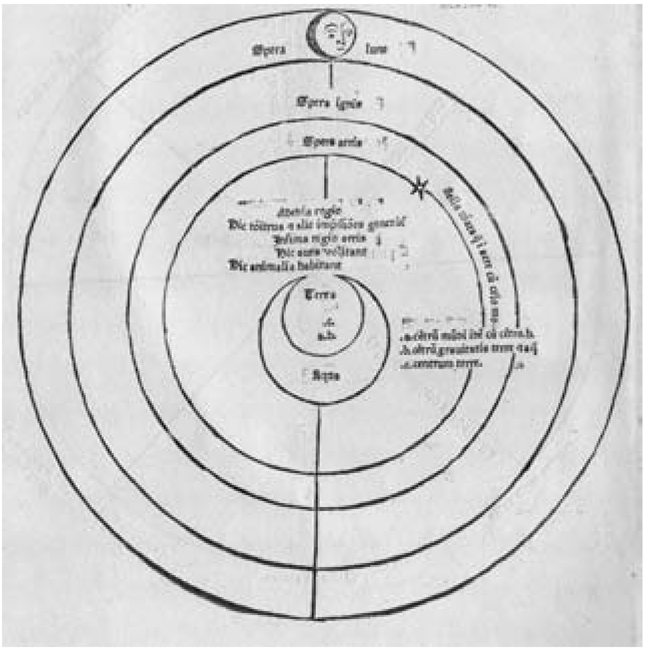

FIG. 3.2. PIERRE D'AILLY'S COSMOGRAPHIC MAP. This diagram of the elemental sphere (with water sphere eccentric to land sphere) is a model of the clear illustration of cosmographic principles in early printed texts. D'Ailly's was the cosmographic work that Columbus is known to have consulted in his preparations for westward Atlantic navigation.
Size of the original: ca. 23 × 23 cm. Pierre d'Ailly, *Imago mundi et tractatus alii* (Louvain: Johann de Paderborn, 1483), 5. Photograph courtesy of MnU.

and Cicero's *De natura deorum.* Neostoics rejected the distinction between elemental and celestial spheres for a single, continuous medium stretching from earth to the farthest stars. They believed that, in a continuous cycle of rarefaction and condensation, terrestrial waters rose into air and were heated by ethereal fire before condensing and returning to the surface. They regarded planets themselves as self-moving intelligences composed of fiery ether.[23] These ideas gained acceptance among Galileo's circle in the early seventeenth-century debate over heliocentricity, and the frequent appearance of epigrams from Cicero and Seneca on world maps in the decades following Ortelius's *Typus orbis terrarum* (1570) may indicate support for such theories among mapmakers.

Observed irregularities in planetary size and circular motion would raise further questions about the Aristotelian-Ptolemaic cosmos. Copernicus's radical reconfiguration of the geocentric image and the competing world system descriptions that followed grew out of debates over the numbers and location of spheres necessary to maintain the Aristotelian hypothesis of cosmic perfection. In the elemental world, the obvious failure of the water sphere to encompass fully that of earth and the irregular distribution of these two elements were also pondered. Here too, the medieval response leaned toward eccentricity: protrusion of the earthly sphere through that of water offered a possible solution, illustrated in Pierre d'Ailly's *Imago mundi,*[24] where terra is shown cutting the circumference of aqua (fig. 3.2). This theory may account for the characteristic circularity of the single continent illustrated on fifteenth-century *mappaemundi* such as those of Andreas Walsperger (1448), Giovanni Leardo (1452/53), and Fra Mauro (1457/59).[25] Oceanic discovery between Vasco da Gama's rounding the Cape of Good Hope and Ferdinand Magellan's circumnavigation would utterly transform the known distribution of these two elements, revealing a larger, more watery, and more geographically diverse globe than Aristotle had theorized or Ptolemy had described. In response, cosmography tackled the problem of maintaining the balance and symmetry of the Aristotelian elements while mapping an increasingly asymmetrical globe. The graticule of latitude and longitude replaced the simple geometry of continent and ocean as the sign of order on globes and world maps. But the empirical uncertainty of coordinates rendered their appearance as much rhetorical as scientific, while the shadow of the previous vision remained in such elements as Magellanica, the vast austral continent that balanced the expanded scale of northern hemisphere landmasses on seventeenth-century maps.[26]

SOCIAL RELATIONS

Cosmography was embedded in the Renaissance social world; in Dee's terms, it was necessary "for due manuring of the earth, for *Nauigation,* for the Alteration of mans body: being, whole, Sicke, wounded, or brused."[27] In addition to navigation and medicine, cosmography was vital for social order: fixing phenomena in space and events in time.

In Iberia, cosmography's value in navigation was primary, and cosmographers were drawn from diverse social and national backgrounds. Applied mathematical

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23. Reeves, *Painting the Heavens,* 58–64.

24. René Faille and Pierre-Jean Mairesse, *Pierre d'Ailly et l'image du monde au XVᵉ siècle* (Cambrai: La Médiathèque Municipale, 1992). D'Ailly's world map is reproduced in Rodney W. Shirley, *The Mapping of the World: Early Printed World Maps, 1472–1700,* 4th ed. (Riverside, Conn.: Early World, 2001), 11 (no. 12).

25. Walsperger's 1448 map is in Vatican City, Biblioteca Apostolica Vaticana (Pal. Lat. 1362B); see the facsimile *Weltkarte des Andreas Walsperger* (Zurich: Belser AG, 1981). Leardo's map is in the collections of the American Geographical Society; see John Kirtland Wright, *The Leardo Map of the World, 1452 or 1453, in the Collections of the American Geographical Society* (New York: American Geographical Society, 1928). On the Fra Mauro map, see note 50.

26. On the continued desire for global geographic symmetry, see Kirsten A. Seaver, "Norumbega and *Harmonia Mundi* in Sixteenth-Century Cartography," *Imago Mundi* 50 (1998): 34–58.

27. Dee, *Mathematicall Praeface,* biii.

knowledge was crucial for Atlantic navigation.[28] Cosmographers' plotting of routes, training of navigators, and updating of charts expanded throughout the sixteenth century as they became "the custodians of most of the new knowledge relating to navigation and exploration."[29] The cosmographers of the Casa de la Contratación in Seville included mapmakers such as Diogo Ribeiro and writers of cosmographic texts: Alonso de Santa Cruz's "Islario general de todas las islas del mundo por Alonso de Santa Cruz, cosmographo mayor de Carlos I de España" (1542) or Pedro de Medina's *Arte de nauegar* (1545), for example.[30] Portuguese cosmographers included the mapmakers Diogo Homem and Bartolomeu Velho and the author of "Esmeraldo de situ orbis" (1505–8), Duarte Pacheco Pereira.[31] The early paradigm for their cosmographic atlases is the Catalan atlas (1375).[32] As France and England entered oceanic competition, navigators as well as chart and instrument-makers such as Guillaume Le Testu and John Dee himself promoted cosmography as an imperial science.

Galenic medicine emphasized the importance of celestial influences on the human body as microcosm, mediated through the sublunar spheres of fire and air; hence the human figure marked for bloodletting that accompanies tidal and calendrical diagrams on the first sheet of the Catalan atlas. In Italy and Germany the study of Aristotle was propaedeutic to the practice of medicine, so that many cosmographers had trained or practiced as physicians, among them Girolamo Fracastoro, Oronce Fine, and Sebastian Münster. Anatomy theaters at Padua and Leiden were designed as cosmic maps; the corpse was displayed at the center of tiered observation spaces arranged in concentric circles, an architectural expression of its microcosmic nature.[33] And in both texts and images Caesare Caesariano and the doctors Jean Bodin and Robert Fludd used cosmography to map the health of whole nations according to climatic zones and zodiacal locations.[34]

In the courts of Europe, where a prince's health embodied that of the realm, cosmographers such as Sebastiano Leandro, Oronce Fine, Giacomo Gastaldi, André Thevet, and Egnazio Danti described and mapped a changing world and collected, ordered, and sought to reconcile with received hypotheses new facts converging from across the globe. Their skills in constructing and manipulating calendar tables and ephemerides enabled them to cast nativities and forecast the conjunctions, eclipses, and comets.[35] Such tables had long been critical for the complex calculation of mobile feasts such as Easter and for the long-anticipated calendar reform, finally achieved in 1582.[36] More locally, cosmographers applied the *Geography*'s principles to pictorial maps of states and provinces connecting chorography to global mapping,[37] as indicated by Egnazio Danti's cosmographic suites at Florence and Rome or Antonio Campi's use of

28. Luís de Albuquerque, "Portuguese Navigation: Its Historical Development," in *Circa 1491: Art in the Age of Exploration,* ed. Jay A. Levenson (Washington, D.C.: National Gallery of Art, 1991), 35–39, esp. 38.

29. Pedro de Medina, *A Navigator's Universe: The Libro de Cosmographía of 1538,* trans. and intro. Ursula Lamb (Chicago: Published for the Newberry Library by the University of Chicago Press, 1972), 12.

30. Ursula Lamb, *Cosmographers and Pilots of the Spanish Maritime Empire* (Aldershot: Variorum, 1995), and Manuel García Miranda, *La contribution de l'Espagne au progrès de la cosmographie et de ses techniques, 1508–1624* (Paris: Université de Paris, 1964). Spain's most prolific cosmographers were Alonso de Santa Cruz and Pedro de Medina. Santa Cruz, in his "Historia universal," completed in 1536, and in "Islario general," defined the three-part hierarchy of cosmography, geography, and chorography. See Mariano Cuesta Domingo, *Alonso de Santa Cruz y su obra cosmográfica,* 2 vols. (Madrid: Consejo Superior de Investgaciones Cientificos, Instituto "Gonzalo Fernández de Oviedo," 1983–84), and Alonso de Santa Cruz, *Islario general de todas las islas del mundo,* 2 vols., ed. Antonio Blázquez y Delgado-Aguilera (Madrid: Imprenta del Patronato de Huérfanos de Intendencia é Intervención Militares, 1918). See also chapter 40 in this volume.

31. On Pacheco Pereira's "Esmeraldo de situ orbis" and Portuguese cosmography more generally, see Joaquim Barradas de Carvalho, *A la recherche de la spécificité de la renaissance portugaise,* 2 vols. (Paris: Fondation Calouste Gulbenkian, Centre Culturel Portugais, 1983), and Armando Cortesaõ and A. Teixeira da Mota, *Portugaliae monumenta cartographica,* 6 vols. (Lisbon, 1960; reprinted with an introduction and supplement by Alfredo Pinheiro Marques, Lisbon: Imprensa Nacional–Casa de Moeda, 1987).

32. Abraham Cresques, *El Atlas Catalán* (Barcelona: Diáfora, 1975).

33. Giovanna Ferrari, "Public Anatomy Lessons and the Carnival: The Anatomy Theatre of Bologna," *Past and Present* 117 (1987): 50–106; Jan C. C. Rupp, "Matters of Life and Death: The Social and Cultural Conditions of the Rise of Anatomical Theatres, with Special Reference to Seventeenth Century Holland," *History of Science* 28 (1990): 263–87. The title page to Vesalius's *De humani corporis fabrica* (1543) shows such an arrangement. See also Denis E. Cosgrove, *The Palladian Landscape: Geographical Change and Its Cultural Representations in Sixteenth-Century Italy* (University Park: Pennsylvania State University Press, 1993), 232–35.

34. Ceasare Caesariano's diagrams relating climatic zones to the health of nations appeared in his Italian translation of Vitruvius Pollio, *De architectura libri dece,* trans. Caesare Caesariano (Como: G. da Ponte, 1521). Caesariano's illustrations of the armillary sphere and world machine are based on Sacrobosco's text, and the work also includes two widely reproduced maps of the male body as microcosm.

35. On natural philosophy and science as cultural capital within the courtly economy of Renaissance Europe, see Lisa Jardine, *Worldly Goods: A New History of the Renaissance* (New York: Nan A. Talese, 1996), 333–76, 395–406. See also David Buisseret, ed., *Monarchs, Ministers, and Maps: The Emergence of Cartography as a Tool of Government in Early Modern Europe* (Chicago: University of Chicago Press, 1992), and James R. Akerman, ed., *Cartography and Statecraft: Studies in Governmental Mapmaking in Modern Europe and Its Colonies,* Monograph 52, *Cartographica* 35, nos. 3 and 4 (1998).

36. Evelyn Edson, "World Maps and Easter Tables: Medieval Maps in Context," *Imago Mundi* 48 (1996): 25–42.

37. In the preface to William Cuningham, *The Cosmographical Glasse, Conteinyng the Pleasant Principles of Cosmographie, Geographie, Hydrographie or Nauigation* (London: Ioan Daij, 1559), A.iiij., Cuningham claims that this role is second only to cosmography's value for the defense of the realm and in warfare, as, he says, Alexander the Great had recognized, being "accustomed to haue the Mappe and Carte of the Country, by his Cosmographers set out."

Apian's cosmographic diagrams on his 1583 map of Cremona. Among southern German humanists, cosmography played a significant role in regional and national consciousness. The small panel landscapes developed by artists such as Albrecht Altdorfer, Jan van Eyck, and Joachim Patinir were described as cosmographies and regarded as a more adequate format than written text for describing the universe. Albrecht Dürer claimed that "the measurement of the earth, the waters, and the stars has come to be understood through painting."[38]

TECHNICAL RELATIONS

Printing had significant impacts on Renaissance cosmography. It made more accessible both ancient texts such as the *Geography* and more contemporary works such as Albert Magnus's *De caelo et mundo* or d'Ailly's *Imago mundi,* and above all Sacrobosco's *Sphaera.* Easily reproduced in consistent form, these could more readily be criticized and updated. Geometrical relations between celestial and terrestrial spheres could be illustrated and alternative hypotheses on the number and rotation of the former disseminated and compared across simple woodcut diagrams (fig. 3.3). Printed texts could also prolong the life of outmoded representations.[39] With Martin Waldseemüller's 1507 introduction of globe gores showing 360 degrees of longitude and 180 degrees of latitude to accompany the cosmographic text, the secondary meaning of cosmography as a description of the whole earth was reinforced.[40] To the mathematical and descriptive parts of the written cosmography was added a third: the printed map of the world.

Printing Ptolemy's *tabulae* or Regiomontanus's ephemerides not only guaranteed the consistency of numerical data between copies, freeing scholars of the need to recalculate for themselves; it also placed a premium on quantification. This was critical for coordinating and plotting the avalanche of information about terrestrial and celestial phenomena that descended on Renaissance Europe. The vast, variegated world illustrated in such encyclopedias and atlases as Hartmann Schedel's *Liber chronicarum* (1493), Sebastian Münster's *Cosmography* (1544), or Abraham Ortelius's *Theatrum orbis terrarum* (1570) was so much altered by the new technology that "the walled libraries of the age of scribes may be related to the closed cosmos envisaged by generations of philosophers."[41] Improved observation of heavens and earth depended on changes in the technologies of vision and representation, especially from about 1600. Copernican heliocentrism had been an outcome of traditional forms of astronomical reasoning rather than new observation. Even Tycho Brahe's and Johannes Kepler's more attentive observations were based upon conventional instruments. It was Galileo's use of the newly invented telescope that radically challenged the perfection of the Aristotelian celestial spaces, revealing corrugations on the lunar sphere, moons revolving around Jupiter, and imperfections on the surface of the sun.[42] On the elemental globe, the unity of cosmography, accepted and repeated by both seamen and scholars, "remained a pious wish as long as portolan charts and the world maps pursued parallel and concurrent developments."[43] Ptolemaic mapping established meridians and *oikoumene* (the inhabited world) independent of astronomical measure, challenging graphically the unity of heavens and earth. The appearance of celestial circles, rhumb lines, *and* graticule on late *mappaemundi* and the joint publication of Ptolemaic and maritime world maps by Waldseemüller, Francesco Rosselli, and others indicate how technical developments exacerbated the problems of illustrating cosmographic unity.[44] But while cartographic projection and oceanic discovery transformed Europe's image of continents and oceans, actual survey techniques on land and sea were not revolutionized until the measurement of terrestrial meridian arcs, accurate longitudinal fixing at sea, and widespread use of triangulation in the eighteenth century.

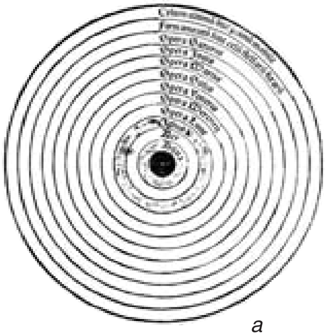
History and Geography of Renaissance Cosmography

Philosophical, social, and technical relations produced a history and geography of cosmography in Renaissance Europe. Simplifying both, I organize cosmography's history into six broad periods marked by the appearance of key texts. Its geography is more complex, with overlapping divisions between the Mediterranean, Iberia, and northern Europe; mercantile and territorial; and Catholic and Protestant states. I discuss these and the relations between cosmographic texts and diagrams before focusing on cosmographic images as such.

HISTORY OF COSMOGRAPHY

The works whose appearance helps shape a summary history of Renaissance cosmography are Francesco

38. Quoted in Christopher S. Wood, *Albrecht Altdorfer and the Origins of Landscape* (Chicago: University of Chicago Press, 1993), 46.
39. Elizabeth L. Eisenstein, *The Printing Press as an Agent of Change: Communications and Cultural Transformations in Early-Modern Europe,* 2 vols. (Cambridge: Cambridge University Press, 1979), 2:510.
40. Shirley, *Mapping of the World,* 28–31 (nos. 26 and 27).
41. Eisenstein, *Printing Press,* 2:518.
42. Albert Van Helden, "The Invention of the Telescope," *Transactions of the American Philosophical Society,* 2d ser., 67, pt. 4 (1977): 3–67.
43. Lestringant, "Crisis of Cosmography," 163.
44. David Woodward, "Maps and the Rationalization of Geographic Space," in *Circa 1491: Art in the Age of Exploration,* ed. Jay A. Levenson (Washington, D.C.: National Gallery of Art, 1991), 83–87.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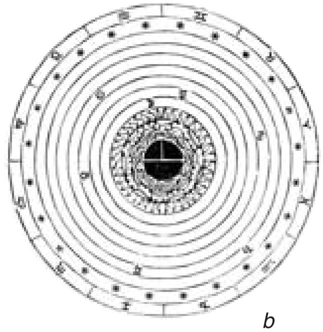
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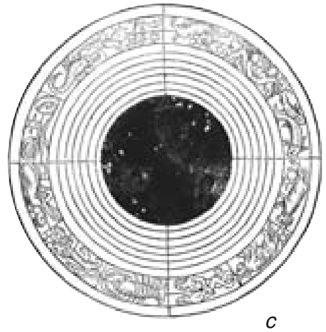
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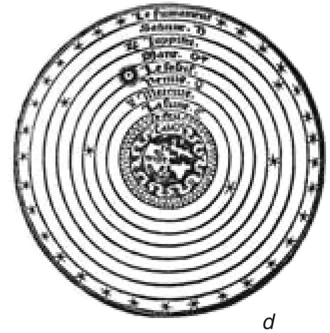
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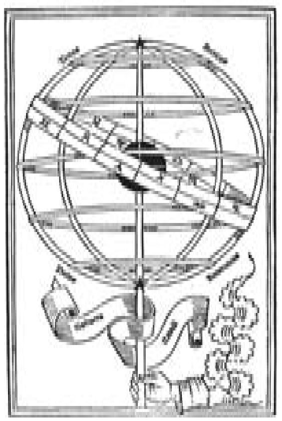
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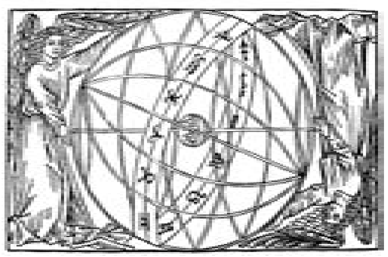
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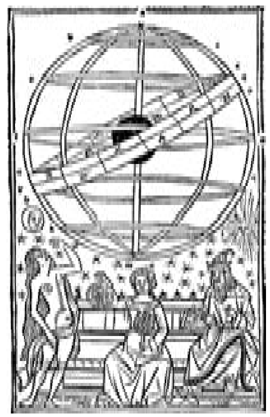
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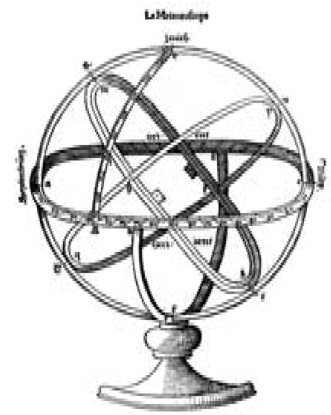
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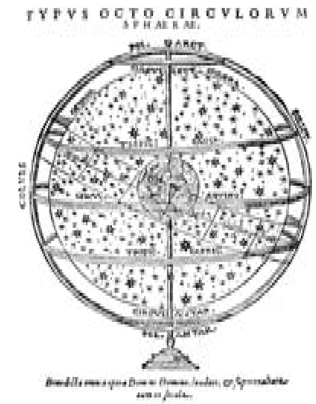

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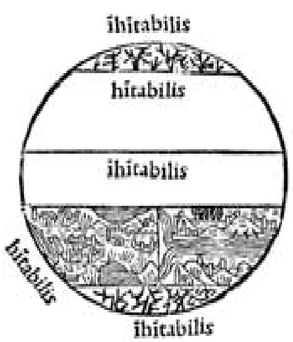

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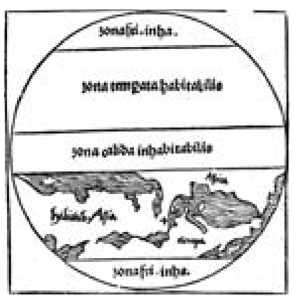

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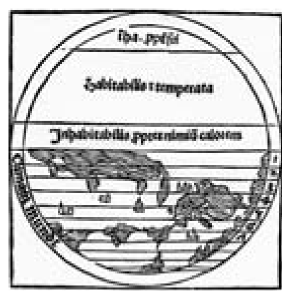
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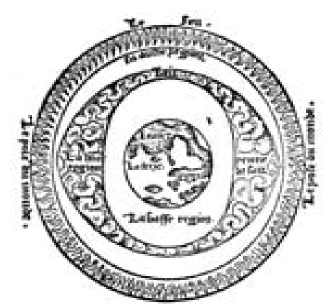
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FIG. 3.3. THE THREE BASIC COSMOGRAPHIC MAPS DERIVED FROM SACROBOSCO'S *SPHAERA MUNDI*. The three left columns are woodcut illustrations taken from incunable editions of Sacrobosco's text; column 4 contains three illustrations from Oronce Fine's *La theorique des cielz* (1528), and column 5 a cosmos from Barthélemy de Chasseneuz's *Catalogus gloriae mundi* (1576) and an armillary from Giovanni Paolo Gallucci's *Theatrum mundi* (1588) to show how the basic diagrams could be elaborated.

Row One: Aristotelian cosmos of four elements, seven planetary spheres, the fixed stars, and the *primum mobile*. Variations occur in the representation of elemental space surrounding a black-inked central earth. In *a* they are named, in *b* conventional symbols and a tripartite division of earth appear, in *c* they are not differentiated. Fine's terraqueous sphere (*d*) suggests a cartographic distribution of land and sea, while Chasseneuz (*e*) replaces this with a zonal map of earth. The planetary spheres are either named or indicated by their conventional astrological symbols. The ninth heaven is often used to show the zodiac symbols. Fine closes his cosmos with a firm double line around the fixed stars, while, by adding a ninth, crystalline sphere between the fixed stars and the *primum mobile* and the immobile *emperium* beyond, Chasseneuz offers the maximum number of circles to which the Aristotelian cosmos could evolve. Peter Apian's influential cosmos map also stretched to ten spheres, but he left the outer boundary of the tenth open. Chasseneuz closes it and divides the images horizontally into elemental and celestial regions, with a landscape view of the richness of the created world, while four angels surround the cosmos to indicate the super-celestial world.

Row Two: Armillary diagrams in Sacrobosco are relatively standard in their contents, with a central earth—which may indicate tripartite division of the continents (*f*) or habitability (*g*) or remain undifferentiated (*h*)—the five great circles (horizon, tropic, and polar circles), colures, axis (which in *g*, unusually, shows both global and celestial axes), and zodiacal band. Greater variation is apparent in the associated images relating to motion. In *f* the hand of God appears from the cloud of unknowing (illustrated by the conventional symbol also used for elemental air) to hold the axis of *sphaera mundi;* in *g* the cosmos is turned on its axis by angelic hands (but, unusually, the angels appear to turn the axis of the terrestrial globe, apparently challenging Aristotelian laws on its mobility), while in *h* the figures of Urania, a seated Astronomia holding armillary and astrolabe, and Ptolemy dressed as an Eastern sage examine the sphere, sun, moon, and stars by instrument and book. This basic image was elaborated by later cosmographers, for example in printings of d'Ailly's text and most notably by Oronce Fine, who replaces Ptolemy with himself (see fig. 3.12). Fine uses the basic image of the armillary for his "meteoroscope," illustrating the use of terrestrial latitude and longitude to make astronomical observations (*i*), while Gallucci uses the armillary for an observationally accurate map of the constellations (*j*).

Row Three: *Mappaemundi*. Cosmography's fundamental principle of homology between the celestial and elemental spheres (a predictable consequence of geocentrism) is revealed through the inscription on the latter of the same elements of axis and great circles seen in the former. From these derived the received image of five zones (two frigid, two temperate, and a single tropical zone). Only the temperate zones were regarded as inhabitable, and only the northern hemisphere was known to be inhabited. The Sacroboscan diagrams (*k*, *l*, *m*) illustrate this through labeling and indicating the known *oikoumene* of the northern habitable zone by means of either a landscape view of cultivated lands, waters, and cities or a crude map of Ptolemy's *oikoumene* with three continents and the location of Jerusalem indicated by a cross; *m* elaborates this by numbering seven climata of the habitable zone. Fine's world map in *n* treats the elemental sphere rather differently, indicating earth and water by means of a circular *mappamundi* with a circumnavigated Africa and the zone of fire by means of a conventional outer circle of flames, but follows Aristotelian meteorology by dividing air into three regions: lower, median, and upper, differentiated by the relative admixture of heat and moisture, thus determining the phenomena that appear within the zone (see plate 1).

Johannes de Sacrobosco, *Sphaera mundi* (Venice: F. Renner, 1478) for *a;* (Venice: Erhard Ratdolt, 1482) for *b* and *f;* (Leipzig: Martin Landsberg, 1494) for *g*, *l*, and *m;* (Paris: Johannes Higman for Wolfgang Hopyl, 1494) for *c* and *k;* and (Paris: Henrici Stephani, 1507) for *h*. Oronce Fine, *La theorique des cielz* (Paris, 1528) for *d*, *i*, and *n*. Barthélemy de Chasseneuz, *Catalogus gloriae mundi* . . . (Venice: Vincentij Valgrisij, 1576) for *e*. Giovanni Paolo Gallucci, *Theatrum mundi, et temporis* . . . (Venice: I. B. Somascum, 1588), 7, for *j*. Photographs courtesy of MnU (*a*); Harvey Cushing/John Hay Whitney Medical Library, Yale University, New Haven (*b* and *f*); Bancroft Library, University of California, Berkeley (*c*); BL (*d, i,* and *n*); © Board of Trustees, National Gallery of Art, Washington, D.C. (*e*); University College London (UCL) Library Services, Special Collections (*g, h, l,* and *m*); Adler (*j*); and Smithsonian Institution Libraries, Washington, D.C. (*k*).

Berlinghieri's *Septe giornate della geographia* (1482), Martin Waldseemüller's *Cosmographiae introdvctio* (1507), Sebastian Münster's *Cosmographia* (1544), Gerardus Mercator's definition of cosmography (1569) for his posthumously published *Atlas sive Cosmographicæ meditationes de fabrica mvndi et fabricati figvra* (1595), and Robert Fludd's *Utriusque cosmi maioris scilicet et minoris metaphysica* (1617).

Before 1482

Cosmography's principal new concern in the immediate aftermath of Jacopo Angeli's translation of Ptolemy lay in realizing the promise of a mathematically secure foundation for geographical mapping. This was not straightforward. No maps dating to their author had survived for Ptolemy's tables of locations.[45] Indeed, the work did not need to be accompanied by actual maps, for the value of the numerical coordinate system lay precisely in the consistency and mobility of the spatial information it offered. The locations themselves lacked accord with modern names, necessitating philological research. Also, portolan charts and navigation records covered a larger space than the ancient *oikoumene,* challenging classical authority. In his "Imago mundi" (1410), d'Ailly already proposed corrections to Ptolemy's locations and projections. By the 1430s, in German monasteries and universities scholars were using refinements in sundials and the newly discovered magnetic declinations to plot Ptolemy's tables onto mathematical projections of the sphere.[46] Based on geometrical principles and illustrating the whole sphere of earth, the resulting two-dimensional images of the terrestrial surface were titled cosmographies. A group of cosmographers at the monastery of Klosterneuburg produced the earliest known graphic renderings of the *tabulae,* although no original copies of their work remain. The "cosmographia septem climatum" was a semicircular hemispheric map, while the "nova cosmographia" was a circular rendering of the world. These advances were disseminated by Nicolaus Germanus, Georg von Peuerbach, and Pius II (Enea Silvio de' Piccolomini) into humanist centers in Nuremberg, Venice, Florence, and Rome. Mathematical descriptions of ancient places and events and their connection to the contemporary world attracted humanist interest in renewal and demonstrated the modern relevance of the ancient Greek principle of *eusunopton*—visible, harmonious form.[47]

That humanist concern with Ptolemy was more than antiquarian is apparent in the use of the appellation cosmography by mid-century in works that applied his coordinate system to contemporary data rather than simply to reproductions of the original *tabulae.* In this, Peuerbach's precocious pupil, Regiomontanus, was significant in collating astronomically determined coordinates for locations across Europe, necessary for accurate use of his *Ephemerides,* which calculated astronomical positions for the years 1475 to 1506. Regiomontanus completed Peuerbach's *Epitome* of the *Almagest* (1462) and crafted new instruments for astronomical observation. He printed Peuerbach's *Theoricae novae planetarum* (1474) with its widely reproduced diagrams reconciling observed planetary movements with the circularity of the Aristotelian spheres (fig. 3.4), so simplified in Sacrobosco's diagrams.[48] Regiomontanus criticized Jacopo Angeli's mistranslation of the title of Ptolemy's *Geography,* of which he planned his own translation, but retained "cosmography" for Ptolemy's work in his own list of mathematical works to be printed. Regiomontanus died in Rome in 1476, probably working on calendar reform, but his observational, mathematical, and philological work in relating the celestial and elemental spheres echoed through cosmography for over half a century: in Copernicus's theory and in Apian's illustrations of comets, for example.[49]

In Venice, the most sophisticated early Renaissance Italian cosmography was Fra Mauro's 1459 *mappamundi* for Afonso V of Portugal. Fra Mauro acknowledged the intellectual significance of Ptolemaic cosmography and in his map commented on advances in cosmography, but avoided using projection. Ptolemy's *tabulae* did not cover the geographical space for which Fra Mauro had information but no coordinate tables. Fra Mauro's is thus a descriptive cosmography—pictorial and textual but not mathematical. It collates and illustrates the world's variety from the vantage point of Europe's premier mercantile city.[50] The various meanings of cosmography coalesce in this remarkable *mappamundi.* The texts elements of the map reveal Fra Mauro's use of the most up-to-date sources, while the landscapes in blue and gold that cover its surface give the earth a jewel-like uniformity that reflects the cosmographic vision. How-

45. O. A. W. Dilke and eds., "The Culmination of Greek Cartography in Ptolemy," and idem, "Cartography in the Byzantine Empire," in *HC* 1:177–200 and 258–75, esp. 266–74.

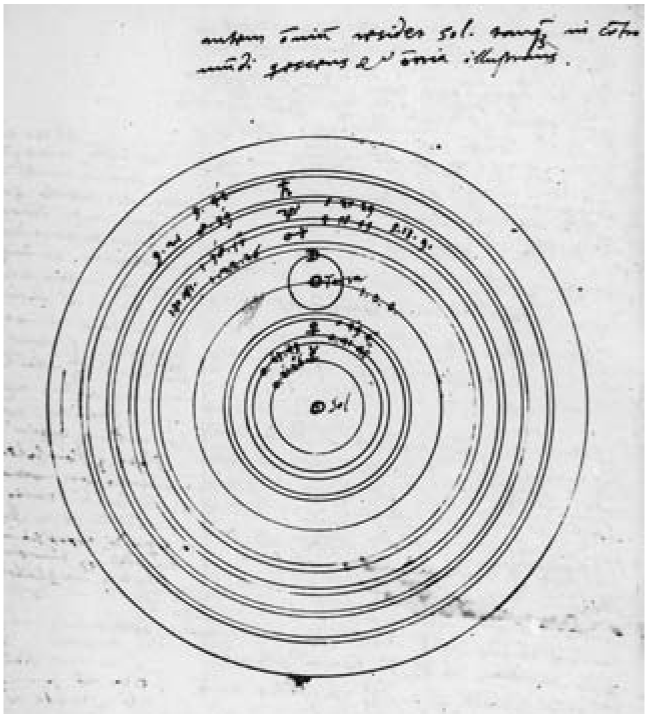
46. Dana Bennett Durand, *The Vienna-Klosterneuburg Map Corpus of the Fifteenth Century: A Study in the Transition from Medieval to Modern Science* (Leiden: E. J. Brill, 1952), and Ernst Zinner, *Regiomontanus: His Life and Work,* trans. Ezra Brown (Amsterdam: North-Holland, 1990), 16–17.

47. The idea of renewal was fundamental to the Renaissance humanists' project of using ancient texts in the service of a modern polity based on the moral and political principles they felt had underpinned the classical world. On the classical principle of *eusunopton,* see Lestringant, "Crisis of Cosmography," 166–67.

48. Zinner, *Regiomontanus,* and Lucien Gallois, *Les géographes allemands de la Renaissance* (Paris: Ernest Leroux, 1890), 1–11.

49. Zinner, *Regiomontanus.*

50. For discussions of the Fra Mauro map, see David Woodward, "Medieval *Mappaemundi,*" in *HC* 1:286–370, esp. 314–18; Peter Whitfield, *The Image of the World: 20 Centuries of World Maps* (London: British Library, 1994), 32–33; J. A. J. de Villiers, "Famous Maps in the British Museum," *Geographical Journal* 44 (1914): 168–84; and pp. 315–17 in this volume.



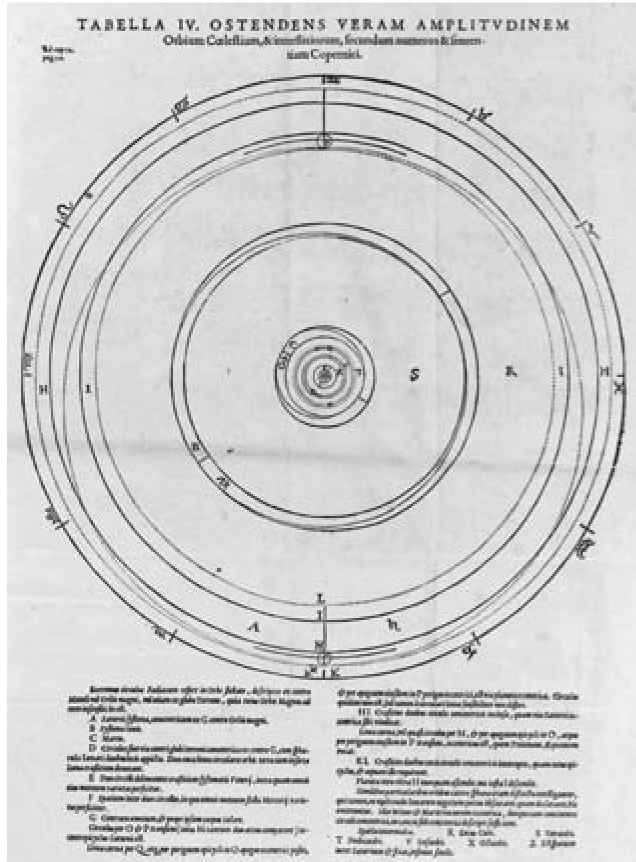


FIG. 3.4. ILLUSTRATING PLANETARY MOVEMENT AND ORBS. According to Aristotle's cosmography and the physical principles that underlay it, each planet in a geocentric cosmos revolved within an orb of ether, an incorruptible substance equivalent in the celestial sphere to the four elements of the corruptible sphere. The principle of plenitude determined that there could be no space between these orbs, and each was generally believed to be enclosed within a crystalline sphere. Observed variation in the distances of the planets from earth produced major problems in seeking to sustain the principles of circularity, equivalence in the width of the orbs, and plenitude in their exact fit that are indicated by world system diagrams in Sacrobosco, for example. Gerard of Cremona's *Theorica planetarum,* an important thirteenth-century contribution to the debate regularly bound with Sacrobosco's *Sphaera,* was discussed in Georg von Peuerbach's *Theoricae novae planetarum* and illustrated by Regiomontanus. The diameter of the world machine was generally accepted to be some forty thousand earth radii. The theory of Copernicus had the effect of either pushing this size virtually to infinity or breaking the principle of plenitude by leaving gaps between the spheres. While his own illustrations do not indicate this, it is suggested in the Copernican diagrams of Johannes Prätorius (left) and Michael Maestlin (in Georg Joachim Rheticus, *De libris revolutionum Nicolai Copernici narratio prima,* 1596) by gaps between the concentric planetary orbs. Kepler's illustration (right) of the proportions and intervals of the celestial orbs following Copernicus's measurements reveal their overlap and thus the impossibility of either their crystalline nature or their concentricity.

Johannes Prätorius, *Compendosia enarratio hypothesium Nicolai Copernici* (1594), photograph courtesy of the Universitätsbibliothek Erlangen-Nürnberg (MS. 814, fol. 92v), and Johannes Kepler, *Mysterium cosmographicum,* 2d ed. (Frankfurt: Erasmi Kempferi, 1621), pl. IV, photograph courtesy of the Beinecke.

ever, the cosmographic argument is made separately, in four circles outside terrestrial space that occupy the corners of the work. These illustrate and explain respectively the elemental and celestial spheres, the division of the elements, the poles and great circles that unify celestial and terrestrial globes, and the terrestrial paradise.

1482–1507

Manuscript copies of the *Geography* and mappings of the *tabulae* were prized in Italian courts as philological exercises and items of beauty. In Florence, cosmography was drawn into the realm of Platonic studies. Francesco Berlinghieri, a member of Marsilio Ficino's Platonic Academy, titled his Italian poetic rendering of Ptolemy *Le septe giornate della geographia,* and it was accompanied by fine copperplates of the original *tabulae.*[51] Berlinghieri places the work within the tradition of narrative and descriptive geography inherited from Herodotus and

51. Shirley, *Mapping of the World,* 9 (no. 9).

Strabo.[52] This confused the connection with cosmography but suited the humanist commitment to style and rhetoric over scholastic logic. Marsilio Ficino, concurrently translating Plato's cosmological text the *Timaeus,* wrote a dedicatory preface for Berlinghieri.

Unlike the Klosterneuburg and Fra Mauro cosmographies, Regiomontanus's and Berlinghieri's work appeared in print. The seventy-five manuscript copies of Ptolemy's *Geography* probably circulating by 1475 compares with an estimated one thousand printed copies in existence by 1500. Many contained cartographic renderings of modern coordinates based on Regiomontanus's tables as well as the conventional *tabulae.*[53] Regiomontanus's 1471 Nuremberg project to publish a library of ancient astronomical and cosmographic texts was posthumously pursued in Nuremberg and Venice by Erhard Ratdolt and Aldus Manutius, who pioneered the reproduction of woodcut and copper illustrations of mathematical diagrams and maps. These largely reproduced manuscript illustrations from Sacrobosco's *Sphaera,* Macrobius's *In somnium Scipionis,* and d'Ailly's *Imago mundi* but with increasing sophistication.[54] Regiomontanus had used different colored inks to mark feast days and golden numbers. In 1493 a group of Nuremberg scholars, mathematicians, and artists coordinated by humanist-publisher Hartmann Schedel published the *Liber chronicarum.* Drawing on established conventions for illustrating the spheres, the book opens with images of the Genesis narrative, day by day. These construct a Christianized Aristotelian cosmos, extending to the super-celestial angelic ranks. Schedel's image of the cosmos is succeeded by a landscape of Eden and a woodcut map of the Ptolemaic *oikoumene.*[55] With its map of "Germania" and northern Europe and its textual reference to Martin Behaim (whose terrestrial globe, manufactured for Nuremburg merchants in the same year, contained information drawn from Portuguese cosmographers and navigators) and to the discovery of islands in the Ocean Sea (a cosmographic term for the Atlantic), this chronicle may properly be regarded as a humanist cosmography. Its emphasis is narrative and description rather than mathematical geography and astronomy. Gregor Reisch's instructional text of 1503, *Margarita philosophica,* also historicized cosmographic materials according to biblical authority.[56]

1507–1544

Such humanist works were not cosmographies in the emerging sense of a universal map or, increasingly after the hemispheric division of the world at Tordesillas, a globe or world map to which text was subordinate. Dawning recognition of America's continental scale and, after the 1522 return of Magellan's remaining circumnavigators, of the true dimensions of the terrestrial sphere stimulated interest in cosmography among princes, merchants, and scholars. Cosmography's favored vehicles became globes and world maps on a global projection, generally accompanied by an explanatory and descriptive text, either separately published or printed on the map itself. Mapping new data graphically and textually was becoming a major stimulus to cosmography. In 1508, Amerigo Vespucci was nominated pilot major at Spain's Casa de la Contratación, its first official cosmographer, a position of vital geopolitical and economic significance. Cosmographic globes and coordinate tables were central to debates over the extension of the papal line to the eastern hemisphere during the 1520s. Vespucci's own narratives of the four Columbian voyages were reproduced in Martin Waldseemüller's 1507 *Cosmographiae introdvctio,* written to accompany a map of the whole world "both in the Solid and Projected on the Plane": *Vniversalis cosmographia secvndvm Ptholomæi: Traditionem et Americi Vespvcii aliorv qve lvstrationes.*[57] Waldseemüller's map, technical handbook, and geographical description established a model for sixteenth-century cosmography. Johannes Schöner published similar texts to

52. On Berlinghieri's interpretation of cosmography, see Milanesi, "Geography and Cosmography," 445, and De Smet, "Géographes de la Renaissance," 18.

53. Cecil H. Clough, "The New World and the Italian Renaissance," in *The European Outthrust and Encounter, the First Phase c. 1400–c. 1700: Essays in Tribute to David Beers Quinn on His 85th Birthday,* ed. Cecil H. Clough and P. E. H. Hair (Liverpool: Liverpool University Press, 1994), 291–328, esp. 296.

54. A significant number of the cosmographic texts that appeared in print before 1500 are reproduced in microfiche in Lotte Hellinga, ed., *Incunabula: The Printing Revolution in Europe, 1455–1500* (Woodbridge, Conn.: Research Publications, 1991–); see also the accompanying guide, unit 3: "The Image of the World: Geography and Cosmography" (especially the commentary on printed cosmographic texts by Denis E. Cosgrove, 13–19).

55. Shirley, *Mapping of the World,* 18–19 (no. 19).

56. *Margarita philosophica* covered all seven liberal arts, touching on cosmography in various sections throughout the vast work and drawing on printings of Sacrobosco's *Sphaera* for his images of the ecliptic and the rotundity of the earth. Republished regularly until 1599, Reisch's text and images were enormously influential for later cosmographic works.

57. *Cosmographiae introdvctio cvm qvibvsdam geometriae ac astronomiae principiis ad eam rem necessariis,* 1507; facsimile, in English, Martin Waldseemüller, *The Cosmographiae Introductio of Martin Waldseemüller in Facsimilie,* ed. Charles George Herbermann (1907; reprinted Freeport, NY: Books for Libraries, 1969). Waldseemüller's title continues: "Vniuersalis Cosmographi[a]e descriptio tam in solido q[uam] plano, eis etiam insertis qu[a]e Ptholom[a]eo ignota a nuperis reperta sunt." On the intellectual context of Waldseemüller's project, see Hildegard Binder Johnson, *Carta Marina: World Geography in Strassburg, 1525* (Minneapolis: University of Minnesota Press, 1963). The world map is reproduced as figure 9.9 and in Shirley, *Mapping of the World,* 30–31 (no. 26).

accompany terrestrial globes in 1515, 1523, and 1533.[58] Globe pairs describing heavens and earth separately, sometimes accompanied by a third, the armillary sphere that modeled their cosmographic relationship, were being produced in increasing numbers. As Hans Holbein's famous portrait *The Ambassadors* (1533) records, possession of such costly items signified the social status of cosmographic knowledge.[59] Navigation was making Ptolemy's mapping techniques ever more vital for plotting global information at the same time as it eroded the authority of his image of lands and seas. To read the emerging picture, the user must understand the geometric principles through which the great circles, colures, axis, poles, and horizon of the celestial sphere are inscribed onto the terrestrial surface.[60] In fact, only 62 of Waldseemüller's 165 pages are devoted to this mathematical cosmography; the text is dominated by Vespucci's reports. Nonetheless, both mathematical cosmography (closely aligned to the science of optics) and navigators' reports shared a common emphasis on autopsy, seeing for oneself and ensuring the accuracy of sight by technical instrumentation. This was becoming an important criterion of cosmographic truth. The scale of the globe and the cosmographer's role as recorder of others' discoveries denied him the possibility of personal autopsy. He relied on the veracity of individual reports and his own capacity to connect these narratively and to secure them through the geometry of the map.

In the early decades of the new century, the monopoly in cosmographic teaching enjoyed by Sacrobosco's *Sphaera* was being challenged by new summaries of cosmography as the significance of geography and navigation increased in prominence to rival that of astronomy and the educational significance of distinct terrestrial and celestial globes gained importance at the cost of the armillary sphere.[61] Peter Apian's *Isagoge in typum cosmographicum seu mappam mundi* of 1521 and *Declaratio: Et usus typi cosmographici* of 1522, forerunners to his immensely successful *Cosmographicus liber* of 1524, coincided with the first circumnavigation. Apian, cosmographer to the emperor Charles V, produced a treatment of mathematical cosmography that was more popular than original and fuller than Waldseemüller's. It included instruction on celestial observation and the practicalities of spatial survey and delineation intended to clarify the accompanying world map. The text was edited in 1529 by Gemma Frisius, and by 1609 had passed through thirty-three editions in five languages.[62] Despite their titles, Gemma's own *De principiis astronomiae & cosmographiae* of 1530 (itself reprinted in ten editions over the following half century) and Oronce Fine's *Protomathesis* (1532) focus on terrestrial space.[63] Part of Gemma's title, "usu globi ab eodem editi," indicates the continued role of the cosmographic text as an aid to understanding the graphic representation of space in globes and world maps. The descriptive cosmography that succeeded the mathematical sections of these works expanded to accommodate new geographical knowledge while increasing dissonance with the geometrical symmetries of the Aristotelian *climata* zones threatened to undermine the intellectual coherence of the work.

Cosmography's graphic emphasis and the enlarging scope it was seeking to accommodate are revealed in popular panel cosmographies or world landscape paintings. Albrecht Altdorfer's *Battle of Issus* (1529), for example, maps the eastern Mediterranean, Sinai, Red Sea, and Nile from a viewpoint high above the earth, witness to its infinite distances and even the curving horizon of the globe. Jan Cornelisz. Vermeyen's drawings of the conquest of Tunis for Charles V, turned into tapestries by Willem de Pannemaker in 1554, incorporate similar perspectives on the western Mediterranean.[64] In the 1560s

58. *Luculentissima quaedā terrae totius descriptio: Cum multis utilissimis cosmographiae iniciis. . . .* See De Smet, "Géographes de la Renaissance," 21.

59. John David North, *The Ambassadors' Secret: Holbein and the World of the Renaissance* (London: Hambledon and London, 2002), and Jardine, *Worldly Goods,* 305–6 and 425–36. See figure 6.1.

60. On the connections between reading the geographical map (whose principles were mathematical in Ptolemy's definition) and looking at the chorographic image (in whose making Ptolemy emphasized the importance of pictorial skills), see Eileen Reeves, "Reading Maps," *Word and Image* 9 (1993): 51–65.

61. Dekker, "Introduction to Globes and Spheres," 6.

62. Apian's cosmographic publishing career began in 1521 with *Isagoge,* a textual description of how to transfer the globe onto a flat sheet. It contains an outline of cosmography, but it was *Cosmographicus liber* (Landshut, 1524) that established his significance as a cosmographer. His student Gemma Frisius contributed to the 1529 edition, *Petri Apiani Cosmographia, per Gemmam Phrysium, apud louanienses medicum ac mathematicum insignem, restituta* (Antwerp: Arnoldo Berckmano). On the continued significance of Apian's handbook into the early seventeenth century, see Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983), esp. 133–39. For basic biographical and bibliographic information on a significant number of the principal cosmographers of the mid-sixteenth century, see Robert W. Karrow, *Mapmakers of the Sixteenth Century and Their Maps: Bio-Bibliographies of the Cartographers of Abraham Ortelius, 1570* (Chicago: For the Newberry Library by Speculum Orbis Press, 1993); Apian is discussed on pages 49–63. Biographical information on the many cosmographers connected with the Roman Catholic Church can be found in *The Catholic Encyclopedia.*

63. Oronce Fine, *Orontii Finei Delphinatis, liberalivm disciplinarivm professoris regii, Protomathesis,* four parts: *De arimetica, De geometria, De cosmographia,* and *De solaribus horologiis* (Paris: Gerardi Morrhij and Ioannis Petri, 1532); idem, *De mundi sphaera, sive Cosmographia* (Paris, 1542). Oronce Fine's 1513 edition of Sacrobosco, *Mu[n]dialis sphere opusculu[m],* had appeared in 1516, containing thirty-two woodcuts taken from Venetian incunabulae. See Karrow, *Mapmakers of the Sixteenth Century,* 168–90.

64. Denis E. Cosgrove, *Apollo's Eye: A Cartographic Genealogy of the Earth in the Western Imagination* (Baltimore: Johns Hopkins University Press, 2001), 125–30, and Lisa Jardine and Jerry Brotton,

FIG. 3.5. SEBASTIAN MÜNSTER'S WORLD SYSTEM OF 1550. Münster's *Cosmography,* like Schedel's chronicle sixty years earlier, included illustrations by many artists, including Hans Holbein. Its relatively brief discussion of theoretical-mathematical cosmography was illustrated with simple diagrams. Münster's synthesis of the world system appears in this title page illustration, a unique circular image, itself owing something to the structure of Schedel's universe, set within a square frame whose upper corners are occupied by angels and its lower ones by anthropomorphic monsters. Arcs divide the circle to give the impression of a three-dimensional globe; three divisions illustrate the elements: land and air together composing a central landscape, positioned between water and fire, while the heavens are represented by images of sun and moon against a background of the starry firmament. The Creator is placed against a source of divine light within the billowing cloud of unknowing. This image owes nothing to mathematical or theoretical cosmography; it is connected much more closely to southern German panel landscape cosmographies and to traditions of biblical representation of space and its pictorial composition, for example Hans Lufft's 1534 image of the Pancreator overseeing his cosmos, with a central Eden landscape, which appears in Heinrich Steiner's German Bible published in Augsburg, 1535.
Size of the original: 11.2 × 15.6 cm. Sebastian Münster, *Cosmographei; oder, Beschreibung aller Länder . . .* (Basel: Apud Henrichum Petri, 1550), title page. Photograph courtesy of the Special Collections Research Center, University of Chicago Library.

and 1570s, Peter Bruegel the Elder would revive this tradition of detailing the richness of the material world in jewel-like images, capturing more coherently than published cosmographies the combination of ornament and harmony that underpinned the idea of cosmos.[65]

1544–1569

Sebastian Münster's *Cosmographia: Beschreibu[n]g aller Lender* of 1544, structured like Schedel's or Reisch's works as a historical narrative, appeared a year after Copernicus's *De revolutionibus orbium coelestium,* Vesalius's *De humani corporis fabrica,* and Niccolò Tartaglia's first vernacular translation of Euclid's *Elements.*[66] Cosmos was becoming a key trope for scientific observation and description of natural phenomena from the scale of the human microcosm to elemental and celestial globes. Münster was a Lutheran doctor, Hebrew scholar, active astronomer, and publisher of a Latin version of the *Geography.* More a humanist encyclopedia than an explanatory adjunct to globe or map, the *Cosmography* demonstrates in words and pictures the universal majesty of God's creation, indicated by its title page illustration and the *mirabilia* that fill it (fig. 3.5). *Eusunopton* is conveyed by the *typus,* or world machine diagram, but Münster's mathematical exposition, simply formulated in standard definitions at the beginning of the work, hardly counterbalances the "thousands of profuse pages that contain the many-hued descriptions of countries, regions, towns, and islands."[67]

Münster's strong geographical focus is shared by Rembertus Dodonaeus's contemporary but less commercially successful work.[68] The printed cosmography was facing competition from collections of firsthand exploration and discovery narratives such as Giovanni Battista Ramusio's three-volume *Navigazioni et viaggi* (from 1550). Like Apian's handbook, Münster's work was translated into and published in the major European languages. The first cosmography composed in English was William Cuningham's *Cosmographical Glasse* of 1559, while in France Guillaume Postel's *Livre des merveilles du monde* was published in 1553. Guillaume Le Testu's unpublished "Cosmographie universelle" was completed in 1556. The expanding volume of materials returned from "new worlds," however, challenged European cosmographers with the increasingly impossible task of reconciling their synoptic

Global Interests: Renaissance Art between East and West (London: Reaktion, 2000), 82–115. See also plate 22.

65. Walter S. Gibson, *"Mirror of the Earth": The World Landscape in Sixteenth-Century Flemish Painting* (Princeton: Princeton University Press, 1989).

66. Kim H. Veltman, "The Emergence of Scientific Literature and Quantification, 1520–1560," <http://www.sumscorp.com/articles/art14.htm>, discusses the significance of these works in the quantification of knowledge and the evolution of a scientific culture at this time. On the impacts of Vesalius's work, see Jonathan Sawday, *The Body Emblazoned: Dissection and the Human Body in Renaissance Culture* (London: Routledge, 1995). On Münster, see Sebastian Münster, *Cosmographiae uniuersalis lib. VI.* (Basel: Henrichvm Petri, 1550); Manfred Büttner and Karl Heinz Burmeister, "Sebastian Münster, 1488–1552," in *Geographers: Biobibliographical Studies,* ed. Thomas Walter Freeman, Marguerita Oughton, and Philippe Pinchemel (London: Mansell, 1977–), 3:99–106; Karl Heinz Burmeister, *Sebastian Münster: Eine Bibliographie* (Wiesbaden: Guido Pressler, 1964); and Besse, *Les grandeurs de la terre,* 151–57.

67. Lestringant, "Crisis of Cosmography," 156.

68. Rembertus Dodonaeus, *Cosmographica in astronomiam et geographiam isogoge,* completed 1546 and published in Antwerp by I. Loei in 1548.

glance with the globe's promiscuous diversity and exotic otherness. As Postel's title *Des merveilles du monde* implies, such reports accentuated descriptive cosmography's appeal to a fascination with the strange and marvelous inherited from Pliny, among others. The florid decoration of his 1578 world map (known from the 1621 edition), complete with rotating scales, perfectly conveys cosmography's attempt to marry marvels and mathematics.[69]

Heliocentricity, which Copernicus saw as a way of maintaining the cosmological principle of uniformity in circular motion, offered the most radical challenge to the Ptolemaic cosmos. Copernicus's text was illustrated by a simple diagram of nine spheres, centered upon the sun and locating the earth with its circling moon on the third circle. Familiarity with his ideas among mathematical cosmographers a decade prior to publication of *De revolutionibus* is apparent in the 1532 *Typvs cosmographicvs vniversalis* by Sebastian Münster, in which the angels normally shown turning the spheres rotate the earthly globe.[70] But the complexity of Copernicus's system offered little improvement over Ptolemy so that the arguments for heliocentricity convinced no more than a handful of sixteenth-century thinkers, most following the supernova of 1572.[71]

1569–1620

By the late sixteenth century, both the synthetic ambitions of cosmographic publications and the countervailing pressures of observation were undermining the project's integrity. Theological division also had an impact on cosmography. Tridentine Catholicism favored Aristotelianism and elevated cautious investigation over speculative natural philosophy. This alone may have made Platonism more attractive among Protestant thinkers. Both camps had long since abandoned the scholastic separation of faith and reason and required natural philosophy to submit to religious doctrine.[72] Thus, the cosmographic concept of a providentially ordered and harmonious world machine, especially when connected to Neostoicism or to Neoplatonic ideas of the soul's ascent toward divine love, could offer a retreat from religious strife and a possible point of doctrinal resolution.[73] But if pietism's disengagement from the excesses of both sides of the doctrinal divide into more private belief favored images of harmony, the unrelenting flow of observational data into the cosmographer's study from navigation and systematic celestial observation undermined synopsis. In 1569, Gerardus Mercator, humanist and philosopher as much as mathematician, who had been charged with heresy in 1544, outlined his program for a multivolume cosmography: a synthesis of knowledge seeking to reconcile the observational sciences and biblical knowledge. Its volumes would cover creation of the universe (*totius mundi fabrica*), astronomy, geography, and the history of states (*geneologicon*). His attempt to harmonize the gospels (*Evangelicae historiae quadriparta Monas*) was published in 1592, an element in Mercator's vast but uncompleted cosmographic project: *Atlas sive Cosmographicæ*.[74] As Mercator's

69. Greenblatt, *Marvelous Possessions;* Postel's map is reproduced as figure 47.6 (detail, fig. 3.18), and in Shirley, *Mapping of the World,* 166–67 (no. 144).

70. Shirley, *Mapping of the World,* 74–75 (no. 67).

71. Hetherington, *Encyclopedia,* 92–99 ("Copernican Revolution"), with bibliography, and Víctor Navarro Brotóns, "The Reception of Copernicus in Sixteenth-Century Spain: The Case of Diego de Zúñiga," *Isis* 86 (1995): 52–78.

72. This is apparent in the writings of Bodin (Blair, *Theater of Nature,* 143–46) and the Jewish cosmographer David Gans (André Neher, *Jewish Thought and the Scientific Revolution of the Sixteenth Century: David Gans [1541–1613] and His Times* [Oxford: Oxford University Press, 1986], esp. 95–165). For an example of the use of a cosmographic image for purely polemical religious purposes, see Frank Lestringant, "Une cartographie iconoclaste: 'La mappe-monde nouvelle papistique' de Pierre Eskrich et Jean-Baptiste Trento (1566–1567)," in *Géographie du monde au Moyen Âge et à la Renaissance,* ed. Monique Pelletier (Paris: Éditions du C.T.H.S., 1989), 99–120. William B. Ashworth, "Light of Reason, Light of Nature: Catholic and Protestant Metaphors of Scientific Knowledge," *Science in Context* 3 (1989): 89–107.

73. The desire for an irenic religious resolution to the great theological divide at the turn of the seventeenth century is well attested. The concept of harmony central to cosmography and the Neoplatonic idea of ascent and mediation between earth and heaven seem to have made this very attractive to cosmographers and geographers, including Mercator, Ortelius, and Hondius. For a history of this idea, see Cosgrove, *Apollo's Eye.* On Mercator and Ortelius, see Giorgio Mangani, "Abraham Ortelius and the Hermetic Meaning of the Cordiform Projection," *Imago Mundi* 50 (1998): 59–83, and idem, *Il "mondo" di Abramo Ortelio: Misticismo, geografia e collezionismo nel Rinascimento dei Paesi Bassi* (Modena: Franco Cosimo Panini, 1998). On Mercator's attachment to such ideas, see Nicholas Crane, *Mercator: The Man Who Mapped the Planet* (London: Weidenfeld and Nicolson, 2002), 50–51 and 149–50. On Bodin, see Blair, *Theater of Nature,* 147–48. The Venetian Accademia della Fama, which was active in these years and whose members included cosmographers Giacomo Gastaldi and Livio Sanuto, had as its motto "I fly to Heaven to rest in God." Manfredo Tafuri, *Venice and the Renaissance,* trans. Jessica Levine (Cambridge: MIT Press, 1989), 114–22. Such ascent could imply the existence of a single, continuous medium between earth and the planets as indicated by Neostoicism. Also, the rhumb line or loxodrome, which Mercator's projection reconciles with the great circle route on the map, describes a spiral that becomes infinite about the pole. A common literary conceit at the turn of the seventeenth century connected the loxodrome (or *cursus obliquus*) to a spiral ascent of the soul, "poised between the straight furrow of bestiality [elemental motion] and the ceaseless revolutions described by the angels [celestial motion]." Reeves, "Reading Maps," 53.

74. Gerardus Mercator, *Atlas sive Cosmographicæ meditationes de fabrica mvndi et fabricati figvra* (Duisburg: Clivorvm, 1595); in English, *Atlas or a Geographicke Description of the Regions, Countries and Kingdomes of the World, through Europe, Asia, Africa, and America,* 2 vols., trans. Henry Hexham (Amsterdam: Henry Hondius and Iohn Iohnson, 1636). Lestringant, in *Mapping the Renaissance World,* 6, uses Mercator's phrase "cosmographical meditation" to refer to this genre of works by geographer-theologians. On Mercator, see Marcel Watelet, ed., *Gérard Mercator cosmographe: Le temps et l'espace* (Antwerp: Fonds Mercator Paribas, 1994), and Crane, *Mercator.*

work suggests, cosmographic unity was evasive, possible, if at all, only through separation of its parts. Abraham Ortelius's *Theatrum orbis terrarum* of 1570 had already shown an alternative route: a collection of geographic maps with no reference to the celestial spheres, which were regarded as the province of astronomy. Traditional cosmographies continued to be produced, such as Urbano Monte's "Trattato universale descrittione et sito de tutte le terre sin qui conosciuto" (1590), although its conservatism probably accounted for its remaining in manuscript rather than reaching the press.[75]

Faced with the publishing success of Ortelius's *Theatrum orbis terrarum* (1570) and collections of discovery reports such as Richard Hakluyt's *Principall Navigations* (1589) or Theodor de Bry's *America* (1596), conventional cosmography was increasingly vulnerable. Both the scope of its claims and the contradictions increasingly revealed by actual observations of celestial and terrestrial space rendered cosmographic unity impossible to sustain across a detailed textual exposition such as Mercator's. Thus André Thevet's *Cosmographie vniverselle* of 1575 claims eyewitness veracity for phenomena well beyond the scope of its author's travels, seeking to secure his claims by allocating often entirely arbitrary locational coordinates to every phenomenon.[76] Such actions vitiated cosmography's claim that creation's diversity could be captured within the mathematically secure grid of the world machine. At the scholarly level, cosmography was beginning to peel apart. At the English universities between 1580 and 1620, geographical description of the earth was becoming distinguished from cosmography as "the study of the globe and its relations with the heavens as a whole."[77]

The late sixteenth century also witnessed a growing dispute over the structure of the world machine itself. In 1573 Valentinus Naiboda's sequence of comparative systems set Copernicus's image alongside Ptolemy's cosmos and Martianus Capella's geocentric map with Mercury and Venus circling the sun.[78] In his 1576 world system, Thomas Digges expanded the width of the earth's orb to contain both the elements and the lunar path. Digges's notation, if not his drawing, embraced the full implication of heliocentrism by combining fixed stars and the empyrean.[79] To accommodate the distances and speeds of planetary revolution in a heliocentric cosmos, the scale of the world machine must be stretched almost to infinity and a huge void opened between planets and stars, undermining Aristotle's principle of plenitude, which disallowed empty space. Heliocentrism also breaks the contiguity and ultimately the very existence of the Ptolemaic spheres, as two 1590s illustrations and Johannes Kepler's *Mysterium cosmographicum* (1596), which claimed to show the true size of the celestial orbs and the intervals, made absolutely apparent. Kepler reflects the mathematical shift in natural philosophy away from the Euclidian geometry appropriate to a fixed and finite cosmos and toward the Archimedian mathematics appropriate to studying motion and attraction between bodies in infinite space.

Tycho Brahe's 1588 alternative world system diagram maintained geocentricity by revolving the inner planets around the sun, while Nicolaus Reimers printed a similar diagram in his *Fundamentum astronomicum* of the same year. In Helisaeus Röslin's *De opere Dei creationis . . .* (1597), five systems were illustrated, allowing immediate visual comparison. By 1600, Ptolemaic, Copernican, and Tychonian models were familiar alternative images of the cosmos promoting broad and intense interest in the world machine among educated Europeans, reflected in its popularity as an artistic and literary theme in metaphysical poetry—sacred and secular—and in painting, drama, and masques (fig. 3.6).[80] As astronomy separated scientifically from geography, the cosmographic claim would be sustained graphically or in religious text whose scientific concerns were subordinate to their doctrinal concerns.

After 1620

By 1620, new optical instruments such as the telescope and microscope were generating volumes of new astronomical observations and revealing previously invisible structures within elemental matter. Autopsy's claims over other forms of authority and those of experience or experiment over rhetoric were ever more powerfully asserted. Such advances intensified rather than removed the questions of verifying observation that had always faced cosmography. The longitude problem remained unsolved, while the phenomena revealed by optical instruments could be made public only by means of graphic images. Questions of vision and the veracity of images underlay the dispute between Kepler and Robert Fludd over the latter's metaphysical maps in his history of the macrocosm and the

75. Urbano Monte, *Descrizione del mondo sin qui conosciuto,* ed. Maurizio Ampollini (Lecco: Periplo, 1994).

76. Lestringant, *Mapping the Renaissance World,* and chapter 47 in this volume.

77. Lesley B. Cormack, *Charting an Empire: Geography at the English Universities, 1580–1620* (Chicago: University of Chicago Press, 1997), 98–110, quotation on 18, and W. R. Laird, "Archimedes among the Humanists," *Isis* 82 (1991): 629–38.

78. Naiboda (or Nabodus) published his diagrams in a commentary on Martianus Capella's widely studied fifth-century *De nuptiis Philologiae et Mercurii libri novem.* The work, titled *Primarum de coelo et terra institutionum quotidianarumque mundi revolutionum, libri tres,* was published in Venice in 1573. See S. K. Heninger, *The Cosmographical Glass: Renaissance Diagrams of the Universe* (San Marino, Calif.: Huntington Library, 1977), 58–59.

79. A selection of Digges's *A Perfect Description of the Celestial Orbs* text is reproduced in Hall, *Nature and Nature's Laws,* 19–34.

80. E. M. W. Tillyard, *The Elizabethan World Picture* (London: Chatto and Windus, 1943); Reeves, "Reading Maps," 52–55; and idem, *Painting the Heavens.*

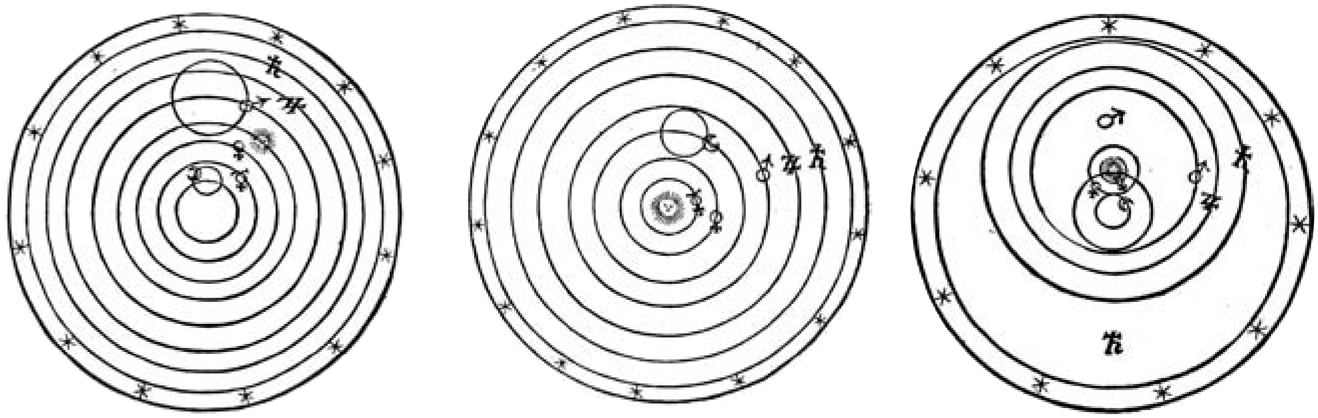


FIG. 3.6. THE COMPETING WORLD SYSTEMS. By the third decade of the seventeenth century, Ptolemaic, Copernican, and Tychonean images (left to right) of the cosmos were regularly compared. Many texts illustrated all three in simple "scientific" style, characterized by a graphic economy of clean compass lines, points, and astronomic notation and an absence of decorative iconography. This aided immediate visual comparison of the systems.
Helisaeus Röslin, *De opere Dei creationis* . . . (Frankfurt: Andræ Wecheli, Claudium Marnium, and Joannem Aubrium, 1597), 51 and 55. Photographs courtesy of the Smithsonian Institution Libraries, Washington, D.C.

microcosm, *Utriusque cosmi maioris* (1617–26) (fig. 3.7).[81] Celestial phenomena, such as the lunar craters mapped by Galileo and Jupiter's moons observed by Galileo, might further challenge faith in the perfection and harmony of an Aristotelian-Ptolemaic cosmos, but they by no means swept it away. Jesuit astronomers such as Christoph Scheiner, Christoph Clavius, and Giovanni Battista Riccioli used the new instruments to map celestial phenomena within the conventional Ptolemaic frame, while revelations of lunar corrugations fueled debates over Mary's immaculate conception (fig. 3.8).[82] Galileo's sunspot images of 1613, traced by the lens directly onto paper, lent support to the idea that mechanization of the image might guarantee its truth.[83] In all ways, therefore, image making, still socially disparaged as the work of mechanicians, assumed an increasingly significant role within natural philosophy.[84] In this context in the seventeenth century, cosmography, while still employed as a title for works that proclaimed the structural unity of terrestrial and celestial space, as a scientific project gave way to the technically distinct disciplines of geography and astronomy.

Cosmography remained a common title on globes, world maps, and atlases, climaxing in elaborate works by Jodocus Hondius, Joan Blaeu, and Vincenzo Coronelli for absolute sovereigns who often styled themselves masters of two spheres. These works, which frequently contained brief summaries of mathematical cosmography, were decorated with globe images and emblems drawn from the repertoire of Renaissance cosmography, rendering them pictorial equivalents of Baroque *Wunderkammern* (fig. 3.9). Louis XIV's life and reign were scripted through the discourse of cosmography and realized in the architecture, gardens, and decoration of Versailles. N. Jaugeon's *Carte generale contenante les mondes coeleste*

81. Robert S. Westman, "Nature, Art, and Psyche: Jung, Pauli, and the Kepler-Fludd Polemic," in *Occult and Scientific Mentalities in the Renaissance,* ed. Brian Vickers (Cambridge: Cambridge University Press, 1984), 177–229.

82. Robert S. Westman, "Two Cultures or One? A Second Look at Kuhn's *The Copernican Revolution,*" *Isis* 85 (1994): 79–115. See also Reeves, *Painting the Heavens.*

83. Francesco Panese, "Sur les traces des taches solaires de Galilée: Disciplines scientifiques et disciplines du regard au XVII^{e} siècle," *Equinoxe: Revue des Sciences Humaines* 18 (1997): 103–23, and Mary G. Winkler and Albert Van Helden, "Representing the Heavens: Galileo and Visual Astronomy," *Isis* 83 (1992): 195–217, esp. 211. Martin Kemp, in *The Science of Art: Optical Themes in Western Art from Brunelleschi to Seurat* (New Haven: Yale University Press, 1990), 169–212, discusses anamorphic images such as Christopher Scheiner's pantograph or those illustrated by Athanasius Kircher in his *Ars magna lucis et vmbrae* (Rome: Sumptibus Hermanni Scheus, 1646) and their claims to mimesis.

84. E. G. R. Taylor, *The Mathematical Practitioners of Tudor & Stuart England* (Cambridge: Cambridge University Press, 1954; reprinted London: For the Institute of Navigation at Cambridge University Press, 1967). Stephen Andrew Johnston, in "Mathematical Practitioners and Instruments in Elizabethan England," *Annals of Science* 48 (1991): 319–44, warns against too neat a distinction between artisan mechanicals and courtly scientists in the use of and attitudes toward instrumentation, arguing that the practitioners served a significant mediating role between "gentlemen and artificers, between patrons and craftsmen," although he points out that such knowledge was confined to urban culture and "would have had little impact on the illiterate majority in the rural population or the labouring poor" (pp. 327 and 342). On the connections between the practitioners and religion, see G. J. R. Parry, *A Protestant Vision: William Harrison and the Reformation of Elizabethan England* (Cambridge: Cambridge University Press, 1987). See also Pamela O. Long, "Power, Patronage, and the Authorship of *Ars:* From Mechanical Know-How to Mechanical Knowledge in the Last Scribal Age," *Isis* 88 (1997): 1–41, and the discussion by Cormack, in *Charting an Empire,* 24–27, referencing the relevant literature.

Popular cosmographies such as Apian's drew upon a tradition of mathematical texts by practitioners, available since the late fifteenth century, especially in Italy, e.g., Luca Pacioli, *Somma di aritmetica,*

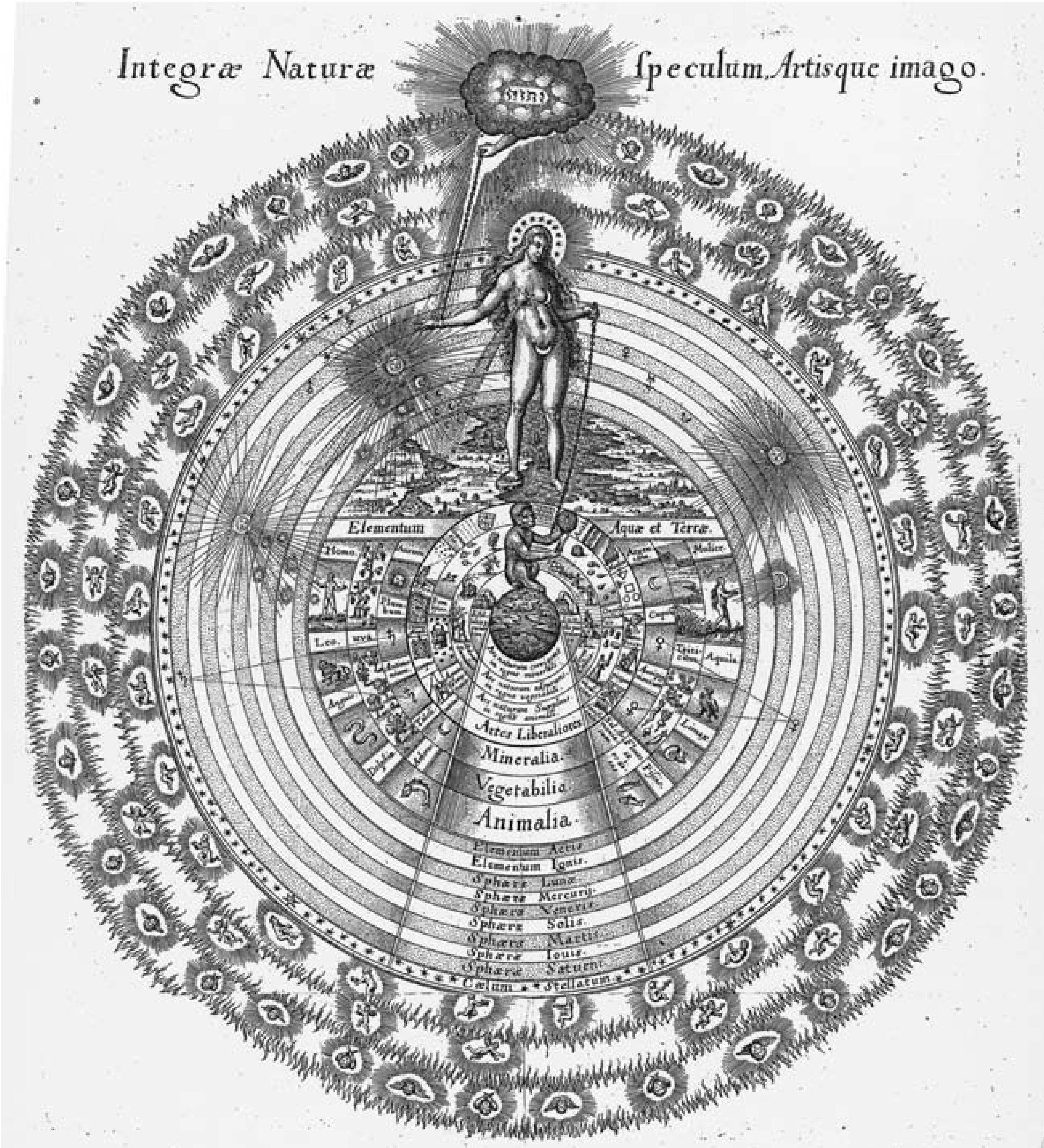


FIG. 3.7. ROBERT FLUDD'S COSMOGRAPHY.
Size of the original: ca. 33.7 × 30.5 cm. Robert Fludd, *Utriusque cosmi maioris scilicet et minoris metaphysica, physica atqve technica historia, in duo volumina secundum cosmi differentiam diuisa* (Oppenheim: Johann Theodor de Bry, 1617). Photograph courtesy of the Department of Special Collections, Kelvin Smith Library, Case Western Reserve University, Cleveland.

FIG. 3.8. JESUIT COSMOGRAPHIC ICONOGRAPHY. The image is a contribution to the seventeenth-century debate over the competing world systems, yet gestures back to Santritter and de Sanctis's 1488 frontispiece to Sacrobosco (see a later reproduction in fig. 3.3*h*) and Fine's reworking of it (see fig. 3.12). Here, Astraea, adorned with stars, holds the armillary in her left hand while with her right she presents a pair of scales to the hundred-eyed Argus, who in turn holds a telescope into which light streams from a sun supported by cherubim among the circumsolar planets. The scales weigh the systems of Copernicus and Riccioli, tipping in favor of the latter, while a seated Ptolemy, his own system now abandoned at Astraea's feet, proclaims, "I am extolled and simultaneously improved." Below the tetragrammaton, the hand of God indicates "number, measure, weight," while various cosmic phenomena, having newly emerged from the shadows of scientific obscurity by means of the telescope, are held aloft by angels: Saturn's rings, Jupiter's moons and colorations, lunar craters, and a comet. The image typifies Jesuit cosmographic iconography, stretched between rigorous observation and obedience to theological convention.
Giovanni Battista Riccioli, *Almagestum novum astronomiam veterem novamque complectens,* 2 vols. (Bologna: Victorij Benatij, 1651), frontispiece. Photograph courtesy of the Adler.

terrestre et civile (1688) used the royal face to illustrate the sun in a cartouche of seasons at the very center of his elaborate map.[85] Tommaso Campanella, whose *City of the Sun* exemplifies a utopian genre of cosmological texts, cast Louis's birth horoscope.

Continued faith in the cosmographic principle underpinned Neoplatonic attempts to synthesize knowledge according to a Christianized metaphysics within the Aristotelian geocentric system. Both the Protestant physician Robert Fludd and the Jesuit polymath Athanasius Kircher published lavishly illustrated works on macrocosm-microcosm relations, journeys through the spheres, the underground world, and planetary influence on terrestrial geography.[86] The scale and graphic complexity of these works reflect the challenge of containing within a single

geometria, proporzione e proporzionalità (Venice: Paganinus de Paganinis, 1494); Francesco Feliciano, *Libro di arithmetica [e] geometria speculatiua [e] praticale . . . Scala grimaldelli* (Venice: Frãcesco di Allesandro Bindoni and Mapheo Pasini, 1518); Cosimo Bartoli, *Del modo di misvrare le distantie, le superficie, i corpi, le piante, le prouincie, le prospettiue, & tutte le altre cose terrene, che possono occorrere a gli huomini, secondo le uere regole d'Euclide, & de gli altri piu lodati scrittori* (Venice: Francesco Franceschi Sanese, 1564); and Silvio Belli, *Libro del misurar con la vista . . .* (Venice: Domenico de' Nicolini, 1565). The place of such works in fifteenth-century Italian culture is discussed in Stillman Drake and I. E. Drabkin, comps. and trans., *Mechanics in Sixteenth-Century Italy: Selections from Tartaglia, Benedetti, Guido Ubaldo, & Galileo* (Madison: University of Wisconsin Press, 1969). Bartoli's title especially indicates the scope of such practical mathematics and of the mechanical arts to which they were applied. Similar texts were published in England after Henry Billingsley's translation of Euclid into English in 1570, for which John Dee's *Mathematicall Praeface* was written, defining and classifying the mathematical arts.

85. Monique Pelletier, "Les globes de Marly, chefs-d'œuvre de Coronelli," *Revue de la Bibliothèque Nationale* 47 (1993): 46–51. See also Chandra Mukerji, *Territorial Ambitions and the Gardens of Versailles* (Cambridge: Cambridge University Press, 1997); Thierry Mariage, *The World of André le Nôtre,* trans. Graham Larkin (Philadelphia: University of Pennsylvania Press, 1999), 27–46, which lists the relevant seventeenth-century French cosmographical literature; Denis E. Cosgrove, "Global Illumination and Enlightenment in the Geographies of Vincenzo Coronelli and Athanasius Kircher," in *Geography and Enlightenment,* ed. David N. Livingstone and Charles W. J. Withers (Chicago: University of Chicago Press, 1999), 33–66; and idem, *Apollo's Eye,* 166–75. For Jaugeon's map, see Shirley, *Mapping of the World,* 535 and 540–41 (no. 538), and Whitfield, *Image of the World,* 97.

86. The *locus classicus* of the Renaissance vision of the human microcosm, placed within the spheres and able through Platonic ascent to move in the spaces of the macrocosm, is Pico della Mirandola's "Oration on the Diginity of Man" (1486), which includes these lines: "We have given to thee, Adam, no fixed seat, no form of thy very own, no gift peculiarly thine, that thou mayest feel as thine own, have as thine own, possess as thine own the seat, the forms, the gifts which thou thyself shalt desire. A limited nature in other creatures is confined within the laws written down by Us. In conformity with thy free judgement, in whose hands I have placed thee, thou art confined by no bounds; and thou wilt fix limits of nature for thyself. I have placed thee at the center of the world, that from there thou mayest more conveniently look around and see whatsoever is in the world. Neither heavenly nor earthly, neither mortal nor immortal have We made thee. Thou, like a judge appointed for being honorable, art the molder and maker of thyself; thou mayest sculpt thyself into whatever shape thou dost prefer. Thou canst grow downward into the lower natures which are brutes. Thou canst again grow upward from thy soul's reason into the higher natures which are divine." Giovanni Pico della Mirandola, *On the Dignity of Man, on Being and the One, Heptaplus,* trans. Charles Glen Wallis, Paul J. W.

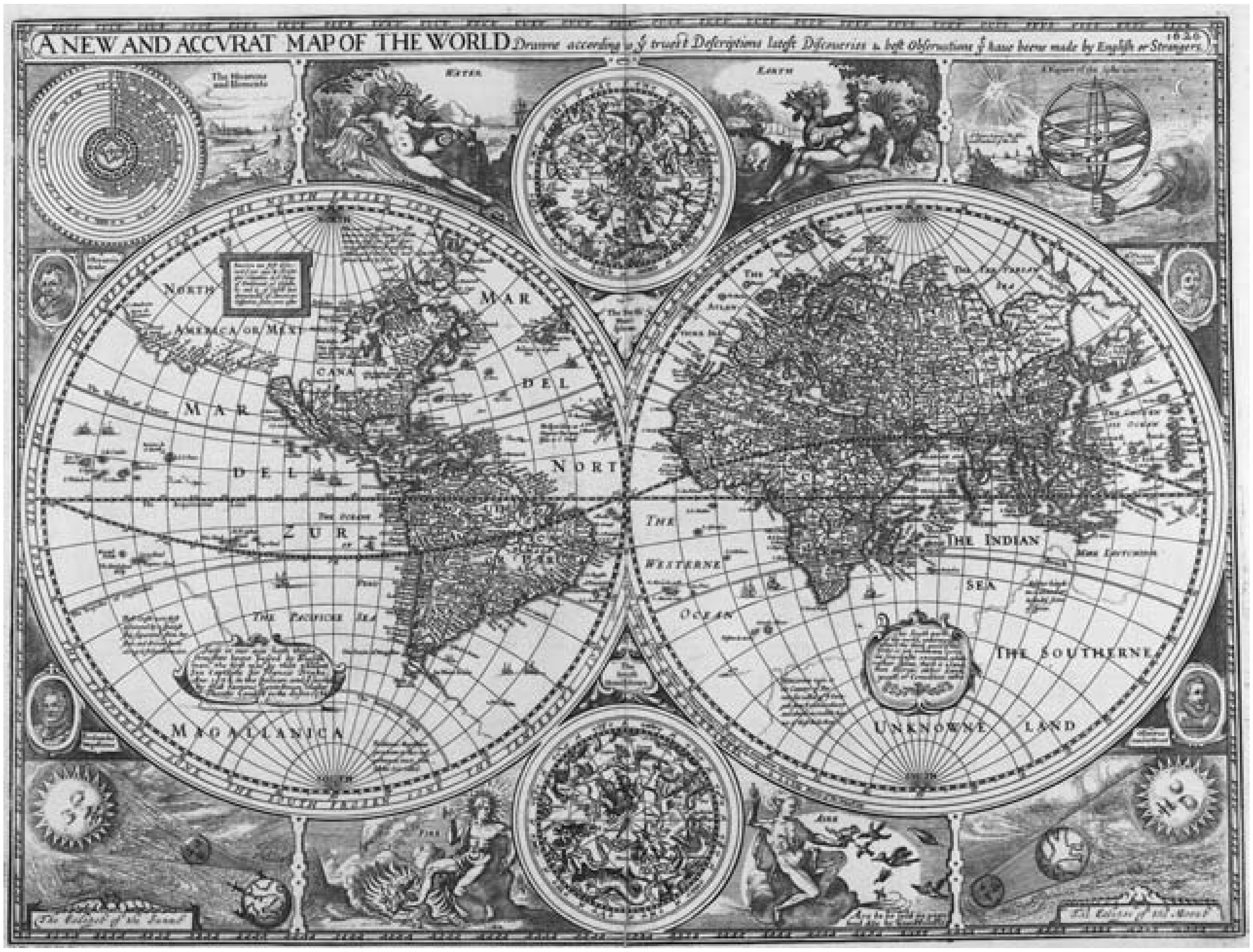


FIG. 3.9. MAPPED COSMOGRAPHY: JOHN SPEED'S MAP OF THE WORLD, 1626 [1632]. Speed's map illustrates the fragmentary incorporation of cosmography into the double hemisphere world map. The space is dominated by the two terrestrial hemispheres, on which the imprint of cosmography remains in the marking of the great circles, the line of the ecliptic, and the large southern continent of Magellanica. Surrounding are familiar cosmographic elements but no text. Two oculi map the northern and southern celestial skies. In the upper left is the world machine of elements and ten spheres, its outer circle left blank. At top right a hand holds the armillary and there are images of sun and moon plus a diagram demonstrating the earth's roundness by means of observing a ship crossing the horizon. To the lower left and right are diagrams of solar and lunar eclipses using familiar intersecting pyramids of vision. Background space is occupied by personifications of the four elements. The cosmography has national and imperial references: Speed accompanies his image with portraits of English explorers.
Size of the original: ca. 38.9 × 51.5 cm. John Speed, *A New and Accvrat Map of the World*, in *A Prospect of the Most Famous Parts of the World* (London, 1632). Photograph courtesy of the BL (Maps C.7.c.6).

conceptual framework the volume and range of empirical material available on the two worlds. Although these works were not titled cosmographies, the speculative use of maps and diagrams in them derives directly from earlier Renaissance projects.[87]

Miller, and Douglas Carmichael (Indianapolis: Bobbs-Merrill, 1965), 3–34, esp. 4–5.

Literature on the microcosm or the macrocosm is vast. An early summary is George Perrigo Conger's *Theories of Microcosms and Macrocosms in the History of Philosophy* (New York: Columbia University Press, 1922). A classic account of microcosmic thought in the Renaissance is Ernst Cassirer, *The Individual and the Cosmos in Renaissance Philosophy,* trans. Mario Domandi (Oxford: Basil Blackwell, 1963). Other accounts are Bernard O'Kelly, ed., *The Renaissance Image of Man and the World* (Columbus: Ohio State University Press, 1966), and Allen G. Debus, *Man and Nature in the Renaissance* (Cambridge: Cambridge University Press, 1978). The theme is also discussed in Jill Kraye, "Moral Philosophy," and Richard H. Popkin, "Theories of Knowledge," both in *The Cambridge History of Renaissance Philosophy,* ed. Charles B. Schmitt et al. (Cambridge: Cambridge University Press, 1988), 303–86, esp. 312–14, and 668–84, esp. 676–78, respectively.

87. On Fludd, see William H. Huffman, *Robert Fludd and the End of the Renaissance* (London: Routledge, 1988); Joscelyn Godwin, *Robert Fludd: Hermetic Philosopher and Surveyor of Two Worlds* (London:

A similar commitment to cosmography underpinned the pious handbook intended to demonstrate God's providential plan, combining a simplified outline of conventional Ptolemaic cosmology with a geographical sketch of the earth. Giuseppe Rosaccio's *Teatro del cielo e della terra* (1598) and Francesco Robacioli's 1602 print with the same title, or William Hodson's *Divine Cosmographer* (1640) and Peter Heylyn's *Cosmographie* (1652), demonstrate that such works existed in Catholic and Protestant regions.[88] In the latter, the printed Bible, itself regarded as the principal vehicle for redemption, offered ample opportunities for cosmographic mapping.[89] Similar illustration is found in emblems and moral devices. Attachment to divinity—in court, in the curiosity cabinet, or in the pious pamphlet—was a consistent if conservative feature of late Renaissance cosmography. William Hodson, writing in 1640, although rehearsing a tired cliché, ably summarizes its appeal: "As it is a most pleasant kind of Geographie, in this large mappe of the World, in the celestiall and terrestriall Globe, to contemplate the Creatour; so there is nothing that obtaineth more of God, than a thankfull agnition of the favours and benefits we daily receive from his bountifull hands."[90]

A GEOGRAPHY OF COSMOGRAPHY AND COSMOGRAPHERS

This survey of European cosmography conceals complex geographical patterns: clusters of connected scholars and works differentiated by the various purposes that cosmography served and by distinctions between northern and Mediterranean countries and between Catholic and Protestant states. And as European overseas presence grew, so the science of globes itself became global. The Relaciones geográficas of Spanish cosmographers Juan López de Velasco and Andrés García de Céspedes are detailed descriptions and inventories of Spanish America; Jesuit missionaries in both Asia and America collected astronomical and geographical information for annual reports to Rome and produced cosmographies locally, such as Matteo Ricci's world map (1602).[91]

One geographical distinction might be made between a more open and commercial cosmography in northern Europe, especially in Germany and Flanders, and a more secretive and courtly cosmography in the south, especially in Iberia and peninsular Italy. Another was between an urban-mercantile cosmography along the axis from Amsterdam through southern German cities to Venice, and a territorial-state cosmography within the Atlantic kingdoms from England to Spain. Commercially successful and widely translated handbooks by Regiomontanus, Apian, and Gemma Frisius; illustrated cosmographies and atlases by Schedel, Münster, Mercator, and Ortelius; and navigation collections such as de Bry's came from publisher-humanists in independent merchant cities such as Nuremberg, Venice, and Antwerp. In these cities cosmographic materials circulated freely through merchant contacts and in independent universities, especially after the Lutheran reform, and printers saw profits in maps, educational handbooks, illustrated encyclopedias, and voyage narratives. These publications spread across the continent. For example, the recommended texts in the Iberian universities of Valencia, Salamanca, Alcalá, and Coimbra, where cosmography was studied alongside judicial astrology and perspective, were those of Apian and Gemma, together with those of Sacrobosco and Euclid and Regiomontanus's *Epitome* of Ptolemy.[92] Court cosmographers operated in a less commercial world. Works produced by Sebastiano Leandro, Egnazio Danti, Giacomo Gastaldi, and Oronce Fine or by Galileo Galilei and

Thames and Hudson, 1979); and Frances Amelia Yates, *Theatre of the World* (London: Routledge and Kegan Paul, 1969). On Kircher, see Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley: University of California Press, 1994); idem, "The Economy of Scientific Exchange in Early Modern Italy," in *Patronage and Institutions: Science, Technology, and Medicine at the European Court, 1500–1750,* ed. Bruce T. Moran (London: Boydell, 1991), 5–24; Joscelyn Godwin, *Athanasius Kircher: A Renaissance Man and the Search for Lost Knowledge* (London: Thames and Hudson, 1979); and Cosgrove, "Global Illumination." As Kemp points out, "optics, mystery and divine awe naturally co-existed as major strands of mediaeval, Renaissance and baroque thought in a manner which is difficult to understand from a modern perspective" (*Science of Art,* 191).

88. Giuseppe Rosaccio, *Le sei età del mondo di Gioseppe Rosaccio con Brevità Descrittione* (Venice, 1595), and idem, *Fabrica universale dell'huomo* . . . (1627). Among Rosaccio's more than forty published works were a pilgrim's guide, *Viaggio da Venetia a Costantinopoli per mare, e per terra* (Venice: Giacomo Franco, 1598), and a world map, *Universale descrittione di tutto il mondo* (1597), reprinted in 1647 and decorated with ethnographic illustrations taken from Theodor de Bry (Shirley, *Mapping of the World,* 222–24 [no. 205]). On Rosaccio, see Giuliano Lucchetta, "Viaggiatori, geografi e racconti di viaggio dell'età barocca," in *Storia della cultura Veneta,* 6 vols. (Vicenza: N. Pozza, 1976–86), vol. 4, pt. 2, 201–50, esp. 201–2. Francesco Robacioli's *Teatro del cielo e della terra* is discussed in Shirley, *Mapping of the World,* 251 (no. 236). See also Robert J. Mayhew, *Enlightment Geography: The Political Languages of British Geography, 1650–1850* (New York: St. Martin's Press, 2000), 49–65.

89. Catherine Delano-Smith and Elizabeth Morley Ingram, *Maps in Bibles, 1500–1600: An Illustrated Catalogue* (Geneva: Librairie Droz, 1991).

90. William Hodson, *The Divine Cosmographer; or, A Brief Survey of the Whole World, Delineated in a Tractate on the VIII Psalme by W. H. Sometime of S. Peters Colledge in Cambridge* (Cambridge: Roger Daniel, 1640), 149.

91. Lamb, *Cosmographers and Pilots;* "Cosmographers in 16th Century Spain and America," <http://www.mlab.uiah.fi/simultaneous/Text/bio_cosmographer.html>; Jonathan D. Spence, *The Memory Palace of Matteo Ricci* (New York: Viking Penguin, 1984); and Cosgrove, "Global Illumination."

92. Ursula Lamb, "The Spanish Cosmographic Juntas of the Sixteenth Century," *Terrae Incognitae* 6 (1974): 51–64; reprinted in *Cosmographers and Pilots of the Spanish Maritime Empire,* by Ursula Lamb, item V (Aldershot: Variorum, 1995).

Johannes Kepler represented one aspect of professional lives subject principally to the demands of patrons for prognostication, technical, or political services. The group gathered around Waldseemüller at St. Die was both commercial and courtly.[93]

Spanish and Portuguese cosmographers operated in a different context. From the late fifteenth century, most were employed in state-regulated navigation and geopolitical matters, in Spain at the Casa de la Contratación, the Consejo Real y Supremo de las Indias, and Philip II's Academia de Matemáticas. They educated and examined pilots, tested and approved instruments, researched the longitude problem, maintained the *padrón real,* and examined the *relaciones* of sailors and administrators. Much of the resulting information was secret, although security was regularly breached, and Iberian cosmographies were produced, for example, Pacheco Pereira's "Esmeraldo de situ orbis" (1505–8), Pedro de Medina's *Libro de cosmographia* (1519), and Alonso de Santa Cruz's "Historia universal" (1536) and "Isolario general."[94] Most such works remained unpublished, failing to nourish the mainstream of European cosmography.[95] Juan Manual Navara's "Art del Tiempo," a manuscript breviary of 1611 into which Antonino Saliba's remarkable *Nvova figvra di tvtte le cose* (plate 1) is bound, is a late example.[96]

In France and England, university cosmography employed standard scholastic texts and summaries from Germany. Cosmographers played similar roles to their peers in Italy or the Habsburg Empire, perhaps more entrepreneurial with individuals such as Dee or Le Testu, who were producing instruments and educating navigators commercially while promoting navigation at court as essential to their respective countries' imperial ambitions.

The Vatican might be regarded as a special case. Both the Papacy's proclaimed spiritual sovereignty over the globe and the long-recognized need for calendar reform generated a strong interest in cosmography. Printed astronomical tables, the refinement of meridian lines and solar gnomons, and more accurate observations and mathematics underpinned calendar reform.[97] Cosmography was significant in the Vatican throughout the Renaissance: Regiomontanus spent his final years in Rome and Egnazio Danti is only the best known of the cosmographers gathered by Gregory XIII for the 1582 reform, while the Jesuit College was a key center of cosmographic scholarship from its foundation into the late seventeenth century.

These geographical groupings should not obscure the high degree of mobility among cosmographers. At the extremes, Waldseemüller remained within Alsace, while Thevet visited Brazil. Most traveled fairly extensively within Europe, between universities (especially Padua, Paris, Leiden, and Bologna) and courts.

The Cosmographic Work: Map, Text, and Illustration

The shifting balance between mathematical and descriptive cosmography was reflected in unstable relations between globe, map, text, and graphic illustration both within and between works. This is further complicated by cosmography's metaphysical and emblematic connections, especially in the seventeenth century.

From the first attempts at Klosterneuberg to map Ptolemy's coordinates, the world or universal map based on projection and coordinates was given the title cosmography. Münster's 1532 *Typvs cosmographicvs vniversalis* is an example. Ptolemaic in conception, these maps commonly show the influence of earlier *mappaemundi* in their descriptive text panels and pictures. Thus, Waldseemüller's *Tabvla terre nove* (1513) contains written description of the Columbian discovery in a panel set across the southern Caribbean. In its decorative border, Apian's cordiform *Tipvs orbis vniversalis* (1520) illustrates the armillary and the graticule from whose combined geometries it was derived.[98] Discovery of the Pacific Ocean allowed space on world maps for longer texts of descriptive cosmography. Mercator's revolutionary *Nova et avcta orbis terrae descriptio ad vsvm nauigantium emendatè accommodata* (1569) includes not only technical text panels explaining map projection and use, but also cartouches recording the legend of Prester John and describing the Ganges River. Late sixteenth- and seventeenth-century wall maps commonly incorporate text explanations of cosmography and cosmographic description either into the empty spaces of oceans and continental interiors or beyond the borders of the map proper.[99]

While Sacrobosco's *Sphaera* supplied a model, cosmographic handbooks never achieved a standardized form. Waldseemüller's mathematical summary in *Cosmographiae introdvctio* (1507) provides the basics for understanding his map and globe in nine chapters, with

93. Gallois, *Géographes allemands,* 38–69.

94. Medina, *Navigator's Universe.*

95. Ursula Lamb, "Cosmographers of Seville: Nautical Science and Social Experience," in *First Images of America: The Impact of the New World on the Old,* 2 vols., ed. Fredi Chiappelli (Berkeley: University of California Press, 1976), 2:675–86, esp. 682–83; reprinted in *Cosmographers and Pilots of the Spanish Maritime Empire,* by Ursula Lamb, item VI (Aldershot: Variorum, 1995).

96. Another example of Saliba's map is in Shirley, *Mapping of the World,* 168–69 (no. 146).

97. J. L. Heilbron, *The Sun in the Church: Cathedrals as Solar Observatories* (Cambridge: Harvard University Press, 1999).

98. Shirley, *Mapping of the World,* 51–53 (no. 45).

99. See, for example, the world maps by Willem Jansz. Blaeu (1606–7),William Grent (1625), John Speed (1626), Jean Boisseau (1636), and Jodocus Hondius (1640 and 1647) in Shirley, *Mapping of the World,* 273–76 (no. 258), 336–37 (no. 313), 340–41 (no. 317), 363–64 (no. 340), 377–79 (no. 354), and 391–92 (no. 370), respectively.

Vespucci's narrative appended. These cover (1) the elements of geometry; (2) the meaning of sphere, axis, poles, etc.; (3) the circles of the heavens; (4) the theory of the sphere according to the system of degrees; (5) the five celestial zones in heavens and earth; (6) parallels; (7) climates; (8) winds; and (9) the divisions of the earth and distances between places. There are five woodcut diagrams of the poles, great circles, and zodiacal ecliptic; the climatic zones; the parallels according to Ptolemy; and a wind calendar with parallels and meridian. The quadrant is illustrated in the appendix. There are also tables of winds and Ptolemaic *tabulae,* but no diagram of the spheres or discussion of planetary movements, eclipses, judicial astrology, the calendar, or meteorological phenomena.

Apian's *Cosmographicus liber* of 1524 (*Cosmographia* in Gemma's edition of 1529) devotes greater space to these technical subjects and correspondingly less to descriptive cosmography. Münster and Thevet give mathematical cosmography scant attention, the latter a mere four pages.[100] Their focus is descriptive cosmography, using a limited set of images to convey mathematical principles. Pacheco Pereira's "Esmeraldo" and Santa Cruz's "Islario general," coast and island descriptions respectively, open with brief, illustrated discourses on mathematical cosmography. Gregor Reisch and Oronce Fine are more balanced between celestial and terrestrial space and between mathematical and descriptive cosmography. Collections of navigation reports by Ramusio, the Hakluyts, or de Bry ignore mathematical cosmography.[101] The theoretically conservative, philosophico-theological cosmography manuals, such as Cuningham's *Cosmographical Glasse* (1559) or Simon Girault's *Globe dv monde* (1519), treat mathematical cosmography very superficially.

While illustration was not a prerequisite (many incunable editions of Sacrobosco's *Sphaera* lack the diagrams found in manuscripts), the spheres, the armillary, and the climates and zones were all more readily understood by means of simple compass and rule drawings. By the early sixteenth century, mathematical cosmography was invariably illustrated, at least by simple woodcuts, reproducing the repertoire of images standardized in manuscript sources. Modern works were commonly bound with classics, generating new images. Thus Gerard of Cremona's *Theory of the Planets* and Peuerbach's *Theoricae novae planetarum,* illustrating relations between the planets' epicentric paths and orbs, appear regularly with Sacrobosco's *Sphaera.* The 1472 printing, for example, illustrates a world machine of twelve circles surrounding an inked central earth and a hemispheric illustration of zones and climates. Erhard Ratdolt's graphically more sophisticated 1482 edition, with its frontispiece image of the armillary sphere, was an influential model (fig. 3.3).[102]

Other printings of medieval texts, including Neoplatonist works such as Proclus's *Sphaera* (ca. 1500) and Macrobius's *Commentary* (1483), often borrowed from Sacrobosco their simple line diagrams of spheres, climates, and zones. D'Ailly's *Imago mundi* (Louvain, ca. 1477) included seven full-page images of the celestial spheres, principal circles, celestial compass points, sub lunar elements, terrestrial zones and climates, and *oikoumene.* The 1500 Florence edition of Leonardo Dati's popular Italian verse cosmography included solar and lunar eclipses, constellations, winds, and the terrestrial divisions.[103] Astrological treatises such as Johannes Angelus's *Astrolabium* (1488) borrowed these illustrations, adding ephemerides and diagrams of the zodiacal houses (fig. 3.10).

If Waldseemüller's woodcuts were strictly limited, Apian's handbook was much more richly illustrated, including vovelles and Ptolemy's four projections; one vovelle illustrates his "cosmographic glass" (fig. 3.11). Apian's images are reproduced in later works.[104] Mid-sixteenth-century manuals used sophisticated armillary diagrams to illustrate cosmography's nomenclature. Gemma's *De principiis astronomiae & cosmographiae* (1530, enlarged 1548) is an early example.[105] Oronce

100. "He [Thevet] would later return to it [mathematical cosmography] only surreptitiously, in pages whose incoherence has been emphasized" (Lestringant, *Mapping the Renaissance World,* 6). On the relative demand for mathematical and descriptive cosmography in England, see Cormack, *Charting an Empire,* 112–18.

101. Collections of narratives of discovery such as these cannot properly be called cosmographies, but the information they contained fell within its scope and was offered as evidence of divine providence, as the younger Richard Hakluyt makes clear in the dedication to his *The Principall Navigations, Voiages and Discoveries of the English Nation* (London: George Bishop and Ralph Newberrie, 1589).

102. For example, the editions of *Sphaera* published in Venice by G. Anima Mia, Tridinensis, in January 1491, or in Leipzig by W. Stöckel in 1499.

103. Leonardo Dati, *La Sfera* (Florence: Lorenzo Morgiani and Johannes Petri, for Piero Pacini, ca. 1495–1500). The twenty-three-page text has an armillary *sphera mundi* based on printings of Sacrobosco as frontispiece, with sixteen simple line drawings. The text is discussed by Anthony Grafton in *New Worlds, Ancient Texts: The Power of Tradition and the Shock of Discovery* (Cambridge: Belknap Press of Harvard University Press, 1992), 63–69.

104. For example, Antonio Campi, in *Tvtto il cremonese,* 1583, reproduces Apian's illustrations of the cosmos and of the earth from a polar projection, with cosmographers using the cross staff to take a sighting on the moon and stars in the eighth sphere. These are reproduced against a chorographic map of the province of Cremona to illustrate Apian's hierarchy of cosmography, geography, and chorography. The arms of Philip II of Spain implicitly dedicate the cosmic order to the sovereign. The "cosmographic glass" illustrated by Apian's vovelle is a cheap, woodcut version of the lavish, hand-colored disks of up to six layers in Apian's *Astronomicum Caesareum,* printed at his private press at Ingolstadt in 1540 for Charles V and Ferdinand of Spain. Ronald Brashear and Daniel Lewis, *Star Struck: One Thousand Years of the Art and Science of Astronomy* (San Marino, Calif.: Huntington Library, 2001), 80–87.

105. Van der Krogt, *Globi Neerlandici,* 35.

FIG. 3.10. THE ZODIACAL HOUSES. Astrology was closely linked to cosmography through its belief in the movement of influences between the spheres. Thus cosmographic texts commonly illustrated the principal diagram for casting nativities and horoscopes. A simple square is divided geometrically into twelve "houses," with the twelve zodiacal signs in four groups of three on its sides. Each "house" is then allocated to planetary positions at the relevant moment of the horoscope. Erhard Ratdolt's explanatory diagram of the generalized heavens shows the majesty of astrology.
Claudius Ptolemy, *Quadripartitum: Centiloquium cum commento Hali* (Venice: Erhard Ratdolt, 1484). Photograph courtesy of the Beinecke.

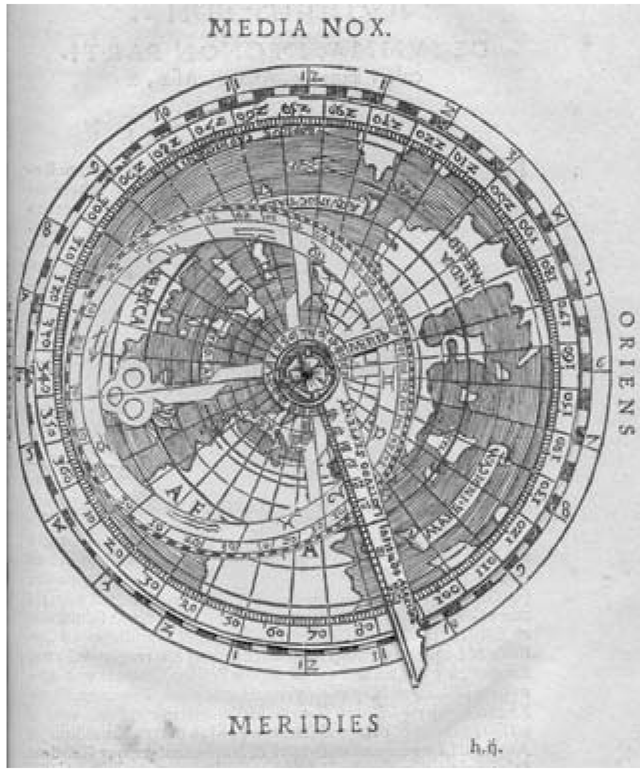


FIG. 3.11. PETER APIAN'S "COSMOGRAPHICAL GLASS." Apian's *Cosmographia* was in two parts; the first, devoted to mathematical cosmography, was heavily illustrated with instructional maps and diagrams, allowing the reader to undertake practical cosmographic exercises. Unique among these were Apian's volvelles, whose circles and compass markers could be revolved in different directions, demonstrating the positions and movements of the planetary bodies. The most elaborate of these is Apian's *speculo cosmographico* (cosmographic glass) divided into twenty-four segments to permit a range of astrological and horological calculations: "For in this mirror we can contemplate the whole world, that it, the likeness, image, and picture of the earth" (quotation on fol. 29).
Size of the original: 25 × 17 cm. Peter Apian, *Cosmographia* (Antwerp: Gregorio Bontio, 1545), fol. 28. Photograph courtesy of MnU.

Fine's *Typvs vniversi orbis* in *Protomathesis* (1532) combines the armillary and planetary spheres in a single image (fig. 3.12). Thevet's *La cosmographie vniverselle* (1575) substitutes a wonderfully complex world machine for the absence of written mathematical cosmography (fig. 3.13). William Cuningham's woodcut *Cœlifer Atlas* supports such a world machine on his shoulders (fig. 3.14).[106] Mercator's *Atlas sive Cosmographiæ* (1595), however, contains no image of the universal machine, a contested image in an era of competing world systems.

The world machine was readily allied to the idea of cosmic vitality, of a physical creation imbued with spiritual forces passing between spheres, planets, elements, and humans. Speculative aspects of metaphysics—astrological influence, various forms of magic, alchemy, and Neoplatonic contemplation—drift across cosmography. Except in such specialized texts as *Liber de intellectu* (1510), by Carolus Bovillus (Charles de Bouelles), Francesco di Giorgio's *De harmonia mundi totius* (1525), or Henricus Cornelius Agrippa's *De occulta philosophia* (1531), the metaphysical significance of cosmographic images is rarely explicit.[107] Certainly, cosmographers such as Dee, Postel, Fludd, and Kircher embraced esoteric themes, but others, such as Robert Recorde in his *Castle of Knowledge* (1556), opposed such speculation. Metaphysicians placed specific emphasis on images, often considering them as active agents through which celestial powers

106. See the discussion in Heninger, *Cosmographical Glass,* 177–79.

107. Bovillus's *Liber de intellectu* is a study of both angelic and human reason, opening with a woodcut image of divine light proceeding from the Father to the celestial realms of angels and the elemental world of man, and thence to the spheres of matter, minerals, life, and sense. On Agrippa, see Thorndike, *History of Magic,* 5:127–38.

FIG. 3.12. ORONCE FINE, *TYPVS VNIVERSI ORBIS.* Fine encloses elemental and celestial spheres (as far as the fixed stars only) within the armillary. Fine drew upon Santritter and de Sanctis's 1488 frontispiece to Sacrobosco (a later reproduction is fig. 3.3*h*), although the author himself, the modern "Orontivs," replaces the ancient Ptolemy as Urania's companion, now set in a landscape with a scatter of cosmographic instruments.
Oronce Fine, *Orontij Finei Delphinatis, . . . De mundi sphaera, sive Cosmographia* (Paris, 1542), before fol. 1. Photograph courtesy of the Adler.

might be "caught, and placated or used," so that graphic images were taken very seriously in Renaissance culture even where occult science was not directly involved.[108]

Illustrations of the microcosms of *mundus, annus,* and *homo* (space, time, and human existence) were familiar from medieval writers such as Isidore of Seville, in whose Platonically inspired works number, form, and idea were regarded as synonymous and interchangeable.[109] The figure of three, for example, drew significance from both the Platonic lambda (λ) and the Christian Trinity.[110] It shared with the number four, which enumerated the elements of the material world, significance as a limiting figure of physical extension. These numbers and the phenomena to which they were attached could be infinitely elaborated and illustrated by progressively complex arrangements of lines, circles, squares, and triangles.[111] Geometrical figures could thus represent invariable form and correspondence patterned into the accidental world of the senses. By manipulating and elaborating forms, letters, words, and numbers, further connections, oppositions, conjunctions, and correspondences could be revealed and explored through images, generating complex exegeses of creation's text.

Cosmography's illustrations could thus connect the accidental world of the senses with the intellectual perfection of the cosmos. Practically, Galenic medicine related human health to astrological and meteorological events, making the armillary sphere the symbol of physicians and generating health maps of relations between macrocosm and microcosm. Helkiah Crooke's 1631 title page for *Μικροκοσμογραφια: A Description of the Body of Man,* incorporating anatomical figures of man and woman with a diagram of the elements and an image of the anatomy theater, follows a graphic tradition dating back to Reisch.[112]

108. Garin, *Astrology in the Renaissance,* 46. See also Ingegno, "New Philosophy of Nature," 240 ff., and Stephen M. Buhler, "Marsilio Ficino's *De stella magorum* and Renaissance Views of the Magi," *Renaissance Quarterly* 43 (1990): 348–71.

109. See, for example, Woodward, "Medieval *Mappaemundi,*" 301–2 and 337 (fig. 18.39).

110. Heninger, *Cosmographical Glass,* 97 ff. Aurelius Theodosius Macrobius, *In Somnium Scipionis expositio* (Venice: P. Pincius, 1500), contains illustrations of the Platonic lambda, the climatic zones of earth, and a crude *mappamundi* showing the habitable and inhabitable, known and unknown parts of earth. Isidore of Seville, *Etymologiae* (Augsburg: Günther Zainer, 1472; Strasburg: Johana Mentelin, 1473); both editions have a limited number of woodcut illustrations of the Pythagorean tetrad. Isidore's shorter *De responsione mundi et astrorum ordinatione* (Augsburg: Günther Zainer, 1472) contains seven elaborate circular illustrations of elemental correspondences within its thirty-three pages of text.

111. John Dee, in *Mathematicall Praeface,* connects the Neoplatonic idea of ascent through the cosmos directly to the study of number: "By *Numbers* propertie therefore, of vs, by all possible meanes, (to the perfection of the Science) learned, we may both winde and draw ourselues into the inward and deepe search and vew, of all creatures distinct vertues, natures, properties, and *Formes:* And also, farder, arise, clime, ascend, and mount vp (with Speculative winges) in spirit, to behold in the Glas of Creation, the *Forme* of *Formes,* the *Exemplar Number* of all thinges *Numerable:* both visible and inuisible, mortall and immortall, Corporall and Spirituall" (j and ver.).

112. The title page engraving by Martin Droeshout combines cosmography's mapping conventions and illustrations by Vesalius. The connections between the Vitruvian design of the anatomy theater, Copernican remapping of the macrocosm, and the Vesalian microcosmic body are discussed in a commentary on Vesalius's well-known frontispiece to *De humani corporis fabrica . . .* (1543) in Sawday, *Body Emblazoned,* 66–78, with a summary of relevant literature.

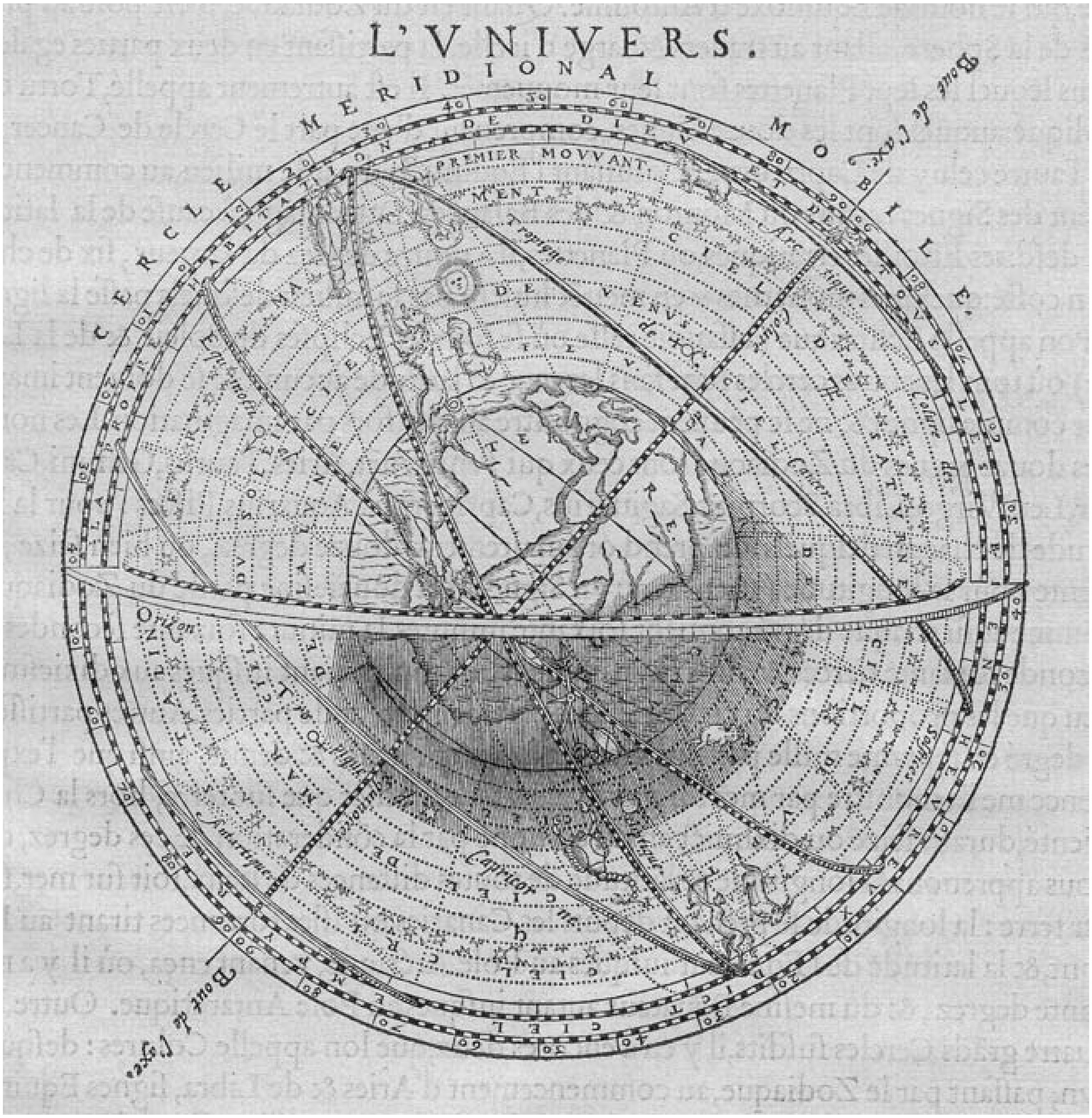


FIG. 3.13. ANDRÉ THEVET, *L'VNIVERS.* Perhaps the most elaborate of all armillary diagrams, Thevet's seeks to illustrate diurnal and seasonal solar movement by means of shading, anticipating the light and shadow that became the focus of interest among cosmographers in the succeeding years. As a detailed illustration of the unity of celestial and terrestrial spheres, Thevet's image is unequaled in the sixteenth century, but by the date of its appearance cosmography was strained from the volume of new information it sought to integrate and the emerging distinction of astronomical from geographical mapping.
André Thevet, *La cosmographie vniverselle,* 2 vols. (Paris: Chez Guillaume Chandiere, 1575), 1:2a. Photograph courtesy of MnU.

All such cosmic relationships were open to esoteric and alchemic interpretation, which became common in the later sixteenth century. Cuningham's *Cœlifer Atlas,* illustrating both worlds, has strong alchemical overtones that are also present in his title page, although the text is not explicitly alchemical, unlike that of Michael Maier's *Atalanta fugiens* (1618) or Thomas Vaughan's *Lumen de lumine* (1651), which similarly contain images of the world system. Maier uses the world system to illustrate the alchemical marriage. Robert Fludd's great study of

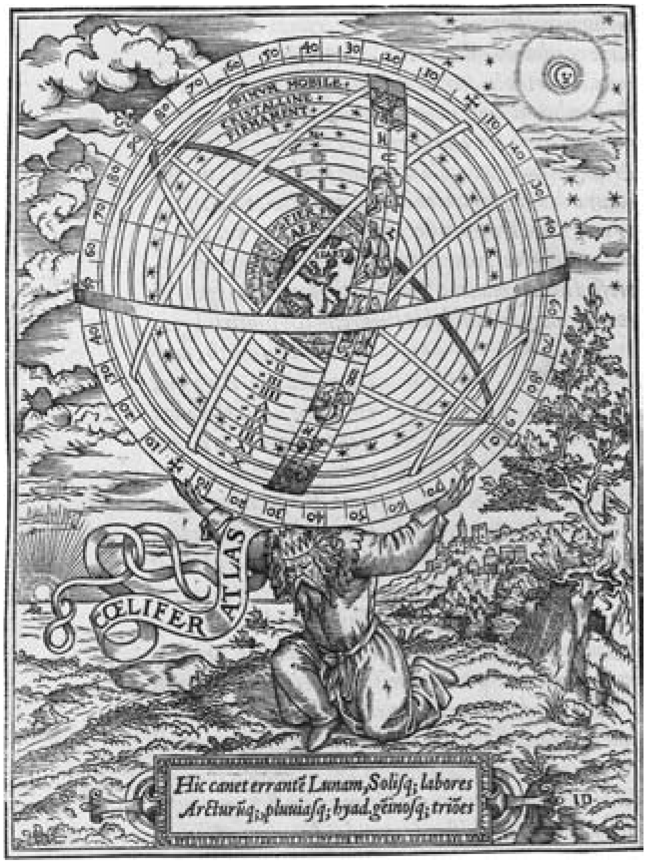


FIG. 3.14. WILLIAM CUNINGHAM, *CŒLIFER ATLAS,* 1559. Cuningham's cosmographic image, which he refers to as "the Type of the world" (fol. 51), draws upon Fine for its basic structure but adds crystalline sphere and *primum mobile* to the celestial spheres and six zodiacal signs of the ecliptic. The cosmos is supported by the figure of Atlas (whose appearance owes a debt to illustrations of the alchemical king), kneeling in a verdant landscape of earth and water, illuminated by sun and moon, amid symbols of renewal such as the tree trunk sprouting new growth, and under a firmament of air and stars. The idea of Atlas supporting the world machine originated in Gregor Reisch's illustration of 1503 in his *Margarita philosophica.* The text lines are from a cosmographic passage in Virgil's *Aeneid.*
William Cuningham, *The Cosmographical Glasse, Conteinyng the Pleasant Principles of Cosmographie, Geographie, Hydrographie or Nauigation* (London: Ioan Daij, 1559), fol. 50. Photograph courtesy of the Adler.

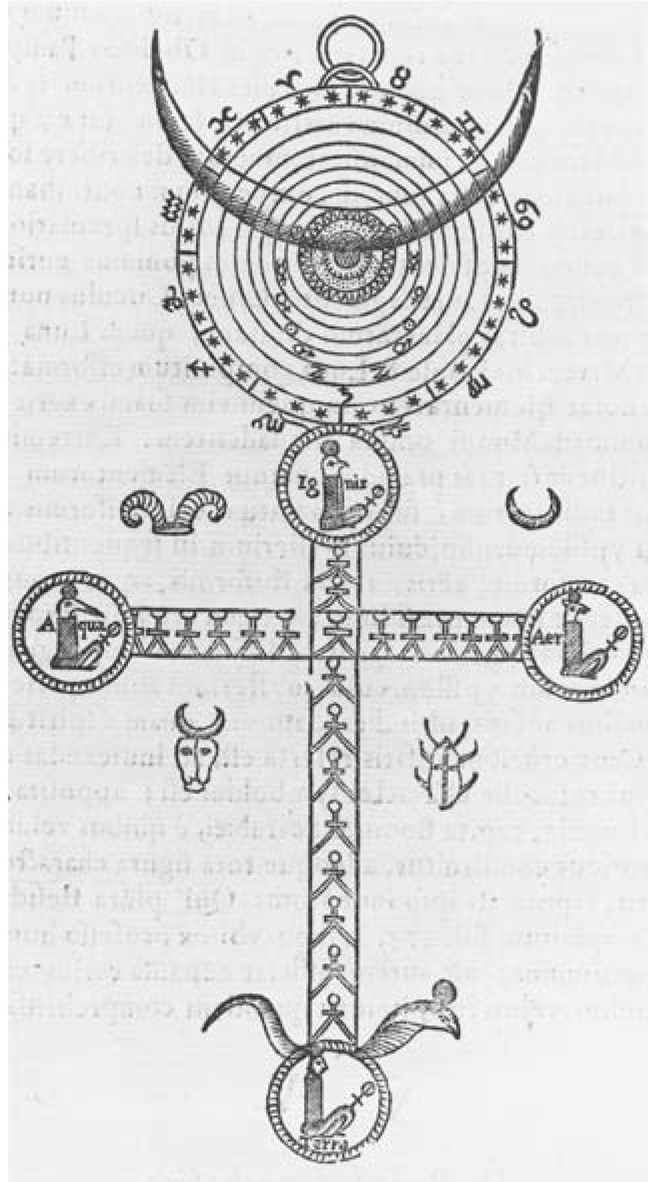


FIG. 3.15. THE HIEROGLYPHIC MONAD. Based on an amalgam of all the planetary and zodiacal signs and the principle geometrical figures, this image was intended as the ultimate emblematic map of the cosmos. Kircher incorporates the circles of the *sphaera mundi* over the cross of the four elements, adding various hieroglyphics that reflect his belief in the Hermetic-Mosaic-Egyptian sources of wisdom. John Dee wrote a cosmological treatise on the image in 1564.
Athanasius Kircher, *Athanasii Kircheri e Soc. Iesv, Oedipus Aegyptiacus,* 3 vols. (Rome: Vitalis Mascardi, 1652–54), 2:ii, 29. Photograph courtesy of the Beinecke.

macrocosm and microcosm, *Utriusque cosmi maioris* (1617), elides conventional medical and alchemical images. Book 2 of volume 1 focuses on mathematics, illustrating a planisphere designed to predict celestial movements. Athanasius Kircher was even more prolific than Fludd in examining and illustrating both exoteric and esoteric aspects of cosmic unity.[113] Kircher's images generate seemingly infinite mathematical, proportional, and linguistic homologies across and beyond the accidental surfaces of material creation. For both scholars, pictorial images became graphic laboratories in which Neoplatonic, hermetic, and cabalistic symbols generate fresh insights into creation (fig. 3.15).

113. Robert Fludd, *Utriusque cosmi maioris scilicet et minoris metaphysica, physica atqve technica historia, in duo volumina secundum cosmi differentiam diuisa* (Oppenheim: Johann Theodor de Bry,

Cosmographic Images

the world machine

The sixteenth-century world machine combines armillary and Aristotelian spheres. The former could be physically modeled, and from the 1520s appears frequently in a trio with terrestrial and celestial globes. After about 1440, terrestrial globes began to be manufactured following Ptolemy's instructions. Behaim's Nuremberg "earth apple" is a terrestrial sphere with no specific reference to the celestial realm. But globe making was one of the cosmographer's tasks, especially in Germany and Flanders. Waldseemüller, Johannes Schöner, Gemma Frisius, and Gerardus Mercator all made celestial and terrestrial globes, which their cosmographic texts accompanied. But the Aristotelian spheres could not easily be modeled, and there is no European parallel to Hindu cosmological globes.[114] On the other hand, the spheres' conceptual nature invited greater variation in representation than the mathematical armillary. While the basic diagram remains relatively consistent from medieval precedents, variations reflect debates within natural philosophy as well as diverse graphic conventions.

Elemental, celestial, and super-celestial regions were each internally subdivided. The most consistent and stable (at least until the Copernican debate accelerated in the 1580s) was the celestial region of seven planetary spheres: the moon, Mercury, Venus, the sun, Mars, Jupiter, and Saturn. Their paths were represented as circular (very occasionally as horizontal) bands of equal width, numbered or marked by their respective astrological symbol, metal, or classical deity. Ratdolt's late fifteenth-century woodcuts of planetary gods directing their chariots around their spheres were widely copied. Actual planetary distances from earth were known from Ptolemy's *Planetary Hypotheses* and studied much by astronomers. With the occasional exception, such as Bartolomeu Velho's spectacular rendering, cosmographers rarely illustrated these. Aristotle's principle of plenitude denied any space between the ethereal orbs within which the planets rotated. Astronomical problems and the philosophical hypotheses necessary to keep the moving planets within their orbs (the subject of Peuerbach's *Theoricae novae planetarum*) are ignored in cosmographic diagrams. Copernicus's new image of the Sacroboscan diagram, and above all Kepler's illustration in *Mysterium cosmographicum* (1597), which demonstrated that no orb is in contact with another and that there are immense distances between the diverse systems, were significant in challenging the very existence of crystalline spheres.[115]

The width of the eighth sphere of fixed stars, identified as the biblical firmament by the majority tradition from Aquinas and Sacrobosco to Riccioli, also presented problems.[116] Saturn's sphere bounded its inner edge, while its outer marked the limit of sensible space. This circle was generally indicated by star symbols, evenly spaced or randomly scattered around the band, occasionally with some attempt to indicate the constellations, or was divided in twelve sections marked by zodiac signs. The Copernican hypothesis and the confirmation by telescope of stellar distances would destroy this orb, as Thomas Digges's 1576 diagram anticipated (fig. 3.16).

Varying opinions on the existence and movement of the heavens beyond the fixed stars are reflected in differences between cosmic diagrams. Was the firmament bounded on its outer edge by further spheres needed to account for observed motions in the firmament, including daily motion from east to west and the precession of the equinoxes? Following Sacrobosco and Albert Magnus, Apian added two further material spheres to account for such movement. A crystalline sphere enclosing the fixed stars is represented by Gregor Reisch as the "waters above the heavens" mentioned in Genesis. The tenth sphere is *primum mobile,* primary cause of all rotation in the world machine. Oronce Fine's armillary diagram, building on Agostino Ricci's arguments in *De motu octavae sphaera* (1521), shows only the eight visible spheres and the empyreum beyond (see fig. 3.12), a minority opinion at this time, but appeared with greater frequency among empirically sensitive cosmographers later in the century. Mercator denied the existence of a *primum mobile,* claiming that God created the world machine *ex nihilo,* although neither his world map of 1569 nor his son's of 1587 (which does illustrate the armillary sphere) illustrates the world machine.[117] Whether the material

1617). Further volumes appeared in 1619, 1620, 1621, and 1624. On Fludd and Kircher, see note 87.

114. Joseph E. Schwartzberg, "Cosmographical Mapping," in *HC* 2.1:332–87, esp. 352–58 on South Asian cosmological globes. The metaphysical implications of the difference between solid and plane figures in representing the cosmos was a matter of considerable concern to Kepler and underlay his work on the Platonic solids. Simon Girault's images of a solid sphere cut open to reveal the concentric spheres represent a rare attempt to picture a cosmographic globe.

115. Johannes Kepler, *Mysterium cosmographicum,* 2d ed. (Frankfurt: Erasmi Kempferi, 1621), widely reproduced. See the discussion by Fernand Hallyn, *The Poetic Structure of the World: Copernicus and Kepler* (New York: Zone, 1993), 185–202, and Westman, "Nature, Art and Psyche," 203. On the developing interest in the Platonic solids, especially in Nuremberg, see Kemp, *Science of Art,* 62–63, esp. 62: "The Nuremberg perspectivists specialised in the portrayal of geometrical bodies, particularly the Platonic solids and their derivatives." According to the theory, earth was represented by the cube (hexahedron), water by the icosahedron, air by the octahedron, fire by the pyramid (tetrahedron), and the cosmos by the dodecahedron.

116. Hetherington, *Encyclopedia,* 79–81. Grant, *Planets,* 696–97, lists six questions "on the orbs and planets and their relations" that dominated scholastic discussion of this matter.

117. Figures 10.12 and 10.6. See also Shirley, *Mapping of the World,* 137 and 139–42 (no. 119) and 178–79 (no. 157).

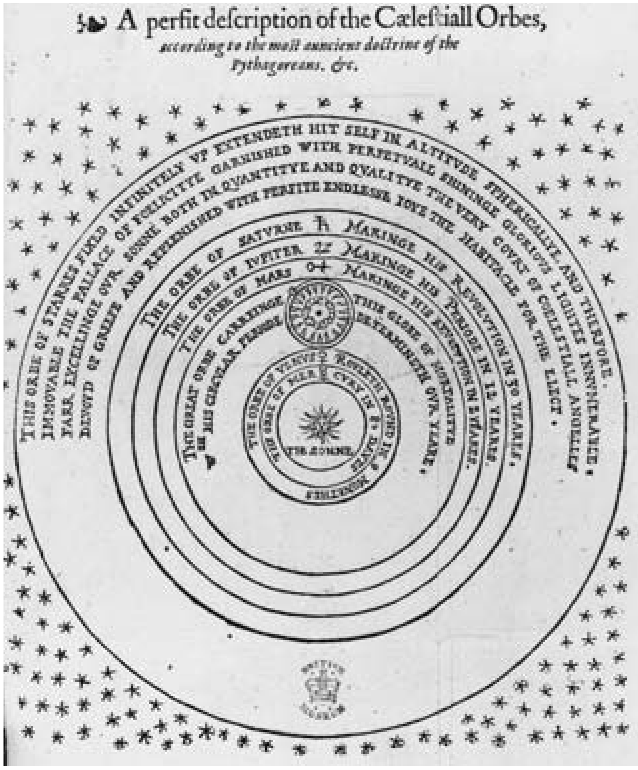


FIG. 3.16. *A PERFIT DESCRIPTION OF THE CÆLESTIALL ORBES:* THE INFINITE COPERNICAN COSMOS. Thomas Digges paraphrased Copernicus's first book in an appendix to his father Leonard's perpetual almanac, illustrating his belief with a heliocentric map that breaks the sphere of the fixed stars. The implication for the empyrean is clearly stated in Digges's text. His fellow Englishman William Gilbert's partial acceptance of heliocentricity, based on studies of magnetism extended to the planetary bodies themselves, led Gilbert, also, to the idea of an infinitely extended cosmos of stars, as shown in the Digges's diagram, which also appeared in a diagram in Gilbert's posthumously published *De mundo sublunari* of 1651.
Size of the original: ca. 22 × 17 cm. Leonard Digges, *A Prognostication of Right Good Effect* . . . (London, 1576). Photograph courtesy of the BL (718.g.52, fol. 43).

cosmos consisted of eight or ten spheres, it was almost invariably contained at its outer edge by a line marking it off from the purely intelligible empyrean realm. The empyreum itself was left as infinite space by Apian and Gemma. But metaphysical cosmography elaborated it according to theological doctrine. The nine angelic choirs reaching to the divine *Mens* and the Trinity could be mapped onto this super-celestial space, as in the very different illustrations from Schedel and Fludd.[118]

Some of the most dramatic illustrations of the world machine are found in Portuguese presentational atlases by André and Diogo Homem (1559) and Bartolomeu Velho (1568) (plate 2).[119] Following the structure already apparent in the Catalan atlas, these incorporated elaborate ephemerides and calendars and calculating instruments such as the Regiment of the Leagues, a cosmographic-horological wheel divided into twelve sectors for the months, with a thirteenth for the "golden numbers" of individual years (fig. 3.17).[120] Velho's five-part "world machine" consists of a single diagram of the two earthly hemispheres, with pyramids reaching to the sphere of Mercury (the nearest planet) and then, with a change of scale, to Venus and the sun, and then to Mars, Jupiter, Saturn, and the fixed stars. For the first four planetary

118. Hartmann Schedel's narrative of creation according to the Genesis account is illustrated in *Liber chronicarum* of 1493 by means of a series of woodcuts that build, circle by circle and under God's creative hand, the Aristotelian cosmos. The complete cosmos places four elemental and seven celestial spheres, the fixed stars or zodiac, crystalline sphere, and *primum mobile* eccentrically within a sphere of the Empyrean, showing God enthroned amid the elect and the nine choirs of angels. The English physician Robert Fludd produced a series of mappings of the world machine to illustrate his metaphysical cosmography, *Utriusque cosmi maioris*. In one example (vol. 2, p. 219) he reproduces the circles as a great spiral of creation, originating in God and descending through the Mens (*primum mobile*) and nine choirs of angels to the fixed stars, planets, and elemental realm. The twenty-two circles are both numbered and allocated Hebrew letter-numbers, while winged figures represent the archetypes of this Platonic cosmos. Both diagrams are illustrated in Heninger, *Cosmographical Glass,* 20 and 164.

119. Cortesaõ and Teixeira da Mota, *Portugaliae monumenta cartographica,* vol. 2, pl. 207 (map), and 103–5 (biography). Bartolomeu Velho, "Cosmographia" (1568), BNF. Velho describes his work as "Principles of true cosmography and universal geography of all the lands that are discovered: situated in proportion to the globe: with all their distances and heights according to the navigators: And with the figures of the proportions of all the parallels both terrestrial and celestial: And many instruments required for navigation with their demonstrations and declarations." The description of the world machine covers folios 19v–21v. Velho's illustrations of the planetary gods drawn across the sky in their chariots owe their origin to Ratdolt's images of planetary gods and zodiacal signs in early printings of Albert Magnus. Ratdolt's images were used to illustrate a number of cosmographic and astrological texts in the incunable period and beyond, for example, Abū Ma'shar, *Introductorium in astronomiam,* trans. Hermannus Dalmata (Augsburg: Erhard Ratdolt, 1489), and Johannes Angelus, *Astrolabium* (Augsburg: Erhard Ratdolt, 1488). The same images were used by Aldus Manutius in Venice to illustrate his printing of Julius Firmicus Maternus, *De nativitatibus* (Venice: Aldus Manutius, 1499). These images of charioted gods reflected and promoted the broad acceptance of pagan figures within Christian calendar iconography that had been growing since the thirteenth century. The classic study is Jean Seznec, *The Survival of the Pagan Gods: The Mythological Tradition and Its Place in Renaissance Humanism and Art,* trans. Barbara F. Sessions (1953; reprinted Princeton: Princeton University Press, 1972), esp. 37–83 on "the physical tradition." Only four works by Velho survive.

120. Edson, in "World Maps and Easter Tables," discusses the longstanding relationships between the computing of Easter tables and that of tetradic diagrams and world maps. Such computation was part of the cosmographer's work. Golden numbers were calculated and printed for the first time by Regiomontanus in his *Calendarium* and *Ephemerides,* published annually for the years between 1475 and 1506. The principle of the golden number is explained by Zinner in *Regiomontanus,* 350–51. See also Evelyn Edson, *Mapping Time and Space: How Medieval Mapmakers Viewed Their World* (London: British Library, 1997), 55–57.

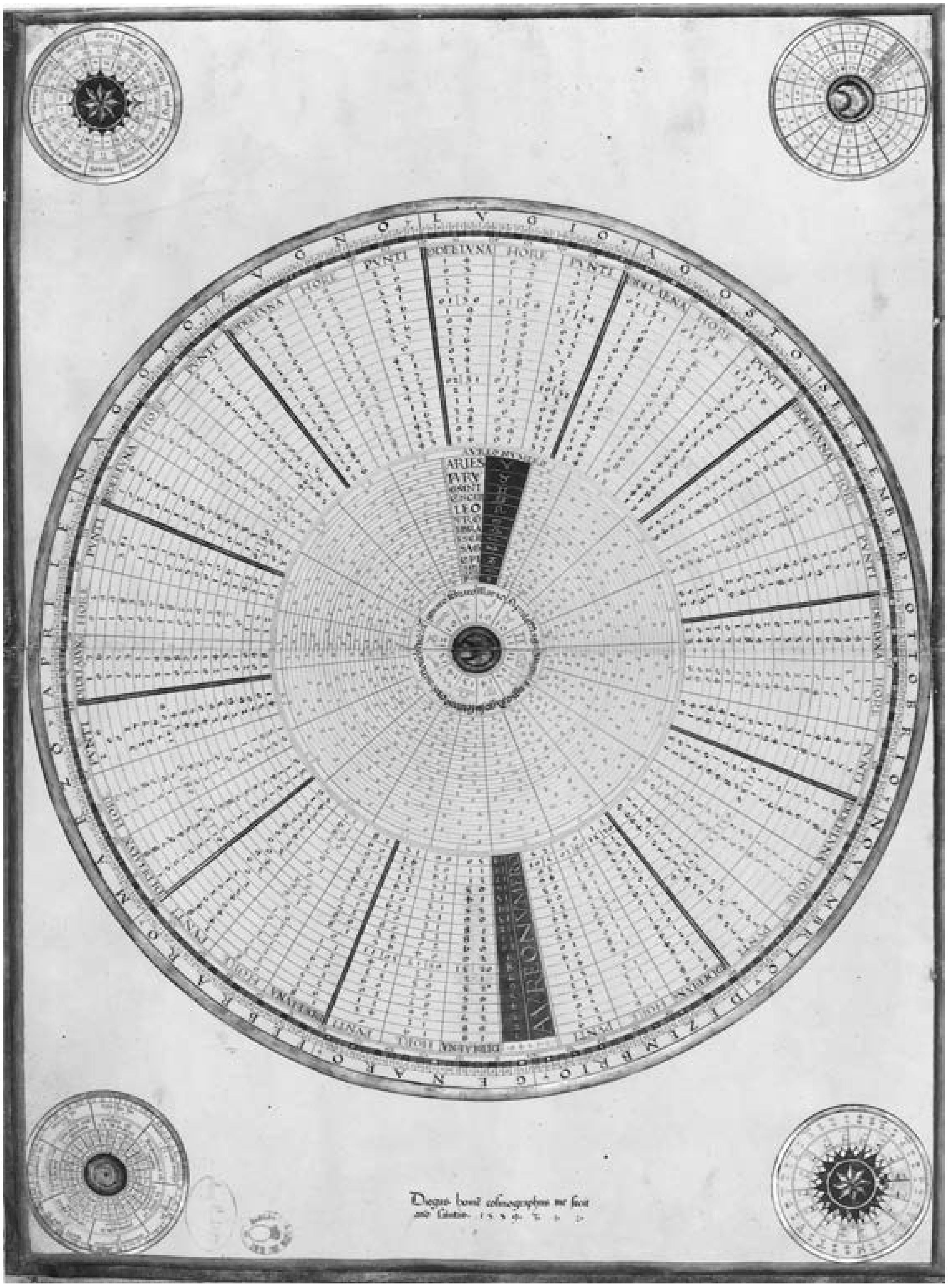


FIG. 3.17. DIOGO HOMEM'S "PERPETUAL NOVILUNAR TABLE," 1559. Portuguese atlases contained numerous cosmographic illustrations, some of them unique. In addition to standard diagrams of the armillary, the spheres (with crystalline sphere, empyreum, and zodiacal bands), and the climatic zones with wind heads, Diogo's world atlases contain a "perpetual novilunar table." Surrounded by nineteen concentric circles giving days, hours, and minutes for every golden number, these tables allow exact calculation of lunar phase hours of moonlight and of the moon's position within the ecliptic for each day of the year.

Size of the original: ca. 57.5 × 42.2 cm. Photograph courtesy of the BNF (Res. Ge DD 2003, fol. 8).

FIG. 3.18. DETAIL FROM GUILLAUME POSTEL'S *POLO APTATA NOVA CHARTA UNIVERSI,* 1578 (1621 EDITION). Postel's polar projection world map is flanked by two cartouches illustrating the machine of the world: on the left (shown here) an armillary with fragments of horological devices, cogwheels, tetrahedrons, and a dodecahedron; on the right a terrestrial globe and other solids (the full map is reproduced as fig. 47.6). The polyhedrons suggest reference to the five platonic solids illustrated in Johannes Kepler's *Mysterium cosmographicum* in an attempt to maintain *harmonia mundi* in a heliocentric cosmos by relating them to the measured planetary orbits of Mercury, Venus, earth, Mars, and Jupiter. The five regular solids had long been associated by Neoplatonists with the four elements: the cube/hexahedron with earth; the icosahedron with water; the octahedron with air; the pyramid/tetrahedron with fire; and the dodecahedron with the cosmos as a whole. In early sixteenth-century Nuremberg, Albrecht Dürer, following the Italian Neoplatonic cosmologist Luca Pacioli, had illustrated the solids, and the theme attracted perspective books such as Jean Cousin's *Livre de perspective* of 1560 (almost certainly Postel's source), Wenzel Jamnitzer's *Perspectiva: Corporum regularium* of 1568, and Daniele Barbaro's *Libro di prospettiva* (1569).
Size of the entire original: 97 × 122 cm. Photograph courtesy of the Service Historique de la Défense, Département Marine, Vincennes (Recueil 1, map no. 10).

bodies, relative size and distance are indicated by scaled dimensions and distances on the chart. More distant planets are shown in the form of their classical gods according to a representational convention derived from Ratdolt's astrological illustrations. Other folios illustrate the different proportions of the parallels for each moving planet and distances from the earth to the concave and convex edges of each celestial orb. Velho's text is restricted to a brief survey of mathematical cosmography. Kepler's unique image of the Platonic solids (1597) as the measure of distance between the planetary orbs is a very different but equally dramatic rendering of cosmic distances. Conceptualizing the cosmos in terms of complex polyhedrons is perhaps hinted at in the unique cosmographic cartouches that support terrestrial and celestial globes on the flanks of Guillaume Postel's world map of 1578 (1621) (fig. 3.18).[121]

Representations of elemental space also varied. At its simplest, in Reisch for example, earth is a solid circle surrounded by a band of watery lines, aerial billows of cloud, and fiery tongues of flame. The elements could be elaborated through color or symbol or reduced to schematic reference. Earth and water were commonly merged within a single central circle of the world machine, implying their nonsymmetrical distribution on the sphere. Apian fills the sphere with an oblique landscape view, while others map the continents or name the elements within the sphere. World maps followed the same representational conventions, often framing the global surface with air and fire by line, color, or such icons as the salamander or phoenix for fire, birds for air, and fish for water.

If maps of the global surface never entirely shook off cosmological references, images of subterranean, aerial, and fiery regions also remained dominated by the idea of a world machine. Aristotle's meteorology concerned the zones of air and fire between the earth's surface and the lunar sphere, including cloud types, all forms of precipitation, winds, climatic phenomena such as lightning, and the aurora and lunar halo. Comets and shooting stars, whose significance and location were critical for both prognostication and astronomical science, were also located in this zone.[122] Reisch and Navara give great attention to comets, and Apian illustrated the direction of the comet's tail with great observational accuracy. Antonino Saliba's "cosmographic wheel" (plate 1) is principally de-

121. See note 69.

122. The location and significance of comets, allocated in Aristotle's *Meteorologia* to the upper parts of the zone of fire, was a matter of continuous debate among Renaissance astronomers and cosmographers; they were eventually accurately located, like novae, beyond the lunar sphere, thus providing evidence for change in the celestial realm. Peuerbach, Regiomontanus, and Apian all made serious contributions to their study. The appearance of comets seems to have overtaken the significance of conjunctions in sixteenth-century prognostication.

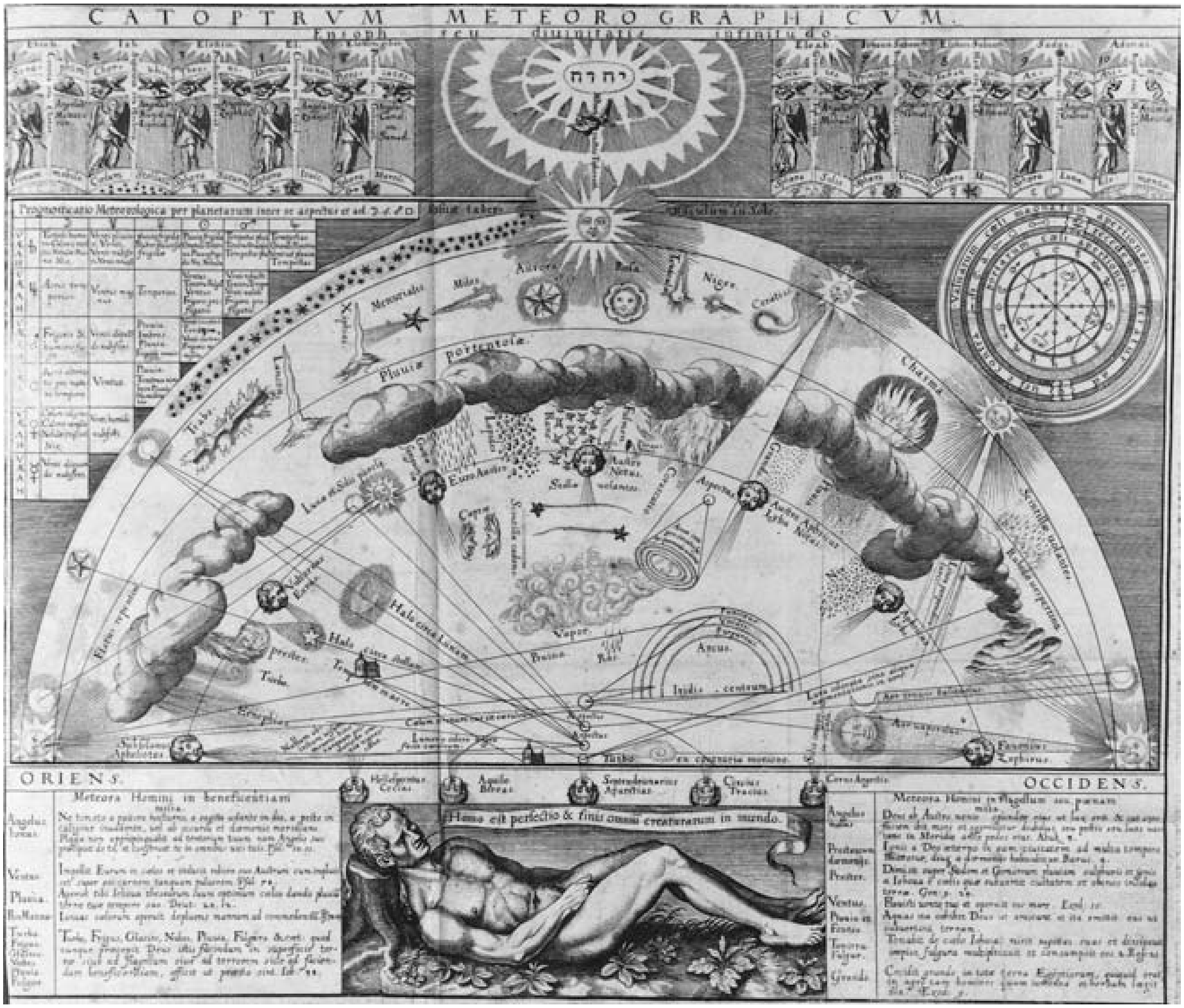


FIG. 3.19. MAPPING THE CORRESPONDENCES OF THE HUMAN MICROCOSM. Belief that the human body contained the form and composition of the greater cosmos was a long-held principle, offering considerable scope for graphic elaboration. The physician Robert Fludd, who shared Paracelsus's belief that medicine's task was to bring macrocosm and microcosm into harmony, devoted numerous illustrations to mapping the microcosm and depicting the immediate influence of the Aristotelian "climate" (i.e., the regions of air) on bodily health. Fludd's image of the regions of air, *Catoptrvm meteorographicvm,* resembles Antonio Saliba's (plate 1) and illustrates the various meteorological phenomena, visible and invisible, described in *De meteoris.* Above is the tetragrammaton and the suggestion that the divine chain reaches down to the reclining, Adamite figure who states: "Man is the perfection and goal of all creatures in the world." Flanking the divine source are ten panels allocated to cosmic spheres, choirs of angels, and Hebrew names of God. Astronomical meteorology is tabulated to the left of the hemisphere of air, and to the right is a circle of planetary aspects allowing prediction of auspicious moments when the "gates of heaven" open to the upper spheres and rains may be expected. Beneficial and evil meteors are listed to the left and right of the microcosmic figure, respectively.

Robert Fludd, *Philosophia sacra et vere Christiana seu meteorologia cosmica* (Frankfurt: Officina Bryana, 1626). Photograph courtesy of the Harvey Cushing/John Hay Whitney Medical Library, Yale University, New Haven.

voted to phenomena in Aristotle's regions of air, as is Robert Fludd's image of their effects on the human microcosm (fig. 3.19).[123] Saliba and also Francesco Robacioli (1602) share the conventional view that the earth's core contains the zones of hell, familiar from illustrations

123. Antonino Saliba's *Nuova figura di tutte le cose* was engraved in Naples in 1582.

of Dante's *Inferno* (fig. 3.20).[124] Kircher's maps of these regions in *Mundus subterraneus* (1665 and 1678) as generative parts of a vital earth allow no space for the damned. His *Arca Noë* (1675) is rather more biblical, using Ortelius's map to plot the regions exposed by the retreating waters of the biblical flood.[125]

Images of the Competing World Systems

Copernicus's *De revolutionibus orbium celestium* (1543) was illustrated by a simple, powerful redrawing of the conventional image of the spheres but centered on the sun, with the earth in the third sphere (fig. 3.21). Only after 1570 did cosmologists begin to replicate the diagram, starting with Valentinus Naiboda and his 1573 sequence and continuing through Thomas Digges (1576), Tycho Brahe (1577–96), and Nicolaus Reimers (1588) before the century's end.[126] Helisaeus Röslin's *De opere Dei creationis . . .* (1597) allowed immediate visual comparison between Ptolemaic, Copernican, and Tychonian systems (fig. 3.6). Galileo himself illustrated heliocentricity by means of the conventional spheres (fig. 3.22). Jean-Baptiste Morin's illustration in *Famosi et antiqui problematis: De telluris motu vel quiete. Hactenus optata solutio* (1631) was succeeded by Pierre Gassendi's in 1647, while Giovanni Battista Riccioli illustrated six possible systems, including his own (fig. 3.8).[127] They were reproduced by Kircher, and they were engraved by Wenceslaus Hollar for Edward Sherburne's translation of Marcus Manilius's *Sphere* a mere decade before Newton's *Principia*.[128] Comparative world systems were illustrated regularly on seventeenth-century cosmographies, for example, those by Willem Jansz. Blaeu (who had worked at Tycho Brahe's observatory in 1596 and published the astronomer's catalog of one thousand stars) and his successors.[129] John Seller's 1673 *Novissima totius terrarum orbis tabula* conveys beautifully the transition from theoretical to observational science of the cosmos (cosmography to astronomy or geography) by surrounding a double hemisphere, "plain style" world map with conventional landscapes of the seasons and zodiac signs and diagrams of the principal world systems as well as lunar maps based on Galileo's observations and Johannes Hevelius's selenography.[130]

Moral and Sacred Dimensions of Cosmographic Images

The elemental spheres of the world machine or surrounding the *mappaemundi* did not readily accommodate the shape of the Ptolemaic *oikoumene*. They disappear from world maps until the double hemisphere format, popular from the latter years of the sixteenth century, offered new opportunities for their representation.[131] In late Renaissance works, texts and epigrams made explicit connection between cosmography and religious or moral life, generally avoiding the pagan use of classical allegory found in a late edition of Natalis Comes's

124. Dante's *Commedia divina* had been a source of cosmographic images since its appearance. Illustrations of the circles of hell appeared in editions of the work throughout the Renaissance. A selection of these and relevant bibliographic reference are available at <http://www.nd.edu/~italnet/Dante/text/Hell.html> ("Dante's Hell"). See also Giuseppe Rosaccio, *Teatro del cielo e della terra* (Venice, 1598), 9. Robacioli's broadside *Teatro del cielo e della terra* (Brescia, 1602) places a world map below a graphic description of the heavens and earth. Unlike Saliba's image, the circles are eccentrically drawn; the innermost circle, which stands directly above the north pole on the world map, is marked "inferno" and contains an image of purgatory and hell.

125. Athanasius Kircher, *Athanasii Kircheri e Soc. Jesu Mundus subterraneus . . .* , 2 vols. (Amsterdam: Joannem Janssonium and Elizeum Weyerstraten, 1664–65), also included a number of images of the sun and moon based on Christoph Scheiner's observations. The map of the postdiluvian world is modeled on Ortelius's *Totius orbis terrarum* and printed in *Athanasii Kircheri è Soc. Jesu Arca Noë . . .* (Amsterdam: Joannem Janssonium, 1675), 158. In addition to his own drawings and maps, Kircher drew promiscuously on the work of others; detailed study of the sources of his imagery is yet to be undertaken.

126. Heninger, in *Cosmographical Glass,* 48–51, discusses the implications of different modes of picturing the firmament. On the reaction of cosmographers such as Gemma Frisius to Copernican heliocentricty, see Hallyn, *Poetic Structure,* 152–53. According to Umberto Eco, in *The Search for the Perfect Language,* trans. James Fentress (Oxford: Basil Blackwell, 1995), Henry Cornelius Agrippa's occult interests led him to the same conclusion: "It was Agrippa who first envisioned the possibility of taking from kabbala and from Lull the technique of combination in order to go beyond the medieval image of a finite cosmos and construct the image of an open and expanding cosmos, or of different possible worlds" (p. 131). See also William Gilbert's image of an open universe of stars in *De mundo nostro sublunari philosophia nova* (Amsterdam: L. Elzevirium, 1651).

127. Westman in "Two Cultures or One?" discusses the Riccioli image; see also Heninger, *Cosmographical Glass,* 66–68.

128. Heninger, *Cosmographical Glass,* 70–79.

129. The results of Tycho Brahe's observations were printed on Blaeu's celestial globe of ca. 1598 (see fig. 44.39). See C. Koeman, "Life and Works of Willem Janszoon Blaeu: New Contributions to the Study of Blaeu, Made during the Last Hundred Years," *Imago Mundi* 26 (1972): 9–16. On the Blaeu map publishing business more generally, see Y. Marijke Donkersloot-De Vrij, *The World on Paper: A Descriptive Catalogue of Cartographical Material Published in Amsterdam during the Seventeenth Century* (Amsterdam: Theatrum Orbis Terrarum, 1967).

130. Shirley, *Mapping of the World,* 478–79 (no. 460), and Whitfield, *Image of the World,* 100–101.

131. Nathaniel Carpenter, in *Geography Delineated Forth in Two Bookes* (Oxford: Iohn Lichfield and William Tvrner, printers to the famous vniversity, for Henry Cripps, 1625), noted that "the Planispheare cannot be expressed without the two faces or Hemispheares; wherof one represents the Easterne, the other the Westerne part of the Terrence Globe." Quoted in Reeves, "Reading Maps," 54. While the double hemisphere world map dates back to the 1520s—it was used by Franciscus Monachus ca. 1527 to represent the division of the globe between Spain and Portugal (fig. 10.2)—its popularity increased markedly in printed world maps from the 1590s (Shirley, *Mapping of the World*, 194 ff.).

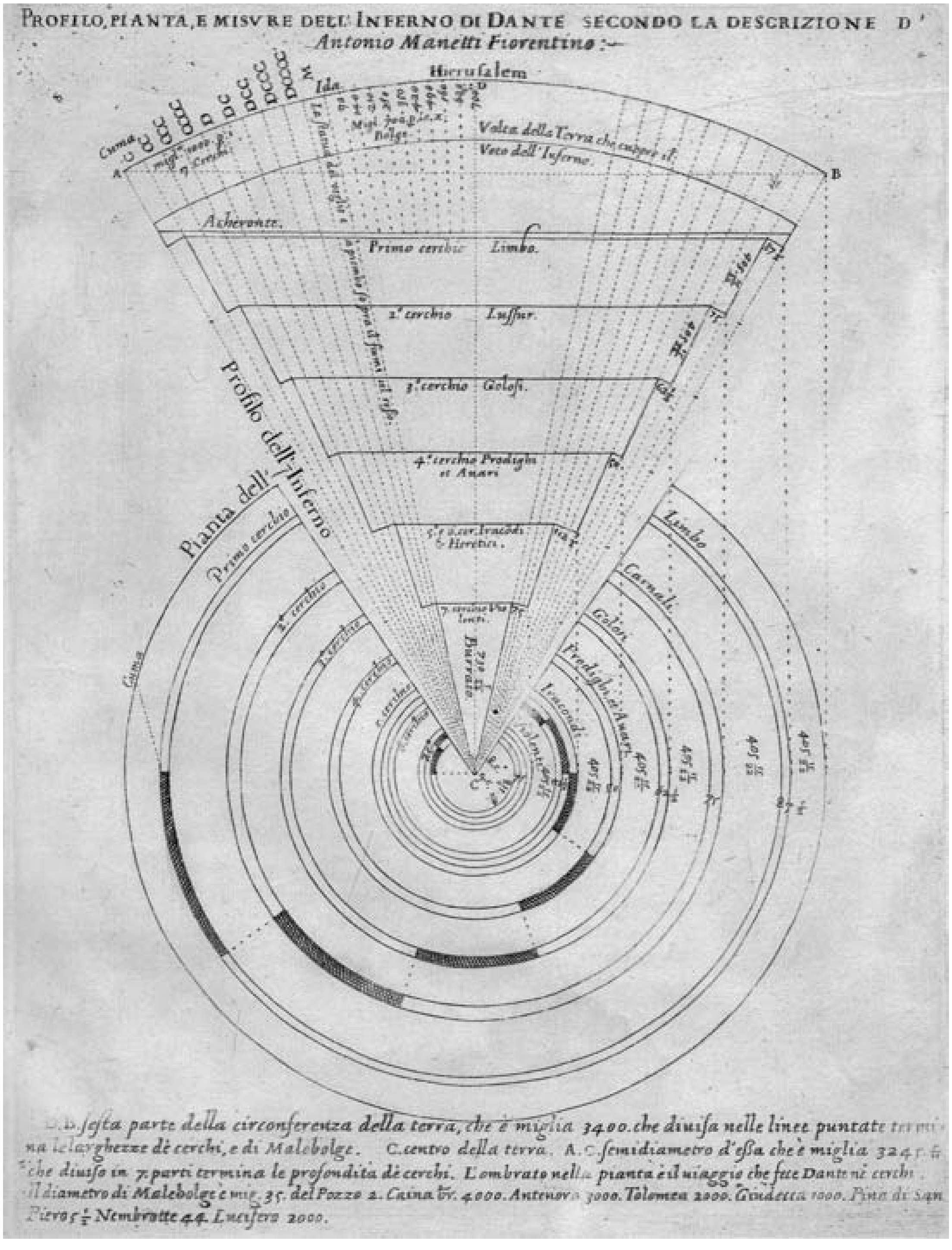


FIG. 3.20. DANTE'S HELL. The seven circles of hell described in Dante's *Inferno* (and corresponding to seven planetary spheres) were first illustrated in crude woodcuts in Girolamo Benivieni's edition of the *Divine Comedy* in 1481 and further elaborated in both the 1515 second edition of Aldus Manutius and Bernardino Daniello's edition of 1568. In 1595 the Accademia della Crusca accompanied its edition with this "scientific" engraving combining circles and triangles, obviously inspired by measured cosmographic drawings of the heavens. Over the course of the sixteenth century, printed editions of the *Divine Comedy* sought to illustrate Antonio Manetti's investigations into the site, shape, and size of Dante's cosmography. Size of the original: 17 × 12 cm. "Profilo, pianta, e misvre dell'Inferno di Dante secondo la descrizione D'Antonio Manetti Fiorentino," in *La Divina commedia . . . Accademici della Crusca* (Florence: Domenico Manzani, 1595), insert preceding p. 1. Photograph courtesy of MnU.

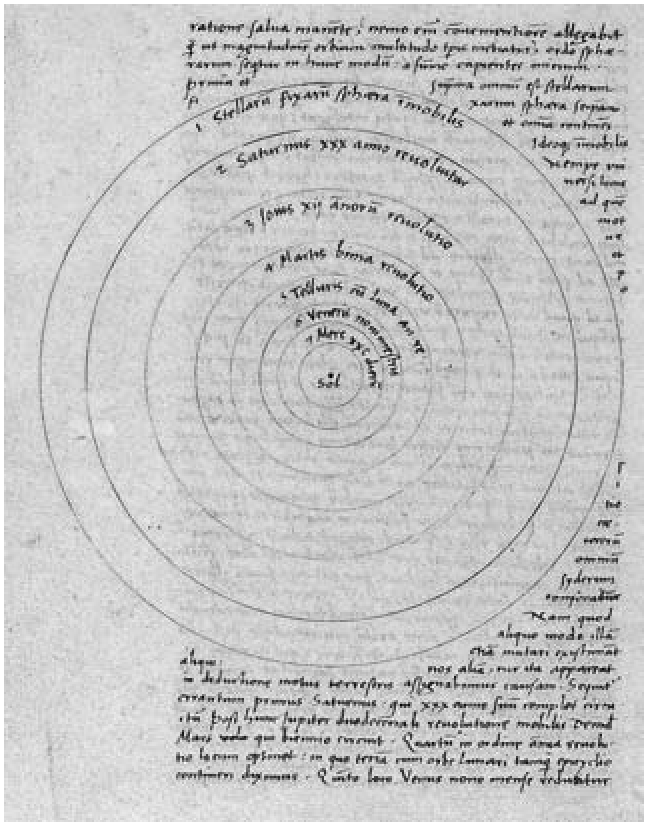


FIG. 3.21. COPERNICUS'S HELIOCENTRIC COSMOGRAPHY. Copernicus employed the conventional circles, mapping seven spheres to illustrate his revolutionary idea of a sun-centered cosmos. They are numbered inward from the sphere of fixed stars (labeled "*imobilis*") through four revolving planets including earth, two inner planets, and a central sun. Although superficially a slightly altered version of the conventional image of the cosmos, Copernicus's mapping clearly challenges the Aristotelian image of a closed, harmonious cosmos as effectively as global geographical mapping upset images of elemental symmetry.
Size of the original: ca. 28 × 19 cm. From an autograph manuscript of Nicolaus Copernicus, "De revolutionibus . . . ," fol. 9v. Photograph by T. Duda, courtesy of Biblioteka Jagiellońska, Cracow (MS. BJ 10000).

Mythologiae (Padua, 1616).[132] Neostoicism's belief in a unified cosmos encouraged the use on world maps of epigrams from Cicero, Seneca, and Tacitus, reminding the viewer that the material world should not distract from matters divine and eternal. Ortelius's *Typus orbis terrarum* quotes Cicero: "What can you see then as great in human affairs [in a map] in which all eternity and the size of the whole earth is shown?" Biblical reference was more common. Simon Girault's image quotes Psalm 19: "The heavens declare the glory of God; and the firmament showeth his handiwork." Lines from Psalm 24, "The earth is the Lord's, and the fullness thereof; the world and they that dwell within it," appear on the *Typus orbis terrarum* illustrating Gerardus Mercator's *Historia mundi* (1635). The tetragrammaton, sign of *unum* and *plenum* and mystical Hebrew name and number of God, is the most common mode of introducing the Creator into the image of creation. On Joan Blaeu's wall map *Nova totius terrarum orbis tabula* (1648) it parts the billowing clouds with light in a dramatic cosmographic chiaroscuro.[133]

Biblical history provided decorative elements on seventeenth-century world maps, reflecting the long-standing relationship between universal history and cosmography. The divine presence in creation is illustrated by two graphic traditions, one devoting a single image to each day of Genesis, the other representing God himself observing, blessing, or embracing a completed cosmos. Hexameral illustrations opened many cosmographic texts and printed Bibles. In Münster's *Cosmography,* Reisch's *Margarita philosophica,* and Miles Coverdale's 1535 Bible, an anthropomorphic God dominates the frame, his handiwork composed of circles, stars, and landscapes. Schedel reduces the divine presence to a single hand, perhaps influenced by Dürer's idea of a supreme artist manifested in the mathematical harmonies of his creation. This idea is dramatically realized in de Hollanda's "De aetatibvs mvndi imagines" (fig. 3.23).[134]

132. Comes's discussion of the classical gods is illustrated by a geocentric mapping of the spheres (shown in a partial pyramidal section), which allocated a cosmos of four terrestrial and seven celestial spheres plus the empyrean region to symbols and personifications of pagan spirits (illustrated in Heninger, *Cosmographical Glass,* 173).

133. Eleven copies of this map exist; the example studied hangs in the Harry Ransom Humanities Center at the University of Texas at Austin. See Shirley, *Mapping of the World,* 392–96 (no. 371), and Minako Deberg, "A Comparative Study of Two Dutch Maps, Preserved in the Tokyo National Museum: Joan Blaeu's Wall Map of the World in Two Hemispheres, 1648 and Its Revision ca. 1678 by N. Visscher," *Imago Mundi* 35 (1983): 20–36. Joan Blaeu's most complete cosmographical work was his *Atlas,* which appeared from 1634 with editions in all of the principal European languages. It reached its fullest development as the eleven-volume *Atlas maior, sive Cosmographiæ Blaviana, qva solvm, salvm, coelvm, accvratissime describvntvr,* 11 vols. (Amsterdam: Ioannis Blaeu, 1662–65), which opens with a statement about the strains of attempting to cover the whole of cosmography and a description of the "harmony of the macrocosm," which deals with the "fabric of the world, the disposition of the heavenly globes, the place of the earth, its form and grandeur." Blaeu continues by dividing the matter of cosmography into astronomy and geography and thenceforth deals with his materials under these distinct headings. See Johannes Keuning, "Blaeu's *Atlas,*" *Imago Mundi* 14 (1959): 74–89. It is tempting to suggest that the symmetrical arrangement of these spaces and their numbers (four and six) were consciously linked to the significant cosmological numbers three, four, and six, discussed earlier, but there is no explicit evidence of this. The arrangement of elements and seasons in the corners is, however, obvious and consistent.

134. Sylvie Deswarte, "Les *'De aetatibus mundi imagines'* de Francisco de Holanda," *Monuments et Mémoires* 66 (1983): 67–190; Jorge Segurado, *Francisco d'Ollanda: Da sua vida e obras . . .* (Lisbon: Edições Excelsior, 1970); J. B. Bury, "Francisco de Holanda and His Illustrations of the Creation," *Portuguese Studies* 2 (1986): 15–48; and

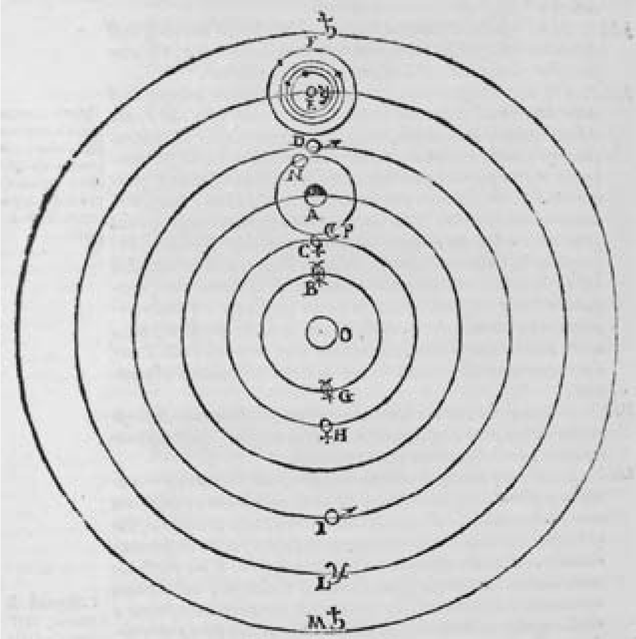


FIG. 3.22. GALILEO'S ILLUSTRATION OF HELIOCENTRICITY. Galileo used the conventional form of equally spaced circles marked by letters and planetary symbols, with additional circles for both the earthly moon and the four moons of Jupiter. Behind this clear style of illustration lay an epistemological assumption of the image's capacity for direct mimesis, which flew in the face of the Platonic assumptions underlying humanist cosmography and was derived in part from the mechanical creation of images by direct action of light through lenses on paper, which Galileo himself had employed in mapping sunspots through the telescope.
Galileo Galilei, *Dialogo . . . sopra i due massimi sistemi del mondo* . . . (Florence: Gio Battista Landini, 1632), 320. Photograph courtesy of the Adler.

Drawing on Sacroboscan illustrations and inspired by Neoplatonic light and geometry symbolism, de Hollanda represented the Trinity by geometrical figures and color alone. In Kircher's *Harmonia nascentis mvndi,* the pipes of a cosmic organ exhale the six days of creation (fig. 3.24), while Joseph Moxon's 1673 work parallels geometrical images of the hexameron with representations of the seven ages of human salvation above and below the world map.[135]

Images of a patriarchal God overseeing creation, juxtaposed with a diagram of the spheres, could suggest either Day 7 of creation or the continuity of divine presence in the world. Bartholomaeus Angelicus's *De proprietabus rerum* (1495) has an enthroned Creator at the center of a celestial circle, separated from material creation and obscured from human senses by the conventional billowing cloud symbol. More frequently the material cosmos occupies the center of the image, while the deity embraces it or gestures from beyond. Such images might include elemental and planetary spheres, the elemental alone, or, unusually in Wenceslaus of Cracow's "Introductionam astrologia ungler" (1515), three regions of air and the zone of fire.[136] The innermost circle was commonly a landscape illustrating the beauty of the finished earth, often Eden complete with Adam, Eve, and the four rivers, as in Hans Lufft's image for the 1534 Wittenberg Bible. Germanic tradition tended to picture the spheres eccentrically, while Italians placed them concentrically, although in Lorenzo Lotto's depiction of the creation of the cosmos (Church of Santa Maria Maggior, choir: Bergamo, 1493) an eccentric composition generates a curving cone of four elemental and ten celestial crescents.[137] The tradition endures in Robert Vaughan's illustration for Elias Ashmole's *Theatrum chemicum Britannicum* (1652) (fig. 3.25).

Like de Hollanda, Lotto focuses on the creative significance of *fiat lux* to connect creation with light and, Neoplatonically, with love, a recurrent theme in cosmographic illustration. The metaphysics of light provided hermeticists such as Giordano Bruno, and possibly Copernicus himself, with a powerful attraction toward heliocentricity.[138] Sacrobosco's illustrations of the solar eclipse connect light to pyramidal form and matter and were readily associated with the Platonic lambda to suggest pathways of creative illumination, as de Hollanda, Fludd, and others illustrate (fig. 3.26). Kircher devoted an entire text to the diverse forms of illumination, summarized in his title page (fig. 3.27). Divine light was assumed to be incorruptible and colorless. For Aristotelians, color inheres in the property of elemental objects and is governed by the same mathematical harmonies as physical phenomena. Each element thus was illustrated in cosmographies by a specific color: air was blue, water green, fire red or golden-yellow, and earth ash-black or "dyed" with different colors (see also fig. 3.23). Jet-black signified ele-

idem, *Two Notes on Francisco de Holanda* (London: Warburg Institute, University of London, 1981).

135. Shirley, *Mapping of the World,* 474–75 (no. 457).

136. Wenceslaus of Cracow, "Cztery sfery elementòw," in "Introductionam astrologia ungler" (1515/24?). In this early sixteenth-century astrological text, the three regions of air and the zone of fire are placed eccentrically above a landscape rendering of earth and water. While the conventional representation of terrestrial and celestial circles, especially in Italian works, rendered them concentric, north of the Alps an eccentric mapping was more common; the reasons for this difference in convention are unclear. They may signal a recognition of eccentricity or be an attempt to indicate a perspective from above down to the earth, because in this image the sun (the face of God?) shines illumination down to the earth, its light reflecting from nature.

137. For examples see Mariano Apa, *Visio mundi: Arte e scienza dal medioevo al rinascimento. Saggi e interventi critici* (Urbino: QuattroVenti, 1986), 17 and 108.

138. On the significance of Pythagoreanism and Neoplatonic metaphysics of light on Copernicus's heliocentricity, see Waldemar Voisé, "The Great Renaissance Scholar," in *The Scientific World of Copernicus: On the Occasion of the 500th Anniversary of His Birth, 1473–1973,* ed. Barbara Bieńkowska (Dordrecht: D. Reidel, 1973), 84–94.

FIG. 3.23. A GEOMETRIC COSMOGONY. The Portuguese humanist Francisco de Hollanda produced a collection of 154 gouache biblical illustrations, some of them dramatically original in replacing conventional figural representation in the hexameral narrative with the geometric figures of triangle, cone, circle, and sphere. On Day 1 of the creation story in Genesis, illustrated here, a triple triangle representing the Trinity descends to the chaos of matter; the Father, an equilateral triangle marked with A and Ω and contained within the circle of intelligible space, extends into an equilateral triangle of light—the "word" of the Son: *fiat lux*—which itself touches the convex edge of a spinning ball of confused elements. A third triangle represents the Holy Spirit "moving over the waters," reaching to the inner, concave edge of matter and setting it in motion. We see air and fire begin to separate from the central sphere. De Hollanda color codes the elements: ash-gray for earth, red for fire, and a mixture of green and white for the confused elements of water and air. Pure white is used for the invisible light of God. Days 2 and 3 of creation are illustrated by similar geometrical images, the cone acting as the conduit between the divine and material worlds and the ocean and coastal promontories of a curving globe emerging below the Trinitarian geometry of the heavens. De Hollanda's image of "two great lights" governing day and night from Day 4 (illustrated in fig. 3.26*e*) is a pure cosmographic image derived from handbook illustrations of the eclipse. De Hollanda's principal source seems to have been mid-sixteenth-century editions of Sacrobosco and Oronce Fine.
Francisco de Hollanda, "De aetatibvs mvndi imagines" (1545–73), fol. 3r (1545). Photograph courtesy of the Biblioteca Nacional, Madrid.

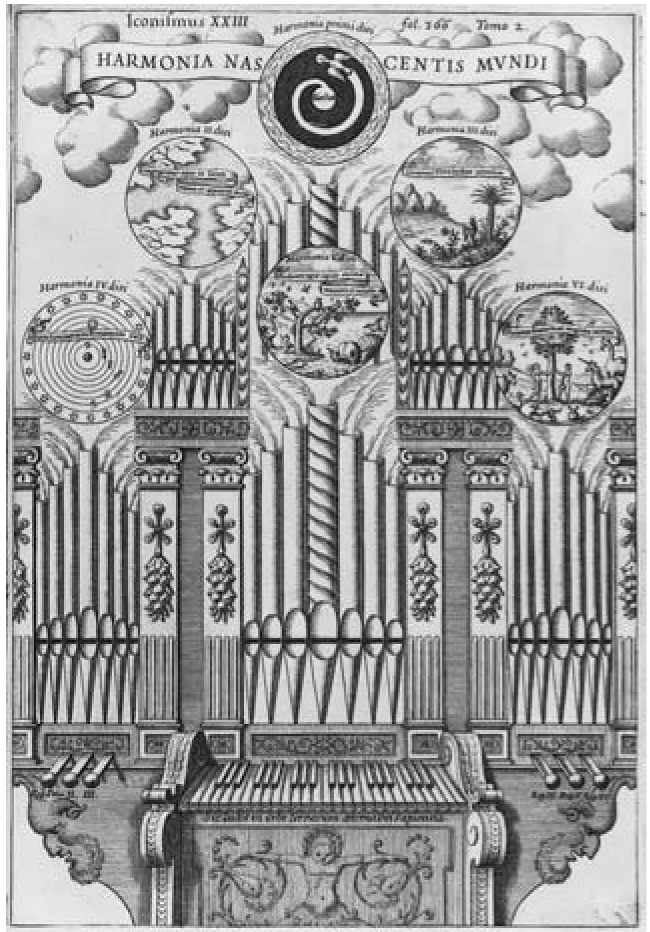


FIG. 3.24. COSMIC HARMONY AS THE BREATH OF THE COSMIC ORGAN. Kircher borrowed from Fludd's images of creation to illustrate the hexameral creation as a function of different musical registers, Christianizing the Pythagorean cosmological theme of musical harmony as the sustaining force of creation while also illustrating the cosmographic theme of the variety and fullness of the elemental realm.
Athanasius Kircher, *Harmonia nascentis mvndi,* in *Musurgia universalis* . . . , 2 vols. (Rome: Haeredum Francisci Corbelleti, 1650), 2:366. Photograph courtesy of the Beinecke.

ments in transition. The principal sixteenth-century color theorist and Neoplatonist, Giovanni Paolo Lomazzo, connected the passage of divine light through the cosmos to color, and it may be that in later Renaissance cosmographic maps color should be read symbolically.[139]

Such a reading is presupposed in the Renaissance emblematic tradition, which frequently exploited the ontological status commonly attributed to *Imago mundi.*[140] As images of divine authority, maps and diagrams of the cosmos were open to appropriation by secular power and

139. See Kemp, *Science of Art,* 264–80, for a full discussion and references.

140. Mangani, *Il "mondo" di Abramo Ortelio.*

FIG. 3.25. SEVENTEENTH-CENTURY CHRISTIAN COSMOS. A century and a half after its publication, the influence of Schedel's image of the Christian cosmos in the *Nuremberg Chronicle* is apparent in Robert Vaughan's metaphysical map illustration for Ashmole's alchemical text. A complex circular geometry generates three eccentric spheres of heaven, earth, and hell. Heaven is occupied by various angels and members of the elect and overseen by an ambiguous winged figure marked by a single star. Demons are cast down across a tripartite elemental *terrarum orbis* of land, air, and water into the fires of the lowest circle. The cosmos is overseen by the figure of the Pancreator, who appears outside the world machine. Vaughan has drawn promiscuously upon a range of iconographic sources to create this late image of the biblical cosmos. Vaughan also designed the title page for Peter Heylyn's *Cosmographie* of 1665.
Size of the original: ca. 19 × 13 cm. Elias Ashmole, *Theatrum chemicum Britannicum* (London: F. Grismond, 1652), facing 211. Photograph courtesy of the BL (E. 653).

to humble use as contemplative icons. European monarchs commonly employed globe pairs to symbolize the spatial reach and divine origin of their temporal power. The Portuguese crown incorporated the armillary into its arms in the late fifteenth century to signal its claims to cosmographic primacy.[141] In 1580, Girolamo Ruscelli, Italian translator of Ptolemy's *Geography,* also published a book of *imprese* for European monarchs. Philip II of Spain's is Apollo's chariot flying between the two globes and the motto "Iam illustrabit omnia." Ferdinand of Austria has the globe set upon a stand with flags at its corners and the words "Christo Duce." François II of France has the dual spheres and the motto "One world is not enough," while the device for Henri II of France sets the microcosm within the cosmic diagram, reaching toward the empyrium, with the word "Orbem."[142]

Such conceits continued into the seventeenth century. Galileo's naming of the moons of Jupiter pandered to his patron Cosimo II de' Medici's given name. In one image Elizabeth I of England's virtues follow the spheres: from "unmoving justice" at the center, through *religio* (sun) and *maiestas* (Jupiter) to the empyreum, around which her titles are inscribed, the queen herself embracing the cosmos as a divinity.[143] The anonymous *Scala Cœli of the Gratious Queene Anne* shows the dead queen of Denmark "on Earth in Heaven the same" at rest in the sublunar world while a ladder leads her spirit through the band of the zodiac toward the angelic spheres.[144] Louis XIV's mastery of universal space and time was proclaimed in medals of Apollo's chariot crossing the zodiac

141. The third in a set of tapestries woven in gold, silver, silk, and wool for King João III of Portugal (between 1520 and 1530) uses the cosmographic image to celebrate his rule and that of his wife, Catherine of Austria. The royal pair appear as Jupiter and Juno, favored by Abundance, Wisdom, Fame, and Victory. See figure 17.1. The king gestures to his kingdom on a central terrestrial sphere with an axis set at forty-five degrees, turned to show circumnavigated Africa and the Indian Ocean with Portuguese flags marking claims to points along the coasts. The image is discussed and illustrated in Jerry Brotton, *Trading Territories: Mapping the Early Modern World* (Ithaca: Cornell University Press, 1998), 17–23 and pl. 1. It seems to be a faithful rendering of a passage from the fifth-century Neoplatonic text *De nuptiis Philologia et Mercurii* that had acted throughout the medieval period as an encyclopedia of natural philosophy and cosmology. See James Nicolopulos, *The Poetics of Empire in the Indies: Prophecy and Imitation in* La araucana *and* Os lusíadas (University Park: Pennsylvania State University Press, 2000), 208–9.

142. Girolamo Ruscelli, *Le imprese illustri con espositioni, et discorsi* (1566; reprint Venice: F. de Franceschi, 1580). Ruscelli was also responsible for the edition of Ptolemy published for the Venetian Accademia della Fama: *La geografia di Claudio Tolomeo, Alessandrino: Nuouemente tradotta di Greco in Italiano* (Venice: Vincenzo Valgrisi, 1561), containing a "new universal map, with a description of the whole world." The breadth of his humanist interest is signaled in his edition of the romance of Lodovico Ariosto, *Orlando Furioso . . . annotationi et auuertimenti & le dichiarationi* (Venice: V. Valgrisio, 1558). On Ruscelli, see William Eamon and Françoise Paheau, "The Accademia Segreta of Girolamo Ruscelli: A Sixteenth-Century Italian Scientific Society," *Isis* 75 (1984): 327–42.

143. Mario Biagioli, "Galileo the Emblem Maker," *Isis* 81 (1990): 230–58, and Frances Amelia Yates, *Astraea: The Imperial Theme in the Seventeenth Century* (London: Routledge and Kegan Paul, 1975), pl. 9c.

144. The engraving is reproduced in Arthur Mayger Hind, *Engraving in England in the Sixteenth & Seventeenth Centuries: A Descriptive Catalogue with Introductions,* 3 vols. (Cambridge: Cambridge University Press, 1952–64), vol. 2, pl. 31. Many of the engravings reproduced in these volumes are emblematic and commonly use cosmographic iconography.

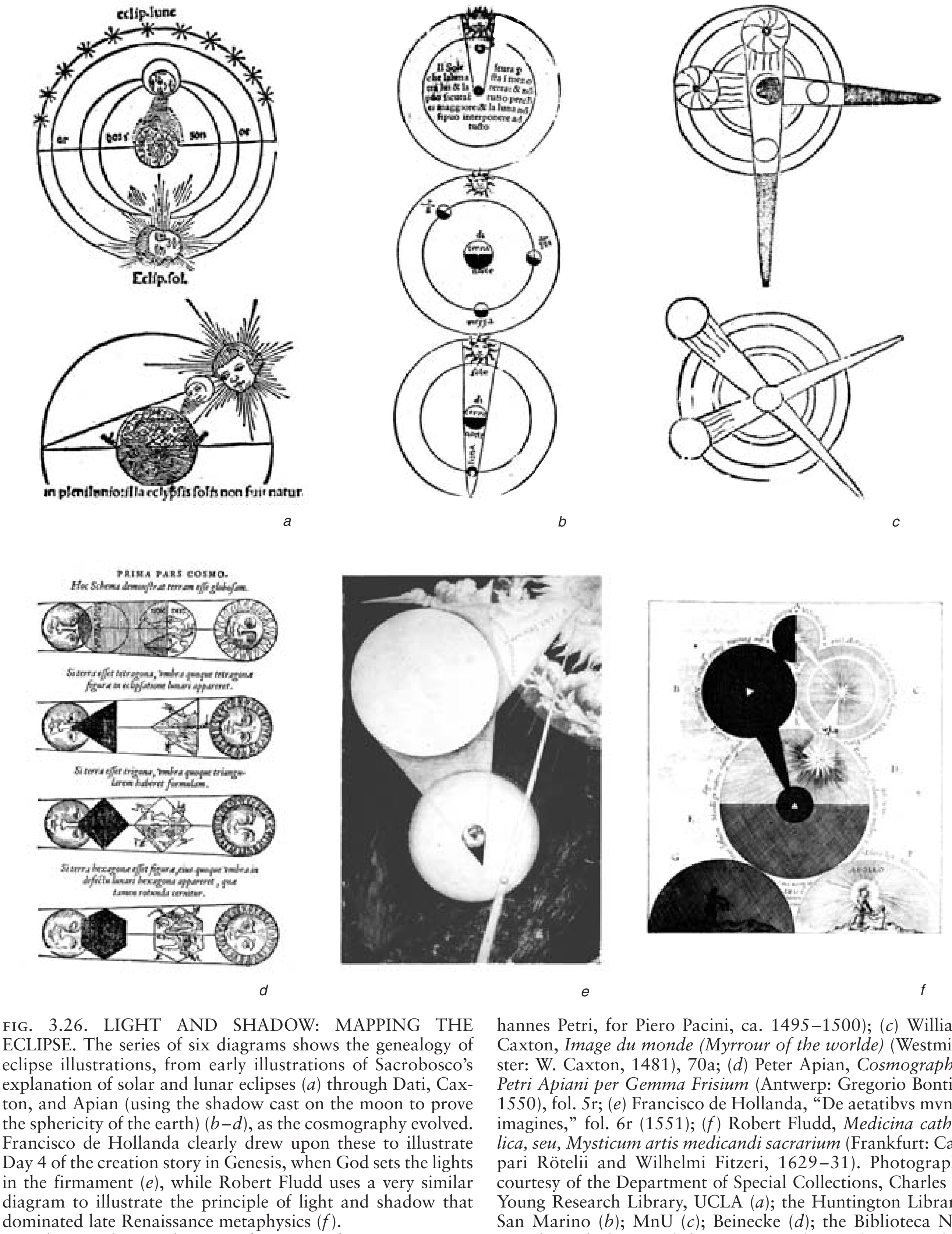


FIG. 3.26. LIGHT AND SHADOW: MAPPING THE ECLIPSE. The series of six diagrams shows the genealogy of eclipse illustrations, from early illustrations of Sacrobosco's explanation of solar and lunar eclipses (*a*) through Dati, Caxton, and Apian (using the shadow cast on the moon to prove the sphericity of the earth) (*b–d*), as the cosmography evolved. Francisco de Hollanda clearly drew upon these to illustrate Day 4 of the creation story in Genesis, when God sets the lights in the firmament (*e*), while Robert Fludd uses a very similar diagram to illustrate the principle of light and shadow that dominated late Renaissance metaphysics (*f*).

(*a*) Johannes de Sacrobosco, *Sphaera mundi* (Venice: Magistrum Gullielmum de Tridino de Monteferrato, 1491); (*b*) Leonardo Dati, *La Sfera* (Florence: Lorenzo Morgiani and Johannes Petri, for Piero Pacini, ca. 1495–1500); (*c*) William Caxton, *Image du monde (Myrrour of the worlde)* (Westminster: W. Caxton, 1481), 70a; (*d*) Peter Apian, *Cosmographia Petri Apiani per Gemma Frisium* (Antwerp: Gregorio Bontio, 1550), fol. 5r; (*e*) Francisco de Hollanda, "De aetatibvs mvndi imagines," fol. 6r (1551); (*f*) Robert Fludd, *Medicina catholica, seu, Mysticum artis medicandi sacrarium* (Frankfurt: Caspari Rötelii and Wilhelmi Fitzeri, 1629–31). Photographs courtesy of the Department of Special Collections, Charles E. Young Research Library, UCLA (*a*); the Huntington Library, San Marino (*b*); MnU (*c*); Beinecke (*d*); the Biblioteca Nacional, Madrid (*e*); and the Harvey Cushing/John Hay Whitney Medical Library, Yale University, New Haven (*f*).

FIG. 3.27. KNOWLEDGE AND COSMIC ILLUMINATION. Baroque fascination with the physics and metaphysics of light as a cosmic principle is captured in Kircher's illustration of cosmic illumination. From the tetragrammaton streams the light of sacred authority inscribing itself into the testament, while Christ/Apollo, bearing the planetary signs, sends beams of light to earth. One beam, via Astraea/Diana's lunar mirror, provides profane illumination. A second beam enters a telescope, inscribing itself on the senses, while a third penetrates the Platonic cave, suggesting the illumination of pure contemplation. Kircher sustained the cosmographic conceit that if the light of divine love streamed down through the cosmos, spiritual purification invited the soul's ascent toward the supercelestial realm.
Size of the original: 26 × 18.7 cm. Athanasius Kircher, *Ars magna lvcis et vmbræ,* 2d ed. (Amsterdam: Joannem Janssonium, 1671), title page. Photograph courtesy of the Beinecke.

above a globe fleur-de-lis, and more concretely in the iconographic program for Versailles. On great globes commissioned for the Sun King, Vincenzo Coronelli illustrated the heavens at the moment of his nativity and the terrestrial reach of his empire.

Use of the graphic device of ladder, rope, chain, or other mechanism to connect material and heavenly spheres is common (fig. 3.28).[145] Jodocus Hondius's *Typus orbis terrarum* (1589) suspends a cordiform world map from a celestial thread, encircled by the motto: "Jehova, Our Lord, how admirable is Thy name throughout all the earth" (fig. 3.29).[146] Many of the emblems in a 1640 Jesuit collection use the orbs to teach moral lessons. Angels turn the machine of the world or hold the arrows of faith over the two hemispheres with the motto "Unus non sufficit orbis."[147] In the hypercoded universe of the emblem, every representation of the sphere—geometric, crystalline, tripartite *imago mundi,* or hemispheric graticule—can signify infinite possible interpretive elaborations to be explored in the textual part of the device (fig. 3.30).[148]

For Mercator, cosmography was itself an emblematic exercise: "the glory of this thy habitation granted unto thee only for a time, who doth so compar it with the heavens, that he may therefore lift up those minds which are drowned in these earthly and transitory things, and shew them the way to more high and eternal things."[149] By contrast, in *Ship of Fools* (1494) cosmography is called an "unsure science of vayne geometry," seeking to circumscribe a world where the certainties of Strabo, Pliny, and Ptolemy are "daily demolished by the mariners."[150]

145. Girolamo Fracastoro describes this chain explicitly as *anima mundi:* "Now then, this chain is nothing other than the soul of the world, of which we have spoken, or the nod and will of God, who wholly permeates the universe and moves and binds all things, moving and drawing them, however, for a purpose known to that First Mover." Girolamo Fracastoro, "Fracastorivs, sive de anima, dialogvs," in *Opera omnia* (Venice: Apvd Ivntas, 1584), 158v.

146. Mangani, "Abraham Ortelius." The image of the earth hanging from the divine hand was widely used in the seventeenth century. The title page of William Hodson's *Divine Cosmographer,* engraved by William Marshall, is an example, picturing the cosmographer standing on the globe of earth, which hangs midway between elemental earth and water. He points into the regions of air and fire, with sun and moon shown on either side, upward toward the hand of God that reaches out from the circle of the Trinity to suspend the globe by a tiny thread. The motto reads: "Neither the heaven, earth, nor water pleases as a boundary."

147. *Imago primi Saecvli Societatis Iesv a provincia Flandro-Belgica eivsdem societatis repraesentata* (Antwerp: Balthasaris Moreti, 1640).

148. Charles Moseley, *A Century of Emblems: An Introductory Anthology* (Aldershot: Scolar, 1989), and Elizabeth See Watson, *Achille Bocchi and the Emblem Book as Symbolic Form* (Cambridge: Cambridge University Press, 1993).

149. Gerardus Mercator, *Historia Mundi; or, Mercator's Atlas, Containing His Cosmographicall Description of the Fabricke and Figure of the World,* trans. Wye Saltonstall (London: T. Cotes for Michael Sparke and Samuel Cartwright, 1635), A3.

150. Sebastian Brant, *Stultifera nauis . . . (The Ship of Fooles),* trans. Alexander Barclay (London: Richard Pynson, 1509). A section titled "Of the folysshe descripcion and inquisicion of dyuers contrees and regyons" (fol. CXXXIX) reads:

> Who that is besy to mesure and compare
> The heuyn and erth and all the worlde large
> Describynge the clymatis and folke of euery place
> He is a fole and hath a greuous charge
> Without auauntage wherfore let hym discharge
> Hym selfe, of that role whiche in his necke doth syt
> About such folyes dullynge his mynde and wyt

FIG. 3.28. MAPPING THE SCALE OF NATURE. The Trinity, represented as a triple-crowned Father with his crucified Son resting in his lap and the dove of the Holy Spirit shining illumination from his breast, occupies the upper center of the image, radiating light into the clouds of unknowing and praised by surrounding archangels. He holds orb and ring while the Virgin looks on. From God's right hand a chain descends via an angel holding the armillary (or speculum?). The chain connects descending orders of angels, humans, birds of the air, fish of the sea, and animals and plants of earth. In roundels below are five world system diagrams, and below these an underworld space of hell. The goal of human existence is ascent up the scale of nature rather than descent into bestiality (cf. Pico della Mirandola's *Oration on the Dignity of Man*), avoiding the fate of the falling angels who plummet down the right margin of the image.
Size of the original: 25 × 19 cm. Diego Valadés, *Rhetorica christiana* . . . (Perugia: Petrumiacobum Petrutium, 1579), 220, insert 2. Photograph courtesy of MnU.

COSMOGRAPHIC MAPPING IN PAINTING, ARCHITECTURE, LANDSCAPE, AND LITERATURE

Cosmography figured within the widespread cultural trope of the "theater of the world," common after 1550 in the dual sense of nature as a stage where the human spectator may marvel at God's work and of the theater as a space in which creation's diversity may be brought into order and coherence.[151] Ortelius's title is the best-known example; it also appears in Jean Bodin's cosmography, *Universae naturae theatrum* (1596).[152] Painters, architects, and poets regularly drew upon the connected cosmographic metaphors of machine and theater of the world, most notably the world landscapists of the 1520s and 1570s.[153] Caesare Caesariano's Italian translation of Vitruvius Pollio's *De architectura libri dece* (Como, 1521), the first to be illustrated, includes woodcuts of the armillary, the spheres, and a map of Italy.[154] Picturing the months and seasons was implicitly cosmographic, inevitably influenced by astrological and speculative themes in natural philosophy. Frescoes at the Palazzo Schifanoia in Ferrara map the labors of the secular year onto a cosmic cycle of zodiacal signs, pagan divinities, and intermediate decans.[155] Paintings and poems of paradise or the Last Judgment also offered scope for cosmographic images, which John Milton's epic would exploit most fully. Cosmography touched upon all four arts of the quadrivium; thus Giorgione's Castelfranco frieze of the liberal arts or Lotto's at Bergamo illustrate instruments of cosmic measure including the *sphaera mundi.*

The world theater is most completely represented in the cosmographic suites of princes, complete with globes, armillary, geographic and chorographic wall maps, and astronomical ceiling. Egnazio Danti designed two such spaces, for Cosimo I de' Medici at Florence and for the Bolognese Pope Gregory XIII in the Vatican. That for Cosimo's Guardaroba Nuova was a gigantic emblem of Cosimo I, relating a trio of globes (celestial, terrestrial, and armillary) at the center of the room to geographical maps of large parts of the world painted on the walls and to the duke's cabinets of curiosities, treasures and marvels gathered from across the world: a three-dimensional and comprehensive mapping of the cosmographic conceit of cosmic correspondence through spatial order. The scheme at the Belvedere mapped Rome's claims to an empire of faith whose boundaries were not

151. Blair, *Theater of Nature,* 153–79, and Mangani, *Il "mondo" di Abramo Ortelio,* 38–84.

152. Denis E. Cosgrove, "Globalism and Tolerance in Early Modern Geography," *Annals of the Association of American Geographers* 93 (2003): 852–70.

153. Gibson, *"Mirror of the Earth."*

154. Denis E. Cosgrove, "Ptolemy and Vitruvius: Spatial Representation in the Sixteenth-Century Texts and Commentaries," in *Architecture and the Sciences: Exchanging Metaphors,* ed. Antoine Picon and Alessandra Ponte (New York: Princeton Architectural Press, 2003), 20–51.

155. The Ferrara works are discussed in Yates, *Giordano Bruno,* 57; see also Valerie Shrimplin-Evangelides, "Sun-Symbolism and Cosmology in Michaelangelo's Last Judgement," *Sixteenth-Century Journal* 4 (1990): 607–44.

FIG. 3.29. THE COSMOGRAPHIC EMBLEM: JODOCUS HONDIUS, *TYPVS ORBIS TERRARVM,* 1589. The cordiform, single hemisphere projection of the earth, attributed hermetic qualities through its cosmographic connection with the Sacred Heart and with redemptive love streaming through the cosmos, here dangles on a celestial thread encircled by lines from Psalm 24: "The earth is the Lord's, and the fullness thereof; the world and they that dwell within it." The celestial spheres are indicated by the hemispheres of light emanating from the tetragrammaton. William Marshall's title page design for William Hodson's *Divine Cosmographer* (1634) uses a similar idea, but a globe rather than a world map dangles from the thread.
Diameter of the original: 9 cm. Photograph © National Maritime Museum, London (G 201:1/2).

FIG. 3.30. EMBLEMATIC MAPPING OF THE TWO SPHERES. In an engraving by William Marshall, the English emblematist Francis Quarles places the poet on a terrestrial globe turning from material temptation (signified by a sack of coins and a sleeping Cupid) and fame (represented by the laurel wreath and heraldic device) to gesture toward the heavenly spheres for inspiration. At his side, the lute signifies Pythagorean music, as Quarles's motto makes clear. Here the two spheres are brought together by inspiration alone.
Francis Quarles, "The Invocation," in *Emblemes* (London, 1635). Photograph courtesy of the Beinecke.

territorial but connected earth to heaven, with the gallery of geographic maps and illustrations of church history connected conceptually and physically to the astronomical instruments and images in the Sala della Meridiana.[156]

The vault or dome is an obvious location for images of the cosmos, exploited by quattrocento artists such as Masaccio and elaborated by Raphael and Giulio Romano. The vault of Gregory XIII's Sala de Bologna, designed by Ottaviano Mascherino and Lorenzo Sabatini, shows the pattern of stars and figures of constellations with the horizon line, cosmic circles, and zodiacal band and a side image of two astronomers under a pergola that mimics the armillary bands.[157] The most elaborate works are mannerist and Baroque, connecting celestial and terrestrial spaces by actual or illusionistic beams of light. In the cathedrals of both Bologna and Palma Mallorca, tiny roof apertures allow a beam of sunlight to move across interior space, illuminating elements of interior design (including Danti's meridian line at Bologna) and in-

156. Lucio Gambi and Antonio Pinelli, eds., *La Galleria delle Carte Geografiche in Vaticano / The Gallery of Maps in the Vatican,* 3 vols. (Modena: Franco Cosimo Panini, 1994); Florio Banfi, "The Cosmographic Loggia of the Vatican Palace," *Imago Mundi* 9 (1952): 23–34; Francesca Fiorani, "Post-Tridentine 'Geographia Sacra': The Galleria delle Carte Geografiche in the Vatican Palace," *Imago Mundi* 48 (1996): 124–48; and idem, *Marvel of Maps.* On the cosmographic ceiling, see Kemp, *Science of Art,* 70–71; see also the discussion of Giulio Romano's design for the Gonzaga family in E. H. Gombrich, *Symbolic Images: Studies in the Art of the Renaissance,* 3d ed. (Chicago: University of Chicago Press, 1972), 109–18.

157. Kemp, *Science of Art,* 72. Kemp points out that "in the minds of Gregory XIII and Danti . . . the science of perspective was deeply interwoven with techniques of cartographic projection, astronomical measurement and related procedures of terrestrial and cosmological

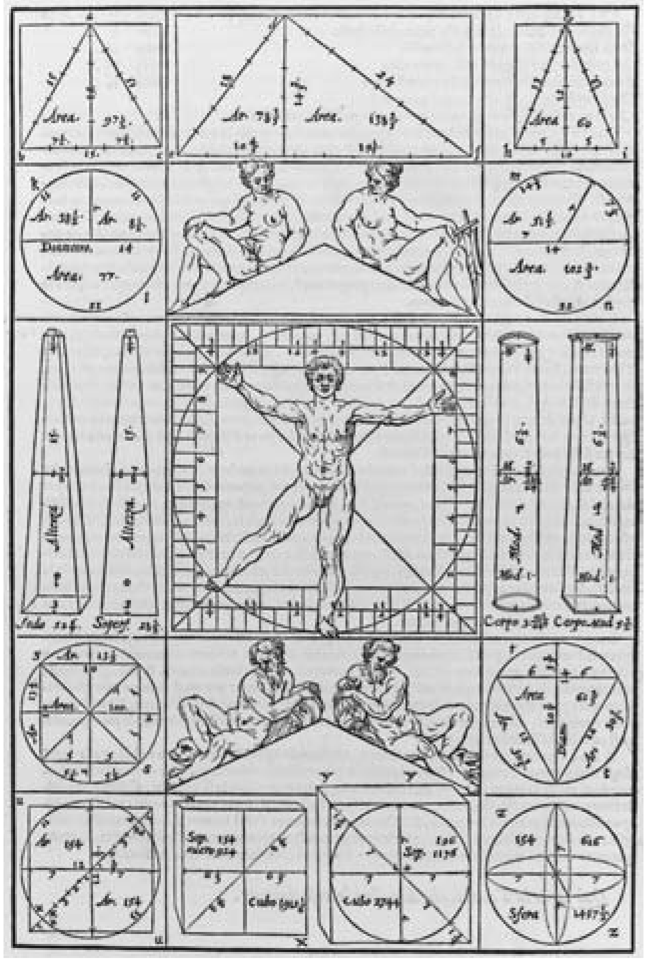


FIG. 3.31. VITRUVIAN MICROCOSM. The classical architectural writer Vitruvius Pollio famously suggested that the proportions of the erect human figure in different positions (arms outstretched or held at different angles to the body) fitted precisely the figures of circle and square whose geometry governed the architecture of the cosmos. Measured illustrations of the Vitruvian microcosm, with circle and square centered upon either navel or genitals, are to be found in virtually every Renaissance architectural treatise, prefacing a discussion of the harmonic proportions of the body and its individual parts: head, foot, arm. The most familiar of these images is Leonardo da Vinci's, but it recurs in architecture from 1450 to the mid-seventeenth century and determined the plans, elevations, and decorative elements of building throughout the Renaissance. Scamozzi's figure is placed at the center of a set of geometrical diagrams, connecting the microcosm to both pure form and specific architectural principles. Scamozzi's treatise also contains illustrations of the terrestrial globe with great circles, graticule, and surrounding winds and of the wind rose, compass, and alidade.
Vincenzo Scamozzi, *L'idea della architettura universale* (Venice, 1615). Photograph courtesy of the Beinecke.

dicating hour and season; Andrea Pozzo's ceiling design for St. Ignazio in Rome illustrates the light of faith descending from an infinite vanishing point, refracted by means of a mirror to the four continents in a cosmographic tour de force.[158] This is a recurrent Jesuit trope; it appears in the emblem of a cordiform world map draped over an altar from which the light of faith beams across the world.[159]

Renaissance architectural treatises, in the tradition of Vitruvius's *De architectura,* illustrate the machine of the world by images of the armillary, global circles, and cardinal winds (fig. 3.31). Cosmic measure was regarded as fundamental to the design of buildings and whole cities.[160] The prevalence of centric ground plan and dome, for example, in Donato Bramante's *tempietti* at Todi and Rome or in Michaelangelo's St. Peter's, reflect the architects' desire to reproduce the *imago mundi.* It has been suggested that cosmographic principles governed the plan of Tycho Brahe's Hven observatory; certainly ideal cities imagined by Thomas More, Francis Bacon, and Tommaso Campanella or designed by Filarete, Vincenzo Scamozzi, and Sébastian Le Prestre de Vauban are cosmological in inspiration and cosmographic in form.[161]

Utopias are as much literary as philosophical works. In this respect they share with poetry and drama a tradition of mapping cosmography in words. The world machine was a common trope in the Renaissance literature of most European countries, especially in epics through which the national territory, like its monarch, is given metaphysical attributes. In the closing cantos of Luís de Camões's *Os*

geometry" (p. 76). The cosmographic and cartographic relationship between Gregory and Danti is fully explored in Fiorani, *Marvel of Maps.*

158. Heilbron, *Sun in the Church,* and Kemp, *Science of Art,* 137–39. Kemp's summary of Pozzo's achievement might stand for the aims of the cosmography: "The whole point of the illusion . . . is that the distorted chaos of shapes is able miraculously to coalesce into a coherent revelation when viewed from the proper position" (p. 139).

159. Reproduced in color in Mangani, "Abraham Ortelius," pl. 2; see also Cosgrove, *Apollo's Eye,* 160–61.

160. Andrea Palladio's buildings and his text, *I quattro libri dell'architettura,* 4 vols. (Venice: Domenico de Franceschi, 1570), exemplify clearly the influence of cosmological thought on Renaissance architecture. Palladio's professional life between the late 1530s and 1580 coincides with the high point of Renaissance cosmography. On Palladio's connections with Venetian cosmography, see Cosgrove, *Palladian Landscape,* 188–250. See also Rudolf Wittkower, *Architectural Principles in the Age of Humanism,* 4th ed. (London: Academy Editions, 1988). On the ideal city, see Giulio Carlo Argan, *The Renaissance City* (London: Studio Vista, 1969).

161. Jole Shackelford, "Tycho Brahe, Laboratory Design, and the Aim of Science: Reading Plans in Context," *Isis* 84 (1993): 211–30; Francis Bacon, *The Essays or Counsels, Civil and Moral, and the New Atlantis of Francis Lord Verulam* (London: Methuen, 1905), 147–76, esp. 169–70, on cosmological influences; and Tommaso Campanella, *The City of the Sun: A Poetic Dialogue . . . ,* trans. A. M. Elliot and R. Millner (London: Journeyman Press, 1981), esp. 15–17. Campanella's *Realis philosophiae epilogisticae partes quatuor* (Frankfurt: G. Tampashii, 1623) is effectively a cosmographic text based on ideas of providential harmony as a principle of creation. An "apologia pro Galileo" is bound into the text. On artillery, warfare, and mapping, see Niccolò Tartaglia, *La nova scientia . . . con una gionta al terzo libro* (Venice: N. de Bascarini, 1550).

Lusíadas, for example, the Atlantic goddess Thetis offers Vasco da Gama, figured in the work as Portugal's Aeneas, a vision of the crystalline orbs.[162] In the final years of the English Renaissance, John Milton staged *Paradise Lost* within a cosmography that moves from the world machine to the landscape of Eden. Moving through the spheres, Satan approaches its center:

> And fast by, hanging in a golden chain,
> This pendent world, in bigness as a star
> Of smallest magnitude close by the moon.
> Thither, full fraught with mischievous revenge,
> Accursed, and in cursed hour, he hies.[163]

Conclusion

Renaissance cosmography evolved in the face of complex empirical, theoretical, and representational challenges. From the West's rediscovery of Ptolemy's promise of mapping an absolute geographical space within the order and harmony of the world machine, cosmic unity itself came under threat from experience in both spheres. Conceptual images, inherited from medieval sources, thus evolved into more complex, disputed illustrations of the world machine and its parts, while the demonstration of cosmos, always more apparent graphically than textually, weakened in the face of observational overload. Both printing and Protestantism brought to European eyes the world and the Bible as parallel texts. Despite the rhetoric of observation and experience, the expanding book of nature required as much exegesis as the vernacular Testaments. Cosmography's probing of the world machine for invariant structures below the accidental nature of the sensible world was conducted in large measure through images: measured and mathematical, iconic and emblematic. Representing an expanding *oikoumene* and deepening heavens itself prompted critical reflection on the means and meanings of vision and illumination at a time before art and science disengaged and parted ways.

The asymmetries, fragmentation, and disharmonies that disrupted Renaissance cosmography, and the sheer volume of accidental nature produced by observation, paralleled other cultural disruptions: accelerated trade, monetization, new geopolitics, and doctrinal conflict. In all respects, Aristotelian spatial closure was being pried open and the simplicity and security of its representation eroded. The attendant anxieties generated further desires and dreams of unity and harmony, met by Christian cosmography's continued offer of reassuring images to princes, alchemists, and pious folk. In their fight to maintain the unitary vision, cosmographers amassed greater volumes of data and synthesized them in ever more elaborate images. But eyewitness descriptions and anamorphic images produced by natural light through lenses increasingly revealed a more accidented creation whose staggering variety evaded capture, even in the extravagant combination of text, diagram, picture, and cartography that constituted the great Baroque world map, such as Hugo Allard's 1652 *Nova totius terrarum orbis tabula.*[164]

We might therefore trace in the maps, diagrams, and texts of Renaissance cosmography an emerging crisis of the image. Was the world machine anything more than a representation? And what claims to truth or efficacy might its representation make? By 1650 observation and experiment seemed to be resolving these questions in favor of mathematics and mechanics rather than maps and metaphysics, restricting cosmography to the theological and moralizing role that it had always served, but whose social significance would thenceforth be more marginal and insecure.

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162. See p. 464 in this volume and Nicolopulos, *Poetics of Empire,* 221–69. Luís de Camões, *Os Lusíadas* (1572); see idem, *The Lusiads,* trans. Richard Fanshawe, ed. Geoffrey Bullough (Carbondale: Southern Illinois University Press, 1963). And see the discussion in Cosgrove, *Apollo's Eye,* 120.

163. John Milton, *Paradise Lost,* 2 vols., ed. A. W. Verity (Cambridge: Cambridge University Press, 1929), 69 (bk. 2, ll. 1051–55).

164. Shirley, *Mapping of the World,* 416–17 (no. 392).