5 • Lunar, Solar, and Planetary Representations to 1650

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The production of maps and representations of individual heavenly bodies between about 1500 and 1650 must be seen in the larger context of the linked developments in media and representational arts. The development of printing, first with woodblocks and then engravings, made possible what Ivins has called "exactly repeatable pictorial statements," prerequisites for a visual dimension of science.[1] At the same time, Renaissance naturalism and perspective in art changed the focus of the artist from symbolic, generalized representations to realistic, particular ones (even if, in art itself, these new forms still served symbolic functions). Along with printing with movable type, the resulting representational developments made possible a new juxtaposition of text and image that constituted an important aspect of the profound changes in natural philosophy during this period.

The links between astronomy and geography were only part of the great changes taking place within astronomy and cosmology that were caused by the development of new instrumentation, especially the telescope. Here accurate observations *and representations* were crucial in the arguments about the nature of the heavens that went together with the change from a finite, two-tiered, full (i.e., no empty spaces), hierarchical universe of words and essences to an infinite, uniform universe of mostly empty Euclidean space of mathematical relations. Ironically, whereas in the Aristotelian cosmos heavenly bodies, especially the planets, were distinguished only by their brightness, color, and orbital characteristics and their individuality came from the symbolic load they carried, in the new, uniform universe in which their symbolism became irrelevant (especially as astrology was gradually separated from astronomy), they gained new individualities: Saturn was not merely a globe; Jupiter had bands; Mars had a variegated surface like that of the moon; and Venus and Mercury went through phases. Conjunctions that had earlier been important for astrological reasons now came to be seen as occasions to improve planetary theories, especially in the cases of transits of Mercury and Venus across the solar disk.

During this change in astronomy and cosmology, art and science initially interacted and borrowed freely from each other. But after a brief flirtation of the artists with the new astronomy, the aims of art and astronomy diverged. If in the new astronomy the heavens retained little symbolic value, the artists found little use for it, and if the astronomers produced maps of the moon that were not realistic representations of the lunar face, they had to develop canons of representation that had little to do with art, except that the craftsman cutting the plates often served both masters.

Finally, the new astronomy was increasingly driven by instrumentation. Improvements in the accuracy of determining positions and orbital elements became more and more a matter of progressive improvements of measuring instruments, so the discovery of novelty in the heavens became a function of the increasing power of telescopes. If we add changes and improvements in the instruments with which the heavens were observed to the earlier changes in which astronomical knowledge was communicated, we can say that between 1500 and 1650 astronomy acquired an entirely new technology, which became the foundation of continuing incremental improvement in this science.

Pre-Telescopic Representations of Heavenly Bodies

In the vast legacy of medieval manuscripts, no realistic representations of heavenly bodies can be found.[2] In a Seleucid astrological handbook on a partly conserved set of cuneiform tablets dating from the early second century B.C.,[3] the planets Mercury and Jupiter are represented by simple star figures, while the lunar disk is drawn with

1. William Mills Ivins, *Prints and Visual Communications* (Cambridge: Harvard University Press, 1953), 158–80, esp. 180.

2. This is not to say that no such representations were made. If they were, however, they did not survive or they were reduced to symbolic renditions in the copying process.

3. The tablets (preserved only for the signs Taurus, Leo, and Virgo) were published in Ernst Weidner, *Gestirn-Darstellungen auf babylonischen Tontafeln* (Vienna: Böhlau in Kommission, 1967). The tablets are also reproduced in B. L. van der Waerden, *Science Awakening II: The Birth of Astronomy* (Leiden: Noordhoff International, 1974), 81 and pl. 11, and Hermann Hunger, Julian Reade, and Simo Parpola, eds., *Astrological Reports to Assyrian Kings* (Helsinki: Helsinki University Press, 1992).

more detail, reflecting a Babylonian version of the "man in the moon." Similarly, on the "lion" horoscope of Antiochus I of Commagene on the summit of Nimrud Dagh in Turkey's Taurus range, the planets Mercury, Mars, and Jupiter are depicted as stars, while the moon is shown as a crescent in the constellation of Leo.[4]

With the rise of astrology in the Near Eastern and Greco-Roman world, the planets, as well as the sun and the moon, were increasingly depicted as the gods with which they were astrologically connected.[5] Early representations of this kind can be found in Carolingian copies of Roman calendrical and astronomical sources, such as the Codex-Calendar of 354[6] and the *Aratea* of Germanicus.[7] Especially in medieval and Renaissance astrological manuscripts, such representations can be found in great abundance.[8]

In addition to presenting Roman-type astrological representations, some Western manuscripts also depict the planetary gods in a more Islamic fashion (Mercury as a scribe, Venus as a woman with a stringed musical instrument, Mars as a warrior carrying a severed head, Jupiter as a scholar, and Saturn as a many-armed old man wielding weapons). These representations are derived from the Islamic astrological traditions, which in turn were ultimately based on late Babylonian astrological traditions.[9]

The sun and moon were always shown in similar symbolic representations. Often, theoretical blinders affected what observers saw in the heavens, and thus, whereas the discussion of spots seen on the sun is very limited in the medieval astronomical-cosmological literature, references are found in other sources, such as chronicles.

In the case of the moon, despite the monthly variations in its visible appearance, early man was undoubtedly aware of the fact that the dark and bright regions of the lunar disk were a permanent feature of this celestial body. In various early traditions found in many ancient cultures, the bright and dark regions were regarded as images of creatures living on the moon. For instance, the best-known of these in the Far East are the hare and the toad in the moon.[10] Around A.D. 100, the Greek historian-philosopher Plutarch of Chaeronea gave a detailed account of various ancient theories on the appearance of the lunar disk in his *De facie in orbe lunae*.[11] In Western

FIG. 5.1. MOON DRAWING BY LEONARDO DA VINCI. A drawing of the western half of the moon (as seen by a terrestrial observer) made by Leonardo between 1505 and 1508. North is at the top.
Diameter of the lunar image: 18.5 cm. Photograph courtesy of the Biblioteca Ambrosiana, Milan ("Codex Atlanticus," fol. 674v).

4. Auguste Bouché-Leclercq, *L'astrologie grecque* (Paris: E. Leroux, 1899), 438–39. According to O. Neugebauer and Henry Bartlett Van Hoesen, *Greek Horoscopes* (Philadelphia: American Philosophical Society, 1959), 14–16, the probable date of the horoscope is 7 July 62 B.C.

5. See the relevant entries in the *Lexicon iconographicum mythologiae classicae (LIMC)* (Zurich: Artemis, 1981–99): Cesare Letta, "Helios/Sol," vol. 4.1, 592–625 and vol. 4.2, 366–85; Françoise Gury, "Selene/Luna," vol. 7.1, 706–15 and vol. 7.2, 524–29; and Erika Simon, "Planetae," vol. 8.1, 1003–9 and 8.2, 661–65.

6. Michele Renee Salzman, *On Roman Time: The Codex-Calendar of 354 and the Rhythms of Urban Life in Late Antiquity* (Berkeley: University of California Press, 1990).

7. Ranee Katzenstein and Emilie Savage-Smith, *The Leiden Aratea: Ancient Constellations in a Medieval Manuscript* (Malibu, Calif.: J. Paul Getty Museum, 1988). For later medieval copies of this unique manuscript, cf. Mechthild Haffner, *Ein antiker Sternbilderzyklus und seine Tradierung in Handschriften vom Frühen Mittelalter bis zum Humanismus: Untersuchungen zu den Illustrationen der "Aratea" des Germanicus* (Hildesheim: Georg Olms, 1997).

8. The classic study on this topic is Jean Seznec, *The Survival of the Pagan Gods: The Mythological Tradition and Its Place in Renaissance Humanism and Art,* trans. Barbara F. Sessions (New York: Pantheon, 1953).

9. Fritz Saxl, "Beiträge zu einer Geschichte der Planetendarstellungen im Orient und im Okzident," *Der Islam: Zeitschrift für Geschichte und Kultur des Islamishen Orients* 3 (1912): 151–77; Anton Hauber, *Planetenkinderbilder und Sternbilder: Zur Geschichte des menschlichen Glaubens und Irrens* (Strassburg: Heitz, 1916); and Dieter Blume, *Regenten des Himmels: Astrologische Bilder in Mittelalter und Renaissance* (Berlin: Akademie, 2000).

10. Timothy Harley, *Moon Lore* (London: Swan Sonnenschein, 1885), and Ernst Hartwig, "Der Hase in der Mondscheibe," *Veröffentlichungen der Remeis-Sternwarte zu Bamberg,* vol. 1, Anhang (1923): 2–4.

11. English translation in Harold Cherniss and William C. Helmbold, *Plutarch's Moralia,* 15 vols. (Cambridge: Harvard University Press, 1957), 12:1–223. A German translation is in Herwig Görgemanns, *Das Mondgesicht* (Zürich: Artemis, 1968).

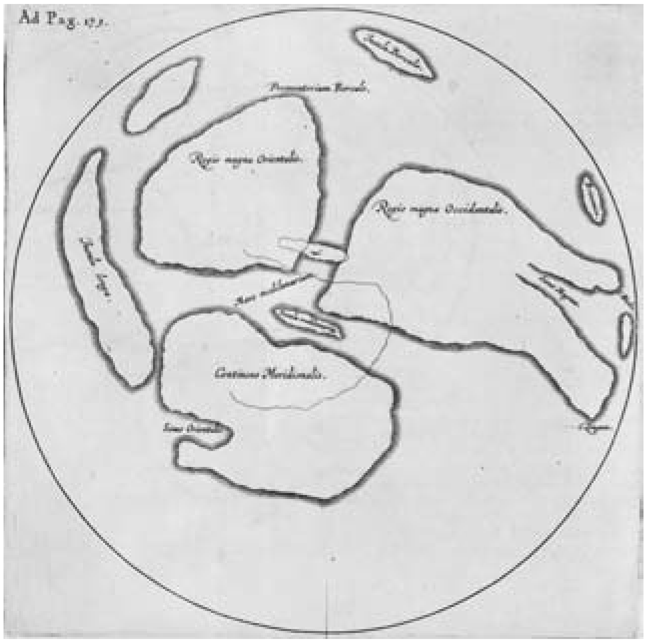

FIG. 5.2. WILLIAM GILBERT'S MOON MAP. Full moon drawn by Gilbert in 1600 from naked-eye observations. North is at the top.
Diameter of the original: ca. 18.5 cm. William Gilbert, *De mundo nostro sublunari philosophia nova* (Amsterdam: L. Elzevirium, 1651), between 172 and 173. Photograph courtesy of the BL.

folklore, the best-known image is probably that of the "man in the moon," which is encountered in numerous literary sources, for instance, William Shakespeare's *Midsummer Night's Dream.*[12]

The first known realistic representations of a heavenly body, the moon, date from the fifteenth century. The brothers Jan and Hubert van Eyck painted the face of the moon in three of their paintings, *The Crucifixion* (1420–25), *St. Barbara* (1437), and the "Knights of Christ" panel in the *Ghent Altarpiece* (1426–32).[13] Several drawings of the face of the moon made by Leonardo da Vinci in the first two decades of the sixteenth century survive in his notebooks (fig. 5.1).[14] But the first attempt to map the moon did not come until the very end of that century, when the English physician William Gilbert of Colchester, better known for his research on magnets, included a moon map based on naked-eye observations in his book *De mundo nostro sublunari philosophia nova,* published posthumously in 1651 (fig. 5.2).[15] Gilbert's map was the first to include names of features, including "Brittannia" and "Long Island."

Viewing the Heavens through the Telescope

Within a month after its existence had been revealed in The Hague, the instrument that would become known as the telescope was turned to the heavens. In a newsletter published in October 1608, the report of the new instrument included the sentence, "And even the stars that are ordinarily hidden to our eyes—are revealed by this new instrument."[16] As others duplicated the device, they, too, turned it to the heavens. In England, Thomas Harriot looked at the moon through a six-powered instrument in August 1609, at about the same time that in Padua Galileo Galilei was making a spyglass with a magnification of about eight for the Venetian senate. That autumn, Galileo began exploring the heavens with telescopes considerably more powerful than those of others. His observations of the moon in December 1609, of the satellites of Jupiter starting in January 1610, and of the fixed stars led to the publication of *Sidereus nuncius* (*The Sidereal Messenger*), in March 1610.[17]

The earliest surviving illustrations of the appearances of the moon are five wash drawings, which were probably based on drawings made at the eyepiece that have not

12. "This man, with lantern, dog, and bush of thorn, / Presenteth Moonshine." William Shakespeare, *A Midsummer Night's Dream,* in *The Norton Shakespeare,* ed. Stephen Greenblatt et al. (New York: W. W. Norton, 1997), 5.1.134–35. In some Christian traditions, alluded to by Dante (*Inferno* 20.126) and Geoffrey Chaucer (*Troilus and Criseyde* 1.1024), the man in the moon was believed to represent Cain, the son of Adam and Eve. In other Christian traditions, the man in the moon was believed to refer to the Old Testament story of the Jew punished for gathering firewood on the Sabbath (Numbers 15:32–36). Charles R. Wicke, "The Mesoamerican Rabbit in the Moon: An Influence from Han China?" *Archaeoastronomy: The Journal of the Center for Archaeoastronomy* 7 (1984): 46–55; Paul-Alain Beaulieu, "The Babylonian Man in the Moon," *Journal of Cuneiform Studies* 51 (1999): 91–99; and Ewen A. Whitaker, *Mapping and Naming the Moon: A History of Lunar Cartography and Nomenclature* (Cambridge: Cambridge University Press, 1999), 3–12.

13. Scott L. Montgomery, "The First Naturalistic Drawings of the Moon: Jan van Eyck and the Art of Observation," *Journal for the History of Astronomy* 25 (1994): 317–20. See also idem, *The Moon and the Western Imagination* (Tucson: University of Arizona Press, 1999), 83–97.

14. Gibson Reaves and Carlo Pedretti, "Leonardo da Vinci's Drawings of the Surface Features of the Moon," *Journal for the History of Astronomy* 18 (1987): 55–58.

15. Suzanne Kelly, ed., *The* De mundo *of William Gilbert,* 2 vols. (Amsterdam: Menno Hertzberger, 1965); the map is illustrated in 2: 172–73. See also Whitaker, *Mapping and Naming the Moon,* 10–15.

16. *Ambassades du Roy de Siam envoyé à l'Excellence du Prince Maurice, arrivé à la Haye le 10. Septemb. 1608* (The Hague, 1608), 11; a facsimile reprint of the newsletter is in Stillman Drake, *The Unsung Journalist and the Origin of the Telescope* (Los Angeles: Zeitlin and Ver Brugge, 1976). For the invention of the telescope, see Albert Van Helden, "The Invention of the Telescope," *Transactions of the American Philosophical Society,* 2d ser., 67, pt. 4 (1977): 3–67; published separately as *The Invention of the Telescope* (Philadelphia: American Philosophical Society, 1977).

17. John J. Roche, "Harriot, Galileo, and Jupiter's Satellites," *Archives Internationales d'Histoire des Sciences* 32 (1982): 9–51, and Ewen A. Whitaker, "Galileo's Lunar Observations and the Dating of the Composition of 'Sidereus Nuncius,'" *Journal for the History of Astronomy* 9 (1978): 155–69.

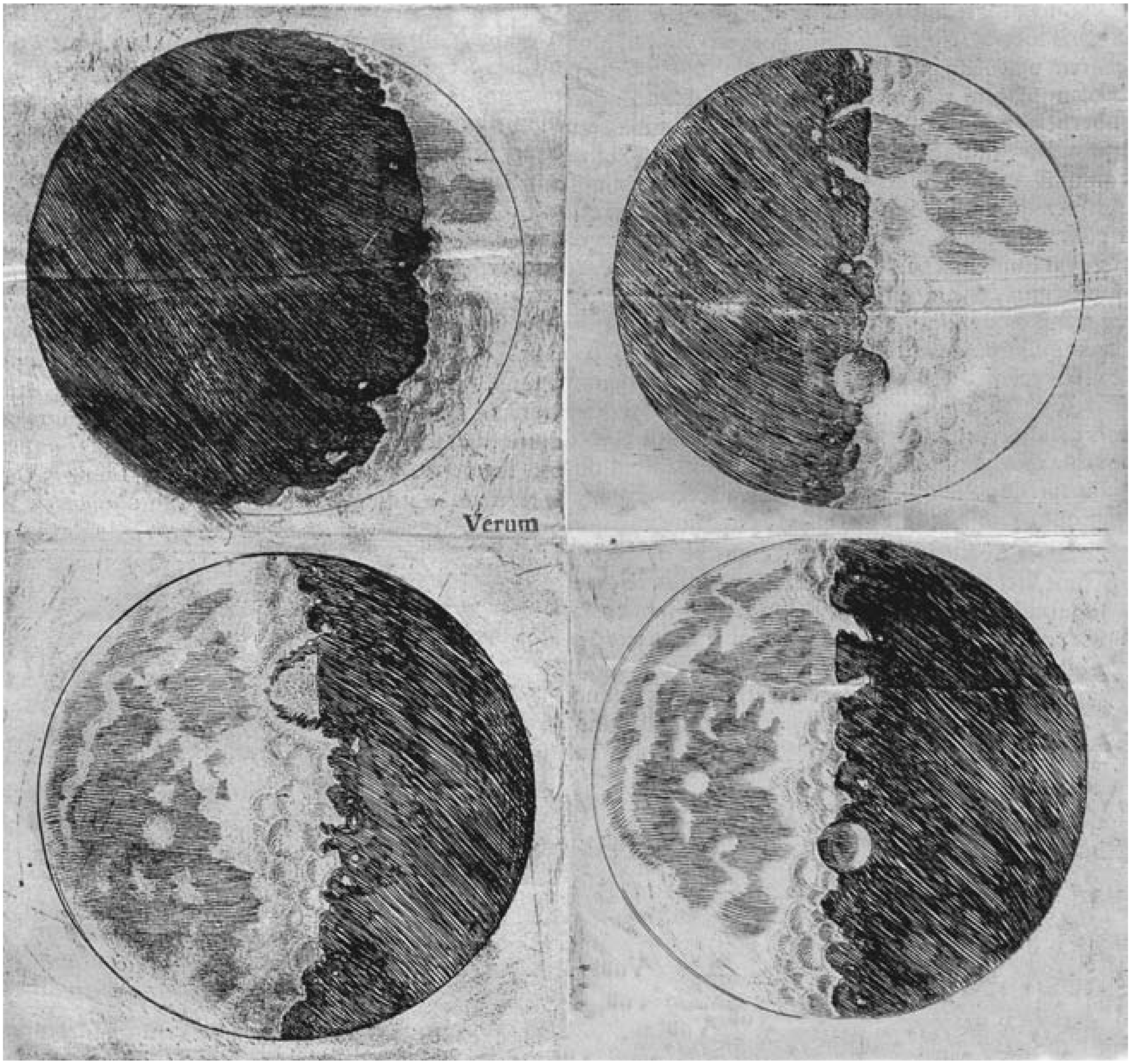

FIG. 5.3. GALILEO GALILEI'S MOON DRAWINGS (COMPOSITE). The moon in various phases (crescent phase, first quarter, waning gibbous phase, and last quarter) as drawn by Galileo with the aid of a telescope and engraved under Galileo's supervision. North is at the top.
Size of each drawing: ca. 9 × 9.5 cm. Galileo Galilei, *Sidereus nuncius* (Venice, 1610), 8r, 9v, and 10r. Photographs courtesy of the Smithsonian Institution Libraries, Washington, D.C.

survived.[18] The washes show that Galileo had a practiced hand. The four engraved illustrations (plus one duplicate) in *Sidereus nuncius* were farmed out to an unknown engraver, but we may assume that Galileo supervised the engraver (fig. 5.3). These illustrations complement the text of *Sidereus nuncius,* in which Galileo argues that the moon's surface is rough, like the earth's. Galileo exaggerated certain features, such as the large spot (crater) just below the center, in order to make his argument, and these illustrations, although recognizably depicting our moon, should not be taken as accurate depictions or maps of the lunar face. Selenographers have remarked, however, on the "curious accuracy" of Galileo's verbal description of the lunar face. It is not clear whether Harriot

18. *Le opere di Galileo Galilei: Edizione nazionale sotto gli auspicii di Sua Maestà il re d'Italia,* 20 vols., ed. Antonio Favaro (Florence: Barbèra, 1890–1909), vol. 3, pt. 1, figs. 48 and 50–53. It is possible that

continued observing the moon after his initial attempt, but it is clear that only after reading Galileo's book did he begin a protracted series of telescopic observations of the moon with instruments of various powers, and it has been argued that Harriot was unable to see relief on the moon's surface before he read Galileo.[19]

In the case of the fixed stars, Galileo's mapping of asterisms was meant to support his argument that nebular stars and the Milky Way were resolved by the telescope into large numbers of individual stars so small that their light mingled, giving the nebular appearance. Galileo selected two larger areas, the area around the sword and belt of Orion and the Pleiades, and two nebulae mentioned as such in the star catalogs of both Claudius Ptolemy and Nicolaus Copernicus, the nebula in the head of Orion and Praesepe in Cancer.[20] Mapping even these small fields was thus extremely cumbersome and prone to error.

In the case of the satellites of Jupiter, Galileo presented numerous observations, made between 7 January and 2 March 1610. Although these little figures and Galileo's matter-of-fact verbal descriptions are repetitive, this series has a cumulative persuasiveness, and the weakness of later claims of the discovery of other satellites based on a single illustration show the wisdom of Galileo's approach. He continued to observe the satellites after the publication of *Sidereus nuncius* for the purpose of using them to determine longitude at sea (a project that never succeeded because of the small field of view of the Galilean telescope), and he managed to determine the periods of the satellites and first suggested the mode of representation of predicted positions that is still used today.[21] The current names of these satellites, although suggested by Johannes Kepler and published by Simon Marius in 1614, did not come into use until after the middle of the nineteenth century.[22]

In Galileo's work we also see, for the first time, the faces of individual planets, Saturn (1610), Venus (1610), and Jupiter (1623). In each case, Galileo's discoveries supported his main argument for the Copernican theory and against the Aristotelian cosmos. The rough surface of the moon (hitherto explained away as being due to "denser and lighter parts") undermined the perfection of the heavens; the similarity of the moon and the earth helped establish the notion that the earth is a planet, as Copernicus had argued; the fact that stars remained points of light (although brighter) when magnified by the telescope, whereas planets were resolved into disks, supported the huge gap between Saturn and the fixed stars necessitated by the Copernican scheme; the satellites of Jupiter showed that there was more than one center of motion in the universe; and the phases of Venus showed that this planet (and, by implication, Mercury) went around the sun. Only the puzzling appearance of Saturn had no particular bearing on the "Great Debate" on the merits of Copernican versus Aristotelian cosmology. It was the first of the new astronomical research questions suggested by the telescope.

Saturn was first observed with a telescope in 1610 by Galileo. To his surprise, the planet appeared not as a simple globe, but rather as a central globe flanked by two round "companions." These were not moons like those he had just discovered about Jupiter, because they virtually touched the central globe, and the appearance of the formation did not change—at least not at the rate of the configuration of Jupiter's satellites. In 1612, Galileo noticed that the lateral companions had vanished, but he confidently predicted that they would reappear. This did indeed happen, and the lateral globes then slowly took on the appearances of "handles," or *ansae*.

There was no quick solution to the problem of these puzzling appearances, and it was only as telescopic astronomy was practiced by more and more astronomers, over the next several decades, that sufficient information became available to allow observers to derive the periodicity of these phenomena by the middle of the century. When the *ansae* again disappeared in the mid-1650s, a number of theories were put forward to explain their appearances (see fig. 5.4 for the various appearances that had been put in print by then), and it was the solution of Christiaan Huygens, published in 1659, that finally proved satisfactory: "Saturn is surrounded by a thin flat ring that does not touch it anywhere and is inclined to the ecliptic."[23]

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the wash drawings preserved in the Galileo manuscripts were original and therefore made at the eyepiece of the telescope. See Elizabeth Cavicchi, "Painting the Moon," *Sky and Telescope* 82 (1991): 313–15.

19. Robert Fox, ed., *Thomas Harriot: An Elizabethan Man of Science* (Aldershot: Ashgate, 2000); Terrie F. Bloom, "Borrowed Perceptions: Harriot's Maps of the Moon," *Journal for the History of Astronomy* 9 (1978): 117–22; Samuel Y. Edgerton, "Galileo, Florentine 'Disegno,' and the 'Strange Spottednesse' of the Moon," *Art Journal* 44 (1984): 225–32; and idem, *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution* (Ithaca: Cornell University Press, 1991), 223–53.

20. The first "nebula" is actually a loose clustering of unrelated stars; modern catalogs no longer list it as a nebula or star cluster. See Galileo Galilei, *Sidereus nuncius; or, The Sidereal Messenger,* trans. Albert Van Helden (Chicago: University of Chicago Press, 1989), 60–63.

21. Galilei, *Opere,* vol. 3, pt. 2, and 5:241–45.

22. Following the suggestion of John F. W. Herschel in his *Outlines of Astronomy* (London: Longman, Brown, Green, and Longmans, 1849). See also John F. W. Herschel, *Results of Astronomical Observations Made during the Years 1834, 5, 6, 7, 8, at the Cape of Good Hope: Being the Completion of a Telescopic Survey of the Whole Surface of the Visible Heavens, Commenced in 1825* (London: Smith, Elder, 1847), 415.

23. Christiaan Huygens, *Oeuvres complètes de Christiaan Huygens,* 22 vols. (The Hague: Martinus Nijhoff, 1888–1950), 15:299; Albert Van Helden, "Saturn and His Anses," *Journal for the History of Astronomy* 5 (1974): 105–21; and idem, "'Annulo Cingitur': The Solution

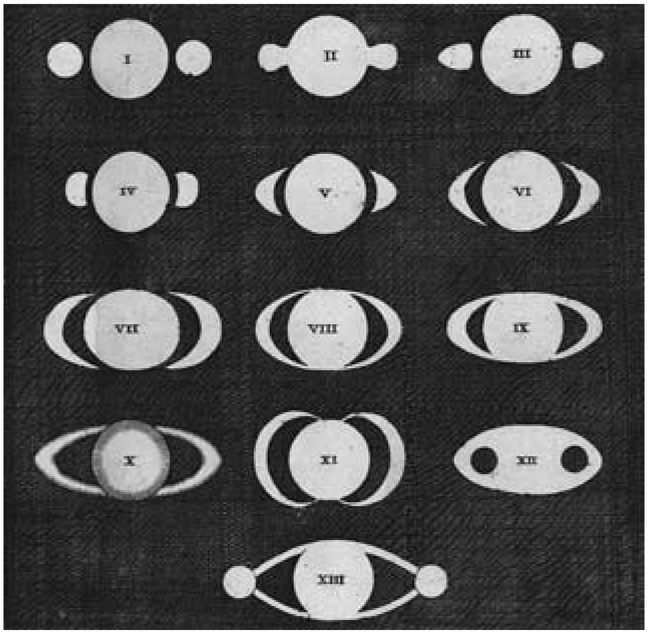

FIG. 5.4. SATURN COMPOSITE BY CHRISTIAAN HUYGENS. Telescopic views of the planet Saturn as drawn between 1610 and 1658 by Galileo Galilei (I), Christoph Scheiner (II), Giovanni Battista Riccioli (III, VIII, and IX), Johannes Hevelius (IV–VII), Eustachio Divini (X), Francesco Fontana (XI and XIII), Giuseppe Biancani (XII), and Pierre Gassendi (XIII).
Size of the original: ca. 12.2 × 12.7 cm. Christiaan Huygens, *Systema Saturnium, sive de causis mirandorum Saturni Phaenomenon* (The Hague, 1659). Photograph courtesy of the John Hay Library, Brown University, Providence, Rhode Island.

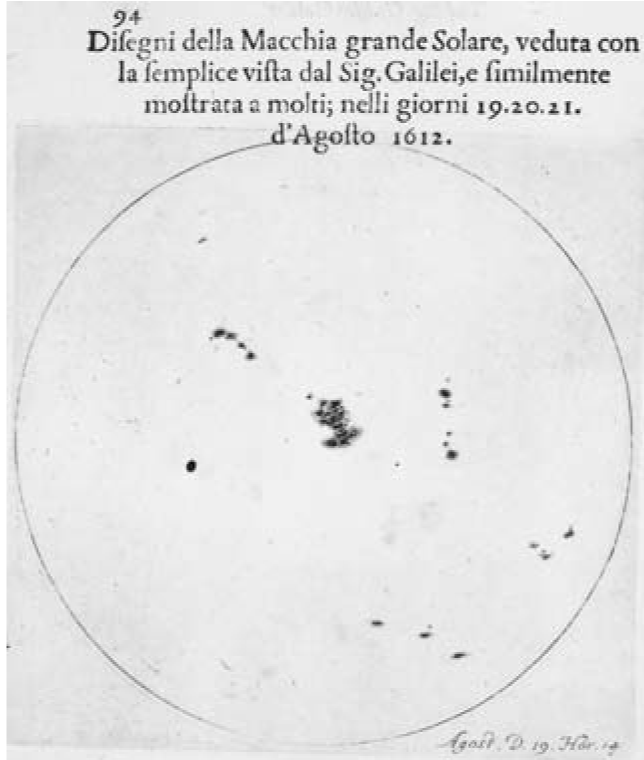

FIG. 5.5. SUNSPOT DRAWING BY GALILEO GALILEI. Galileo's drawing of the solar disk with sunspots on 19 August 1612 at 2 P.M.
Diameter of the original: ca. 12.4 cm. Galileo Galilei, *Istoria e dimostrazioni intorno alle macchie solari e loro* (1613), 94. Photograph courtesy of the BL.

Galileo continued the argument against Aristotle and Ptolemy in his controversy with Christoph Scheiner about the nature of sunspots two years after his initial telescopic discoveries. Although Thomas Harriot was the earliest known observer of sunspots, he did not publish his findings. Those of Johann Albert Fabricius and his father, David, in East Frisia, were published in 1611 but drew no attention.[24] Christoph Scheiner's publication of *Tres Epistolae de maculis solaribus,* in January 1612, set off a debate about these phenomena in which the exact shapes of spots as well as the demonstration of their "coming to be and passing away" were crucial in his argument with Galileo about the nature of sunspots.[25] Whereas Scheiner looked directly at the sun through a telescope with the aid of pieces of colored glass, Galileo used a projection technique, which was vastly superior as a research tool (and much safer as well). In his 1613 *Istoria e dimostrazioni intorno alle macchie solari e loro accidenti,* Galileo set the example for accurate depictions of heavenly phenomena (fig. 5.5). Scheiner went on to refine this method, and in 1630 he published the definitive work on sunspots, *Rosa ursina,* which, because of the ensuing minimum in sunspot activity, the so-called Maunder Minimum (ca. 1645–1715), remained the standard work on sunspots until well into the eighteenth century (fig. 5.6).

But whereas sunspots, whose positions and shapes were evanescent phenomena—no sunspot retained its shape, and one could never be entirely sure that a spot that appeared on the eastern limb was the same that had disappeared two weeks earlier on the western limb—lunar phenomena were permanent. The purpose of Galileo's depictions in *Sidereus nuncius* was to support his verbal argument that the lunar surface was not perfectly smooth and spherical, but was rough and mountainous like the

to the Problem of Saturn," *Journal for the History of Astronomy* 5 (1974): 155–74. See also idem, "Saturn through the Telescope: A Brief Historical Survey," in *Saturn,* ed. Tom Gehrels and Mildred Shapley Matthews (Tucson: University of Arizona Press, 1984), 23–43.

24. Johann Albert Fabricius, *Joh. Fabricii Phrysii De maculis in sole observatis, et apparente earum cum sole conversione narratio* (Wittenberg: Impensis Iohan Borneri Senioris & Eliae Rehifeldii, 1611).

25. The books of Scheiner and Galileo on sunspots are included in Galilei, *Opere,* 3:369–508. A partial translation of Galileo's *Istoria e dimostrazioni* can be found in Galileo Galilei, *Discoveries and Opinions of Galileo,* ed. Stillman Drake (New York: Doubleday, 1957), 87–144.

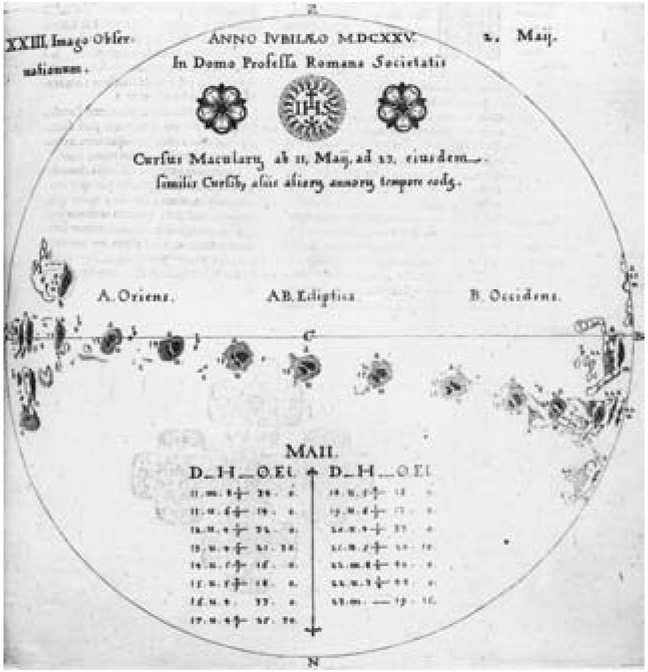

FIG. 5.6. CHRISTOPH SCHEINER'S SUNSPOT DRAWINGS. Composite drawing of Scheiner's sunspot observations from 11 to 23 May 1625. The horizontal line denotes the ecliptic, and the table lists the day and hour of observation with the sun's altitude above the horizon.
Diameter of the original: ca. 21 cm. Christoph Scheiner, *Rosa ursina* (Bracciano, 1630), 211. Photograph courtesy of the BL.

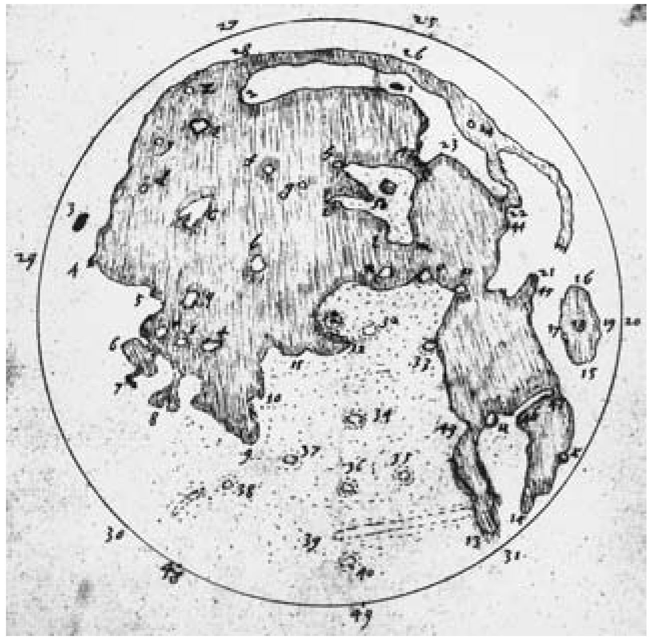

FIG. 5.7. THOMAS HARRIOT'S MOON MAP. A full moon drawn by Harriot with the aid of a telescope in about 1610. North is at the top. The numbers and letters indicate various features observed by Harriot on the lunar surface.
Diameter of the original: ca. 15.1 cm. Photograph courtesy of Lord Egremont and the West Sussex Record Office, Chichester (Harriot Papers, Petworth House Archives, HMC 241/9, fol. 30).

Earth's. And for two decades depictions of the moon in printed works reflected this, as seen, for instance, in the images published by Christoph Scheiner in 1614 and Giuseppe Biancani in 1620.[26] But as the argument about the nature of the moon receded from the research front, another aspect became central: the use of the moon in determining longitude on earth.

The telescope, it was thought, made it possible to time accurately the progress of the edge of the earth's shadow as it crossed the moon's face during a lunar eclipse. If one could specify exact local times (determined by astronomical means) when, for instance, the advancing edge of the shadow crossed a certain spot (now seen to be a crater), one could compare this with the local time noted by an astronomer in another location for the same event. But in order to do this, a standard map was needed with a nomenclature or numbering system for the important features of the moon. As early as 1612, Thomas Harriot made a rough moon map (fig. 5.7), but it remained unpublished, as did the rest of his astronomical observations. The determination of longitude, on land as well as at sea, became an important astronomical research topic in the 1630s.[27]

Shortly after the publication of Galileo's *Sidereus nuncius,* Nicolas-Claude Fabri de Peiresc, a member of the parliament of Aix en Provence, a humanist, and a patron of learning, had already begun a project to use the varying configurations of the satellites of Jupiter to determine longitudes by means of a network of correspondents. His plan for a "bureau of longitude" failed because the positions of the satellites changed too slowly to provide the requisite precision. In the 1630s, together with the astronomer Pierre Gassendi, de Peiresc revived the idea, this time with the plan of making observations during lunar eclipses. For this purpose he began making a map of the moon's surface, and the effort was taken over by other observers in Aix. It was finally the well-known engraver

26. This was also the case with the ancient method of lunar dichotomy, where determining the exact moment when the terminator bisected the disk of the moon could be used, it was thought, to measure the ratio of the geocentric distances of sun and moon. John William Shirley, *Thomas Harriot: A Biography* (Oxford: Clarendon, 1983). For the diagram-like images of the lunar face of Scheiner and Biancani, see Christoph Scheiner and Johannes Georgius Locher, *Disquisitiones mathematicae de controversiis et novitatibus astronomicis* (Ingolstadt, 1614), 58, and Giuseppe Biancani, *Sphaera mundi, seu Cosmographica demonstrativa ac facili methodo tradita* (Bologna, 1620), 150.

27. Two drawings of the full moon made by Harriot survive: West Sussex Record Office, Harriot Papers, Petworth House Archives, HMC 241/9, fols. 28 and 30. For reproductions, see Whitaker, *Mapping and Naming the Moon,* 18, and O. van de Vijver, *Lunar Maps of the XVIIth Century* (Vatican City: Specola Vaticana, 1971), fig. 3.

FIG. 5.8. CLAUDE MELLAN'S MOON MAP. First quarter moon as observed on 7 October 1636, drawn and engraved by Mellan. The lunar surface is illuminated from the west (as seen by a terrestrial observer). North is at the top.
Size of the original: 22.3 × 16.8 cm. Photograph courtesy of the BNF (Ed. 32, P.119 Mellan).

Claude Mellan who produced three engravings of the moon's face, first quarter (fig. 5.8), full moon, and last quarter (1636–37).[28] These remarkable likenesses show Mellan's skill as well as the scientific limitations of the artistic approach. Mellan represented the moon the way it appears, with the most contrast around the terminator (the boundary between the illuminated and dark areas on the lunar disk) and little contrast toward the limb. The full moon shows relatively little contrast because there are nearly no shadows. What observers needed, however, was not so much a likeness of the moon as a map. At this point, the aims of the artist and the astronomer diverged.

The first published scientific map of the moon was produced by the Dutch-Flemish cartographer Michael Florent van Langren, who in 1631 had been appointed by the Habsburg king Philip IV as royal cosmographer and mathematician.[29] His moon map entitled *Plenilunii lumina austriaca philippica* (The luminaries of Felipe of Austria on the full moon) and measuring about 39.5 by 50.5 centimeters (with a lunar disk of 35 cm), was published in 1645 (fig. 5.9).[30]

Following the belief of Galileo Galilei and other early telescopic observers that the darker areas on the moon represented water, Van Langren named these, depending on their size and location, *oceanus* (ocean), *mare* (sea), *sinus* (gulf or bay), *lacus* (lake), or *fretum* (strait). The largest dark area in the northwestern corner of the moon was called Oceanus Philippicus, with its northern extensions Mare Austriacum and Sinus Principis. Van Langren's lunar map contained 322 named features, of which the largest were named after members of the Habsburg and other ruling families, while many of the smaller were named after famous scholars and astronomers.

The most widely distributed map of the first half of the seventeenth century was made by the Polish astronomer Johannes Hevelius, who produced a large and sumptuous book on the study of the moon, *Selenographia,* in 1647. In his earlier travels, Hevelius had met Gassendi in France, and when, upon the death of de Peiresc, the "bureau of longitude" project languished, Hevelius took it up

28. Pierre Humbert, "La première carte de la lune," *Revue des Questions Scientifiques* 100 (1931): 194–204; idem, *Un amateur: Peiresc, 1580–1637* (Paris: Desclée de Brouwer et Cie, 1933), 226–31; Whitaker, *Mapping and Naming the Moon,* 29–35; and Van de Vijver, *Lunar Maps,* figs. 4–6. See also William B. Ashworth, *The Face of the Moon: Galileo to Apollo,* exhibition catalog (Kansas City, Mo.: Linda Hall Library, 1989).

29. For recent literature on Van Langren, see Peter van der Krogt, *Globi Neerlandici: The Production of Globes in the Low Countries* (Utrecht: HES, 1993), 263–71, and idem, "Das 'Plenilunium' des Michael Florent van Langren: Die erste Mondkarte mit Namenseinträgen," *Cartographica Helvetica* 11 (1995): 44–49.

30. The moon map is preserved in an autograph version and five printed copies. The autograph version is located in Brussels, Archives Générales. For a reproduction of this copy, see Van de Vijver, *Lunar Maps,* fig. 7, and Whitaker, *Mapping and Naming the Moon,* 39, fig. 25 (only forty-eight lunar features are named). For reference to the copy in Leiden, Universiteitsbibliotheek, see A. J. M. Wanders, *Op ontdekking in het maanland* (Utrecht: Het Spectrum, 1950), pl. VI. For reference to the copy at the BNF, see Zdeněk Kopal, *The Moon* (Dordrecht: D. Reidel, 1969), 228, fig. 15.3; and Zdeněk Kopal and Robert W. Carder, *Mapping of the Moon: Past and Present* (Dordrecht: D. Reidel, 1974), 13, fig. 1.9. For a reproduction of the copy in Edinburgh, Crawford Library of the Royal Observatory, see Van de Vijver, *Lunar Maps,* fig. 8; Ewen A. Whitaker, "Selenography in the Seventeenth Century," in *Planetary Astronomy from the Renaissance to the Rise of Astrophysics,* 2 vols., ed. René Taton and Curtis Wilson (Cambridge: Cambridge University Press, 1989–95), vol. 2, pt. A, 118–43, esp. 130, fig. 8.8; and idem, *Mapping and Naming the Moon,* 41, fig. 26. For reference to the copy in San Fernando (Cádiz), Biblioteca del Instituto y Observatorio de Marina, see Julio González, "Plenilunii Lumina Austriaca Philippica: El mapa de la luna de Miguel Florencio Van Langren (1645)," *Revista de Historia Naval* 4, no. 13 (1986): 99–110. For a reproduction of the copy in Strasbourg, Bibliothèque Nationale et Universitaire, see Van de Vijver, *Lunar Maps,* fig. 9, and Whitaker, *Mapping and Naming the Moon,* 43, fig. 27. The map was originally bound in a copy of the *Selenographia sive lunae descriptio* of Hevelius.

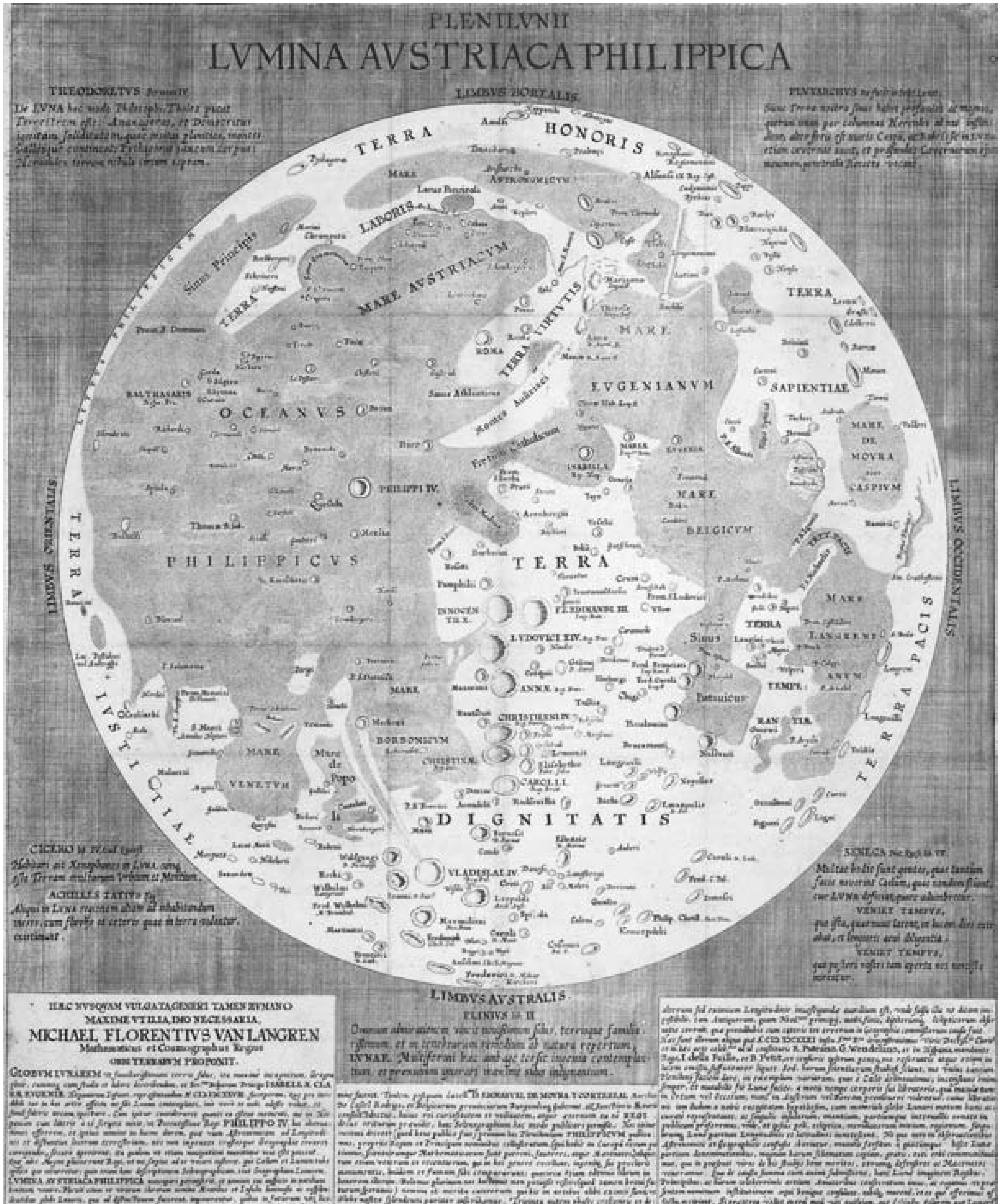

FIG. 5.9. *PLENILUNII LUMINA AUSTRIACA PHILIPPICA* BY MICHAEL FLORENT VAN LANGREN, 1645. An annotated map of the moon by Van Langren, published in Brussels in 1645. North is at the top. Size of the original: 50.5 × 39.5 cm (lunar disk, 35 cm). Photograph courtesy of the Universiteitsbibliotheek Leiden (Collectie Bodel Nijenhuis, nr. 505-10-003).

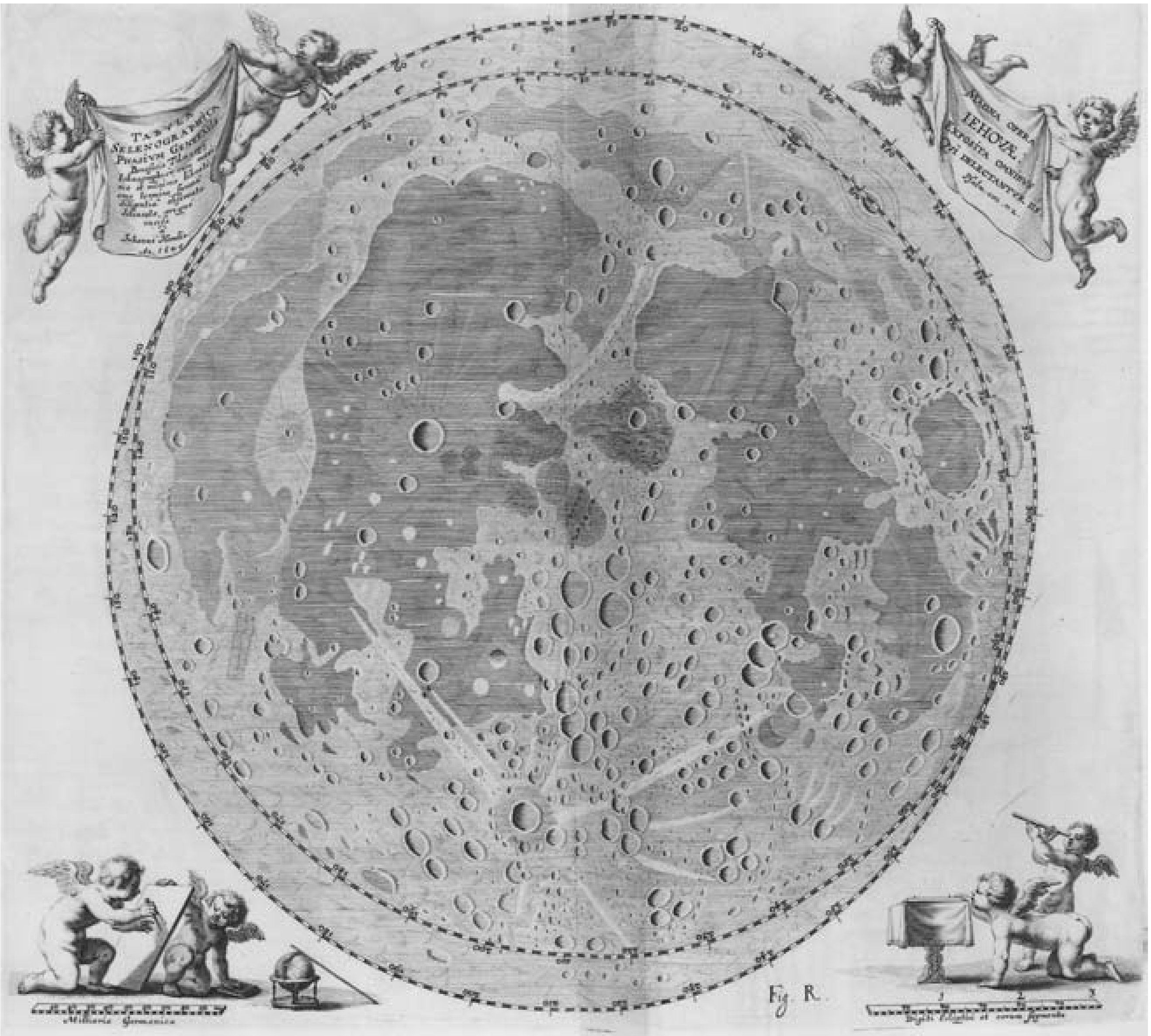

FIG. 5.10. MOON MAP BY JOHANNES HEVELIUS, 1647. A map of the moon based on the observations of Hevelius. The lunar surface is shown realistically as illuminated from the east (i.e., between full moon and new moon). North is at the top. Johannes Hevelius, *Selenographia, sive lunae descriptio* (Danzig, 1647), fig. R (between 262 and 263). Photograph courtesy of the Beinecke Rare Book and Manuscript Library, Yale University, New Haven.

with Gassendi's approval and encouragement. For several years Hevelius observed the moon during all its phases, drawing and engraving the lunar face himself and personally supervising the printing of the plates. *Selenographia* contained three large (28 cm) renderings of the full moon, marked P, R (fig. 5.10), and Q, which illustrate the problems of lunar cartography of the time.[31] Figure P shows an accurate telescopic likeness of the full moon. In order to enhance the details, Hevelius turned the image into a map, R, in which an artificial morning illumination makes the spots (craters) stand out: these features were the most useful in timing shadow fronts in eclipses. But there was also the matter of naming the features, and Hevelius used the names of terrestrial features, in the hope of avoiding controversy. These names are presented

31. Johannes Hevelius, *Selenographia, sive lunae descriptio* (1647; reprinted New York: Johnson Reprint, 1967), and Mary G. Winkler and Albert Van Helden, "Johannes Hevelius and the Visual Language of Astronomy," in *Renaissance and Revolution: Humanists, Scholars, Craftsmen and Natural Philosophers in Early Modern Europe*, ed. J. V. Field and Frank A. J. L. James (Cambridge: Cambridge University Press, 1994), 97–116.

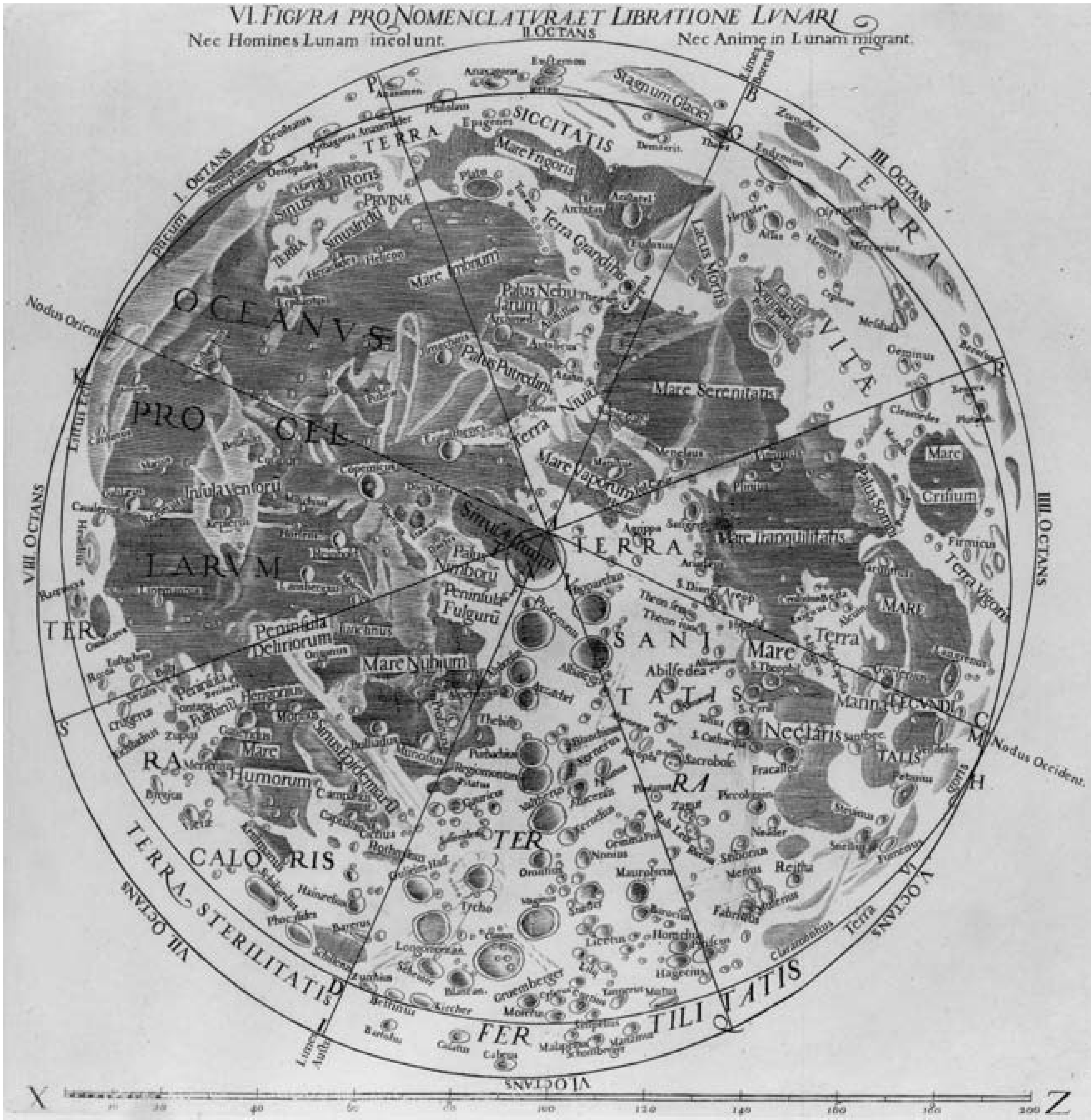

FIG. 5.11. GIOVANNI BATTISTA RICCIOLI'S MOON MAP, 1651. A map of the moon based on the moon maps of Van Langren and Hevelius, supplemented with the observations of Francesco Maria Grimaldi. North is at the top.

Size of the original: ca. 31.7 × 31.1 cm. Giovanni Battista Riccioli, *Almagestum novum astronomiam veterem novamque complectens,* 2 vols. (Bologna: Victorij Benatij, 1651), 1:204½. Photograph courtesy of Special Collections and Rare Books, Wilson Library, University of Minnesota, Minneapolis.

in a list but also labeled on a map, Q, which was drawn using the conventions of terrestrial mapmaking (and engraved not by Hevelius himself, but by Jeremias Falck, an engraver with more than a passing acquaintance with cartography). In the transition from the developing astronomical to the established earthly cartographic conventions, a number of features were misrepresented; for instance, so-called crater rays were represented as a chain of mountains. Hevelius's lunar nomenclature harks back to Galileo's argument for the earthlike nature of the moon. Hevelius's maps were the first to show more than half the moon's surface, using two overlapping circles.

And although Hevelius marked the circumference(s) in degrees, there was no attempt to establish latitude and longitude division. Hevelius also engraved small outline maps of the moon, and he used these to communicate his observations of lunar eclipses to his correspondents.[32]

Selenographia became the most authoritative monograph on the moon of the seventeenth century,[33] and Hevelius's nomenclature was used by many astronomers, whereas Van Langren's nomenclature, bound as it was to the Spanish monarchy and the Catholic religion, was quickly forgotten. But Hevelius's nomenclature was cumbersome because of its many types of characterizations: there were not only continents, seas, regions, and bays, but also rocks, swamps, marshes, and eruptions (outbreaks).[34] Giovanni Battista Riccioli, a Jesuit professor at Bologna, proposed a simpler alternative nomenclature in his influential 1651 review and compilation of astronomy, *Almagestum novum.* Riccioli published two moon maps made by his associate Francesco Maria Grimaldi, who drew on the moon maps of Van Langren, Hevelius, and others but improved them by means of his own observations. The first is a blank map with the features accented by evening illumination (following Van Langren rather than Hevelius). The second map (fig. 5.11) shows the libration limits[35] by means of two overlapping circles (after Hevelius) and is divided into eight sectors. Here Riccioli's proposed nomenclature was added. Riccioli used fewer physical characterizations than Hevelius (e.g., ocean, sea, land, peninsula) and named the smaller spots (craters) after philosophers and scientists. The followers of Copernicus were thrown together in the Ocean of Storm (Oceanus Procellarum).[36] Riccioli's nomenclature vied with that of Hevelius for the remainder of the seventeenth century, and in the eighteenth century replaced it because it was easier to use. It is the system we still use today, with only minor corrections and a large number of additions.

Conclusion

By the middle of the seventeenth century, astronomers were well on their way to developing their own conventions for representing heavenly bodies as they were revealed by the telescope. The study of sunspots had come to a virtual stop because of the absence of these phenomena during what is now referred to as the Maunder Minimum. Therefore, Scheiner's *Rosa ursina* remained the definitive treatment. In the case of the moon, although there was no agreement yet on whether to use morning or evening illumination (favored, respectively, by Hevelius and Van Langren), the example of Riccioli meant that in this respect Van Langren would win out in the long run. As for the engraving, it was the continuous burin-cut method used by Mellan and followed by both Hevelius and Riccioli that won out. Hevelius's method of representing the libration limits by means of overlapping circles was also adopted by Riccioli and was the dominant technique for more than a century.

With each increase in light-gathering power of the telescope, new celestial discoveries were made (five new satellites of Saturn, for instance, between 1655 and 1684), and the individual planets were beginning to show surface features (Jupiter, Mars, and Saturn). Most important for terrestrial cartography, astronomical measuring instruments improved to allow the first accurate determination of the length of a degree and the shape of the Earth (a subject of considerable controversy until the middle of the eighteenth century), while the eclipses of Jupiter's satellites provided, for the first time, a convenient method of determining longitude on land (although they never solved the problem of calculating longitude at sea) and thus lay at the heart of the revolution in geodesy and cartography.

32. Whitaker, *Mapping and Naming the Moon,* 50–57, and Van de Vijver, *Lunar Maps,* 76 and figs. 14–17.

33. It is interesting to note that in his world map of 1673, *Novissima totius terrarum orbis tabula,* John Seller included small reproductions of Hevelius's moon maps Q and R. See Rodney W. Shirley, *The Mapping of the World: Early Printed World Maps, 1472–1700,* 4th ed. (Riverside, Conn.: Early World, 2001), 478–79 (no. 460) and XXXIX (pl. 12).

34. Whitaker, *Mapping and Naming the Moon,* 45–46 and 51–56.

35. Due to the apparent "nodding" of the moon, caused by the axial rotation of the moon in its elliptical orbit and the position of the terrestrial observer, up to 59 percent of the lunar surface can be seen from the earth at one time or another.

36. Giovanni Battista Riccioli, *Almagestum novum astronomiam veterem novamque complectens,* 2 vols. (Bologna: Victorij Benatij, 1651), 1:204–6; Whitaker, *Mapping and Naming the Moon,* 60–68; and Van de Vijver, *Lunar Maps,* 77–78 and figs. 20–21.