4 • Renaissance Star Charts

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Between the early fifteenth and the early seventeenth centuries, star charts progressed from imprecise, often decorative illustrations based on medieval manuscripts to sophisticated map projections with systematized nomenclature for the stars. The reimportation into Europe of technical classical texts such as Ptolemy's *Almagest,* as well as Islamic works such as Abū al-Ḥusayn ʿAbd al-Raḥmān ibn ʿUmar al-Ṣūfī's constellation maps, appears to have played a significant role in this transformation. By the early sixteenth century, with the publication of Albrecht Dürer's pair of maps in 1515, the most popular format for small celestial maps was definitively set: two hemispheres, north and south, on some sort of polar projection. Around the turn of the seventeenth century, when Johannes Bayer published his 1603 *Uranometria,* the basic star atlas format was solidified, with one page for each constellation and perhaps a few hemispherical charts covering larger regions of the sky.

The revolutionary star charts of Conrad of Dyffenbach and the earliest of Paolo dal Pozzo Toscanelli's comet maps mark the beginning of a new focus on a more precise representation of the night sky than had previously been apparent in medieval manuscripts. Three distinct traditions for Renaissance star charts emerged: decorative—in which star positions do not conform to observable star patterns; rigorous—where star positions more accurately reflect the star patterns in the night sky and attention to mathematical and scientific precision; and specialized—where star maps help record celestial phenomena and/or new discoveries or demonstrate practical uses for the stars. By the end of the sixteenth century, the decorative tradition began to wane, although the others coexisted throughout the Renaissance and beyond.

Many factors came into play in the evolution of Renaissance star maps, in addition to classical and Islamic scientific texts. Medieval manuscripts set the stage for all three traditions.[1] Globes influenced star charts, providing new information and artistic styles. Star charts likewise influenced globes.[2] Astrolabes also played a role in the evolution of star charts, providing a model of the stereographic projection. As was the case in much of cartography in general, makers often drew upon the work of their predecessors for both technical data and artistic style, with certain works reflecting moments of breakthrough and the founding of new traditions.

Historiography

Despite the recent publication of a number of lavish illustrated books intended for a general public audience,[3] the study of Renaissance star charts (and indeed star charts in general) has been largely neglected by the scholarly

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A note on terminology: given the lack of consensus on the proper term for a two-dimensional rendering of the stars (among the options—star/celestial/astronomical chart and star/celestial/astronomical map), "star chart" and "star map" are used interchangeably in this chapter; "celestial and astronomical chart/map" refers, in my opinion, to a much broader category of maps than those of the stars.

Abbreviations used in this chapter include: *Globes at Greenwich* for Elly Dekker et al., *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum, Greenwich* (Oxford: Oxford University Press and the National Maritime Museum, 1999), and Adler for the Adler Planetarium & Astronomy Museum, Webster Institute for the History of Astronomy, Chicago.

1. In this chapter I attempt to partially redress the omission of a complete discussion of medieval European star charts in volume 1 of *The History of Cartography* series.

2. Although the main focus of this chapter remains star charts, globes are introduced into the discussion as appropriate due to the overlapping and complementary histories of these two forms of maps of the stars.

3. For example, see (in chronological order): George Sergeant Snyder, *Maps of the Heavens* (London: Deutsch, 1984); Giuseppe Maria Sesti, *The Glorious Constellations: History and Mythology,* trans. Karin H. Ford (New York: Harry N. Abrams, 1991); Carole Stott, *Celestial Charts: Antique Maps of the Heavens* (London: Studio Editions, 1991); Peter Whitfield, *The Mapping of the Heavens* (San Francisco: Pomegranate Artbooks in association with the British Library, 1995); and Marc Lachièze-Rey and Jean-Pierre Luminet, *Celestial Treasury: From the Music of the Spheres to the Conquest of Space,* trans. Joe Loredo (Cambridge: Cambridge University Press, 2001).

community.[4] Celestial globes, on the other hand, have been more extensively researched.[5] This is, to a large extent, the result of a historiographical separation of two-dimensional and three-dimensional material. The history of celestial globes has tended to be subsumed by the study of globes in general, whereas celestial charts are infrequently discussed in general histories of two-dimensional cartography. This division of globes and charts has carried over into the popular literature as well, where the broad term "celestial cartography" has been primarily applied to star charts, with a limited inclusion of globes and other types of celestial charts. Occasionally, however, scholarly studies of celestial material have bridged this divide.[6]

Historians of art and astronomy have contributed the greatest numbers of works about star charts, many, if not most, of which are cited in this chapter. Prior to 1979, however, no specialized catalog of celestial cartography was published.[7] To be sure, there were some early attempts at general histories, but these suffer from inaccuracies and often limited information. For example, in his 1932 work *Astronomical Atlases, Maps and Charts: An Historical and General Guide,* Brown asserts that "the earliest actual map of the heavens, with figures of constellations shown and the stars of each group marked with any precision, appears to be that of Peter Apian"—one of many gross errors in the volume.[8] In addition to star charts, Brown does, however, include sections on many other types of celestial cartography excluded from most later general works on "celestial charts" or "celestial cartography."

In 1979, Warner authored *The Sky Explored: Celestial Cartography 1500–1800.* Although its scope was primarily limited to star charts (including specialized star charts such as comet path maps) and a few important celestial globes, her work provided a sound foundation upon which future scholars could build.[9] Yet despite this groundbreaking work, new scholarship on star charts is sparse. Journal articles, both pre- and post-Warner, have provided detailed research on particular makers and themes, most notably those by various authors on the Dürer hemispherical maps and their manuscript predecessors and Dekker's many articles; exhibit catalogs have provided brief accounts of a number of other charts.[10]

4. There are many examples, of which only a few are mentioned: *The History of Cartography* series neglected to cover medieval star charts in volume 1. Leo Bagrow, in *History of Cartography,* rev. and enl. R. A. Skelton, trans. D. L. Paisey, 2d ed. (Chicago: Precedent Publishing, 1985), makes but two fleeting references to celestial globes. Norman J. W. Thrower, although regularly discussing the contributions of astronomy and astronomers to terrestrial mapping in *Maps & Civilization: Cartography in Culture and Society,* 2d ed. (Chicago: University of Chicago Press, 1999), rarely mentions any sort of celestial map or globe, except for brief discussions of the contributions of Edmond Halley and a slightly more extensive discussion of lunar maps, starting with Galileo and ending with modern technology; his only two celestial illustrations are both lunar maps. A survey of all issues of *Imago Mundi* finds that only a handful of articles have been written about any aspect of celestial cartography, half of which are about celestial globes. In a relatively recent guide to map terminology, Wallis and Robinson relegate "astronomical maps" to "maps of natural phenomena" rather than categorizing them as a major "type of map," as they do celestial globes; Helen Wallis and Arthur Howard Robinson, eds., *Cartographical Innovations: An International Handbook of Mapping Terms to 1900* (Tring, Eng.: Map Collector Publications in association with the International Cartographic Association, 1987), 135–38.

5. Much of this work has been done in journals such as *Der Globusfreund,* with more recent work in catalogs; see, for example, *Globes at Greenwich* or Peter van der Krogt, *Globi Neerlandici: The Production of Globes in the Low Countries* (Utrecht: HES, 1993).

6. For example, see Zofia Ameisenowa, *The Globe of Martin Bylica of Olkusz and Celestial Maps in the East and in the West,* trans. Andrzej Potocki (Wrocław: Zakład Narodowy Imienia Ossolińskich, 1959); Deborah Jean Warner, *The Sky Explored: Celestial Cartography, 1500–1800* (New York: Alan R. Liss, 1979); Rochelle S. Rosenfeld, "Celestial Maps and Globes and Star Catalogues of the Sixteenth and Early Seventeenth Centuries" (Ph.D. diss., New York University, 1980); and many of the works of Elly Dekker, in particular "Der Himmelsglobus—Eine Welt für sich," in *Focus Behaim Globus,* 2 vols. (Nuremberg: Germanisches Nationalmuseums, 1992), 1:89–100, and "Andromède sur les globes célestes des XVI^e et XVII^e siècles," trans. Lydie Échasseriaud, in *Andromède; ou, Le héros à l'épreuve de la beauté,* ed. Françoise Siguret and Alain Laframboise (Paris: Musée du Louvre / Klincksieck, 1996), 403–23.

7. Many of the major Renaissance works are cited in Ernst Zinner, *Geschichte und Bibliographie der astronomischen Literatur in Deutschland zur Zeit der Renaissance* (1941; 2d ed. Stuttgart: A. Hiersemann, 1964); however, this listing is not indexed or arranged by type of work, so it is impossible to tell which volumes contain celestial charts except in the occasional instances when Zinner annotates an entry. For medieval and early Renaissance manuscript charts and constellation drawings, see the four volumes of Fritz Saxl, *Verzeichnis astrologischer und mythologischer illustrierter Handschriften des lateinischen Mittelalters:* vol. 1, *[Die Handschriften] in römischen Bibliotheken* (Heidelberg: Carl Winters Universitätsbuchhandlung, 1915); vol. 2, *Die Handschriften der National-Bibliothek in Wien* (Heidelberg: Carl Winters Universitätsbuchhandlung, 1927); vol. 3, in two parts, with Hans Meier, *Handschriften in Englischen Bibliotheken* (London: Warburg Institute, 1953); and vol. 4, by Patrick McGurk, *Astrological Manuscripts in Italian Libraries (Other than Rome)* (London: Warburg Institute, 1966). The latter two volumes have the series title translated into English as Catalogue of Astrological and Mythological Illuminated Manuscripts of the Latin Middle Ages. For both medieval and Renaissance sources, see also A. W. Byvanck, "De Platen in de Aratea van Hugo de Groot," *Mededelingen der Koninklijke Nederlandsche Akademie van Wetenschappen* 12 (1949): 169–233.

8. Basil Brown, *Astronomical Atlases, Maps and Charts: An Historical and General Guide* (London: Search, 1932), 13. The well-known 1515 Dürer hemispherical maps predate the Apian map, as do several important manuscript maps. Interestingly, Brown laments the general neglect of celestial cartography within both academic and collecting circles.

9. Warner's work should, however, be used with caution, as many more star charts have come to light since its publication more than a quarter century ago.

10. Useful museum catalogs include: *Celestial Images: Astronomical Charts from 1500 to 1900* (Boston: Boston University Art Gallery, 1985); *Focus Behaim Globus,* 2 vols. (Nuremberg: Germanisches Nationalmuseums, 1992); Anna Felicity Friedman [Herlihy], *Awestruck by the Majesty of the Heavens: Artistic Perspectives from the History of Astronomy Collection* (Chicago: Adler Planetarium & Astronomy Museum, 1997); and the online catalog *Out of this World: The Golden Age of the Celestial Arts* (Kansas City, Mo.: Linda Hall Library, ongoing), <http://www.lindahall.org/pubserv/hos/stars/>.

Medieval and Renaissance Star Knowledge and Representation

measuring and plotting star locations

Very few medieval star maps can be considered scientifically rigorous.[11] Late medieval astronomers did conduct some direct observation of the sky, especially of comets and eclipses and for time-finding purposes, but most astronomical scholarship was literary and mathematical in nature, derived from texts translated from or based on classical works as well as a few Arabic ones.[12] Many, if not most, of the constellation illustrations that accompanied medieval astronomical and astrological texts were intended as decorative illustration, not something that an astronomer or student would take outside and compare to the sky.[13] Since astronomers, astrologers, students, and others rarely conducted actual observation of the sky during this period, the decorative images sufficed, even for such weighty scientific texts as Ptolemy's *Almagest*.

There are early indications of a move toward scientifically rigorous mapping of the sky in a handful of Arabic-influenced manuscripts dating from the late medieval period. With very few exceptions, medieval and Renaissance mapmakers did not look at the stars and directly sketch the patterns they were seeing to create a new map; instead, scientific star mapping was a process of indirect observation. Mapmakers or astronomers used the coordinates listed in a star catalog to plot star positions onto a map grid. In many cases, however, they did not even create original maps, but copied from earlier maps or globes, bypassing both star catalogs and observation of the sky.

To create a new star chart prior to Tycho Brahe's publication of his catalog of stars, astronomers and mapmakers relied on existing star catalogs that were essentially versions of the star catalog contained in Ptolemy's *Almagest* but updated to account for the effects of precession. Such catalogs often contained errors due to inaccurate precessional calculations or miscopied or misread values. In essence, medieval and some early Renaissance mapmakers relied upon the eyes of classical scholars for their star positions.

By the early Renaissance, several astronomers began to focus on observational astronomy, and enough observations were conducted to determine that there were serious problems with practicing an astronomy that relied on antiquated sources.[14] Finally, in the late 1500s, after hundreds of years of reliance on outdated stellar measurements, Tycho Brahe undertook his project to reobserve and measure the position of every visible star with new and significantly more accurate instruments, creating a star catalog so momentous that it made its way into celestial globes and star charts circulated around Europe through manuscript versions before the catalog had even been printed. It must be noted that prior to about 1660, all astronomers used the naked eye (aided by instruments such as the cross staff, torquetum, and quadrant—not telescopes) to determine positions of celestial bodies.[15]

internal versus external perspective and the hipparchus rule

From antiquity until well into the seventeenth century, scholars envisioned the stars as being located on a sphere surrounding the earth (with, post-Copernicus, the solar system at its center). This gave rise to two possible ways to map the stars, either from inside the sphere, as seen from a point standing on the earth looking up at the sky, or from outside the sphere, as if looking down upon the surface of a celestial globe. The resulting "internal" and

11. In this chapter I attempt to address the assertion by many recent authors that scientifically rigorous manuscript maps of the heavens were commonplace or widespread. Such maps are the exception rather than the rule. Both Warner, in *Sky Explored,* xi, and Wallis and Robinson, in *Cartographical Innovations,* 136, erroneously assert that in medieval constellation images the stars were *often* correctly positioned.

12. For more on astronomical scholarship and teaching in the Middle Ages, see Olaf Pedersen, "European Astronomy in the Middle Ages," in *Astronomy before the Telescope,* ed. Christopher Walker (New York: St. Martin's, 1996), 175–86, and Michael Hoskin and Owen Gingerich, "Medieval Latin Astronomy," in *The Cambridge Illustrated History of Astronomy,* ed. Michael Hoskin (Cambridge: Cambridge University Press, 1997), 68–97.

13. One of the few well-documented instances of early medieval star viewing concerned the monastic practice of timekeeping after dark. Monks kept time by watching certain constellations. Gregory of Tours created and illustrated his own constellations for this purpose in the sixth century in his "De cursu stellarum," although it is unclear whether creating such constellations was common practice or an unprecedented novelty. See Stephen C. McCluskey, "Gregory of Tours, Monastic Timekeeping, and Early Christian Attitudes to Astronomy," *Isis* 81 (1990): 9–22; republished in *The Scientific Enterprise in Antiquity and the Middle Ages: Readings from Isis,* ed. Michael H. Shank (Chicago: University of Chicago Press, 2000), 147–61. A later instance concerns the use of the Pole Star and α Ursa majoris to tell the time at night, documented as early as 844 in the writing of Pacificus of Verona. See Joachim Wiesenbach, "Pacificus von Verona als Erfinder einer Sternenuhr," in *Science in Western and Eastern Civilization in Carolingian Times,* ed. Paul Leo Butzer and Dietrich Lohrmann (Basel: Birkhäuser, 1993), 229–50. In general, however, such explicit references to observation of the stars and realistic illustrations are rare from this time.

14. For details about some of these men, see N. M. Swerdlow, "Astronomy in the Renaissance," in *Astronomy before the Telescope,* ed. Christopher Walker (New York: St. Martin's, 1996), 187–230. There is some evidence for star charts drawn in the early Renaissance with original observations, for example, the comet maps of Paolo dal Pozzo Toscanelli, some of which feature carefully plotted star positions.

15. Telescopes were, however, used from the early seventeenth century on for the observation of the moon and stars. For a detailed account of the instruments of observation during the classical, medieval, and Renaissance periods, see J. A. Bennett, *The Divided Circle: A History of Instruments for Astronomy, Navigation and Surveying* (Oxford: Phaidon, Christie's, 1987), esp. 7–26.

"external" perspectives become an issue in looking at star charts.[16]

A result of this issue relates to the orientation of the figures depicted in star charts and globes. The so-called Hipparchus rule, described by Hipparchus in the second century B.C. (although it may be from an even earlier source), prescribed that human constellation figures should be depicted such that when observed from Earth, the front of the figure faces the viewer. Thus figures on external perspective charts and on celestial globes should be depicted from the back.[17] Problems arose with adherence to this rule, although for the most part, Renaissance celestial cartography (both charts and globes) faithfully followed it.[18]

PRECESSION OF THE EQUINOXES AND EPOCHS

Although the apparent positions of the stars are "fixed" with respect to one another, resulting in unchanging constellation patterns, the position of the celestial sphere with respect to the earth gradually shifts over a cycle of 25,800 years because of the wobble of the earth's axis, as if around a cone, due to differential gravity effects of the sun and moon. Thus the points at which the celestial equator crosses the ecliptic (the equinoxes) gradually drift westward. Precession affects the stellar longitude at a constant rate (around one degree of change every seventy years), but not stellar latitude. This resulting precession of the equinoxes causes star maps to be useful for observational purposes for only a limited time.

From Ptolemy on, astronomers had proposed various values that could be added to celestial longitude to correct for the effects of precession. All these proposed corrections were inaccurate to a greater or lesser degree; thus the accuracy of star charts for a particular date depended on which updated star catalog a mapmaker was using. This complicates determining the epoch (the actual date that corresponds to the star positions on a map) of any particular map; it can be dramatically different from the date of the making of the map (for example, although the well-known Dürer et al. star maps are dated 1515, they were actually drawn for an epoch of ca. 1440).[19] Determining the epoch of a map can help to unravel what star catalog and precessional constant a mapmaker may have used in creating the map; determining the epochs of similar maps can help to trace whether their makers were using the same star catalog.

NEW CONSTELLATIONS AND ASTRONOMICAL DISCOVERIES

During the Middle Ages, the constellations depicted followed the text that they were illustrating—the forty-eight Ptolemaic constellations, the forty-four of Aratus, the forty-two of Hyginus, and so on.[20] During the Renaissance, mapmakers created star maps unrelated to any particular text, but the prominence of Ptolemy's *Almagest* led to the solidification of the forty-eight Ptolemaic constellations as foundational. However, as is apparent in any polar projection star map produced prior to 1600, the center of the southern hemisphere contains a vast expanse of empty, unrecorded space (fig. 4.1). This is due to the incomplete "passage" of the entire celestial sphere over any particular point on Earth (except along the equator); some stars (and, by extension, constellations) are never seen from certain latitudes. Because the Ptolemaic constellations had been recorded from a Mediterranean latitude, the southernmost stars are excluded. The celestial latitude line beyond which stars cannot be seen from a European point of view (the boundary of visibility or line of never-visibility) is slightly south of the celestial Tropic of Capricorn, depending upon exactly where in Europe one is. Thus the only way to record these stars and to fill the empty space on star maps was to travel farther south.

The largest contribution to new constellations in the Renaissance came from the travels of Pieter Dircksz. Keyser and Frederik de Houtman, who measured the positions of the southern stars not visible from Europe on their expeditions to the southern hemisphere in the mid-1590s. Petrus Plancius formed these into twelve new constellations that were first published on the 1597/98 globe he made in conjunction with Jodocus Hondius Jr. and later in Johannes Bayer's 1603 atlas (fig. 4.2).[21] Keyser and De Houtman's trip was the first systematic expedition to record the southern stars, although prior to their travels there had been sporadic reports of sightings of the Southern Cross, the Magellanic Clouds (two galaxies prominently visible in the southern sky), and the Coal-

16. Warner labels this way of viewing the stars "geocentric" versus "external," but this presents potential confusion in post-Copernican eras as many cartographers created "geocentric" maps although their cosmology was decidedly not geocentric. Dekker labels the different views "sky view" versus "globe view."

17. For more information on the Hipparchus rule, see Dekker, "Andromède," 408–9, or Dekker, "Der Himmelsglobus," 92.

18. Johannes Bayer is a notable exception. Dekker considers the Renaissance adherence to the Hipparchus rule a remarkable feat, given that there is no extant evidence of Renaissance mapmakers' familiarity with Hipparchus (personal communication, 2002).

19. For a detailed explanation of precessional theories and their relationship to the epoch of the maps by Dürer et al., see Warner, *Sky Explored,* 71 and 74.

20. The Aratus constellations are technically those of Eudoxus, whose work is no longer extant. For a useful index of the Eudoxan versus Ptolemaic constellations, see Michael E. Bakich, *The Cambridge Guide to the Constellations* (Cambridge: Cambridge University Press, 1995), 83–84.

21. Elly Dekker, "Early Explorations of the Southern Celestial Sky," *Annals of Science* 44 (1987): 439–70.

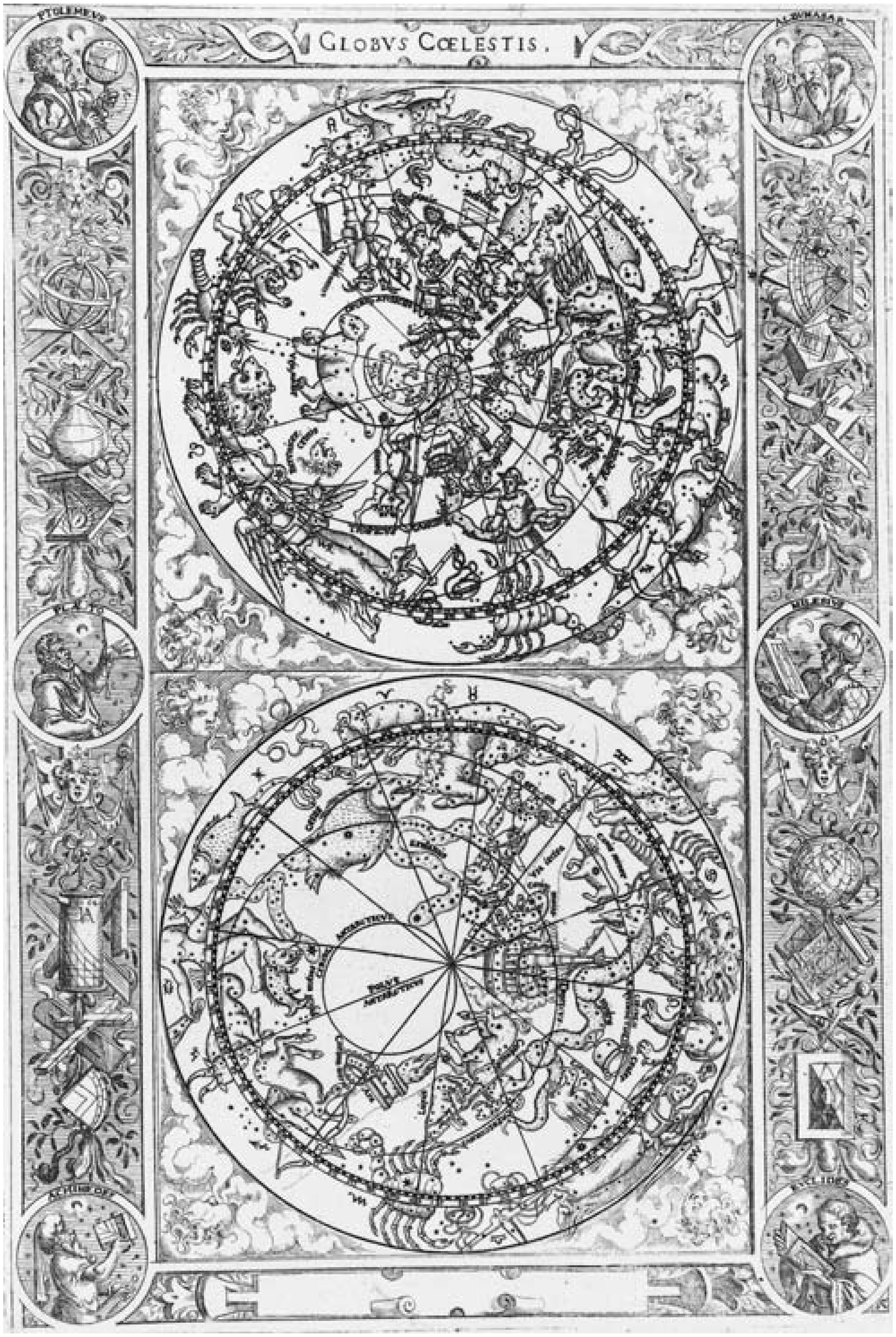

FIG. 4.1. CELESTIAL MAP BY JOST AMMAN. This map exhibits an unusual vertical arrangement that is also seen in its companion terrestrial map. The border, unusually decorative for a celestial map from this time, features portraits of six prominent ancient philosophers and a variety of scientific instruments. The artistry of some constellations reflects those of Johannes Honter, in that many of the characters are clothed. However, others, such as Orion, reflect the Dürer tradition. Amman employs an external perspective and has added the constellation Coma Berenices. Note that there is a large empty space in the center of the southern hemisphere; this is due to the invisibility of that area of the sky from European latitudes. *Ptolemaeus, Geographia, libri octo* (Cologne, 1584). Photograph courtesy of the John Carter Brown Library at Brown University, Providence.

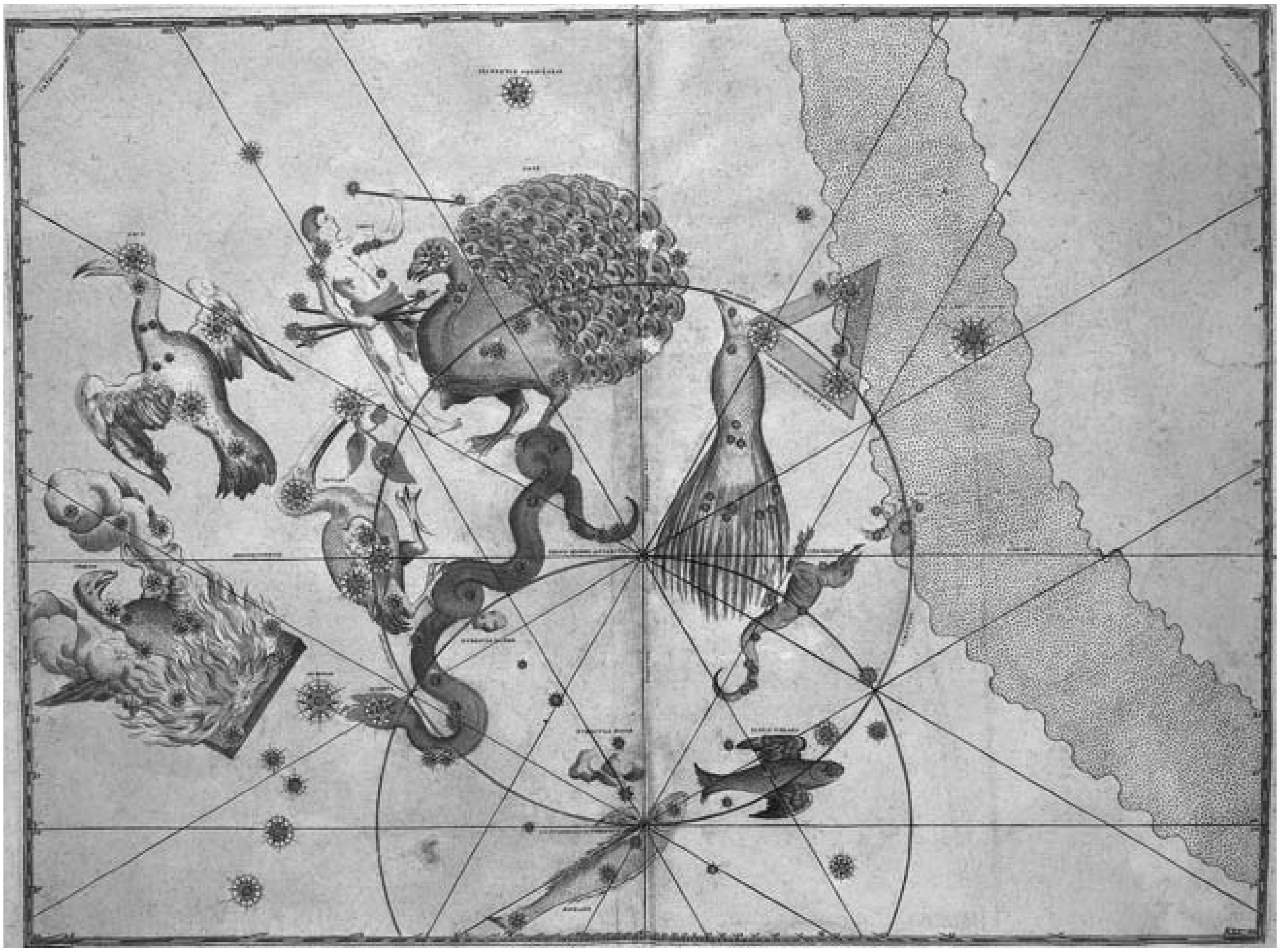

FIG. 4.2. MAP OF THE NEW SOUTHERN CONSTELLATIONS. Shortly after Plancius and Hondius introduced constellations based on Keyser and De Houtman's newly recorded southern stars, Johannes Bayer published this two-dimensional version. In addition to the twelve new constellations of Plancius, Bayer includes the two Magellanic Clouds (labeled "Nubacula Major" and "Nubacula Minor"), visible at the center of the map. It is unclear why he did not assign letters to the stars in these new constellations, as he did throughout the rest of his atlas.
Johannes Bayer, *Uranometria* (1603). Photograph courtesy of the Adler.

sack nebula.[22] Small, regional maps sometimes documented these three celestial features. In northern skies, several comets and novae appeared during the Renaissance; they were sometimes recorded on celestial globes and on star charts, but more often formed the basis for regional, topical star charts that focused on these unusual phenomena.[23]

Other new constellations were created during the Renaissance in order to corporealize areas of stars that had been recorded, but were noted as unformed or outside the boundaries of any particular Ptolemaic constellation. In 1536, Caspar Vopel introduced Coma Berenices and Antinous on a new globe. In 1589, Petrus Plancius and Jacob Floris van Langren added Crux and Triangulus Antarcticus, likewise on a globe. In 1592, Plancius created Columba and Polophylax on the inset celestial maps of a larger world map. Plancius added nine biblical-themed constellations in 1612 on a globe produced in conjunction with Pieter van den Keere.[24] Jakob Bartsch replaced Plancius's Apes with his own Vespa in 1624, and Isaac Habrecht II introduced Rhombus (an early predecessor of Reticulum) on his celestial globe of 1625.[25]

22. See Elly Dekker, "The Light and the Dark: A Reassessment of the Discovery of the Coalsack Nebula, the Magellanic Clouds and the Southern Cross," *Annals of Science* 47 (1990): 529–60, for an extensive account of the recording and mapping of the Southern Cross.

23. For a chronology of comets appearing over Europe in the Renaissance, see Donald K. Yeomans, *Comets: A Chronological History of Observation, Science, Myth, and Folklore* (New York: John Wiley and Sons, 1991), 405–19, and Gary W. Kronk, *Cometography: A Catalog of Comets* (Cambridge: Cambridge University Press, 1999–), 1:260–347.

24. For a detailed listing of Plancius's biblical constellations, see Warner, *Sky Explored,* 206.

25. See Elly Dekker, "Conspicuous Features on Sixteenth Century Celestial Globes," *Der Globusfreund* 43–44 (1995): 77–106 (in English

Medieval Constellation Illuminations as Precursors to the Renaissance

Most early Renaissance constellation images derived from medieval manuscript examples. Except for a few manuscripts based on the work of the Islamic astronomer al-Ṣūfī and the occasional planisphere and planisphere-like celestial depiction,[26] European constellation images from the medieval period are not, in fact, maps, but instead are fanciful drawings with star configurations rendered in a manner that does not conform to the appearance of the stars in the sky. Typically, each constellation appears as a separate drawing, although some manuscripts include a circular celestial image encompassing the visible sky. In some illustrations, stars are placed within constellation figures according to mythological accounts of their position, in essence mapping the text rather than the sky; in other illustrations, stars are merely decorative additions that embellish the constellation figures. Manuscripts also commonly featured constellation illustrations without any stars, but with only the mythological figures.

Throughout the Middle Ages, various astronomical, astrological, and mythological texts were illustrated with constellation figures. The oldest images accompany versions of the mythological "Aratea,"[27] dating back at least as far as the early ninth century, and they continued to be popular texts until at least the seventeenth century (figs. 4.3 and 4.4).[28] Other texts illuminated with constellation figures during the Middle Ages include the "Poeticon Astronomicon" of Hyginus, Bede's "De signis coeli" (often referred to as the Pseudo-Bedan catalog), the "Liber introductorius" of Michael Scot, and the astronomical work of the ancient astronomer Nimrod.[29]

Most constellation images from the early medieval period tend to follow the model of the early "Aratea" manuscripts in terms of the design of the figures, retaining a classical aesthetic. As time progressed, constellation images began to reflect Romanesque and Gothic styles; as Islamic constellation texts became available, certain Arabic attributes began to be incorporated into constellation iconography.[30] Some authors, such as Michael Scot, included atypical constellations, such as Tarabellum and Vexillum, along with the traditional Aratean choices (fig. 4.5).[31]

By the late thirteenth century, a body of manuscripts emerged that began to lean in the direction of scientifically rigorous maps of individual constellations, in that the positions of the stars reflected the actual patterns in the sky, although without any sort of map projection. Called the Sufi Latinus corpus, they were derived from al-Ṣūfī's constellation treatise, which included a complete Ptolemaic star catalog with individual constellation maps.[32] The earliest seems to have been derived from a now lost manuscript from Sicily (plate 3);[33] others date to the early years of the Renaissance. In the Sufi Latinus manuscripts, the figures have been modified to fit a Western European aesthetic to varying degrees, but all retain Arabic iconographic and stylistic influence to a greater or

and German), for information on the depiction of Coma Berenices and Antinous on sixteenth-century celestial globes; see also her listing of new constellations, including when and by whom they were introduced, in *Globes at Greenwich,* 559–60.

26. The term "planisphere" should be used only in the specific sense of a representation based on the stereographic projection, as in Ptolemy's *Planisphaerium.* For many of the medieval and early Renaissance maps that depict the entire visible sky, it is impossible to determine if the projection was intended to be stereographic. In addition, circular hemispherical maps in a projection other than the stereographic have also commonly been called planispheres in the past. In this chapter I use the term "planisphere-like map" to describe these two types of circular maps when a general descriptor is needed, as their overall circular format and coverage of either the visible sky or each hemisphere is reasonably similar.

27. Three main versions of the astronomical myths of Aratus were used during the Middle Ages. They are commonly referred to as the Aratus Latinus, the Germanicus Aratea, and the Ciceronian Aratea. For a good discussion of the various Aratea versions and an annotated list of Carolingian Aratus manuscripts, see Patrick McGurk, "Carolingian Astrological Manuscripts," in *Charles the Bald: Court and Kingdom,* ed. Margaret T. Gibson and Janet L. Nelson (Oxford: B.A.R., 1981), 317–32.

28. The earliest extant illustrated Aratea appears to be Vienna, Österreichische Nationalbibliothek, Cod. 387 (dated between 809 and 821); for many others, see the Aratus sections in the source lists of illustrated astronomical manuscripts in Byvanck, "De Platen in de Aratea," 204–33. Byvanck cites relevant catalog pages and illustrations for Saxl, vol. 1, *[Die Handschriften] in römischen Bibliotheken,* and vol. 2, *Die Handschriften der National-Bibliothek in Wien,* among other secondary source materials. See also Alfred Stückelberger, "Sterngloben und Sternkarten: Zur wissenschaftlichen Bedeutung des Leidener Aratus," *Museum Helveticum* 47 (1990): 70–81; revised and published in *Antike Naturwissenschaft und ihre Rezeption* 1–2 (1992): 59–72.

29. For numerous illustrations, see the four Saxl volumes and also Byvanck, "De Platen in de Aratea," 204–33. For a discussion of Bede's "pseudepigrapha," including *De signis coeli,* see Charles William Jones, *Bedae Pseudepigrapha: Scientific Writings Falsely Attributed to Bede* (Ithaca: Cornell University Press, 1939). For a detailed study on one of the Michael Scot manuscripts, see Ulrike Bauer [Bauer-Eberhardt], *Der Liber introductorius des Michael Scotus in der Abschrift Clm 10268 der Bayerischen Staatsbibliothek München* (Munich: Tuduv-Verlagsgesellschaft, 1983). For a brief description of Nimrod's constellation images, see Charles Homer Haskins, *Studies in the History of Mediaeval Science* (1924, reprinted New York: Frederick Ungar, 1960), 338–41; Haskins reports that of the two manuscripts he discusses, only one (MS. Lat. VIII 22, at the library of St. Mark's in Venice) has illustrations.

30. For a useful account of stylistic and iconographic changes in constellation renderings throughout the Middle Ages, see Erwin Panofsky and Fritz Saxl, "Classical Mythology in Mediaeval Art," *Metropolitan Museum Studies* 4 (1933): 228–80, esp. 230–41.

31. Bauer, *Michael Scotus;* Franz Boll, *Sphaera: Neue griechische Texte und Untersuchungen zur Geschichte der Sternbilder* (Leipzig: B. G. Teubner, 1903), 439–49; and Lynn Thorndike, *Michael Scot* (London: Thomas Nelson and Sons, 1965), 100–102.

32. Emilie Savage-Smith, "Celestial Mapping," in *HC* 2.1:12–70, esp. 60. For detailed information on the Sufi Latinus corpus, see Paul Kunitzsch, "The Astronomer Abu 'l-Ḥusayn al-Ṣūfī and His Book on the Constellations," *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 3 (1986): 56–81, or idem, "Ṣūfī Latinus," *Zeitschrift der Deutschen Morgenländischen Gesellschaft* 115 (1965): 65–74.

33. BNF (Arsenal MS. 1036 [Bologna, ca. 1270]). See Kunitzsch, "Astronomer Abu 'l-Ḥusayn al-Ṣūfī," 74.

FIG. 4.3. AQUARIUS FROM ARATUS, “PHAENOMENA,” MANUSCRIPT. The printed version of the constellation Aquarius seen in figure 4.4 derives directly from this Leiden “Aratea” manuscript predecessor. Most of the stars, especially those in the stream of water, are merely decorative; others, however, do correspond to mythological descriptions of star placement within this constellation, although not to their actual patterns in the sky.
Size of the original: 17.5 × 15.3 cm. Photograph courtesy of the Universiteitsbibliotheek Leiden (MS. Voss. Lat. Q 79, fol. 48v).

FIG. 4.4. AQUARIUS FROM ARATUS, *PHAENOMENA*, PRINTED VERSION BY HUGO GROTIUS. Compare figure 4.3.
Aratus of Soli, *Syntagma Arateorum opus antiquitatis et astronomiae studiosis utilissimum . . .* , ed. Hugo Grotius (Leiden: Christophorus Raphelengius, 1600). Photograph courtesy of the Adler.

lesser extent.[34] Like the al-Ṣūfī maps, these renderings also include a numbering system for the stars corresponding to that of the Ptolemaic star catalog and a graduation of sizes of stars, reflecting different magnitudes.

In addition to the manuscripts derived from al-Ṣūfī, medieval circular celestial charts constitute a rudimentary type of map. The majority mapped the relationship of neighboring constellations, and in this capacity they lack stars (fig. 4.6). The earliest map of this type, in an “Aratea” manuscript, dates to 818, and examples of such charts, in varying stages of complexity, appeared until the early years of the Renaissance.[35] Most include circles representing the tropics, equator, or ecliptic, and some seem to have been constructed using a rough version of the stereographic projection.[36] Some are divided into northern and southern hemispheres; others depict only the portion of the sky visible from a typical European latitude (from either the north ecliptic or equatorial pole to the boundary of visibility). Such maps also vary between internal and external perspective. One unusual variant, in an “Aratea” manuscript that dates from ca. 900, uses an equatorial projection of sorts.[37]

Advances in Two-Dimensional Mapping

It seems that it was not until the early fifteenth century that rigorous star maps appeared with map grids and precisely placed stars, despite the availability in Europe (via Moorish Spain) as early as the tenth century of astrolabes, which provided a model of the stereographic projection, and Is-

34. Kunitzsch classifies them into four groups. See Kunitzsch, “Astronomer Abu ’l-Ḥusayn al-Ṣūfī,” 68–71.

35. Munich, Bayerische Staatsbibliothek (Clm. 210). For more information on such charts, see Saxl, *Die Handschriften der National-Bibliothek in Wien,* 19–28, or Savage-Smith, “Celestial Mapping,” 13–17 (both also include the relationship of such charts to similar Islamic examples).

36. For a diagram of such charts, see Savage-Smith, “Celestial Mapping,” 15 and fig. 2.3.

37. Stiftsbibliothek St. Gallen, Switzerland (Cod. Sangall. 902). This manuscript is pictured in Saxl, *Die Handschriften der National-Bibliothek in Wien,* 22.

FIG. 4.5. MICHAEL SCOT'S CONSTELLATIONS TARABELLUM AND VEXILLUM. Scot's "Liber introductorius," an astronomical and astrological manuscript, enjoyed a certain amount of popularity between the thirteenth and fifteenth centuries; the particular copy in which these constellations appear dates from the second half of the fifteenth century. Scot introduced a number of unusual constellations not seen in other astronomical works. Tarabellum and Vexillum are both located in the southern celestial hemisphere; the former is an awl, while the latter is a flag or banner.
Photograph courtesy of the Pierpont Morgan Library, New York (MS. M.384, fol. 28).

FIG. 4.6. MAP SHOWING GENERAL RELATIONSHIP OF CONSTELLATIONS TO ONE ANOTHER FROM A TENTH-CENTURY ARATUS MANUSCRIPT. This map, while not showing star positions, conveys the general relationship of one constellation to another in the sky. The constellations are arranged according to an internal perspective, and the figures are facing forward following the Hipparchus rule. The map is constructed with the center on the ecliptic pole; the celestial equator is indicated by the offset circle.
Size of the original: 37 × 28.5 cm; diameter: ca. 23.5 cm. Photograph courtesy of the Burgerbibliothek, Bern (Cod. 88, fol. 11v).

lamic and classical resources such as al-Ṣūfī and Ptolemy from the late thirteenth century. The earliest extant two-dimensional star maps other than astrolabes with identifiable projections appear to be those in the Vatican library manuscript attributed to the copyist Conrad of Dyffenbach and dated 1426.[38] This manuscript contains four maps that chart a limited number of stars with sketched-in outlines of selected constellations (fig. 4.7). The star catalog information derives from Gerard of Cremona's Latin translation of an Arabic version of Ptolemy's *Almagest;* the constellations do not seem to have been influenced by the work of al-Ṣūfī.[39] Numbers indicate the positions of the stars and represent their magnitudes. Three of the maps employ unusual trapezoidal projections that may have been developed based on the works of Hipparchus (transmitted through Arabic sources);[40] these maps appear to have had no influence on other contemporary charts. The fourth map is a circular map drawn using the azimuthal equidistant projection and centered on the ecliptic pole.[41]

38. Vatican City, Biblioteca Apostolica Vaticana (Codex Palat. Lat. 1368), 63r, 63v, 64r, and 64v. For detailed information on these maps, see 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), 114–17, and Saxl, *[Die Handschriften] in römischen Bibliotheken,* 10–15. Two are illustrated in Durand, pl. I, the other two in Saxl, pl. XI. See also John Parr Snyder, *Flattening the Earth: Two Thousand Years of Map Projections* (Chicago: University of Chicago Press, 1993), 9 and 29–30.

39. Kunitzsch, "Astronomer Abu 'l-Ḥusayn al-Ṣūfī," 67, n. 36. Kunitzsch corrects Saxl's assertion that the style of the constellations exhibits Arabic influence.

40. Durand, *Vienna-Klosterneuberg,* 115.

41. Durand suggests that this projection may have come from an Arabic source, possibly Abū al-Rayḥān Muḥammad ibn Aḥmad al-Bīrūnī (*Vienna-Klosterneuberg,* 116).

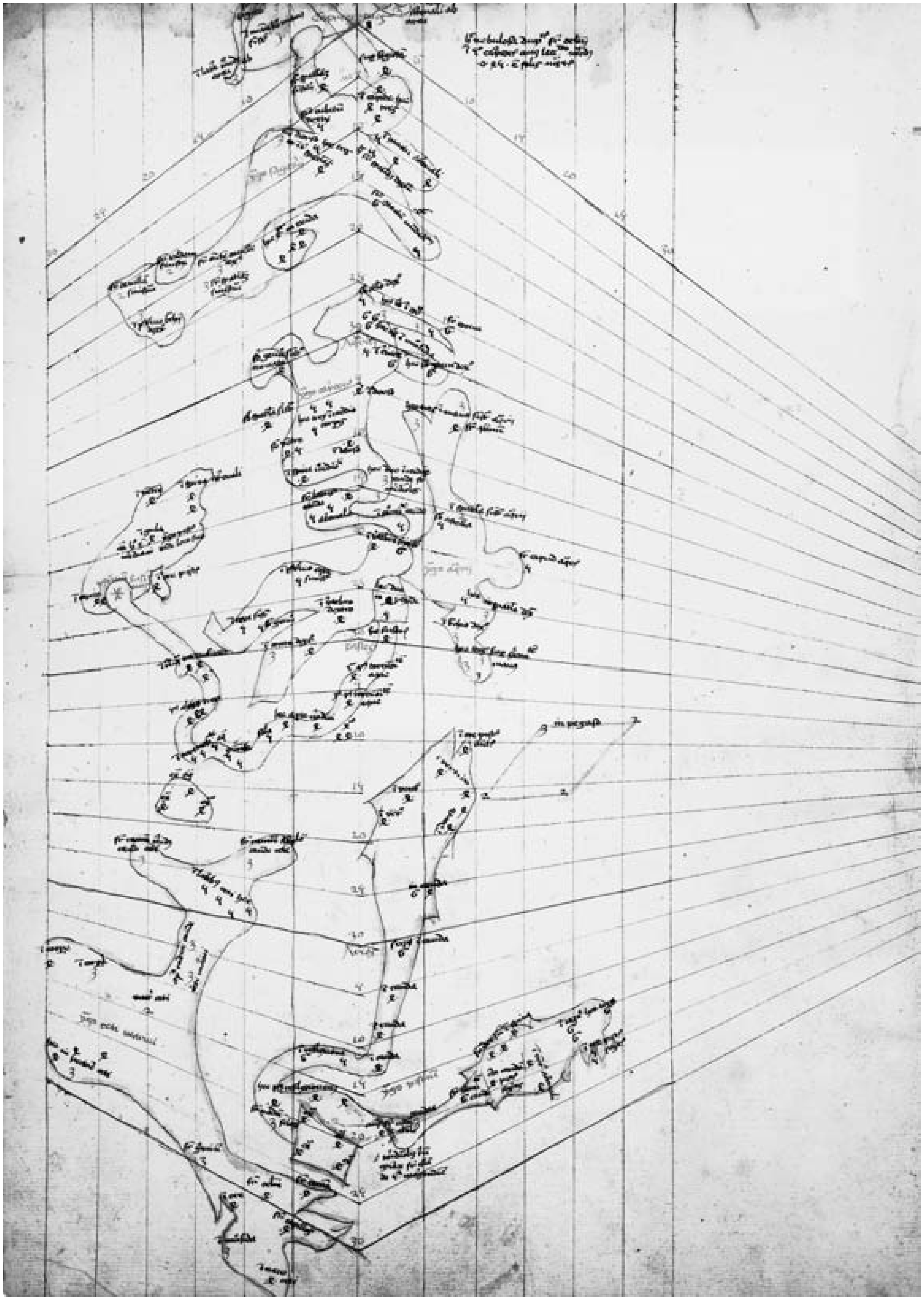

FIG. 4.7. TRAPEZOIDAL PROJECTION MAP FROM 1426 BY CONRAD OF DYFFENBACH. One of the four earliest extant, nonastrolabic star maps, this map curiously uses the trapezoidal projection, one usually reserved for smaller area regional maps. It shows a portion of the ecliptic (Sagittarius, Capricorn, Aquarius, and Pisces) and several surrounding constellations (for example, the Great Square of Pegasus asterism is indicated above Pisces). The star positions are indicated with numbers that correspond to their magnitude.

Photograph © Biblioteca Apostolica Vaticana, Vatican City (Codex Palat. Lat. 1368, fol. 64v).

The circular Conrad of Dyffenbach map may have served as a model for later polar projection maps of the north and south celestial hemispheres, such as the more complete and elaborate maps of ca. 1440 occasionally attributed to Johannes von Gmunden (they were produced in Vienna and are hereafter referred to as the Vienna maps); the Vienna manuscript also contains individual maps of each constellation with star lists.[42] The Vienna maps also use the Ptolemaic star catalog as the basis for star positions—each star is numbered to correspond to the Ptolemaic catalog. This numbering feature was present on individual-constellation maps in medieval European copies of al-Ṣūfī manuscripts as well as original Islamic al-Ṣūfī manuscripts.[43] Despite their overall Western appearance, the Vienna maps manifest Arabic influence in certain iconographic attributes of constellations.[44] They also adhere to the Hipparchus rule, faithfully showing the constellations from their backs, given that these are external perspective charts (which is notable given that Islamic cartographers regularly ignored the Hipparchus rule).[45] The Vienna maps appear to have influenced several celestial globes, including that of Hans Dorn from 1480 and that of Johannes Stöffler from 1493.[46]

Around the turn of the sixteenth century, polar projection star maps shifted from the equidistant to the stereographic projection, which had been well established centuries earlier on astrolabes.[47] This change to the stereographic is exhibited by the next extant maps in the early Renaissance chronology—a pair of northern and southern hemispheres from 1503 (now in Nuremberg, and hereafter referred to as the Nuremberg maps).[48] These planispheres seem to be derived from a map in the tradition of the ca. 1440 Vienna maps; they share the epoch 1424 as well as similar artistry and a star-numbering system that corresponds to that used in the Ptolemaic catalog. There may also be evidence for at least one other pair of manuscript maps in this tradition, said to have been owned by Johannes Regiomontanus, and perhaps also a set that predates the ca. 1440 Vienna maps.[49]

Individual-Constellation Illustrations in the Early Renaissance

By the beginning of the fifteenth century, the rendering of individual constellations had split into two strains: one continued in the decorative tradition of the Middle Ages, while the other began to render star positions in keeping with the actual appearance of the night sky. Both traditions seem to have been influenced by Islamic maps and globes and the reimportation of classical authors, although to different extents.

Decorative manuscript images of individual constellations began to coalesce into a more uniform iconography, regardless of which text they were illustrating.[50] Reflecting Renaissance scholars' renewed interest in the scholarship of the classical period, the selection of illuminated texts narrowed: Caius Julius Hyginus and the Germanicus edition of the "Aratea" predominated, with occasional reference to works by other authors, such as the "Astronomicon" by the Renaissance humanist Basinio da Parma.[51] As with earlier medieval illustrations, certain constellation figures manifest Islamic attributes, but the overall aesthetic followed Western European traditions.

Early Renaissance illuminations that did indeed map the stars as seen in the sky were comparatively rare, as was the case with medieval manuscripts. Several maps of the Sufi Latinus corpus of manuscripts date to the early Renaissance.[52] Other manuscript maps of individual constellations from the Renaissance, which depict rea-

42. Vienna, Österreichische Nationalbibliothek (Cod. 5415). Durand attributes these maps to "Magister Reinhardus" at Salzburg in 1434 (*Vienna-Klosterneuberg,* 116). For more information, see Saxl, *Die Handschriften der National-Bibliothek in Wien,* 25 and 150–55, and pls. IX and X.

43. Such as Paris, Bibliothèque Nationale (Arsenal MS. 1036).

44. Kunitzsch, however, asserts that they are not part of the Sufi Latinus corpus ("Astronomer Abu 'l-Ḥusayn al-Ṣūfī," 6 n. 3).

45. Elly Dekker, "From Blaeu to Coronelli: Constellations on Seventeenth-Century Globes," in *Catalogue of Orbs, Spheres and Globes,* by Elly Dekker (Florence: Giuti, 2004), 52–63, esp. 56, and Savage-Smith, "Celestial Mapping," 60–61.

46. Dekker, "Andromède," 409. The Stöffler globe also exhibits influence from Hyginus constellation illustrations, and there is also an anonymous globe influenced by these maps. The Dorn globe was owned by Martin Bylica and is described in detail in Ameisenowa, *Globe of Martin Bylica;* see esp. 36–41 for the relationship to the Vienna maps, and see also Savage-Smith, "Celestial Mapping," 60–61.

47. Very few polar projection maps used the equidistant projection after this point, most notably those of Peter Apian, Lucas Jansz. Waghenaer, and Johannes Bayer.

48. Germanisches Nationalmuseum; see *Focus Behaim Globus,* 2: 519–21, and W. Voss, "Eine Himmelskarte vom Jahre 1503 mit den Wahrzeichen des Wiener Poetenkollegiums als Vorlage Albrecht Dürers," *Jahrbuch der Preussischen Kunstsammlungen* 64 (1943): 89–150. For an English account of these charts and their relationship to a nonextant celestial globe that belonged to Conrad Celtis, professor at the University of Vienna around the turn of the sixteenth century, and also to the celestial globe of Martin Bylica, see Ameisenowa, *Globe of Martin Bylica,* 47–55.

49. Ameisenowa, *Globe of Martin Bylica,* 40.

50. McGurk, *Astrological Manuscripts in Italian Libraries,* xxi.

51. McGurk, *Astrological Manuscripts in Italian Libraries,* xxi. McGurk also lists copies of Michael Scot, Ludovicus de Angulo, and the Alphonsine Tables as other illustrated fifteenth-century manuscripts, with limited copies of the Aratus Latinus and the Ciceronian Aratea, and no copies of the Carolingian Pseudo-Bedan and anonymous star catalogs.

52. Such as the Vienna and the Catania; for Vienna (MS. 5318 [1474]), see Saxl, *Die Handschriften der National-Bibliothek in Wien,* 132–41, and for Catania (MS. 85 [fifteenth century]), see McGurk, *Astrological Manuscripts in Italian Libraries,* 10–16.

sonably accurate star configurations, do not seem to be stylistically influenced by the al-Ṣūfī maps.[53]

The presence of individual-constellation star maps that corresponded to actual star configurations had little impact on *printed* constellation images during the earliest years of the Renaissance. Such illustrations continued in the decorative tradition, with Hyginus and Aratus manuscripts predominating as sources for constellation information. This attests to an interest in the constellation myths in those publications rather than any scientific content pertaining to observing the sky. Erhard Ratdolt appears to have been the first to publish constellation illustrations in 1482 in an edition of Hyginus's *Poeticon astronomicon.* Although no one has identified a particular manuscript that served as a model for Ratdolt's illustrations, the figures in several Renaissance constellation manuscripts exhibit similarities to his figures.[54] Ratdolt's edition served, in turn, as a model for many other illustrated editions of both the *Poeticon astronomicon* and Aratus's *Phaenomena.*[55]

Astrological texts, on occasion, also included constellation illustrations, especially for sections on the zodiac. For example, Ratdolt's 1489 edition of a Latin translation of the *Kitāb al-qirānāt* (Book of conjunctions) by Abū Maʿshar Jaʿfar ibn Muḥammad al-Balkhī illustrates the zodiacal constellations with the woodblocks used in his 1485 edition of Hyginus's text.[56] Although most early printed constellation images seem to be limited to either the Hyginus or Aratus texts or images derived from them, there appear to be at least a few works that contain illustrations of some of the anomalous constellations reported by Michael Scot.[57]

The impact of printing on the dissemination of text and image turned the *Poeticon Astronomicon* and *Phaenomena* into popular Renaissance texts. It was not until 1540, with the publication of Alessandro Piccolomini's star atlas (discussed later), that the stellar placements within *printed* individual maps of the constellations resembled those seen in the night sky. The copying of manuscript sources for constellation illustrations continued even as late as 1600 with the publication of Hugo Grotius's elaborate edition of the *Phaenomena.* The artist Jacob de Gheyn III made nearly exact renderings of the illustrations contained in a Carolingian Aratus manuscript, the Leiden "Aratea" (figs. 4.3 and 4.4).[58]

Early Renaissance Printed Planispheres and Planisphere-like Maps

As with the first printed constellation illustrations, the first printed planisphere-like map followed an older medieval model that predated the Islamic-influenced advances in celestial mapping of the early fifteenth century. Contained in the aforementioned Pisanus edition of the *Phaenomena,*[59] it may be traceable to particular manuscript sources, although it is a mirror image of possible models.[60] Like its sources, the planisphere-like map lacks stars and simply shows the general arrangement of the constellation figures, with the north celestial pole at the center and the boundary of visibility at the edge.[61]

53. For Vienna (MS. 5415), see Saxl, *Die Handschriften der National-Bibliothek in Wien,* 150–55. For information correcting Saxl about this manuscript, see Kunitzsch, "Astronomer Abu 'l-Ḥusayn al-Ṣūfī," 67 n. 36. For the fifteenth-century Florence manuscript, Biblioteca Nazionale Centrale (MS. Angeli 1147 A. 6), see McGurk, *Astrological Manuscripts in Italian Libraries,* 33.

54. Such as Vatican City, Biblioteca Apostolica Vaticana (Urb. Lat. 1358), and Florence, Biblioteca Medicea Laurenziana (Cod. Plut. 89); see Saxl with Meier, *Handschriften in Englischen Bibliotheken,* pt. 1, lvii–lviii.

55. For example, Thomas de Blavis, a fellow Venetian printer, copied the second edition (1485) of Ratdolt's work, creating mirror images of Ratdolt's constellations during the process of tracing them onto new woodblocks. Many of these reversed (and artistically cruder) printing blocks were then used in a 1488 edition of the *Phaenomena* published by Antonius de Strata and edited by Victor Pisanus. Ara, Boötes, and the Pleiades have been replaced with wood-engraved images, presumably because the publisher was lacking these particular woodblocks. These particular representations of Boötes and Ara deviate from the standard models.

An unusual example of an early *Poeticon astronomicon* edition is one published by Melchior Sessa (Venice, 1512). A later edition was published in 1517 by Sessa with Pietro di Ravani. Many of the constellation illustrations differ dramatically from those by Ratdolt and his imitators. Some descriptions of star placements and numbers of stars have been altered to be in keeping with Ptolemaic star positions (the source for the revised star numbers and positions is unclear; they closely resemble those of Ptolemy, but do not correspond exactly), and the illustrations that accompany these altered passages reflect the new text. Certain maps, such as those for Ursa Major and Taurus, seem to reflect the influence of direct observation of the night sky. Some constellations, however, mimic earlier models, particularly those in the southernmost part of the sky; the illustrations for these constellations derive from Ratdolt.

56. Ten of the woodblocks are reused; the woodblock that fused the figures of Scorpio and Libra was recut so as to create two separate illustrations.

57. Warner mentions an anonymous work, *Astronomia Teutsch, Himmels Lauf, Wirckung unnd Natürlich Influenz der Planeten unnd Gestirn . . .* (Frankfurt, 1578) that depicts Michael Scot's constellations Tarabellum and Vexillum. She surmises that the anonymous *Eyn newes complexions-buchlein* (Strassburg: Jakob Cammerlander, 1536), which is an illustrated Michael Scot text, likewise contains images of these two constellations (*Sky Explored,* 272–73).

58. Leiden, Bibliotheek der Rijksuniversiteit (MS. Voss. Lat. Q. 79). Warner's assertion that the de Gheyn illustrations derive from the Ratdolt images is incorrect. For more information on the Leiden "Aratea," see Ranee Katzenstein and Emilie Savage-Smith, *The Leiden Aratea: Ancient Constellations in a Medieval Manuscript* (Malibu, Calif.: J. Paul Getty Museum, 1988), and Dekker, "Blaeu to Coronelli."

59. Warner, *Sky Explored,* 270.

60. Possible models include the manuscript maps in the Pierpont Morgan Library, New York (Giovanni Cinico, Naples, 1469), and the BL (Add. MS. 15819).

61. As happened with individual constellation images, this map was copied and reprinted in other texts, such as *Scriptores astronomici veteres,* 2 vols. (Venice: Aldus Manutius, 1499). The map is not derived from Ratdolt, as were the other illustrations in the volumes.

Albrecht Dürer was the first to publish scientifically rigorous star charts in 1515; they derive from manuscript sources—either the Vienna ca. 1440 maps or the Nuremberg 1503 maps.[62] Dürer created this pair of planispheres in collaboration with two mathematicians: Johannes Stabius, who drew the coordinates, and Conrad Heinfogel, who positioned the stars; Dürer was responsible for the artistry of the constellation figures surrounding the stars.[63] Dürer's charts closely resemble the manuscript predecessors, including his labeling of the stars with numbers corresponding to those in the Ptolemaic catalog. As with the 1503 Nuremberg maps, they employ the stereographic projection. The corners of the northern map contain drawings of four figures that reference the influence of classical and Arabic authors (Aratus, Manilius, Ptolemy, and al-Ṣūfī). The Dürer charts influenced the style of many subsequent planispheres and planisphere-like maps, individual-constellation maps, specialized charts, and globes.[64] In 1537, Gemma Frisius copied Dürer's charts nearly exactly for a globe, creating essentially a three-dimensional version of the two maps fused together along the ecliptic.[65] François Demongenet, who produced celestial globes in 1552 and ca. 1560, appears to have been influenced by the Dürer tradition, although he added elements such as the hunting dogs of Boötes, Caspar Vopel's constellation Antinous, and a figure in the constellation Eridanus.[66] Demongenet's work in turn served as source material for the elaborate celestial ceiling by Giovanni Antonio Vanosino (ca. 1575) in the Sala del Mappamondo at Caprarola, as well as globes by a variety of makers.[67] The Dürer maps also helped to popularize the representation of the constellation Lyra as a hybrid of an eagle and a lyre; the roots for such iconography can be traced to Islamic influence.[68]

As popular as the Dürer charts, if not more so, was a pair of planispheres by Johannes Honter, published initially in 1532.[69] Honter was obviously influenced by the Dürer maps, but made significant changes. He reversed the perspective of the stars from external to internal, as well as changing the artistry to reflect a less classical aesthetic. Curiously, Honter constructed these star charts

62. Dekker mentions the source as "an earlier manuscript map dated 1440" (presumably the Vienna Cod. 5415 maps); see Dekker, "Conspicuous Features," 81. Warner says that the source could be "the star catalog and planisphere in the mid-fifteenth-century Viennese astronomical manuscript (Vienna Codex 5415)" or "the manuscript planisphere of 1503, drawn by an anonymous artist of Nuremberg in collaboration with Conrad Heinfogel, Sebastian Sperantius, and Theodore Ulsenius." This is because of similar mistakes in labeling the stars; see Warner, *Sky Explored,* 71–75, quotations on 74. Ameisenowa surmises that Dürer's model may have been a manuscript chart that is no longer extant (*Globe of Martin Bylica,* 40–44). See also the extensive article linking Dürer's work to the 1503 manuscript planisphere, Voss, "Eine Himmelskarte vom Jahre 1503"; the detailed description of the charts in Rosenfeld, "Celestial Maps and Globes and Star Catalogues," 154–72; and articles by Edmund Weiss, "Albrecht Dürer's geographische, astronomische und astrologische Tafeln," *Jahrbuch der Kunsthistorischen Sammlungen des Allerhöchsten Kaiserhauses* 7 (1888): 207–20, and Günther Hamann, "Albrecht Dürers Erd- und Himmelskarten," in *Albrecht Dürers Umwelt: Festschrift zum 500. Geburtstag Albrecht Dürers am 21. Mai 1971* (Nuremberg: Selbstverlag des Vereins für Geschichte der Stadt Nürnberg, 1971), 152–77.

63. The roles of the three men are clearly described in the attribution on the southern hemisphere map.

64. Maps include those by Eufrosino della Volpaia (1530), Peter Apian (1536 and 1540), Caspar Vopel (1545), and several anonymous versions. Volpaia included non-Ptolemaic southern hemisphere stars according to Andrea Corsali. Apian's original map, *Imagines syderum coelestium . . .* (Ingolstadt, 1536), was reprinted as a volvelle in the *Astronomicum Caesareum* (Ingolstadt, 1540), which was an important work in the history of astronomy, filled with volvelles (mostly planetary). In contrast to Dürer, however, Apian employed the polar equidistant projection instead of the stereographic. Apian also slightly modified Dürer's figures, adding the hunting dogs to Boötes and a figure in Eridanus; the hunting dogs had previously appeared on the 1493 manuscript globe of Johannes Stöffler (for more information on this globe, see the entry by Elly Dekker in *Focus Behaim Globus,* 2:516–18). The Apian map was copied in turn by James Bassantin in *Astronomique discours* (Lyons, 1557); see Warner, *Sky Explored,* 10, and Dekker, "Conspicuous Features," 81. For a detailed account of Apian and his work, including his connections to Islamic source material, see Paul Kunitzsch, *Peter Apian und Azophi: Arabische Sternbilder in Ingolstadt im frühen 16. Jahrhundert* (Munich: Bayerische Akademie der Wissenschaften, 1986). Individual constellation maps include those by Heinrich Decimator (1587) and Zacharias Bornmann (1596). Specialized charts include those of Cornelius Gemma (of the comet of 1577) and Thaddaeus Hagecius ab Hagek (of the nova of 1572 and the comet of 1577). Further information on all two-dimensional maps cited in this note can be found in Warner, *Sky Explored.* The globes include, in addition to the Gemma Frisius and Demongenet works mentioned in the text, one from 1506 by Johannes Prätorius; see Dekker in *Focus Behaim Globus,* 2: 637–38. For a study of six globes from the mid-sixteenth century, see Dekker, "Conspicuous Features," in which she uses the Dürer maps as a basis for comparison.

65. The only significant difference is the constellation Eridanus; see Elly Dekker, "Uncommonly Handsome Globes," in *Globes at Greenwich,* 87–136, esp. 87–91 (including complete photographic documentation); idem, "Conspicuous Features"; and Elly Dekker and Peter van der Krogt, "Les globes," in *Gérard Mercator cosmographe: Les temps et l'espace,* ed. Marcel Watelet (Antwerp: Fonds Mercator, 1994), 242–67, esp. 263–66.

66. The 1552 gores included only the hunting dogs. For more on the Demongenet tradition, see Elly Dekker, "The Demongenet Tradition in Globe Making," in *Globes at Greenwich,* 69–74.

67. For other Demongenet-influenced globes, see Dekker, "Demongenet Tradition," 72. For more on the Caprarola celestial ceiling, see Loren W. Partridge, "The Room of Maps at Caprarola, 1573–75," *Art Bulletin* 77 (1995): 413–44; Kristen Lippincott, "Two Astrological Ceilings Reconsidered: The *Sala di Galatea* in the Villa Farnesina and the *Sala del Mappamondo* at Caprarola," *Journal of the Warburg and Courtauld Institutes* 53 (1990): 185–207; and Deborah Jean Warner, "The Celestial Cartography of Giovanni Antonio Vanosino da Varese," *Journal of the Warburg and Courtauld Institutes* 34 (1971): 336–37. Vanosino also created the celestial ceiling in the Sala Bologna in the Vatican.

68. For more information on this particular manifestation of Lyra, see Paul Kunitzsch, "Peter Apian and 'Azophi': Arabic Constellations in Renaissance Astronomy," *Journal for the History of Astronomy* 18 (1987): 117–24, esp. 122, or idem, *Peter Apian und Azophi,* 45–50.

69. Warner, *Sky Explored,* 123.

FIG. 4.8. AN ASTROLABE-LIKE STAR MAP, 1596. Not only a mapmaker, but an instrumentmaker as well, John Blagrave designed this map as part of his work describing one of his inventions, the Uranical astrolabe. The design of the map reflects the rete of a traditional astrolabe. It is also a good example of a single planispheric star map that shows only the sky visible from Europe. Notice that the outside boundary is not the ecliptic or celestial equator, as might have been expected at this time, but instead a latitude somewhat south of the Tropic of Capricorn (which is not marked on this map because it is in ecliptic rather than equatorial coordinates). Although in most respects the style of Blagrave's figures follows Mercator, Lyra is quite different, looking somewhat like the Dürer model.
Size of the original: ca. 25.7 × 25.7 cm. "Astrolabium vranicum generale" (London, 1596). Photograph courtesy of the BL (Harl. MS. 5935, fol. 14).

with the coordinate system shifted by thirty degrees longitude from what would have been correct for the date, putting the vernal equinox in the constellation Aries. It is unclear whether Honter intended the maps to be for an ancient epoch or if this was an unintentional mistake. Despite their lack of utility for the epoch in which they were published, this pair of maps was republished numerous times, in 1541, 1553, 1559, and 1576, as the woodblocks changed hands between various publishers.[70] This may indicate that the pair of maps was not actually used for serious scientific work, but rather was intended to merely illustrate the classical texts they were accompanying, which included an edition of Ptolemy's *Almagest* and several *Aratea* editions.[71]

The manuscript maps of the fifteenth century and those of Dürer and Honter mark a drastic change in the construction of star maps.[72] These new, scientifically rigorous maps plotted the stars according to the celestial coordinates assigned to them, resulting in significantly more accurate representations of stellar patterns. In addition, polar projection charts of the northern and southern celestial hemispheres (either stereographic or equidistant) became the typical way in which mapmakers rendered the entire celestial sphere, in contrast to maps of individual constellations that focused on small sections of the sky.[73] Even at the end of the sixteenth century, when mapmakers began to use models other than Dürer or Honter, they still regularly employed a pair of polar projections. For example, Thomas Hood's maps from 1590 show the influence of Gerardus Mercator's celestial globe of 1551, but retain the double hemisphere format.

Occasionally, post-Dürer maps hearkened back to an earlier model, one often seen in manuscript planispheres and planisphere-like maps and likely influenced by astrolabe retes. A single polar projection map was drawn that encompassed the entire visible sky rather than drawing two maps representing the entire sky (including those parts not visible). In contrast to astrolabe retes, however, such maps were not limited to the brightest stars and included constellation figures. The format made sense, because at this time much of the center of the southern hemisphere maps (beyond the boundary of visibility for Europeans) contained expanses of blank space as the southernmost stars had not been recorded adequately, if at all. Peter Apian seems to have been the first to create a detailed map of this sort in 1536, followed by John Blagrave in 1596 (fig. 4.8); such printed maps were relatively rare in the Renaissance.[74]

Early Atlases

In 1540, Alessandro Piccolomini created what might be called the first star atlas. Writing in the vernacular (Italian, in this case) rather than Latin, Piccolomini sought to expand his audience beyond scholarly confines. *De le stelle fisse* featured individual maps for each of the Ptolemaic constellations, rendered from an internal perspective.[75] In contrast to those who had produced earlier works, however, Piccolomini charted the stars simply, with no adornment from constellation figures (fig. 4.9), a feature unique to atlases (although not single maps) until the late seventeenth century, except for Julius Schiller's published counterproofs (discussed later). Piccolomini's maps lacked grid lines and were designed to be read with the assistance of a device that would enable the user to determine star positions.[76] His atlas also attempted to create a system of nomenclature for the stars; in contrast to the Dürer charts and their manuscript predecessors, which assigned numbers to the stars, Piccolomini's used letters, with the brightest star typically labeled "a" and subsequent letters assigned based on decreasing magnitude, a system similar to that employed by Johannes Bayer over sixty years later.

Other attempts at star atlases followed those of Piccolomini: Heinrich Decimator published *Libellus de stellis fixis et erraticis* in 1587, and Giovanni Paolo Gallucci published *Theatrum mundi, et temporis . . .* in 1588. Although different in many respects, the two works, likely created independently despite their closeness in date, feature grid lines and constellation figures, and would allow a user to locate star patterns or individual stars more easily than Piccolomini's atlas. Decimator's charts seem to have been copied from either a chart or globe in the Dürer tradition, although from which specific work it is un-

70. The 1541 republication illustrated the Ptolemaic star catalog in Claudius Ptolemy, *Omnia, quae extant opera, geographia excepta* (Basel: Henrich Petri, 1541). Other republications are listed in Warner, *Sky Explored,* 123–26.

71. The Honter maps served as inspiration for a number of other makers, including Adam Gefugius (1565), Lucilio Maggi (1565), Jan Januszowski (1585), and Simon Girault (1592); they also seem to have influenced the style of certain figures (although not the overall star map) of Jost Amman (1564). See individual entries in Warner, *Sky Explored.* The Amman map is listed in *Sky Explored,* 274, as "Anonymous VII"; it has a terrestrial mate listed in Rodney W. Shirley, *The Mapping of the World: Early Printed World Maps, 1472–1700,* 4th ed. (Riverside, Conn.: Early World, 2001), 129 and 132 (no. 113), which mentions the celestial companion.

72. For a brief discussion of the projections employed by these two cartographers, see Snyder, *Flattening the Earth,* 22–23.

73. Snyder asserts that the equidistant was "only half as popular for polar celestial maps as the stereographic"(*Flattening the Earth,* 29).

74. See Savage-Smith, "Celestial Mapping," 15, for a diagram of a polar stereographic projection as it pertains to a Byzantine map, which also helps to explain maps such as Blagrave's that extend to the boundary of visibility.

75. For detailed information about Piccolomini and his atlas, see Rufus Suter, "The Scientific Work of Allesandro Piccolomini," *Isis* 60 (1969): 210–22.

76. Suter, "Allesandro Piccolomini," 221.

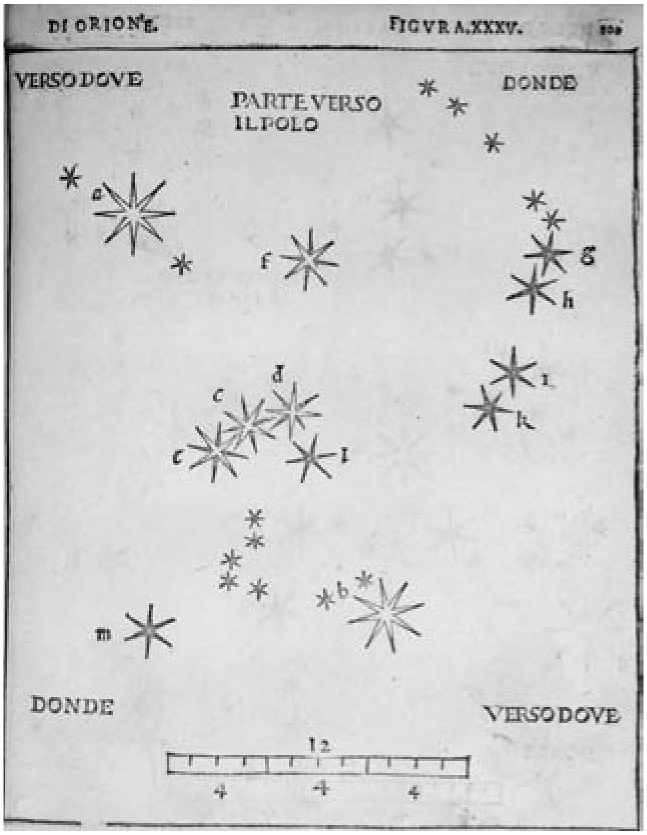

FIG. 4.9. ORION, FROM THE FIRST EDITION OF PICCOLOMINI'S *DE LE STELLE FISSE,* 1540. This atlas is unusual for the time because the stars are unadorned with decorative constellation figures. It may have been the first work of celestial cartography intended specifically for a popular audience; it was written in the vernacular (Italian, in this case) and dedicated to Lady Laudomia Forteguerri, with the intention that she (and others) use it to educate themselves about the stars. *De le stelle fisse*'s numerous republications in several languages attest to its popularity. Note the three bright stars forming Orion's belt in the center of the image (labeled *c, d,* and *e*).
Photograph courtesy of the Adler.

clear.[77] The stars seem to be numbered according to the Ptolemaic catalog, although again there are variations.[78] Information about the constellations, compiled from a variety of sources, accompanies each map.

Gallucci's *Theatrum mundi, et temporis* is a comprehensive six-book volume about astronomy and geography noted for its numerous volvelles.[79] The maps are more complicated than those of Decimator. Gallucci rendered the charts using a trapezoidal projection, and he substantially increased the number of grid lines over any maps previously published, enabling the user to more easily read star coordinate positions off of the charts. The constellation figures in this atlas are extremely rudimentary, rough outlines of the overall shapes of the figures, and their source is unclear. Some scholars have deemed Gallucci's atlas the first "true" star atlas, as rough coordinates of the stars can be determined from the charts themselves without reference to a star catalog or other aid.[80] Yet, although *Theatrum mundi, et temporis* included a star catalog, there is no attempt at labeling the stars to correspond to the catalog, another feature that would have enhanced its utility. It was not until the next century that all the sixteenth-century modifications designed to enhance practical use—internal perspective, a system of stellar numbering/nomenclature, map grids, and scales, introduced by such cartographers as Dürer, Honter, Piccolomini, and Gallucci—would be synthesized into a single atlas.

Trends and Changes Regarding Iconography and Format

The overall aesthetic of most celestial maps during the sixteenth and early seventeenth century appeared relatively similar whether their makers used Dürer, Honter, Mercator, or another artistic tradition as inspiration. There were some notable exceptions to the aesthetic of elaborate constellation figures adorning the stars. Drawing perhaps upon Piccolomini's charts that represented the stars with no constellation figures, a few large-scale maps were published in this spartan form. Guillaume Postel appears to have been the first to create a pair of planispheres, in 1553,[81] followed by Lucas Jansz. Waghenaer, whose popular navigational maps were first printed in 1584.[82]

Most sixteenth-century star charts illustrated the Ptolemaic constellations, with the exception of editions of Hyginus and Aratus. A few maps, however, began to include the new constellations that had been introduced by such map and globe makers as Vopel and Plancius.[83] At least one chart, however, presented constellation figures never

77. There are slight differences between the Decimator charts and the Dürer charts. For example, in the Decimator charts Lyra lacks strings and the face of Ophiuchus is quite different. The Decimator charts also contain an increased number of grid lines, similar to Dürer tradition charts such as Warner's "Anonymous III" or a globe (*Sky Explored,* 271).

78. For example, Taurus has thirty-four stars numbered instead of the thirty-three on the Dürer charts.

79. Gallucci's work was published in several editions (Warner, *Sky Explored,* 91).

80. For example, see Warner, *Sky Explored,* xi.

81. In Guillaume Postel, *Signorum coelestium vera configuratio aut asterismus* . . . (Paris: Jerome de Gourmont, 1553).

82. Lucas Jansz. Waghenaer, *Spieghel der zeevaerdt* (Leiden: Christoffel Plantijn, 1584–85); for more information and other editions, see C. Koeman, *Atlantes Neerlandici: Bibliography of Terrestrial, Maritime, and Celestial Atlases and Pilot Books Published in the Netherlands Up to 1880,* 6 vols. (Amsterdam: Theatrum Orbis Terrarum, 1967–85), 4: 465–501.

83. For example, Coma Berenices appears in Amman (1564) and Januszowski (1585), and Antinous appears on a Cornelius Gemma comet chart of 1578 (discussed later in this chapter).

before seen on European works: Peter Apian included several traditional Bedouin constellations in the chart that appeared in his *Instrument Buch* and *Horoscopion.*[84]

In the mid-sixteenth century, polar projection celestial maps began to appear as small insets on maps of the world (for example, see fig. 3.9). Vopel seems to have been the first to include such charts on his large wall map of 1545. This map is now lost,[85] but the Bernard van den Putte reissue of 1570 shows that, as with Vopel's celestial globe, the original chart would likely have followed in the Dürer tradition, with the addition of Vopel's Coma Berenices and Antinous; the 1570 reissue even goes so far as to include mirror images of the four personages that inhabit the corners of Dürer's northern hemisphere map, although it is unknown whether this feature was present in the original edition.

Soon thereafter, numerous mapmakers from all areas of Europe began including similar inset charts on their world maps, continuing this tradition well into the seventeenth century; many of these cartographers never published separately issued celestial charts of their own.[86] Copies and reprintings of these and other similar maps comprise at least several dozen known instances of star charts inset into world maps from the mid-sixteenth to the late seventeenth century.[87]

Nearly all star maps inset into world maps view the sky from an external perspective; early charts follow in the tradition of Dürer, while later charts draw upon the newly created artistic traditions of such map and globe makers as Mercator, Hondius, and Blaeu.[88] Only a few employ an internal perpective, most notably the ca. 1561 map of Giacomo Gastaldi (but not the Matteo Pagano ca. 1550 copy of his 1546 map) and the 1582 map of Postel; both cartographers used the Honter charts as source material for their insets. Gerard de Jode's map includes only one star map, rather than a pair, and it is rendered in what appears to be an oblique orthographic projection to give it a globelike appearance. As cartographers drafted new constellations, they added them to the inset maps.[89] Although small and often overlooked, star charts included on world maps provided a widespread form of access to stellar information. During the first half of the seventeenth century, they by far outnumbered separately issued star maps.

Despite the overwhelming popularity of the equatorial stereographic projection for world maps, there were few attempts in the fifteenth and sixteenth centuries at creating star maps that showed a large region of the sky in any format other than that of polar projections of the north and south celestial hemispheres. The equatorial format was not commonly seen until the mid- to late seventeenth century.[90] One exception can be found in *Globe du monde, contenant un bref traité du ciel & de la terre* (1592), a book designed by Simon Girault to teach astronomy to his children. In addition to including rough copies of the Honter charts, Girault created a pair of equatorial hemispherical maps (fig. 4.10). They are quite crude, however and merely contain the outlines of the figures without stars.[91] Occasionally cartographers also employed formats that gave their maps a globelike appearance; this seems to have been the case most often with maps of comet paths.[92] For regional maps, such as those in atlases like Gallucci's *Theatrum mundi,* and some topical maps, such as comet path maps, the trapezoidal projection became the favored choice.

Bayer's *Uranometria:* A Model for the Future

Johannes Bayer's *Uranometria* broke new ground in the history of star charts. Published in Augsburg in 1603, the *Uranometria* far surpassed any celestial atlas or map created before it, in both scope and artistry. Alexander Mair

84. Both works were published in Ingolstadt in 1533. This chart was described in great detail in Savage-Smith, "Celestial Mapping," 61–62; Kunitzsch, "Peter Apian and 'Azophi,'" 117–24; and idem, *Peter Apian und Azophi.*

85. For the copies of Vopel's map, see Jerónimo Girava (1556), Giovanni Andrea Valvassore (1558), and Bernard van den Putte (1570); they are described in Shirley, *Mapping of the World,* 114–17 (nos. 101–2), 146 and 148–49 (no. 123). The 1556 edition is a very sketchy copy, whereas the other two can be considered much closer to the original.

86. Maps included those by Giacomo Gastaldi and Matteo Pagano (ca. 1550), Giacomo Gastaldi (and others) (ca. 1561), Gerard de Jode (1571), Guillaume Postel (1582), Petrus Plancius (1592 and 1594), Willem Jansz. Blaeu (ca. 1608 and 1619), Jodocus Hondius Jr. (1617), John Speed (1626), Cornelis Danckerts (1628), Jean Boisseau (1636 and ca. 1645), Claes Jansz. Visscher (1638), Melchior II Tavernier (1643), Joan Blaeu (1648), Nicolas I Berey (ca. 1650), and Hugo Allard (ca. 1652).

87. Further information on all of these charts can be found in Shirley, *Mapping of the World.* It is unclear as to whether the Gastaldi 1546 map was originally designed to have inset celestial maps, as does the Pagano copy; the only extant copy of the earlier map is a proof that lacks the border illustrations.

88. For more information on the influence and development of different artistic styles as they relate to Renaissance celestial globes and star charts, see Dekker, "Blaeu to Coronelli."

89. For example, the aforementioned Vopel example; Plancius first published his new constellations Columba and Polophylax on his 1592 world map, including Crux, Triangulum Australe, and the Magellanic Clouds that he had introduced on his 1589 globe.

90. It is possible that there were instances of equatorial celestial hemispheres inset into world maps during the sixteenth century, although none survive from that period. A 1795 copy of a map presumably from 1559 contains such star charts (Shirley, *Mapping of the World,* 118–19 [no. 103]).

91. It is doubtful that Girault devised this map himself given the crude artistry, history of copying from other makers, and likely precedent for the existence of equatorial maps during the sixteenth century, although none survive.

92. For example, the 1533 Prugner comet map discussed later in this chapter. For information on globular and other globelike projections such as the oblique orthographic, see Snyder, *Flattening the Earth,* 14–18.

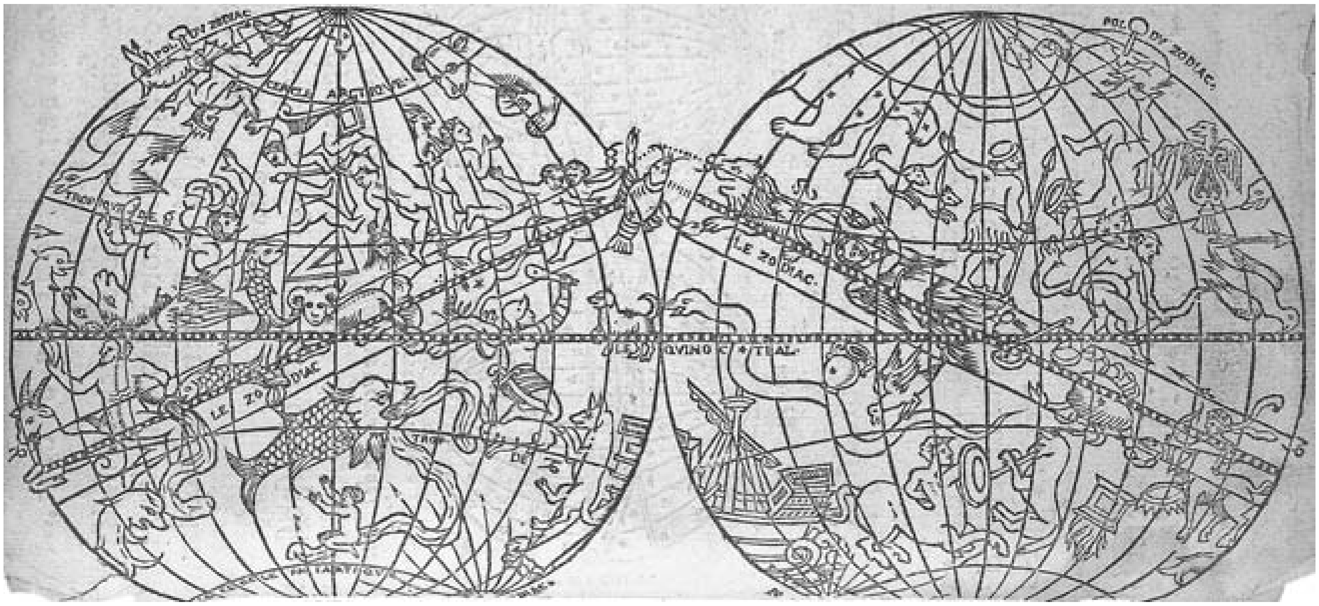

FIG. 4.10. EARLY EQUATORIAL CELESTIAL MAP, 1592. Simon Girault designed this map in part to show the points of intersection between the equator (labeled "le eqvinoctial") and the ecliptic (labeled "le zodiac"). The only stars indicated are those of the Big Dipper in Ursa Major, but presumably the other chart in his book—a pair of polar projection maps copied from Honter—fulfilled the need for illustrating the approximate patterns of the stars.
Simon Girault, *Globe du monde* (Langres: Iehan des Preyz, 1592), 37. Photograph courtesy of the Adler.

engraved the elegant illustrations, but rather than following the model of one particular star chart or globe, Mair (presumably in consultation with Bayer) seems to have relied on a variety of sources for guidance.[93] Prominent among them is Grotius's edition of Aratus, which Bayer quoted. However, several constellations were derived from other sources, and the Grotius models were often married with aspects of iconography from other constellation renderings such as Ratdolt's Hyginus illustrations and a Dutch Saenredam-style globe.[94]

Many of Bayer's constellation figures violate the Hipparchus rule. According to the rule, since Bayer's atlas mapped the stars from an internal perspective, the constellation figures that adorn the stars should have been depicted from the front. However, only some *Uranometria* figures face forward; others face backward. Whether this was due to Bayer's unfamiliarity with the Hipparchus rule or represented an intentional break with historical precedent is unclear.

Bayer plotted the stars in the *Uranometria* on a trapezoidal projection, and the star positions were determined largely from Tycho Brahe's 1,005-star catalog, which, although not yet published at this time, had been available in the form of manuscript copies and had been incorporated into several globes. For the southern sky, however, Bayer turned to Hondius's 1597/98 celestial globe, which featured constellations formed from Keyser and De Houtman's star positions. At the end of the volume, Bayer included the first printed two-dimensional map of these recently charted southern stars (see fig. 4.2).

Bayer's greatest legacy, perhaps, is the system of stellar nomenclature he introduced in the *Uranometria,* one that is still used today for most stars visible with the naked eye, although over half a century passed before other astronomers began to use Bayer's system.[95] Bayer departed from the Ptolemaic model, which used long and often ambiguous phrases of text to describe each star. He may have been influenced by Piccolomini's system, which labeled the stars with letters, or the Dürer maps and preceding manuscripts (including al-Ṣūfī manuscripts and European copies derived from them), which numbered the stars according to their order in the Ptolemaic catalog. Bayer's system, for most constellations, assigned the Greek letter alpha to the brightest star, then each subsequent Greek letter to the other stars in order of descend-

93. This is contrary to Warner's assertion that they came strictly from de Gheyn's illustrations in the Grotius Aratus (*Sky Explored,* 18). Certain constellations do correspond, such as Andromeda, Cassiopeia, Cetus, and some of the zodiac, but many others do not.

94. Bayer also incorporated the Islamic-influenced eagle-instrument combination for Lyra, although the design of the instrument part only is from the Grotius Aratus. For more information on Bayer's influences, see Dekker, "Blaeu to Coronelli," 55–57. For more on the Saenredam style, which refers to Jan Pietersz. Saenredam, the engraver of Blaeu's celestial gores of about 1598, see "Blaeu to Coronelli," 52 and 57.

95. Austin Royer was the first in 1679; see Warner, *Sky Explored,* 18.

ing brightness; when all twenty-four Greek letters had been used, Bayer switched to Latin letters.[96]

Curiously, the *Uranometria* inspired few copies, perhaps because it was republished in so many editions.[97] Aegidius Strauch, however, produced a tiny pocket atlas based on Bayer, *Astrognosia synoptice et methodice in usum gymnastorum academicum adornata* (Wittenberg, 1659), which lacks grid lines and the nomenclature system, and consequently was likely designed as a novelty rather than for actual use.

After Bayer's monumental publication, few star charts or atlases seem to have been published until the mid-seventeenth century, aside from the tiny star charts inset into world maps (discussed earlier).[98] Several publications appeared during the 1610s: an illustrated star catalog by Christoph Grienberger (1612) and a pair of celestial charts by Jodocus Hondius Jr. (1616). Also produced during this decade were a number of charts showing the path of the comet of 1618. Grienberger employed the gnomonic projection; he was the first to use this projection for a significant number of maps.[99] Only one chart is recorded from the 1630s: an unusual hand fan design embellished with tiny star charts by Melchior Tavernier (1639).[100] No separately issued star charts or atlases seem to have been drafted in the 1640s. The paucity of new star charts during the first half of the seventeenth century may also be due in part to possible decreased academic production during the Thirty Years War of 1618–48.

The 1620s, however, saw the publication of several charts and an atlas. In 1623, Wilhelm Schickard published a pair of conical star maps in his *Astroscopium, pro facillima stellarum cognitione noviter excogitatum;* the volume was republished in 1655. In addition to the innovative conical projection, Schickard provided alternate biblical names for a number of the traditional constellations.[101] The next year, Jakob Bartsch included three celestial maps in his *Usus astronomicus planisphaerii stellati . . .* (1624). Employing new formats for star charts, Bartsch devised two rectangular projection maps, each covering half of the zodiacal region, in addition to a polar projection chart of the night sky to somewhat outside the Tropic of Cancer. Additionally, Bartsch included all of the new biblical-themed constellations of Plancius. In a more traditional vein, Isaac Habrecht II published a pair of hemispherical charts in 1628 based on his globe of 1621, which was in turn based on the work of Plancius; these were the first two-dimensional maps to include the constellation Rhombus.[102]

Julius Schiller oversaw the production of *Coelum stellatum christianum*—the most significant of the star atlases published between Bayer's atlas and that of Johannes Hevelius (1690). Published posthumously in 1627, Schiller's atlas implemented a thorough and radical reworking of the constellations. Each constellation was transformed into a figure from the Bible, and elaborate new maps were engraved (fig. 4.11). No other cartographer had carried out such a detailed reassignment project—or has since. The maps, however, are often neglected by historians, perhaps dismissed because of the biblical content. Schiller's *Coelum stellatum christianum* was essentially a revision of Bayer's atlas, and Bayer himself consulted on the project. It incorporated an extensive amount of new material that had been published since 1603.[103] A team of scholars worked on the project, including Schickard, who had included many biblical identifications for constellations on his maps from 1623, and Bartsch, who finished the project after Schiller's death.

Schiller's atlas included fifty-one maps, forty-nine of which were centered on a constellation; some of the existing constellations were combined into larger star groups.[104] The twelve apostles replaced the zodiacal constellations, while figures from the New Testament populated the north celestial hemisphere, and figures from the Old Testament the South. Although they represented a revision of Bayer's internal perspective atlas, these maps employed an external perspective, likely so that they would be represented from a "God's-eye" view. Schiller produced a companion volume, *Coelum stellatum christianum concavum* (published in 1627), which featured counterproofs of the star maps before the figures had been engraved, resulting in internal perspective, stars-

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96. Certain of Bayer's constellations were labeled inconsistently. For a detailed description of Bayer's assignment of letters, see Joseph Ashbrook, "Johann Bayer and His Star Nomenclature," in his *The Astronomical Scrapbook: Skywatchers, Pioneers, and Seekers in Astronomy,* ed. Leif J. Robinson (Cambridge: Cambridge University Press, 1984), 411–18.

97. For a listing of later editions, see Warner, *Sky Explored,* 19.

98. The distribution of celestial charts in the first half of the seventeenth century is based on both the Warner survey of celestial charts in *Sky Explored* and that of Anna Friedman Herlihy in *Star Charts of the Adler Planetarium & Astronomy Museum* (Chicago: Adler Planetarium & Astronomy Museum, forthcoming).

99. Snyder, *Flattening the Earth,* 19. Johannes Kepler seems to be the first to have used this projection for a celestial map of the nova of 1604 (1606). Orazio Grassi also used this projection in his three comet maps (1619). The next significant use of this projection seems to have been by Ignace Gaston Pardies (1673).

100. Friedman, *Awestruck,* 16. It is not know whether this is Melchior I or Melchior II Tavernier.

101. For more about the use of conical projections in star charts, see Snyder, *Flattening the Earth,* 31 and 68. There has been little research about biblical constellation forming and renaming projects. For Christian interpretations of the zodiac, see the following detailed study: Wolfgang Hübner, *Zodiacus Christianus: Jüdisch-christliche Adaptationen des Tierkreises von der Antike bis zur Gegenwart* (Königstein: Hain, 1983).

102. Warner, *Sky Explored,* 104–5.

103. For details of the additions, see Warner, *Sky Explored,* 229–32.

104. For a complete listing of the biblical constellations and their traditional counterparts, see Warner, *Sky Explored,* 231.

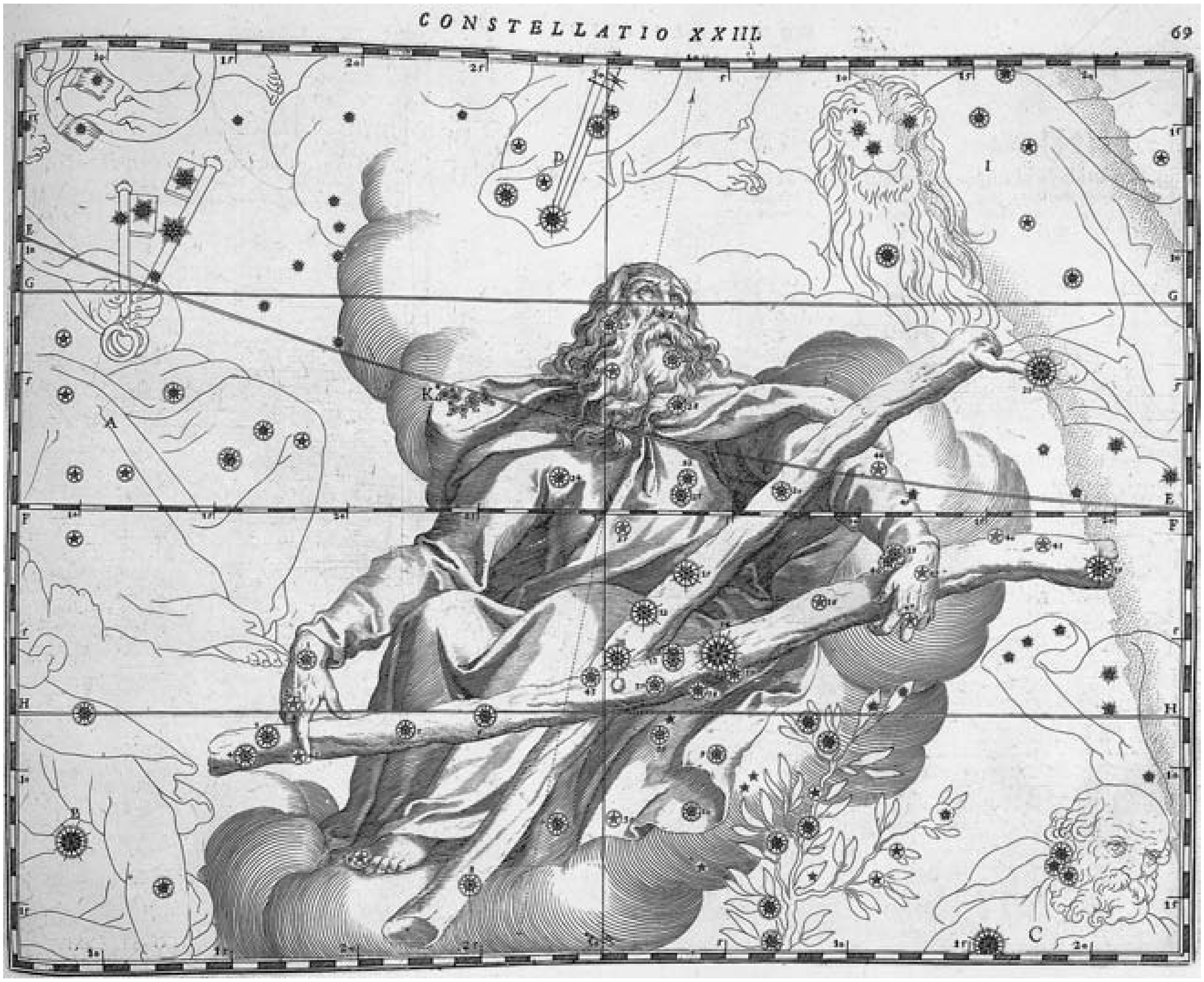

FIG. 4.11. ONE OF SCHILLER'S NEW BIBLICAL CONSTELLATIONS. Julius Schiller replaced the constellation Taurus with that of Saint Andrew. The V shape that makes up the horns and face of the bull in the traditional constellation constitutes half of the cross that Saint Andrew carries. The stars of the Pleaides are positioned in the figure's shoulder, transferring what had been in the shoulder of an animal to that of a man. Compare figure 4.12.
Julius Schiller, *Coelum stellatum christianum* (Augsburg, 1627). Photograph courtesy of the Adler.

only charts (fig. 4.12).[105] Two equatorial stereographic projection planispheres illustrated the entire heavens, later republished in a larger format in the *Harmonia macrocosmica seu atlas universalis et novus* (1660/61) of Andreas Cellarius.[106]

After the mid-seventeenth century, three sets of charts (ca. 1650) by Antoine de Fer, Melchior II Tavernier, and Pierre I Mariette marked the beginning of a flurry of celestial mapmaking, much of it influenced by the works of both Willem Jansz. and Joan Blaeu. The highly decorative maps of Andreas Cellarius in the *Harmonia macrocosmica* may have sparked the publication of many such maps throughout the last decades of the seventeenth century.

Specialized Star Charts

In this period, several specialized types of star charts emerged, intended to do more than merely map the locations of the stars. Many depicted the location of astronomical phenomena, while others demonstrated new dis-

105. Counterproofs are reverse images taken from freshly inked prints. Not all copies of the atlas have the counterproofs. An example at the Adler features stars-only proofs from an external perspective, despite having the "concave" title page. Additionally, at least one copy (in private hands) has counterproofs of the maps with the constellation figures.

106. Andreas Cellarius, *The Finest Atlas of the Heavens,* intro. and texts R. H. van Gent (Hong Kong: Taschen, 2006), and Warner, *Sky Explored,* 53–54.

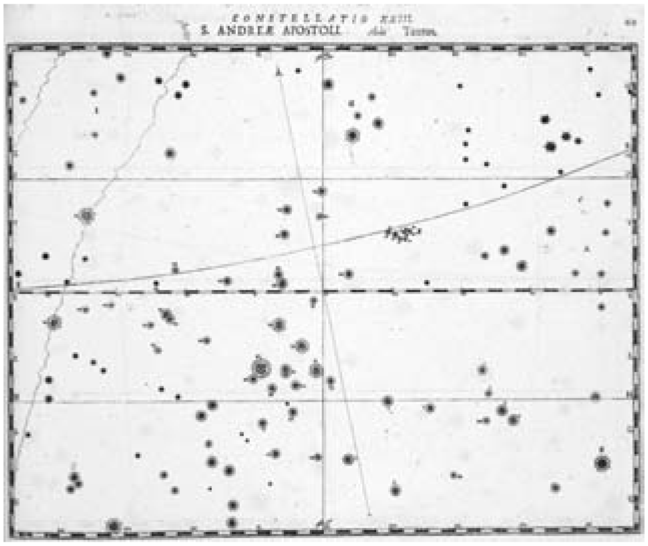

FIG. 4.12. PUBLISHED COUNTERPROOF OF SCHILLER'S CONSTELLATION SAINT ANDREW. This internal perspective star map is a mirror image of figure 4.11, although rendered without the constellation figures.
Julius Schiller, *Coelum stellatum christianum concavum* (Augsburg, 1627), 69. Photograph courtesy of the Linda Hall Library of Science, Engineering & Technology, Kansas City.

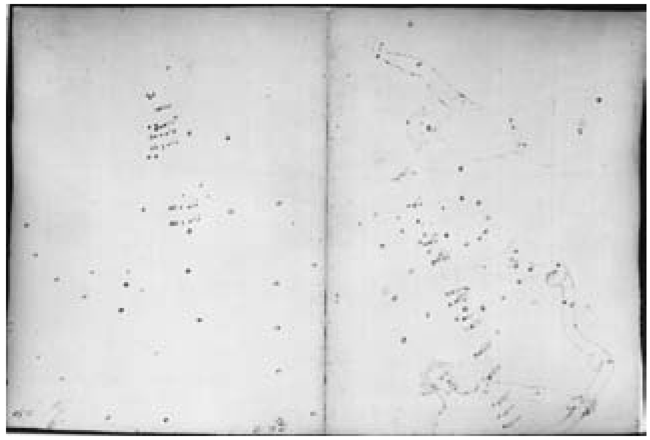

FIG. 4.13. COMET PATH MAP BY PAOLO DAL POZZO TOSCANELLI. Toscanelli's chart of the comet of 1449-50 clearly shows a linear progression against a backdrop of stars (with a few constellation figures sketched in). The length and direction of the tail and the date on which each observation was made are given.
Size of the original: 29.8 × 44.6 cm. Biblioteca Nazionale Centrale, Florence (Banco Rari 30, fols. 251v-250r). By concession of the Ministero per i Beni e le Attività Culturali della Repubblica Italiana.

coveries. Some showed readers how to use instruments that relied on stellar positions or how to use the stars themselves to solve problems. In contrast to large-scale charts and atlases, which on occasion also show phenomena and discoveries, specialized charts constitute a separate category because of their small, regional format and their topical focus on something other than a general mapping of the night sky, as well as their variable standards of mathematical and scientific exactness within the subgenre.

Charts that map the location and/or path of comets appear to be the first such specialized charts, as well as by far the most common. Significantly, a map of the path of a comet exhibits a new kind of mapping, one that is concerned with mapping movement across space rather than mapping static objects in space. A format of depicting the comet's path as linear became the most common way to chart these phenomena, particularly during the comet-rich seventeenth century. Medieval attempts to represent comet locations lacked the precision of Renaissance and later efforts, depicting decorative constellation images that only vaguely hinted at their place in the sky, if they suggested it at all.[107] In addition to precise maps, comet illustrations similar to the medieval models continued to appear throughout the Renaissance.[108]

Comet maps range from the general, merely locating a comet in a particular area of the sky, to the specific, showing a precise location or path in the sky on particular dates and at particular times; in many instances planetary locations were charted with respect to the positions of the surrounding stars and/or constellations, which were relevant to their prognosticative meaning. Comet maps often included the length and direction of the tail of the comet; direction was an important component of divination.[109]

The earliest extant comet maps are those by Paolo dal Pozzo Toscanelli, an avid comet observer and recorder from Italy (fig. 4.13).[110] Toscanelli's manuscript charts track the path of the comets of 1433, 1449–50, and 1456, and the two in 1457 as a series of dots labeled with dates; these dots are superimposed upon the background of the fixed stars. Some charts include sketched-in constellation figures and comet tails. The implied line that

107. For example, the often reproduced section of the Bayeux tapestry (1073–83) showing the comet of 1066.

108. For example, the Nuremberg Chronicle (1493) or the Diebold Schilling manuscript (ca. 1508–13). For other examples, see Roberta J. M. Olson, "... And They Saw Stars: Renaissance Representations of Comets and Pretelescopic Astronomy," *Art Journal* 44 (1984): 216–24, and Sara Schechner Genuth, *Comets, Popular Culture, and the Birth of Modern Cosmology* (Princeton: Princeton University Press, 1997).

109. For detailed information on divination based on cometary appearances, see Schechner Genuth, *Comets*.

110. For more information on Toscanelli, see Clarisse Doris Hellman, *The Comet of 1577: Its Place in the History of Astronomy* (New York: Columbia University Press, 1944), 74–75; Jane L. Jervis, *Cometary Theory in Fifteenth-Century Europe* (Wrocław: Ossolineum, Polish Academy of Sciences Press, 1985), 43–48; and Yeomans, *Comets,* 24–26.

FIG. 4.14. EARLY PRINTED COMET PATH MAP. Nicolaus Prugner's map of the comet of 1533 shows it traveling through the constellations Auriga, Perseus, and Cassiopeia (although stylistically this figure is similar to Andromeda). Lacking the precision of Toscanelli's earlier manuscript charts, which plotted daily cometary positions, this map does, however, give a sense of a linear path. The comet is also clearly positioned within the celestial realm rather than the atmospheric, though astronomers did not prove until nearly half a century later that this was truly the realm of comets.
Size of the image: ca. 12.1 × 10.7 cm. Photograph courtesy of the BL (8563.aaa.33[2.]).

would connect these dots represents the path of the comet. Toscanelli's charts vary in the method of mapping, from freehand versions to those with grids and scales.[111] His maps were significant not only because they were the first to precisely map comets; they were also, aside from astrolabes, among the earliest extant two-dimensional star maps to employ map projections.[112]

It was about three-quarters of a century before similar charts of later comets began to appear in printed works, although this may be explained in part by the lack of comets observed over Europe between 1476 and 1531. In the early 1530s, a comet mapping tradition arose in Germany independent of Toscanelli's work in Italy. Apian appears to have spurred the movement with his publication of *Ein kurtzer bericht der Obseruation vnnd vrtels, des Jüngst erschinnen Cometen* (1532), about the comet of 1531. As part of his proof that comet tails always point away from the sun, Apian produced a diagram of the comet's path for the title page. This illustration shows nine positions of the comet along a trajectory that intersects the ecliptic, labeled with dates; additionally Apian shows an astronomer in the corner measuring the comet's position through triangulation with a star in Bootes and the star in the tail of Leo.[113] By at least 1533, with the publication of the rough map by Nicolaus Prugner (Nicolas Pruckner) that positions the comet passing through several constellations on the surface of the celestial sphere, comet path maps appear to have taken hold as a concise way of depicting changing location over time (fig. 4.14).[114]

After the appearance of the comet of 1556, several more examples of comet path maps surfaced. Conrad Lycosthenes produced a path map in his chronicle of 1557 showing the comet on a partial planispheric projection—in essence synthesizing Apian's comet path illustration and the planispheric star maps that had been popularized by Dürer and Honter during the first half of the sixteenth century. Paul Fabricius, Joachim Heller, and Johann Hebenstreit also produced path maps for this comet.[115] For the 1577 comet, Fabricius and Cornelius Gemma improved upon previous models; Fabricius not only indicated the dates of the cometary appearance, but specified the length and direction of the comet tails, while Gemma connected cometary position marks and labeled the resulting line "via cometae," emphasizing the pathlike nature of cometary motion. Similar maps for the comet of 1577 that appeared later include those by Nicolaus Bazelius, Theodorus Graminaeus, Hagecius ab Hagek, Michael Mästlin, and Leonhard Thurneysser.[116] Comet path maps became increasingly common during the sev-

111. For extended descriptions of these charts and biographical material on Toscanelli, see Jervis, *Cometary Theory,* 43–85.

112. The others would be Conrad of Dyffenbach's four maps from 1426.

113. Apian produced two similar illustrations in his *Practica auff das MDXXXVIIII Jar gemacht in der Löblichen hohenschul zu Ingolstadt* (Landshut, 1539), but both are less precise than the *Kurtze*r title page. The *Practica* title page shows a comet passing through the constellation Leo, but lacks the references to specific stars or the labeling of daily cometary appearances by date; an interior illustration shows the comet traveling in a path nearly parallel with the ecliptic—in this second illustration the dates of observed locations are indicated, as is a star in Bootes—but this map lacks the precision of the one in the *Kurtzer.*

114. It is possible that other comet path maps were produced for the comets of 1532 or 1533, but I have not yet found evidence of such. It is also possible that Apian was not the originator of the format in Germany, but no earlier printed comet maps have been forthcoming.

115. Hellman, *Comet of 1577,* 107, 108 n. 233, and 109 n. 241. These are the first instances in which she mentions maps of comet paths.

116. For details, see Hellman, *Comet of 1577,* or Warner, *Sky Explored.*

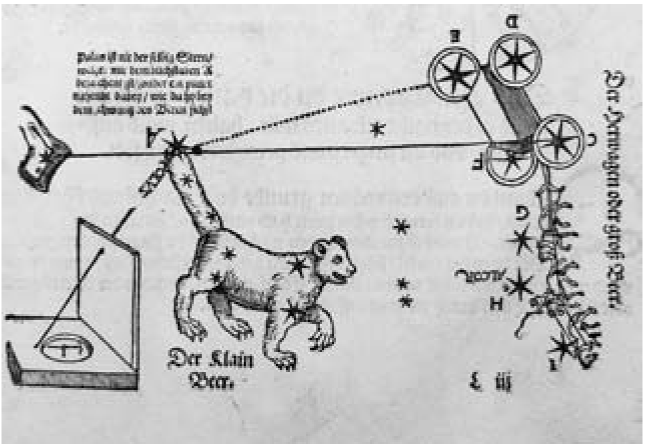

FIG. 4.15. A POLE STAR CHART BY PETER APIAN. This diagram shows how to use stars in the Big Dipper asterism as pointers to find the Pole Star. Ursa Major, however, is depicted according to an old, non-Ptolemaic model that views this arrangement of stars as a wagon being led by three horses. Note also the early inclusion of the star Alcor and the foot of the constellation Cepheus. A sundial—an instrument designed to be used during the day—is curiously included as part of this illustration; this is because one must orient a sundial toward the north in order for it to tell the time properly.
Peter Apian, *Quadrans Apiani astronomicus et iam recens inuentvs et nunc primum editus* (Ingolstadt, 1532), fol. 24v. Photograph courtesy of the Adler.

enteenth century, especially for the comets of 1618, 1664, 1665, and 1680.

Accompanying many Renaissance comet tracts were charts that illustrated the position of the comet in relation to the elemental spheres, similar to the center of cosmographical diagrams of the universe. Until Tycho Brahe's revolutionary determination that comets existed in a superlunary realm, they were thought to be atmospheric phenomena. These types of maps show the comet as existing in the sphere of air, often with reference to the cardinal directions, the ecliptic, or certain constellations. Other maps take still different approaches at mapping the locations of comets and documenting the passage of time. One interesting work from 1619 by Johann Baptist Cysat creates a series of such static images, much like a filmstrip, showing the comet of 1618 progressing through several different constellations.

Novae, in addition, were a popular subject of specialized charts. The 1572 nova in Cassiopeia was charted by Brahe, Cunradus Dasypodius, Thomas Digges, Hagecius ab Hagek, Cyprianus Leovitius, and Michael Mästlin, among others. Willem Jansz. Blaeu included the novae of 1572, 1600 (in Cygnus), and 1604 (in Serpentarius) on his globes; he observed the latter two himself.[117] The 1604 nova was also charted by Johannes Kepler.[118]

Another function of specialized charts was to demonstrate how the Pole Star could be located. Peter Apian published several different versions of such charts (fig. 4.15),[119] and similar ones appeared in books ranging from those on navigation to, in later centuries, those for teaching astronomy to children. Diagrams of nocturnal use often included maps of Ursa Major and Ursa Minor, as certain stars in the dipper-shaped asterisms in these two constellations figure directly into finding the time at night with this instrument; such diagrams can be traced to medieval illustrations of *horologium nocturnum* use from the eleventh and twelfth centuries.[120] Other specialized star charts that relate to instrument use are less obvious—for example, to help the reader locate certain stars used in the design of some of his instruments, Apian includes non-coordinate maps of the brightest stars in a handful of relevant constellations.[121]

Discoveries sparked the creation of topical charts. As described earlier, Bayer included a chart of the new southern constellations developed by Plancius. Earlier manuscripts and texts, especially those concerned with navigation and the voyages of discovery, contained diagrams of the Southern Cross, including those by Alvise Cà da Mosto (ca. 1470), João de Lisboa (1514), Fracanzio da Montalboddo (1507), and Pedro de Medina (1545).[122] Amerigo Vespucci's observations of the southern sky, including the Coalsack nebula, were published in 1503 or 1504. In 1500, João Faras (Maître João) sent a letter to the Portuguese king containing a map of the stars surrounding the Antarctic pole. Later maps by Andrea Corsali (1516) and Piero di Dino (1519) include not only stars but the Magellanic Clouds.[123]

Galileo Galilei produced what are perhaps the most well-known specialized star charts of all time. With the newly developed telescope, Galileo observed stars not able to be seen by the naked eye. He published four non-coordinate drawings of the formations of these new stars

117. R. H. van Gent, "De nieuwe sterren van 1572, 1600 en 1604 op de hemelglobes van Willem Jansz. Blaeu," *Caert-Thresoor* 12 (1993): 40–46, and Van der Krogt, *Globi Neerlandici,* 493, 494, 504, 507, and 517.

118. For more information about these maps, see Warner, *Sky Explored.*

119. Warner, *Sky Explored,* 8.

120. Medieval examples can be seen in Wiesenbach, "Pacificus von Verona," 233 and 236. A typical Renaissance example is the nocturnal illustration from Peter Apian, *Cosmographicus liber* (Landshut, 1524, and numerous later editions).

121. For example, Apian's quadrant design includes sixteen principal stars that aid in its function; in his illustrations of the quadrants, the stars are numbered to correspond to star maps included later in the book. Peter Apian, *Instrument Buch* (Ingolstadt, 1533; reprinted Leipzig: ZA-Reprint, 1990), and idem, *Quadrans Apiani astronomicus et iam recens inuentvs et nunc primum editus* (Ingolstadt, 1532).

122. Dates refer to first extant copy or publication.

123. Although Corsali and de Dino's maps predate Magellan's voyage, these two celestial formations (which are now known to be galaxies) are today commonly called the Magellanic Clouds, using a term seemingly created in the seventeenth century. For a comprehensive study of the early mapping of the southernmost sky, see Dekker, "The Light and the Dark."

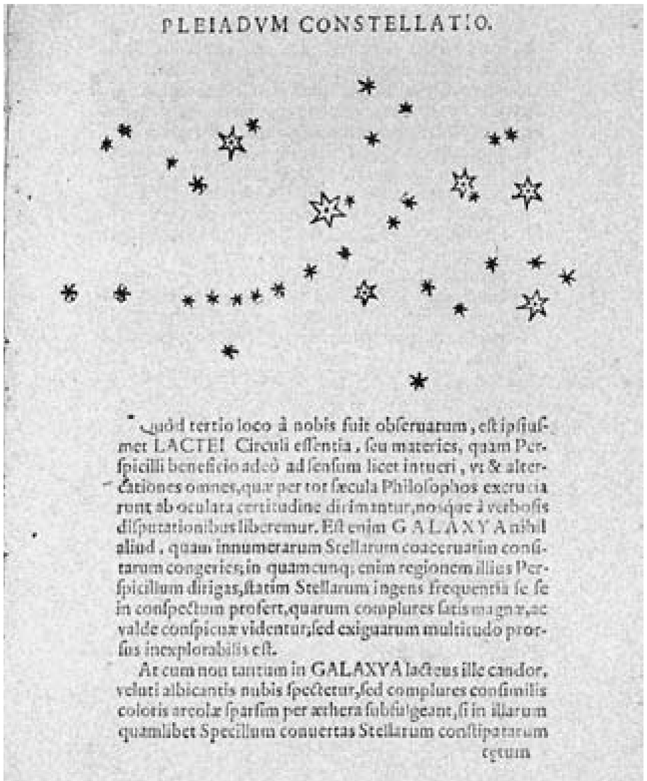

FIG. 4.16. A CHART OF THE PLEIADES BY GALILEO GALILEI. Included around the six easily visible stars of this group are thirty previously invisible stars that Galileo observed. Size of the original page: 24 × 17 cm. Photograph courtesy of the Smithsonian Institution Libraries, Washington, D.C.

in the *Sidereus nuncius* (1610): the belt and sword of Orion, the Pleiades (fig. 4.16),[124] the stars comprising the Orion nebula, and the stars comprising the Praesepe nebula.[125] Significantly, Galileo's maps showed not only that there were far more stars than previously believed, but that nebulous stars were, in actuality, many stars clustered close together.

Concluding Remarks

Dramatic changes in the mapping of stars marks the Renaissance period, as authors and mapmakers moved away from a reliance on classical scholarship to original work. By 1650, star maps had become firmly entrenched as scientific illustrations intended for scholarship or education rather than as decorative additions. Yet at both the beginning and the end of the Renaissance, technology limited star mapmakers. In the early years prior to Tycho Brahe, instruments lacked precision, and in the later years, Galileo's experiments with the telescope yielded a new world of stars that needed to be mapped.

Despite the newfound ability to see more stars, by the mid-seventeenth-century instruments had not been developed that could aid astronomers in accurately measuring their positions and, by extension, charting them. It was not until the end of the seventeenth century that telescopically viewed stars came to be charted on traditional star maps. By the beginning of the eighteenth century, the telescope became an integral part of mapping the stars, and the mapping of ever-increasing numbers of telescopically viewed stars would radically alter the aesthetic of celestial charts. Despite technological advances that enabled astronomers to better locate, measure, and subsequently map more stars, Renaissance star charts had a lasting impact on these later mapping projects. Artistic constellation styles have dramatically changed over time, but the formats for atlases and planispheric maps developed during the Renaissance have persisted for hundreds of years and continue to influence modern-day mapmakers.

124. The first accurate separate map of the Pleiades was produced by Mästlin in 1579; see Warner, *Sky Explored,* 169. Prior to Mästlin's chart, this asterism had often been separately illustrated in both manuscript and printed versions of Hyginus and Aratus.

125. For details on these maps, see Warner, *Sky Explored,* 88–89.