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Of Beauties and Beasts: The Golden Age of Celestial Cartography

by

Nick Kanas, M.D.

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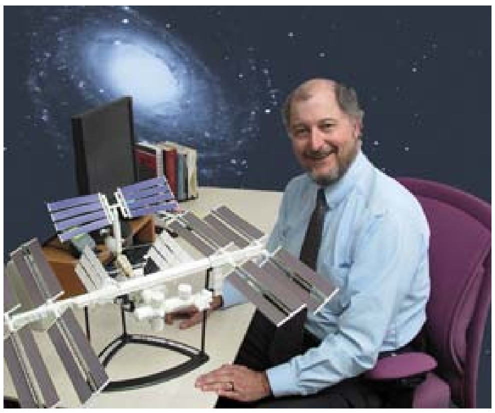


Dr. Kanas is Professor Emeritus (Psychiatry) at the University of California, San Francisco. He is a NASA-funded Principal Investigator and an amateur astronomer. He has collected antiquarian celestial maps and books for over 30 years. Among his 200+ publications are the books *Space Psychology and Psychiatry* (with Dietrich Manzey, now in its 2nd Edition) and *Star Maps: History, Artistry, and Cartography*. All images in this paper are from the Nick and Carolynn Kanas Collection.

Cover illustration: Plate showing several northern constellations, taken from Jean Fortin's 1795 French edition of John Flamsteed's famous atlas, entitled: ***Atlas Celeste de Flamsteed***. 15.7 X 20.6 cm (from re-engraved plates about a third the size of Flamsteed's originals, making Fortin's popular atlas easier to use). In addition to the classical Greek constellations, note the constellations introduced by Johannes Hevelius: Lacerta ("le Lezard"), Vulpecula ("le Renard"), and Anser ("l' Oye"), which is now obsolete in modern star charts.

The California Map Society was founded in 1978, an outgrowth of the historically-oriented Sir Francis Drake Quadracentennial Commission, State of California. The focus of the Society has been on maps of California, mapping in California, map collections and map collecting. As such, the Society is not centered on a single cartographic aspect or group; rather it retains a diversified membership and reaches out to all map enthusiasts. Everyone is welcome at our Society's meetings and costs are nominal. Visit our website, www.californiamapsociety.org for information about recent and upcoming meetings, membership, and more.

Of Beauties and Beasts: The Golden Age of Celestial Cartography

From 1600 to 1800, celestial cartography reached its peak in beauty and quality with the publication in Europe of a number of breathtaking atlases and prints related to the heavens. Some of the images depicted were maps of lunar or planetary surfaces or diagrams of the solar system according to various cosmological theories (e.g., the Earth-centered universe of the classical Greeks, the Sun-centered system of Copernicus). But the most striking images were of the constellations. Classical Greek traditions abounded, with allegorical visual representations of heroes and heroines, real and imaginary animals, and scientific and artistic tools and instruments. But why were such constellation images used in star maps?

The Importance of Constellations

The ability to predict celestial events and to accurately locate heavenly bodies in the night sky had practical significance for many early cultures. For the ancient Egyptians, the yearly first appearance before sunrise (heliacal rising) of the star Sirius anticipated the flooding of the Nile, signaling the optimal time for planting. For the early Chinese, events in the heavens (such as the appearance of a comet or nova) could be a measure of the success of the Emperor and astrologically foretold the fate of their country. For the classical Greeks, accurately locating a heavenly body in the sky using their skill with spherical geometry satisfied their urge to understand the structure of the cosmos. To help organize the heavens, these early cultures used fixed stellar patterns that became the constellations.

The number and subject of these constellations were culture-specific. For example, given the importance of the Sun and of the solar calendar to the ancient Egyptians, their night sky included 36 constellations called *decans*, each of which announced itself every 10 days by rising just before the Sun. In contrast, the Vedic Indians, having a lunar calendar, divided the sky into 27 or 28 groupings called *nakshatras* located along the path of the Moon. Since events in the sky impacted the world of the Chinese, their sky included 284 constellations that represented a variety of living things and places on the Earth.

In Europe, the constellation tradition went back to the third Millennium B.C. to the Sumerians, who recorded names (e.g., bull, lion, scorpion) on clay tables that suggested they envisioned some constellations that were similar to those we imagine today. By the first Millennium B.C., the Mesopotamians depicted three 12-constellation bands in the sky named for their creator gods, and by the 5th Century B.C. a zodiac had evolved along the ecliptic, which is the path of the Sun in the sky. Many of these constellations were imported into Greece. In the 8th Century B.C., Homer mentioned several constellations and asterisms, such as Ursa Major, Orion, the Pleiades and the Hyades. By the 3rd Century B.C., books were written by Aratus and Eratosthenes describing over 40 constellations that reflected Greek mythology and lore, and a complete system of celestial cosmology began to crystallize.

Early Maps of the Heavens

This system was summarized by the Greek geographer and astronomer Ptolemy (ca. 100-178 A.D.), who around 150 A.D. wrote his famous *Almagest*. This influential book described Greek mathematical astronomy and theory, which viewed the Earth as being in the center of the cosmos surrounded by the fixed stars as well as the "wandering" stars (e.g., the Sun, Moon, and planets), which orbited around it in the ecliptic. To mathematically predict the locations of these heavenly bodies, a system of eccentric orbits or epicycles spinning on geocentric orbits called deferents was developed.

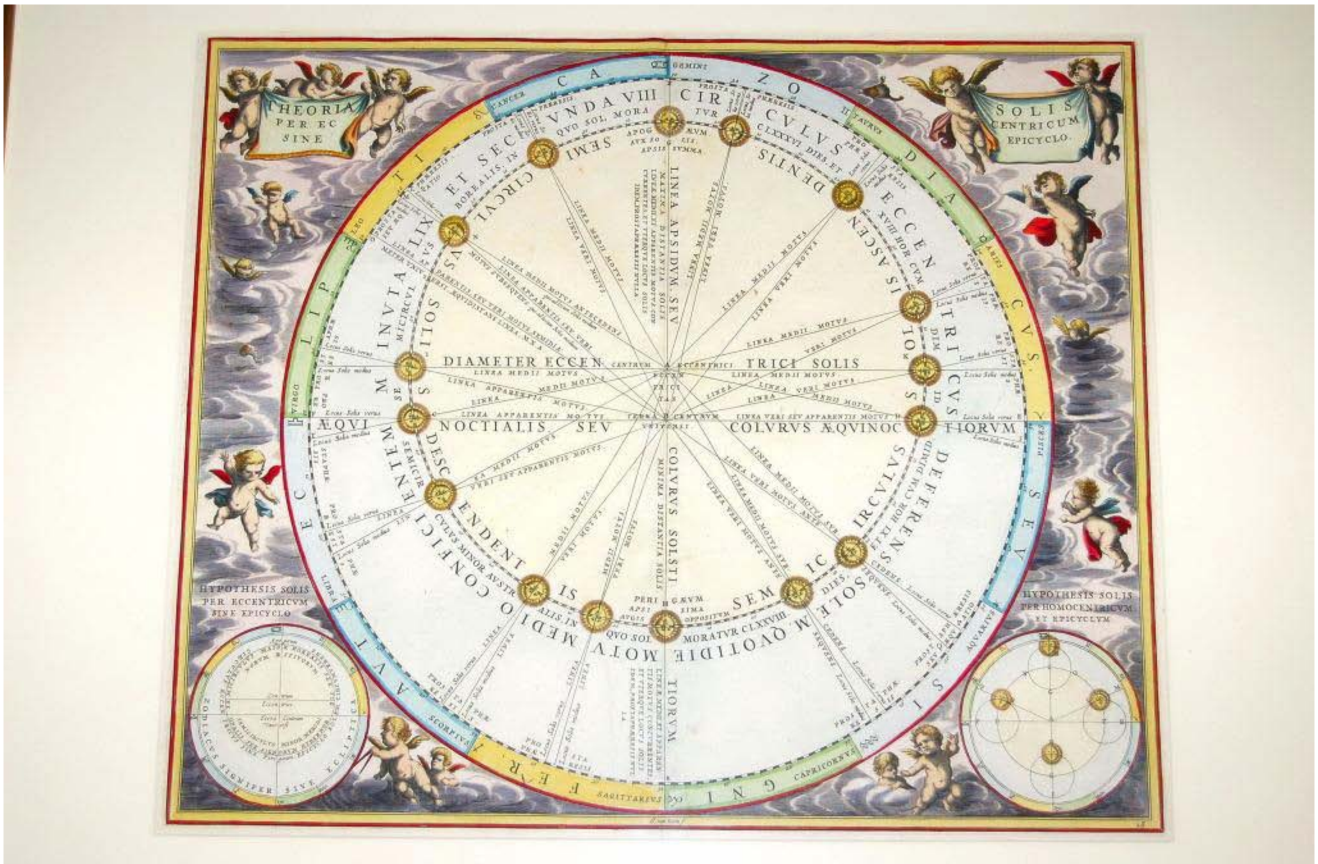


Figure 1. A plate showing the orbit of the Sun around the Earth (which is represented by the point in the center of the large circle rimmed by the 12 colored zodiac constellations), according to the ancient Greek astronomer Hipparchus and adapted by Ptolemy. The plate is from Cellarius' 1660 edition of *Harmonia Macrocosmica*. 42.1 X 50.4 cm (height X width of the image margins). Note that the eccentric solar orbit models the unequal period of time between the equinoxes (at the 3 and 9 o'clock positions of the zodiac circle), with the shorter lower arc (representing the time interval from autumn to spring) accounting for the observed nine day difference from the longer upper arc (from spring to autumn). Note also an equivalent model in the lower right of the plate that is based on a solar epicycle spinning around its deferent orbit.

But in addition, the *Almagest* included a catalog of 1,022 stars in 48 classical Greek constellations that were named for mythological figures. Star magnitudes were listed and categorized. Stellar positions were given according to their celestial latitude and longitude, oriented to the ecliptic, as well as to their location in the figure representing each constellation. The system described in the *Almagest* was preserved by the Arabs and the Byzantines and was brought back to Europe in the Middle Ages.

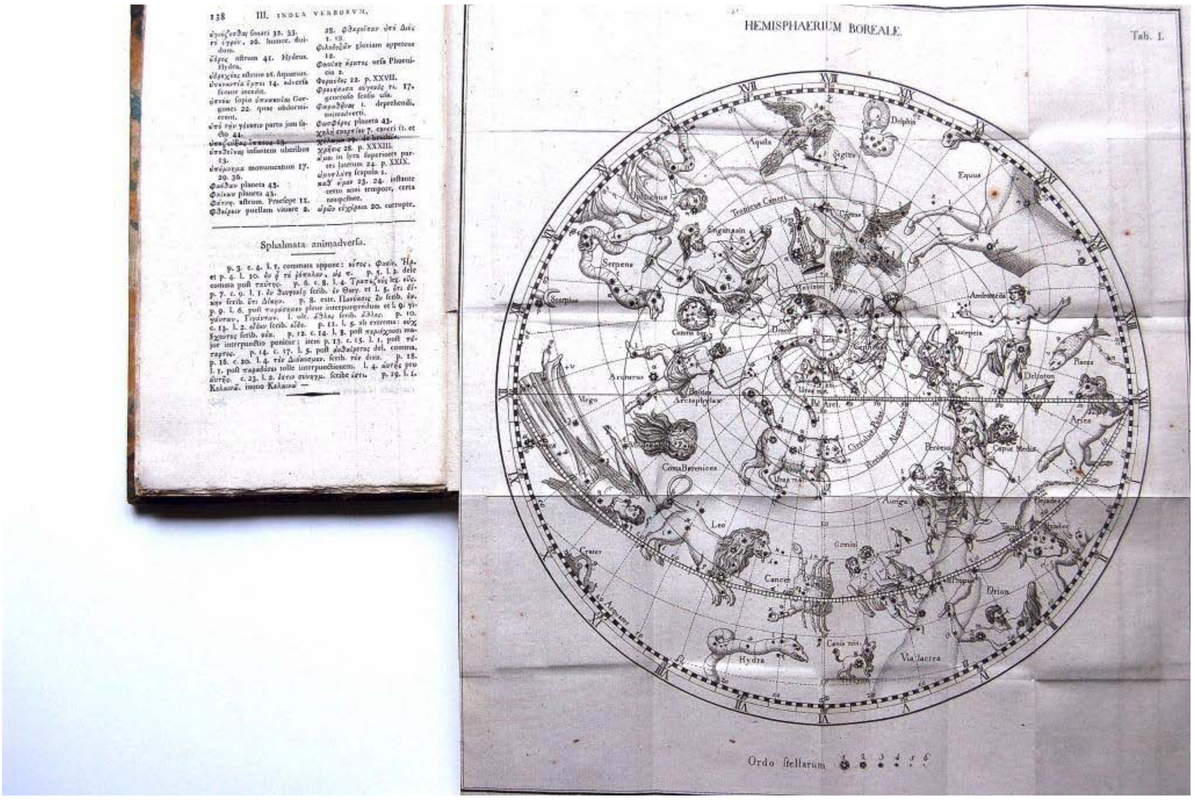


Figure 2. A pull-out plate depicting the northern celestial hemisphere centered on the north equatorial pole, from Schaubach's *Eratosthenis' Catasterismi*, 1795. 31.8 X 29.1 cm, 24.6 cm dia. hemisphere. Note the classical Greek constellations as depicted by this source, including some of the zodiacal constellations along the ecliptic line near the bottom.

It was to last until 1543 A.D., when Copernicus placed the Sun in the center of the universe, and the early 1600s, when Kepler developed a system of elliptical planetary orbits that did away with the need for eccentrics and epicycles.

There are no existing flat maps of the heavens from classical Greece. The earliest celestial maps from this time are actually celestial globes. An example is the Farnese Atlas, which is in the National Museum in Naples. This marble statue dates back to the 2nd Century A.D. but is likely a copy of a Greek original from the time of the famous Greek astronomer Hipparchus (ca. 190-120 B.C.). It depicts Atlas holding a celestial globe on his back on which are carved 43 Greek constellations. The images are shown left to right from the way we see them when looking up at the sky from the Earth (called the "geocentric" orientation—see Figure 2). The mirror-reversed "external" orientation shown in Figure 3 became the norm for many centuries, not only with globes but also with flat maps of the sky.

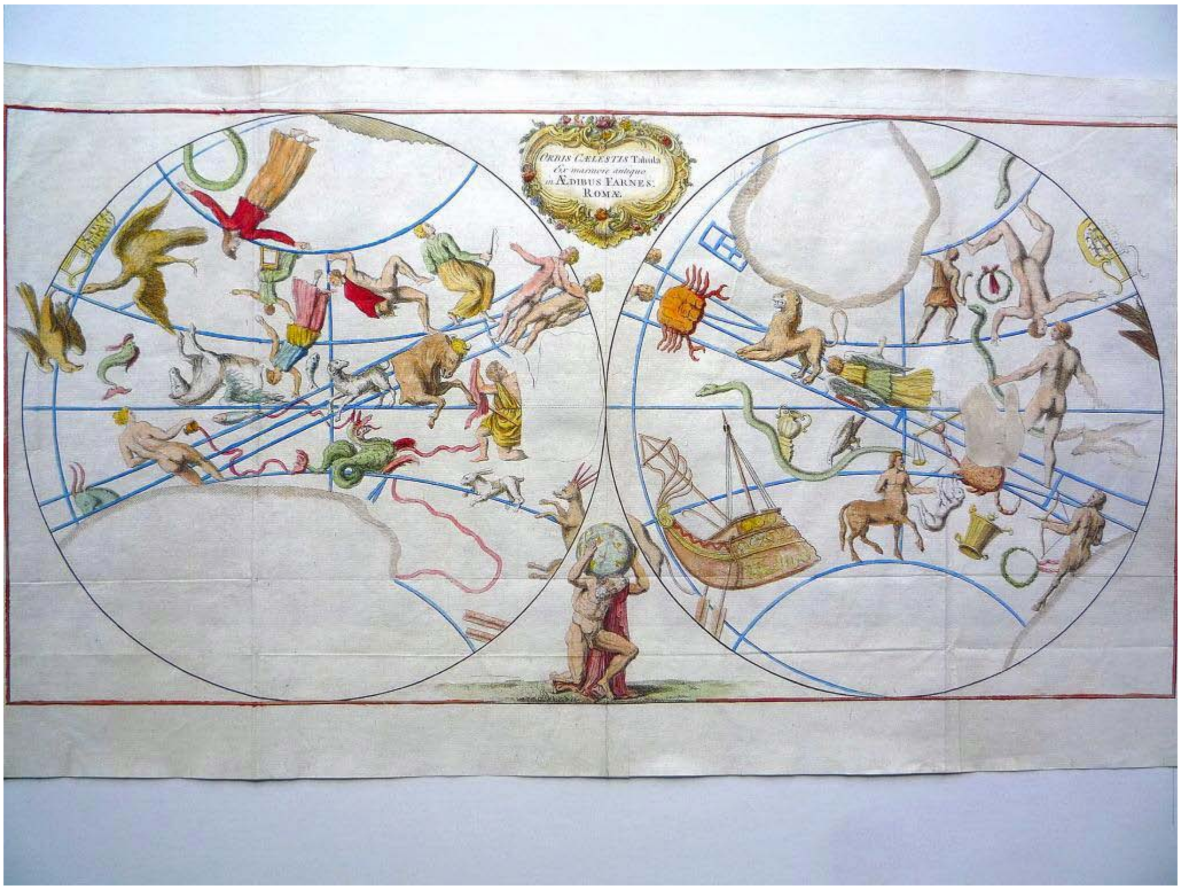
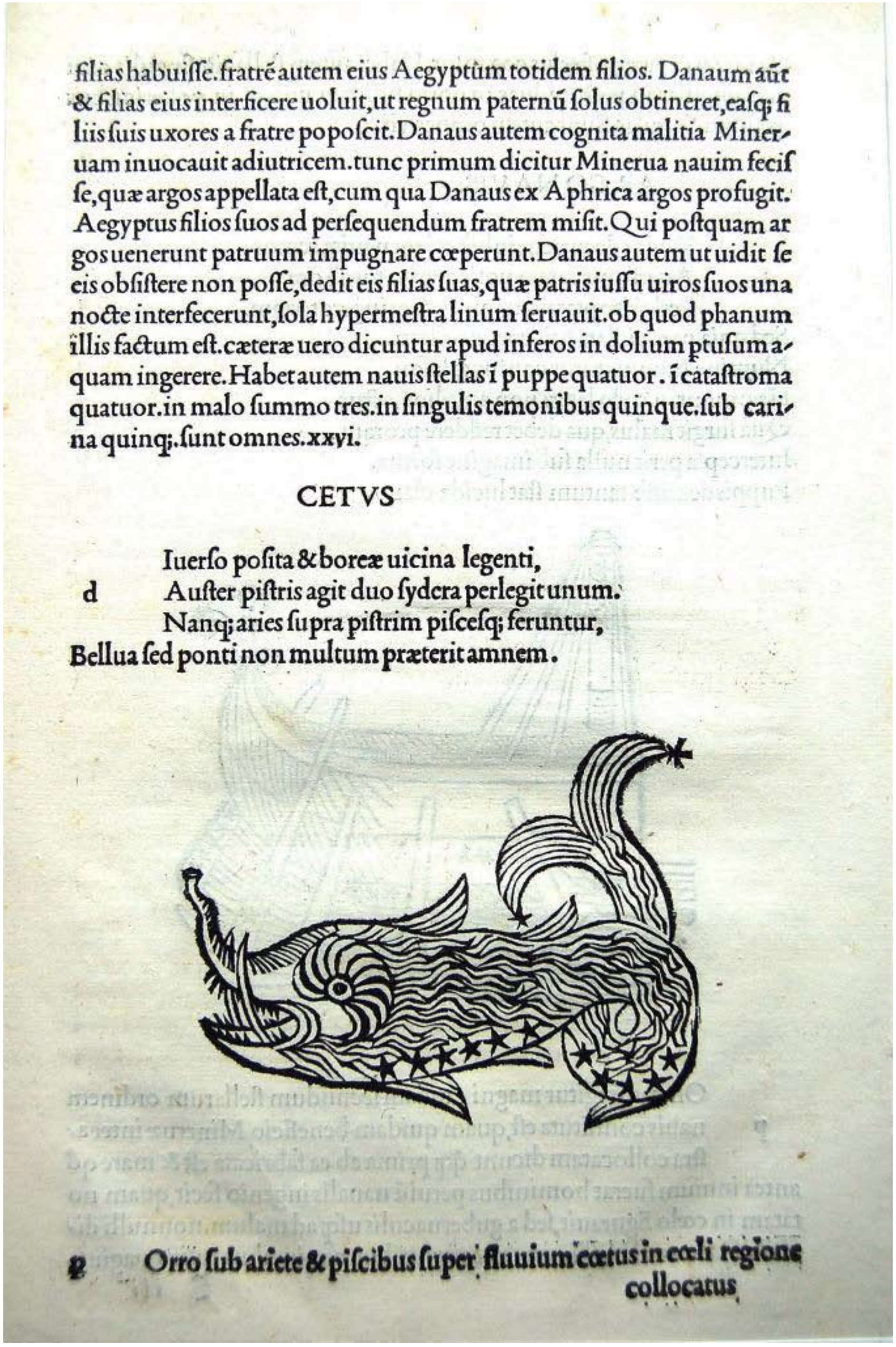


Figure 3. This paper transcription from the Farnese Atlas was drawn in stereographic projection by Martin Folkes. It appeared in the 1739 edition of *Manilius' Astronomicon ex Recensione et cum Notis Richardi Bentleii*, edited by the English classicist Richard Bentley. 25.9 X 52.1 cm. Note many of the classical Greek constellations, the zodiacal constellations along the triple lines indicating the region around the center ecliptic line, the gaps representing areas of damage or places where Atlas is holding the globe, and a picture of the statue in the lower center.

In the Middle Ages, constellations were hand drawn on vellum or parchment. Although the images included stars, these were placed almost at random, since the purpose of the constellation was to illustrate the accompanying text rather than to be an accurate star map. When moveable-type printing developed in Europe in the 1450s, the same situation occurred. For example, one of the earliest printed sources of constellation images comes to us from the great Aldine Press, where in 1499 woodcut figures were used to illustrate a Latin version of Aratus' *Phaenomena.* Even though the text of the poem described the position of some of the stars with reference to their location in a constellation, the stars in the accompanying images were placed haphazardly. Thus, these images were not true star maps.



filias habuisse. fratrē autem eius Aegyptūm totidem filios. Danaum aũt
& filias eius interficere uoluit, ut regnum paternũ solus obtineret, easq; fi
liis suis uxores a fratre poposcit. Danaus autem cognita malitia Miner-
uam inuocauit adiutricem. tunc primum dicitur Minerua nauim fecis
se, quæ argos appellata est, cum qua Danaus ex Aphrica argos profugit.
Aegyptus filios suos ad persequendum fratrem misit. Qui postquam ar
gos uenerunt patruum impugnare cœperunt. Danaus autem ut uidit se
eis obsistere non posse, dedit eis filias suas, quæ patris iussu uiros suos una
nocte interfecerunt, sola hypermestra linum seruauit. ob quod phanum
illis factum est. cæteræ uero dicuntur apud inferos in dolium ptusum a-
quam ingerere. Habet autem nauis stellas ĩ puppe quatuor. ĩ catastroma
quatuor. in malo summo tres. in singulis temonibus quinque. sub cari-
na quinq;. sunt omnes. xxvi.

CETVS

Iuerso posita & boreæ uicina legenti,
d Auster pistris agit duo sydera perlegit unum.
Nanq; aries supra pistrim piscesq; feruntur,
Bellua sed ponti non multum præterit amnem.

g Orro sub ariete & piscibus super fluuium cœtus in cœli regione
collocatus

Figure 4. The constellation of Cetus, from Firmicus Maternus' *Scriptores Astronomici Veteres*, Aldine Press, 1499. 27.4 X 17.8 cm (page size). Note the simple but dynamic figure and the lack of relationship of the stars to their actual position in the sky. This was because the image was meant to be an illustration for the text describing Cetus and not a true star map.

This situation began to change in the 16th Century. In 1515, the famous artist and mathematician from Nuremberg, Albrecht Durer (1471-1528), printed two woodcuts showing the Greek constellations in the northern and southern celestial hemispheres. Each employed a polar stereographic projection, with the ecliptic celestial pole in the center and the zodiac constellations around the periphery. The stars in the constellations were positioned in a primitive coordinate system based on Ptolemy's star catalog. However, the star patterns and constellation figures were depicted in a globe-like external orientation, and there was no indication of stellar magnitudes.

Further progress in star mapping occurred in 1540, when the Italian polymath Alessandro Piccolomini (1508-1578) published the first star atlas, *De Le Stelle Fisse*. Although he did not include constellation figures, he depicted the star patterns geocentrically

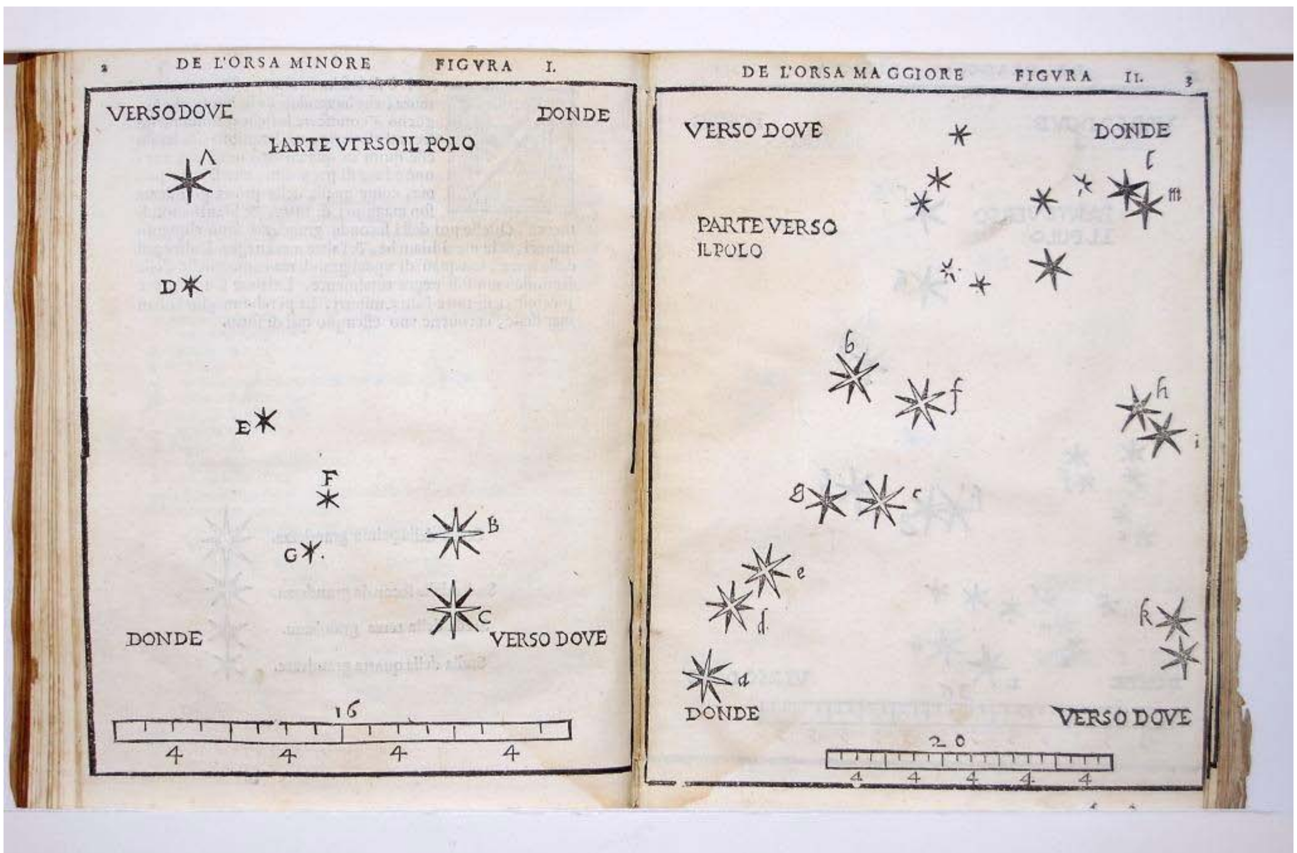


Figure 5. The constellations of Ursa Minor (left) and Ursa Major (right), from the 1579 edition of Piccolomini's *De le Stella Fisse*. 17.5 X 13.9 cm (left image), 17.7 X 14.1 cm (right image). Note the geocentric orientation, the Roman letters and different sizes and shapes of the symbols representing the stars' magnitudes, and the generally accurate star pattern for the constellation, despite the absence of an artistic image.

in each woodcut plate, which corresponded to a Ptolemaic constellation. Star magnitudes were indicated by the size and shape of the stellar symbols and by their Roman letter labels (with "a" being brightest, "b" next, etc.). A degree scale at the bottom gave a sense of the constellation's size. Constellation and star locations were indicated through statements on each plate identifying the direction to the celestial pole.

The Golden Age: The Big Four

The 17th Century ushered in the Golden Age of celestial cartography in Europe. Four individuals particularly advanced the field and influenced the work of other celestial cartographers. The first of these was Johann Bayer (1572-1625), a Bavarian lawyer and amateur astronomer, who in 1603 published his great star atlas, *Uranometria*. It contained a chart for each of the 48 classical Greek constellations. Each of these was engraved in copper, allowing for finer precision of the lines depicting the beautifully illustrated constellation figures, a great improvement over earlier woodcuts. Each plate employed

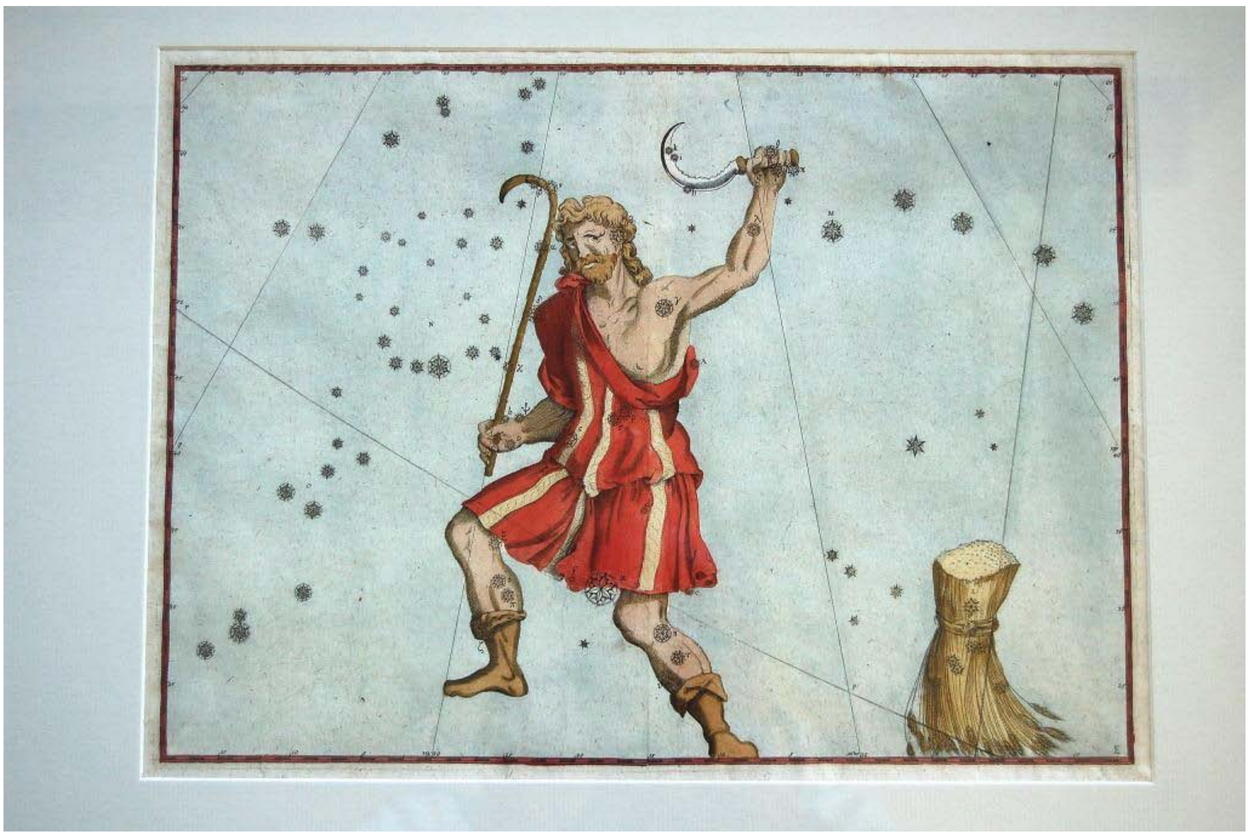


Figure 6. A later-colorized image featuring the constellation Bootes, from a mid-1600 edition of Bayer's *Uranometria*. 27.5 X 37.8 cm. Note the use of Greek letters to indicate stellar magnitude (with alpha being the brightest), the use of an accurate grid system aligned with sub-degree indicators in the margins, and non-featured constellation star patterns surrounding Bootes (e.g., the handle of the Big Dipper in the upper right).

a trapezoidal projection and included a celestial latitude/longitude coordinate grid oriented to the ecliptic. The margins were calibrated to allow star positions to be determined to a fraction of a degree using a simple straightedge. Over 2,000 stars were plotted and labeled in order of magnitude using Greek letters (with "alpha" being the brightest in the constellation, "beta" being second, etc.). In addition, 12 new constellations were depicted that were created from stars catalogued by explorers sailing into the southern hemisphere. But despite these advances in celestial cartography, Bayer chose to illustrate many of his constellation figures as if seen from the back, even though the star patterns themselves were depicted geocentrically. Nevertheless, Bayer's atlas set a standard for future celestial atlases due to its beauty and accuracy.

The next star atlas to rival Bayer's in terms of innovation and accuracy was produced by Johannes Hevelius (1611-1687). The son of a wealthy brewer in Poland, Hevelius used the profits from the family business to support his interest in astronomy. In addition to an influential lunar atlas published in 1647 (the first of its kind), Hevelius' work led to his famous celestial atlas, *Firmamentum Sobiescianum sive Uranographia*, published in 1687. The stars were precisely plotted in a trapezoidal projection using ecliptic coordinates, and they were based on Hevelius' own accurate star catalog of over 1,500 stars.

Figure 7. The northern celestial hemisphere, from Zahn's *Specula Physico-Mathematico-Historica …*, published in 1696. 35.2 X 40.7 cm, 31.9 cm dia. hemisphere. Note that as inferred in the text of the scroll at the bottom right of the image, this hemisphere was meant to be an accurate copy of Hevelius' northern hemisphere map, which is indeed the case.

The plates included 11 new constellations and newly charted stars in the southern hemisphere. Harkening back to Durer and the celestial globe tradition, the star patterns and constellations were shown in an external orientation. This bow to the past was typical of Hevelius (he also insisted that the eye was more accurate than the telescope in plotting stellar positions), and it limited the usefulness of his otherwise precise atlas.

Another major advance occurred in 1729 with the posthumous publication of the *Atlas Coelestis*, the great star atlas that developed from the work of John Flamsteed (1646-1719), England's first Astronomer Royal. In this atlas, the positions of some 3,000 stars were plotted geocentrically based on Flamsteed's meticulous star catalog, published four years earlier. The atlas used a sinusoidal projection (also known as the Sanson-Flamsteed projection), which was designed to lessen the distortions in constellation star patterns found in trapezoidal projections. It was also the first major work to use

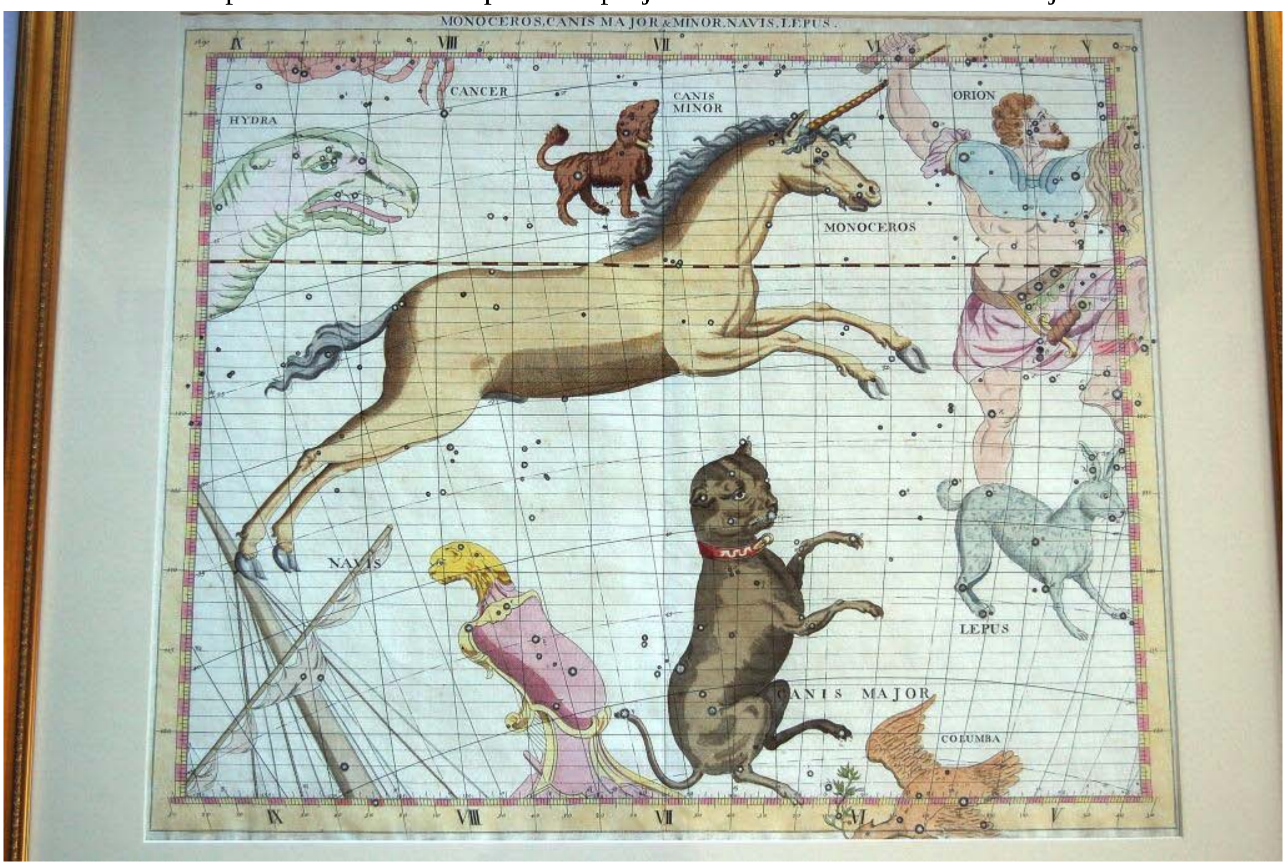


Figure 8. The map labeled "Monoceros, Canis Major & Minor, Navis, Lepus", from Flamsteed's *Atlas Coelestis*, published in 1729. 47.3 X 58.2 cm. Note the great detail and the double-grid coordinate system, with the new one oriented to the celestial equator (shown here as the prominent horizontal line going through Monoceros and Orion), and the older system off-set 23½ degrees and oriented to the ecliptic.

a coordinate system oriented to the celestial equator (which was a projection of the Earth's equator in the sky), making it useful for the newer equatorially-mounted telescopes that could more easily track the movement of the stars in the sky throughout the night. But the plates also included the more commonly used coordinate system that was oriented to the ecliptic. The two systems were offset to one another, due to the fact that the Earth (and its equator) is tilted 23½ degrees from the plane of the solar system, and hence the ecliptic. Flamsteed's atlas was a milestone in celestial cartography that influenced later atlases for the next 100 years.

In 1801, the great German astronomer and Director of the Berlin Observatory, Johann Bode (1747-1826), published his magnum opus: *Uranographia*. This was the largest pictorial star atlas produced up until that time, and it used a geocentric orientation. It included over 17,000 stars, over 100 constellations and asterisms, and a conic projection that minimized distortions in stellar patterns. Some of the constellations depicted had been invented by Bode to honor patrons or popular figures, continuing

Figure 9. An unusual hemispheric view that is not centered on a celestial pole but instead is centered on the position in the sky of the vernal equinox, from Bode's 1801 *Uranographia*. 56.6 cm dia. hemisphere. Note the plethora of stars and constellations, more than in any previous atlas. Note also the crossing of the horizontal celestial equator line and (23½ degrees apart) the ecliptic line at the so-called "first point of Aries", designated as the point of 0 degrees celestial longitude.

a trend that led to a cluttered appearance and a lack of consistency in future celestial atlases.

The Golden Age: Other Contributions

Although not advancing the field cartographically like the Big Four, a number of other individuals published beautiful and instructive atlases during the Golden Age. One such individual was Andreas Cellarius (ca. 1596-1665), a rector at Latin schools in The Hague. In 1660, he published *Harmonia Macrocosmica*, one of the most beautiful star atlases ever produced. The plates illustrated a text that described various cosmological systems dating back to the classical Greeks (see Figure 1), and these were followed by eight beautiful constellation plates, including two taken from Julius Schiller (died 1627), who depicted Ptolemaic constellations in images taken from the Bible rather than Greek mythology.

Another prominent figure was Johann Doppelmayr (1677-1750), a German mathematician and cartographer who linked up with the famous publishing house of Johann Homann to produce a number of accurate celestial plates, culminating in the *Atlas Coelestis*, published in 1742. Like Cellarius, the Doppelmayr-Homann plates were in Baroque style and are valued today for their beauty and accuracy.

Figure 10. A plate produced by Doppelmayr for Homann Publications, ca.1720, which also appeared in Homann's 1742 *Atlas Coelestis*. 48.2 X 56.8 cm, 43.6 cm dia. hemisphere. It depicts the state of astronomical knowledge in the early 1700s. Note the Copernican cosmological system in the center, complete with the planets and their moons. The Earth in the solar eclipse model in the lower left of the plate shows California as an island, and the images in the lower right show the universe based on Ptolemy, Tycho Brahe, and Copernicus (going from left to right).

One of the more interesting characters in this period was John Bevis (1695-1771), a prosperous London physician who developed a passion for observational astronomy. He was the first European to describe the Crab Nebula (in 1731), and he is the only person to describe the visual occultation of one planet by another (Venus occulting Mercury in 1737). He set out to create a state-of-the-art star atlas modeled after Bayer but containing over 3,500 stars and more constellations and nebulae than his German predecessor. Sadly, during production his partner went bankrupt, and Bevis' *Atlas Celeste* was never produced in great volume, although a few collections of his plates appeared as a set in 1786. This was unfortunate, since in terms of beauty and accuracy, his atlas would have made an important contribution to celestial cartography.

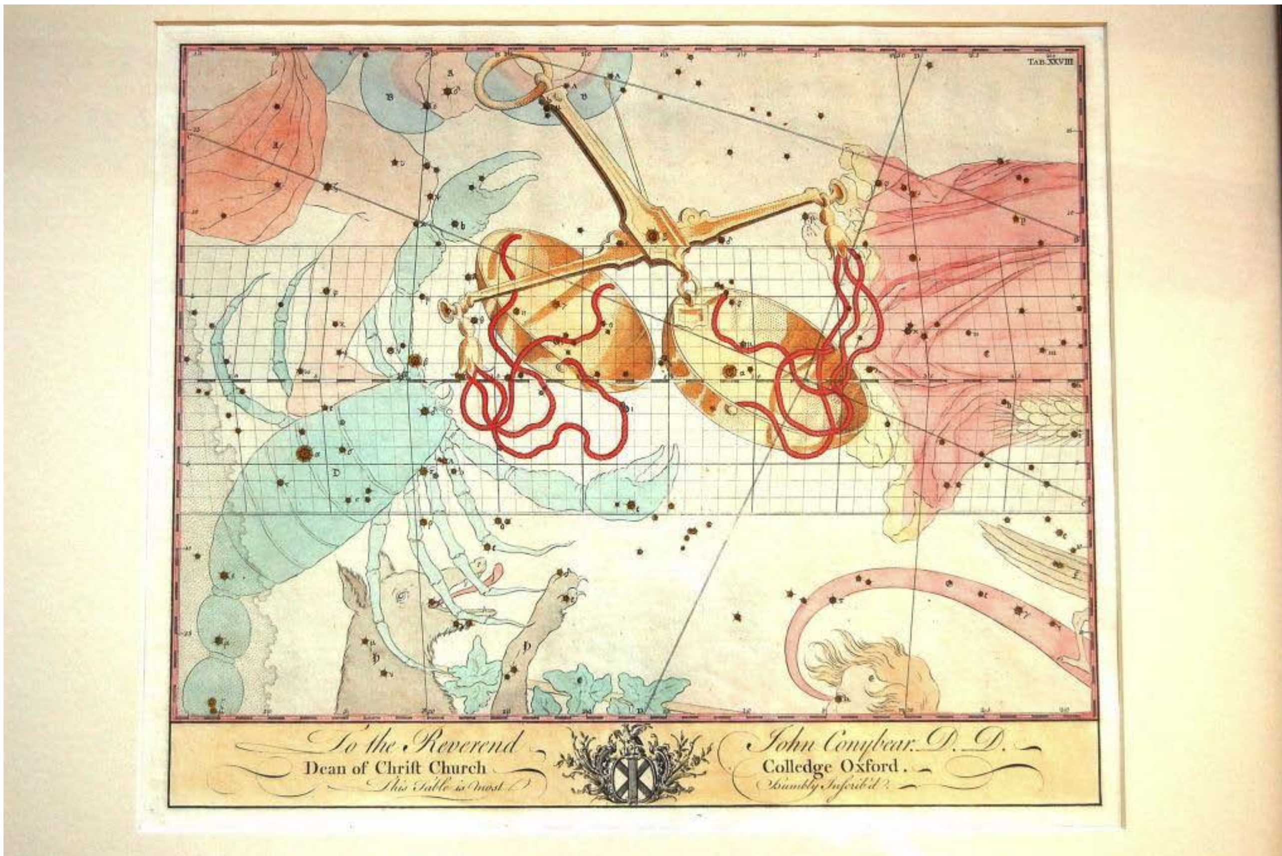


Figure 11. The constellation of Libra, the only zodiacal constellation that is not a person or animal, from Bevis' *Atlas Celeste*, ca. 1786. 26.8 X 36.3 cm. Note the central grid area that represents the area of the zodiac around the ecliptic line, and the dedication at the bottom to the Dean of Christ Church, Oxford, one of the sponsors of the atlas.

The Decline of Pictorial Star Maps

In the 19th Century, the development of photography and micrometers that could be used with ever more powerful telescopes made it easier to create celestial maps that showed faint stars that could be placed in more accurate grid systems. Consequently, the need for constellation images was lessened. In addition, in 1922, the International Astronomical Union decided to promote universal standards in celestial mapping by agreeing upon 88 official constellations and drawing up their boundaries based on agreed-upon areas of the sky rather than on constellation figures. As a result of these changes, celestial maps began to lose their images, first by subduing the figures, then by deleting them in favor of lines connecting the principal stars, and then by omitting these line patterns altogether. Modern star atlases hardly resemble the atlases of the Golden Age, although they show many more stars along with deep sky objects such as galaxies and nebulae, and they are much more accurate in terms of star positioning. Most

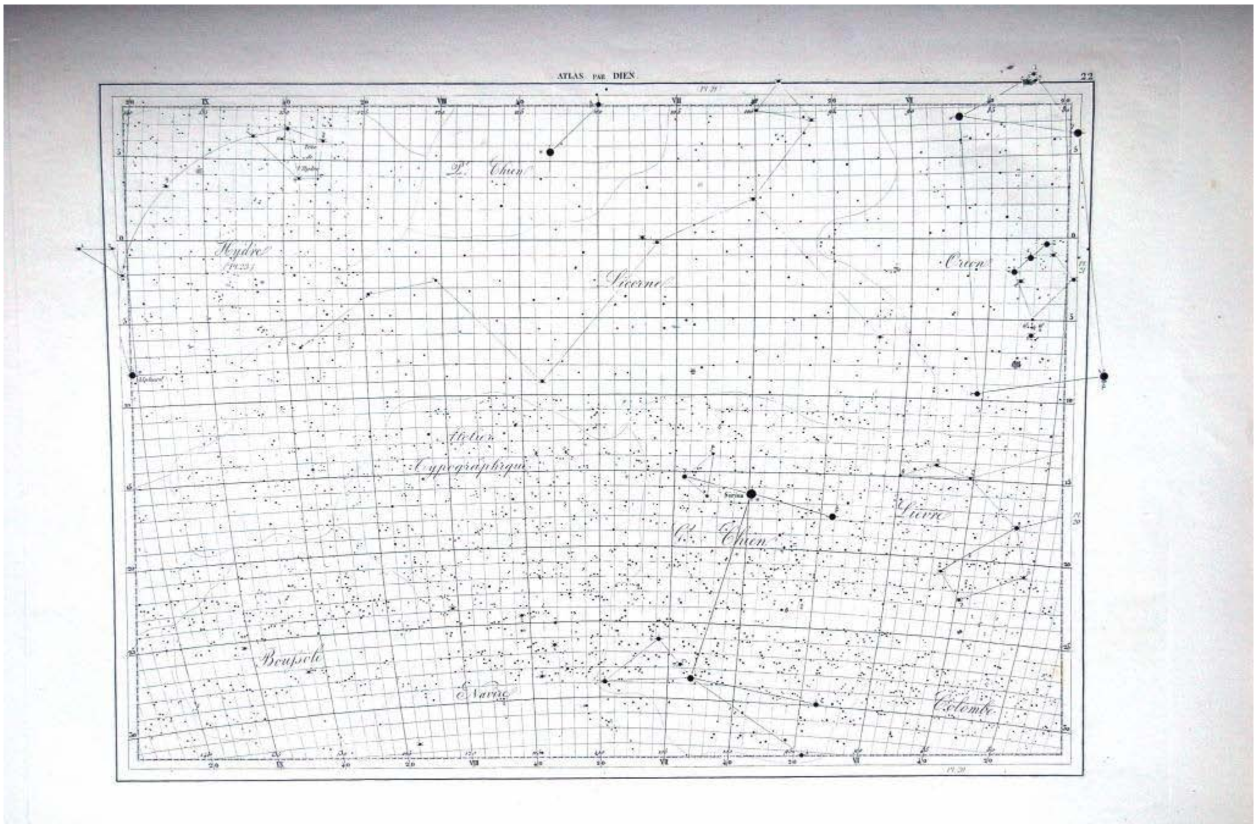


Figure 12. Chart 22 from the 11th edition of *Atlas Celeste* by Dien and Flammarion, published in 1904. 23.8 X 33.9 cm. Note the absence of constellation images, although there are connecting lines for the featured constellations (like Orion in the upper right corner). Note also the presence of loose and curvy constellation boundaries, a plethora of stars based on telescopic observations, and a very detailed coordinate system.

printed versions today are computer-generated, and modern telescopes include finder systems where a star or deep sky object can be located automatically using the telescope's own computer. Although today's printed star atlases are less stunning than those of centuries past, they are more suitable to modern day astronomy and are here to stay.