2

Non-European cosmology and constellation development

The study of the structure and evolution of the universe belongs to the field of cosmology, as opposed to the description and representation of this structure, which is cosmography. Cosmographical images are depicted in many celestial charts, so it is important to have a sense of various cosmological systems. Since printed star maps are essentially a European development, I will go into much detail in the next chapter about the thread of cosmological development that began with the classical Greeks as background for an understanding of what is shown on these maps.

However, a number of cultures interacted with Europe and influenced the course of its development. In particular, Mesopotamia and Egypt played a role in Greek astronomy. In turn, Hellenistic astronomy influenced India after the conquests of Alexander the Great, and in turn India influenced Islamic (and then European) astronomy during the Middle Ages. Although China had less direct impact, the Chinese were great traders with India and Europe and had some scientific influences on the West as well.

An example of the fertility that ensued from such inter-cultural contact has been nicely summarized by the great historian of astronomy, Otto Neugebauer:

> Three different systems of astronomical reference were independently developed in early antiquity: the "zodiac" in Mesopotamia, the "lunar mansions" in India, and the "decans" in Egypt. The first system alone has survived to the present day because it was the only system which at an early date (probably in the fifth century BC) was associated with an accurate numerical scheme, the 360-division of the ecliptic. The lunar mansions, i.e., the twenty-seven or twenty-eight places occupied by the Moon during one sidereal rotation, were later absorbed into the zodiacal system which the Hindus adopted through Greek astronomy and astrology. With Islamic astronomy the mansions returned to the west but mainly as an astrological concept. A similar fate befell the decans. When Egypt became part of the Hellenistic world the zodiacal signs soon show a division into three

decans of 10° each. As "drekkana" they appear again prominently in Indian astrology, and return in oriental disguise to the west, forming an important element in the iconography of the late Middle Ages and the Renaissance (Neugebauer, 1983, p. 205).

For these reasons, this chapter will focus on cosmological developments in four ancient cultures: China, Mesopotamia, Egypt, and India. Although the Mesopotamian constellation system was on the direct path leading to Greek constellation development, Chinese, Egyptian, and Indian constellations for a time preserved their own unique constellation features that were separate from those in the West. Since some star maps depict these non-European models, I will present an overview of these as well. For information on other interesting cosmological development in places such as early Britain, Australia and Polynesia, Africa, and the Americas, the reader is referred to the standard texts mentioned in the Bibliography (e.g., Selin, 2000; Walker, 1996).

2.1 CHINA

2.1.1 Cosmology

The Chinese have been recording celestial events since at least the time of the Shang Dynasty (ca. 1600 BC–ca. 1046 BC). The evidence for this has been markings made on oracle bones, which were fragments of mammalian bones or tortoise carapaces that were subjected to heat. The paths made by the resulting cracks were read as answers to questions inscribed on the bone asking about current or future events. Some of these bones have been dated to ca. 1300 BC and recorded stars, solar eclipses, and even a nova that occurred near the star that we now call Antares. In subsequent centuries, the Chinese systematically recorded a number of celestial events, including the probable earliest sighting of Halley's comet in 611 BC, a nova noted by Hipparchus in 134 BC, sunspots (seen through smoky crystal or jade) from around 28 BC, the stellar explosion that created the Crab Nebula in 1054 AD, and the novae described by Tycho Brahe and Kepler in 1572 AD and 1604 AD, respectively.

The reason for this diligence has to do with the way the Chinese viewed themselves and their world. According to their perspective, there was a close association between the Earth and the heavens. In fact, events on the Earth mirrored those in the sky, and vice versa. For example, the appearance of a comet or nova near the area of the sky representing the emperor might mean that he was corrupt or serving his people poorly. Consequently, the Chinese emperors employed astronomers and astrologers to monitor celestial events and to look for signs that might portend the future. Careful astronomical records were kept for centuries, and patterns related to such things as eclipses and planetary orbits were noted, much as was the case for the Babylonians.

The Chinese believed that there were five elements: wood, fire, earth, metal, and water. These were related to each other in complicated ways. For example, wood could produce fire, which could produce earth, which could produce metal, which could produce water, which could produce wood again. However, wood could destroy earth, but fire would mask this process, and fire could destroy metal, but earth masked this process, and so on. Each element was also associated with certain numbers, parts of the body, grains, and animals, as well as to the planets (wood, Jupiter; fire, Mars; earth, Saturn; metal, Venus; and water, Mercury).

There were three main cosmological models in ancient Chinese thinking. The oldest, which was developed by the 3rd Century BC, conceived of the heavens as a large dome covering a similar dome-shaped Earth, which nevertheless had a square base. The highest point of the Earth's dome was the North Pole. The heavens rotated around the Earth to the west like a turning mill-stone. Although the Sun and Moon moved to the east, they were dragged along by the heavens and thus appeared to set in the west. The second model, which was developed by the 1st Century AD, viewed the heavens as resembling a round egg, with the Earth floating within it like the yolk. Both inside and outside the heavens was water, which allowed both the heavens and Earth to rotate. The Earth and the celestial bodies were supported by *qi*, a vaporous substance that was analogous to the Greek *pneuma* and the Hindu *prana*. The final model, which was developed by the 3rd Century AD, visualized the heavens as being infinite. Celestial bodies, including the Earth, floated within it at rare intervals, and the movement of these bodies was directed by *qi*. Despite the prescience of the infinite space model for today's cosmology, the egg model was most favored until the arrival of the Jesuits and their western ideas.

2.1.2 Time and the calendar

Issues involving time and the calendar also were important. Oracle bones suggest that even as far back as the Shang Dynasty the Chinese had been using a luni-solar calendar, whereby both the lunar and solar cycles were important. The lunar months alternated between 29 and 30 days, and an extra intercalary lunar month was introduced every three or four years to match up with the solar year, which the Chinese knew was $365\frac{1}{4}$ days. Through their careful record keeping, they also discovered what was later called the Metonic Cycle, whereby the number of days in 235 lunations were equivalent to 19 solar years that included 7 intercalary months, as well as other cyclical patterns that were even longer. They also had 24 fortnightly periods based on the solar cycle, so that each corresponded to the movement of the Sun by about 15 degrees in longitude on the ecliptic. Note that, like the Babylonians, the Chinese were interested in patterns of events that could be predicted algebraically through the keeping of records, rather than making predictions based on geometric models of nature, which was the strategy used by the ancient Greeks. New calendars have been published regularly in China since 104 BC. The year usually began with the winter solstice. There were minor modifications made to the calendrical system over the centuries until the adoption of the Western-style calendar in 1644.

2.1.3 Chinese constellations

The Chinese oriented themselves to the north celestial pole, around which all the stars revolved. Our current pole star, *Alpha Ursae Minoris* (i.e., the brightest star in the constellation of Ursa Minor, in which the Little Dipper is located) was not the pole star to the ancient Chinese due to precession, but other stars received this honor. For example, in the 2nd Millennium BC, *Alpha Draconis* was the pole star, and Ho *et al.* (2000) has calculated that a faint star in our constellation of Camelopardalus was the "pivot star" during the early Tang period (7th Century AD). Due to their philosophical orientation that events on the Earth and in the heavens mirrored each other, and to their belief that China was the center of the world, it was natural for them to think that the area around the north celestial pole represented the emperor and the imperial household. *Beta Ursae Minoris* was the brightest star in this area at the time, so it was thought to represent the emperor. The second brightest star, *Gamma Ursae Minoris*, stood for the crown prince, and a fainter star in the area represented the empress. Two long chains of stars represented the walls of the imperial palace, and other stars enclosed by these walls in the "Purple Forbidden Enclosure" stood for concubines, eunuchs, and other court officials. The Chinese saw our Big Dipper asterism as a bushel or plough, and it was thought to regulate the seasons as it moved around the pivot star (Figure 2.1).

Any abnormal occurrence in the sky, such as a nova, comet, meteor, or eclipse, might portend a (usually) negative repercussion for society, especially for that aspect represented by the area of the sky in which the occurrence took place. For example, a nova discovered in an agricultural-related area of the sky would likely signify poor crops, or a comet moving into the Purple Forbidden Enclosure would bode poorly for the emperor and his central government. The location of the planets and other celestial phenomena (e.g., zodiacal light, clouds) also had astrological ramifications. Such events might signify that a ruler was misconducting his government or following an immoral path, actions that would disturb the natural order and lead to famines, plague, and disturbances in the heavens. In general, predictable phenomena were good signs and unpredictable phenomena were bad signs. Royal astrologers were kept busy interpreting the meaning of unusual celestial events, and their prognostications were often treated as state secrets (especially if they were negative). It should be noted that Chinese astrology mainly involved areas of interest to society rather than to individuals, except in the case of the emperor and his court.

By the 5th Century BC, the Chinese had developed a system of dividing the broad area of the sky through which the Moon moved into 28 unequal parts called lunar mansions (Figure 2.2). Each was numbered and named for a constellation or asterism located more or less along the celestial equator. For example, the 18th lunar mansion was called *Mao* (representing a Stopping Place) and was formed by the stars of the Pleiades, and the 21st lunar mansion was called *Shen* (representing an Investigator) and was nearly identical to our modern Orion. The lunar mansions served as reference points, and by linking them with the north celestial pole the location of a heavenly body could be identified. For example, the location of a star could be described in terms of how many degrees south of the north celestial pole it was

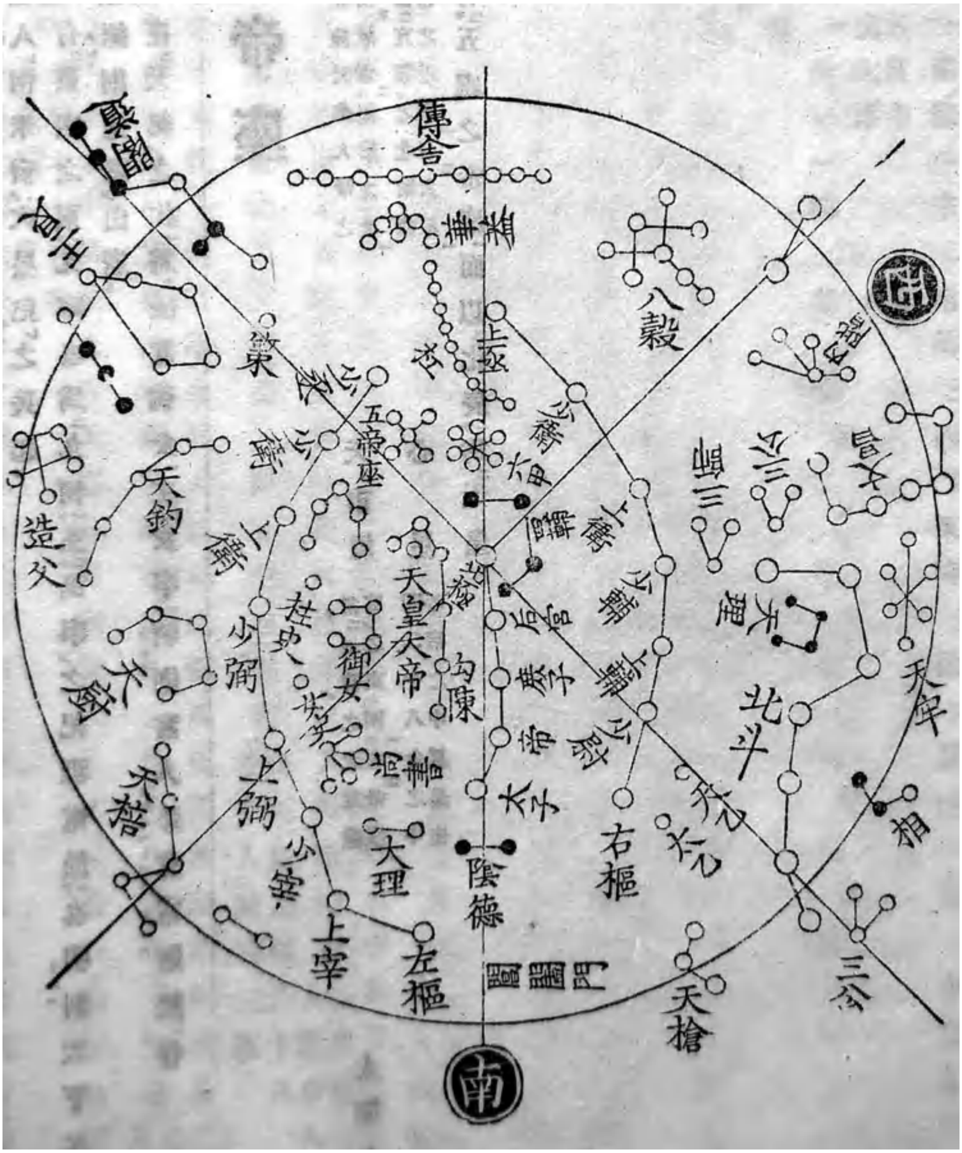

Figure 2.1. The Chinese northern circumpolar constellations, from the 1901 edition of a book first written in Japan in 1712 by Terashima Ryoan, a naturalist and physician at Osaka Castle. The title, *Wakan Sansai Zue*, states that this is a Japanese/Chinese picture book of the heavens, the Earth, and human beings. The Japanese adopted the Chinese view of the heavens. 26.2 × 17.5 cm (page size). Note the two vertical chains of stars, which represented walls around the Purple Forbidden Enclosure, and the Big Dipper beyond the right wall, which the Chinese viewed as a bushel or plough.

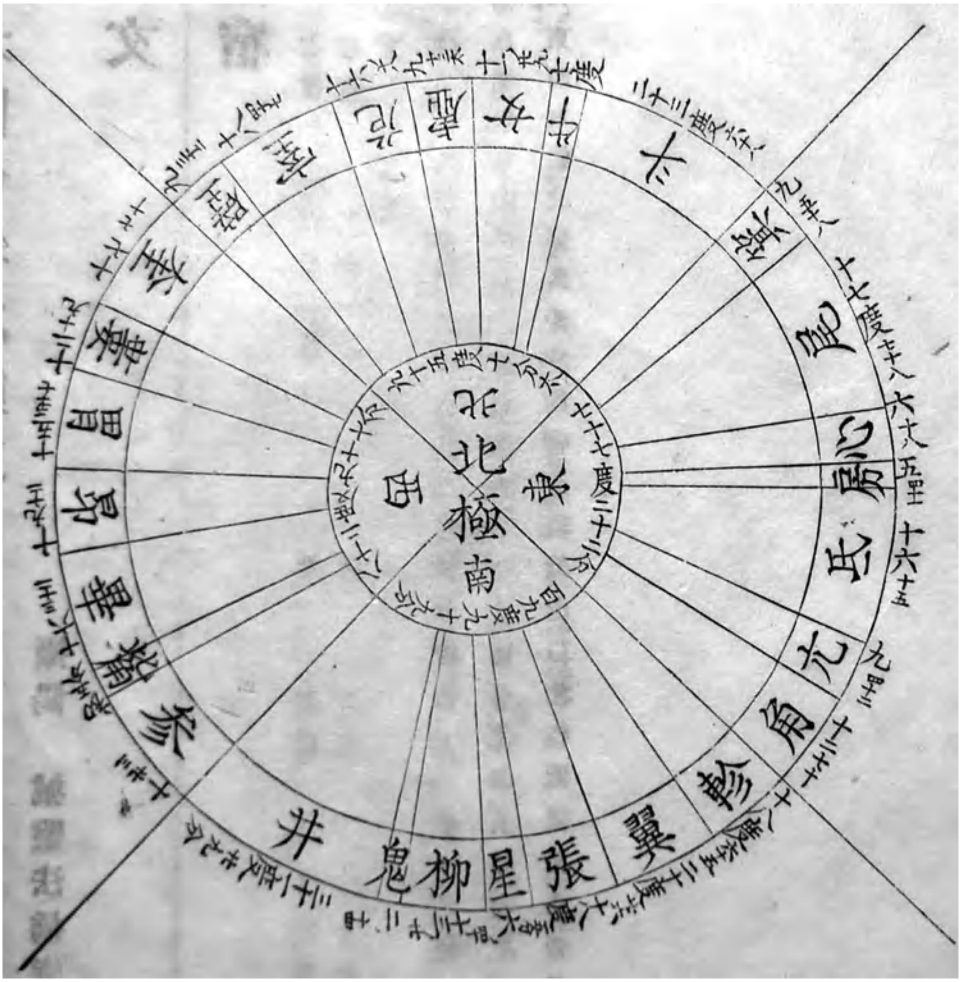

Figure 2.2. A diagram of the 28 Chinese lunar mansions, from the 1901 edition of Ryoan's *Wakan Sansai Zue*. 26.2 × 17.5 cm (page size). Note that, although the area of the sky represented by each mansion constellation was different in size, they were organized into four equal-sized "palaces" of seven mansions, indicated by the crossed lines.

and how many degrees it was from the edge of the nearest lunar mansion. Note that the Chinese celestial sphere contained $365\frac{1}{4}$ degrees, not the 360 degrees that we use today. This system was probably put in use by the 3rd or 4th Centuries BC. Thus, the Chinese employed an equatorial celestial coordinate system centuries before it was used in the West (which preferred an ecliptic-oriented system until the 18th Century). For this reason, many of their astronomical instruments used a mounting oriented to the equator and were the forerunners of our modern telescopic equatorial mounts.

The Chinese had been creating star maps and catalogs since at least the 5th Century BC. In the 4th and 3rd Centuries BC, three notable Chinese astronomers, Shi Shen, Gan De, and Wu Xian each created their own star map and catalog. Chinese author Deng Yinke states that the catalog of Shi Shen provided equatorial coordinates for 120 stars, and both he and Gan De observed the five known planets and noted that Jupiter's sidereal period was 12 years (close to the exact 11.86 years). The earliest existing book to systematically describe the Chinese constellations in the sky was the *Tianguan Shu* by Sima Qian (ca. 145 BC–ca. 87 BC). Some 90 constellations were mentioned, including the 28 lunar mansions. These were organized into five palaces. The Central (or Purple) Palace was the area surrounding the north celestial pole and has been alluded to earlier. The rest of the sky was divided into four equal segments that were called the palaces of the North (or Somber Warrior, represented by an entwined turtle and snake), East (or Azure Dragon), South (or Red Bird), and West (or White Tiger). Each of these palaces represented one of the four seasons, and each consisted of seven lunar mansions. Stars in these areas represented and were named for more mundane aspects of Chinese society, such as temples, philosophical concepts, shops and markets, farmers, soldiers, etc.

In the 3rd Century AD, astronomer Chen Zhuo integrated the records of Shi Shen, Gan De, and Wu Xian. The result was a star map and catalog of 1,464 stars grouped into 284 constellations. Early in the 4th Century AD, the imperial astronomer Qian Luozhi cast a bronze celestial globe with stars colored on it to distinguish the listings of these earlier astronomers. A similar range of stars and constellations is also reflected in the earliest existing printed star map, the Chinese *Tunhuang* manuscript, dating back to the later Tang Dynasty (618 AD–907 AD). Most of these constellations were different from those we are familiar with, although a few were patterned the same way. The great Chinese historian, Joseph Needham, mentions five: Great Bear, Orion, Auriga, Corona Australis, and Southern Cross.

As the Chinese had more contact with Indian and then Islamic astronomers, they became exposed to the Greek system of constellation development, and some of these ideas were incorporated into Chinese thought. This continued when the Jesuits entered China in the 16th Century, as we shall see below.

2.1.4 Chinese influences in Korea and Japan

In large part, the astronomical ideas expressed above were imported by both the Koreans and Japanese, in part as a reflection of the political dominance of China in the region. There were a few minor differences. For example, despite being forced to use the Chinese calendar system, Korean calendars were independently calculated after the early 11th Century, and the two systems were not successfully resolved until the early 15th Century. In Japan some of the mythology associated with the Sun goddess *Amaterasu* and with *Subaru* (the Pleiades), as well as the appearance of the three belt stars of Orion to govern times for the cultivation of rice and millet at the latitude of Japan, needed to be integrated with Chinese models. Other differences exist that are beyond the reach of this book—see Selin (2000) and Walker (1996) for more details. But, in essence, the Koreans and Japanese used Chinese methods to observe the skies, record celestial events, conceive of time and the calendar, and orient themselves to their universe. They also adopted the Chinese constellations.

2.1.5 Outside influences on China

Early China has a reputation of being closed to outside influences, but is this really true? It would appear that there was indeed limited early contact between the Chinese and the classical Greeks and that astronomy developed differently in each country. For sure, there were some similarities: both cultures developed star catalogs, both were interested in the calendar, and both tracked the movement of the planets in the heavens. However, the constellation systems were quite different, as will be shown in the next chapter. In addition, China seemed to echo the Babylonian algebraic traditions, where the positions of heavenly objects in the sky were determined by calculating from patterns identified through centuries of record keeping. The Greeks, by contrast, developed a new way of speculative thinking, where they created geometrical models to explain heavenly phenomena and applied methods of geometry and spherical trigonometry to these models to calculate the location of objects in the sky. In addition, the Chinese were interested in the celestial equator and the circumpolar region, whereas the Greeks were interested in the ecliptic, the location of the Sun, Moon, and planets.

But Needham (1970) has pointed out a number of factors that suggest there was contact between China and the West later on. For example, by the 1st Century AD, there were numerous trade routes from China to other places, such as India, the Middle East, and the scholarly city of Alexandria, Egypt. These included both land and sea routes, and Chinese navigators were adept at using the stars to guide them through the water of the Indian Ocean. We also know that paper, which was invented in China around 105 AD, and the printing of books, which was developed in western China around 870 AD, both made their way to Europe during the Middle Ages, along with other technologies. But what about scientific activities? According to Needham, Chinese pure science seemed to have been filtered out; it went into Arabic cultures but did not penetrate further west. However, the exchange between China and Islam was rich. For example, Needham points out that after al-Tusi's famous observatory and library were built at Maragha in the late 13th Century AD, astronomers were sent from China to collaborate.

Buddhism was introduced into China in the 1st Century AD, and this opened the door to Indian science and medicine. Traditional Indian astronomy had little impact initially, but in the 5th Century it underwent changes due to the influences of Greek astronomy, and these ideas began to be introduced into China. In subsequent centuries many Indian astronomers served at national observatories in China and had an impact, especially in the area of calendrical reform. By the 8th Century, astronomers from Persia also worked in China, and together with later Islamic astronomers they added additional input from the West.

Along with other sciences, Chinese astronomy declined during much of the Ming period (1368 AD–1644 AD), but it was revived in the early 1580s with the arrival of the Jesuit Matteo Ricci, who followed St. Francis Xavier's successful mission to Japan from 1549 to 1552. In addition to gifts, such as clocks, maps, armillary spheres, and sundials, Ricci also brought knowledge of Western mathematics and astronomy to China, and he translated several books in these areas into Chinese. After Ricci's death in 1610, other Jesuit missionaries followed, including Johann Adam Schall von Bell, whose knowledge of astronomy greatly impressed the Chinese, and his successor, Ferdinand Verbiest. As a result, a number of Western ideas infiltrated into the Chinese view of the heavens, such as the Earth-centered cosmology of Aristotle and Ptolemy, Tycho Brahe's hybrid model of the solar system and his ideas on astronomical instruments, the use of the ecliptic coordinate system, and classical Greek views of the constellations. Although some of the concepts were adopted, they were changed to suit Chinese sensibilities. For example, the Chinese zodiac constellations used a set of animals rather than the mixed god/animal representations from the Greek system (see Figure 2.3). Although relations between the Chinese court and the Pope soured in the early 18th Century, with the result that all missionaries were expelled from China by the end of the century, a few Jesuits employed in the astronomy bureau were allowed to remain.

2.2 MESOPOTAMIA

2.2.1 Historical interlude

Although much of Mesopotamian cosmology reflected ideas initiated in the city of Babylon, there were additional contributions from other groups that lived in and around the Tigris and Euphrates Rivers (essentially modern-day Iraq). Thus, a brief review of the history and peoples of this area is in order.

The Sumerians, who lived in the southern part of the area near the delta of the two rivers, were the first group to emerge. They developed cuneiform writing on clay tablets, and existing samples place their civilization as existing earlier than 3000 BC. Their city-states dominated the area, the most famous of which was Ur. In the mid-2300s BC, semitic Akkadians from the central part of the region invaded and conquered Sumer under their king, Sargon, and tablets were written in both the Sumerian and Akkadian languages. Regional power shifted from Ur to Babylon in the 19th Century BC, especially under Hammurabi, who unified the area into one empire and developed a law code that influenced Western thinking to the present day. For some 300 years, Babylon was the center of this empire, and it became a rich and powerful city. Its influence as a center of learning continued even after it fell to the Hittites around 1530 BC and then became part of the Cassite Empire from around 1500 to the mid-1100s BC.

In the 14th Century BC the Assyrians from the mountainous north began to assert themselves in the region, and within a few hundred years they had taken over much of Mesopotamia. By the mid-7th Century BC, they controlled large areas of modern Iraq, Syria, Israel, and Egypt from their capital, Nineveh, although Babylon continued to be viewed as a commercial and intellectual center. But later in this

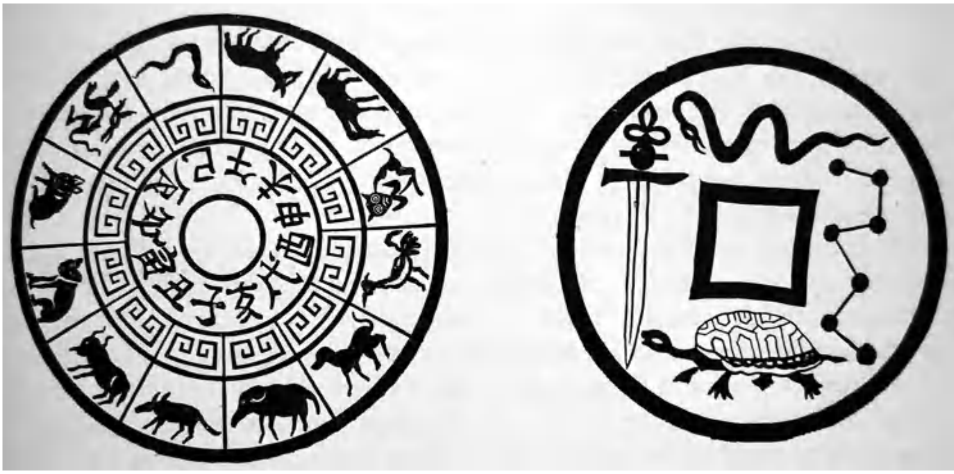

Figure 2.3. The 12 Chinese constellations of the zodiac (left), from the 1894 American edition of Flammarion's *Popular Astronomy*. 23.2 × 15.5 cm (page size). Note that the depictions are different from those of the Greeks and include a rat, ox, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster, dog, and pig. To the right is a drawing of an ancient Chinese medal with the Big Dipper engraved on it.

century there was a revolt, Nineveh was destroyed in 612 BC, and Babylon again came into prominence under the Chaldean (or "new" Babylonian) Empire. Its great king, Nebuchadnezzar, expanded its influence and built a great palace with its hanging gardens. However, in 539 BC Cyrus the Great conquered Babylon, and the region became part of the Persian Empire.

In 331 BC Alexander the Great took Babylon from the Persians on his way to India, initiating the Hellenistic period. Upon Alexander's death in 323 BC, his successor in Mesopotamia and Iran, General Seleucus, began the Seleucid dynasty and continued the Greek influence in the region. After being conquered by the Parthinians from Iran in the mid-2nd Century BC, the area came under the control of the Romans in 64 BC, and the influence of Babylon declined.

2.2.2 Cosmology

The mythology of the Sumerians viewed the cosmos as being ruled by three primordial gods: An, the god of the remote heavens; En-Lil, the god of the sky and wind; and En-Ki, the god of the waters around and below the Earth (including the underworld). Earth itself was created from a primordial unity when En-Lil intervened to separate the heavens from the area below. The Sumerians worshipped these and lesser gods, and each city-state had its favorites.

With the unification of the empire under Hammurabi, the Babylonian sun-god Marduk was given supremacy, and a mythology was created that expanded his powers, which is summarized in the *Enuma Elish*, a mythology text dating from the late 2nd Millennium BC. Now the gods are created out of a watery chaos, the sweet sea being the primeval male Apsu, and the salty sea being the primeval female Tiamat. From them are descended the sky Anu and the Earth Ea, and Ea becomes the father of Marduk. When Apsu and Tiamet threaten to destroy all of their offspring, Ea succeeds in killing Apsu (taking over the sweet water domains for himself). Marduk subsequently kills the powerful Tiamat only after the other gods agree that by doing so he will become the supreme god. From her corpse, he rearranges the cosmos into areas governed by cosmic deities: the heavens (Anu), the sky/wind (Enlil—not to be confused with the Sumerian En-Lil), the subterranean waters (Ea), and the Earth itself, which Marduk took over. One system describes this system as consisting of three heavenly areas and three earthly areas (including the underworld). In either event, the Earth is seen as the center of the universe, with Marduk's temples in Babylon making this city its cosmic capital. This cosmic design gave mythological credence to the idea of a unified Heaven and Earth.

Astrological interests led the astronomer-astrologers in Mesopotamia to keep careful records of celestial events for centuries in tablets such as the *Enuma Anu Enlil*. This source consisted of some 70 clay tablets written early in the 1st Millennium BC and later excavated from the ruins of Ashurbanipal's library at Nineveh. Especially during the Chaldean period and in the years thereafter, a number of tables were produced that recorded data, especially from lunar and planetary events. From these records a number of celestial patterns were deduced, such as the orbits of the planets, the periodic appearances of comets, the times of solar and lunar eclipses, and the variable speeds of the heavenly bodies. Some of these patterns (e.g., the variable speed of the Moon in the sky) could be characterized mathematically in one of two ways developed by the Mesopotamians. One way, System A, assumed that the velocity was held constant over a period of time (say, several days), and then changed suddenly to another value during a second period. Plotted against time over several months, a crenulated pattern emerged, giving average approximations of the changes in velocity. The other way, System B, gave the measured positions of the Moon in celestial longitude for each day, thus tracking its actual speed in smaller increments. If plotted against time, a zig-zag pattern emerged, as the velocity of the Moon was seen to first increase for a while, then decrease. The second system was more complicated since it took actual incremental values rather than averages for its computations, but it was more accurate as well. Both of these mathematical systems were in use from about the 3rd Century BC, with System A being the first to be invented.

Calculations were assisted by the mathematical system originally started by the Sumerians. Rather than using a decimal system based on powers of 10, a sexagesimal system based on powers of 60 was used. For example, a vertical stroke made by a stylus stood for a "1", and a wedge mark like a " > " stood for "10". These marks were built up like Roman numerals up to a value of 60. But unlike the Roman system, Mesopotamian mathematicians used a place-value notation, whereby numbers larger than 60 were indicated by adding similar marks, but separated from the others by a space. This system allowed for the use of basic mathematical operations, such as addition, subtraction, multiplication, etc., provided that the person doing the calculations kept the base 60 in mind. The Sumerians, and the Babylonians after them, became quite proficient in mathematics and over time developed calculation tables for multiplication, reciprocals, square roots, etc. Elements of this sexagesimal system persist today in our 360-degree circle, 60-minute hour, and 60-second minute.

2.2.3 Time and the calendar

The Mesopotamian calendar was initially based on the lunar cycle alone, with the month beginning on the evening when the lunar crescent was first visible. As far back as 1800 BC, the Babylonians were recording the times of moonrise and the date of the new Moon. Under Hammurabi, the calendar was unified throughout the empire, and the months were given Babylonian names. But in time the calendar became luni-solar in its orientation, where the lunar months were integrated in with the solar year. Since the actual number of lunations in a year is a fraction over 12, and since each lunar cycle averaged about 29.5 days, rules had to be set up to govern whether in a given year an extra "intercalary" month should be added and which months would have 29 or 30 days. However, these rules were sometimes applied haphazardly. Around 400 BC, astronomers in Babylon began using the Metonic Cycle, proposed by the Athenian astronomer Meton, who realized that the number of days in 235 lunations were equivalent to 19 solar years, provided that the equivalent of seven months were added during this time span. Thereafter, the Babylonians followed a regular pattern of intercalating seven months in every 19 years.

Based on later Greek sources, we know that the Mesopotamians used water clocks, or clepsydras, to measure time during the day. In these devices, which could have been a simple bowl, time was indicated by marks on the inner wall showing the changing level as the water dripped out of a narrow opening at a constant rate.

2.2.4 Mesopotamian constellations and the zodiac

The names of constellations were being recorded on clay tablets as far back as the time of the Sumerians, around 3000 BC. Some of these names are familiar to us today: the bull (Taurus), the lion (Leo) and the scorpion (Scorpius). This interest in forming constellations may have reflected their desire to organize the sky in a mythologically meaningful manner, particularly the area through which traveled the Sun, Moon, and planets, which we now call the ecliptic. In this way, a reference point for describing the location of these heavenly bodies was made, and this information was useful in preparing calendars for agricultural and social purposes, improving navigation at sea, and making astrological predictions.

Since the calendar consisted of 12 months by the time of the first Babylonian period (around 1800 BC), it seemed reasonable to divide this area into a like number of parts. By 1100 BC, a system had been created where three groups of 12 stars were arranged in three paths across the sky, each of which was related to a creator god. These are described in the *Mul Apin* clay tablets, which were produced early in the 1st Millennium BC and contained a catalog of important stars and some 60 constellations, along with their rising and setting times. The middle path was roughly plus or minus 17 degrees from the ecliptic line and was related to Anu. The path north of this area was named for Enlil, and the path south for Ea. Based on his review of the appearances and locations of the constellations in the sky taken from the *Mul Apin* clay tables and other sources, astronomy historian Bradley Schaefer has concluded that the bulk of the Mesopotamian constellations were developed between 1300 and 1100 BC by Assyrian observers in the northern part of the region. The influence of this system spread widely into India, China, Egypt, and Greece.

Paralleling this development was the creation of 18 "constellations" that were easily observed at night to be in the path of the Moon. These included not only star groups more or less similar to our own, but also some asterisms that we do not recognize as constellations. Historian Nicholas Campion (2000) gives a list of these 18 groups from the *Mul Apin*, and this list includes a number of familiar names: the bull (Taurus), the twins (Gemini), the crab (Cancer), the lion (Leo), the scales (Libra), the scorpion (Scorpius), and the goat fish (Capricornus). Thus, a lunar zodiac was created that was based primarily on star groupings, and this soon took on astrological meaning. For example, the *Enuma Anu Enlil* contains omens whereby the positions of the planets are described in relation to some of these constellations. It was perhaps inevitable that this 18-constellation lunar zodiac would evolve into a 12-constellation solar zodiac more similar to our own by the 5th Century BC. Although the constellations differed in size, they were given $\frac{1}{12}$th of the ecliptic each, and in time this was transitioned into an astrological area of 30 degrees. This focus on the ecliptic and the zodiac (rather than on the celestial equator, such as happened in China) was transported to Greece, and this became the preferred orientation in the West for describing the positions of the heavenly bodies until the 18th Century AD.

2.3 EGYPT

2.3.1 Cosmology

The ancient Egyptians have had a civilized society for millennia, and their mythological system and views of an afterlife were major components of this society. In fact, the sky figured prominently in this mythology. The sky goddess, Nut, was often described in papyrus texts and portrayed on coffin lids and temple ceilings as a naked woman, sometimes arching over her consort Geb, who was the Earth deity. Ra, the Sun god, was frequently shown as entering the mouth of Nut every sunset, traversing her body during the night, and finally being reborn from her every morning at sunrise (Figure 2.4). Associated with this image were figures representing the Moon, planets, and constellations, which will be discussed below. From the union of Nut and Geb came a number of Egyptian gods and goddesses, such as Isis, Osiris, Seth, and Nephthys, and their offspring. This rich mythology dates back to at least the 3rd Millennium BC and was often depicted in connection with descriptions and images of the afterlife. One common image was the weighing of the deceased's heart to see if it was lighter than the feather of truth, suggesting purity and the lack of sinful behavior "weighing it down" during the course of a life. In Figure 2.5 Maat, the goddess of

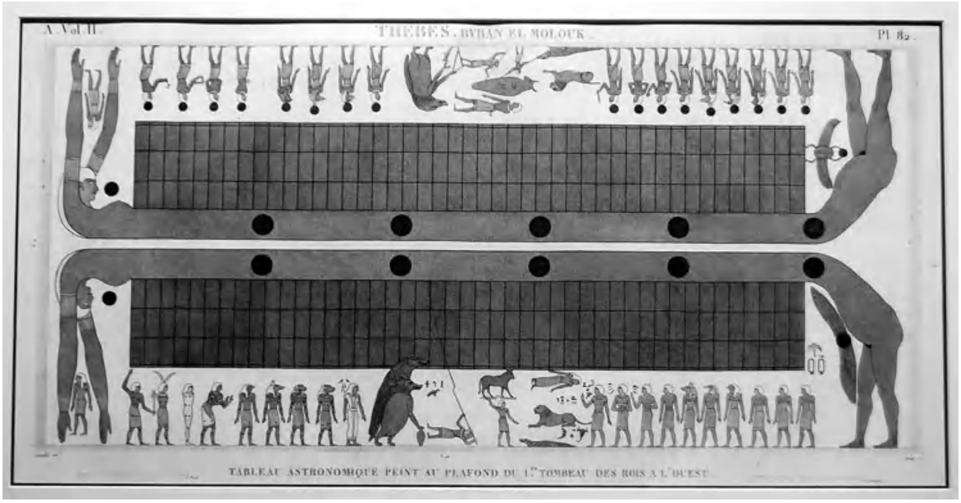

Figure 2.4. Drawing of a ceiling painting from a temple at Thebes, from *Description de l'Egypte,* ca. 1802. This book resulted from Napolean's military and scientific expedition to Egypt. 25.7 × 55 cm. Note the double depiction of Nut, the sky goddess, with the Sun shown entering her mouth at sunset, traversing her body, and flying out of her at sunrise. Note also a number of traditional Egyptian constellations in the center. See Section 2.3.4 for details.

truth, is presiding over this activity, with the deceased man shown on her left. On the other side of the scales is Thoth, the god of wisdom and writing who is shown in his baboon form, who is prepared to record the verdict. Below is Ammit the devourer, with crocodile head, lion body, and hippopotamus legs, waiting to destroy the heart of the deceased if there is an unfavorable outcome.

2.3.2 Time and the calendar

The practice of religion and its festivals, as well as other activities such as planting crops and regulating a complex society, created a need for an accurate method of determining time. As an agricultural people, the Egyptians noted that there was a yearly rise in the Nile River, which flooded their soil and prepared it for planting. By the beginning of the 3rd Millennium BC, they were recording an association between this flooding and the first pre-dawn or heliacal appearance of the star Sirius, which they called Sothis (which occurs in our mid-July). They set up a calendar system of three seasons: flooding, planting, and harvesting. Each consisted of four lunar months, which were named for important agricultural and religious festivals that occurred within the month. Unlike the ancient Mesopotamians and the Chinese, the Egyptian month began with the disappearance of the waning crescent Moon before sunrise, not with the appearance of the new crescent just after sunset. This interest in the dawn sky might have been related to their interest in the daily rebirth of Ra, as mentioned above. Like other luni-solar people who realized that there was not

Figure 2.5. Chromolithograph of an Egyptian papyrus "Judgment of the Dead", from Binion's (1887) *Ancient Egypt or Mizraim*. 21 × 43.6 cm. Note the goddess of truth, Maat, presiding over the weighing of the heart of the deceased man on the left. Thoth, the god of wisdom and writing, is ready to record the outcome, and the "devourer" is waiting to destroy the heart if there is an unfavorable outcome. Being a lunar deity, Thoth has a Moon over his head. *See also* Color Section 1.

an even number of lunar months in a solar year, they added an intercalary month periodically. For the Egyptians, this occurred whenever Sothis rose late in the 12th month (about every three years), and this kept the lunar months synchronized with their New Year festival.

In addition to this agricultural/religious calendar, the Egyptians developed a parallel administrative civil calendar around the beginning of the 3rd Millennium BC that was based on 12 months of 30 days each, followed by five extra days. Since this 365-day calendar lost $\frac{1}{4}$ day each year, it soon lost step with the agricultural/religious calendar, but a systematic correction of one day each four years (like our leap-year) was not instituted until late in the 1st Millennium BC.

In the civil calendar each 30-day month was divided into three 10-day periods and was associated with the heliacal rising of a star or group of stars called a decan. These were located in a band parallel to but slightly south of ecliptic. Discounting daybreak and nightfall, about 12 decans could be seen rising during the darkness of night, and it was logical to use these as time markers. In fact, priests could regulate the times of nightly temple services by watching the successive appearances of the decans. Another way of monitoring time at night was through a clepsydra, or water clock, which was used as far back as the 16th Century BC. The custom of dividing the night into 12 decanal "hours" may have led to the parallel division of the daytime into 12 hours. To tell the time during the day, sundials and shadow clocks were used, examples of which date back to about the 13th Century BC. Clepsydras of course could also be used during the daytime.

In the latter part of the 2nd Millennium BC, tomb paintings began to show images of a person sitting before a grid surrounded by stars. This is thought to be a method of telling time at night by recording the array of stars transiting the meridian behind an actual sitting person at a given time and comparing this array with standard tables. Although this probably was an attempt to increase the accuracy of measuring the time at night using the stars, it was not terribly successful since there was no attempt to standardize the size of the sitter. Thus, a star appearing near the left shoulder of one person might be documented as near the left ear of another.

2.3.3 Orientation of temples

Much has been written about the orientation of Egyptian pyramids and temples with reference to the sky. Popularized by the great British scientist J. Norman Lockyer in his book *The Dawn of Astronomy*, the idea was that the Egyptians oriented the axes of their religious structures in the direction of the cardinal compass points (especially the meridian line) or some important astronomical event, such as the rising or setting of the Sun or a star during a religious festival day or during an equinox or solstice (Figure 2.6). For example, the entrances for the three pyramids at Giza all face north, and the entrance corridors are angled such that one could see the northern circumpolar stars from them. Many structures located close to the Nile were oriented on an east–west axis, but this was probably because the Nile flows northward, and it was appropriate to align a rectangular building facing toward the river for aesthetic (not necessarily religious) reasons. In some cases, a temple was oriented so that the inner shrine was illuminated by the rays of the rising Sun during a certain festival day. In other cases, there seemed to be an intent to orient a building toward the rising or setting point of a bright star that had a special meaning, like Sirius. But there did not seem to be a universal pattern, and one gets the impression that a supporter of the orientation hypothesis can almost always find a good justification for a particular orientation. Work in this area continues, with scientists performing statistical analyses on a number of temples looking for specific orientation patterns and ways of explaining them—see Belmonte and Shaltout (2006) and Shaltout and Belmonte (2005) in the Bibliography.

2.3.4 Egyptian constellations

The Egyptians developed their own constellation system based on important gods and animals in their mythology, although it was not as extensive as in other cultures. For example, historian and mathematician Hugh Thurston (1996) mentions an Egyptian catalog of the universe dating to about 1100 BC that lists only five constellations, two of which are similar to our Orion and Ursa Major. Of course, if one includes the decan star groups, then this number jumps by 36.

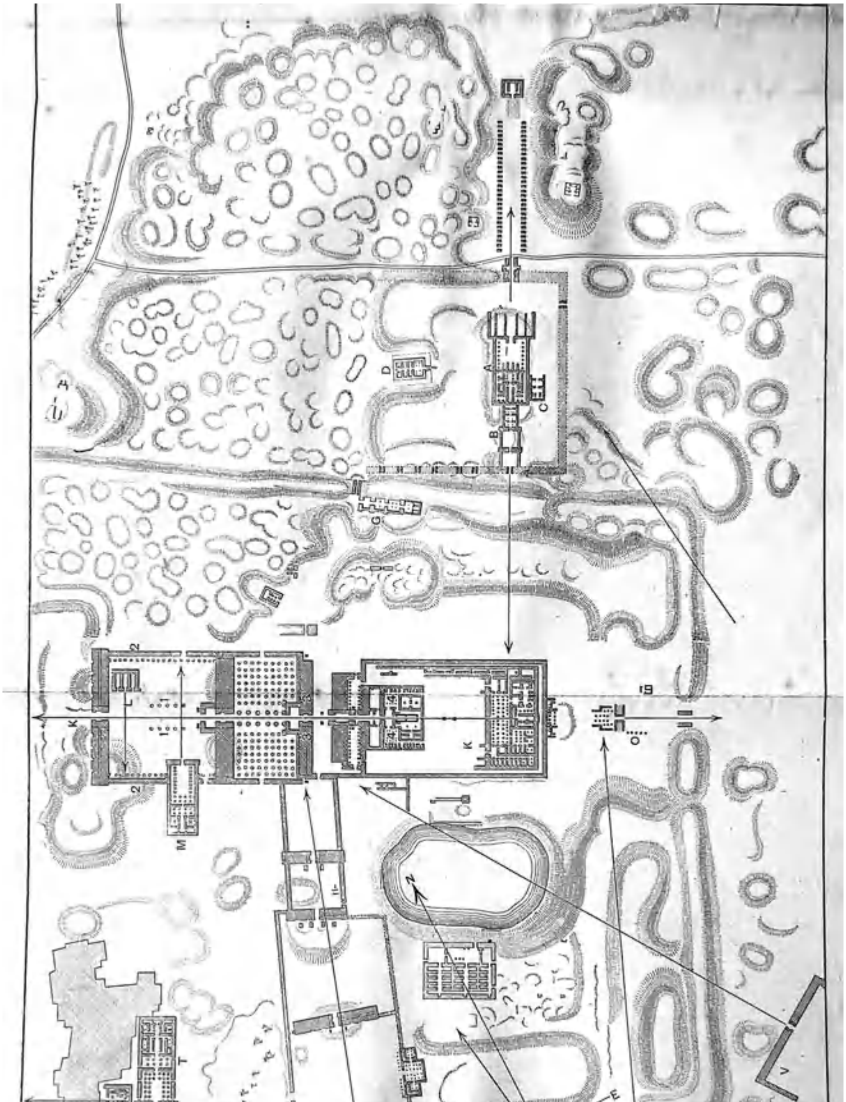

Figure 2.6. A pull-out plate of the plan of the temples at Karnak, from J. Norman Lockyer's (1894) *The Dawn of Astronomy*. 17.5 × 41.2 cm. Note the arrows indicating the orientations of the main buildings. For example, the text tells us that temple M at the upper center faces the direction where the star *Gamma Draconis* rises in the sky, and temple L faces where the star Canopus sets.

Like the Mesopotamians and Chinese, the circumpolar constellations were important to the Egyptians, not so much because they never set but because they never appeared before the rising Sun. Thus, they were often linked with the powers of darkness and with ferocious animals. For example, the circumpolar area around our Draco was often associated with a crocodile or hippopotamus, and the Plough (our Big Dipper) asterism of Ursa Major was viewed as the thigh or foreleg of an ox or bull (representing the evil god Seth). Thoth, a lunar deity, was usually shown with a Moon symbol above its head. It was also depicted as a baboon (an animal that shrieks before dawn), representing the transition from night to day. Both of these images could be combined, as is illustrated in Figure 2.5. And, as we have seen, Nut was associated with the Milky Way as it arched across the sky.

Lull and Belmonte (2006) have recently analyzed a number of Egyptian images located in tombs and on temple ceilings to find parallels between the traditional Egyptian constellations and the constellations that we visualize today. For example, they would view the female hippopotamus image in the lower left center of Figure 2.4 as representing the large area of the sky centering around the circumpolar constellation Draco, from Lyra to Bootes. The crocodile on her back would represent the area around the head of Serpens. The reclining lion and crocodile images in the lower right center represents Leo and Hydra, respectively. And, of course, the thigh/bull combination located in the upper center part of Figure 2.4 would be Ursa Major.

Following the death of Alexander the Great, one of his generals, Ptolemy, took over the administration of Egypt, thus initiating the Ptolemaic Period (323–30 BC). During this time, Greek ideas involving the cosmos and astrology began to gain influence in Egypt. In addition, Greek constellations were intermingled with those native to Egypt in images on temple ceilings and other monuments. A case in point is the famous image that dates from just after this period that was once located on the ceiling from the Temple of Hathor at Dendera. This so-called "Dendera zodiac" depicts the circle of the heavens held up by 12 figures representing the constellations of the zodiac (Figure 2.7). The outer ring of figures in the circle represents the 36 traditional decanal stars and constellations. The innermost figures are Egyptian constellations, and these are surrounded by the Greek constellations of the zodiac mixed in with images representing the planets, depicted as gods holding staffs.

2.3.5 Differences from China and Mesopotamia

Egyptian cosmology differed in two important ways from that of China and Mesopotamia. First, it was less interested in perceiving omens from celestial events. Portent-based interpretations were not central to the Egyptian mythology, and a system of astrology did not appear until it was imported from Mespotamia and Greece. Without the stimulus of omens, the Egyptians consequently did not produce the kinds of regular records of eclipses, planetary movements, or other celestial events that we have seen in other ancient cultures.

Second, the Egyptians eschewed mathematical approaches to astronomical events. Although some celestial patterns were noted and used qualitatively when they related to religious notions or agricultural needs (e.g., the heliacal rising of

Sirius), a numbering system amenable to algebraic calculations did not develop along the Nile. Instead of a place–value system, the Egyptians had symbols for different numbers (like 1, 10, 100), and they simply repeated them as was necessary. Thus, although many early Greek astronomers and philosophers, like Thales of Miletus, Democritus, and Plato, spent time with scholars in Egypt, it is likely that they were more influenced by Babylonian imports than native Egyptian traditions, since the direction of Greek astronomy seemed to follow Mesopotamian models more than anyone else. Two exceptions were the 365-day civil calendar and the division of the day and night into 12 hours, both of which were homegrown Egyptian products that were taken up by the Greeks.

2.4 INDIA

2.4.1 Cosmology

Cosmology in India goes back several thousand years to Vedic times. Historian and engineer Subhash Kak has categorized early Indian astronomy into several periods. The first was Rgvedic astronomy (Kak: ca. 4000 BC–2000 BC; other scholars: several centuries later), which focused on the motions of the Sun and Moon, the observations of planetary periods, and the division of the sky into *naksatras* (which will be described in Section 2.4.3). Historian John North has cited creation myths from this period that included ideas that the universe was a building of wood made by the gods, with the heavens and the Earth supported by posts, or that it was created from the body of a primeval giant and inhabited by a world-soul. The Sun was sometimes seen as an astral god drawn in a chariot by seven horses.

The second period related to the texts of the Brahmanas (2000 BC–1000 BC), which described the non-uniform motions of the Sun and Moon in non-circular orbits, calculated the cycles of time that were related to the relative positions of the heavenly bodies, formalized the luni-solar calendar with its intercalations, presented cosmological ideas related to the "strings of wind" joining the Sun with the planets, and suggested that the Earth rotated on its axis (an idea later popularized by Aryabhata around 500 AD). This is known to us from later Indian texts and from the writings of Lagadha (ca. 1350 BC, or perhaps later), whose *Vedanga Jyotisa* is the only extant astronomical text from the Vedic period, according to Kak. During this period, there was much symbolism in the field, with certain numbers having special meanings and altars being constructed to represent the geometry of the heavens. Kak relates this to the connection or equivalence between astronomical, terrestrial, physiological, and psychological realms that characterizes Indian thought and is often represented by similar numbers—for example, the 360 bones of the infant being related to the 360 days of the year.

The third period consisted of early Puranic and early Siddhantic writings (1000 BC–500 BC). Kak views the Siddhantas as being more mathematical and the Puranas as being more encyclopedic and empirical but also more cryptic and

Figure 2.7. Copper schematic engraving of the famous "Dendera zodiac" planisphere at the Temple of Hathor at Dendera, from Denon's (1808) *Viaggio nel Basso e Alto Egitto*. 29.1 × 28.8 cm. Note the traditional Egyptian constellations in the center: hippopotamus (area around Draco) and thigh of an ox (Big Dipper). These are surrounded by figures representing the Greek zodiac and the planets (depicted as gods holding staffs). On the rim of the circle are figures representing the 36 decans.

speculative. These sources provided information on the relative sizes and distances of the Sun, Moon, and planets; introduced the concept of kalpa (i.e., a day of Brahma, the creator of time, equaling 4.32 billion years); and described and further developed the great cycles of time that were of interest to early Indian astronomers. Some of these implied that the planets revolved around the Sun, which in turn went around the Earth. There were also hints of a primitive epicycle theory.

In addition, Kak cites later Indian sources as giving a figure for the speed of light that is much like our own and supposedly reflected an earlier Puranic tradition; however, he believes that the accuracy of this value was probably a lucky guess. Some early Indian sources described an atomic theory that consisted of four atoms (earth, water, fire, and air) that combined to form matter. Light rays were a stream of high-velocity fire atoms.

After 500 BC, there were additional Puranic and Siddhantic writings. Kak describes two models of the universe mentioned in the Puranas. One conceived of it as consisting of seven underground worlds below the orbital plane of the planets and seven regions that encircled the Earth. In the center of the flat, circular Earth is a large mountain, Meru, which represents the axis of the universe. In another model, there is a central Earth that is orbited by the Sun, beyond which are the orbits of the Moon, asterisms, planets (in order: Mercury to Saturn), and then Ursa Major followed by the pole star. Beyond this are four additional spheres. Surrounding our universe is the limitless space with countless other universes. This cosmology envisions cycles of creation and destruction of 8.64 billion years, or a day and night of Brahma. The universe itself was said to last for 100 Brahma years (each of which has 360 Brahma days and nights).

Of the later Siddhantic writings, those of the great Indian astronomer Aryabhata (born 476 AD) were influential in southern India and dealt with the size of the universe and distances to the Sun and Moon, as well as making refinements to Puranic ideas concerning the relative diameters of the Earth, Sun, and Moon (although the angular sizes of the planets were too large by a factor of four). He also presented epicyclic models of the orbits of the planets that were different from those presented by Greek astronomers. For example, to account for two anomalies in location of a planet in the sky using a geocentric framework (due to the ellipticity of its real orbit around the Sun and to the fact that it is observed from a moving Earth), he employed two concentric epicycles rather than using an equant like Ptolemy (see Section 3.1.12). His writings also included some spherical trigonometry, a procedure for calculating the duration of an eclipse, and a mathematics section that allowed one to calculate an accurate value for pi. Finally, although his cosmology included Mount Meru as the center of the Earth, he also made statements supporting the rotation of the Earth and the revolution of the planets around the Sun.

A competing Siddhantic system was put forth by Brahmagupta (born 598 AD) that made improvements to some of Aryabhata's ideas and calculations and was influential in northern and western India, as well as in the Islamic world through its Arabic translations. Later, Bhaskara II (ca. 1150 AD) produced a comprehensive Siddhanta that was based on Brahmagupta's work and further developed the epicyclic theories involving the motions of the planets. He also developed notions of trigonometry that probably reflected Islamic influences, as did later Indian astronomy as well.

Mention should be made of the great stone observatories created by Jai Singh in the early 1700s, which were modeled after that built by Ulugh Beg at Samarkand. Although out of date when they were built, this effort nevertheless demonstrated a valiant attempt at observational astronomy, which had generally been neglected in India in favor of mathematical astronomy until the late 14th Century. Their remains can still be seen at Delhi, Jaipur, and Ujjain.

2.4.2 Time and the calendar

Traditionally, the Indian calendar was based on lunar months, each of which began with the full Moon. In time, this was integrated with the solar year. According to Kak, the lunar and solar calendars were brought into harmony in a variety of ways depending on local traditions: adding 11 days each year to the 354-day lunar year (i.e., 12 months of 29.5 days each); adding five days to a year made up of 30-day months; adding an intercalary 13th month twice in every five years; etc.

Attention was paid to both equinoxes and solstices, with the ritual year starting with the winter solstice and the civil year starting with the spring equinox. The ritual year was divided into two halves: when the Sun moved north in the sky, and when it moved south. The summer solstice was the midpoint, and it was recognized as far back as the Brahmanas that the number of days in each half were not equal due to the varying speed of the Sun in the sky (a fact not noted by the Greeks until the 5th Century BC). Ceremonies and festivals marked the time, such as the closing rite at the end of the year to celebrate the first ploughing. There were also sacrificial rituals every four months, ceremonies for the full and new Moons, and rites to mark the passage of the day.

2.4.3 Indian constellations

In keeping with the lunar calendar system, Indians astronomers during the Rgvedic period divided the sky along the Moon's path into 27 equal parts called *naksatras* (Figure 2.8). Specific stars or constellations associated with these areas were also called *naksatras*. In later literature the number of both the regions and associated stars was increased to 28, which better matched the Moon's progress in the sky. Other constellations were recognized that were similar to our own, such as the Bears (Ursa Major and Minor), the two divine Dogs (Canis Major and Minor), the Boat (Argo Navis), and the Pleiades in Taurus. According to Kak, in the Brahmanas period, Orion and the bright star Sirius were singled out, as well as possibly stars in our Gemini, Capricornus, and Cassiopeia.

The naked eye planets also were known and named since the Rgvedic period. In Vedic mythology, they were traditionally the offspring of other heavenly beings and were themselves equated with the gods: Mercury (Visnu), Venus (Indra), Mars

(Skanda, the son of Siva), Jupiter (Brahman), and Saturn (Yama). Venus was sometimes associated with the twins Asvins, reflecting its appearance as both a morning and evening planet. The Sun was linked to Siva, and the Moon to Uma, Siva's wife. The planets were also associated with colors (e.g., Mercury and Jupiter, yellow; Venus, white; Mars, red; Saturn, black). They were also part of references that alluded to the 34 lights in the sky, which were the 27 *naksatras*, the Sun, the Moon, and the five planets.

2.4.4 Outside influences

There is evidence for contact between Indian and Mesopotamian cultures during the Assyrian period. For example, North (1995) cites similarities with some of the statements found in the *Mul Apin* clay tables, which were produced early in the

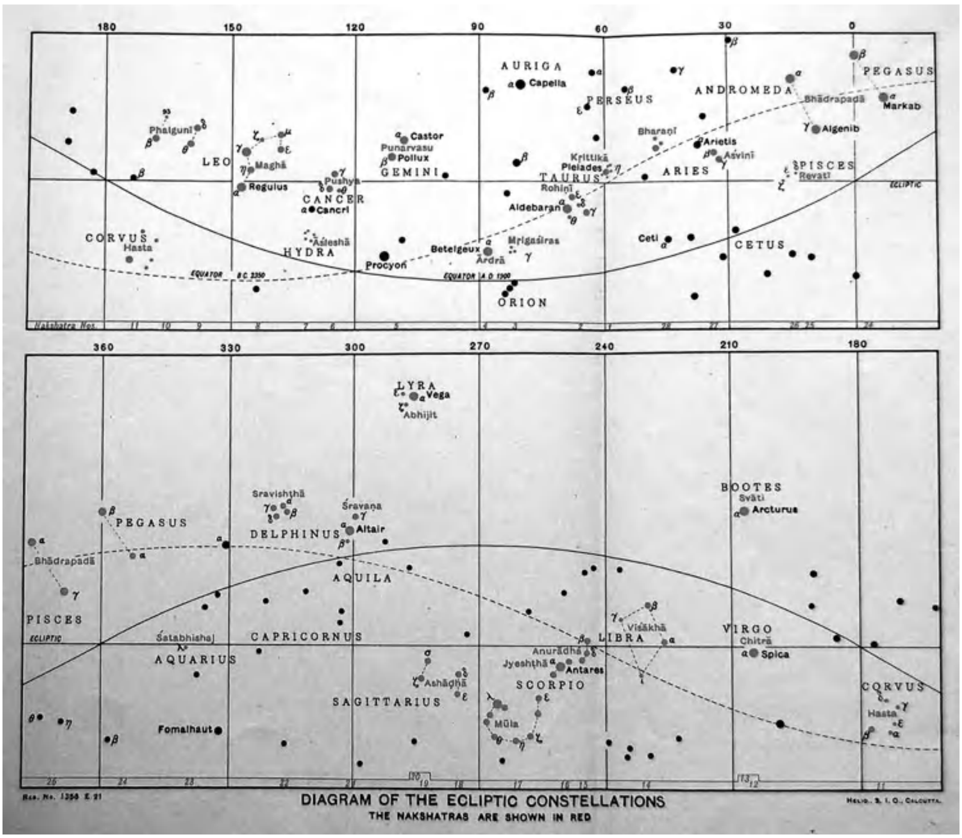

Figure 2.8. The 27 *naksatra* constellations from Vedic mythology, from G.R. Kaye's *Memoirs of the Archaeological Survey of India, No. 18: Hindu Astronomy*, published in Calcutta in 1924. 22.7×27.4 cm. Note that they include both constellations and individual stars, some of which are familiar (e.g., *Krittika*, the Pleiades; *Svati*, the star Arcturus). *See also* Color Section 1.

1st Millennium BC, and later Vedic texts. In addition, the Persians moved into northwest India during the late 5th Century, bringing with them Babylonian ideas involving astronomy and astrology, including omens related to those found in the *Enuma Anu Enlil*.

During the Hellenistic period after Alexander the Great's conquests, Greek influences made their way into the region. Needham (1970) points out that settlers were left behind in India to form the Greek kingdoms of Bactria and Sogdia. In fact, an examination of Indian texts gives some insight into pre-Ptolemaic astronomy from Greece, especially since few Greek texts survive from this period as a result of being replaced by Ptolemy's great work. Gradually, the ideas of Aristotle and Ptolemy took hold, and Indians made refinements to epicyclical theory (such as the use of an oval-shaped epicycle) that they later shared with the Arabs. They also adopted the 7-day week and the dedication of each day to the deities of the Sun, Moon, and five known planets. In addition, they adopted the Greek constellation system. In later Indian manuscripts, one sees the zodiac represented, along with traditional Greek constellations. Often, the figures were dressed in traditional Indian clothing or were altered to match Indian prototypes, sometimes resulting in curious hybrids (Figure 2.9). But the influence is unmistakable. However, Kak (2000) has provided some evidence for reciprocal influence from India to the West, in that the Druids used a calendar system similar to that mentioned in the *Vedanga Jyotisa*, and they employed a 27-day lunar month suggesting a linkage of the lunar phases and the 27 *naksatras*. Also, some of the Venus mythologies of Mesopotamia and Greece seem to have been predated by Vedic texts, as well as images of elephants in ancient European artwork. Finally, some elements of Indian geometry and mathematics predated those in Babylonia and Greece.

2.5 ASTROLOGY IN ANCIENT TIMES

Although existing clay tablets tell us that the Sumerians were the first to record the names of constellations, regular observations of the Moon and planets began with the Babylonians. For example, the Venus tablet, which was made around 1600 BC, contains 59 omens grouped into 8-year cycles based on the first and last appearances of Venus in the sky. Thus, by this time the Babylonians were observing and recording events in the sky, recognizing the periodicity of some of these events and using this information to make predictions about the future. These predictions generally related to issues involving society at large, such as the weather, agricultural productivity, and politics, rather than to specific individuals (excepting, of course, the king and his court). Thus, there was a fusion between what we now call astronomy and astrology, representing a worldview that events in the sky resonated with events on Earth and that knowledge of these events could affect man's future. This preoccupation with knowing and influencing one's future occurred in other areas as well, such as the omens made from reading the entrails (especially the livers) of animals and from abnormal births.

Astrological issues continued into the Assyrian period. For example, clay tablets record that the 8th-Century emperor Sargon II used the advice of court astrologers in planning his military campaigns. In addition, the *Enuma Anu Enlil* is a comprehensive compendium of astronomical observations and some 7,000 astrological omens. Most of the material dealt with the appearances and movement of the Moon and Sun, although the planets and weather issues also were included. By now, the planets had taken on special meanings associated with personifications of gods. For example, Mars was the "star" of Nergal, the god of pestilence, and was seen as an evil body, whereas Jupiter was associated with Marduk and was seen as being lucky.

Figure 2.9. Indian constellations, from the 1894 American edition of Flammarion's *Popular Astronomy*. 23.2×15.5 cm (page size). Note that the figures are stylized using an Indian perspective. The outer constellations represent the zodiac, and the inner ones represent the Sun, planets, and the Moon and its ascending and descending nodes.

After the fall of the Assyrian empire, there was a shift in astrological emphasis, particularly during the Persian occupation. Although astronomical observations continued to be made, the role of astrology in making political decisions declined, and a new form developed that related to predicting one's individual destiny based on the positions of the heavenly bodies in the sky at the time of conception or (more practically) at birth: natal astrology. The idea was that the configuration of heavenly bodies when one came into the world would influence a person's subsequent personality and destiny. Once again, the link between the heavens and the Earth was presupposed, but this time the effects of this relationship were personal and potentially available to everyone, although astronomy historian Nicholas Campion states that the small number of surviving birth charts compared with the large number of astronomical tables suggests that the former were mainly used by the social elite. Campion gives an example of a birth chart for a nameless child born on April 29, 410 BC, that gives the date, the names of its father and grandfather, astronomical details at the time of birth, and astrological predictions.

This change in favor of birth charts may have reflected the increased information on planetary periodicities and the meanings of birth defects that had been acquired over the previous centuries. Alternatively, it may have reflected the discomfort of the Persian rulers for making political decisions based on earlier Babylonian ideas. In addition, the main religion of Persia, Zoroastrianism, viewed a person's soul as coming from and being influenced by the heavens, particularly the planets, and this idea supported the value of having a personal horoscope. Finally, the shaping of the birth chart was influenced by ideas involving the zodiac, a Mesopotamian invention.

The Mesopotamian zodiac and constellation system were imported into Greece midway through the 1st Millennium BC, as were many astrological concepts. But, once in Greece, natal astrology became more rational and precise. In earlier times the heavens and Earth were unified and mutually affected each other. Thus, events on Earth could affect those in the heavens, and vice versa. In the Greek system, however, the celestial regions were seen as being purer and metaphysically superior to the sub-lunar regions. Consequently, events in the heavens could bring changes on Earth, but the reverse did not occur. In addition, astrology developed a more scientific emphasis, in keeping with cosmological developments that encouraged mathematics and geometrical model building. According to astronomy historian James Evans, the area of the sky and its relationship to the horizon became important, being divided into four centers: ascendant or horoscopic point, mid-heaven, setting point, and under-earth. Pairs of zodiac signs were designated as the solar and lunar houses of a planet. The precise location of heavenly bodies in the zodiac at different points in time became part of the astrological forecast. As Campion puts it, Babylonian astrology relied on what was observed, whereas Greek astrology depended on accurate predictions that could be made of planetary positions.

According to Evans (2004), the Greek system of horoscopic astrology really began to grow in the 1st Century BC and continued into the Roman period. It was during this time that it also picked up elements of eastern mysticism. This was especially true in Greco-Roman Egypt, where there was a syncretic fusion of Western concepts involving the constellations, especially those of the zodiac, with

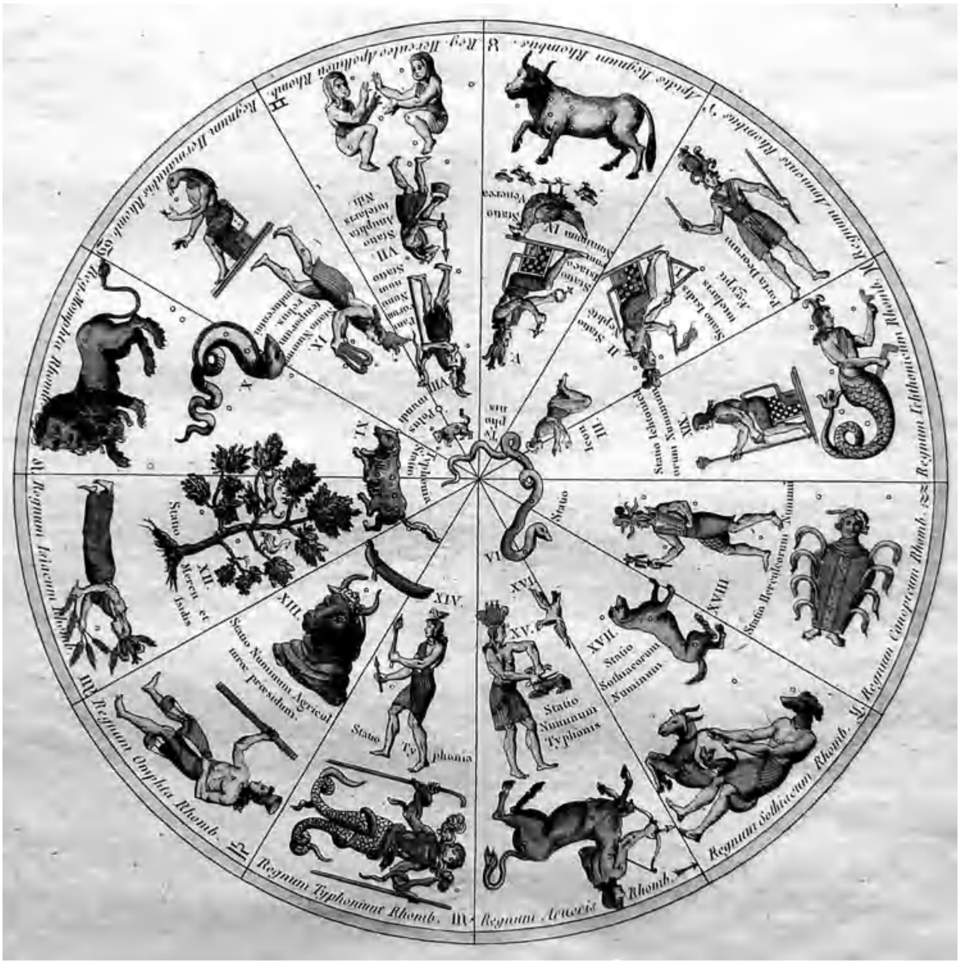

Figure 2.10. "Planisphere Egyptien" representing the Egyptian sky according to Athanasius Kircher, from Charles-François Dupuis' *L'Origine de tous les Cultes ou Religion Universelle*, ca. 1795. 18.1 cm dia. Note the syncretic mixture of western and eastern zodiacal images around the periphery and the more traditional western constellations in the center. *See also* Color Section 1.

native Egyptian elements (Figure 2.10). Not only were the constellation images altered to conform to both systems, but the use of the decans was included. Each of the zodiac signs was divided into three 10-degree areas, which were named and associated with a decan (Figure 2.11). Furthermore, each Egyptian constellation was linked to one of the zodiac signs. Based on archeological evidence, Evans has given us a picture of astrological practice in Greco-Roman Egypt. This included the use of papyrus horoscopes as well as marble or ivory astrologer's boards engraved with numbers and figures of zodiac signs and decans, on which were placed colored stones with images of planetary gods. By setting the stones on the board, the

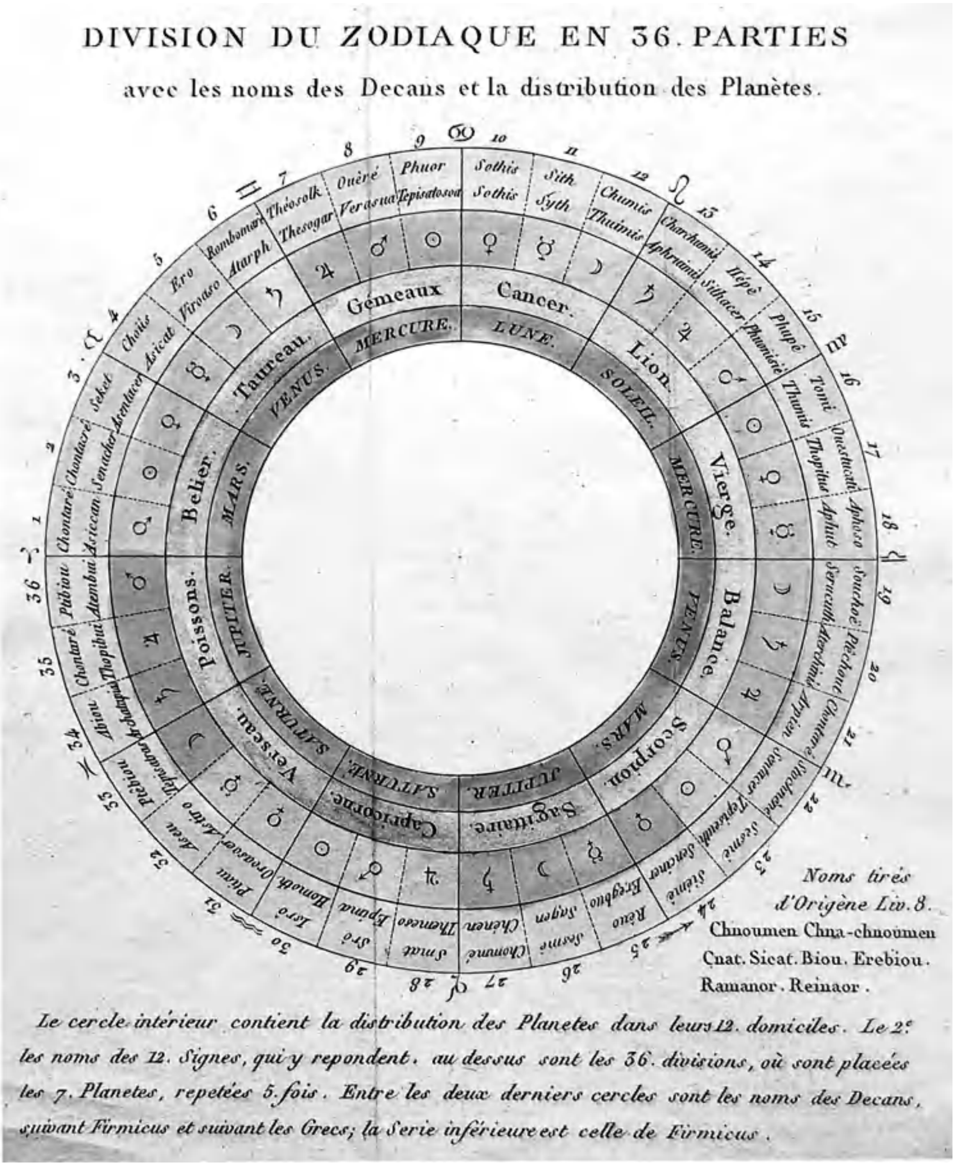

Figure 2.11. A figure from Charles-François Dupuis' *L'Origine de tous les Cultes ou Religion Universelle*, ca. 1795, which summarizes important astrological information and is reminiscent of a Greco-Roman astrological board from Egypt (see text). 16.2 cm dia. Note the concentric rings that represent (from the outside in) the names of the 36 decans and the symbols for their planetary associations, and the names of the 12 zodiac constellations and the names of their planetary associations. *See also* Color Section 1.

astrologer could illustrate for his client the basis for a prediction. Much of this astrological work occurred in temples dedicated to the cult of Serapis, who himself was a Hellenized fusion of Egyptian (e.g., Osiris and Apis) and Greek (e.g., Helios or Zeus) gods.

The principles of ancient astrology were written down in texts, such as Marcus Manilius' *Astronomica* and Dorotheus of Sidon's *Carmen*, both from the 1st Century AD. However, the definitive text of astrology was Claudius Ptolemy's 2nd-Century-AD *Tetrabiblos*. We shall meet this famous scholar from Alexandria, Egypt, in Section 3.1.12 in the context of his astronomical works. But his well-known astrological treatise summed up the state of this subject to that time and became the foundation for modern astrology as it was to be practiced in the West. Originally known as the *Mathematical Treatise in Four Books*, it did indeed consist of four parts. Book 1 dealt with the basic principles of astrology, such as the characteristics of the heavenly bodies and signs of the zodiac (e.g., favorable/unfavorable, masculine/feminine), and the various alignments of the Sun, Moon, and planets. Book 2 dealt with astrological issues related to society at large, such as which planets ruled over which countries and the impact of the heavenly bodies on the weather. Book 3 dealt with the individual, such as the importance of the phase of the Moon or the sign that was rising in the sky at the time of conception in predicting future events in a person's life, and the astrological influences of issues antecedent to conception, such as those related to his or her parents and siblings. Book 4 dealt with additional astrological issues that Ptolemy considered as being more external, such as later occupation, marriage, children, and travel. In the *Tetrabiblos*, Ptolemy defended astrology as being scientific because it operated according to natural laws. This treatise was a textbook rather than a how-to-do-it manual, focusing more on a systematic presentation of general themes than on specific details of practice. For over 1,200 years, Islamic and European scholars regarded this book as the definitive reference in astrology (much as Ptolemy's other books on astronomy and geography were considered in their areas of specialty).

When the Roman Empire broke up, astrology in the West began to lose its influence, as Greek mathematical astronomy went into hibernation and as the Catholic Church began to condemn its practices. But as we shall see in Section 3.6, astrology continued on in the East and became even more complex and mystical during the Middle Ages.

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