The Origin of the Greek

By Bradley E. Schaefer

ASTRONOMY AND ARCHAEOLOGY HAVE TOGETHER UNCOVERED THE HISTORY OF HOW THE STAR PICTURES CAME TO BE—AND HOW PEOPLE HAVE USED THEM OVER TIME

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My grandfather first taught me about the Great Bear constellation. After that, I had fun wielding an old pair of binoculars and picking out other constellations in the wide sky over Colorado—or even inventing my own. At the time, of course, I gave no thought to the age or origin of the constellations, but the curious pictures in the sky present a fascinating scientific puzzle.

In 1922, when the International Astronomical Union officially defined 88 constellations, it drew the bulk of them from Ptolemy's *The Almagest,* which was written around A.D. 150 and described the traditions widespread among the Greeks. These traditions had been popularized in the "best-selling" poem *The Phaenomena,* by Aratus (275 B.C.). The great astronomer Hipparchus's sole surviving book, *The Commentary* (147 B.C.), tells us that Aratus's poem is for the most part a copy of a work with the same name by Eudoxus (366 B.C.), which no longer survives. These books held the earliest descriptions of the Greek skies, and in them the constellations are already fully formed. But where did the Greek constellations come from?

Paleolithic Hunters

TO TRACE THE HISTORY of the constellations, we need to go back to a time long before the Greeks. Constellations are ubiquitous throughout the world's cultures. In the millennia before light pollution dimmed the night sky, people would watch the ceaseless motion

CONSTELLATIONS

GREAT BEAR is shown as it was depicted by Alexander Jamieson in his 1822 celestial atlas. The three stars in the tail are often referred to as three hunters.

of the stars overhead. Humans are naturals at pattern recognition, and so it is not surprising that the collection of neighboring stars into groups was a universal preoccupation from the earliest times. The best place to start is where my grandfather did, with the Great Bear (or Ursa Major).

These seven moderately bright stars are known by other names—the Big Dipper (or Drinking Gourd), the Wagon (or Wain) and the Plow. Aratus calls the grouping both Bear and Wagon. The wagon name must, of course, have come after the invention of the wheel (roughly the fourth millennium B.C.), but the bear name is undoubtedly much older. Early societies throughout Eurasia recognized the Great Bear stars and myth. The most common version was that the four stars in the bowl of the dipper were the bear, which was perpetually chased by the three stars in the handle, which represented three hunters. The Greeks, Basques, Hebrews and many tribes in Siberia had this basic star/myth combination. Surprisingly, the same bear stars and stories surfaced throughout North America. With some variations, many tribes of the New World—including the Cherokee, Algonquin, Zuni, Tlingit and Iroquois—share the interpretation of the bear followed by three hunters.

How can we explain the close matching of widespread traditions between the Old World and the New? The Bear is unlikely to be an independent invention, because the stars do not look like a bear. Also, we can rule out the possibility of contamination from the first missionaries and explorers, because the Indian lore was often collected very early, and the stories do not mirror exactly the Greek version carried by European settlers. The most logical explanation to connect the traditions holds that the first settlers of the New World carried the basic myth across the Bering Strait.

Roughly 14,000 years ago Paleolithic hunters and gatherers first migrated across a land bridge that formed during the last ice age, when sea level was low, and connected Siberia and the Americas. Their culture lived on in their descendants, who populated the New World. It is easy to envision a chain of grandfathers stretching from Paleolithic Siberia to the mountains and plains of the New World and eventually to modern Colorado, telling about the Bear in the sky.

The actual origin of the Bear constellation could have been very long indeed before this migration. European cave paintings, artifacts and ensembles of cave bear skulls date to more than 30,000 years ago and suggest some kind of bear worship. The constellation may have originated as a folk depiction of a shamanistic icon. However it came to be, the Great Bear is quite likely one of the oldest inventions of humanity.

Assyrian Priests

THE EARLIEST DIRECT EVIDENCE for the constellations comes from inscribed stones and clay writing tablets dug up in Mesopotamia (within modern Iraq). A text called "Prayer to the Gods of the Night" from old Babylon, dated to around 1700 B.C., mentions four constellations, including the Wagon, plus three individual stars and the Pleiades. Stone inscriptions from before 1300 B.C. show icons that in later centuries referred to constellations, but these early icons do not appear in a celestial context, implying that the figures had not yet been projected onto the sky. Although the scarcity of evidence makes it hard to reach a confident conclusion, the Mesopotamians apparently had formed only a few constellations before 1300 B.C.

After that time, boundary markers and cylinder seals begin to depict constellation icons grouped together and in conjunction with known symbols for the sun, moon and planets. These close associations assure us that the icons refer to constellations. Starting around 1100 B.C., cuneiform tablets list more than 30 constellation names from three bands stretching around the sky. One series of three tablets called MUL.APIN contains long lists of observations about the positions and movements of almost all the Mesopotamian star groups. MUL.APIN was copied repeatedly, with little variation, apparently as a textbook or almanac; surviving copies date from 687 B.C. to the third century B.C.

EARLIEST DIRECT EVIDENCE FOR THE CONSTELLATIONS COMES FROM INSCRIBED STONES AND CLAY WRITING TABLETS DUG UP IN MESOPOTAMIA.

Fortunately for those of us who study ancient astronomy, we can date constellation lore by a unique method based on the precession of the skies. Precession is the shifting of stars against the coordinate grid defined by the North Pole and the equinoxes [*see box on opposite page*]. We can read the date like a clock, with stars forming a very slow hour hand moving against the face of the sky coordinates. MUL.APIN gives the relative positions of stars on the sky, and we can translate these into approximate dates. For example, the tablets say that the spring equinox is in the eastern side of what we now call the Ram, and this reads as late in the second millennium B.C. Many of the observations also depend on the latitude of the observer, and thus a full analysis can produce both a date and the observer's latitude.

Hermann Hunger of the University of Vienna and the late David Pingree of Brown University analyzed several of the lists in MUL.APIN, in part by comparing them with a later accounting of star appearance dates from Ptolemy. They derive a date of 1000 B.C. and a latitude of 36 degrees, suggesting that the observer—or observers—might have worked in Assyria (the northern part of Mesopotamia). Because MUL.APIN mentions almost all the Mesopotamian constellations, which must have been formed before this date, it appears that the bulk of the Mesopotamian constellations were created within a relatively short interval from around 1300 to 1000 B.C.

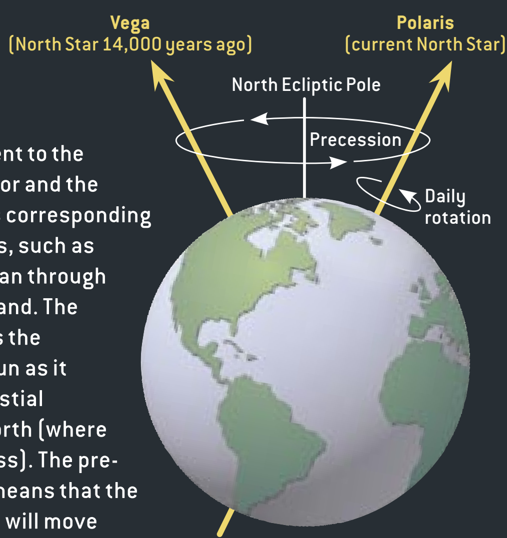
Independently, I have identified 114 observations in MUL.APIN that imply the date and latitude for the observations. No one item will yield a date and latitude with enough precision to be of much use, but the statistical combination of all 114 observations can lead to fairly accurate values. I find that the reports in MUL.APIN date to 1100 B.C. (with an uncertainty of 80 years) from a latitude of 33 degrees north (with an uncertainty of 1.5 degrees). My results agree with those of Hunger and Pingree in pointing to Assyrian observers and suggesting a formative period of less than two centuries.

A separate analysis of the constellation data can determine the time and place of the origin of the southernmost constellations visible from the Northern Hemisphere. The idea behind this calculation is that the stars too far south to be visible from a mid-northern site would form a roughly circular void centered on the South Pole. The position of the void's center, the implied site of the pole, would tell the date, and the radius of the void would indicate the latitude of the constellations' inventors. Using this basic concept, I calculated that the six southern constellations that define the edge of the void were invented early in the first millennium B.C. from a latitude of roughly 33 degrees.

The archaeological evidence plus the epoch and latitude from MUL.APIN and from the six southernmost constellations all give a consistent story. Most of the Mesopotamian constellations and observational data were made from near a latitude of 33 to 36 degrees between 1300 and 1000 B.C., by people we would call Assyrians.

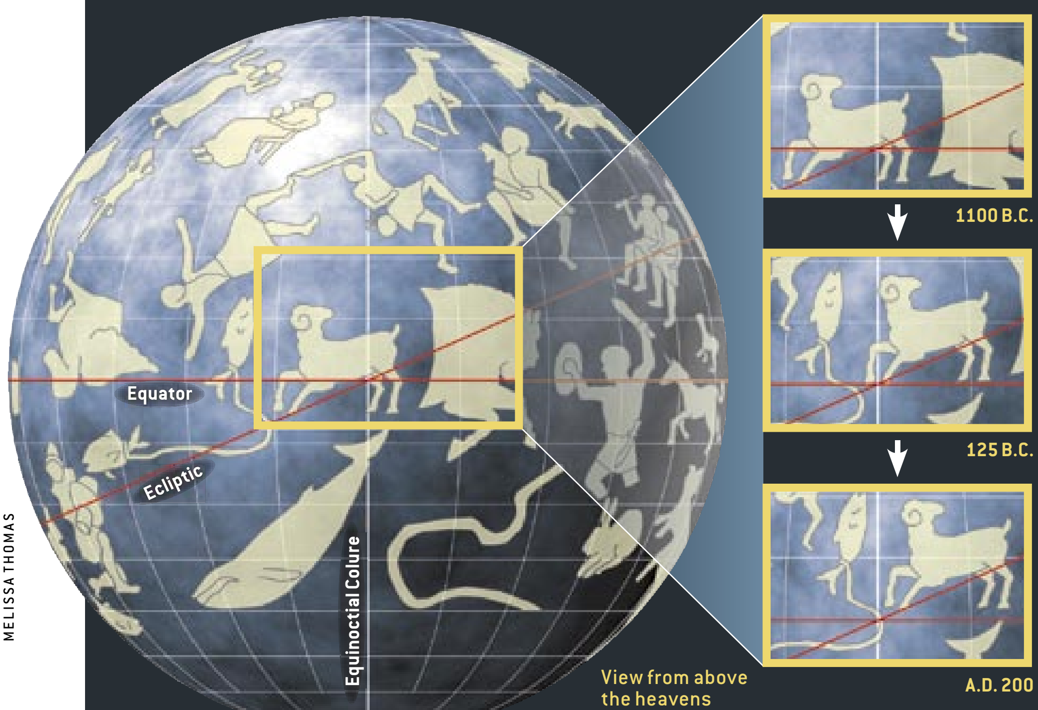
The constellations in MUL.APIN are a curious mixture. Some are gods, others represent animals, and the remainder depict everyday farm implements. The text gives many omens

PRECESSION: The Shifting Stars



The dating of constellations requires knowledge of a process called precession, the slow wobbling of the earth's pole, caused by tidal forces from the moon, that makes the positions of the stars shift over the centuries. A toy top will totter in much the same way as it slows down. One consequence of this wobble is that the earth's North Pole shifts in a big circle in the sky, and thus the so-called polestar, or North Star, the star nearest to the pole, changes from time to time (*diagram at upper right*). Another consequence is that the positions of the stars slide along the ecliptic (the path of the sun in the sky) at a rate of almost one degree (twice the moon's angular diameter) every 72 years.

Star positions are measured with respect to conceptual lines (actually great circles) on the sky. These lines are analogous to those on the earth's globe, with the celestial equator equivalent to the terrestrial equator and the celestial colures corresponding to longitude lines, such as the prime meridian through Greenwich, England. The spring equinox is the position of the sun as it crosses the celestial equator going north (where the red lines cross). The precessional shift means that the equinox position will move against the background stars, changing zodiacal constellations roughly once every two millennia. In classical Greek times the equinox was in Aries; it then moved into Pisces and more recently has moved into Aquarius (hence the "Age of Aquarius"). Hipparchus discovered precession sometime around 128 B.C., as he noted the shifting position of the equinoxes when compared with what were then old reports on its position—a stunning intellectual feat that establishes him as one of the greatest of ancient astronomers. *—B.E.S.*



CONSTELLATION POSITIONS shift slowly over time with respect to the colures and equator, thus providing a way to determine dates. An analysis of the position of the Ram on the sky globe of the Farnese Atlas [*see box on next page*] shows that the original of the Atlas statue was made around 125 B.C.—when the edge of the Ram's horn was just past the colure.

MELISSA THOMAS

THE FARNESE ATLAS

The oldest surviving depiction of the set of Greek constellations appears on a second-century A.D. Roman statue called the Farnese Atlas. Art historians conclude that the statue is a copy of a Greek original. Now in Naples, the marble carving depicts the god Atlas holding a sky globe on his shoulder.

My detailed analysis of the positions of the constellations on the globe reveals that the figures are placed with an accuracy of better than two degrees for a date of 125 B.C., with an uncertainty of 55 years. The accuracy indicates that the original data were systematic and precise—such as those in a star catalogue. Hipparchus's catalogue was the only one then in existence, and a careful comparison of the constellations on the globe with the verbal descriptions in Hipparchus's *Commentary* and in other works provides a match only with Hipparchus. Of course, another astronomer could have made an independent catalogue around that time, but no hint of one survives, and Hipparchus is almost certainly the source. *—B.E.S.*

RELIEF FIGURES on the sky globe trace the constellations in fine detail and include the celestial equator, tropics and colures.

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based on the star groups and also uses them to form a calendar—vital for any farming economy. Omens, gods and calendars were the province of the priesthood, a persuasive clue that the constellations were developed by priests.

Greek Scholars

THE MESOPOTAMIAN GROUPINGS turn up in many of the classical Greek constellations. The stars of the Greek Capricorn and Gemini, for example, were known to the Assyrians by similar names—the Goat-Fish and the Great Twins. A total of 20 constellations are straight copies. Another 10 have the same stars but different names. The Assyrian Hired Man and the Swallow, for instance, were renamed Aries and Pisces.

The constellation called the Triangle provides a good example of how the Greeks adopted the Mesopotamian stars. In MUL.APIN, the stars of the Triangle were designated the Plow (a name that had also been used for the Bear). In Mesopotamia and Egypt, geometry was well known to scholars but only as a mundane engineering tool. Thales (585 B.C.) brought geometry from Egypt to Greece, where it was transformed from a practical set of rules of thumb to an organized logical system of great beauty and generality, culminating in Euclid's definitive book *The Elements* (300 B.C.). Only with this transformation would anyone seek to commemorate the triangle, as the basis of geometry, in the sky. The Triangle is thus certainly a Greek renaming of a Mesopotamian star group between the time of Thales and Eudoxus or sometime in the sixth to fourth centuries B.C.

Whether the Greeks had adopted many constellations at the time of the Triangle's introduction is unknown, but the limited information on the subject suggests not. The two earliest written sources from the Greeks—the epics of Homer (assumed to be eighth century B.C.) and the farmer's almanac of Hesiod (also dated to the eighth century)—both mention two prominent constellations (Orion and the Great Bear), two star clusters (the Pleiades and the Hyades), and two stars (Sirius and Arcturus). But nothing more. And all other Greek sources from before about 500 B.C. are silent on the stars. So the Greeks had the most prominent star pictures before 500 B.C., but perhaps not many more.

The first complete discussion of the Greek skies comes from Eudoxus's fourth-century B.C. book, now known only through extensive copying by Aratus and Hipparchus. Eudoxus contains many reports such as "that head [of the Dragon] wheels near where the limits of setting and rising blend," which is to say that the stars in the head of Draco are at a distance from the pole such that they skim the northern horizon. This observation is true only for a given latitude that varies with date. This constraint on latitude and epoch is rather loose and is not helpful by itself. Eudoxus also writes, "At the rising of the Scorpion in the East Orion flees at the

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Western verge"; in other words, the Scorpion and Orion appear simultaneously on opposite horizons. This second statement also leads to a fuzzy constraint on latitude and epoch.

The two constraints can be combined to derive a unique date and latitude for the observations, but with an accuracy still too poor to be useful. To get around this problem, I identified 172 statements in Eudoxus that depend on the latitude and epoch. The combined constraints from all observations result in a final uncertainty that is 0.9 degree (100 kilometers, or 62 miles) in latitude and 80 years in time. I find that all of Eudoxus's lore is consistent with coming from one time and place—1130 B.C. at 36 degrees latitude, which would have been in Assyria.

BOUNDARY STONE from Mesopotamia dates from sometime after 1300 B.C. It depicts constellation icons.

MUL.APIN, a cuneiform tablet with observations from 1100 B.C., lists the Mesopotamian constellations.

The derived time and place match well with those determined for the MUL.APIN observations. Indeed, I have noticed that MUL.APIN and Eudoxus share a substantial amount of information, leading me to conclude that the data used by both came from an original database made by an Assyrian observer around 1100 B.C. Because both surviving branches contain most of the ancient constellations (albeit some with different names), I conclude that the set of constellations was largely complete by sometime around 1100 B.C.

Therefore, it is reasonable to conclude that sometime after this and before the existence of Eudoxus's book (366 B.C.), the Greeks received the Mesopotamian star groups. The lack of any evidence for the Greek constellations (other than the Bear and Orion mentioned in Homer) before 500 B.C. suggests that most of the transfer happened after that time. We know from textual evidence that the Babylonian zodiac system came to Greece around 400 B.C. (The zodiac was the track that the sun took as it traveled around the earth; as the sun moved along the zodiac, it passed in front of 12 constellations that had animal and human forms.) Intellectual knowledge could have spread from Mesopotamia to Greece in many ways, but we do not know enough to choose between them.

Despite the heavy reliance on Mesopotamian star groups, the Greek system of constellations still has 18 star pictures with no roots in the East nor anywhere else that we can discover. Moreover, the nature of these constellations is characteristically Greek. There is the quintessential Greek hero Hercules, for example, joined in the sky by other constellations that represent creatures the great warrior had defeated—Leo and Draco among them. Ophiuchus, carrying the Serpent, is there as well, and the Dolphin, as would be appropriate for a seafaring people such as the Greeks. Six of these constellations depict a tableau from Greek mythology concerning Perseus's rescue of Andromeda. Most likely, these "new" star pictures were invented by the Greeks themselves.

Modern Scientists

OVER TIME, the way the Greeks used the constellations changed. The images started out telling stories about legendary heroes and animals. Then they became tools for calendars and navigators. Later the zodiac became a coordinate system for measuring planetary positions as part of astrology learned from the Babylonians.

The writings of Hipparchus mark the shift to the scientific study of the stars. Early in his career, he made detailed quantitative comparisons of the constellations in Eudoxus's book with what was actually visible in the sky—and he found many differences. In 135 B.C. he discovered a nova, an exploding star, and that discovery inspired him to construct a complete catalogue of the stars (now lost) so that later novae could be identified. With both a quantitative catalogue and the earlier Greek data in hand, Hipparchus was able to figure out the shifting of the stars caused by precession, a watershed discovery. Constellation study had become essentially scientific in the modern sense.

The origins of the Greek constellations from a patchwork of sources superimposed on the sky lie so far in the past that evidence is sketchy, and we must acknowledge that the story will have significant gaps and that some points can only be reasonable speculation. But the basic outline is clear, and it shows us how knowledge is transferred across time and space as changing parts of culture. Constellations provide a unique way of gaining insight into a culture (different from, say, pottery styles) because they consider an intellectual aspect of prehistoric society, something that is hard to discern from more typical archaeological sources. Furthermore, the sequence in the uses to which societies put constellations tracks the way one aspect of astronomy was transformed into a modern science. The sequence moves from religious to folk to practical to scientific usages, a consistent trend toward decreasing spirituality and increasing quantification. And yet today as in the past, the tales of our grandparents continue to link generations and cultures. SA

MORE TO EXPLORE

Asiatic Parallels in North American Star Lore: Ursa Major. W. B. Gibbon in *Journal of American Folklore,* Vol. 77, pages 236–250; 1964.

The Mithraic Mysteries. D. Ulansey in *Scientific American,* Vol. 261, No. 6, pages 130–135; December 1989.

Astral Sciences in Mesopotamia. H. Hunger and D. Pingree. Brill, 1999.