I.
Introduction
Alexander Jones

A Roman mosaic found at Daphne, near Antioch on the Orontes, captures in its essence how people of the Greco-Roman world came to be like us in their relationship with measured time, as well as how their understanding of time was unlike ours (fig. I-1). The image is simple: a strolling man looks at a sundial on top of a column, and realizes that he had better hurry if he does not want to be late for an invitation to dine. In case the message is not clear enough, Greek words written in the mosaic read, "The ninth hour has caught up" or, roughly in modern terms, "It's 3 p.m. already," standard dinnertime in those days.

In a present-day version of this picture—say, on a magazine cover—a man, or woman, would be staring at a smartphone, and today's viewer might reflect on how our civilization has allowed technology and science to impose a rigid framework of time on our lives. The same thought could have crossed the mind of a guest admiring his or her host's mosaic floors in Daphne two thousand years ago, while nostalgically regretting the simpler ways of yore, when days were divided just into morning and afternoon and one guessed how much daylight remained by the length of one's own shadow without giving much thought to punctuality.

What distinguishes our experience of time from that of the Greek or Roman is that our time technology is centralized and conceals the science on which it is based, whereas ancient time-telling devices were individual, local illustrations of the cosmology in which their designers believed. Today we learn in school how days and nights are caused by the earth's spinning on its axis, and how the seasons of the year result from the tilt of that axis and the earth's orbiting around the sun; but the times and dates that we read off our clocks and calendars have no visible relation to these facts. Though practically no one is aware of it, our time is measured out by an atomic clock at Schriever Air Force Base, in Colorado, which uses radiation from Cesium-133 atoms to count seconds with an accuracy of plus or minus a few billionths of a second, feeding this pulse out to the world by way of the internet and the Global Positioning System. The emblematic clock of Greco-Roman antiquity, the sundial, was seldom accurate enough to show quarter hours reliably, but it presented an image of the cosmos on which one could trace the sun's daily course from rising to setting, and its annual transitions from north to south and back again in the viewer's sky. The practical instruments for telling time were an integral part of a rich visual imagery of time and the cosmos that people encountered in many contexts of ancient private and public life.

For the Greeks and Romans, as for all people in antiquity, the fundamental, inescapable manifestation of time's passage was the succession of days and nights. Spending much of their lives outdoors, and having only lamps and other flames for artificial light, they arranged their daily routine—work, meals, sleep—around the daily cycle of light and dark, warm and cool. Their approaches to keeping track of time and conceptualizing it thus fall into two distinct categories: structuring time on a scale longer than days, and measuring time on a scale shorter than days. The former category is the domain of calendars; the latter, of clocks.

MONTHS AND YEARS

Besides the day, nature offers two longer recurring cycles. The round of the seasons, with its repeating pattern of weather, climate, and agricultural activities, provides a convenient unit for time on the longer scale, so the bounds of the year could be set more precisely by reference to solstices (observed as the approximate dates when the sun's rising point on the horizon reached its furthest north or furthest south extreme) or to the first appearances and disappearances of bright stars and constellations in the night sky. The easily observed cycle of the moon's phases determined a unit, the lunar month, that was conveniently intermediate in length between the day and the year. In principle, months could be considered to begin at any phase, but the most common practice in antiquity was to consider the day when the crescent moon was first sighted in the evening sky as the first of the month.

We may define a calendar as a specific practice of structuring time according to years, months bearing an established set of names and recurring in the same order every year, and days designated by numbers or names in a fixed sequence within the months (see the chapter by Daryn Lehoux in this volume). There were numerous calendars in the Greek world, with each city and its region having its own names for the months and starting the years at diverse seasons.[1] The calendar had many uses in public and private life, but its fundamental role was to be the temporal framework for religion as manifested especially in annual festivals that typically coincided with events of the agricultural year, such as plowing and harvest (fig. IV-1). Keeping their calendars in line with the seasons was thus an important consideration for the Greeks.

About half of the lunar months are 30 days long and the rest are 29 days, so that twelve months are about 354 days, a bit too short for the natural or solar year, and thirteen months are about 384 days, rather too long. Like the calendars of Mesopotamia, Greek calendars were lunisolar—that is, some years comprised twelve lunar months and others thirteen (with the extra month being named as a repetition of one of the twelve), so that the months and their festivals never drifted too far from the desired seasons. By the last few centuries BCE, it was becoming increasingly common for Greek calendars to follow a predefined pattern of twelve-month and thirteen-month years in a nineteen-year cycle, which was attributed to the fifth-century-BCE astronomer Meton of Athens, though it may in fact have been learned from the Babylonians, who were already using it around 500 BCE.[2] Widespread adoption of the Metonic

FIG. 1–1.
(detail) Roman Mosaic Representing a Man Looking at a Sundial. Stone, H. 143 cm; W. 94 cm, Daphne, 4th century CE. Hatay Arkeoloji Müzesi, Hatay, Turkey: 865.

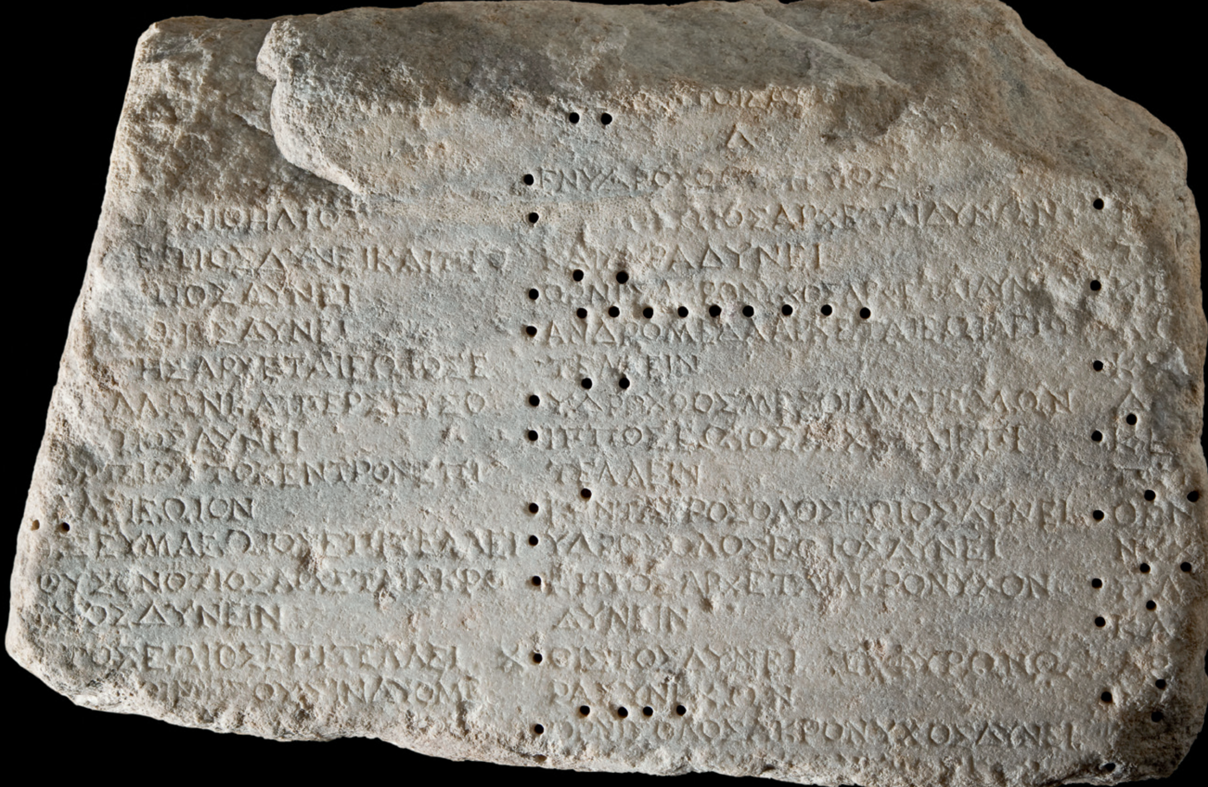


FIG. I–2.
Greek *Parapegma* with Stellar Phenomena and Weather Predictions. Marble, Theater, Miletus, ca. 100 BCE. ASMB: SK 1606 IV Milet Inv. 456B. Checklist no. 23.

cycle also facilitated synchronization of the local calendars so that, for example, someone journeying to one of the Panhellenic athletic competitions such as the Olympic Games would know when, according to his own calendar, it would be held.

A properly regulated lunisolar calendar keeps its months in line with the seasons over the long term; the Metonic cycle, for example, can be used for several centuries without any noticeable drift. In the short term, however, any particular calendar month shifts back and forth from year to year over a range of about thirty days relative to a solstice or equinox, and from comparatively early times, the Greeks were conscious that their calendars were not good frameworks for describing or predicting natural phenomena that are affected by the seasons or the solar year. Thus the poet Hesiod (ca. 700 BCE) taught the audience of his *Works and Days* when to engage in various agricultural labors by referring to the annual risings of stars and the solstices, and the same kind of dating was employed by the anonymous fifth-century-BCE physicians whose records of weather conditions and ensuing patterns of sickness in the communities they visited have come down to us as the *Epidemics* ascribed to Hippocrates.[3] The most elaborate application of this star-and-sun temporal framework was in the *parapegmata*, lists of days—in their order of occurrence in a solar year—on which one could expect astronomical events such as appearances and disappearances of constellations, solstices, and equinoxes, as well as meteorological events such as storms and seasonal winds (see the chapter by Daryn Lehoux in this volume).[4] Fragments of two *parapegmata* erected as public inscriptions in Miletus around the second century BCE explain for us the meaning of the name *para-pegma* (literally, "alongside pegging"), since the days are indicated on them by drilled holes so that the current date and its associated forecasts could be marked by a peg moved one hole forward each day (fig. I-2).[5]

The Roman calendar—the direct ancestor of our modern-day Gregorian calendar—represents a different approach to reconciling months with years. In its familiar structure following the reform instituted by Julius Caesar in 46 BCE, the Roman calendar's years were always either 365 or (every fourth year) 366 days long, and divided into twelve months of fixed lengths that had no relation to the moon's phases. The calendar year was thus practically equivalent to the natural year (fig. IV-4), but anyone living under the Roman calendar who wanted to keep track of days according to the lunar month had to maintain a count independent of the calendar—for example, by means of pegboard inscriptions analogous to the Greek *parapegmata* but with just thirty peg holes (figs. IV-6, IV-7, IV-8).

GREEK COSMOLOGY, SEASONAL HOURS, AND ANCIENT CLOCKS

The various calendars and day-count cycles employed by the Greeks and Romans were essentially arithmetical in basis, and involved no theoretical understanding of the time units they allowed one to organize and name. Their approach to reckoning the passage of time within the day, on the other hand, derived from a distinctively Greek concept of the world and its place in the universe, out of which came a definition of uniformly flowing time that could be displayed and measured with instruments (see the chapter by Karlheinz Schaldach in this volume). The creation of this technology was due in the first instance to Greek technicians, craftspeople, astronomers, and mathematicians, and it is noteworthy that time-telling devices from the western, Latin-speaking parts of the Roman Empire not infrequently bear inscribed labels in Greek (cf. fig. III-14).

By about 400 BCE, a basic cosmological framework had gained currency in Greek philosophy and science, which we call the "Two-Sphere Model."[6] It takes as its starting point the observed fact that all the heavenly bodies—the stars, the sun, the moon, and the planets—rise in the east and set in the west, except for stars within a certain region of the northern night sky, which never are seen to rise or set but are apparently always above the horizon, circling in a counterclockwise direction around a point above the northernmost point of the horizon that we call the North Celestial Pole. This gave rise to a visualization of the heavens as a vast spherical shell revolving about once a day and with a perfectly uniform rate of motion around the earth. This shell was usually considered to be the invisible surface bearing the stars.[7] Compelling arguments were also known that concluded that the earth too is a sphere, such as the circular outline of the earth's shadow cast on the moon during a lunar eclipse, and the fact that the North Celestial Pole was higher above one's northern horizon the farther north one traveled. It was easy to deduce that the inhabitants of the eastern Mediterranean regions were somewhere between the equator and the earth's north pole, so from the Greek perspective the Two-Sphere Model should be tilted to put the observer on top of the terrestrial sphere (fig. I-3).

This model is enough to provide a satisfactory explanation of the apparent motions of the stars in the night sky. To account for the sun, moon, and planets requires a bit more. For our present purposes, we only need to consider the sun (fig. I-4). Unlike the stars, the sun does not always rise and set at the same points on the horizon; its rising points move northward from winter to summer and southward from summer to winter between certain limiting points. Also, the fact that we can see different constellations at different times of year means that the sun is moving slowly eastward against the background of the stars, even if we can't see this directly because the stars are invisible when the sun is up. Hence Greek astronomers described the sun's eastward path on the celestial sphere as an inclined circle that we call the ecliptic. The ecliptic is bisected by the celestial equator and has its northern and southern limits at circles parallel to the equator that are called the summer and winter tropic circles. These are the celestial counterparts of the Tropics of Cancer and Capricorn of modern geography.

For the purposes of reckoning time, the Two-Sphere Model has two crucial implications. During the course of any single day, the sun moves only a fraction of a degree northward or southward relative to the stars, so for practical purposes we can say that the sun's apparent path across the sky from sunrise to sunset is an arc of a circle centered on and perpendicular to the axis of the celestial sphere's daily spinning. Since the sphere is spinning at a perfectly uniform rate, the model predicts that the sun will also traverse approximately equal fractions of its day arc in equal intervals of time. From day to day, though, the sun's day arc shifts progressively north or south according to the seasons. On the summer solstice, the day arc approximately coincides with the summer tropic circle, and since more than half this circle is above the horizon, day is longer than night. On the winter solstice, the day arc coincides with the winter tropic circle, and night is longer than day because less than half the winter tropic circle is above the horizon. On the equinoxes, the sun is on the celestial equator, so day and night are equal in length.

We take it for granted that our modern units of time—hours, minutes, and seconds—are constant in length, and it may seem strange that the Greeks and Romans counted twelve hours from sunrise to sunset and twelve from sunset to sunrise. This meant that, except on the equinoxes, daytime hours were a different length from nighttime hours, and daytime hours were longer in the summer and shorter in the winter (and vice versa for nighttime hours). The division of daytime and nighttime into twelve "seasonal hours" originated in Egypt (see the chapter by John Steele in this volume); but Egyptian methods of determining the current hour, whether by observing stars or reading the time off a water clock or sundial, did not even ensure that all the hours within a *single* day or night were equal in length. When the Greeks took over the idea of seasonal hours (perhaps in the fourth century BCE, and possibly through a Babylonian intermediary), they added this requirement. The Two-Sphere Model provided a suitable geometrical definition of a seasonal hour as the interval during which the sun traverses exactly one-twelfth of its day arc or night arc, however long that arc may be.

The quintessential ancient Greek sundial design—not necessarily the earliest one—consisted of a concave spherical surface sculpted in a block of stone and a shadow-casting metal rod, or gnomon, whose tip was located at the sphere's geometrical center. The surface thus acted as an inverted but otherwise exact copy of the celestial sphere, on which the shadow point marked the sun's current location. A splendid example from about the first century CE, found at the beginning of the nineteenth century near the Esquiline Hill, Rome, and now in the Vatican (see the chapter by Karlheinz Schaldach in this volume). A spherical bowl sundial found in Rome is engraved with day arcs for the solstices, equinoxes, and the date on which the sun enters each sign of the zodiac, all labeled in Greek (fig. I-5).[8] Crossing these arcs are curves dividing each arc into equal twelfths, and thus marking where the shadow point falls at the beginning of each seasonal hour. The spherical sundial was not merely an instrument for time-telling but a vivid didactic image of the foundations of Greek geometrical astronomy.

Another, rarer type of ancient sundial that could have served as a cosmological illustration was a solid spherical globe that showed the time by the slowly moving boundary between its sunlit and shadowed halves (fig. III-8).[9] It could be thought of as a miniature-scale model of the spherical earth; if a map of the known regions of the world had been drawn on the globe's surface, with one's own location at the top, the shadow boundary would show where on earth the sun was currently being seen rising or setting. Unlike the concave spherical sundial, the globe sundial was not a good practical clock because the shadow boundary would always have been too indistinct to show the hour with precision, so the two known examples must have been intended as showpieces representing an idea.

The profusion of sundial types invented in Greco-Roman antiquity attests to other motivations besides conveying a scientific lesson to the viewer. The difficulty of sculpting an accurate spherical bowl may be one reason that conical surfaces were often preferred; the day arcs on such a sundial could still be divided into equal twelfths to obtain the seasonal hours, but the portrayal of the celestial sphere was sacrificed. Flat surfaces such as horizontal or vertical slabs (figs. III-11, III-12, III-14) or walls (as on the octagonal Tower of the Winds in Athens [fig. III-4]) were easily executed, but the day curves on a planar sundial are conic sections—hyperbolas—and the correct placement of the seasonal hour divisions requires a geometrical construction of some sophistication. Greek mathematicians such as Archimedes (third century BCE) and Apollonius (ca. 200 BCE) made profound investigations of the properties of conic sections, and the best planar sundials were probably intended in part as practical exhibitions of the power of intellect. Ancient mathematical virtuosity was also on show in the type known as "roofed spherical sundials," in which a spot of sunlight was projected on a

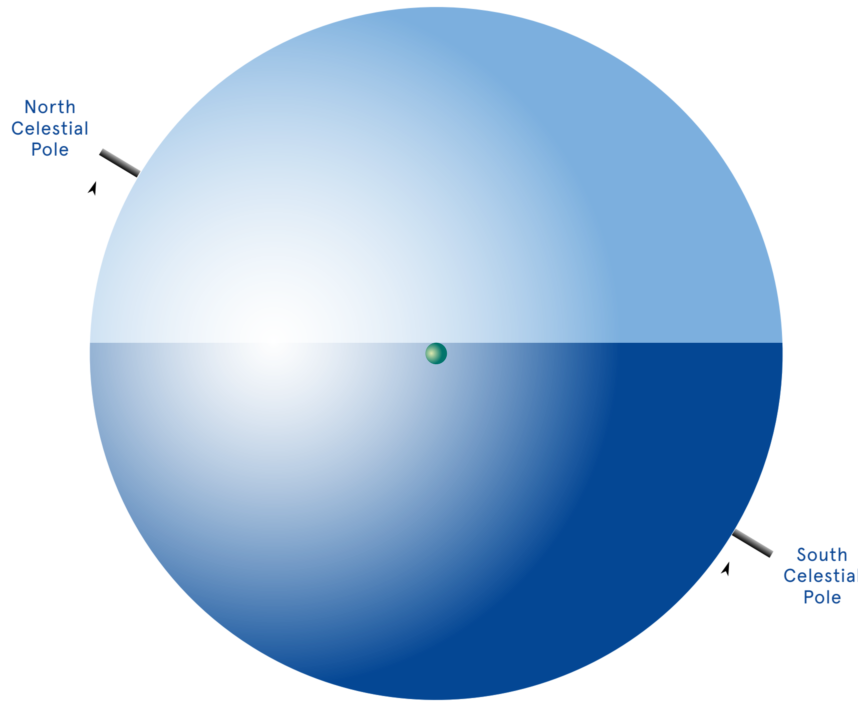


FIG. 1–3.
The Two-Sphere Model of Greek Cosmology. The small green sphere at center is the earth, with the diagram oriented so that the human observer on earth is at the top. The pale half of the celestial sphere is the part above the observer's horizon. If the sun is in this half, it will be daytime for the observer; otherwise it will be night, and any stars and planets that are above the horizon will be visible, weather permitting.

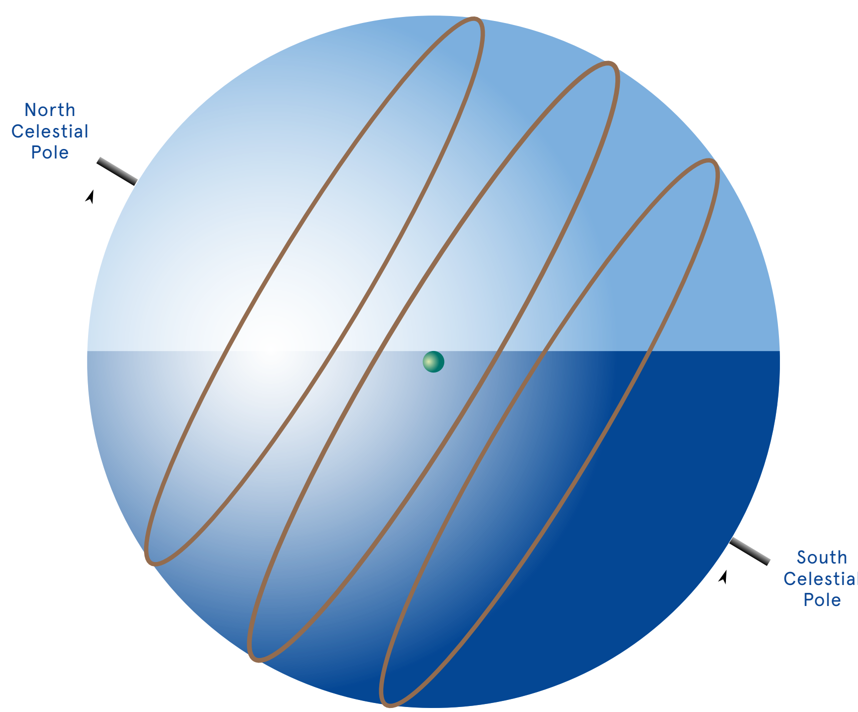
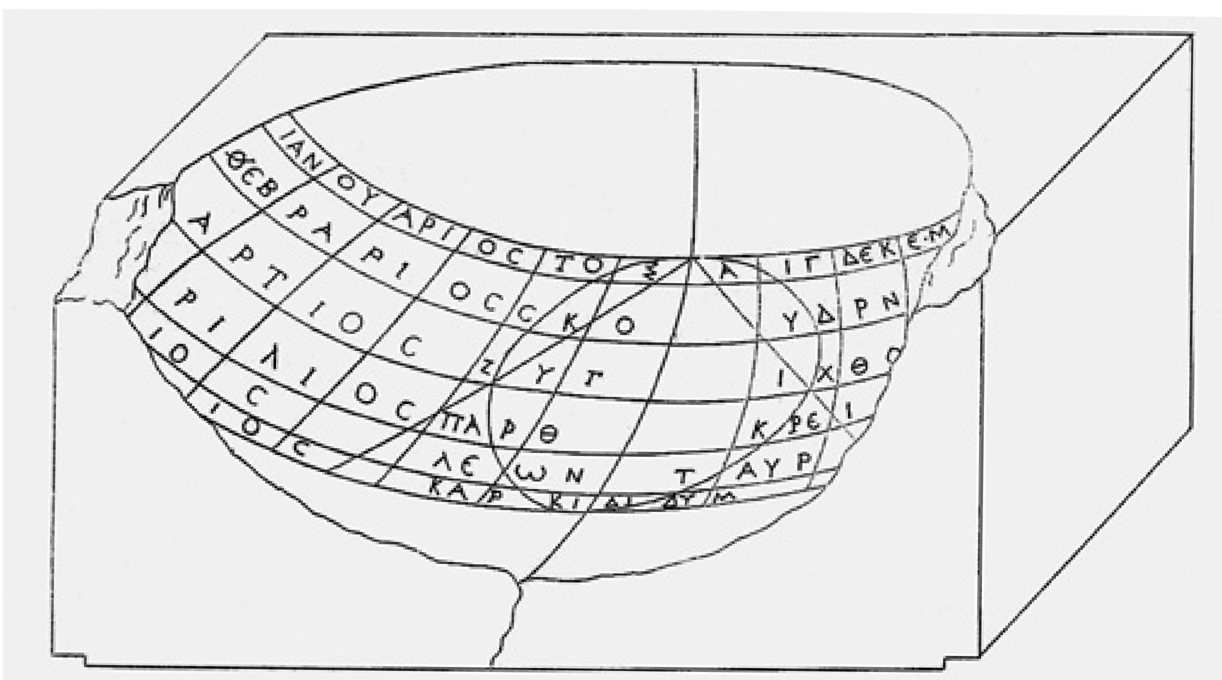


FIG. 1–4.
The ecliptic (in copper) and, from north to south, the summer tropic circle, the celestial equator, and the winter tropic circle. The sun travels eastward around the ecliptic once in a solar year. When it lies on one of the tropic circles, the corresponding solstice takes place; when it lies on the equator, an equinox takes place.

FIG. 1–5.
Spherical Bowl Sundial Found Near the Esquiline Hill, Rome. Now Musei Vaticani, Galleria dei Candelabri: II 90. Drawing from Guattani 1811: 102. The bowl originally would have faced south, and a gnomon, now lost, projected upward from the front center. Running from east to west are the day arcs of the sun, with the summer solstice arc closest to the gnomon and the winter solstice arc furthest. The arcs running from south to north mark the twelve seasonal hours of the day.



spherical surface through a small eyehole at the sphere's zenith point, resulting in a system of day curves of complexity and beauty that would now be described as projections of quartic plane curves.[10] A particularly fine example of this type from the first century CE, now in the Louvre (figs. I-6a,b), takes the form of a drinking cup (*skyphos*), resembling examples from the first-century-CE Boscoreale Treasure (fig. I-7), and unites the geometrical elegance of these curves on its bowl with an exterior decoration of oak leaves and acorns.

Sundials were ubiquitous in the Greco-Roman world—more than 500 surviving examples are known—and one would have encountered them in both public and private spaces.[11] Stone sundials were obviously meant to remain in one place, mounted with respect to the cardinal directions so as to project the sun's daily path correctly, and any particular sundial would have shown the time and season accurately only when located at the specific terrestrial latitude for which it was designed. By contrast, many varieties of ancient portable sundials have been found that were owned by private individuals, including such professionals as a late first-century-CE physician in whose tomb a portable sundial was deposited together with his medical instruments and his pills for eye ailments (figs. III-17, III-18; see the chapter by Karlheinz Schaldach in this volume). Portable sundials were not simply miniaturizations of the stationary types, as they were intended to be dangled in an orientation determined by the direction of sunlight at any particular moment, which results in different geometrical constraints; several kinds of portable sundial could also be used at more than one latitude (fig. III-20). They were articles of personal prestige as much as of practical utility. In most cases, the scientific principles underlying their operation would not have been well understood by their owners; an interesting exception, as well as a specimen of ancient precision metalworking, is a small sundial (ca. 300 CE) from Philippi composed of nested rings that functioned as scaled-down images of circles on the celestial sphere (fig. I-8).

The archaeological record has given us scanty remnants of the alternative ancient technology for displaying the time, the water clock. The simplest Greek water clocks, or clepsydras, such as those used in fifth- and fourth-century-BCE Athens to allot equal speaking time to the parties in trials, were vessels filled with a specified volume of water that flowed out through a small orifice at the bottom; only one fragmentary example, from the Agora of Athens, has been found (fig. III-1). Much more sophisticated clocks, known primarily from ancient literature, were developed in the Hellenistic period (the last three centuries BCE) that solved the mechanical problem of obtaining a constant rate of water flow to represent uniformly flowing time as well as the mathematical problem of transforming this uniform flow into a display of the time in seasonal hours appropriate for the stage of the year on a drum or circular dial, which did double duty as a map of the heavens (fig. III-15). Such devices would have been the pride of a city or a very wealthy private individual.

Confronted as they were with time-keeping devices wherever they turned, we may wonder about the degree to which the ancient Greeks and Romans came to regulate their activities by the numbered hours. The testimony of the surviving Greek and Latin literature and of Greek documentary papyri from Ptolemaic and Roman Egypt suggests that, in private life, hours were seldom invoked; the conventional "ninth hour" for dinner invitations that we have already mentioned is perhaps the only important exception. Few ancient sundials bore inscribed numerals for the hours, while one sometimes finds a special mark such as an × distinguishing just the third, sixth, and ninth hours, seemingly signifying that it was only important to know when it was mid-morning, noon, or mid-afternoon. And most of the extant sundials, especially those from the second century CE and after, when the demand for them became widespread, are crude and would not have displayed accurate time anyway.

A few branches of state administration seem to have taken the lead in antiquity in paying attention to times in seasonal hours.[12] This is particularly evident in daybooks of state postal services in both Hellenistic and Roman Egypt, which recorded times when couriers arrived at postal stations, probably in the interest of keeping an eye on the efficiency of the transmission. Hours also appear in records of military activities, whereas in documents of civilian administration precise times are rarely specified.

TIME AND PERSONAL DESTINY

There was one aspect of private life in which knowledge of hours was desirable, in fact necessary, namely, personal astrology (see the chapter by Stephan Heilen and Dorian Gieseler Greenbaum in this volume). Greco-Roman astrology evolved, probably about the second century BCE in Egypt, as a complex fusion of ideas and practices of divination deriving from Babylonia, Egypt, and Greece, and it quickly gained enormous popularity at all levels of society throughout the Mediterranean world and beyond. The basic principle of astrology was that the configuration of the heavenly bodies at any time influenced or even determined subsequent developments in the terrestrial environment according to patterns that could be interpreted by someone with the suitable expertise. In particular, the state of the heavens at the moment of an individual's conception or birth, constituting the person's horoscope, was held to contain information from which his or her character and life story could be predicted.

In a Greco-Roman horoscope, the positions of the sun, moon, and the five planets known in antiquity (Mercury, Venus, Mars, Jupiter, and Saturn) were considered simultaneously according to two frames of reference, the zodiac and the horizon of the place where the individual was born. The zodiac originated in Babylonian astronomy as the "path of the moon," the belt of constellations through which the moon and planets (and also, though this was not directly observable, the sun) traveled with diverse periodicities (see the chapter by John Steele in this volume). By about 400 BCE, Babylonian astronomers had established a ring of twelve zodiacal constellations, and for computational purposes, they divided the zodiac into twelve equal parts or "signs" of thirty degrees each, which were named after the zodiacal constellations that roughly coincided with them; the zodiac was transmitted to Greek astronomy soon after. It provided a uniform scale for describing observed or calculated planetary motion, but in astrology the signs were also believed to have certain astrological influences on the human world. The time scale on which the heavenly bodies move through the zodiac is from two or three days per sign (in the case of the fastest body, the moon) to two or three years (in the case of Saturn, the slowest body).

But meanwhile, as the Greeks understood it, the entire celestial sphere is revolving once a day around the earth, carrying the zodiac and its slowly moving occupants with it, so that the sun, moon, and planets are continually changing their locations

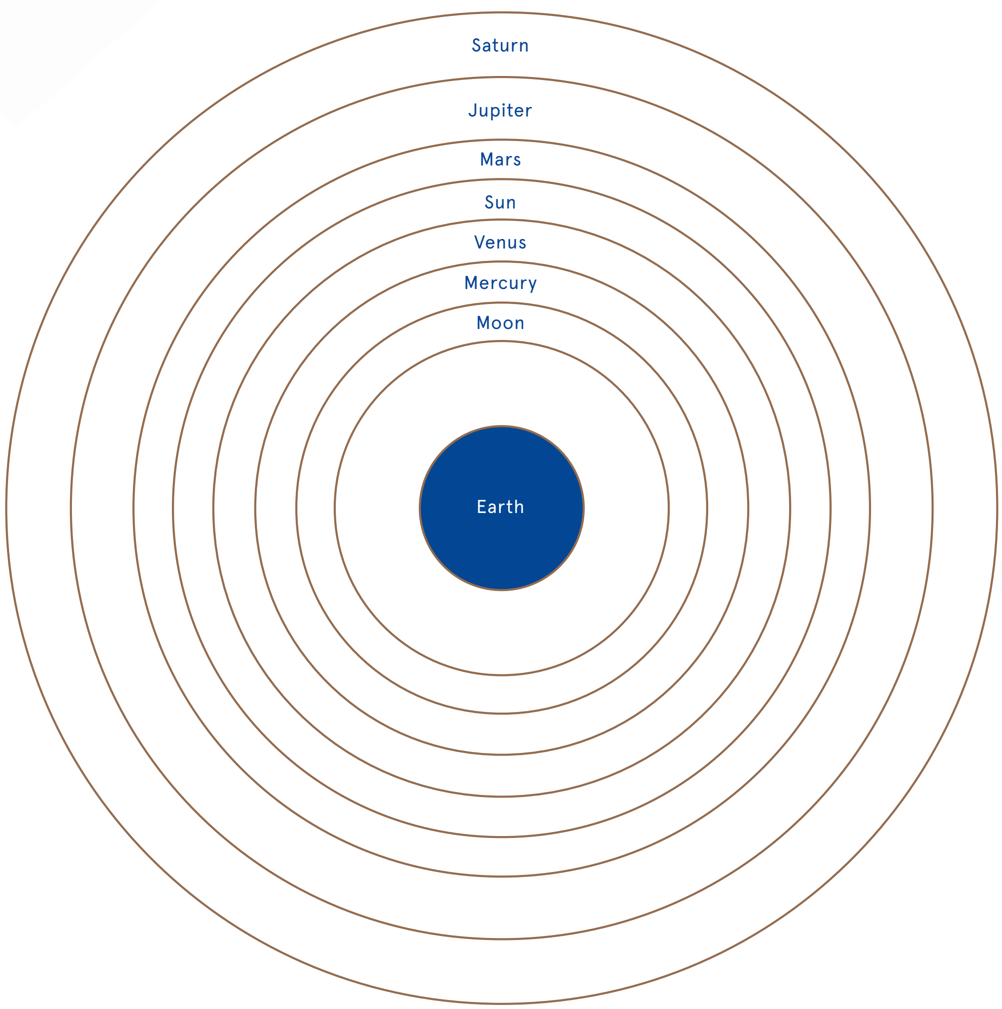
FIG. 1–6A,B.
Roofed Spherical Sundial with Greek Inscriptions: Side View (left), Interior View (right). Marble, Carthage (?), ca. 1st–2nd century CE. ML: MNE1178/ MA 5074. Checklist no. 6.

FIG. 1–7.
Skyphos Representing Two Olive Branches, from the Boscoreale Treasure. Silver, H. 8.10 cm; W. 19.50 cm; Diam. 12 cm, Boscoreale, late 1st century BCE–early 1st century CE. Musée du Louvre, Paris, Département des Antiquités grecques, étrusques et romaines: BJ 1915.

FIG. 1–8.
Portable Armillary Sundial. Copper Alloy, Octagon, Philippi, ca. 250–350 CE. EKT: ATK B43. Checklist no. 14.

FIG. 1–9.
Ring with Horoscope and Bust of Asclepius. Gold and Niello, Tartus, Syria, 4th century CE. VMFA: 67.52.11. Checklist no. 60.

FIG. 1–10.
Schematic diagram showing relative distances of the sun, moon, and planets from the earth in the geocentric cosmology assumed by many Greek astronomers. The astrological lords of the seasonal hours were assigned cyclically beginning with Saturn and continuing inward: Saturn, Jupiter, Mars, the sun, Venus, Mercury, and the moon, followed again by Saturn and repeating. Since the lords of the days were the same as the lords of their first hours, they followed the same sequence but in steps of three: Saturn, the sun, the moon, Mars, Mercury, Jupiter, Venus, Saturn, the sun, etc.



relative to the horizon of any locality on the earth. Astrologers believed that the local sky, comprising both the half above the horizon and the half below, was divided radially into twelve "places" (*topoi*) along a north–south axis, each with its own astrological character; the most important of the *topoi* was at the currently rising portion of the celestial sphere around the eastern horizon (the "ascendant" or *horoskopos*, that is, "hour-watcher"). The alignment of zodiacal signs with *topoi* changes roughly every two hours, so that even without taking fine details of the astronomical configuration into account, an astrologer would consider the horoscopes of two individuals born in the same place and on the same day or night but a few hours apart to be radically different.

Numerous horoscopes survive on papyri from Greco-Roman Egypt for individuals born between the first century BCE and the sixth century CE (figs. V-14, V-15); these were generally documents, or copies of documents, provided by an astrologer to his client as a summary of the astronomical and astrological data on which an orally presented interpretation would have been based. Even the tersest and crudest of the horoscopes routinely stated the seasonal hour of day or night when the client was born, and the zodiacal sign lined up with the ascendant at that time. Where did this information come from, one wonders? Even given the popularity of astrology in this period, it seems unlikely that someone rushed off to the nearest sundial or, for a night birth, a water clock the moment a child was born. Most of the times are probably estimates, and astrologers also believed that they could deduce or refine a birth time from other information provided by a client. The horoscopes are thus probably not evidence for a widespread practice of *observing* times to a precision of single hours, but they doubtless propagated a popular *awareness* of these units.

A striking illustration of how horoscopes mattered to individuals is a gold ring inscribed in Greek with the precise data of its owner horoscope (fig. I-9). Since this was not a documentary record but rather a personal emblem or even talisman, the date and time and birth are not recorded on it, though we can deduce from the locations of the heavenly bodies and the ascendant that it took place on August 17 of 327 CE at about 4 a.m. by our reckoning, or about the beginning of the eleventh hour of night. A few personal horoscopes also exist in the form of engraved gems.[13]

Horoscopes from the western regions of the Greco-Roman world are scarce, but we do have a large number of funerary inscriptions that mention hours.[14] These typically record not the date and time of an individual's birth, but either the date and time of death or the length of his or her life in years, months, days, and hours (and, in a few instances, also the duration of marriage). Whether these reflect quasi-astrological or numerological practices or just aim to find solace in precise biographical data is not clear, but again they attest to a growing consciousness of time in connection with the greatest landmarks of one's life.

Besides horoscopes, astrology offered another resource that made the flow of seasonal hours a guide to one's everyday decisions, with no need to consult a professional astrologer. Thus in his *Satire 6* on women (lines 572–81), the Roman poet Juvenal (ca. 100 CE) warns us to avoid the type of woman who goes about with a well-worn "ephemeris" in her hands and who will not take a meal or a journey without first establishing the auspicious hour to do so. An ephemeris was an astrological calendar, tabulating for every day the locations of the sun, moon, and planets in the zodiac, and in the case of the moon often giving the precise hour when it crossed from one sign to another; from the angles between the moon and the other bodies, among other considerations, one could work out whether a particular day or time of day would be good or bad for engaging in any activity.[15] Each seasonal hour, moreover, was held to be ruled astrologically by one of the seven heavenly bodies in turn, in the order that many Greek astronomers assumed to apply to their distances from the earth, from outermost to innermost (fig. I-10). The ruler of the first hour of the day was also the ruler of the day, conferring upon it the body's own benefic or malefic character (figs. IV-7, IV-8, IV-9, IV-10). The complete cycle repeats every seven days, and our modern names for the weekdays derive from their planetary lords and the associated Roman divinities (day of Saturn, day of the sun, day of the moon, and so forth).

THE IMAGERY OF TIME AND COSMOS

Ancient Greek and Roman conceptions of time and cosmology left a rich visual heritage in many media (see the chapter by James Evans in this volume). The chief iconographic themes expressing underlying meanings include sundials, celestial and terrestrial spheres, the sun, moon, and planets, and the zodiac and its constituent constellations. (The four seasons and the Roman calendar months were also common motifs—for example, in mosaics—but their role was more decorative than emblematic.) Here we can touch on only a few of the roles that these images played.

Time is neither visible nor tangible. One way of making a visual symbol of time is to show an instrument that reckons time. The most common emblem of time nowadays is the clockface; in antiquity it was the sundial. The significance of sundials figuring in Greco-Roman art was often the idea of fleeting time and mutability (fig. VI-9), and they are particularly common in funerary contexts such as sarcophagi, where they project the harsh fact of mortality—most touchingly in connection with children (fig. VI-8). A Hellenistic terracotta figurine from Myrina (fig. I-11) showing a grief-stricken slave—mourning his master?—beside a sundial on a plinth might have been a memorial object for a specific person or just a memento mori.

Globes or pictures of globes representing the celestial sphere could be furnished with the figures of the constellations (figs. VI-2, VI-3), but it was sufficient to provide a sphere with some of the imaginary circles of astronomical significance such as the equator, tropics, and ecliptic to mark it as celestial (or in some instances terrestrial, since the visual clues were ambiguous). Like sundials, globes could convey ideas of time, mortality, and destiny, no doubt partly through associations with astrology, though the fundamental role of the celestial sphere's revolutions in defining cosmic time was also probably a factor in this symbolism.

Both the sundial, as an invention of human minds, and the celestial sphere, as an object of study and contemplation, were linked to wisdom and intellectual life. The classic image of seven sages or philosophers, one of whom is discoursing while pointing at a sphere with a rod, is best known from a first-century-CE mosaic from Pompeii (fig. I-12). Its earliest known version, however, dating back to about 300 BCE, is in a recently discovered tomb at Pella; each sage is figured separately around the sides, symmetrically arranged around the one with the globe at one end of the tomb.[16] The Roman picture adds two architectural features in the background: a sundial on a column, and a sort of archway with several large oil lamps on top—clearly standing for daytime and nighttime, though the

FIG. I-11.
Statuette of Grieving Slave with Sundial. Terracotta, Necropolis, Myrina, Hellenistic (?). NAMA: 5007/D.95. Checklist no. 34.

FIG. I–12.
Roman Mosaic Depicting the Seven Sages ("Plato's Academy"). Stone, Villa of Titus Siminius Stephanus, Pompeii, 1st century BCE–1st century CE. MANN: 124545. Checklist no. 32.

FIG. 1–13.
Byzantine Plate Representing Ptolemy and Hermes in Colloquy. Silver, H. 45 cm; W. 28 cm, Eastern Mediterranean, 500–600 CE. The J. Paul Getty Museum, Villa Collection, Malibu, California: 83.AM.342.

precise bearing on the philosophical theme is not clear (see the chapter by James Evans in this volume). Remarkably, key features of the seven-sages image recur in a fine silver plate from late antiquity (sixth century CE?) in the Getty Villa collection of the J. Paul Getty Museum (fig. I-13).[17] Here the great second-century-CE Alexandrian scientist Claudius Ptolemy converses with the legendary sage Hermes Trismegistus, probably on astrology, with a celestial globe on a tripod between them. Female allegorical figures stand behind the two men; the one behind Ptolemy is Skepsis, "rational inquiry," so Hermes' companion may have represented revealed wisdom. A seated, somewhat Christ-like figure in the background might have played the role of an arbiter or judge, and flanking him are two arches, one of which bears a shell-shaped object recognizable as a sundial.

The sun, moon, and planets were typically represented by the busts of the Greco-Roman divinities with which each was linked (e.g., figs. IV-7, IV-8, IV-9, IV-10), an iconography especially popular in the western Roman Empire. No example survives from antiquity of a cosmological image showing the heavenly bodies in their appropriate distances from the central earth, though diagrams of this kind occur in medieval manuscripts derived from ancient originals as well as in Renaissance paintings that combine Greek cosmology with Christian theology (fig. I-14). We now know from its inscribed texts that the astonishing gearwork known as the Antikythera Mechanism (second–first century BCE) had a mobile display of this kind on its front face, with the heavenly bodies represented by small spherical attachments to revolving pointers that marked their locations in the zodiac for whatever date the mechanism was set to show (fig. IV-12).[18]

Imagery of the zodiacal constellations was very common, though it is not always easy to tell whether a particular image refers to one of the constellations or just the kind of figure that the constellation represents—for example, Taurus as opposed to simply a bull. One distinctive zodiacal image, the "goat-fish" Capricorn, had an exceptional history. This imaginary beast was an emblem of Ea, one of the most important gods of the Babylonian pantheon, who resided in the watery abyss below the earth; the constellation of the Goat-Fish was part of the Babylonian zodiac, and was subsequently taken over with the same iconography by the Greeks (see the chapter by John Steele in this volume). In the late first century BCE, Augustus adopted the goat-fish image as emblematic of his auspicious horoscope (exactly how Capricorn was involved in his horoscope remains uncertain); its frequent appearances on coins and other objects from his reign, such as a gilded sardonyx cameo with his bust and a double Capricorn (fig. I-15), would not have invited strictly astrological interpretation (see the chapter by Bernhard Weisser in this volume). Through the association with Augustus, Capricorn was adopted as an emblem of certain legions of the Roman army, including the Legion II Augusta, while subsequent Roman emperors from the late first century CE through to late antiquity frequently revived the Capricorn image as a historically rich symbol of their power.

Lastly, the zodiac taken as a whole, as the pathway of the sun and the other heavenly bodies, was a spatial cycle that could stand as a visual metaphor for cosmic cycles of time, especially the supposed restoration of a Golden Age. The allegorical figure Aion—the word may be interpreted as "cyclic eternity"—appears in several Roman mosaics as a standing nude male figure steadying with his hand a hoop or belt figured with the zodiacal constellations (fig. I-16). The image was sufficiently familiar so that an aureus from Hadrian's reign (ca. 119–122 CE) bearing a miniature version of it on the reverse

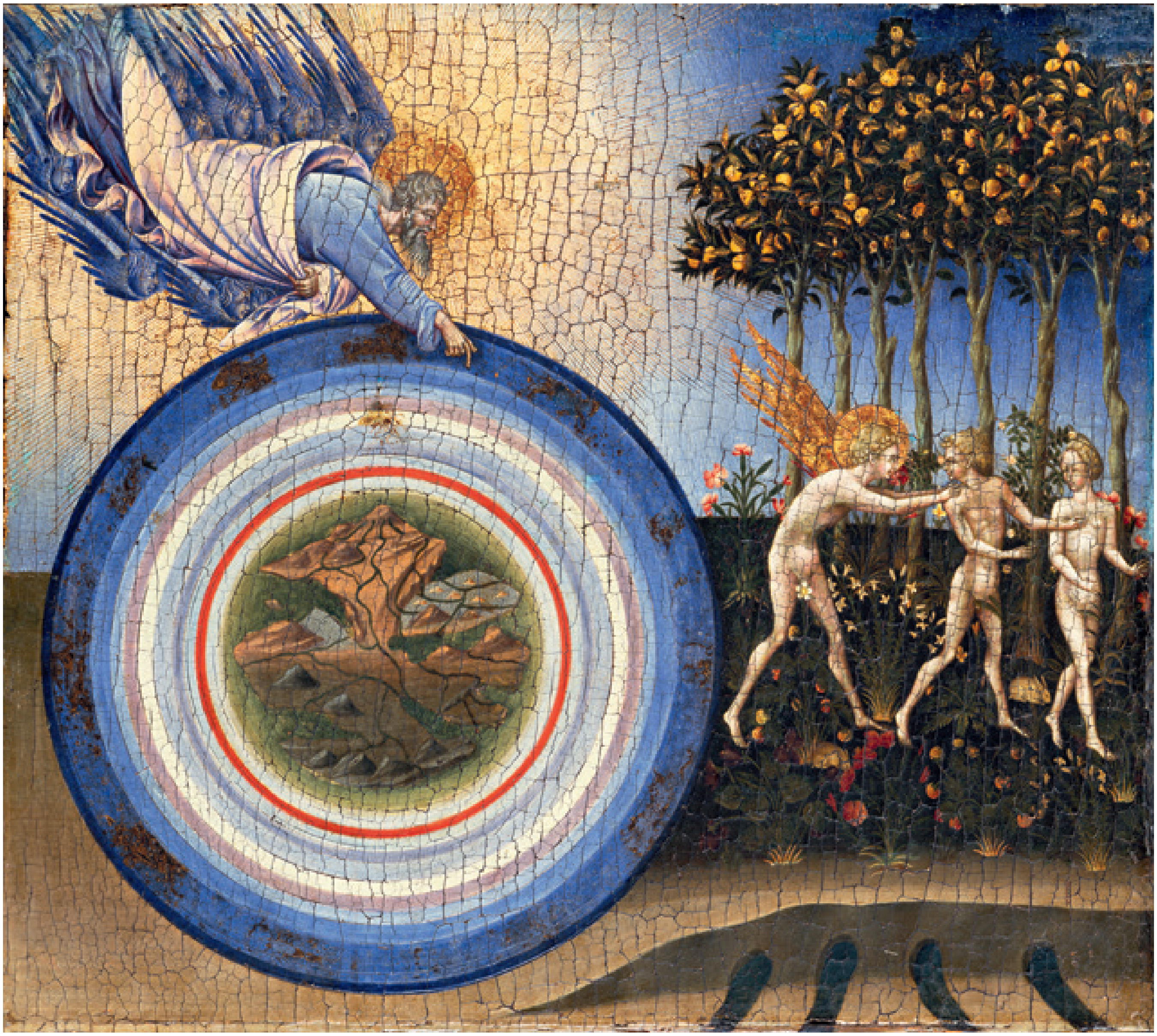


FIG. 1–14.
Giovanni di Paolo, *The Creation of the World and the Expulsion from Paradise*. Tempera and Gold on Wood, H. 46.4 cm; W. 52.1 cm, Siena, Italy, 1445 CE. The Metropolitan Museum of Art, New York, Robert Lehman Collection, 1975: 1975.1.31.

FIG. 1–16.
(detail) Roman Mosaic Representing Aion Standing in Zodiac with Tellus and Her Children. Stone, H. 550 cm; W. 500 cm, Sentinum, ca. 200–250 CE. Glyptothek, Staatliche Antikensammlung, Munich: GI 504.

FIG. 1–15.
Cameo Representing Double Capricorn with Portrait of Emperor Augustus. Sardonyx and Gold, Egypt (?), ca. 27 BCE–14 CE. MMA: 29.175.4. Checklist no. 72.

FIG. 1–17.
Aureus Issued by Hadrian: (obverse) Head of Hadrian, (reverse) Aion Standing in Zodiac, Holding Phoenix and Globe. Gold, Rome, ca. 119–122 CE. MSMB: 18204693. Checklist no. 81.

would have had obvious implications even if it was not labeled “SAEC. AVR.,” “golden age” (fig. I-17).

A more complex and subtle appeal to the concept of cyclic cosmic regeneration was made in a remarkable issue of coins in Alexandria in 144–145 CE, during the reign of Hadrian’s successor Antoninus Pius (fig. IV-11a–n). Until Augustus instituted a four-year cycle of leap years similar to those of the Roman calendar, the Egyptian calendar year was always exactly 365 days, so that it underwent a gradual backward shift relative to the seasons. The coin series of 144–145 CE evidently commemorated the presumably auspicious occasion, only occurring every 1,461 years, when the beginning of the year according to the old calendar returned to its presumed original alignment with the natural year. On the reverse of one coin of the series is a double zodiac, standing for the chronological alignment, while each single zodiacal sign was figured on its own coin, accompanied by the bust of the planetary divinity that astrological doctrine assigned as the sign’s ruler. The sophistication of the concept implies a more than ordinary familiarity with the ancient astral sciences, and one might wonder whether Claudius Ptolemy, who was writing his great astronomical treatise in precisely these years, might have had some part in it.

1 Hannah 2005; Trümpy 1997; Samuel 1972.
2 Jones 2016.
3 Jones 2007.
4 Lehoux 2007.
5 Lehoux 2005; Diels and Rehm 1904; Rehm 1904.
6 For an excellent general introduction to Greek astronomy, see Evans 1998.
7 The astronomical researches of Hipparchus (second century BCE) and Ptolemy (second century CE) revealed that the stars have an extremely slow revolution relative to the celestial sphere and around the poles of the ecliptic, a phenomenon known as the "precession of the equinoxes."
8 The illustration is from the earliest published description of the sundial by Stefano Piale, in Guattani 1811: 102–9.
9 Schaldach and Feustel 2013.
10 Jones forthcoming.
11 Bonnin 2015.
12 Remijsen 2007.
13 Heilen 2009.
14 Ehrlich 2012.
15 Jones 1999b.
16 Lilibaki-Akamati 2007.
17 Plate with Relief Decoration, inv. no. 83.AM.342, http://www.getty.edu/art/collection/objects.
18 Bitsakis and Jones 2016; Freeth and Jones 2012.