THREE

Mapping the World: Greek Initiatives from Homer to Eratosthenes

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Introduction

In 423 BCE, when the comedy *The Clouds* was first produced at Athens, the two most powerful Greek city-states and bitter rivals, Athens and Sparta, had been at war for several years (fig. 3.1). Much of the literature of that period reflects the social and political anxieties felt by all Athenian citizens in wartime. In this connection, the author of the *Clouds*, Aristophanes, ingeniously employs a map as a focal point of the geography of contemporary politics. In the comedy, Strepsiades, an everyman Athenian farmer, argues with his son Pheidippides over his profligate lifestyle of horseracing and gambling but fails to talk his son into enrolling in college. In fear for his own economic security, Strepsiades decides to attend college himself in order to learn the art of persuasion: he aims to talk himself out of his debts. As he awaits his meeting with the principal, a comically exaggerated Socrates, he tours the grounds of the school, the *Phrontisterion*, asking his student guide about various astronomical and geographic instruments there. When prompted, the student explains geometry as the science of measuring land and, by way of explanation, points out a map of the Greek world on display. Strepsiades asks to be shown Athens and his neighborhood within it, and the student obliges. However, when Strepsiades asks the student to show him where his friend Cicynna might be, the exasperated student dismisses the question, and instead draws attention to Euboea, a "long island lying off the coast." Strepsiades then asks where Sparta is. The student obligingly points it out, indicating its spatial relationship to Athens. Strepsiades's reaction, in alarm at the proximity of the enemy state, is a vehement demand that the student move Sparta further away (*Clouds* 200–18).

This charmingly naive scene reveals something about Greek maps and Greek attitudes toward them. Large-scale maps were known in Athens from the fifth

FIGURE 3.1 Greece, the Aegean Sea, and western Asia Minor. Reproduced with permission of the Ancient World Mapping Center, University of North Carolina, Chapel Hill.

century onward, and they were symbolically powerful. Both practical and artistic, they were displayed in private and public places. For example, in his will,[1] Theophrastus (d. 287/6), who had studied in Athens under Plato and Aristotle, requested that a world map painted on wooden panels be displayed at the Lyceum, where he himself had taught. This Athenian institution, founded by Aristotle, was a semipublic place for exchanging knowledge. Likewise, in the *Argonautica*, an epic tale of the sea journey of Jason and the quest for the Golden Fleece, the third-century poet Apollonius of Rhodes refers to maps on display on pillars at the court of Medea's father, King Aeëtes, "on which are all the roads and paths of the sea and land flowing all around" (4.279–81). Founders of colonies drew maps to demarcate the allotment of lands and resources to the community, gods, and settlers. On a wider scale, Greek writers compiled lengthy geographic descriptions of the Mediterranean world. Among the most important of them is Strabo (ca. 30 BCE–24 CE), who was born in the Black Sea region, worked in Rome, and traveled widely. In his *Geography* of the Mediterranean world, comprising seventeen books, he describes a celestial globe which showed the celestial sphere marked with the major zones of latitudes and the ecliptic (the sun's apparent orbit around the earth: 1.1.21).

Greek maps undoubtedly reflected the prejudices and philosophies of those who made them. Geometric aesthetics and philosophical beliefs dictated the shape of the entire world (cylindrical or spherical) and of the inhabited portion of it (the *oikoumene*). At its center might be placed the mapmaker's own city-state (*polis*), or some site of particular cultural importance. In all likelihood the *Phrontisterion* map, to be used by students in Athens, would have shown either Athens itself at its center, or Delphi, a "central" religious site where worshippers sought advice on many issues including colonization, or Delos, the small Aegean island chosen as the meeting place for the fifth-century league that Athens provocatively transformed into an empire.

Greek maps stemmed from abstract philosophical theories, and the geographic texts which explained them treated not only topography and relative distances, but also cosmogony and humanity's place in the universe. Cartographers and geographers were guided by various precepts drawn from the Greek sense of aesthetics, superiority, and vanity. Greeks were aware of climatological differences and consequently developed a theory of geographic determinism: climate—a combination of latitude, longitude, and weather—shapes character.[2] For the Greek historian Herodotus (fl. ca. 445–420), this is a connective theme: Egypt's unique climate results in peculiar topography and customs (2.35); Greece is the best land because of its moderate and temperate climate (3.106); by contrast, a climate where the living is too easy produces soft men (9.122). The unnamed author of the Hippocratic treatise *Airs, Waters, Places* (fl. ca. 430–400) explains (12, 14) how climate accounts for character: Asia is mild and fertile, being close to the east, but its people are indolent and submissive; the northern Scythians are chilled, watery, and almost barren, like their wintry land; variable climate accompanies variable terrain and produces peoples of more changeable character and livelier and freer minds. Strabo (6.4.1) famously attributes the rise of Rome to Italy's temperate, yet varied, climate.

Pictorial maps may have accompanied geographic treatises. Anaximander of Miletus (fl. ca. 600–545) is said to have drawn the first Greek geographic map, and he may have written a book entitled *Circuit of the Earth*. Hecataeus, also from Miletus (fl. ca. 520–490) and author of the first systematic textual description of the world in Greek, may have included a map with his book. In producing physical maps, Greeks used the essential scientific tools of mathematics and astronomy, but they also relied upon a variety of written and oral sources, including what they learned from mariners. Cartographic data are integral to Greek expeditionary treatises[3] and histories, as well as to those guidebooks which list and describe places in the order encountered while traveling along a road (*periegesis*, "trip around the world") or coast (*periplous*, "a sailing around"). Cartographic advances were made especially during times of intense colonization and interstate trade (700–500, when the Greeks extensively colonized the Mediterranean) and of foreign warfare (500–480 and 340–323, against the Persians). The practical knowledge gained from military expeditions encouraged Greek cartographic initiatives. Although the actual maps rarely survive[4]—and maps were almost never included in manuscripts—some maplike descriptions do: the information was considered useful, worth copying, and often entertaining. Early Greek maps, like those made by Babylonians and Egyptians discussed in this volume, could range in scope from city plans or mine tunnels[5] to geographic regions or the entire inhabited world.

Challenges to the Study of Greek Cartography

We cannot know how many Greek maps were produced, or what exactly their content and purpose may have been. The different materials on which they were presented have rarely survived. Papyrus and vellum are perishable; bronze and other metals were frequently melted down; stonework and mosaics were stolen, defaced, or buried. Our reconstructions must therefore depend upon later descriptions by authors sometimes removed from the original artifacts by centuries: Strabo, for example, lived three centuries after Eratosthenes (fl. ca. 276–194), whose work he described. Texts preserve merely a selection of descriptions of the original maps, and their authors often interpret as much as they describe. They employ similes and evoke familiar geometric shapes and objects from daily life: Sicily is triangular, Attica crescent shaped; the Peloponnese resembles the leaf of a plane tree, Italy an oak leaf.[6] Further, how accurately writers quote their sources we cannot say. Geographic reconstructions are by their very nature interpretative and speculative. Because the textual descriptions reflect the knowledge and theoretical initiatives of the culture which created them, our understanding of this material and our resulting images are reliant upon an adequate grasp of it. As with translating literary texts, there is ample room here for misrepresentation, factual distortion, and philosophical misinterpretation of geographic texts. Moreover, geographic data are easily garbled in copying. Maps too large to be incorporated into papyrus rolls and vellum codices were liable to be separated from their manuscripts and then further damaged or lost. Although maps were useful, artistic, and of immense symbolic and practical value, they may also have suffered from intellectual prejudices against material artifacts, which some considered to be secondhand imitations of life appealing to humanity's less rational nature.[7]

Issues of scale and perspective further obstruct us. Greek mapmakers were prone to exaggerate the size and importance of their own surroundings; for more remote regions, the scale grew smaller and the details fewer. Strabo even claims that the need to know about distant places is minimal: "For purposes of government there would be no advantage in knowing such countries and their inhabitants, particularly if the people live in islands which are such that they can neither injure nor benefit us in any way because of their isolation" (2.5.8). Moreover, there was no absolute Greek unit of length for measuring distance. To be sure, one *stadion* was reckoned as 600 Greek feet, but a standard "foot" was lacking: at Olympia one *stadion* was 192.8 m, the length of the stadium there, while the Athenian *stadion* measured 185 m, and the Egyptian only 157.5 m. In addition, before the time of Alexander the Great (356–323) there were no coordinated efforts to map the Mediterranean world.

Greeks realized that maps and geographic knowledge have political value. Alexander engaged "bematists," men whose sole job was to measure distances between places.[8] Strabo (1.1.16) asserts that maps are useful to governors, who can better manage affairs if they know the size of a country, the lay of the land, the peculiarities of sky and soil, and the local peoples and their customs. In his view, maps also benefit hunters for understanding the character and extent of a terrain, and commanders for pitching camp, setting ambushes, and marching in unfamiliar territory. Even so, Greek interest in mapmaking and in describing the topography and the location of settlements predates the first formal illustrative maps. Indeed, such interest goes all the way back to Homer, whom Strabo (1.1.11) called the "father of geography."

Homer

Attributed to Homer and committed to writing in the mid-eighth century are the earliest extant Greek literary works, the *Iliad* and *Odyssey*. They recount episodes from the Trojan War, and both reflect a strong geographic curiosity and awareness. Homer was clearly engaged by the nature of the world, its origins, its shape, and the relationships between places. In his lengthy catalog of Greek ships (*Iliad* 2.494–759), he lists 29 contingents, 44 Greek leaders, and 175 towns and locales by name.[9] The catalog incorporates topographical details for many places: Aulis and Pytho are rocky; Eteonos has many hilly valleys; Asine lies down a deep gulf. Of particular importance is proximity to the sea: Chalcis and Antron are by the shore; Cerinthos is a seaborne island; the landlocked Arcadians, to whom "the work of the sea was nothing," had to borrow ships from King Agamemnon. Certain places are characterized by weather: Euboea, whose "wind was fury"; "wintry" Dodona. Human and political data are likewise noted. Thus, places are distinguished by landmarks: strong-founded citadels at Medeon, lower Thebes, and Mycenae; Tiryns of the huge walls. Populations, too, are tallied: Crete is said to have one hundred cities. Several sites are characterized by economic strength: Arne and Histiaia of the great vineyards; silver-shining Lycastos and Cameiros; Iton, mother of sheepflocks. Some peoples' physical characteristics and fighting skills are noted: the Abantes (of Euboea) "their hair grown long at the back," who are "furious spearmen"; the Arcadians fight at close quarters. Herodotus, Strabo and other geographic writers would later incorporate similar information into their own geographic accounts.

In Homer's catalog, details regarding the spatial relationships between places are limited, restricted usually to neighboring bodies of water: Lilaia, for example, is beside the wellspring of the river Cephisus; Doulichion and Echinai are across the water from Elis (far across, according to modern maps); Pherai is beside Lake Boebeis. Sites are grouped in rough geographic succession, spiraling clockwise from Greece north of the Corinthian isthmus, to the Peloponnese, the western islands and western Greece, southeastern islands, and finally northern Greece. Exceptionally, the southeastern islands (Crete and its environs) are inserted between the western islands and northern Greece. The catalog omits altogether many Aegean islands and *poleis* of Asia Minor which were of considerable historical importance.

Within each region, Homer proceeds only roughly in a circumnavigational fashion, ordering place-names according to the demands of his poetic rhythm rather than the practical considerations of a journey. The *poleis* of Euboea, for example, are listed as follows: Chalcis, Eretria, Histiaia, Cerinthus, Carystus, Styra. In reality these are all coastal communities located as follows from north to south: Histiaia (north shore), Cerinthus (east), Chalcis, Eretria, Styra (all west), Carystus (south). Although Homer's catalog is the earliest Greek map-type description, an actual map cannot be drawn from it.

Opinion is divided over the catalog's origin, purpose, and geographic veracity. Some scholars consider it a much later insertion into the *Iliad*, because the contingents listed as important (such as the Boeotians, listed first) turn out to play no significant role in the action of the epic; in addition, places not founded until the eighth century (four centuries after the Trojan War) are included, as well as sites of no Bronze Age importance, Athens among them. It may be true, as many argue (Dickie 1995, 29–30), that Homer's attempt to re-create the Mycenaean past was largely imaginative and self-conscious. Others conclude that the catalog preserves an accurate record of expeditionary forces, modified appropriately for inclusion in an account of an episode late in the Trojan War (Willcock 1976, 23). Certainly it is likely that the catalog reflects Homer's contemporary geography projected onto an imagined landscape of the Bronze Age Mediterranean.

The *Odyssey*, with its tale of a Greek hero's homeward sea journey from Troy featuring geographically relevant details, reads in part much like a technical sailing log, a *periplous*. Homer paints vivid topographies of Sicily, of the wind god Aeolus's island, of Circe's island, Aeaea, and, fancifully, of the Underworld. It is no surprise that a poetic account of a sea journey would also furnish rich maritime data, including harbors and anchorages in Aeaea ("fit for ships"), Sicily ("where the harbor is easy, with no need for a hawser or anchor stones"), and northern Europe (the harbor of the Laestrygones is "glorious") (Hexter 1993, 139).

Moreover, Odysseus, like any sailor, was deeply concerned with the winds, and he knew them well. His diligent observations suggest growing efforts to map them, a critical step to nautical cartography. By the winds (named for the direction from which they blow), one can occasionally trace Odysseus's path: a west wind carried his ship from Aeolus's island to Ithaca; southerly and easterly winds prevented him from leaving Thrinacia, the island of the sun god (well to the east, where the sun rises; he needed to travel west or north). After he left Ogygia, Calypso's island, the west wind ceased to blow, and a south wind blew him back past Scylla and Charybdis, driving him ultimately toward Scherie, the land of the Phaeacians.

In the *Odyssey*, as in the *Iliad*, explicit directional and spatial details are few. The suggestion that Ethiopia is a divided territory—some Ethiopians dwell in the east, some by the setting sun (*Odyssey* 1.22–24)—is unusual, as is the clarity of Circe's directions to the Underworld: "Let the blast of the north wind carry you. But when you have crossed with your ship the stream of Ocean, you will find there a thickly wooded shore, and the groves of Persephone, and tall black poplars growing, and fruit-perishing willows, then beach your ship on the shore of deep-eddying Ocean."[10] Circe's directions and her landmarks are vivid. The Underworld is a difficult destination only for its remoteness, and a map is hardly necessary. Furthermore, Homer's description of the journey suggests something about the accepted view of the shape of the earth. He writes that at its limit "lie the community and city of the Cimmerian people, hidden in fog and cloud, nor does Helios, the radiant sun, ever break through the dark, to illuminate them with his shining, neither when he climbs up into the starry heaven, nor when he wheels to return again from heaven to earth, but always a glum night is spread over wretched mortals" (*Odyssey* 11.13–19). This description implies a flat worldview and a sun whose path across the sky does not change regardless of the season.[11]

According to Strabo (1.2.7), the third-century scholar Eratosthenes (see further below) rejected all attempts to map the sites to which Odysseus ventured in Homer's epic. Yet scholars contemporary with Eratosthenes proposed likely equivalents for several of the places featured there. The truth is, however, that these cannot be identified conclusively, and modern scholars continue to dispute the geographic integrity of Odysseus's journey. Certainly, Homer's descriptions of Ithaca and surrounding islands are not corroborated by geographic facts, and his references to Egypt, Cyprus, and Phoenicia suggest the political geography of the eighth century, not of the Bronze Age Trojan War era.

It is unlikely that Homer used maps or knew of them.[12] The opulent artwork on Achilles's shield (*Iliad* 18.483–607), however, strongly suggests an early attempt at mapmaking. Hephaestus, the Greek god of the forge, created a great shield with five layers of metallic laminate and a triple-layered metallic rim. The shield's face was decorated with a gold plate in the center, two plates of tin, and two of bronze. One of the bronze plates engraved onto the shield showed the earth in its relationship to celestial bodies: "[Hephaestus] made the earth upon it, and the sky, and the sea's water, and the tireless sun, and the moon waxing into her fullness, and on it all the constellations that festoon the heavens, the Pleiades and the Hyades and the strength of Orion and the Bear, whom men give also the name of the Wagon, who turns about in a fixed place and looks at Orion and she alone is never plunged in the wash of the Ocean." Hephaestus then depicted two cities, one of peace, another of war, and around the "uttermost rim" he engraved Ocean, which was thought to circle the earth. In short, the shield is a synthesized microcosm of

Homer's world, both terrestrial and celestial. It was not intended to communicate a physical geography, but it rather served as a generalized and metaphorical depiction of human activity and the interdependence of humanity with surrounding environs, a powerful image of the cosmos (Hardie 1985, 11).

Despite Homer's geographic curiosity and awareness, only the vaguest of maps could be generated from his data, comprising little more than a set of cardinal points. His geography lacks a frame within which to delimit boundaries. Nonetheless, early Greek sailors knew the nautical and geographic markers scattered along well-established shipping lanes. "By connecting these dots, as it were, an outline of the *oikoumene* appears" (Hahn 2001, 205), and so the nautical accounts in Homer prove essential to the advancement of mapmaking. In fact, the paradigm presented on Achilles's shield, the circular cosmos framed by Ocean, may have inspired early efforts in Miletus to produce "scientific" maps.

Miletus and Its Thinkers

Homer was thought to have lived somewhere in Ionia, the culturally Greek area of Asia Minor, perhaps not too far from Miletus, where Greek rational science was born and Greek mapmaking began. Early rational attempts to describe the earth, if not to map it, were abstract and theoretical. Along with other Greek cities in Asia Minor, Miletus benefited from numerous intellectual, economic, and cultural stimuli which fostered scholarly and rational activity. Until its destruction by the Persians in 494, it was a wealthy center of trade, in contact with the scientific and artistic achievements of the Near East and Egypt. Its citizens openly engaged in political debate. The laws they formulated were intended both to engender citizen consent and to express the political will of the majority; in addition, a widely disseminated and fully alphabetic script rendered the laws easily accessible.

The philosophical analog to political debate and open discussion is critical inquiry, which forms the foundation of rational science. As a vigorous center of commercial and colonizing activity, Miletus was likely a hub of varied geographic information circulated by sailors in port, and it was from this environment that geographic theory and empirical frameworks were developed. Early Greek terrestrial maps probably reflected both practical and abstract aims: to demonstrate the physical relationship between places as well as to prove a sense of order in the world and human (that is, Ionic Greek) control over that world order.

Early efforts to produce terrestrial maps lacked a strictly empirical tradition. In contrast, sky maps were developed from both abstract geometric principles and from direct observations of the risings and settings of stars, carefully recorded. Sky maps had both theoretical (cosmology) and practical (astrology and calendars) applications. Although early Greek cartographic initiatives in all likelihood derived from Babylonian and Egyptian traditions, the evidence for the transmission and reception of the relevant mathematical concepts is circumstantial at best. Only in the third century do the paths of transmission become securely detectable.[13] Otherwise, the earlier Greek evidence is either entirely lost or survives merely quoted without context in scant fragments.

ANAXIMANDER

Anaximander of Miletus was not only the first Greek to be credited with drawing a map in the formal sense according to Eratosthenes, but he also engaged in broad intellectual pursuits and may even have founded a colony, perhaps on the Black Sea.[14] Among the geographic titles attributed to him are *Circuit of the Earth*, *On Fixed Stars*, and *Celestial Globe* (*Souda* A-1986). We cannot be certain of the content of these works or even of their existence. It is also debated whether Anaximander wrote a commentary on his map or on the construction of his celestial globe.[15] Even so, works with the titles cited, whether real or apocryphal, imply an informed preoccupation with both celestial and terrestrial cartography, and it seems credible that Anaximander was motivated to give a rational and critical account of the origin of the cosmos and the spread of human civilization. He believed that the same forces underlying the creation of the cosmos continued to guide it, and that these forces accounted for meteorological phenomena and climatic conditions.[16]

Anaximander's terrestrial map comprised an outline (*perimetron*) of the earth and sea; the late antique Greek geographer Agathemerus (ca. 400–600) adds that Anaximander "dared to draw" a map of the *oikoumene* on a *pinax* (tablet), a Greek word used both of painted panels and of bronze tablets.[17] It is impossible to reconstruct with any reliable accuracy either the map or even its shape and size, let alone Anaximander's written account. His treatise perhaps began with a cosmological introduction; then, by combining history, astronomy, and geography, it may well have proceeded in lecture format to discuss the arrangement of natural and man-made landmarks, cities, and climate as revealed in the pictorial map.[18] His geographic successors followed this approach.

Anaximander envisioned the world as a shallow but broad cylinder, its depth one third of its width, "like a stone column," hanging freely in the air, equidistant from other celestial objects. All scholarly reconstructions of his map envision a flat circle of earth surrounded by the stream of Ocean (fig. 3.2). His *oikoumene* was seemingly divided into thirds, namely, Europe, Asia and Libya, separated by the Nile and Phasis rivers and the Mediterranean Sea and Black Sea. There is no consensus regarding the relative sizes of the landmasses, let alone the map's center: Delphi, Delos, and Miletus have all been proposed. The shape of the *oikoumene* is further disputed. His map may have incorporated a three-point coordinate system, corresponding to the rising and setting of the sun on the days of the equinoxes and solstices.[19]

Anaximander is also said to have constructed a celestial globe, placing the earth

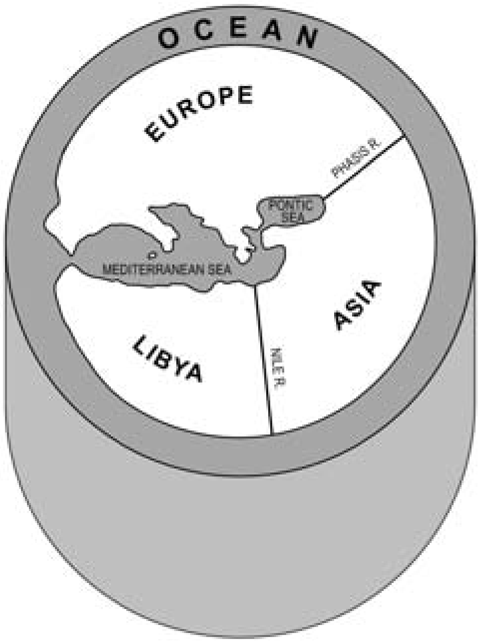

FIGURE 3.2 Anaximander's map of the earth. Reconstruction by the author.

at the center, following the pattern noted above on Achilles's shield. Anaximander devised ratios for relative distances between celestial bodies, placing the sun, equal in size to the earth, in a terrestrial orbit of twenty-seven times the diameter of the earth; the radius of the moon's orbit was eighteen times the earth's diameter, a progression of multiples of the number nine (fig. 3.3). The distance of the sphere of fixed stars, which he placed closest to the earth, was presumably nine times the earth's diameter. [20] The ratios of this celestial map have been connected to architectural proportions, and, intriguingly, Anaximander's approach to drafting both celestial and terrestrial maps may have derived from architecture.[21] Like an architect designing a temple, a cartographer would sketch a frame of the *oikoumene* on bronze or wood and build up his plan of the world from it. To both his cosmic and terrestrial plans Anaximander applied a tripartite division together with the rules of proportionality and symmetry which guided Mediterranean architecture, especially column drums; he is known to have compared the earth to a stone column. Clearly, his efforts were further guided by the practical applications of mathematics.

HECATAEUS

Anaximander's fellow Milesian Hecataeus was the first Greek to produce a systematic written description of the world in his geographic treatise *Periodos* (or

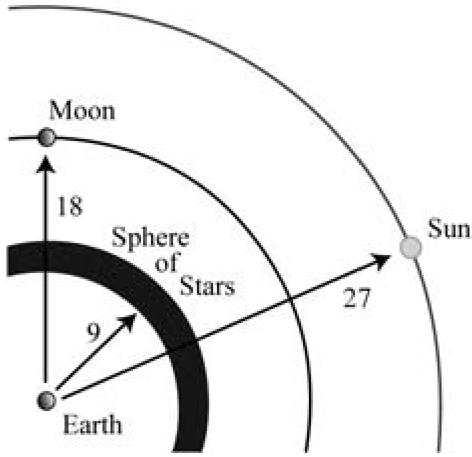

FIGURE 3.3 Anaximander's celestial map. Reconstruction by the author.

Periegesis) *Ges, Journeying around the Earth*. The surviving fragments suggest that he had traveled widely in Europe, Asia, and Africa. He may also have copied, or improved upon, Anaximander's terrestrial map; at least, Agathemerus proclaimed the new edition "more accurate so that it became a source of wonder."[22] Even so, rather than redrawing the map from scratch, Hecataeus perhaps just criticized his predecessor's work, in the typical way of Greek thinkers. Modern reconfigurations of Hecataeus's map closely resemble Anaximander's map. They show a circular earth, with Ocean surrounding the landmasses and the Mediterranean Sea in the middle (fig. 3.4). The *oikoumene* is depicted as tripartite: a strip of land lies to the north of the Mediterranean Sea (Iberia, Italy, Greece, and Asia Minor); another to the south (Egypt, Libya); and a third to the east (Palestine, Assyria, Persia, and Arabia). The lands to the north are the cold countries where dwell the mythical Hyperboreans (literally, peoples "of the far north"), separated from the rest of the world by the Rhipaean ("gusty") Mountains, whose location has always been a matter of debate. The lands to the south are the hot countries inhabited by the Ethiopians ("burnt faced" because of their proximity to the sun) and the crane-fighting pygmies.

In short, this is a worldview that relies heavily on mathematical and ethnographic symmetry and balance, and mixes fact and fiction. Hecataeus's erroneous impression that the Hyrcanian (Caspian) Sea flowed into Ocean long persisted, and he also believed that the Nile arose from the southern Ocean. It is no surprise, by contrast, that he was particularly knowledgeable about the Black (Euxine) Sea, an area colonized by Miletus. He mentioned various Scythian peoples there, including the "black-cloaks." He described the flora of the Caucasus, including the thick forest cover and the native prickly artichokes, and he was aware of the varying topography (plain and mountain) of the Chorasmians' country in modern Uzbekistan.

FIGURE 3.4 Hecataeus's world map. Reconstruction by the author.

ARISTAGORAS'S MAP

A portable map commissioned by the ruler of Miletus, Aristagoras, was probably developed from those of Anaximander and his contemporary Hecataeus. Aristagoras used it when he toured the Greek mainland in 499–498 in search of supporters for a revolt against Persian rule.[23] The map was engraved on a bronze *pinax* like Anaximander's. According to the Spartans, Herodotus recounts, it was a circular "journeying around" (*periodos*), on which all the earth appeared along with all the sea and all the rivers. Herodotus represents Aristagoras showing it to the Spartan king Cleomenes with the following explanation (5.49):

> The lands in which the earth's peoples dwell lie next to each other, as I shall show you: here are the Ionians, and here the Lydians, who inhabit a good land and have a great store of silver . . . and next to the Lydians you see the Phrygians, to the east, men that of all those known to me are the richest in flocks and in the earth's fruits. Close by them are the Cappadocians, whom we call Syrians; and their neighbors are the Cilicians, whose land reaches to the sea here, where you see the island of Cyprus located. The annual tribute which they pay to the king is 500 talents. Next to the Cilicians, here are the Armenians, another people rich in flocks, and after the Armenians, the Matieni, whose country is here; and you see the Cissians' land adjoining theirs; it is there, on this particular river the Choaspes, that Susa is situated, the residence of the Great King, where his treasure-stores are.

On this detailed and informative map Aristagoras was able to show a vast swath of territory spanning mainland Greece, Ionia, and Persia. Even so, the map probably lacked any measurable scale. When Cleomenes inquired about the length of the march between Sparta and Asia, he was told "three months," a standard but ambiguous measure of the distance between places far apart.[24]

Herodotus

Although there is no evidence to suggest that Herodotus included maps with his history, his ideas influenced the development of Greek cartography. He ridiculed circular maps which showed landmasses symmetrically divided by the Mediterranean Sea, and he doubted the existence of the Eridanus (Po) River, from which amber was thought to originate. As he discusses lands increasingly distant from the Mediterranean, the details become scanty, and his geography of the Indus is minimal (4.44). More generally, he raised several geographic questions: Why were three names (Europe, Libya, Asia) given to the earth, which is a single entity? Why were these landmasses all named after women? Who fixed the boundary of Asia and Africa at the Nile, and that of Asia and Europe at the Phasis River? (To Herodotus these boundaries were arbitrary.) Does water surround Europe to the west and north? Where precisely are the Cassiterides islands, the source of tin? What causes the Nile's annual flood?

To improve mapmaking, Herodotus gave precedence to data derived from empirical accounts. For example, he accepts that the continent of Africa ("Libya") is almost entirely surrounded by water (4.42), excepting the Isthmus of Suez, as proved by pharaoh Neco's circumnavigation of Africa (ca. 600). However, given the lack of empirical evidence that Ocean surrounds the contiguous landmasses of Europe, Libya, and Asia, he rejects this theory. Giving preeminence to data gleaned from exploration and travel, Herodotus attacks cartographers who utilized only geometry. His various criticisms imply a high, but repetitive, level of contemporary map production. Even if he did not use maps himself, his text can still be employed to produce an outline of the *oikoumene*. The framework is in place: there are limits to the extent of the world and boundaries between landmasses.

Herodotus was certainly forthright in his advice for drawing maps. He declares (4.36), "In a few words I will make clear the size [of Asia and Europe] and in what manner each should be depicted." He starts with Persia, delimited by the Persian Gulf and Arabia to the south. From the Black Sea are two peninsulas separated by the Phasis River: one arcs north to the Hellespont; the other extends south along the Red Sea to the Arabian Gulf and west to include Egypt and Libya. The Caspian Sea and the Araxes River delimit the extreme northeast, but east of India there is an uninhabitable desert whose topography is unknown. Libya is circumnavigable except where it borders Asia. But there is no certain knowledge of bodies of water delimiting northern Europe. Herodotus finds fault with cartographers for dividing

Europe, Libya, and Asia into three roughly equal landmasses, "because the differences between them are great." He gives the length of Libya as 100,000 *stadia* and asserts that Europe is "as broad as Asia and Libya together." Altogether, with his preference for empirically derived data, he rejects the philosophical paradigm of cartography and aspires to some degree of topographical accuracy.

Like Homer, Herodotus includes cardinal directions and topographical landmarks: bounding Egypt beyond Heliopolis, for example, are the Mountains of Arabia, oriented north to south and the site of quarries for the building of pyramids (2.8). Unlike Homer, Herodotus indicates approximate distances between places: the port of the Borysthenites lies at the midpoint of the Scythian coast (4.17); across from the Tanais River dwell the Sauromatae, whose lands stretch northward from Lake Maeotis (the Sea of Azov) and can be crossed in fifteen days (4.21); at its widest, Egypt is traversable in two months, whether by camel or on foot we are not told. Some distances in Egypt are given with deceptive precision: the seacoast reaches 60 "ropes" (*schoinoi*), or 3,600 *stadia* (2.6); the distance between the sea and the city of Heliopolis is reported as 1,500 *stadia*, only 15 *stadia* longer (he says) than the route between Athens and Olympia (2.7); and Heliopolis lies 4,860 *stadia* (81 *schoinoi*) up the Nile from Thebes, which is 6,120 *stadia* inland from the Red Sea (2.10). Nonetheless, despite his interest in geography and his unequivocal opinions regarding cartography, Herodotus utilized geography primarily to reinforce his presentation of history.[25]

Democritus

Herodotus's contemporary, the widely traveled and creatively brilliant Democritus of Abdera (ca. 440–380) on the Aegean coast in Thrace, developed a theory of atomism and worked extensively in all areas of the mathematical sciences. He also wrote a *Description of the World*, now lost, which may have included a map.[26] We know that he gave considerable thought to the shape of the earth—perhaps in answer to Herodotus's criticisms of circular maps. He considered it to be a hollow disk sloping down ("inward"?) in the temperate hot southern regions because of the loose texture of the surroundings there, in contrast to the intemperate, frozen, congealed north. The southern terrestrial area, he thought, was weighed down by the accretion of vegetation.[27] Democritus proposed that the *oikoumene* was an oblong oval with a length-to-width ratio of 3:2; this ratio may imply ignorance of the Far East, but it influenced some later mapmakers.[28]

Spherical Earth

The question of the earth's shape challenged many Greek thinkers, from Homer onward. Although the notion of a flat earth observed in the early maps and cosmographies of Anaximander and others was quickly abandoned, the symmetry

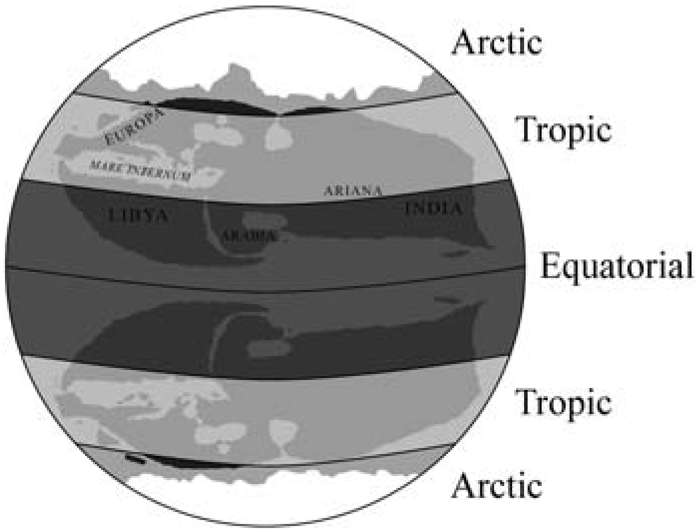

FIGURE 3.5 The spherical world divided into five symmetrically balanced zones (*klimata*). Drawing by the author.

and geographic determinism of the Greek mainland as the earth's center point nonetheless persisted, bolstered by philosophical and ethnic prejudices of Greek superiority. The Pythagoreans (ca. 450) at Croton in southern Italy, an area of extensive Greek colonization, may have been the first to suggest a spherical earth,[29] and the theory gained philosophical currency because the sphere was thought to be the "perfect" shape.[30] All parts of the cosmos were envisioned as spherical, and all celestial movements were explained as circular orbits or combinations of circles. In a neighboring region of southern Italy, likewise colonized extensively by Greeks, Parmenides of Elea (ca. 490–450) seems to have been the first to divide the spherical world into five symmetrically balanced zones (*klimata*): a hot zone at the equator, two temperate zones, and two cold.[31] He may have illustrated this division on a map or a globe (fig. 3.5). Henceforth, the sphere was taken as the orthodox shape of the earth. Plato (*Phaedo* 110b6) compared it to a leather ball made of twelve pentagons of different colors. Aristotle[32] subsequently proved the earth's sphericity from the evidence of lunar eclipses. As the moon wanes during an eclipse, it invariably retains a curved shape: this is possible, he argued, only if the earth, whose shadow causes the eclipse, is spherical.

To represent the earth on a three-dimensional sphere was impractical at best, and cartographers continued to employ a facile two-dimensional projection on papyrus, wood, or bronze. Furthermore, long after geographic inquiry confirmed that the *oikoumene* was greater in longitude than latitude, the circular paradigm endured. Echoing Herodotus, Aristotle (*Meteorology* 2.5.362b.13) deplored the way in which his contemporaries illogically continued to depict the *oikoumene* as circular. In his opinion such a representation was theoretically impossible given the sphere's geometry, and empirically impractical due to the ratio of the *oikoumene*'s width to its breath. Much later, in the first century BCE, the Greek mathematician and astronomer Geminus[33] again complained about the artificiality of circular maps still in use in his own day that distorted relative distances.

Fourth-Century Perspectives

Even so, by the fourth century maps began to show greater sophistication. Eudoxus (fl. ca. 365–340), a celebrated geometer and astronomer, composed a *Trip around the World* (*Periodos Ges*), of which only fragments survive. Strabo (9.1.2) praises his skill in rendering figures (*schemata*) and understanding latitudinal zones (*klimata*, based on the maximum hours of sunshine). Eudoxus's *schemata* imply geometrically informed maps designed to accompany his text. His determination that the *oikoumene*'s length is double its breadth became the simple and elegant ratio adopted by most Greek cartographers, including Geminus, who advised that "to draw a map to scale one should use a rectangular panel, with its length twice its breadth" (*Introduction to Phaenomena* 16.5–6).

Eudoxus's contemporary, the historian Ephorus (fl. ca. 360–330), recognized the value of geography to the historian. Only fragments of his work survive, but we know that—unlike Herodotus, who synthesized his discussions of geography and history—Ephorus presented an overview of the *oikoumene*. He treated world geography organically and in the order established by Hecataeus, starting from the Pillars of Hercules (Straits of Gibraltar) and working clockwise around the Mediterranean.[34] Ephorus's geographic interests included historical geography and the foundations of cities, and he also inquired into the theoretical geography of peripheral peoples. He viewed the earth as a flat rectangle, whose cardinal limits, cited according to the winds (Strabo 1.2.28), are represented by the Scythians (north), Indians (east), Ethiopians (south), and Celts (west). He believed that the two largest areas were Ethiopia, which extended from the sun's winter rising to setting, and Scythia, reaching from its summer setting to rising. We are further told by Cosmas Indicopleustes (fl. ca. 530–570), a Christian writer of the Byzantine period, that Ephorus illustrated his arguments "with the help of the enclosed drawings" (2.80). The illustration that Cosmas offers (fig. 3.6) shows a geometric figure keyed with the wind names and oriented (contrary to modern convention) with the north at the bottom (Boreas), east to the left (Apeliotes), south at the top (Notus), and west at the right (Zephyrus). The ecliptic (the sun's apparent orbit around the earth) crossed diagonally (from southeast to northwest), and the Aegean Sea was undoubtedly envisaged as the center.

With advances in theoretical cartography came debates about the extent of the inhabitable earth (*oikoumene*). Greek geographers doubted their ability to glean useful, let alone accurate, information about distant places. Plato (*Phaedo* 109b) speculated on the extent of the *oikoumene*. He posited that the Greeks,

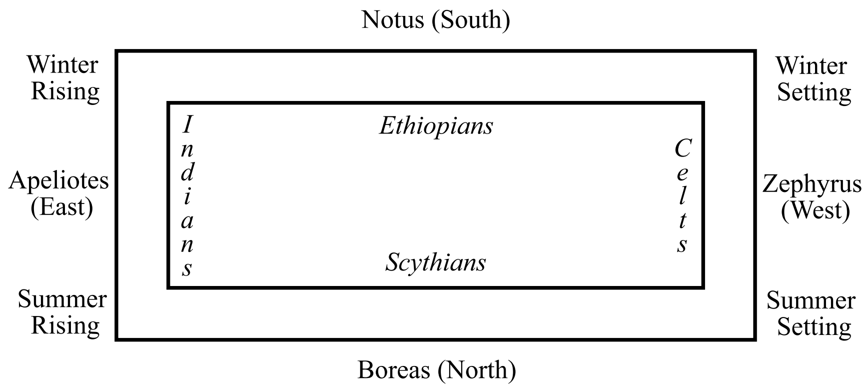

FIGURE 3.6 Ephorus's flat earth. Drawing by the author.

situated between the Phasis River (at the eastern end of the Black Sea) and the Pillars of Hercules, in fact inhabited only a small portion of the earth and were "living around the [Mediterranean] sea like ants or frogs around a marsh." He hypothesized that "many other peoples live in many other places." Aristotle, too, perceived a greatly restricted habitable range. Advancing Parmenides's division of the earth into five zones, he named the zones—equator, tropics, arctic circles—and compared each to a drum. He argued (*Meteorology* 2.5.362a.33) that the earth had two habitable zones, the one where we (Greeks) dwell, toward the upper pole, and a corresponding one toward the lower pole. The upper zone of the *oikoumene* extends from the Pillars of Hercules to India and from Ethiopia to Lake Maeotis (the Sea of Azov), a ratio exceeding 5:3. Excessive heat and cold prevent habitation, and even exploration, to the north or south; Ocean between the Pillars of Hercules and India interrupts the habitable stretch of land and "prevents it from forming a continuous belt around the globe." Aristotle's view gained currency.

Although philosophy continued to guide mapmaking initiatives, a trove of fresh empirical data was acquired during the rule of Aristotle's famous student, Alexander the Great of Macedon, as well as in the scientific "golden age" immediately following his death. Theories and mathematical models came to be correlated with a growing body of facts about the world. Alexander was passionately eager to explore the entirety of the *oikoumene* east of the Aegean, and he endeavored to extend Greek culture as far east as the Punjab. Scholars in numerous disciplines accompanied him: biologists, zoologists, physicians, historians, geographers, and surveyors. They were instructed to collect data and to produce full records of their observations. From this endeavor there survive fragments of a *periplous* of the Black Sea (and probably beyond) written by the historian Callisthenes, as well as of two accounts of Alexander's expedition to India by his admiral Nearchus and helmsman Onesicritus.[35] Eumenes of Cardia recorded daily reports of the king's travels. Baito and Diognetus, professional road surveyors, were retained to measure distances between stops, and they also made notes of local geographic features, including topography, soil, flora, and fauna (Pliny, *NH* 6.61.4). Alexander's ambitions to explore the Far East were thwarted only by his mutinous troops. Nonetheless, for centuries afterward geographers continued to draw from the information gleaned during his expedition, and these new data were soon employed to draw maps of Asia and to complete the contours of the *oikoumene*.

Alexander's contemporary Pytheas (fl. ca. 320–305) is in turn significant for extending geographic knowledge of western Europe, especially the coasts along the English Channel, and for his use of astronomical observations to compute latitudes. A navigator and astronomer from the Greek colony of Massalia (Marseilles), he explored the Ocean west of the European mainland and recorded his journey and observations in *On the Ocean*, now lost but quoted and criticized by Strabo. Pytheas's claim to have explored "in person" the entire northern region of Europe "as far as the ends of the world" met with disbelief; Strabo accused him of shameless mendacity.[36] Nonetheless, other writers used his observations. Most modern scholars agree that his journey in fact occurred, yet there is no consensus regarding its date or route or scope—perhaps reaching to islands north of Scotland, to Norway, to Jutland, or even to Iceland (fig. 3.7).

Pytheas sailed from Massalia through the Pillars of Hercules up the Iberian coast to the "Tin Islands" (Cassiterides, whose location is contested) and across to Britain; next probably the east coast to Scotland, its Northern Isles, and the island of Thule; then back east to the Baltic, where he found the source of amber on the island of Abalus. He described Britain as a triangle, and with reasonable accuracy he estimated the island's circumference at more than 40,000 *stadia*, a length considered excessive by Strabo but accepted by Eratosthenes.[37] Using a gnomon (the part of the sundial which casts the shadow), Pytheas calculated the latitudes of Massalia and other places he visited. He observed that the summer solstitial day lengthened as he ventured northward, and he may have been the first to connect latitude to the duration of a place's solstitial day. At a place 9,100 *stadia* north of Massilia (Mona, the island of Anglesey?), he observed that the winter solstice sun rose only to 6 cubits (12 degrees) and that daylight on the summer solstice lasted nineteen equinoctial hours.[38]

Describing Thule as a place where land, sea, and air lose their distinctive properties—"congealing together in substances resembling a sea-lung [probably comb jellies], upon which one can neither walk nor sail"—Pytheas observed (or theorized) that this island was the northernmost point of the British chain, where "the circle of the summer tropic is the same as the arctic circle."[39] He knew from the geometry of the sphere that there must be some point on the globe where the sun would shine for a full day at the summer solstice. He also noted that the amplitude of ocean tides depends on lunar phases, and that the celestial North Pole is marked not by a single star, Polaris, but rather by a rectangle of Polaris together with three faint stars.[40]

While there is no record that Pytheas produced a map, both his theoretical

FIGURE 3.7 Pytheas's travels. Map by the author.

approach and his assemblage of data greatly advanced the science of cartography. Pytheas creatively exploited the abstract and precise language of mathematics and astronomy together with a mass of carefully gathered empirical evidence. He extended Greek knowledge of the geography of the European northwest and, despite Strabo's scorn, laid the foundation for incorporating parallels of latitude into maps.

A contemporary of Pytheas who, in contrast, gained recognition for making a significant contribution to cartography was Dicaearchus of Messana in Sicily (fl. ca. 340–290). A polymath who studied under Aristotle at Athens, he established the foundation of a coordinate system by imposing onto the *oikoumene* an axis with a meridian (through Rhodes) and a parallel, or line of latitude (*diaphragma*), extending from the Straits of Gibraltar, through Sicily, and along the Taurus Mountains to Mount Himaeus (in the Himalayas). For this advance, he was ranked by Strabo (1.1.1) alongside Democritus, Ephorus, and Eudoxus. He described the *oikoumene* in his lost *Trip around the World* (*Periodos Ges*), which was probably accompanied by a map. Following Democritus, Dicaearchus adopted the ratio of 3:2 for the *oikoumene*'s extent (fig. 3.8). He reported distances between certain places and measured the heights of mountains, which he then compared with

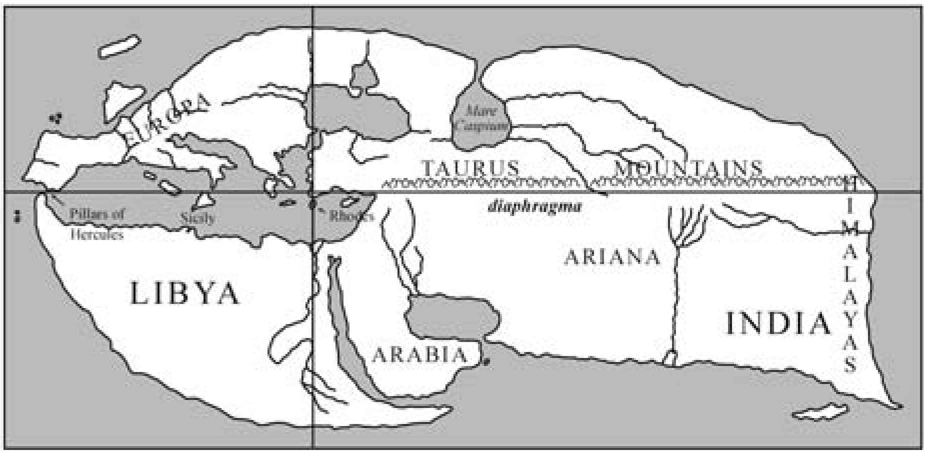

FIGURE 3.8 Dicaearchus's world map. Reconstruction by the author.

the size of the *oikoumene* to show that they did not significantly affect the earth's sphericity.[41] In addition, he correctly oriented the eastern extent of the Taurus Mountains along an east-west coordinate, instead of diverting them to the north, as had earlier Greek geographers.

The Museum at Alexandria and Its Director, Eratosthenes

Although neither maps nor texts survive intact, it is clear that after Alexander Greek cartography of the *oikoumene* changed markedly in methodology, scope, and accuracy. The "Museum" at Alexandria, a center of learning founded by Ptolemy II Philadelphus (ruled 285–246), served as the central meeting place for Greek-speaking scholars of nearly all disciplines; it was also a conduit of learning from the east. The scientific documents collected for the Museum's library proved instrumental in codifying cartographic and geographic knowledge and in fostering advances in mathematics, astronomy, and geography during the third century. It was at the Museum that Aristarchus (ca. 280–270) shockingly proposed a heliocentric model of the universe, envisioning that the earth revolved around the sun and that it was not, after all, at the center of the cosmos. Availing himself of the Museum's resources, Hipparchus (fl. ca. 140–120) detected the precession of the equinoxes, observing that the stars were indeed not "fixed" and motionless; rather, like a very slow spinning top, they made a gradual rotation about the earth's axis every twenty-five thousand years.

The polymath Eratosthenes of Cyrene directed the Museum's library for forty years (ca. 245–205) and in this position helped to advance Greek theoretical cartography to its acme (Geus 2002). In particular, his world map and his estimate of the earth's circumference were enduring. He had studied at Athens with Stoic and Academic philosophers, including a student of the mathematician Autolycus (fl. ca. 300 BCE), whose works *On Rotating Spheres* and *On Risings and Settings* focus on sphere geometry. Under such influences Eratosthenes composed his two geographic treatises, both now lost, *Geographica* and *Measurement of the Earth*, the latter explaining his process for determining the earth's circumference.

For this purpose, Eratosthenes used astral data together with a simple and elegant ratio based on the geometry of the sphere: he assumed that the earth was a perfect sphere.[42] Ascertaining that two Egyptian cities, Syene (modern Aswan) and Alexandria, lie on the same meridian (see fig. 2.1), Eratosthenes compared readings from both on the day of the summer solstice, at high noon. At Syene no shadows were cast at that moment because the sun was precisely at its zenith, but a slight shadow was cast at Alexandria, because of the curvature of the earth and Alexandria's higher longitude. Eratosthenes assumed that the sun was infinitely distant, so that its rays were parallel everywhere on the earth. He then measured the angle of the shadow cast at Alexandria as one-fiftieth of a circle (see fig. 3.9). This angle was equal to the angle subtended at the earth's center, and the length of arc between Syene and Alexandria was approximately 5,000 *stadia*. Eratosthenes multiplied the latter figure by fifty (the number of units in his circle) to find the earth's circumference: 250,000 *stadia*, in other words 39,375 km = 24,412.5 miles if we credit that he employed the Egyptian *stadion* noted above (= 157.5 m). In fact, this result is remarkably close to today's estimate of 40,076 km (24,901 miles). Eratosthenes later adjusted his figure to 252,000 *stadia* (39,690 km = 24,608 miles), a number divisible by sixty. Then, after dividing the earth's circumference into sixtieths—yielding intervals of 4,200 *stadia* each—he imposed dimensions onto Parmenides's zones of latitude: eight sixtieths (33,600 *stadia*) for the torrid zone, seven (29,400 *stadia*) for the two temperate zones, and four (16,800 *stadia*) for the frigid zones.

The theoretical and empirical advances noted in the *Measurement of the Earth* were further expanded in Eratosthenes's *Geographica*, a work in three books, known primarily through Strabo's direct citations of it and Hipparchus's criticisms. The term *Geographica* was possibly coined by Eratosthenes to imply "world cartography," reflecting the new rational, quantitative, and scientific trends in mapmaking. In this work Eratosthenes discussed the history of Greek geographic scholarship (significantly omitting Homer from his list of predecessors), and he took up the debate regarding the dimensions and shape of the *oikoumene*. He compared its shape to the short Macedonian cloak, the *chlamys*, a curving trapezoid tapering at its lower edge.[43] Assuming a spherical earth "with certain irregularities of surface" (Strabo 1.3.3), he placed the *oikoumene* entirely north of the equator, between the Cinnamon country in the south and Thule in the north (a span of 37,600 *stadia*), the Pillars of Hercules in the west, and the Taurus Mountains in the east (a span of 76,000 *stadia*). The ratio is nearly 2:1. He expressed latitudes with regard to distances north of the main parallels—the equator ("Cinnamon country"), and then those marked by four important cities (south to north): Meroe (in modern

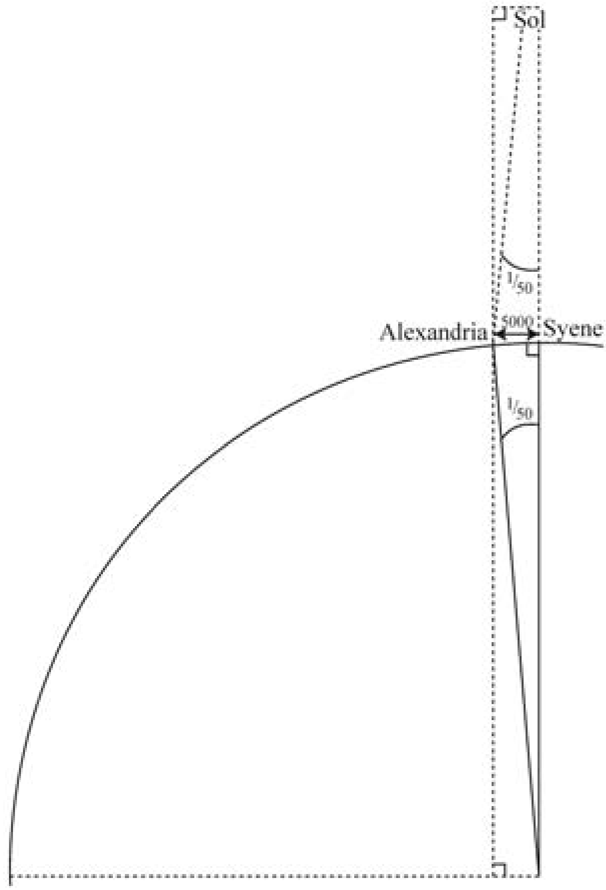

FIGURE 3.9 Eratosthenes's calculation of the circumference of the earth. Drawing by the author.

Sudan), Syene, Alexandria, and Rhodes. His meridians may have included Europe's western capes, the Pillars of Hercules, Straits of Messana/Carthage, Rhodes/Alexandria, Issus, Caspian Gates/Persian Gulf, and the Indus River.[44] The result is a rough coordinate system.

In the third book of his *Geographica*, Eratosthenes guided readers in envisaging a map of the *oikoumene* (fig. 3.10). Building on Dicaearchus's *diaphragma* and rejecting a division of landmasses only by bodies of water, he split the *oikoumene* into two equal halves, with a parallel from the Pillars of Hercules to the easternmost limit of the Taurus Mountains; hence, Dicaearchus's symmetrical axis was reinforced (Strabo 2.1.1). Eratosthenes then subdivided his northern and southern halves into "seals," or *sphragides*, irregular quadrilateral shapes resembling document seals. Thus, India was rhomboidal, bounded by oceans on two sides, by the Taurus Mountains to the north and the Indus River to the west; Ariana was a parallelogram delimited by the Caspian Sea, the capes of Carmania (in southern

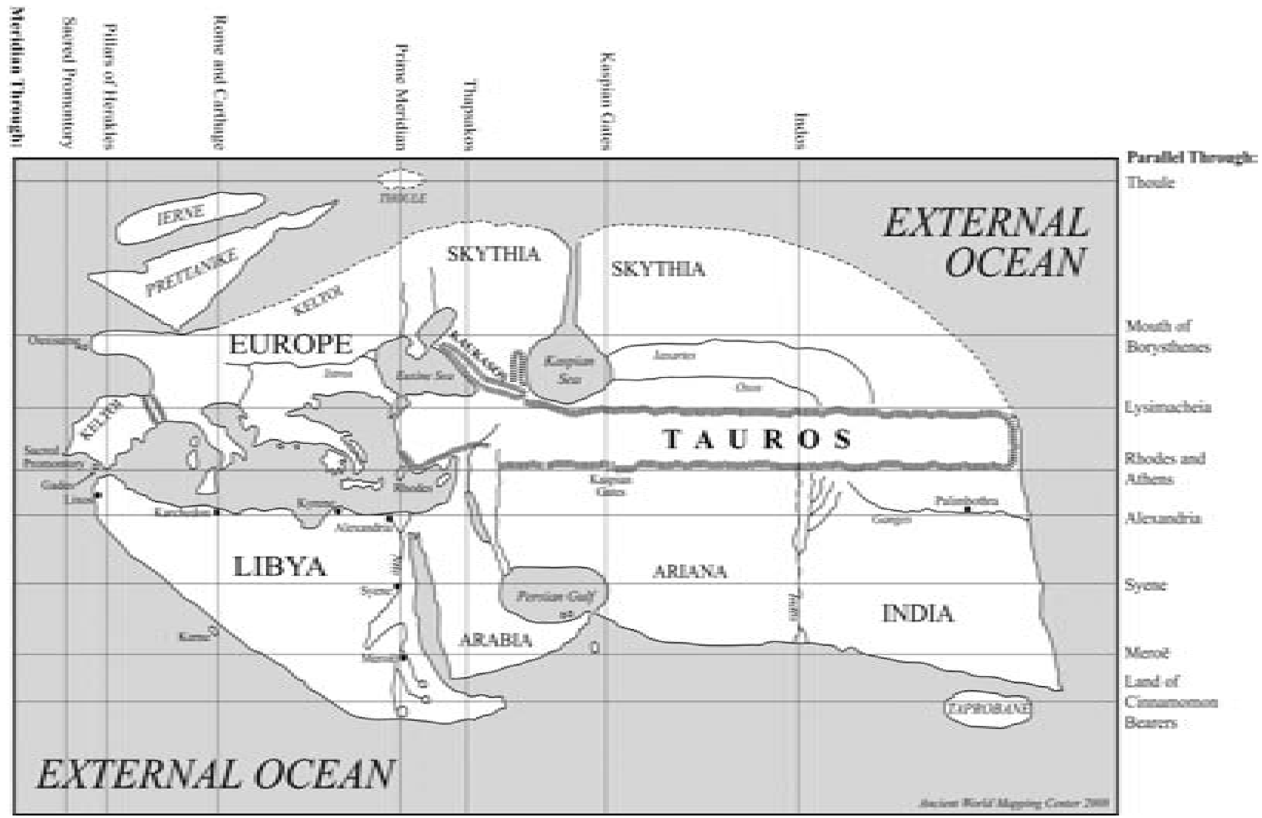

FIGURE 3.10 Eratosthenes's world map. Reconstruction reproduced from Duane W. Roller, *Eratosthenes' Geography.* Princeton University Press. Reprinted by permission of Princeton University Press.

Iran), and the Persian Gulf.[45] Eratosthenes divided his northwest region, Europe, on the basis of three promontories projecting into the Mediterranean: the Peloponnese, Italy, and the Ligurian "promontory" of Corsica and Sardinia. Even though his excessive generalizations were later subjected to harsh criticism by Hipparchus (see below) and Strabo, his *sphragides* still represent a concerted effort to compartmentalize, categorize, and impose order on the *oikoumene*. It is not certain whether he drew a map to accompany his text, although Strabo (2.1.2) implies that he did. Nonetheless, his theories regarding the shape and deployment of the *oikoumene* provided the standard paradigm of both textual and pictorial maps well into the Roman period, a trend which culminated in Ptolemy's *Geography* (see chap. 4 below).

Hipparchus

Hipparchus (fl. ca. 140–120) was primarily an astronomer and mathematician with a strictly theoretical and mathematical interest in geography. He was deeply critical of Eratosthenes's regard for descriptive geography and of the inconsistencies in his measurements.[46] In fact, it may have been Eratosthenes's sloppy arithmetic that provoked Hipparchus to write his treatise bluntly entitled *Against the "Geographica" of Eratosthenes*, now lost except for sparse quotations by Strabo. After double-checking Eratosthenes's distances between places and discovering incongruities and arithmetical impossibilities—the numbers simply do not add up—Hipparchus next examined Eratosthenes's geographic hypotheses and postulates, and then criticized his methods, in particular reliance upon ambiguous and generalized evidence and use of theory without any factual basis.[47] Even though Eratosthenes's method of estimating the earth's circumference and the resulting value met with approval, Hipparchus asserted that contemporary geographic practices were sorely inadequate for making a new world map. In Hipparchus's view, geography must be advanced on strictly mathematical and astronomical grounds, and the arbitrary distances reported by merchants and travelers who lacked rigorous mathematical training were useless (Strabo 1.1.12).

Hipparchus connected terrestrial locations to celestial phenomena, demonstrating that it was possible to develop a mathematically robust system of real map projections on grids of parallels and meridians, with some points fixed by the stars. Solar and stellar observations give estimates of latitude with reasonable accuracy, as Pytheas had shown, and simultaneous eclipse observations could yield similarly reliable longitudes, provided that such observations were communicated and correlated. Even so, the data for longitudes remained inadequate or nonexistent. Hipparchus made it easy for the layman to find latitudes, however, by including astronomical tables in his third book; these tables recorded data calculated for several of the parallels between the equator and North Pole.[48] With knowledge of the earth's circumference, and an understanding of spherical geometry, one could estimate the circumference of any terrestrial parallel or meridian, a system of coordinates could be established, and distances could be calculated trigonometrically.[49]

Hipparchus rejected many of Eratosthenes's distances on methodological grounds, but he failed to take into account the increase in geographic knowledge resulting from Alexander's conquests. He especially criticized Eratosthenes for distorting the eastern portion of the *oikoumene*, accusing him of placing India too far south, for example.[50] Instead, Hipparchus erroneously adhered to the old Ionian map paradigm for the Far East, but he was right in correcting Eratosthenes on several points regarding the topography of the western Mediterranean.[51] Among Hipparchus's enduring contributions to Greek cartography was his call for a scientific and mathematical approach based on trigonometrical determinations of latitude and longitude. His own idealized and theoretical approach might have proven more productive in the early years of the Museum at Alexandria if only geographic theory and data had advanced sufficiently by the early third century. Changing political conditions, however (including the advance of Rome), prevented long-term scientific research. Furthermore, the educated elite strongly favored descriptive and political geography, to the exclusion of mathematically informed studies.

Conclusion

Maps are an important expression of Greek culture. In their shape and deployment are embedded social, cultural, and political prejudices: the superiority of Greek over non-Greek, of one city-state over a rival. Cartographic data were derived from political, commercial, and military sources, and successive advances came in the wake of increased interaction with other peoples in the Mediterranean and beyond. The flat-earth theory and Anaximander's column drum map were abandoned for a spherical earth organized into zones of latitude as set by Parmenides and advanced by Aristotle and Eratosthenes. Anaximander's vision of a circular and tripartite landmass grew into a complex conception of lands arranged and ordered by a scientifically informed system of coordinates, as found in Pytheas, Eratosthenes, Hipparchus, and, later, Ptolemy. The philosophy of symmetry was never entirely abandoned. Descriptive maps were included in a wide variety of writings. Maps were never primarily intended just to show precise spatial relationships between places. Early Greek maps, in particular, had no practical application, but they stimulated the imagination and enriched Greek ideas about humans' relationship to the natural world; they also reflected the Greek zest for adventure and exploration. Ultimately these maps and their successors served to impose order and reason upon the physical landscape.

NOTES

1. Known from Diogenes Laertius, *Lives of the Philosophers* 5.51.

2. Newmeyer (1983); Romm (1992), 64–68.

3. Herodotus 4.44; Panchenko (1998, 2003). Scylax of Caryanda (fl. ca. 510–500), a Greek commissioned by the Persian Great King Darius I (522–486) to explore the Indus river basin, "proved" that Asia, like "Libya" (Africa), was almost completely circumnavigable.

4. Interpretation of a coin reverse from Ionia (ca. 335) as a topographic map of the hinterland of Ephesus fails to convince: see Johnston (1967); Dilke (1988), 92; Brodersen (2001), 10. Equally, both the authenticity and the scope of an unfinished map (perhaps of Spain) associated with a fragment of the *Geographoumena* of Artemidorus of Ephesus (ca. 100) are matters of ongoing debate: see now Brodersen and Elsner (2009), esp. 63–71. The "Soleto map" of Italy's Sallentine Peninsula in the fifth century is surely a hoax: see Yntema (2006).

5. At Thoricus in southeast Attica there survives on the rock face immediately above the entrance to silver mine 3 (fourth century) a petroglyph which appears to be a plan of the mine corresponding to the 120 m section thus far excavated: see Mussche (1978), 44, 48, fig. 53.

6. See Jacob (1998), 30–36; Dueck (2005).

7. Harley and Woodward (1987), 106.

8. Pliny, *Natural History* 6.61.4.

9. See the maps in Willcock (1976), 24, 28, 36.

10. *Odyssey* 10.506–15; the translation of this passage, and those below, is by Lattimore (1965).

11. See Hexter (1993), 147. Homer's view fails to explain seasonal changes in the length of daylight.

12. Severin (1987), 235–45, concludes that Homer neither thought in cartographic terms nor even had maps.

13. Neugebauer (1963), 529–30, 533.

14. Strabo 1.1.11; Hahn (2001), 202–3.

15. Kirk, Raven, and Schofield (1983), 104; Harley and Woodward (1987), 134.

16. Couprie, Hahn, and Naddaf (2003), 32, 49.

17. Diogenes Laertius, *Lives of the Philosophers* 2.1–2; Agathemerus 1.1 (for him, and other Greek scientists discussed in this chapter, see further Keyser and Irby-Massie 2008, s.v.).

18. Couprie, Hahn, and Naddaf (2003), 49.

19. For an overview of the debate about Anaximander's map and its features, see Couprie, Hahn, and Naddaf (2003), 194–201.

20. Hippolytus, *Refutation of all Heresies* 1.6.4–5; Aetius 2.20.1, 2.21.1; O'Brien (1967), 425–26.

21. Couprie, Hahn, and Naddaf (2003), 82–83. Full-scale architectural plans (made around 250 BCE) appear to be etched into the walls of the temple of Apollo at Didyma, south of Miletus: see Haselberger (1985), 129.

22. Agathemerus 1.1, 2.461; cf. Strabo 1.1.1.

23. Couprie, Hahn, and Naddaf (2003), 33.

24. No doubt the map marked the route of the Persian Royal Road, which Herodotus (5.52–54) proceeded to describe in some detail, stating the short distances between staging posts in both Persian *parasangs* and Greek *stadia*; see Silverstein (2007), 9–15.

25. See further Dewald and Marincola 2006.

26. Diogenes Laertius, *Lives of the Philosophers* 9.46, where the title given, *Kosmographie*, emphasizes the orderly arrangement of the universe and the earth.

27. Pseudo-Plutarch, *Epitome* 3.10.4–5, 3.12.1–2; Taylor (1999), 100–2.

28. Strabo 1.1; Agathemerus 1.2 and 12; Dilke (1985), 25, 29.

29. Aristotle, *On the Sky* 285b25–27, 293b25–30.

30. Plato, *Timaeus* 31b4–34b9; Dicks (1970), 72–73; Dilke (1985), 25.

31. Strabo 2.2.1–2; Plutarch, *On the Opinions of the Philosophers* 2.12, 3.14 attributes the division to Pythagoras.

32. *On the Sky* 297a8–298a20.

33. *Introduction to Phaenomena* 16.4.5.

34. Barber (1935), 26–29, 175–76.

35. Pearson (1960), 22–49, 83–114; Pédech (1984), 15–158.

36. Strabo 2.4.1–2. For translation and discussion of the fragments of Pytheas, note Roseman (1994); Bianchetti (1998); Roller (2006), chap. 4.

37. Strabo 1.4.3; 2.4.1–2.

38. Strabo 2.1.18; he assumes that the measurement was taken on or near the same parallel as the Bactrians near the Caucasus.

39. Strabo 2.4.1, 2.5.8 and 43.

40. Hipparchus, *Commentary on the Phaenomena of Aratus and Eudoxus* 1.4.1; Dicks (1960), 171.

41. Strabo 2.4.2. Dicaearchus's estimate of the earth's circumference, derived from data reported by Cleomedes 1.8, adds up to 300,000 *stadia*: see Keyser 2001.

42. Cleomedes 1.10.3–4; Dutka (1993–94), 60–64; Irby-Massie and Keyser (2002), 120–21.

43. Strabo 2.5.6; Dueck (2005), 28, 45–46.

44. Strabo 2.5.16; Cimino (1982); Geus (2004), 19.

45. Geus (2004), 21; Strabo 2.1.21–24.

46. Eratosthenes himself was aware that his measurements were approximations at best: Strabo 2.77–78, 80–82, 86, 89, 91–92. Strabo, in turn, who had little tolerance for mathematics, considered Hipparchus's criticisms unfair and unreasonable: cf. 3.131–32.

47. Dicks (1960), 32, 114–21.

48. Strabo 1.4.1, 2.5.34, 3.131–32; Duke (2001–2).

49. Strabo 1.4.6. To determine the circumference of any parallel or meridian of a sphere, one must first determine the radius at a given latitude and longitude, by multiplying the cosine of the latitude angle by the radius at the equator (for Eratosthenes's earth: 40,127 *stadia*). Then, the circumference at that latitude is 2π times the latitude radius. Although the Greeks lacked sines and cosines, a table of chords prepared by Hipparchus served the same function (Theon, *Commentary on Ptolemy's Syntaxis* 1.10).

50. Strabo 2.1.34, 2.1.27.

51. Dicks (1960), 35; Strabo 2.92, on promontories in the Peloponnese, Italy, and Liguria.