10 · Greek Cartography in the Early Roman World

Prepared by the Editors from Materials Supplied by Germaine Aujac

The Roman republic offers a good case for continuing to treat the Greek contribution to mapping as a separate strand in the history of classical cartography. While there was a considerable blending—and interdependence—of Greek and Roman concepts and skills, the fundamental distinction between the often theoretical nature of the Greek contribution and the increasingly practical uses for maps devised by the Romans forms a familiar but satisfactory division for their respective cartographic influences. Certainly the political expansion of Rome, whose domination was rapidly extending over the Mediterranean, did not lead to an eclipse of Greek influence. It is true that after the death of Ptolemy III Euergetes in 221 B.C. a decline in the cultural supremacy of Alexandria set in. Intellectual life moved to more energetic centers such as Pergamum, Rhodes, and above all Rome, but this promoted the diffusion and development of Greek knowledge about maps rather than its extinction. Indeed, we can see how the conditions of Roman expansion positively favored the growth and applications of cartography in both a theoretical and a practical sense. Not only had the known world been extended considerably through the Roman conquests—so that new empirical knowledge had to be adjusted to existing theories and maps—but Roman society offered a new educational market for the cartographic knowledge codified by the Greeks. Many influential Romans both in the republic and in the early empire, from emperors downward, were enthusiastic Philhellenes and were patrons of Greek philosophers and scholars. In the middle of the second century B.C. the Scipionic circle, a group of prominent Philhellenes, promoted the study of all things Greek; and when in 146 B.C. military rivalry from Carthage and Greece was eliminated, Rome wielded the political power, but Greece provided the chief intellectual output within, and often on behalf of, Roman dominions. Throughout the second and first centuries B.C. and beyond, it was thus men of Greek birth and education—such as Polybius, Crates of Mallos, Hipparchus, and Strabo—who continued to make fundamental contributions to the development of scientific mapping and who provided a continuous link with these activities in the Hellenistic world and their culmination in the later syntheses of Claudius Ptolemy.

Continuity and Change in Theoretical Cartography: Polybius, Crates, and Hipparchus

The extent to which a new generation of scholars in the second century B.C. was familiar with the texts, maps, and globes of the Hellenistic period is a clear pointer to an uninterrupted continuity of cartographic knowledge. Such knowledge, relating to both terrestrial and celestial mapping, had been transmitted through a succession of well-defined master-pupil relationships, and the preservation of texts and three-dimensional models had been aided by the growth of libraries. Yet this evidence should not be interpreted to suggest that the Greek contribution to cartography in the early Roman world was merely a passive recital of the substance of earlier advances. On the contrary, a principal characteristic of the new age was the extent to which it was openly critical of earlier attempts at mapping. The main texts, whether surviving or whether lost and known only through later writers, were strongly revisionist in their line of argument, so that the historian of cartography has to isolate the substantial challenge to earlier theories and frequently their reformulation in new maps.

In relation to the geography of Europe, the cartographic material in the *History* of Polybius (ca. 200 to post 118 B.C.) provides a first illustration of this tendency. Born at Megalopolis in the Peloponnese, Polybius had been active in the political and military life of Greece. Taken to Rome as a hostage in 168 B.C., he also demonstrates by his career the importance of Roman patronage in the continuation and spread of Greek cartography, for he attracted the attention of L. Aemilius Paullus and became a close friend of Scipio Aemilianus, who, besides giving him access to public records, took Polybius with him on some of his campaigns to Spain and to North Africa.

Polybius composed a *History* in forty books (of which the first five books are extant and the remainder are known through Strabo and other sources) describing the prodigious rise of Rome in the fifty years between the Second Punic War and the battle of Pydna (218–168

B.C.).[1] Conscious of the importance of a close critical knowledge of the countries in which historical events took place, Polybius devoted part of his work to a geographical description of Europe. Strabo tells us that "Polybius, in his account of the geography of Europe, says he passes over the ancient geographers but examines the men who criticise them, namely, Dicaearchus, and Eratosthenes, who has written the most recent treatise on Geography; and Pytheas, by whom many have been misled."[2] Strabo then gives us an example of such criticism, citing Dicaearchus's distances along the *diaphragma* (p. 152 above), and Polybius's use of geometric arguments to prove them erroneous. Dicaearchus, according to Polybius, had estimated the distance between the Straits of Messina and the Straits of Gibraltar at 7,000 stades. This line can be considered the base of an obtuse-angled triangle with Narbo (Narbonne) as its apex (fig. 10.1). Polybius argued that one side of the obtuse angle, from the Straits of Messina to Narbo, measured more than 11,200 stades, the other a little less than 8,000. Since the perpendicular dropped from Narbo to the base is 2,000 stades, "it is clear from the principles of elementary geometry that the length of the coast-line from the Strait [of Messina] to the Pillars [via Narbo; totals 19,200 stades] exceeds the length of the straight line through the open sea by very nearly five hundred stadia."[3] Thus the distance from the Straits of Messina to the Straits of Gibraltar along the *diaphragma* is at least 18,700 stades instead of the 7,000 given by Dicaearchus.[4] This brief example clearly shows the part geometric reasoning played in Polybius's assessment of the map drawn by Dicaearchus.

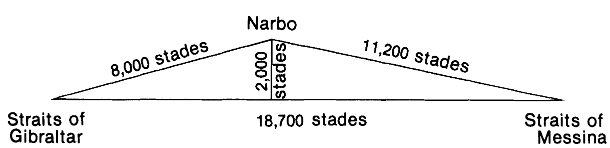

FIG. 10.1. POLYBIUS'S ESTIMATE OF THE LENGTH OF THE WESTERN MEDITERRANEAN. Whereas Dicaearchus stated a distance of 7,000 stades from the Straits of Gibraltar to the Straits of Messina, Polybius used basic geometry to show that it was, in fact, at least 18,700 stades.

As for Europe in general, Polybius likewise severely criticized Eratosthenes' map, saying he was ignorant of the western parts of the world and quoting his own experience in Spain and North Africa. Above all, he criticized him for having trusted Pytheas and having put the boundary of the inhabited world as far north as Thule. Polybius refused to believe that inhabited places could exist at these high latitudes and therefore would not extend the map of the inhabited world to the Arctic Circle. So he cut off the northern edge of Eratosthenes' map and put the northern limit of the inhabited world at the parallel of Ierne (Ireland) (54°N), situated under the arctic circle containing the stars always visible from mainland Greece and Rhodes (36°N).[5]

These criticisms by Polybius show the impact of Eratosthenes' work and methods on the subsequent development of cartography and mapping. In particular, the rigorous application of geometry had come to be considered essential for drawing maps to scale. Polybius had applied these principles to Eratosthenes' map and measurements when he undertook his description of Europe and, as a result, probably drew a new map, with reduced latitudinal extent.

The continuing influence of Greek cartography, as reinterpreted by Greeks, within the new framework of Roman society is also shown by references to the famous terrestrial globe of Crates of Mallos (fl. 150 B.C.), known to us through Strabo.[6] Although born at Mallos in Cilicia, Crates spent most of his life in Pergamum, as head of the newly established library, one of the institutions to challenge the supremacy of Alexandria. He was in

1. Polybius also took up Eratosthenes' idea that the regions near the equator had a more temperate climate than the ones near the tropics. Writing a book called *The Inhabited World below the Equator*, known to us through Geminus, *Introduction to Phenomena*, Polybius applied the tenets of spherical geometry to this problem; see Geminus, *Introduction aux phénomènes*, ed. and trans. Germaine Aujac (Paris: Belles Lettres, 1975), 16.32. The main argument in favor of Eratosthenes' hypothesis is that the sun, around the time of the solstices, lingers for a long while over the tropics, burning the country, but at the equinoxes it passes quickly over the equator. The basis for this interpretation is that in its annual apparent motion along the ecliptic, the sun, though moving at constant speed, appears to us to be almost motionless as it approaches and recedes from a tropic (the days, longer than those at the equator, are almost the same length for forty days). These conclusions are likely to have been illustrated by diagrams. For a general work on Polybius, see Frank William Walbank, *A Historical Commentary on Polybius*, 3 vols. (Oxford: Clarendon Press, 1957–79).

2. Strabo *Geography* 2.4.1; see *The Geography of Strabo*, 8 vols., trans. Horace Leonard Jones, Loeb Classical Library (Cambridge: Harvard University Press; London: William Heinemann, 1917–32). Also see Strabo, *Géographie*, ed. François Lasserre, Germaine Aujac, et al. (Paris: Belles Lettres, 1966–).

3. Strabo *Geography* 2.4.2 (note 2). See also Walbank, *Polybius*, 1:371 (note 1).

4. The actual distance between the Straits of Messina and the Straits of Gibraltar is about 1,200 miles (1,930 kilometers).

5. The arctic circle for a given terrestrial latitude is the celestial parallel circle that includes all the ever-visible circumpolar stars for that latitude. It is as distant from the celestial pole as the terrestrial parallel of latitude is from the equator.

6. Although the globe is not extant, it can be reconstructed from literary sources. References to Crates in Strabo's *Geography* (note 2) include: 1.1.7; 1.2.24; 1.2.31; 2.5.10 (globe); 3.4.4; 13.55 (date); 14.16 (birthplace). For fragments of Crates, see Hans Joachim Mette, *Sphairopoiia: Untersuchungen zur Kosmologie des Krates von Pergamon* (Munich: Beck, 1936), and the discussion in J. Oliver Thomson, *History of Ancient Geography* (Cambridge: Cambridge University Press, 1948; reprinted New York: Biblo and Tannen, 1965), 202.

Rome about 168 B.C. when Polybius was brought there as a hostage. Crates was detained in Rome because he broke his leg while inspecting a sewer (Cloaca Maxima), and during this stay he delivered a series of influential lectures. A Stoic philosopher and a well-known scholar, he was much admired in Rome for his erudition and eloquence.

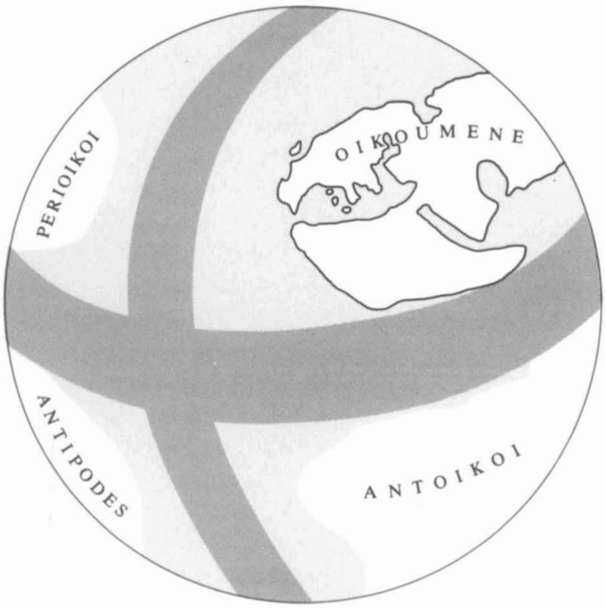

FIG. 10.2. RECONSTRUCTION OF THE GLOBE OF CRATES OF MALLOS, CA. 150 B.C. After Edward Luther Stevenson, *Terrestrial and Celestial Globes: Their History and Construction, Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy*, 2 vols., Publications of the Hispanic Society of America, no. 86 (New Haven: Yale University Press, 1921; reprinted New York and London: Johnson Reprint Corporation, 1971), vol. 1, fig. 5.

His fame in the history of cartography rests largely on his construction of a large terrestrial globe, at least ten feet in diameter,[7] to illustrate his own interpretation of Ulysses' wanderings. The motive for his cartography was thus partly literary and historical rather than purely scientific. As a Stoic, Crates proclaimed Homer the founder of geography, crediting him with belief in a spherical earth and commenting on his poems accordingly. To explain Homer's line, "The Ethiopians who dwell sundered in twain, the farthermost of men,"[8] Crates argued that on each side of an equatorial ocean there lived the Ethiopians, divided by the ocean, one group in the Northern Hemisphere, the other group in the Southern, without any interchange between them (fig. 10.2). Strabo thus reports:

> Crates, following the mere form of mathematical demonstration, says that the torrid zone is "occupied" by Oceanus, and that on both sides of this zone are the temperate zones, the one being on our side, while the other is on the opposite side of it. Now, just as these Ethiopians on our side of Oceanus, who face the south throughout the whole length of the inhabited world, are called the most remote of the one group of peoples, since they dwell on the shores of Oceanus, so too, Crates thinks, we must conceive that on the other side of Oceanus also there are Ethiopians, the most remote of the other group of peoples in the temperate zone, since they dwell on the shores of this same Oceanus.[9]

The scientific thinking behind the geography on Crates' globe was derived directly from the teaching of Eratosthenes about the relative size of the known world. By combining the geometric approach of his predecessor with his own interpretation of Homer, he represented four inhabited worlds on the surface of his terrestrial globe. Two were in the Northern Hemisphere—the one where the Greeks lived, occupying far less than half of the Northern Hemisphere, and another symmetrically situated in the other half. Two other inhabited worlds are found in the Southern Hemisphere, symmetrical with the two north of the equator. These four worlds were separated by oceans along the equator (occupying the torrid zone made uninhabitable by heat) and along a meridian. The inhabited areas were thus islands, with no communication between them.

It is clear that this conception of four symmetrical land areas was a direct consequence of the geometry of the sphere and of the size Eratosthenes attributed to the inhabited world in relation to the total globe. Crates demonstrated this by drawing the four areas on the surface of his globe and suggesting that the three unknown lands could be similar to the known one. To give it

Crates was supposed to have displayed this globe in Pergamum about 150 B.C. See Edward Luther Stevenson, *Terrestrial and Celestial Globes: Their History and Construction, Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy*, 2 vols., Publications of the Hispanic Society of America, no. 86 (New Haven: Yale University Press, 1921; reprinted New York and London: Johnson Reprint Corporation, 1971), 1:7–8; Carl Wachsmuth, *De Crate Mallota* (Leipzig, 1860); Hugo Berger, "Entwicklung der Geographie der Erdkugel bei den Hellenen," *Die Grenzboten: Zeitschrift für Politik, Literatur und Kunst* 39.4 (1880): 403–17, esp. 408 ff.; Karl Müllenhoff, *Deutsche Altertumskunde*, 5 vols. (Berlin: Weidmann, 1890–1920), 1:248.

7. While Strabo, *Geography* 2.5.10 (note 2), clearly had Crates in mind when discussing the construction of a ten-foot globe, he does not claim that Crates' globe was this size. See Thomson, *History of Ancient Geography*, 202–3 (note 6).

8. Homer *Odyssey* 1.23; see *The Odyssey*, 2 vols., trans. A. T. Murray, Loeb Classical Library (Cambridge: Harvard University Press; London: William Heinemann, 1919–31).

9. Strabo *Geography* 1.2.24 (note 2), translation adapted from H. L. Jones edition.

further credibility, he also drew in the main parallel circles, emphasizing those defining the zones: these were the tropics (at 24° distance from the equator), between which flowed the Ocean as envisaged by Homer, and the two polar circles (at 66° distance from the equator).

Crates' globe was thus a product of theoretical mathematical cartography, communicating an image of the world that was very far from reality. Our understanding of its physical characteristics is meager, and there is no evidence to suggest how or of what material it was made, but its influence on the history of cartographic thought has been considerable. It was widely admired, and the probability of the four inhabited worlds was generally admitted. As we shall see in a later chapter, the concept of the equatorial ocean was transmitted to medieval Europe through Macrobius's commentary on Cicero's *Dream of Scipio*. Scholars of later times also vied eagerly to give adequate names to these unknown worlds, but on the whole they did not doubt their existence.[10] Everyone, at least in the educated class, was used to the idea that the Antipodes flourished in the other temperate zone. Later on, coins were struck in Rome representing the quadripartite globe crossed by two perpendicular bars as an imperial symbol, as shown in figure 10.3.[11]

FIG. 10.3. COIN OF LUCIUS AEMILIUS BUCA, 44 B.C. The obverse design on this coin minted by a Roman patrician is derived from the globe of Crates, the crossed lines representing the oceans.
Diameter of the original: 3.7 cm. Photograph from the Bibliothèque Nationale, Paris (A 12355).

The writings of Polybius and Crates, even though the former is known to us largely and the latter wholly at second hand, can thus be used to monitor a process of change by which Greek cartography under the patronage of Rome had been challenged and its Hellenistic foundations modified. In the second century B.C., however, it is the work of their contemporary Hipparchus (ca. 190 to post 126 B.C.) that most clearly demonstrates both an indebtedness to the earlier legacy and an ability to reform it through rigorous scientific observation and deduction. To Ptolemy, Hipparchus was "that enthusiastic worker and lover of truth."[12] Modern historians of science have recognized his major contributions to the development of astronomy, resulting in his catalog of star positions, his writings on mathematical geography establishing the division of the circumference into 360 degrees (the basis also for his instruments), and his use of tables of astronomically observed latitudes to determine positions on the terrestrial globe.[13]

Hipparchus was born in Nicaea (Iznik) in Bithynia, but he spent most of his life in Rhodes, where he is known to have made astronomical observations from 161 to 126 B.C. As an astronomer, Hipparchus was particularly interested in celestial cartography, and it is to this subject that his only surviving work, the *Commentary on Eudoxus's and Aratus's Phaenomena*,[14] relates. It dealt with the celestial sphere, which had been carefully described by Eudoxus and then popularized through Aratus's poem (see above, pp. 141–42). Hipparchus aimed to correct errors committed by Eudoxus, repeated by Aratus, and thereafter commonly adopted by educated people. His revision was designed to prevent students of astronomy from being led astray by the magic of poetry. So Hipparchus went through the whole poem systematically correcting mistakes and thus revising the globe it represented.

First of all, he criticized Eudoxus for having located the celestial pole at the wrong place, marked by a star,

10. See Stevenson, *Terrestrial and Celestial Globes*, 1:13 n. 26 (note 6).

11. L. Buca's coin (44 B.C.), showing a globe divided into four parts by crossed oceans, similar to Crates' globe.

12. Ptolemy *Almagest* 3.1, 9.2; see *Ptolemy's Almagest*, trans. G. J. Toomer (London: Duckworth, 1984). "Lover of truth" was Ptolemy's most frequent epithet for Hipparchus; G. J. Toomer, "Hipparchus," in *Dictionary of Scientific Biography*, 16 vols., ed. Charles Coulston Gillispie (New York: Charles Scribner's Sons, 1970–80), 15:220.

13. Only Hipparchus's commentary on Aratus survives. Nevertheless, Hipparchus's work is known to have exerted a profound influence in the history of astronomy: Toomer, "Hipparchus," 220 (note 12), concludes that Hipparchus's "main contributions were to develop mathematical methods enabling one to use the geometrical models for practical prediction, and to assign numerical parameters to the models." This is seen in Hipparchus's discovery of the precession of the equinoxes, his star catalog, his theory of the sun and moon, and his mathematical geography. The contributions of Hipparchus are placed in their context as predecessors to Ptolemy's *Almagest* (from which we have gained much of our knowledge of Hipparchus) by Otto Neugebauer, *A History of Ancient Mathematical Astronomy* (New York: Springer-Verlag, 1975), 274–343.

14. Hipparchus, *In Arati et Eudoxi Phaenomena Commentariorum libri tres*, ed. C. Manitius (Leipzig: Teubner, 1894). See also *The Geographical Fragments of Hipparchus*, ed. D. R. Dicks (London: Athlone Press, 1960).

for it was well known that there was no star at the celestial pole, as Pytheas had correctly noted: the pole was a point in the sky, close to three stars with which it completed a rectangle.[15] A second criticism related to Eudoxus's failure to have observed the general principle regularly used in drawing constellations: "All constellations should be drawn from the observer's point of view, as if they were facing us, unless they are in profile."[16] This rule was a basic one, since in Greece stars were distinguished only by the place they occupied on the figure representing the constellation. For instance, the star we call α Orionis or Betelgeuse was indicated as "the star on the right shoulder of Orion," and our β Orionis or Rigel was called "the star on the left foot of Orion." If Orion was drawn facing the wrong way, the image of the constellation would also be reversed. Thus when Eudoxus, and Aratus after him, declared that the throat and right temple of the Dragon were in line with the Bear's tail,[17] Hipparchus corrected them, saying that the left (not the right) temple of the Dragon was in line with the stars in question. He rejected indignantly the explanation of one of Aratus's commentators who had supposed the head of the Dragon to be turned toward the outside, instead of toward the inside, of the universe.[18] So Hipparchus was emphatic: the figures representing the constellations, when drawn on a solid globe, had to be represented in rear view, looking inward; when drawn on a flat map, they had to be represented in front view, looking at the map reader.

In addition to enunciating these principles, Hipparchus determined a precise location on the globe for most of the stars. Thus, when discussing the couplet in Aratus's poem in which the head of the Dragon is described as brushing the horizon,[19] Hipparchus declared that the star at the extremity of its mouth (μ Draconis) was 34⅗° distant from the pole, its southern eye (β Draconis) 35° from it, and its southern temple (γ Draconis) 37°. Thus, anyone in Athens (latitude 37°N) could observe the head of the Dragon turning around entirely inside the ever-visible portion of the sphere, with only the left temple on the ever-visible circle.[20] This example confirms not only that the outlines of the various constellations were drawn on Hipparchus's sphere, but also that the stars thus located were marked as precisely as possible.

The latitudinal position of a star was indicated, in Hipparchus's *Commentary*, by its distance from the pole. For the longitude, its position was noted in relation to the signs of the zodiac, that is, by the degree of the zodiacal sign that is on the same meridian circle as the star, or what is sometimes defined as the polar longitude.[21]

At the end of his *Commentary*, Hipparchus enumerated the main stars situated on twenty-four semicircles constructed from these principles, going from one pole to the other, each separated from the next by a distance of one equinoctial hour.[22] The first is the semicircle going through the summer solstitial point, on which one can see the star at the extreme end of the Dog's tail (η Canis Majoris).[23] Each subsequent interval of one equinoctial hour was equivalent to fifteen degrees of longitude. It is very likely that these twenty-four semicircles, together with a corresponding number of parallel circles, were drawn on Hipparchus's sphere as a graticule. They made it easier for a globe maker to mark in the stars and for the student to find the position of each star. The celestial globe had become a scientific tool that could be used to calculate the time at night or to find how long an eclipse of the moon lasted.[24]

Following these procedures, it is known that Hipparchus produced a catalog listing at least 850 stars.[25] This catalog was certainly illustrated by stellar globes of various kinds, both artistically drawn and scientifically accurate. It is also quite possible, at least for portions of

15. Hipparchus *In Arati et Eudoxi Phaenomena* 1.4.1 (note 14).

16. Hipparchus *In Arati et Eudoxi Phaenomena* 1.4.5 (note 14), translation by O. A. W. Dilke.

17. Aratus *Phaenomena* 59–60, in *Callimachus: Hymns and Epigrams; Lycophron; Aratus*, trans. A. W. Mair and G. R. Mair, Loeb Classical Library (Cambridge: Harvard University Press; London: William Heinemann, 1955). Also see Aratus, *Phaenomena*, ed. Jean Martin, Biblioteca di Studi Superiori: Filologia Greca 25 (Florence: Nuova Italia, 1956).

18. Hipparchus *In Arati et Eudoxi Phaenomena* 1.4.5 (note 14).

19. Aratus *Phaenomena* 60–62 (note 17).

20. Hipparchus *In Arati et Eudoxi Phaenomena* 1.4.8 (note 14).

21. Neugebauer, *History of Ancient Mathematical Astronomy*, 277–80 (note 13). In astronomy, a zodiacal sign is either one of the twelve constellations on the zodiac or a segment of the ecliptic circle, thirty degrees in length, named after the corresponding constellation. Here the second meaning is used.

22. An equinoctial hour is the twenty-fourth part of one day. The ancients in ordinary life used "temporary" or "unequal" hours, each hour being the twelfth part of the daytime; these varied according to the season.

23. Hipparchus *In Arati et Eudoxi Phaenomena* 3.5.2 (note 14).

24. Hipparchus *In Arati et Eudoxi Phaenomena* 3.5.1 (note 14).

25. The star catalog has not been preserved, but information about it has been gleaned from Ptolemy's references to it and from Hipparchus's *In Arati et Eudoxi Phaenomena* (note 14). The value of 850 for the number of stars recorded is found in F. Boll, "Die Sternkataloge des Hipparch und des Ptolemaios," *Biblioteca Mathematica*, 3d ser., 2 (1901): 185–95. For a summary of the complexities of the reconstruction of Hipparchus's star catalog, see Neugebauer, *History of Ancient Mathematical Astronomy*, 280–88 (note 13). On Hipparchus's use of coordinates in the catalog, Toomer, "Hipparchus," 217 (note 12) points out that there is no evidence that he assigned coordinates to all—or, indeed, to any—of the large number of stars he listed. On the other hand, in his commentary on Aratus, Hipparchus used a mixture of ecliptic and equatorial coordinates to indicate the positions of stars. See Toomer, "Hipparchus," 217–18 (note 12).

the sky or for individual constellations, that Hipparchus tried to represent the sky on a flat map, with the constellations drawn in front view. A surviving contemporary artifact may demonstrate that such a possibility is not out of the question: it is a bas-relief dated 98 B.C., illustrating the royal horoscope of Antiochus of Commagene (northern Syria). It shows a lion, one of the zodiacal signs, carved in front view, its body outlined with stars, and three planets above it (fig. 10.4).[26] This individual case suggests that other single constellations were also drawn for specific, presumably astrological purposes.[27]

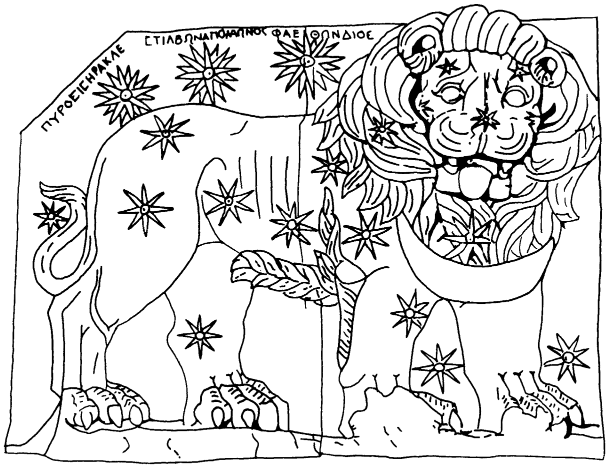

FIG. 10.4. THE LION OF COMMAGENE. This depicts the horoscope of Antiochus I (born 98 B.C.), king of Commagene. The original bas-relief was found on his tomb at Nimroud-Dagh in Turkey.
Size of the original: 1.75 × 2.4 m. After A. Bouché-Leclercq, *L'astrologie grecque* (Paris; E. Leroux, 1899; reprinted Brussels: Culture et Civilisation, 1963), 439 and fig. 41.

Equally interesting from a cartographic viewpoint is Hipparchus's concern with the improvement of geographical maps. This was dependent upon, and closely related to, his studies of the celestial globe. In this case, however, our knowledge of his treatise in three books (now lost), *Against Eratosthenes*, is derived at second hand through Strabo.[28] In this work he criticized Eratosthenes' map as being drawn without sufficient knowledge of the exact position of the different countries. In particular he objected that the Taurus range, following Dicaearchus, still appeared along the central parallel of the map:

> Since we cannot tell either the relation of the longest day to the shortest, or of gnomon to shadow, along the mountain-range that runs from Cilicia on to India, neither can we say whether the direction of the mountains lies on a parallel line, but we must leave the line uncorrected, keeping it aslant as the early maps give it.[29]

Some authorities have emphasized that Hipparchus's criticism of Eratosthenes was "sometimes erroneous and unfair."[30] But one should remember that as a mathematician and astronomer Hipparchus conceived of the value of cartography primarily in those terms. In particular, he emphasized the need for astronomical observations to locate exactly any place on the earth, pointing out the inadvisability of drawing a general map of the inhabited world before such observations had been made for every country. Thus Strabo reports:

> Hipparchus, in his treatise *Against Eratosthenes*, correctly shows that it is impossible for any man, whether layman or scholar, to attain to the requisite knowledge of geography without a determination of the heavenly bodies and of the eclipses which have been observed. For instance, it is impossible to determine whether Alexandria in Egypt is north or south of Babylon, or how far north or south of Babylon it is, without investigation by means of the "climata." In like manner, we cannot accurately fix points that lie at varying distances from us, whether to the East or the West, except by a comparison of eclipses of the sun and the moon.[31]

Hipparchus's *climata* thus appear to be a systematic method of locating towns or countries in their correct latitudinal positions. Strabo reports that he recorded the different celestial phenomena for the regions in the inhabited world between the equator and the North Pole.[32] While he accepted Eratosthenes' meridian through Meroë, and the mouth of the Borysthenes, he faced the same problem as Eratosthenes of estimating distances along it. Figure 10.5 reconstructs that portion of the meridian and also compares the longitudes of the key places along the meridian with their actual values.[33] The

26. A. Bouché-Leclercq, *L'astrologie grecque* (Paris: E. Leroux, 1899; reprinted Brussels: Culture et Civilisation, 1963), 439.

27. For examples of single constellations used on medals and for calendrical purposes, see Georg Thiele, *Antike Himmelsbilder, mit Forschungen zu Hipparchos, Aratos und seinen Fortsetzern und Beiträgen zur Kunstgeschichte des Sternhimmels* (Berlin: Weidmann, 1898), 64–75.

28. Dicks, *Geographical Fragments* (note 14).

29. Hipparchus, in Strabo *Geography* 2.1.11 (note 2), translation adapted from H. L. Jones edition.

30. Armando Cortesão, *History of Portuguese Cartography*, 2 vols. (Coimbra: Junta de Investigações do Ultramar-Lisboa, 1969–71), 1:85; Thomson, *History of Ancient Geography*, 321 (note 6). Strabo defends Eratosthenes against many of Hipparchus's criticisms but also points out some of Eratosthenes' "errors" in his *Geography* 2.1.4–41 (note 2).

31. Strabo *Geography* 1.1.12 (note 2), translation adapted from H. L. Jones edition.

32. Strabo *Geography* 2.5.34 (note 2).

33. Dicks, *Geographical Fragments*, 160–64 (note 14), discusses the nature of Hipparchus's table of latitude and longitude.

celestial phenomena related to latitude were the distance from the pole of the arctic (ever-visible) circle for each latitude (see note 5), the stars situated inside the arctic circle or on its circumference, the relation between the height of the gnomon and its shadow on solstitial and equinoctial days, and the length of the solstitial day. All these phenomena could be either calculated or observed on a globe or an armillary sphere.

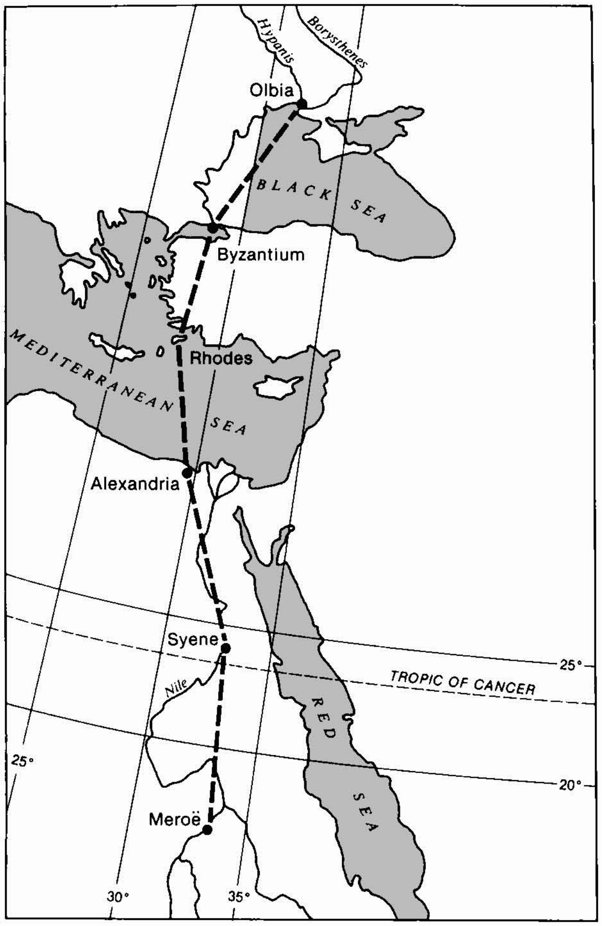

FIG. 10.5. THE MERIDIAN OF ALEXANDRIA. If Strabo's account of Hipparchus's *Against Eratosthenes* is correct, Hipparchus believed the mouth of the Borysthenes, Alexandria, and Meroë to be on the same meridian. This diagram shows its relation to the actual meridian. From *The Geographical Fragments of Hipparchus*, ed. D. R. Dicks (London: Athlone Press, 1960), p. 147, fig. 3.

Hipparchus's contribution to the history of map projections is more controversial. While some authors have claimed that his description of the *oikoumene* as a trapezium indicates an attempt to improve on the rectangular system of Eratosthenes, there is no direct evidence that this is not simply a reference to the chlamys-shaped inhabited world, as Dicks has pointed out.[34] Conversely, although some authors have questioned whether Hipparchus was aware of the stereographic projection (for terrestrial or celestial use) or the astrolabe, the weight of opinion now points to his invention of both.[35]

Maps and Globes in Education

In addition to Hipparchus's fundamental challenge to preexisting theories underlying the construction of maps and globes, some treatises were compiled in the first century B.C. that concerned not so much the creation of new knowledge as the wider functions of education. New schools and libraries had been founded as Rome extended its empire over the inhabited world.[36] In Greece and elsewhere, scholars appear in the record who were concentrating on digests of the new discoveries—both theoretical and geographical—for the benefit of their Roman students. While the distinction is less sharply drawn than in the modern world, some of the treatises, it may be said, were pitched at the level of textbooks. Much more succinct than the encyclopedic works of Polybius or Strabo, they presented compendiums of astronomical and geographical knowledge that help to illuminate our understanding of the diffusion of a knowledge of maps in Greek and Roman society.

The nature of such textbooks is indicated by the writings of Theodosius of Bithynia (ca. 150–70 B.C.). Of his known treatises, his *Spherics* (in three books) is the earliest extant textbook of this kind, and his work *On Inhabitable Places* describes the celestial phenomena visible at various latitudes.[37] Both treatises are purely geometric: the first deals implicitly with the celestial sphere and its various circles; the second refers explicitly to the

34. Dicks, *Geographical Fragments*, 148, 206 (note 14).

35. Dicks, *Geographical Fragments*, 207 (note 14). Toomer, "Hipparchus," 219 (note 12), believes the "balance of probability is that Hipparchus used (and perhaps invented) stereographic projection. If that is so, there is no reason to deny his invention of the plane astrolabe." Neugebauer, *History of Ancient Mathematical Astronomy*, 858, 868–79 (note 13), reviews the sources for the theory of stereographic projection and for its possible use in the construction of the astrolabe.

36. Elmer D. Johnson, *A History of Libraries in the Western World* (New York and London: Scarecrow Press, 1965), describes the new schools and libraries that emerged as Rome extended its empire.

37. Theodosius *On Inhabitable Places*; see *De habitationibus liber: De diebus et noctibus libri duo*, ed. Rudolf Fecht, Abhandlungen der Gesellschaft der Wissenschaften zu Göttingen, Philologisch-Historische Klasse, n.s., vol. 19, 4 (Berlin: Weidmann, 1927); and Theodosius's *Sphaerica*; see *Sphaerica*, ed. J. L. Heiberg, Abhandlungen der Gesellschaft der Wissenschaften zu Göttingen, Philologisch-Historische Klasse, n.s., vol. 19, 3 (Berlin: Weidmann, 1927). The name on this translation of *Sphaerica*, "Theodosius Tripolites," has caused some commentators to think that Theodosius was from Tripoli, despite the corrigendum on page XVI. Neugebauer discusses the "textbook" style of Theodosius's works as well as the basic geometry of his spherical astronomy in *History of Ancient Mathematical Astronomy*, 748–51, 757–67 (note 13).

earth at the center of the celestial sphere. The diagrams illustrating the demonstrations show a small circle (theoretically infinitely small) tangent to a diameter of the celestial sphere, itself drawn as a circle (fig. 10.6). The plane ABCD is meant to represent the astronomical horizon, and the small circle represents the terrestrial globe. Through geometry Theodosius demonstrated phenomena already known to Pytheas: that under the polar circle (then regarded as 66°N latitude) the longest day lasted twenty-four hours;[38] that at the pole the solar year was composed of one day six months long and one night six months long; and so forth. The diagram of Theodosius thus apparently represented the armillary sphere, with rings (Latin *armillae* [bracelets]) indicating the main celestial circles and a small globe in the center fixed on the axis of rotation representing the earth. Such models were commonly used in Greece.[39]

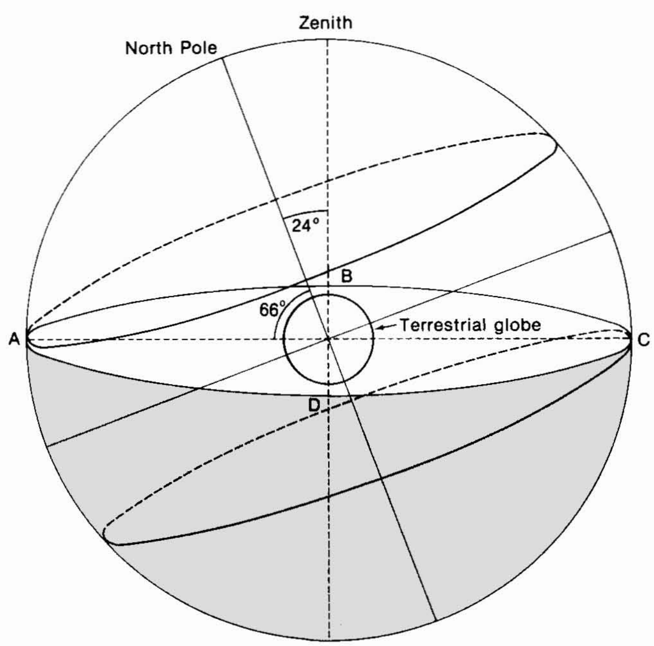

FIG. 10.6. THEODOSIUS'S FIGURE OF A CELESTIAL SPHERE. Theodosius showed that if an observer's ever-visible circle was coincident with the summer tropic, then the observer is situated at the Arctic Circle and has a twenty-four-hour day (see fig. 8.8). The inner circle, representing the terrestrial globe, is theoretically infinitely small. The observer's horizon plane is ABCD.
Developed from the description in Theodosius, *De habitationibus liber: De diebus et noctibus libri duo*, ed. Rudolf Fecht, Abhandlungen der Gesellschaft der Wissenschaften zu Göttingen, Philologisch-Historische Klasse, n.s., vol. 19, 4 (Berlin: Weidmann, 1927).

The better-known contemporary of Theodosius, Posidonius (ca. 135–51/50 B.C.), is generally associated with his measurement of the circumference of the earth. By some scholars, who view the history of mapping as mainly concerned with the diagnosis of increasing accuracy, this measurement has been "deemed disastrous in the history of geography."[40] Depending on the value of the stade we adopt, it may be true that Posidonius, seeking to improve on Eratosthenes, underestimated the size of the earth, and this measurement, copied by Ptolemy, was thereafter transmitted to Renaissance Europe.

But Posidonius clearly did more than measure the earth: such was his reputation as an educator that Strabo described him as "one of the most learned philosophers in our time."[41] He was born in Apamea in Syria; after traveling widely in the western Mediterranean countries and visiting Rome on several occasions, he established himself in Rhodes, where he opened a school. This was patronized by distinguished visitors, including Pompey, the Roman general and statesman, and Cicero, from whom some of our knowledge of Posidonius derives. It was also at Rhodes that he constructed a planetarium in the style of Archimedes, intended for teaching students the laws of the cosmos. Cicero describes "the orrery recently constructed by our friend Posidonius, which at each revolution reproduces the same motions of the sun, the moon and the five planets that take place in the heavens every twenty-four hours."[42]

Besides demonstrating his mechanical skill in this way, Posidonius was engaged in reassessing some of the theories about the earth current in his day. Indeed, in this respect his writing was to serve as an important conceptual link between cartography in the ancient and medieval worlds. In his treatise *The Ocean* (now lost but known to us through Strabo), for example, he discussed the problem of terrestrial zones, which is relevant to an understanding of the zonal *mappaemundi* of the Middle Ages.[43]

38. In fact Theodosius establishes that, in places 66° distant from the equator, the sun does not disappear below the horizon on the solstitial day. But by reason of crepuscular light it is daytime for about a month in those latitudes.

39. Strabo *Geography* 12.3.11 (note 2) confirms that globes existed in the area where Theodosius flourished. On the tradition of sphere construction (*sphairopoiia*) see p. 136 and n. 33 above.

40. Cortesão, *History of Portuguese Cartography*, 1:88 (note 30); Lloyd A. Brown, *The Story of Maps* (Boston: Little, Brown, 1949; reprinted New York: Dover, 1979), 30–32; and see E. H. Warmington, "Posidonius," in *Dictionary of Scientific Biography*, 11:104 (note 12).

41. Strabo *Geography* 16.2.10 (note 2), translation by O. A. W. Dilke.

42. Cicero *De natura deorum* 2.34.88, in *De natura deorum [and] Academica*, trans. H. Rackham, Loeb Classical Library (Cambridge: Harvard University Press; London: William Heinemann, 1924).

43. See below, chapter 18, "Medieval *Mappaemundi*."

In this text, inspired by the work of Pytheas, Posidonius began by criticizing the usual division of the earth into five zones—one uninhabited (torrid) zone, two inhabitable (temperate) zones, and two uninhabited (frigid) zones—for he considered the limits between them to be uncertain and inaccurate.[44] Instead of employing the traditional terms for the zones, based on temperature or habitability, he proposed terms based on clearly defined astronomical criteria. He divided the terrestrial globe by means of the tropics and the polar circles and named the zones as in table 10.1.[45]

TABLE 10.1 Posidonius's Terrestrial Zones

Zone	Area	Meaning
Amphiskian	Between the tropics (one zone)	Where the shadow of the gnomon is directed alternately to the north and to the south
Heteroskian	Between each tropic and each polar circle (two zones)	Where the shadow of the gnomon is directed either to the north or to the south, depending on the hemisphere
Periskian	From each polar circle to each pole (two zones)	Where the shadow of the gnomon makes a complete rotation

Note: The Greek *skia* means shadow.

At the same time, Posidonius appreciated that if he altered the criteria for the division, so as to take temperature distribution more fully into account, the earth could be divided into seven zones. These he identified as the two frigid zones around the poles, the two temperate zones in their usual places, two narrow, extremely arid zones along the terrestrial tropics having the sun directly overhead for about half a month each year, and finally the equatorial zone, more temperate and better watered than the two tropical ones.[46] At one point Posidonius also proposed dividing the inhabited world not into continents, as was usual in his day, but by means of circles parallel to the equator, indicating variations in fauna, flora, and climate. However, Strabo commented unfavorably on this innovative idea. It was, he said, "a mere matter of argument, with no useful end in view."[47]

Equally revisionist was Posidonius's challenge to Eratosthenes' measurement of the circumference of the earth. Our knowledge of his methods, as with the earlier reasoning of Eratosthenes, is derived from Cleomedes,[48] and it becomes clear that it was based on assumptions that were sometimes false.[49] These assumptions included the belief that Rhodes and Alexandria lay on the same meridian and that the distance between the two places was 5,000 stades. Then Posidonius (according to Cleomedes), noting that Canopus (α Carinae) was seen just on the horizon at Rhodes but rose as far as a quarter of a zodiacal sign (7½°) above the horizon at Alexandria, concluded that the center angle intercepting the Rhodes-Alexandria arc of meridian was one-forty-eighth of the total circle or 7½° (the arc is actually 5°14′). Thus, he argued, the total length of the meridian was forty-eight times the distance between Rhodes and Alexandria, and, assuming this latter to be 5,000 stades, this gave a figure of 240,000 stades for the circumference of the earth.[50]

This, however, is only a partial history of the confusion attached to the measurement. As a teacher interested in promoting discussion, Posidonius seems to have criticized his own assumptions,[51] in particular the estimate of 5,000 stades for the distance from Rhodes to Alexandria. Evidently, at some point in his calculations he employed an alternative value of 3,750 stades, derived from a careful estimate Eratosthenes made "by means of shadow-catching sundials."[52] When applied to the 1:48 ratio, this gave a correspondingly smaller length for the circumference of the earth of 180,000 stades.[53]

What is important for the history of cartography is that it was this measurement—whether directly or

44. According to Strabo *Geography* 2.2.2 (note 2), Posidonius criticized Parmenides' division of the earth into five zones because he represented the torrid zone as almost double its real breadth, and he criticized Aristotle for calling the region between the tropics "torrid" and the regions between the tropics and the arctic circles "temperate." Posidonius disagreed with both Parmenides and Aristotle and asked "how one could determine the limits of the temperate zones, which are non-variable, by means of the 'arctic circles,' which are neither visible among all men nor the same everywhere."

45. Germaine Aujac, "Poseidonios et les zones terrestres: Les raisons d'un échec," *Bulletin de l'Association Guillaume Budé* (1976): 74–78. Neugebauer, *History of Ancient Mathematical Astronomy*, 736–46 (note 13), discusses shadow tables.

46. Strabo *Geography* 2.2.3 (note 2).

47. Strabo *Geography* 2.3.7 (note 2).

48. See chapter 9 above, pp. 154–55.

49. See Cortesão, *History of Portuguese Cartography*, 1:86–88 (note 30), for a fuller discussion with a diagram of the methods Posidonius employed.

50. Cleomedes *De motu circulari* 1.10; see *De motu circulari corporum caelestium libri duo*, ed. H. Ziegler (Leipzig: Teubner, 1891). An English translation of book 1, chap. 10, appears in Cortesão, *History of Portuguese Cartography*, 1:141–43 (note 30).

51. Strabo *Geography* 2.2.2 (note 2). C. M. Taisbak, "Posidonius Vindicated at All Costs? Modern Scholarship versus the Stoic Earth Measurer," *Centaurus* 18 (1973–74): 253–69, attributes more precise scientific theory to Posidonius than seems warranted by the information at our disposal.

52. Strabo *Geography* 2.5.24 (note 2). Neugebauer, *History of Ancient Mathematical Astronomy*, 653 (note 13), dismisses this because sundials cannot measure distance directly.

53. See Neugebauer, *History of Ancient Mathematical Astronomy*, 652–54 (note 13), on Posidonius's measurements.

through an intermediary—that was later adopted by both Marinus of Tyre and Ptolemy. Its main effect was greatly to exaggerate the portion of the globe occupied by the inhabited world, so that the length from the Straits of Gibraltar to India, along the parallel of Rhodes, came to be considered half of the entire parallel around the earth.[54] And such was the authority of Ptolemy that this misconception was carried forward by geographers, cosmographers, and cartographers into the sixteenth century. Historians of discovery have noted that it long colored the perception of that age as to the size of the unknown portion of the world.[55]

A final example from the first century B.C. of the extent to which globes and maps were used in education is provided by Geminus of Rhodes (fl. ca. 70 B.C.). His elementary textbook on astronomy and mathematical geography—*Introduction to Phaenomena*[56]—has survived. It points the historian of cartography to some definite evidence for the regular use of celestial and terrestrial globes in the schools of that day.[57]

To explain celestial phenomena to his students, Geminus uses various types of three-dimensional models: a celestial sphere representing all the constellations, a simpler theoretical celestial sphere containing only the main celestial circles, an armillary sphere, and a planetary model consisting of a series of concentric spheres. He has the most to say about the characteristics of the first category, the celestial spheres. On the solid stellar globe, he tells us, "are designed all the constellations. Now it must not be supposed that all the stars lie upon one surface; some of them are higher, others lower, but as our vision extends only to a certain uniform height, the difference in altitude is imperceptible to us."[58] Such globes depicted five parallel circles (the equator, the two tropics, the two arctic circles), the two colures, and the three oblique circles representing the zodiac.[59] The horizon and the meridian of the place of observation could not, however, be drawn upon it, Geminus explained, because these circles were motionless and did not rotate with the globe itself. It was left to the user of such a globe, he added, to imagine the position of the horizon from the stand on which the globe rested.[60]

Geminus also specified that all stellar globes, at least those used for teaching, should be constructed for the latitude of Rhodes, that is, 36°N,[61] so that the polar axis makes an angle of 36° with the plane of the horizon. Figure 10.7 shows the distances between the parallel circles.[62] The zodiacal zone is twelve degrees wide. Its median circle, called the ecliptic, touches the summer tropic at the first point of Cancer and the winter tropic at the first point of Capricorn. And here it divides the equator into two equal parts at the first point of Aries and at the first point of Libra.[63] Curiously enough, the Milky Way, the only circle visible in the night sky, is not drawn on celestial globes. Geminus explained its absence on the grounds that it is not of the same width throughout.[64] Thus he believed that the Milky Way could not be treated similarly to the other celestial circles.[65]

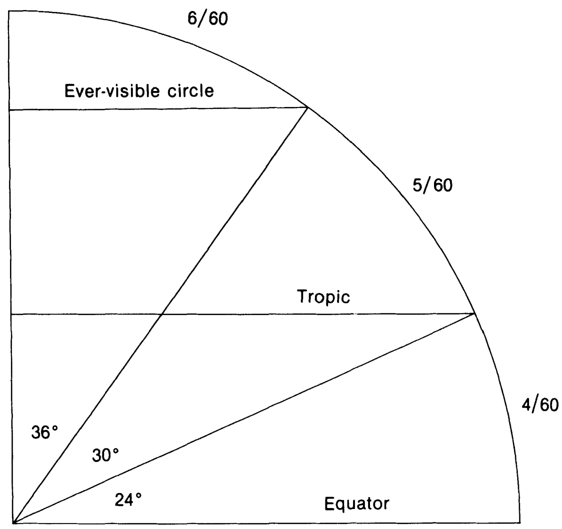

FIG. 10.7. DISTANCES BETWEEN THE PARALLEL CIRCLES ACCORDING TO GEMINUS. The distances between the parallel circles would be:

Fraction	*Degrees*	*Area*
4/60 of the circle	24°	From the celestial equator to the tropic
5/60 of the circle	30°	From the tropic to the arctic circle
6/60 of the circle	36°	From the arctic circle to the pole

54. See chapter 11 below on Ptolemy's dimensions for the inhabited world.

55. Most famously in Columbus's belief in the proximity of the Indies when sailing westward; see also chapter 18, p. 354.

56. Geminus *Introduction* (note 1); see also *Elementa astronomiae*, ed. C. Manitius (Leipzig: Teubner, 1898).

57. Germaine Aujac, "Une illustration de la sphéropée: L'*Introduction aux phénomènes* de Géminos," *Der Globusfreund* 18–20 (1970): 21–26; and Aujac, "La sphéropée ou la mécanique au service de la découverte du monde," *Revue d'Histoire des Sciences* 23 (1970): 93–107.

58. Geminus *Introduction* 1.23 (note 1), translation by O. A. W. Dilke.

59. Geminus *Introduction* 5.50–51 (note 1).

60. Geminus *Introduction* 5.62–65 (note 1).

61. Geminus *Introduction* 5.48 (note 1). This means that the ever-visible (or arctic) circle is 36° distant from the pole.

62. This division into zones is reminiscent of Eratosthenes; see D. R. Dicks, "Eratosthenes," in *Dictionary of Scientific Biography*, 4:388–93, esp. 391 (note 12), and Geminus *Introduction* 5.46 (note 1).

63. Geminus *Introduction* 5.51–53 (note 1).

64. Geminus *Introduction* 5.68–69 (note 1).

65. Geminus *Introduction* 5.11 (note 1).

The terrestrial globe was also frequently used for teaching. It was a replica of the celestial globe, similarly constructed according to the latitude of Rhodes, 36°N, so that the arctic circle was fixed at 36° distance from the pole.[66] It also showed the same division into zones by tropics and arctic circles drawn at the same relative distances as the corresponding circles on the celestial globe. Hence, with an earth 252,000 stades in circumference and 84,000 stades in diameter (Geminus took $\pi = 3$), the circle was divided into sixty parts of 4,200 stades each. The frigid zones occupied six-sixtieths or 25,200 stades, the temperate zone five-sixtieths or 21,000 stades, and the torrid zone in the northern hemisphere a breadth of four-sixtieths or 16,800 stades. The same was true of the southern hemisphere. On the semicircle from pole to pole, therefore, the total was 126,000 stades.[67]

To such three-dimensional globes the educated Greeks and Romans were also adding a knowledge of two-dimensional maps. Geminus tells us that both circular and oblong maps were regularly drawn and reiterates the well-established view of earlier writers that oblong maps were more reliable, pointing out that, since the length of the inhabited world was twice its width, a circular map of the same area would distort distances.[68] It must be recognized, therefore, that notwithstanding the public's wider exposure to globes and maps by the first century B.C., there was no standard image of the world that had been disseminated by the Greek writers as a whole and then generally accepted. Indeed, we see from Geminus's comments that alongside the mathematically constructed maps founded on the measurements of Eratosthenes and his revisers there had survived the much older pre-Hellenistic view of the earth mapped in circular form as if representing a flat disk.

This should not be interpreted as an anomaly when set against the record of scientific cartography. Throughout the classical period, as when Geminus wrote, it is clear that maps and globes were not regarded solely as the media of astronomical or geographical instruction seeking to convey a literal view of reality; they were also frequently used as symbols to convey other meanings. As well as appearing in some treatises, they are illustrated in paintings, incorporated in other objets d'art, and, as earlier with the poem of Aratus, described in verse. Globes, in particular, as striking artifacts, were used in symbolic representations, and a general knowledge of their nature may often have depended on their use in this way. Celestial globes, sometimes associated with sundials, can be seen on various Roman sarcophagi as attributes of the Parcae (Fates);[69] and their popularity is also attested by their inclusion in several paintings roughly contemporary with Geminus. A painting in the Casa dei Vettii, Pompeii, represents the Muse Urania pointing at a celestial globe. On this globe, which rests on a small cubic pedestal, are drawn meridians, parallels, and the oblique zodiacal circle; the polar axis makes an angle with the horizontal plane of the stand.[70] Similarly, another painting in the Casa dell'Argentaria in Pompeii shows Apollo holding in his left hand a celestial globe on which are clearly drawn two great circles, the equator and the ecliptic.[71] From the position of the equator, we may infer that the axis of the poles is inclined to the horizontal plane on which Apollo is standing.

A celestial globe, probably intended also to be a sundial, is found on a fresco acquired by the Metropolitan Museum of Art in 1903 from a villa at Boscoreale near Pompeii, dating from about A.D. 50. It exhibits the celestial circles in lifelike perspective (plate 4).[72] Or again, in a different medium but conveying a similar message for our interpretation of the place of maps in Roman society, we encounter a cartographic motif within the famous "philosopher" mosaic from Torre Annunziata near Pompeii. The design here, like the similar mosaic in the Villa Albani in Rome, was probably inspired by a Hellenistic painting and, along with a sundial, it shows one half of a globe, with meridians and parallels somewhat roughly drawn and wholly inaccurate, emerging from a box supported by four feet.[73] The upper part of the box defines the horizon, dividing the visible hemisphere from the invisible one.

Poetry—sometimes illustrated by maps—also continued to be used as a way of memorizing and popularizing the knowledge or meaning seen in cartographic images. Such literary sources do, however, give the impression that the educated class largely preferred to ignore new discoveries, and earlier Hellenistic concepts of geography persisted long after they had ceased to reflect up-to-date knowledge. A late example is provided by Dionysius, born in Alexandria and called "Periegetes" after the title of his poem.[74] A contemporary of Marinus and Ptolemy, he composed a description in verse of the inhabited world (A.D. 124) that was long used as a school textbook. He presented the *oikoumene* as an island,

66. Geminus *Introduction* 16.12 (note 1); armillary spheres were also constructed to this latitude.
67. Geminus *Introduction* 16.7–8 (note 1).
68. Geminus *Introduction* 16.4–5 (note 1).
69. Otto J. Brendel, *Symbolism of the Sphere: A Contribution to the History of Earlier Greek Philosophy* (Leiden: E. J. Brill, 1977), 70–85 and pls. XXIII, XXVI, XXVIII–XXX.
70. Brendel, *Symbolism of the Sphere*, pl. IX (note 69).
71. Brendel, *Symbolism of the Sphere*, pl. XVII (note 69).
72. Stevenson, *Terrestrial and Celestial Globes*, 1:21 (note 6).
73. Brendel, *Symbolism of the Sphere*, pls. I–VI, VII (note 69).
74. Dionysius *Periegesis*, in *Geographi Graeci minores*, 2 vols. and tabulae, ed. Karl Müller (Paris: Firmin-Didot, 1855–56), 2:103–76. It is followed by Avienius's translation into Latin, 177–89, and by Eustathius's *Commentary*, 201–407.

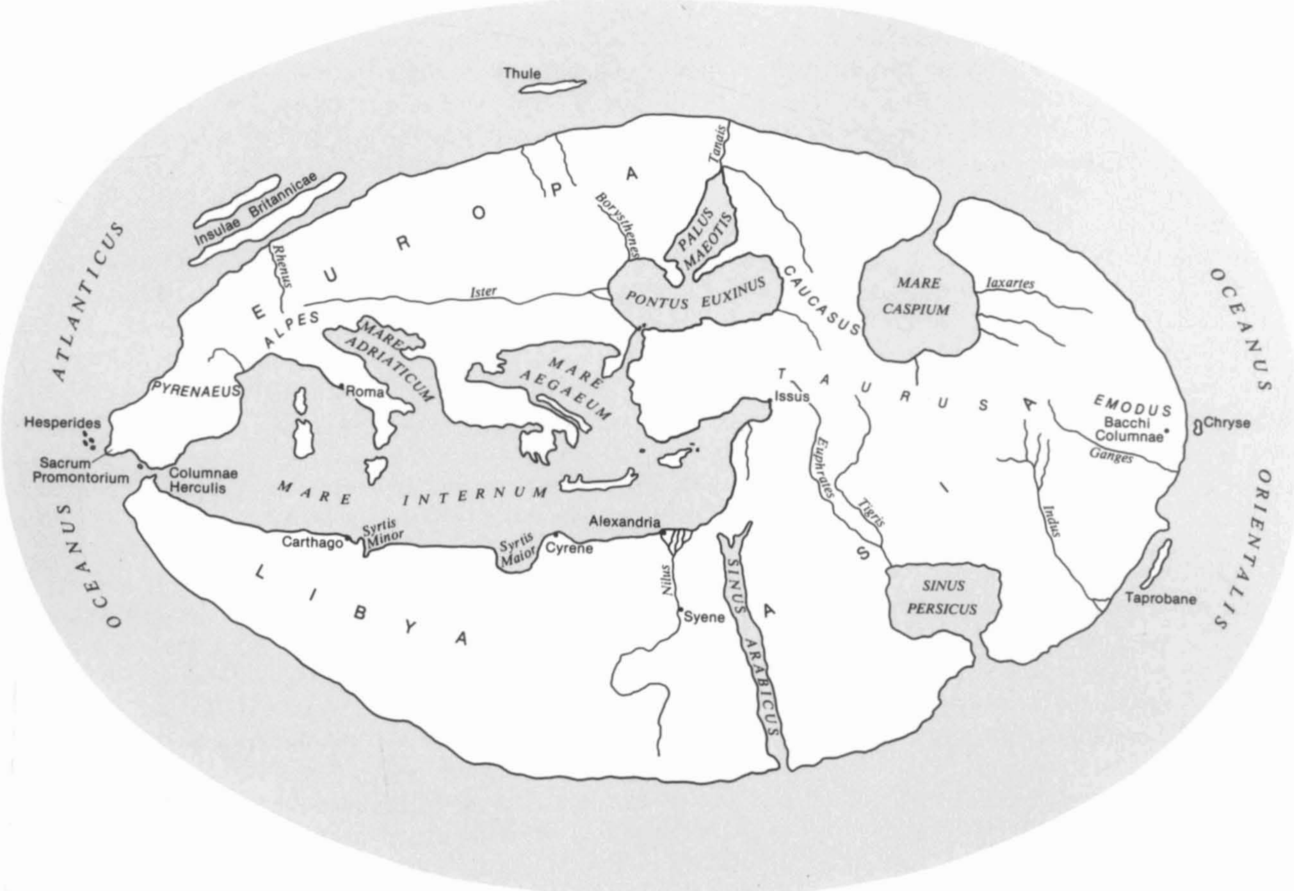

FIG. 10.8. THE RECONSTRUCTED WORLD OF DIONYSIUS PERIEGETES, A.D. 124. After Edward Herbert Bunbury, *A History of Ancient Geography among the Greeks and Romans from the Earliest Ages till the Fall of the Roman Empire*, 2d ed., 2 vols., (1883; republished with a new introduction by W. H. Stahl, New York: Dover, 1959), vol. 2, map facing p. 490.

sling-shaped, entirely north of the equator, extending from Thule to Libya (fig. 10.8). He did not mention either Agisymba or the promontory of Prasum.[75] He limited the inhabited world eastward by the river Ganges, taking into account the Seres (Chinese and Tibetans), but locating them much less far east than Marinus.

Dionysius's poem, like Aratus's *Phaenomena*, was a success partly because it summarized, and made easier to remember, traditional teachings since Eratosthenes. It was first translated into Latin by Rufius Festus Avienius (fourth century A.D.), who had also translated Aratus's *Phaenomena*, then by Priscian the grammarian, who taught in Constantinople in the sixth century A.D. Cassiodorus (also sixth century), who had founded a convent in southern Italy, asked the young monks to learn geography and cosmography through Dionysius's map and Ptolemy's work.[76] Subsequently, in the twelfth century, Eustathius, later archbishop of Thessalonica, who had already commented on the *Iliad* and the *Odyssey*, composed a detailed commentary on this poem that remained in regular use during the whole of the Middle Ages.

The poem was originally supplied with maps, probably drawn on the models of Eratosthenes' or Strabo's maps. Various annotations preserved in the margins of the existing manuscripts refer to maps illustrating the poem: some of them point out that such and such a place is lacking on the map or that the outlines of such and such a country do not agree with Dionysius's de-

75. Agisymba is a kind of generic name referring to central Africa and the land of the Ethiopians. Cape Prasum is somewhere near Zanzibar, south of Rhapta (possibly Cape Delgado).

76. Cassiodorus *Institutiones divinarum et saecularium litterarum* 1.25; see *Institutiones*, ed. R. A. B. Mynors (Oxford: Clarendon Press, 1937), or for an English translation, Cassiodorus Senator, *An Introduction to Divine and Human Readings*, ed. and trans. Leslie Webber Jones (New York: Columbia University Press, 1946).

scription. These seem to provide evidence that such mapmakers continued to copy their models uncritically and rarely tried to adapt the map to the written description to be illustrated.

In the case of Dionysius, both maps and poem were behind their time, even at the date of their composition; but they reflect the ordinary level of knowledge. His description of the British Isles may be rendered:

Two islands are there, British, off the Rhine,
By Ocean's northern shores; for there the Rhine
Sends out its furthest eddies to the sea.
Enormous is their size: no other isles
Equal the British isles in magnitude.[77]

Such a poor description, and the lack of revision elsewhere, suggests too close a reliance on Eratosthenes.

In all these examples, despite the fragmentary nature of our sources, the wider educative power of the map can be glimpsed. Globes and maps, in particular as displayed in public or incorporated into the composition of paintings, poetry, mosaics, and sculpture, communicated an image of the world with Greece and Rome at its center but with the possibility of other lands and zones—indeed the universe—lying beyond and interrelated in one coherent system.

The Map of the Inhabited World Recommended by Strabo

The contribution of Strabo (ca. 64/63 B.C. to A.D. 21 or later), a native of Amasia (Amasya) in Pontus and a scholar of great stature as philosopher, historian, and geographer,[78] sums up the main themes of this chapter. As a Greek, he epitomizes the continuing importance of the Greek intellectual heritage—and contemporary practice—to the development of cartography in the early Roman world. As the reviser of Eratosthenes, he also illustrates the continuous way later generations had built on the cartographic concepts first clearly set out in the Hellenistic age.

Strabo is said to have visited Rome as a young man (he was an exact contemporary of Augustus), and he pretended to have traveled widely to bring together an enormous amount of geographical knowledge. It is generally accepted, however, that he must have compiled much of this information in the great library at Alexandria, where he had access to many earlier texts now lost. All his writings were firmly set in, if not direct extensions of, the work of his predecessors. Thus his *Historical Memoirs* in forty-seven books, now lost, was a continuation of Polybius. Fortunately, his *Geography* in seventeen books, composed toward the end of his life, has come down to us intact (apart from the seventh book, which survives only as an epitome).[79] The work is of key importance to our whole knowledge of the history of Greek cartography as well as to the history of science in general.[80] It has already been shown that many of the earlier treatises that touch upon maps are known to us only through Strabo, while the interest of his commentary on these writers is in its critical handling of their theories, albeit he sometimes fails to advance truth by this process.

In many ways the most interesting passages relating to cartography in Strabo's *Geography* are those that, although they contain no maps, give an account, for the first time in a surviving text, of how a description of the known world should be compiled. His motives for writing such a geography (so he tells us) were that he felt impelled to describe the inhabited world because of the considerable strides in geographical knowledge that had been made through the numerous campaigns of the Romans and Parthians.[81] The world map had to be adjusted to take account of these facts, and thus Strabo almost certainly proceeded by taking Eratosthenes' map—and the criticism of it by Polybius, Crates, Hipparchus, and Posidonius—as the basis for his own work.[82]

In this task of compilation Strabo seems to have worked systematically. The first stage was to locate the portion of the terrestrial globe that was known to be inhabited. Strabo reasoned that it lay in a northern quadrant of a globe, in a quadrilateral bounded by the frigid zone, the equator, and two meridians on the sides.[83] In this design Strabo had been influenced not only by Eratosthenes' measurement of the earth but also by the concept of the four inhabited worlds, known and unknown, expounded by Crates, to whom he refers explicitly.[84] Thus far Strabo had relied on theoretical argument derived from his authorities. But he also adduced good empirical grounds for this cartographic reasoning. He continued:

77. Dionysius *Periegesis* 565–69 (note 74), translation by O. A. W. Dilke.

78. E. H. Warmington, "Strabo," in *Dictionary of Scientific Biography*, 13:83–86 (note 12); Germaine Aujac, *Strabon et la science de son temps* (Paris: Belles Lettres, 1966).

79. Strabo *Geography* (note 2).

80. Thus George Sarton writes of the value of this "first attempt to write a geographical encyclopaedia, including mathematical, physical, political and historical geography" in his *Introduction to the History of Science*, 3 vols. (Baltimore: Williams and Wilkins, 1927–48), 1:227, and Cortesão states that as a source it was "second to none in the history of geography and cartography" of this period; see his *History of Portuguese Cartography*, 1:89 (note 30).

81. Strabo *Geography* 1.2.1 (note 2).

82. Cortesão, *History of Portuguese Cartography*, 1:90 n. 3 (note 30).

83. Strabo locates the frigid zone, or arctic circle, at 54° distance from the equator. The so-called quadrilateral, bounded by half of this arctic circle, half of the equator, and segments of two meridians, is a spherical quadrilateral, a portion of a sphere.

84. Strabo *Geography* 2.5.10 (note 2).

> But if anyone disbelieves the evidence of reason, it would make no difference, from the point of view of the geographer, whether we make the inhabited world an island, or merely admit what experience has taught us, namely, that it is possible to sail round the inhabited world on both sides, from the east as well as from the west, with the exception of a few intermediate stretches. And, as to these stretches, it makes no difference whether they are bounded by sea or by uninhabited land; for the geographer undertakes to describe the known parts of the inhabited world, but he leaves out of consideration the unknown parts of it—just as he does what is outside of it. And it will suffice to fill out and complete the outline of what we term "the island" by joining with a straight line the extreme points reached on the coasting-voyages made on both sides of the inhabited world.[85]

Despite the extension of the geographical horizons of the inhabited world since the time of Eratosthenes, Strabo's *oikoumene* was smaller. Although Pytheas, Eratosthenes, and perhaps Posidonius had fixed its northern limit on the parallel through Thule (66°N), Strabo, like Polybius, refused to believe that human life was possible so far north, and he blamed Pytheas for having misled so many people by his claim that the "summer tropic" becomes the "arctic circle" at the island of Thule.[86] Again following Polybius, Strabo thus chose as the northern limit of the map and of the inhabited world the parallel through Ierne (Ireland), "which island not only lies beyond Britain but is such a wretched place to live in on account of the cold that the regions on beyond are regarded as uninhabitable."[87] This parallel (54°N) is the projection of the celestial arctic circle constructed for the latitude of Rhodes (36°N); it coincides with the one mentioned by Geminus as the northern limit of the temperate zone. The southern limit of habitable land, for Strabo as for Eratosthenes, is the parallel through the "Cinnamon-producing country" (now in Ethiopia) at about 12°N. He estimated the latitudinal extent of the inhabited world as less than 30,000 stades (compared with Eratosthenes' 38,000 stades) and reduced its length to 70,000 stades instead of Eratosthenes' 78,000.

In order to avoid the deformational problems of flat maps, Strabo stated that he preferred to construct his map on a globe large enough to show all the required detail.[88] He recommended that it be at least ten feet (approximately three meters) in diameter and mentions Crates in this regard. On the other hand, if a globe of this size could not be constructed, Strabo was familiar from Eratosthenes with the transformation necessary to draw it on a plane surface. For a graticule, Strabo adopted the straightforward rectangular network of parallels and meridians. He defended his projection on the ground that it would make only a slight difference if the circles on the earth were represented by straight lines, "for our imagination can easily transfer to the globular and spherical surface the figure or magnitude seen by the eye on a plane surface."[89] The dimensions of this flat map were also to be generous. Strabo envisaged that it would be at least seven feet long and presumably three feet wide, which would suit the length of the inhabited world (70,000 by 30,000 stades), one foot being equivalent to 10,000 stades (fig. 10.9).

As with all Greek world maps, the great impediment to study for the historian of cartography is that we have only these verbal descriptions, not the images themselves.[90] Nevertheless, apart from the reduced size of the inhabited world, the map Strabo envisaged was similar in its overall shape to that drawn by Eratosthenes.[91] In describing its detailed geography, however, Strabo did not employ, at least overtly, Eratosthenes' division of the world into irregular quadrilaterals or *sphragides*, but he often used geometric figures or comparisons to everyday objects to describe the general outline of a country. For instance, he says that the province of Gallia Narbonensis presents the shape of a parallelogram;[92] that the rivers Garumna (Garonne) and Liger (Loire) are parallel to the Pyrenaeus (Pyrenees), forming with the ocean and the Cemmenus Mountains (Cévennes) two parallelograms;[93] that Britain is triangular;[94] that Italy has been shaped sometimes like a triangle, sometimes like a quadrilateral;[95] that Sicily is indeed triangular,[96] though one side is convex and the two others slightly concave. Similarly, Strabo compares the shape of Iberia to an oxhide,[97] the Peloponnese to a plane-tree leaf,[98] and the northern part of Asia, east of the Caspian, to a kitchen knife with the straight side along the Taurus

85. Strabo *Geography* 2.5.5 (note 2).
86. Strabo *Geography* 2.5.8 (note 2).
87. Strabo *Geography* 2.1.13 (note 2).
88. Strabo *Geography* 2.5.10 (note 2).
89. Strabo *Geography* 2.5.10 and 2.5.16 (note 2), where Strabo says the parallels and meridians allow one to correlate regions that are parallel.
90. Désiré Raoul Rochette, *Peintures antiques inédites, précédées de recherches sur l'emploi de la peinture dans la décoration des édifices sacrés et publics, chez les Grecs et chez les Romains* (Paris: Imprimerie Royale, 1836), suggests that geographical maps, like other pictures, were painted with encaustic, first on easels, and later fixed in their proper place under a portico or in a picture gallery. This again provides further evidence for the wider dissemination of maps in the Greek and Roman world: see above, p. 158.
91. Aujac, *Strabon*, 213 (note 78), speculates on whether Strabo drew a map to accompany the text and on whether he had the map of Eratosthenes in front of him as a model.
92. Strabo *Geography* 4.1.3 (note 2).
93. Strabo *Geography* 4.2.1 (note 2).
94. Strabo *Geography* 4.5.1 (note 2).
95. Strabo *Geography* 5.1.2 (note 2).
96. Strabo *Geography* 6.2.1 (note 2).
97. Strabo *Geography* 2.5.27 (note 2).
98. Strabo *Geography* 8.2.1 (note 2).

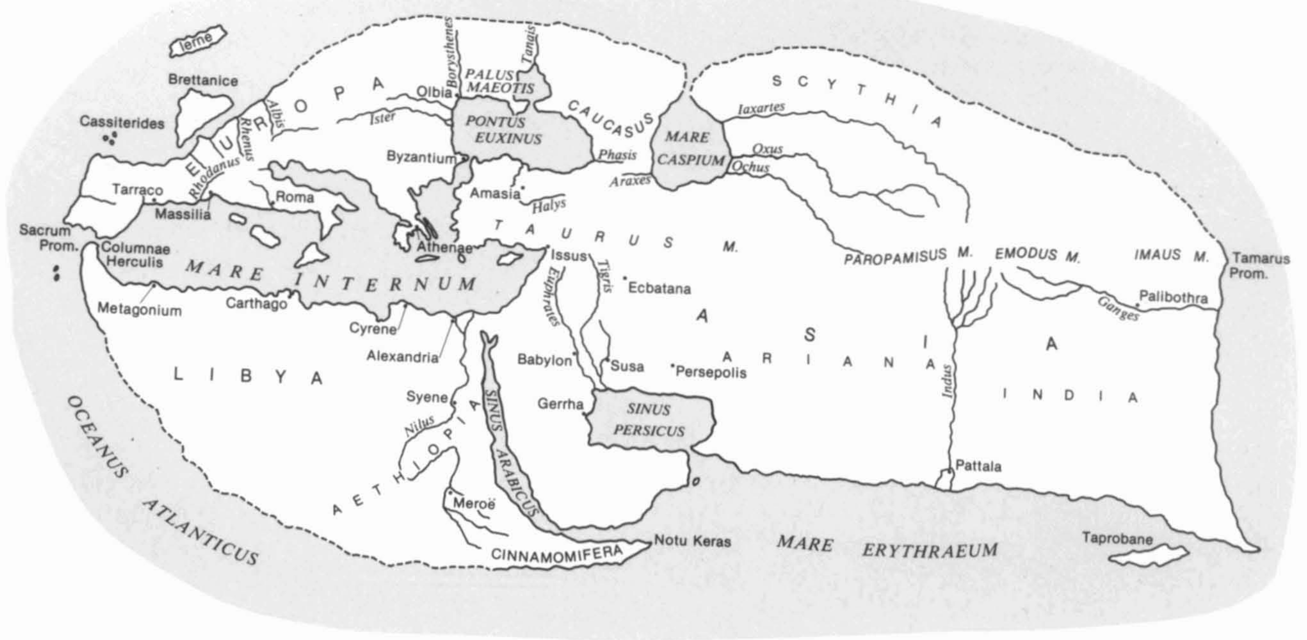

FIG. 10.9. THE SHAPE OF THE INHABITED WORLD RECONSTRUCTED FROM STRABO. After Edward Herbert Bunbury, *A History of Ancient Geography among the Greeks and Romans from the Earliest Ages till the Fall of the Roman Empire*, 2d ed., 2 vols. (1883; republished with a new introduction by W. H. Stahl, New York: Dover, 1959), vol. 2, map facing p. 238.

range and the curved side along the northern coastline.[99] India, with two adjacent sides (south and east) much longer than the two others, he described as rhomboidal;[100] Mesopotamia, between the Tigris and Euphrates rivers, he saw as being like a boat drawn in profile, with the deck on the Tigris side and the keel near the Euphrates.[101] Strabo repeats that the river Nile was described by Eratosthenes as a reversed N,[102] and that its mouth was named after the Greek capital letter Δ, delta.[103]

It is not clear how we should interpret these familiar graphic similes Strabo employed to describe to his readers the land areas and other features on the world map. But they do suggest that he was writing with a map in front of him. In some cases, where alternative descriptions are provided, he may have been attempting to collate the outlines of more than one map. It is also probable that students were expected to consult the text of the *Geography* with the help of maps, so that the shapes thus enumerated may have served as a simple mnemonic. Yet if such suggestions must remain speculative, there can be little doubt that by the early Roman period world maps and globes drawn by Greek scholars were encouraging a distinctively geographical way of thinking about the world. And it is likely, among the educated group at least, that an increasingly standard image of the inhabited world had come to be more widely accepted through the use of these maps.

99. Strabo *Geography* 11.11.7 (note 2).
100. Strabo *Geography* 15.1.11 (note 2).
101. Strabo *Geography* 16.1.22 (note 2).
102. Strabo *Geography* 17.1.2 (note 2).
103. Strabo *Geography* 17.1.4 (note 2).

Bibliography

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Aujac, Germaine. *Strabon et la science de son temps*. Paris: Belles Lettres, 1966.

———. "Une illustration de la sphéropée: L'*Introduction aux phénomènes* de Géminos." *Der Globusfreund* 18–20 (1970): 21–26.

Brendel, Otto J. *Symbolism of the Sphere: A Contribution to the History of Earlier Greek Philosophy*. Leiden: E. J. Brill, 1977.

Dubois, M. *Examen de la Géographie de Strabon*. Paris: Imprimerie Nationale, 1891.

Fiorini, Matteo. *Sfere terrestri e celesti di autore italiano oppure fatte o conservate in Italia*. Rome: Società Geografica Italiana, 1899.

Geminus. *Elementa astronomiae*. Edited by C. Manitius. Leipzig: Teubner, 1898.

———. *Introduction aux phénomènes*. Edited and translated by Germaine Aujac. Paris: Belles Lettres, 1975.

Hipparchus. *In Arati et Eudoxi Phaenomena commentariorum libri tres*. Edited by C. Manitius. Leipzig: Teubner, 1894.

Mette, Hans Joachim. *Sphairopoiia: Untersuchungen zur Kosmologie des Krates von Pergamon*. Munich: Beck, 1936.

Neugebauer, Otto. *A History of Ancient Mathematical Astronomy*. New York: Springer-Verlag, 1975.

Prontera, Francesco. "Prima di Strabone: Materiali per uno studio della geografia antica come genere letterario." In *Strabone: Contributi allo studio della personalità e dell'opera*. Università degli Studi, Perugia. Rimini: Maggioli, 1984.

Stevenson, Edward Luther. *Terrestrial and Celestial Globes: Their History and Construction, Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy*. 2 vols. Publications of the Hispanic Society of America, no. 86. New Haven: Yale University Press, 1921; reprinted New York and London: Johnson Reprint Corporation, 1971.

Strabo. *The Geography of Strabo*. 8 vols. Edited and translated by Horace Leonard Jones. Loeb Classical Library. Cambridge: Harvard University Press; London: William Heinemann, 1917–32.

———. *Géographie*. Edited by François Lasserre, Germaine Aujac, et al. Paris: Belles Lettres, 1966–.

Walbank, Frank William. *A Historical Commentary on Polybius*. 3 vols. Oxford: Clarendon Press, 1957–79.