PTOLEMY'S

Geography

AN ANNOTATED TRANSLATION

OF THE THEORETICAL CHAPTERS

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TO OUR TEACHERS

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and

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Preface

On any list of ancient scientific works, Ptolemy's Geography will occupy a distinguished place, and Ptolemy's contributions to ancient, medieval, and Renaissance geography receive respectful notice in books devoted to the history of science.

It is, however, the respect usually reserved for the dead, and one who wishes to examine the sources firsthand will soon come to an impasse. No complete edition of the Greek text has appeared since C.F.A. Nobbe's of 1843–1845; and while good translations of parts of the Geography have been produced in German and French, the only version in English has been the nearly complete, but in all other respects very unsatisfactory, translation by E. L. Stevenson.

The centerpiece of Ptolemy's book is an enormous list of place names and coordinates that were intended to provide the basis for drawing maps of the world and its principal regions. A reliable translation of this part, and of another long section consisting of descriptions (or, as we prefer to call them, captions) of the regional maps, is unattainable in our present defective state of knowledge of the manuscript tradition of the Geography. These passages are in any case not designed for continuous reading, and we believe that most readers will not be disappointed to find them represented here by a description and a representative excerpt.

The remaining chapters of the Geography, which we have translated in their entirety, may be read as a series of essays of varying length dealing with aspects of scientific cartography. The work has, however, a unity of purpose and design that is possibly easier to grasp when these theoretical sections are not overshadowed by the geographical catalogue.

In our introduction and notes, we have assumed that our likely readers will be varied: historians of science (and their students) wanting familiarity with a classic of science; historians of the ancient world, hitherto lacking convenient access to the work of its greatest mathematical geographer; and, finally, those geographers who are interested in the origins of their discipline. We are well aware, however, that the line between pleasing and offending these disparate groups is a thin one, and we can only take comfort in the closing words of Samuel Johnson's introduction to his edition of Shakespeare.
It is impossible for an expositor not to write too little for some and too much for others. He can only judge what is necessary by his own experience: and how longsoever he may deliberate, will at last explain too many lines which the learned will think impossible to be mistaken, and omit many for which the ignorant will want his help. These are censures merely relative, and must be quietly endured.

This book had its beginnings at a time when one of us (AJ) was a student in the History of Mathematics Department at Brown University and the other (JLB) was there for a short visit. In the intervening years, the book took shape as each of us tested his contributions against the friendly skepticism of his co-author. In addition, a number of individuals and institutions have helped over this time, and it is a pleasure to thank them here: Gerald Toomer, for suggesting the project and encouraging the authors to believe that they could handle it; Asger Aaboe, who, when he heard of the project, gave JLB his copy of Nobbe's text of the work; Sarah Pothecary, for critically reading our early drafts; the Biblioteca Apostolica Vaticana, the British Library, the Bodleian Library, the Houghton Library (Harvard University), the John Hay Library (Brown University), and the Newberry Library, for supplying microfilms and photographs of manuscripts; the Natural Sciences and Engineering Research Council of Canada, for grants that made it possible for JLB to visit Brown University and to obtain photocopies of a number of rare printed editions of the Greek text of Ptolemy's work; our home institutions, for unfailing support of our scholarly endeavors over many years; and our wives, for not only gracefully surrendering family time so that the work might progress, but also hosting visits by the co-authors for periods of concentrated work.

Note on Citations of Classical Authors

Where a standard division of a Greek or Latin author into books and chapters exists, we have used it, providing just the author's name when only one work is in question. For authors who have more than one established system for referencing, we have chosen the one that is in most common use. Thus passages of Strabo's Geography are cited by book number, chapter, and section number, e.g., Strabo 2.5.5, rather than by the page numbers of Casaubon or Almaloveen that appear in some editions. For the reader's convenience we have added page references to the translation in the Loeb Classical Library where one exists, and in the case of Ptolemy's Almagest, to Toomer's translation. Quotations are our own translations unless otherwise noted.
Introduction

Ptolemy’s Geography is a treatise on cartography, the only book on that subject to have survived from classical antiquity. Like Ptolemy’s writings on astronomy and optics, the Geography is a highly original work, and it had a profound influence on the subsequent development of geographical science. From the Middle Ages until well after the Renaissance, scholars found three things in Ptolemy that no other ancient writer supplied: a topography of Europe, Africa, and Asia that was more detailed and extensive than any other; a clear and succinct discussion of the roles of astronomy and other forms of data-gathering in geographical investigations; and a well thought out plan for the construction of maps.

Ptolemy himself would not have claimed that the Geography was original in all these aspects. He tells us that the places and their arrangement in his map were mostly taken over from an earlier cartographer, Marinus of Tyre. Again, Ptolemy comprehended fully the superior value of astronomical observations over reported itineraries for determining geographical locations, but in this he was, on his own admission, anticipated by other geographers, notably Hipparchus three centuries earlier. Even so, he was too far ahead of his time in maintaining this principle to be able to follow it in practice, because he possessed reliable astronomical data for only a handful of places.

But in the technique of map-making Ptolemy claims to break new ground. He introduced the practice of writing down coordinates of latitude and longitude for every feature drawn on a world map, so that someone else possessing only the text of the Geography could reproduce Ptolemy’s map at any time, in whole or in part, and at any scale. He was apparently also the first to devise sophisticated map projections with a view to giving the visual impression of the earth’s curvature while at the same time preserving to a limited extent the relative distances between various localities.

At the very outset of the Geography, Ptolemy describes his subject as “an imitation through drawing of the entire known part of the world together with the things that are, broadly speaking, connected with it,” and the work’s Greek

1The geographer Strabo (1.1.12, Loeb 1:23–25) also ascribes to Hipparchus the opinion that the relative positions of widely separated places must be determined by astronomical observation.
title, Geògraphikò hypògraphèta, can be rendered as “Guide to Drawing a World Map.” The core of the Geography consists of three parts necessary for Ptolemy’s purpose: instructions for drawing a world map on a globe and on a plane surface using two new map projections (Book 1.22–24), a catalogue of localities to be marked on the map with their coordinates in latitude and longitude (2.1–7.4), and a caption or descriptive label (hypògraphè) to be inscribed on the map (7.5). As a supplement Ptolemy adds instructions for making a picture of a globe with a suitable caption (7.6–7), and describes a way of partitioning the known world into twenty-six regional maps, with a detailed caption for each (Book 8). The introductory chapters (1.1–21) set out fundamental principles for obtaining the data on which the world map is to be based, and necessary conditions for a good map projection; Ptolemy devotes much space here to criticism of his predecessor, Marinus.

For most modern readers, the parts of greatest interest will be those treating the theoretical questions and the relationship of Ptolemy’s work to that of his predecessors. The enormous catalogue of localities and their coordinates is chiefly of concern to specialists in the geography of various parts of the ancient world, for whom an edited Greek text is indispensable. Accordingly, our translation omits the geographical catalogue and the captions for the regional maps, although we have provided a specimen of each.

The plan of the Geography is, for such a long work, very simple; yet certain of its features have turned out to be pitfalls. First, there is Ptolemy’s characteristic parenthetic style of writing. His thoughts are continually being suspended partway through by qualifications and digressions, and completed only much later, which tends to give rise not only to long, elaborately nested sentences, but also to paragraphs of reasoning that sometimes extend over several chapter divisions. The reader who is not prepared for Ptolemy’s fondness for suspension and resumption of argument may be led to suspect that the text has been subjected to extensive interpolations, or even that Ptolemy did not know his own mind.

Another serious difficulty is presented by the chapters in Books 7 and 8 that are entitled hypògraphè, a word that has usually been interpreted as “description” (of a map). If they are read in the same way as the other narrative parts of the Geography, that is, as Ptolemy speaking to the reader, then it is not easy to see the reason for their presence in the text. Historians have been taxed to explain why these chapters repeat material presented elsewhere in the Geography, and why the hypògraphai for the twenty-six regional maps express the locations of cities according to a system of coordinates different from the latitudes and longitudes of the catalogue in Books 2–7. These apparent redundancies and inconsistencies, together with variations in the order and contents of the Geography as it is presented in the medieval manuscripts, have given rise to theories of the work’s origin that deny its integrity—for example, hypothesizing that Ptolemy wrote Book 8 long before the rest of the Geography, or even that the various parts of the work were originally separate compositions by perhaps several authors, united only in the Middle Ages under Ptolemy’s name. The scribes who furnished some of the medieval manuscripts of the Geography with maps comprehended the function of the hypògraphai, however: they rightly used them as captions to be “written below” (hypògraphèin) the maps. In these chapters Ptolemy is not addressing the cartographer; rather the cartographer is addressing the public. The hypògraphai should be understood as if within quotation marks, as part of the map-making kit.

A third obstacle is the degree to which different manuscripts diverge in the versions that they present of parts of the Geography, which is one reason why no satisfactory edition of the whole text of the work has been achieved in modern times. There can be no doubt that the Geography was badly served by its manuscript tradition; the most conscientious scribe was certain to introduce numerous errors in copying its inextricable lists of numbers and place names, and some copyists did not resist the temptation to “emend” the text. The instability of the textual tradition chiefly affects the geographical catalogue and the captions for the regional maps.

Our translation attempts to redirect the reader’s focus away from the topographical details of the map, as represented in the catalogue and the regional captions, to where we believe it belongs, which is on Ptolemy’s exposition of the theory and method of cartography. We accepted as a working hypothesis that the Geography as it has come down to us is a coherent, intelligent, and logically organized treatise that forms an integral part of Ptolemy’s scientific oeuvre and belongs to an identifiable stage in the development of his thought. The experience of interpreting and annotating the work has only confirmed our belief that this is the appropriate way to approach it.

What Ptolemy Expected His Reader to Know

In addition to the circumstances that we have already described that have tended to obscure Ptolemy’s purpose in writing the Geography, the book presents diff-

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5It is not clear to what extent Ptolemy was himself responsible for the traditional division of the Geography’s text into chapters. Toomer (1984, 51) has raised doubts about whether the chapter divisions of the Almagest are Ptolemy’s; and some of the chapter titles in the Geography break the text in awkward places or inadequately describe the contents.

6Talascsek (1990) is particularly given to hypotheses of this kind.

7On the regional hypògraphai in Book 8 see, for example, Roger 1903, 643–644; and on 7.7 (the hypògraphè to the picture of the zodiac globe), Neugebauer 1936, 20.

8For the first theory, see Schusbel 1939; for the second, Bagrow 1943.
difficulties for the modern reader that would not have been felt by readers of his own time. Sites to which he refers, which would have been instantly recognized by his contemporaries as thriving emporia and capitals of great kingdoms, are to most of us only names in a long list of places we have, at best, only read of as archaeological sites. Or, if they are known to the modern world, they often come to us cloaked in unrecognizable names, such as “Lake Maiotis” for the Sea of Azov or “Taprobane” for Sri Lanka. We have tried to lessen this last difficulty by providing the modern equivalents of places mentioned (when they can be identified) in the Geographical Index (Appendix II).

But Ptolemy writes against the background not only of a world that has vanished but also of a set of assumptions about the cosmos and its mathematical description, some of which are as foreign to the modern reader as are most of the localities he mentions. Accordingly, this section reviews the most important of Ptolemy’s cosmographical presuppositions and their meanings, drawing where possible on Ptolemy’s own treatment of these topics in his earlier astronomical treatise, the *Almagest*. We also discuss here the units of distance measurement and ways of describing directions that occur in the *Geography*.

**The Terrestrial and Celestial Spheres**

Ptolemy assumes that the reader understands and accepts the two-sphere model of the cosmos, that is, the geometrical conception of the heavens as an immense sphere that rotates daily around an axis through its center, with this center occupied by a second sphere, that of the earth (Fig. 1). The stars are thought of as fixed to the surface of the outer sphere, which is so vast that, as Ptolemy says in the *Almagest* (1.6, Toomer 43), “the earth has, so far as the senses can perceive, the relation of a point to the distance to the sphere of the so-called fixed stars.” The intersections of the axis of rotation with the sphere of the fixed stars define the north and south celestial poles, and, with respect to these directions, the daily rotation of the heavens is in a direction from east to west (i.e., clockwise if we imagine ourselves viewing the celestial sphere from outside and above its north pole). As a result of this daily rotation, the stars fixed to the surface of the celestial sphere trace out parallel circles, all centered on the poles, and the largest of these parallel circles is the equator, which is defined by the plane through the center of the cosmos and perpendicular to the axis.

**The Horizon**

Since the earth is a sphere, each locality on its surface admits a tangent plane, known as its horizon plane. However, Ptolemy reminds his readers in the *Almagest* (1.6, Toomer 43) that one of the reasons for regarding the earth as being so small relative to the cosmos is that the horizon plane seems to divide the celestial sphere into two exactly equal parts and could, therefore, be taken as passing through the center of the earth. The horizon, then, is another great circle of the cosmos, but it must not be thought of as rotating, for the earth did not rotate in the Ptolemaic cosmos. Rather, for a particular locality, the horizon is imagined as being fixed and therefore as making a fixed angle of inclination with the axis of rotation of the celestial sphere (Fig. 2).

**Parallels and Latitude**

This angle of inclination, known to Ptolemy as the latitude of a locality, varies with the location of the observer and determines which stars are capable of being seen. An observer at the north or south poles, whose latitude is 90°, would...
find that the equator coincides with the horizon and that stars north of the equator are always visible at night, and those south of the equator are always invisible. When the inclination is 0° (i.e., the horizon plane is parallel to the axis of the cosmos), the observer is on the earth's equator; both celestial poles are on the horizon, and all stars rise and set—each spending as much time above the horizon as below.

Ptolemy assumes, however, that his reader is at an intermediate latitude of the northern hemisphere, and for such a person the stars fall into three groups: stars that never set but are always above the horizon; stars that rise and set, and therefore are sometimes visible and at other times invisible, and stars that never rise and therefore are always invisible (Fig. 3). Separating these three groups of stars on the celestial sphere are two parallel circles of equal size. The one, to the viewer's north, separates the stars that never set from those that set and rise and is known as the greatest of the always visible circles. The other, to the viewer's south, separates the stars that never rise from those that set and rise and is known as the greatest of the always invisible circles. The two points where these circles touch the horizon mark due north and south for the observer, and the intersections of the equator with the horizon mark the points due east and west of the observer. Thus for the ancient geographers, geographical directions were in the first instance defined astronomically.

As one proceeds northward from the equator, the circle of ever-visible stars grows until, at the north pole, it coincides with the horizon. Simultaneously, the circle of always invisible stars also increases. Consequently, it can be demonstrated that locality A is north of locality B if some star in the northern hemisphere is always visible at A but rises and sets at B, or if some star that cannot be seen at A rises and sets at B.

These are just two astronomical criteria among many that may be used to judge how far north of the equator a locality is. Because all these phenomena remain unaltered if one travels due east or west on the earth's surface, they define a parallel of latitude, that is, a circle on the terrestrial sphere parallel to the equator. The concept of identifying the phenomena characteristic of all localities having the same latitude, i.e., lying along the same parallel, had been known to geographical writers since the fourth century B.C., and Ptolemy specifically refers to it at several places in the Geography (1.2, 1.7, and 1.9). In Almagest 2.1 (Toomer 75–76) he lists as being among the more important phenomena characteristic for a latitude:

1. the elevation of the north or south celestial pole above the horizon;
2. whether, at any time during the year, the sun passes directly overhead;
3. the ratio of an upright stick (grōnos) to its shadow on the longest and shortest days of the year, as well as on the equinoxes; and
4. the amount by which the longest day of the year exceeds the equinoctial day, or equivalently, the ratio of the longest day of the year to the shortest, or simply the length of the longest day, measured in uniform time units.

In Almagest 2.6 (Toomer 82–90) Ptolemy adds two further phenomena to this list:

5. whether shadows in a given locality can point both north and south at different times of the year; and
6. which stars are always visible, which stars rise and set, and which stars can be directly overhead.

Phenomena (2) and (5) determine the latitude only within certain bounds. However, given any one of (1), (3), (4), and (6), we can determine the latitude and all the other phenomena, so that it is sufficient to specify any one of these three for a given locality. Ptolemy's basic datum is often the length of daylight; hence his principal parallels are chosen at constant increments of longest day. The latitudes corresponding to the regular sequence of increments in daylight are not equally spaced, but become more crowded the further we get from the equator. For this reason Ptolemy uses quarter-hour increments until he reaches the parallel for which the longest day is 15½ hours, and increments of half an hour thereafter until he reaches the parallel that he believes marks the northern limit of the known world, where the longest day is twenty hours. Some of

*Analogous rules apply to places south of the equator (none are involved in the Geography).
*The traveler Pythias of Massalia (c. 350 B.C.) reported polar elevations and lengths of longest day for several of the places in northwestern Europe that he claimed to have visited; see Dicks 1960, 160, 165–167.
Ptolemy’s principal parallels, including those that mark the southern and northern limits of the part of the world covered by his map, are shown in Figure 4.

Ptolemy’s highlighting of a sequence of unequally spaced parallels defined by the maximum length of day instead of parallels at uniform intervals of, say, 5° seems awkward from a modern perspective, but reflects the traditional practice of Greek geography. Earlier writers often made use of a division of the Greco-Roman world into latitudinal strips, or klimata (sing. klima), such that within each klima the maximum length of day was supposed not to vary significantly. (Klima means “inclination,” signifying the angle between the axis of the celestial sphere and the plane of the horizon.) The lists of klimata that are found in various classical authors vary in the range of latitudes that they cover, although the number of klimata was by convention seven, counted from south to north. Ptolemy generally eschews the klimata in his own astronomical and geographical writings, but they figured in the work of his predecessor Marinus.

Meridians and Longitude

Intervals of time are also fundamental in the division from east to west. If we imagine a plane containing the north-south axis and passing through a locality on the earth’s surface, this plane will intersect the terrestrial sphere in a great circle called a meridian. All places on the same meridian will observe the sun’s noon crossing of the meridian plane at the same time. Whereas latitude is readily defined by taking the arc of any meridian cut off between a special parallel, the equator, and a given parallel, there is no natural counterpart of the equator among the meridians from which the longitude, or angle to the other meridians, should be measured. By convention Ptolemy chooses to count longitudes eastward from the meridian at the western limit of the world known to him, and he writes (1.23) that “it is appropriate to draw the meridians at intervals of a third of an equinoctial hour,” that is, at intervals of 5°. Thus it is fundamentally a net of time, not of degrees, that Ptolemy casts over the earth (Fig. 5).

The Ecliptic

An important great circle on the celestial sphere, and rotating with it, is the ecliptic, which Ptolemy refers to either as “the zodiacal circle” or as “the circle through the middle of the signs [of the zodiac].” The sun traverses this circle annually at an average rate of just under a degree each day, from west to east relative to the stars—that is, opposite to the daily rotation of the celestial sphere.

Since the ecliptic is the central circle of the belt of signs making up the zodiac, it inherits that belt’s division into signs—the familiar Aries, Taurus, Gemini, etc., shown in Figure 6. The annual eastward progress of the sun is counterclockwise in the diagram. The signs are each 30° in length, and so coincide only approximately with the constellations for which they are named.

Since the ecliptic is a great circle like the equator, it intersects the equator in two diametrically opposite points: the beginning of Aries, where the sun is at the spring equinox, and the beginning of Libra, where the sun is at the autumnal equinox. The ecliptic is tilted at an angle of about 24° with respect to the celestial equator, and so there is a most northerly point on the ecliptic, located...
at the beginning of the zodiacal sign of Cancer, and a most southerly point, at
the beginning of the sign of Capricorn. The circles on the celestial sphere that
are parallel to the equator and that pass through these two points are known,
respectively, as the Tropic of Cancer (or Summer Tropic) and the Tropic of Cap-
ricorn (or Winter Tropic). As the sun travels annually around the ecliptic, it
moves alternately north and south of the equator, with the two tropic circles as
the limits of this motion (Fig. 7).

The center of the earth is the center of the cosmos; hence it may be used to
define “down” in the cosmos as toward the center of the earth and “up” as away
from the center. With this understood, one can imagine for the equator and
tropic circles on the celestial sphere a corresponding circle directly below it on
the earth, and we shall follow the Greeks in using the same names for the
terrestrial circles as for their celestial counterparts. The terrestrial tropics are
limiting circles for one of the varieties of astronomical phenomena used to de-
termine latitude: only for observers in the belt between them does the sun pass
directly overhead in the course of the year.

Another pair of circles closer to the terrestrial poles have a corresponding
limiting role for a different latitudinal phenomenon. For observers at these circles,
the length of the longest day of the year just reaches its greatest possible value,
twenty-four hours, so that between these circles and the poles there will be
some days of the year when the sun never sets. The limiting circle surrounding
the north pole is the arctic circle, and its southern counterpart is the antarctic
circle. Each is as far from its pole as the tropics are from the equator.

Climatic Zones

Although the various circles on the celestial sphere are primarily of astronomi-
cal significance, some ancient geographers used the corresponding circles on
the earth’s surface to divide the earth into zones with geographical, and even
climatic, significance. Thus, according to Aristotle (Meteorology 2.5, 363b32, Leob
179–181), there were two “frigid” zones (one north of the arctic circle and one
south of the antarctic circle), two “temperate” zones (between the frigid zones
and the two tropics), and a torrid zone (located between the tropics). It appears
from 1.7 that Marinos set the limits of the torrid zone at a bit more than 12°
north and south of the equator—as did Poseidonius before him.\(^5\) Ptolemy oc-
casionally makes use of the principle that climate (including the range of plant
and animal life and the appearance of the human inhabitants) is dependent on
latitude to deduce that localities sharing the same climate must be at approxi-
mately the same distance from the equator.

Ptolemy also uses an even simpler division of the earth’s surface, based on
shadows rather than climata. At localities between the two tropics the noon
sun would be, according to the time of the year, sometimes to the north and
sometimes to the south of the zenith, so that the corresponding shadows of a
vertical rod (gnomón) would, during the course of the year, point north on one
day and south on another. (Thus the regions are referred to as emphoskeon,
for the Greek word signifying that the shadows point in both directions, north
and south, during the course of a year.) For persons exactly on the tropic circles,
the noon shadows would point always north or always south, with the exception of
one day of the year on which there is no noon shadow. At localities between the
tropics and the arctic or antarctic circles, noon shadows will always point north
or always point south. Such localities are known as heteroskeion. Finally, at lo-
calities between the poles and the arctic or antarctic circles, there will be a part
of the year during which the gnomon’s shadow makes a complete circuit around
it. These localities, called periskion, play no role in the Geography.\(^6\)

\(^5\) Strabo (2.2.1–2.2.1, Leob 1:361–371) has a very interesting discussion of geographical zones.
\(^6\) See the discussion in Almagest 2.6 (Toomer 89–90) and Strabo 2.5.43 (Leob 1:517–521).
Degrees
Ptolemy makes use of the degree as a unit for measuring arcs along meridian circles and parallels of latitude. This unit, which had its origin in the Babylonian practice of dividing both the day and the zodiac into 360 equal parts, was already being applied by the Greeks to circles on the celestial and terrestrial spheres in Hipparchus' time. Ptolemy, however, seems to have been the first geographer to establish a uniform coordinate system in degrees for specifying precise positions on the earth's surface. This system was devised on analogy with a conventional astronomers had long been using to specify positions of stars and planets on the celestial sphere by two numbers: a latitude ("breadth") above or below the ecliptic, and a longitude ("length") measured along the ecliptic from a conventional zero point. For geographical purposes the equator replaces the ecliptic, and Ptolemy measures latitude north or south from the equator to a locality along a meridian circle, and longitude along the equator between that meridian and the meridian passing through the westernmost place on his map (the Islands of the Blest). Compared to the divisions of the globe based on celestial phenomena, the coordinates of latitude and longitude had the practical advantage for the cartographer of precision and uniformity of units. Nevertheless Ptolemy preferred that the finished map and its captions should express everything in terms of hour divisions and the other fundamental, astronomically defined circles.

Units of Distance
Measured linear distances from place to place were expressed in several different kinds of unit in the various sources on which Marinus and Ptolemy drew. The most important of these units was the stade, the standard unit of terrestrial distance in classical geography, which was probably understood by Ptolemy and his predecessors as a distance amounting to approximately 185 meters. Stades could be converted into degrees according to the assumed equivalence of 500 stades to one degree measured along the equator or along a meridian. Distances from Roman sources, for example those pertaining to the Roman roads, would be expressed in the Roman mile (approximate 1.48 kilometers), which was usually treated as interchangeable with eight stades. In Egypt distances could be stated in the schoinos, which Ptolemy takes to be thirty stades. For the roads of the Ptochian Empire the old Persian parasang was used, this was near enough in length to the schoinos so that in Ptolemy's sources the Egyptian name is substituted, and the same ratio is applied to convert to stades.

Directions
Ptolemy alludes to two ways of describing directions of travel, one based on the points of the horizon where the sun rises and sets, the other based on conventional names of the winds that blow from various directions. On the vernal and autumnal equinoxes, the sun is seen to rise due east of an observer, and to set due west. Hence these directions are sometimes called the directions of equinoctial sunrise and sunset. During the half of the year when the sun is north of the equator, which includes the summer for the northern hemisphere, the points of sunrise and sunset on the horizon are north of due east and west, reaching an extreme limit on the summer solstice; and similarly the rising and setting points are furthest south of due east and west on the winter solstice. Ptolemy refers to these directions as the directions of the sun's summer or winter rising or setting. In fact, they are not the same for observers at different latitudes: at the equator they are approximately 24° from due east and west, but the angles become larger as one moves further away either north or south. Ptolemy treats them, however, as being 30° from the east-west line regardless of the latitude; this is approximately correct for the latitude of Rhodes, which was traditionally thought of as the central east-west axis of the known world.

Additionally, Ptolemy and his sources use a scheme of twelve winds to specify directions. Four of these are equivalent to the cardinal directions, north, south, east, and west. The remainder are treated as equally spaced at 30° intervals between the cardinal directions, so that for Ptolemy the system based on the sun's rising and setting points is largely interchangeable with the system based on winds. The whole scheme is illustrated in Figure 8 (wind names in parentheses do not occur in the Geography). Note that the arrowheads indicate the direction of travel toward the designated wind, which is of course opposite to the direction from which the wind is supposed to blow.

![Diagram of wind directions](image-url)
Conversion of Distance Measurements to Degrees

Ptolemy often has to translate a given interval between two localities, expressed as a number of units of distance in a particular direction, into the number of degrees of longitude between the meridians through the two localities and the number of degrees of latitude between their parallels. His procedure sometimes involves several stages.

a. If a locality A is $s$ stades due north of another locality B, or vice versa, they lie along the same meridian (Fig. 9). Since a meridian is a great circle, Ptolemy uses the assumed equivalence of one degree with 500 stades along a terrestrial great circle. The difference in degrees between their latitudes is $s/500$.

b. If locality A is $s$ stades due west of locality C, or vice versa, they lie along the same parallel (Fig. 9). Since a parallel is not a great circle (unless it happens to be the equator), Ptolemy has to find the number of stades corresponding to $1^\circ$ along the parallel, which is in the same ratio to 500 as the circumference of the parallel is to the circumference of the equator. Suppose that the latitude of A and C is $\phi$ degrees. The circumference of the parallel at latitude $\phi$ is $\cos \phi$ times the circumference of the equator. Thus the difference in degrees between the longitudes of A and C is $s/(500\cos \phi)$.

c. If A is $s$ stades from D in some intermediate direction (Fig. 9), we must analyze the interval between them into north-south and east-west components, AC and CD respectively. In doing this, Ptolemy neglects for the moment the sphericity of the earth; that is, he regards the spherical triangle ACD as so small relative to the earth that it may be treated as a plane triangle with a right angle at C. Let the horizon angle between AD and the parallel through A (i.e., angle CAD) be $\theta$. Then the east-west component of the interval in stades is $s(\cos \theta)$, and the north-south component is $s(\sin \theta)$. Each component is separately converted to intervals in degrees as described above.

Ptolemy would not have employed the modern trigonometrical functions $\sin$ and $\cos$, but rather the "chord" function, which is the length of a chord subtended by a given angle in a circle of radius 60. A table of chords as a function of angles is presented in Almagest 1.11. What we call $\cos \theta$, Ptolemy would have calculated as chord $(180^\circ - 2\theta)/120$.

d. We have assumed that we know the direct-line distance between A and B. Ptolemy recognizes, however, that distances estimated by travelers generally are longer than the most direct route. One reason for this was that the route taken was not always straight; for example, mariners would follow the outlines of bays rather than sail straight across. Moreover, distances expressed in stades were sometimes calculated from the time taken in making the journey by multiplying by an assumed ideal rate of travel, but this would lead to an exaggerated figure if there had been delays on the route. Ptolemy allows for these tendencies in a very arbitrary way, typically by reducing a reported stade distance by one-third. Thus Ptolemy's analysis of a reported interval from one place to another can often involve steps (d), (c), and (a) and (b), in that order.

The Place of the Geography in Ptolemy's Work

Ptolemy (or, to give his full name, Claudios Ptolemes) was born about a.d. 100 and began his scientific career in the mid-120s, working in or near Alexandria in Egypt. He probably lived into the last quarter of the century. Ptolemy's incitement to determine numerical coordinates for geographical locations throughout the known world may have come from the astronomical researches with which his scientific career began, and for which he is now best known.

We can see this origin in the Almagest. Ptolemy's great treatise on the mathematical theory of the motions of the heavenly bodies, which is generally regarded as his earliest major writing. The Almagest is concerned with the apparent motions of the sun, moon, planets, and fixed stars, how to account for them quantitatively by means of models involving combinations of circular motions, and how to compute the instantaneous positions of the heavenly bodies and other celestial phenomena using tables based on these models. Geographical considerations arise in various ways in the execution of Ptolemy's project, most obviously in the fundamental problem of converting the recorded times of astronomical observations made in different places to Alexandria mean time. The same astronomical event will be observed in two places of different longitude at different intervals of time since the preceding local noons, and this difference is proportional to the difference in longitude between the two places. Moreover, ancient observers did not measure the times of observations in constant equinoctial hours after noon or midnight. Instead they divided the two intervals between sunrise and sunset and between sunset and sunrise into twelve equal seasonal hours, and described observations as having occurred at such-
1. On the difference between world cartography and regional cartography

World cartography is an imitation through drawing of the entire known part of the world together with the things that are, broadly speaking, connected with it. It differs from regional cartography in that regional cartography, as an independent discipline, sets out the individual localities, each one independently and by itself, registering practically everything down to the least thing therein (for example, harbors, towns, districts, branches of principal rivers, and so on), while the essence of world cartography is to show the known world as a single and continuous entity, its nature and how it is situated, [taking account] only of the things that are associated with it in its broader, general outlines (such as gulfs, great cities, the more notable peoples and rivers, and the more noteworthy things of each kind).

The goal of regional cartography is an impression of a part, as when one makes an image of just an ear or an eye; but [the goal] of world cartography is a general view, analogous to making a portrait of the whole head. That is, whenever a portrait is to be made, one has to fit in the main parts [of the body] in a determined pattern and an order of priority. Furthermore the [surfaces] that are going to hold the drawings ought to be of a suitable size for the spacing of the visual rays at an appropriate distance [from the spectator], whether the drawing be of whole or part, so that everything will be grasped by the sense [of sight].

1 We thus translate geographia in accordance with the restricted sense that Ptolemy defines for the word in this chapter. "Regional cartography" represents Ptolemy's chirographia. Other Greek authors, such as Strabo, use geographia to mean a written geographical work.

What Ptolemy is asserting is that when making any picture, one should decide how big it should be in accordance with the level of detail and the expected distance of the spectator. He expresses the fact that the eye perceives less detail with greater distance in terms of the concept of visual rays found in Euclid's Optics. The rays were supposed to radiate from the eye to the object of vision and to transmit color to the eye. Euclid assumes that there are a finite number of rays separated by spaces that widen with increasing distance from the eye; the gaps explain loss of resolution when one views an object at a distance. In his own Optics, Ptolemy rejects these discrete rays in favor of a continuous visual cone that emanates from the eye. See Smith 1986, 91–92.
In the same way, reason and convenience would both seem to dictate that it should be the task of regional cartography to present together even the most minute features, while world cartography should present the countries themselves along with their grosser features. This is because with respect to the oikoumenē it is the geographical placements of countries that are the main parts, [namely] the ones that are well placed and of suitable sizes [for a map], whereas the various things contained in these [countries have the same relationship] with respect to [the countries themselves].

Regional cartography deals above all with the qualities rather than the quantities of the things that it sets down; it attains everywhere to likeness, and not so much to proportional placements. World cartography, on the other hand, [deals] with the quantities more than the qualities, since it gives consideration to the proportionality of distances for all things, but to likeness only as far as the coarser outlines [of the features], and only with respect to mere shape. Consequently, regional cartography requires landscape drawing, and no one but a man skilled in drawing would do regional cartography. But world cartography does not [require this] at all, since it enables one to show the positions and general configurations [of features] purely by means of lines and labels.

For these reasons, [regional cartography] has no need of mathematical method, but here [in world cartography] this element takes absolute precedence. Thus the first thing that one has to investigate is the earth's shape, size, and position with respect to its surroundings [i.e., the heavens], so that it will be possible to speak of its known part, how large it is and what it is like, and moreover so that it will be possible to specify under which parallels of the celestial sphere each of the localities in this [known part] lies. From this last, one can also determine the lengths of nights and days, which stars reach the zenith or are always borne above or below the horizon, and all the things that we associate with the subject of habitations.¹

¹Literally, "the inhabited [part of the world]."
²This technical term of Greek geography is sometimes used interchangeably with "the known part of the world," although the concepts are not strictly equivalent.
³This passage makes it clear that the "regional cartography" that Ptolemy has in mind not only covers smaller areas of the world than his world cartography, but also follows different principles. It seems to have been something closer to landscape drawing, incorporating lifelike images of features of the area portrayed. The closest counterparts we have from antiquity are mosaic maps such as the Madaba mosaic; see Dike 1985, 148–153.
⁴Ptolemy uses the term "mathematic" not only for the abstract sciences of numbers and geometry but also for subjects such as optics, harmonics, and astronomy, in which physical objects are investigated from the point of view of their mathematical properties.
⁵Literally, "below the earth."
⁶Habitations (οἰκήσεις) means the determination of the astronomical phenomena characteristic for particular terrestrial latitudes. Book 2 of the Almagest is largely devoted to a theoretical treatment of this topic.

These things belong to the loftiest and loveliest of intellectual pursuits, namely to exhibit to human understanding through mathematics [both] the heavens themselves in their physical nature (since they can be seen in their revolution about us), and [the nature of] the earth through a portrait (since the real [earth], being enormous and not surrounding us, cannot be inspected by any one person either as a whole or part by part).⁸

2. On the prerequisites for world cartography

We shall let this serve as a brief sketch of the purpose of anyone who would be a world cartographer, and how he differs from the regional cartographer. Our present object is to map our oikoumenē as far as possible in proportionality with the real [oikoumenē]. But at the outset we think it is necessary to state clearly that the first step in a proceeding of this kind is systematic research, assembling the maximum of knowledge from the reports of people with scientific training who have toured the individual countries; and that the inquiry and reporting is partly a matter of surveying, and partly of astronomical observation. The surveying component is that which indicates the relative positions of localities solely through measurement of distances; the astronomical component [is that which does the same] by means of the phenomena [obtained] from astronomical sighting and shadow-casting instruments.⁹ Astronomical observation is a self-sufficient thing and less subject to error, while surveying is cruder and incomplete without [astronomical observation].

For, in the first place, in either procedure one has to assume as known the absolute direction of the interval between the two localities in question, since it is necessary to know not merely how far this [place] is from that, but also in which direction, that is, to the north, say, or to the east, or more refined directions than those. But one cannot find this out accurately without observation by means of the aforesaid instruments, from which the direction of the meridian line [with respect to one's horizon], and thereby [the absolute directions] of the traversed intervals, are easily demonstrated at any place and time.

⁸This rather obscure peroration entertains two ideas: that astronomy and geography are parts of a single rational science, and that whereas astronomy can make its demonstrations using the heavens themselves as a visible object of study, geography must make use of maps. We are inside the celestial sphere, and can behold half of it at once. By way of contrast, our position on the surface of the earth prevents us from taking in the earth's form at a glance, and it is too large for any single person to explore.
⁹A sighting instrument (astronomon) is one that permits the direct measurement of the apparent position of a heavenly body through a dioptra, for example, Ptolemy's armillary spheres (the astroblemos described by Ptolemy in Almagest 7, 1 or the meteoroepereon mentioned below in 1.3). A shadow-casting instrument could be a simple goēa or upright stick, used to determine the sun's altitude.
In the next place, even when this [direction] has been given, having a measurement of distance in stades does not guarantee that the [interval] we find is the correct one, because one seldom encounters rectilinear journeys on account of the numerous diversions that are involved in both land and sea travel. For land journeys one has to estimate the surplus [in the reported distance] corresponding to the kind and magnitude of the diversions and subtract this from the total of stades to find the [number of stades] of the rectilinear [route]. For sea journeys one also has to account for the variation in speed corresponding to the blowing of the winds, since at least over long periods these do not maintain constant force. But even if the interval between the localities traveled through has been accurately determined, this does not also yield its ratio to the whole circumference of the earth, or its position with respect to the equator and poles.

The [method] using the [astronomical] phenomena determines each of these things accurately, since it shows the magnitudes of the arcs that the parallel and meridian circles drawn through the given localities cut off on each other—the arcs, that is, that the parallels [cut off on the meridians] between themselves and the equator, and those that the meridians cut off between themselves on the equator and on the parallels. [The astronomical method] also reveals the size of the arc that the two localities cut off along the great circle drawn through them on the earth. [This method] does not even need reckoning in stades, either to get the ratios of the earth's parts [with respect to each other and the whole], or in the entire process of map-making. It is enough to assume that [the earth's] circumference comprises any arbitrary number of units, and then to show how many [such units] make up the specific intervals along the great circles drawn on the earth.

Admittedly, [the astronomical method] will not [also be able to yield] the division of the whole circumference or its parts into the established and familiar measures of length [used in] our distance measurements. For this sole reason it has been necessary to match a single rectilinear route [on the earth] to the [geometrically] similar great-circle arc on the surrounding [celestial sphere] and, having determined the ratio of this [arc] to the circle by means of the [astronomical] phenomena, and the number of stades in the route beneath it by means of distance measurement, to produce from the given part [of the circumference] the number of stades in the whole circumference. For it has already been mathematically determined that the continuous surface of land and water is (as regards its broad features) spherical and concentric with the celestial sphere [Almagest 1.4–5], so that every plane produced through the [common] center makes as its intersections with the aforesaid surfaces [of the terrestrial and celestial spheres] great circles on [the spheres], and angles in [this plane] at the center cut off similar arcs on [the celestial and terrestrial great] circles. As it happens, although the number of stades in intervals on the earth (if they are straight) can be determined from distance measurements, their ratio to the whole circumference cannot be determined at all from [distance measurements] because of the impossibility of making the comparison. But [this ratio can be determined] from the similar arc of the circle on the surrounding [celestial sphere], because one can determine the ratio of this [similar arc] to the circumference [i.e., the great circle] to which it belongs, and this [ratio] is the same as that of the similar segment along [the surface of] the earth to the great circle on [the earth].

3. How the number of stades in the earth's circumference can be obtained from the number of stades in an arbitrary rectilinear interval, and vice versa, even if [the interval] is not on a single meridian

Now, our predecessors looked not just for a rectilinear interval on the earth to treat as an arc of a great circle, but also one that was directed in the plane of a single meridian. Using shadow-casting instruments, they observed the zenith points at the two ends of the interval, and obtained directly the arc of the meridian cut off by [the zenith points], which was geometrically similar to [the arc] of the journey [between the two locations]. This is because these things were set up (as we said) in a single plane (since the lines produced through the two ends of the journey) to the zenith points intersect), and because the point of intersection is the common center of the circles. Hence they assumed that the fraction that the arc between the zenith points was seen to be of the circle through the [celestial] poles [i.e., the common meridian of the two locations] was the same fraction that the interval on the earth was of the whole [earth's] circumference.

We, however, have established by means of the construction of a meteoroscopic instrument that [the same] object can be achieved even if we

3Posidonius means that because of the immensity of the terrestrial globe, one cannot directly measure its circumference or apprehend that a given measured distance is a particular fraction of the whole circuit.

4I.e., one place of observation was assumed to be due south of the other. This is true of Eratosthenes' famous measurement of the size of the earth based on the interval from Alexandria to Syene, as well as the similar method ascribed to Posidonius, based on the interval from Alexandria to Rhodes. See Neugebauer 1975a, 215–15; 555–59; and Taisbak 1974.

5Posidonius described his "meteoroscope" (meteoroiskopion) in a lost work known to us through references by Ptolemy and Pappus. It was an armillary sphere with nine rings, i.e., two more than the astrolabium of the Almagest. Posidonius' armillary sphere had three rings for the ecliptic system, three for the equator system, and one sliding ring for sighting. From the present context it is clear that Posidonius had added to his earlier instrument further rings for the horizon system. For an attempted reconstruction and discussion of how the instrument could have performed the tasks described in this chapter, see Rome 1927.
4. That it is necessary to give priority to the [astronomical] phenomena over [data] from records of travel

These things being so, if the people who visited the individual countries had happened to make use of some such observations, it would have been possible to make the map of the oikoumenē with absolutely no error. But Hipparchus alone has transmitted to us [observed] elevations of the [celestial] north pole for a few cities, i.e., few when compared to the multitude of [cities] to be recorded in the world cartography, and [lists of] the [localities] that are situated on the same parallels. And a few of those who came after him [have transmitted] some of the localities that are "opposite situated" (not [meaning] those that are equidistant from the equator, but simply those that are on a single meridian, based on the fact that one sails from one to another of them by Apariktias or Notos winds). Most intervals, however, and especially those to the east or west, have been reported in a cruder manner, not because those who undertook the researches were careless, but perhaps because it was not yet understood how useful the more mathematical mode of investigation is, and because no one bothered to record more lunar eclipses that were observed simultaneously at different localities (such as the one that was seen at Arbōlia at the fifth hour and at Carthage at the second hour), from which it would have been clear how many equinoctial time units separated the localities to the east or west. It would therefore also be reasonable for one who intended to practice world cartography following these [principles] to give priority in his map to the [features] that have been obtained through the more accurate observations, as foundations, so to speak, but to fit [the features] that come from the other [kinds of data] to these, until their positions with respect to each other and to the first [features] stand as much as possible in agreement with those reports that are less subject to error.

5. That it is necessary to follow the most recent researches because of changes in the world over time

The foregoing would provide a plausible basis for the project of drawing a map. But in all subjects that have not reached a state of complete knowledge, whether because they are too vast, or because they do not always remain the same, the passage of time always makes far more accurate research possible; and such is the case with world cartography, too. For the consensus of the very reports that have been made at various times is that many parts of our oikoumenē have not reached our knowledge because its size has made them inaccessible, while other [parts] have been described falsely because of the carelessness of the people who undertook the researches; and some [parts] are themselves different now from what they were before because features have ceased to exist or have changed. Hence here [in world cartography], too, it is necessary to follow in general the latest reports that we possess, while being on guard for what is and is not plausible in both the exposition of current research and the criticism of earlier researches.

6. On Marinos' guide to world cartography

Marinos of Tyre seems to be the latest [author] in our time to have undertaken this subject, and he has done it with absolute diligence. He has clearly laid his
hands on numerous records of research besides those that had come to knowledge still earlier, and treated those of nearly all his predecessors with care, giving appropriate correction to everything that he found that either they or he himself, at first, had trusted without good reason, as can be seen from his publications of the revision of the geographical map, which are numerous.

Now if we saw no defect in his final compilation, we would content ourselves with making the map of the αἰκούμενα on the basis of these writings alone, without taking any more trouble about it. Since, however, even he turns out to have given assent to certain things that have not been creditably established, and in many respects not to have given due thought to the method of map-making, with a view either to convenience or to the preservation of proportionality, we have justifiably been induced to contribute as much as we think necessary to the map's work to make it more logical and easier to use. We will do this as concisely as possible, starting with a brief examination of each kind of thing that needs some comment.

And the first of these is about the research on the basis of which he thinks the longitudinal dimension of the known world has to be increased to the east, and its latitudinal dimension to the south. For we can reasonably call the dimension of the surface in question [i.e., of the αἰκούμενα] from east to west "longitude," and that from north to south "latitude," since we call the [dimensions] that are parallel to these in the celestial motions by the same names, too, and because in general we use "longitude" [i.e., "length"] for the greater dimension, and it is agreed by absolutely everybody that the dimension from east to west of the αἰκούμενα, too, is much greater than that from north to south.

7. Revision of Marinus' latitudinal dimension of the known world on the basis of the [astronomical] phenomena

First, in the case of the latitudinal dimension, Marinus, too, assumes [as we do] that the island of Thulē is on the parallel that marks the most northerly limit of our known world and shows as best he can that this parallel is approximately 63° from the equator (where the meridian circle is 360°), 39 or 31,500 stades [from the equator] (assuming that a degree contains approximately 500 stades). 30 Then he sets the country of the Athiopians called Agisymba, and Cape Prason, on the parallel that marks the southernmost limit of the known world, and he puts this at the Winter Tropic [circle]. Hence, according to him, the whole latitudinal dimension of the αἰκούμενα (adding the interval between the equator and the Winter Tropic [to the 63°]) amounts to approximately 87°, or 43,500 stades. He tries to show that [his] southern limit is plausible both by certain [astronomical] phenomena (as he supposes them to be) and by the records of land and sea journeys. Each of these has to be examined for excess.

As to the phenomena, he says the following in the third [book of his] compilation (I quote): "For in the torrid zone the ecliptic passes overhead so that shadows alternate there, 32 and all the stars set and rise, except for Ursa Minor. The whole of [Ursa Minor] begins to be always visible when one is 500 stades north of Okellis. This is because the parallel through Okellis is elevated 11° north of the equator, and Hipparchus reports that the southernmost star of Ursa Minor (the last of the tail [υ UMi]) is 12° 30' from the pole. 33 Moreover, when one is going from the equator toward the Summer Tropic, the north pole is always elevated above the horizon, while the south pole is below the horizon; but when one is proceeding from the equator toward the Winter Tropic, the south pole is raised above the horizon, while the north pole is below the horizon." Now in these words he is describing merely what ought to occur in locations on the equator or between the tropics; but he does not tell us whether there has actually been any research into the phenomena on [parallels] south of the equator, for example, that somewhere some stars that are south of the [celestial] equator reach the zenith, or that noon shadows point south at the equinoxes, or that all the stars of Ursa Minor rise or set, or even that some of them are not visible at all, whereas the south pole is above the horizon. 34

32 By "alternate," Marinus means "point sometimes north and sometimes south," i.e., the torrid zone falls within the belt of the globe between the two tropics (see pp. 12–13). The subsequent statement that some of the stars of Ursa Minor are not visible within the torrid zone sets the northern limit of this zone at a latitude equal to approximately 12° 30' north of the equator, that is, one degree, or 500 stades, north of Okellis.

33 For an observer at a terrestrial latitude φ north of the equator, a particular star will never set if the arc between it and the north celestial pole (i.e., 90° minus its declination) is less than φ. The star of the constellation Ursa Minor that was farthest from the pole in Marinus' time was υ UMi, the "last star of the tail," now commonly known as Polaris. Marinus cites Hipparchus as having stated that υ UMi is 12° 30' from the pole, from which he concludes that the southernmost latitude at which the star never sets is 12° 30' N, and this is one degree north of his latitude for Okellis. It is noteworthy that Marinus was not aware that the precessional motion of the stars slowly changes their declinations; and Ptolemy, who was aware of this phenomenon (cf. Almagest 7.3), does not draw attention to it here since it does not materially affect his criticism. In 158 a.d., the approximate date of Hipparchus' observations, υ UMi was 12° 28' from the pole, in good agreement with his measurement. By a.d. 100 its distance was only 11° 13', so that Marsilius should have set the limit of the torrid zone at the latitude of Okellis or very slightly to the south. In our time υ UMi has of course become the northernmost bright star, being less than 4° from the pole.

34 Ptolemy does not doubt that these phenomena would actually be observed by someone south of the equator, but in this and the following sentences he denies, first, that any observations that would indicate a place lies south of the equator have ever actually been recorded, and second, that the phenomena Marinus describes are unique to places south of the equator.
In what follows he does adduce some observed phenomena, but not such as can prove his thesis in the least. Thus he says: "The people from India who sail to Limyriki (as Diodorus of Samos says in his third book) see Taurus in midheaven and the Pleiades along the middle of the yard.

Those who set sail from Arabia to Azania direct their sail towards the south and the star Canopus [α. Car], which is called Hippos [i.e., 'horse'] there and is in the extreme south. Stars are visible to them that we have no name for; and Sirius [α CMa] rises before Procyon [α CMi], 24 and all of Orion before the summer solstice." Now, some of these phenomena too clearly indicate habitations north of the equator (such as Taurus and the Pleiades being at zenith, since these stars are north of the [celestial] equator), while the others no more [indicate] southern [habitations] than northern. Thus Canopus can be visible to people quite far north of the Summer Tropic, and many stars that are always below the horizon for us can be above the horizon in locations south of us but still north of the equator, such as [locations] near Merese, just as Canopus itself can [be seen] here [at Alexandria] though it is not visible to people north of us. 25 And yet the more southern peoples give the name Hippos to this [star], and not to some other [star] unknown to us. [Marinos] himself adds that by mathematical arguments it has been established that all of Orion is visible to people living on the equator before the summer solstice; and Sirius begins to rise before Procyon for those living on the equator, and as far [north] of them as Soene. 26 Hence neither of these phenomena is a particular characteristic of the habitations south of the equator.

3The first part of this sentence is puzzling, since Limyriki is part of India, and it would be strange to speak of sailing "from India to Limyriki." We take the phrase as an indication of the origin of the mariners, not where they began their journey. Dible (1974, 11) sees it as a relic of a stage in earlier Greek exploration of the Indian Ocean when Limyriki was not yet thought of as part of India.

4Possibly, "Canus Major rises before Canis Minor," since the stars bear the same names in Greek as the constellations that contain them. As Marinos' next example shows, the risings discussed in this passage are the heliacal risings, i.e., the dates in the year when stars or constellations first become visible near the eastern horizon just before dawn.

5Canopus does not rise above the horizon for an observer north of 37°, so that it would be visible in Egypt, but not Greece.

6Ptolemy's criticisms of Marinos are not intended to be obvious, but would need to be confirmed by a work such as Ptolemy's Almagest or his Phainon (a calendar of risings and settings of a selection of bright stars). According to the Phainon (Heiberg 1907, 59), Procyon is first visible in the morning at the latitude of Soene about July 13, just three days before Sirius at the equator; Sirius is seen earlier. Similarly, the stars of Orion would all be visible at the equator before the summer solstice; but for the latitude of Soene, the Phainon (Heiberg 1907, 58) gives the summer solstice itself (June 22) as the date of first appearance of one of the stars in Orion (α Ori).

8. The same revision [of the latitudinal dimension], on the basis of land journeys

Let us now turn to the journeys. For the land journey, [Marinos], counting the days of the individual marches from Leptis Magna to the country of Agisymba, reckons that [Agisymba] is 24,680 stades south of the equator. For the sea journey, again using the days of sail from Ptolemais in Tragodylitis to Cape Prason, he reckons [Cape Prason] also to be 27,800 stades south of the equator. In this way he moves Cape Prason and the country Agisymba—which belongs to the Aithiopians—and, as he himself says, does not constitute the southern limit of Aithiopia—to the frigid zone of the antoskoumeni; for 27,800 stades make 55% on the meridian, and this is as many degrees [south] from the equator as the Skythians and Sarmatians who live to the north of Lake Malakas are in the other direction, and the Skythians and Sarmatians live in this kind of [frigid] climate.

Now [Marinos] himself reduces the foregoing number of stades to less than half, that is, to 12,000 stades, which is approximately how far the Winter Tropic is from the equator. The only reasons that he gives for the reduction are the diversions from rectilinear routes and the variable speeds of the journeys, while he passes over still more fundamental and obvious [reasons] that make it clear not only that a reduction is necessary, but also that it must be reduced to this extent.

First, concerning the land journey from Garambi to the Aithiopians he says that Septimius Scaccus, who made a campaign out of Libya, reached the Aithiopians after leaving the people of Garambi after marching south for three months; and Julius Maternus, who [campaigned] from Leptis Magna, leaving Garambi together with the king of the people of Garambi (who was making an expedition against the Aithiopians), after they had all marched for four months to the south, reached Agisymba, the Aithiopians' country, where the rhinoceroses congregate. 21 Each of these [accounts] is implausible even on its own, both because the inland Aithiopians are not so far as a three-month journey from the people of Garambi (who are themselves more or less Aithiopians and have the same king as the inland Aithiopians) and because it would be absolutely pre-
posterous [to imagine that] the king's expedition toward his subjects was in just one direction, from north to south, when these peoples are stretched out far on either side, to the east and west, to say nothing of making no significant pauses anywhere. For these reasons it is likely that [these] men either told travelers' tales or used the expression "to the south" for "toward the Nato's wind" or "toward the Lips wind," as the locals tend to talk, misusing the rough [term] in place of the exact.

9. The same revision [of the latitudinal dimension], on the basis of sea journeys

Next, concerning the sail between Arōmata and Rhapta, he says that a certain Diogenes, who was one of those who sailed to India, returning the second time, was driven back when he got to Arōmata by the Aparthias [north] wind and had Trōglōdytiā on his right for twenty-five days, and [then] reached the lakes from which the Nile flows, slightly to the south of which is Cape Rhapta. [Marinos also says] that a certain Theophilos, one of those who sailed to Azania, set sail from Rhapta by the Natos wind, and on the twentieth day reached Arōmata. Neither of these said that it was a sail "of so many days." Theophilos said that he came to land on the twentieth day, and Diogenes [said] that he sailed along Trōglōdytiā for twenty-five days; thus they reported only how many days they sailed, without reckoning how many days' sail it was, taking account of the variation and shifting of the winds over such a long time. Nor [did they say] that their sail was entirely to the north or to the south. Diogenes said only that he had been driven by the Aparthias wind, and Theophilos, that he had set sail by the Natos wind, neither of them saying that the rest of the voyage maintained the same direction; for it is not to be believed that the course of the winds would be maintained for so many days.

But there is also this reason [for doubting Marinos' calculation]: whereas Diogenes traveled the interval from Arōmata to the lakes to the south of which is Cape Rhapta in twenty-five days, Theophilos sailed the interval from Rhapta to Arōmata, which is greater, in twenty days. Though Theophilos set down the travel of a day and a night as a sail of a thousand stades, which [Marinos], too, follows, nevertheless [Marinos] says that the sail from Rhapta to Cape Prason, which is of many days, was set down by Dioskoros as only five thousand stades, presumably because the winds on the equator are easily changeable since the shifting positions of the sun from side to side [i.e., from north to south] are more pronounced there.

Not only for these reasons should he have abandoned the number of days recorded, but also for the most manifest reason of all: the resulting computation brings the Aithiopians and the gathering place of rhinoceroses into the frigid zone of the antoikoumenē, although all animals and plants that are on the same parallels or [parallels] equidistant from either pole ought to exist in similar combinations in accordance with the similarity of their environments.

And for this very reason Marinos reduced the distance [to the southern limit of the olkhounenē] to just as far as the Winter Tropic. But he gave not a single logical reason for reducing by this amount, [even] if one were to accept (as he does) both the number of days and the [assumption] that the journeys were uniform [in direction and speed]; retaining these [data], he merely reduces the number of stades per day beyond what is reasonable or usual, until the [southern] limit reaches the parallel that he thinks it ought to reach. On the contrary, it would have been logical for one to believe that a day's travel could be so far, while not believing that they were uniformly constant in speed and direction. So that on the basis of these [data] we cannot obtain the distance we are looking for, but merely the fact that [this distance] is greater than the distance to the equator.

Instead, [the distance could have been obtained] from some one of the more unambiguous [i.e., astronomical] phenomena—and something of this kind would be...
also have been absolutely accurate—supposing someone making the investigation in a more mathematical manner had come across the [phenomenal] characteristic to those countries. But since such research has not been made, there is nothing for it but to examine more roughly, and on the basis of a simpler [kind of evidence], what a reasonable amount for the extension [of the known world] beyond the equator would be. This is the evidencival of the forms and colors of the local animals, from which it would follow that the parallel through the country of Agiysyma, which clearly belongs to the Aithiopians, is not as far as the Winter Tropic, but lies nearer the equator. For in the correspondingly situated places on our side [of the equator], that is those on the Summer Tropic, people do not yet have the color of the Aithiopians, and there are no rhinoceroses and elephants; but in places not much to the south of these, moderately black people are to be found, such as those who live in the “Thirty Schoinoi” outside Soenē. Of the same type, too, are the people of Garamē, whom Marinos also says (and indeed for this very reason) live neither right on the Summer Tropic nor to the north, but entirely to the south of it. But in places around Meroē people are already quite black in color, and are at last pure Aithiopians, and the habitat of the elephants and more wonderful animals is there.

10. That one should not put the Aithiopians south of the parallel situated opposite to that through Meroē

Thus, it would be best at this stage of the question, that is, so long as the report of those who reach there records [the presence of] Aithiopians, to draw the country of Agiysyma and Cape Prason, together with whatever lies on the same parallel, approximately on the parallel correspondingly situated to the one through Meroē, that is, the parallel which is south of the equator by the same number of degrees, 16°11′, or approximately 8,200 stades. Hence the whole latitudinal breadth amounts roughly to 79°41′, or in whole numbers 80° or 40,000 stades.

We should, however, retain the interval between Leptis Magna and Garamē as Flaccus and Maternus set it, as 5,400 stades. For the twenty days belong to a return journey, which was shorter in comparison with the first, since the return was in a north-south direction while the first journey was thirty days long because of the diversions. Moreover, [Marinos] says that the travelers stated the number of stades for each day, [this number] having often been not just possible but also necessary because of the distances between the watering places. Just as one has to reserve judgment concerning great distances and those which have seldom been traveled, or not [traveled] in a way about which there is general agreement, so one should trust those which are not great but have been traveled often and by many people in a way that is agreed upon.

11. On the computations that Marinos improperly made for the longitudinal dimension of the oikoumenē

The foregoing should have made it clear how far it would make sense to extend the latitudinal dimension of the oikoumenē. Marinos makes its longitudinal dimension bounded within two meridians that cut off fifteen hour-intervals. We think that he has also extended the eastern part of this dimension more than necessary, and that when a reasonable reduction has been applied here, too, the whole longitudinal extent does not amount quite to twelve hour-intervals, where we (like [Marinos]) set the Islands of the Blest at the westernmost limit, and the farthest parts, [namely] Sēra, Sinaï, and Kattigura, at the eastern limit.

For in the first place one should follow the numbers of stades, from place to place, set down by [Marinos] for the distance from the Islands of the Blest to the crossing of the Euphrates at Hierapolis (as if the journey were made along the parallel through Rhodes). This is both because it is continually being checked and because [Marinos] has manifestly taken into account the amount by which the greater distances ought to be corrected on account of diversions and variations in the itineraries. Furthermore, [he has taken into account] the fact that one degree (of such as the great circle is 360°) contains 500 stades on the surface of the earth—in accordance with the surface measurements that are generally agreed upon—while an arc similar to [one degree of the equator] on the parallel through Rhodes (that is, the parallel 38° from the equator) contains approximately 400 stades. (We may ignore, in such a rough determination, the slight excess over [400]) that follows from the [exact] ratio of the parallels.

However, we reduce according to the appropriate correction both the distance from that crossing of the Euphrates to the Stone Tower, which amounts (according to him) to 876 schoinoi or 26,280 stades, and that from the Stone Tower to Sēra, the metropolis of the Sēras, a journey of seven months, or [according to Marinos] 36,390 stades reckoned on the same parallel [through Rhodes]. For in the case of both journeys, [Marinos] has clearly not subtracted the excess resulting from diversions, and in the case of the second, he has fallen as well into the same illogicalities that he also fell into concerning the journey from the people of Garamē to Agiysyma. There he was compelled to subtract

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*This distance is discussed below in 1.12; see also Appendix D.

*Taking tan (38°) = 0.609, one obtains for the distance 4041 stades, so that using 400 stades per degree for this parallel involves an error of about 1 percent. On the method of converting terrestrial distances in stades to degrees of longitude and latitude, see pp. 16–17.

*The route discussed here and in the next chapter is a version of the “Silk Road” to China. See Appendix C.

*By “illogicalities,” Ptolemy here means Marinos’ assumption that a long journey through difficult country could be made at an ideal marching speed without interruptions. In the case of the journey to Agiysyma, this resulted in the initial calculation that Agiysyma was 24,680 stades south of the equator, which Marinos recognized was impossible (cf. 1.8).
more than half from the number of stades added up over [a journey of] four months and fourteen days because the road journey could not have been uninterrupted over such a great time. Logically this ought also to have been the case with the seven months’ journey, indeed, much more so than with the route from Garamē. After all, that journey was made by the country’s king, who had (it would be reasonable to suppose) some considerable advance knowledge [of the route], and the weather was completely favorable. But the route from the Stone Tower to the Sēres is subject to bad storms (for according to Marinus’s assumptions it falls on the parallels through the Hellespont and Byzantion), so that for this reason, too, there must have been numerous pauses in the journey.

Moreover, it was because of the opportunity for commerce that [the route] came to be known. Marinus says that one Maes, also known as Titianus, a Macedonian and a merchant by family profession, recorded the distance measurements, though he did not traverse it himself but sent certain others to the Sēres. [Marianus] himself apparently did not trust merchants’ reports: at least, he did not give assent to the account of Philémon, in which he has reported the longitudinal extent of the island of Hibernia [i.e., Ireland] from east to west as a twenty days’ journey, because Philémon said that he heard it from merchants. For, Marinus says, these merchants do not concern themselves with finding out the truth, being occupied with their commerce; rather, they often exaggerate the distances out of boastfulness. But here also the circumstance that nothing else in the seven months’ journey was deemed worthy of any record or report by the travelers reveals that the length of time is a fiction.

12. The revision of the longitudinal dimension of the known world on the basis of journeys by land

For these reasons, and also because the road is not on a single parallel (rather, the Stone Tower is near the parallel through Byzantion, and Sēra is south of the parallel through the Hellespont), it would appear sensible here, too, to diminish the number of stades added up from the seven months’ itinerary, namely 36,200, to less than half. Let it, however, be reduced just to half, for this rough determination, so that the distance in question will be reckoned as 18,100 stades, or 45°. It would, after all, be absurd and unheard of, when reason dictates the same size of reduction for both the routes, to follow it in the case of the route from the people of Garamē [to Agiasymba] because the refutation was staring us in the face (namely the various animals in the country of Agiasymba), which could

not be moved outside their natural places), yet in the case of the route from the Stone Tower (to Sēra), not to accept the logical consequence since such a refutation did not happen to be applicable there because the environment along the whole distance would be the same, whether [the distance] be greater or smaller—just as if someone were not to act rightly, [that is], in the manner appropriate to philosophy, so long as he was not about to be caught.

The first interval, by which I mean the 876 schoiniai from the Euphrates to the Stone Tower, must be reduced, because of the diversions in the routes, to just 800 schoiniai, or 24,000 stades. For, granted that the total distance of the whole [route] may be believed because it has been measured in moderately sized parts that have been much traveled, nonetheless it is obvious even from Marinus’s assumptions that it has numerous detours. It is true that the route from the crossing of the Euphrates at Hierapolis through Mesopotamia to the Tigris, and from thence through the Garamai in Assyria and Media to Ecbatana and the Caspian Gates, and to Hekatompyles in Parthia, can be situated near the parallel through Rhodes, since this parallel, according to [Marianus], too, is drawn through the countries mentioned. But the road from Hekatompyles to the city of Hyrkania must veer to the north, since the city of Hyrkania lies more or less between the parallel through Smyrna and the parallel through the Hellespont because the parallel through Smyrna is drawn right under the country of Hyrkania, while that through the Hellespont is drawn through the southern end of the Hyrkanian [Caspian] Sea, which is a little to the north of the city of the same name [i.e., Hyrkania].

Again, the road thence to Antiocheia Margianē through Areia inclines at first to the south, since Areia lies on the same parallel as the Caspian Gates, and then to the north, since Antiocheia is situated near the parallel through the Hellespont. Thence, the road to Baktra extends to the east, from there to the ascent of the range of the Komai (the road goes) to the north, and from this range to the gorge that follows upon the plains [it goes] to the south. For [Marianus] places the northern and the westernmost parts of the range, where the ascent is, on the parallel through Byzantion, and the southern and the eastern parts on the parallel through the Hellespont; this is why he says that [the route], though it leads pretty well straight east, tends to the Nodos [south] wind. And apparently the fifty schoiniai from thence toward the Stone Tower incline to the north, for he says that as one ascends the gorge, the Stone Tower comes next, and from thence the mountains go off to the east and join up with the Imaon [range], which goes up from Palimbothra to the north.

Thus when the 60° that correspond to the 24,000 stades have been added to the 45° from the Stone Tower to the Sēres, the distance from the Euphrates to the Sēres along the parallel through Rhodes would be 105°. And according to
Marinos, on the basis of the individual numbers of stades that he assumes, and reckoning as on the same parallel, the distance from the meridian through the Islands of the Blest to the Sacred Cape of Spain amounts to 21° 15', and that from thence to the mouth of the Baetic, and that from the Baetic to the Straits of Herakleia and Calpe each amounts again to 21° 15'. And, of the following intervals, that from the Straits to Caralis in Sardinia amounts to 25°, that from Caralis to Lilybaeum in Sicily to 4° 25', that from thence to Pachynus to 3°, and next that from Pachynus to Tainaros in Laconia to 1°, that from thence to Rhodes to 8° 4', that from Rhodes to Issus, 11° 4', that from Issus to Hierapolis on the Euphrates to 2° 4'. Thus the sum for this distance is 72°, and for the whole longitudinal extent of the known earth, from the meridian of the Islands of the Blest to the Sires, 177° 40' in total.67

13. The same revision [of the longitudinal dimension] on the basis of journeys by sea

One might also estimate that this is the size of the longitudinal dimension from the distances that [Marinos] sets down for the sail from India to the Bay of the Sinai and Kattigara, if account is taken of the effects of bays and variable speed of sailing, as well as of the approximate directions of the landfalls.49 Thus [Marinos] says that after the cape marking the end of the Bay of Kolchoi, which is called Kory, follows the Bay of Argarou, and this is 3,040 stades as far as the city of Kouroula; and the city of Kouroula is in the direction of the Boreas [north-northeast] wind from Kory. Hence if a third is subtracted to account for following [the arc of] the Bay of Argarou, the crossing will amount to approximately 2,030 stades, with the irregularities of the daily sails [still incorporated in the total]. If a third is again subtracted from these 2,030 stades to get the total distance, approximately 1,350 stades will remain in the direction of the Boreas wind. When this has been transferred to the [circle] parallel to the equator, and to the direction of the Apellates [east] wind, by subtracting half in accordance with the subtended angle, we will get the distance between the two meridians through Cape Kory and the city of Kouroula as 675 stades. This is approximately 16° since the parallels through these places do not differ significantly from the great circle [i.e., the equator].

49On the foregoing list of longitudinal intervals, see Appendix D.
49The basis of the discussion in this and the following chapter is a spice-trade route along the coasts of the Indian Ocean from India to southeastern Asia (and indirectly to China). For the calculations, see Appendix E.
49We take σπῆληθα here to mean "landfall," as it does in Periplus 65 (Casson 1988, 18). See pp. 16–17 for Ptolemy's procedure for converting these reported distances into longitudinal intervals in degrees.

Next, he says, the sail from the city of Kouroula is in the direction of the [sun's] winter rising [i.e., east-southeast] for 9,450 stades as far as Paloura. Again subtracting a third from this on account of the variation of the daily sails, we will obtain the total distance toward the Euros [east-southeast] wind, approximately 6,300 stades; and if we subtract a sixth of this in order to make the distance parallel to the equator,48 we will find the distance between these meridians [through Kouroula and Paloura] as 5,250 stades, or 10½°. He sets down [the width of] the Bay of Ganges as 19,000 stades [starting] from this point, and the sail across it from Paloura to Sada as 13,000 [stades] in the direction of the equinoctial sunrise [i.e., due east]. It follows that only a third of this has to be subtracted to account for the variability of the sail, so that there remain 8,670 stades, or 17½°, as the interval between the meridians.

Next, he makes the sail from Sada to the city of Tamala 3,500 stades in the direction of the winter sunset. Again subtracting a third of this on account of the variation [of daily sails], we obtain 2,330 stades for a continuous course, and, because of the inclination toward the Euros [east-southeast] wind, we again subtract a sixth of this, to find 1,940 stades, or approximately 3¾°, for the distance between the stated meridians.

After this, he records the traversal from Tamala over the Golden Peninsula as 1,600 stades, again in the direction of the winter sunrise, so that here, too, when the same fractions have been subtracted, there remains a distance between the meridians of 900 stades, or 1¾°. Thus the distance from Cape Kory to the Golden Peninsula amounts to 34½°.

14. On the crossing from the Golden Peninsula to Kattigara

Marinos does not list the numbers of stades for the sail across from the Golden Peninsula to Kattigara. However, he does say that Alexandros50 had written that the land from thence faces the south, and those who sail along it reach the city of Zabai in twenty days; and, after sailing from Zabai in the direction of the Notos [south] wind and rather more to the left for a few days, there follows...

50Deducting one-sixth implies an angle of about 24° between due east and the sun's winter rising point (equated with the direction of Euros). This would be astronomically correct for a much more northerly latitude (about 44°), near the equator the angle approaches its minimum, about 24°. Ptolemy probably took the direction to be simply 30° from due east regardless of one's latitude, and his deduction of one-sixth is also likely to be a rough schematic correction, adequate given the crudeness of the data.
50The word we translate "traversal" (διασκέδασμος) is rare, and occurs nowhere else in the Geography. It apparently means a crossing of a narrow neck of sea or land. Comparison with Ptolemy's own map suggests that at this stage the trade route took a shortcut across the Golden Peninsula.
50Otherwise unknown. It is not clear whether this Alexandros is reporting his own travels or those of another.
Kattigara. [Marinos] exaggerates the distance in question, taking the expression “some days” as meaning “many days,” and saying that because of their multitude they could not be expressed by a number. This, in my opinion, is ridiculous: what number of days would be inexpressible, even if it comprised the circuit of the entire traveled world? Or what was to prevent Alexandros from saying “many” instead of “some,” just as [Marinos] said Dioskoros had reported that the sail from Rhipta to Cape Prason was “many days”? One would more reasonably interpret the expression “some” as meaning “few,” for we usually use this word in this way.

But in order that we should not ourselves appear to be adjusting our estimates of the distances to make them fit some predetermined amount, let us treat the sail from the Golden Peninsula to Kattigara, which comprises twenty days as far as Zabai and “some” more as far as Kattigara, in the same way as we treated the sail from Arômata to Cape Prason, which also consists of the same number of days (twenty) to Rhipta according to Theophilos, plus “many” more to Prason according to Dioskoros. Hence we, too, in Marinos’ manner, shall make the expression “some days” equivalent to “many days.” Now we have shown from reasonable arguments and on the basis of the [natural] phenomena themselves that Cape Prason is on the parallel that is 16°14’ south of the equator, while the parallel through Arômata is 44°14’ north of the equator, so that the distance from Arômata to Cape Prason amounts to 20°28’ south. Hence it would be reasonable for us to make the voyage from the Golden Peninsula to Zabai and from thence to Kattigara the same number of degrees’ worth of distance.

There is no need to diminish [the sail] from the Golden Peninsula to Zabai, since it is parallel to the equator because the country in between lies facing the south; but that from Zabai to Kattigara should be reduced to get the direction parallel to the equator, because the sail is toward the Notos wind and to the east. If we assign half the degrees to each of the intervals, because the difference between them is not clear, and again subtract a third of the 10°12’ from Zabai to Kattigara on account of the inclination [from due east], we will get the distance from the Golden Peninsula to Kattigara, as measured in the direction parallel to the equator, as approximately 17°14’. But the distance from Cape Köry to the Golden Peninsula was shown to be 34°14’, hence the whole distance from Cape Köry to Kattigara is approximately 52°.

In the geographical catalogue (4.7) Ptolemí assigns Arômata a different latitude, 6° north of the equator. The latitude given here is likely to be Marinos’, retained by Ptolemí here through oversight (see Appendix B). Ptolemí’s whole argument here is clearly designed to obtain by hook or by crook a longitude for Kattigara just slightly short of the preconceived figure of 100° for the breadth of the obesaean; notwithstanding what he said at the outset of this paragraph.

Subtraction of one-third would correspond to an angle of about 45°, i.e., roughly 45°, between due east and the direction of sail. For the present calculation, Ptolemí evidently interprets "in the direction of the Notos wind and rather more to the left," as halfway between due south and due east.

But according to Marinos, the meridian through the beginning of the river Indus is a little to the west of the northermost point of Taprobâne, which lies opposite [i.e., due south of] Cape Köry; and the meridian through the mouths of the river Bœta is eight hour-intervals from this [meridian], or 129°, and moreover the meridian, though the Islands of the Blest is 5° from this. Hence the meridian through Cape Köry is a little more than 125° from the meridian through the Islands of the Blest, and [the meridian] through Kattigara is a little more than the sum, 177°, from that through the Islands of the Blest. This is roughly the same distance as was computed [above] along the parallel through Rhodes.

Let, however, the longitudinal dimension as far as the metropolis of the Sinai be assumed to be, in round numbers, 180° or twelve hour-intervals, since all agree that [the metropolis of the Sinai] is east of Kattigara. Thus the longitudinal dimension [along the parallel] through Rhodes amounts to approximately 72,000 stades.

15. On the inconsistencies in details of Marinos’ exposition

We have reduced the distances in longitude to the east and in latitude to the south to this extent for the reasons that we have given. We have also concluded that the positions of the individual cities call for correction in many places where, because of the copiousness and detail of his compilations, [Marinos] gives them positions in different passages that conflict with one another or are illogical; for example, in the [features] that are believed to be "oppositely situated" [i.e., due north or south].

He says, for instance, [1] that Tarraco is opposite Caesarea Iol, although he draws the meridian through [Caesarea Iol] also through the Pyrenees, which are more than a little to the east of Tarraco. Again [2] he says that Pachynus is opposite Leptis Magna, and Himera opposite Théna, yet the distance from Pachynus to Himera amounts to about 400 stades, while that from Leptis Magna to Théna amounts to over 1,500 [stades] according to what Timotheobile records. [3] Again he says that Tergéstë lies opposite Ravenna, whereas Tergéstë is 480 stades from the inlet of the Adriatic at the river Tieleventus in the direction of the summer sunrise, and Ravenna is 1,000 stades in the direction of the winter sunrise. [4] Similarly he says that Chelidionia lies opposite Canopus, and Askamas opposite Paphos, and Paphos opposite Sebennytos, where again he sets the stades from Chelidionia to Askamas as 1,000, and Timotheophile sets those from Canopus to Sebennytos as 290; but this distance [between Canopus and Sebennytos] should actually have been larger if it lay between the same
meridians [as the interval between Chelidonai and Akamas] because it subtends a [similar] arc of a larger parallel.

Again, [5] he says that Pisa is 700 stades from Ravenna, in the direction of the Libonotos [south-southwest] wind, but in the division of the klimata and of the hour-intervals he puts Pisa in the third hour-interval and Ravenna in the second. And [6] though he has said that Londinium in Britain is fifty-nine [Roman] miles north of Noviomagus, he then represents [Noviomagus] as north of [Londinium] in his division of the klimata. Moreover, [7] having put Athōs on the parallel through the Hellespont, he puts Amphipolis and its surroundings, which lie north of Athōs, and the mouths of the Strymon, in the fourth klima, which is below the Hellespont. Similarly, [8] although almost the whole of Thrace lies below the parallel through Byzantium, he has set all Thrace's inland cities in the klima above this parallel. Again, [9] he says: "We shall situate Trapezus on the parallel through Byzantium"; and after showing that Satala in Armenia is sixty miles south of Trapezus, nevertheless in the description of the parallels he puts the parallel through Byzantium through Satala, and not through Trapezus.

[10] He even says that the river Nile, from where it is first seen up to Merē, will be drawn correctly [going] from south to north. Likewise, he says that the sail from Ariōnata to the lakes from which the Nile flows is effected by the Aperkias [north] wind. But Ariōnata is quite far east of the Nile; for Polemais Thrēn is east of Merē and the Nile by a march of ten or twelve days, and the Bay of Adoula is... stades from Polemais, and the straits between the peninsula of Oktētēs and Dērē are 3,500 stades from Polemais, and the cape of Great Ariōnata is 5,000 stades to the east of these. 38

16. That certain matters escaped [Marinos'] notice in the boundaries of the provinces

Some things have escaped his notice also in the definition of the boundaries: for example [11] when he has the whole of Mysia bordered by the Sea of Pontos to the east, but he has Thrace border Upper Mysia to the west; and [12] when he has Italia bordered to the north by Rhaetia and Noricum but also by Pannonia, whereas he has Pannonia [border] only Dalmatia, and no longer Italia, to the south. [He describes] 13 the inland Sogdians and Saka as being neighbored by India to the south. However, he does not draw through these peoples the two parallels (namely, the parallels through the Hellespont and through Byzantium) that are [immediately] north of the Imaon range—i.e., the most northerly part of India. On the contrary, the first [parallel that he draws through these peoples] is the one through the middle of Pontos.

17. On the inconsistencies between [Marinos] and the reports of our time

Marinos did not notice these and similar things, either because his compilations were so voluminous and treated [various] topics separately, or because he did not have time in his final publication, as he himself says, to draw a map, which is the only way that he could have corrected the klimata and the hour-intervals. In some matters he is also not in agreement with present-day accounts. For example, he places the Bay of Sacthálites to the west of Cape Syagros, when absolutely everyone who has sailed through these places agrees with our opinion that the country of Sacthálites in Arabia and the bay of the same name are east of Syagros. Again, he puts "Simylla" (the trading post in India) west not only of Cape Kemaria, but also of the river Indus. But there is a consensus among those who have sailed there and visited the places over a long period, as well as among those who have come to us from there, that [this place] is just south [and not west] of the mouths of the river, and it is called "Timoula" by the natives.

From these people we have also learned other details about India, especially about the provinces and the more remote parts of this country as far as the Golden Peninsula and from that point on to Kattigara. First, they agree in reporting that the sail is eastward when one is sailing there, and westward when departing. 49 [Second], they agree that the direction varies and the journeys are unequal in duration. [Third], the country of the Sēres and the metropolis of the Sēres lie above [i.e., to the north of] the Sinaii. To the east of these is an unknown country that has reedy lakes in which reeds grow so densely that one is borne by [the reeds] as one crosses [the lakes]. They further [agree] that not only is there a route from [the Sēres] to Buktria via the Stone Tower, but also to India via Palimmothra; 50 and the route from the metropolis of the Sinaii to the station at Kattigara is to the west and south. Consequently [this route] does not fall along the meridian through the Sēres and Kattigara, as Marinos says, but on [meridians] that are east of it.

And we learn from the merchants who have crossed from Arabia Felix to Ariōnata and Azania and Rhapta (they give all these [places] the special name

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38See Textual Notes (Appendix G).
39The words between angle brackets have been restored on geographical grounds; see Appendices F and G (Textual Notes).
Barbaria) that the sail is not exactly to the south; but rather this part is to the west and south, while they make the sail across from Rhapta to Prason toward the east and south. And the lakes from which the Nile flows are not right by the sea but quite far inland.

[We learn] also that the sequence of beaches and bluffs to Cape Prason from the Cape of Aricama is different from what it is according to Marinus, and the sail of a day and night there does not amount to many stades, because of the swift changeability of the winds at the equator, but is generally four or five hundred stades. [We learn also that] immediately following Aricama is a first bay, and in it, after a day's travel from Aricama, is the town of PanÖm and the trading post Opôné, which is six days' journey from the town. Another bay, which is the beginning of Azania, follows after this trading post, and at its beginning is situated the headland of Zingis and the mountain Phalangis, which has eight peaks. This bay alone is called “Bluff”; it takes two days and nights to cross. Following this is the Little Beach, whose crossing requires three intervals [i.e., day's or night's sails], and then the Great Beach, which requires five intervals to cross. To cross the two together requires four days and nights in all. Another bay is adjacent to these, in which, after a sail of two days and nights, there is the trading post called Essina. Then comes the anchorage of Sarapôn after one day's sail, and then begins the bay leading to Rhapta, with a crossing time of three days and nights. At its beginning is a trading post called Tonik, and by Cape Rhapton is the river called Rhapatos, and a metropolis of the same name [Rhapta], which is a little distance from the sea. The bay from Rhapta to Cape Prason is very big and not deep, and barbarous cannibals live about it.

18. On the inconvenience of Marinus' compilations for drawing a map of the oioumenê

We shall make this the end of our outline of the things that need some attention in the research of Marinus itself, lest it should seem to anyone that we are undertaking a prosecution rather than a revision; for everything will be clear to us in the guide to the individual parts of the map. We must still investigate the method of drawing the map. This undertaking can take two forms: the first sets out the oioumenê on a part of a spherical surface, and the second on a plane. The object in both is the same, namely convenience; that is, to show how, without having a model already at hand, but merely by having the texts beside us, we can most conveniently make the map. After all, continually transferring a map from earlier exemplars to subsequent ones tends to bring about grave distortions in the transcriptions through gradual changes.

If this method based on a text did not suffice to show how to set [the map] out, then it would be impossible for people without access to the picture to ac-

complish their object properly. And in fact this is what happens to most people [who try to draw] a map based on Marinus, since they do not possess a model based on his final compilation; instead they draw on his writings and err in most respects from the consensus of opinion, because his guide is so hard to use and so poorly arranged, as anyone who tries it can see.

For example, one has to have the position in longitude and latitude for each locality that is to be marked, if one is to place it where it belongs. But this cannot be found directly in Marinus' compilations; rather, one finds it separately, in one place maybe just the latitudes, in the section on the setting out of the parallels, and in some other place just the longitudes, say in the section on inscribing the meridians. (What is more, the same [localities] are not found in each section: the parallels are drawn through some places and the meridians through others, so that such localities lack one or the other position i.e., longitude or latitude). In general, one needs to have practically all Marinus' writings to make the investigation for each [locality] that is to be set down, because something different is said about the same [locality] in every one of them. If we did not check each category of information that is listed for each [locality], we would inadvertently err in many matters that ought to be checked. Again, when one is putting the cities in their positions, one might have an easier time labeling those that are on the coast, since in general some indication of position is noted for them, but this is not so for the inland ones, since their relative positions with respect to each other with respect to the cities on the coast are not indicated, with few exceptions—and in these instances sometimes only the longitude is defined, sometimes only the latitude.

19. On the convenience of our catalogue for making a map

We have thus taken on a twofold task: first to preserve Marinus' opinions as expressed through the whole of his compilation, except for those things that need some correction; second to see to it that the things that he did not make clear will be inscribed as they should be, as far as is possible, using the researches of those who have visited the places, or their positions as recorded in the more accurate maps. We have taken care also that the method should be convenient. Hence we have written down for all the provinces the details of their boundaries (i.e., their positions in longitude and latitude), the relative situations of the more important peoples in them, and the accurate locations of the more noteworthy cities, rivers, bays, mountains, and other things that ought to be in a map of the oioumenê. (By "location" I mean the number of degrees of such as the great circle is 360) in longitude along the equator between the meridian drawn through the place and the meridian that marks off the western limit of the oioumenê, and the number of degrees in latitude between the
20. On the proportional nature of Marinus’ geographical map

Each of the two approaches [to map-making] is characterized in the following way. Making the map on the globe gets directly the likeness of the earth’s shape, and it does not call for any additional device to achieve this effect; but it does not conveniently allow for a size [of map] capable of containing most of the things that have to be inscribed on it, nor can it permit the sight to fix on [the map] in a way that grasps the whole shape all at once, but one or the other; that is, either the eye or the globe, has to be moved to give a progressive view [of the whole]. Drawing the map on a plane eliminates these [difficulties] completely; but it does require some method to achieve a resemblance to a picture of a globe, so that on the flattened surface, too, the intervals established on it will be in as good proportion as possible to the true [intervals].

Marinus paid considerable attention to this problem, and found fault with absolutely all the [existing] methods of making plane maps. Nonetheless, he himself turns out to have used the one that made the distances least proportionate. He made the lines that represent the parallel and meridian circles all straight lines, and also made the lines for the meridians parallel to one another, just as most [mapmakers] have done; but he kept only the parallel through Rhodes proportional to the meridian in accordance with the approximate ratio of 5:4 that applies to corresponding arcs on the sphere (that is, the ratio of the great circle to the parallel that is 36° from the equator), giving no further thought to the other [parallels], neither for proper proportionality nor for a spherical appearance. Now when the line of sight is initially directed at the middle of the northern quadrant of the sphere, in which most of the oikoumenē is mapped, the meridians can give an illusion of straight lines when, by revolving [the globe or the eye] from side to side, each [meridian] stands directly opposite [the eye] and its plane falls through the apex of the sight. The parallels do not do so, however, because of the oblique position of the north pole [with respect to the viewer]; rather, they clearly give an appearance of circular segments bulging to the south.

In the next place, although in both truth and appearance the same meridians cut off similar but unequal arcs on the parallels of different sizes, and always greater [arcs] on those nearer the equator, Marinus makes them all equal, stretching the intervals in the klimata north of the parallel through Rhodes more than they are in truth, and making the southern ones smaller. Hence [the arcs] no longer match the numbers of stades that he has set down, but those on the equator fall short by about one-fifth (which is the amount by which the parallel through Rhodes falls short of the equator [in length]), and those on the parallel through Thulē are in excess by four-fifths (the amount by which the parallel through Rhodes excess that through Thulē—for in such units as the equator is 115, the parallel 36° from the equator and drawn through Rhodes is 93, and the parallel 63° [from the equator] and drawn through Thulē is 52).60

21. On the things that should be preserved in a planar map

For these reasons it would be well to keep the lines representing the meridians straight, but [to have] those that represent the parallels as circular segments described about one and the same center, from which [imagined as the north pole] one will have to draw the meridian lines. In this way, above all, a semblance of the spherical surface will be retained in both its actual disposition and its visual effect, with the meridians still remaining uniltited with respect to the parallels and still intersecting at that common pole. Since it is impossible to preserve for all the parallels their proportionality on the sphere, it would be adequate [1] to keep this [proportionality] for the parallel through Thulē and the equator (so that the sides that enclose our oikoumenē’s latitudinal dimension will be in proper proportion to their true magnitudes), and [2] to divide the parallel that is to be drawn through Rhodes (on which most of the investigations of the longitudinal distances have been made) in proportion to the meridian, as Marinus does, that is in the approximate ratio of similar arcs of 5:4 (so that the more familiar longitudinal dimension of the oikoumenē is in proper proportion to the latitudinal dimension). We will make clear how these things will be done, after first setting out how a map should be made on the globe.

22. On how one should make a map of the oikoumenē on a globe

The size of the [globe] should be determined by the number of things that the map-maker intends to inscribe [on it]; and this depends on his competence and ambition, since the larger the globe is, the more detailed and at the same time the more reliable [the map] will prove to be. Whatever size it may be, we are to take its poles and accurately attach through them a semicircle very slightly separated from the [globe’s] surface, so that it only just avoids rubbing against it when it is turned. Let the semicircle be narrow in order not to obstruct many

60See 1.44, p. 86 n. 68, for the derivation of the units on which these approximate ratios are based.
localities; and let one of its edges pass precisely through the points [representing] the poles, so that we can use it to draw the meridians. We divide this edge into 180 parts and label them with the [corresponding] numbers, starting from the middle division, which is going to be at the equator. Similarly, we draw the equator and divide one of its semicircles into the same number, 180, of divisions, and inscribe [their] numbers on this [semicircle] too, starting from the endpoint through which we are going to draw the most western meridian.

Now we will make the map, on the basis of the degrees of longitude and latitude recorded in [the present] writings for each marked locality, using the divisions of the semicircles of the equator and the moving meridian. We move this along to the indicated degree of longitude, that is, to the division of the equator containing the number, and take the interval in latitude from the equator directly from the divisions of the [moving] meridian; and we make a mark at the indicated number, just as we did in inscribing the stars on the solid [celestial] globe.\textsuperscript{41}

In the same way it will be possible to draw the meridians at as many degrees of longitude as we choose, using the divided edge of the ring directly as a ruler, and [to draw] the parallels at as many intervals [from the equator] as will produce a suitable spacing, by fixing the instrument that is to draw them next to the number on the [divided] edge of the meridian that indicates the appropriate interval and revolving it with the [meridian] ring itself as far as the meridians that mark the limits of the known world.

23. List of the meridians and parallels to be included in the map

These [limiting meridians] will enclose twelve hour-intervals according to what has been demonstrated [above].\textsuperscript{44}

However, we have decided it is appropriate [to the size of the map] to draw the meridians at intervals of a third of an equinoctial hour, that is, at intervals of five of the chosen units [i.e., degrees] of the equator, and [to draw] the parallels north of the equator as follows:\textsuperscript{45}

[1.] The first parallel differing [in length of longest daylight] from [the equator's twelve hours] by \(\frac{1}{4}\) hour, and distant [from the equator] by

\textsuperscript{\textsuperscript{41}}This refers to Almagest 9.3, where Ptolemy describes the construction of a globe representing the constellations on the celestial sphere.

\textsuperscript{\textsuperscript{44}}In 1.11–14. Note that this sentence is partly part of the closing paragraph of the preceding chapter. We have transposed the sentence that follows this in all manuscripts to its proper place at the end of the chapter.

\textsuperscript{\textsuperscript{45}}The following results are extracted (with latitudes rounded to the nearest twelfth of 1°) from the list of astronomical characteristics of the significant parallels in Almagest 2.6. The list incorporates Ptolemy's seven klimata.

24. Method of making a map of the oikoumenē in the plane in proper proportionality with its configuration on the globe

For the map on the [planar] surface, our procedure for [maintaining] the proper proportionality of the extreme parallels will be as follows [Fig. 14].

\textsuperscript{\textsuperscript{46}}This sentence follows the first sentence of this chapter in the manuscripts, but clearly belongs here.
[Ptolemy’s first projection]

[Stage 1: Preparation of the rectangular surface on which the map is to be drawn; construction of the central meridian, the common intersection of all meridians, and the parallel through Rhodes.] Let us fashion a [planar] surface in the shape of a rectangular parallelogram $ABGD$, with side $AB$ approximately twice $AG$. Let line $AB$ be assumed to be in the top position; this is going to be at the north end of the map. Then we will bisect $AB$ by the perpendicular straight line $EZ$, and attach a rule $EH$ to $[AB]$, of suitable size and perpendicular to $[AB]$ so that the line $[EH]$ down the middle of its length is in a straight line with $EZ$. Let there be taken on it a length $EH$ of 34 [units] such that straight line $HZ$ is $131\frac{1}{2}$, and with center $H$ and radius [to reach] the point 79 units away on $HZ$, we will describe a circle $EKL$, which will represent the parallel through Rhodes.

This rule is a temporary attachment to the surface on which the map will be drawn, to provide a base for point $H$, which will be the intersection of the all the meridians and center of all the parallels of latitude in the map.

These units will be equivalent to degrees of latitude on the lines representing the meridians and degrees of longitude along the circle representing the equator. The unit is chosen so that the radius of the arc representing the equator (115 units) exceeds that of the arc representing the northernmost parallel through Thule (62 units) by 63 units, corresponding to the 63rd of latitude between the equator and the parallel through Thule. $HZ$ is made equal to 115 units plus $10\%$ for the latitude of the northernmost parallel bounding the $ehzoumenon$, so that this parallel will just graze the bottom of the rectangle. The length of 24 units for $EH$ seems to have been empirically chosen to accommodate the largest map in the given rectangle without excessive truncation of the corners at $C$ and $P$.

[Stage 2: Construction of meridian lines at five-degree intervals.] For the limits of the longitude, which comprise six-hour-intervals on each side of $K$, we take an interval of 4 units on the middle meridian $HZ$ (i.e., five degrees on the parallel through Rhodes because of the approximate ratio of 5:4 between the great circle and the [the parallel]), and we count off eighteen intervals of this size on each side of $K$ along arc $EKL$. [In this way] we get the points through which the meridians that will enclose the intervals of one-third of an hour will have to be drawn from $H$, and consequently also the [meridians] marking off the limits of [longitude], namely $HEM$ and $HLN$.

[Stage 3: Construction of arcs representing the equator and limiting parallels, and the other parallels.] Next the parallel $COP$ through Thule will be drawn, with radius 52 units from $H$ on $HZ$, and the equator $RST$, [with radius] 115 units from $H$, and the parallel $MUN$ oppositely situated to the parallel through Meroë—this is the farthest south [of the parallels], [with radius] 131$\frac{1}{2}$ units from $H$. Hence the ratio of $RST$ to $COP$ will amount to 115:52, in agreement with the ratio of these parallels on the globe, since $HO$ is 52 of such units as $HS$ was assumed to be 115, and as $HS$ is to $HO$, so is arc $RST$ to [arc] $COP$.

Also, the interval $OK$ of the meridian, that is, the [interval] from the parallel through Thule to that through Rhodes, will turn out to be 27 units; and $KS$, the [interval] from the parallel through Rhodes to the equator, will turn out to be 36 of the same [units]; and $ST$, the [interval] from the equator to the parallel oppositely situated to that through Meroë, will turn out to be 16$\frac{1}{2}$ of the same [units]. Moreover, of such [units] as the latitudinal dimension $OU$ of the known world is 79$\frac{1}{2}$, or as a round number, 80, $EKL$, the middle interval in longitude [measured along the parallel through Rhodes], will be 144, in agreement with the hypotheses derived from the demonstrations [in 1.7–1.14]—i.e., the 40,000 stades of latitude have approximately the same ratio to the 72,000 stades of longitude on the parallel through Rhodes as [the ratio 79$\frac{1}{2}$:144.

We will also draw the rest of the parallels, if we choose, again using $H$ as center and radius [extending to the points] as many units away from $S$ as the [numbers] set out in the [list] of distances from the equator [1.23].

[Stage 4: Infection of meridian lines south of the equator.] Instead of having the lines representing the meridians straight as far as parallel $MUN$, we can have them [straight] just as far as the equator $RST$; then, dividing arc $MUN$.

If one has followed Ptolemy’s instructions, the midpoint of this arc will be point $Z$. Nevertheless, this point is consistently referred to as $U$, as if it were distinct from $Z$. The violation of the alphabetic order in which Ptolemy assigns letters to the points in his figure suggests that he originally called this point $Z$, and then changed his mind. He may have realized that one might choose to draw the map on a larger surface than he specifies, with room for margins; thus, point $Z$ at the bottom of the rectangle would not be the same as point $U$ at the bottom of the map.

In this paragraph Ptolemy wishes to bring home to the reader the extent to which he has succeeded in attaining the preservation of proportions of distances that is his goal.
into parts that are equal and equal in number to [the parts] established on the parallel through Merod,18 (we can) draw between these divisions and the [divisions] on the equator the straight lines for the meridians that fall between [the parallel and the equator] (e.g., lines RF and TX), so that the bending away on the other, south side of the equator is in some way apparent from the infection [of the meridian lines] incorporated [in the map].

[Stage 5: Drawing of the map.] Next, to make the labeling of the localities that are to be included convenient, we will also make a narrow little ruler, equal in length to HZ (or just to HS),19 and peg it to H so that as it is revolved along the whole longitudinal dimension of the map, one of its edges will exactly fit the straight lines of the meridians because it is cut away so as to be in line with the middle of the pole. We divide this edge into the 131½ parts corresponding to HZ (or the 115 parts corresponding to just HS), and label the numbers starting from the division at the equator in order not to divide the middle meridian of the map into all the [115] parts and label them [all], thereby making a mess of the inscriptions of the localities that are to be made next to [the middle meridian]. It will also be possible to draw the parallels using these [marks].20

Then we divide the equator, too, into the 180° of the twelve hour-intervals, and annex the numbers starting at the westernmost meridian. And we shift the edge of the ruler in each case to the indicated degree of longitude, and, using the divisions on the ruler, we arrive at the indicated position in latitude as required in each instance, and make a mark just as we have explained for the globe.

[Prolemy's second projection]

We could make the map of the oikoumenē on the [planar] surface still more similar and similarly proportioned [to the globe] if we took the meridian lines, too, in the likeness of the meridian lines on the globe, on the hypothesis that the globe is so placed that the axis of the visual rays passes through both (1) the intersection nearer the eye of the meridian that bisects the longitudinal dimension of the known world and the parallel that bisects its latitudinal dimension, and also (2) the globe's center.21 In this way the oppositely situated limits [of the sphere's surface] will be taken in and perceived by the visual rays at equal distances.

[Stage 1: Determination of an appropriate point to serve as the common center of the arcs representing the parallels.] First, [we want] to establish the magnitude of inclination of the parallel circles with respect to the plane that is perpendicular to the meridian in the middle of the latitude and [that passes] through both the stated intersection [of the bisecting meridian and parallel] and the sphere's center. Let us imagine [Fig. 15] the great circle ABGD that delimits the visible hemisphere; the semicircle AEG of the meridian that bisects the hemisphere; and point E, which is the intersection nearer the eye of the [central meridian] and the parallel bisecting the latitudinal dimension. And let there be described through E another semicircle of a great circle, BGD, perpendicular to AEG. Obviously the plane of (BED) lies along the axis of the visual rays. Let arc EZ be measured off as 23½° (since the equator is this many [degrees] from the parallel through Soìnē, which is approximately the middle of the latitudinal breadth), and let the semicircle BZD of the equator be described. theory of visual rays, see p. 57 n. 2. The axis of the rays is the line in the middle of the field of vision that points to an object when we look straight at it; this concept is not present in Euclid's Optics but plays a prominent role in Ptolemy's Optics.

18That is, the whole length of arc MUN is not used, but only a part of it equal in length to the arc representing the parallel through Merod.

19If Ptolemy's suggestion for inscribing the meridians at the equator is followed, this ruler will be useless for localities south of the equator.

20This would be done, as with the globe, by attaching the pen to the appropriate mark on the moving ruler.

21Since (as Ptolemy points out presently) the parallel through Soìnē (i.e., the Summer Tropic) is close to halfway between the northernmost and southernmost limits of the oikoumenē, Ptolemy means that the eye should be imagined as directly above a point that lies both on this parallel and on the central meridian of the map. Ptolemy specifies the intersection "nearer the eye" to avoid ambiguity, since any parallel and meridian intersect twice on opposite sides of the globe. For the
scribed through Z. Then the plane of the equator and the [planes] of the other parallels will appear inclined with respect to the [aforesaid] plane through the axis of the visual rays at [the angle of] arc EZ, which is 23½°.

Now [Fig. 16] let AEZG and BDE be imagined as straight lines representing arcs, such that BE has a ratio to EZ of 90:23. And let GA be produced, and let the center about which the circular segment BZD is to be described be at H, and let it be required to find the ratio of HZ to EB.

Let straight line ZB be drawn, and bisected at Θ, and let ΘH (which is of course perpendicular to BZ) be drawn. Then since EZ was assumed to be 23% of such [units] as straight line BE is 90, the hypotenuse BZ will be 93% of the same [units]. And angle BZE will be 150% of such [units], i.e., half-degrees as two right angles are 360, and the remaining angle ΘHZ will be 29% of the same [half-degrees]. Consequently the ratio of HZ to ZΘ is 181½: 46½°. But of

Figure 16 is the skeleton of the map, with points corresponding in meaning to the similarly named points in Figure 15. Since distances along the central meridian are to be drawn in correct proportion to the corresponding intervals on the globe, and BE represents half a great circle (i.e., the equivalent of 180° of the central meridian), Ptolomy takes ½ of BE as equal to 1° along the meridian, and places Z (representing the central point of the equator) as many of these "degrees" south of E as the equator is south of Soēnē. The equator is going to be drawn as a circular arc passing through B, Z, and D, and the center H of this arc is determined as the intersection of the perpendicular bisectors of the two chords ZD and BD. By hypothesis, H will be the center of all the area representing the parallels on the map.

This is an exercise in trigonometry similar to many in the Almagest. A circle is tacitly imagined as circumscribing triangle BZE; obviously BZ is a diameter of this circle, and angle BZE is half the angle subtended at the circle's center by chord BE (or equivalently, as many half-degrees as the angle at the center is in degrees). Ptolomy used his table of chords (Almagest 1.11) to get this angle.

Such [units] as ΘZ is 46½°, straight line BE is 90; so that also of such [units] as straight line BE is 90 (and ZE is 23% of the same), we will have straight line HZ too as 181½%. And we will thus obtain point H, about which all the parallels in the plane map are to be described.

[Stage 2: Construction of the arcs for the parallels.] Now that these things have been established, let the [plane] surface ABGD be set out [Fig. 17] with AB again being twice AG, and AE equal to EB, and EZ at right angles to [AEB]. Also let some straight line equal to EZ be divided into the 90 units [corresponding to the degrees] of the quadrant. Let ZH be taken with length 10½ units, and HΘ with length 23½ units, and HK with length 63 units. If H is assumed to be on the equator, Θ will be the point through which the parallel through Soēnē (which is approximately in the middle of the latitudinal dimension) will be drawn; and Z will be the point through which the parallel will be drawn that marks the southern limit and is opposite to the parallel through Meroē, and K will be the point through which the parallel will be drawn that marks the northern limit and passes through the island of Thulē.

Points L, Θ, and H in Figure 17 correspond respectively to H, E, and Z in Figures 15 and 16.
We now produce [line EZ's] extension HL with length 181½ units of the same units (as for that matter just 180 units, since the map will not be significantly different on this account). And with center L and radii [extending to] Z, Θ, and K, we describe arcs PQR, C60, and MZN. The proper pattern of inclination of the parallels with respect to the plane through the axis of the visual rays will thus have been preserved, since here, too, [as in the hypothetical view of the globe], the axis [of the visual rays] ought to point to Θ and be at right angles to the plane of the map, so that the oppositely situated limits of the map will again be perceived by the sight as equidistant [from the center].

[Stage 3: Construction of the arcs for the meridians.] The longitudinal dimension should be proportional to the latitudinal dimension. On the globe, of such [units] as the great circle is 5, the parallel through Thulë amounts to approximately 2⅔, and that through Soēnê 4½, and that through Meroë 4⅔. One has to place eighteen meridians at intervals of one-third hour on each side of the meridian line ZK to complete the semicircles [of the parallels of latitude] contained by the total longitudinal dimension, so that we will take, on each of the three parallels that have been set out, segments equivalent to 5°, i.e., one-third of an hour-interval. [Thus] we will make the divisions from K at intervals of 2⅔ units such as straight line EZ is 90, and from Θ at intervals of 4½, and from Z at intervals of 4⅔. Then we will draw the arcs to represent the remaining meridians through [each set of] three corresponding points, e.g., the [meridians] that are to mark the limits of the whole longitudinal dimension, STU and FXY.13 We shall then add the rest of the [arcs] representing the remaining parallels, with center again L and radii [extending to] the divisions on ZK according to their distances from the equator.

It is immediately obvious how such a map is more like the shape on the globe than the former map. For there [i.e., on the globe], too, when the globe is stationary and not turned about (which is necessarily the case with the situation represented on the [planar] surface), since the sight is directed toward the middle of the map, a single meridian, [namely] the one in the middle, would be in the plane through the axis of the visual rays and so would give the illusion of a straight line; whereas the [meridians] on either side of it all appear curved with their concavities toward it, and the more so the farther from it they are. Here, too, [in the present map] one will retain this [appearance] with the proper relative curvatures. Moreover, the proportionality of the parallel arcs with respect to each other preserves the proper ratio, not just for the equator and the parallel through Thulë (as in the former [map]), but also as very nearly as possible for the other [parallels], as anyone can discover who makes the experiment.

13 Polonyi does not explain how these arcs are to be drawn. For the meridians close to the central meridian, the curvature is so slight that it would be impracticable to use a compass.

And [the ratio] of the total latitudinal dimension to the total longitudinal dimension [will be preserved] again not only for the parallel drawn through Rhodes (as in the former [map]), but [at least] roughly for absolutely all [the parallels]. For if here, too, [as in the former drawing], we draw the straight line SWU, arc OW will obviously make a smaller ratio to [area] ZS and RU than the correct ratio in this map, which was obtained using all of [arc] ΘT (imagined as being along the equator). And if we make this [arc ΘW] in correct ratio to the latitudinal interval ZK, then ZS and RU will be greater than the [areas] that are in correct ratio to ZK [on these parallels], just as ΘT is. Or, if we keep ZS and RU in correct ratio to ZK, then OW will be less than the [area] that is in correct ratio to KZ, just as it is less than ΘT.

In these respects, then, this method is superior to the former. But it might be inferior to the other with respect to the ease of making the map, since [in the former method] it was possible to inscribe each locality by revolving and moving the ruler from side to side, with just one of the parallels drawn and divided into degrees; whereas here such a ruler is of no advantage because of the bending of the meridians lines from the central [meridian], so that all the circles have to be drawn on the map, and positions falling between the grid lines have to be guessed at by calculating on the basis of the recorded fractional parts with reference to the [four] whole sides of the grid that surround the place in question. Even so, I think that, here as on all occasions, the superior and more troublesome method is to be preferred to the inferior and easier one; but all the same, one should hold on to the descriptions of both methods, for the sake of those who will be attracted to the handier one of them because it is easy.14

14 In some manuscripts (including U but not X) the end of Book 1 is followed by a list of the ratios between the parallels through Meroë, Soēnê, Rhodes, and Thulë, and the equator. These are simply extracted from the foregoing chapter.