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Eratosthenes of Cyrene

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Cover: Eratosthenes, ancient Greek mathematician and scientist. (Public Domain: Source; Wikimedia Commons)

19th century reconstruction of Eratosthenes' map of the known world, c. 194 BC. from Bunbury, E.H. (1811-1895), **A History of Ancient Geography among the Greeks and Romans from the Earliest Ages till the Fall of the Roman Empire**, page 667. London, John Murray, 1883. (Public Domain: Wikimedia Commons)

Eratosthenes of Cyrene

> *Eratosthenes of Cyrene was, according to Suidas, the son of Aglaus, according to others, the son of Ambrosius, and was born B. C. 276. He was taught by Ariston of Chius, the philosopher, Lysanias of Cyrene, the grammarian, and Callimachus, the poet. He left Athens at the invitation of Ptolemy Euergetes, who placed him over the library at Alexandria. Here he continued till the reign of Ptolemy Epiphanes. He died at the age of eighty, about B. C. 196, of voluntary starvation, having lost his sight, and being tired of life. He was a man of very extensive learning: we shall first speak of him as a geometer and astronomer.* [1]

Born in modern-day Libya, Eratosthenes (c. 276 –194 BC) is best known for his remarkably accurate calculation of the circumference of the Earth by comparing angles of the mid-day Sun at two locations a known distance apart on a north-south meridian.

At noon on the summer solstice in Syene (near modern-day Aswan, due south of Alexandria and almost on the Tropic of Cancer), the Sun was directly overhead since the shadow of someone looking down a deep well there blocked the Sun's reflection on the water.

In Alexandria, Eratosthenes used a *gnomon* (the projecting piece of a sundial) to measure the Sun's angle at noon on the summer solstice, working from the length of its shadow on the ground.

He established the angle of the Sun's rays was about 7°, around one-fiftieth of the circumference of a circle.

Knowing Earth is spherical, and that Syene was around 5,000 stadia due south of where he was, Eratosthenes concluded that the Earth's circumference was fifty times that distance.

Eratosthenes rounded the result of his observations to a value of 700 stadia per degree, giving a circumference of 252,000 stadia (around 46500 km).

Although that figure is well off the Earth's currently accepted polar circumference (40,008 km), Eratosthenes worked on some assumptions that were not entirely accurate.

The distance between Alexandria and Syene was not exactly 5000 stadia, and Syene is not right on the Tropic of Capricorn and is not due south of Alexandria.

The Earth is not a perfect sphere, but his false assumptions cancel each other out.

A repetition of Eratosthenes's calculations in 2012 using more accurate data; delivered a result of 40,074 km, just 66 km off the mark.

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[1] William Smith, **Dictionary of Greek and Roman Biography and Mythology**, Vol. 1 p. 44)

Eratosthenes would have started his education by studying the regular curriculum at the local gymnasium. He moved to Athens to continue his studies with Zeno of Citium, the founder of Stoicism, Aristo of Chios, and Arcesilaus of Pitane, who headed the Platonic Academy.

Eratosthenes' first scholarly work, **Platonikos**, inquired into the mathematical basis of Plato's philosophies. He made his name as a talented and imaginative poet.

He produced many significant works:

Hermes portrays the god's life history;

Erigone, about the suicide of the Athenian daughter of Icarius;

Chronographies, an accurate listing of dates from the beginning of the Trojan War and dating the sack of Troy to 1183 BC;

Olympic Victors, covering the winners of the Olympic Games.

In 245 BCE, the quality of those works led h Ptolemy III Euergetes to offer him a position as a librarian at the Library of Alexandria. Around five years later, he replaced the poet Apollonius Rhodius as head of the Library.

Eratosthenes expanded the Library's holdings, adding a section devoted to Homer and original copies of great tragic dramas by Aeschylus, Sophocles, and Euripides.

They may not have been the only original copies of works added to the Library.

The owner of any privately owned text that arrived in Alexandria was required to surrender it to the Library for duplication, if necessary.

The quality of reproduction reputedly meant that it was impossible to tell if the owner had received the original or the Library's copy when they returned the volume.

Apart from that calculation and his literary work, Eratosthenes made several significant contributions to mathematics and science.

He calculated the Earth's axial tilt, developed the armillary sphere (a celestial globe), and introduced an efficient method to identify prime numbers (the sieve of Eratosthenes).

He may have calculated the distance from the Earth to the Sun and the Moon and the Sun's diameter.

He devised a calendar based on a 365-day year, with every fourth year having an extra 'leap day.'

However, for all that, one development overshadowed the rest. Eratosthenes effectively invented the discipline of geography, including terminology still used today.

His position at the Library of Alexandria gave him access to the accumulated knowledge of the classical world.

The collection would have included almost every existing travel book, and their descriptions of the known world and information needed to be pieced together and collated into an organised format.

Eratosthenes' three-volume **Geography** (*Geographika*) described and mapped the known world and divided the Earth into five climatic zones. It also named and located more than four hundred cities.

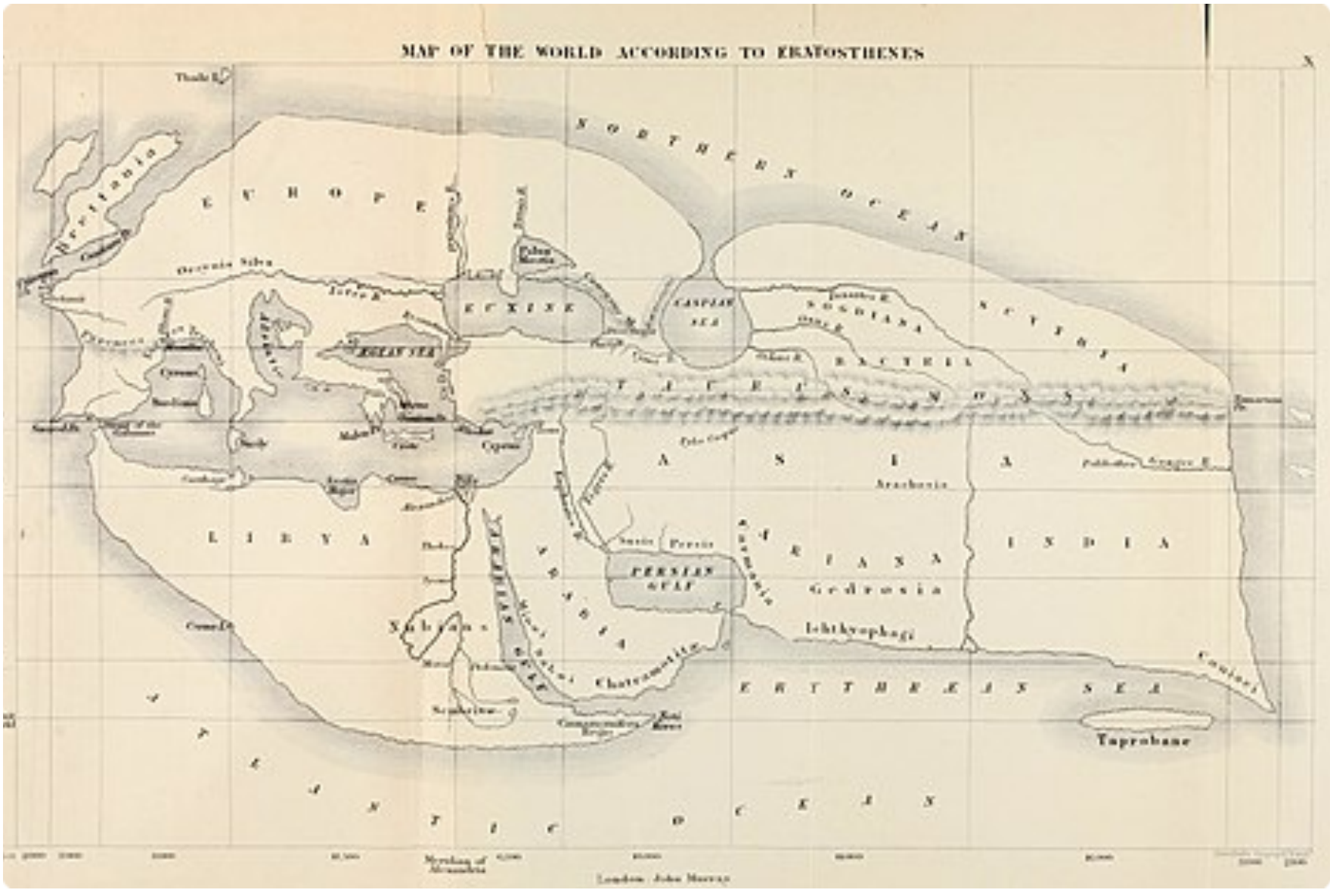
Eratosthenes drew a world map from that data on a grid of parallels and meridians.

He based his longitudes on a meridian running through Alexandria and his latitude on a line passing through the Pillars of Hercules and Rhodes.

The result would have been a reasonably accurate map of the Mediterranean, but the map has been lost. So have the three volumes of his **Geography**.

Fragments of the project can be pieced together from the works of writers like Marcianus, Pliny, Polybius, and Strabo.

In his version, the inhabited Earth ended at the Ganges, one-third of the way around the globe on the Rhodes parallel.



Beyond the Ganges and the Pillars of Hercules at the western end of the parallel, there was Ocean.

Eratosthenes did not deny the possibility of land beyond the extremities of the oikoumene or in the southern temperate zone.

Since their existence was a matter of speculation and supposition, there was no way he could include them on his map.

Still, he seems to have assumed the temperate zone south of the equator was inhabited.

Eratosthenes also commented on the nature and origin of the Earth, which he thought was an immovable globe with a changing surface.

He hypothesised that at one time, the Mediterranean was a vast lake that had only become connected to the ocean to the west when a passage had opened up at the Pillars of Hercules.

His conclusions, however, were not universally accepted:

> *Eratosthenes describes the figure of the Earth, not merely of the habitable Earth, an account of which would have been very suitable, but of the whole Earth, which should certainly have been given too, but not in this disorderly manner. He proceeds to tell us that the Earth is spheroidal, not, however, perfectly so since it has certain irregularities; he then enlarges on the successive changes of its form, occasioned by water, fire, earthquakes, eruptions, and the like; all of which is entirely out of place, for the spheroidal shape of the whole Earth is the result of the system of the universe, and the phenomena which he mentions do not in the least change its general form; such little matters being entirely lost in the great mass of the Earth. Still, they cause various peculiarities in different parts of our globe and result from various causes.*
>
> *He points out as a most interesting subject for disquisition the fact of our finding, often quite inland, two or three thousand stadia from the sea, vast numbers of muscle, oyster, and scallop shells, and salt-water lakes.* [2]

Undoubtedly, Eratosthenes was one of the most pre-eminent scholars of his time.

He accumulated a vast body of knowledge covering chronology, geography, grammar, literary criticism, mathematics, philosophy, and poetry.

To his critics, however, Eratosthenes was *Beta* (the second letter of the Greek alphabet), the scholar who never achieved the highest rank in any field. [3]

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[2] **The Geography of Strabo**, I, iii, 3, 4.

[3] "... nicknamed 'Beta' because, despite being a good all-rounder, he was second best in every discipline (though as the first to calculate the circumference of the globe to an error of just 1.6 per cent, he deserved at least beta plus." (David Stuttard, **A History of Ancient Greece in Fifty Lives**, p. 238.)

To Strabo, he frequently runs into scientific speculations, having little to do with the subject, resulting in vague and inexact conclusions.

> *Thus he is a mathematician in geography and in mathematics, a geographer, and so lies open to the attacks of both parties*. [4]

His supporters, however, nicknamed him *Pentathlos*, the well-rounded competitor, since, as a genuine polymath, he had demonstrated his mastery of every learning area.

Around 195 BC, however, the onset of ophthalmia took away his sight. Unable to read or observe nature, depression followed, and Eratosthenes reputedly opted to starve himself to death.

He died the following year, aged 82, in Alexandria.

Eratosthenes' work

> *"... survived only in fragments quoted by other writers, and he had no influence in the Middle Ages, except that through Macrobius his value for the size of the globe was widely accepted; but Roger Bacon, for instance, followed Ptolemy in thinking that the distance between Spain and 'the beginning of India' was quite small.* [5]

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[4] **The Geography of Strabo**, I, i, 41

[5] O.H.K. Spate, **The Pacific Since Magellan, Volume I: The Spanish Lake**, p. 8.

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