ERATOSTHENES OF CYRENE

MEASURING THE CIRCUMFERENCE OF THE EARTH

By Cynthia Stokes Brown, adapted by Newsela
More than 2,000 years ago Eratosthenes figured out the size of the Earth with great accuracy. His tools: a stick, the Sun’s rays, and simple math.
Eratosthenes was born in the Greek colony of Cyrene, now Libya. In Cyrene, he made a name for himself as a great scholar. The Greek ruler of Egypt decided to bring him to Alexandria to tutor his son. In 236 BCE, the chief librarian of the famous Library of Alexandria in Egypt died. Eratosthenes was given the job around age 40.

Eratosthenes was a man of many talents. He was a librarian, geographer, mathematician, astronomer, historian, and poet. Most of Eratosthenes’s writings have been lost. Luckily, other scholars have recorded his wide-ranging work.

**Studying the Earth**

Eratosthenes was the father of geography. He invented a system of longitude and latitude. He made a map of the world as it was known at the time. He also designed a system for finding prime numbers — whole numbers that can only be divided by themselves or by the number 1. His system is still in use today.

Eratosthenes was also the first to figure the tilt of the Earth’s axis. His calculation was impressively close to being correct.

Eratosthenes also calculated the distance from the Earth to the Moon and to the Sun, but with less accuracy. He cataloged 675 stars. He made a calendar with leap years. He laid the foundation of chronology, the science of arranging historical events in order by when they happened. He organized the dates of events from the siege of Troy (about 1194 — 1184 BCE) to his own time.

But he is best known for figuring the distance around the Earth. His calculation was not correct, but it was impressively close. He computed the circumference by using simple geometry and trigonometry. Most Greek scholars by the time of Aristotle (384 — 322 BCE) agreed that Earth was a sphere. None, however, knew how big it was.

How did Greek scholars know the Earth was a sphere? They noticed that when ships disappeared over the horizon, their masts were still visible for a few extra moments. They also saw that the Earth made a curved shadow on the Moon during lunar eclipses. This happens a couple times each year when the moon passes directly behind the Earth and into its shadow. The Greeks had also noticed the changing positions of the stars in the sky.
Measuring the Earth

Eratosthenes heard about a famous well in the Egyptian city of Syene, now known as Aswan, on the Nile River. The summer solstice falls one day each year between June 20 and 22. At noon on that day, the Sun’s rays shone straight down into the well’s deep pit. On other days, the sides of the well would be lit. But not on this day. On the Solstice, the rays lit up only the water at the bottom. This proved that the Sun was directly overhead.

Back in Alexandria, Eratosthenes erected a pole. On the summer solstice, he observed that it cast a shadow. The Sun was not directly overhead there. Instead, it was slightly south. Eratosthenes knew that the Earth was curved. By also knowing the distance between the two cities, Eratosthenes could calculate the planet’s circumference.

Eratosthenes measured the angle of the Sun’s rays off the vertical. He divided the length of the leg opposite the angle (the length of the shadow) by the leg adjacent to the angle (the height of the pole). This gave him an angle of about 7.2 degrees. He knew that the Earth was a 360-degree circle. He also knew the approximate distance between Alexandria and Syene. He had everything he needed to set up this equation:

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\frac{360 \text{ degrees}}{7.2 \text{ degrees}} = \frac{\text{circumference of the Earth}}{\text{distance from Alexandria to Syene}}
\]

Eratosthenes knew the distance from Alexandria to Syene was about 5,000 “stadia.” To us, that distance would equal about 500 miles (800 kilometers). By solving the equation, he calculated the Earth’s circumference at 250,000 stadia, or 25,000 miles (40,000 kilometers).

His calculations were incredibly close. The Earth’s actual circumference is 24,860 miles (40,008 kilometers).

Yet, Eratosthenes’s calculations had errors. For one thing, he was using the “stadion” as his unit of measure. A stadion was the length of an athletic stadium. But stadiums were different lengths in Egypt and Greece. We don’t know which unit Eratosthenes used.

If he used the Egyptian measure, he would have been nearly spot on. However, if he used the Greek one, his calculation would have been off by about 16 percent.
A century after Eratosthenes, the Greek astronomer Posidonius of Rhodes (c. 135 — 51 BCE) calculated the Earth’s circumference. Instead of using the Sun, Posidonius used the star Canopus as point of reference. When the star is visible at the horizon in Rhodes, it is 7.5 degrees above the horizon in Alexandria. He was very close to Eratosthenes’s calculation of 7.2 degrees. Posidonius’s calculations came out almost exactly correct.

But then he changed the distance between Rhodes and Alexandria. This resulted in a calculation of 18,000 miles (about 29,000 kilometers). His new calculation was about 28 percent smaller than the actual circumference of 24,860 miles.

The writer Ptolemy reported the calculations of Posidonius, instead of those of Eratosthenes. Christopher Columbus read Ptolemy’s writings. If Ptolemy had used Eratosthenes’s larger, closer figure for Earth’s circumference, history might have had a different outcome. Columbus might never have sailed west. The Americas might not have been reached by Europeans until much later.

Eratosthenes died around the age of 82. He starved himself to death because he feared going blind.

Sources


Image credits

An undated illustration of scholars at the Library of Alexandria
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A reconstruction of Eratosthenes’s c. 194 BCE map of the world,
from E.H. Bunbury’s 1883 A History of Ancient Geography among
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A diagram showing how Eratosthenes measured the Earth,
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