# ERATOSTHENES MEASURES THE EARTH

That the earth was round has been known since at least 240 BCE, when Eratosthenes calculated its circumference. His method used only the simplest mathematics, and will be explained here. It depends on the fact that the Sun is sufficiently far away from Earth that its rays arriving at Earth are essentially parallel, no matter what part of Earth they strike:
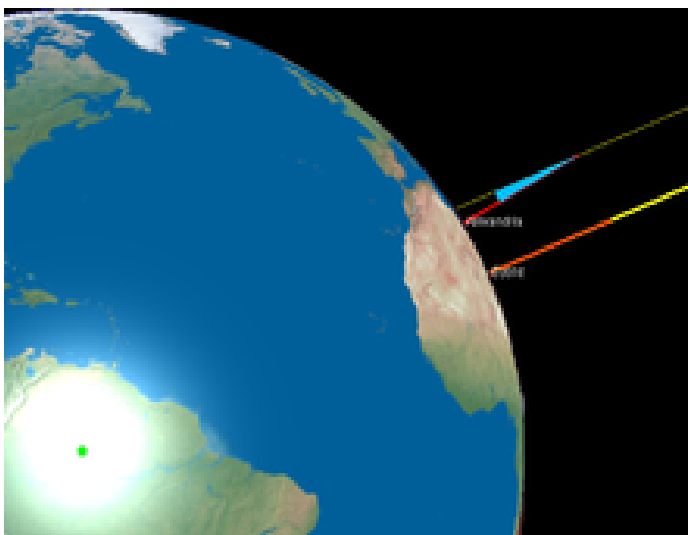
The picture shows two rays of light, one landing at Alexandria, Egypt (where Euclid lived and worked), and one landing at Syene, Egypt (modern-day Aswan). Syene is approximately due south of Alexandria, and it happens to be located on the Tropic of Cancer, which means that at the summer solstice (June 21), the sun is directly overhead at noon. At that time and day, the sun in Alexandria will be a little south of the zenith, i.e., the shadow cast by a vertical stick will be short, but will point north.

Eratosthenes measured the angle between the sun's rays and the vertical in Alexandria, and found 7 degrees and 12 minutes. Since there are 360 degrees in a circle, that is about 1/50 of a circle. If we imagine the two vertical lines at Alexandria and Syene meeting in the middle of the earth, the angle between them will also be one-fiftieth of a circle. Therefore, the circumference of the Earth is fifty times the distance between Syene and Alexandria.

To complete his calculation, Eratosthenes needed to measure the distance between Syene and Alexandria, and multiply by 50. He had some experience as a surveyor, and based on his knowledge of Egypt, he thought the distance was 5000 "stadia". He inquired of traders about the time required to travel between the two cities by camel, to corroborate this estimate.

Historians argue about how long one station was. Apparently there was a Greek station and and Egyptian stadion. If he used the Egyptian definition, then his answer for the circumference of the Earth was only off by 1.6%. Otherwise it was off by 16.3%. Either way, it was pretty accurate for 240 BCE.

Eratosthenes worked at the Musaeum in Alexandria. The Museum was not what we now think of as a "museum"; it was a research center, where scholars lived and worked. It had lecture halls, meeting rooms, gardens, and apartments. Associated with the Museum was the Library of Alexandria, which archived the work of the entire Greek civilization. The Library was burned (probably not just once, but several times, starting with a fire set by Julius Caesar in 42 BCE, and ending in final destruction with the Muslim invasion of Egypt in 642.)

Contrary to what you may have been taught in school, the knowledge that the Earth is spherical (or nearly so) and not flat was never lost, in spite of the destruction of the Musaeum and Library, the fall of the Roman Empire, the Plague, and the Dark Ages. People always knew that the Earth was round.

When Columbus wanted funding for his expedition, he went first to the King of Portugal, who refused funding. It is a myth that the King thought the Earth was flat and Columbus would sail off the edge; instead, his advisors knew that the Earth was spherical, but too large for Columbus to make it to India in the tiny ships of that day. What they didn't know, of course, was that North and South America lay within reach. The Spanish royalty must have not had such good advice, and they were eager to compete with the Portugese, who had recently established trade routes to the East around the southern tip of Africa, so they did fund Columbus.