

Eratosthenes and the Earth

Eratosthenes was born in North Africa about 276 BCE. From the age of thirty he lived in Alexandria, Egypt, where he served as librarian of the great Library of Alexandria. Eratosthenes was interested in many things: poetry, math, astronomy, geography, music theory, etc. He is one of my heroes! Many of you just worked on the Sieve of Eratosthenes, a clever trick he devised to find prime numbers by getting rid of the composite numbers. Now we'll study another amazing accomplishment of his: Eratosthenes measured the circumference of the earth without leaving his backyard! His measurement was quite accurate! How was he able to do this? Here are some things he knew:

a) He knew a basic fact about geometry. You can know it too. Draw two parallel lines on lined paper, and a third slanting line that intersects the other two lines. Use a protractor to measure all eight angles. Write down what you notice!

b) He knew that the sun's rays are not parallel—they all meet in the center of the sun. But he also knew that the sun is *very* far away, and that the earth is small compared to the sun, so that the sun's rays that hit the earth can be considered parallel.

c) He had heard that in the southern Egyptian town of Syene (modern Aswan) at noon on the summer solstice, the sun was directly overhead.

d) He knew Syene was about 500 miles south of his home in Alexandria.

e) When Eratosthenes set up a vertical pole in his backyard on the summer solstice, he noticed the sun was *not* overhead at noon where he lived. The shadow showed that the sun was about 7 degrees, or a fiftieth of a circle, away from vertical.

1) Explain how Eratosthenes measured the earth! Use carefully made drawings and diagrams to support your written explanation. In your drawing it's okay to exaggerate the 7 degree angle to make the drawing easier to read.

2) What measurement would Eratosthenes get, based on the numbers in this POW? What is the correct circumference of the earth?

3) Why do you think people like Eratosthenes already thought of the earth as a sphere? What evidence would they have had? What additional evidence do we have nowadays?

4) Ancient Alexandria was a pretty amazing place. One of the most important books in the history of the human race, Euclid's *Elements*, was written there. (Many things can be found in that book, including the proof that the number of primes is infinite.) The *Septuagint*, the first translation of the Hebrew bible into Greek, was made there as well. Appolonius Rhodius wrote the *Argonautica* there—the fabulous story of Jason and the Argonauts. What do you think made it a place where so much progress was made in literature, math, science, geography, etc.? Are there lessons we can learn from Alexandria?

- 5) Can you make a very simple sketch of our school showing north, south, east and west?
- 6) When you get to school in the morning and face the rising sun, which direction are you facing? How about when you face the sun at lunchtime? How about when you face the setting sun late in the day? Would an Australian student give the same answers?
- 7) What if you had a magic airplane and could fly forever, and someone told you to “fly north as far as you can”? Would you be flying forever? If not, where would you stop?
- 8) What if you were told to fly east as far as you can in your magic plane?
- 9) A person travels one mile south, one mile east, and one mile north. And she’s right back where she started! Where on earth did she start?
- 10) On Tuesday, September 20, 1519, Ferdinand Magellan left Spain with five ships in an attempt to sail around the world. His fleet sailed west through the Atlantic, rounded the southern part of South America (through the strait now named *Magellan*) and entered the Ocean to which he gave the name *Pacific*. Magellan died in battle in the Philippines, but the expedition continued westward around the world past India and Africa. After many misadventures, just one ship, with eighteen sick and starving men aboard, returned to Spain on Sunday, September 7, 1522, after a round-the-world journey of almost three years. But wait! An Italian member of the expedition, Antonio Pigafetta, had kept a daily journal of the voyage. Both his journal and the ship's log said it was September 6! Explain that missing day!
- 11) Oh no! You went on a one hour hot air balloon trip, and this storm came out of nowhere, and after four days of being blown around in a super storm, you're stranded on a desert island! (I stole this idea from *The Mysterious Island*, a wonderful book by Jules Verne.) Is there a way to decide if you're in the northern or southern hemisphere? Let's say you're in the northern hemisphere, is there a way to determine your latitude? Oh, and you're still wearing your digital watch, which is still going. Is there a way to determine your longitude? Explain fully!
- 12) The ancient Greek historian Herodotus mentioned being told that an Egyptian pharaoh, around 600 BCE, sent out an expedition of Phoenician sailors to sail all around Africa. According to the story, the sailors accomplished this, and they reported that as they were sailing westward around the southern part of Africa, they "had the sun on their right hand." This detail made the report seem unbelievable to Herodotus! Can we believe it?! Explain!
- 13) Have fun!