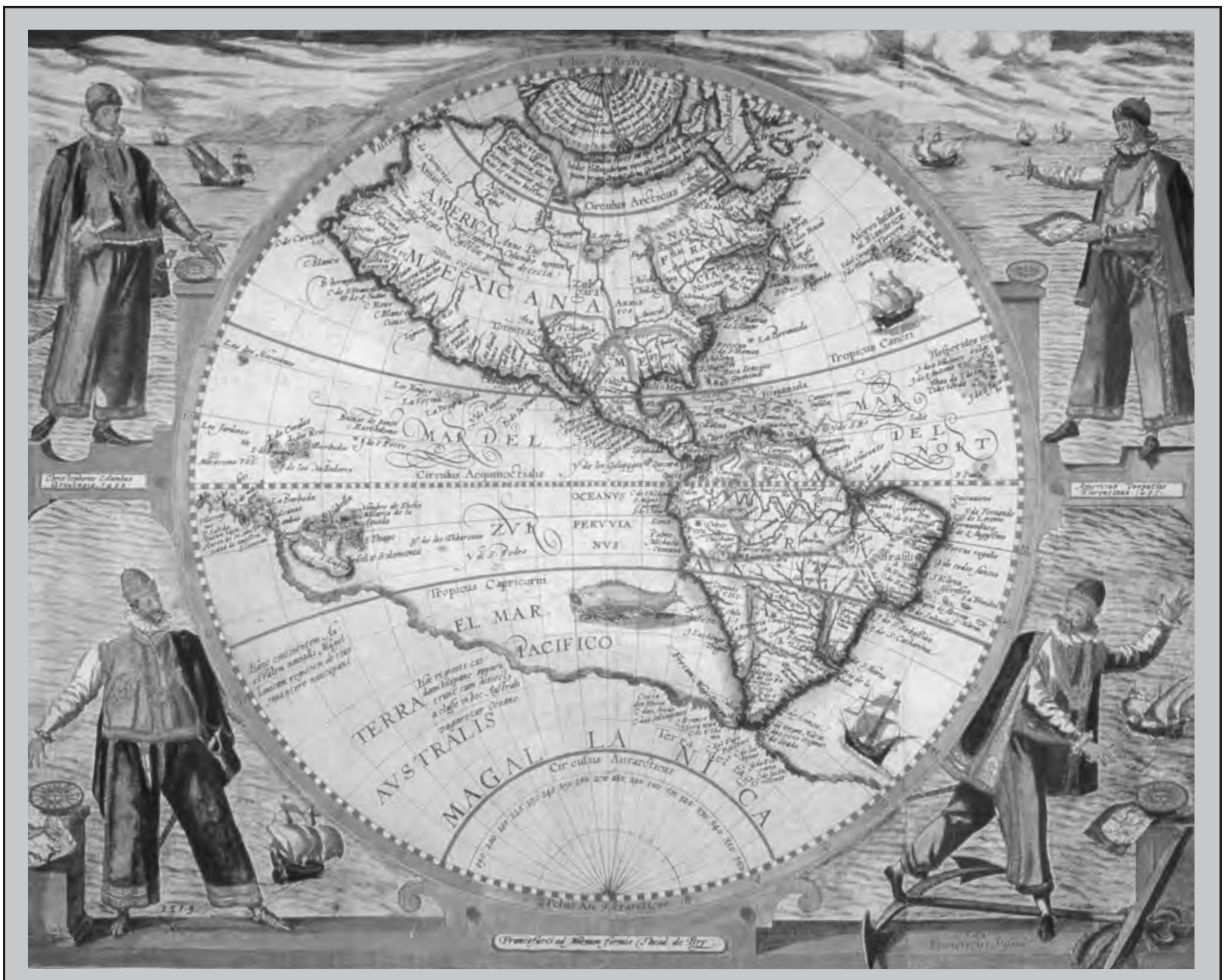
EXPLORING PLANET EARTH

JOHN HUDSON TINER



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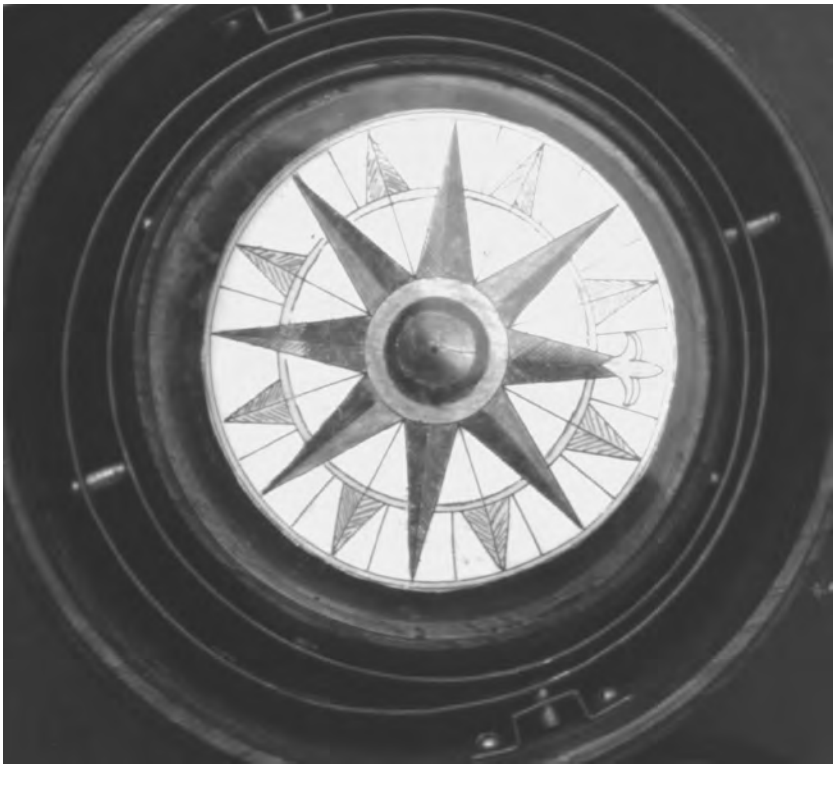
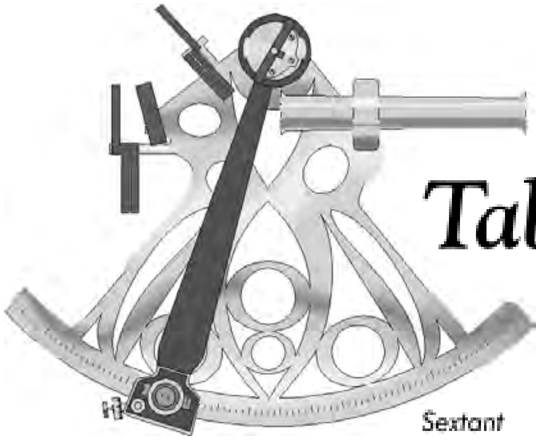
Dedication

This book is dedicated to LaMar and Janice Marshall



This compass is a replica of the one used by Christopher Columbus on his first voyage across the Atlantic Ocean.



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CHAPTER 1

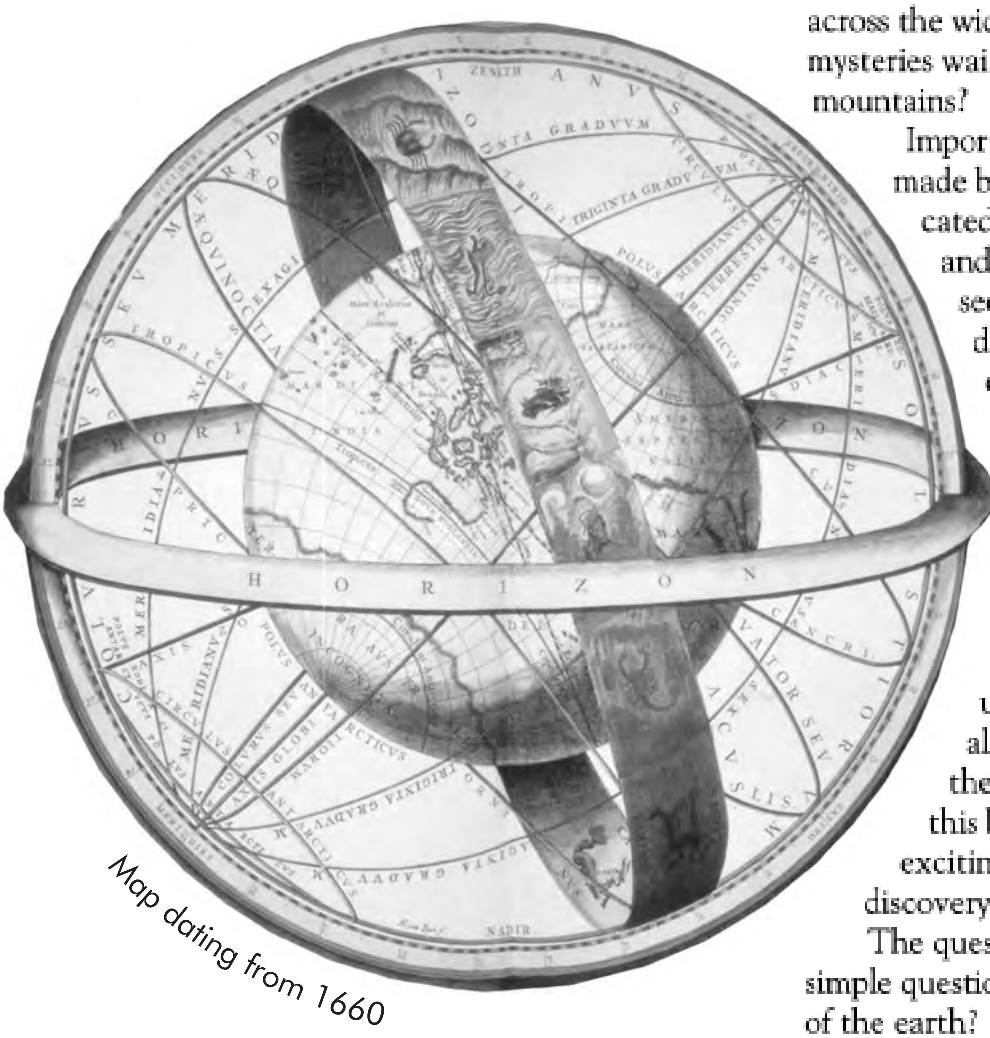
HOW BIG IS THE EARTH?

People throughout the ages have felt the urge to explore beyond the horizon. What wonders lay across the wide expanse of the ocean? What mysteries waited on the other side of the mountains?

Important discoveries have been made by professional explorers, dedicated scientists, talented amateurs, and ordinary people who became seekers after adventure. Their discoveries are interesting and exciting. Just as dramatic are the stories of how the discoveries came to be made.

Exploration takes many forms. It is not merely the quest for new lands, but the quest for knowledge about the earth. The earth does not give up its secrets easily. Exploration alone is not enough. Research in the laboratory plays a part, too. In this book we'll look at the most exciting examples of each kind of discovery.

The quest for adventure began with a simple question. What is the shape and size of the earth?



Map dating from 1660

Eratosthenes (er-uh-TAS-theh-neez) grew up in a town on the coast of Libya in northern Africa. He lived about 250 years before the birth of Christ, more than two thousand years ago. He studied at Alexandria in Egypt and at Athens in Greece. He traveled widely. He studied and wrote on mathematics, astronomy, and geography. He gained fame as Greece's most talented scholar.

Although born and raised in Africa, Eratosthenes was a Greek.

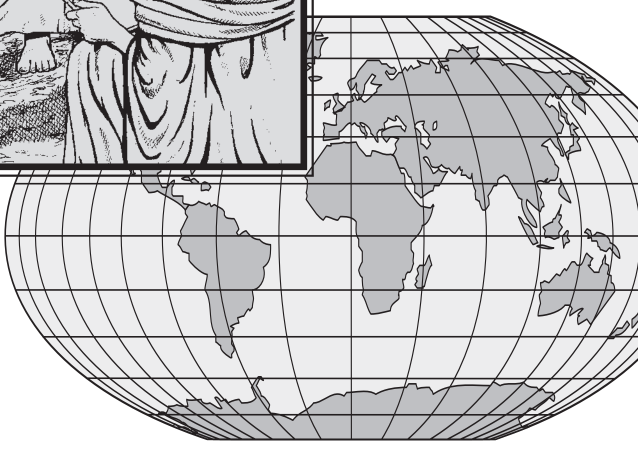
The cities of northern Africa became Greek following their conquest by the greatest general of ancient times, Alexander the Great. This famous general lived almost 350 years before the birth of Christ and well before the Roman Empire. Alexander the Great conquered Egypt, parts of Europe, and Asia as far east as India. He died of a fever in Babylon at age 32.

Ancient Greeks discussing their different ideas about the earth.

Upon the death of Alexander the Great, his conquest was divided among four Greek generals. Ptolemy III (TOL-uh-mee, the "P" is silent), a descendent of one of these generals, ruled northern Africa. This kingdom included part of Egypt and the city of Alexandria.

In Alexandria, Ptolemy opened a library and museum. He ordered a search of all ships, caravans, and visitors who entered his realm. When Ptolemy's men found books, maps, or interesting documents, they sent the documents to the library to be copied.

Ptolemy chose Eratosthenes to take charge of the library. Eratosthenes threw himself into the task. The library at Alexandria became a storehouse of the vast knowledge of the ancient world. Scientists came from all over Greece to study there.



Eratosthenes made many exciting discoveries. But his most astonishing achievement was calculating the distance around the earth. He did this at a time when many of the more backward and superstitious people still believed the earth to be flat.

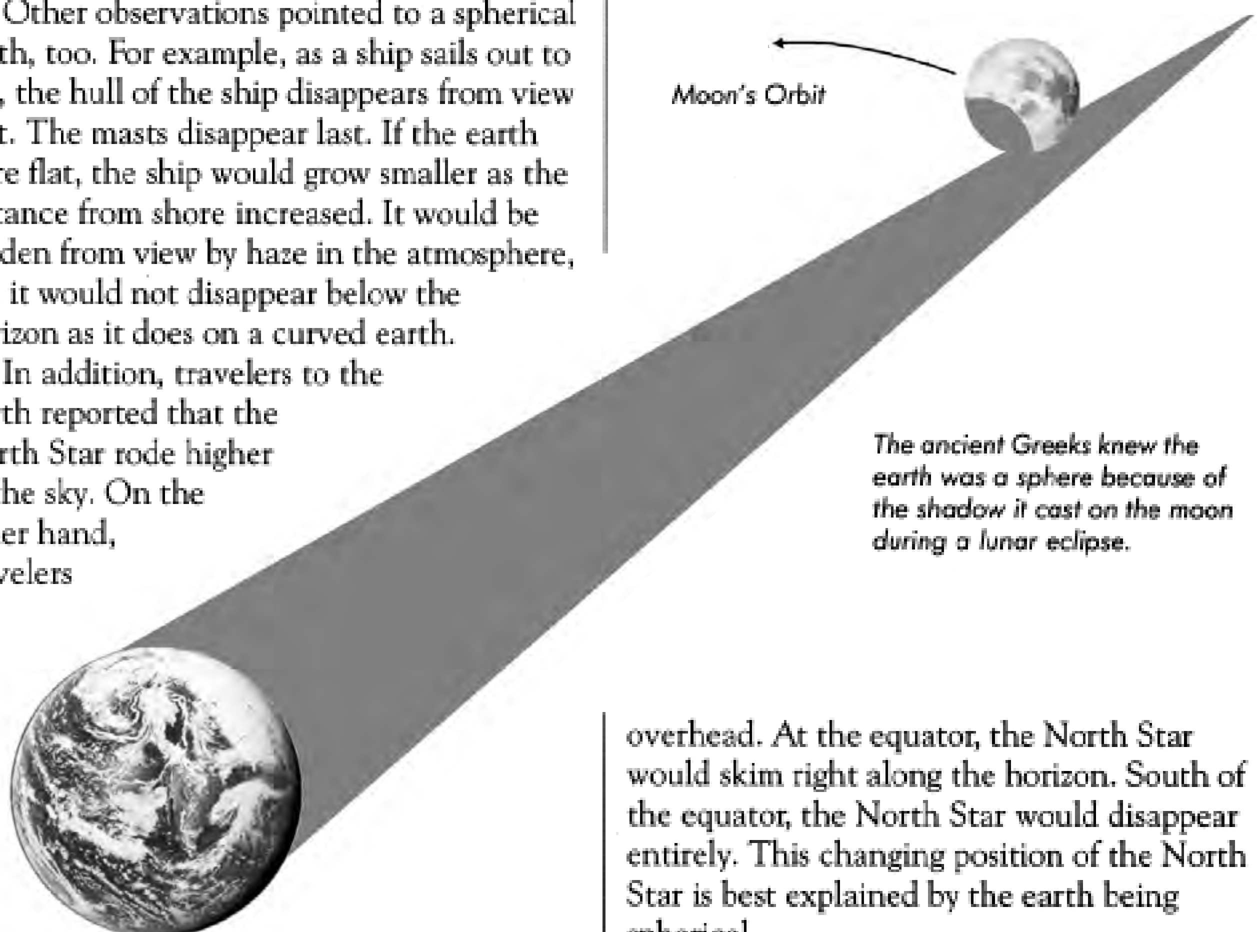
The ancient Greeks understood that the earth was a sphere; that is, a ball. This was clear from several observations. The best argument for a spherical earth occurred during a lunar eclipse. The shadow of the earth as it fell on the moon was circular in outline.

Other observations pointed to a spherical earth, too. For example, as a ship sails out to sea, the hull of the ship disappears from view first. The masts disappear last. If the earth were flat, the ship would grow smaller as the distance from shore increased. It would be hidden from view by haze in the atmosphere, but it would not disappear below the horizon as it does on a curved earth.

In addition, travelers to the north reported that the North Star rode higher in the sky. On the other hand, travelers to the south said the North Star circled closer to the horizon.

None of the Greeks ever traveled to the North Pole or to the equator. They believed the North Pole to be eternally frozen and far colder than a human being could endure. Nor did the Greeks ever travel as far south as the equator. They believed scorching sands of a worldwide desert circled the earth at the equator. Explorers foolish enough to travel there faced certain death.

But if an explorer could go to the North Pole or to the equator, the Greeks knew what he would see in the night sky. At the North Pole the North Star would be directly overhead. At the equator, the North Star would skim right along the horizon. South of the equator, the North Star would disappear entirely. This changing position of the North Star is best explained by the earth being spherical.



The ancient Greeks knew the earth was a sphere because of the shadow it cast on the moon during a lunar eclipse.

Eratosthenes agreed with the other Greeks that the earth was spherical.

Very well, Eratosthenes wondered, *how big is the earth?* If a person set out in one direction and traveled until he returned to his starting point, how far would he travel? No one knew. Without actually making the journey, how could a person find the distance around the earth?

The answer came to Eratosthenes as he read about a deep water well in Syene (now Aswan) in southern Egypt. On June 21, the longest day of the year, the sun is at its highest position. Each year at noon on that day in Syene, the sun's rays reflected from the water at the bottom of the deep well. The sun had to be exactly overhead.

At the same hour on the first day of summer in Alexandria, the sun never becomes exactly overhead. Tall buildings cast small shadows.

The sun does not precisely repeat its path every day. During winter the sun's path takes it lower in the south. Its rays are more slanted. During summer the sun's path carries it higher to the north. Its rays are more directly overhead. (The changing path of the sun is actually due to the tilt of the earth's axis, not a change in the sun's position.)

The distance between Syene and Alexandria is 1/50th of the distance around the earth.

Imagine this experiment. Eratosthenes goes out at noon each day and measures the shadow of a nearby tall building. The length of the shadow doesn't change much from one day to the next. But from month to month it becomes clear that the shadow isn't always the same length, even at noon. During winter, the shadow is long and points north at noon. During summer, the shadow points north, too, but it is much shorter.

The sun's rays are more direct during summer. This warms the earth's surface. The sun's rays are more slanted during winter. Sunlight is spread out over a greater area and doesn't warm the earth's surface as much.

Why did the sun shine directly overhead in Syene on the first day of summer, but not in Alexandria? In fact, the sun never reached directly overhead in Alexandria. Why?

Then Eratosthenes figured out the answer. Syene was directly south of Alexandria. This difference in position of the sun, Eratosthenes reasoned, could only be due to the curve of the earth's surface from Syene to Alexandria.

The Greeks measured angles by dividing a circle into 360 equal parts. Each part is a degree. Point straight out at the horizon and then bring your arm directly overhead. Your hand has traced out an angle of 90 degrees.

The length of the shadows showed that the sun was seven degrees south of the overhead point in Alexandria. Seven degrees is about 1/50th of a complete circle. Therefore, the north-south distance from Syene to Alexandria is 1/50th of the total distance around the earth.

Eratosthenes could calculate the distance around the earth by measuring the distance from Alexandria to Syene and multiplying this distance by 50.

What was the distance between the two cities? His calculations would be no better than his knowledge of their distance. He checked the maps of his day, but the maps were much too crude and inaccurate to be of help.

Eratosthenes questioned professional runners who carried messages from town to town. Their routes had been established for hundreds of years. These professional runners set the distance between the two cities at 5,000 stadia.

Eratosthenes wasn't satisfied. He asked for the help of the military. A general instructed his soldiers to march off the distance between the cities. They, too, arrived at a distance of 5,000 stadia.

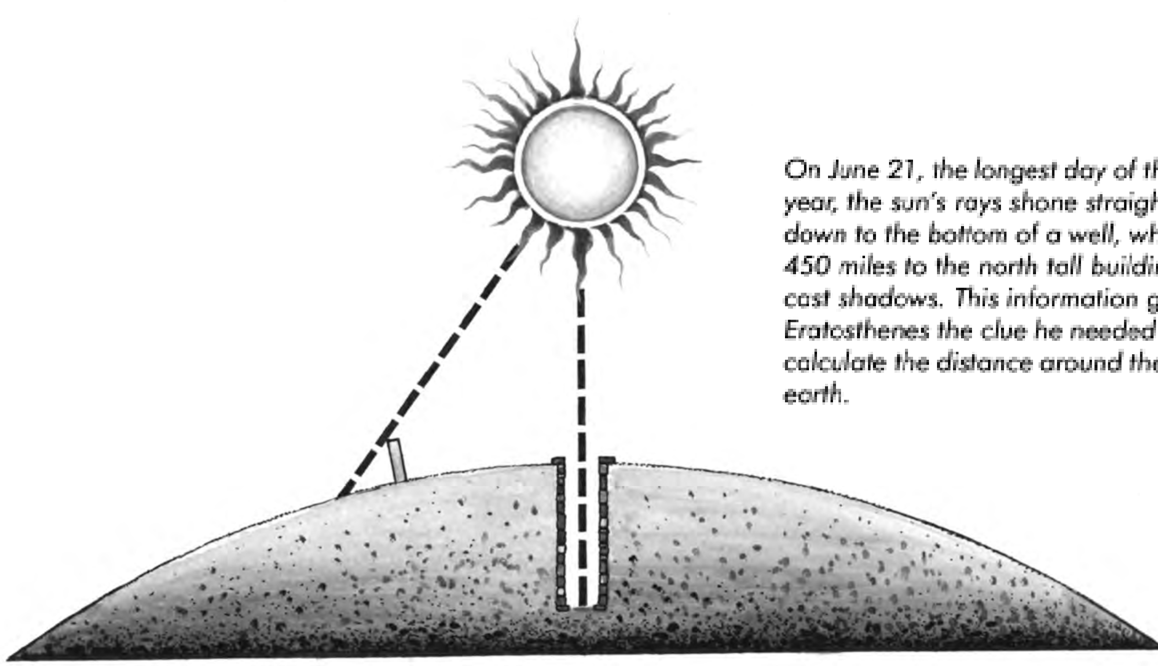
Eratosthenes carried through with the calculations. He reached the conclusion that the earth's circumference is 250,000 stadia. We're not certain today the length of a stadia. We think it is the distance of an event in the Greek athletic games, the distance a sprinter could run without getting out of breath. Using the best value for the stadia that we have, Eratosthenes' distance around the earth works out to be about 24,540 miles. The accepted value is 24,875 miles, a difference of only 335 miles. So he was very accurate, indeed.

Eratosthenes said, "If the great distance were not an obstacle, we might easily pass by sea from Spain to India!" This idea went unheeded until 1492 when Columbus began such a voyage.

Eratosthenes' result was so good that in modern times scientists refused to believe it. How could an ancient Greek use a water well to determine the earth's size? Preposterous! It seemed almost improper for Eratosthenes to be so accurate. He had no business being so good!

Other Greeks refused to accept the figure for an entirely different reason. Eratosthenes made the earth a much larger place than the Greeks had imagined, and it made the known world too small in comparison. It made Greece a tiny country in a vast, unexplored world. They rejected Eratosthenes' value in favor of a smaller, incorrect one.

Today, however, we know that he succeeded to an amazing degree. Eratosthenes is known as the man who measured the earth.



On June 21, the longest day of the year, the sun's rays shone straight down to the bottom of a well, while 450 miles to the north tall buildings cast shadows. This information gave Eratosthenes the clue he needed to calculate the distance around the earth.

Questions

How Big Is the Earth?

Choose A or B to complete the sentence.

1. Exploration is a quest for
   - A. knowledge about the earth.
   - B. new lands.
2. Alexandria was a Greek city, but located in
   - A. the Arctic.
   - B. Egypt.
3. Alexandria had
   - A. the greatest library of the ancient world.
   - B. the world's deepest well.
4. Eratosthenes needed to know the distance from Syene to Alexandria to
   - A. prove the earth is round.
   - B. calculate the distance around the earth.
5. Some ancient Greeks refused to accept Eratosthenes' measure of the size of the earth because it made the earth seem too
   - A. large.
   - B. small.

Thought questions:

6. Is intelligence the same as knowledge?

____

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7. Do you think ancient people were as intelligent as people of today?

____

____

8. In what way can it be said that Eratosthenes explored the earth?

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