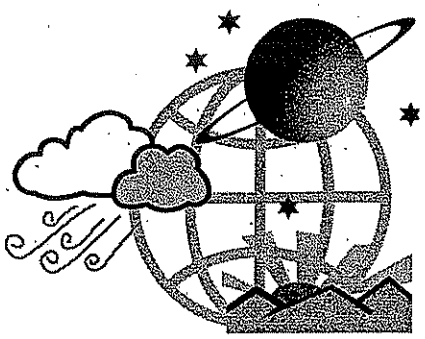
Name Teacher Period Date



Chapter 2
Earth's Dimensions and Navigation

CHAPTER 2—SKILL SHEET 1: CLUES TO EARTH'S SHAPE

Although there are still a few people who think that Earth is flat, most people know that our planet is a sphere. See Figure 2-1. However, as with other facts that you will learn this year, the most important issue is not what you know, but how you know it is true.

For thousands of years it was obvious that Earth must be flat. If it were not, people on the other side would fall off. When we began to realize how gravity pulls us toward the center of planet Earth, we could better understand a round planet. In fact, gravity has given us an important method to determine the exact shape of Earth.

Gravity becomes increasingly weaker the further you are from Earth's center. With sensitive instruments, scientists can measure tiny changes in gravity. For example, the pull of gravity is slightly weaker high in the mountains than it is at sea level. Over the whole Earth, the strength of gravity varies by about 1%. Gravity is slightly stronger at the poles than it is near the equator. There are two reasons for this. First, the spin of Earth creates a slight force, which can counteract gravity. Second, and more importantly, Earth bulges slightly at the equator. A person at the equator is about 20 km farther from Earth's center than a person at the poles. See Figure 2-2.

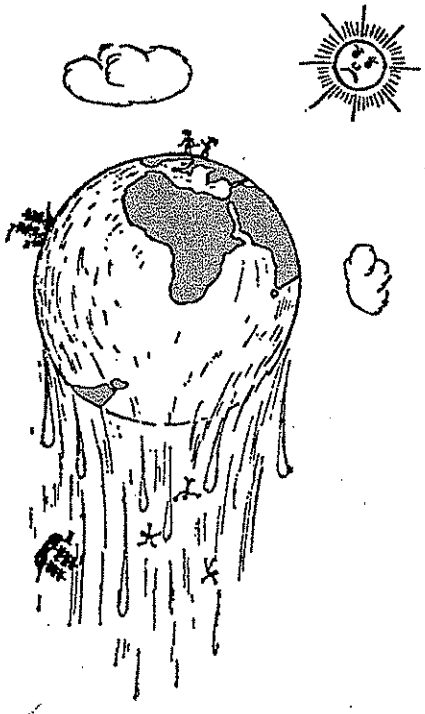


FIGURE 2-1. An argument against the round Earth.

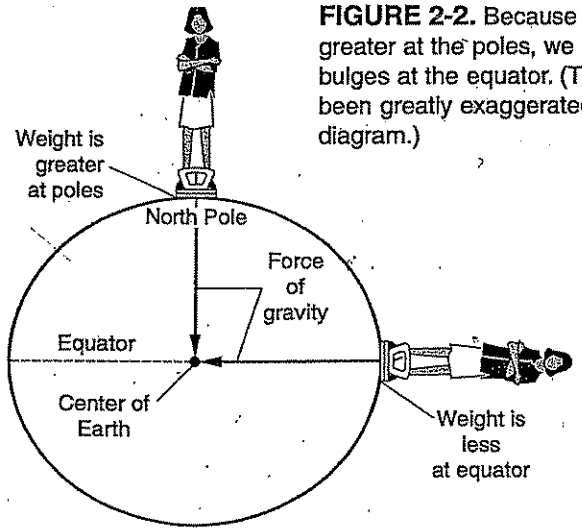


FIGURE 2-2. Because gravity is slightly greater at the poles, we know that Earth bulges at the equator. (The bulge has been greatly exaggerated in this diagram.)

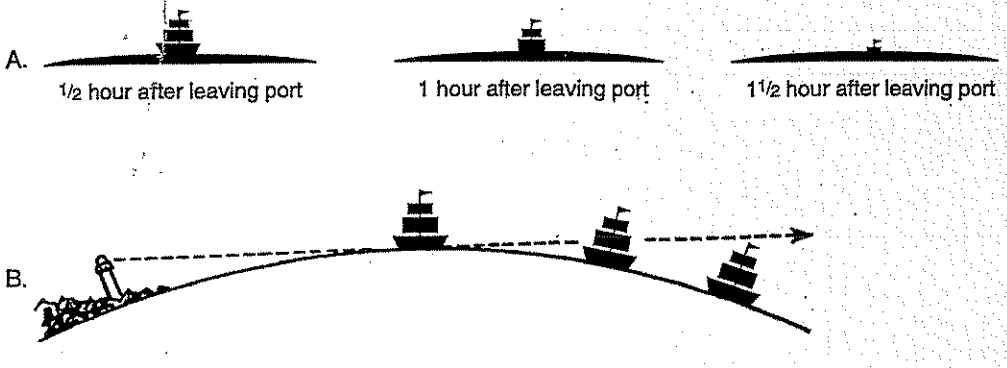


FIGURE 2-3. As a tall ship puts out to sea, it appears to sail "over the horizon." Viewed through a telescope, the ship would disappear from the bottom up, as shown in Part A. (The ships to the right are increasingly magnified.) As shown in Part B, Earth's curvature is responsible for this observation.

The true shape of Earth has been described as a spheroid, very slightly flattened at the poles and very slightly bulging at the equator. Please note that the flattening has been greatly exaggerated in Figure 2-2. In fact, Earth looks like a perfect sphere from every direction.

Long before the voyages of Columbus, people noticed that a distant ship seems to sail "over the horizon." On a clear day, and especially through a telescope, a ship can be seen to disappear from the bottom up, as it "sinks" below the horizon. See Figure 2-3. This effect can be seen when you look out to sea in any compass direction. It is caused by the curvature of Earth's surface. More than 2000 years ago, some enlightened people interpreted this to mean that Earth is a sphere.

A third way to determine the shape of Earth is to make observations of stars and planets. If people over the whole Earth try to observe the sun at any particular time, some will see it, and some (where it is night) will not. For some people, the sun will be high in the sky. For others it will be near or even below the horizon. When we account for all these observations in a logical model, we can determine that Earth must be a sphere.

On a spherical planet, when it is noon in one place, it must be midnight on the opposite side of Earth, 180° of longitude away. Meanwhile, 90° to the east or west, the time will be 6 A.M. or 6 P.M. Consider Figure 2-4. A person at the equator can observe the North

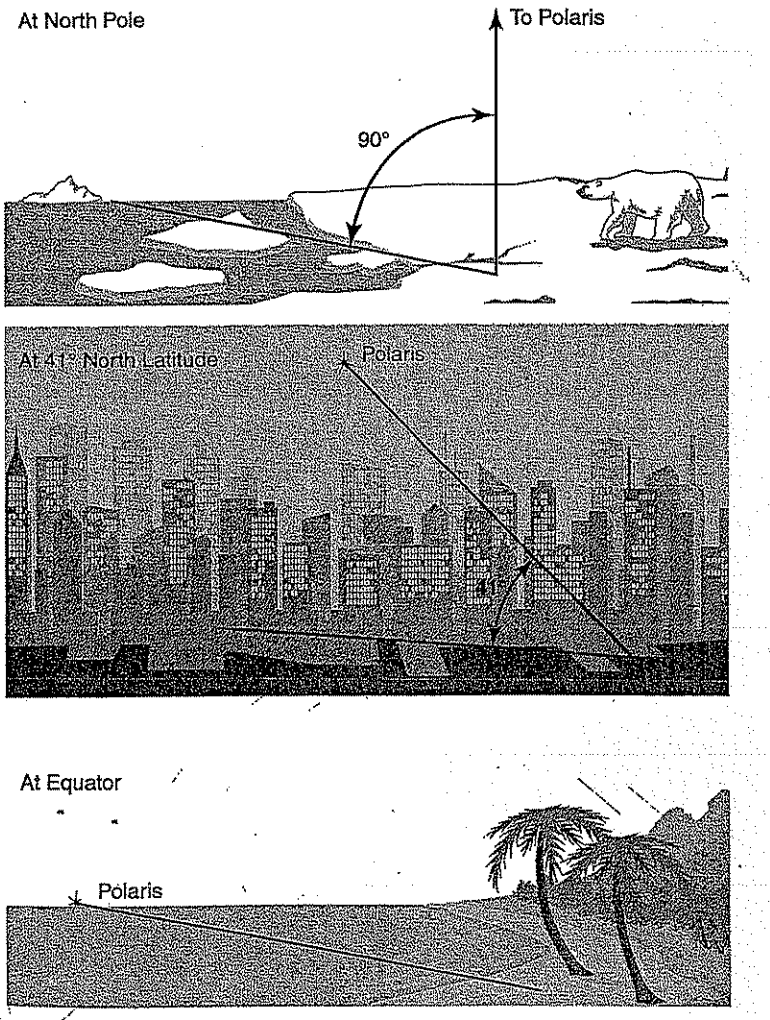


FIGURE 2-4. As an observer travels north from the equator, the North Star moves higher in the sky.

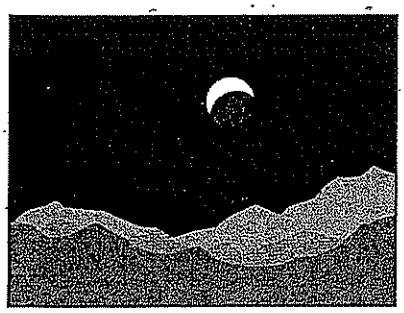


FIGURE 2-5. An eclipse of the moon, when the moon moves into Earth's shadow.

Star along the horizon. As she or he travels northward, Polaris will rise in the sky. Finally, at the North Pole, it will be directly overhead.

When the moon moves in its orbit into the shadow of Earth, we observe an eclipse of the moon. Because the moon is smaller than Earth, we cannot see the whole shadow. However, the edge of Earth's shadow is always round. See Figure 2-5. The sphere is the only shape with a shadow that is always round. In this way, observations of lunar eclipses support the spherical shape of Earth.

So far, we have considered only indirect evidence. The space age has allowed scientists to make direct observations and take photographs of our home planet. It was no surprise to observe the nearly spherical shape of planet Earth. See Figure 2-6. In fact, Earth is so close to a perfect sphere that we cannot detect the slightest flattening without the use of precision instruments.

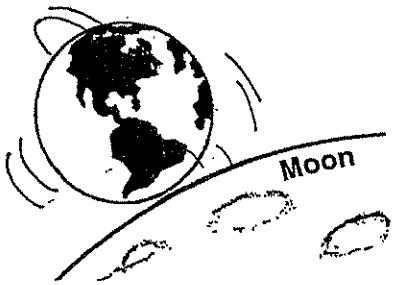


FIGURE 2-6. Earth looks perfectly spherical.

1. State four ways to determine Earth's shape without leaving the ground.

   a. _____

   _____

   b. _____

   c. _____

   d. _____

2. How close to a perfect sphere is Earth's true shape?

   _____

3. At the equator, how high in the sky is the North Star?

   _____

4. Why do objects weigh slightly more at Earth's poles than they do at the equator?

   _____

   _____