78 The Earth on the Move

READING

It takes much longer for Earth to revolve around the Sun than to rotate on its axis. The period of time it takes for Earth to completely circle the Sun is called an Earth year—what we know simply as a year. During each year, the cycle of the seasons takes place.

Emily's cousin Charlotte from Australia came to visit her in June. One day, Emily took Charlotte to meet Tyler.

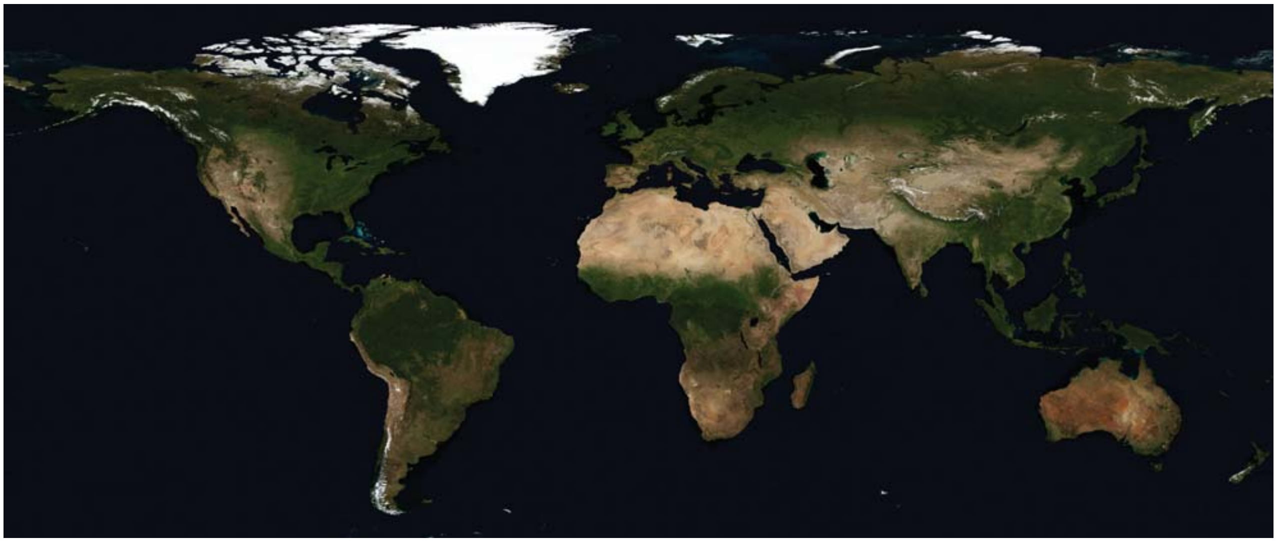
"This is so strange," Charlotte said. "At home, it's almost winter. Here it's hot and the flowers are blooming. I know it has something to do with the Northern and Southern Hemispheres, but I don't completely understand it."

Tyler went into his room and grabbed a globe. "Don't worry," he said, "Emily and I can explain."

CHALLENGE

How do the rotation and revolution of Earth explain the length of a year and the seasons?

A spiral rock marking is lit by the morning sun on the longest day of the year. Ancient Pueblo people may have made such carvings to mark the seasons.



Earth viewed from space in July. Compare the amount of snow in the Northern and Southern Hemispheres in this photo to the one on the next page.

MATERIALS

For each student

1 **Student Sheet 78.1, "Three-Level Reading Guide: The Earth on the Move"**

1 **completed Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Moon Phases: Before"**

1 **Student Sheet 71.1b, "My Ideas About the Day, Year, Seasons, and Moon Phases: After"**

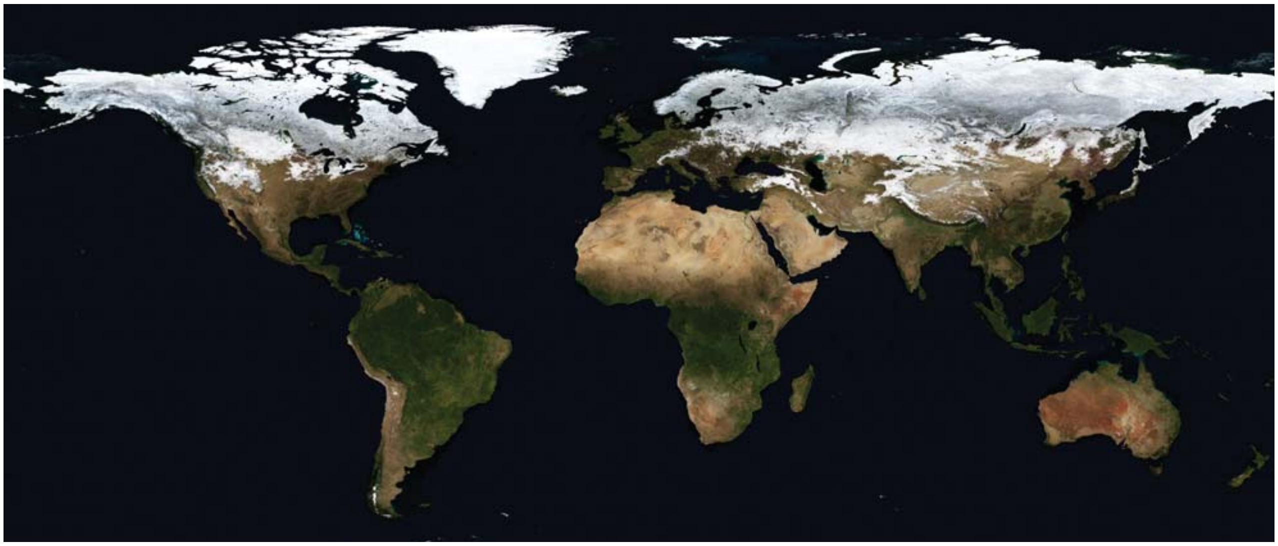
READING

Use Student Sheet 78.1, "Three-Level Reading Guide: The Earth on the Move" to guide you as you complete the following reading.

Earth's Year and the Seasons

As Earth orbits the Sun, the seasons change, but that does not mean Earth's orbiting causes the seasons. To understand seasons, you must consider both Earth's motion around the Sun and Earth's tilt.

Also, you might have thought that seasons are caused by changes in the distance between Earth and the Sun. This explanation could make



Earth viewed from space in January. Compare this with the photo on the facing page. Notice that there is more snow in North America, but less snow in the mountains of South America, where it is summer in January.

sense because Earth's orbit is an ellipse, not a perfect circle—that means that sometimes Earth is closer to the Sun than at other times. However, you learned in the last activity that this idea doesn't fit the evidence that scientists have collected.

The computer simulation showed that Earth is about 6 million km closer to the Sun in December than it is in June, and yet Chicago has much warmer weather in June than in December. If closeness of Earth to the Sun explained the seasons, both the Northern and Southern hemispheres would have winter in June and July and summer in December and January!

If the seasons are not caused by changes in Earth's distance from the Sun, what does cause them? The computer simulation showed that the seasons are related to Earth's tilt. During the time of year when the Northern Hemisphere is tilted toward the Sun, the Northern Hemisphere, which includes the United States, experiences summer. The seasons in the Southern Hemisphere are opposite from the seasons in the Northern Hemisphere. This is because the Southern Hemisphere is tilted away from the Sun when the Northern Hemisphere is tilted toward the Sun, as shown in Figure 1 on the next page. Australia and much of South America and Africa have winter from June through September, when the United States has summer!

Figure 1: Earth's Tilt
*This diagram shows that when one hemisphere is tilted toward the Sun, the other is tilted away from the Sun. (Size and distance are **not** to scale.)*

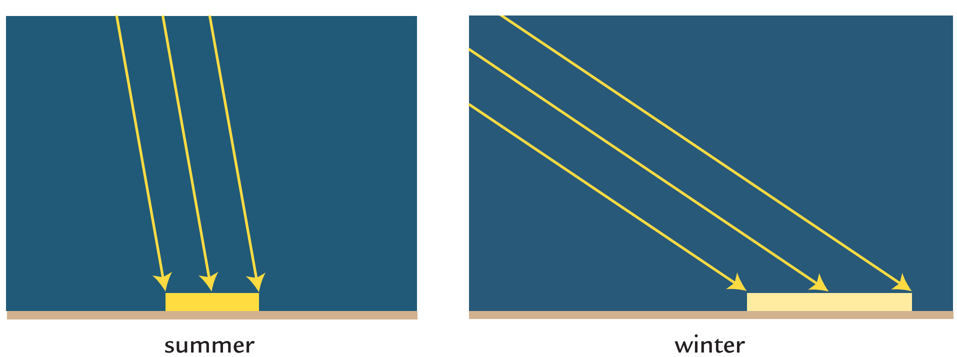
Earth's Tilt and the Light from the Sun

Why does Earth's tilt make such a difference? There are two reasons. The first reason is that the tilt puts part of Earth into the Sun's rays at a more direct angle than other parts.

When a part of Earth tilts toward the Sun, the Sun is higher in the sky and its rays hit that section of Earth at a higher angle. The higher the angle of the Sun's rays, the closer together they are when they hit Earth's surface. The closer together the rays are, the more effective they are at heating up the Earth. So, since the Northern Hemisphere is most tilted toward the Sun during June, that is when the United States experiences the beginning of summer. You observed the effect of sunlight striking a surface at a higher angle when you held your solar cell directly facing toward the Sun. The solar cell received more energy, which made the motor turn faster.

When you tilted the solar cell at an angle to the Sun's rays, it received less energy, which made the motor slow down. When you did this, you were modeling the change in the angle of the Sun's rays from summer to winter. Figure 2 below shows why the angle of the Sun's rays hitting Earth's surface in summer and winter affects the amount of energy hitting the surface.

Figure 2: Angle of Sunlight at Earth's Surface
When the sunlight strikes Earth's surface at a lower angle, as on the right, the Sun's energy is spread out more and is less effective in heating the Earth.



Earth's Tilt and Daylight Length

The second reason why the tilt makes such a difference is its effect on the length of daylight. Figure 3 shows how Earth's tilt causes longer summer days in the United States. More hours of daylight in summer allow more time for the Sun's rays to heat the Earth. The longest day and highest angle of sunlight occur around June 21. However, the warmest days usually come later in the summer because heat builds up over time. The opposite occurs in winter. The shortest days and lowest angle of sunlight occur around December 21. But it continues to get colder after that, as heat is gradually lost.

If Earth were not tilted, most places would have very little difference in average daily temperature over the year. You saw this in the computer simulation when you set Earth's tilt to "0°." But if Earth tilted even more, the difference in temperature and daylight hours between summer and winter would be more extreme.

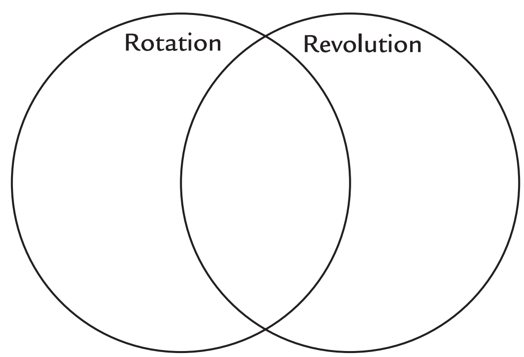
Figure 3: Seasons and Day Length
In the summer, Chicago's day is longer than its night because the Northern Hemisphere is tilted toward the Sun. (Sizes and distances are ***not*** *to scale.)*

Ancient Cultures and the Seasons

Ancient people knew the Sun and the seasons were important in their lives. For example, it was important for them to know when to plant crops. If they planted too early, a cold spell might kill the crops. If they planted too late, the plants might not have a long enough growing season. They needed to plant the seeds at just the right time of year so that the crops could grow during the long and sunny days of summer. Evidence gathered from ancient structures suggests that as long as 5,000 years ago, people made careful observations of the Sun's position and the shadows cast by the Sun. They used their observations to predict the seasons and know when to plant and harvest their crops. They also held celebrations at different times of the year, based on the Sun's position.

ANALYSIS

1. Rotation and revolution are both motions of the Earth.
   - **a.** How does each of these motions help us mark time?
   - **b.** In your science notebook, create a larger version of the Venn diagram shown below. Compare and contrast the rotation and the revolution of the Earth by recording the unique features of each phenomenon on the far side of each circle. Record common features of Earth's rotation and revolution in the space where the circles overlap. **Hint:** Think about what you have learned about these motions in the last few activities.



2. Prepare a labeled diagram that includes a caption that explains to Emily's cousin Charlotte how Earth's tilt and its revolution around the Sun cause each of the following:
   - **a.** changes in the angle of sunlight hitting the Earth's surface
   - **b.** the seasons in the Southern Hemisphere to be opposites of the seasons in the Northern Hemisphere
3. **Reflection:** Review your ideas about the seasons that you recorded on Student Sheet 71.1a, "My Ideas About the Day, Year, Seasons, and Phases of the Moon: Before." How have your ideas about the reasons for the seasons changed since you began this unit?

EXTENSION

Visit the *Issues and Earth Science* page of the SEPUP website to research structures built by ancient cultures to indicate the position of the Sun and predict the seasons. You can also find links to animations that explain the seasons.