Section Preview of the Student Book for

The Earth in Space, *Issues and Earth Science, 2nd Edition*

Activities 76-78

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Issue-Oriented Science

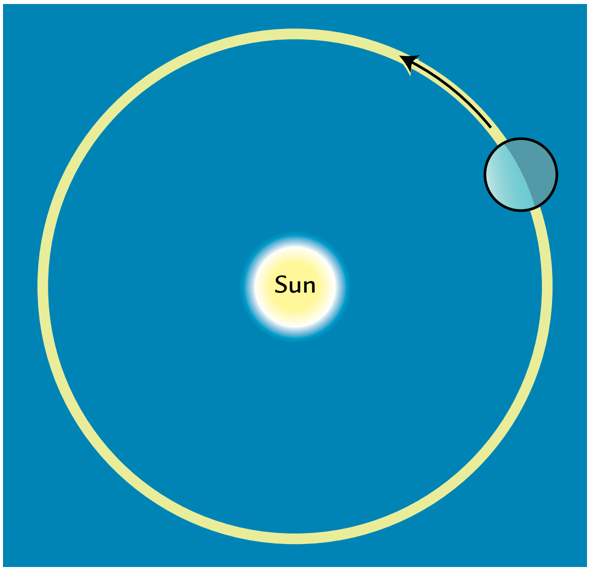
76 A Year Viewed from Space

You have learned that Earth's 24-hour day–night cycle is caused by Earth's rotation around its axis. The year is another cycle caused by Earth's motion. A year is the amount of time it takes a planet to make one complete trip around the Sun. Scientists use the term **revolve** to describe the movement of a planet around the Sun. The path a planet follows around the Sun is called its **orbit.** One complete orbit around the Sun is called a **revolution** (rev-ah-LOO-shun). Earth's year is about 365¼ days long because Earth rotates a little more than 365 times in the same amount of time it takes for Earth to make one complete revolution around the Sun.

After school let out in June, it got hotter and hotter, and Tyler wondered why the seasons change each year. He thought it might have something to do with what he was noticing about the Sun's position and the length of daylight.

CHALLENGE

What causes the yearly cycle of the seasons on Earth?



Diagrams like this one of Earth in its orbit around the Sun are much too small to show sizes and distances to scale, but they can help show how Earth revolves in its orbit around the Sun.

MATERIALS

For each pair of students

1 **computer with access to the SEPUP Seasons Interactive Simulation**

For each student

1 **Student Sheet 76.1, "Earth's Year Viewed from Space: Top View"**

1 **Student Sheet 76.2, "Earth's Year Viewed from Space: Side View"**

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

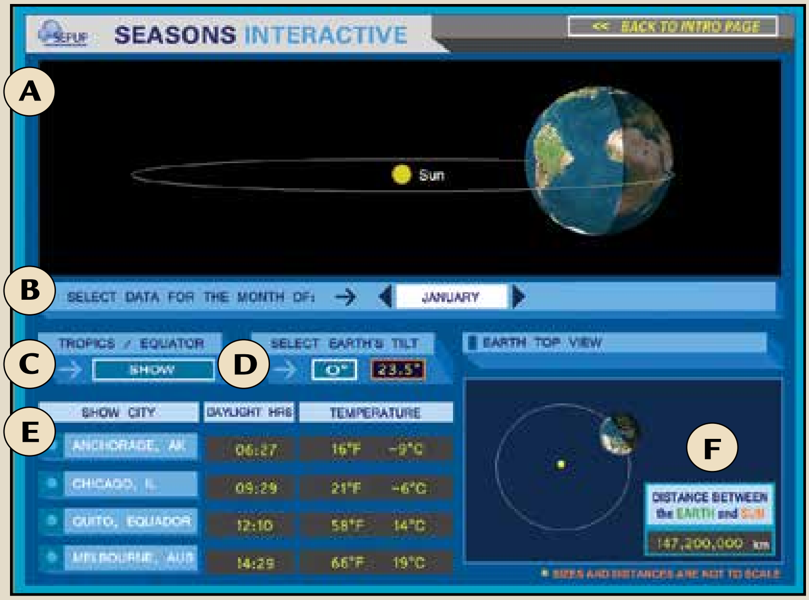
PROCEDURE

Part A: Analyzing Data on the Distance from Earth to the Sun

1. Open the Seasons Interactive Simulation and review the introduction. Find each of the following on the screen:
   - North America and the United States
   - the Northern Hemisphere
   - the equator
   - the Southern Hemisphere

2. Begin the simulation by clicking in the box on the upper right of the screen that says, CONTINUE TO INTERACTIVE. Find Earth and the Sun. Remember, the size of Earth and the Sun, and the distance between Earth and the Sun, are *not to scale.*

3. Use the diagram on the next page to find and set the following things on the screen:



(A) EARTH SIDE VIEW shows Earth and its orbit.

(B) MONTH SELECTOR: Use the arrows to move from month to month.

(C) TROPICS/EQUATOR selector: Make sure this is set to SHOW.

(D) SELECT EARTH'S TILT setting: Make sure this is set to 23.5°, the actual tilt of Earth.

(E) SHOW CITY buttons and columns for daylight hours and temperature: Try clicking on each of these to see what happens. Then turn them all off.

(F) EARTH TOP VIEW shows Earth from above the North Pole.

4. Look at the EARTH TOP VIEW. Notice how the distance from Earth to the Sun is displayed in millions of kilometers at the bottom right corner.

5. Set the month to December, the beginning of winter. Record the distance from Earth to the Sun in the appropriate space on Student Sheet 76.1, "Earth's Year Viewed from Space: Top View."

6. What do you think the distance from Earth to the Sun will be at the start of spring (March), of summer (June) and of fall (September)? Record your predictions in your science notebook.

7. Repeat Step 5 for March, June, and September to find out if your predictions are correct.

Part B: Analyzing Data on Earth's Tilt and the Seasons

8. Compare Student Sheet 76.2, "Earth's Year Viewed from Space: Side View" with the side view of the Sun and Earth at the top of your computer screen.

9. On the simulation, set the month for December, and click on the SHOW CITY button for Chicago.

10. Look at the top view and side view of Earth, and record each of the following on Student Sheet 76.2 for December in Chicago:

    - the position of Earth and direction of its tilt
    - the number of daylight hours
    - the average temperature

11. Repeat Step 10 three more times: once for March, once for June, and once for September.

12. What do you think the number of daylight hours and average temperature for Chicago would be in December, March, June, and September if Earth were not tilted? Record your ideas in your science notebook.

13. Change the tilt to **0°**, and then describe what happens to daylight hours and temperature in Chicago as you change the months of the year and Earth revolves around the Sun.

14. Return the tilt to **23.5°**. Now investigate Melbourne, Australia. Notice that Melbourne is in the Southern Hemisphere. Explore its daylight hours and average temperature as you change the months. Record:

    - its average daylight length in December and June
    - its average temperature in December and June
    - a description of the seasons in Melbourne, Australia and how they compare to seasons in Chicago

ANALYSIS

1. What motion of Earth causes the yearly cycle of the seasons?
2. Why does a year on Earth have 365¼ days?
3. In which month(s) is Earth:
   a. closest to the Sun?
   b. farthest from the Sun?
4. Based on what you have observed about the distance from Earth to the Sun, does the distance from Earth to the Sun determine the seasons? Explain the evidence for your answer.
5. In what month is the Northern Hemisphere most tilted *toward* the Sun?
6. In what month is the Northern Hemisphere most tilted *away* from the Sun?
7. Explain how the tilt of the Earth affects the seasons and daylight length.

EXTENSION

Graph the daylight length versus month for one of the cities presented in the simulation or for your city in the United States. Compare it to the graph you did in Activity 75, "Sunlight and Seasons." How are the graphs similar? How are they different?

77 Explaining the Seasons

In the last activity, you used a computer simulation to investigate why there are seasons on Earth. Like any model, the simulation has some strengths and weaknesses. It shows the orbit and tilt of Earth to help you understand the seasons. But it doesn't show the correct relationship between the size of the Earth and Sun or the distance between them. It also might give you the incorrect idea that Earth's tilt causes one hemisphere to be significantly nearer to the Sun. Let's take a closer look at the ways in which the tilt of Earth makes a difference.

CHALLENGE

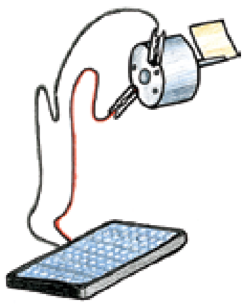
Why does the tilt of Earth lead to different surface temperatures?

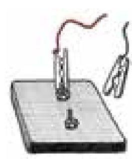
This globe, called the Unisphere, was built for the 1964 World's Fair in Queens, New York. Like most globes, it shows Earth's tilt.

MATERIALS

For each group of four students

1 solar cell
1 electric motor with flag on axle
2 wire leads with alligator clips (one red and one black)





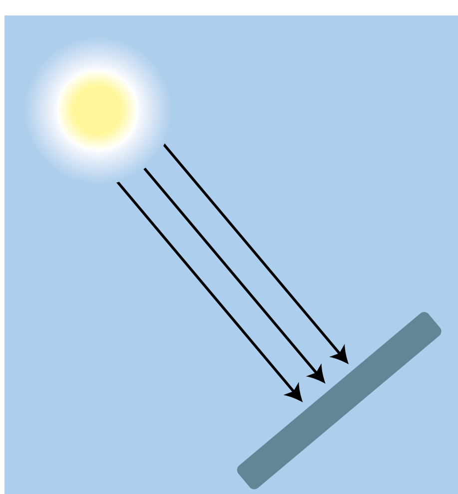
PROCEDURE

1. Work with your group to set up the solar cell. Use the diagrams at left as a guide.

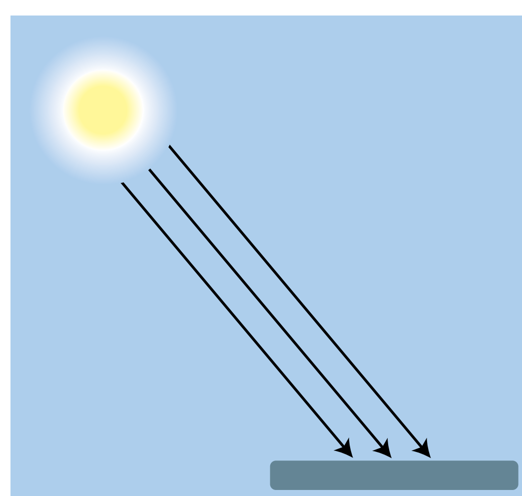
2. Hold the solar cell so it directly faces the Sun, as shown in Position A below. Describe in your notebook what happens to the motor.

3. Gradually tilt the solar cell so that it still gets sunlight but does not directly face the Sun, as shown in Position B below. Describe in your notebook what happens to the speed of the motor.

4. Tilt the solar cell back to directly face the Sun. Keeping it directly facing the Sun, move it closer to and farther from the Sun. Describe what happens to the speed of the motor.



Position A



Position B

ANALYSIS

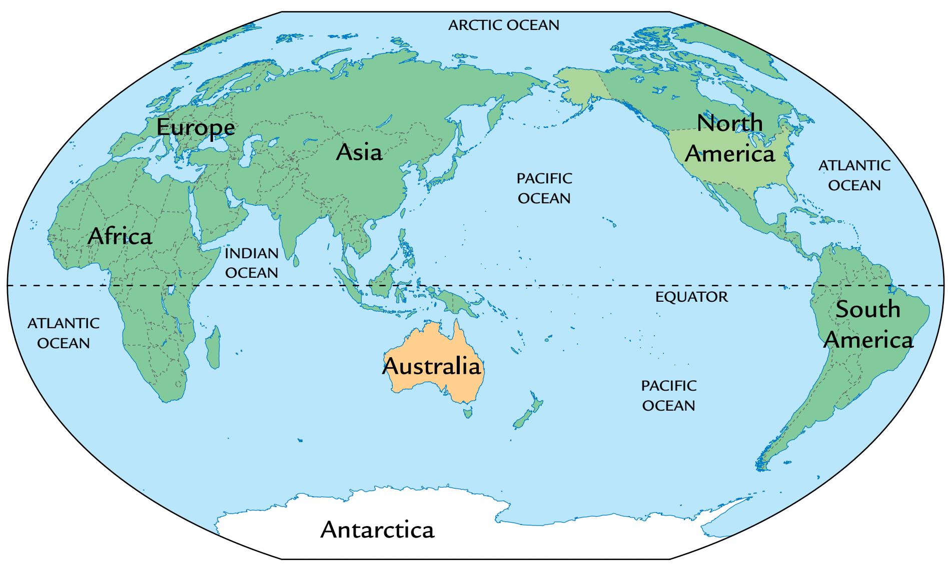
1. When your teacher tilted a portion of the globe directly into light from a flashlight, what happened to the light striking the globe?

2. When you tilted the solar cell from Position A to Position B, what effect did it have on the speed of the motor attached to the solar cell?

3. What does this tell you about the amount of the Sun's energy transferred to the solar cell in the two different positions? Be sure to give a complete explanation.

4. Why is the Northern Hemisphere warmer when it is tilted toward the Sun?

5. In Australia, it is summer in December and winter in July. Why is this?



6. **Reflection:** How did each of the following models help you understand how Earth's tilt causes the seasons?
   - the computer model
   - the globe and a flashlight
   - the solar cell and motor

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.

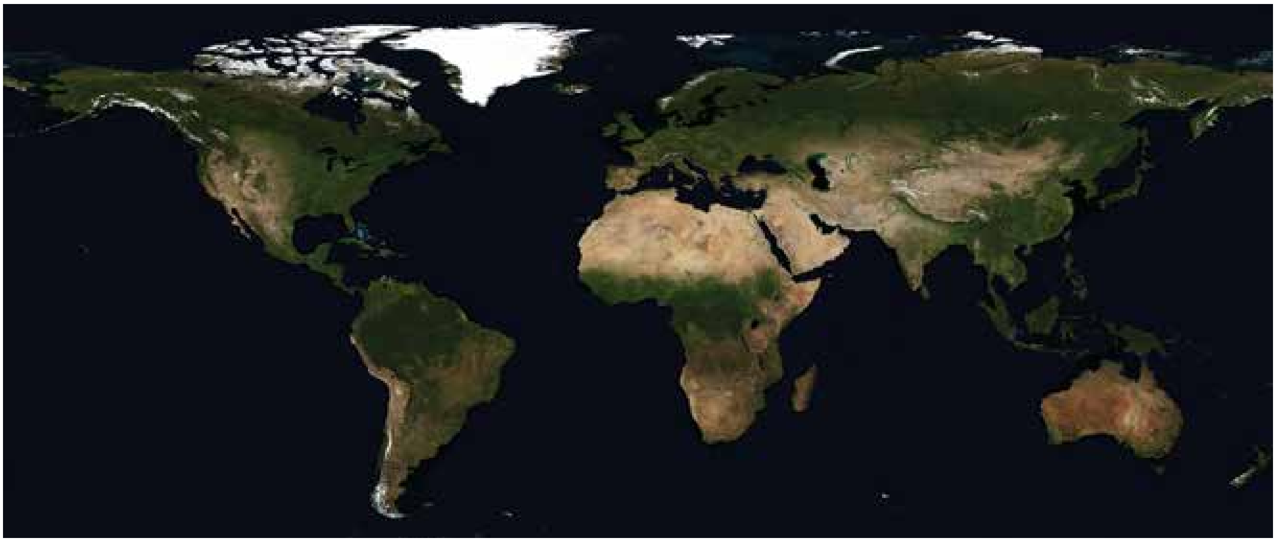
"This is so strange," Charlotte said. "At home, it's almost winter. Here it's hot and the flowers are blooming. I know it has something to do with the Northern and Southern Hemispheres, but I don't completely understand it."

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"**

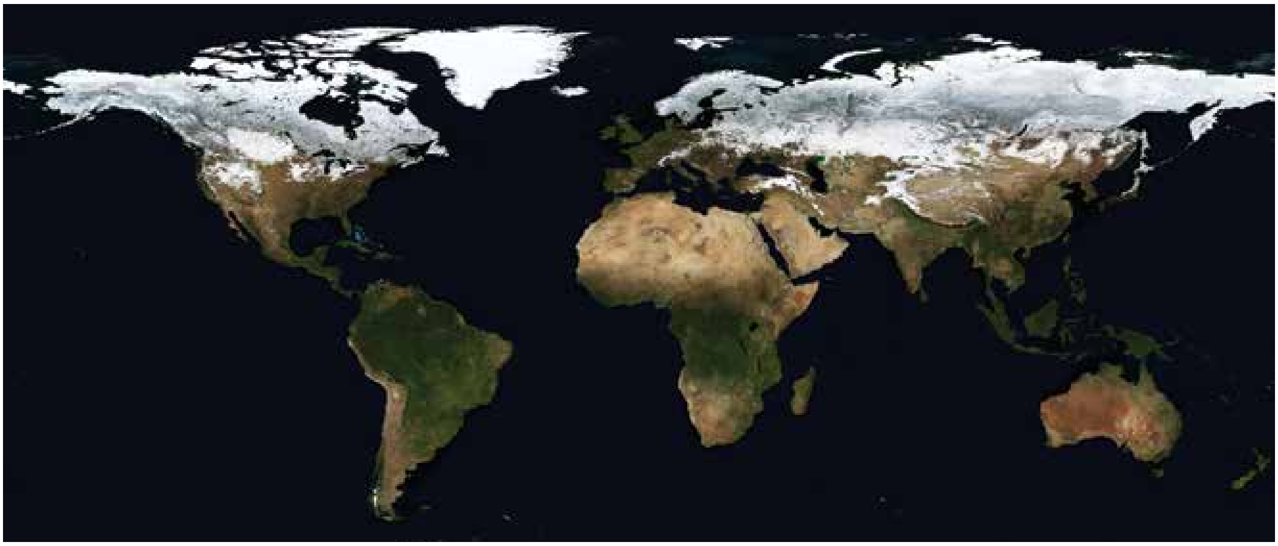
READING

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 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.



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.

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 below. 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.

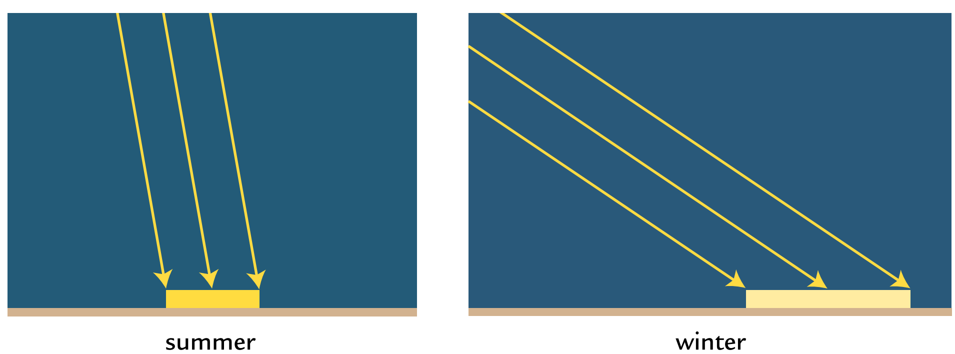


FIGURE 2:
ANGLE OF SUNLIGHT AT EARTH'S SURFACE

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 on the following page 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

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.)*

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.

Ancient Cultures and the Seasons

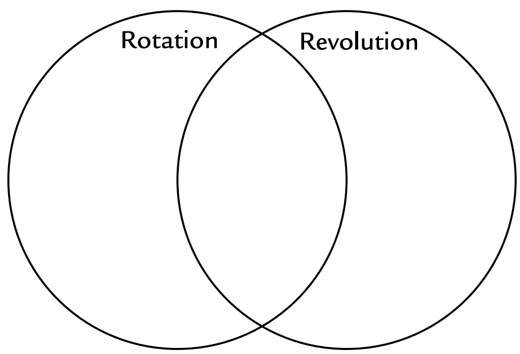
Ancient people knew the Sun and the seasons were important in their lives. For example, it was important for them to know when to plant crops. If they planted too early, a cold spell might kill the crops. If they planted too late, the plants might not have a long enough growing season. They needed to 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.