Section 1

Earth in Space

Reading Preview

Key Concepts

- How does Earth move in space?
- What causes the cycle of seasons on Earth?

Key Terms

- astronomy
- axis
- rotation
- revolution
- orbit
- calendar
- solstice
- equinox

Target Reading Skill

Using Prior Knowledge Your prior knowledge is what you already know before you read about a topic. Before you read, write what you know about seasons on Earth in a graphic organizer like the one below. As you read, write in what you learn.

What You Know
1. The sun's rays heat Earth. 2.

What You Learned
1. 2.

Lab zone

Discover Activity

What Causes Day and Night?

1. Place a lamp with a bare bulb on a table to represent the sun. Put a globe at the end of the table about 1 meter away to represent Earth.
2. Turn the lamp on and darken the room. Which parts of the globe have light shining on them? Which parts are in shadow?
3. Find your location on the globe. Turn the globe once. Notice when it is lit—day—at your location and when it is dark—night.

Think It Over

Making Models What does one complete turn of the globe represent? In this model, how many seconds represent one day? How could you use the globe and bulb to represent a year?

Each year, ancient Egyptian farmers eagerly awaited the flood of the Nile River. For thousands of years, their planting was ruled by it. As soon as the Nile's floodwaters withdrew, the farmers had to be ready to plow and plant their fields along the river. Therefore, the Egyptians wanted to predict when the flood would occur. Around 3000 B.C., people noticed that the bright star Sirius first became visible in the early morning sky every year shortly before the flood began. The Egyptians used this knowledge to predict each year's flood. The ancient Egyptians were among the first people to study the stars. The study of the moon, stars, and other objects in space is called **astronomy.**

FIGURE 1
Ancient Egyptian Farmers
Egyptian farmers watched the sky in order to be prepared to plow and plant their fields.

How Earth Moves

Ancient astronomers studied the movements of the sun and the moon as they appeared to travel across the sky. It seemed to them as though Earth was standing still and the sun and moon were moving. Actually, the sun and moon seem to move across the sky each day because Earth is rotating on its axis. Earth also moves around the sun. **Earth moves through space in two major ways: rotation and revolution.**

Rotation The imaginary line that passes through Earth's center and the North and South poles is Earth's **axis.** The spinning of Earth on its axis is called **rotation.**

Earth's rotation causes day and night. As Earth rotates eastward, the sun appears to move westward across the sky. It is day on the side of Earth facing the sun. As Earth continues to turn to the east, the sun appears to set in the west. Sunlight can't reach the side of Earth facing away from the sun, so it is night there. It takes Earth about 24 hours to rotate once. As you know, each 24-hour cycle of day and night is called a day.

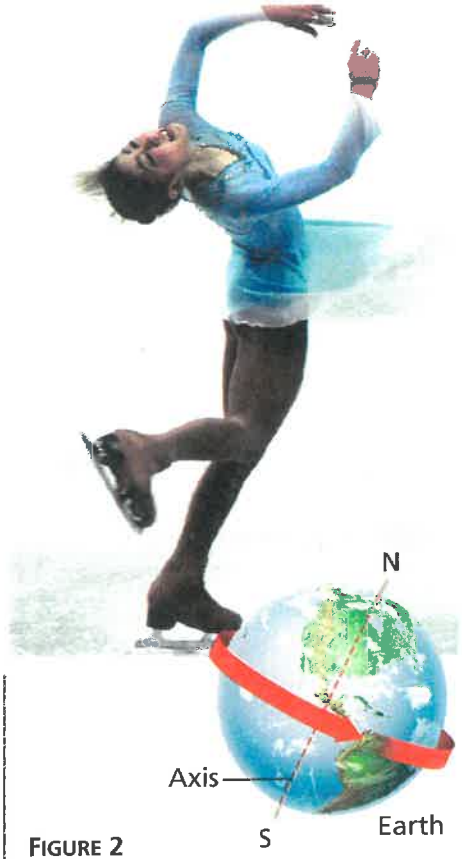


FIGURE 2
Rotation
The rotation of Earth on its axis is similar to the movement of the figure skater as she spins.

Revolution In addition to rotating on its axis, Earth travels around the sun. **Revolution** is the movement of one object around another. One complete revolution of Earth around the sun is called a year. Earth follows a path, or **orbit,** as it revolves around the sun. Earth's orbit is not quite circular. It is a slightly elongated circle, or ellipse.

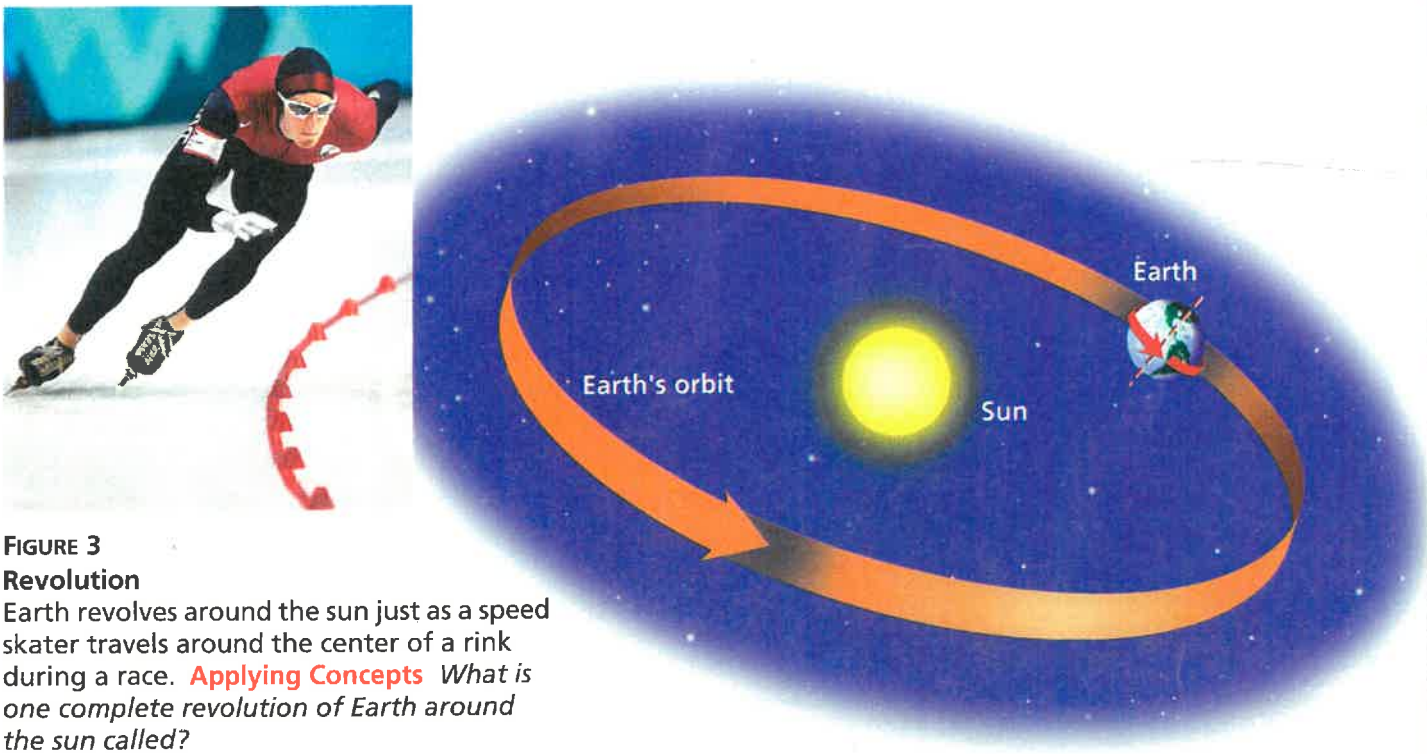


FIGURE 3
Revolution
Earth revolves around the sun just as a speed skater travels around the center of a rink during a race. **Applying Concepts** *What is one complete revolution of Earth around the sun called?*

Calendars People of many different cultures have struggled to establish calendars based on the length of time that Earth takes to revolve around the sun. A **calendar** is a system of organizing time that defines the beginning, length, and divisions of a year.

The ancient Egyptians created one of the first calendars. Egyptian astronomers counted the number of days between each first appearance of the star Sirius in the morning. In this way, they found that there are about 365 days in a year.

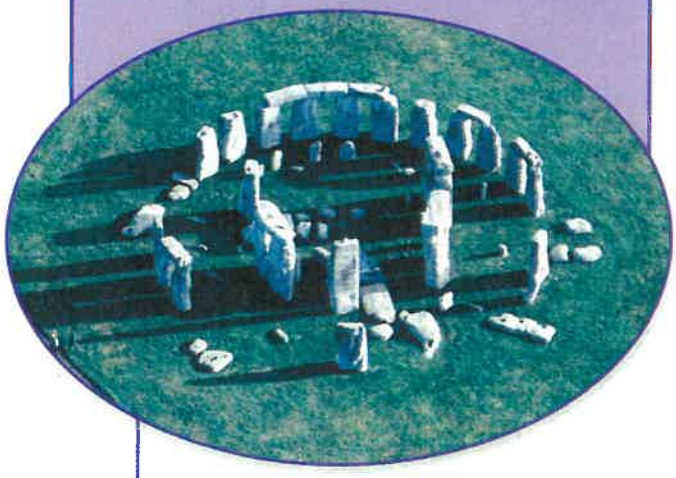
Dividing the year into smaller parts was also difficult. Early people used moon cycles to divide the year. The time from one full moon to the next is about 29 $\frac{1}{2}$ days. A year of 12 of these "moonths" adds up to only 354 days. The ancient Egyptian calendar had 12 months of 30 days each, with an extra 5 days at the end.

Science and History

Tracking the Cycle of the Year

For thousands of years, people have used observations of the sky to keep track of the time of year.

1500 B.C. British Isles
Ancient peoples complete Stonehenge, a monument with giant stones that mark the directions in which the sun rises and sets on the shortest and longest days of the year.



1300 B.C. China
Chinese astronomers make detailed observations of the sun, planets, and other objects they see in the night sky. Chinese astronomers calculated that the length of a year is 365 $\frac{1}{4}$ days.

80 B.C. Greece
Astronomers in Greece develop an instrument called the Antikythera Calculator. This instrument used a system of gears to show the movement of the sun, moon, planets, and stars.

1500 B.C. 1000 B.C. 500 B.C.

The Romans borrowed the Egyptian calendar of 365 days. But in fact, Earth orbits the sun in about $365\frac{1}{4}$ days. The Romans adjusted the Egyptian calendar by adding one day every four years. You know this fourth year as "leap year." During a leap year, February is given 29 days instead of its usual 28. Using a system of leap years helps to ensure that annual events, such as the beginning of summer, occur on the same date each year.

The Roman calendar was off by a little more than 11 minutes a year. Over the centuries, these minutes added up. By the 1500s, the beginning of spring was about ten days too early. To straighten things out, Pope Gregory XIII dropped ten days from the year 1582. He also made some other minor changes to the Roman system to form the calendar that we use today.

Reading Checkpoint What is a leap year?

Writing in Science

Writing Dialogue Research one of the accomplishments discussed in the timeline. Write a conversation, or dialogue, in which two people from the time and culture that made the discovery or structure discuss its importance in their lives. Examples might include their work or the timing of their celebrations.

A.D. 600 Korea
The Cheomseongdae Observatory is built. The hollow, 9.2-meter-tall tower is the oldest existing observatory in the world. The tower was probably used for a variety of astronomical observations.

A.D. 900 Mexico
The Mayas study the movement of the sun, the moon, and the planet Venus. They had two different calendars, one with 365 days for everyday use and the other with 260 days for religious uses.

A.D. 1600 Turkey
Astronomers use a variety of astronomical instruments, including astrolabes, at an observatory in Istanbul. Astrolabes were used to predict the positions of stars and planets.

A.D. 500 A.D. 1000 A.D. 1500

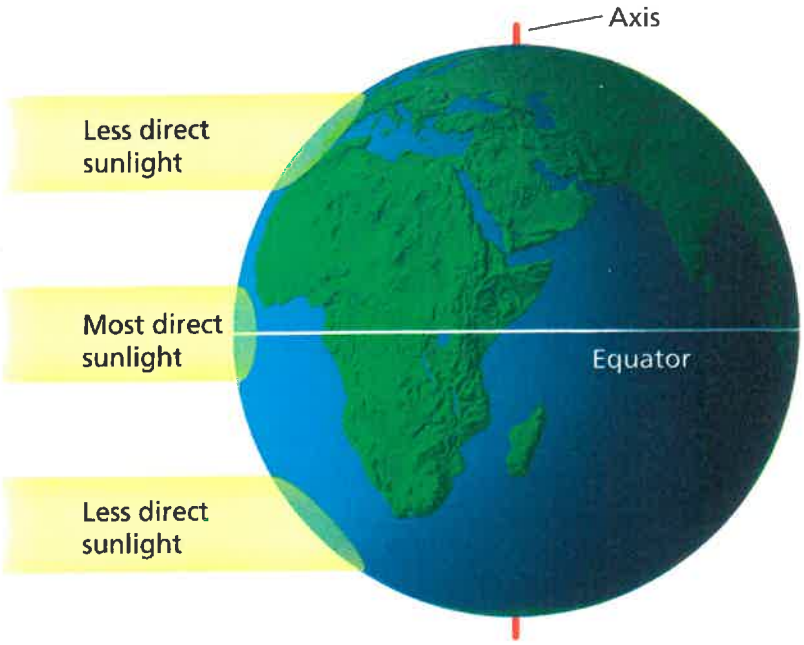


FIGURE 4
Sunlight Striking Earth's Surface Near the equator, sunlight strikes Earth's surface more directly and is less spread out than near the poles. **Relating Cause and Effect** *Why is it usually colder near the poles than near the equator?*

Lab zone **Try This Activity**

Sun Shadows

The sun's shadow changes predictably through the day.

1. On a sunny day, stand outside in the sun and use a compass to find north.
2. Have your partner place a craft stick about one meter to the north of where you are standing. Repeat for east, south, and west.
3. Insert a meter stick in the ground at the center of the craft sticks. Make sure the stick is straight up.
4. Predict how the sun's shadow will move throughout the day.
5. Record the direction and length of the sun's shadow at noon and at regular intervals during the day.

Predicting How did the actual movement of the sun's shadow compare with your prediction? How do you think the direction and length of the sun's shadow at these same times would change over the next six months?

The Seasons on Earth

Most places outside the tropics and polar regions have four distinct seasons: winter, spring, summer, and autumn. But there are great differences in temperature from place to place. For instance, it is generally warmer near the equator than near the poles. Why is this so?

How Sunlight Hits Earth Figure 4 shows how sunlight strikes Earth's surface. Notice that sunlight hits Earth's surface most directly near the equator. Near the poles, sunlight arrives at a steep angle. As a result, it is spread out over a greater area. That is why it is warmer near the equator than near the poles.

Earth's Tilted Axis If Earth's axis were straight up and down relative to its orbit, temperatures would remain fairly constant year-round. There would be no seasons. **Earth has seasons because its axis is tilted as it revolves around the sun.**

Notice in Figure 5 that Earth's axis is always tilted at an angle of 23.5° from the vertical. As Earth revolves around the sun, the north end of its axis is tilted away from the sun for part of the year and toward the sun for part of the year.

Summer and winter are caused by Earth's tilt as it revolves around the sun. The change in seasons is not caused by changes in Earth's distance from the sun. In fact, Earth is farthest from the sun when it is summer in the Northern Hemisphere.

Reading Checkpoint **When is Earth farthest from the sun?**

FIGURE 5

The Seasons

The yearly cycle of the seasons is caused by the tilt of Earth's axis as it revolves around the sun.

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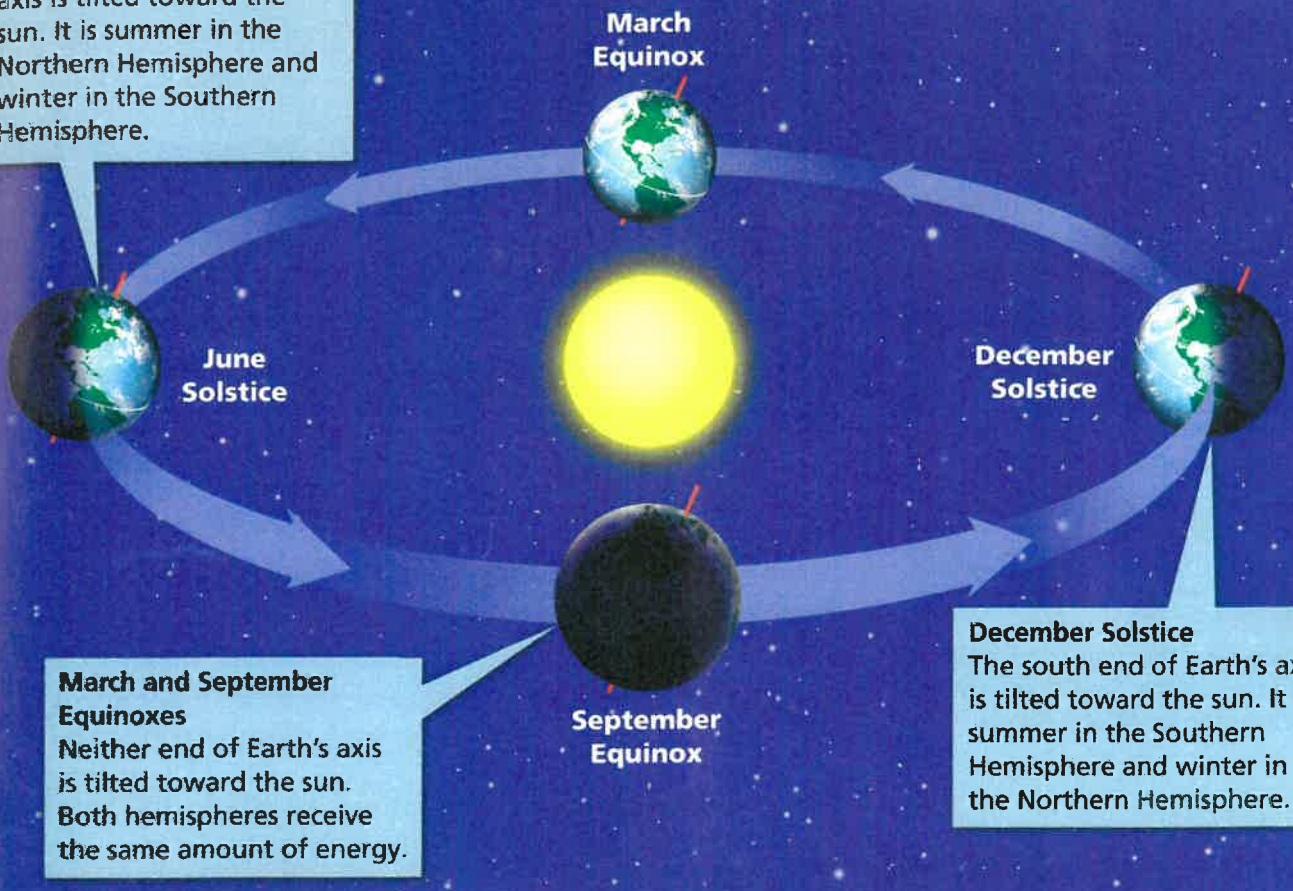
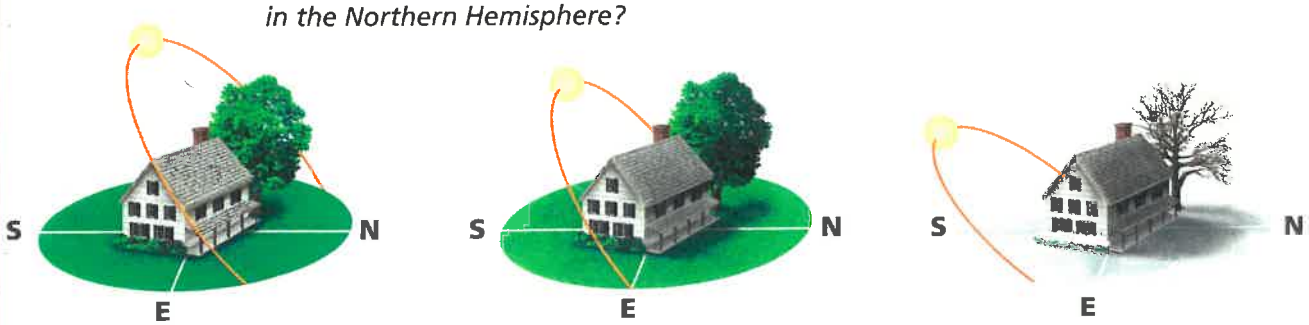


The height of the sun above the horizon varies with the season.
Interpreting Graphics *When is the sun at its maximum height in the Northern Hemisphere?*



June Solstice | **March and September Equinoxes** | **December Solstice**

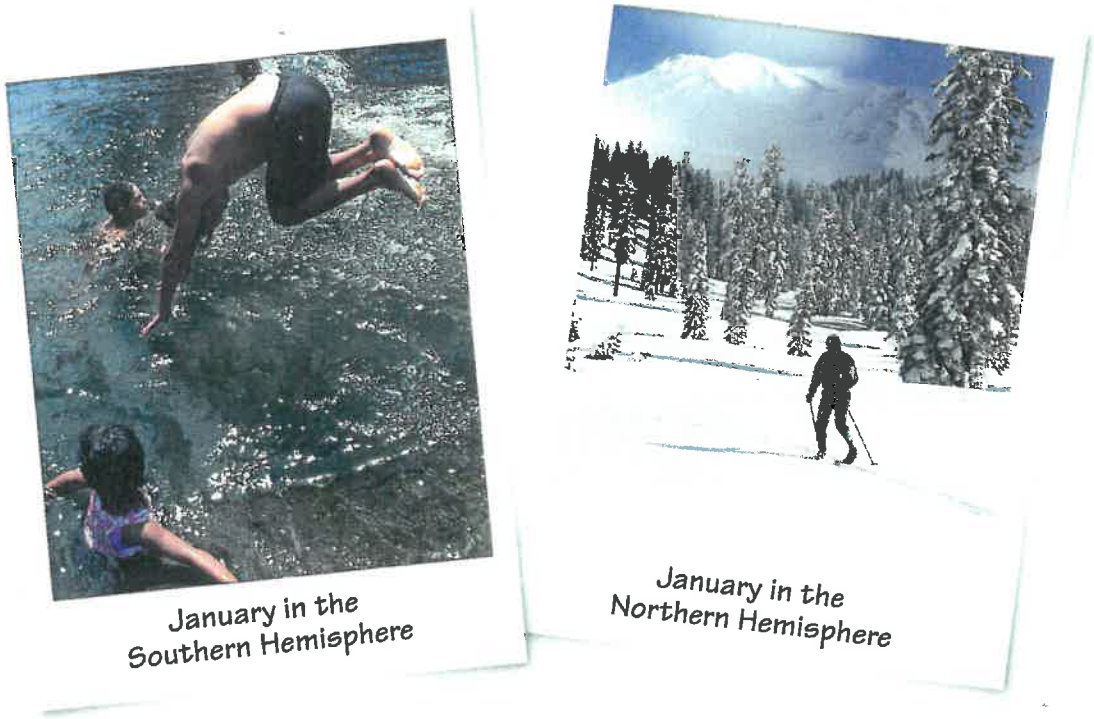


FIGURE 6

Solstices and Equinoxes

Summer in the Southern Hemisphere (left) occurs at the same time as winter in the Northern Hemisphere (right). Similarly, when it is spring in the Southern Hemisphere, it is fall in the Northern Hemisphere.

Interpreting Photographs *In which direction was Earth's axis pointing at the time that each of the photographs was taken?*

Earth in June In June, the north end of Earth's axis is tilted toward the sun. In the Northern Hemisphere, the noon sun is high in the sky and there are more hours of daylight than darkness. The combination of direct rays and more hours of sunlight heats the surface more in June than at any other time of the year. It is summer in the Northern Hemisphere.

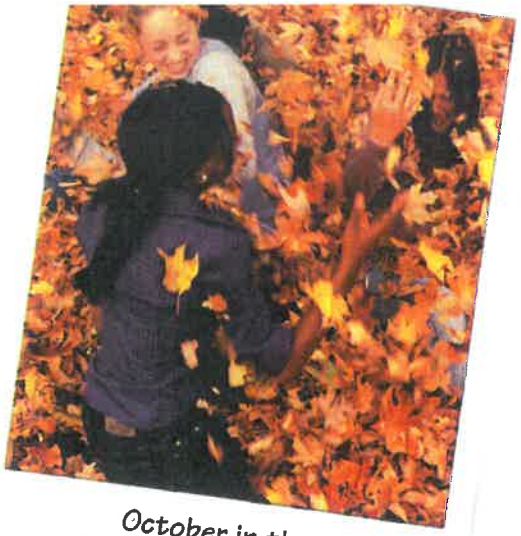
At the same time south of the equator, the sun's energy is spread over a larger area. The sun is low in the sky and days are shorter than nights. The combination of less direct rays and fewer hours of sunlight heats Earth's surface less than at any other time of the year. It is winter in the Southern Hemisphere.

Earth in December In December, people in the Southern Hemisphere receive the most direct sunlight, so it is summer there. At the same time, the sun's rays in the Northern Hemisphere are more slanted and there are fewer hours of daylight. So it is winter in the Northern Hemisphere.

Solstices The sun reaches its greatest distance north or south of the equator twice each year. Each of these days, when the sun is farthest north or south of the equator, is known as a **solstice** (SOHL stis). The day when the sun is farthest north of the equator is the summer solstice in the Northern Hemisphere. It is also the winter solstice in the Southern Hemisphere. This solstice occurs around June 21 each year. It is the longest day of the year in the Northern Hemisphere and the shortest day of the year in the Southern Hemisphere.

Similarly, around December 21, the sun is farthest south of the equator. This is the winter solstice in the Northern Hemisphere and the summer solstice in the Southern Hemisphere.

October in the Southern Hemisphere



October in the Northern Hemisphere

Equinoxes Halfway between the solstices, neither hemisphere is tilted toward or away from the sun. This occurs twice a year, when the noon sun is directly overhead at the equator. Each of these days is known as an **equinox,** which means "equal night." During an equinox, day and night are each about 12 hours long everywhere on Earth. The vernal (spring) equinox occurs around March 21 and marks the beginning of spring in the Northern Hemisphere. The autumnal equinox occurs around September 22. It marks the beginning of fall in the Northern Hemisphere.

Reading Checkpoint **What is an equinox?**

Section 1 Assessment

Target Reading Skill Using Prior Knowledge Review your graphic organizer and revise it based on what you just learned in this section. Use it to help answer Question 2.

Reviewing Key Concepts

1. a. Identifying What are the two major motions of Earth as it travels through space?
   b. Explaining Which motion causes day and night?
2. a. Relating Cause and Effect What causes the seasons?
   b. Comparing and Contrasting What are solstices and equinoxes? How are they related to the seasons?
   c. Predicting How would the seasons be different if Earth were not tilted on its axis?

Writing in Science

Descriptive Paragraph What seasons occur where you live? Write a detailed paragraph describing the changes that take place each season in your region. Explain how seasonal changes in temperature and hours of daylight relate to changes in Earth's position as it moves around the sun.