

Objectives

After this lesson, students will be able to

J.1.1.1 Demonstrate how Earth moves in space.

J.1.1.2 Explain the causes of the cycle of seasons on Earth.

Target Reading Skill

Using Prior Knowledge Explain that using prior knowledge helps students connect what they already know to what they are about to read.

Answers

Possible answers:

What You Know

1. The sun's rays heat Earth.
2. Earth has seasons.
3. In the Northern Hemisphere, fall begins in September and spring begins in March.

What You Learned

1. Areas where the sun hits Earth at a more direct angle are generally warmer than areas where the sun's rays are more spread out.
2. The tilt of Earth's axis as it moves around the sun causes seasons.
3. Around March 21 and September 22, day and night are each 12 hours long.

All in One Teaching Resources

- [Transparency J1](#)

Preteach

Build Background Knowledge

L2

Changes in Daylight

Ask students to estimate what time the sun rises in the morning and sets at night. Tell them the actual times from a daily newspaper. Next, ask students to describe how the number of hours of daylight changes during the winter and summer. *(There are fewer hours of daylight in winter than in summer.)*

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.

FIGURE 1

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

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**.



Lab zone

Discover Activity

Skills Focus Making models

Materials lamp, light bulb, globe

Time 15 minutes

Tips Place the bulb at a height approximately level with the globe's equator. Alternatively, use flashlights and have students work in pairs. One student can hold the flashlight steady while the other turns the globe.

L1 Expected Outcome The half of the globe facing the bulb will be lit and will move into shadow as the globe rotates.

Think It Over A complete spin of the globe represents one rotation of Earth on its axis, which equals one day. In the model, one day is five seconds. One possible way to model a year is to carry the spinning globe in a circle around the bulb.

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.

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

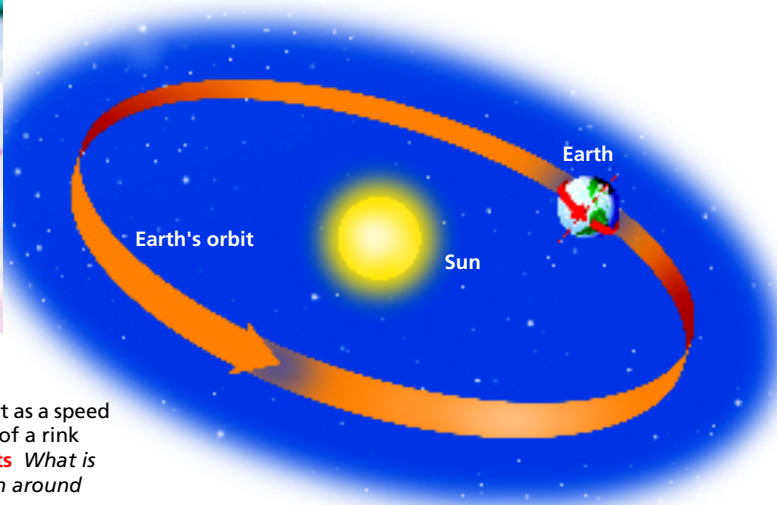
Earth revolves around the sun just as a speed skater travels around the center of a rink during a race. **Applying Concepts** What is one complete revolution of Earth around the sun called?



FIGURE 2

Rotation

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



Instruct

How Earth Moves

Teach Key Concepts

L2

Earth's Rotation and Revolution

Focus Remind students that Earth moves through space in two major ways.

Teach Refer students to the photographs of the skaters in Figures 2 and 3. Point out that the skater who is rotating is moving around her own center. The skater who is revolving is moving around the center of another object—the rink. Ask students to use this analogy to compare and contrast Earth's rotation and revolution. (*Earth's rotation and revolution are similar because both represent types of movement. They are different because rotation is the movement of Earth on its axis, whereas revolution is the movement of Earth around another object—the sun.*)

Apply Have students suggest other examples of rotation and revolution. **learning modality: visual**

Independent Practice

L2

All in One Teaching Resources

- [Guided Reading and Study Worksheet: Earth in Space](#)



Student Edition on Audio CD

Differentiated Instruction

English Learners/Beginning Comprehension: Key Concepts

L1

The word pair *rotation* and *revolution* can be confusing. Provide examples such as *rotating* a doorknob (it moves around its center). Relate the expression of someone's life *revolving* around something; for example, "The athlete's life revolved around sports." Point out that sports is the center. Ask students to think of other

examples in their native language and translate into English. **learning modality: verbal**

English Learners/Intermediate Comprehension: Key Concepts

L2

Have students make a table that compares and contrasts rotation and revolution. **learning modality: verbal**

Monitor Progress

L1

Writing Ask each student to write a short paragraph describing either Earth's rotation or Earth's revolution around the sun.

Answer

Figure 3 A year

Modeling Rotation

Materials ring stand, string, tape, turntable (such as a lazy Susan), weight

Time 15 minutes

Focus Tell students that in 1851, a French physicist named Jean Foucault used a pendulum to prove that Earth rotates.

Teach To model Foucault's pendulum, hang a small weight from the arm of a ring stand. Swing the pendulum, and ask students to describe what happens. (*The weight swings back and forth in one plane.*) Next, place the pendulum in the center of the turntable. Mark one side of the turntable with a piece of tape. Swing the pendulum as you slowly spin the turntable. Ask: **What does the turntable represent?** (*Earth rotating on its axis*) **What does the tape represent?** (*A location on Earth*)

Apply Tell students to suppose that this activity models a pendulum at the North Pole. Challenge them to explain how such a model could prove that Earth rotates. (*If a pendulum were swinging above the North Pole, the direction of its swing would appear to make one complete rotation every 24 hours.*) **learning modality: visual**

Help Students Read

Reciprocal Teaching Refer to the Content Refresher, which provides the guidelines for reciprocal teaching. Have students read the section with a partner. One partner reads a paragraph aloud. Then the other partner summarizes the paragraph's contents and explains the main concepts. The partners continue to switch roles with each new paragraph until they have finished the section.

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 "moon months" 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.

Background

Facts and Figures Stonehenge was built over three main periods. The first period began about 3100 B.C. and included the digging of the circular ditch and a ring of 56 pits. During the second period, about 2100 B.C., huge pillars of rock were erected in concentric circles around the center of the site. The 35-ton heel stone may have been placed during this building period. The placement of this stone was one of the

most sophisticated accomplishments of the time. On the morning of the summer solstice, a person standing in the center of the circle can see the sun rising directly over this stone. During the third period, the monument was remodeled, and a circle of 30 upright stones, each weighing up to 50 tons, was erected. The final phase ended around 1500 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.

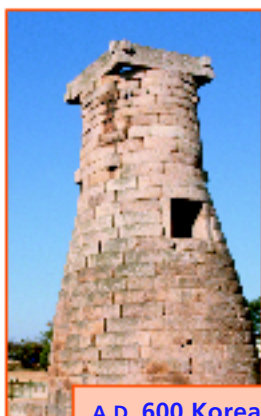


What is a leap year?



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. 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.

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. 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

Science and History

Focus Tell students that anything used to keep track of days, months, and years—as well as the events that occur during various times—can be thought of as a calendar.

Teach Encourage students to discuss how the cultures in the timeline used their astronomical observations. Ask: **How do you think the physical structures shown in the timeline could serve as astronomical observatories?** (Possible answers: The giant stones at Stonehenge marked sunrise and sunset on the longest day of the year. The Korean and Mayan towers put observers above obstructions on the ground so that repeating patterns in the sky could be more easily observed, measured, and recorded.)

Writing in Science

Writing Mode Research

Scoring Rubric

- 4 Exceeds criteria by including a dialogue that is historically correct and exceptionally well written
- 3 Includes all criteria but does not go beyond requirements
- 2 Includes a brief dialogue based on weak research
- 1 Is incomplete and inaccurate

Differentiated Instruction

Gifted and Talented

Calculating Earth's Movements Tell students that Earth moves at a speed of about 30 km/sec as it travels around the sun. Ask: **How many kilometers does Earth travel in a minute? An hour? A day? A year?** Before they begin their

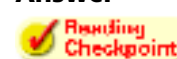
L3

calculations, suggest that students set up the problems on paper to make sure that units cancel out. (In one minute, 1,800 km; in one hour, 108,000 km; in one day, 2,592,000 km; in one year, about 946.7 million km) **learning modality:** logical/mathematical

Monitor Progress L2

Oral Presentation Have students explain why it was difficult for ancient peoples to develop workable calendars. (*The length of a year and a month are not exact multiples of the length of a day.*)

Answer



A leap year is an adjustment made to the Egyptian calendar by the Romans. During a leap year, which occurs every four years, February is given 29 days instead of its usual 28.

The Seasons on Earth

Teach Key Concepts

L2

Angle of Sunlight

Focus Remind students that Earth's poles are colder than areas closer to Earth's equator.

Teach Ask: **Is it warmer directly beneath a heat lamp or somewhat to the side?**

(*Directly beneath the lamp*) **Why?** (*The heat comes down at a more direct angle and so is more concentrated in that area.*) Help students understand that Earth's equatorial regions receive sunlight at a more direct angle than Earth's polar regions.

Apply Ask: **Where on Earth could you find tropical plants, such as banana trees?** (*Near the equator*) **Where could you find large continental glaciers?** (*Near the poles*)

learning modality: logical/mathematical

All in One Teaching Resources

- [Transparency J2](#)

Lab zone Build Inquiry

L1

Comparing and Contrasting Angles of Sunlight

Materials flashlight, graph paper

Time 15 minutes

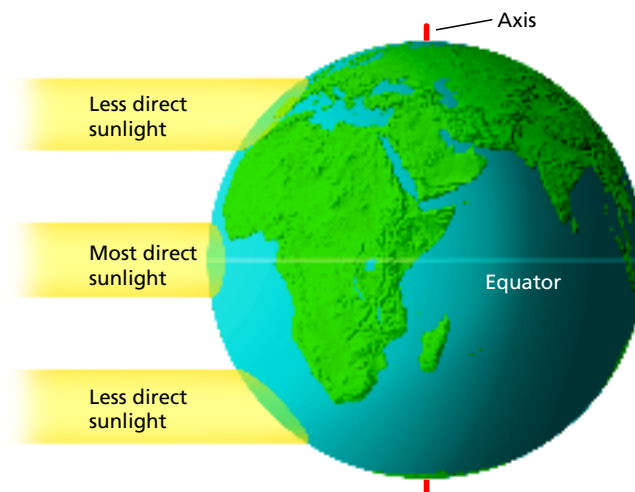
Focus Remind students that sunlight hits Earth's surface at different angles.

Teach Have students work in groups to shine a flashlight directly above the paper and trace around the lighted area. Next, have students shine the flashlight at an angle and trace around the lighted area. Ask: **Which area represents sunlight at the equator?** (*The smaller area*)

Apply Ask: **Which receives more energy, the smaller area or the larger area?** (*Both areas receive the same amount.*) **If this were Earth's surface, why would the larger area be colder? Explain in terms of the graph paper squares.** (*Each square in the larger area, the poles, receives less energy than each square in the smaller area, the equator.*)
learning modality: visual

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.



When is Earth farthest from the sun?

Lab zone Try This Activity

Skills Focus Predicting

Materials compass, craft sticks, meter stick

Time 20 min to set up; 10 min for each observation time

Tips Select at least four times during the day to record the shadow's length and position. Times should be at regular intervals.

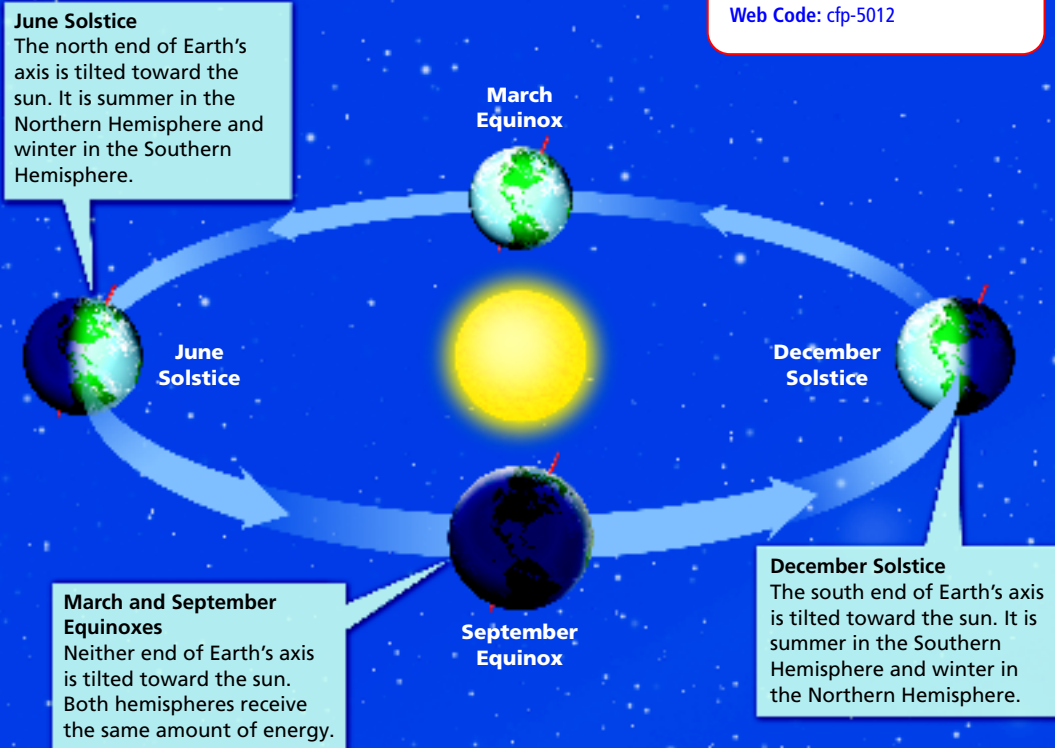
L2

Expected Outcome Shadows will move around the stick in a clockwise direction. Shadows will be longest in early morning and late afternoon and shortest around noon.

Extend Repeat the activity throughout the school year, selecting times in different seasons so that students can see how the shadow's length varies with the season.

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.



Go online
active art

For: Seasons activity
Visit: PHSchool.com
Web Code: cfp-5012

Go online
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Students can interact with the art of the seasons online.

Use Visuals: Figure 5

L2

The Seasons

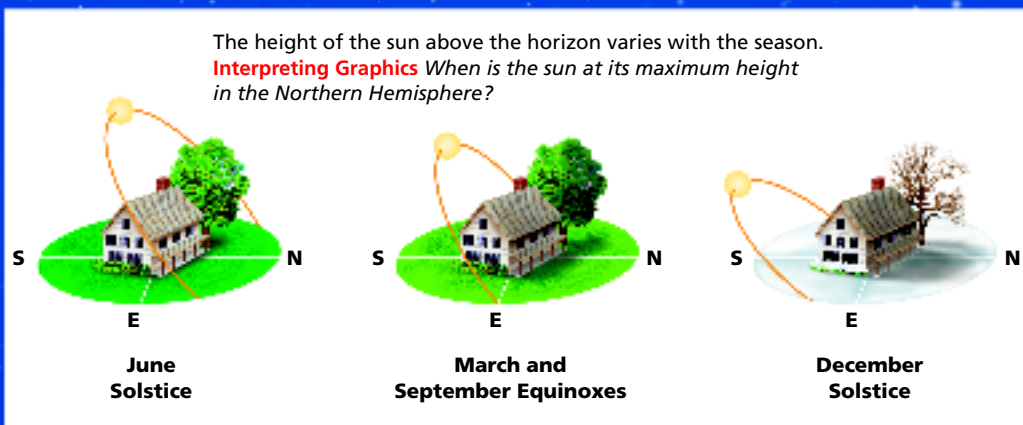
Focus Point out that the lines showing Earth's axis are all tilted.

Teach Ask: Is the angle of the tilt different at different points in Earth's revolution? (No) What is different? (Whether the north end of the axis is pointing toward or away from the sun) What is it called when the north end or the south end of the axis is pointed the most directly toward the sun? (The solstice) What is the position of the axis during an equinox? (Neither end of the axis is pointed toward the sun.)

Apply Direct students' attention to the figure in the lower left. Ask them to list two things that cause it to be summer in the Northern Hemisphere. (In June, the sun shines more directly on the surface. The sun is above the horizon for a longer period each day.) Now have students look at the visual in the lower right. Ask them to identify two things that cause it to be winter in the Northern Hemisphere. (In December, the sun shines less directly on the surface. The sun is above the horizon for a shorter period each day.) **learning modality: visual**

All in One Teaching Resources

- [Transparency J3](#)



Differentiated Instruction

Special Needs

L1

Modeling Seasons Place a lamp with a bare bulb on a desk. Tilt a globe so that the Northern Hemisphere is pointed toward the lamp. Ask: Which season does this represent in the Northern Hemisphere? (Summer) Walk around the lamp in a circle, but keep the tilt of the globe the

same relative to the room, not the lamp. Turn the globe so that the United States is facing the sun. As you walk, stop every 90° to represent Earth's position at the equinoxes and the winter solstice. Have students identify each season and describe the conditions in the United States. **learning modality: visual**

Monitor Progress

L2

Drawing Have students draw Earth, showing its tilt in relation to the sun, during a season in the Northern Hemisphere and a different season in the Southern Hemisphere.

Answers

Figure 4 It is colder near the poles because sunlight hits Earth there at a less direct angle and the sun's rays are spread over a larger area.

Figure 5 The sun is at its maximum height in the Northern Hemisphere at the June solstice.



When it is summer in the Northern Hemisphere

Developing and Testing Hypotheses

Materials lamp with bare bulb, modeling clay, plastic foam ball, thin wooden dowel

Time 30 minutes

Focus Challenge small groups to make models to test this hypothesis: *If Earth's axis were not tilted, the length of the days would not change over the course of a year.*

Teach Ask: **How will you model Earth's axis?** (By placing the dowel through the foam ball) **How will you ensure that the axis does not tilt?** (By placing the dowel vertically in the lump of modeling clay) **How will you model Earth's revolution and rotation?** (By spinning the ball as it is moved around the lamp) After groups have set up their models, turn off the lights so that they can demonstrate them. Ask students to observe the pattern of light and shadow on the ball.

Apply Ask: **How do your observations support your hypothesis?** (As the ball moves around the lamp, the line between light and shadow passes through each pole and does not change. This indicates that the length of days would not change over the year if Earth's axis were not tilted.) **learning modality:** kinesthetic

Address Misconceptions L1

Earth's Orbit and the Seasons

Focus Drawings of Earth's elliptical orbit are often exaggerated. Students may misinterpret such drawings and think that as Earth comes closer to the sun we have summer and that as Earth swings away from the sun, we have winter.

Teach Explain that Earth's orbit is only slightly elliptical. The distance between Earth and the sun does not change enough to have a large effect on the seasons. Direct students' attention to Figure 5.

Apply Point out the shape of Earth's orbit. Explain that, although it is an ellipse, Earth's orbit is almost a circle. Ask: **Why does the diagram show Earth's orbit as an oval if it's really nearly circular?** (The diagram is drawn as if you are looking at the ellipse from its side, similar to looking at a dinner plate on edge. If viewed from above, the orbit would more closely resemble a circle.) **What causes the seasons?** (The tilt of Earth's axis) **learning modality:** logical/mathematical



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.



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.



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.

Monitor Progress L2

Answers

Figure 6 In January, shortly after a solstice, the south end of Earth's axis is tilted toward the sun. In October, shortly after an equinox, neither end of the axis is pointed toward the sun.



A day during which the noon sun is directly overhead at the equator and there are equal hours of day and night

Assess

Reviewing Key Concepts

1. **a.** Rotation and revolution **b.** Rotation
2. **a.** The tilt of Earth's axis as it revolves around the sun **b.** A solstice occurs when the sun is farthest north or south of the equator. During an equinox, the noon sun is directly over the equator. Solstices mark the beginnings of summer and winter; equinoxes mark the beginnings of fall and spring. **c.** There would be no seasons—temperatures would remain fairly constant year-round at any given location.

Reteach L1

Use Figure 5 to review the yearly cycle of the seasons. Have students describe the tilt of Earth's axis during the December and June solstices and the March and September equinoxes.

Performance Assessment L2

Writing Challenge each student to choose a place on the globe that he or she is not familiar with and write a description of the amount of sunlight received there throughout the year.

All in One Teaching Resources

- [Section Summary: Earth in Space](#)
- [Review and Reinforce: Earth in Space](#)
- [Enrich: Earth in Space](#)

Lab Zone Chapter Project

Keep Students on Track Check that students have begun recording their daily observations of the moon. Remind them to draw maps of their observation sites. Help them define coordinate systems and make map keys. Demonstrate how to estimate the moon's altitude by making a fist and holding it at arm's length. One fist is 10° above the horizon, two fists are 20°, and so on.

Writing in Science

Writing Mode Description

Scoring Rubric

- 4 Exceeds criteria; includes seasonal changes in relation to Earth's position; descriptions are vivid, detailed, and realistic
- 3 Includes all criteria, but description lacks interest and detail
- 2 Includes a brief paragraph with some explanations
- 1 Is inaccurate and incomplete

Reasons for the Seasons

L2

Prepare for Inquiry

Key Concept

The seasons are determined by the tilt of Earth's axis as Earth revolves around the sun.

Skills Objectives

After this lab, students will be able to

- make an Earth/sun model to observe the effect of the tilt of Earth's axis on the seasons
- observe the effect of the angles of light on the amount of energy at different places on the model
- infer the amount of heat received by different parts of the model at different times of the year
- predict the time of year when the model receives different amounts of energy



Prep Time 10 minutes

Class Time 40 minutes

Advance Planning

Make sure that the flashlights are working properly. Have extra batteries on hand. The room must be dim enough for the light from the flashlights to be seen. One acetate sheet can be cut into six grids.

All in One Teaching Resources

- [Lab Worksheet: Reasons for the Seasons](#)

Reasons for the Seasons

Problem

How does the tilt of Earth's axis affect the light received by Earth as it revolves around the sun?

Skills Focus

making models, observing, inferring, predicting

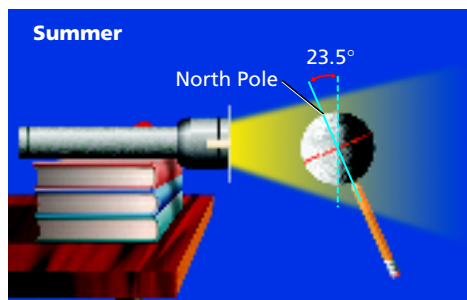
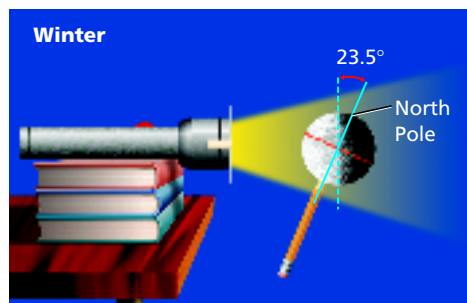
Materials (per pair of students)

- books
- flashlight
- paper
- pencil
- protractor
- toothpick
- acetate sheet with thick grid lines drawn on it
- plastic foam ball marked with poles and equator

Procedure

1. Make a pile of books about 15 cm high.
2. Tape the acetate sheet to the head of the flashlight. Place the flashlight on the pile of books.
3. Carefully push a pencil into the South Pole of the plastic foam ball, which represents Earth.
4. Use the protractor to measure a 23.5° tilt of the axis of your Earth away from your "flashlight sun," as shown in the top diagram. This position represents winter in the Northern Hemisphere.
5. Hold the pencil so that Earth is steady at this 23.5° angle and about 15 cm from the flashlight head. Turn the flashlight on. Dim the room lights.
6. The squares on the acetate should show up on your model Earth. Move the ball closer if necessary or dim the room lights more. Observe and record the shape of the squares at the equator and at the poles.

7. Carefully stick the toothpick straight into your model Earth about halfway between the equator and the North Pole. Observe and record the length of the shadow.
8. Without changing the tilt, turn the pencil to rotate the model Earth once on its axis. Observe and record how the shadow of the toothpick changes.
9. Tilt your model Earth 23.5° toward the flashlight, as shown in the bottom diagram. This is summer in the Northern Hemisphere. Observe and record the shape of the squares at the equator and at the poles. Observe how the toothpick's shadow changes.
10. Rotate the model Earth and note the shadow pattern.



Guide Inquiry

Invitation

Ask: **Why is it warmer in the summer?**

(Many students may hold the common misconception that Earth is closer to the sun.)

Tell students that because Earth's orbit is slightly elliptical, Earth is actually a bit farther from the sun during the Northern Hemisphere summer than it is in the winter. In this activity, they will relate the tilt of Earth's axis to the seasons.

Introduce the Procedure

- Tell students that the ball must be close enough to the flashlight for several grid squares to be seen on the ball.
- Review how to use the protractor to measure the angle of Earth's axis.



Analyze and Conclude

1. **Observing** When it is winter in the Northern Hemisphere, which areas on Earth get the most concentrated light? Which areas get the most concentrated light when it is summer in the Northern Hemisphere?
2. **Observing** Compare your observations of how the light hits the area halfway between the equator and the North Pole during winter (Step 6) and during summer (Step 9).
3. **Inferring** If the squares projected on the ball from the acetate become larger, what can you infer about the amount of heat distributed in each square?
4. **Inferring** According to your observations, which areas on Earth are consistently coolest? Which areas are consistently warmest? Why?
5. **Predicting** What time of year will the toothpick's shadow be longest? When will the shadow be shortest?

6. **Drawing Conclusions** How are the amounts of heat and light received in a square related to the angle of the sun's rays?
7. **Communicating** Use your observations of an Earth-sun model to write an explanation of what causes the seasons.

More to Explore

You can measure how directly light from the sun hits Earth's surface by making a shadow stick. You will need a stick or pole about 1 m long. With the help of your teacher, push the stick partway into the ground where it will not be disturbed. Make sure the stick stays vertical. At noon on the first day of every month, measure the length of the stick's shadow. The shorter the shadow, the higher the sun is in the sky and the more directly the sun's rays are hitting Earth. At what time of the year are the shadows longest? Shortest? How do your observations help explain the seasons?

Troubleshooting the Experiment

- Students may have difficulty maintaining the tilt of the ball at 23.5° as they move it. Have the partner measure the angle before recording information on the size and shape of the grid squares.

Expected Outcome

- The grid squares will be smaller and more square in the region of the ball where the light hits directly.
- The grid squares will be larger and more lengthened where the light hits at an angle.

Analyze and Conclude

1. During winter, the area near 23.5° south latitude receives the most concentrated light. In summer, the region near 23.5° north latitude gets the most concentrated light.
2. Light is more concentrated in the middle zone during the summer and more spread out during the winter.
3. The same amount of energy is spread out over a larger area.
4. The poles are consistently coolest because sunlight is most spread out there. The equator is warmest because sunlight is most concentrated there.
5. The shadow will be longest during winter and shortest during summer.
6. As the angle becomes less direct, light and heat become less concentrated and spread out over a larger area. Each square receives a smaller portion of light and heat.
7. During summer in the Northern Hemisphere, the sun's rays hit the Northern Hemisphere most directly. The heating effect is greater, and the Northern Hemisphere is warmed. During winter the rays hit the Northern Hemisphere at a less direct angle, so the heating effect decreases.

Extend Inquiry

More to Explore Over the course of time, the length of the shadow at noon varies. The shadow grows longer and longer until the December solstice, around December 21. Then the shadow grows progressively shorter

until the June solstice, on or near June 21. When the shadow is longest, the sun's rays are the most spread out and are the least effective at heating the surface.