Chapter 12

Earth, Moon, and Sun

CALIFORNIA Standards Preview

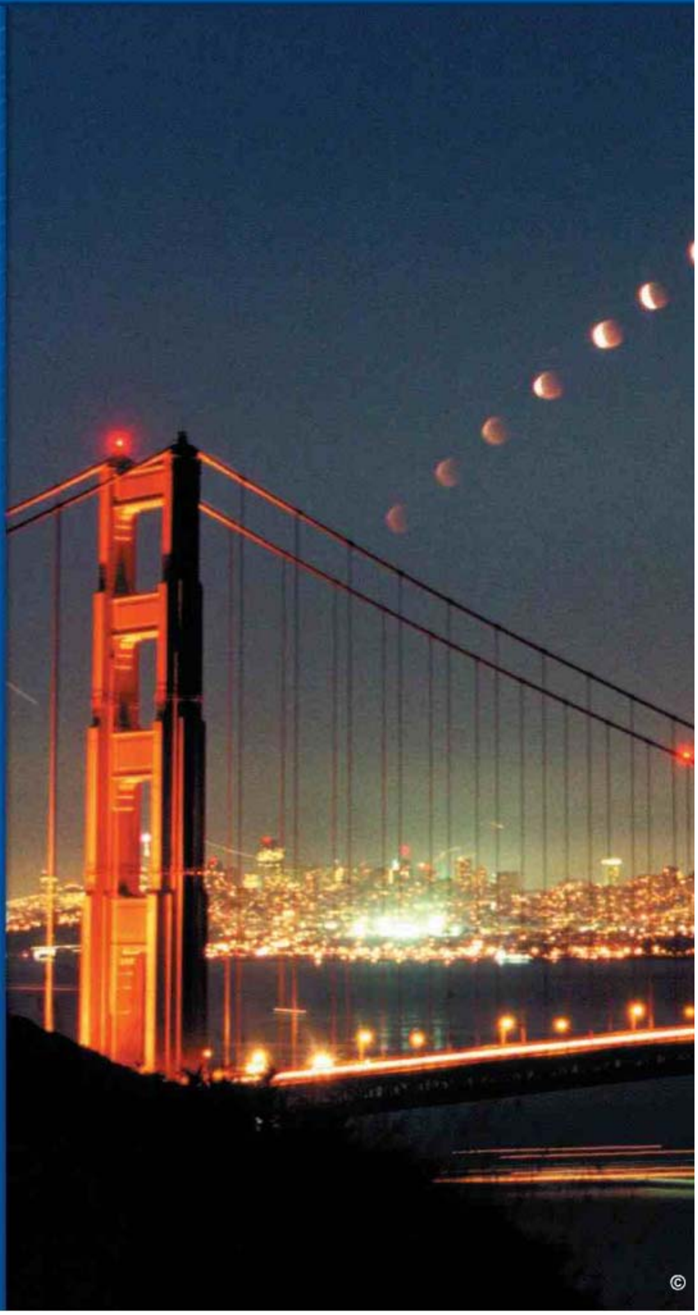
S 8.2 Unbalanced forces cause changes in velocity. As a basis for understanding this concept:

g. Students know the role of gravity in forming and maintaining the shapes of planets, stars, and the solar system.

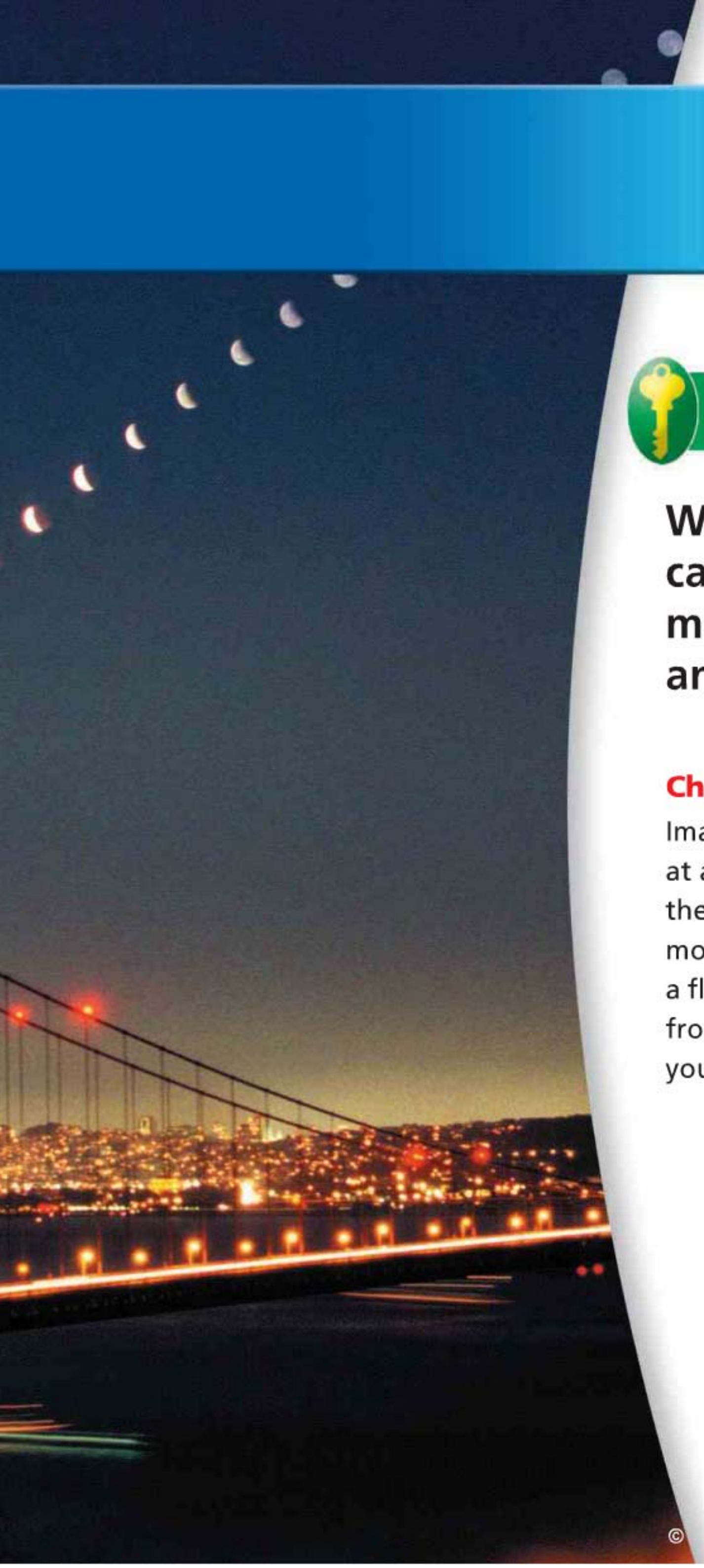
S 8.4 The structure and composition of the universe can be learned from studying stars and galaxies and their evolution. As a basis for understanding this concept:

d. Students know that stars are the source of light for all bright objects in outer space and that the Moon and planets shine by reflected sunlight, not by their own light.

e. Students know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets, and asteroids.



This time lapse photo shows an eclipse of the moon as it rises over the Golden Gate Bridge in San Francisco.



Video Preview
Discovery Channel School
Earth, Moon, and Sun

Focus on the
BIG Idea

S 8.4.e

What events are caused by the motion of Earth and the moon?

Check What You Know

Imagine that you are looking up at a full moon in the sky. Why is the moon so bright? Does the moon produce its own light, like a flashlight, or does its light come from somewhere else? Explain your reasoning.

Build Science Vocabulary

The images shown here represent some of the key terms in this chapter. You can use this vocabulary skill to help you understand the meaning of some key terms in this chapter.

Vocabulary Skill

Latin Word Origins

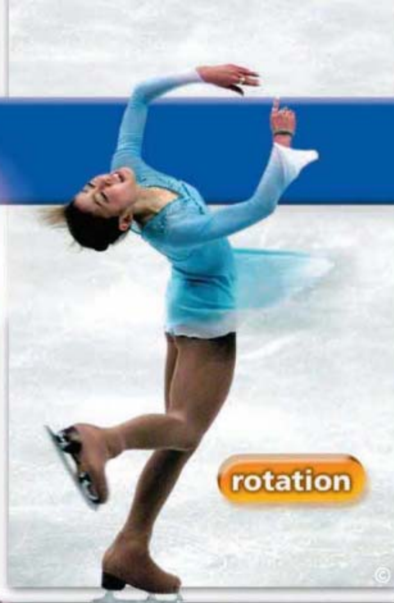
Many science words come to English from Latin. For example, the adjective *solar*, which means "of the sun," comes from the Latin word *solaris*, or "sun."

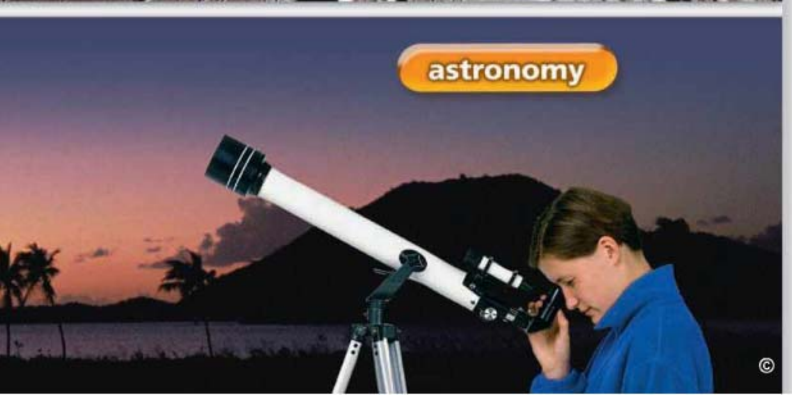
Use the Latin words in the table below to help you remember the Key Terms.

Latin Word	Meaning	Key Terms
aequalis	equal	equinox
crater	large mixing bowl	crater
gravitas	weight, heaviness	gravity, gravitation
luna	moon	lunar eclipse, lunar highlands
mare	sea	mare, maria
solaris	sun	solar eclipse
umbra	shade, shadow	umbra, penumbra

Apply It!

Review the Latin words and meanings in the chart. Look at the meaning of *crater*. Predict what a *crater* might be if it were seen on the surface of the moon. Revise your definition as needed.





Chapter 12 Vocabulary

Section 1 (page 464)

astronomy
axis
rotation
revolution
orbit
calendar
solstice
equinox

Section 2 (page 474)

force
gravity
Universal Law of Gravitation
mass
weight
inertia
Newton's first law of motion

Section 3 (page 478)

phase
eclipse
solar eclipse
umbra
penumbra
lunar eclipse
tide
spring tide
neap tide

Section 4 (page 488)

telescope
maria
crater
meteoroid

Interactive Textbook
Build Science Vocabulary *Online*
Visit: PHSchool.com
Web Code: cxj-4120

How to Read Science

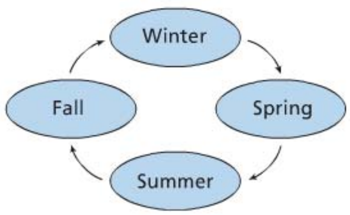
Reading Skill

Sequence

Some processes in science occur as part of a cycle. A cycle is a continuous process or sequence of events that does not have an end. When the final event is over, the first event begins again. The changing seasons on Earth are an example of a cycle.

Use a cycle diagram to show a cycle. Write the first event in a circle at the top of the page. Then, write each event in sequence, moving clockwise. Draw arrows to connect each event to the one that occurs next.

Seasons of the Year



Apply It!

Review the diagram. Why is using a cycle diagram a good way to explain the seasons?

1. After you read about the seasons in Section 1, create your own cycle diagram of the seasons. Include information about the tilt of Earth's axis and how the tilt affects the seasons in the Northern and Southern Hemispheres.

2. As you read Section 3, prepare a cycle diagram showing four major phases of the moon.

Lab zone

Standards Investigation

S 8.4.e, 8.9.e

Track the Moon

How does the moon move across the sky? How does its appearance change over the course of a month? In this investigation, you will observe how the position and apparent shape of the moon change over time.

Your Goal

To observe the shape of the moon and its position in the sky every day for one month

To complete this project, you must

- observe the compass direction in which you see the moon, its phase, and its height above the horizon
- use your observations to explain the phases of the moon
- develop rules you can use to predict when and where you might see the moon each day

Plan It!

Begin by preparing an observation log. You will record the date and time of each observation, the direction and height of the moon, a sketch of its shape, and notes about cloud cover and other conditions. Observe the moon every clear night, looking for patterns.

Make a map of your observation site on which you will plot the direction of the moon. You can measure the moon's height in degrees above the horizon by making a fist and holding it at arm's length. One fist above the horizon is 10°, two fists are 20°, and so on. On at least one day, compare your observations of the moon an hour or two apart.

Once your observations are complete, prepare a presentation of your results. Your presentation should include a set of graphs and a discussion of any patterns that you noticed.

Section 1

Earth in Space

CALIFORNIA Standards Focus

S 8.4.e Students know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets, and asteroids.

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

Key Terms

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

Lab zone Standards Warm-Up

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 Look at Figure 2. 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. As shown in Figure 3, a **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.

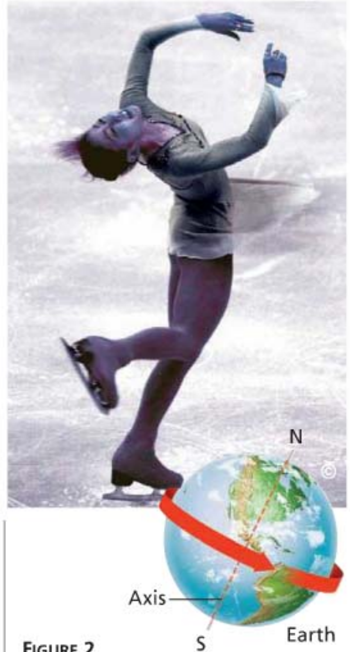


FIGURE 2
Rotation
The rotation of Earth on its axis is similar to the movement of the figure skater as she spins.

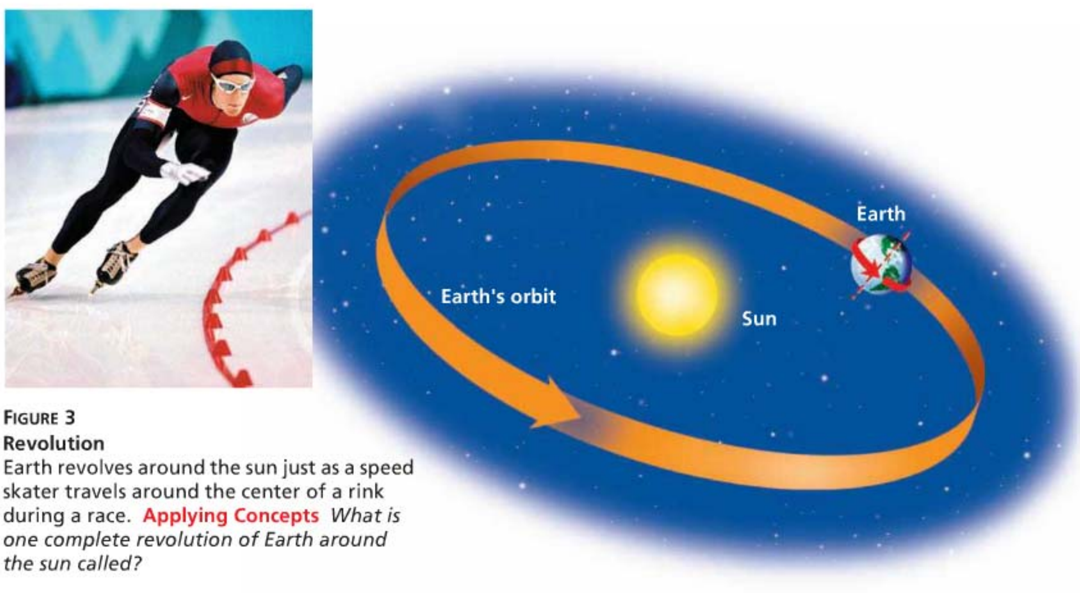


FIGURE 3
Revolution
Earth revolves around the sun just as a speed skater travels around the center of a rink during a race. **Applying Concepts** *What is one complete revolution of Earth around the sun called?*

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.

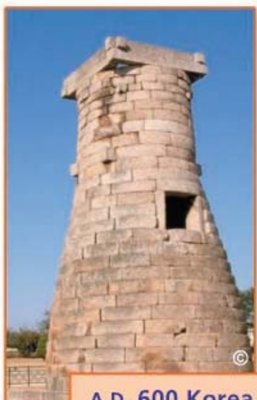
The Romans borrowed the Egyptian calendar of 365 days. But in fact, Earth orbits the sun in about $365\frac{1}{4}$ days. The Romans adjusted the Egyptian calendar by adding one day every four years. You know this fourth year as "leap year." In a leap year, February is given 29 days instead of its usual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

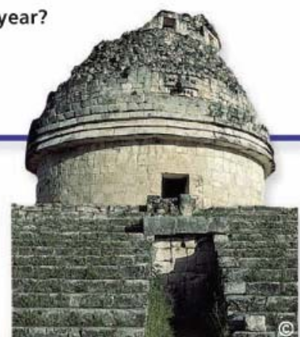
Reading Checkpoint What is a leap year?

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.

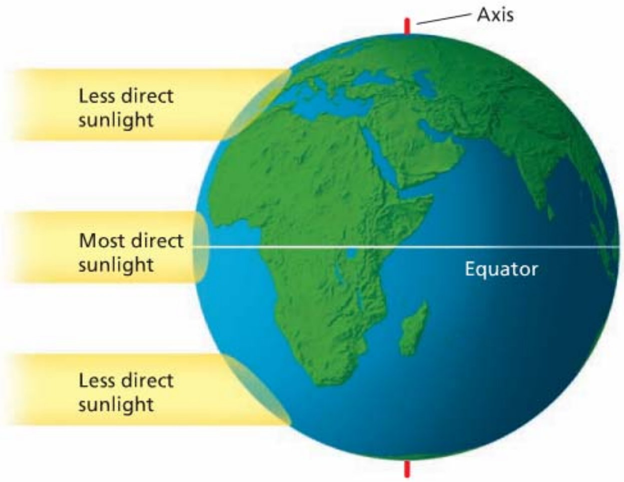


A.D. 900 Mexico
The Mayas study the movement of the sun, the moon, and the planet Venus. They had two different calendars, one with 365 days for everyday use and the other with 260 days for religious uses.

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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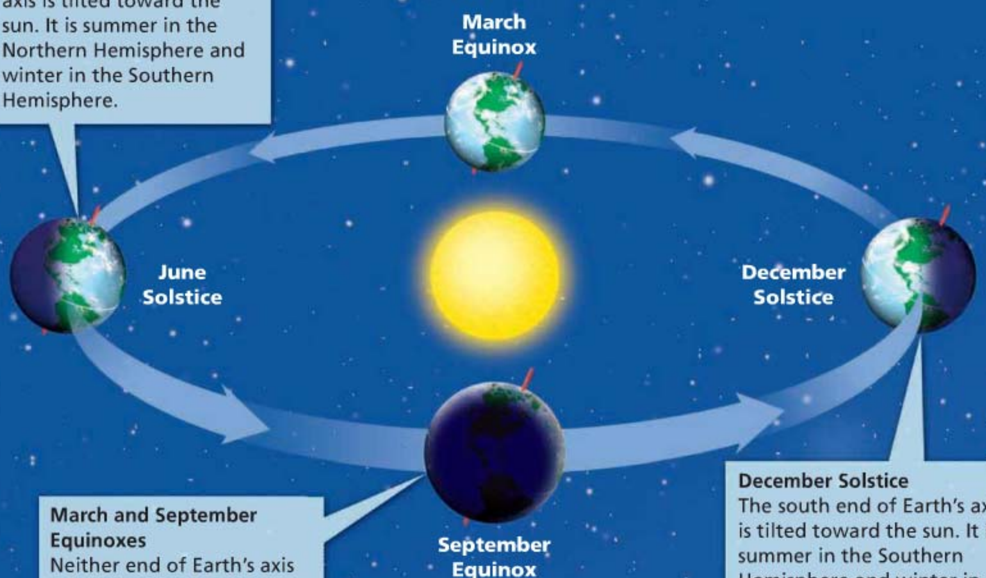
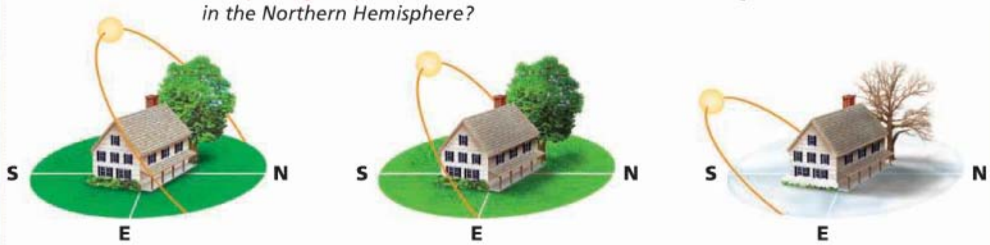
June Solstice
The north end of Earth's axis is tilted toward the sun. It is summer in the Northern Hemisphere and winter in the Southern Hemisphere.



March and September Equinoxes
Neither end of Earth's axis is tilted toward the sun. Both hemispheres receive the same amount of energy.

December Solstice
The south end of Earth's axis is tilted toward the sun. It is summer in the Southern Hemisphere and winter in the Northern Hemisphere.

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?*

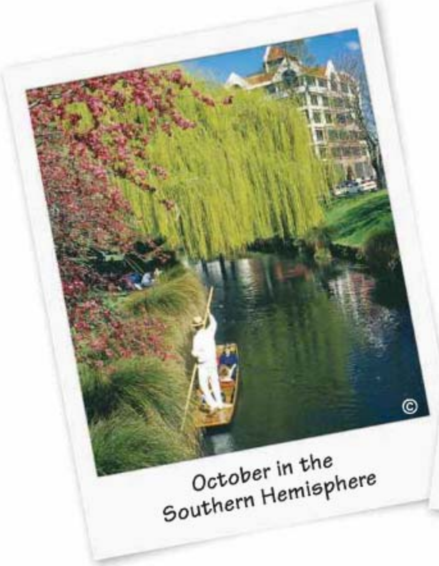
Earth in June In June, the north end of Earth's axis is tilted toward the sun. In the Northern Hemisphere, the noon sun is high in the sky and there are more hours of daylight than darkness. The combination of direct rays and more hours of sunlight heats the surface more in June than at any other time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

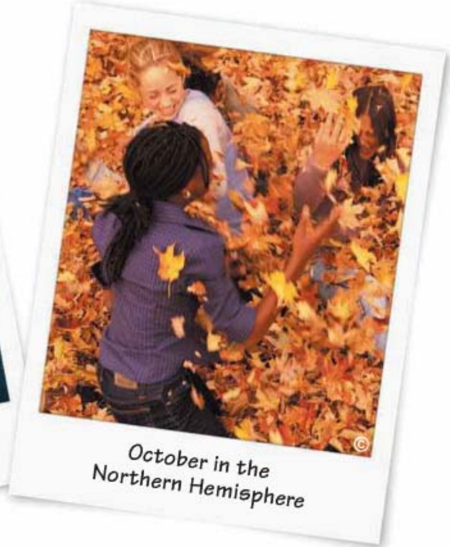
At the same time south of the equator, the sun's rays are less direct. The sun is low in the sky and days are shorter than nights. The combination of less direct rays and fewer hours of sunlight heats Earth's surface less than at any other time of the year. It is winter in the Southern Hemisphere.

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 farthest position 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.

Reading Checkpoint What is an equinox?

Section 1 Assessment

S 8.4.e, E-LA: Writing 8.2.0, Reading 8.2.0

Target Reading Skill **Sequence** Use your cycle diagram of the seasons to help answer the following questions.

Reviewing Key Concepts

HINT
1. a. **Identifying** What are the two major motions of Earth as it travels through space?

HINT
b. **Explaining** Which motion causes day and night?

HINT
2. a. **Relating Cause and Effect** What causes the seasons?

HINT
b. **Comparing and Contrasting** What are solstices and equinoxes? How are they related to the seasons?

HINT
c. **Predicting** How would the seasons be different if Earth were not tilted on its axis?

HINT

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.

Lab zone Skills Lab

Reasons for the Seasons

S 8.4.e, S 8.9

Problem

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

Skills Focus

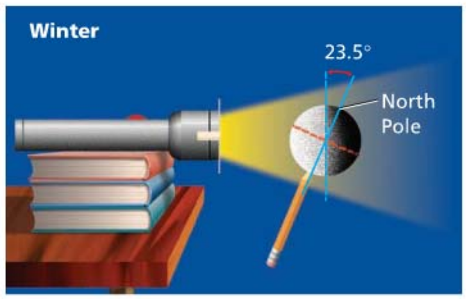
making models, observing, inferring, predicting

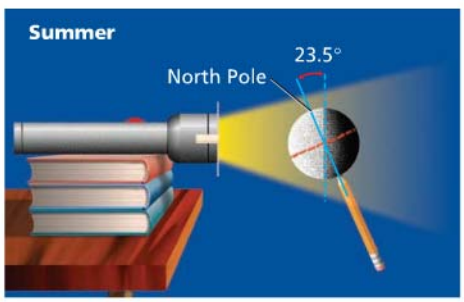
Materials (per pair of students)

- 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.





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?

Section 2

Integrating Physics

Gravity and Motion

CALIFORNIA Standards Focus

S 8.2.g Students know the role of gravity in forming and maintaining the shapes of planets, stars, and the solar system.

- What determines the strength of the force of gravity between two objects?
- What two factors combine to keep the moon and Earth in orbit?

Key Terms

- force
- gravity
- Universal Law of Gravitation
- mass
- weight
- inertia
- Newton's first law of motion

Lab zone Standards **Warm-Up**

Can You Remove the Bottom Penny?

1. Place 25 or so pennies in a stack on a table.
2. Write down your prediction of what will happen if you attempt to knock the bottom penny out of the stack.
3. Quickly slide a ruler along the surface of the table and strike the bottom penny. Observe what happens to the stack of pennies.
4. Repeat Step 3 several times, knocking more pennies from the bottom of the stack.

Think It Over

Developing Hypotheses Explain what happened to the stack of pennies as the bottom penny was knocked out of the stack.

Earth revolves around the sun in a nearly circular orbit. The moon orbits Earth in the same way. But what keeps Earth and the moon in orbit? Why don't they just fly off into space?

The first person to answer these questions was the English scientist Isaac Newton. Late in his life, Newton told a story of how watching an apple fall from a tree in 1666 had made him think about the moon's orbit. Newton realized that there must be a force acting between Earth and the moon that kept the moon in orbit. Recall that a **force** is a push or a pull. Most everyday forces require objects to be in contact. Newton realized that the force that holds the moon in orbit is different in that it acts over long distances between objects that are not in contact.

Gravity

Newton hypothesized that the force that pulls an apple to the ground also pulls the moon toward Earth, keeping it in orbit. This force, called **gravity**, attracts all objects toward each other. In Newton's day, most scientists thought that forces on Earth were different from those elsewhere in the universe. Although Newton did not discover gravity, he was the first person to realize that gravity occurs everywhere. Newton's **Universal Law of Gravitation** states that every object in the universe attracts every other object.

The force of gravity is measured in units called newtons, named after Isaac Newton. **The strength of the force of gravity between two objects depends on two factors: the masses of the objects and the distance between them.**

Gravity, Mass, and Weight According to the law of universal gravitation, all of the objects around you, including Earth and even this book, are pulling on you, just as you are pulling on them. Why don't you notice a pull between you and the book? Because the strength of gravity depends in part on the masses of each of the objects. As you have learned, **mass** is the amount of matter in an object.

Because Earth is so massive, it exerts a much greater force on you than this book does. Similarly, Earth exerts a gravitational force on the moon, large enough to keep the moon in orbit. The moon also exerts a gravitational force on Earth, as you will learn later in this chapter when you study the tides.

The force of gravity on an object is the object's **weight**. Unlike mass, which doesn't change, an object's weight can change depending on its location. For example, on the moon you would weigh about one sixth of your weight on Earth. This is because the moon is much less massive than Earth, so the pull of the moon's gravity on you would be far less than that of Earth's gravity.

Gravity and Distance The strength of gravity is affected by the distance between two objects as well as their masses. The force of gravity decreases rapidly as distance increases. For example, if the distance between two objects were doubled, the force of gravity between them would decrease to one fourth of its original value.

Reading Checkpoint What is an object's weight?

FIGURE 7
Gravity, Mass, and Distance
The strength of the force of gravity between two objects depends on their masses and the distance between them.
Inferring *How would the force of gravity change if the distance between the objects decreased?*

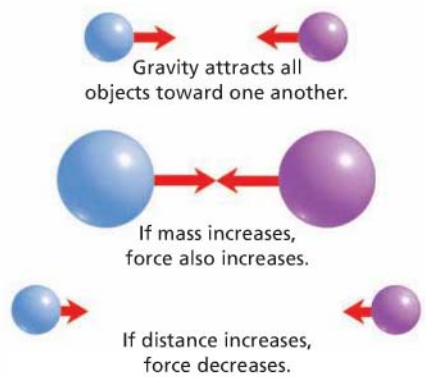
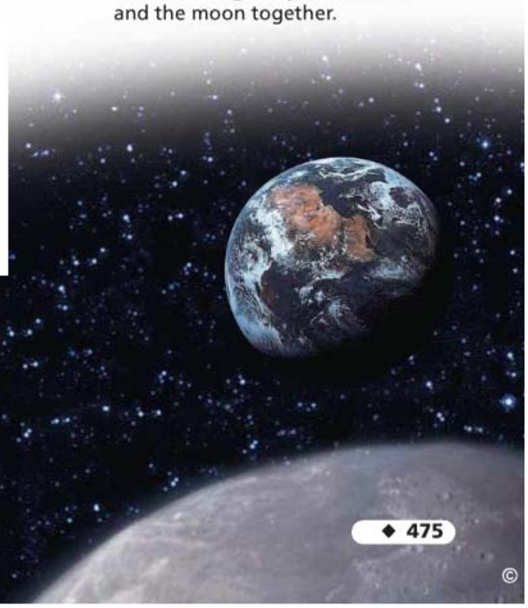


FIGURE 8
Earth Over the Moon
The force of gravity holds Earth and the moon together.



Reviewing Math: Algebra and Functions 7.1.5

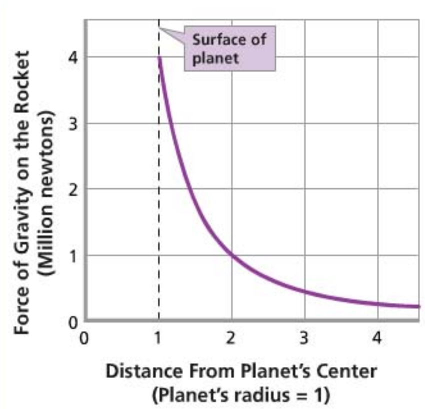
Math Analyzing Data

Gravity Versus Distance

As a rocket leaves a planet's surface, the force of gravity between the rocket and the planet changes. Use the graph at the right to answer the questions below.

1. **Reading Graphs** What is the force of gravity on the rocket at the planet's surface?
2. **Reading Graphs** What is the force of gravity on the rocket at a distance of two units (twice the planet's radius from its center)?
3. **Making Generalizations** According to the graph, is the relationship between gravity and distance linear or nonlinear? Explain.
4. **Drawing Conclusions** In general, how does the force of gravity pulling on the rocket change as the distance between it and the planet increases?
5. **Predicting** Estimate the force of gravity on the rocket at a distance of five units.

Gravity and Distance



Inertia and Orbital Motion

If the sun and Earth are constantly pulling on one another because of gravity, why doesn't Earth fall into the sun? Similarly, why doesn't the moon crash into Earth? The fact that such collisions have not occurred shows that there must be another factor at work. That factor is called inertia.

Inertia The tendency of an object to resist a change in motion is **inertia.** You feel the effects of inertia every day. When you are riding in a car and it stops suddenly, you keep moving forward. If you didn't have a seat belt on, your inertia could cause you to bump into the car's windshield or the seat in front of you. The more mass an object has, the greater its inertia. An object with greater inertia is more difficult to start or stop.

Isaac Newton stated his ideas about inertia as a scientific law. **Newton's first law of motion** says that an object at rest will stay at rest and an object in motion will stay in motion with a constant speed and direction unless acted on by an unbalanced force.

Reading Checkpoint What is inertia?

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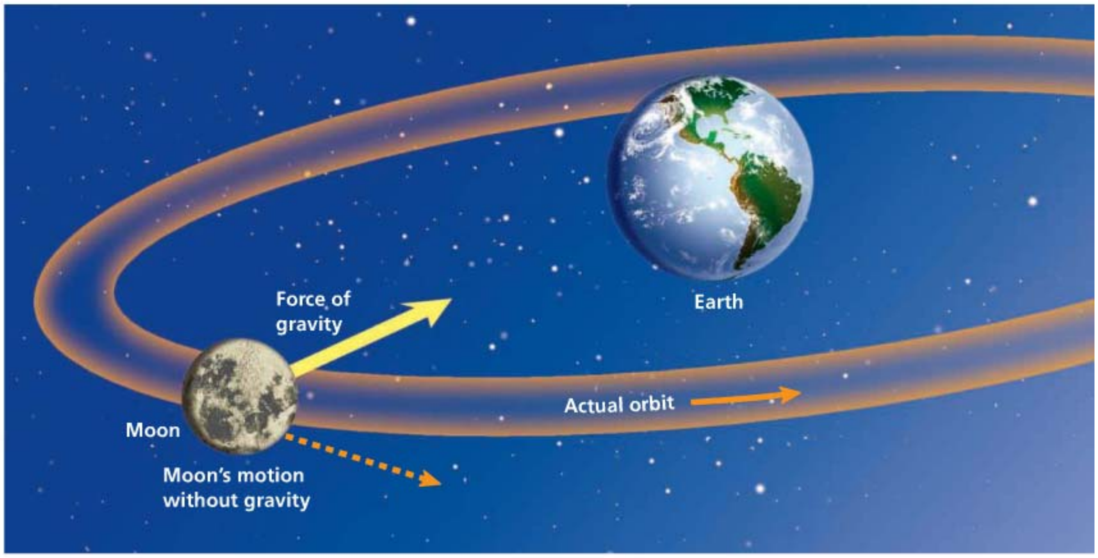
Visit: www.SciLinks.org
Web Code: scn-0612



Orbital Motion Why do Earth and the moon remain in their orbits? **Newton concluded that two factors—inertia and gravity—combine to keep Earth in orbit around the sun and the moon in orbit around Earth.**

As shown in Figure 9, Earth's gravity keeps pulling the moon toward it, preventing the moon from moving in a straight line. At the same time, the moon keeps moving ahead because of its inertia. If not for Earth's gravity, inertia would cause the moon to move off through space in a straight line. In the same way, Earth revolves around the sun because the sun's gravity pulls on it while Earth's inertia keeps it moving ahead.

FIGURE 9
Gravity and Inertia
A combination of gravity and inertia keeps the moon in orbit around Earth. If there were no gravity, inertia would cause the moon to travel in a straight line.
Interpreting Diagrams *What would happen to the moon if it were not moving in orbit?*

Section 2 Assessment

S 8.2.g, E-LA: Writing 8.2.0, Reading 8.1.2

Vocabulary Skill **Latin Word Origins** How does the Latin word origin of *gravity* help you to remember its meaning?

Reviewing Key Concepts

HINT
1. a. **Summarizing** What is the law of universal gravitation?

HINT
   b. **Reviewing** What two factors determine the force of gravity between two objects?

HINT
   c. **Predicting** Suppose the moon were closer to Earth. How would the force of gravity between Earth and the moon be different?

HINT
2. a. **Identifying** What two factors act together to keep Earth in orbit around the sun?

   b. **Applying Concepts** Why doesn't Earth simply fall into the sun? HINT

   c. **Predicting** How would Earth move if the sun (including its gravity) suddenly disappeared? Explain your answer. HINT

Writing in Science

Cause and Effect Paragraph Suppose you took a trip to the moon. Write a paragraph describing how and why your weight would change. Would your mass change too?

Section 3 Phases, Eclipses, and Tides

CALIFORNIA Standards Focus

S 8.2.g Students know the role of gravity in forming and maintaining the shapes of planets, stars, and the solar system.

S 8.4.d Students know that stars are the source of light for all bright objects in outer space and that the Moon and planets shine by reflected sunlight, not by their own light.

- What causes the phases of the moon?
- What are solar and lunar eclipses?
- What causes the tides?

Key Terms

- phase
- eclipse
- solar eclipse
- umbra
- penumbra
- lunar eclipse
- tide
- spring tide
- neap tide

Lab zone **Standards Warm-Up**

How Does the Moon Move?

1. Place a quarter flat on your desk to represent Earth. Put a penny flat on your desk to represent the moon.
2. One side of the moon always faces Earth. Move the moon through one revolution around Earth, keeping Lincoln's face always looking at Earth. How many times did the penny make one complete rotation?

Think It Over

Inferring From the point of view of someone on Earth, does the moon seem to rotate? Explain your answer.

When you look up at the moon, you may see what looks like a face. Some people call this "the man in the moon." What you are really seeing is a pattern of light-colored and dark-colored areas on the moon's surface that just happens to look like a face. Oddly, this pattern never seems to move. That is, the same side of the moon, the "near side," always faces Earth. The "far side" of the moon always faces away from Earth. The reason has to do with how the moon moves in space.

Motions of the Moon

Like Earth, the moon moves through space in two ways. The moon revolves around Earth and also rotates on its own axis.

As the moon revolves around Earth, the relative positions of the moon, Earth, and sun change. **The changing relative positions of the moon, Earth, and sun cause the phases of the moon, eclipses, and tides.**

The moon rotates once on its axis in the same amount of time as it revolves around Earth. Thus, a "day" and a "year" on the moon are the same length. For this reason, the same side of the moon always faces Earth. The length of the moon's day is somewhat shorter than the 29.5 days between consecutive full moons. This is because as the moon revolves around Earth, Earth revolves around the sun. Thus, the moon has to travel a little farther than one complete orbit between each full moon.

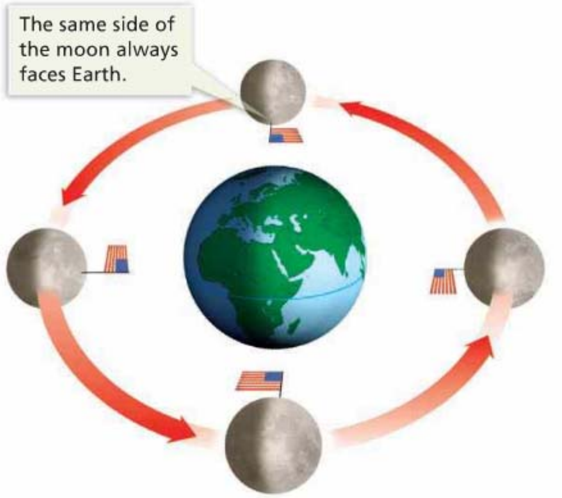


FIGURE 10
The Moon in Motion
The moon rotates on its axis and revolves around Earth in the same amount of time. As a result, the near side of the moon (shown with a flag) always faces Earth.
Interpreting Diagrams *Would Earth ever appear to set below the horizon for someone standing next to the flag on the moon? Explain.*

Phases of the Moon

On a clear night when the moon is full, the bright moonlight can keep you awake. But the moon does not produce the light you see. Instead, it reflects light from the sun. Imagine taking a flashlight into a dark room. If you were to shine the flashlight on a chair, you would see the chair because the light from your flashlight would bounce, or reflect, off the chair. In the same way that the chair wouldn't shine by itself, the moon doesn't give off light by itself. You can see the moon because it reflects the light of the sun.

When you see the moon in the sky, sometimes it appears round. Other times you see only a thin sliver, or crescent. The different shapes of the moon you see from Earth are called **phases.** The moon goes through its whole set of phases each time it makes a complete revolution around Earth.

Phases are caused by changes in the relative positions of the moon, Earth, and the sun. Because the sun lights the moon, half the moon is almost always in sunlight. However, since the moon revolves around Earth, you see the moon from different angles. The half of the moon that faces Earth is not always the half that is sunlit. **The phase of the moon you see depends on how much of the sunlit side of the moon faces Earth.**

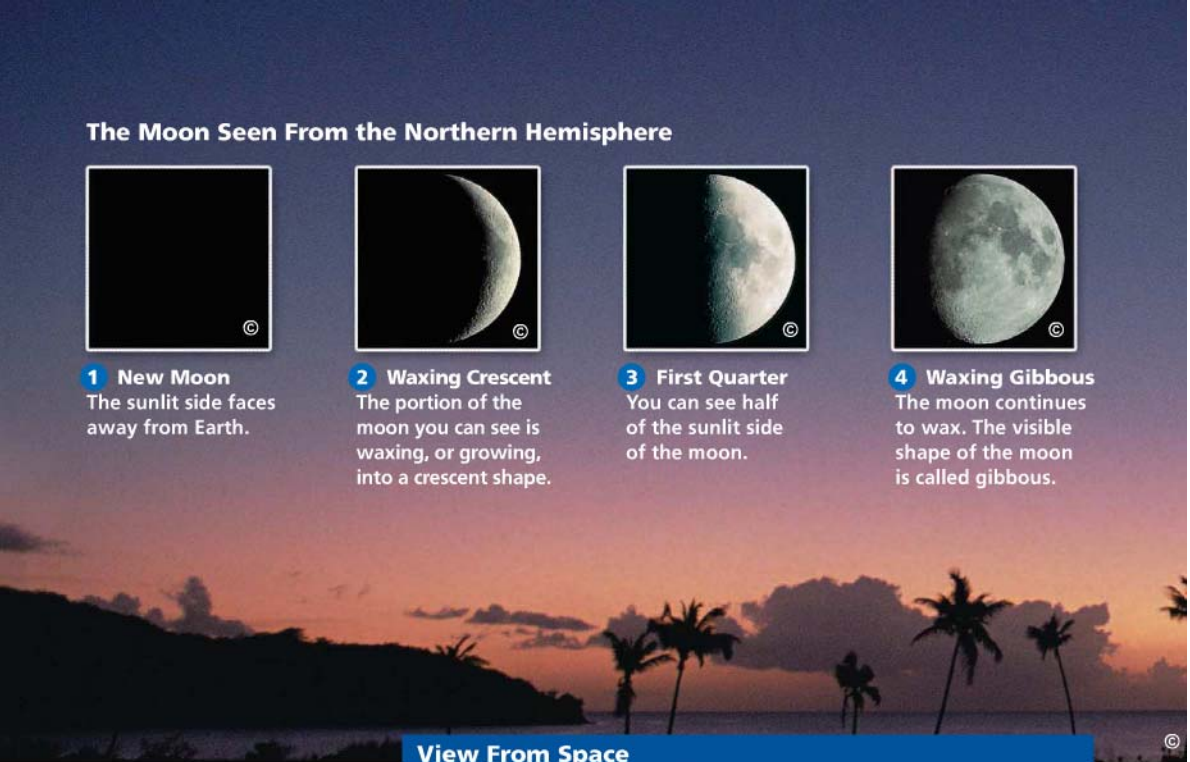


FIGURE 11
Phases of the Moon

The photos at the top of the page show how the phases of the moon appear when you look up at the moon from Earth's surface. The circular diagram at the right shows how the Earth and moon would appear to an observer in space as the moon revolves around Earth.
Interpreting Diagrams *During what phases are the moon, Earth, and sun aligned in a straight line?*

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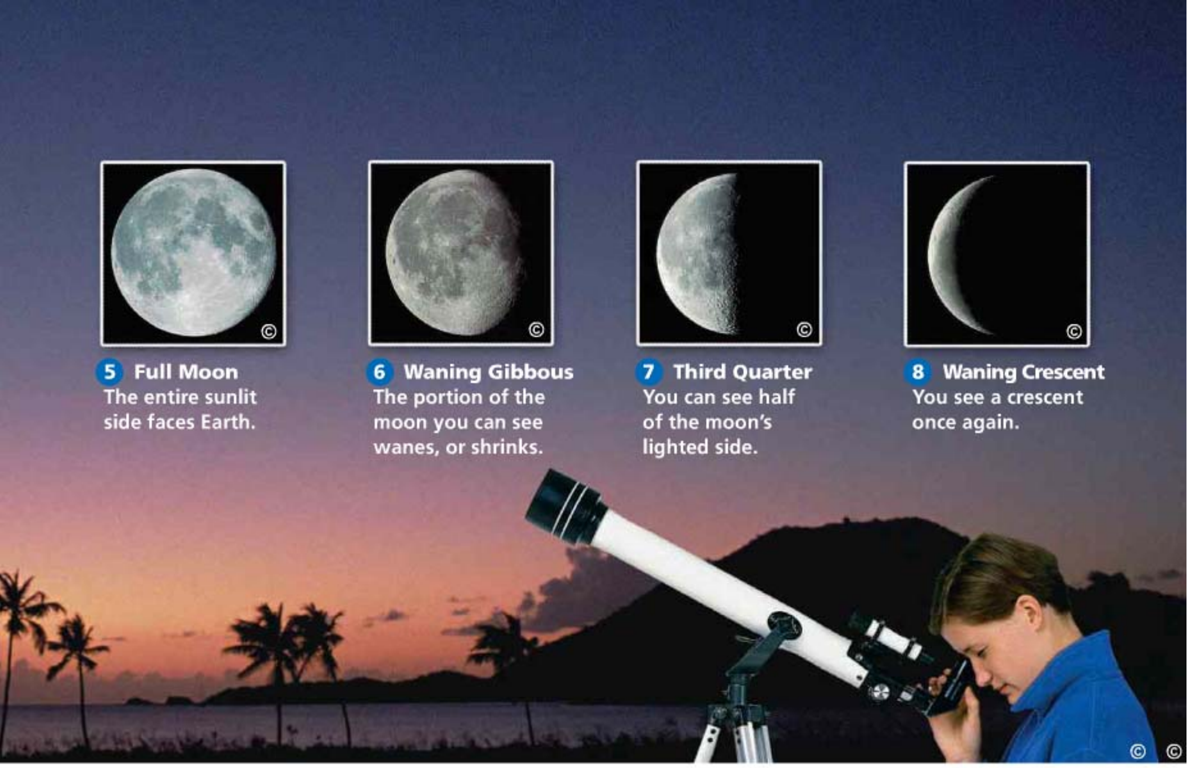


To understand the phases of the moon, study Figure 11. During the new moon, the lit side of the moon faces completely away from Earth. As the moon revolves around Earth, you see more and more of the lighted side of the moon every day, until the side of the moon you see is fully lit. As the moon continues in its orbit, you see less and less of the lighted side. About 29.5 days after the last new moon, the cycle is complete, and a new moon occurs again.

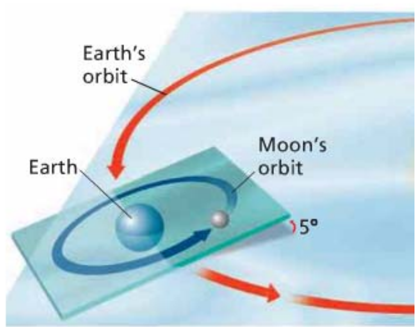
Reading Checkpoint **What is a new moon?**

Eclipses

As Figure 12 shows, the moon's orbit around Earth is slightly tilted with respect to Earth's orbit around the sun. As a result, in most months the moon revolves around Earth without moving into Earth's shadow or the moon's shadow hitting Earth.

When the moon's shadow hits Earth or Earth's shadow hits the moon, an eclipse occurs. When an object in space comes between the sun and a third object, it casts a shadow on that object, causing an **eclipse** (ih KLIPS) to take place. There are two types of eclipses: solar eclipses and lunar eclipses. (The words *solar* and *lunar* come from the Latin words for "sun" and "moon.")

FIGURE 12
The Moon's Orbit
The moon's orbit is tilted about 5 degrees relative to Earth's orbit around the sun.



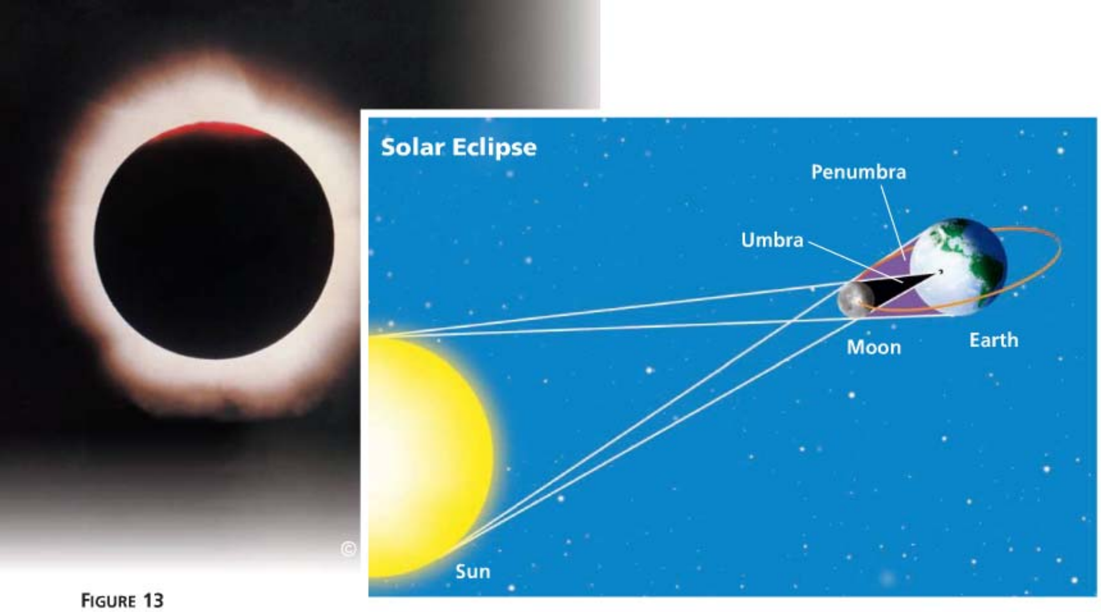


Figure 13
The outer layer of the sun's atmosphere, the solar corona, is visible surrounding the dark disk of the moon during a solar eclipse. During a solar eclipse, the moon blocks light from the sun, preventing sunlight from reaching parts of Earth's surface.

When Do Solar Eclipses Occur? During a new moon, the moon lies between Earth and the sun. But most months, as you have seen, the moon travels a little above or below the sun in the sky. **A solar eclipse occurs when the moon passes directly between Earth and the sun, blocking sunlight from Earth.** The moon's shadow then hits Earth, as shown in Figure 13. So a **solar eclipse** occurs when a new moon blocks your view of the sun.

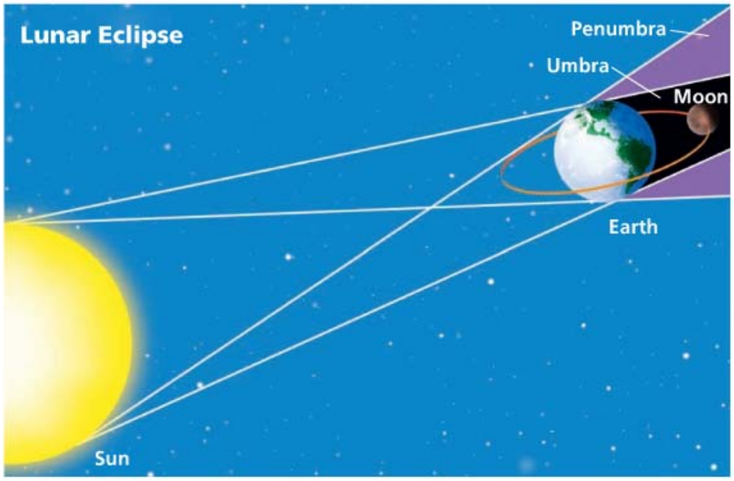
Total Solar Eclipses The very darkest part of the moon's shadow, the **umbra** (UM bruh), is cone-shaped. From any point in the umbra, light from the sun is completely blocked by the moon. The moon's umbra happens to be long enough so that the point of the cone can just reach a small part of Earth's surface. Only the people within the umbra experience a total solar eclipse. During the short period of a total solar eclipse, the sky grows as dark as night, even in the middle of a clear day. The air gets cool and the sky becomes an eerie color. You can see the stars and the solar corona, which is the faint outer atmosphere of the sun.

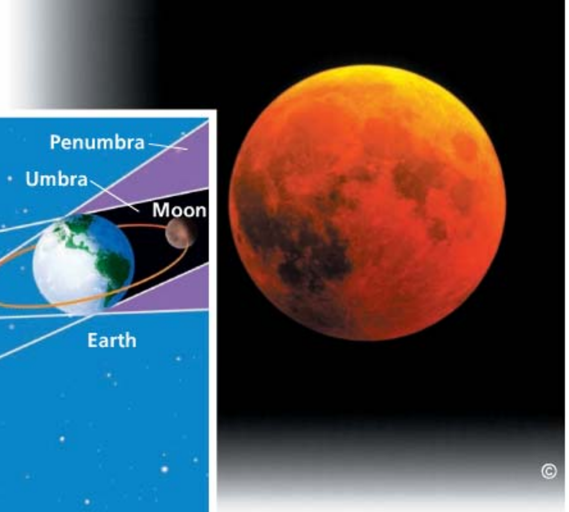
Partial Solar Eclipses In Figure 13, you can see that the moon casts another part of its shadow that is less dark than the umbra. This larger part of the shadow is called the **penumbra** (peh NUM bruh). In the penumbra, part of the sun is visible from Earth. During a solar eclipse, people in the penumbra see only a partial eclipse. Since an extremely bright part of the sun still remains visible, it is not safe to look directly at the sun during a partial solar eclipse (just as you wouldn't look directly at the sun during a normal day).

Lab zone Skills Activity

Making Models

Here is how you can draw a scale model of a solar eclipse. The moon's diameter is about one fourth Earth's diameter. The distance from Earth to the moon is about 30 times Earth's diameter. Make a scale drawing of the moon, Earth, and the distance between them. (*Hint:* Draw Earth 1 cm in diameter in one corner of the paper.) From the edges of the moon, draw and shade in a triangle just touching Earth to show the moon's umbra.





When Do Lunar Eclipses Occur? During most months, the moon moves near Earth's shadow but not quite into it. A **lunar eclipse** occurs at a full moon when Earth is directly between the moon and the sun. You can see a lunar eclipse in Figure 14. **During a lunar eclipse, Earth blocks sunlight from reaching the moon.** The moon is then in Earth's shadow and looks dim from Earth. Lunar eclipses occur only when there is a full moon because the moon is closest to Earth's shadow at that time.

Total Lunar Eclipses Like the moon's shadow in a solar eclipse, Earth's shadow has an umbra and a penumbra. When the entire moon is in Earth's umbra, you see a total lunar eclipse. You can see the edge of Earth's shadow on the moon before and after a total lunar eclipse.

Unlike a total solar eclipse, a total lunar eclipse can be seen anywhere on Earth that the moon is visible. So you are more likely to see a total lunar eclipse than a total solar eclipse.

Partial Lunar Eclipses For most lunar eclipses, Earth, the moon, and the sun are not quite in line, and only a partial lunar eclipse results. A partial lunar eclipse occurs when the moon passes partly into the umbra of Earth's shadow. The edge of the umbra appears blurry, and you can watch it pass across the moon for two or three hours.

Reading Checkpoint **During which phase of the moon can lunar eclipses occur?**

FIGURE 14
During a lunar eclipse, Earth blocks sunlight from reaching the moon's surface. The photo of the moon above was taken during a total lunar eclipse. The moon's reddish tint occurs because Earth's atmosphere bends some sunlight toward the moon.
Interpreting Diagrams *What is the difference between the umbra and the penumbra?*

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FIGURE 15
High and Low Tides
In some locations, such as along this beach in Australia, there can be dramatic differences between the height of high and low tides.

Tides

Have you ever built a sand castle on an ocean beach? Was it washed away by rising water? This is an example of **tides,** the rise and fall of ocean water that occurs every 12.5 hours or so. The water rises for about six hours, then falls for about six hours, in a regular cycle.

The force of gravity pulls the moon and Earth (including the water on Earth's surface) toward each other. **The tides are caused mainly by differences in how much the moon's gravity pulls on different parts of Earth.**

The Tide Cycle Look at Figure 16. The force of the moon's gravity at point A, which is closer to the moon, is stronger than the force of the moon's gravity on Earth as a whole. The water flows toward point A, and a high tide forms.

The force of the moon's gravity at point C, which is on the far side of Earth from the moon, is weaker than the force of the moon's gravity on Earth as a whole. Earth is pulled toward the moon more strongly than the water at point C, so the water is "left behind." Water flows toward point C, and a high tide occurs there too. Between points A and C, water flows away from points B and D, causing low tides.

At any one time there are two places with high tides and two places with low tides on Earth. As Earth rotates, one high tide stays on the side of Earth facing the moon. The second high tide stays on the opposite side of Earth. Each location on Earth sweeps through those two high tides and two low tides every 25 hours or so.

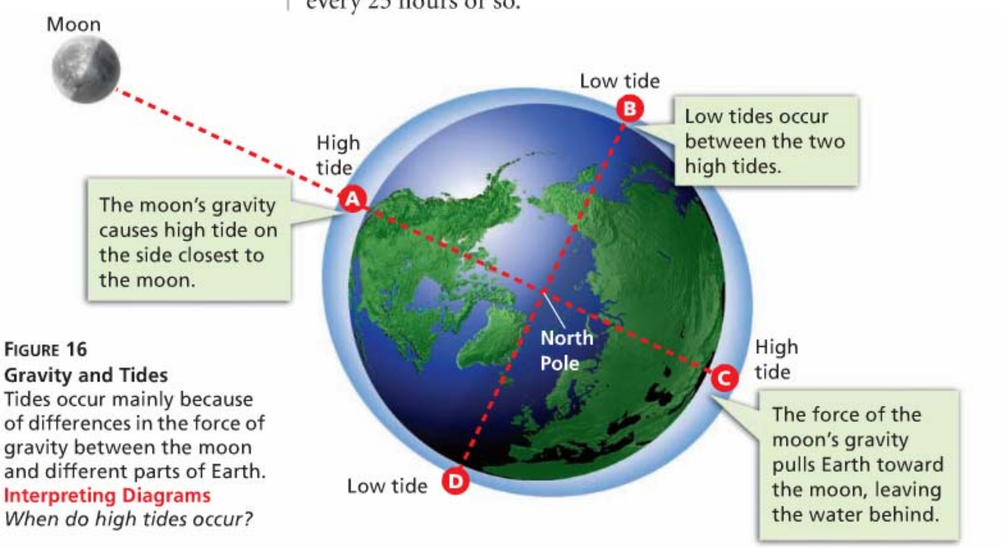


FIGURE 16
Gravity and Tides
Tides occur mainly because of differences in the force of gravity between the moon and different parts of Earth.
Interpreting Diagrams
When do high tides occur?

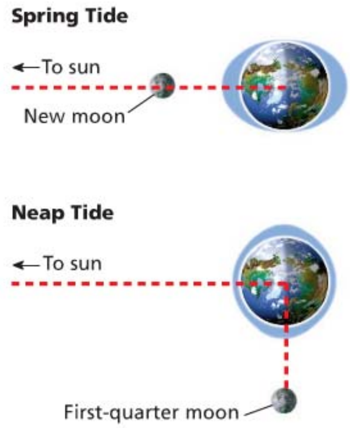
Spring Tides The sun's gravity also pulls on Earth's waters. As shown in the top diagram of Figure 17, the sun, moon, and Earth are nearly in a line during a new moon. The gravity of the sun and the moon pull in the same direction. Their combined forces produce a tide with the greatest difference between consecutive low and high tides, called a **spring tide**.

At full moon, the moon and the sun are on opposite sides of Earth. Since there are high tides on both sides of Earth, a spring tide is also produced. It doesn't matter in which order the sun, Earth, and moon line up. Spring tides occur twice a month, at new moon and at full moon.

Neap Tides During the moon's first-quarter and third-quarter phases, the line between Earth and the sun is at right angles to the line between Earth and the moon. The sun's pull is at right angles to the moon's pull. This arrangement produces a **neap tide**, a tide with the least difference between consecutive low and high tides. Neap tides occur twice a month.

Reading Checkpoint What is a neap tide?

FIGURE 17
Spring and Neap Tides
When Earth, the sun, and the moon are in a straight line (top), a spring tide occurs. When the moon is at a right angle to the sun (bottom), a neap tide occurs.



Section 3 Assessment

S 8.2.g, 8.4.d,
E-LA: Reading 8.2.0

Target Reading Skill **Sequence** Create a cycle diagram with four phases of the moon: new moon, first quarter, full moon, and third quarter. For each phase, include a sketch of how the moon looks from Earth.

Reviewing Key Concepts

HINT HINT HINT

1. a. **Explaining** What causes the moon to shine?
   b. **Relating Cause and Effect** Why does the moon appear to change shape during the course of a month?
   c. **Interpreting Diagrams** Use Figure 11 to explain why you can't see the moon at the time of a new moon.

HINT HINT HINT

2. a. **Explaining** What is an eclipse?
   b. **Comparing and Contrasting** How is a solar eclipse different from a lunar eclipse?
   c. **Relating Cause and Effect** Why isn't there a solar eclipse and a lunar eclipse each month?

HINT HINT HINT HINT

3. a. **Summarizing** What causes the tides?
   b. **Explaining** Explain why most coastal regions have two high tides and two low tides each day.
   c. **Comparing and Contrasting** Compare the size of high and low tides in a spring tide and a neap tide. What causes the difference?

Lab zone At-Home Activity

Tracking the Tides Use a daily newspaper or the Internet to track the height of high and low tides at a location of your choice for at least two weeks. Make a graph of your data, with the date as the *x*-axis and tide height as the *y*-axis. Also find the dates of the new moon and full moon and add them to your graph. Show your completed graph to a relative and explain what the graph shows.

Lab zone **Skills Lab**

A "Moonth" of Phases

S 8.4.d, 8.4.e

Problem

What causes the phases of the moon?

Skills Focus

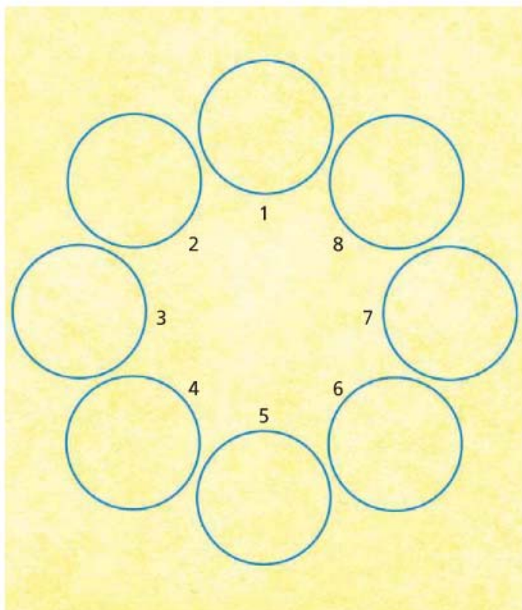
making models, observing, drawing conclusions

Materials

- floor lamp with 150-watt bulb
- pencils
- plastic foam balls

Procedure

1. Place a lamp in the center of the room. Remove the lampshade.
2. Close the doors and shades to darken the room, and switch on the lamp.
3. Carefully stick the point of a pencil into the plastic foam ball so that the pencil can be used as a "handle."
4. Draw 8 circles on a sheet of paper. Number them 1–8.
5. Have your partner hold the plastic foam ball at arm's length in front and slightly above his or her head so that the ball is between him or her and the lamp. **CAUTION:** *Do not look directly at the bulb.*
6. The ball should be about 1 to 1.5 m away from the lamp. Adjust the distance between the ball and the lamp so that the light shines brightly on the ball.
7. Stand directly behind your partner and observe what part of the ball facing you is lit by the lamp. If light is visible on the ball, draw the shape of the lighted part of the ball in the first circle.
8. Have your partner turn 45° to the left while keeping the ball in front and at arm's length.
9. Repeat Step 7. Be sure you are standing directly behind your partner.
10. Repeat Steps 8 and 9 six more times until your partner is facing the lamp again. See the photograph for the 8 positions.
11. Change places and repeat Steps 4–10.

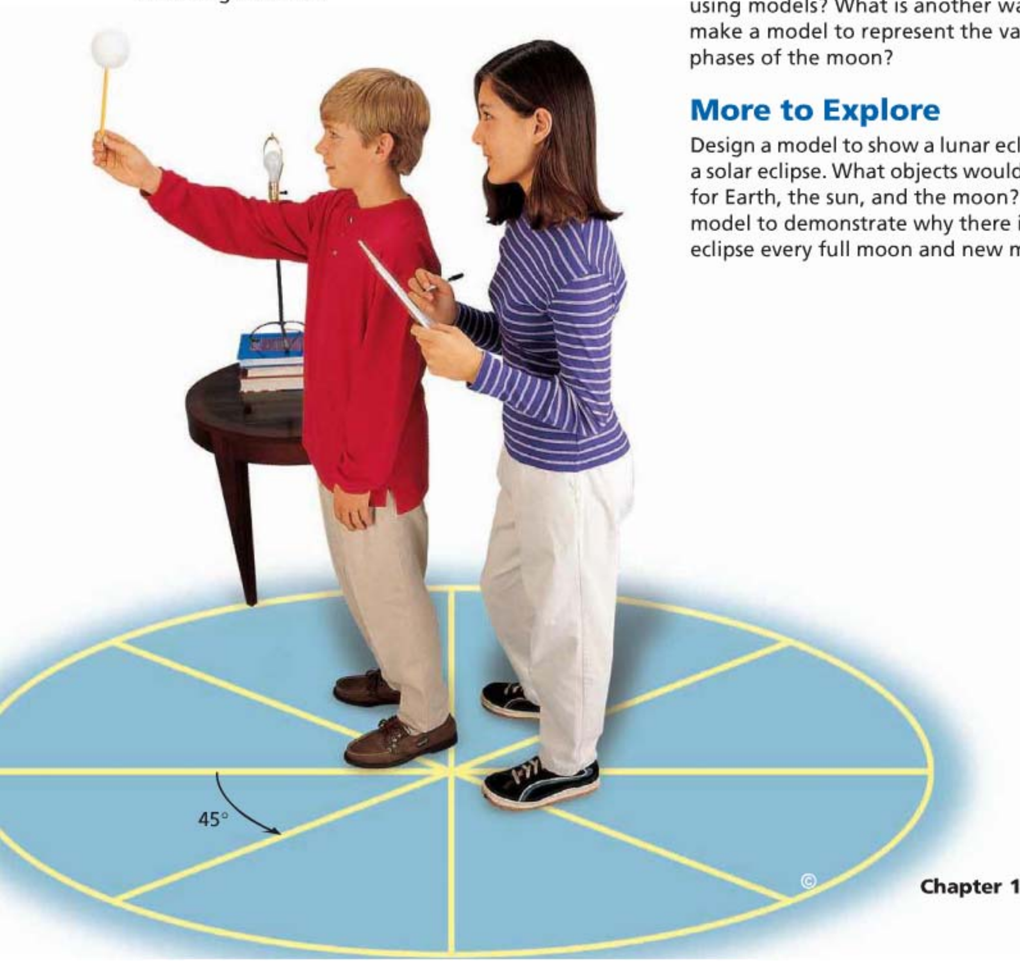


Analyze and Conclude

1. **Making Models** In your model, what represents Earth? The sun? The moon?
2. **Observing** Refer back to your 8 circles. How much of the lighted part of the ball did you see when facing the lamp?
3. **Classifying** Label your drawings with the names of the phases of the moon. Which drawing represents a full moon? A new moon? Which represents a waxing crescent? A waning crescent?
4. **Observing** How much of the lighted part of the ball did you see after each turn?
5. **Drawing Conclusions** Whether you could see it or not, how much of the ball's surface was always lit by the lamp? Was the darkness of the new moon caused by an eclipse? Explain your answer.
6. **Communicating** Write a brief analysis of this lab. How well did making a model help you understand the phases of the moon? What are some disadvantages of using models? What is another way to make a model to represent the various phases of the moon?

More to Explore

Design a model to show a lunar eclipse and a solar eclipse. What objects would you use for Earth, the sun, and the moon? Use the model to demonstrate why there isn't an eclipse every full moon and new moon.



Section 4

Earth's Moon

CALIFORNIA Standards Focus

S 8.4.e Students know the appearance, general composition, relative position and size, and motion of objects in the solar system, including planets, planetary satellites, comets, and asteroids.

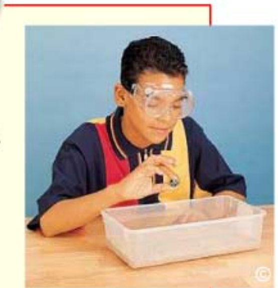
- What features are found on the moon's surface?
- What are some characteristics of the moon?
- How did the moon form?

Key Terms

- telescope
- maria
- crater
- meteoroid

Lab zone Standards Warm-Up

Why Do Craters Look Different From Each Other?



The moon's surface has pits in it, called craters.

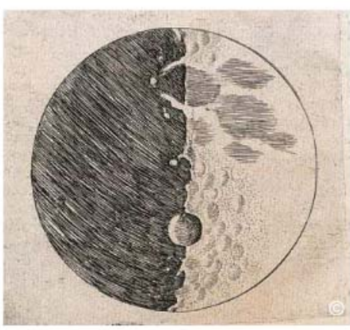
1. Put on your goggles. Fill a large plastic basin to a depth of 2 cm with sand.
2. Drop marbles of different masses from about 20 cm high. Take the marbles out and view the craters they created.
3. Predict what will happen if you drop marbles from a higher point. Smooth out the sand. Now drop marbles of different masses from about 50 cm high.
4. Take the marbles out and view the craters they left.

Think It Over

Developing Hypotheses In which step do you think the marbles were moving faster when they hit the sand? If objects hitting the moon caused craters, how did the speeds of the objects affect the sizes of the craters? How did the masses of the objects affect the sizes of the craters?

For thousands of years, people could see shapes on the surface of the moon, but didn't know what caused them. The ancient Greeks thought that the moon was perfectly smooth. It was not until about 400 years ago that scientists could study the moon more closely.

In 1609, the Italian scientist Galileo Galilei heard about a **telescope**, a device built to observe distant objects by making them appear closer. Galileo soon made his own telescope by putting two lenses in a wooden tube. The lenses focused the light coming through the tube, making distant objects seem closer. When Galileo pointed his telescope at the moon, he was able to see much more detail than anyone had ever seen before. What Galileo saw astounded him. Instead of the perfect sphere imagined by the Greeks, he saw that the moon has an irregular surface with a variety of remarkable features.



Galileo used a telescope to help make this drawing of the moon.

The Moon's Surface

Recent photos of the moon show much more detail than Galileo could see with his telescope. **Features on the moon's surface include maria, craters, and highlands.**

Maria The moon's surface has dark, flat areas, which Galileo called **maria** (MAH ree uh), the Latin word for "seas." Galileo incorrectly thought that the maria were oceans. The maria are actually hardened rock formed from huge lava flows that occurred between 3 and 4 billion years ago.

Craters Galileo saw that the moon's surface is marked by large round pits called **craters.** Some craters are hundreds of kilometers across. For a long time, many scientists mistakenly thought that these craters had been made by volcanoes. Scientists now know that these craters were caused by the impacts of **meteoroids,** chunks of rock or dust from space.

The maria have few craters compared to surrounding areas. This means that most of the moon's craters formed from impacts early in its history, before the maria formed. On Earth, such ancient craters have disappeared. They were worn away over time by water, wind, and other forces. But since the moon has no liquid water or atmosphere, its surface has changed little for billions of years.

Highlands Galileo correctly inferred that some of the light-colored features he saw on the moon's surface were highlands, or mountains. The peaks of the lunar highlands and the rims of the craters cast dark shadows, which Galileo could see. The rugged lunar highlands cover much of the moon's surface.

Reading Checkpoint What are meteoroids?

FIGURE 18
The Moon's Surface
The moon's surface is covered by craters, maria, and highlands. Craters on the moon formed from the impact of meteoroids. Most large craters are named after famous scientists or philosophers.
Observing *What are the light regions in the top photograph called?*

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FIGURE 19
The Moon's Size
The diameter of the moon is a little less than the distance across the contiguous United States.
Calculating *What is the ratio of the moon's diameter to the distance between Earth and the moon?*

Characteristics of the Moon

Would you want to take a vacation on the moon? At an average distance of about 384,000 kilometers (about 30 times Earth's diameter), the moon is Earth's closest neighbor in space. Despite its proximity, the moon is very different from Earth. **The moon is dry and airless. Compared to Earth, the moon is small and has large variations in its surface temperature.** If you visited the moon, you would need to wear a bulky space suit to provide air to breathe, protect against sunburn, and to keep you at a comfortable temperature.

Size and Density The moon is 3,476 kilometers in diameter, a little less than the distance across the United States. This is about one-fourth Earth's diameter. However, the moon has only one-eightieth as much mass as Earth. Though Earth has a very dense core, its outer layers are less dense. The moon's average density is similar to the density of Earth's outer layers.

Temperature and Atmosphere On the moon's surface, temperatures range from a torrid 130°C in direct sunlight to a frigid –180°C at night. Temperatures on the moon vary so much because it has no atmosphere. The moon's surface gravity is so weak that gases can easily escape into space.

Water The moon has no liquid water. However, there is evidence that there may be large patches of ice near the moon's poles. Some areas are shielded from sunlight by crater walls. Temperatures in these regions are so low that ice there would remain frozen. If a colony were built on the moon in the future, any such water would be very valuable. It would be very expensive to transport large amounts of water to the moon from Earth.

Reading Checkpoint **Where on the moon is there evidence of the existence of ice?**

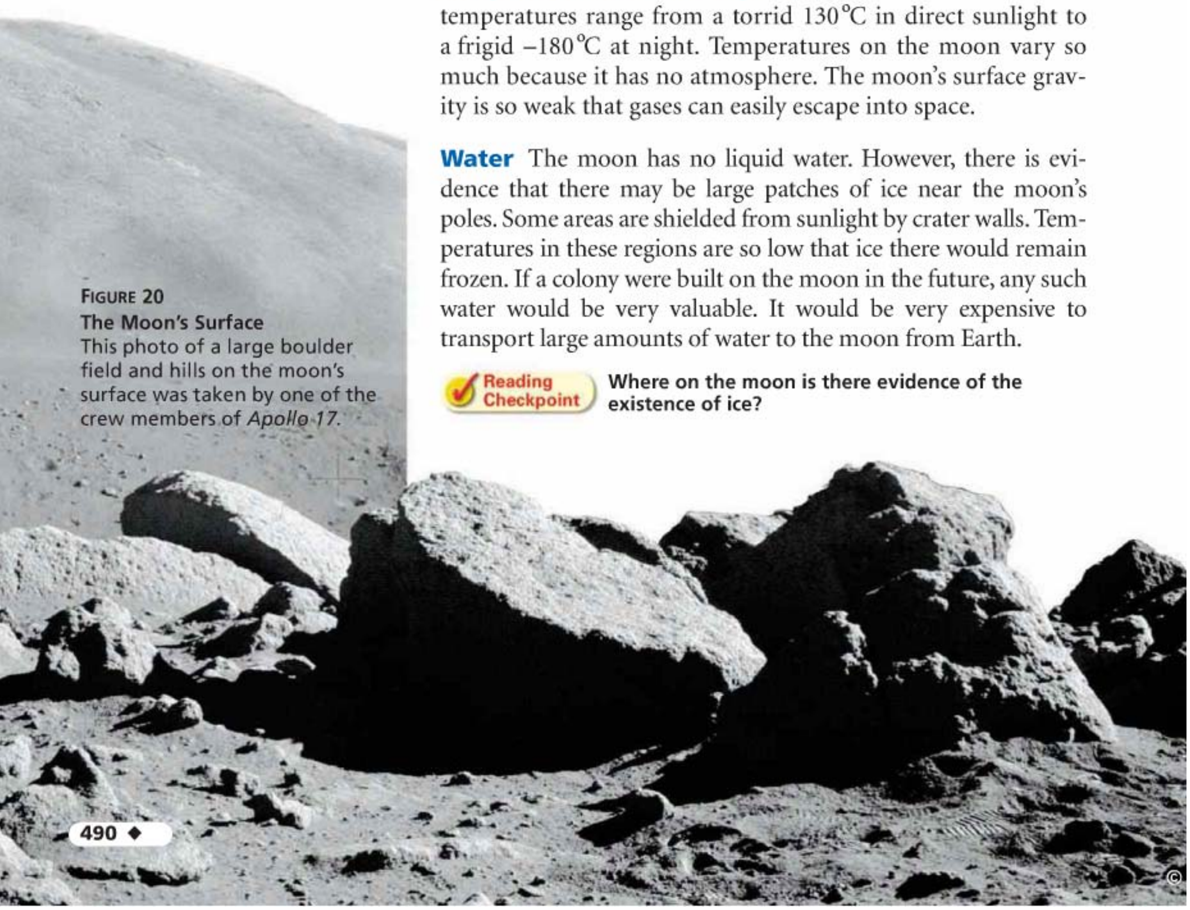
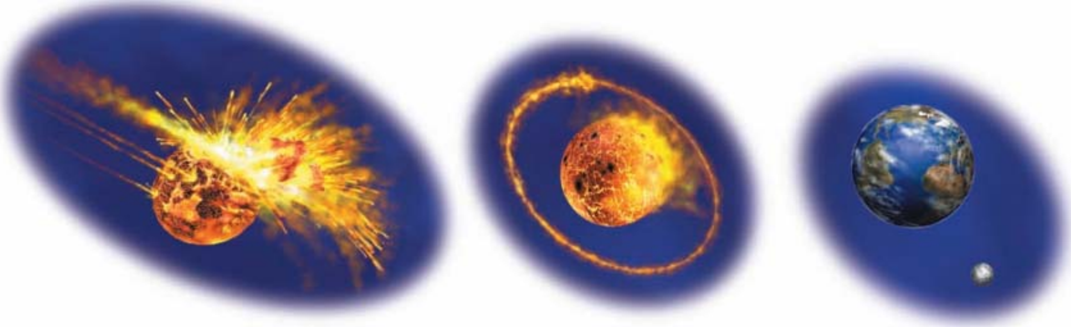


FIGURE 20
The Moon's Surface
This photo of a large boulder field and hills on the moon's surface was taken by one of the crew members of *Apollo 17.*



The Origin of the Moon

People have long wondered how the moon formed. Scientists have suggested many possible hypotheses. For example, was the moon formed elsewhere in the solar system and captured by Earth's gravity as it came near? Was the moon formed near Earth at the same time that Earth formed? Scientists have found reasons to reject these ideas.

The theory of the moon's origin that seems to best fit the evidence is called the collision-ring theory. It is illustrated in Figure 21. About 4.5 billion years ago, when Earth was very young, the solar system was full of rocky debris. Some of this debris was the size of small planets. **Scientists theorize that a planet-sized object collided with Earth to form the moon.** Material from the object and Earth's outer layers was ejected into orbit around Earth, where it formed a ring. Gravity caused this material to combine to form the moon.

FIGURE 21
Formation of the Moon
According to the collision-ring theory, the moon formed early in Earth's history when a planet-sized object struck Earth. The resulting debris formed the moon.

Video Field Trip
Discovery Channel School
Earth, Moon, and Sun

Section 4 Assessment

S 8.4.e, E-LA: Reading 8.1.2

Vocabulary Skill Latin Word Origins What are maria? Why did Galileo select the word *maria* for this feature of the moon? Does the Latin origin of this word accurately describe what scientists today know about the moon? Why or why not?

Reviewing Key Concepts

HINT
1. a. Identifying Name three major features of the moon's surface.

HINT
b. Explaining How did the moon's craters form?

HINT
c. Relating Cause and Effect Why is the moon's surface much more heavily cratered than Earth's surface?

HINT
2. a. Describing Describe the range of temperatures on the moon.

HINT
b. Comparing and Contrasting Compare Earth and the moon in terms of size and surface gravity.

HINT
c. Relating Cause and Effect What is the relationship between the moon's surface gravity, lack of an atmosphere, and temperature range?

HINT
3. a. Identifying What theory best describes the moon's origin?

HINT
b. Describing What was the solar system like when the moon formed?

HINT
c. Sequencing Explain the various stages in the formation of the moon.

Lab zone At-Home Activity

Moonwatching With an adult, observe the moon a few days after the first-quarter phase. Make a sketch of the features you see. Label the maria, craters, and highlands.

Chapter 12 Study Guide

The BIG Idea The motions of Earth and the moon and their position relative to the sun result in day and night, the seasons, phases of the moon, eclipses, and tides.

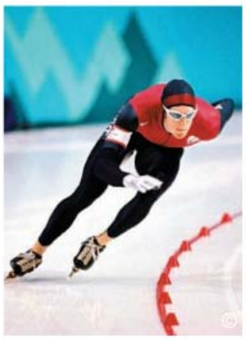
1 Earth in Space

Key Concepts S 8.4.e

- Earth moves through space in two major ways: rotation and revolution.
- Earth has seasons because its axis is tilted as it revolves around the sun.

Key Terms

astronomy
rotation
orbit
solstice
axis
revolution
calendar
equinox




2 Gravity and Motion

Key Concepts S 8.2.g

- The strength of the force of gravity between two objects depends on two factors: the masses of the objects and the distance between them.
- Newton concluded that two factors—inertia and gravity—combine to keep Earth in orbit around the sun and the moon in orbit around Earth.

Key Terms

force
gravity
Universal Law of Gravitation
mass
weight
inertia
Newton's first law of motion

3 Phases, Eclipses, and Tides

Key Concepts S 8.2.g, 8.4.d

- The changing relative positions of the moon, Earth, and sun cause the phases of the moon, eclipses, and tides.
- The phase of the moon you see depends on how much of the sunlit side of the moon faces Earth.
- When the moon's shadow hits Earth or Earth's shadow hits the moon, an eclipse occurs.
- A solar eclipse occurs when the moon passes directly between Earth and the sun, blocking sunlight from Earth.
- During a lunar eclipse, Earth blocks sunlight from reaching the moon.
- The tides are caused mainly by differences in how much the moon's gravity pulls on different parts of Earth.

Key Terms

phase
solar eclipse
penumbra
tide
neap tide
eclipse
umbra
lunar eclipse
spring tide

4 Earth's Moon

Key Concepts S 8.4.e

- Features on the moon's surface include maria, craters, and highlands.
- The moon is dry and airless. Compared to Earth, the moon is small and has large variations in its surface temperature.
- Scientists theorize that a planet-sized object collided with Earth to form the moon.

Key Terms

telescope
maria
crater
meteoroid

Review and Assessment

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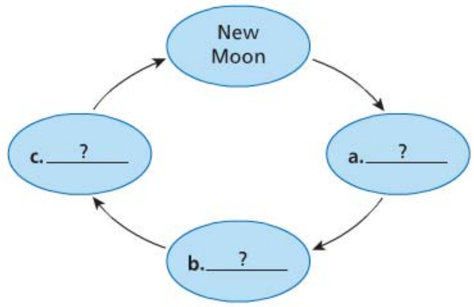
Target Reading Skill

Sequence Draw a cycle diagram for the phases of the moon. Label the phases in which a solar eclipse and a lunar eclipse could occur.

Phases of the Moon



Reviewing Key Terms

Choose the letter of the best answer.

HINT **1.** The movement of Earth around the sun once a year is called Earth's
a. inertia. **b.** rotation.
c. revolution. **d.** axis.

HINT **2.** A day when the sun reaches its farthest position north or south of the equator is called a(an)
a. umbra. **b.** penumbra.
c. equinox. **d.** solstice.

HINT **3.** The tendency of an object to resist a change in motion is called
a. gravity.
b. inertia.
c. force.
d. the Universal Law of Gravitation.

HINT **4.** When Earth's shadow falls on the moon, the shadow causes a
a. new moon.
b. solar eclipse.
c. full moon.
d. lunar eclipse.

HINT **5.** The craters on the moon were caused by
a. tides.
b. volcanoes.
c. meteoroids.
d. maria.

Complete the following sentences so that your answers clearly explain the key terms.

6. Earth completes one **revolution,** or ________, in about 365 1/4 days. HINT

7. Newton's **Universal Law of Gravitation** states that ________ . HINT

8. A **solar eclipse** occurs when ________ . HINT

9. The gravitational effects of the moon and sun combine to influence the height of the **tides,** which are ________ . HINT

10. The moon's surface is marked by **craters** because ________ . HINT

Writing in Science

News Report Imagine that you are a reporter asked to write a story about the origin of the moon. Write an article explaining how the moon formed.

Video Assessment
Discovery Channel School
Earth, Moon, and Sun

Review and Assessment

Checking Concepts

11. Explain how the length of the day and year are related to Earth's movement through space.

12. Suppose you moved two objects farther apart. How would this affect the force of gravity between those objects?

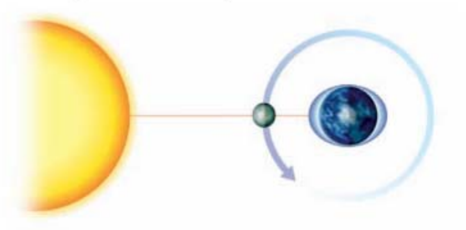
13. Explain Newton's first law of motion in your own words.

14. Why does the moon have phases?

15. Why do more people see a total lunar eclipse than a total solar eclipse?

16. Why is there a high tide on the side of Earth closest to the moon? On the side of Earth farthest from the moon?

17. Does the diagram below show a spring tide or a neap tide? How do you know?



18. How did the invention of the telescope contribute to our knowledge of the moon's surface?

19. Why do temperatures vary so much on the moon?

20. Explain how scientists think the moon originated.

Thinking Critically

21. Inferring Mars's axis is tilted at about the same angle as Earth's axis. Do you think Mars has seasons? Explain your answer.

22. Comparing and Contrasting How are mass and weight different?

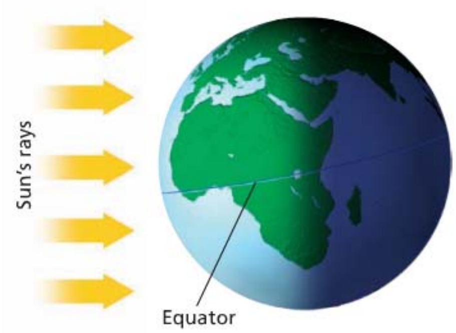
23. Calculating Suppose a person weighs 450 newtons (about 100 pounds) on Earth. How much would she weigh on the moon?

24. Applying Concepts At about what time does the full moon rise? Is it visible in the eastern sky or the western sky?

25. Posing Questions Suppose you were assigned to design a spacesuit for astronauts to wear on the moon. What characteristics of the moon would be important to consider in your design?

Applying Skills

Use the illustration below to answer Questions 26–28.



26. Interpreting Diagrams On which hemisphere are the sun's rays falling most directly?

27. Inferring In the Northern Hemisphere, is it the summer solstice, winter solstice, or one of the equinoxes? How do you know?

28. Predicting Six months after this illustration, Earth will have revolved halfway around the sun. Draw a diagram that shows which end of Earth's axis will be tilted toward the sun.

Lab zone Standards Investigation

Performance Assessment Present your observation log, map, and drawings of the moon. Some ways to graph your data include time of moonrise for each date; how often you saw the moon in each direction; or how often you saw the moon at a specific time. Display your graphs. Discuss any patterns that you discovered.

CALIFORNIA Standards Practice

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Choose the letter of the best answer.

1. You observe a thin crescent moon in the western sky during the early evening. About two weeks later, a full moon is visible in the eastern sky during the early evening. Which conclusion is best supported by these observations?

A The moon revolves around Earth.
B The moon rotates on its axis.
C Earth revolves around the sun.
D Earth's axis is tilted relative to the moon. **S 8.4.e**

2. Only one side of the moon is visible from Earth because

A the moon does not rotate on its axis.
B the moon does not revolve around Earth.
C the moon rotates faster than it revolves.
D the moon revolves once and rotates once in the same period of time. **S 8.4.e**

3. What type of eclipse occurs when Earth's umbra covers the moon?

A a partial solar eclipse
B a total solar eclipse
C a partial lunar eclipse
D a total lunar eclipse **S 8.4.d**

4. The force of gravity depends on

A mass and weight.
B speed and distance.
C mass and distance.
D weight and speed. **S 8.2.g**

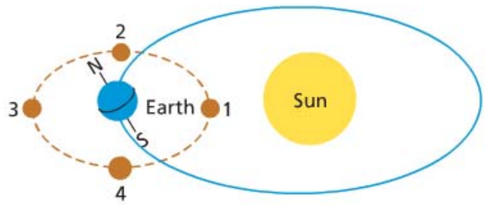
5. The craters on the moon were caused by

A tides.
B volcanoes.
C meteoroids.
D maria. **S 8.4.e**

6. You can see the moon at night because

A the moon produces its own light.
B the moon reflects light from the sun.
C the moon reflects light produced on Earth.
D the near side of the moon always faces the sun. **S 8.4.d**

The diagram below shows the relative positions of the sun, moon, and Earth. The numbers indicate specific locations of the moon in its orbit. Use the diagram to answer Questions 7–9.



7. Which of the following can occur when the moon is at location 1?

A only a lunar eclipse
B only a solar eclipse
C both a solar and a lunar eclipse
D neither a solar nor a lunar eclipse **S 8.4.d**

8. When the moon is at location 2, at most coastal locations there would be

A only one high tide each day.
B only one low tide each day.
C two high tides and two low tides each day, with the most difference between high and low tide.
D two high tides and two low tides each day, with the least difference between high and low tide. **S 8.2.g**

9. When the moon is in location 3, a person standing on Earth at night would see

A a full moon.
B a crescent moon.
C a quarter moon.
D a new moon. **S 8.4.d**

Apply the BIG Idea

10. In what ways do Earth and the moon move through space? How do these motions produce such phenomena as day and night, the seasons, phases of the moon, and eclipses? **S 8.4.e**