LESSON

6.1 Earth's Motion

INQUIRY

Floating in Space? From the *International Space Station,* Earth might look like it is just floating, but it is actually traveling around the Sun at more than 100,000 km/h. What phenomena does Earth's motion cause?

Write your response in your interactive notebook.

LAB Manager

Go to your Lab Manual or visit connectED.mcgraw-hill.com to perform the labs for this lesson.

MiniLAB: *What keeps Earth in orbit?*
TEKS 8.1(A); 8.2(A), (C), (E); 8.4(A), (B)

Skill Practice: *How does Earth's tilted rotation axis affect the seasons?*
TEKS 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A), (B); 8.7(A)

PAGE KEELEY SCIENCE PROBES

Phases of the Moon

Ma[redacted]different parts of the Moon (moon phases). Which idea [redacted]our thinking?

- [ ] **A.** The Earth casts a shadow on the Moon that allows us to see [redacted]

- [ ] **B.** The Moon moves into the Sun's shadow, blocking [redacted] the Moon's light.

- [ ] [redacted]he part we see depends on where the Moon is in relation to Earth and the Sun.

- [ ] **D.** Sun's movement around Earth causes different parts o[redacted] Moon to be reflected.

- [ ] [redacted] rotation causes different parts of the Moon to be reflected back to Earth.

- [ ] **F.** None of these. I think there is something else that causes u[redacted] see different moon [redacted]

Explain y[redacted]nking. Describe your ideas about why we see different phases o[redacted]

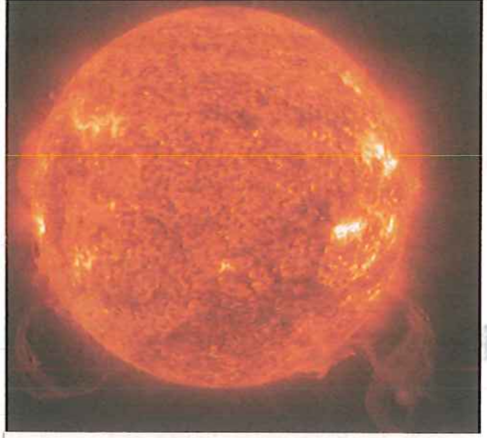


Figure 1 The Sun is a giant ball of hot gases that emits light and energy.

Earth and the Sun TEKS 8.7(A)

If you look outside at the ground, trees, and buildings, it does not seem like Earth is moving. Yet Earth is always in motion, spinning in space and traveling around the Sun. As Earth spins, day changes to night and back to day again. The seasons change as Earth travels around the Sun. Summer changes to winter because Earth's motion changes how energy from the Sun spreads out over Earth's surface.

The Sun

The star nearest to Earth is the Sun, which is shown in **Figure 1.** The Sun is approximately 150 million km from Earth. Compared to Earth, the Sun is enormous. The Sun's diameter is more than 100 times greater than Earth's diameter. This means you would need 100 Earths lined up end-to-end to stretch across the face of the Sun. The Sun's mass is more than 300,000 times greater than Earth's mass. Approximately 1 million Earths would fit inside the Sun.

Deep inside the Sun, nuclei of atoms combine, releasing huge amounts of energy. This process is called nuclear fusion. The Sun releases so much energy from nuclear fusion that the temperature at its core is more than 15,000,000°C. Even at the Sun's surface, the temperature is about 5,500°C. A small part of the Sun's energy reaches Earth as light and thermal energy.

Organize

1. Organize information about the Sun.

The Sun

- about ______ km from Earth
- energy from ______ ______
- core temperature: more than ______ surface temperature: ______
- Sun's energy reaches Earth as ______ and ______

Explore Activity

TEKS 8.1(A); 8.2(A), (C), (E); 8.3(B); 8.4(A); 8.7(A)

How does Earth's tilt affect temperature?

Have you ever noticed how hot the surface of a blacktop driveway can get during the day? The Sun's rays hit Earth more directly as the day progresses. Consider the fact that Earth is tilted on its axis. How does this affect the amount of heat an area on Earth receives from the Sun?

Procedure

1. Read and complete a lab safety form.
2. Lay a **thermometer** on a sheet of **black paper.**
3. **Tape** a **ruler** to the underside of a **flashlight** so that 12 cm of the ruler is sticking out to where the beam will shine.
4. Hold the flashlight at a 90-degree angle so that the beam shines directly down onto the thermometer. The ruler will keep the flashlight 12 cm from the thermometer. After 5 min, observe and record the temperature in your Lab Manual or interactive notebook.
5. Let the thermometer return to room temperature.
6. Next, use a **protractor** to adjust the flashlight so it is at a 45-degree angle in relation to the thermometer. Make sure the flashlight is still about 12 cm from the thermometer. After 5 min, observe and record the temperature.

Think About This

1. Why do some areas of Earth receive direct rays and others angled rays?

2. How does this activity model why Earth experiences seasons? Explain.

TEKS in this Lesson

8.7(A) Model and illustrate how the tilted Earth rotates on its axis, causing day and night, and revolves around the Sun causing changes in seasons

Also covers Process Standards: 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A), (B)

Essential Questions

- What causes day and night?
- Why do the seasons change as Earth moves around the Sun?

Vocabulary

orbit
revolution
rotation
rotation axis
solstice
equinox

Earth's Orbit TEKS 8.7(A)

As shown in **Figure 2,** Earth moves around the Sun in a nearly circular path. *The path an object follows as it moves around another object is an* **orbit.** *The motion of one object around another object is called* **revolution.** Earth makes one complete revolution around the Sun every 365.24 days.

Recall

2. How long does it take Earth to make one revolution around the Sun?

The Sun's Gravitational Pull

Why does Earth orbit the Sun? The answer is that the Sun's gravity pulls on Earth. The pull of gravity between two objects depends on the masses of the objects and the distance between them. The more mass either object has, or the closer together they are, the stronger the gravitational pull.

The Sun's effect on Earth's motion is illustrated in **Figure 2.** Earth's motion around the Sun is like the motion of an object twirled on a string. The string pulls on the object and makes it move in a circle. If the string breaks, the object flies off in a straight line. In the same way, the pull of the Sun's gravity keeps Earth revolving around the Sun in a nearly circular orbit. If the gravity between Earth and the Sun were to somehow stop, Earth would fly off into space in a straight line.

LAB Manager

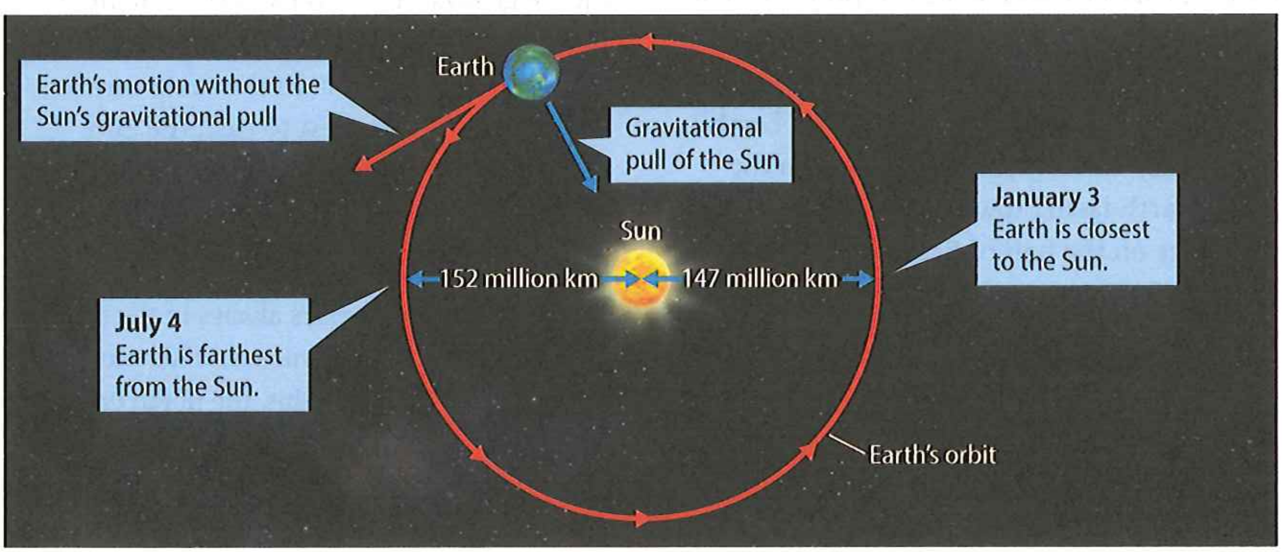
MiniLAB: *What keeps Earth in orbit?*

TEKS 8.1(A); 8.2(A), (C), (E); 8.4(A), (B)

Summarize

3. What produces Earth's revolution around the Sun?

Figure 2 Earth moves in a nearly circular orbit. The pull of the Sun's gravity on Earth causes Earth to revolve around the Sun.



Earth's Rotation Axis

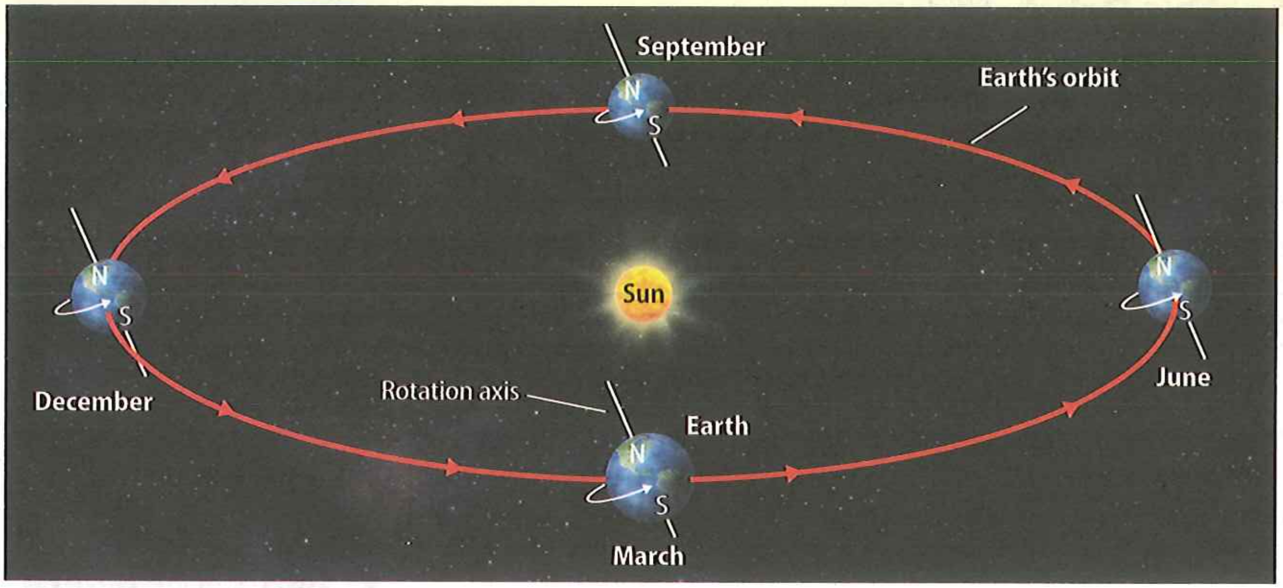


Figure 3 This diagram shows Earth's orbit, which is nearly circular, from an angle. Earth spins on its rotation axis as it revolves around the Sun. Earth's rotation axis always points in the same direction.

Earth's Rotation

As Earth revolves around the Sun, it spins. *A spinning motion is called* **rotation.** Some spinning objects rotate on a rod or axle. Earth rotates on an imaginary line through its center. This imaginary line is tilted 23.5° from vertical. Most globes show Earth tilted in this way. *The line on which an object rotates is the* **rotation axis.**

Suppose you could look down on Earth's North Pole and watch Earth rotate. You would see that Earth rotates on its rotation axis in a counterclockwise direction, from west to east. One complete rotation of Earth takes about 24 hours. This rotation helps produce Earth's cycle of day and night. It is daytime on the half of Earth facing toward the Sun and nighttime on the half of Earth facing away from the Sun.

Explain

4. Highlight what direction Earth rotates on its axis. Underline what is caused by Earth's rotation.

The Sun's Apparent Motion Each day the Sun appears to move from east to west across the sky. It seems as if the Sun is moving around Earth. However, it is Earth's rotation that causes the Sun's apparent motion.

Earth rotates from west to east. As a result, the Sun appears to move from east to west across the sky. The stars and the Moon also seem to move from east to west across the sky due to Earth's west-to-east rotation.

To better understand this, imagine riding on a merry-go-round. As you and the ride move, people on the ground appear to be moving in the opposite direction. In the same way, as Earth rotates from west to east, the Sun appears to move from east to west.

The Tilt of Earth's Rotation Axis As shown in **Figure 3,** Earth's rotation axis is tilted. The tilt of Earth's rotation axis is always in the same direction by the same amount. This means that during half of Earth's orbit, the north end of the rotation axis is toward the Sun. During the other half of Earth's orbit, the north end of the rotation axis is away from the Sun.

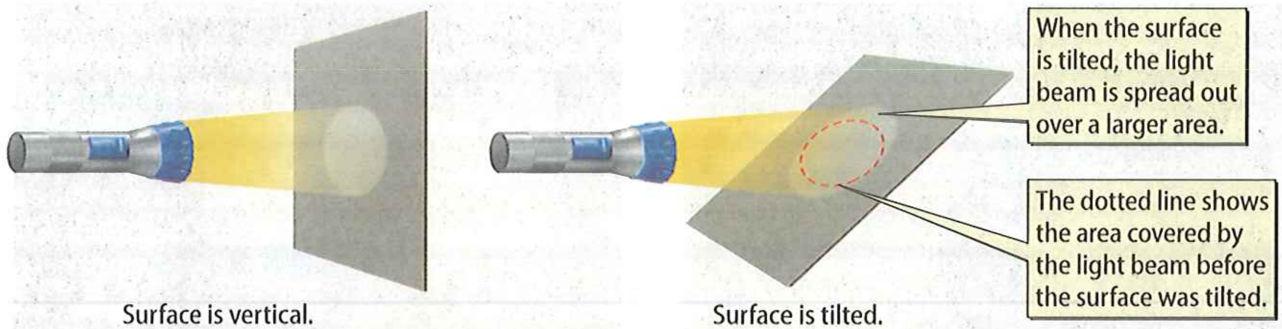


Figure 4 The light energy on a surface becomes more spread out as the surface becomes more tilted relative to the light beam.

Temperature and Latitude

As Earth orbits the Sun, only one-half of Earth faces the Sun at a time. A beam of sunlight carries energy. The more sunlight that reaches a part of Earth's surface, the warmer that part becomes. Because Earth's surface is curved, different parts of Earth's surface receive different amounts of the Sun's energy.

Energy Received by a Tilted Surface

Suppose you shine a beam of light on a flat card, as shown in **Figure 4.** As you tilt the card relative to the direction of the light beam, light becomes more spread out on the card's surface. As a result, the energy that the light beam carries also spreads out more over the card's surface. An area on the surface within the light beam receives less energy when the surface is more tilted relative to the light beam.

Infer

5. Why is Earth warmer at the equator and colder at the poles?

The Tilt of Earth's Curved Surface

Instead of being flat like a card, Earth's surface is curved. Relative to the direction of a beam of sunlight, Earth's surface becomes more tilted as you move away from the equator. As shown in **Figure 5,** the energy in a beam of sunlight tends to become more spread out the farther you travel from the equator. This means that regions near the poles receive less energy than regions near the equator. This makes Earth colder at the poles and warmer at the equator.

Academic Vocabulary

equator ***(noun)*** the imaginary line that divides Earth into its northern and southern hemispheres

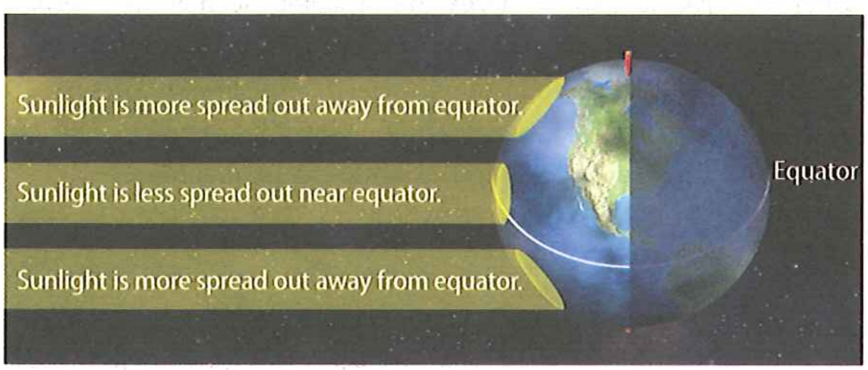


Figure 5 Energy from the Sun becomes more spread out as you move away from the equator.

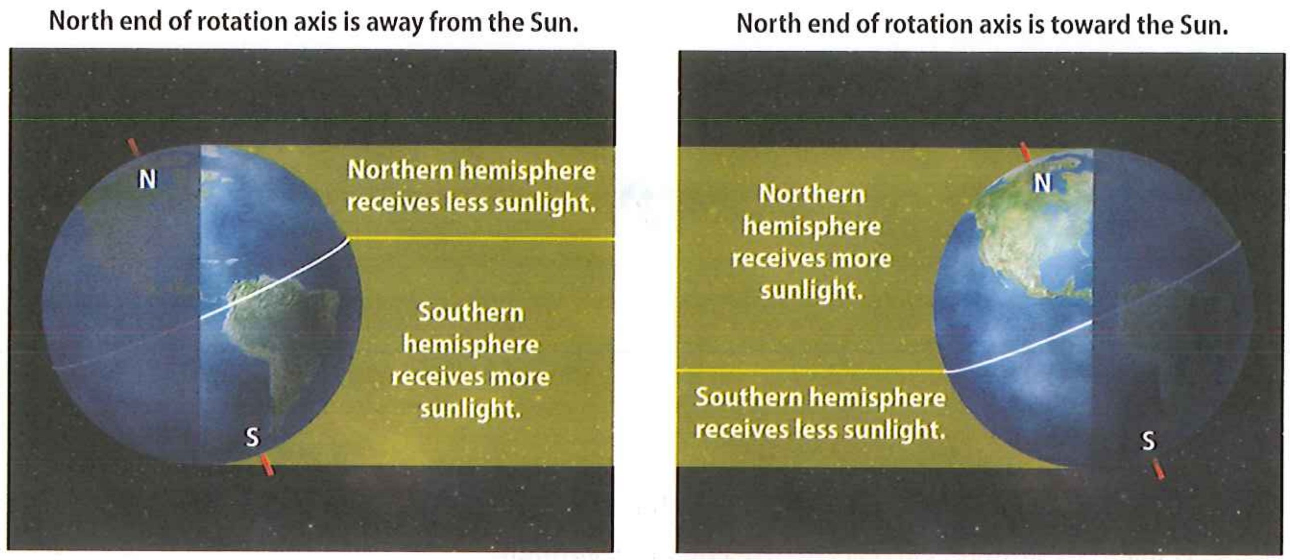


Figure 6 The northern hemisphere receives more sunlight in June, and the southern hemisphere receives more sunlight in December.

Math Skills Math TEKS 8.1(A), (B); 8.2

Convert Units

When Earth is 147,000,000 km from the Sun, how far is Earth from the Sun in miles? To calculate the distance in miles, multiply the distance in kilometers by the conversion factor

$147{,}000{,}000 \text{ km} \times \frac{0.62 \text{ miles}}{1 \text{ km}}$

$= 91{,}100{,}000 \text{ mi}$

Practice

When Earth is 152,000,000 km from the Sun, how far is Earth from the Sun in miles?

Go Online! Check Tutor

Seasons TEKS 8.7(A)

You might think that summer happens when Earth is closest to the Sun, and winter happens when Earth is farthest from the Sun. However, seasonal changes do not depend on Earth's distance from the Sun. In fact, Earth is closest to the Sun in January! Instead, it is the tilt of Earth's rotation axis, combined with Earth's motion around the Sun, that causes the seasons to change.

Spring and Summer in the Northern Hemisphere

During one-half of Earth's orbit, the north end of the rotation axis is toward the Sun. Then the northern hemisphere receives more energy from the Sun than the southern hemisphere, as shown in **Figure 6.** Temperatures increase in the northern hemisphere and decrease in the southern hemisphere. Daylight hours last longer in the northern hemisphere, and nights last longer in the southern hemisphere. This is when spring and summer happen in the northern hemisphere, and fall and winter happen in the southern hemisphere.

Fall and Winter in the Northern Hemisphere

During the other half of Earth's orbit, the north end of the rotation axis is away from the Sun. Then the northern hemisphere receives less solar energy than the southern hemisphere, as shown in **Figure 6.** Temperatures decrease in the northern hemisphere and increase in the southern hemisphere. This is when fall and winter happen in the northern hemisphere, and spring and summer happen in the southern hemisphere.

Understand

6. Underline what causes the seasons to change.

Earth's Seasonal Cycle

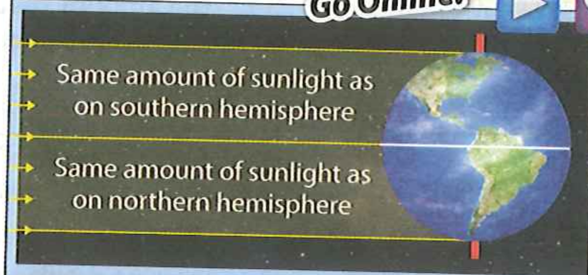
Figure 7 The seasons change as Earth moves around the Sun. Earth's motion around the Sun causes Earth's tilted rotation axis to be leaning toward the Sun and away from the Sun.

Watch Tutor Go Online!

December Solstice

The December solstice is on December 21 or 22.
On this day

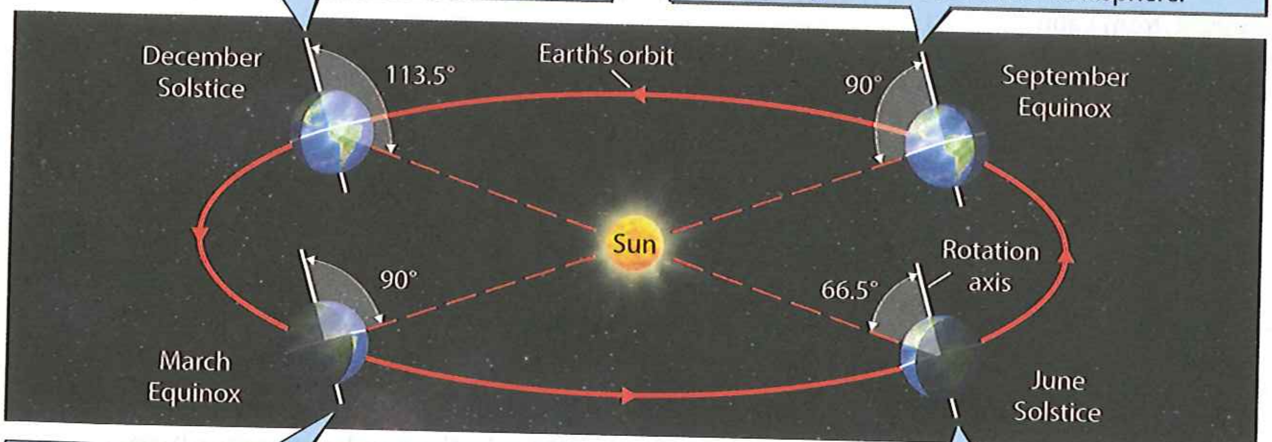
- the north end of Earth's rotation axis is away from the Sun;
- days in the northern hemisphere are shortest and nights are longest; winter begins;
- days in the southern hemisphere are longest and nights are shortest; summer begins.

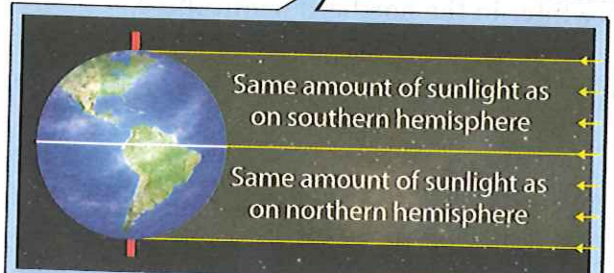


September Equinox

The September equinox is on September 22 or 23.
On this day

- the north end of Earth's rotation axis leans along Earth's orbit;
- there are about 12 hours of daylight and 12 hours of darkness everywhere on Earth;
- autumn begins in the northern hemisphere;
- spring begins in the southern hemisphere.

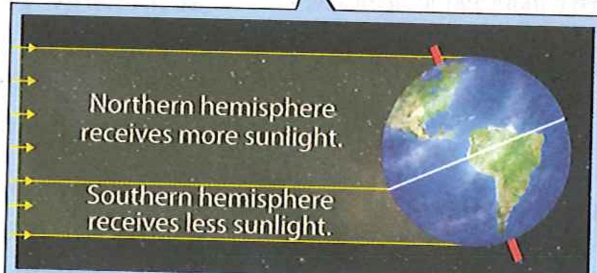




March Equinox

The March equinox is on March 20 or 21.
On this day

- the north end of Earth's rotation axis leans along Earth's orbit;
- there are about 12 hours of daylight and 12 hours of darkness everywhere on Earth;
- spring begins in the northern hemisphere;
- autumn begins in the southern hemisphere.



June Solstice

The June solstice is on June 20 or 21.
On this day

- the north end of Earth's rotation axis is toward the Sun;
- days in the northern hemisphere are longest and nights are shortest; summer begins;
- days in the southern hemisphere are shortest and nights are longest; winter begins.

Solstices, Equinoxes, and the Seasonal Cycle

Figure 7 shows that as Earth travels around the Sun, its rotation axis always points in the same direction in space. However, the amount that Earth's rotation axis is toward or away from the Sun changes. This causes the seasons to change in a yearly cycle.

There are 4 days each year when the direction of Earth's rotation axis is special relative to the Sun. A **solstice** *is a day when Earth's rotation axis is the most toward or away from the Sun.* An **equinox** *is a day when Earth's rotation axis is leaning along Earth's orbit, neither toward nor away from the Sun.*

March Equinox to June Solstice When the north end of the rotation axis gradually points more and more toward the Sun, the northern hemisphere gradually receives more solar energy. This is spring in the northern hemisphere.

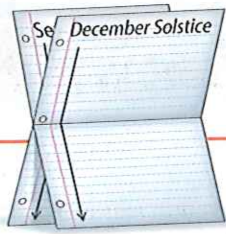
June Solstice to September Equinox The north end of the rotation axis continues to point toward the Sun but does so less and less. The northern hemisphere starts to receive less solar energy. This is summer in the northern hemisphere.

September Equinox to December Solstice The north end of the rotation axis now points more and more away from the Sun. The northern hemisphere receives less and less solar energy. This is fall in the northern hemisphere.

December Solstice to March Equinox The north end of the rotation axis continues to point away from the Sun but does so less and less. The northern hemisphere starts to receive more solar energy. This is winter in the northern hemisphere.

FOLDABLES®

Make a bound book with four full pages. Label the pages with the names of the solstices and equinoxes. Use each page to organize information about each season.



Word Origin

equinox from Latin *equinoxium,* means "equality of night and day"

LAB Manager

Skill Practice: *How does Earth's tilted rotation axis affect the seasons?*

TEKS 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A), (B); 8.7(A)

Changes in the Sun's Apparent Path Across the Sky

Figure 8 shows how the Sun's apparent path through the sky changes from season to season in the northern hemisphere. The Sun's apparent path through the sky in the northern hemisphere is lowest on the December solstice and highest on the June solstice.

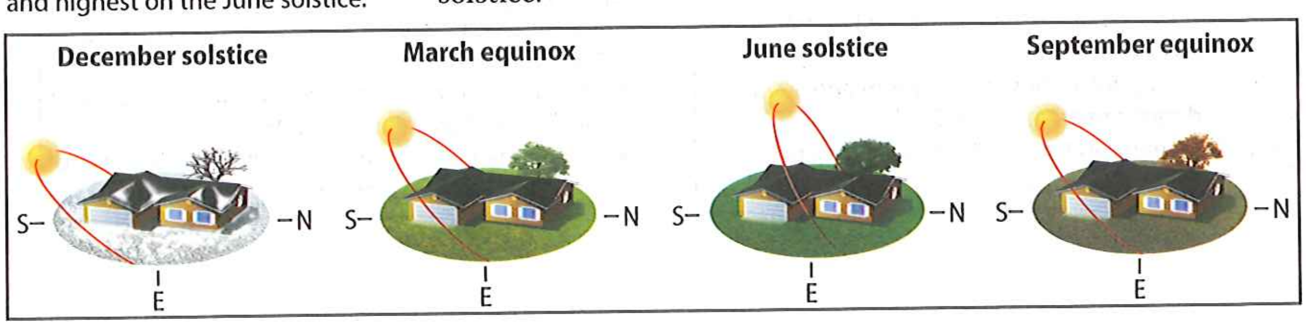


Figure 8 As the seasons change, the path of the Sun across the sky changes. In the northern hemisphere, the Sun's path is lowest on the December solstice and highest on the June solstice.

LESSON

6.1 Review

Go Online! Check

Summarize it!

Identify the direction of the north end of Earth's rotation axis for each of the four seasons. Put a check mark in the appropriate column. TEKS 8.7(A)

Direction in which Earth's rotation axis is leaning

Season	Toward the Sun	Away from the Sun	Neither toward nor away
Winter			
Spring			
Summer			
Fall			

Explain Is there an exception to the chart above? TEKS 8.7(A)

Connect it! **Assess** what the seasons might be like if Earth's axis were tilted 90° from vertical instead of 23.5° from vertical. TEKS 8.7(A)

Summarize it!

Earth's Motion

Apply the Essential Questions

1. **Explain** what causes day and night.
TEKS 8.7(A) *readiness*

2. **Illustrate** the reason for season change as Earth moves around the Sun. Explain your illustration. TEKS 8.7(A) *readiness*

H.O.T. Questions (Higher Order Thinking)

3. **Summarize** why the temperature of Earth varies between the equator and the poles. How could you model your answer?
TEKS 8.7(A) *readiness*

4. **Defend** the following statement: The December solstice is often called the winter solstice. Do you think this is an appropriate label? Write and illustrate your response on a separate sheet of paper. TEKS 8.7(A) *readiness*

Math Skills Math TEKS 8.1(A), (B); 8.2

Convert Units

5. The Sun's diameter is about 1,390,000 km. What is the Sun's diameter in miles?

Go Online! Check Tutor

LESSON

6.2 Earth's Moon

INQUIRY

Two Planets? The smaller body is Earth's Moon, not a planet. Just as Earth moves around the Sun, the Moon moves around Earth. The Moon's motion around Earth causes what kinds of changes to occur?

Write your response in your interactive notebook.

LAB Manager

Go to your Lab Manual or visit connectED.mcgraw-hill.com to perform the lab for this lesson.

MiniLAB: *How can the Moon be rotating if the same side of the Moon is always facing Earth?*

TEKS 8.2(A), (C), (E); 8.3(B); 8.4(A); 8.7(B)

My Notes

Explain

1. Why can you see the Moon? Write your answer below. Then confirm your answer by discussing it with a classmate.

Seeing the Moon

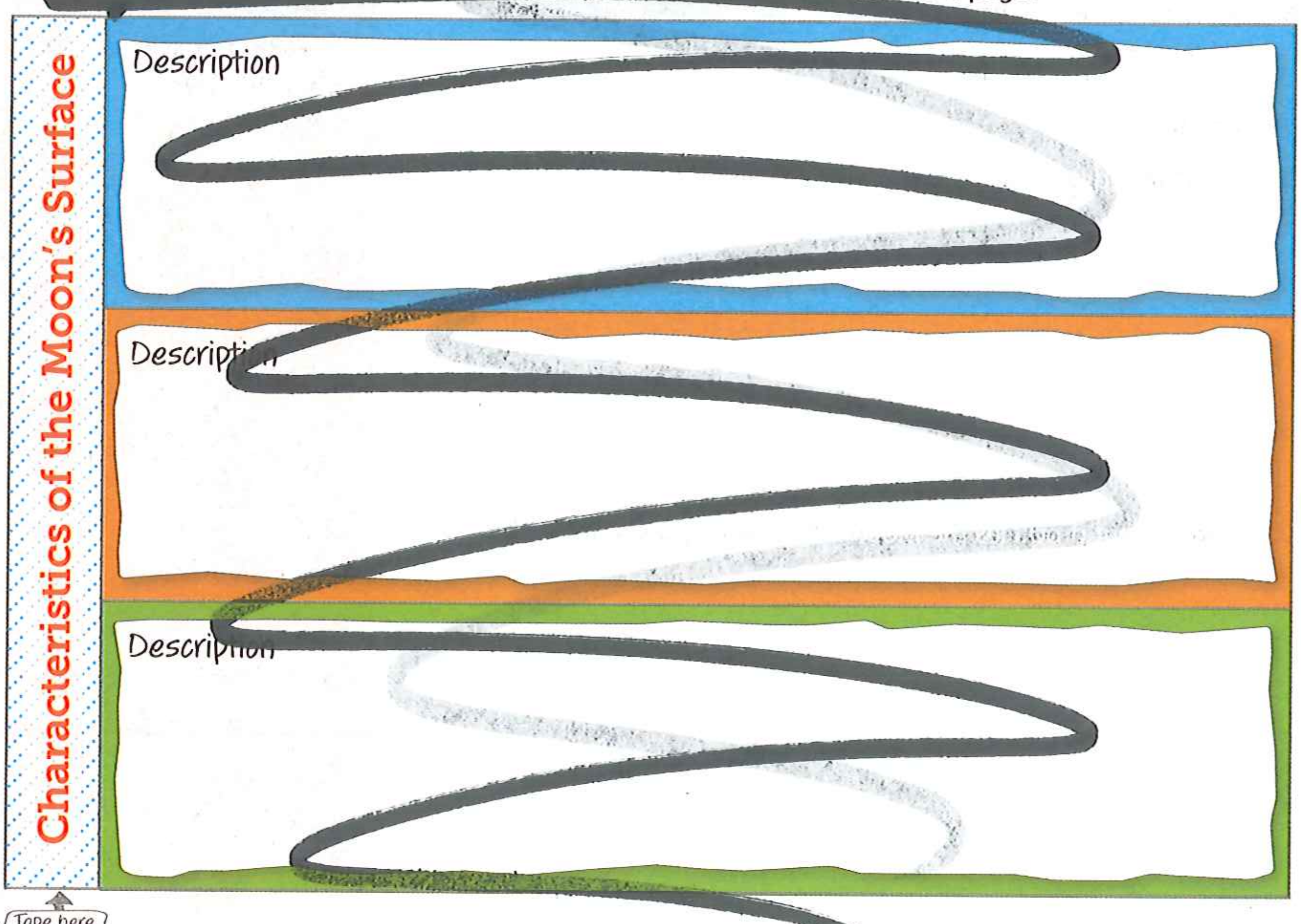
Imagine what people thousands of years ago thought when they looked up at the Moon. They might have wondered why the Moon shines and why it seems to change shape. They probably would have been surprised to learn that the Moon does not emit light at all. Unlike the Sun, the Moon is a solid object that does not emit its own light. You see the Moon only because light from the Sun reflects off the Moon and into your eyes. Some facts about the Moon, such as its mass, size, and distance from Earth, are shown in **Table 1.**

Table 1 Moon Data

Mass	Diameter	Average distance from Earth	Time for one rotation	Time for one revolution
1.2% of Earth's mass	27% of Earth's diameter	384,000 km	27.3 days	27.3 days

FOLDABLES®

Cut out the Lesson 6.2 Foldables in the back of your book. Use it to compare information on the characteristics of the Moon's surface that you will learn about on the next page.



Explore Activity

TEKS 8.1 (A); 8.2(A), (C); 8.3(B); 8.4(A); 8.7(B)

Why does the Moon appear to change shape?

The Sun is always shining on Earth and the Moon. However, the Moon's shape seems to change from night to night and day to day. What could cause the Moon's appearance to change?

Procedure

1. Read and complete a lab safety form.
2. Place a **ball** on a level surface.
3. Position a **flashlight** so that the light beam shines fully on one side of the ball. Stand behind the flashlight.
4. Make a drawing of the ball's appearance in your Lab Manual or interactive notebook.
5. Stand behind the ball, facing the flashlight, and repeat step 4.
6. Stand to the left of the ball and repeat step 4.

Think About This

1. What caused the ball's appearance to change?

2. Predict what produces the Moon's changing appearance in the sky.

TEKS in this Lesson

8.7(B) Demonstrate and predict the sequence of events in the lunar cycle

Also covers Process Standards: 8.1(A); 8.2(A), (C), (E); 8.3(B); 8.4(A)

Essential Questions

- What are the phases in a lunar cycle?
- Why does the Moon's appearance change?

Vocabulary

maria
phase
waxing phase
waning phase

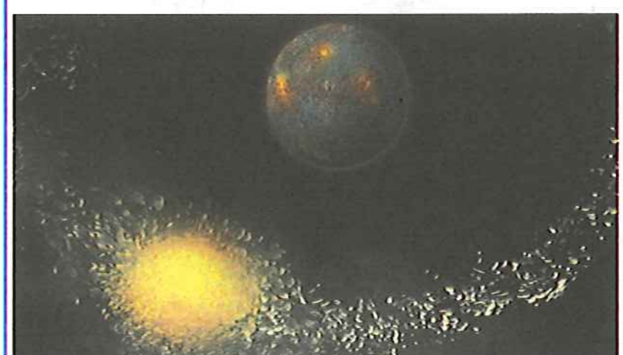
The Moon's Formation

The most widely accepted idea for the Moon's formation is the giant-impact hypothesis, shown in **Figure 1.** According to this hypothesis, shortly after Earth formed about 4.5 billion years ago, an object about the size of the planet Mars collided with Earth. The impact ejected vaporized rock that formed a ring around Earth. Eventually, the material in the ring cooled, clumped together, and formed the Moon.

Figure 1 The Moon probably formed when a large object collided with Earth 4.5 billion years ago. Material ejected from the collision eventually clumped together and became the Moon. Watch

An object the size of Mars crashes into the semi-molten Earth about 4.5 billion years ago.

The impact ejects vaporized rock into space. As the rock cools, it forms a ring of particles around Earth.



The particles gradually clump together and form the Moon.

The Moon's Surface

The surface of the Moon was shaped early in its history. Examples of common features on the Moon's surface are shown in **Figure 2.**

Craters The Moon's craters were formed when objects from space crashed into the Moon. Light-colored streaks called rays extend outward from some craters. Most of the impacts that formed the Moon's craters occurred more than 3.5 billion years ago, long before the dinosaurs lived. Earth was also heavily bombarded by objects from space during this time. However, on Earth, wind, liquid water, and plate tectonics erased the craters. The Moon has no atmosphere, liquid water, or plate tectonics, so craters formed billions of years ago on the Moon have hardly changed.

Maria *The large, dark, flat areas on the Moon are called* **maria** (MAR ee uh). The maria formed after most impacts on the Moon's surface had stopped. Maria formed when lava flowed up through the Moon's crust and solidified. The lava covered many of the Moon's craters and other features. When this lava solidified, it was dark and flat.

Highlands The light-colored highlands are too high for the lava that formed the maria to reach. The highlands are older than the maria and are covered with craters. Rocks that have been collected from the lunar highlands are estimated to be about 4 billion years old.

Word Origin

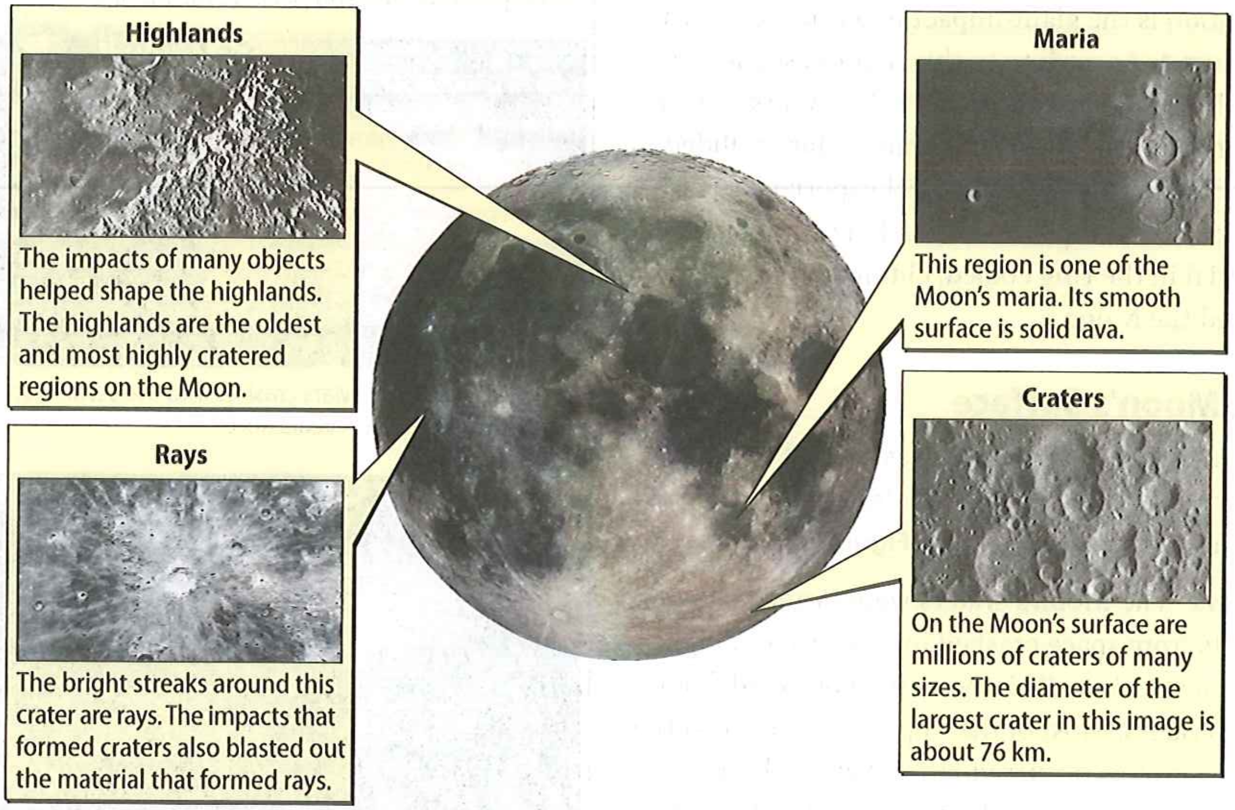
maria from Latin *mare*, means "sea"

Create

2. Design a comic strip in your interactive notebook that explains the formation of the Moon.

The Moon's Surface Features

Figure 2 The Moon's surface features include craters, rays, maria, and highlands.



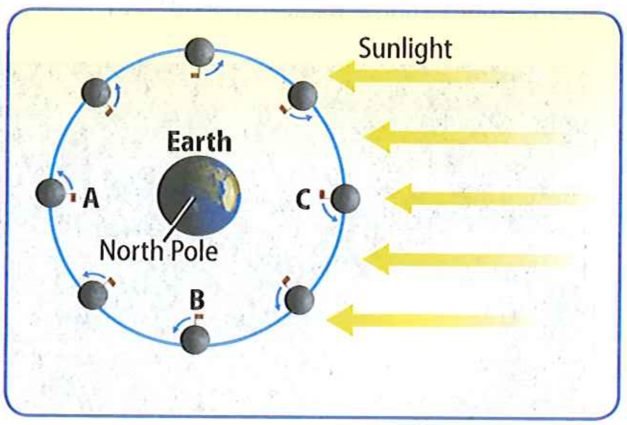


Figure 3 The Moon rotates once on its axis and revolves around Earth in the same amount of time. As a result, the same side of the Moon always faces Earth.

The Moon's Motion

While Earth is revolving around the Sun, the Moon is revolving around Earth. The gravitational pull of Earth on the Moon causes the Moon to move in an orbit around Earth. The Moon makes one revolution around Earth every 27.3 days.

The Moon also rotates as it revolves around Earth. One complete rotation of the Moon also takes 27.3 days. This means the Moon makes one rotation in the same amount of time that it makes one revolution around Earth. **Figure 3** shows that, because the Moon makes one rotation for each revolution of Earth, the same side of the Moon always faces Earth. This side of the Moon is called the near side. The side of the Moon that cannot be seen from Earth is called the far side of the Moon.

LAB Manager

MiniLAB: *How can the Moon be rotating if the same side of the Moon is always facing Earth?*

TEKS 8.2(A), (C), (E); 8.3(B); 8.4(A); 8.7(B)

Phases of the Moon TEKS 8.7(B)

The Sun is always shining on half of the Moon, just as the Sun is always shining on half of Earth. However, as the Moon moves around Earth, usually only part of the Moon's near side is lit. *The portion of the Moon or a planet reflecting light as seen from Earth is called a* **phase.** As shown in **Figure 4,** the motion of the Moon around Earth causes the phase of the Moon to change. The sequence of phases is the lunar cycle. One lunar cycle takes 29.5 days or slightly more than four weeks to complete.

Science Use v. Common Use

phase

Science Use how the Moon or a planet is lit as seen from Earth

Common Use a part of something or a stage of development

Waxing Phases

During the **waxing phases,** *more of the Moon's near side is lit each night.*

Week 1—First Quarter As the lunar cycle begins, a sliver of light can be seen on the Moon's western edge. This is called the waxing crescent. Gradually, the lit part becomes larger. By the end of the first week, the Moon is at its first quarter phase. In this phase, the Moon's entire western half is lit.

Week 2—Full Moon The waxing gibbous occurs when more and more of the near side becomes lit after the first quarter. When the Moon's near side is completely lit, it is at the full moon phase.

Waning Phases

During the **waning phases,** *less of the Moon's near side is lit each night.* As seen from Earth, the lit part is now on the Moon's eastern side.

Week 3—Third Quarter During the waning gibbous phase, the lit part of the Moon becomes smaller and smaller. The third quarter, or last, phase occurs when only the eastern half of the Moon is lit.

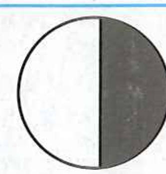
Week 4—New Moon During this week, less and less of the near side is lit. This is called the waning crescent. When the Moon's near side is completely dark, it is at the new moon phase.

Identify

4. What produces the phases of the Moon?

Predict

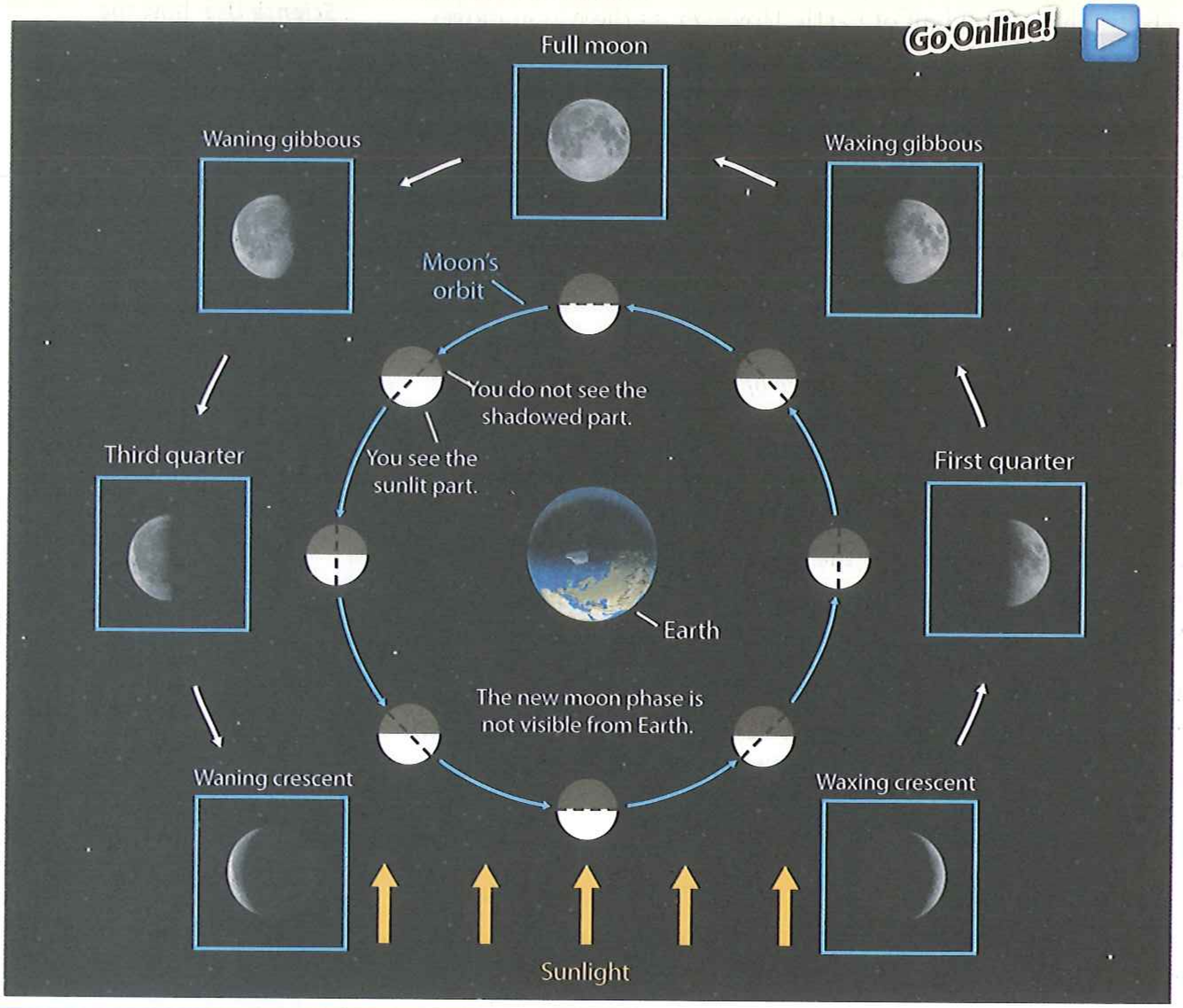
3. Predict, in order, what moon phases will follow this illustration. Draw and identify each phase.



The Lunar Cycle

Figure 4 As the Moon revolves around Earth, the part of the Moon's near side that is lit changes. The figure below shows how the Moon would look at different places in its orbit.

Watch



The Moon at Midnight

The Moon's motion around Earth causes the Moon to rise, on average, about 50 minutes later each day. The figure below shows how the Moon looks at midnight during three phases of the lunar cycle.

At midnight, the first quarter moon is setting. It rises during the day at about noon.

The full moon is highest in the sky at about midnight. It rises at sunset and sets at sunrise.

The third quarter moon rises at about midnight, about six hours later than the full moon rises.

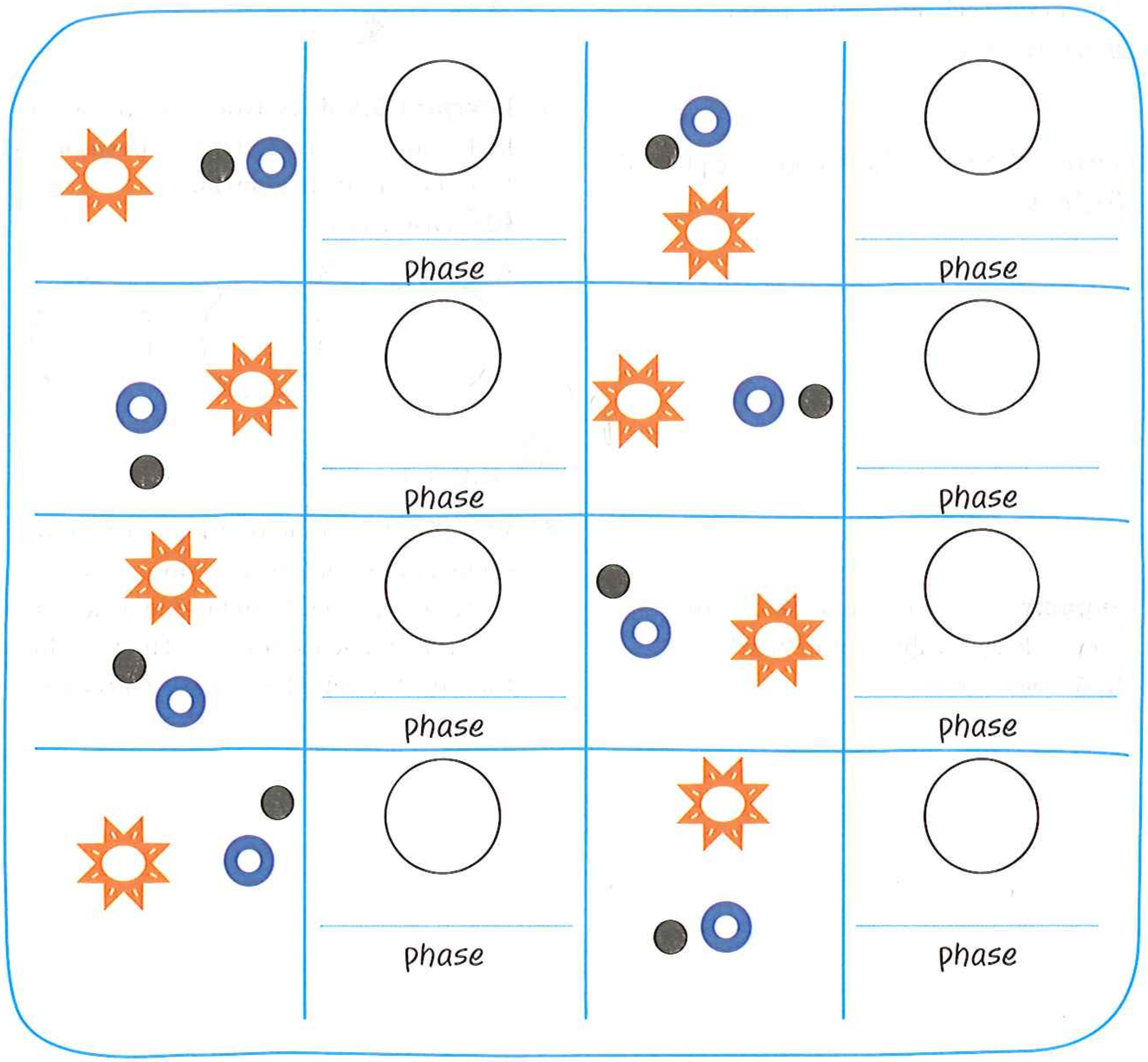
LESSON

6.2 Review

Go Online! Check Virtual

Summarize it!

Summarize what moon phase is represented by each illustration. Then draw what each phase looks like from Earth. TEKS 8.7(B)



Connect it! Predict Create a chart in your interactive notebook that lists all the Moon phases you identified above. For each phase listed, predict what Moon phase will come next in the following time increments: 4 days, 7 days, 14 days. Discuss your answers with a partner, then record the phase names in your chart. TEKS 8.7(B)

Summarize it!

Earth's Moon

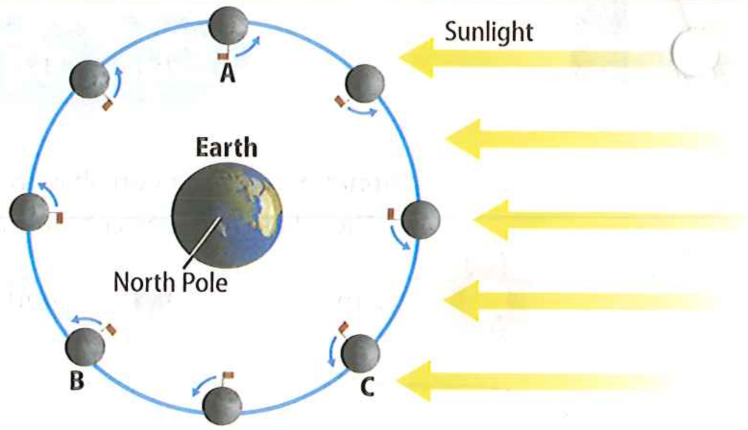
Apply the Essential Questions

1. **Identify** Which phase occurs when the Moon is between the Sun and Earth?
TEKS 8.7(B) *readiness*

2. **Predict** which moon phase will occur about one week after a full moon.
TEKS 8.7(B) *readiness*

3. **Justify** Why does the Moon have phases?
TEKS 8.7(B) *readiness*

4. **Support** Why is the same side of the Moon always visible from Earth?
TEKS 8.7(B) *readiness*



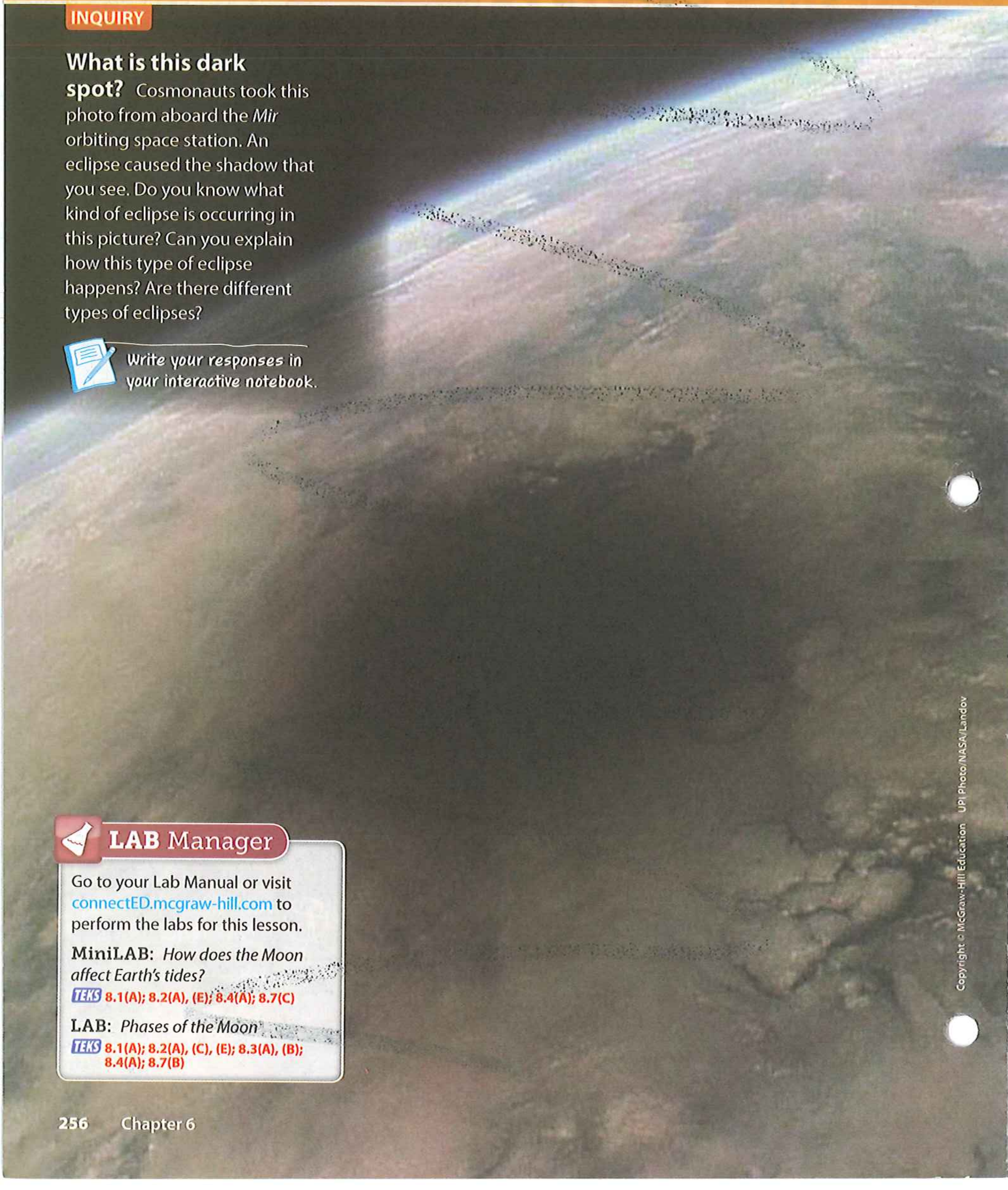
5. **Interpret Graphics** Draw how the Moon looks from Earth when it is at positions A, B, and C in the diagram above.
TEKS 8.7(B) *readiness*

A B C

H.O.T. Question (Higher Order Thinking)

6. **Visualize** the Moon rotating twice in the same amount of time the Moon orbits Earth once. Would you be able to see the Moon's far side from Earth? How would this affect moon phases? TEKS 8.7(B) *readiness*

LESSON
6.3 Eclipses and Tides



INQUIRY

What is this dark spot? Cosmonauts took this photo from aboard the *Mir* orbiting space station. An eclipse caused the shadow that you see. Do you know what kind of eclipse is occurring in this picture? Can you explain how this type of eclipse happens? Are there different types of eclipses?

Write your responses in your interactive notebook.

LAB Manager

Go to your Lab Manual or visit connectED.mcgraw-hill.com to perform the labs for this lesson.

MiniLAB: *How does the Moon affect Earth's tides?*
TEKS 8.1(A); 8.2(A), (E); 8.4(A); 8.7(C)

LAB: *Phases of the Moon*
TEKS 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A); 8.7(B)

Return to the Moon

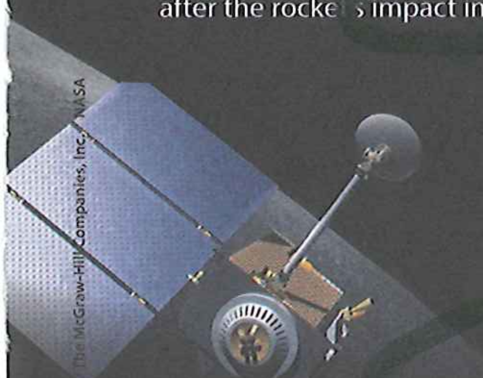
Explorin[illegible] [illegible]th's Moon is a step toward exploring other [illegible]anets and building outposts in space.

Th[illegible] undertook a series of human spaceflight missions from 1961 to 1975 called the Apollo program. The goal of the program was to land humans on the Moon and bring them safely back to Earth. Six of the missions reache[illegible] this goal. The Apollo program was a huge suc[illegible] it was just the beginning.

NASA began another spa[illegible]ogram that had a goal to return astronauts to the Mo[illegible] live and work. However, before that could happen, scienti[illegible] needed to know more about conditions on the Moon and w[illegible]t materials are available there.

Collecti[illegible] data was the first step. In 2009, NASA launched the *Lunar Reconnaissance Orbiter* (LRO) spacecraft. The LRO spen[illegible] year orbiting the Moon's two poles. It collected detailed data that scientists can use to make maps of the Moon's features and resources, such as deep craters that formed on the Moon when comets and asteroids slammed into it billions of years ago. So[illegible] scientists predicted that these deep craters contai[illegible] water.

One of the instruments launched wi[illegible] LRO was the *Lunar Crater Observation and Se[illegible] Satellite* (LCROSS). LCROSS observations confirmed [illegible] scientists' predictions that water exists on the Moon. A roc[illegible] launched from LCROSS impacted the Cabeus crater near the M[illegible]on's south pole. The material that was ejected after the rocke[illegible]s impact included water.



NASA's goal of returning astronauts to the Moon was delayed, and its missions now focus on exploring Mars instead. However, the discoveries made o[illegible] Moon will help scienti[illegible] [illegible]lop future missions th[illegible] take humans farther int[illegible] solar system.

Apollo SPACE PROGRAM

The Apollo Space Program included 17 missions. Here are so[illegible] milestones:

January 27, 1967

Apollo 1: Fire kills all three astronauts on board during a launch simulation for the first piloted flight to the Moon.

December 21–27, 1968

Apollo 8: First crewed spacecraft orbits the Moon.

[illegible]ly 16–24, 1969

A[illegible]llo 11: First humans, Neil Armstrong and Buzz Aldrin, walk on the Moon.

July 1971

Apollo 15: Astronauts drive the first rover on the Moon.

December 7–19, 1972

[illegible]llo 17: The first phase of hu[illegible]an exploration of [illegible] Moon ends with this last lunar landing mission.

AMERICAN MUSEUM of NATURAL HISTORY

It's Your Turn!

BRAINSTORM With your class, brainstorm the different occupati[illegible] that would be needed to successfully ope[illegible] [illegible] Moon or another planet. Discuss th[illegible] [illegible] a person would perform in each occupation.

Shadows

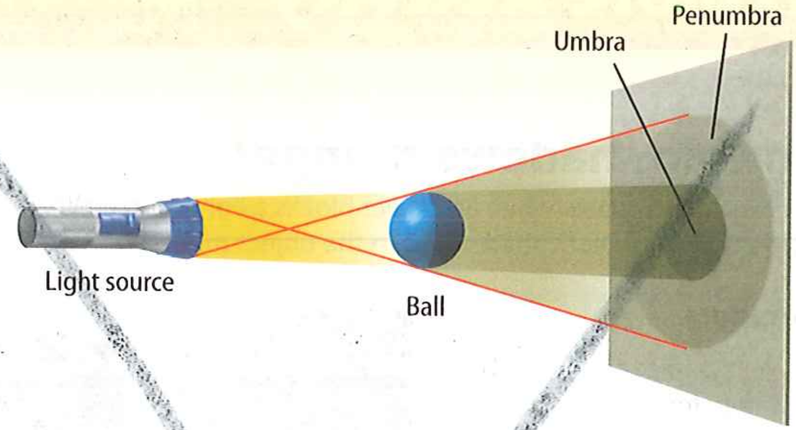


Figure 1 The shadow that a wide light source produces has two parts—the umbra and the penumbra. The light source cannot be seen from within the umbra. The light source can be partially seen from within the penumbra.

Recognize

1. Why does a solar eclipse occur only during a new moon?

Shadows—The Umbra and the Penumbra

A shadow results when one object blocks the light that another object emits or reflects. When a tree blocks light from the Sun, it casts a shadow. If you want to stand in the shadow of a tree, the tree must be in a line between you and the Sun.

If you go outside on a sunny day and look carefully at a shadow on the ground, you might notice that the edges of the shadow are not as dark as the rest of the shadow. Light from the Sun and other wide sources casts shadows with two distinct parts, as shown in **Figure 1.** The **umbra** *is the central, darker part of a shadow where light is totally blocked.* The **penumbra** *is the lighter part of a shadow where light is partially blocked.* If you stood within an object's penumbra, you would be able to see only part of the light source. If you stood within an object's umbra, you would not see the light source at all.

Word Origin

penumbra from Latin *paene,* means "almost"; and from Latin *umbra,* means "shade, shadow"

Solar Eclipses

As the Sun shines on the Moon, the Moon casts a shadow that extends out into space. Sometimes the Moon passes between Earth and the Sun. This can happen only during the new moon phase. When Earth, the Moon, and the Sun are lined up, the Moon casts a shadow on Earth's surface, as shown in **Figure 2.** You can see the Moon's shadow in the photo at the beginning of this lesson. *When the Moon's shadow appears on Earth's surface, a* **solar eclipse** *is occurring.* As Earth rotates, the Moon's shadow moves along Earth's surface, as shown in **Figure 2.** The type of eclipse you see depends on whether you are in the path of the umbra or the penumbra. If you are outside the umbra and penumbra, you cannot see a solar eclipse at all.

Explore Activity

TEKS 8.1(A); 8.2(A), (C), (E); 8.4(A)

How do shadows change?

You can see a shadow when an object blocks a light source. What happens to an object's shadow when the object moves?

Procedure

1. Read and complete a lab safety form.
2. Select an **object** provided by your teacher.
3. Shine a **flashlight** on the object, projecting its shadow on the wall.
4. While holding the flashlight in the same position, move the object closer to the wall and away from the light. Then move the object toward the light. Record your observations in your Lab Manual or interactive notebook.

Think About This

1. Compare and contrast the shadows created in each situation. Did the shadows have dark parts and light parts? Did these parts change?

2. Imagine you look at the flashlight from behind your object, looking from the darkest and lightest parts of the object's shadow. How much of the flashlight would you see from each location?

TEKS

TEKS in this Lesson

8.7(B) Demonstrate and predict the sequence of events in the lunar cycle

8.7(C) Relate the position of the Moon and Sun to their effect on the ocean tides

Also covers Process Standards: 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A)

Essential Questions

- How do the Moon and the Sun affect Earth's oceans?
- What are spring and neap tides?

Vocabulary

umbra
penumbra
solar eclipse
lunar eclipse
tide

Solar Eclipse

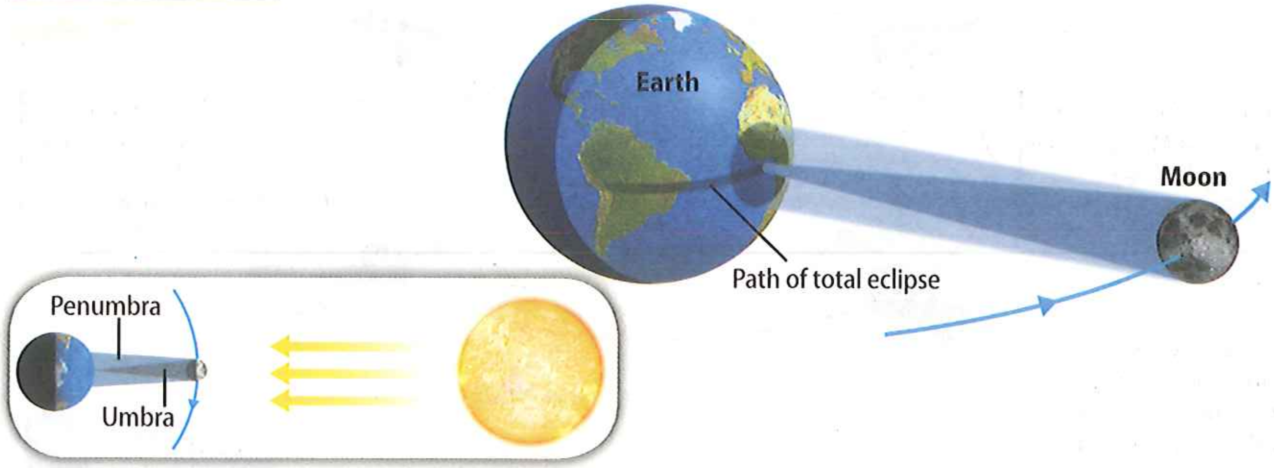


Figure 2 A solar eclipse occurs only when the Moon moves directly between Earth and the Sun. The Moon's shadow moves across Earth's surface.

Total Solar Eclipses

You can see a total solar eclipse only from within the Moon's umbra. During a total solar eclipse, the Moon appears to cover the Sun completely, as shown in **Figure 3.** Then, the sky becomes dark enough that you can see stars. A total solar eclipse lasts no longer than about 7 minutes. Total solar eclipses are very rare. The number of total solar eclipses that take place each year can range from 2 to 5. On average, a person might have to wait 375 years to see two total eclipses from one place. This time span can be longer or shorter depending on the location. The next total solar eclipse will occur in Texas in 2024.

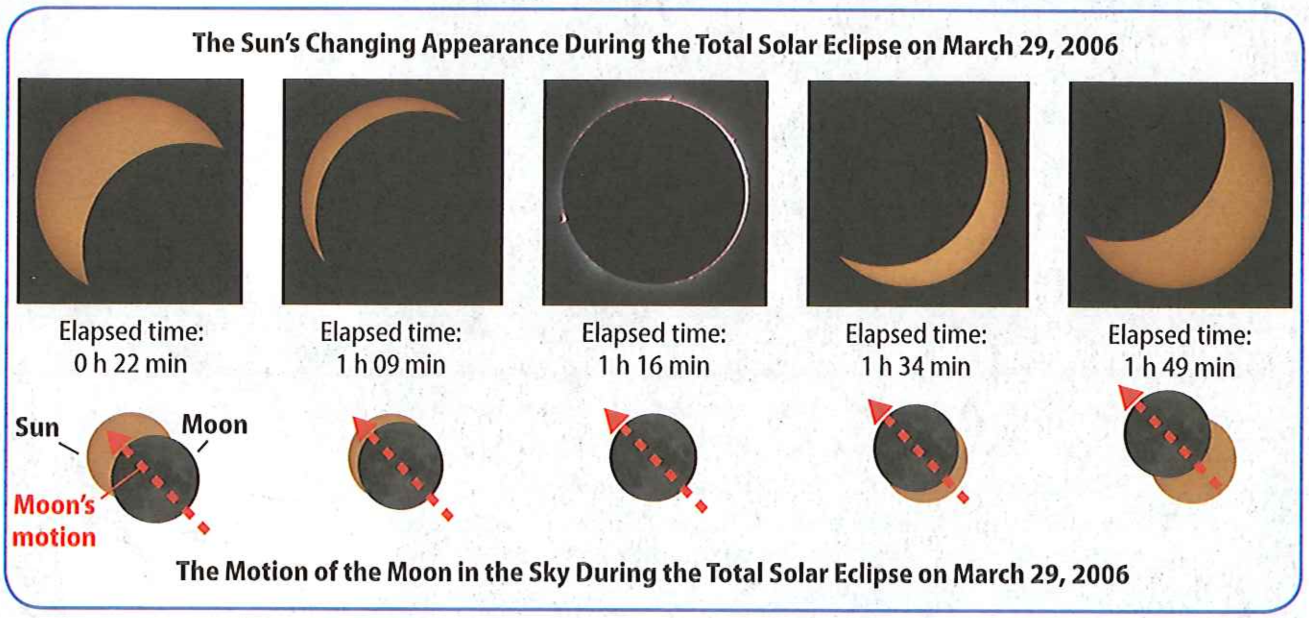
Partial Solar Eclipses

You can see a total solar eclipse only from within the Moon's umbra, but you can see a partial solar eclipse from within the Moon's much larger penumbra. The stages of a partial solar eclipse are similar to the stages of a total solar eclipse, except that the Moon never completely covers the Sun.

Research

2. Investigate partial and total solar eclipses in Texas. When and where did they occur? When will they occur again? Write your response in your interactive notebook.

Figure 3 This sequence of photographs shows how the Sun's appearance changed during a total solar eclipse in 2006.



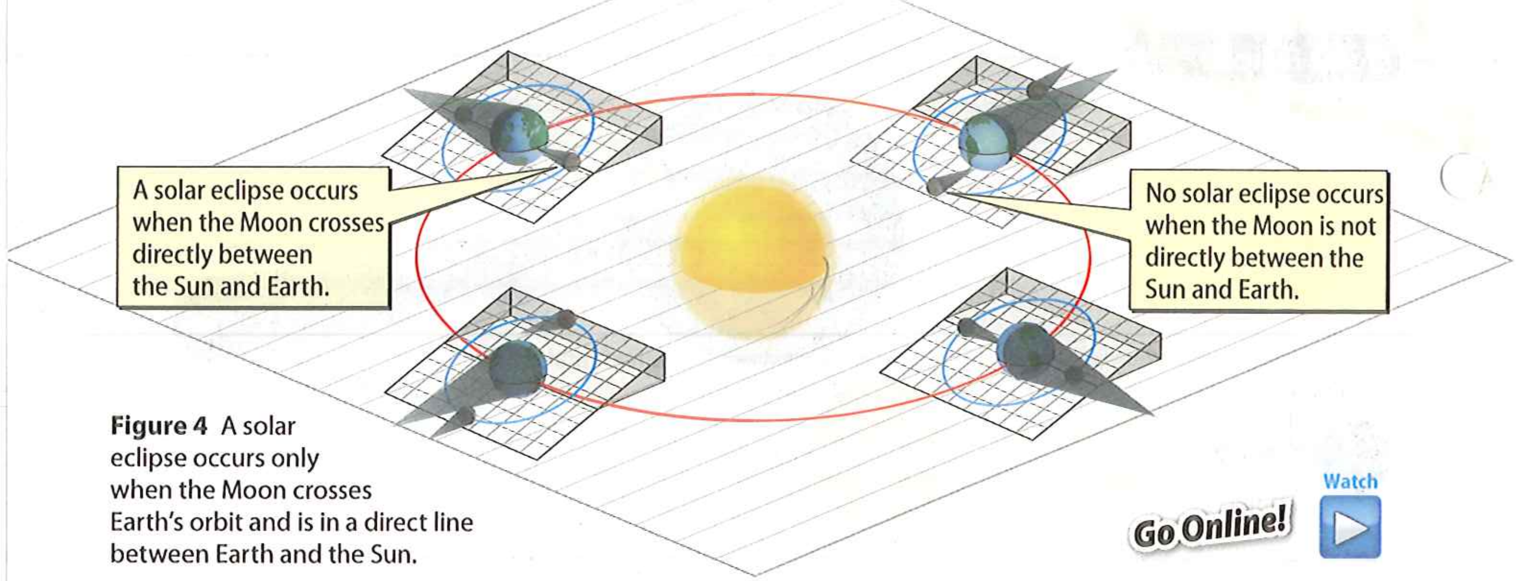


Figure 4 A solar eclipse occurs only when the Moon crosses Earth's orbit and is in a direct line between Earth and the Sun.

Go Online! Watch

Why do solar eclipses not occur every month?

Solar eclipses can occur only during a new moon, when Earth and the Sun are on opposite sides of the Moon. However, solar eclipses do not occur during every new-moon phase. **Figure 4** shows why. The Moon's orbit is tilted slightly compared to Earth's orbit. As a result, during most new moons, Earth is either above or below the Moon's shadow. However, every so often the Moon is in a line between the Sun and Earth. Then the Moon's shadow passes over Earth and a solar eclipse occurs.

Understand

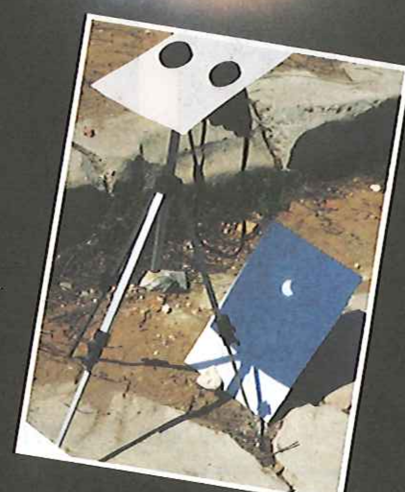
3. Highlight why solar eclipses do not occur during every new moon.

A *Closer* Look at Solar Eclipses

The Sun is the only star that you can observe during the day. Looking directly at the Sun, even briefly, can be very harmful to your eyes. But what about looking at a solar eclipse of the Sun? Would it be safe to observe, since most of the Sun will be blocked?

Although the Sun's light is being blocked by the Moon during a solar eclipse, UV rays are still being emitted and could cause damage to your eyes. If you want to observe a solar eclipse, special precautions should be used to stay safe.

To safely observe a solar eclipse, you should use protective eyewear, such as eclipse glasses, telescope filters, or welder's goggles. These items block the dangerous infrared and ultraviolet light. The simplest safe way to view a solar eclipse is to watch the Sun's image through a pinhole projection. This device allows the solar eclipse image to be projected through the tiny pinhole onto a sheet of paper.



Lunar Eclipse

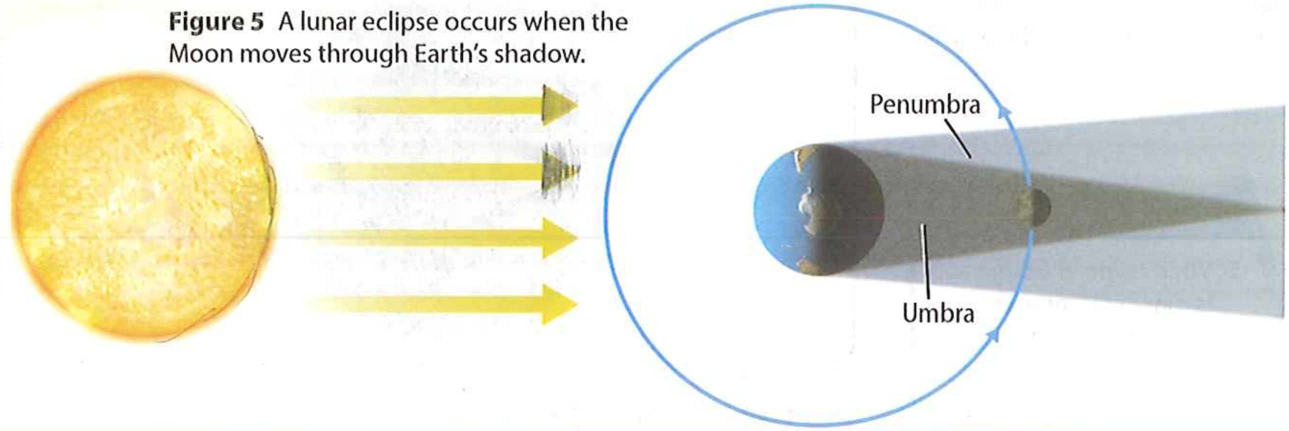


Figure 5 A lunar eclipse occurs when the Moon moves through Earth's shadow.

Lunar Eclipses

Just like the Moon, Earth casts a shadow into space. As the Moon revolves around Earth, it sometimes moves into Earth's shadow, as shown in **Figure 5.** *A* **lunar eclipse** *occurs when the Moon moves into Earth's shadow.* Then Earth is in a line between the Sun and the Moon. This means that a lunar eclipse can occur only during the full-moon phase.

Like the Moon's shadow, Earth's shadow has an umbra and a penumbra. Different types of lunar eclipses occur depending on which part of Earth's shadow the Moon moves through. Unlike solar eclipses, you can see any lunar eclipse from any location on the side of Earth facing the Moon.

Total Lunar Eclipses

When the entire Moon moves through Earth's umbra, a total lunar eclipse occurs. **Figure 6** shows how the Moon's appearance changes during a total lunar eclipse. The Moon's appearance changes as it gradually moves into Earth's penumbra, then into Earth's umbra, back into Earth's penumbra, and then out of Earth's shadow entirely.

You can still see the Moon even when it is completely within Earth's umbra. Although Earth blocks most of the Sun's rays, Earth's atmosphere deflects some sunlight into Earth's umbra. This is also why you can often see the unlit portion of the Moon on a clear night. Astronomers often call this Earthshine. This reflected light has a reddish color and gives the Moon a reddish tint during a total lunar eclipse.

Recall

4. Circle in which moon phase a lunar eclipse can occur. Underline where a lunar eclipse can be seen.

LAB Manager

LAB: *Phases of the Moon*

TEKS 8.1(A); 8.2(A), (C), (E); 8.3(A), (B); 8.4(A); 8.7(B)

FOLDABLES®

Make a two-tab book from a sheet of notebook paper. Label the tabs *Solar Eclipse* and *Lunar Eclipse*. Use it to organize your notes on eclipses.

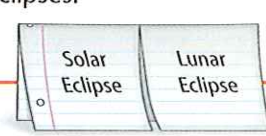
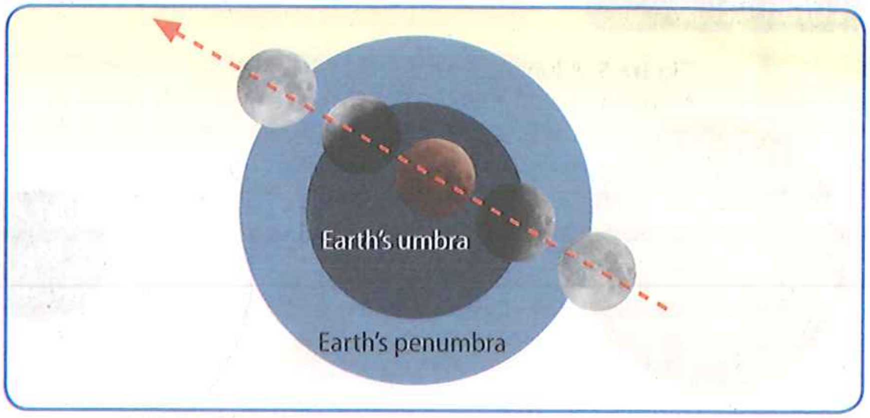


Figure 6 If the entire Moon passes through Earth's umbra, the Moon gradually darkens until a dark shadow covers it completely.



Infer

5. Which type of eclipse is more common, solar or lunar? Explain.

Partial Lunar Eclipses

When only part of the Moon passes through Earth's umbra, a partial lunar eclipse occurs. The stages of a partial lunar eclipse are similar to those of a total lunar eclipse, shown in **Figure 6,** except the Moon is never completely covered by Earth's umbra. The part of the Moon in Earth's penumbra appears only slightly darker, while the part of the Moon in Earth's umbra appears much darker.

Why do lunar eclipses not occur every month?

Lunar eclipses can occur only during a full-moon phase, when the Moon and the Sun are on opposite sides of Earth. However, lunar eclipses do not occur during every full moon because of the tilt of the Moon's orbit with respect to Earth's orbit. During most full moons, the Moon is slightly above or slightly below Earth's penumbra.

LAB Manager

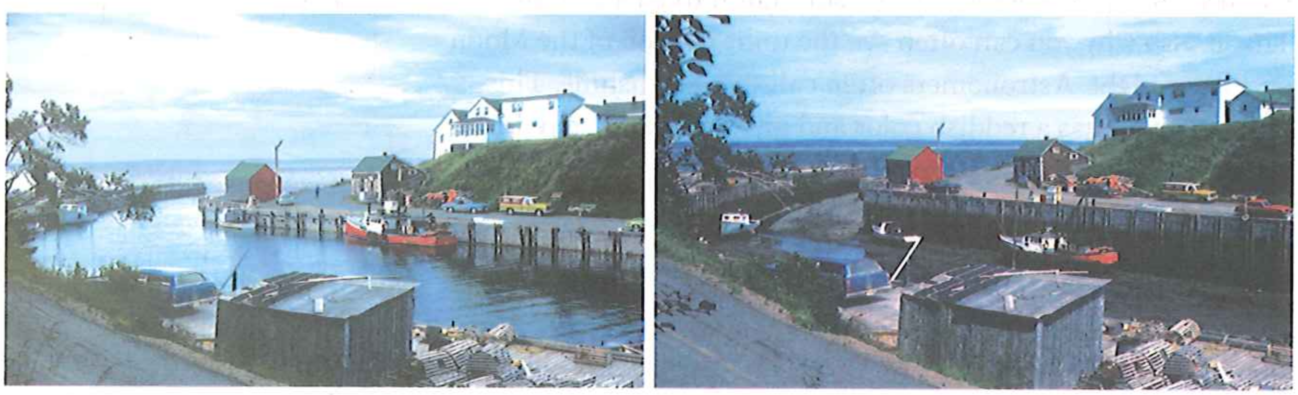
MiniLAB: *How does the Moon affect Earth's tides?*

TEKS 8.1(A); 8.2(A), (E); 8.4(A); 8.7(C)

Tides TEKS 8.7(C)

The positions of the Moon and the Sun also affect Earth's oceans. If you have spent time near an ocean, you might have seen how the ocean's height, or sea level, rises and falls twice each day. A **tide** *is the daily rise and fall of sea level.* Examples of tides are shown in **Figure 7.** It is primarily the Moon's gravity that causes Earth's oceans to rise and fall twice each day.

Figure 7 In the Bay of Fundy, high tides can be more than 10 m higher than low tides.



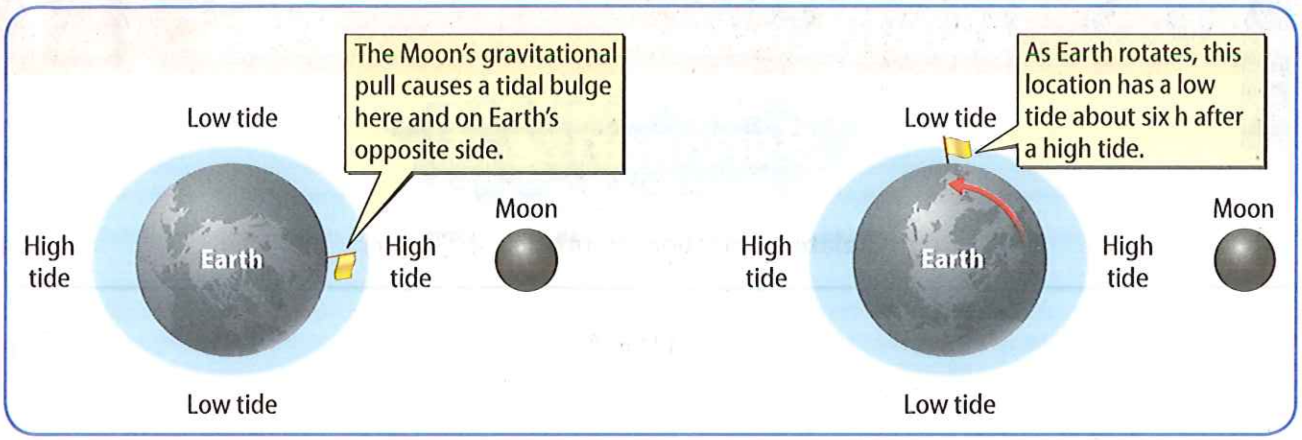


Figure 8 In this view down on Earth's North Pole, the flag moves into a tidal bulge as Earth rotates. A coastal area has a high tide about once every 12 h.

The Moon's Effect on Earth's Tides

The difference in the strength of the Moon's gravity on opposite sides of Earth causes Earth's tides. The Moon's gravity is slightly stronger on the side of Earth closer to the Moon and slightly weaker on the side of Earth opposite the Moon. These differences cause tidal bulges in the oceans on opposite sides of Earth, shown in **Figure 8.** High tides occur at the tidal bulges, and low tides occur between them.

The Sun's Effect on Earth's Tides

Because the Sun is so far away from Earth, its effect on tides is about half that of the Moon. **Figure 9** shows how the positions of the Sun and the Moon affect Earth's tides.

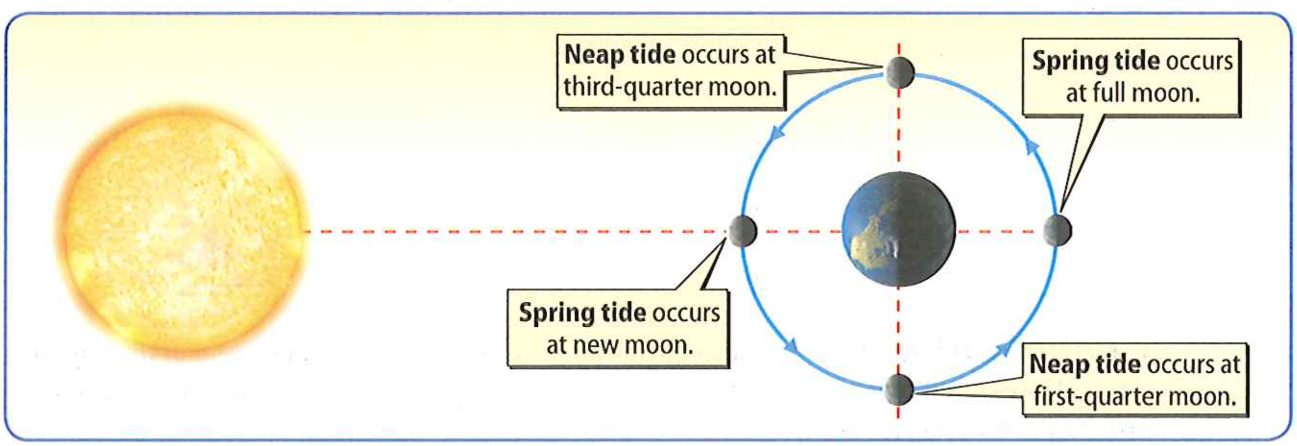
Spring Tides During the full-moon and new-moon phases, spring tides occur. This is when the Sun's and the Moon's gravitational effects combine and produce higher high tides and lower low tides.

Neap Tides A week after a spring tide, a neap tide occurs. Then the Sun, Earth, and the Moon form a right angle. When this happens, the Sun's effect on tides reduces the Moon's effect. High tides are lower and low tides are higher at neap tides.

Express

6. Highlight why the Sun's effect on tides is less than the Moon's effect.

Figure 9 A spring tide occurs when the Sun, Earth, and the Moon are in a line. A neap tide occurs when the Sun and the Moon form a right angle with Earth.



LESSON

6.3 Review

Go Online! Check Virtual

Summarize it!

Relate information about tides. TEKS 8.7(C)

Tides

Definition	
Force that causes tides	
Where the low tide occurs	
Where the high tide occurs	
How often high tide occurs	

Compare spring tides and neap tides. Draw the position of the Moon, the Sun, and Earth during a spring tide and a neap tide. Label the moon phases for each. TEKS 8.7(C)

Connect it! **Analyze** Suppose the Moon were smaller in size but greater in mass than it is now. How would that affect solar eclipses and tides? Write your response in your interactive notebook. TEKS 8.7(C)

Apply the Essential Questions

1. **Identify** Which moon phases would produce higher high tides?
TEKS 8.7(C) *supporting*

A. third quarter and new moon

B. full moon and first quarter

C. full moon and new moon

D. first quarter and third quarter

2. **Illustrate** the positions of the Sun, Earth, and the Moon during a solar eclipse and during a lunar eclipse. Then explain what type of tide occcurs during each eclipse.
TEKS 8.7(C) *supporting*

Solar eclipse:

Lunar eclipse:

3. **Relate** How do the positions of the Sun and the Moon affect Earth's tides?
TEKS 8.7(C) *supporting*

H.O.T. Question (Higher Order Thinking)

4. **Analyze** How would tides be affected if the Moon was farther away from Earth?
TEKS 8.7(C) *supporting*

Green SCIENCE

Tidal Energy

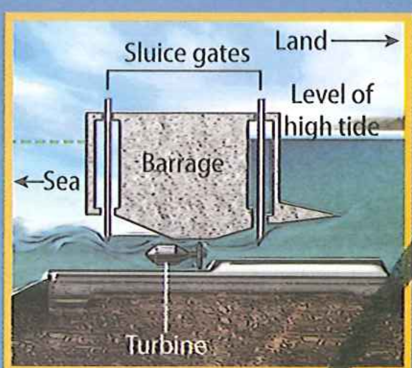
Harnessing the Power of Tides

Have you ever built a sand castle on a beach far from the water, only to see the ocean wash it away later in the day? If so, you have seen the effects of tides—the rise and fall of water levels caused by the gravitational pulls of the Moon and the Sun.

Tides can do more than wash away sand castles. The energy of flowing tidal water can be converted to electric energy and used to heat and cool buildings and to power appliances.

The power of tides can be harnessed in several ways. In an area where the difference in water level between high tide and low tide is great, a damlike structure called a tidal barrage (BAHR ij) can be built. A barrage temporarily holds water at high tide. When enough water has accumulated, the water is released through turbines. The turbines convert the mechanical energy of moving water into electrical energy.

Tidal barrages hold water like dams do. However, instead of stopping the flow of a river, a tidal barrage collects ocean water at high tide and releases it at low tide. ▼



◀ Tidal barrages work only in places where the water level at high tide is at least 5–7 m higher than the water level at low tide.

Tides also generate currents, or streams of moving water, in the ocean. Turbines placed in these currents harness the energy of the moving water, which turns the turbines. The turbines convert the mechanical energy of the moving water into electric energy.

Tidal power is an inexhaustible resource. It is also a predictable source of energy. So why does tidal power not meet more of our energy needs? First, most tidal regions are not well-suited to tidal power production. Second, the structures needed to capture tidal power can be expensive to build. And third, constructing tidal-power structures in the ocean or along ocean shorelines can impact the environment and natural habitats. However, as costs become lower and environmental concerns are addressed, tidal power could meet more of our energy needs in the future.

▲ Turbines that capture tidal energy are similar to turbines on land that capture wind energy.

It's Your Turn!

RESEARCH AND EXPLAIN If you were going to build a tidal barrage, where would you build it? What location would enable your barrage to generate the most electricity? How would the Sun and the Moon affect your barrage's energy production? Discuss your answers with a partner.