Section 3

Phases, Eclipses, and Tides

Objectives

After this lesson, students will be able to

J.1.3.1 Explain the causes of the phases of the moon.

J.1.3.2 Describe solar and lunar eclipses.

J.1.3.3 Identify the causes of tides.

Target Reading Skill

Previewing Visuals Explain that looking at the visuals before students read helps them activate prior knowledge and predict what they are about to read.

Answers

Possible questions and answers:

Why does the moon have phases? *(The changing relative positions of the moon, Earth, and the sun cause the phases of the moon.)* **Do we see different sides of the moon as the phases of the moon appear?** *(No; the same side of the moon always faces Earth.)*

All in One Teaching Resources

- Transparency J7

Preteach

Build Background Knowledge L1

Observing the Moon

Have students describe observations they have made about the moon. Use questions to help prompt their memories. For example, ask: **Have you ever seen the moon low on the horizon? Was it full at the time? Have you ever seen the moon in daytime?** Encourage students to think about their observations as they read this section.

Section 3

Phases, Eclipses, and Tides

Reading Preview

Key Concepts

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

Key Terms

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

Target Reading Skill

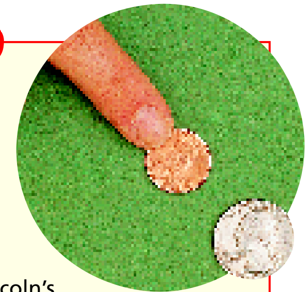
Previewing Visuals Preview Figure 11. Then write two questions about the diagram of the phases of the moon in a graphic organizer like the one below. As you read, answer your questions.

Phases of the Moon

Q.	Why does the moon have phases?
A.	
Q.	

Lab zone Discover Activity

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 people look up at the moon, they often see what looks like a face. Some people call this "the man in the moon." Of course, the moon really has no face. What people are seeing is a pattern of light-colored and dark-colored areas on the moon's surface that just happens to look like a face.

It is interesting to note that this pattern never seems to change. 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, so you never see it 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. It takes the moon about 27.3 days to revolve around Earth.

The moon rotates slowly on its own axis once every 27.3 days. Because the moon also revolves around Earth every 27.3 days, a "day" and a "year" on the moon are the same length. For this reason, the same side of the moon always faces Earth. 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.**

Lab zone Discover Activity

Skills Focus Inferring L1

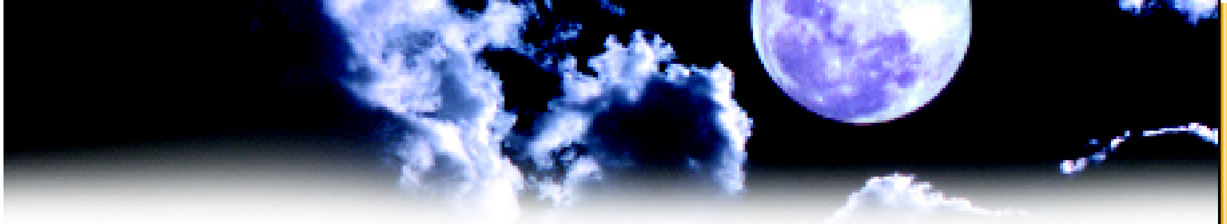
Materials quarters, pennies

Time 10 minutes

Tips Before students try this activity, have them predict how many times the penny will rotate during its revolution around the quarter.

Expected Outcome The penny makes one complete rotation on its axis as it revolves around the quarter.

Think It Over The moon does not appear to rotate when seen from Earth because the same side of the moon is always visible from Earth.



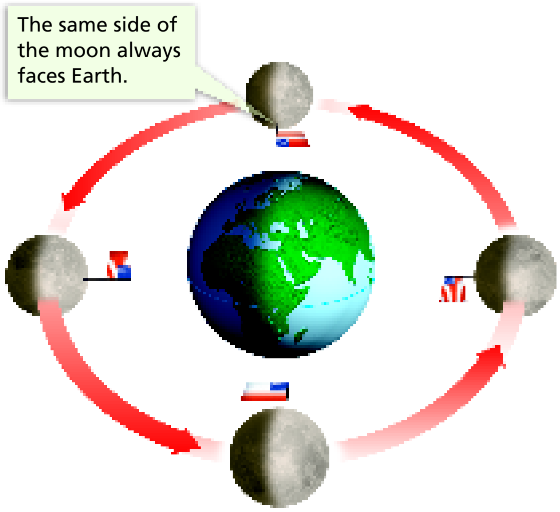


FIGURE 10
The Moon in Motion
The moon rotates on its axis and revolves around Earth in the same amount of time. As a result, the near side of the moon (shown with a flag) always faces Earth.
Interpreting Diagrams *Would Earth ever appear to set below the horizon for someone standing next to the flag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

Differentiated Instruction

Gifted and Talented L3

Identifying How Full Moons Were Named Before artificial lighting, the phases of the moon were important in planning activities. For example, the full moon nearest the fall equinox is called the harvest moon. Have students find out why the harvest moon was so named. *(The harvest moon provides extra light during the early evening hours to help farmers gather their crops.)* Encourage students to find out the names of other full moons throughout the year, such as the Full Wolf Moon and the Full Flower Moon. *The Old Farmer's Almanac* is a good place to start. **learning modality: verbal**

Instruct

Motions of the Moon

Teach Key Concepts L2

Moon Movements

Focus Review the definitions of rotation and revolution.

Teach Ask: **How long does it take the moon to rotate on its axis?** *(27.3 days)* **How long does it take the moon to revolve around Earth?** *(27.3 days)* **As the moon revolves, what happens to the relative positions of the moon, Earth, and the sun?** *(The angle between them changes.)*

Apply Have students examine Figure 10. Ask: **Which way would the flags be pointing if the moon did not rotate?** *(Only one flag would point toward Earth. The others would point either perpendicular or facing away from Earth.)* **learning modality: visual**

Independent Practice L2

All in One Teaching Resources

- Guided Reading and Study Worksheet: *Phases, Eclipses, and Tides*

Student Edition on Audio CD

Monitor Progress L2

Skills Check Have students contrast the revolution of the moon around Earth with the revolution of Earth around the sun and infer why the moon's period of revolution is so much shorter. *(The revolution of Earth around the sun is 365 1/4 days. The circumference of the moon's orbit around Earth is much shorter than that of Earth's orbit around the sun.)*

Answer

Figure 10 No; Earth would not appear to set because that point on the moon's surface is always facing Earth.

Phases of the Moon

Teach Key Concepts

L2

Exploring Phases of the Moon

Focus Have students examine Figure 11.

Teach Tell students that although the same side of the moon always faces Earth, the moon's position in relation to the sun is not fixed. As the moon revolves around Earth, sunlight shines on the near and far sides of the moon at different times. Ask: **Why can you not see the far side of the moon from Earth?** *(The far side always faces away from Earth.)* Prompt students to connect each phase with how the moon looks from Earth. For example, ask: **What do you see in the first quarter?** *(Half of the lighted side of the moon)* **What is happening in the waning gibbous phase?** *(You see more than half of the lighted side of the moon. The amount you can see from Earth decreases each day.)*

Apply Ask: **How can you tell whether the moon is waxing or waning?** *(Observe it over time; a waxing moon gets larger, and a waning moon gets smaller. Also, the right side of the moon is visible during a waxing moon; the left side is visible during a waning moon.)* **learning modality: visual**

All in One Teaching Resources

- Transparency J8

Lab zone Build Inquiry

L2

Predicting Phases of the Moon

Materials newspapers for the current or previous day, current calendar

Time 20 minutes

Focus Remind students that it takes 29.5 days for the moon to complete a cycle.

Teach Have students predict the number of days between the new moon, first quarter, full moon, and third quarter. Students can then use the weather report from the newspaper to compare the data with their predictions.

Apply Ask: **How long does it take for the new moon to reach the first quarter?** *(About one week)* **Why do you think this phase is called a "quarter moon?"** *(One week is about one-quarter of the complete cycle of moon phases.)* **learning modality: logical/ mathematical**

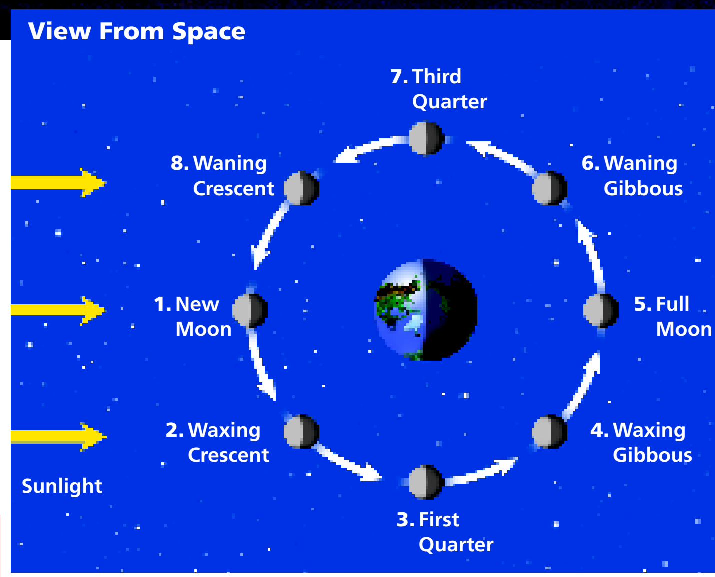


FIGURE 11
Phases of the Moon
The photos at the top of the page show how the phases of the moon appear when you look up at the moon from Earth's surface. The circular diagram at the right shows how the Earth and moon would appear to an observer in space as the moon revolves around Earth.
Interpreting Diagrams *During what phases are the moon, Earth, and sun aligned in a straight line?*

Go Online active art
For: Moon Phases and Eclipses activity
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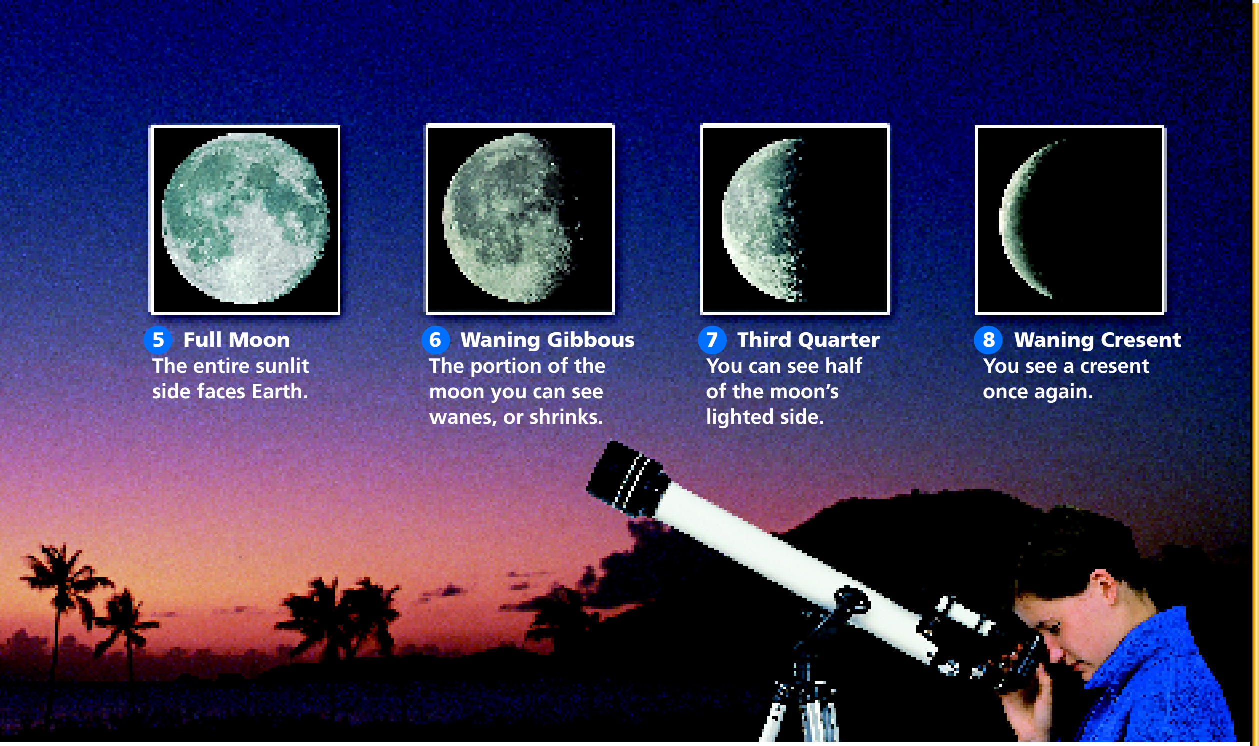
Web Code: cfp-5013



5 Full Moon The entire sunlit side faces Earth.

6 Waning Gibbous The portion of the moon you can see wanes, or shrinks.

7 Third Quarter You can see half of the moon's lighted side.

8 Waning Cresent You see a cresent once again.

To understand the phases of the moon, study Figure 11. During the new moon, the side of the moon facing Earth is not lit because the sun is behind the moon. 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.

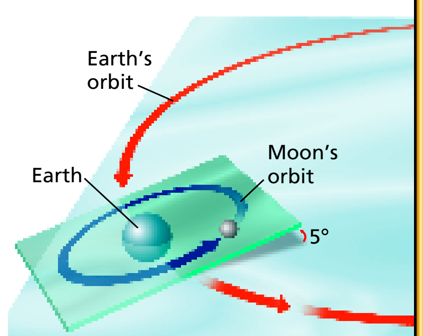
Reading Checkpoint **What is a new moon?**

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.



Go Online active art

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Students can interact with moon phases and eclipses online.

Eclipses

Teach Key Concepts L2

Causes and Effects of Eclipses

Focus Remind students about the moving shadow cast by an isolated cloud.

Teach Ask: **What causes an eclipse?** *(When an object in space moves between the sun and a third object, it casts a shadow on the third object.)* **Describe some events that might occur when the moon blocks out the sun.** *(Possible answer: Day becomes as dark as night, the air cools, and the sky becomes an eerie color.)*

Apply Ask students to describe what has to happen to the relative positions of the sun, the moon, and Earth for an eclipse to occur. *(They all have to line up perfectly so that the moon blocks the sun from Earth or Earth blocks the sun from the moon.)* **learning modality: verbal**

Help Students Read

Visualizing Instruct students to close their eyes and form mental pictures as you slowly read aloud *Eclipses*. Then tell students to read the passage by themselves and recreate the mental images they formed earlier. Explain that visualizing the text as they read will be particularly useful throughout the next two pages, which discuss the positions of the moon, Earth, and the sun during solar and lunar eclipses.

Monitor Progress L2

Drawing Have students sketch the position of the moon relative to Earth and the sun at the time of new moon, first-quarter moon, full moon, and third-quarter moon and write brief explanations for how these phases occur. Students can save their drawings in their portfolios.

Portfolio

Answers

Figure 11 A new moon and a full moon

Reading Checkpoint The phase in which the side of the moon facing Earth is not lit because the sun is behind the moon

Differentiated Instruction

English Learners/Beginning L1

Vocabulary: Prior Knowledge The term *phase* is used in many different ways in science. Give examples of how *phase* is used in science, such as phases of the moon, phases of matter, and color phases in a species of animal or plant. Give the appropriate definition for each example. **learning modality: verbal**

English Learners/Intermediate L2

Vocabulary: Prior Knowledge Have students brainstorm at least three different ways that the term *phase* is used in science. Use one of the meanings in a sentence, such as "The moon undergoes a cycle of phases." Have students write sentences incorporating other scientific meanings of the term *phase*. **learning modality: verbal**

Use Visuals: Figure 13 L1

Solar Eclipses

Focus Tell students that the words *umbra* and *penumbra* are derived from Latin words meaning "shadow" and "almost shadow."

Teach Ask: **What causes a solar eclipse?** *(The moon passes directly between the sun and Earth.)* **Which side of the moon receives the light of the sun during a solar eclipse?** *(The far side)* **Would people in the moon's penumbra experience a total or a partial eclipse?** *(Partial)*

Apply Ask students to infer whether a solar eclipse can be viewed from a large area of Earth. *(No; the sun's rays are blocked over only a small area.)* **Why does a solar eclipse last only a few minutes?** *(Because Earth rotates)* **learning modality: visual**

All in One Teaching Resources

- Transparency J9

Use Visuals: Figure 14 L2

Lunar Eclipses

Focus Show students photographs of a full moon. Have them compare these images with the photograph of the moon during a total lunar eclipse.

Teach Ask: **Why do lunar eclipses occur only during a full moon?** *(Earth must come between the sun and moon during a lunar eclipse; this happens only during the full-moon phase.)* **Why does the moon appear reddish during a lunar eclipse?** *(Some sunlight is bent as it passes through Earth's atmosphere and then strikes the moon.)*

Apply Have students infer why lunar eclipses last much longer than solar eclipses. *(Earth is much larger than the moon. Its shadow is also larger. As a result, the moon may take several hours to pass completely through Earth's shadow. In contrast, during a solar eclipse, the moon's small shadow sweeps across a point on Earth's surface in a matter of minutes.)* **learning modality: visual**

All in One Teaching Resources

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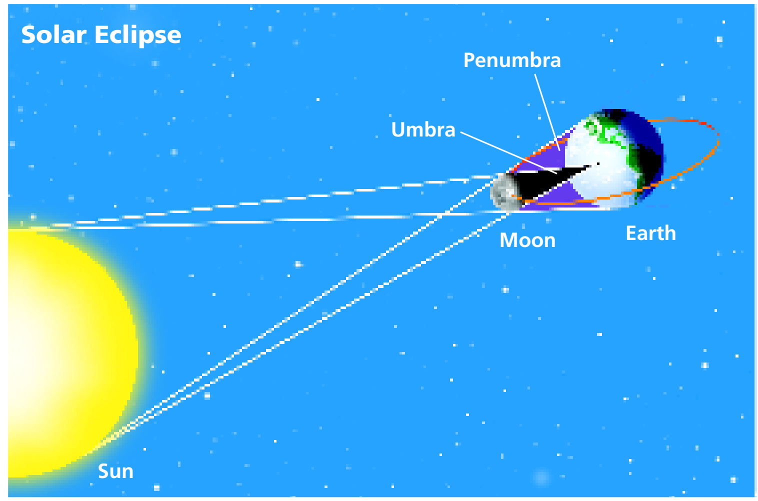

FIGURE 13
The outer layer of the sun's atmosphere, the solar corona, is visible surrounding the dark disk of the moon during a solar eclipse. During a solar eclipse, the moon blocks light from the sun, preventing sunlight from reaching parts of Earth's surface.

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.

Lab zone Skills Activity

Skills Focus Making models L2

Materials paper, metric rulers, calculators

Time 15 minutes

Tips Guide students to find the other distances in terms of Earth's diameter.

Expected Outcome With Earth as 1 cm in diameter, the moon will be 2.5 mm in diameter, 30 cm away in the opposite corner of the page.

Extend Challenge students to find the distance from Earth to the sun and then estimate where they would place the sun in their scale drawings. *(At about 11,725 cm, or 117 m)* **learning modality: logical/mathematical**

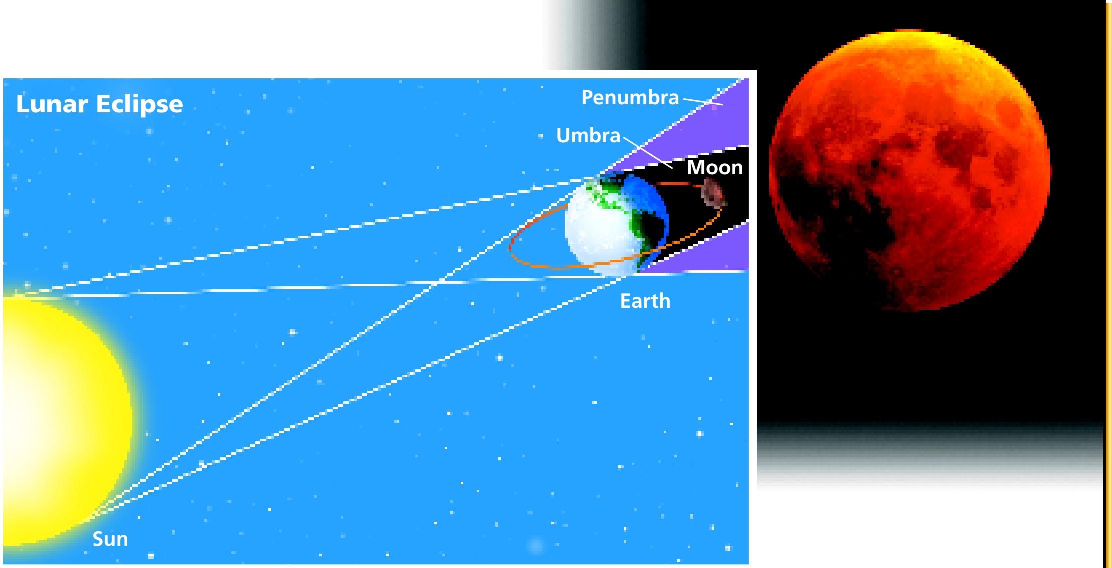

FIGURE 14
During a lunar eclipse, Earth blocks sunlight from reaching the moon's surface. The photo of the moon above was taken during a total lunar eclipse. The moon's reddish tint occurs because Earth's atmosphere bends some sunlight toward the moon.
Interpreting Diagrams *What is the difference between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

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 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?**

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Students can interact with moon phases and eclipses online.

Lab zone **Build Inquiry** L2

Comparing and Contrasting Solar and Lunar Eclipses

Materials pen, paper
Time 15 minutes

Focus Tell students that *comparing* means "explaing how things or events are similar" and that *contrasting* means "explaining how things or events are different."

Teach Organize students into small groups. Tell them to make tables that compare and contrast the umbra and penumbra of the moon during a total and partial solar eclipse with the umbra and penumbra of Earth during a total and partial lunar eclipse. Groups should first decide what headings to use for their tables—that is, which aspects of the umbra and penumbra to compare and contrast. Suggested headings might include: "Portion of the surface covered by the umbra," "Phase of the moon when the eclipse occurs," and "Portion of Earth from which eclipse is visible." Have students present their tables to the class.

Apply Tell students to suppose they are standing on the near side of the moon. The moon moves between Earth and the sun. Would they see an eclipse? If so, where? *(The shadow of the moon would fall on Earth; they would see a partial "Earth eclipse.")* **learning modality: verbal**

Differentiated Instruction

Special Needs L1

Modeling Eclipses Give students three different-sized balls. Tell them that the largest ball represents the sun, the second-largest ball represents Earth, and the smallest ball represents the moon. Have students arrange the balls in proper order to model the positions of the sun, the moon, and Earth during a solar eclipse and a lunar eclipse. You might also try using the natural light from a window as the sun. *(During a solar eclipse, the balls should be arranged in the following order: sun, moon, Earth. During a lunar eclipse the balls should be arranged in the following order: sun, Earth, moon.)*

Monitor Progress L2

Drawing Have students sketch the positions of the sun, the moon, and Earth during a solar eclipse and a lunar eclipse.

Answers

Figure 14 During a lunar eclipse, the umbra is the darkest part of Earth's shadow. The penumbra is the larger, less dark part of Earth's shadow.

Reading Checkpoint Full moon

Tides

Teach Key Concepts

L2

What Causes Tides

Focus Tell students to look at points A and C in Figure 16.

Teach Explain that the moon's gravity is pulling Earth's water at A, and a high tide forms. Ask: **What happens at C?** *(The moon pulls more strongly on the solid part of Earth than on the water at C. Earth is pulled toward the moon and water flows toward point C, causing a high tide there.)* **What happens at B and D?** *(Water is flowing away toward A and C, so low tides form at B and D.)*

Apply Ask: **Why might it be helpful to know when high and low tides occur?** *(Possible answer: People who fish need to know the tide cycle because it affects when they fish and what they catch.)* **learning modality: visual**

All in One Teaching Resources

- Transparency J11

Lab zone Teacher Demo

L1

Modeling the Moon's Pull of Gravity

Materials round balloon

Time 10 minutes

Focus Tell students that you are going to demonstrate the moon's pull of gravity on Earth.

Teach Partially blow up the balloon and knot the stem. Hold the balloon securely by the knotted end and the opposite end. Pull on the knotted end. Ask: **What represents the moon in this model?** *(The hand pulling the knotted end)*

Apply Have students draw diagrams showing the shape of the balloon as it is being pulled and indicating where tides would occur if the balloon were Earth. **learning modality: visual**

Help Students Read

Outline Instruct students to outline the passage *Tides,* writing the subheads and leaving room between each one. As students read, they can list details under each subhead.

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. **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.

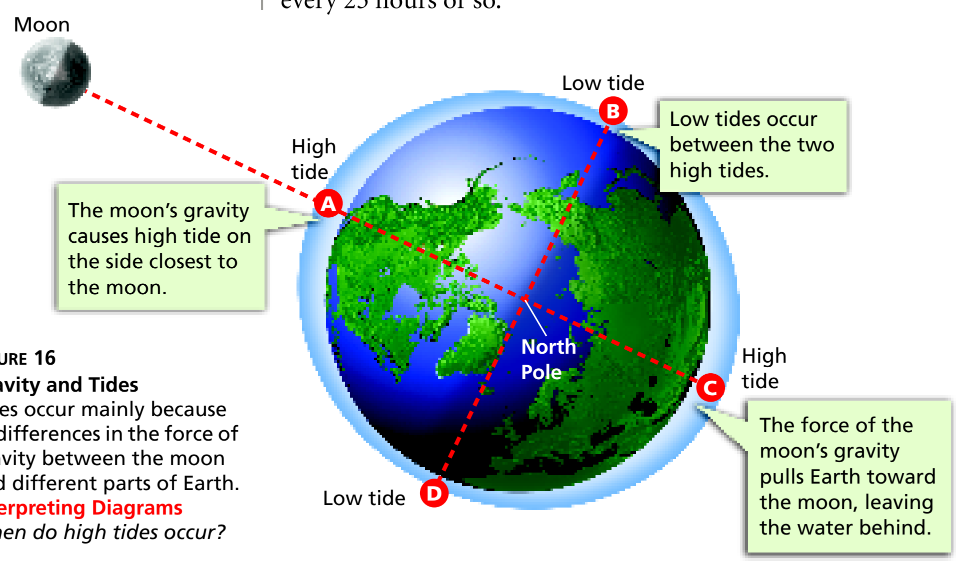


FIGURE 16
Gravity and Tides
Tides occur mainly because of differences in the force of gravity between the moon and different parts of Earth.
Interpreting Diagrams
When do high tides occur?

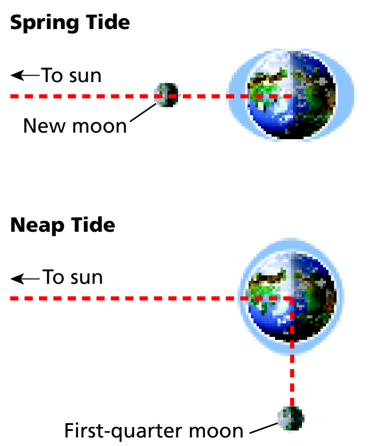
Spring Tides The sun's gravity also pulls on Earth's waters. As shown in the top diagram of Figure 17, the sun, moon, and Earth are nearly in a line during a new moon. The gravity of the sun and the moon pull in the same direction. Their combined forces produce a tide with the greatest difference between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

Target Reading Skill **Previewing Visuals** Refer to your questions and answers about Figure 11 to help you answer Question 1 below.

Reviewing Key Concepts

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.
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?
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.

Monitor Progress L2

Answers

Figure 16 High tides occur on the side of Earth closest to the moon and the side directly opposite to the moon.

Reading Checkpoint A neap tide occurs when the moon is at a right angle to the sun. This tide has the least difference between consecutive low and high tides.

Assess

Reviewing Key Concepts

1. a. Reflected light from the sun **b.** The relative positions of the moon, Earth, and the sun change. **c.** The moon's sunlit side is facing away from Earth.

2. a. An eclipse occurs when an object in space comes between the sun and a third object, casting a shadow on that object.
b. During a solar eclipse, the moon blocks sunlight from Earth. During a lunar eclipse, Earth blocks sunlight from the moon.
c. The moon's orbit is tilted with respect to Earth's orbit, so the moon rarely goes directly between the sun and Earth or directly behind Earth.

3. a. Tides are caused mainly by differences in how much the moon's gravity pulls on different parts of Earth. **b.** High tides occur on both the side of Earth closest to the moon and the side farthest from the moon. Every point on Earth moves through these two locations once every 25 hours or so. Low tides occur between each high tide.
c. During a spring tide, high tides are higher than usual and low tides are lower than usual. During a neap tide, high tides are lower than usual and low tides are higher than usual. The difference is caused by the different positions of Earth, the moon, and the sun.

Reteach L1

Review the phases of the moon and the relative positions of the sun, the moon, and Earth during a solar eclipse and a lunar eclipse.

All in One Teaching Resources

- Section Summary: *Phases, Eclipses, and Tides*
- Review and Reinforce: *Phases, Eclipses, and Tides*
- Enrich: *Phases, Eclipses, and Tides*

Lab zone At-Home Activity

Tracking the Tides L3 Use local tide tables if available. The United States National Oceanic and Atmospheric Administration (NOAA) has a Web site with a tide predictor. If possible, have students track tide heights for 30 days to see a full monthly tide cycle.

Lab zone Chapter Project

Keep Students on Track Provide newspapers in the classroom so that students can check the times of moonrise and moonset each day. Encourage students to look for the moon at these times, even during daylight hours, and to include small drawings in their journals along with their daily observational notes. Drawings should show the phase and orientation of the moon.

Lab zone Skills Lab

L2

A "Moonth" of Phases

Prepare for Inquiry

Key Concept
The phases of the moon are caused by the moon's position relative to Earth and the sun.

Skills Objectives
After this lab, students will be able to
- make a model of the Earth-moon-sun system to explore the phases of the moon
- observe and record the phases of the model system

Prep Time 15 minutes
Class Time 40 minutes

Advance Planning
Collect lamps (one for each pair of students), extra bulbs (150-watt bulbs work best), and plastic foam balls (one per student pair).

Safety
Remind students to be careful while moving around the lamps and extension cords. Tell them not to look directly into the lights. Review the safety guidelines in Appendix A.

All in One Teaching Resources
- Lab Worksheet: *A "Moonth" of Phases*

Guide Inquiry

Invitation
Have students think about the variations of the moon's appearance in the night sky. Ask volunteers to describe variations they have seen. *(Possible answer: The moon may appear round. Sometimes, it cannot be seen at all, or only part of it may be visible.)*

Introduce the Procedure
- Review the photograph to make sure that students understand how to position themselves.
- Suggest that students make sketches of their predictions, showing what they will see at each turn.

Lab zone Skills Lab

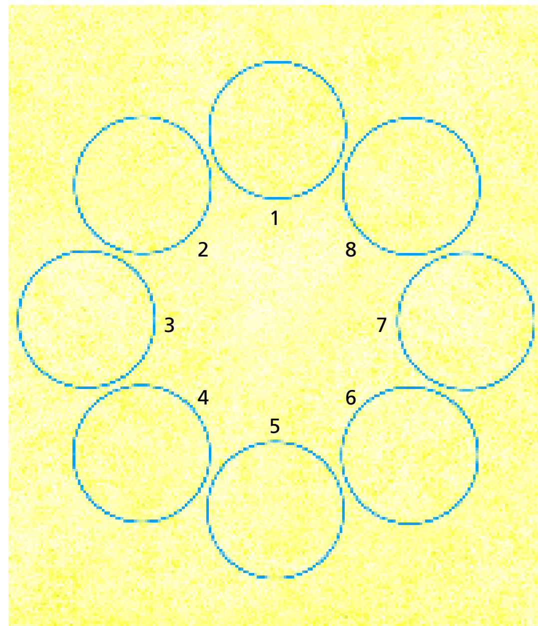
A "Moonth" of Phases

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.

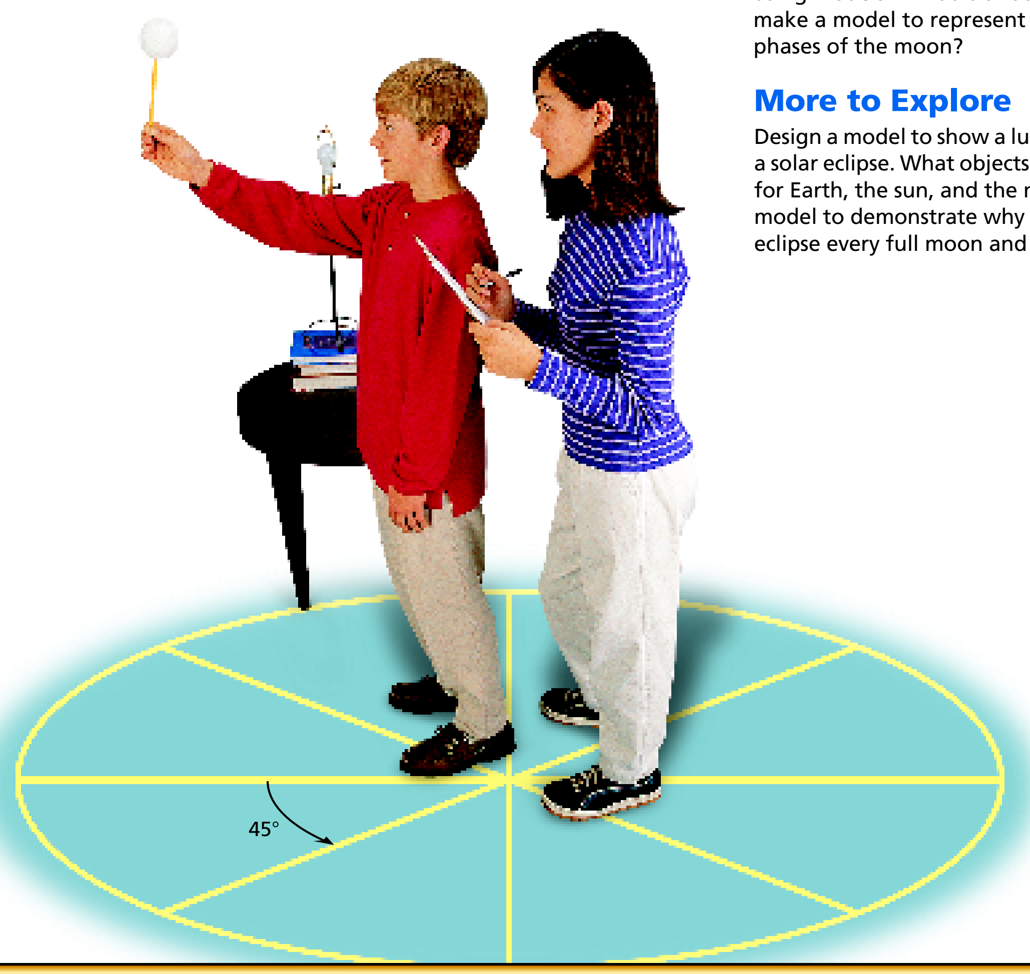


Troubleshooting the Experiment
- When students model the full moon, make sure that they hold the ball slightly above their heads so that the ball is not in their shadow.
- Make sure that the student who is drawing stands directly behind the student with the ball so that they have the same view.

Expected Outcome
Students will identify the eight phases of the moon.

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.

Analyze and Conclude

1. The student holding the ball represents Earth. The lamp represents the sun. The plastic foam ball represents the moon.

2. None

3. 1: new moon, 2: waxing crescent, 3: first quarter, 4: waxing gibbous, 5: full moon, 6: waning gibbous, 7: third quarter, 8: waning crescent

4. For the first four turns, about 25% more of the lighted part of the ball was visible with each turn. Then the lighted part of the ball was completely visible (full moon). For the next four turns, about 25% less of the lighted part was visible with each turn until the dark side of the moon (new moon) faced the observer again.

5. One-half of the ball was always lit. The darkness of the new moon was not caused by an eclipse; when the moon is between Earth and the sun, an observer on Earth sees the moon's unlit side.

6. Possible answer: The model allows you to observe the cycle of phases in a short amount of time. The disadvantage of a model is that it does not always show the true size, shape, or color of the real item. Another model could use a ball painted black on one hemisphere and white on the other. The white half would represent the sunlit side of the moon. A student could walk around the ball to view the different phases.

Extend Inquiry

More to Explore A solar eclipse occurs when the moon (plastic foam ball) is directly between the sun (lamp) and Earth (partner holding the ball). In this position, the new moon casts a total eclipse (shadow) on one part of Earth and a partial eclipse on another part. A lunar eclipse appears during a full moon when the moon (plastic foam ball) passes through the shadow of Earth (partner holding the ball). The moon's orbit is tilted slightly with respect to Earth's orbit around the sun.