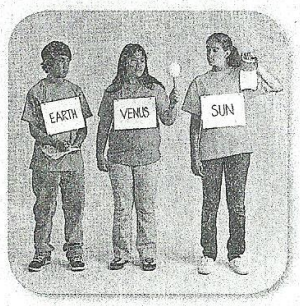
Launch Lab

20 minutes

What is the center of the solar system?



For thousands of years, people believed Earth was the center of the solar system. Then, in the 1600s, Galileo viewed Venus with a telescope and discovered that Venus shows phases similar to the phases of the Moon. This discovery helped prove that the Sun is the center of the solar system.

1. Read and complete a lab safety form.
2. In groups of three, assume roles as the Sun, Venus, or Earth. The Sun holds a **battery-powered lamp.** Venus holds a **plastic foam ball** on a **pencil.** Line up so Venus is between the Sun and Earth.
3. To model an Earth-centered system: In a darkened room, Earth stands still while the Sun and Venus orbit it, staying close together. Earth watches the ball held by Venus and draws diagrams in his or her Science Journal of what the ball looks like at four locations in its orbit.
4. To model the Sun-centered system: The Sun stands still while Earth and Venus orbit it. Earth takes small steps. Venus takes large steps. Earth watches the ball held by Venus and draws diagrams of what the ball looks like at four locations in its orbit..

Think About This

1. How did the appearance of Venus differ in the Earth-centered and Sun-centered systems?
2. **Key Concept** How do you think Earth and other objects in the solar system move?

Earth and the Universe

Have you ever noticed how the Moon is in a different place each night, or wondered why summer days seem longer than winter days? Long ago, people carefully studied the positions and motions of the Sun, the Moon, and other objects in the sky. They noticed patterns in the motions. Using the patterns, they were able to predict future positions of objects in the sky. But they did not understand how the objects were related.

People today know that Earth is not the center of the universe. The Moon moves around, or orbits, Earth. Earth is just one of eight planets that orbit the Sun. The Sun is one of billions of stars that make up the Milky Way galaxy. And the Milky Way is one of billions of galaxies in the universe.

Reading Check How many planets orbit the Sun?

Objects in the solar sytem orbit the Sun because it has a huge gravitational pull. The Sun contains more than 99 percent of the solar system's mass. It is also the biggest object in the solar system. As shown in **Figure 1**, the Sun's diameter is 100 times greater than Earth's and 10 times greater than Jupiter's.

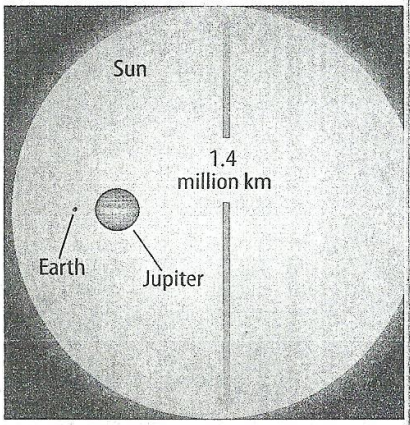
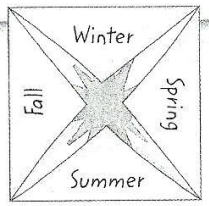


Figure 1 The Sun is 100 times wider than Earth and 10 times wider than Jupiter, the second largest object in the solar system.

Review Personal Tutor

FOLDABLES®

Make an envelope book. Label it as shown. Draw an image of the Sun on the inside center. On the inside tabs, draw the position of Earth for each season.



Motions of Earth

Have you ever flown in an airplane? Some airplanes can travel over 900 km/h. Yet, as you sit in one, you hardly feel that you are moving. Living on Earth is like traveling in an airplane. It seems as if Earth is still and the Sun and stars move around it. But Earth is not still. It moves in space.

Earth's Orbit

As you read this, Earth is moving around the Sun because of the Sun's huge gravitational pull. Without the Sun's pull, Earth would move off into space in a straight line, as shown in Figure 2. Earth's orbit is elliptical, or nearly round. *The orbit of an object around another object is* **revolution.** It takes Earth 365.25 days, or one year, to revolve around the Sun once.

As shown in Figure 2, the distance between Earth and the Sun is not always the same. An astronomical unit (AU) is the average distance between Earth and the Sun. One AU is nearly 150 million km. Scientists often use AUs to measure distances to planets and other objects within the solar system.

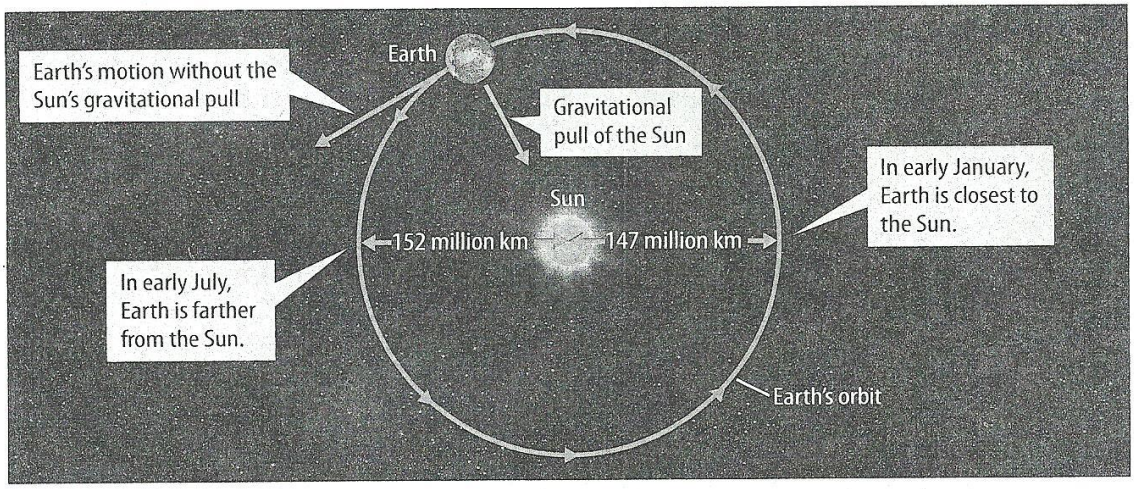


Figure 2 Earth orbits the Sun because of the Sun's gravitational pull.

Visual Check When is Earth closest to the Sun?

SCIENCE USE V. COMMON USE

revolution

Science Use orbit of one object around another object

Common Use a complete change, often in government or technology

Earth's Rotation

Imagine a rod pushed through the center of Earth, from the North Pole to the South Pole, as shown in the images of Earth in Figure 3. The rod represents Earth's axis. Earth spins, or rotates, on its axis like a top. **Rotation** *is the spin of an object around its axis.* Rotation is what causes day and night. The side of Earth facing the Sun is in daylight, and the side of Earth away from the Sun is in darkness. Earth makes one full rotation every 24 h.

Reading Check How long does it take Earth to rotate once?

Earth's Tilt and Seasons

You might think that summer occurs when Earth is closest to the Sun. However, Earth is actually closest to the Sun in January, when it is winter in the northern hemisphere. As shown in **Figure 3**, seasons occur because Earth's tilt does not change as Earth orbits the Sun. This alternates the amount of direct sunlight that each hemisphere receives.

If you drew a line perpendicular to Earth's orbital path, the angle of tilt between Earth's axis and that line would be 23.5°. As Earth moves, this angle of tilt remains the same. The North Pole and the South Pole always point in the same directions. However, as shown in **Figure 4**, the position of Earth's tilt as it relates to the Sun does change.

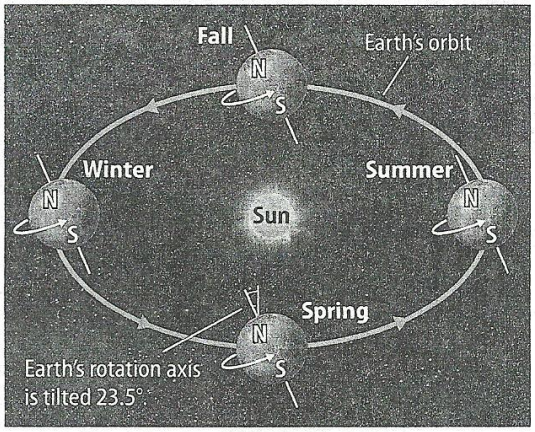
Spring and Fall

An **equinox** (EE kwuh nahks) *occurs when Earth's rotation axis is tilted neither toward nor away from the Sun. Equinox* means "equal night." Hours of daylight equal hours of darkness during an equinox. An equinox occurs two days of the year, one in March and one in September. These days are used to signify the beginning of spring or fall.

Summer and Winter

When the Earth's rotation axis is tilted directly toward or away from the Sun a **solstice** (SAHL stuhs) *occurs, as shown in the bottom of* **Figure 4**. Solstices happen in June and December. When the North Pole is toward the Sun, the northern hemisphere experiences summer. The northern hemisphere receives more direct sunlight, and there are more hours of sunlight during the day. At the same time, the South Pole is tilted away from the Sun, and the southern hemisphere experiences winter. This hemisphere receives less direct sunlight, and there are fewer hours of sunlight. Six months later, the seasons are reversed.

Key Concept Check What causes seasons?



▲ **Figure 3** The tilt of Earth's axis does not change as Earth moves around the Sun.

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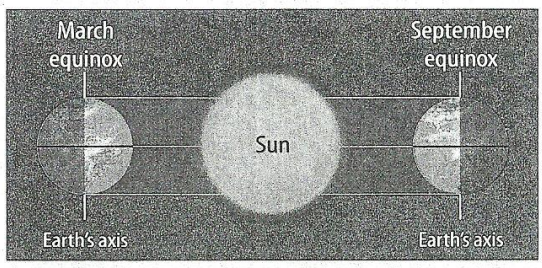
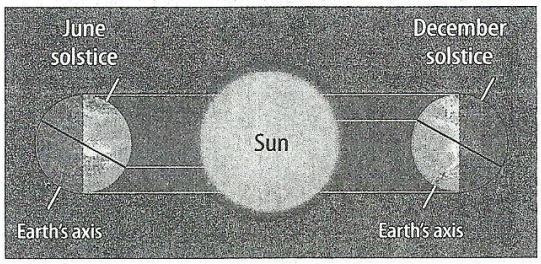
Figure 4 The position of Earth's tilt relative to the Sun causes the seasons. Each season starts at an equinox or a solstice.

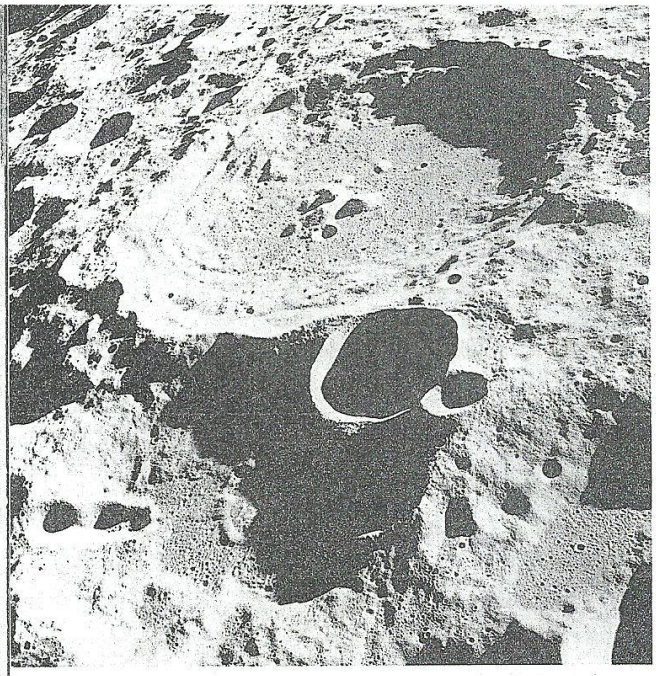
Visual Check How are the beginnings of spring and fall similar?



At two points in Earth's orbit—the March and September equinoxes— Earth's axis does not point either toward or away from the Sun. Light is distributed equally in the northern and southern hemispheres.



At two points in Earth's orbit—the June and December solstices—Earth's axis points the most toward or away from the Sun. Light is not distributed equally in the northern and southern hemispheres.

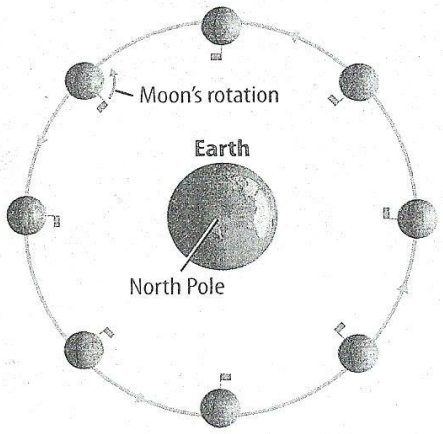


▲ **Figure 5** Early in the Moon's history, collisions with asteroids and comets created huge impact craters. The large crater above is about 93 km in diameter and is on the far side of the Moon.

REVIEW VOCABULARY

lava
molten volcanic material

Figure 6 Because the Moon rotates once as it makes one orbit around Earth, the same side of the Moon always faces Earth. ▼



Earth's Moon

You can probably guess what force holds the Moon in orbit around Earth. It's the same force that holds Earth in orbit around the Sun—gravity! The Moon is about one-fourth the size of Earth. It is a dry, airless object made mostly of rock. Early in the Moon's history, many asteroids and comets crashed into it, leaving huge craters on its surface, such as those shown in **Figure 5.** The Moon also has mountains and smooth, dark **lava** plains from ancient volcanoes.

Reading Check What created the Moon's craters?

Formation of the Moon

Scientists propose that the Moon formed when a Mars-sized object collided with Earth soon after Earth formed. This collision threw debris into orbit around Earth. Gravity pulled the debris together forming the Moon.

Motions of the Moon

Like Earth, the Moon moves in different ways. It rotates on its axis, and it revolves around Earth. It orbits Earth once every 27.3 days. That is also how long it takes the Moon to rotate once. Because the Moon revolves and rotates in the same amount of time, the same side of the Moon always faces Earth, as shown in **Figure 6.** The side of the Moon that does not face Earth is called the far side. You cannot see the Moon's far side from Earth.

Phases of the Moon

The Moon does not create its own light. The Moon is visible only because it reflects sunlight. As the Moon orbits Earth, the half of the Moon facing the Sun is in sunlight, and the half facing away is in shadow, as shown in **Figure 7.** However, as the Moon orbits Earth, the visible part of the Moon seems to change shape. These shapes are the phases of the Moon. The Moon completes a cycle of phases every 29.5 days.

New Moon and Waxing Phases When the Moon is between Earth and the Sun, the sunlit half of the Moon faces away from Earth. The half facing Earth is dark because it is in shadow, as shown in Figure 7. This phase is called a new moon. During the two weeks following a new moon, more of the Moon becomes visible. *As the lit portion of the Moon becomes larger, the Moon is* **waxing.** The waxing phases are waxing crescent, first quarter, and waxing gibbous.

Full Moon and Waning Phases When Earth is between the Moon and the Sun, the entire sunlit half of the Moon faces Earth. This phase, represented by the image of the Moon at the top of Figure 7, is called a full moon. During the two weeks following a full moon, less of the sunlit side of the Moon is visible. *As the lit portion of the Moon becomes smaller, the Moon is* **waning.** The waning phases are waning gibbous, last quarter, and waning crescent.

Phases of the Moon

Concepts in Motion Animation

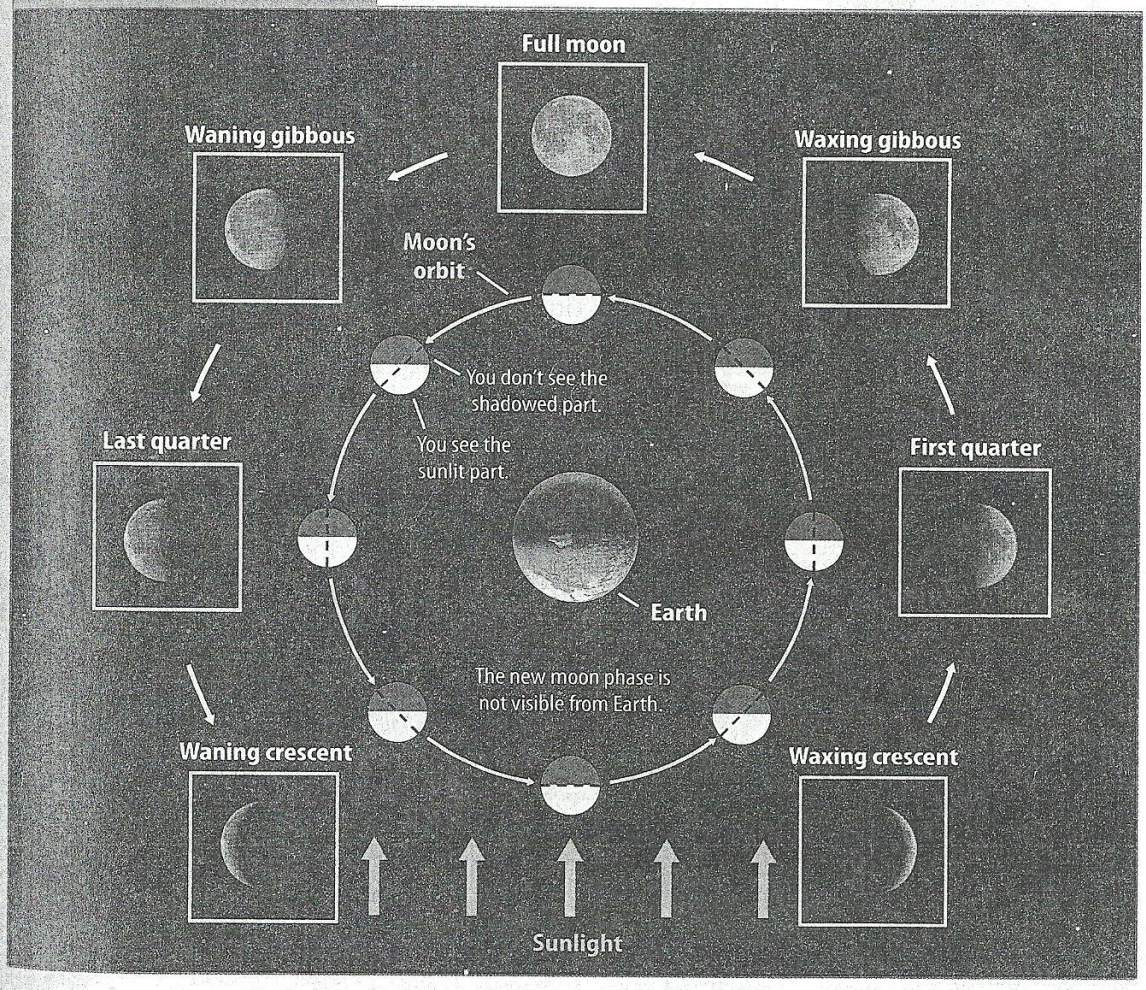
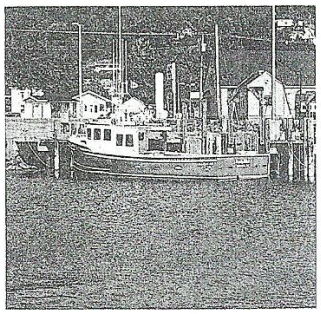
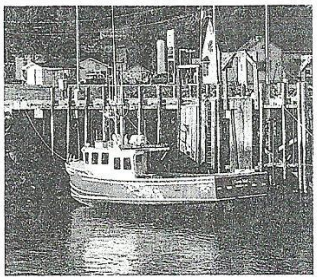


Figure 7 The Sun always shines on half of the Moon as the Moon orbits Earth. But only part of the Moon's sunlit half is visible from Earth.

Visual Check When does the Moon appear to get larger? When does is appear to get smaller?





▲ **Figure 8** These pictures were taken at the same place but at different times of day. The top photograph shows high tide, and the bottom photograph shows low tide.

Tides

Water levels of the ocean change, as shown in **Figure 8.** **Tides** *are the periodic rise and fall of the oceans' surfaces caused by the gravitational force between Earth and the Moon and the Sun.* The Moon has about twice as much influence on tides because it is so much closer to Earth than the Sun.

Effect of the Moon

Locations on Earth closest to and farthest from the Moon undergo the largest tidal effect. Water on Earth bulges slightly at these locations, as illustrated in **Figure 9,** and high tides occur. Places on Earth halfway between the two high-tide regions have low tides. As Earth rotates, the locations of high tide and low tide change in predictable ways. Most coastlines have two high tides and two low tides each day. But tides also are affected by water depth, coastline shape, and weather.

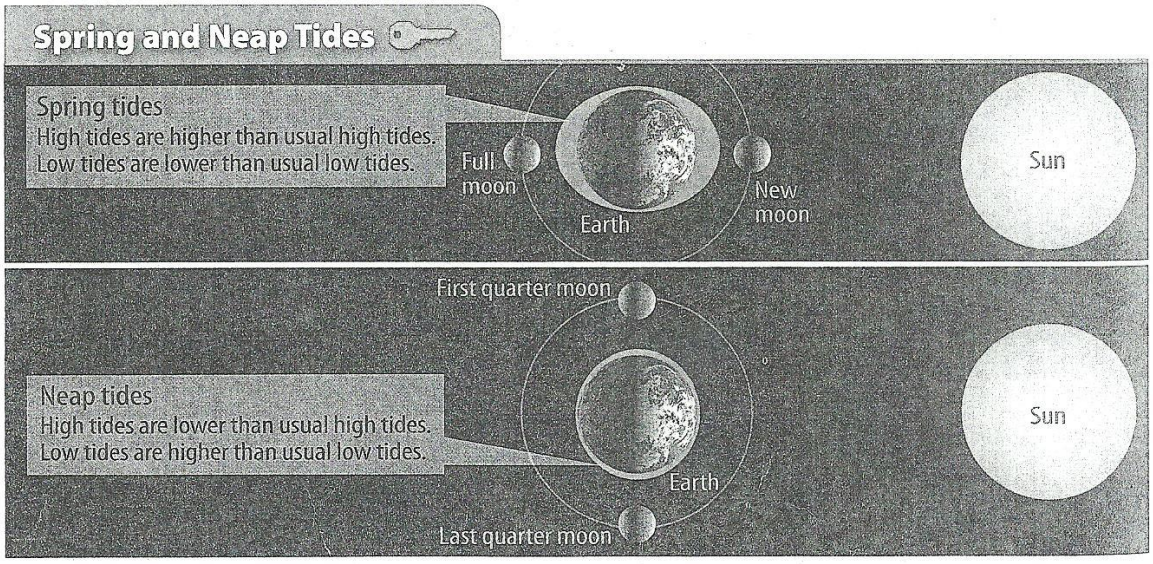
Key Concept Check How does the Moon cause tides on Earth?

Effect of the Sun

When Earth and the Moon are in line with the Sun, the Sun's gravitational pull adds to the Moon's gravitational pull. As a result, high tides are higher than usual, as shown in the top of **Figure 9.** Tides at this time are called spring tides. Spring tides occur during full moon and new moon phases.

During the first and third quarter moons, the gravitational pull of the Moon is perpendicular to the gravitational pull of the Sun, as shown in the bottom of **Figure 9.** High tides are lower than usual. Tides at these times are called neap tides.

Figure 9 The Sun's gravity affects tides more when the Moon is in line with, not perpendicular to, the Sun. ▼



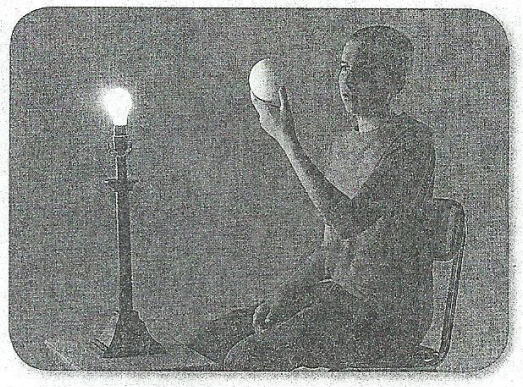
MiniLab

10 minutes

What causes eclipses?

Throughout human history, people have interpreted eclipses as signs of war or disaster. But there is nothing superstitious about eclipses. They are natural events.

1. Read and complete a lab safety form.
2. Hold a **plastic foam ball** between your face and a **lightbulb.** The ball represents the Moon, the lightbulb represents the Sun, and your head represents Earth. Sit or stand so the Moon covers the Sun. What is this phase of the Moon? Have a partner observe where the Moon's shadow falls. Record your observations in your Science Journal.
3. Turn so your head is directly between the Sun and the Moon. Hold the ball in front of your face. What is this phase of the Moon? Record your observations.



Analyze and Conclude

1. **Identify** Which type of eclipse did you model each time?
2. **Key Concept** How do the positions of Earth and the Moon cause eclipses?

Eclipses

An **eclipse** *is the movement of one solar system object into the shadow of another object.* You can view solar and lunar eclipses from Earth.

Solar Eclipses

A solar eclipse can only occur during a new moon, as shown in the top of **Figure 10.** During a solar eclipse, a small part of Earth is in the Moon's shadow. The Moon appears to completely or partially cover the Sun.

Lunar Eclipses

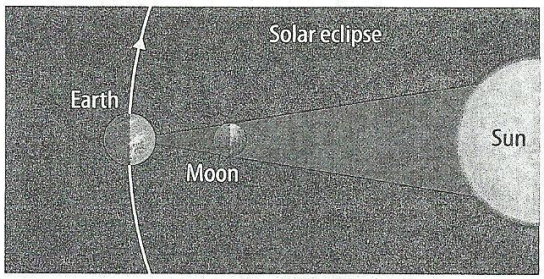
A lunar eclipse only can occur during a full moon, as shown in the bottom of **Figure 10.** During a lunar eclipse, Earth's shadow completely or partially covers the Moon. The Moon is visible during a total lunar eclipse because light changes direction as it passes through Earth's atmosphere. The light that reaches the Moon appears red.

Key Concept Check How do solar and lunar eclipses differ?

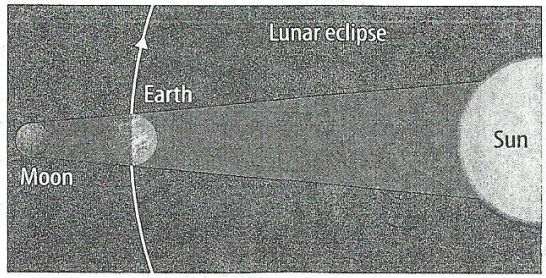
Figure 10 The type of eclipse depends on the positions of the Moon, Earth, and the Sun.

Visual Check Where would you have to be on Earth to see this total solar eclipse?

Concepts in Motion Animation



During a total solar eclipse, only a small part of Earth is covered by the Moon's shadow.



During a total lunar eclipse, the Moon is completely covered by Earth's shadow.