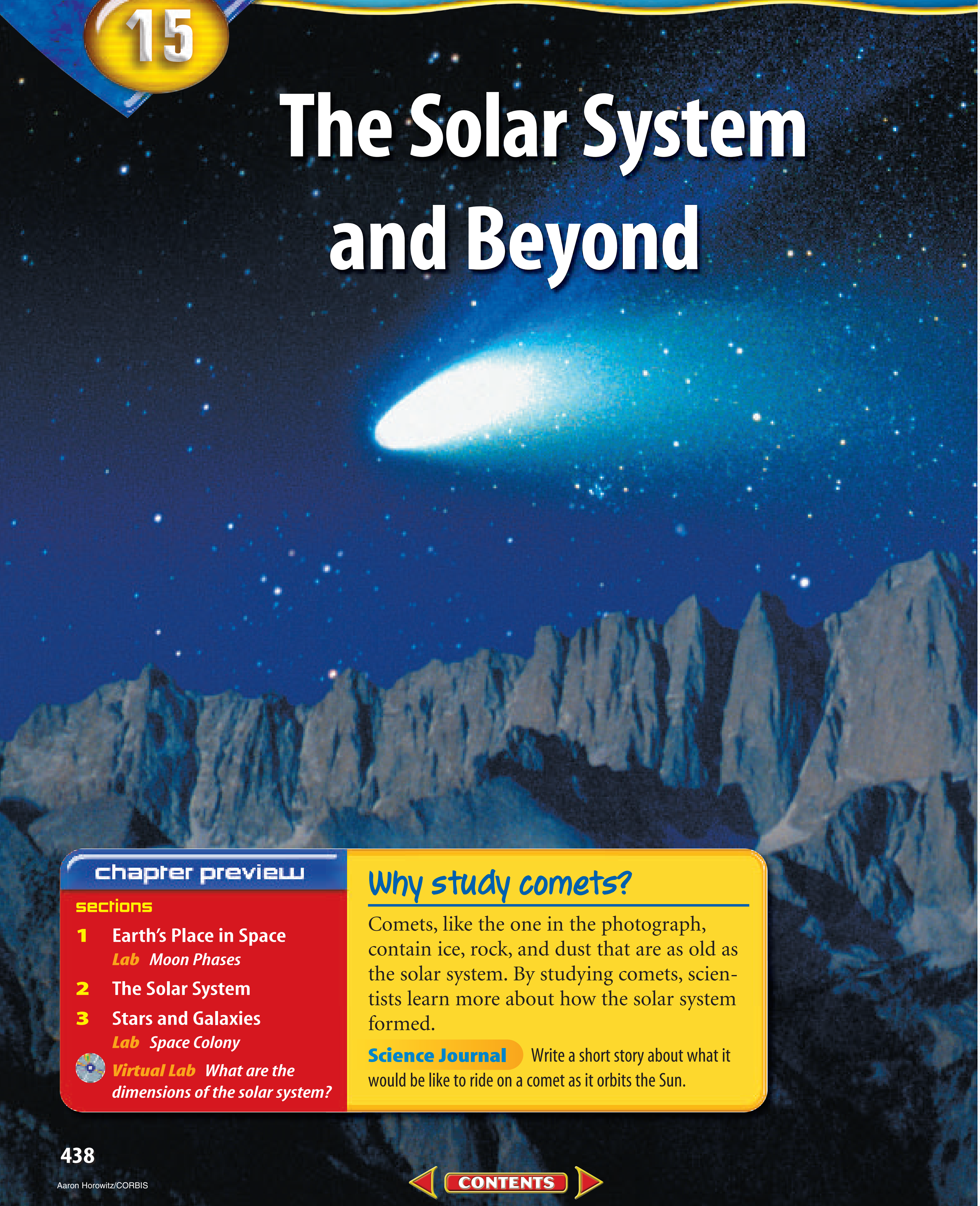
chapter 15

The Solar System and Beyond



chapter preview

sections

1 Earth's Place in Space
Lab *Moon Phases*

2 The Solar System

3 Stars and Galaxies
Lab *Space Colony*

Virtual Lab *What are the dimensions of the solar system?*

Why study comets?

Comets, like the one in the photograph, contain ice, rock, and dust that are as old as the solar system. By studying comets, scientists learn more about how the solar system formed.

Science Journal Write a short story about what it would be like to ride on a comet as it orbits the Sun.

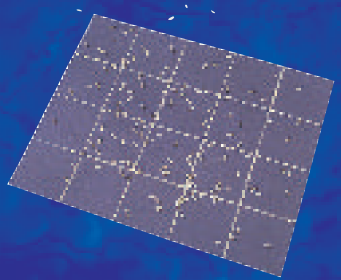
Aaron Horowitz/CORBIS

Start-Up Activities

Launch LAB

How many stars are in the sky?

On a clear night, the sky is full of sparkling points of light. With the unaided eye, you can see hundreds of these sparkles. How many stars are there?



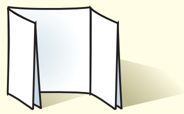
1. Using white crayon or chalk and a ruler, draw grid lines on a sheet of black construction paper, dividing it into 5-cm squares.
2. Spill 4 g of rice grains onto the black paper.
3. Count the number of grains of rice in one square. Repeat this step with a different square. Add the number of grains of rice in the two squares. Divide this number by two to calculate the average number of grains of rice in the two squares.
4. Multiply this number by the number of squares on the paper to get an estimate of the number of rice grains on the paper.
5. **Think Critically** How could scientists use a similar method to estimate the number of stars in the sky?

FOLDABLES™ Study Organizer

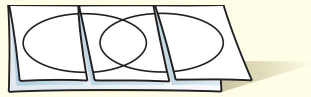
Planets in the Solar System Make the following Foldable to compare and contrast the inner planets and the outer planets.

STEP 1 **Fold** one sheet of paper lengthwise.

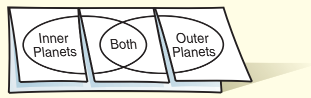
STEP 2 **Fold** into thirds.



STEP 3 **Unfold and draw** overlapping ovals. Cut the top sheet along the folds.



STEP 4 **Label** the ovals as shown.



Construct a Venn Diagram As you read the chapter, list the characteristics unique to the inner planets under the left tab. List those unique to the outer planets under the right tab. List characteristics that are common to both inner and outer planets under the middle tab.

Science Online

Preview this chapter's content and activities at red.msscience.com

section 1

Earth's Place in Space

as you read

What You'll Learn

- **Explain** Earth's rotation and revolution.
- **Explain** why Earth has seasons.
- **Model** the relative positions of Earth, the Moon, and the Sun during different lunar phases.

Why It's Important

You'll understand night and day and the seasons.

Review Vocabulary

axis: the imaginary line around which a planet or moon rotates

New Vocabulary

- rotation
- orbit
- revolution
- lunar highlands
- maria
- eclipse
- tides

Earth Moves

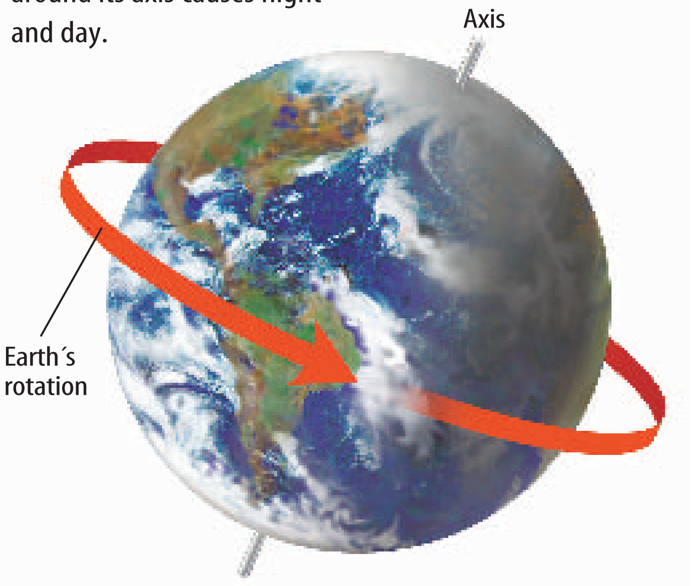
You wake up, stretch and yawn, then glance out your window to see the first rays of dawn. By lunchtime, the Sun is high in the sky. As you sit down to dinner in the evening, the Sun appears to sink below the horizon. Although it seems like the Sun moves across the sky, it is Earth that is moving.

Earth's Rotation Earth spins in space like a twirling figure skater. Your planet spins around an imaginary line running through its center called an axis. **Figure 1** shows how Earth spins around its axis.

The spinning of Earth around its axis is called Earth's **rotation** (roh TAY shun). Earth rotates once every 24 h. The Sun appears each morning due to Earth's rotation. Throughout the day, Earth continues to rotate and the Sun appears to move across the sky. In the evening, the Sun seems to go down because the place where you are on Earth is rotating away from the Sun.

You can see how this works by standing and facing a lamp. Pretend you are Earth and the lamp is the Sun. Now, without pivoting your head, turn around slowly in a counterclockwise direction. The lamp seems to move across your vision, then disappear. You rotate until you finally see the lamp again. The lamp didn't move—you did. When you rotated, you were like Earth rotating in space, causing different parts of the planet to face the Sun at different times. The rotation of Earth—not movement of the Sun—causes night and day.

Figure 1 The rotation of Earth around its axis causes night and day.



Reading Check *Why does the Sun appear to move across the sky?*

Because the Sun only appears to move across the sky, this movement is called apparent motion. Stars, planets, and the Moon also appear to move across the sky. You might have observed the Moon rise and set, just like the Sun. How can you recognize apparent motion that results from Earth's rotation?

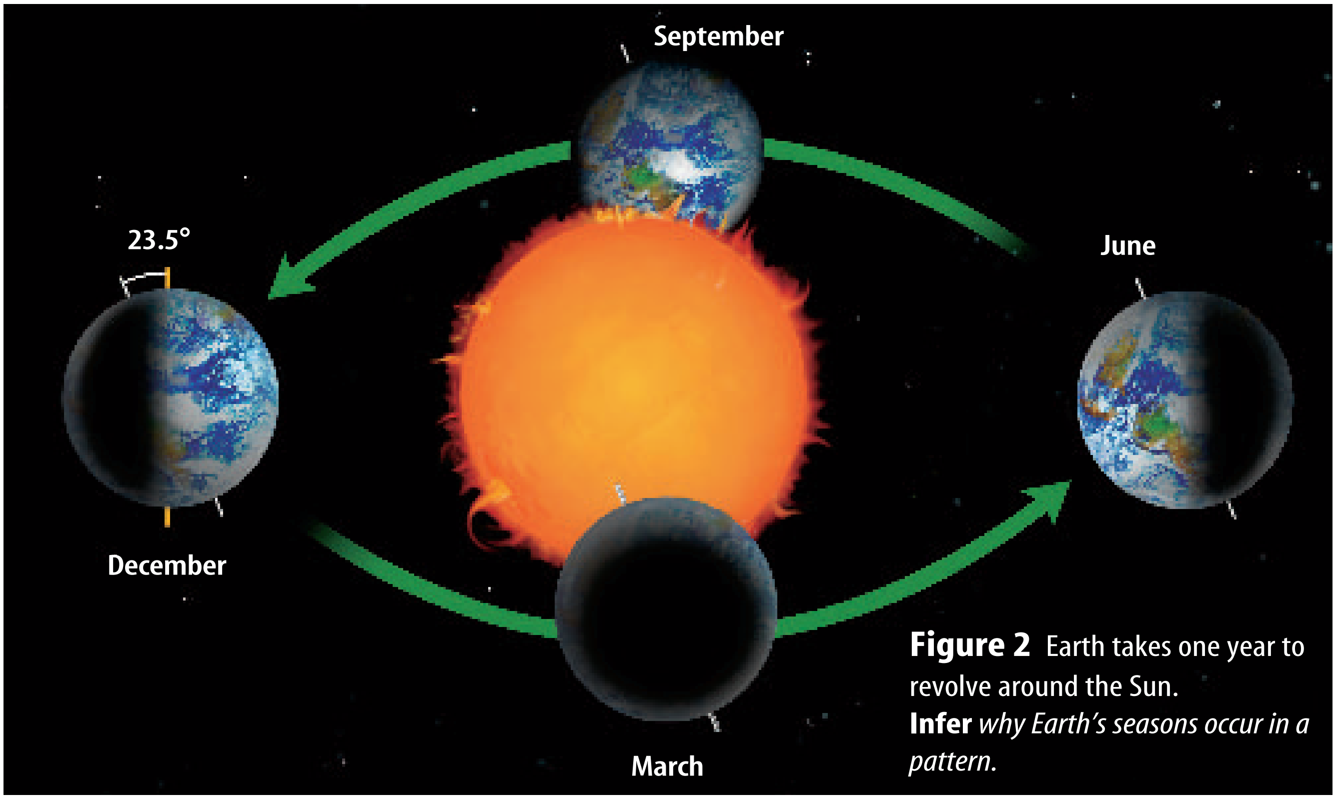


Figure 2 Earth takes one year to revolve around the Sun.
Infer *why Earth's seasons occur in a pattern.*

Earth's Revolution

Earth rotates in space, but it also moves in other ways. Like an athlete running around a track, Earth moves around the Sun in a regular, curved path called an **orbit**. The movement of Earth around the Sun is known as Earth's **revolution** (reh vuh LEW shun). A year on Earth is the time it takes for Earth to complete one revolution, as seen in **Figure 2.**

Seasons

Who doesn't love summer? The long, warm days are great for swimming, biking, and relaxing. Why can't summer last all year? Blame it on Earth's axis and revolution around the Sun. The axis is not straight up and down like a skyscraper—it is slightly tilted. It's because of this tilt and Earth's revolution that you experience seasons.

Look at **Figure 2.** Summer occurs when your part of Earth is tilted toward the Sun. During summer, sunlight strikes at a higher angle than it does during winter. You might have noticed that when you go outside at noon, your shadow is shorter during summer than during winter. Because summer sunlight strikes at a higher angle, it is more intense than winter sunlight. There also are more hours of daylight during summer than during winter. These two factors cause summer to be warm. Six months later, when the part of Earth that you live on is tilted away from the Sun, you have winter. During winter, sunlight strikes at a lower angle than during summer. The days are short, and the nights are long. Autumn and spring begin when Earth is neither tilted toward nor away from the Sun.

Mini LAB

Modeling Earth's Seasons

Procedure

1. Place a **shaded lamp** on a **table** in your classroom. The lamp represents the Sun. Turn on the lamp, and turn off the overhead lights.
2. Using a **globe,** model Earth's position during each of the four northern hemisphere seasons. Remember to tilt the globe so that its axis makes an angle of about 23.5° from straight up.

Analysis

During which season did the light shine most intensely on the northern hemisphere of the globe? During which season did it shine least intensely?

INTEGRATE Career

Astronaunt Dr. Mae Jemison was a Science Mission Specialist on the space shuttle *Endeavor.* While in space, she studied bone cells and biofeedback. On Earth, she directs the Jemison Institute, which brings new technologies to developing countries. If you want to be an astronaunt, like Dr. Jemison, you'll need to exercise your mind and your body.

Earth's Moon

Does the Moon look perfect to you? Many ancient people thought that the Moon's surface was perfectly smooth. This belief was common until about 400 years ago when a scientist named Galileo looked at the Moon through his telescope. Galileo saw large, mountainous regions with many craters. He also saw smooth, dark regions. The mountainous areas of the Moon are called **lunar highlands.** The lunar highlands are about 4.5 billion years old. The many craters on the lunar highlands formed when meteorites hit the Moon just after it formed. The smooth, dark regions of the Moon are called **maria,** which is the Latin word for *sea.* The maria formed when lava erupted from the Moon's interior and cooled in low areas on its surface.

Orbiting Earth While Earth revolves around the Sun, the Moon and a variety of human-made objects orbit Earth. The Moon revolves around Earth once every 27.3 days. It has an average distance from Earth of 384,400 km. This is like traveling from Los Angeles to New York and back again 49 times. Other objects orbit much closer to Earth than the Moon does. These objects include the *International Space Station,* a wide variety of satellites, and much debris. The debris, often called space junk, consists of parts from old rockets and a variety of discarded tools and equipment.

Rotation and Revolution How long does it take for the Moon to rotate one time? The answer is 27.3 days—exactly the same amount of time that it takes for the Moon to revolve around Earth one time. Because the Moon rotates and revolves at the same rate, the same side of the Moon always faces Earth. The side of the Moon that faces Earth is called the near side. The opposite side of the Moon is called the far side. If you've ever ridden on a playground merry-go-round, you rotated and revolved somewhat like the Moon. Look at **Figure 3.** When you ride on a merry-go-round, your body rotates at exactly the same rate as it revolves. You always face the center of the merry-go-round, just like the Moon always keeps the same face toward Earth.

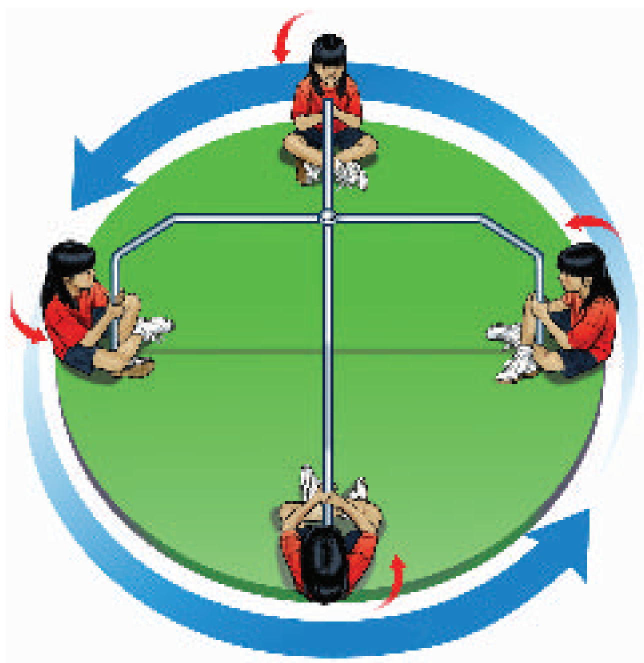
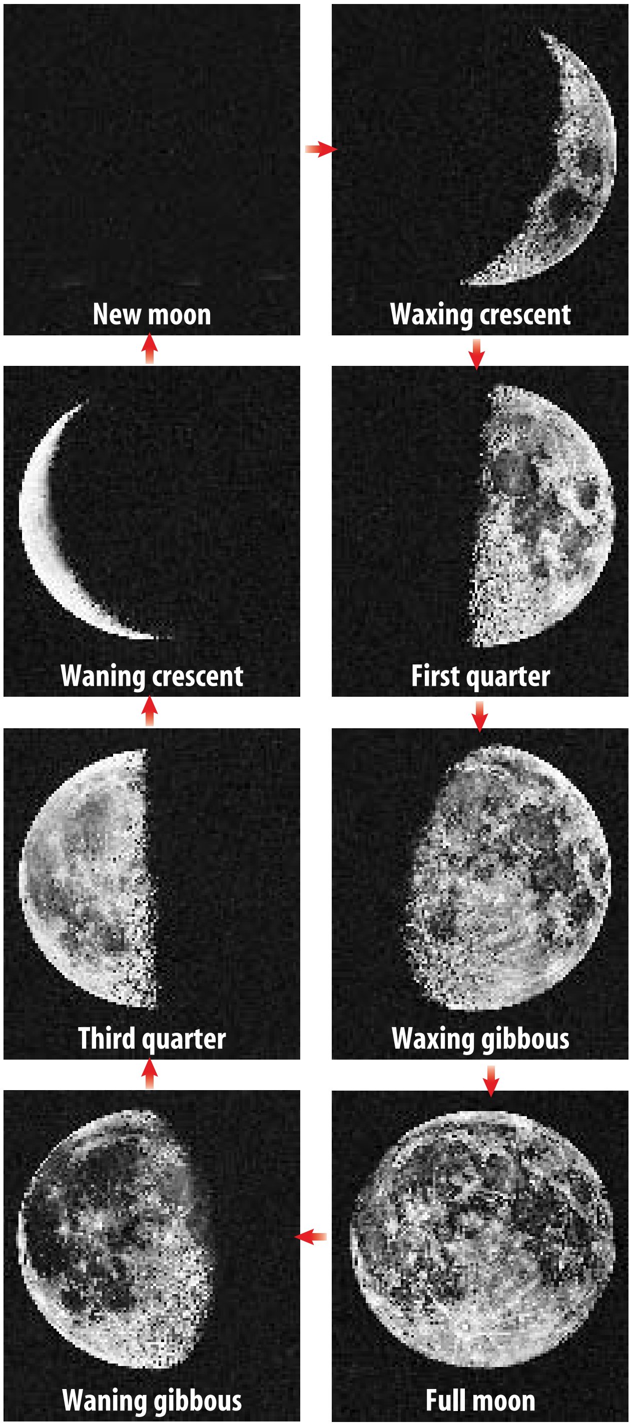


Figure 3 When you ride on a merry-go-round, it takes the same amount of time for you to rotate as it does for you to revolve around the center.
Explain *how this is similar to the way the Moon rotates and revolves.*

Moon Phases How many different moon shapes have you seen? Have you seen the Moon look round or maybe like a half circle? Although the Moon looks different at different times of the month, it doesn't change. What does change is the way the Moon appears from Earth. These changes are called phases of the Moon. **Figure 4** shows the various phases of the Moon.

Figure 4 When the moon phases get larger, they are said to be waxing. When the moon phases get smaller, they are waning. **Explain** *the difference between a waxing crescent and a waning crescent.*



Lick Observatory

Light from the Sun The Moon does not produce its own light. The light that comes to Earth from the Moon is reflected sunlight. Also, just as half of Earth experiences day while the other half experiences night, one half of the Moon is lit by the Sun while the other half is dark.

The Lunar Cycle The phase of the Moon that you see on any given night depends on the relative positions of the Moon, the Sun, and Earth in space. These positions change because the Moon is continually revolving around Earth as Earth revolves around the Sun. It takes the Moon about one month to go through its phases. During that time, called a lunar cycle, you see different portions of the daylight side of the Moon.

The lunar cycle begins with new moon. During new moon, the Moon is between Earth and the Sun. Half of the Moon is lit by the Sun, but this half can't be seen from Earth. For about two weeks after new moon, the portion of the lit side of the Moon that can be seen from Earth increases. At first, only a small crescent is visible. Then, you see the first quarter moon followed by the gibbous moon. Finally, the Moon is full. At full moon, Earth is between the Moon and the Sun, and the entire near side of the Moon is visible from Earth. For about two weeks after full moon, the moon phase appears to get smaller. The phase gradually changes from a gibbous moon, to a third quarter moon, crescent moon, and finally new moon again.

Reading Check *What is the lunar cycle?*

Recall that the near side of the Moon always faces Earth. This means that during the new moon phase, the far side of the Moon is lighted by the Sun. The far side of the Moon is lighted just as much as the near side is. The far side can't be seen from Earth because it is always facing away from it.

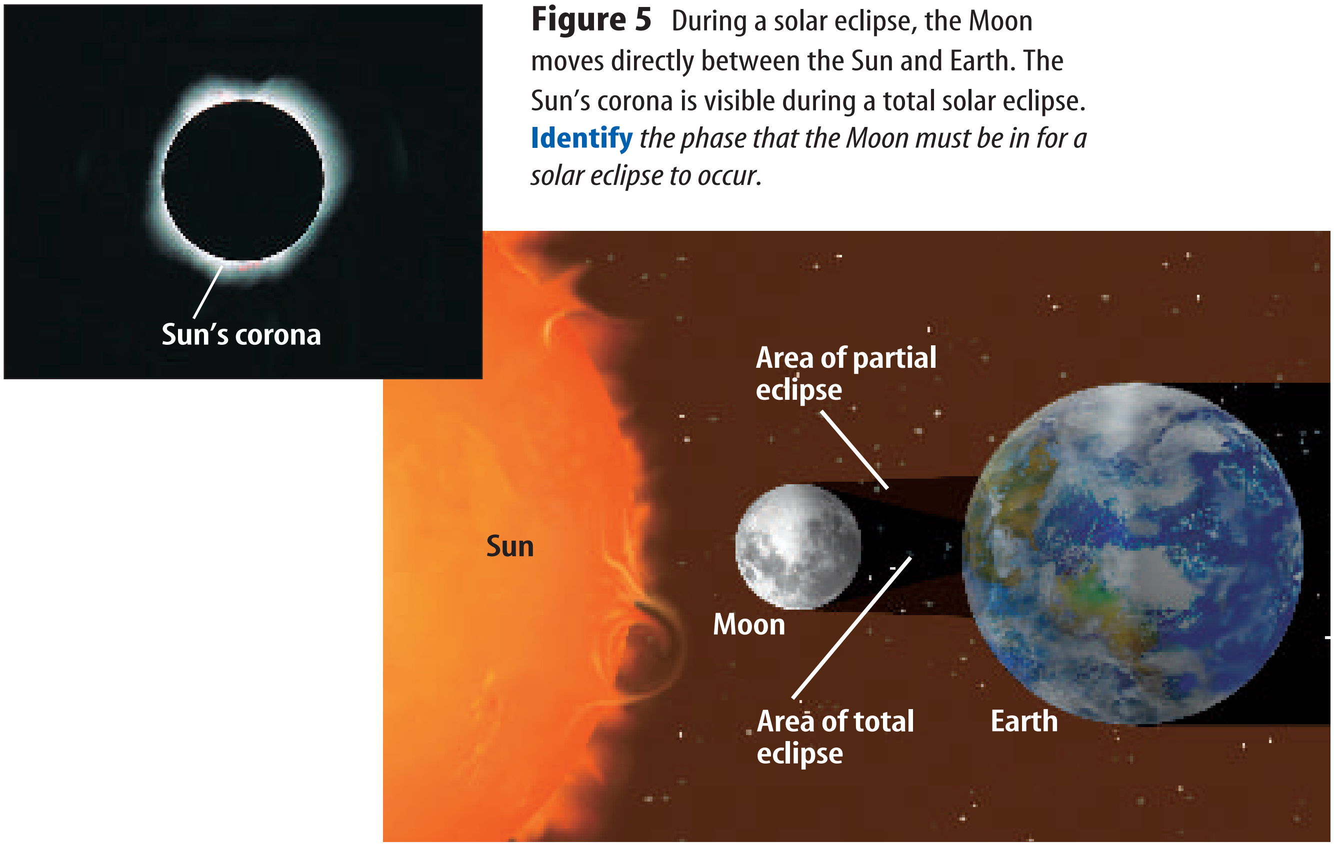


Figure 5 During a solar eclipse, the Moon moves directly between the Sun and Earth. The Sun's corona is visible during a total solar eclipse.
Identify *the phase that the Moon must be in for a solar eclipse to occur.*

Science Online
Topic: Eclipse Data
Visit red.msscience.com for Web links to information about future solar and lunar eclipses.

Activity Find out when you will next be able to observe an eclipse in your region.

Solar Eclipse Have you ever tried to watch TV with someone standing between you and the screen? You can't see a thing. The picture from the screen can't reach your eyes because someone is blocking it. Sometimes the Moon is like that person standing in front of the TV. It moves directly between the Sun and Earth and blocks sunlight from reaching Earth. The Moon's shadow travels across parts of Earth. This event, shown in **Figure 5,** is an example of an **eclipse** (ih KLIHPS). Because it is an eclipse of the Sun, it is known as a solar eclipse. The Moon is much smaller than the Sun, so it casts a small shadow on Earth. Sunlight is blocked completely only on the small area of Earth where the Moon's darker shadow falls. In that area, the eclipse is said to be a total solar eclipse.

Reading Check *What causes solar eclipses?*

Due to the small size of the shadow—about 269 km wide—only a lucky few get to experience each solar eclipse. For the few minutes the total eclipse lasts, the sky darkens, flowers close, and some planets and brighter stars become visible. The Sun's spectacular corona, its pearly white, outermost layer, can be observed. Far more people will be in the lighter part of the Moon's shadow and will experience a partial solar eclipse. **WARNING:** *Never look at the Sun during an eclipse. You might damage your eyes.*

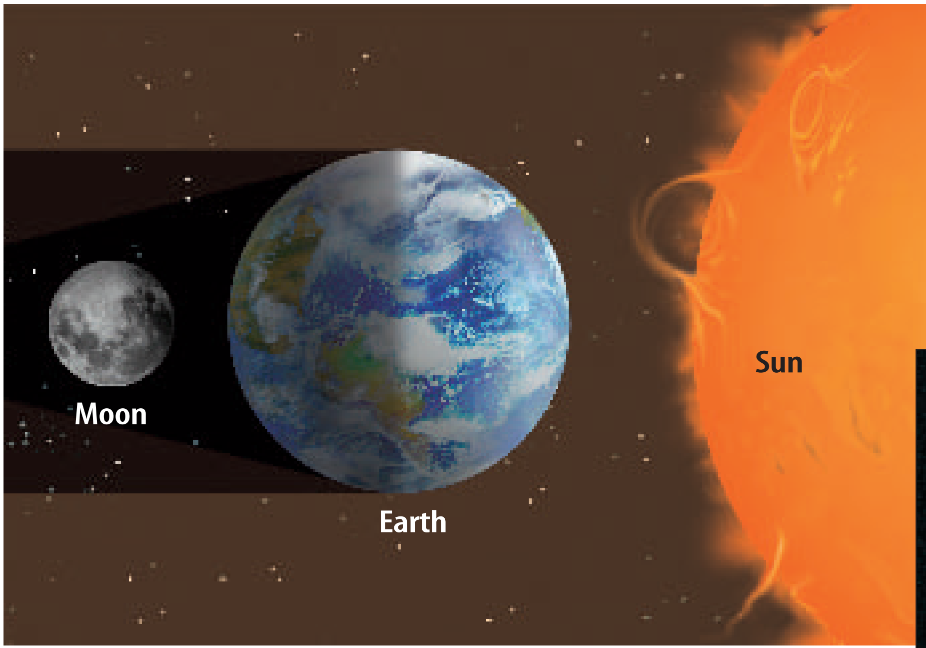


Figure 6 During a lunar eclipse, Earth is between the Sun and the Moon. The Moon often appears red during a lunar eclipse.
Infer *why lunar eclipses are observed more frequently than solar eclipses.*

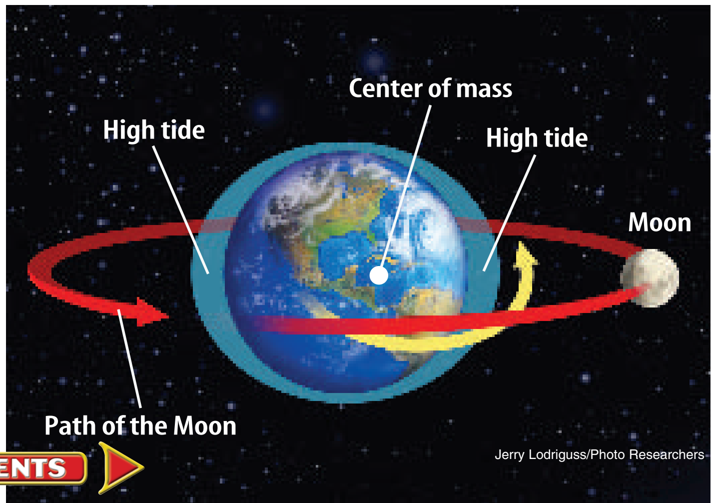
Lunar Eclipse Sometimes Earth is directly between the Sun and the Moon. When Earth's shadow falls on the Moon, an eclipse of the Moon occurs. This is called a lunar eclipse. Everyone on the nighttime side of Earth, weather permitting, can see a lunar eclipse. When eclipsed, the full moon becomes dim and sometimes turns deep red, as shown in **Figure 6.**

Tides The Moon's gravity pulls on Earth. One effect of the Moon's gravity is tides. **Tides** are an alternate rise and fall in sea level. They are most noticeable along a beach. At high tide, water moves farther onto the beach. At low tide, water moves off the beach.

Tides occur because the Moon's gravity decreases with distance from the Moon. Places on Earth closer to the Moon are pulled harder than places that are farther from the Moon. The Moon's gravity holds Earth in its path around the center of mass of the Earth-Moon system. At places on Earth that are closer to the Moon, the Moon's gravity is a bit stronger than it needs to be to hold Earth. At places on Earth that are farther from the Moon, the Moon's gravity is a bit weaker than it needs to be.

The small differences in the Moon's gravity cause the water in Earth's oceans to form two bulges, shown in **Figure 7.** One bulge is on the side of Earth toward the Moon, and one is on the opposite side. These bulges of water are the high tides. The areas of Earth that are neither toward nor away from the Moon are the low tides. As Earth rotates, different places pass through high and low tide.

Figure 7 Tides form because the Moon's gravity pulls harder on parts of Earth that are closer to it. Two tidal bulges occur—one on the side of Earth closest to the Moon, and one on the opposite side of Earth.



Jerry Lodriguss/Photo Researchers

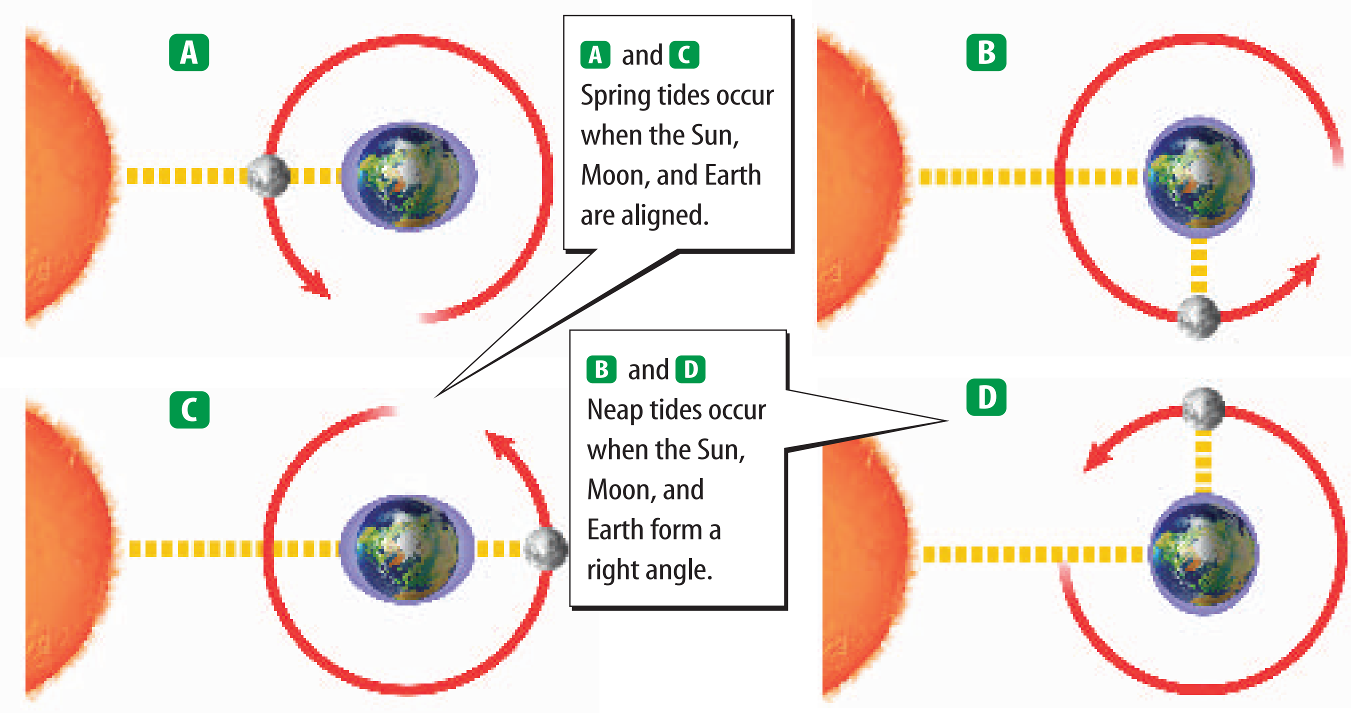


Figure 8 Because the Moon revolves around Earth, spring tides and neap tides occur about twice each month.

The Sun's Effect on Tides The Sun also affects tides on Earth. Because the Sun is much farther from Earth, it has about half as much tide-generating force as the Moon. When the Sun, Earth, and the Moon are lined up, high tides are higher and low tides are lower. This is called spring tide, as shown in **Figure 8.** Spring tides occur because the Moon's gravity and the Sun's gravity combine to produce a greater effect. When the Sun, Earth, and the Moon form a 90° angle, high tides are lower and low tides are higher. This condition, also shown in **Figure 8,** is called neap tide. During neap tide, the Sun's gravity reduces the tide-generating effect of the Moon's gravity.

section 1 review

Summary

Earth Moves

- Seasons occur because of Earth's tilted axis and Earth's revolution around the Sun.

Earth's Moon

- The Moon has many surface features including craters, maria, and lunar highlands.
- Different moon phases occur depending on the positions of the Sun, Earth, and the Moon.

Tides

- The Moon has the greatest effect on Earth's tides. The Sun has a lesser effect.

Self Check

1. **Define** Earth's revolution and rotation.
2. **Explain** why lunar eclipses occur during a full moon.
3. **Compare and contrast** spring tides and neap tides.
4. **Think Critically** What would seasons be like if Earth's axis were tilted at a higher angle (more than 23.5°)?

Applying Skills

5. **Research Information** Some scientific knowledge is very old, yet it still is correct today. Do research to learn how much the ancient Mayan civilization knew about the length of a year.

Science Online red.msscience.com/self_check_quiz
CONTENTS

Moon Phases

The Moon is Earth's nearest neighbor in space. The Sun, which is much farther away, is the source of light that reflects off of the moon. In this lab, you'll observe how the positions of the Sun, the Moon, and Earth cause the different phases of the Moon.

Real-World Question

How do the positions of the Sun, the Moon, and Earth affect the phases of the Moon?

Goals

- **Model and observe** moon phases.
- **Record and label** phases of the Moon.
- **Infer** how the positions of the Sun, the Moon, and Earth affect phases of the Moon.

Materials

drawing paper (several sheets)
softball
flashlight

Safety Precautions

Procedure

1. Turn on the flashlight and darken other lights in the room. Select a member of your group to hold the flashlight. This person will be the Sun. Select another member of your group to hold up the softball so that the light shines directly on the ball. The softball will be the Moon in your experiment.
2. Everyone else represents Earth and should sit between the Sun and the Moon.
3. **Observe** how light shines on the Moon. Draw the Moon, being careful to add shading to represent its dark portion.

4. The student who is holding the Moon should begin to walk in a slow circle around the group, stopping at least seven times at different spots. Each time the Moon stops, observe it, draw it, and shade in its dark portion.

Conclude and Apply

1. **Compare and contrast** your drawings with those of other students. Discuss similarities and differences in the drawings.
2. In your own words, explain how the positions of the Sun, the Moon, and Earth affect the phase of the Moon that is visible from Earth.
3. **Compare** your drawings with **Figure 4.** Which phase is the Moon in for each drawing? Label each drawing with the correct moon phase.

Communicating Your Data

Use your drawings to make a poster explaining phases of the Moon. **For more help, refer to the Science Skill Handbook.**

Doug Martin

section 2

The Solar System

as you read

What You'll Learn

- **Compare and contrast** the planets and moons in the solar system.
- **Explain** that Earth is the only planet known to support life.

Why It's Important

Much can be learned about Earth by studying the solar system.

Review Vocabulary

system: a portion of the universe and all of its components, processes, and interactions

New Vocabulary

- solar system
- astronomical unit
- comet
- meteorite

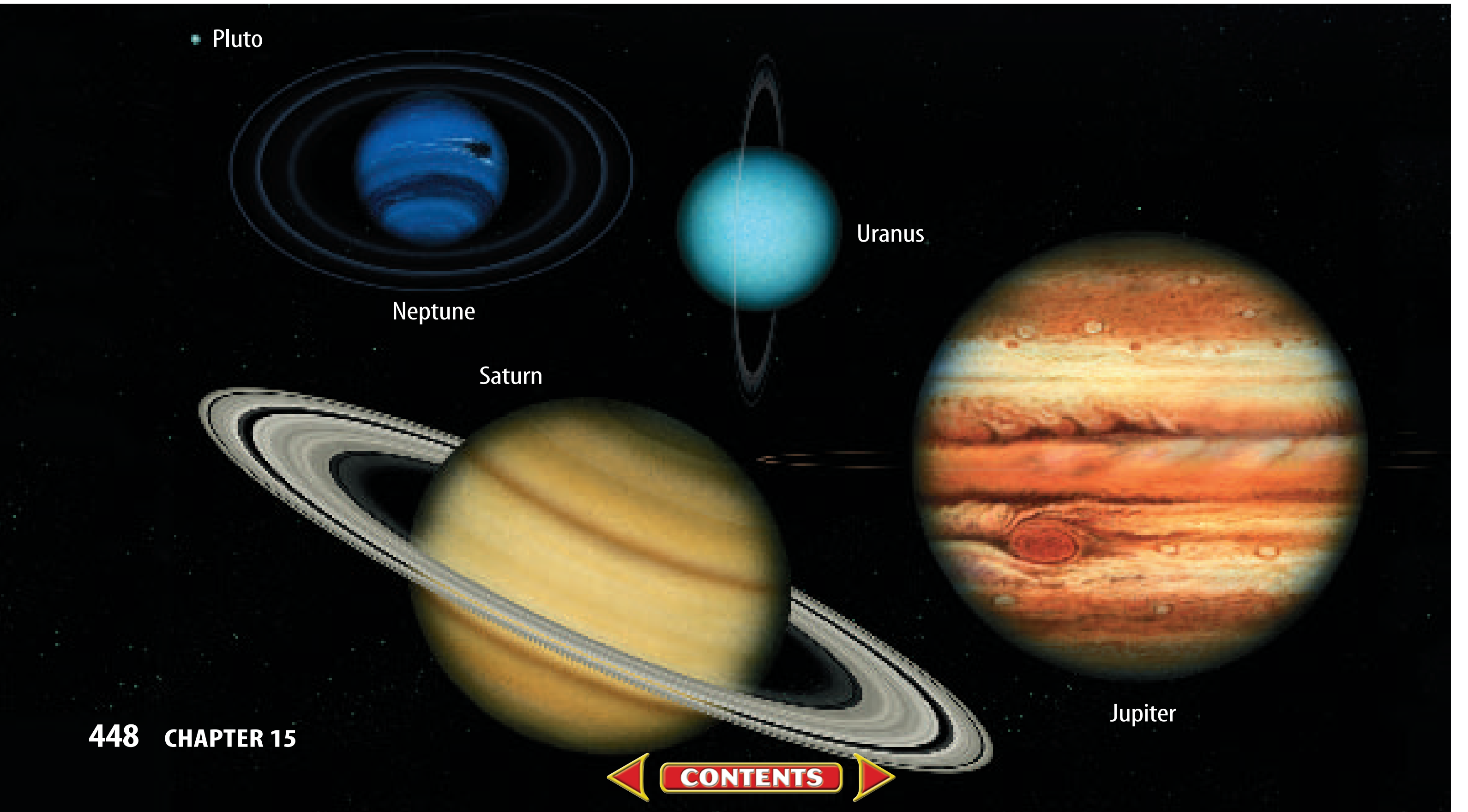
Distances in Space

Imagine that you are an astronaut living in the future, doing research on a space station in orbit around Earth. You've been working hard for a long time and need a vacation. Where will you go? How about a tour of the solar system? The **solar system**, shown in **Figure 9**, is made up of the nine planets and numerous other objects that orbit the Sun, all held in place by the Sun's immense gravity.

Reading Check *What holds the solar system together?*

The planets in the solar system revolve around the Sun in elliptical orbits. The orbits of most of the planets are only slightly elliptical. They are almost circular. Pluto and Mercury have orbits that are more elliptical. Their orbits are similar to a slightly flattened circle.

Figure 9 The Sun is the center of the solar system, which is made up of the nine planets and other objects that orbit the Sun.
Compare and contrast *the sizes of the different planets.*



Measuring Space Distances in space are hard to imagine because space is so vast. Suppose you had to measure your pencil, the hallway outside your classroom, and the distance from your home to school. Would you use the same unit for each measurement? No. You probably would measure your pencil in centimeters. You would use something bigger to measure the length of the hallway, such as meters. You might measure the trip from your home to school in kilometers. Larger units are used to measure longer distances. Imagine trying to measure the trip from your home to school in centimeters. If you didn't lose count, you'd end up with a huge number.

Astronomical Unit Kilometers are fine for measuring long distances on Earth, such as the distance from New York to Chicago (about 1,200 km). Even bigger units are needed to measure vast distances in space. One such measure is the astronomical (as truh NAH mih kul) unit. An **astronomical unit** equals 150 million km, which is the average distance from Earth to the Sun. Astronomical unit is abbreviated *AU*. If something is 3 *AU* away from the Sun, then the object is three times farther from the Sun than Earth is. The *AU* is a convenient unit for measuring distances in the solar system.

Reading Check *Why is the astronomical unit useful for measuring distances in the solar system?*

Science Online

Topic: Space Technology
Visit red.msscience.com for Web links about technology that is used to explore space.

Activity Create a concept map that explains why technology is essential to science.

Mini LAB

Observing Planets

Procedure

1. Research which planets currently are visible in the night sky.
2. Select a planet to watch for three to four weeks. You might choose Jupiter, Saturn, Mars, or Venus.
3. Observe the planet at the same time each clear night. Note the planet's position compared to background stars.
4. You might want to use a **camera** to photograph the planet and background stars each night.

Analysis

1. Did the planet move against the background stars? If so, did it move from west to east or from east to west?
2. How can you explain the planet's movement?

Try at Home

Touring the Solar System

Now you know a little more about how to measure distances in the solar system. Next, you can travel outward from the Sun and take a look at the objects in the solar system. Maybe you can find a nice destination for your next vacation. Strap yourself into your spacecraft and get ready to travel. It's time to begin your journey. What will you see first?

Inner Planets

The first group of planets you pass is the inner planets. These planets are mostly solid, with minerals similar to those on Earth. As with all the planets, much of what is known comes from spacecraft that send data back to Earth. Various spacecraft took the photographs shown in **Figure 10** and the rest of this section. Some were taken while in space and others upon landing.

Mercury The first planet that you will visit is the one that is closest to the Sun. Mercury, shown in **Figure 10,** is the second-smallest planet. Its surface has many craters. Craters form when meteorites, which are chunks of rock or metal that fall from the sky, strike a planet's surface. You will read about meteorites later in this section. Because of Mercury's small size and low gravity, gases that could form an atmosphere escape into space. The lack of an atmosphere and the closeness of this planet to the Sun cause great extremes in temperature. Mercury's surface temperature can reach 425°C during the day and drop to −170°C at night, making the planet unfit for life.

Reading Check *Why do surface temperatures on Mercury vary so much?*

Venus You won't be able to see much at your next stop, also shown in **Figure 10.** Venus, the second-closest planet to the Sun, is hard to see because its surface is surrounded by thick clouds. These clouds trap the solar energy that reaches the surface of Venus. That energy causes surface temperatures to hover around 472°C—hot enough to bake a clay pot.

Figure 10 Mercury and Venus are closer to the Sun than Earth is.

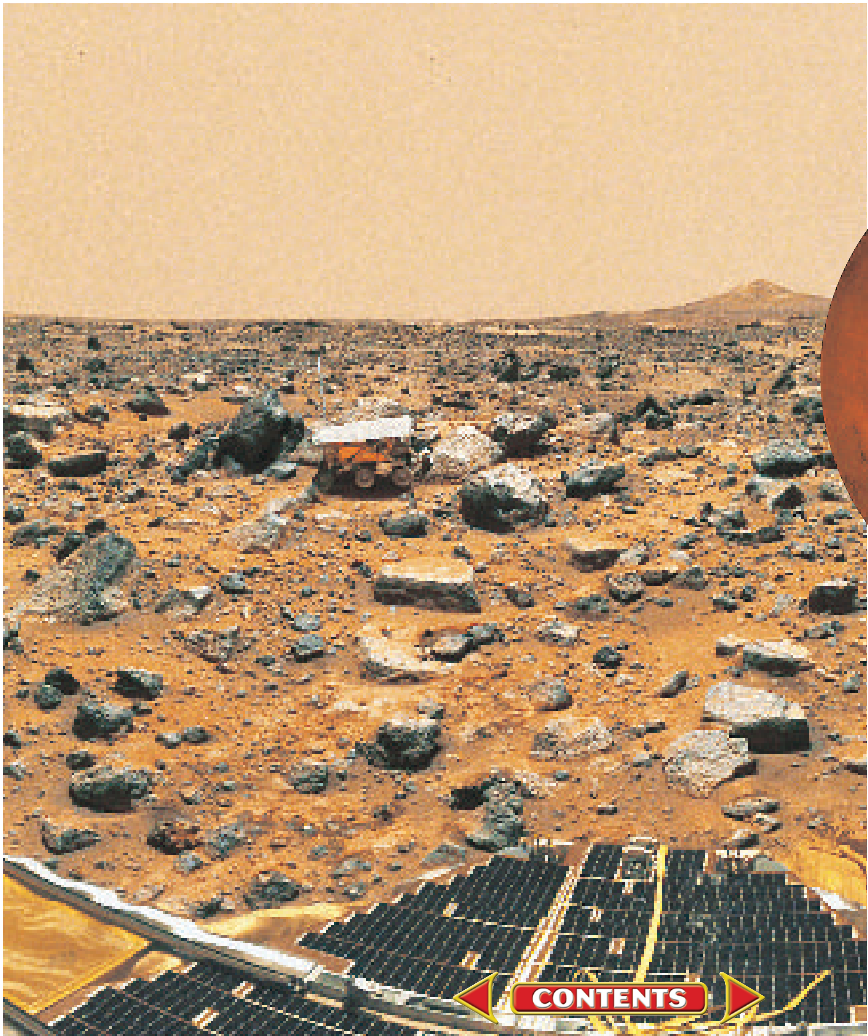
Like the Moon, Mercury's surface is scarred by craters.

Earth's closest neighbor, Venus, is covered in clouds.

Earth Home sweet home. You've reached Earth, the third planet from the Sun. You didn't realize how unusual your home planet was until you saw other planets. Earth's surface temperatures allow water to exist as a solid, a liquid, and a gas. Also, ozone in Earth's atmosphere works like a screen to limit the number of ultraviolet (ul truh VI uh lut) rays that reach the planet's surface. Ultraviolet rays are harmful rays from the Sun. Because of Earth's atmosphere, life can thrive on the planet. You would like to linger on Earth, shown in **Figure 11,** but you have six more planets to explore.

Mars Has someone else been here? You see signs of earlier visits to Mars, the fourth of the inner planets. Tiny robotic explorers have been left behind. However, it wasn't a person who left them here. Spacecraft that were sent from Earth to explore Mars's surface left the robots. If you stay long enough and look around, you might notice that Mars, shown in **Figure 12,** has seasons and polar ice caps. Signs indicate that the planet once had abundant liquid water. Water might even be shaping the surface of Mars today. You'll also notice that the planet looks red. That's because the sediment on its surface contains iron oxide, which is rust. Two small moons, Phobos and Deimos, orbit Mars.

Figure 11 As far as scientists know, Earth is the only planet that supports life.



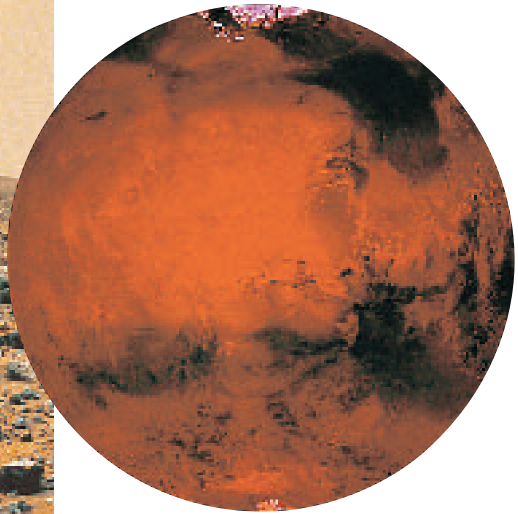


Figure 12 Mars often is called the Red Planet.
Explain *what causes Mars's surface to appear red.*

Asteroid Belt Look out for asteroids. On the next part of your trip, you must make your way through the asteroid belt that lies between Mars and the next planet, Jupiter. As you can see in **Figure 13,** asteroids are pieces of rock made of minerals similar to those that formed the rocky planets and moons. In fact, these asteroids might have become a planet if it weren't for the giant planet, Jupiter. Jupiter's huge gravitational force might have prevented a small planet from forming in the area of the asteroid belt. The asteroids also might be the remains of larger bodies that broke up in collisions. The asteroid belt separates the solar system's planets into two groups—the inner planets, which you've already visited, and the outer planets, which are coming next.

Reading Check *What are asteroids?*

Figure 13 This close-up of the asteroid Gaspra was taken by the *Galileo* spacecraft in 1991.
Describe *Gaspra's surface features.*

Outer Planets

Moving past the asteroids, you come to the outer planets. The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto. Let's hope you aren't looking for places to stop and rest. Trying to stand on most of these planets would be like trying to stand on a cloud. That's because all of the outer planets, except Pluto, are huge balls of gas called gas giants. Each might have a solid core, but none of them has a solid surface. The gas giants have lots of moons that orbit the planets just like Earth's Moon orbits Earth. They have rings surrounding them that are made of dust and ice. The only outer planet that doesn't have rings is Pluto. Pluto also differs from the other outer planets because it is composed of ice and rock.

Figure 14 Jupiter is the largest planet in the solar system.

Jupiter If you're looking for excitement, you'll find it on Jupiter, which is the largest planet in the solar system and the fifth from the Sun. It also has the shortest day—less than 10 h long—which means this giant planet is spinning faster than any other planet. Watch out for a huge, red whirlpool near the middle of the planet! That's the Great Red Spot, a giant storm on Jupiter's surface. Jupiter, shown in **Figure 14,** looks like a miniature solar system. It has 61 moons. One called Ganymede (GA nih meed) is larger than the planet Mercury. Ganymede, along with two other moons, Europa and Callisto, might have liquid water under their icy crust. Another of Jupiter's moons, Io, has more active volcanoes than any other object in the solar system.

Saturn You might have thought that Jupiter was unusual. Wait until you see Saturn, the sixth planet from the Sun. You'll be dazzled by its rings, shown in **Figure 15.** Saturn's several broad rings are made up of hundreds of smaller rings, which are made up of pieces of ice and rock. Some of these pieces are like specks of dust. Others are many meters across. Saturn is orbited by at least 31 moons, the largest of which is Titan. Titan has an atmosphere that resembles the atmosphere on Earth during primitive times. Some scientists hypothesize that Titan's atmosphere might provide clues about how life formed on Earth.

Uranus After Saturn, you come to Uranus, the seventh planet from the Sun. Uranus warrants a careful look because of the interesting way it spins around its axis. The axis of most planets is tilted just a little, somewhat like the handle of a broom that is leaning against a wall. Uranus, also shown in **Figure 15,** is nearly lying on its side. Its axis is tilted almost even with the plane of its orbit like a broomstick lying on the floor. Uranus's atmosphere is made mostly of hydrogen with smaller amounts of helium and methane. The methane gives Uranus its distinctive bluish-green color. Uranus has rings and is thought to have at least 21 moons.

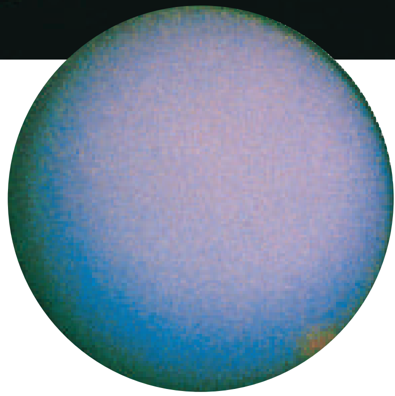


Figure 15 Saturn and Uranus are two of the four gas giant planets.

Applying Science

How can you model distances in the solar system?

The distances between the planets and the Sun are unimaginably large but definitely measurable. Astronomers have developed a system of measurement to describe these distances in space. Could you represent these vast distances in a simple classroom model? Use your knowledge of SI and your ability to read a data table to find out.

Identifying the Problem

The table shows the distances of the planets and asteroid belt from the Sun. Notice that the inner planets are fairly close together, and the outer planets are far apart. Study the distances carefully, then answer the questions.

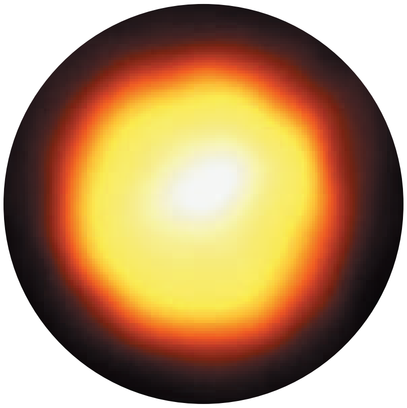
Solving the Problem

1. How can you make a scale model of the solar system that will fit in your classroom? What unit will you use to show the distances?
2. Show the conversion between astronomical units and the unit you use for your model.

Solar System Data

Planet	Distance from the Sun (AU)
Mercury	0.39
Venus	0.72
Earth	1.00
Mars	1.52
Asteroid belt	2–4
Jupiter	5.20
Saturn	9.54
Uranus	19.19
Neptune	30.07
Pluto	39.48

Neptune



Pluto

Figure 16 The outermost planets are Neptune and Pluto. This is the best image available of Pluto, which has not yet been visited by spacecraft.

Neptune Neptune is the next stop in your space travel. Neptune, shown in **Figure 16,** is the eighth planet from the Sun. Neptune's atmosphere is composed of hydrogen, helium, and methane. The methane gives the planet a blue color. In 1989, *Voyager 2* sent pictures of Neptune showing a Great Dark Spot in its atmosphere. The spot was gone when observations were made using the *Hubble Space Telescope* in 1994. Neptune is the last of the big, gas planets with rings around it. It has 11 moons. Triton, the largest of these, has geysers that shoot gaseous nitrogen into space. The low number of craters on Triton indicates that lava still flows onto its surface.

(t)NASA/JPL, (b)Dr. R. Albrecht, ESA/ESO Space Telescope European Coordinating Facility/NASA

Pluto The last planet that you come to on your tour is Pluto, a small, rocky planet with a frozen crust. Pluto was discovered in 1930 and is farthest from the Sun. It is the smallest planet in the solar system—smaller even than Earth's moon—and the one scientists know the least about. It is the only planet in the solar system that has never been visited by a spacecraft. Pluto, shown in **Figure 16,** has one moon, Charon, which is nearly half the size of the planet itself.

Comets

A **comet** is a large body of ice and rock that travels around the Sun in an elliptical orbit. These objects are like dirty snowballs that often are between one and fifty kilometers across. Comets might originate in a cloud of objects far beyond the orbit of Pluto known as the Oort Cloud. This belt is 50,000 AU from the Sun. Some comets also originate in the Kuiper Belt, which lies just beyond the orbit of Neptune. As a comet approaches the Sun, solar radiation changes some of the ice into gas. Solar winds blow gas and dust away from the comet, forming what appears from Earth as a bright tail, shown in **Figure 17.**

Reading Check *Why do comets have tails?*

Figure 17 Solar wind is a stream of charged particles moving away from the Sun. Comet tails point away from the Sun because they are pushed by solar wind.

Meteorites Occasionally, chunks of extraterrestrial rock and metal fall to Earth. **Meteorites** are any fragments from space that survive their plunge through the atmosphere and land on Earth's surface. Small ones are no bigger than pebbles. The one in **Figure 18** has a mass of 14.5 metric tons. Hundreds of meteorites fall to Earth each year. Luckily, strikes on buildings or other human-made objects are rare. In fact, only a tiny fraction of the meteorites that fall are ever found. Scientists are extremely interested in those that are, because they yield important clues from space. For example, many seem to be about 4.5 billion years old, which provides a rough estimate of the age of the solar system. Several thousand meteorites have been collected in Antarctica, where moving ice sheets concentrate them in certain areas. Any rock seen on an ice sheet in Antarctica is probably a meteorite, because few other rocks are exposed. Meteorites can be one of three types—irons, stones, and stoney-irons. Irons are almost all iron, with some nickel mixed in. Stones are rocky. The rarest, stoney-irons, are a mixture of metal and rock.

Figure 18 This meteorite on display at the American Museum of Natural History in New York has a mass of 14.5 metric tons.
Explain *why meteorites are rare.*

section 2 review

Summary

Distances in Space

- The planets in the solar system orbit around the Sun.
- Distances in the solar system are vast. Scientists measure these distances using the astronomical unit (AU).

Inner Planets

- The inner planets are solid, rocky planets.
- Earth is the only planet known to support life.

Outer Planets

- Jupiter, Saturn, Uranus, and Neptune are gas giants that have ring systems.
- Pluto is a small planet made up of ice and rock.

Comets

- Comets are bodies of ice and rock that orbit the Sun.

Self Check

1. **Explain** why the planets and other objects in the solar system orbit around the Sun.
2. **List** the planets in the solar system in order starting with the planet that is closest to the Sun.
3. **Compare and contrast** the moons that were discussed in this chapter.
4. **Infer** why carbon dioxide ice exists on Mars but not Earth.
5. **Think Critically** Earth has abundant life. Do you think that other planets or moons might support life? If so, which ones? Which characteristics of the planets or moons might be conducive to life?

Applying Skills

6. **Compare and contrast** Earth to other planets in terms of size, composition, distance from the Sun, and surface features. You might want to make a table to record your data.

Science Online red.msscience.com/self_check_quiz

CONTENTS

section 3

Stars and Galaxies

as you read

What You'll Learn

- **Explain** why stars appear to move across the sky.
- **Describe** some constellations.
- **Explain** the life cycle of stars.

Why It's Important

Understanding the vastness of the universe will help you to appreciate Earth's place in space.

Review Vocabulary

star: a large, spherical mass of gas that gives off light and other types of radiation; the Sun is a typical star

New Vocabulary

- constellation
- galaxy
- supernova
- light-year

Stars

Every night, a new world opens to you as the stars come out. Stars are always in the sky. You can't see them during the day because the Sun's light makes Earth's atmosphere so bright that it hides them. The Sun is a star, too. It is the closest star to Earth. Each night the stars appear to move across the sky. This happens because Earth is rotating around its axis. The stars that can be seen in the sky also change with the season as Earth revolves around the Sun.

Constellations Ursa Major, Ursa Minor, Orion, Taurus—do these names sound familiar? They are **constellations** (kahn stuh LAY shunz), or groups of stars that form patterns in the sky. **Figure 19** shows some constellations.

Constellations are named after animals, objects, and people—real or imaginary. Many of the names that early Greek astronomers gave to the constellations are still in use. However, throughout history, different groups of people have seen different things in the constellations. In early England, people thought the Big Dipper and the constellation Ursa Major looked like a plow. Native Americans saw a horse and rider. To the Chinese, it looked like a governmental official and his helpers moving on a cloud. What image does the Big Dipper bring to your mind?

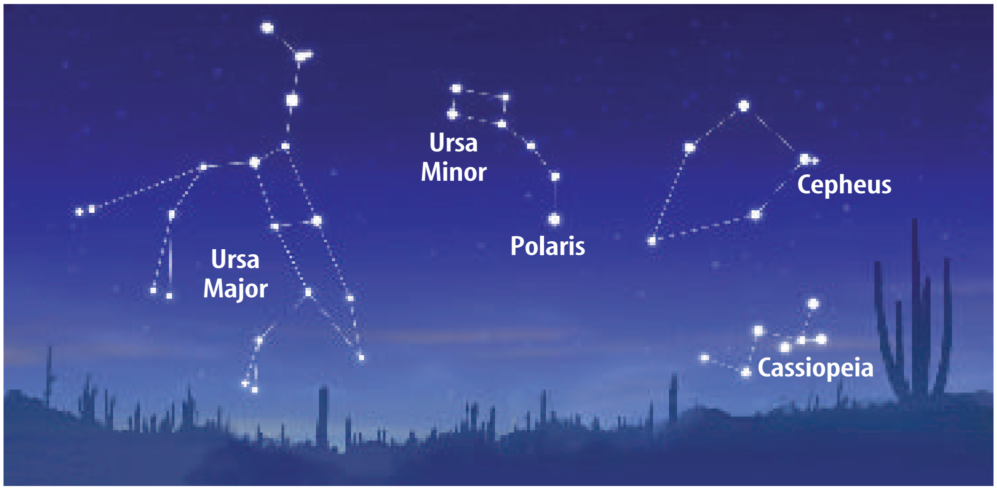


Figure 19 Find the Big Dipper in the constellation Ursa Major.
Explain *why people call it the Big Dipper.*

Starry Colors Although they look similar from Earth, stars are different colors. The color of a star is a clue about its temperature. Just as the red flames in a campfire are cooler, red stars are the coolest visible stars. Yellow stars have medium temperature. Bluish-white stars, like the blue flames on a gas stove, are the hottest.

Reading Check *How is a star's color related to its temperature?*

Stars also vary in size. Most of the stars in the universe are small. The Sun is a yellow, medium-sized star. Betelgeuse (BEE tul joos) is much bigger than the Sun. If this huge star were in the same place as the Sun, it would swallow Mercury, Venus, Earth, and Mars.

Apparent Magnitude Look at the sky on a clear night and you can easily notice that some stars are brighter than others. A system called apparent magnitude is used for classifying how bright a star appears from Earth. The dimmest stars that are visible to the unaided eye measure 6 on the apparent magnitude scale. A star with an apparent magnitude of 5 is 2.5 times brighter. The smaller the number is, the brighter the star is. The brightest star in the sky, Sirius, has an apparent magnitude of −1.5, and the Sun's apparent magnitude is −26.7.

Compared to other stars, the Sun is medium in size and temperature. It looks so bright because it is so close to Earth. Apparent magnitude is a measure of how bright a star looks from Earth but not a measure of its actual brightness, known as absolute magnitude. As **Figure 20** shows, a small, close star might look brighter than a giant star that is far away.

Figure 20 This flashlight looks brighter than the car headlights because it is closer. In a similar way, a small but close star can appear brighter than a more distant, giant star.

Dominic Oldershaw

Mini LAB

Modeling Constellations

Procedure

1. Draw a dot pattern of a constellation on a piece of **black construction paper.** Choose a known constellation or make up your own.
2. With an adult's help, cut off the end of a **cardboard cylinder** such as an oatmeal box. You now have a cylinder with both ends open.
3. Place the cylinder over the constellation. Trace around the rim. Cut the paper along the traced line.
4. **Tape** the paper to the end of the cylinder. Using a **pencil,** carefully poke holes through the dots on the paper.
5. Place a **flashlight** inside the open end of the cylinder. Darken the room and observe your constellation on the ceiling.

Analysis

1. Turn on the overhead light and view your constellation again. Can you still see it? Why or why not?
2. The stars are always in the sky, even during the day. How is the overhead light similar to the Sun? Explain.

Try at Home

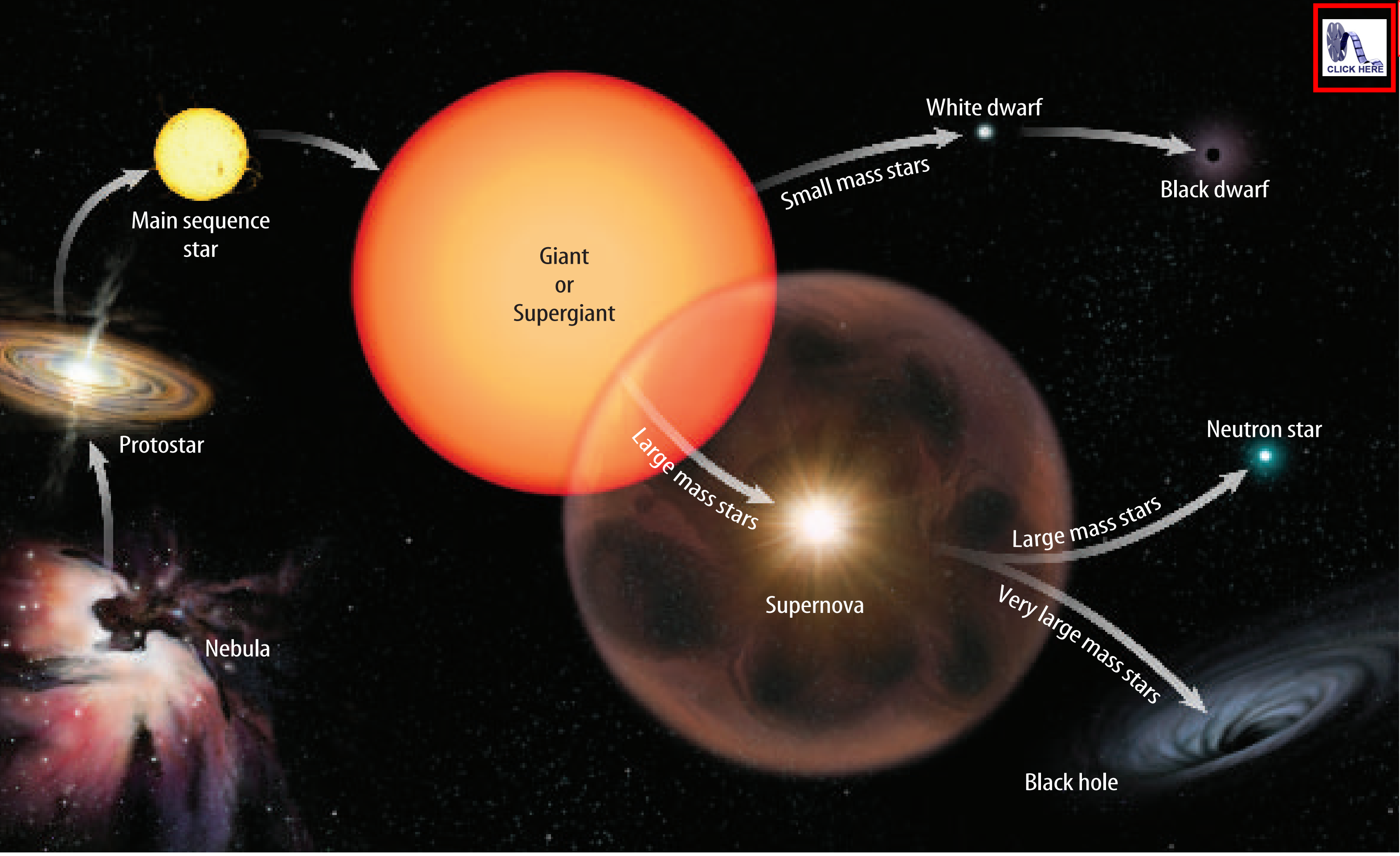


Figure 21 The events in the lifetime of a star depend on the star's mass.
Describe *what happens to giant stars when their cores collapse.*

The Lives of Stars

Scientists hypothesize that stars begin their lives as huge clouds of gas and dust. The force of gravity, which causes attraction between objects, causes the dust and gases to move closer together. When this happens, temperatures within the cloud begin to rise. A star forms when this cloud gets so dense and hot that the atoms within it merge. This process is known as fusion, and it changes matter to the energy that powers the star.

After a star has formed, it continues to evolve. When a medium-sized star like the Sun uses up some of the gases in its center, it expands to become a giant star. Giants are large, cool stars that have a red color. The Sun will become a giant in about five billion years. At this time, it will expand to cover the orbits of Mercury, Venus, and possibly Earth. It will remain that way for about a billion years. Then, the Sun will lose its outer shell, and the core will shrink to become a white dwarf star. A white dwarf is a hot, small star. Eventually, the white dwarf will cool and stop shining to become a black dwarf.

How long a star lives depends on how massive it is. Stars more massive than the Sun complete their life cycles in shorter amounts of time. The smallest stars shine the longest. **Figure 21** illustrates how the course of a star's life is determined by its size.

INTEGRATE Physics

Determining the Age of Stars Some groups of stars, called clusters, contain stars that all formed at the same time. Scientists study these stars through a telescope to determine their color and brightness. This information can be used to find out how far along each star is in its life cycle. Because scientists know how long it takes for different stars to go through their life cycles, the age of the star cluster can be estimated.

Supergiants When a large star begins to use up the fuel in its core, it expands to become a supergiant. These stars are similar to giant stars, except they are much larger. Eventually, the core of the supergiant will collapse. A huge shock wave moves through the star, and the star explodes and becomes bright. This exploding star is called a **supernova.** For a few brief days, the supernova might shine more brightly than a whole galaxy. The dust and gas released by this explosion, shown in **Figure 22,** might eventually become part of a new star.

Figure 22 This photo shows the remains of a supernova.

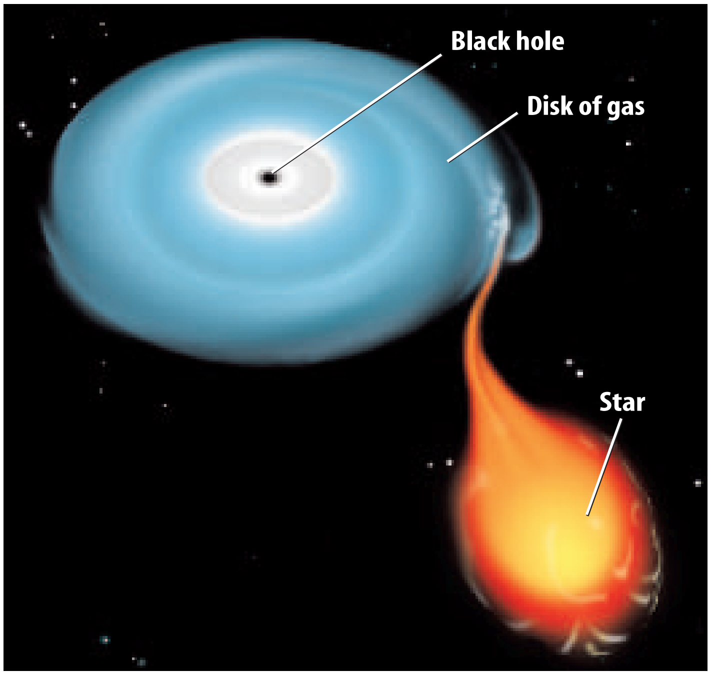
INTEGRATE Physics Meanwhile, the core of the supergiant is still around. If the core isn't too large, it becomes a neutron star. These are small objects that are extremely dense. However, if the core is more than about three times as massive as the Sun, it collapses rapidly to form a black hole, shown in **Figure 23.** Light shone into a black hole disappears, and no light can escape from a black hole.

Galaxies

If you travel far from city lights and point a telescope toward the sky, you might see dim clumps of stars. These groups of stars are called galaxies. A **galaxy** is a group of stars, gas, and dust held together by gravity.

Types of Galaxies You now know how planets and stars differ from one another. Galaxies come in different shapes and sizes, too. The three major types of galaxies are elliptical, spiral, and irregular. These three types of galaxies are distinguished by their shapes. Elliptical galaxies are very common. They're shaped like huge footballs or spheres. Spiral galaxies have arms radiating outward from the center, somewhat like a giant pinwheel. As shown in **Figure 24,** some spiral galaxies have bar-shaped centers. Irregular galaxies are just that—irregular. They come in all sorts of different shapes and can't be classified easily. Irregular galaxies usually are smaller than other galaxies. They also are common.

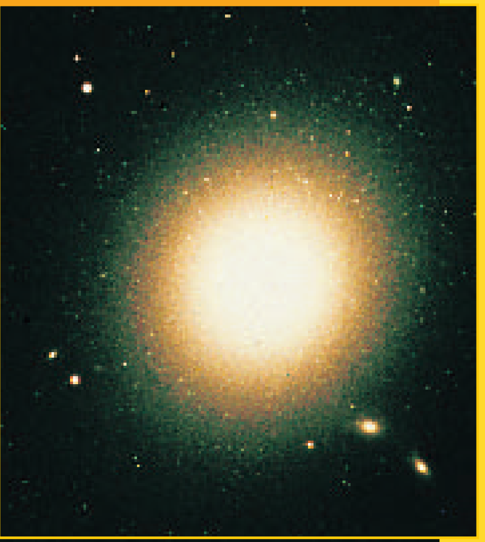
Figure 23 A black hole has such strong gravity that not even light can escape. This drawing shows a black hole stripping gas from a nearby star.
Explain *how black holes form.*



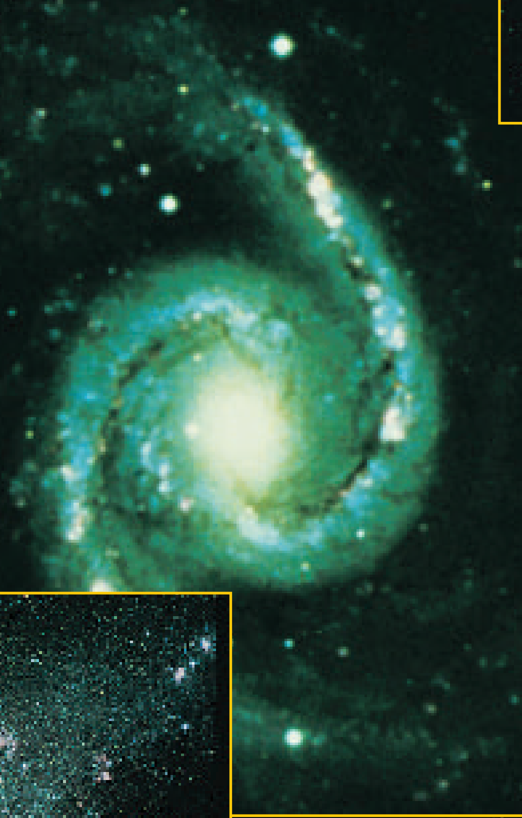
NATIONAL GEOGRAPHIC VISUALIZING GALAXIES

Figure 24

Most stars visible in the night sky are part of the Milky Way Galaxy. Other galaxies, near and far, vary greatly in size and mass. The smallest galaxies are just a few thousand light-years in diameter and a million times more massive than the Sun. Large galaxies—which might be more than 100,000 light-years across—have a mass several trillion times greater than the Sun. Astronomers group galaxies into four general categories, as shown here.



ELLIPTICAL GALAXIES They are nearly spherical to oval in shape and consist of a tightly packed group of relatively old stars.



SPIRAL GALAXIES Spiral galaxies consist of a large, flat disk of interstellar gas and dust with arms of stars extending from the disk in a spiral pattern. The Andromeda Galaxy, one of the Milky Way Galaxy's closest neighbors, is a spiral galaxy.

IRREGULAR GALAXIES Some galaxies are neither spiral nor elliptical. Their shape seems to follow no set pattern, so astronomers have given them the general classification of irregular.

BARRED SPIRAL GALAXIES Sometimes the flat disk that forms the center of a spiral galaxy is elongated into a bar shape. Two arms containing many stars swirl out from either end of the bar, forming what is known as a barred spiral galaxy.

(bl)Royal Observatory, Edinburgh/Science Photo Library/Photo Researchers, (others)Anglo-Australian Observatory

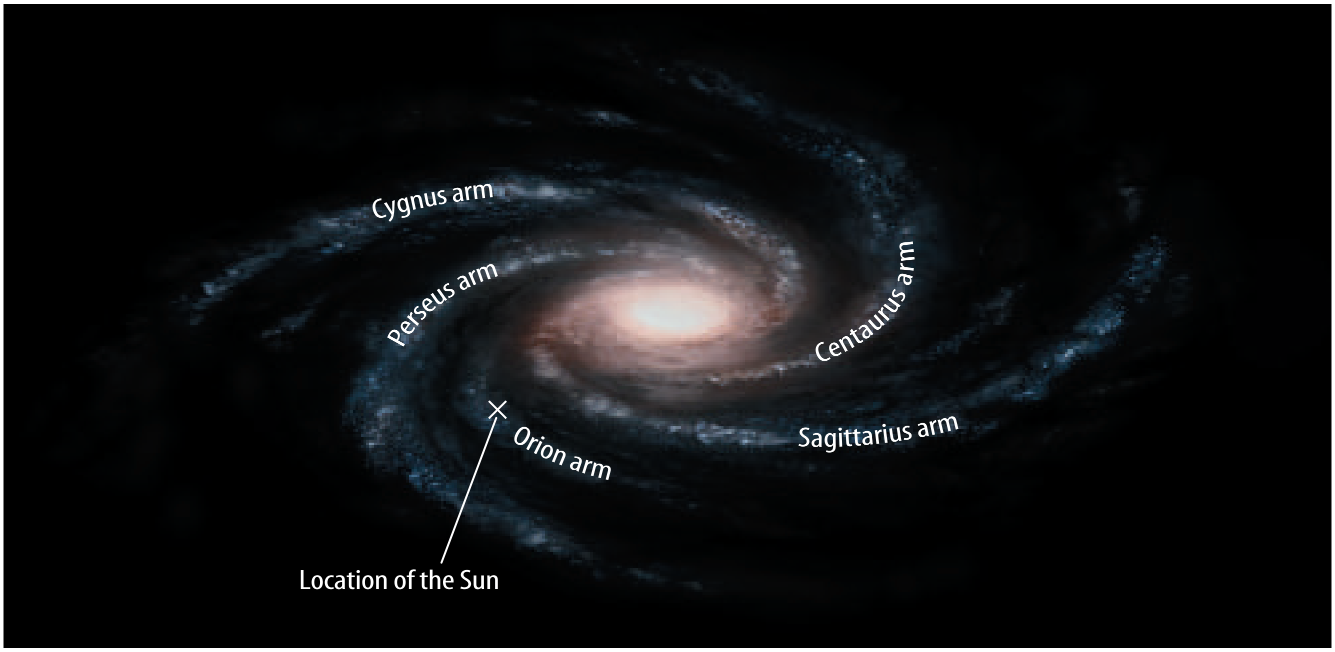


Figure 25 The Sun is located toward the edge of the Milky Way.

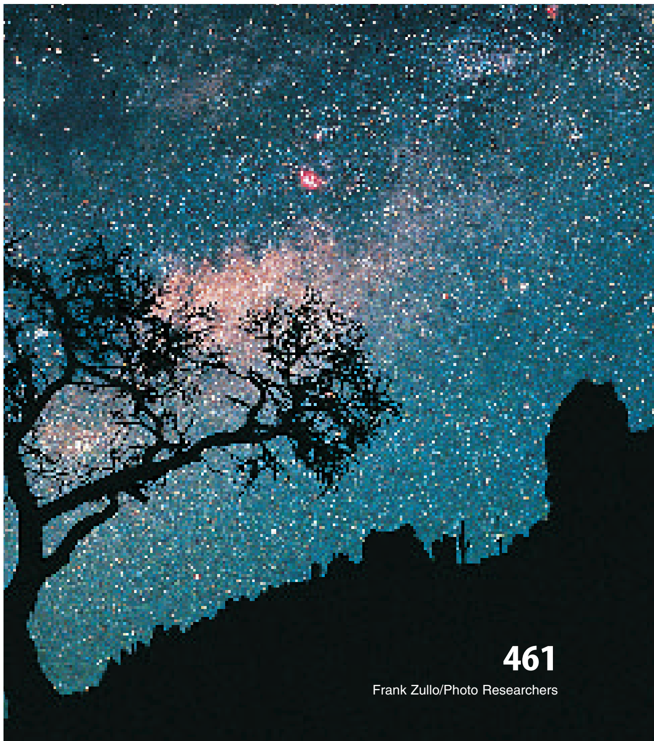
The Milky Way Galaxy Which type of galaxy do you live in? Look at **Figure 25.** You live in the Milky Way, which is a giant spiral galaxy. Hundreds of billions of stars are in the Milky Way, including the Sun. Just as Earth revolves around the Sun, stars revolve around the centers of galaxies. The Sun revolves around the center of the Milky Way about once every 225 million years.

A View from Within You can see part of the Milky Way as a band of light across the night sky. However, you can't see the whole Milky Way. To understand why, think about boarding a Ferris wheel and looking straight up. Can you really tell what the ride looks like? Because you are at the bottom looking up, you get a limited view. Your view of the Milky Way from Earth is like the view of the Ferris wheel from the bottom. As you can see in **Figure 26,** you can view only parts of this galaxy because you are within it.

Reading Check *Why can't you see the entire Milky Way from Earth?*

The faint band of light across the sky that gives the Milky Way its name is the combined glow of stars in the galaxy's disk. In 1609, when the Italian astronomer Galileo looked at the Milky Way with a telescope, he showed that the band was actually made of countless individual stars. The galaxy is vast—bigger and brighter than most of the galaxies in the universe. Every star you see in the sky with your naked eye is a member of the Milky Way Galaxy.

Figure 26 This is the view of the Milky Way from inside the galaxy. **Infer** *why it is called the Milky Way.*



Frank Zullo/Photo Researchers

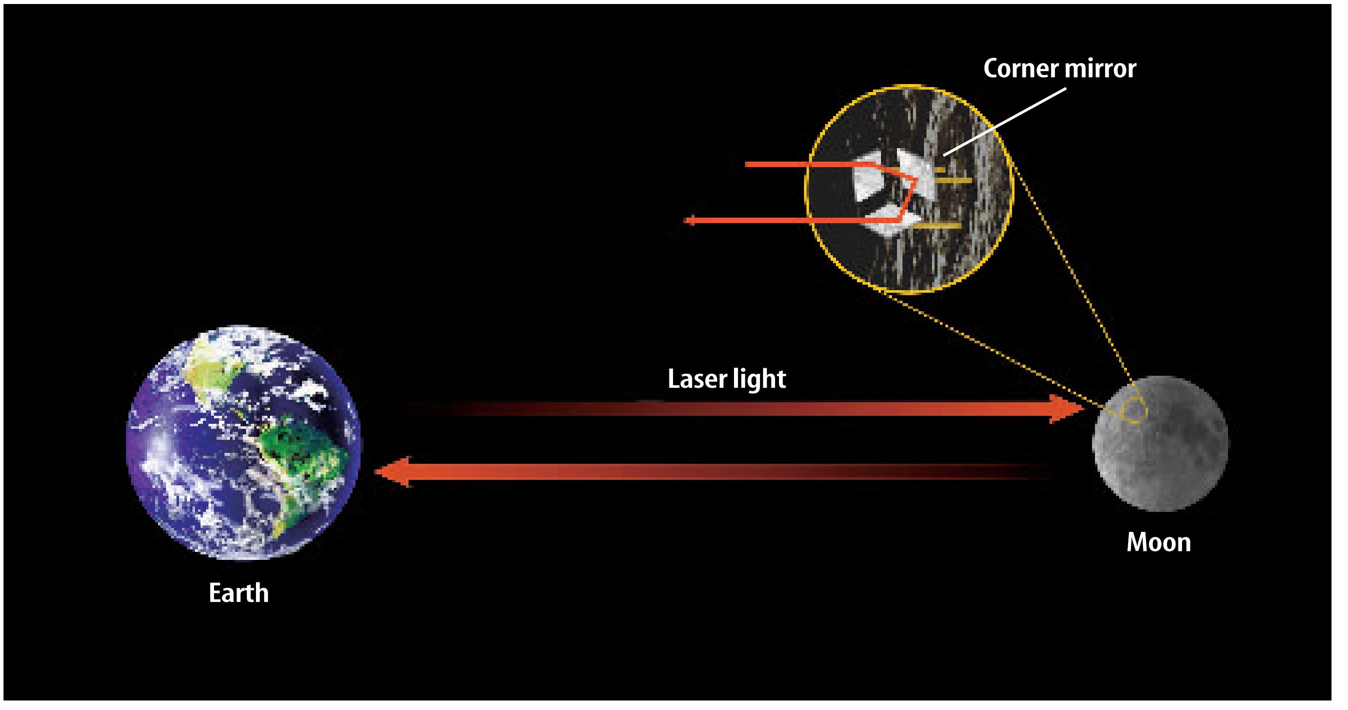


Figure 27 The constant speed of light through space helps astronomers in many ways. For example, the distance to the Moon has been determined by bouncing a laser beam off mirrors left by *Apollo 11* astronauts.

Speed of Light The speed of light is unique. Light travels through space at about 300,000 km/s—so fast it could go around Earth seven times in 1 s. You can skim across ocean waves quickly on a speedboat, but no matter how fast you go, you can't gain on light waves. It's impossible to go faster than light. Most galaxies are moving away from the Milky Way and a few are moving closer, but the light from all galaxies travels toward Earth at the same speed. The constant speed of light is useful to astronomers, as shown in **Figure 27.**

Light-Years Earlier you learned that distances between the planets are measured in astronomical units. However, distances between galaxies are vast. Measuring them requires an even bigger unit. Scientists often use light-years to measure distances between galaxies. A **light-year** is the distance light travels in one year—about 9.5 trillion km.

Reading Check *Why is a light-year better than an astronomical unit for measuring distances between galaxies?*

Would you like to travel back in time? In a way, that's what you're doing when you look at a galaxy. The galaxy might be millions of light-years away. The light that you see started on its journey long ago. You are seeing the galaxy as it was millions of years ago. On the other hand, if you could look at Earth from this distant galaxy, you would see events that happened here millions of years ago. That's how long it takes the light to travel the vast distances through space.

INTEGRATE Physics

Red Shift The Milky Way belongs to a cluster of galaxies called the Local Group. Scientists have determined that galaxies outside of the Local Group are moving away from Earth. Based on this, what can you infer about the size of the universe? Research the phenomenon known as red shift and describe to the class how it has helped astronomers learn about the universe.

The Universe

Each galaxy contains billions of stars. Some might have as many stars as the Milky Way, and a few might have more. As many as 100 billion galaxies might exist. All these galaxies with all of their countless stars make up the universe.

Look at **Figure 28.** The *Hubble Space Telescope* spent ten days in 1995 photographing a tiny sector of the sky to produce this image. More than 1,500 galaxies were discovered. Astronomers think a similar picture would appear if they photographed any other sector of the sky. In this great vastness of exploding stars, black holes, star-filled galaxies, and empty space is one small planet called Earth. If you reduced the Sun to the size of a period on this page, the next-closest star would be more than 16 km away. Earth looks even lonelier when you consider that the universe also seems to be expanding. Most other galaxies are moving away at speeds as fast as 20,000 km/s. In relation to the immensity of the universe, Earth is an insignificant speck of dust. Could it be the only place where life exists?

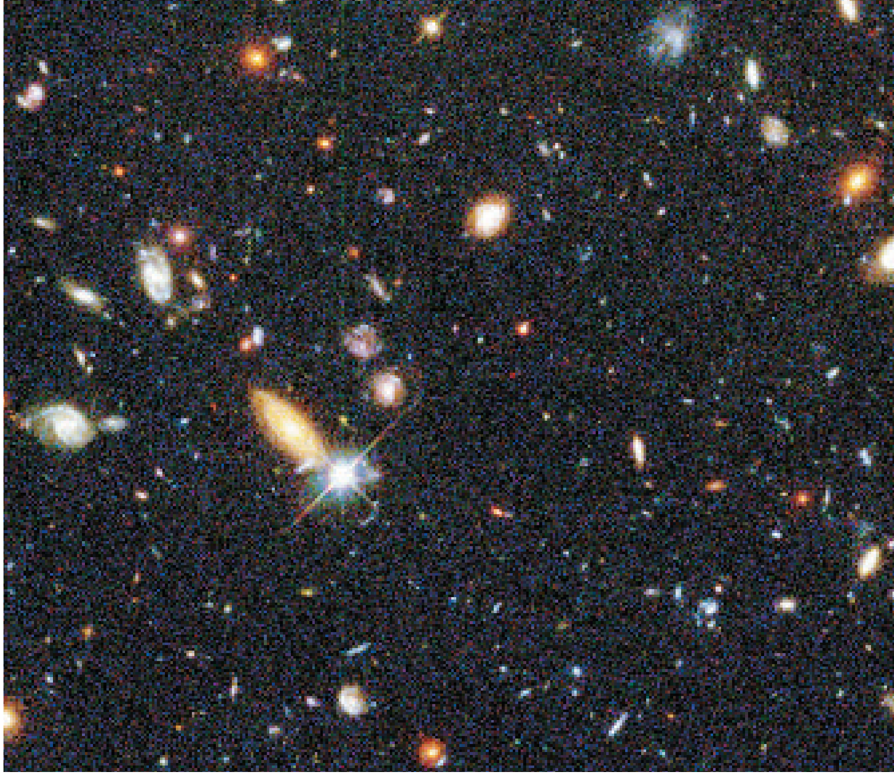


Figure 28 The *Hubble* Deep Field Image shows hundreds of galaxies in one tiny sector of the sky.
Explain *what this image indicates about the sky.*

Reading Check *How do other galaxies move relative to Earth?*

section 3 review

Summary

Stars

- Constellations consist of stars that form patterns in the sky.

The Lives of Stars

- Stars evolve through time.
- How stars evolve depends on how massive they are.

Galaxies

- A galaxy is a group of stars, gas, and dust held together by gravity.
- You live in the Milky Way Galaxy.

The Universe

- The universe might include 100 billion galaxies.

Self Check

1. **Explain** why stars appear to move across the sky each night. Why are some stars only visible during certain seasons?
2. **List and describe** some constellations.
3. **Describe** the life cycle of a star like the Sun.
4. **Think Critically** Some stars might no longer be in existence, but you still see them in the night sky. Why?

Applying Math

5. **Convert Units** A light-year is about 9.5 trillion kilometers. Alpha Centauri is a star that is 4.3 light-years from Earth. How many trillion kilometers away is this star?

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LAB Design Your Own

Space Colony

Goals
- **Infer** what a space colony might look like on another planet.
- **Classify** planetary surface conditions.
- **Draw** a space colony for a planet.

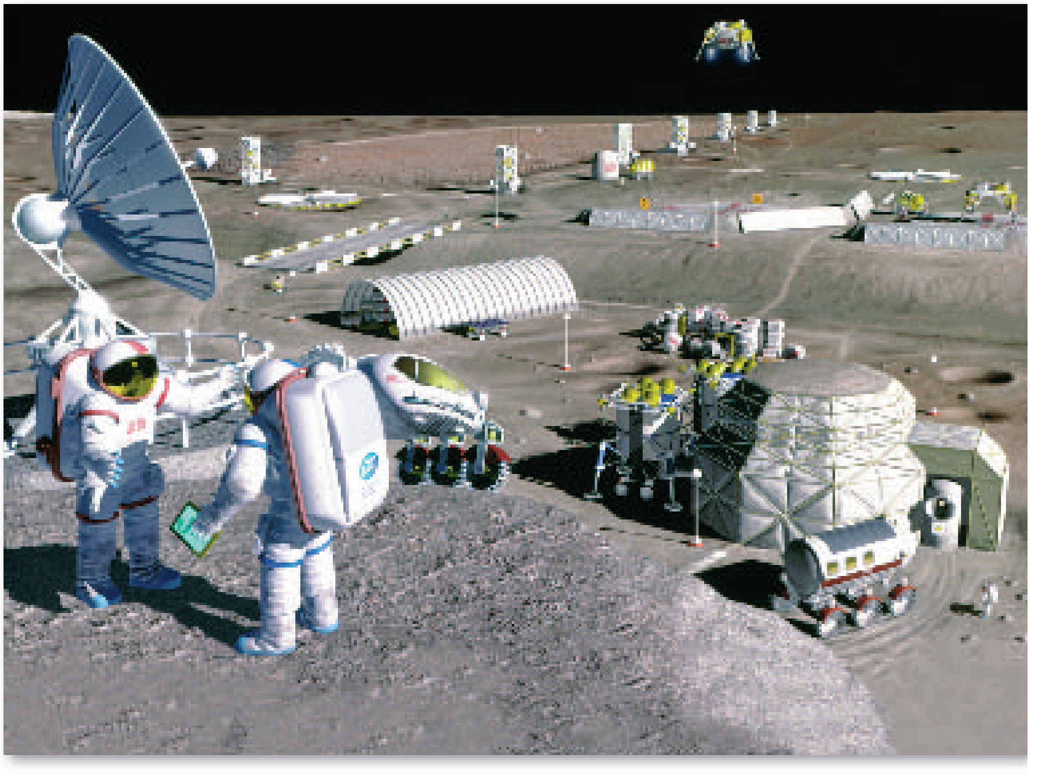
Possible Materials
drawing paper
markers
books about the planets

Real-World Question

Many fictional movies and books describe astronauts from Earth living in space colonies on other planets. Some of these make-believe societies seem far-fetched. So far, humans haven't built a space colony on another planet. However, if it happens, what would it look like?

Form a Hypothesis

Research a planet. Review conditions on the surface of the planet. Make a hypothesis about the things that would have to be included in a space colony to allow humans to survive on the planet.



(t)Movie Still Archives, (b)NASA

Test Your Hypothesis

Make a Plan

1. Select a planet and study the conditions on its surface.
2. **Classify** the surface conditions in the following ways.
   a. solid or gas
   b. hot, cold, or a range of temperatures
   c. heavy atmosphere, thin atmosphere, or no atmosphere
   d. bright or dim sunlight
   e. unique conditions
3. **List** the things that humans need to survive. For example, humans need air to breathe. Does your planet have air that humans can breathe, or would your space colony have to provide the air?
4. Make a table for the planet showing its surface conditions and the features the space colony would have to have so that humans could survive on the planet.
5. **Discuss** your decisions as a group to make sure they make sense.

Follow Your Plan

1. Make sure your teacher approves your plan before you start.
2. **Draw** a picture of the space colony. Draw another picture showing the inside of the space colony. Label the parts of the space colony and explain how they aid in the survival of its human inhabitants.

Analyze Your Data

1. **Compare and contrast** your space colony with those of other students who researched the same planet you did. How are they alike? How are they different?
2. Would you change your space colony after seeing other groups' drawings? If so, what changes would you make? Explain your reasoning.

Conclude and Apply

1. **Describe** the most interesting thing you learned about the planet you studied.
2. Was your planet a good choice for a space colony?
3. Would humans want to live on your planet? Why or why not?
4. Could your space colony be built using present technology? Explain.

Communicating Your Data

Present your drawing and your table to the class. Make a case for why your planet would make a good home for a space colony. **For more help, refer to the Science Skill Handbook.**

Mark Burnett

Science and Language Arts

The Sun and the Moon

A Korean Folktale

The two children lived peacefully in the Heavenly Kingdom, until one day the Heavenly King said to them, "We can not allow anyone to sit here and idle away the time. So I have decided on duties for you. The boy shall be the Sun, to light the world of men, and the girl shall be the Moon, to shine by night." Then the girl answered, "Oh King, I am not familiar with the night. It would be better for me not to be the Moon." So the King made her the Sun instead, and made her brother the Moon.

It is said that when she became the Sun, the people used to gaze up at her in the sky. But she was modest, and greatly embarrassed by this. So she shone brighter and brighter, so that is why the Sun is so bright, that her modesty might be forever respected.

Understanding Literature

Cause and Effect The folktale explains why the Sun and the Moon exist, as well as why you should never look directly at the Sun. No one is allowed to be idle in the Heavenly Kingdom. This is a cause. What is the effect?

Respond to the Reading

1. What was the purpose of this folktale?
2. What clues does the folktale give about the personalities of the girl and the King?
3. **Linking Science and Writing** Using the form of a folktale, explain what causes something that happens in the solar system.

INTEGRATE Astronomy

The cause-and-effect relationships that astronomers use to explain the origin of the Sun and the Moon are different from what is told in this folktale. Astronomers hypothesize that the Sun formed from a collapsing cloud of ice, gas, and dust. As the cloud contracted, the temperature at its center became so high that nuclear fusion began, and the Sun was born. Many hypotheses about how the Moon formed have been suggested. The most favored of these suggests that the Moon formed from the matter that was blasted into space when a Mars-sized object struck Earth just after it formed.

Kevin Morris/CORBIS

Reviewing Main Ideas

Section 1 Earth's Place in Space

1. Day and night occur because Earth rotates around its axis.
2. Earth's axis is tilted about 23.5° from straight up.
3. Earth's revolution and Earth's tilted axis cause seasons to occur.

Section 2 The Solar System

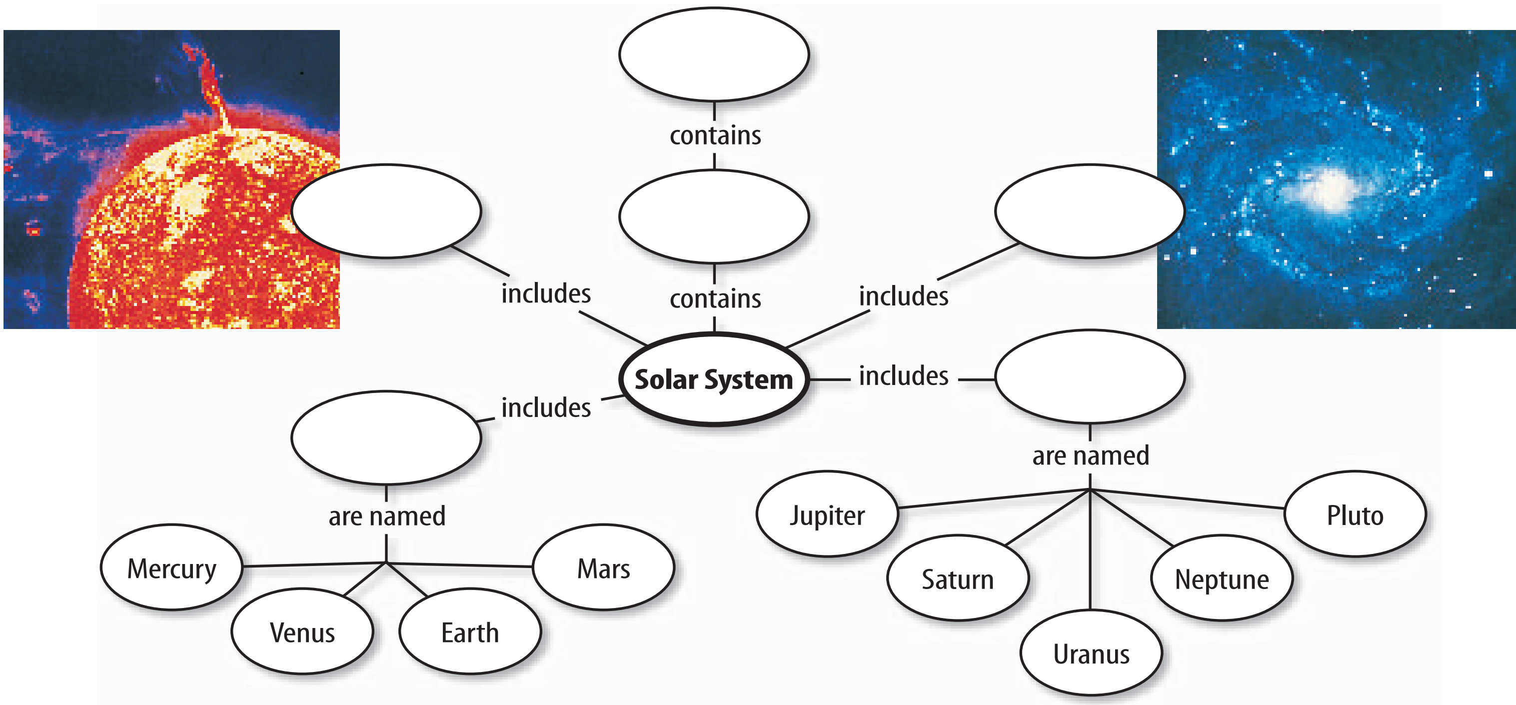
1. The inner planets include Mercury, Venus, Earth, and Mars.
2. The outer planets are Jupiter, Saturn, Uranus, Neptune, and Pluto.
3. Meteorites are pieces of rock that fall to Earth from space.

Section 3 Stars and Galaxies

1. Apparent magnitude is a way to describe how bright stars appear from Earth. It is different from a star's actual brightness, or absolute magnitude.
2. Stars change throughout their lives. How they change depends on how massive they are.
3. There are four types of galaxies: elliptical, spiral, irregular, and barred spiral.

Visualizing Main Ideas

Copy and complete the concept map below using the following terms: asteroid belt, galaxy, universe, inner planets, comets and meteorites, *and* outer planets.



chapter 15 Review

Using Vocabulary

astronomical unit p. 449	meteorite p. 455
comet p. 454	orbit p. 441
constellation p. 456	revolution p. 441
eclipse p. 444	rotation p. 440
galaxy p. 459	solar system p. 448
light-year p. 462	supernova p. 459
lunar highlands p. 442	tides p. 445
maria p. 442	

Each question below asks about a vocabulary word from the list. Write the word that best answers each question.

1. What event occurs when Earth's shadow falls on the Moon or when the Moon's shadow falls on Earth?
2. Which Earth motion causes day and night?
3. What is a large group of stars, gas, and dust held together by gravity called?
4. What is a group of stars that forms a pattern in the sky called?
5. Which movement of Earth causes it to travel around the Sun?

Checking Concepts

Choose the word or phrase that best answers the question.

6. What is caused by the tilt of Earth's axis and its revolution?
   A) eclipses **C)** tides
   B) phases **D)** seasons
7. Which of the following is caused by the gravity of the Moon and the Sun?
   A) stars **C)** comets
   B) tides **D)** maria
8. An astronomical unit equals the distance from Earth to which of the following?
   A) the Moon **C)** Mercury
   B) the Sun **D)** Pluto

Use the photo below to answer question 9.

9. Why is Earth, shown above, a unique planet in the solar system?
   A) it is spherical
   B) it has surface oceans
   C) it has an elliptical orbit
   D) it is the largest planet
10. How many galaxies could be in the universe?
   A) 1 billion **C)** 50 billion
   B) 10 billion **D)** 100 billion
11. Which results from Earth's rotation?
   A) night and day **C)** phases
   B) summer and winter **D)** eclipses
12. What unit is often used to measure long distances in space, such as between stars and galaxies?
   A) kilometer **C)** light-year
   B) astronomical unit **D)** meter
13. How many planets are in the solar system?
   A) six **C)** eight
   B) seven **D)** nine
14. Which object's shadow travels across part of Earth during a solar eclipse?
   A) the Moon **C)** an asteroid
   B) the Sun **D)** a comet
15. If a star is massive enough, what can result after it produces a supernova?
   A) a galaxy **C)** a black dwarf
   B) a black hole **D)** a white dwarf

Science Online red.msscience.com/vocabulary_puzzlemaker
CONTENTS

Thinking Critically

16. Compare and Contrast Which of the planets in the solar system seems most like Earth? Which seems most different from Earth? Explain your answers using facts about the planets.

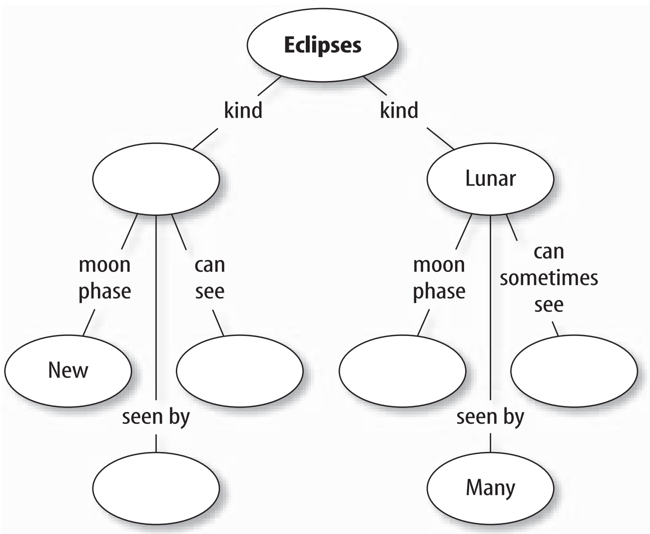
17. Predict How might a scientist predict the day and time of an eclipse?

18. Recognize Cause and Effect Which of the Moon's motions are real? Which are apparent? Explain each.

19. Make and Use Tables Research the size, composition, and surface features of each planet. Show this information in a table. How do tables help you to organize information?

20. Make a model of a lunar or solar eclipse based on what you have learned about the Sun, the Moon, and Earth. Use simple classroom materials.

21. Concept Map Copy and complete the following concept map using the following terms: *full, red surface, corona, solar,* and *few.*



Performance Activities

22. Model Make a three-dimensional model showing the relative positions of the Sun, Earth, and the Moon during spring tides and neap tides. Which moon phase corresponds to each arrangement?

23. Poster Research the moons of Jupiter, Saturn, Uranus, or Neptune. Make a poster showing the characteristics of these moons. Display your poster for your class.

Applying Math

24. Distances in the Solar System

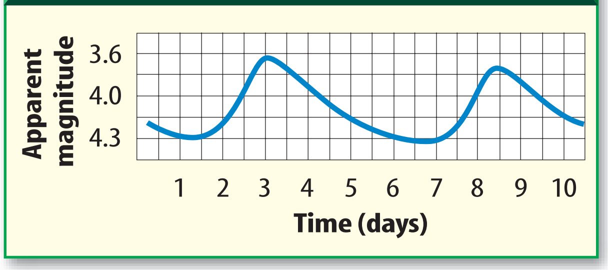
a. Venus is 0.72 AU from the Sun. Neptune is 30.07 AU from the Sun. How many times farther from the Sun is Neptune than Venus?

b. Jupiter is 5.20 AU from the Sun. Pluto is 39.48 AU from the Sun. How many times farther from the Sun is Pluto than Jupiter?

25. Earth's Circumference Earth's diameter at the equator is about 12,756 km. Using the equation $C = \pi d$, where C is circumference, d is diameter, and π is about 3.14, calculate Earth's circumference at the equator.

Use the graph below to answer question 26.

Light Curve of Delta Cephei



26. Variable Stars The brightness of some stars varies with time. The graph above shows how the apparent magnitude of a star named Delta Cephei varies with time. What is the period of this star's light curve? *Hint: The period is found by determining the time between apparent magnitude peaks.*

Part 1 Multiple Choice

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Examine the photo of the Moon below. Then, answer questions 1–3.

1. Which term refers to the dark, smooth regions on the Moon's surface?
   A. lunar highlands **C.** maria
   B. craters **D.** rills

2. Which term refers to the light-colored, mountainous regions on the Moon?
   A. craters **C.** rills
   B. lunar highlands **D.** maria

3. What formed when meteorites struck the Moon's surface?
   A. lunar highlands **C.** plateaus
   B. maria **D.** craters

4. Which planet is closest to the Sun?
   A. Pluto **C.** Mercury
   B. Saturn **D.** Earth

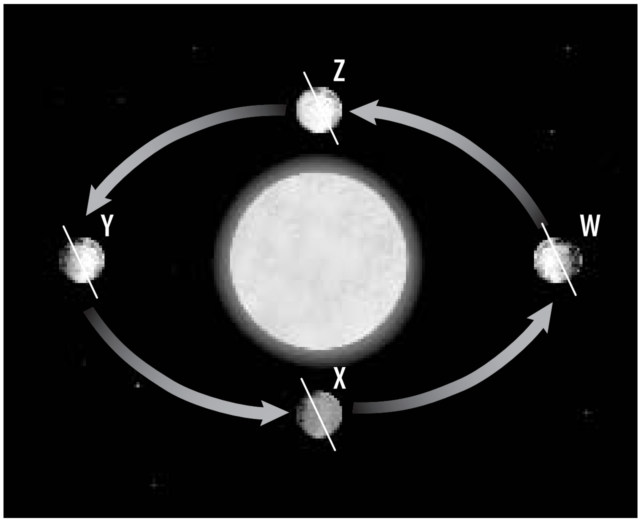
5. What is composed of ice and rock?
   A. an asteroid **C.** a meteorite
   B. a comet **D.** Venus

6. Which of the following is largest?
   A. the universe **C.** the Sun
   B. the Milky Way **D.** the solar system

7. Which of these terms refers to an alternate rise and fall in sea level?
   A. tide **C.** eclipse
   B. revolution **D.** phase

8. Which of the following units is most useful for measuring distances in the solar system?
   A. kilometer **C.** meter
   B. light-year **D.** astronomical unit

Use the diagram below to answer questions 9–10.



9. By which angle is Earth's axis tilted?
   A. 25° **C.** 15°
   B. 23.5° **D.** 27.5°

10. Assuming the top of the diagram represents north, which season occurs in the northern hemisphere when Earth is at position Z?
    A. spring **C.** summer
    B. autumn **D.** winter

Test-Taking Tip

Timing If you are taking a timed test, keep track of time during the test. If you find that you're spending too much time on a multiple-choice question, mark your best guess and move on.

NASA

Part 2 Short Response/Grid In

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

11. Explain how stars form. Write your answer as several steps.

12. Describe the planet Earth. How is this planet different from the other planets in the solar system?

13. What is an asteroid? Where do many asteroids occur in the solar system?

14. Explain how constellations are different from galaxies.

15. How is a neutron star different from a black hole?

16. How do the Moon and the Sun cause tides to occur in Earth's oceans?

17. How is Uranus's axis of rotation different from the axis of rotation of most other planets?

The temperatures of stars usually are measured using the kelvin scale. Use the equations below to answer questions 18–21. °C represents degrees Celsius, and K represents the temperature in kelvins.

$$°C = K - 273$$

$$K = °C + 273$$

18. The surface temperature of the Sun is about 6,000 K. How many degrees Celsius is this?

19. The cool supergiant Betelgeuse has a surface temperature of about 2,827°C. How many kelvins is this?

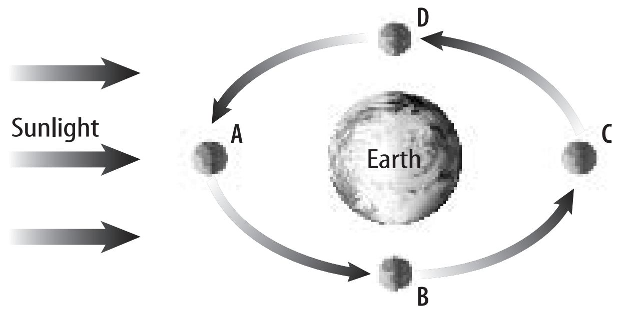
20. A typical white dwarf star has a surface temperature of 10,000 K. What is its surface temperature in degrees Celsius?

21. The lowest possible temperature is called absolute zero. This temperature is 0 K. What is this temperature in degrees Celsius?

Part 3 Open Ended

Record your answers on the answer sheet provided by your teacher or on a sheet of paper.

Use the illustration below to answer questions 22 and 23.



22. Identify each lunar phase shown as A–D in the diagram above.

23. Explain why the lunar phases change in a cycle.

24. Describe the shapes of the planets' orbits around the Sun. How is Pluto's orbit different from most other planets in the solar system?

25. How are the characteristics of the inner planets different from those of the outer planets?

26. Summarize the life cycle of a very large mass star. How is the life cycle of a very large mass star different from the life cycle of stars that have less mass?

27. Why does the same side of the Moon always face Earth?

28. Why do the stars appear to move in the sky each night?

29. Why are different stars visible during different seasons?

30. Explain how technology helps scientists learn about the universe. List several different types of technology that are used to study the universe in your answer.