CHAPTER

2 Our Solar System

8 Historical Knowledge of Our Solar System

SC.8.E.5.8

Getting the Idea

Key Words
solar system
geocentric model
orbit
heliocentric model

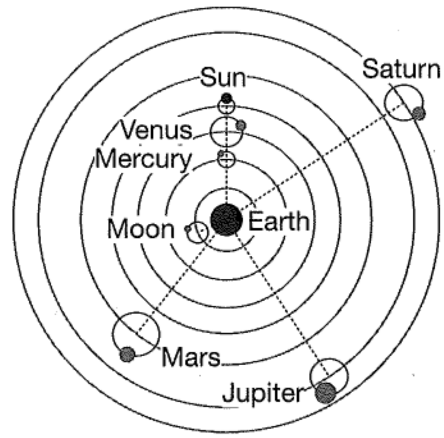
Scientists estimate that our sun and its planets formed about 4.6 billion years ago. Modern scientists gathered evidence from the sun and planets to develop theories about how these objects formed billions of years ago. In this lesson, you will learn about some of the first models developed to explain the existence and movements of our sun and planets.

Our Solar System

Our **solar system** consists of a star, the sun, and various other objects that move in paths around the sun. These objects include the planets, their moons, asteroids, and other bodies that you will learn about in Lesson 11.

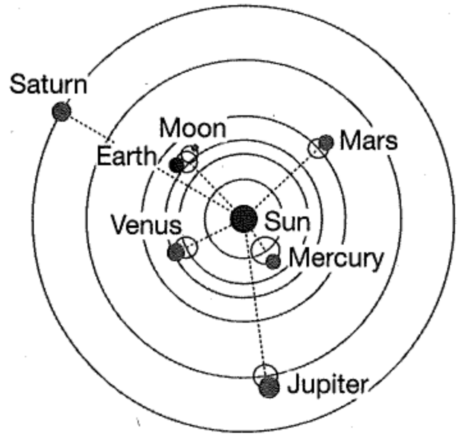
About 2000 years ago, an astronomer named Ptolemy developed a model of the solar system. Because he placed Earth in the center of the solar system, this model is called the **geocentric model**. (*Geo-* means "Earth.") Ptolemy showed the moon and the sun in circular orbits around Earth. He also included the planets that were known at the time. He thought that the planets moved in little circles as they moved around Earth. The diagram below shows the geocentric model.

Geocentric Model



People accepted Ptolemy's model for more than 1000 years. Then, in the early 1500s, a Polish scientist named Copernicus proposed a new model. He said that the sun, not Earth, is the center of the solar system. This model is called the heliocentric model. (*Helio-* refers to the sun.) The heliocentric model was not accepted at first. Over the next hundred years, the work of other astronomers added support for the heliocentric model. The diagram below shows this model.

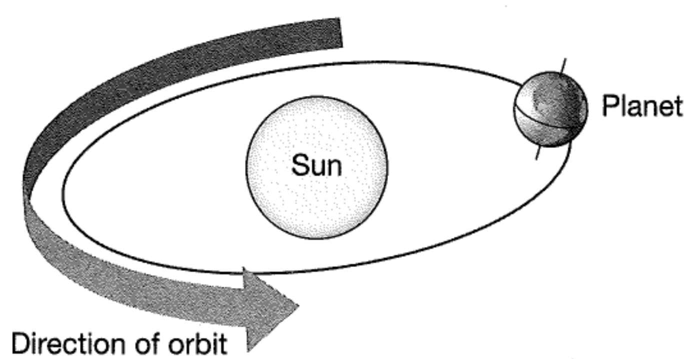
Heliocentric Model



Orbit Shape

In the geocentric model of our solar system, planets move in circular orbits around Earth. In the heliocentric model, planets move in circular orbits around the sun. Today, scientists know that all orbits cannot be thought of as circular. Most bodies in the solar system travel in orbits that are ellipses. An ellipse is shaped like an oval or flattened circle.

The Modern View of Earth's Orbit



The concept that the planets move around the sun in elliptical orbits was developed in the early 1600s by German astronomer Johannes Kepler. The ideas of scientists like Kepler inspired others to learn more and ask more questions about the solar system. Their ideas led directly to the collection of knowledge we have today regarding our solar system.

DISCUSSION QUESTION

Imagine that a conversation between Ptolemy and Copernicus took place. How would they agree in their views of the motions of the bodies in the solar system? How would they disagree?

LESSON REVIEW

1. What is the shape of planetary orbits?

A. circular

B. square

C. rectangular

D. elliptical

2. The solar system model that places Earth at the center of the solar system is the ______ model.

A. heliocentric

B. geocentric

C. Kepler

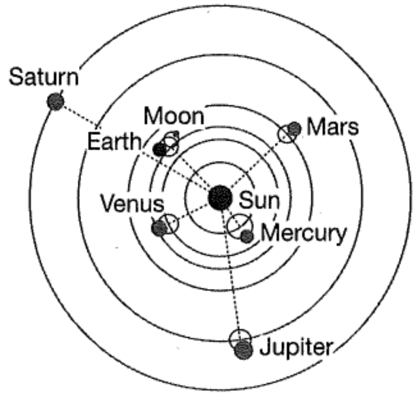
D. elliptical orbit

Test Tips . . .

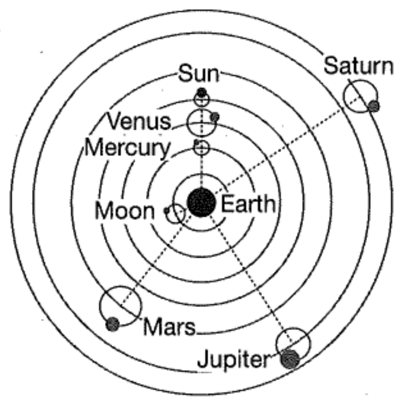
On multiple-choice exams, try to come up with the answer in your head before looking at the answer choices. This way you will not be persuaded by the choices, some of which may be purposely misleading.

3. Which illustration below MOST accurately shows the model of the solar system accepted by today's scientists?

A.



B.



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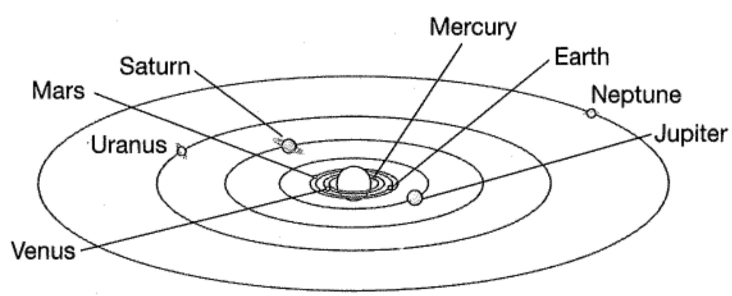
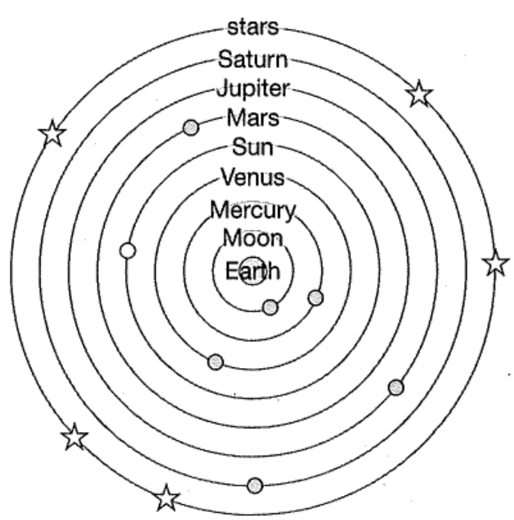


D.



9 Gravity

SC.8.E.5.4

Getting the Idea

Key Words
orbit
gravity
Law of Universal Gravitation
inertia
nebula
inner planet
outer planet
asteroid
asteroid belt

The planets, moons, and other bodies in our solar system each move in an **orbit**, an elliptical path around the sun. What keeps the planets moving this way? What prevents them from flying off into space? In this lesson, you will learn about the two factors that produce an orbit.

Law of Universal Gravitation

Gravity is an attractive force that works to pull objects together. Gravity can act across great distances. The sun's gravity, for example, pulls on all the planets in their orbits while they travel at speeds up to 216,000 kilometers per hour. That is the same as saying that they move at about 134,000 miles per hour.

The **Law of Universal Gravitation** states that every object in the universe exerts an attractive force on every other object. In other words, gravity acts between all objects in the universe. Two things determine the force of this attraction: the masses of the objects and the distance between them.

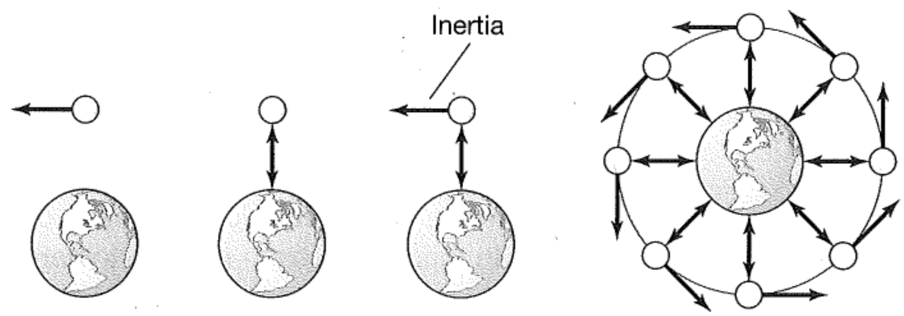
The force of gravity is directly proportional to the product of the masses of the two objects. This means that, if the mass of an object doubles, the gravitational force exerted by that object also doubles. Gravitational attraction is inversely proportional to the square of the distance between the two objects. So, if the distance between two objects doubles, you divide the gravitational force between them by 4.

Gravity and Orbits

If gravity pulls all objects toward each other, why don't the planets just fall straight into the sun? The answer is the other half of this puzzle: Inertia. **Inertia** is an object's resistance to a change in motion. Inertia causes an object that is in motion to keep moving in a straight line. It also causes an object at rest to remain at rest. Inertia is the result of an object's mass. The more mass the object has, the greater its inertia.

Inertia and gravity work together to keep objects in orbit. Consider the example of the moon orbiting Earth. The moon's inertia causes it to move past Earth in a straight line, at the same speed and in the same direction. At the same time, Earth and its moon pull toward each other due to gravity. There is a balance between these two movements. This causes the moon to follow a curved path around Earth. Without gravity, the moon would fly off on a straight-line path into space. Without inertia, the moon would fall straight down to Earth.

The Production of the Moon's Orbit Around Earth



Moon passes by Earth.

Moon and Earth pull at each other.

Moon tends to move forward, but is pulled by gravity as well.

The balance of the moon moving forward (inertia) and the pull of gravity produce an orbit.

Because gravity and the inertia of the moon are balanced, the moon orbits Earth in a regular path. If the force of gravity between Earth and its moon were too strong, the moon would crash into Earth. If the moon's inertia was stronger than the gravitational force between Earth and its moon, the moon would travel away from Earth.

The same combination of inertia and gravity keeps all the planets in orbit around the sun. It also keeps the moons of the other planets in their orbits.

Gravity and Formation of the Solar System

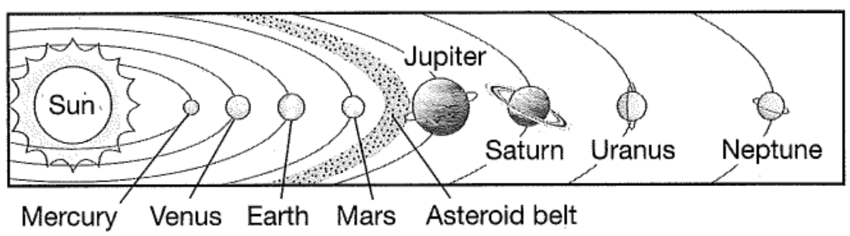
You have read how gravity keeps the planets in their orbits. Gravity is also responsible for the formation of the sun, planets, and moons of the solar system.

Most scientists think the solar system began as a nebula. A **nebula** is a huge cloud of dust and gas in space. As the particles in the nebula whirled around, they bumped into each other. Gravity began to hold some of the particles together. Over vast amounts of time, gravity pulled together particles to form the sun, the planets, their moons, and other bodies in space.

Most of the matter gathered in the center to form the sun. The sun became hotter and hotter from the energy of the colliding particles. The rest of the nebula formed a flat disk. The planets, their moons, and other bodies in space formed from this disk. You will learn more about the sun in Lesson 10.

The rocky **inner planets**, the four planets nearest the sun, formed from substances that do not evaporate at high temperatures. These planets include Mercury, Venus, Earth, and Mars. The four gaseous **outer planets**, Jupiter, Uranus, Saturn, and Neptune, formed from different substances. You will learn more about the inner and outer planets in Lesson 11.

A region of asteroids remains between the inner and outer planets. **Asteroids** are small rocky bodies that orbit the sun. The region in which they are located is called the **asteroid belt**. Scientists think that the gravitational force Jupiter exerts on asteroids keeps the asteroids in this region from moving toward the sun and colliding with the inner planets. You will learn more about the asteroid belt in Lesson 11. The diagram below shows the arrangement of the planets in the solar system and the location of the asteroid belt.



Formation of Earth and its Moon

Like all the other objects in the solar system, Earth formed from colliding particles that collected to form larger and larger pieces of matter. Early Earth was so hot that it was completely melted. Heavier substances, such as iron and nickel, gathered to form Earth's core, or center. This core was surrounded by lighter materials, while the lightest materials rose to Earth's surface. These light materials cooled quickly to form a thin, solid crust.

The planets' natural satellites, or moons, formed in different ways. The large moons of the outer planets formed in the same way as the planets themselves. Their smaller moons are most likely asteroids pulled into orbit by the force of gravity. The two moons of Mars are also probably captured asteroids. You will learn more about asteroids in Lesson 11.

Test Tips . . .

Your brain runs on electricity. Like an engine, it needs fuel to generate power. Be sure to fuel up with healthy food on test days so your brain will have the energy it needs.

Most scientists today think Earth's moon formed differently from the moons of the other planets in the solar system. Earth and its moon have unusually similar structures. Analysis of moon rocks collected by astronauts show that Earth and its moon are made of many of the same substances. Scientists hypothesize that Earth, while it was still forming, collided with another large object in space. Some of that object's matter became part of Earth. The rest formed the moon.

DISCUSSION QUESTION

How was Earth's formation like the formation of the outer planets? How was Earth's formation different?

LESSON REVIEW

1. What is a nebula?

A. a new star that is forming

B. a cloud of gases and dust

C. one of the objects in the solar system

D. a new planet that is forming in space

2. Which of these was MOST important in forming the solar system?

A. darkness

B. evaporation

C. cooling

D. gravity

3. Which statement is TRUE?

A. Moons in the solar system form in different ways.

B. Earth's moon is a captured asteroid.

C. Earth's moon formed much later than the planet.

D. All moons in the solar system form in the same way.

4. An object in orbit around Earth weighs less than the same object at Earth's surface. Why?

10 Properties of the Sun

SC.8.E.5.6

Getting the Idea

Key Words
core
photosphere
chromosphere
corona
solar wind
rotation
sunspot
solar cycle
prominence
solar flare
convection

The sun is a medium-sized star that is the center of our solar system. It appears so much larger than other stars because it is the closest star to Earth. The sun does not have a solid surface. The sun is a burning ball of gas that releases great amounts of energy. In this lesson, you will learn more about the structure of the closest star to planet Earth.

Structure of the Sun

The sun is nearly 150 million kilometers from Earth. The sun is nearly 1.4 million kilometers in diameter. It would take more than one hundred Earths side-by-side to reach across this distance.

The center of the sun is called its **core**. The temperature in this core can be as high as 15,000,000°C. Two different zones surround the sun's core: the radiation zone and the convection zone. Energy produced in the sun's core travels out through the radiation and convection zones before entering the sun's atmosphere. The sun's atmosphere is made of three layers: the photosphere, the chromosphere, and the corona.

The **photosphere** is the innermost layer of the sun's atmosphere. This layer gives off light. When you look at an image of the sun, you are looking at the photosphere. Although it is not a solid, the photosphere is often referred to as the so-called surface of the sun. The gases that spread out from the photosphere make up the chromosphere. The **chromosphere** is the thin layer of these gases above the visible surface of the sun. The chromosphere merges into the outermost region of the sun's atmosphere, the **corona**. The corona extends for millions of kilometers into space above the photosphere. Usually, we cannot see the corona because of the brightness of the photosphere. But during a solar eclipse, the photosphere is blocked out by the moon. The corona is then visible and appears as a white halo around the sun.

Did You Know?

The North Star (also called Polaris) is one of the brightest stars visible from Earth. Although it may look closer than other stars, it is actually 430 light-years from Earth.

Solar Rotation

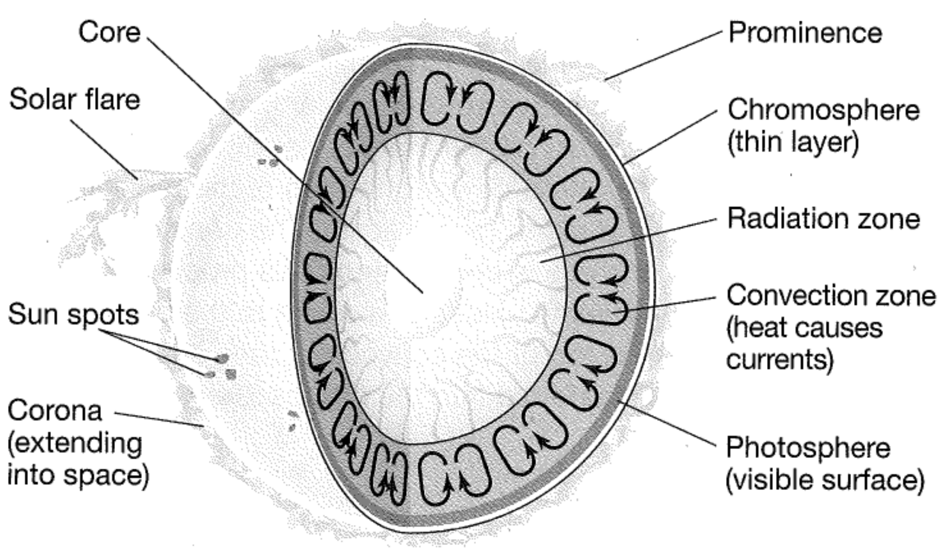
The sun rotates on its axis once in about 27 days. The sun's **rotation**, or spinning on its axis, was first noticed by scientists who observed the movement of dark spots across the surface of the sun. Different parts of the sun rotate faster than others. The regions located in the middle of the sun rotate faster than the regions at poles of the sun.

Flowing outward from the sun's corona are thin streams of electrically charged particles. The continuous outward flow of these particles is called **solar wind**. The sun constantly produces solar wind. The wind flows around the sun and outward from the sun. The path that the wind follows as it flows outward from the sun is determined by the sun's magnetic field. Solar wind continuously affects Earth's upper atmosphere.

Sometimes bubbles of gas burst suddenly and violently from the corona. These events are called *coronal mass ejections*. These events can produce solar wind gusts that blow off the sun at speeds as high as 1.6 million km per hour. When these gusts blow by Earth, they disrupt Earth's own magnetic field. The result is disturbances to power systems, spacecraft operations, radio communication, and navigation systems all over the world.

Surface Features of the Sun

The sun appears to have a smooth surface when viewed from Earth. However, scientists have observed many features on the sun's surface through telescopes. These features include sunspots, prominences, and solar flares.



Not to scale

The average surface temperature of the sun is about 5,510°C. **Sunspots** are temporary dark spots on the sun's corona. They look dark because they are cooler when compared to the surrounding areas. A cooler gas gives off less light than a hotter gas. Sunspots can be very large. In fact, some sunspots are larger than Earth. Sunspots often appear in groups. Sunspot activity tends to increase at regular intervals about every 11 years. This recurrence of sunspot activity is known as the **solar cycle**.

Sunspots relate to other features on the sun's surface: prominences and solar flares. A **prominence** appears as a huge reddish loop of gas that links different areas of sunspots. **Solar flares** occur when gaseous loops near sunspots suddenly connect and release large amounts of magnetic energy. This energy causes the gas to heat up and erupt suddenly into space.

Energy Transfer

The sun is the main source of Earth's light and heat. The energy given off by the sun is called solar energy. The sun's energy travels to Earth by radiation—the transfer of energy by electromagnetic waves.

Electromagnetic waves differ from other types of energy because they do not require matter to transfer energy. Thus, these waves can transfer energy through empty space. You experience radiant energy on Earth in the heat and light given off by a lightbulb, a campfire, or a burning candle. You will learn more about electromagnetic waves in Lesson 17.

Energy from the core of the sun travels outward through two zones. Hotter gas coming from the radiation zone expands and rises through the convection zone. This takes place because the convective zone is cooler than the radiation zone and therefore less dense. As the gas rises, it cools and begins to sink again. As it falls down to the top of the radiation zone, the gas heats up and starts to rise again. The transfer of heat by the circulation of the gas is **convection**. This process repeats, creating convection currents. Heat is released to the outside when the gas reaches the top of the convective zone and cools. In this way, energy is transferred into the photosphere.

DISCUSSION QUESTION

Astronomers often use astronomical units, instead of kilometers, to measure the distances between the sun and the planets. One astronomical unit is equal to 150 million kilometers. What is the distance between the sun and Earth in astronomical units? How do you think this unit could be useful in astronomy? Explain your answer.

LESSON REVIEW

1. The sun is made of

A. minerals.
B. energy.
C. heat.
D. gases.

2. What are the three layers of the sun's atmosphere?

A. core, radiation zone, convection zone
B. core, interior, photosphere
C. photosphere, chromosphere, corona
D. sunspots, prominences, solar flares

3. Why do sunspots appear darker than the surrounding areas on the sun?

A. They are areas of gas that are hotter than the surrounding areas.
B. They are areas of gas that are cooler than the surrounding areas.
C. They are craters that were formed from space debris crashing into the sun.
D. Objects in space are blocking those areas of the sun from our view.

4. Streams of charged particles flowing outward from the sun are

A. sunspots.
B. chromospheres.
C. solar flares.
D. solar winds.

11 The Objects of Our Solar System

SC.8.E.5.7

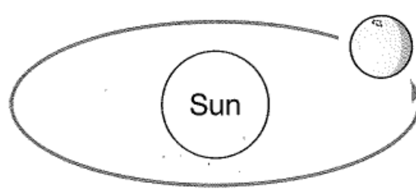
Getting the Idea

Key Words
- period of revolution
- rotation
- axis
- period of rotation
- inner planets
- outer planets
- moon
- asteroid
- comet
- meteoroid
- meteor
- meteorite

The solar system consists of the sun, the planets, and other celestial bodies that orbit the sun. The sun accounts for 99.8 percent of the mass of our solar system. Less than 1 percent of the mass is made up of planets and other smaller objects that orbit the sun. These smaller objects include moons, dwarf planets, comets, asteroids, and meteoroids. The solar system also contains large clouds of dust and gas and huge stretches of empty space.

Movements of the Planets

Modern scientists know that the solar system is sun-centered, or heliocentric. All other objects orbit around the sun in elliptical paths. The time it takes a planet (or other body in space) to complete one orbit around the sun is referred to as its **period of revolution**. The period of revolution of a planet determines the length of its year. Planets closer to the sun have shorter periods of revolution than those farther from the sun. As a result, each planet has a year of a different length.



One complete period of revolution is one year.

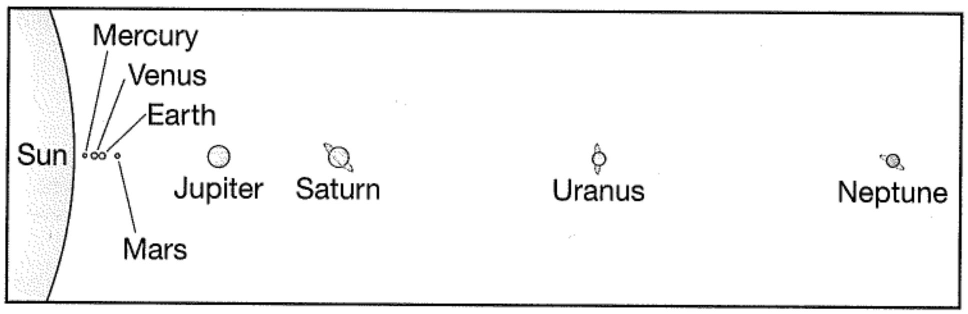
Another motion common to the planets is rotation. **Rotation** is the spinning of a planet around an imaginary line that runs through the center of the planet from one pole to the other. This line is called an **axis**. The time needed for a planet to make one full turn on its axis is called its **period of rotation**. A planet's period of rotation determines the length of its day.

The length of a day also varies among the planets. Larger planets generally rotate more rapidly and have shorter days than Earth. Recall from Lesson 10 that the sun also rotates on an axis.

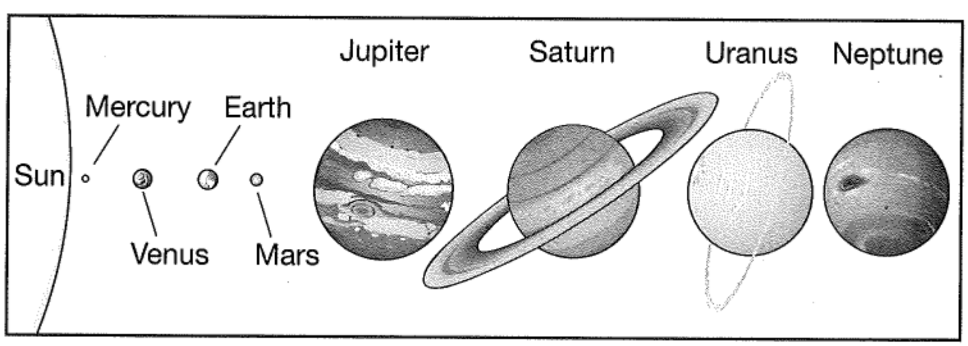
Planets and Moons

Eight planets orbit the sun. In order from the sun, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The four planets closest to the sun (Mercury, Venus, Earth, and Mars) are the **inner planets**. The inner planets are relatively small and are composed mainly of rock and iron. The planets have few or no moons.

The four farthest from the sun (Jupiter, Saturn, Uranus, and Neptune) are the **outer planets**. The outer planets are large, gaseous bodies that are composed mostly of hydrogen, helium, and ice. These planets are often referred to as the "gas giants." Each of the outer planets has both rings and many moons.



The diagram above is not to scale, but it gives you an idea of the relative distances of the planets from the sun and from each other. You can see that the inner planets are short distances from the sun compared with the outer planets. Planets closer to the sun have shorter periods of revolution than those farther from the sun. Planets closer to the sun also tend to have higher surface temperatures than those farther from the sun.



Planets vary considerably in size. The diagram at the bottom of page 65 helps show the relative sizes of the planets. The diagram is not to scale, but it gives you an idea of the relative sizes of the planets when compared to one another.

Until 2006, Pluto was also considered a planet. However, a group of astronomers, scientists who study the universe, voted to redefine what makes something a planet. This vote resulted in Pluto being reclassified as a *dwarf planet*.

Moons are natural bodies that orbit planets. Earth has one moon. This moon orbits Earth, taking almost 28 days to complete one revolution. Earth's moon also rotates on an axis. Planets such as Jupiter and Saturn have many moons. Only two planets, Mercury and Venus, do not have any moons. Most moons are solid or partly solid. Earth's moon, as you leaned in Lesson 9, is made of rocky materials, as are the two moons of Mars.

The table below compares many of the characteristics of the inner planets.

Inner Planets

	Mercury	**Venus**	**Earth**	**Mars**
Number of Moons	0	0	1	2
Diameter (km)	4,879	12,104	12,756	6,794
Rotation (in Earth days)	58.6	243	1	1.03
Average Distance from Sun (millions of km)	58	108	150	228
Revolution (in Earth years)	0.24	0.62	1	1.88
Average Surface Temperature (°C)	166.86	456.85	14	−23
Gravitational Pull (Earth = 1)	0.376	0.903	1	0.38

The table below compares many characteristics of the outer planets.

Outer Planets

	Jupiter	Saturn	Uranus	Neptune
Number of Moons	63	57	27	13
Diameter (km)	142,984	120,536	51,118	49,528
Rotation (in Earth days)	0.41	0.44	0.72	0.67
Average Distance from Sun (millions of km)	778	1,426	2,870	4,498
Revolution (in Earth years)	11.9	29.4	84	165
Average Surface Temperature (°C)	14.85–19.85	−139.15	−197.15	−200.15
Gravitational Pull (Earth = 1)	2.34	1.16	1.15	1.19

Other Bodies of the Solar System

Asteroids are small, rocky bodies that revolve around the sun. Asteroids range in size from 1 to about 1,000 kilometers across. Unlike planets and most moons, asteroids have irregular shapes. In our solar system, most asteroids occur in the asteroid belt located between the orbits of Mars and Jupiter. Asteroids sometimes collide with objects such as planets and moons, creating huge craters on their surfaces.

A **comet** is a body of ice, dust, and small, gritty particles that orbits the sun. As comets approach the sun, the ice and gas vaporize, producing a spectacular streak often referred to as a tail. This tail can be more than 100 million kilometers long and always points away from the sun. Comets originate in the region of dwarf planet Pluto's orbit, called the Kuiper belt. This region contains billions of comets.

Meteoroids are small particles of rock and metal that break free from asteroids or comets. When meteoroids enter Earth's atmosphere, they get hot and begin burning. While a meteroid is burning up, it produces a streak of light called a **meteor**. Meteors can often be seen moving across the night sky and are sometimes called "shooting stars." Meteoroids that land on Earth are called **meteorites**.

Test Tips . . .

It's a good idea to wear a watch on test days so that you can pace yourself. Remember not to wear one with an alarm that might distract you or other test-takers.

DISCUSSION QUESTION

A classmate looks up into the night sky in August and says, "I just saw a shooting star!" Did your friend really see a star? What would you tell your classmate? How is it different from a star?

LESSON REVIEW

1. Which of these is NOT one of the inner planets?

A. Earth

B. Venus

C. Uranus

D. Mercury

2. Which of the following BEST describes a comet?

A. a large mass of burning hot gas

B. a body of ice, dust, and small, gritty particles that orbits the sun

C. a large rocky ball with a tail that points toward the sun

D. a small rocky object that burns up in Earth's atmosphere

3. Most asteroids in our solar system are found

A. circling around Jupiter.

B. orbiting in a belt between Mars and Jupiter.

C. on the moon.

D. moving toward the sun.

4. How are Jupiter, Saturn, and Uranus similar?

A. They are all large, gaseous planetary bodies.

B. They are all planets that are the same size.

C. They are all the same distance from the sun.

D. They all have the same surface temperature.

12 Earth in the Solar System

SC.8.E.5.9

Getting the Idea

Key Words
revolution
rotation
elliptical
Northern Hemisphere
Southern Hemisphere
solstice
equator
equinox

Objects in space often affect each other. You learned that all the planets of the solar system orbit the sun. In this lesson, you will examine some ways the sun affects Earth.

Gravity and Earth's Orbit

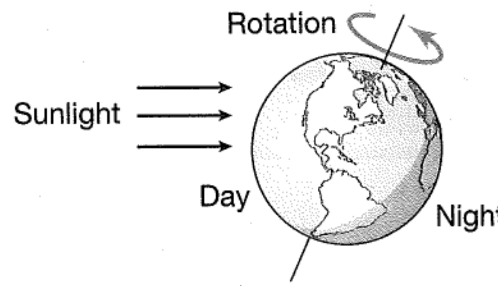
Recall that **revolution** is the movement of Earth or any other planet around the sun. The time it takes for a planet to complete one orbit around the sun determines the length of its year. For example, Earth takes 365.25 days to travel around the sun. Therefore, one year on Earth is equal to 365.25 days.

Recall from Lesson 9 that Earth's moon remains in orbit because of the gravitational attraction between Earth and its moon, as well as the moon's inertia. Gravity and inertia also keep Earth revolving around the sun. Earth's inertia causes it to travel in space at a constant speed along a straight path. However, gravity causes the sun and Earth to pull toward each other. The gravitational force between the sun and Earth balances with the movement of Earth caused by its inertia. This prevents Earth from moving off into space. Instead, Earth follows a regular, curved path around the sun.

Day, Night, and Rotation

Like other planets, Earth spins on an imaginary axis that runs through the center of the planet from its North Pole to its South Pole. The spinning of a planet on its axis is called **rotation**. The time required for a planet to make one full turn on its axis determines the length of its day. Earth takes 24 hours to complete one rotation, so the length of a day on Earth is 24 hours.

Day and Night



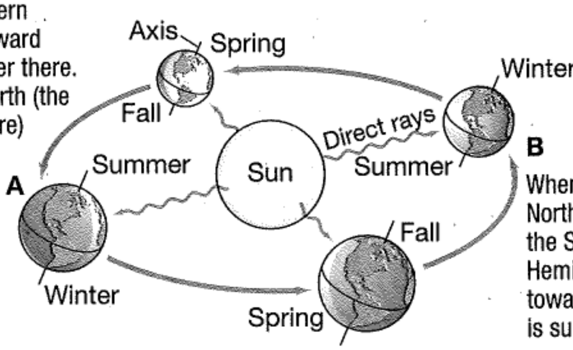
Earth rotates on its axis from west to east. As Earth rotates, only one half of Earth faces the sun. The side of Earth facing the sun experiences daylight. At the same time, the parts of Earth that face away from the sun experience night. Earth continues to rotate, and the area experiencing day and night shifts over a 24-hour period.

What Causes the Seasons?

The **elliptical** shape of Earth's orbit causes Earth's distance from the sun to vary at different times in its orbit. You may expect warm seasons to occur when Earth is closer to the sun. However, Earth's seasons do not result from our distance away from the sun. The seasons occur because of the tilt of Earth's axis.

Earth tilts on its axis in relation to its path around the Sun. Earth rotates on an axis tilted at a 23.5° angle. This tilt affects how much sunlight different areas of Earth receive at various times of the year. In many parts of Earth, the temperature changes with the seasons during the year. Earth's tilt on its axis and revolution around the sun cause Earth to experience seasons.

When Earth's Northern Hemisphere tilts toward the sun, it is summer there. The other half of Earth (the Southern Hemisphere) is having winter.



When it is winter in the Northern Hemisphere, the Southern Hemisphere tilts toward the sun and it is summer there.

The "top" half of Earth located north of the equator is the **Northern Hemisphere**. The "bottom" half, located south of the equator, is the **Southern Hemisphere**. Areas tilted toward the sun have a summer of longer days and higher temperatures because they receive more direct sunlight. Areas tilted away from the sun have a winter of shorter days and cooler temperatures because they receive less direct sunlight. If Earth were not tilted on its axis, there would be no seasons.

In summer in Florida, the Northern Hemisphere is tilted toward the sun. The tilt causes the sun's rays to shine more directly on Florida in summer. Think of the sun shining overhead on a hot summer day. The rays shine down on you directly. When the sun is shining on you from lower in the sky, such as on a winter day, the rays don't warm you as much. The rays come from a different angle. They are less direct, so less energy reaches you.

A **solstice** is a point in Earth's orbit when a hemisphere tilts most toward or away from the sun. There are two solstices in a year, a winter and a summer solstice. For the Northern Hemisphere, the winter solstice occurs on December 21 or 22, and marks the first day of winter. The summer solstice occurs on June 20 or 21, and marks the first day of summer.

Spring and fall occur when neither hemisphere tilts toward or away from the sun. At the beginning of these seasons, the sun heats both hemispheres equally. Since areas closer to the equator receive the most direct sunlight year round, these regions are hot year round. There is not as much of a difference between winter and summer in Florida as compared to areas farther north because those areas are farther from the equator. The equator is the part of Earth that gets direct sunlight throughout the year. The **equator** is an imaginary line that divides Earth horizontally into two halves, or hemispheres.

An **equinox** is a point in Earth's orbit when it tilts neither toward nor away from the sun. Earth experiences two equinoxes a year. The vernal equinox, or first day of spring, occurs in the Northern Hemisphere on March 20 or 21. The autumnal equinox, or first day of fall, occurs in the Northern Hemisphere on September 22 or 23. As with winter and summer, these seasons in the Southern Hemisphere are opposite those in the Northern Hemisphere.

The length of daylight each day also changes with the seasons. This has an effect on the temperature of the seasons. The period of daylight gets longer each day between December 21 and June 21. In summer, there are more hours of daylight than in winter. So not only are the sun's rays more direct, but the sun also heats Earth's surface for a longer period each day. Between June 21 and December 21, the period of daylight gets shorter each day. In winter, the sun's rays are less direct, and there are fewer hours of daylight. As a result, temperatures are lower in winter.

DISCUSSION QUESTION

Relative to its orbit, Mercury is not tilted on its axis. How do you think this affects the seasons on Mercury?

LESSON REVIEW

1. If the time it takes for Earth to rotate once on its axis increased, what would happen?

   A. A day would be longer.

   B. A day would be shorter.

   C. A year would be longer.

   D. A year would be shorter.

2. Which of these is the primary cause of Earth's seasons?

   A. Earth's gravitational attraction to the sun

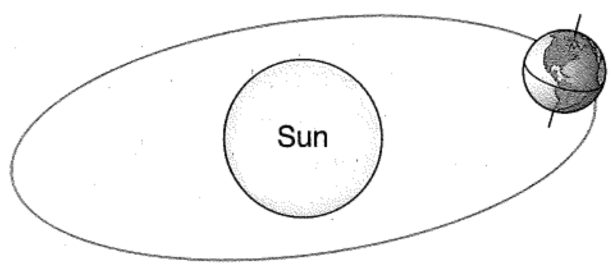
   B. the distance between Earth and the sun

   C. the tilt of Earth's axis as Earth revolves around the sun

   D. the moon's revolution around Earth

Use the following diagram and information to answer question 3.

3. The diagram below shows Earth in orbit around the sun.



   What season would the position shown above cause in the Southern Hemisphere?

   A. winter

   B. spring

   C. summer

   D. fall

13 The Effects of Earth's Moon on Earth

SC.8.E.5.9

Getting the Idea

Key Words
moon phase
new moon
full moon
waxing
waning
tide
spring tide
neap tide

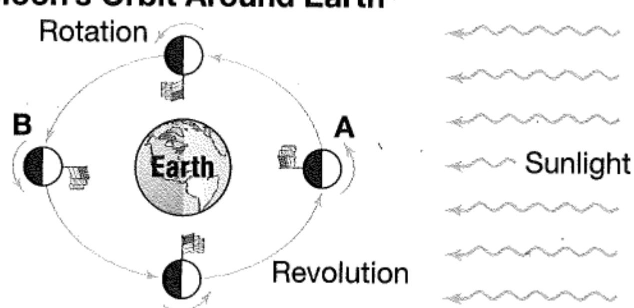
The Earth and moon move in relation to each other and to the sun. This causes predictable changes on Earth. Earth's rotation on its axis, for example, causes day and night. Earth's tilt and revolution around the sun cause the seasons. In this lesson, you will explore changes that result from the moon's revolution around Earth.

Motions of the Moon

Like Earth, the moon follows two patterns as it moves through space. First, it rotates on an axis. Second, it revolves around Earth. The changing positions of the Moon relative to Earth and the sun cause both the phases of the Moon and Earth's ocean tides.

As the moon revolves and rotates, the same side of the moon always faces Earth. This occurs because the moon takes the exact same amount of time to orbit Earth as it does to make one turn on its axis. The diagram below shows that the same side of the moon always faces Earth.

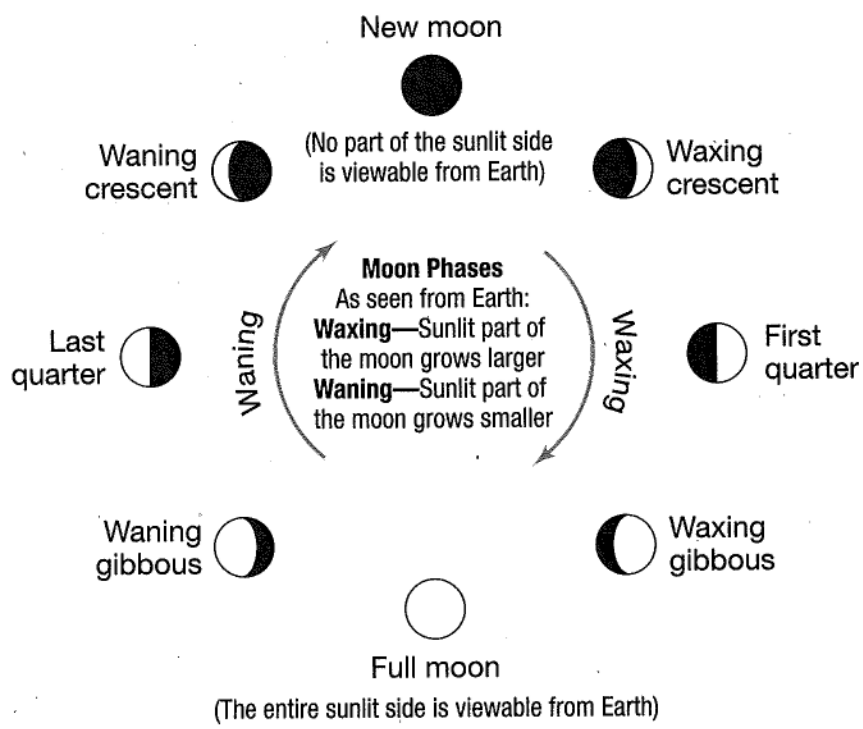
Moon's Orbit Around Earth



Another important point to remember is that the moon does not produce its own light. The moon is visible because it reflects light from the sun off its surface. The diagram above shows that one-half of the moon is always lit by the sun's light while the other half is in darkness.

As the moon revolves around Earth, different parts of the moon's sunlit side become visible from Earth. Sometimes the entire half that is lit is visible. At other times, no visible part of the moon appears to be lit. The shape of the lit portion of the moon that can be seen from Earth is called a **moon phase**. Look at the previous diagram. Note that in position A, only the Moon's shadowed side faces Earth; none of the lit portion can be seen. This phase is called a **new moon**. At position B, all the moon's lit portion can be seen from Earth. This phase is called a **full moon**.

All of the moon phases are shown in the diagram below. As the visible portion of sunlit area of the moon grows larger from day to day, the moon phases are said to be **waxing**. As the visible portion of sunlit area of the moon grows smaller from day to day, the moon phases are said to be **waning**. The moon repeats all its phases about every 29 days.



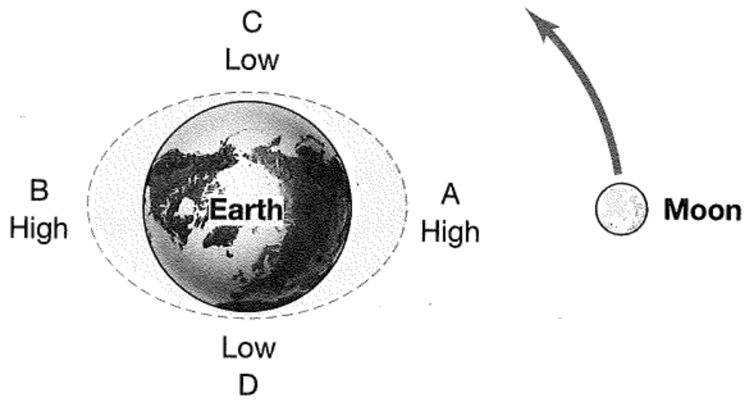
Tides

The changing positions of the moon relative to Earth and the sun produce ocean tides on Earth. A **tide** is a rise or fall of surface water caused by the pull of gravity. The Law of Universal Gravitation explains tides. Recall from Lesson 9 that the Law of Universal Gravitation states that every object in the universe attracts every other object. The moon's gravity attracts Earth and everything on it including its waters, which are free to move.

Did You Know?

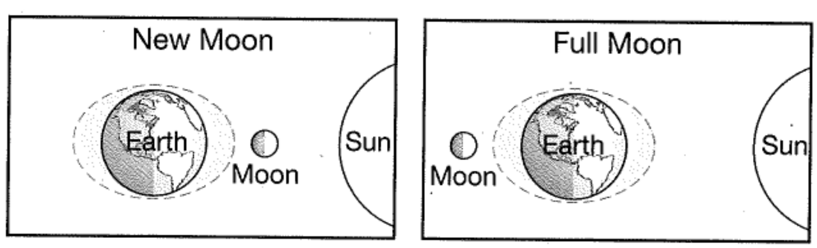
Every person is a tiny bit heavier at low tide. Due to the saltwater content of our bodies, people lose a fraction of a kilogram with each rise of the tide, and gain it back when the tide recedes.

Tides are largely caused by how much the moon's gravity pulls on different parts of Earth. When the moon's gravity pulls on Earth's surface water, it causes oceans to bulge on the side of Earth nearest to the moon (label A). At the same time, the moon's gravity pulls Earth toward the moon, leaving ocean on the opposite side (label B) behind. This produces high tides on opposite sides of Earth. A high tide is a rising of water. As the diagram shows, areas between the high-tide regions experience low tides (labels C and D). A low tide is a falling of water. At any time, two regions on Earth experience high tides, while two regions experience low tides. Usually, a given location experiences two high tides and two low tides each day.



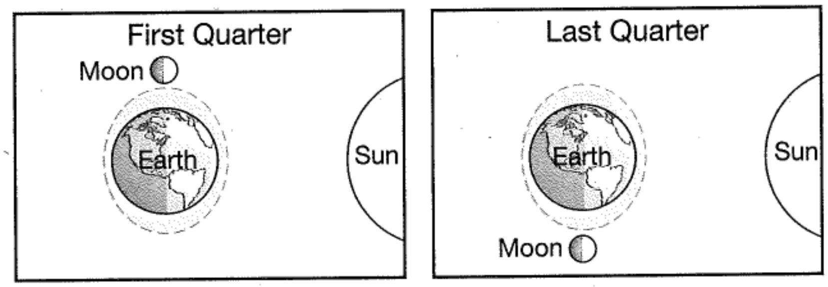
Recall that the sun's gravity pulls on Earth. The relative positions of Earth, the moon, and the sun produce spring and neap tides. **Spring tides** are higher than normal tides caused by the alignment of the Earth, sun, and moon. **Neap tides** are lower-than-normal tides caused by the sun and moon being perpendicular to Earth.

The diagram below shows the positions of Earth, the moon, and the sun during spring tides. Notice that during this type of tide, the sun, Earth, and moon are in alignment with each other. As a result, the gravitation pull of the sun and moon on Earth's waters combine to cause larger-than-normal tides. Notice also that spring tides occur only when the moon is in its new moon or full moon phase.



Alignment of Moon, Sun, and Earth during Spring Tides

The diagram below shows the relative positions of Earth, the moon, and the sun during a neap tide. The moon and sun are at right angles to each other when compared to Earth. As a result, the effect of some of the gravitational pull of each body on Earth and its waters is lessened, causing lower-than-normal tides. Neap tides occur only during the first quarter and last quarter phases of the moon.



Alignment of Moon, Sun, and Earth during Neap Tides

DISCUSSION QUESTION

Captains of large ships must be familiar with the moon's cycle. Why do you think this is true?

LESSON REVIEW

1. When the entire lit surface of the moon is seen from Earth, which phase of the moon is observed?

- **A.** first quarter
- **B.** last quarter
- **C.** new moon
- **D.** full moon

2. How are the sun, Earth, and moon arranged during a spring tide?

- **A.** They are in first-quarter phase.
- **B.** They are in last-quarter phase.
- **C.** The moon must be at a right angle to the sun.
- **D.** All three are aligned.

3. The main reason we can see the moon in the night sky is because the moon

- **A.** reflects sunlight.
- **B.** emits its own light.
- **C.** reflects light from Earth.
- **D.** is a glowing ball of gas.

14 Relative Positions of the Sun, Earth, and Moon

SC.8.E.5.9

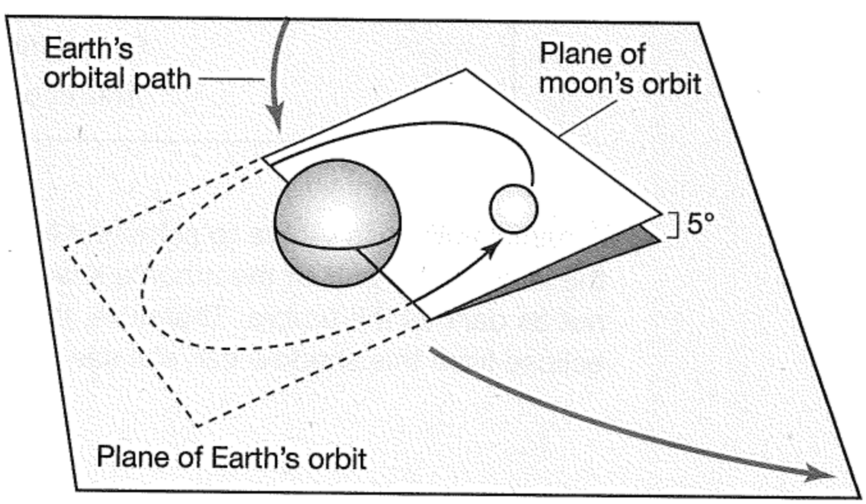
Getting the Idea

Key Words
orbital plane
eclipse
solar eclipse
umbra
penumbra
lunar eclipse

When you are outdoors on a sunny day, you have certainly noticed that your body casts a shadow on the ground. Your shadow results from your body blocking light from the sun. Objects in space can also block the sun's light and cast shadows on other bodies in space. In this lesson, you will learn how shadows can change the way objects in our solar system appear on Earth.

Understanding Orbits

A *plane* is a flat surface that extends outward in all directions. An **orbital plane** is an imaginary flat surface extending outward on all directions upon which a moon or planet's orbit is located. Each planet travels around the sun within an orbital plane. The moon also revolves around Earth in an orbital plane. As shown in the diagram below, the moon's orbital plane around Earth is slightly tilted relative to Earth's orbital plane around the sun. As a result, the moon sometimes travels slightly above or below Earth's path.



Did You Know?

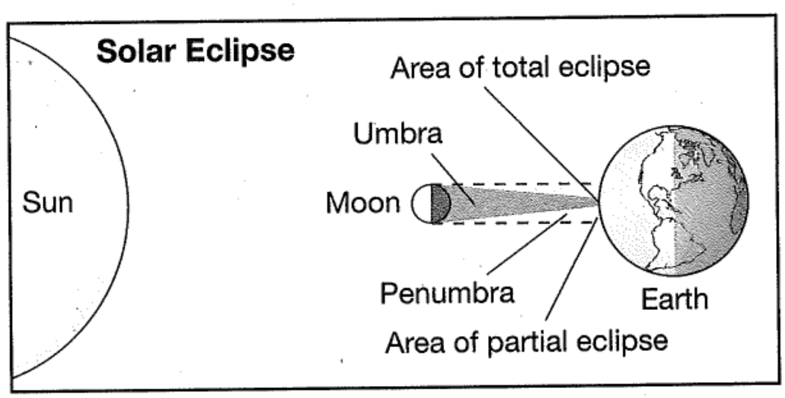
According to NASA, the next total solar eclipse that will be viewable from anywhere in the United States will occur on August 21, 2017.

When one object comes between the sun and another object, it casts a shadow onto the other object. The shadow that forms when a body in space comes between the sun and another object is an **eclipse**. The changing positions of the moon and Earth relative to the sun can cause eclipses. These eclipses occur only when the sun, Earth, and moon are in alignment. There are two different types of eclipses: solar and lunar.

Solar Eclipse

As the moon travels within its orbital plane, it sometimes passes directly between the sun and Earth. A **solar eclipse** take place when the moon blocks the sun's light, and casts a shadow onto Earth. A solar eclipse happens only during the new moon phase.

A total solar eclipse is visible when you are in the **umbra**, the darkest inner part of the shadow. As shown in the diagram, the umbra reaches only a small area of Earth's surface. As a result, only a few people experience a total solar eclipse. During a total solar eclipse, a bright blue daytime sky can grow as dark as night, and stars become visible. The corona, or outermost layer of the sun's atmosphere, can be seen as a white halo surrounding the darkened sun. You learned about the corona and other parts of the sun in Lesson 10.

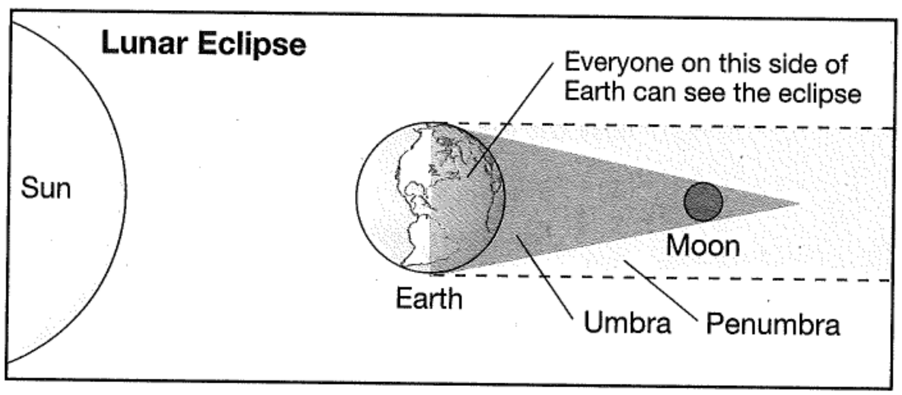


A partial eclipse is visible to someone located in the **penumbra**, the large, outer part of the moon's shadow. The penumbra is not as dark as the umbra. Therefore, those who are viewing the eclipse from this shadow can still see part of the sun.

Lunar Eclipse

A **lunar eclipse** occurs when the moon passes into Earth's shadow. A lunar eclipse takes place only during a full moon, when the entire lit side of the moon can be seen from Earth. During a lunar eclipse, Earth is positioned between the sun and the moon. This position blocks much of the sun's light from striking the moon. In other words, Earth gets in the way.

Like the moon's shadow during a solar eclipse, Earth's shadow also has an umbra and a penumbra. As the moon moves from Earth's penumbra to the umbra, you see the curved shadow of Earth fall on the moon's surface. Finally, when the moon is completely in the umbra, a total lunar eclipse occurs. During a total lunar eclipse, the moon can appear dim with a reddish tint, as Earth's atmosphere bends some sunlight toward the moon. Unlike a total solar eclipse, a total lunar eclipse can be seen from all locations on Earth.



During most lunar eclipses, the sun, the moon, and Earth are not completely aligned. As a result, most lunar eclipses are partial. During a partial lunar eclipse, the moon is not positioned totally in Earth's umbra.

Look again at the illustrations of the two types of eclipses. Compare the positions of the moon, Earth, and sun. You will notice that they change relative to each other during each type of eclipse. Remember that during a solar eclipse, the moon is located between the sun and Earth. During a lunar eclipse, Earth is located between the sun and the moon.

DISCUSSION QUESTION

The moon's diameter is about one-quarter the diameter of Earth. If the moon were larger than Earth, how would this affect solar and lunar eclipses? Assume for this question that Earth and the moon remain the same distance from the sun.

LESSON REVIEW

1. During which phase of the moon can a solar eclipse occur?

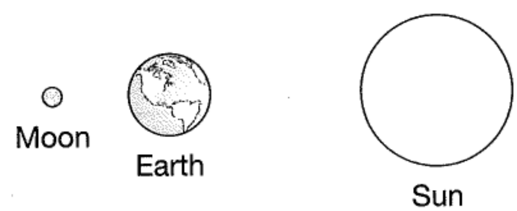
A. full moon
B. new moon
C. first quarter moon
D. last quarter moon

2. If the moon, Earth, and sun were in the same plane, how often would an eclipse occur?

A. once a day
B. once a month
C. twice a month
D. twice a year

Use the diagram to answer question 3.

3. The diagram shows a celestial event that occurs during the moon's cycle.



What celestial event is shown?

A. solar eclipse
B. lunar eclipse
C. new moon
D. crescent moon

4. Which of these can a person view if they are located in the moon's umbra?

A. total solar eclipse
B. partial solar eclipse
C. total lunar eclipse
D. partial lunar eclipse

2 Review

1. Which of the following provides evidence that the sun rotates on its axis similarly to Earth?

   A. the sun appearing to move across the sky

   B. the sun not being visible in the night sky

   C. the occurrence of solar eclipses

   D. the regular movement of sunspots

2. Which scientist is associated with the formation of the geocentric model of the solar system?

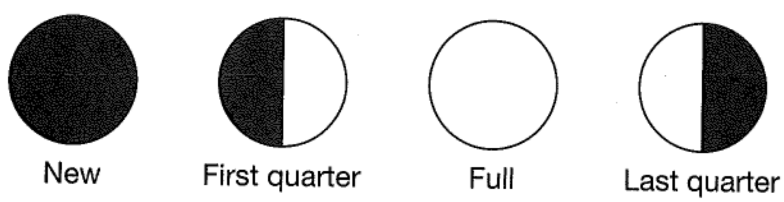
   A. Newton

   B. Ptolemy

   C. Copernicus

   D. Kepler

3. As the moon revolves around Earth, it appears to change shape. The moon goes through phases during a period that lasts about one month.



Describe what causes the moon to change shape as it goes from a full moon to a last-quarter moon.

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4. Which of the following layers do you see when looking at a picture of the sun?

   A. corona

   B. chromosphere

   C. photosphere

   D. biosphere

5. Planets orbit the sun in slightly elliptical paths. What is the force that, along with inertia, keeps the planets in their orbits?

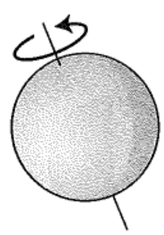
   A. friction

   B. magnetism

   C. electromagnetism

   D. gravity

6. The diagram shows a planet spinning on its axis.



   What does one rotation equal?

   A. one hour

   B. one day

   C. one month

   D. one year

7. Dark, planet-sized areas can be seen on the sun's surface with the unaided eye. These areas are dark because they are a lower temperature than their surroundings. What are these dark areas called?

   A. corona

   B. sunspots

   C. prominences

   D. solar flares

8. What happens to the force of gravity between two objects if the distance between them decreases?

   A. gravity increases

   B. gravity decreases

   C. gravity stays the same

   D. gravity disappears

9. In what way are Earth and Mars similar?

A. They each have two moons.

B. They both have rocky surfaces.

C. They are both outer planets.

D. They both have rings.

10. Explain how the geocentric model of the solar system differs from the heliocentric model of the solar system.

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11. If the force of gravity between Earth and the sun were greater than Earth's inertia, what would happen to Earth?

A. Earth would be pulled into the sun.

B. It would escape its orbit around the sun and travel into space.

C. Nothing would change. Earth would remain in its orbit around the sun.

D. Earth would stop moving.

12. The planets Jupiter, Neptune, Uranus, and Saturn are the largest planets in our solar system. Which term do astronomers use to describe these planets?

A. supernovas

B. inner planets

C. asteroids

D. gas giants

13. In the Northern Hemisphere's summer, Earth's axis points toward the sun. In the Northern Hemisphere's winter, Earth's axis points away from the sun. How does Earth's tilt explain spring temperatures?

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14. Which arrangement of the sun, Earth, and moon would produce a solar eclipse?

A. The sun is between the moon and Earth.

B. Earth is between the sun and the moon.

C. The moon is between Earth and the sun.

D. The sun and the moon are at right angles to Earth.

15. What does the term "heliocentric" mean?

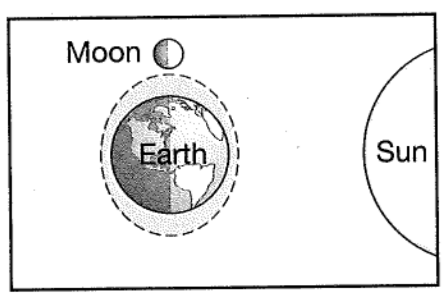
A. sun-centered

B. Earth-centered

C. land-centered

D. space-centered

16. The illustration below shows the effect of the sun and moon on Earth's tides.



What type of tide does this illustration show?

A. spring tide

B. neap tide

C. high tide only

D. low tide only

CHAPTER

3 Outer Space

15 Understanding Distances in Space

SC.8.E.5.1; SC.8.E.5.2; SC.8.E.5.3

Getting the Idea

Key Words
galaxy
Milky Way galaxy
light-year
universe

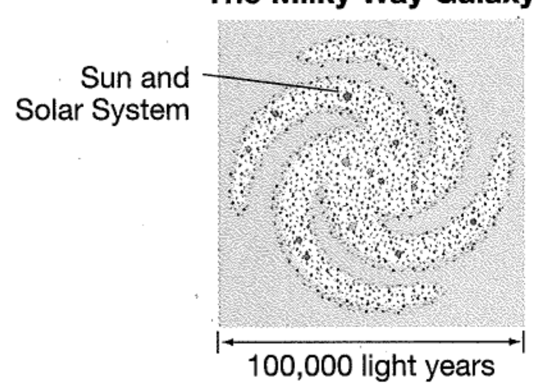
The universe contains countless stars and other objects. The stars are not scattered evenly through the universe, even though it may seem that way as you gaze into the night sky. The stars are actually organized into very large groups. In this lesson, you will explore these star groups and learn how the large distances between individual stars and star groups are measured.

The Milky Way Galaxy

Earth is part of a solar system that revolves around one star—the sun. However, the sun is not a lone star. The sun is a member of a family of stars called a galaxy. A **galaxy** is a large group of stars, space dust, and gases that are held together by gravity. Galaxies are classified into three types, according to their shape: spiral, elliptical, and irregular. No matter what their shape, an individual galaxy may contain billions or even trillions of stars.

The galaxy to which the sun belongs, the **Milky Way galaxy**, has a spiral shape. A spiral galaxy has "arms" that wind outward from the center, resembling a pinwheel. Many spiral galaxies have a "bar" of stars in the center. Scientists think that the Milky Way is a barred spiral galaxy.

The Milky Way Galaxy



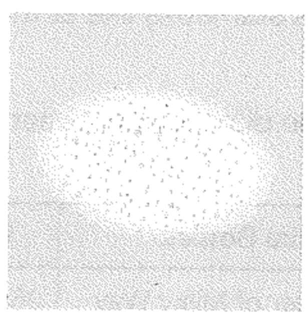
Our sun is only one average-sized star in the Milky Way galaxy. Many scientists estimate that there are between 100 and 300 billion stars in this galaxy. If you were able to view the Milky Way from above, you would see its spiral shape. You cannot see the spiral shape of the Milky Way from Earth because of your position within it. That position gives you a view of the galaxy from near its edge. In other words, you are looking across, or through the diameter of the galaxy. This side view produces the band of light that crosses the night sky. It is within the milky band of light that most of the stars of our galaxy are located.

The Milky Way galaxy is very large. In fact, it is so large that Earth is located nearly 26,000 light-years away from its center. You will learn more about light-years later in this lesson. Our solar system is located closer to the outer edge of the galaxy than it is to the center.

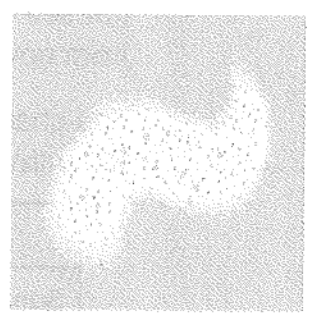
Other Types of Galaxies

An elliptical galaxy has an oval or near-spherical shape. Elliptical galaxies can have billions of stars, but these galaxies have little gas and dust. They are typically filled with older stars because, without gas and dust, new stars do not form.

Irregular galaxies are galaxies that do not fit into the other two groups. They have many different shapes and are typically smaller than the others. They tend to have bright, young stars and lots of dust and gas to form new stars.



Elliptical galaxy



Irregular galaxy

Measuring Distances in Space

Astronomers use different techniques to measure distances between stars and galaxies. One way is by measuring the apparent shift in the position of an object when you look at it from two different places.

You can model this idea by closing your left eye and holding your thumb up in front of your face. Block your view of something in your classroom. Without moving your thumb, open your left eye and close your right eye. You will notice that the object appears to move. Scientists look at stars from different points in Earth's orbit. They also look at how much the star appears to move against a background of stars farther away. By measuring the apparent change in position, a scientist can determine the object's distance from Earth.

Units of Measurement in Space

When you measure distances on Earth, you typically use units like meters or kilometers. The distance to most stars, however, is so large that these units are not practical. Instead, scientists use a unit called a light-year to measure distances in space. A **light-year** is the distance that light travels in one year. In space, light travels at a speed of nearly 300,000 kilometers per second, or almost 9.5 trillion kilometers per year. A light-year is thus equal to about 9.5 trillion kilometers.

After our sun, the nearest star to Earth is Proxima Centauri. This star is a little more than 4.2 light-years (40 trillion kilometers) away. The distance to a star or galaxy in light-years is equal to the number of years needed for the light from that object to reach an observer on Earth. Light from Proxima Centauri takes a little more than 4.2 years to reach Earth. If you observe this star tonight, you would see Proxima Centauri as it looked 4.2 years ago. You will not see what this star looks like at this very moment until 4.2 years from now.

The chart lists the distances between some other structures in the universe.

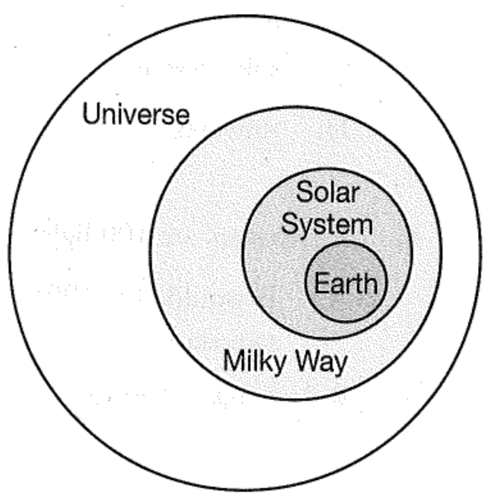
Celestial Bodies	Distance Between Them
Sun and center of Milky Way galaxy	26,000–27,000 light-years
Milky Way galaxy and Andromeda spiral galaxy	2.3 million light-years or 22 million, trillion kilometers
Earth and the edge of the universe	More than 13 billion light-years

Relationships within the Universe

The **universe** is a vast place made up of all the matter and energy that exists. When you try to understand this concept, it is helpful to examine the relationships among the different structures that the universe includes. For example, you know that Earth is one of the planets in our solar system. The solar system is composed of the eight planets and their moons, comets, asteroids, and many other objects that orbit our sun. The solar system of which Earth is a part is only one of a vast number of solar systems that exist throughout the universe.

The sun is only one of the billions of stars in the Milky Way galaxy. The Milky Way galaxy in turn is only one of the countless number of galaxies that make up the universe. Like the Milky Way, each of these other galaxies contains its own millions or even billions of stars. Each of these individual galaxies can be thousands of light-years across and be located millions of light years away from each other.

To study large amounts of information, scientists often find it helpful to organize information in a simplified concept map. The diagram below can help you visualize the hierarchal relationship among the different groups and bodies that make up the universe. Notice that this concept map is arranged from body containing the largest number of objects—the universe—to that containing the fewest objects—in this case, a single planet—Earth.



Test Tips . . .

When an answer includes numbers and units of measure, be sure to read all the answer options carefully before making your selection. Answers that look similar at first may differ slightly in the position of a decimal point or a unit of measure.

DISCUSSION QUESTION

When you look up into the sky, you can see stars that no longer exist. How do you explain this?

LESSON REVIEW

1. What does a group of stars, dust, and gas held together by gravity form?

A. a star system

B. a solar system

C. a galaxy

D. a constellation

2. Which type of galaxy contains mostly new stars because it has lots of dust and gas?

A. irregular

B. spiral

C. elliptical

D. regular

3. Which of these is largest?

A. the sun

B. galaxy

C. solar system

D. universe

4. If two stars are 100 light-years apart, what does this mean?

A. It would take 100 years for a spaceship to travel between these two stars.

B. It takes 100 years for light to travel from one star to the other.

C. One of the stars formed 100 years before the other.

D. The stars are 100 million kilometers from each other.

16 Properties of Stars

SC.8.E.5.5

Getting the Idea

Key Words
star
apparent magnitude
absolute magnitude
Hertzsprung-Russell (H-R) diagram
nebula
protostar
nuclear fusion
luminosity
white dwarf
black dwarf
red giant
planetary nebula
supergiant
supernova
neutron star
black hole

Our sun is only one of countless billions of other stars. Stars have similar compositions, but different ages and characteristics. By studying many different stars at different stages of development, scientists have gained an understanding of the star life cycle.

Properties of Stars

A **star** is a massive ball of hot gases that gives off its own light. All stars are made mostly of hydrogen and helium. However, stars vary in size, temperature, color, brightness, age, and distance from our solar system.

The sun is the nearest star to Earth. Recall from the last lesson that Proxima Centauri, the second nearest star to Earth, is about 4.2 light-years from our sun. Polaris (the North Star) is 390 light-years from the sun.

The Sun

Characteristic	Data
Age	4.5 billion years
Diameter	1.4 million kilometers
Average Surface Temperature	5,510°C
Color	Yellow
Mass	1.99 × 1030 kilograms

The table above lists some characteristics of our sun. Our sun is a medium-sized star in terms of both mass and diameter. Small, hot stars can be as small as Earth. Large, cooler stars can be many times larger than the sun.

Stars vary widely in their surface temperatures. The coolest stars have surface temperatures as low as 3,000°C, while the hottest stars have surface temperatures ten times higher. The temperature of a star determines its color—from cool, red stars to hot, blue ones. The table below shows how temperature and star color are related. Recall that the sun is a medium-temperature yellow star.

Star Color and Temperature

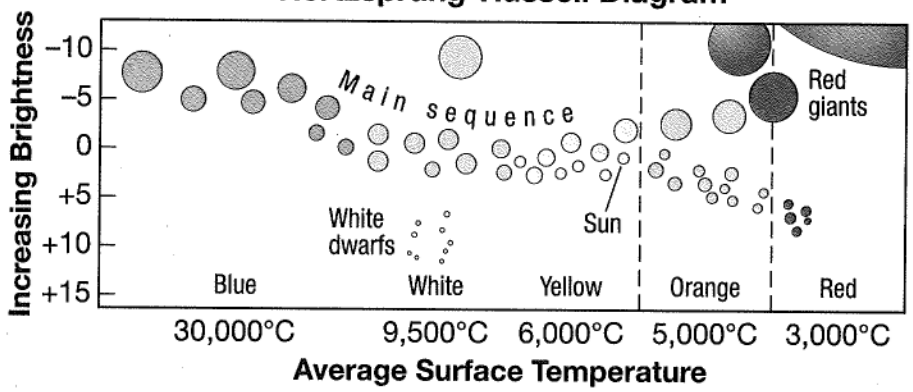
Color	Average Surface Temperature
Blue	30,000°C
White	9,500°C
Yellow	6,000°C
Orange	5,000°C
Red	3,000°C

The term *magnitude* is used to describe the brightness of a star. **Apparent magnitude** is the brightness of a star as it appears from Earth. This brightness depends partly on how far away the star is. **Absolute magnitude** describes the actual brightness of a star without considering its distance from the observer. The absolute magnitude of stars is measured on a scale from about −15 to +15. On this scale, negative numbers correspond to brighter stars.

Around 1910, Ejnar Hertzsprung and Daniel Russell independently developed means for showing how a star's magnitude relates to its surface temperature. Their findings were later combined into a graph called the **Hertzsprung-Russell (H-R) diagram**. This graph displays the relationship between a star's average surface temperature and its brightness.

On the H-R diagram, most stars, including the sun, fall within a diagonal band of stars called the *main sequence*. Main-sequence stars show a direct relationship between temperature and brightness: hotter stars burn brighter. Note that the cool red giants in the upper right burn brightly because of their enormous size. The hot white dwarfs near the center have low brightness because they are so small.

Hertzsprung-Russell Diagram



Life Cycles of Stars

Stars exist for billions of years. A star begins forming when gravity pulls together the gas and dust that make up a **nebula**. As the particles pull together, they form a dense, rotating sphere. This rotating sphere becomes hot, due to friction caused by the collisions of its particles. This glowing, hot, condensed sphere of dust and gas is a beginning star, called a **protostar**.

Stars form when the temperature in a protostar becomes hot enough to start the process of nuclear fusion. **Nuclear fusion** is the joining of the nuclei of light atoms to form a heavier atomic nucleus. This process releases enormous amounts of energy. In young stars, hydrogen undergoes fusion and becomes helium.

The mass of a star determines its temperature, its luminosity, and its diameter. **Luminosity** is a measure of the energy released each second from the surface of a star. The brightness of a star depends on its luminosity and its distance from observers on Earth.

Did You Know?

A star named Betelgeuse (pronounced "beetle-juice"), located in the Orion constellation, is a supergiant. It has a diameter several hundred times larger than the sun.

The mass of a star determines the different changes it will go through. For example, mass determines if a star will expand and become larger or contract and get smaller.

Most stars enter the main-sequence phase a few million years after they begin to form. Most stars in the main-sequence stage are medium-mass stars,which are stars with masses similar to the sun. Medium-mass stars use hydrogen in their cores for nuclear fusion. The fusion process continues until the hydrogen runs out.

After the hydrogen is gone, the star's mass determines which phase of its life cycle it enters. Low-mass stars collapse and become white dwarfs. **White dwarfs** are small, hot, dense stars that can radiate heat for billions of years. Eventually, a white dwarf cools and becomes a **black dwarf**.

Medium-sized stars enter a period of expansion and contraction. The core shrinks as the hydrogen burns away, but the star itself expands because gravity can no longer hold the outer layers in tightly. The star becomes a **red giant**, a large, bright, cool star.

After another billion years or so, the outer layers of a red giant expand to form a glowing cloud of gas called a **planetary nebula**. The remaining core of the star collapses into a white dwarf that eventually cools into a black dwarf.

Very massive stars become **supergiants**—huge, cool, red stars that burn helium in the core. When the helium is gone, the core contracts again. When a massive star dies, the huge explosion that results is a **supernova**. If a supergiant is massive enough, it will collapse into a **neutron star**, an extremely dense object that consists mainly of closely-packed neutrons. The most massive stars, however, collapse into black holes. A **black hole** is a small, extremely dense object. The pull of gravity from a black hole is so strong that not even light can escape from it.

A star may release some of its gases at different stages in its life cycle. These gases then become the material from which new stars form.

Test Tips . . .

Remember to stay positive. Don't get upset if you don't know the answer to a question right away. Just move on and come back to it later. You may remember the answer once you relax!

DISCUSSION QUESTION

Imagine that you could watch our sun undergo its own life cycle. What would you see happen?

LESSON REVIEW

1. Which of the following is MOST important in determining a star's life cycle?

A. its mass

B. its diameter

C. its color

D. its brightness

2. What fuel does a main-sequence star use for nuclear fusion?

A. oxygen

B. petroleum

C. helium

D. hydrogen

3. What phase takes place after the most massive of stars is already a supernova?

A. a planetary nebula

B. a black hole

C. a white dwarf

D. a black dwarf

Lesson

17 Applications of the Electromagnetic Spectrum

SC.8.E.5.10; SC.8.E.5.11

Getting the Idea

Key Words

- electromagnetic spectrum
- wavelength
- frequency
- electromagnetic radiation
- telescope
- optical telescope
- spectroscope
- satellite

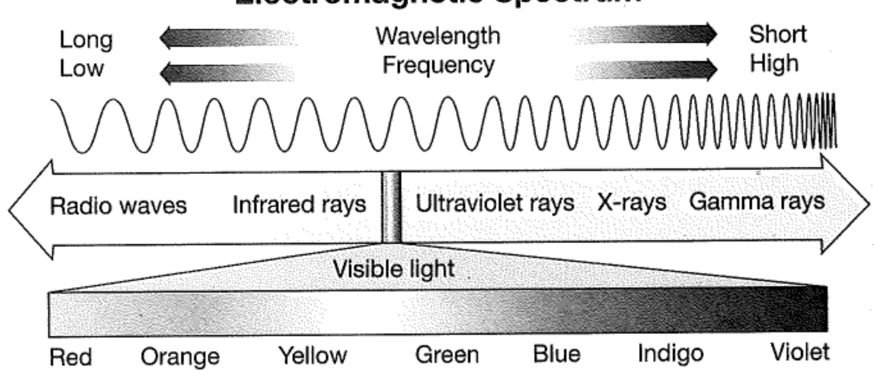
Light is a form of energy. Light travels in waves. However, visible light is only one type of a large spectrum of energy that travels in the same way. These other types of energy affect you in many different ways. In this lesson, you will learn about these different kinds of energy waves.

The Electromagnetic Spectrum

The **electromagnetic spectrum** is the range of all possible waves that transfer energy through an electric and a magnetic field that are perpendicular to each other. Electromagnetic (EM) waves can travel through empty space. All EM waves travel at the same speed—about 300,000 km per second in a vacuum. However, the waves of the EM spectrum vary widely in wavelength and frequency. **Wavelength** is the distance between a point on one wave and its corresponding point on the next wave. **Frequency** is the number of waves produced in a given amount of time.

Energy transmitted by electromagnetic waves is called **electromagnetic radiation**. EM waves are categorized by their wavelengths. As you look at the diagram below, notice that wavelength and frequency are inversely proportional. As one value increases, the other decreases.

Electromagnetic Spectrum



There are different categories of electromagnetic waves. The chart below describes each category of EM wave and identifies some of its uses:

Types of Electromagnetic Waves

Name	Description
Gamma Rays	• highest energy, highest frequency • waves about the size of an atom's nucleus • produced by the sun and other stars • very damaging to cells • used to sterilize medical equipment by destroying germs
X-rays	• waves about the size of atoms • can travel through skin and muscle, but not through hard bone; used for imaging • Repeated exposure can damage cells • used in security checks to find any hidden objects
Ultraviolet (UV) Light	• higher energy and higher frequency compared to visible light • waves about the size of molecules • UV rays from the sun can tan or burn skin • can make certain minerals glow • Prolonged exposure can damage cells
Visible Light	• longest wavelengths of visible light is red and the shortest is violet • waves about the size of bacteria • the only part of the EM spectrum humans can see • includes the visible spectrum (rainbow)
Infrared Waves	• Heat from the sun travels to Earth in this form. • waves about the size of a needle point • not seen by humans but can be felt as heat • Night vision goggles use infrared sensors • Some toaster ovens also produce these waves to toast the bread
Microwaves	• shorter wavelengths and higher frequency compared to radio waves • waves the size of an adult person • used to heat foods in microwave ovens • used to send cell phone signals • Radars also use these waves
Radio Waves	• lowest energy • waves range from the the size of people to the size of tall buildings • transmit radio and television signals • used in items such as cell phones, radios, and televisions, and in radar • TVs and FM radio use shorter wavelengths, AM radio uses longer wavelengths

Telescopes

Telescopes are among the most common instruments used to study space. **Telescopes** are devices that detect the various forms of energy in the electromagnetic spectrum. As objects in space emit electromagnetic radiation, telescopes collect and focus these energy waves. Scientists then use the focused waves to learn about their source.

The telescopes you are most familiar with are optical telescopes. An **optical telescope** is a device that uses lenses or a combination of lenses and mirrors to gather visible light from space. Visible light is the only type of electromagnetic radiation you can see. The lenses, or lenses and mirrors, in an optical telescope work to make distant objects appear closer and brighter.

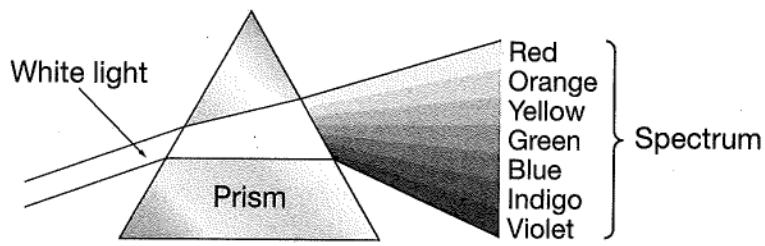
Many other telescopes gather invisible radiation from space. The invisible radiation may include infrared (heat) radiation, ultraviolet radiation, X-ray radiation, and radio waves. The table below describes some common types of telescopes.

Types of Telescopes

Type of Telescope	Type of Radiation	Source of Radiation	Function
Optical	Visible light	Most stars, planets	Detects and enhances visible light
Radio	Radio waves	Galactic centers, stars, black holes	Detects radio waves
Ultraviolet	Ultraviolet	Distant stars, clouds of dust, and gas	Maps sources, analyzes composition
Infrared	Infrared (heat)	Stars, galaxies	Finds new objects in space

Spectroscopes

A **spectroscope** is a special telescope that can analyze visible light by acting like a prism. As shown below, a prism is an optical device that separates visible light into its component colors (or spectrum). For example, a prism will separate white light from a flashlight into bands of red, orange, yellow, green, blue, indigo, and violet.



A prism separates white light into the colors of the spectrum.

Substances, such as those in stars, give off light when heated. Many elements produce their own distinct spectral "fingerprints." These fingerprints are composed of bands of color of specific patterns and widths. Scientists can use these patterns to study a star's composition by comparing the patterns to those produced by starlight that passes through a spectroscope.

Satellites

A **satellite** is a natural or artificial object that revolves around another object in space. The moon is Earth's natural satellite. Artificial satellites are built on Earth. They are put into orbit around Earth by rockets or the space shuttle. For example, in 1990 scientists sent the Hubble Space Telescope into orbit around Earth to study objects both in and beyond our solar system.

Thousands of artificial satellites orbit Earth. Some of these gather scientific data from outer space. Others are used to track weather and climate changes on Earth, to transmit television and radio signals around Earth, to help ships and land vehicles navigate on Earth, and for military purposes.

DISCUSSION QUESTION

A student turns on the radio to listen to music. Then she cooks a bag of popcorn in the microwave as she checks text messages on her phone. What different types of electromagnetic waves are involved in this scenario?

LESSON REVIEW

1. Which of the following correctly lists electromagnetic waves in order from highest to lowest frequency?

A. X-rays, gamma rays, visible light, microwaves, radiation

B. microwaves, infrared radiation, ultraviolet, gamma rays

C. gamma rays, ultraviolet, visible light, microwaves, radio waves

D. radio waves, visible light, ultraviolet, X-rays, gamma rays

2. Which type of telescope uses visible light emitted by a star to make it appear closer?

A. radio

B. ultraviolet

C. optical

D. infrared

3. Which tool would an astronomer MOST LIKELY use to collect information about the chemical composition of a star?

A. infrared telescope

B. radio telescope

C. satellite

D. spectroscope

18 Technology and Its Contributions to Astronomy

SC.8.E.5.10, SC. 8.E.5.11

Getting the Idea

Key Words
technology
model
National Aeronautics and Space Administration (NASA)
space shuttle
International Space Station (ISS)
space probe
telescope

Galileo first used a telescope to study the night sky in the 1600s. Since that time, scientists have continued to develop more advanced tools for collecting information about space. In the last lesson, you read about how scientists use spectroscopes, satellites, and different types of telescopes to study space. In this lesson, you will examine other forms of technology scientists use to study space.

What Is Technology?

Science and technology are different, but related, fields. Science is the search for answers to questions about the natural world. **Technology** is the application of science to everyday life. Thus, technology involves applying scientific knowledge to solve problems or to fill needs that arise.

Almost all science inquiry relies on some form of technology. Use of technology helps scientists work more efficiently. Scientists who study outer space use technology in the following ways:

- to access outer space and other remote locations
- for sample collection
- to make measurements and computations
- for data collection and storage
- to communicate information

Much of the research done by scientists involves the use of tools. All of these tools are products of technology. Some tools such as the optical telescope devised by Galileo to study the night sky are fairly simple in design. Others, such as the remote-controlled rovers NASA scientists have sent to Mars to photograph the surface and collect and analyze Martian soil samples, are more precise and sophisticated.

Use of Computers

Over the last 50 years, the computer has become an essential tool for science research. One use of computers is for data collection and storage. They are also used to carry out mathematical calculations, analyze data, and create visual displays of these data. Scientists use computers to communicate with one another as well as with the various forms of technology that are sent into outer space to investigate planets and stars more closely.

Recall that a **model** is a representation of an object, process, or phenomenon. Models are important investigative tools for space scientists. Computer simulations, mathematical models, and computer models are all used to study space. Such tools have been used to investigate star formation, black holes, gravitational interactions within galaxies, and the formation of the universe.

Space scientists input data or conditions into their models until the results closely match observations they have made about an object, process, or phenomenon. The models can be used to reconstruct how galaxies and other features in space formed. Simulations and models are also used to predict what galaxies and stars will look like in the future.

Travel in Space

In the United States, most exploration and research of space is carried out by the **National Aeronautics and Space Administration (NASA)**. NASA is an agency of the United States government established in 1958. NASA is responsible for the nation's public space program. Eleven years after it was established, NASA succeeded in developing the technology and spacecraft needed to place astronauts on the surface of the moon.

Astronauts landed on the moon on six separate occasions. These astronauts walked on the moon's surface, collected rock and soil samples, conducted demonstrations and experiments, and gathered large amounts of data. The information they gathered was about subjects such as magnetic fields, mineral compositions, and meteor impacts on the moon's surface. Scientists used technology to return all of this information to Earth for analysis.

Did You Know?

The last man to set foot on the moon was part of the Apollo 17 mission in December of 1972. NASA planned three more Apollo lunar landing missions, Apollo 18 through Apollo 20. However, NASA cancelled these missions to make funds available for the development of the space shuttle.

In the 1970s, NASA developed a new type of spacecraft commonly called the space shuttle. The **space shuttle** is the first reusable spacecraft that is capable of carrying astronauts into orbit around Earth. The space shuttle also has a large cargo bay that carries equipment into space, including satellites that have been placed into orbit around Earth.

In recent years, the space shuttles carried astronauts and equipment to the International Space Station (ISS). The **International Space Station** is a satellite that orbits Earth in which astronauts from different nations live and work together for months at a time.

Space Probes

More recently, scientists developed technology that allows them to send objects rather than humans into space to gather information. **Space probes** are unmanned spacecrafts used to gather information about parts of the solar system and relay that data back to Earth. Each probe contains scientific instruments that collect data or perform experiments.

Telescopes

Earth-based radio telescopes and space-based telescopes provide valuable information about many space objects, processes, and phenomena. A **telescope** is a device that detects the various forms of energy in the EM spectrum.

Many optical telescopes are in use throughout the United States. The Very Large Array in New Mexico is a series of linked radio telescopes used to study radio waves from space. Telescopes for other types of electromagnetic radiation must be launched into space because Earth's atmosphere blocks some gamma rays, X-rays, ultraviolet radiation, and infrared radiation. NASA has launched several telescopes into orbit around Earth. It has also launched telescopes beyond Earth's atmosphere. These include the Hubble Space Telescope, the Far Ultraviolet Spectroscopic Explorer, the Chandra X-ray Observatory, and the Compton Gamma Ray Observatory.

DISCUSSION QUESTION

Using information gathered by space probes, scientists found evidence that water may have once flowed over the surface of Mars. Why is this discovery significant?

LESSON REVIEW

1. Which of these BEST describes a space probe?

   A. a spacecraft in which astronauts can travel

   B. a tool that makes distant objects appear closer

   C. an unmanned spacecraft used to collect data from the solar system

   D. an object that revolves around Earth, collecting data about the planet's weather

2. Which form of technology are space scientists MOST LIKELY to use to calculate the distance to a newly-discovered planet?

   A. computer

   B. space shuttle

   C. space probe

   D. radio telescope

3. Which force, coupled with inertia, keeps satellites orbiting Earth?

   A. Earth's gravity

   B. the sun's gravity

   C. the moon's gravity

   D. Earth's magnetic field

19 Space Exploration and Its Effects on Florida

SC.8.E.5.12

Getting the Idea

Key Word
spinoff

Two of the most challenging questions in science deal with how the universe began and how long it will exist. The U.S. government established NASA to help answer these types of questions through space exploration. Since NASA was established, the state of Florida has played a very important role in our nation's space program.

NASA and the Kennedy Space Center

As you learned in Lesson 18, NASA was established in 1958. Within two years, NASA began operating within the state of Florida as part of the Cape Canaveral Air Force Station. In 1963, the parts of the Cape Canaveral facility dedicated to space exploration were renamed the John F. Kennedy Space Center in honor of the late president.

The Kennedy Space Center is one of more than a dozen NASA centers in the United States. It is located near the center of the state, close to the Atlantic coast of Florida. The temperate climate of the region is suited to the Kennedy Space Center's service as the primary launch center for spacecraft.

Space Exploration and Florida

As a Floridian, you are certainly affected by space exploration. These effects result largely from having the Kennedy Space Center located within your home state.

Space exploration has many effects on the economy of Florida. One way this occurs is through the jobs the Kennedy Space Center provides to residents of Florida. At present, the space center employs about 15,000 people. These jobs include people who work in science and technology, tour guides, food service workers, maintenance staff, and construction workers, among others.

In addition to the people it employs directly, NASA and the space center also provide an economic benefit to people living outside of Florida. Some of these benefits come directly from employment of people at NASA facilities located in other parts of the country. Other economic benefits are provided through employers who help provide NASA with the technologies and services that allow space exploration to occur.

The Kennedy Space Center also provides money to the state through tourism. Some of this money comes from admission tickets, food, and souvenir sales from visitors to the space center. Additional money is made by hotels, motels, restaurants, gift shops, and other service providers that cater to tourists.

Not all of the effects of the space program are economic. Space exploration also affects the culture of Florida. For example, NASA missions play a major role in history, technology, and education. Some historical and technological achievements of NASA include placing the first human on the moon and developing the world's first reusable spacecraft, the space shuttle.

NASA plays a role in education by sharing much of the information it gathers with the public. In many cases, people can view new data and pictures of bodies in space almost immediately by visiting NASA's Web site. NASA also offers many programs to students including opportunities to speak with astronauts.

One educational opportunity provided only by the Kennedy Space Center is the ability to view a launch first-hand. Tickets for many launches are available through the space center. In addition, NASA provides information about how to view launches from a distance at various off-site locations.

Technological Contributions of NASA

One of the most interesting contributions of the space program is in the area of spinoffs. A **spinoff** is a technology developed for a specific use in science or industry that becomes useful for other purposes in everyday life.

Technologies originally developed by NASA for space exploration have become common in everyday life. For example, NASA developed cordless tools powered by rechargeable batteries for astronauts in space to use. Astronauts used some of these tools during construction of the International Space Station (ISS).

Today, many people use cordless tools such as drills, saws, hedge trimmers, and blowers to do repairs or maintenance in their homes.

Scientists developed cameras that use infrared technology. These hand-held cameras study the heat emitted from objects in space. Today, firefighters use similar technology to help them identify people, objects, and hot spots within burning buildings.

DISCUSSION QUESTION

The money needed to carry out space exploration through NASA is provided by tax dollars. A single mission can cost many millions or even billions of dollars to carry out. Do you think the technologies and knowledge that result from such exploration are worthy of such funding. Explain your response.

LESSON REVIEW

1. Which of these is an economic effect of space exploration in Florida?

- **A.** improved education
- **B.** people viewing launches
- **C.** increased tourism dollars
- **D.** its well-documented temperate climate

2. Which correctly defines a spinoff?

- **A.** the launching of a spacecraft
- **B.** use of a technology created for a specific purpose for that purpose
- **C.** money generated by tourism dollars
- **D.** a technology developed for a specific use that becomes useful for other purposes in everyday life

3 Review

1. Which tool travels through the solar system relaying information back to Earth?

   A. telescope

   B. satellite

   C. space probe

   D. spectroscope

2. A light-year is a unit of measurement that would MOST appropriately be used to measure which of the following distances?

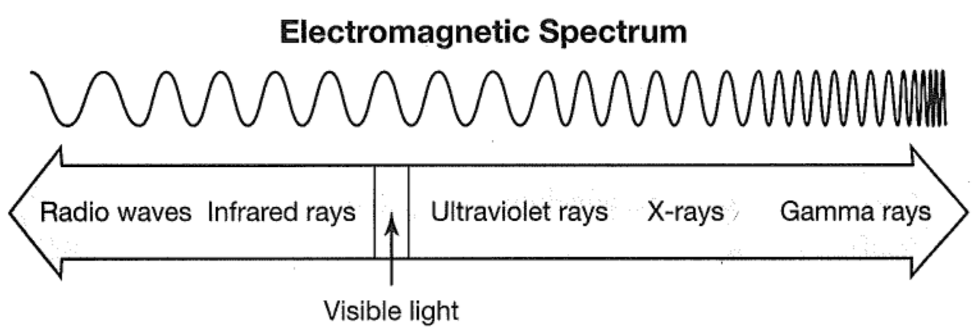
   A. Earth to the sun

   B. the Milky Way to the next nearest galaxy

   C. Earth to Jupiter

   D. the sun to Pluto

Use the diagram below to answer questions 3 and 4.



3. The diagram shows the electromagnetic spectrum. Which type of wave has the the LEAST amount of energy?

   A. gamma

   B. ultraviolet

   C. infrared

   D. radio

4. What type of telescope collects radiation from waves that are shorter than visible light?

   A. ultraviolet telescope
   B. infrared telescope
   C. optical telescope
   D. radio telescope

5. Which statement is correct?

   A. The sun is the only star in the Milky Way.
   B. The Milky Way is part of the solar system.
   C. The Milky Way is a galaxy far from the solar system.
   D. The sun is one of billions of stars in the Milky Way.

6. Explain why scientists use telescopes that detect types of electromagnetic radiation, in addition to visible light, to study objects in space.

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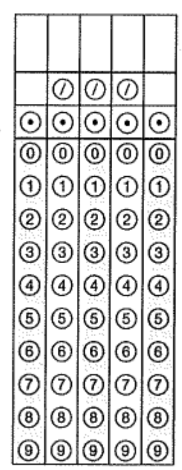
7. Which choice orders the average size of these star groups from smallest to largest?

   A. white dwarf, main sequence, red giant
   B. main sequence, white dwarf, red giant
   C. red giant, main sequence, white dwarf
   D. white dwarf, red giant, main sequence

8. A light-year is the distance light travels in one year, about 9.5 trillion kilometers. If it takes 5 years for light from a star to reach you, how many trillions of kilometers away from you is that star?



9. Which of the following astronomical tools uses a prism to separate light into its characteristic colors?

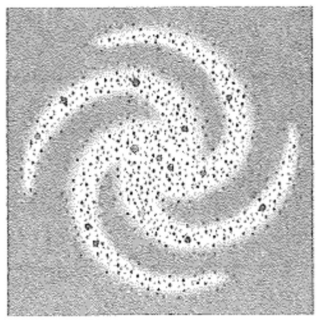
   A. radio telescope

   B. reflecting telescope

   C. spectroscope

   D. satellite

10. What type of galaxy is shown below?



   A. irregular

   B. spiral

   C. elliptical

   D. regular

11. What is a space probe and what are the advantages of using space probes to explore objects in the solar system?

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12. Which of the following shows the correct order for systems in space from smallest to largest?

A. solar system ➔ galaxy ➔ universe

B. universe ➔ solar system ➔ galaxy

C. space probe ➔ universe ➔ solar system

D. galaxy ➔ solar system ➔ universe

13. A light-year is the distance light travels in a year, or 9.5 trillion kilometers. If a star is 8 light-years from Earth, how far away is it?

A. 7.6 kilometers

B. 1.2 trillion kilometers

C. 76 trillion kilometers

D. 1.5 trillion kilometers

14. Which of the following BEST describes a galaxy?

A. a huge body of interstellar gas and dust

B. an irregularly shaped rocky object in space

C. a group of billions of stars, space dust, and gases held together by gravity

D. an attractive force that works to pull objects together

15. Identify and describe one effect of space exploration on the culture and economy of Florida.

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16. Which of the following is an example of a spinoff resulting from the space program?

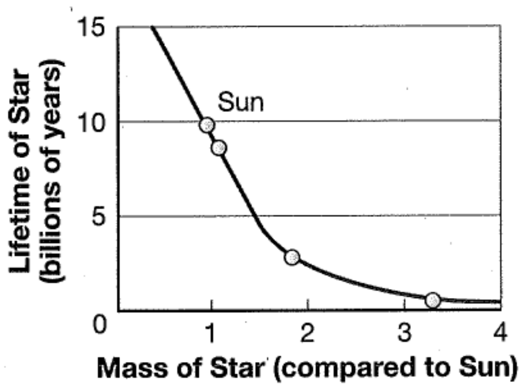
A. space probe

B. space shuttle

C. telescope

D. cordless tools

17. The graph compares star mass and lifetime. Based on the graph, which statement is TRUE?



A. The lifetime of a star is inversely proportional to its mass.

B. Stars with greater mass generally live longer than less massive stars.

C. Stars that are two to three times the mass of the sun are younger.

D. The relationship between the lifetime of a star and its mass is linear.

18. Which property of a star does absolute magnitude describe?

A. color

B. temperature

C. age

D. brightness

19. Which of these is largest?

A. the sun

B. solar system

C. universe

D. galaxy

CHAPTER

4 Properties of Matter

20 Physical Properties of Matter

SC.8.P.8.1; SC.8.P.8.2; SC.8.P.8.3; SC.8.P.8.4

Getting the Idea

Key Words

physical properties
mass
weight
volume
density
state of matter
solid
liquid
gas
conductivity
magnetism
texture
solubility

You identify things around you by describing their qualities. You use your senses and gather information about things you want to describe. Recall that these qualities and characteristics are called properties. A **physical property** is a characteristic of a substance that can be observed without changing the identity of the substance. Every substance has its own set of physical properties. You can identify different substances by using your senses and making measurements.

Mass, Weight, and Volume

Mass and weight are physical properties of matter. In everyday life, the two are sometimes treated as if they are the same thing. However, they are really two different properties. **Mass** is the amount of matter that makes up an object. You measure mass by using a balance. Mass is expressed in units such as kilograms (kg) and grams (g). **Weight** is a measure of the force of gravity pulling on an object. You measure weight by using a spring scale. Weight is expressed in units such as newtons (N). The weight of an object is proportional to its mass. This means that objects with larger masses also have greater weights.

Volume is the amount of space that matter occupies. A blown-up balloon takes up more space than a marble. The balloon has a larger mass. The volume of solids is expressed in units such as cubic centimeters (cm^3). Liquid volume is expressed in units such as liters (L) and milliliters (mL). You measure liquid volume with a graduated cylinder. Both mass and volume are fundamental properties of all matter.

Density

Density is also a physical property of matter. **Density** is the ratio of an object's mass to that object's volume. Every substance has its own known density. For example, gold has a different density than water, and water has a different density than oxygen. You find the density of an object using the following equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

or

$$D = \frac{m}{V}$$

Consider this example: What is the density of a piece of iron with a volume of 2 cm^3 and a mass of 15.72 g? By placing the values for mass and volume into the density equation, you get:

$$D = \frac{15.72 \text{ g}}{2 \text{ cm}^3}$$

$$D = 15.72 \text{ g} \div 2 \text{ cm}^3$$

$$D = 7.86 \text{ g/cm}^3$$

Density is the quotient of mass and volume, so it is expressed in a unit that displays this relationship. Density is measured g/cm^3, which reads as, "grams per cubic centimeter" or "grams per centimeter cubed."

States of Matter

The **state of matter** is the physical form in which matter exists. Most matter on Earth exists as a solid, liquid, or gas. A **solid** is matter that has a definite volume and a definite shape. Examples of solids are a wooden block and a ceramic mug. A **liquid** is matter that has a definite volume, but not a definite shape. Examples of liquids include rubbing alcohol and water. A **gas** is matter that does not have a definite volume or a definite shape. Examples of gases include oxygen and helium.

All matter is made of particles that are always in motion. These particles are arranged differently in each state of matter.

Did You Know?

Magnets can generate electric current in wires. Electricity can also turn a piece of iron into a temporary magnet.

In fact, the arrangement and motion of its particles determine the state of a substance. The table below provides a summary of matter in each state.

States and Properties of Matter

Physical Property	Solid (Brick)	Liquid (Water)	Gas (Air)
Shape	Definite shape	No definite shape	No definite shape
Volume	Definite volume	Definite volume	No definite volume
Particle arrangement	Densely packed	Close	Far apart

Matter can change from one state to another when it absorbs or releases heat. Melting point is the temperature at which a solid changes to a liquid. The melting point of water is 0°C. Boiling point is the temperature at which gas bubbles form in a liquid and rise to the surface to escape the liquid as a gas. The boiling point of water is 100°C.

The temperature at which a type of matter changes state is another physical property. For example, if a colorless liquid boils at 78.4°C, you know it is not water. Water boils at 100°C. Through research, you could discover that ethanol boils at 78.4°C. This might indicate that the colorless liquid is ethanol. However, you cannot be sure until you test or measure other properties of the liquid.

Conductivity

Conductivity describes how easily a material transfers energy, usually heat or electricity. A material or substance that allows heat or electric current to flow through it easily is a conductor. Most metals are good conductors. This property makes many metals useful in making cooking pots and pans and electrical wiring. Most nonmetals are insulators, or materials that do not allow heat or electric current to flow through them easily.

Examples of materials with high conductivity (conductors) and low conductivity (insulators) are in the table below.

Conductors and Insulators

Good Conductors (High Conductivity)	Good Insulators (Low Conductivity)
Copper	Rubber
Silver	Wood
Aluminum	Plastic
Iron	Glass
Gold	Foam
Electrolyte Solutions	Air

Magnetism

The metals iron, cobalt, and nickel have strong magnetic properties. **Magnetism** is a force of attraction or repulsion that exists between like or unlike poles. You probably have magnets made of iron in your home. Such magnets are useful for holding papers and photos on refrigerator doors. Magnets are also very important parts in different types of motors.

Other Physical Properties

Other physical properties of matter include size, shape, color, texture, and solubility. **Texture** is how a surface feels, such as rough or smooth. Picture yourself describing a glass marble to a friend. You might describe the marble as small, round, and smooth.

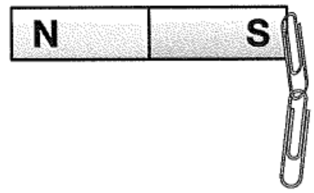
Solubility is a measure of how much of a substance dissolves in a given amount of another substance. For example, more carbon dioxide gas would dissolve into a given volume of water than oxygen gas. This is one reason why carbon dioxide gas rather than oxygen gas is added to give some beverages their "fizz." You will learn more about solubility in Lesson 24.

DISCUSSION QUESTION

People place insulation in the walls of their homes to prevent the flow of unwanted heat into or out of the home. Which substance would be a better choice for insulating the walls of a home—foam or aluminum? Why?

LESSON REVIEW

1. Examine the following illustration.



What property of matter does the drawing above illustrate?

A. ability to conduct electricity
B. magnetism
C. malleability
D. ability to conduct heat

2. Which of the following BEST defines a general state of matter?

A. It is either liquid or solid.
B. It is either ice or water.
C. It is the form a substance has when the substance is at a certain temperature.
D. It is how much of a substance will fit within a given area.

3. What two quantities do you need to know if you want to calculate the density of a sample of matter?

A. color and mass
B. volume and mass
C. length and mass
D. solubility and mass

4. Which substance is likely to be the BEST conductor of electricity?

A. a block of wood
B. a sheet of paper
C. a piece of plastic
D. a metal pipe

5. A student records a physical property of a rock as 2.2 N. Which physical property has the student measured?

A. weight
B. mass
C. volume
D. density

21 Atomic Theory

SC.8.P.8.7

Getting the Idea

Key Words
- atomic theory
- atom
- element
- nucleus
- proton
- neutron
- electron
- Bohr model
- energy level
- electron cloud model

Aluminum is a type of matter, like every other substance around you. What do you end up with if you tear a thin piece of aluminum in half? You still have aluminum; it is just in two pieces. You can tear aluminum into smaller and smaller pieces. Imagine that the pieces become so small you cannot even see them, but you could still cut them in half. Could you keep making smaller pieces? Eventually, you would no longer be able to cut the aluminum in half anymore. You would have the smallest piece you could possibly make. In this lesson, you will learn about the smallest possible pieces of matter.

Atomic Theory

All matter consists of many small particles that are in constant motion. Scientists today use atomic theory to describe the particles that make up matter. The **atomic theory** states that:

- Atoms are the basic building blocks of all matter.
- Atoms are composed of subatomic particles.

An **atom** is the smallest particle of a pure substance that has all the properties of that substance. In the example above, you considered what it would be like to cut a piece of aluminum in half again and again. If you kept on doing this until you could no longer cut it in half, the smallest piece that you could possibly have would be an atom. Atoms are extremely small. If you lined up one million atoms in a row, the row would still be smaller than the thickness of a human hair.

A pure substance made up of only one kind of atom is an **element**. There are about 90 elements that you can find naturally on Earth. About another 25 elements can be made by scientists. Carbon, oxygen, gold, silver, and iron are some elements you can find in nature. What makes elements different from each other? To answer this question, you must look inside atoms.