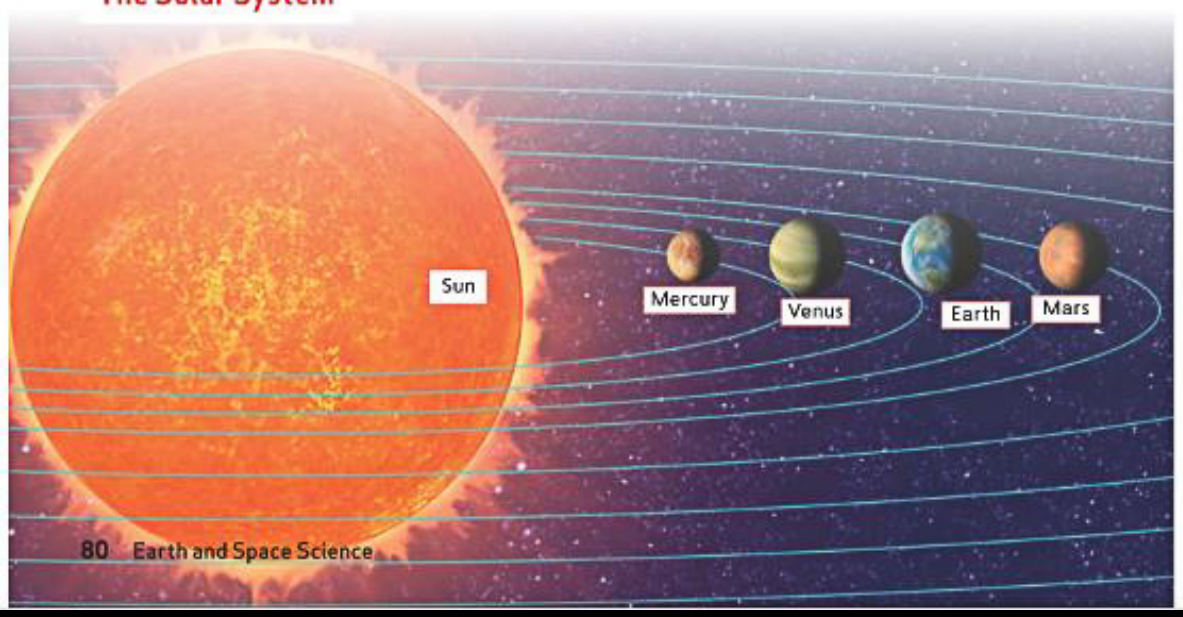
Objects in Space

The universe is gigantic. It contains all the matter and space that exists. There are billions of galaxies, each of which has billions of stars. A star is a sphere of hot gases that produces its own energy, including heat and light. The Sun is the closest star to Earth and, although it may look different from other stars, it is rather ordinary. Our Sun is a medium-sized star with an average surface temperature. Without the Sun, however, life on Earth could not exist.

The Solar System

The Sun and all the objects that orbit around it make up our solar system. The Sun has many satellites. A **satellite** is any object that orbits another larger body. An **orbit** is the nearly circular path that an object travels around a larger object. The Moon is a satellite that orbits Earth. On a clear evening you may see a planet or two in the sky, as well. A planet is a large, round object in space that orbits a star. Planets in our solar system, including Earth, orbit the Sun.

The Solar System



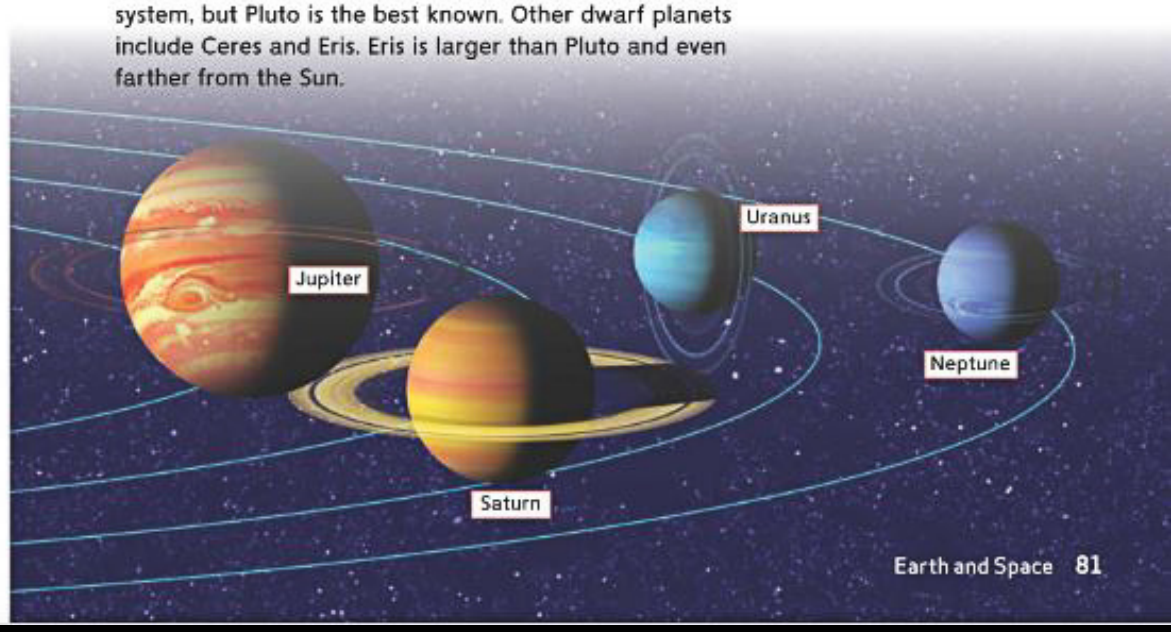
Planets of the Solar System

From nearest to farthest from the Sun, the planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The planets travel in elliptical, or nearly circular, orbits around the Sun.

Several planets are visible in the night sky from time to time, even without the use of a telescope. A telescope is an instrument that makes distant objects seem larger. Visible planets include Mercury, Venus, Mars, Jupiter, and Saturn. Planets do not make their own light. They reflect the light of the Sun. These lights move slowly in the night sky as the planets orbit the Sun.

Dwarf Planets Pluto was once known as the ninth planet. However, Pluto's elongated orbit and small size are different from those of the eight planets. These differences, among others, caused scientists to debate whether Pluto should be called a planet. In August 2006, the International Astronomical Union officially reclassified Pluto as a dwarf planet. *Dwarf planets* are made of rock and ice, and their orbits cross the paths of other space objects.

Scientists have discovered many dwarf planets in the solar system, but Pluto is the best known. Other dwarf planets include Ceres and Eris. Eris is larger than Pluto and even farther from the Sun.



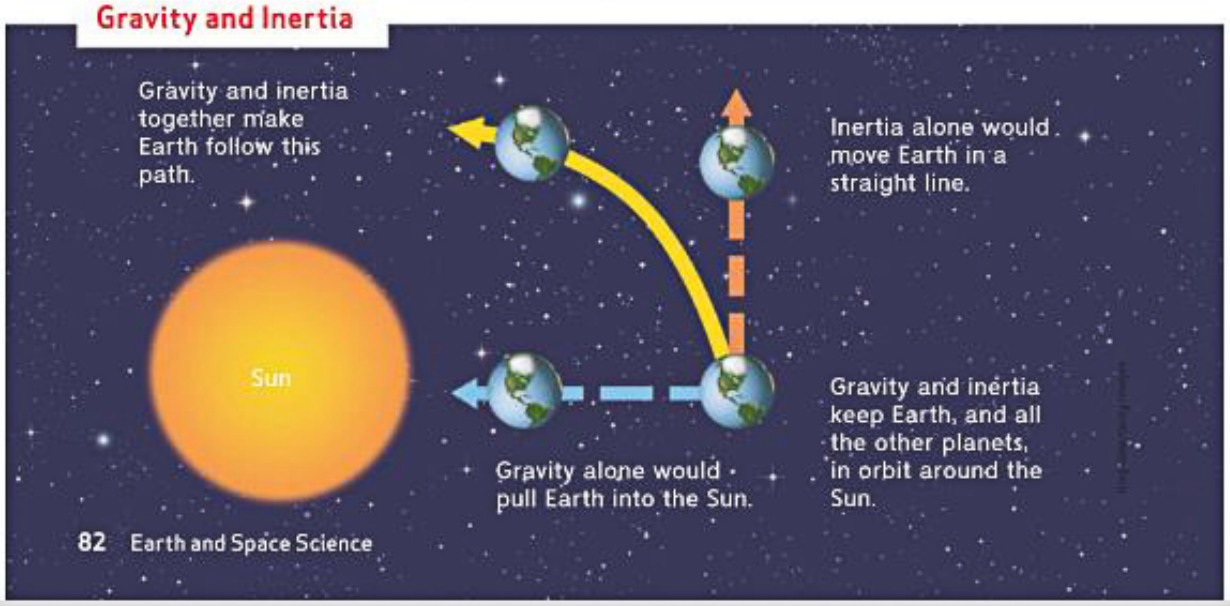
Gravity in the Solar System

Gravity is a force of attraction, or pull, between any two objects. The strength of gravity is affected by the total mass of the two objects and the distance between them. The pull of gravity decreases when the total mass of the two objects decreases and when the two objects are farther apart.

At the center of the solar system is the Sun, the most massive object in the solar system. It would take 109 Earths to fit across the Sun. The more massive an object is, the stronger its gravitational attraction. The Sun's gravitational attraction keeps Earth in orbit. In fact, gravitational attraction holds the entire solar system together.

The planets are held in their orbits around the Sun by the force of gravity between the Sun and each planet. Yet if gravity were the only force acting on a planet, the planet would be pulled into the Sun. This event does not happen because of another property, called inertia. **Inertia** is the tendency of an object to keep moving in a straight line. As Earth orbits the Sun, it is pulled toward the Sun because of gravity. At the same time, Earth's inertia makes it move away from the Sun. Together, these factors produce Earth's nearly circular, elliptical orbit.

Gravity and Inertia



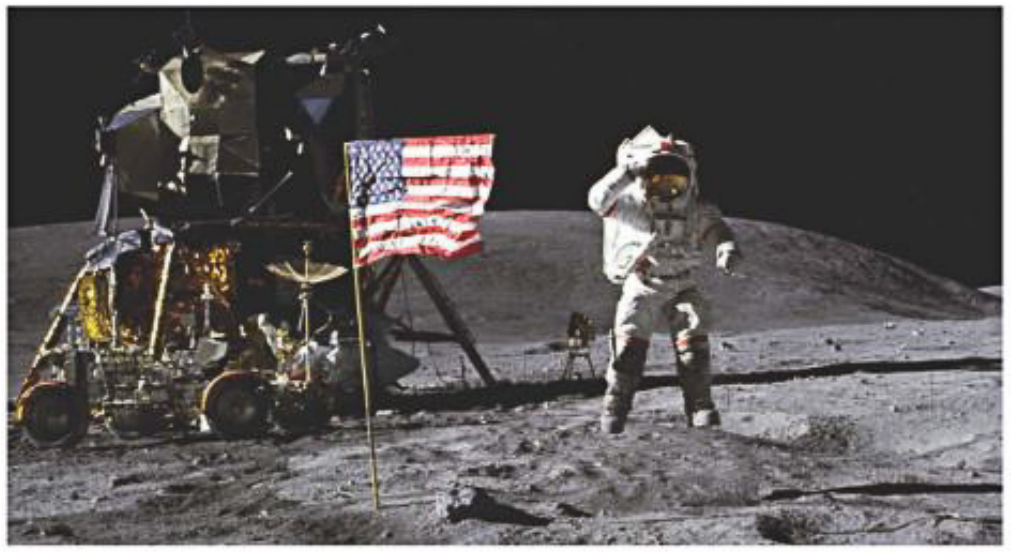
Earth's Gravitational Attraction

The Moon is Earth's only natural satellite. It is also Earth's closest neighbor in space. Some planets, such as Mercury and Venus, do not have moons. Jupiter has the most moons of any planet in the solar system. Scientists have observed 63 moons of Jupiter. Moons orbit planets for the same reason that planets orbit the Sun—because of gravitational attraction and inertia.

The Moon is less massive than Earth, so it has a weaker pull of gravity than Earth. In fact, the Moon's gravity is about one sixth of Earth's gravity. Think how high you can throw a because the force of gravity is not as strong.

This photo shows what Earth looks like from the Moon.

In this photo, you can see the height of astronaut John Young's jump on the Moon. He can jump higher on the Moon than on Earth because the Moon's gravity is about one-sixth of Earth's gravity.



Inner Planets of the Solar System

The four planets closest to the Sun are called the *inner planets*. They are also called the terrestrial, or rocky, planets because they are made mostly of rock. Evidence suggests that each has a core of iron. They have relatively similar sizes and closely spaced orbits. They have few, if any, moons. All the inner planets rotate relatively slowly and none of them have rings. Despite these similarities, each planet has its own unique features.

Mercury Mercury is the closest planet to the Sun. That closeness makes it very hot. It has almost no water and very little air. The surface has many craters, like Earth's Moon. A *crater* is a hollow area or pit in the ground. Craters form when large space rocks crash into other space objects. Mercury is the smallest inner planet. At its equator, it is less than half the size of Earth.

Venus Venus is the second closest planet to the Sun. It has a thick atmosphere that is made mostly of carbon dioxide, with atmospheric pressure 90 times greater than that of Earth. The atmosphere does not allow heat to easily escape. This atmosphere makes Venus the hottest planet. There are many volcanoes on Venus, and its surface is covered in lava flows.

DID YOU KNOW

Mercury's Sun-facing side is hot enough to melt zinc. However, on the night side of the planet, temperatures can drop to -170°C (-274°F).

Distance to the Sun: 58 million km
Diameter: 4,880 km
Fast Fact: Mercury's surface is covered with craters.

Distance to the Sun: 108 million km
Diameter: 12,100 km
Fast Fact: Temperatures on Venus can reach 500°Celsius (932°Fahrenheit).

(l) ©Ivan Images/Alamy (r) NASA, JHU Applied Physics Laboratory/Johns Hopkins University/Carnegie Institution of Washington

Earth Earth is unique in our solar system. It has oxygen and liquid water. Earth is the only planet known to support life. Earth's atmosphere keeps temperatures from getting too hot or too cold to sustain life as we know it. It is the largest of the inner planets.

Mars Of all the planets, Mars is the most like Earth. It has two small moons and a thin atmosphere. Mars has volcanoes, but they are no longer active. The surface has many features that show evidence of erosion by floods and rivers. Today, Mars is much colder than Earth. Its water is frozen in ice caps near both poles. NASA has sent probes to Mars and hopes to send astronauts to the red planet one day.

DID YOU KNOW?

The largest asteroid in the asteroid belt is about one fourth the diameter of Earth's moon.

Beyond the Inner Planets

Beyond the orbit of Mars is a belt of space rocks called **asteroids.** These are rocky or metallic objects that orbit the Sun. Scientists have accumulated a great deal of information about asteroids in recent years. Space probes have sent back information that provides pictures of these orbiting objects.

Ida is a heavily cratered, irregularly shaped asteroid.

Distance to the Sun: 150 million km
Diameter: 12,756 km
Fast Fact: Earth's atmosphere makes it suitable for life.

Distance to the Sun: 228 million km
Diameter: 6,794 km
Fast Fact: Iron oxide, or rust, gives Mars its reddish color.

(c) NASA/JPL; (b) SteckBrok/Getty Images Digital Vision

Outer Planets of Earth's Solar System

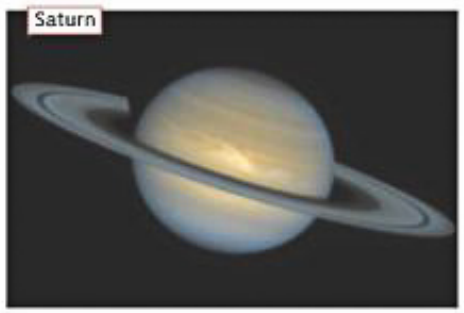
The four planets beyond Mars are called the *outer planets*. They are also called *gas giants* because they are huge compared with the inner planets, and because they consist mostly of gases. The largest gas giant, Jupiter, is five times farther from the Sun than Earth is.

The gas giants do not have solid surfaces. They are made mostly of the gases hydrogen and helium. Scientists have evidence that they may have some rock and ice at their cores. Each has a ring system, although most are difficult to see. They also have many moons and some have atmospheres.

Jupiter This planet's atmosphere is divided into bands of strong winds. The winds in each band blow in directions opposite the bands on either side of it. One band has a large red spot the size of Earth. The red spot is a storm that has been blowing for over 400 years. The storm is known as The Great Red Spot. One of Jupiter's moons, Ganymede, is the largest moon in the solar system. Another, Europa, may have an ocean of water beneath its icy crust. The moon named Io has active volcanoes.

Saturn Saturn is the second largest planet. It is famous for its system of rings. The rings are made of pieces of ice and rock. Most of these pieces are less than a couple meters in diameter. Saturn has at least 34 moons. The largest is named Titan.

Distance to the Sun: 778 million km
Diameter: 143,000 km
Fast Fact: Jupiter's four largest moons were first observed by Galileo in 1610.



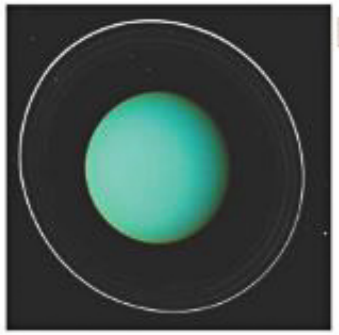
Distance to the Sun: 1 billion, 429 million km
Diameter: 120,536 km
Fast Fact: Winds on Saturn can blow at 500 meters per second.

Uranus Uranus is sometimes known as the "sideways" planet. The axis is tilted so much that it rotates on its side. An *axis* is an imaginary line down an object's center that it appears to rotate around. Uranus's tilted axis means that one pole faces the Sun during parts of Uranus's orbit. The unusual blue-green color of this planet is due to gases in its upper atmosphere, including methane. Uranus has at least 27 moons. One of its moons, Miranda, looks as though it broke apart and the pieces clumped back together several times as it formed.

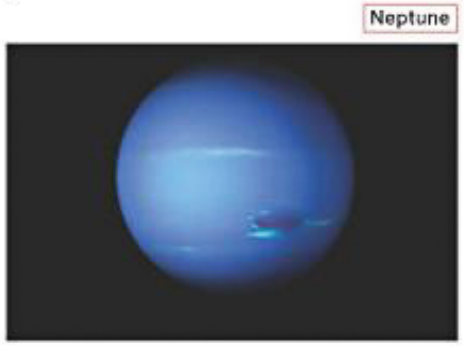
Neptune Neptune is the farthest gas giant from the Sun. Winds on Neptune can blow at speeds of 2,000 kilometers (1,200 miles) per hour. Its atmosphere, like that of Uranus, is mostly hydrogen, helium, and methane. There may be an ocean underneath Neptune's clouds. Scientists have observed 13 moons orbiting Neptune. Triton is the largest moon. Triton is known to have "ice volcanoes" that shoot material up to 8 km (5 mi) high.

Beyond the Outer Planets

Beyond Neptune's orbit lie the Kuiper Belt and the Oort Cloud. Both of these regions are composed of small, icy bodies and are the origin of comets. Scientists hypothesize that the bodies that make up these regions are the remnants from the formation of the solar system.



Distance to the Sun: 2 billion, 871 million km
Diameter: 51,118 km
Fast Fact: The axis of Uranus is tilted toward the Sun.



Distance to the Sun: 4 billion, 504 million km
Diameter: 49,528 km
Fast Fact: Neptune takes 165 Earth years to orbit the Sun.

Other Objects in the Solar System

Other than the Sun, planets and moons are the largest objects in the solar system. The next largest objects are dwarf planets. However, many smaller objects are also found in our solar system.

Meteoroids A *meteoroid* is a small, rocky or metallic object that orbits the Sun in both the inner and outer regions of the solar system. The craters on the Moon were formed by meteoroids colliding with its surface.

Meteors A *meteor* is a meteoroid that enters Earth's atmosphere. It appears as a bright streak in the sky. If a meteor does not break apart and burn up in the atmosphere, it can hit Earth's surface. You may have heard meteors called shooting stars. Some evenings you can observe many meteors in the night sky. These events are called meteor showers.

Meteorites A meteor that strikes Earth's surface is called a meteorite. Many places on Earth show evidence of meteorite impacts. One such place is Meteor Crater in Arizona. About 50,000 years ago, a large meteorite crashed there, forming a crater that is as wide as 11 football fields.

DID YOU KNOW

Many meteoroids are no bigger than grains of sand.

This is a meteorite.

A meteorite caused this crater when it collided with Earth's surface.

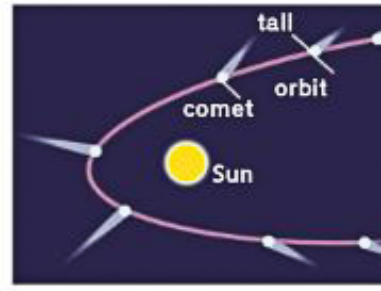
Comets

A **comet** is a mixture of frozen gases, ice, dust, and rock that moves in an elliptical orbit around the Sun. Comets are thought to be bits of material left over from the formation of the solar system about 4.6 billion years ago.

When a comet is farther away from the Sun, the gases and ice in the comet are frozen. As the comet moves toward the Sun, the core, or nucleus, of the comet warms up. Some of the ice and dust in the nucleus form a cloud or coma around the nucleus. Together, the coma and the nucleus make up the head of the comet.

As the comet gets closer to the Sun, heat from the Sun's rays pushes some of the coma away from the comet. This material forms a glowing tail that may stretch millions of kilometers behind the head. Sometimes two tails will form. One tail is made of ice, and one is made of gases.

Heat moves out from the Sun in every direction. As a comet moves around the Sun, the head stays closest to the Sun and the tail trails out behind it. No matter where the comet is in its path around the Sun, the comet's tail always points away from the Sun.



Comets have tails of ice and gases.

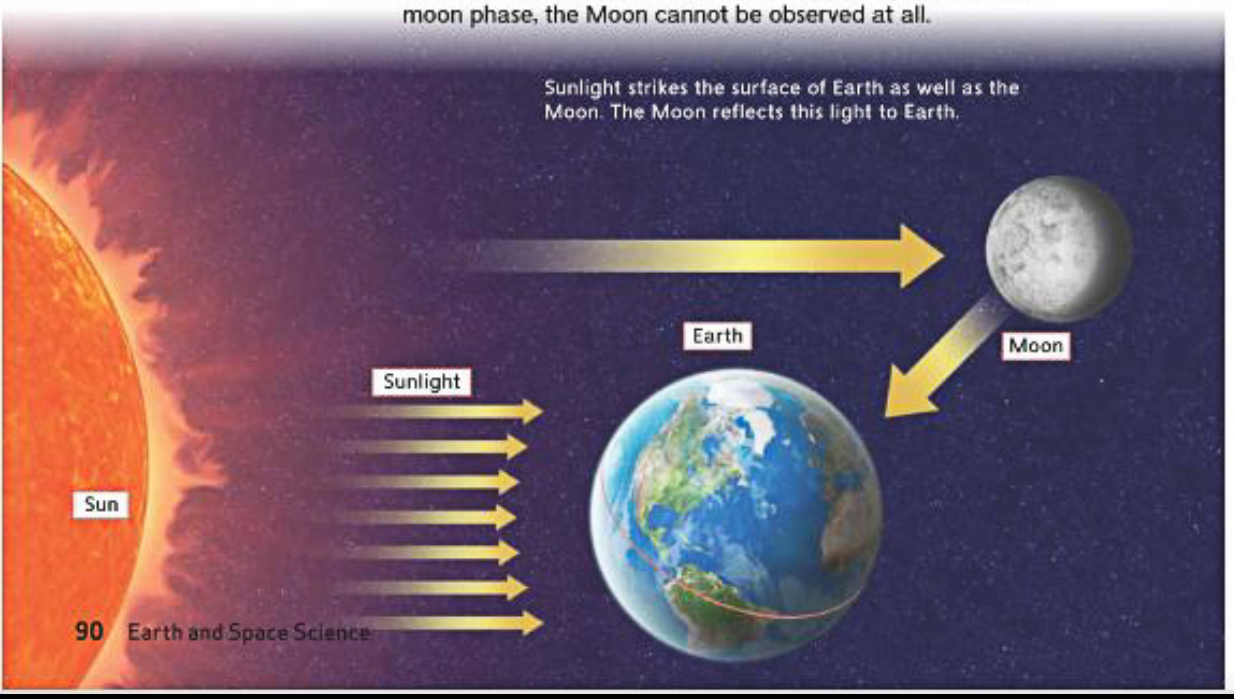
Earth's Moon

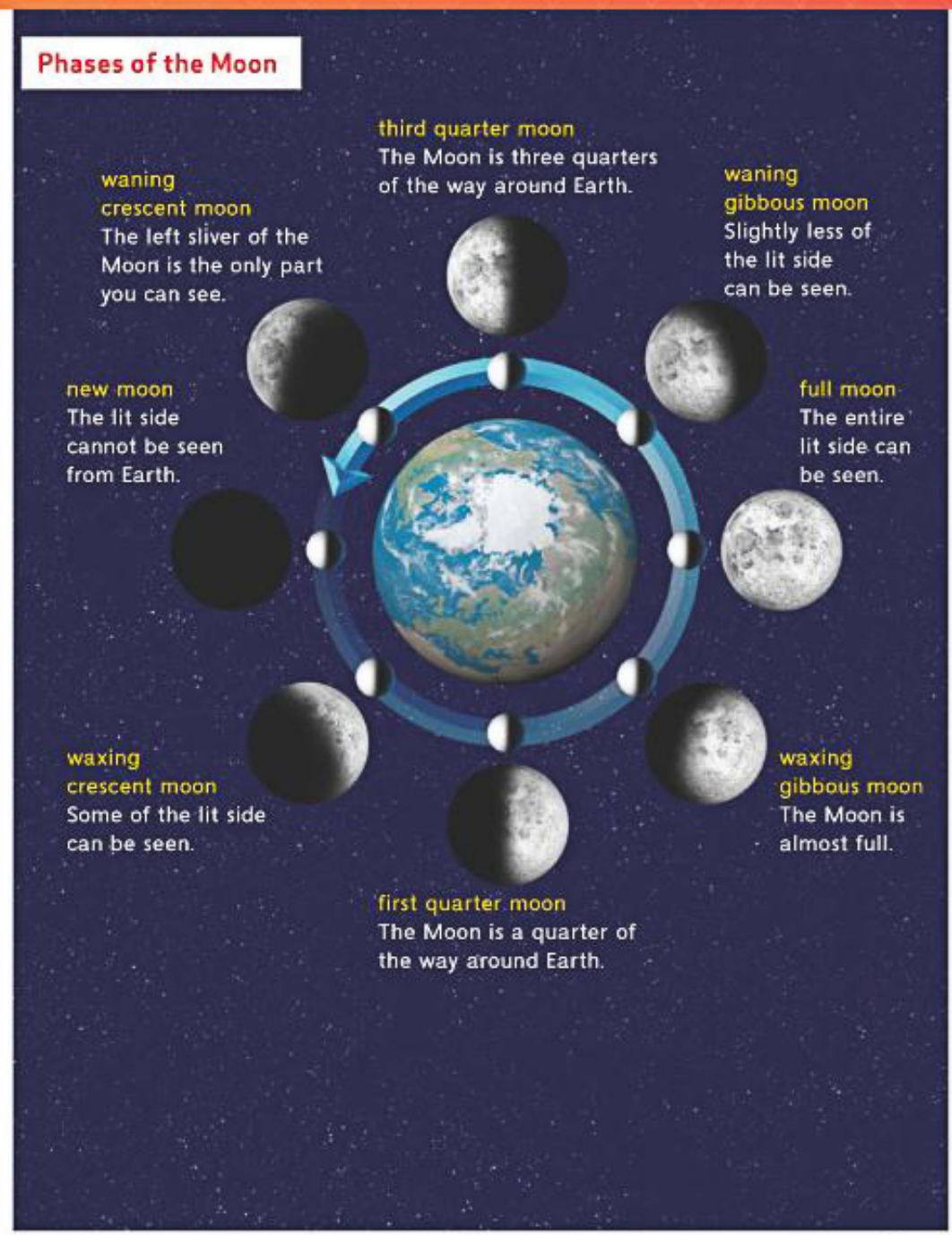
On many nights, the Moon appears to be the largest, brightest object in the sky. Unlike stars, however, the Moon does not make its own light. Instead, it reflects the light of the Sun.

Moon Phases Like the Sun, the Moon appears to rise and set. As Earth revolves around the Sun, the Moon revolves around Earth. The Moon's appearance changes as it revolves. The Moon completes one orbit around Earth in just over 29 days. This amount of time is almost as long as an average month.

As the Moon orbits Earth, the Sun is shining. The Sun lights one half of the Moon at a time. The other half is dark. During the Moon's orbit, we see different amounts of the half of the Moon that is lit by the Sun. The apparent shapes of the Moon in the sky are called **phases.** During one complete orbit, the Moon cycles through all of its phases.

As the Moon appears to get larger, it is waxing. As it appears to get smaller, it is waning. A crescent moon appears to be a sliver, while a gibbous moon is almost full. During the new moon phase, the Moon cannot be observed at all.





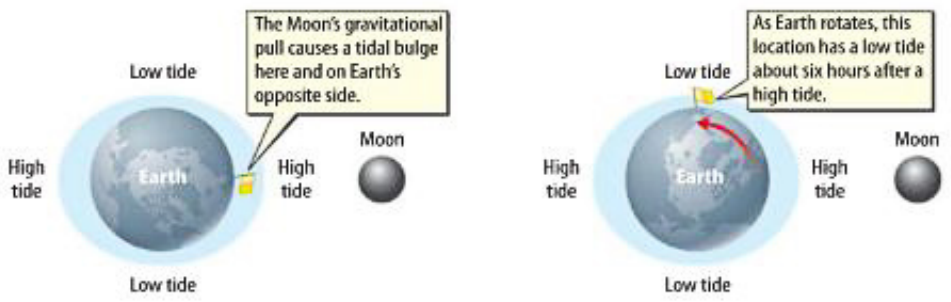
Tides

The Moon has a gravitational pull on Earth. As Earth rotates, the strongest pull moves across the surface of the planet. Rocks and soil do not move easily, so we do not notice the pull on land. In the oceans and large lakes, the water flows as gravity pulls on it. This pull causes space **tides,** a regular rise and fall in the level of the water.

Water bulges up on the side of Earth facing the Moon. It also bulges on the side opposite the Moon. This happens because gravity pulls stronger on the whole Earth than on the water farthest from the Moon. As Earth rotates, these bulges move across the ocean. The water rises compared to land twice each day. These rises are known as high tides. On the parts of the planet that are at right angles to the Moon, the water is low compared to land. This is known as a low tide. There are two high tides and two low tides each day.

The Sun also affects tides, but not as much as the Moon. When the Sun, the Moon, and Earth are in a straight line, high tides are higher than usual. This is called a spring tide. When the Sun, the Moon, and Earth are arranged like an L, the high tides are lower than usual. These are neap tides. Spring tides and neap tides occur twice each month.

This illustration shows how the Moon affects tides on Earth.

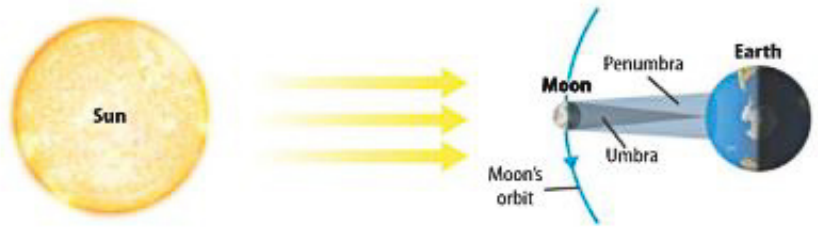


Eclipses

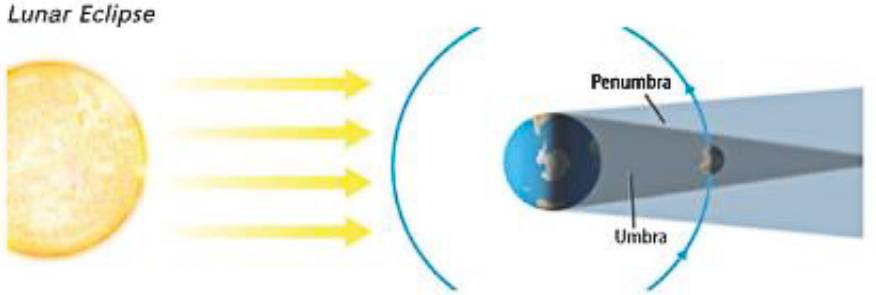
Sometimes, the Sun, the Moon, and Earth form a straight line. If the Moon is between the Sun and Earth, the Moon blocks sunlight. When the shadow of the Moon falls on Earth's surface, a solar eclipse occurs. A **solar eclipse** is a blocking of the Sun's light when Earth passes through the Moon's shadow. During a solar eclipse, part or all of the Sun may be blocked from view.

If Earth is between the Sun and the Moon, the shadow of Earth blocks sunlight from reaching the Moon. This is called a **lunar eclipse.** If the Moon is in deep shadow, it may disappear for a short time. During a lunar eclipse, the Moon often looks dim and red. This happens when the Moon is in a partial shadow called the penumbra.

Solar Eclipse



Lunar Eclipse



Stars

A **star** is a sphere of hot gases that gives off light and heat. The only star you can observe during the daytime is the Sun. The Sun is the closest star to Earth. Other stars are much farther away. Throughout the universe, stars are found in large groups called galaxies. Our Sun is near the edge of a galaxy with billions of other stars. You may know this galaxy as the Milky Way. Our galaxy's nearest neighbor is the Andromeda Galaxy.

Star Colors and Temperature

Stars are different colors. These colors occur because of the surface temperature of each star. Think about the flames of a bonfire. Different parts of the fire are different temperatures. Cooler areas are red. The hottest areas are orange-yellow. This same relationship between color and temperature applies to stars. The Sun's temperature makes it look yellow. Cooler stars are red or orange. Warmer stars are white or blue.

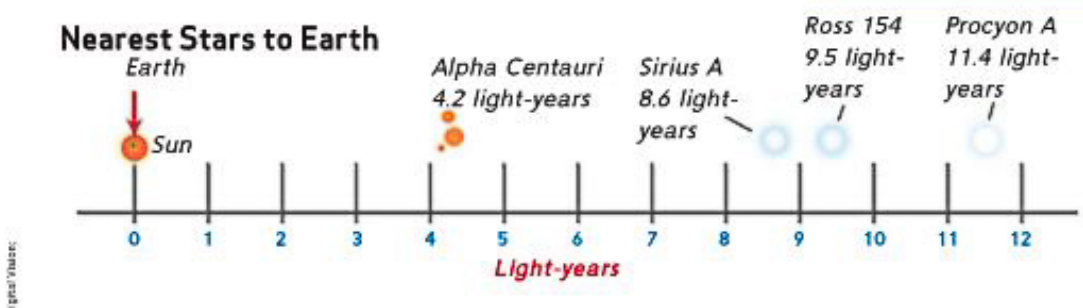
Like the Milky Way, the Andromeda Galaxy is shaped like a spiral. It is wider than our own Milky Way Galaxy.

Star Distances

The Sun is about 150 million km (93 million mi) from Earth. It takes about eight minutes for its light to reach Earth. Most stars are much farther away. The Sun appears to be the brightest star because it is the closest star to Earth. Other stars may be brighter but are much farther away. After the Sun, the next closest star to Earth is Proxima Centauri. This star is about 40 trillion km (24.8 trillion mi) away. Because stars are so far from Earth, writing their distance in kilometers or miles becomes awkward.

To simplify the writing of such large distances, astronomers use a unit called a light-year. A **light-year** is the distance light travels in one year, which is nearly 10 trillion km (6 trillion mi). Proxima Centauri is 4.2 light-years from Earth.

When you observe a distant star, you are seeing what it looked like in the past. A star you observe today may have stopped glowing millions of years ago. However, its light is still making its way through space. The light we see from the Proxima Centauri system left there about 4.2 years ago.



SKILL BUILDER

Read a Diagram
In this diagram, Earth is right next to the Sun at 0. Count the light-years from Earth-Sun to Alpha Centauri.

FACT CHECKER

A light-year is not a measure of time, but of distance.

Star Cycles

Stars form when matter comes together and starts to give off energy. Stars go through stages, or cycles, between their beginning and ending. Different kinds of stars have different cycles. The cycle of a star depends on how much hydrogen the star contains. A star's cycle ends when it stops giving off energy.

A star forms out of a nebula. A **nebula** is a huge cloud of gases and dust. Gravity pulls the mass of the nebula, most of which consists of hydrogen gas, closer together. As hydrogen atoms move closer, they collide with one another. These collisions produce heat, and the temperature in the cloud rises. When the temperature reaches at least 10,000,000° Celsius (18,000,000° Fahrenheit), hydrogen atoms begin combining to form a new gas, helium. This process gives off tremendous amounts of heat and light. The nebula becomes a protostar, or beginning star. The protostar continues to gain mass because of its gravitational pull. Its heat makes it glow.

The Sun, and other stars like it, started with a medium amount of hydrogen. That hydrogen is the fuel that produces energy in the Sun. For a few billion years, hydrogen atoms continue combining to form helium, and the star increases in temperature.

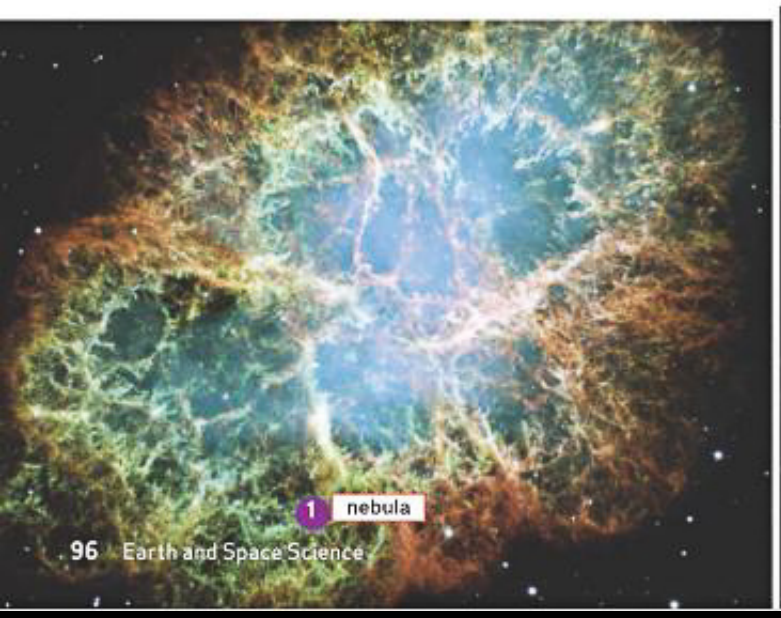
Eventually the heat forces the hydrogen on the edge of the star to expand into space. As the expanding hydrogen moves farther from the center of the star, it cools and turns red. At this stage in its cycle, the star has become a red giant. A red giant is many times larger than the original star. In the star's core, the temperature has risen to about 100,000,000°C (180,000,000°F). Helium atoms now combine to form atoms of carbon.

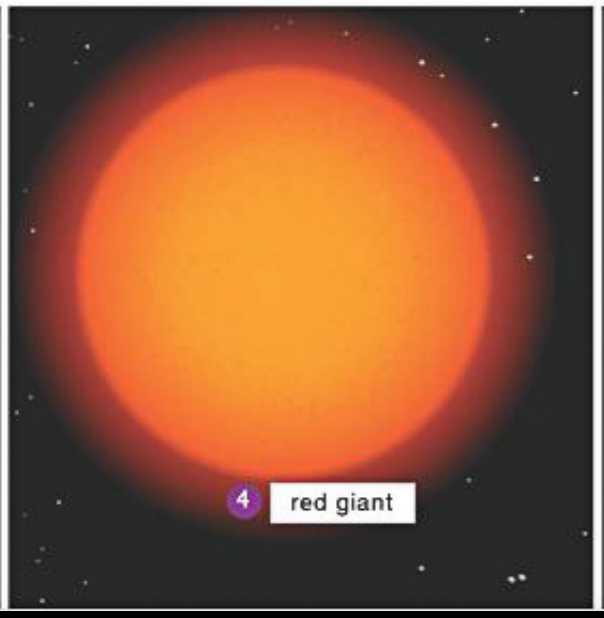
When all the helium is gone, the star can no longer combine helium to form carbon. Now the star begins to cool and shrink, becoming a white dwarf. A **white dwarf** is a small and very dense star that shines with a cooler white light. The white dwarf stage is the end of a medium-sized star's cycle.

About 10 billion years pass during this cycle. Because the Sun is approximately 5 billion years old, it is about halfway through the cycle.

SKILL BUILDER

Read a Diagram
Follow the numbers to better understand the stages of a medium-sized star. The Sun is in stage 3 of this cycle.





Star Cycles of Larger Stars

Stars that start off with greater amounts of hydrogen end their cycle differently. After they become red giants, the temperature of the core of these stars increases to about 600,000,000°C (1,080,000,000°F). At this temperature, their atoms combine to form atoms of iron.

Eventually the iron core produces more energy than gravity can hold together, and the star explodes. The exploding star is called a **supernova.** Supernovas shine brightly for days or weeks and then fade away. A supernova will form a new nebula.

If a star is very massive, it may end its cycle as a black hole. A **black hole** is an object that is so dense and has such powerful gravity that nothing can escape from it, not even light.

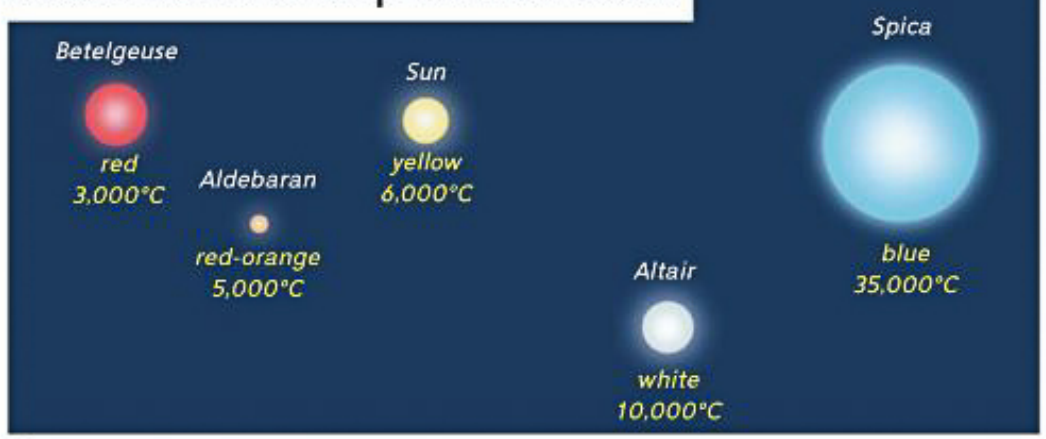
SKILL BUILDER

Read a Diagram
Look for a pattern between temperature and color in these different stars.

Star Classification

Stars are characterized by their size, color, and temperature. The Sun is a medium-sized yellow star with a surface temperature of about 6,000°C (11,000°F). Giant stars have diameters that are 10 to 100 times that of the Sun. Super giants may have diameters that are 1,000 times that of the Sun. Neutron stars are the smallest stars and are 60,000 times smaller than the Sun.

Color and Surface Temperatures of Stars



The Milky Way and Other Galaxies

Our solar system is part of a larger region of space called a galaxy. A galaxy contains billions of stars, dust, and gas that are held together by gravity. Our galaxy is known as the Milky Way.

The Milky Way contains more than 200 billion stars. The dust and gas in the galaxy is enough material to make billions more stars. Even so, the Milky Way is not the largest galaxy. A galaxy known as IC1101 includes more than 100 trillion stars. It is approximately 60 times larger than the Milky Way Galaxy! The smallest known galaxy is called M60-UCD1 and is approximately 300 times smaller than the Milky Way.

Spiral Galaxies These galaxies are shaped like disks. They contain gas, dust, and young stars in their arms. Some spirals arms are long and symmetrical, while others are short and stubby. The Milky Way is a spiral galaxy.

Elliptical Galaxies These galaxies do not have an internal structure. Some are spheres, like basketballs, while others resemble footballs. Elliptical galaxies contain older, redder stars than spiral galaxies do. They also contain little or no gas and dust.

Irregular Galaxies These galaxies are oddly shaped and contain large amounts of gas and dust. They have the highest rate of star formation of any galaxy type. These galaxies do not have bright centers.

Our solar system is in one of the arms of the Milky Way Galaxy.

Spiral Galaxy

Elliptical Galaxy

Irregular Galaxy

Constellations

When people in ancient cultures looked at the night sky, they saw patterns in the stars. These patterns are called **constellations.** They were named after animals, fictional characters, or objects.

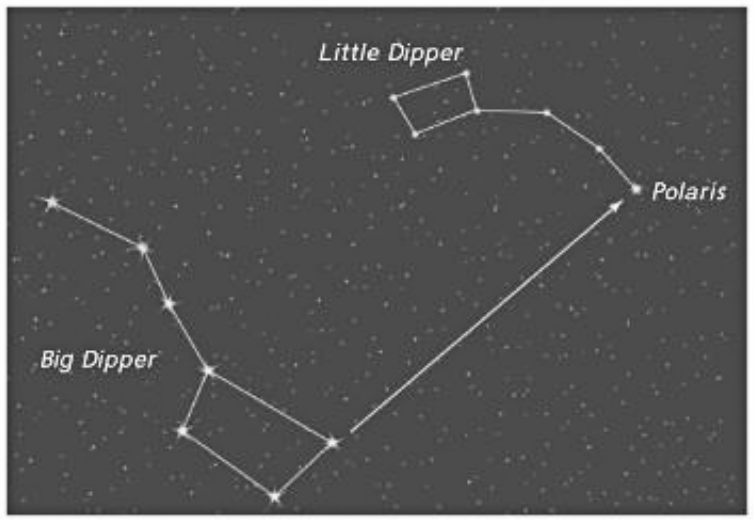
Star patterns have been useful to ancient and modern travelers. For example, if you can see either the Big Dipper or the Little Dipper in the night sky, you can use them to easily find Polaris, the North Star. If you travel in the direction of Polaris, you willbe moving north.

The ancient Greeks divided the sky into 12 sections and named some constellations after characters from Greek myths, such as the hunter Orion and the hero Hercules. The ancient Chinese divided the sky into four major regions. The name of each region included a color, an animal, and a direction. For example, the western region was called the White Tiger of the West.

Today, astronomers divide the sky into 88 constellations. Many of the ancient names for constellations are still used today. Modern astronomers have named constellations visible in the Southern Hemisphere, which could not be seen by Ancient Greeks and Romans.

SKILL BUILDER

Read a Diagram
To find Polaris, first find the stars in the bowl of the Big Dipper.



Apparent Motion

The stars in the northern sky seem to circle around Polaris. The stars appear to move because of Earth's rotation. Although the stars appear to change position, their positions within constellations do not change.

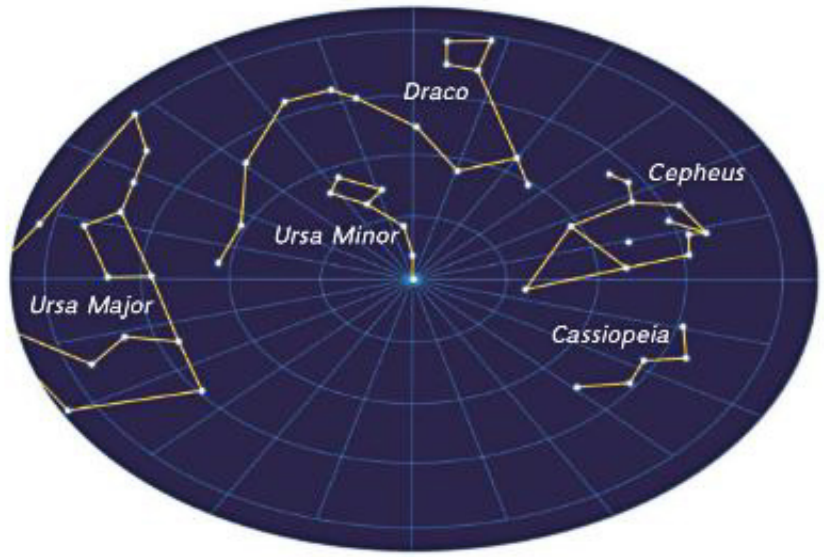
As Earth revolves around the Sun, different constellations are visible to an observer on Earth. For example, Orion is a winter constellation in the Northern Hemisphere. It can be seen rising in the eastern sky on winter evenings. As the season changes, Orion sets earlier and earlier each night. In May, Orion disappears from the night sky in the Northern Hemisphere. In June, the constellation Scorpius, the scorpion, becomes visible.

These seasonal changes are caused by Earth's orbit around the Sun. Each night, the position of most stars shifts slightly to the west. Soon the stars once visible in the west cannot be seen, and other stars appear in the east.

WORD STUDY

The word *circumpolar* comes from two words. *Circum means* "around," and *polar* means "of the poles."

A star map shows the locations of constellations in the night sky.



Space Exploration

Until the early 1600s, people observed the night sky with only their eyes. Then early astronomers, including the Italian astronomer named Galileo Galilei, began looking at the sky through telescopes. Galileo observed things in space that no one had seen before.

an example of an optical telescope

Optical Telescopes

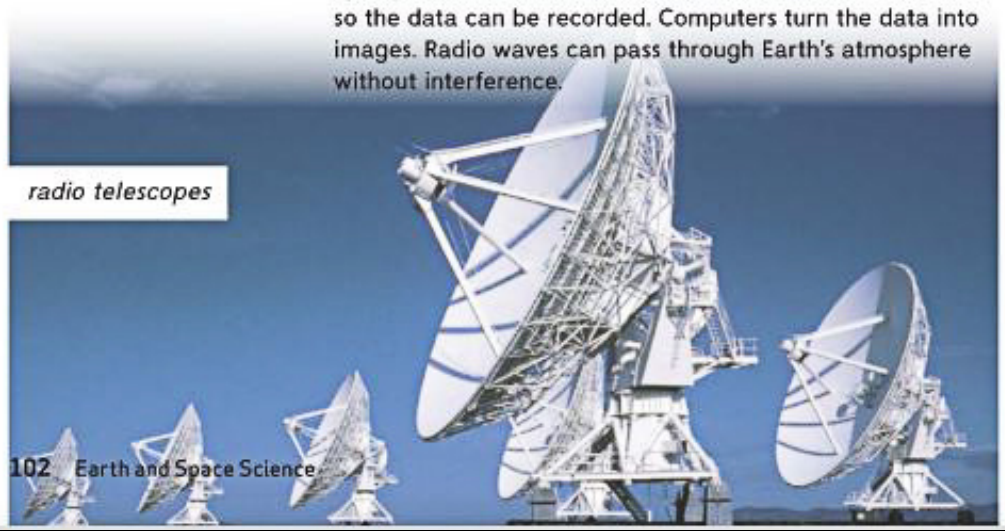
Galileo used an optical telescope, which uses lenses or mirrors to gather visible light. Among the objects Galileo saw were four moons revolving around the planet Jupiter. At that time, most people believed that all the objects in the solar system revolved around Earth.

Telescopes in Space

Clouds and city lights can make it hard to see through optical telescopes. For this reason, many telescopes are located in clear, deserted areas or on mountaintops. One good place for a telescope is outside Earth's atmosphere, in space. In 1990, the Hubble Space Telescope was placed into orbit around Earth. This telescope can show objects that are billions of trillions of kilometers from Earth.

Radio Telescopes

Back on Earth, radio telescopes record radio waves given off by objects in space. Groups of dishes focus the radio waves so the data can be recorded. Computers turn the data into images. Radio waves can pass through Earth's atmosphere without interference.



radio telescopes

Astronauts

In the 1960s, NASA launched rockets that took people into space. Those people were the first astronauts. In the 1980s space shuttles carried astronauts to conduct experiments and launch satellites. Now, many countries, including the United States, share the *International Space Station* (ISS). Unlike rockets and the shuttles, the space station has stayed in orbit around Earth for a long time.

Space Probes

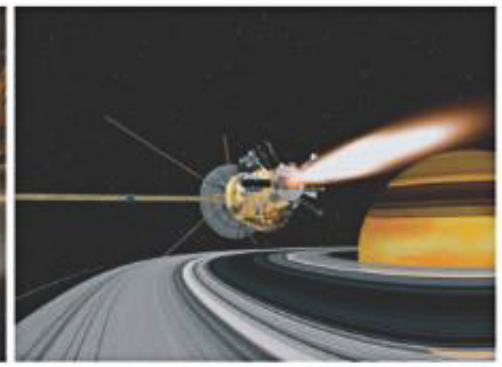
Space probes are unpiloted spacecraft that leave Earth's orbit. NASA has launched probes to planets, moons, and other objects. The probes send pictures and other data from space to Earth. Using space probes is safer and less expensive than sending astronauts into space.

In 2004 a space probe landed on Mars. Two robot explorers, called rovers, studied the surface and recorded data. These Mars rovers are named *Spirit* and *Opportunity*. On August 5, 2012, NASA's newest rover, *Curiosity*, landed on Mars. Its mission is to determine whether Mars ever had an environment able to support living organisms.

Because the solar system is so vast, some probes need many years to reach their targets. Probes have been launched to explore Saturn and its moons and even Pluto.

Astronauts on the ISS learn how to work in microgravity.

The Cassini spacecraft is exploring the planet Saturn and its moons.



Earth's Place in Space

Earth is moving at 30 km/s (19 mi/s) as it orbits the Sun. Earth is also spinning on its axis at about 1,600 km/h (1,000 mph).

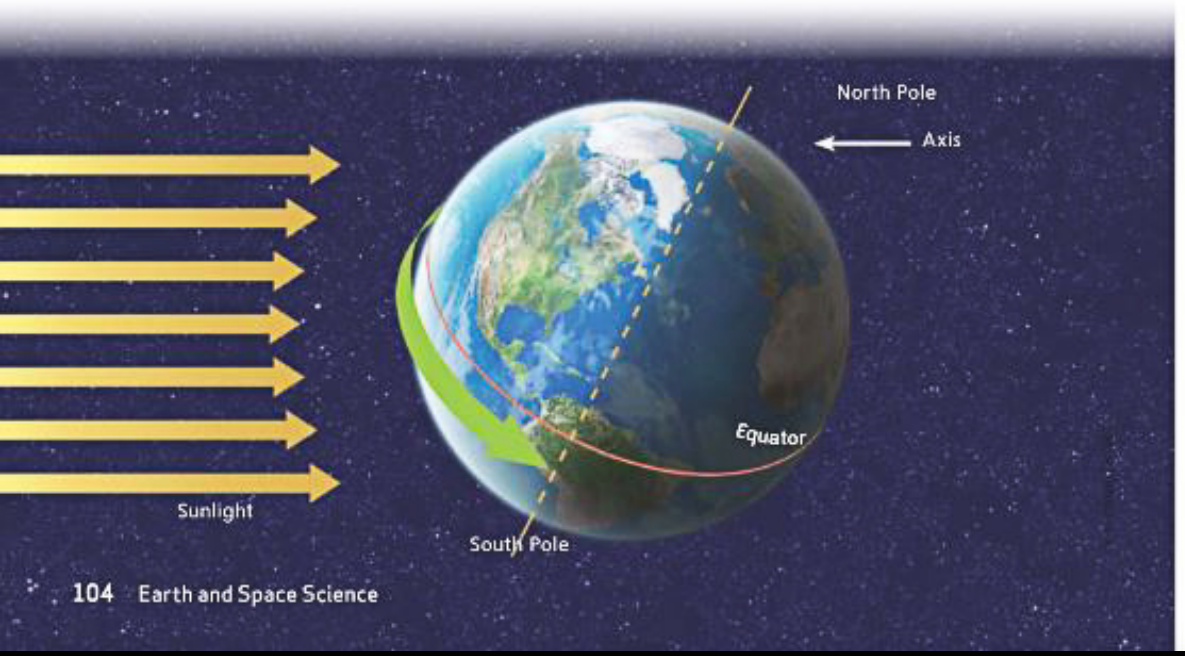
Earth's Rotation

One **rotation** is a complete spin on the axis. Earth makes one rotation every day, or 24 hours. Living things do not feel these movements because they are moving with Earth. At any point in time, half of Earth's surface faces the Sun and is in daylight. The other half of Earth's surface faces away from the Sun and is in darkness.

The tilt of Earth's axis affects the length of the day. If the axis were not tilted, day and night would each be twelve hours long. Instead, there are more hours of daylight and fewer hours of darkness during the summer. In winter, the amount of daylight is shorter.

SKILL BUILDER

Read a Diagram Follow the green arrow to observe the direction of Earth's rotation.



Apparent Motion

As Earth rotates, you see different parts of space. During the day, the side of Earth you live on faces the Sun. As that part turns away from the Sun, it becomes night. The rotation of Earth changes day into night and night into day again.

If you watch objects in the sky, such as the Sun, they appear to rise in the east, move across the sky, and set in the west. What you are seeing is the apparent motion of these objects, not their real motion. Apparent motion is the way something appears, or seems, to move. As Earth rotates from west to east, objects in the sky appear to move from the east to the west. Earth's rotation causes the apparent motion of many objects in space. Stars only seem to move. The Moon and planets do not always move in the same direction as their apparent motion.

Shadows

A shadow forms when light is blocked. The light strikes an object but cannot pass through it. You cast a shadow when your body blocks sunlight. Your shadow always points away from the Sun. As the position of the Sun in the sky changes, your shadow changes, too. Early in the morning, your shadow is long. It shrinks until midday. Then it grows longer again until sunset.

When the Sun is high in the sky, an object has a shorter shadow.

When the Sun is low in the sky, an object has a longer shadow.

DID YOU KNOW?

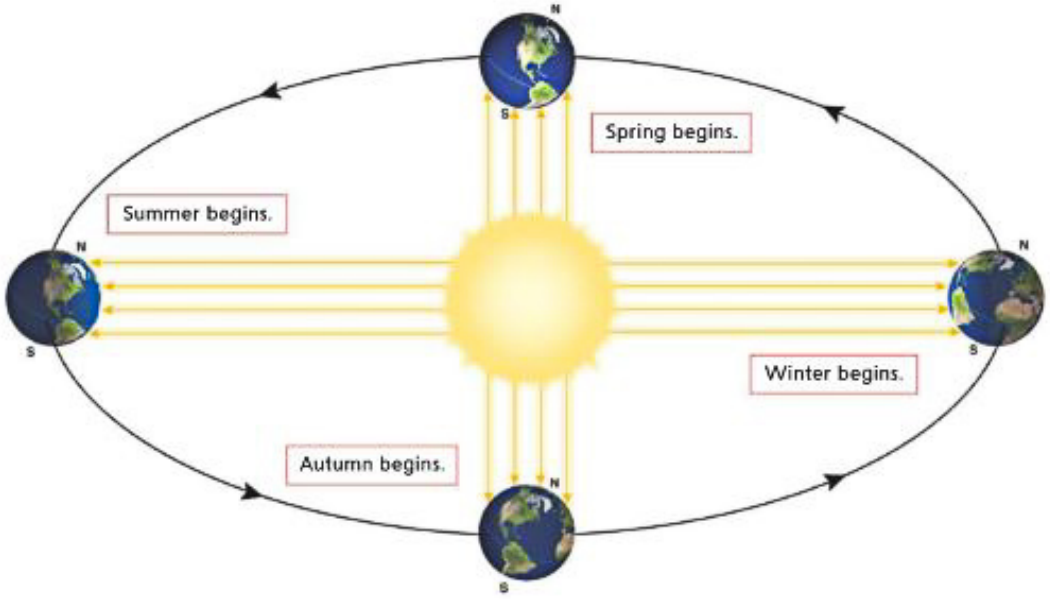
Every four years is a "leap" year—a year in which a 366th day is added to the calendar. This day is necessary because Earth takes slightly less than 365¼ days to orbit the Sun. Adding an extra day every four years keeps the calendar in line with the seasons.

Earth's Revolution

Earth revolves around the Sun. To revolve means to move around another object. Earth makes one **revolution** around the Sun every 365¼ days, or one year. The path a revolving object follows is its **orbit**. Earth's orbit is shaped like an oval, or a circle stretched out more in one direction than the other.

Recall that Earth's axis, the imaginary line about which it rotates, is tilted. It is tilted at an angle of 23.5°. The tilt causes sunlight to strike different parts of Earth at different angles. At any given time, each hemisphere, or half, of Earth gets more or less sunlight than the other. The seasons result from both Earth's tilted axis and its revolution around the Sun.

How Seasons Change in the Northern Hemisphere during a Year



Seasons

As Earth revolves around the Sun, the tilted axis always points in the same direction. When the Northern Hemisphere is tilted away from the Sun, the surface of that hemisphere does not receive as much energy, and temperatures are lower. It is winter in the Northern Hemisphere when this happens.

At the same time, it is summer in the Southern Hemisphere. The Southern Hemisphere is angled toward the Sun, so the energy of sunlight is more concentrated. The surface receives more energy, and temperatures are warmer.

Because the tilt of Earth's axis always points in the same direction, the seasons in the Northern Hemisphere and the Southern Hemisphere are always opposite. In spring and autumn, both hemispheres receive equal energy from the Sun, making temperatures mild.

The Four Seasons in the Northern Hemisphere

Winter	Spring	Summer	Autumn
late December – late March	late March – late June	late June – late September	late September – late December

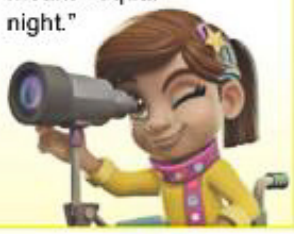
Bill Brooks/Alamy RM

FACT CHECKER

Seasons do not have anything to do with how close Earth is to the Sun at any point in time. In fact, Earth is closer to the Sun in January than in July. Seasons occur because of Earth's tilted axis.

WORD STUDY

The word *equinox* means "equal night."



Earth's Revolution—Seasons and the Sun

The Sun's apparent path changes from season to season. The diagram shows the Sun's apparent path across the sky during the day. Each yellow circle represents the Sun's position at midday. Notice that the Sun rises much higher in the sky during a summer day. The day on which the Sun appears highest in the sky is known as the summer solstice. In the Northern Hemisphere, the summer solstice occurs around June 21 each year. During this time of year, the Northern Hemisphere is tilted more toward the Sun.

In winter, the Sun appears much lower in the sky. In the Northern Hemisphere, the winter solstice occurs around December 21. This is the day on which the Sun appears lowest in the sky. At this time, the Northern Hemisphere is tilted away from the Sun.

Halfway between the solstices, neither hemisphere is tilted toward the Sun. During an equinox, day and night are each about 12 hours long. In the Northern Hemisphere, the spring equinox occurs around March 21. The fall, or autumnal, equinox occurs around September 22.

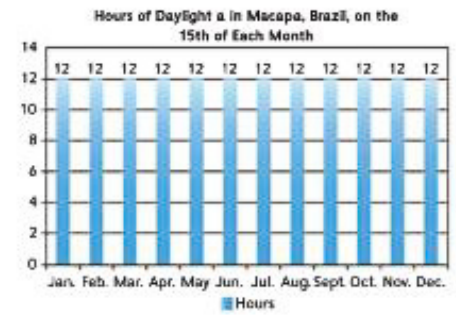
Apparent Path of the Sun

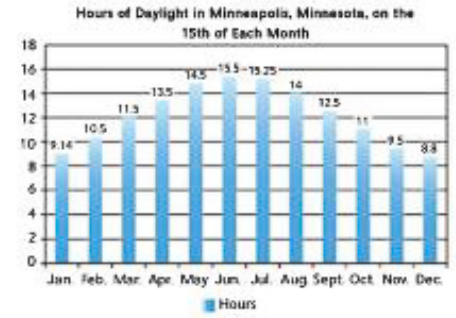
Note that the diagram showing the Sun's apparent path does not apply to all parts of the world. At the equator, the Sun's apparent path changes much less during the year. The farther away you travel from the equator, the greater the change in the Sun's height throughout the year. For example, near the poles in summer, there are more hours of daylight. During winter, the Sun hardly appears above the horizon. Examine the three graphs, which show the number of daylight hours throughout the year for three cities in the Northern Hemisphere. The height of the bars indicates the number of daylight hours on the 15th of each month throughout the year.

SKILL BUILDER

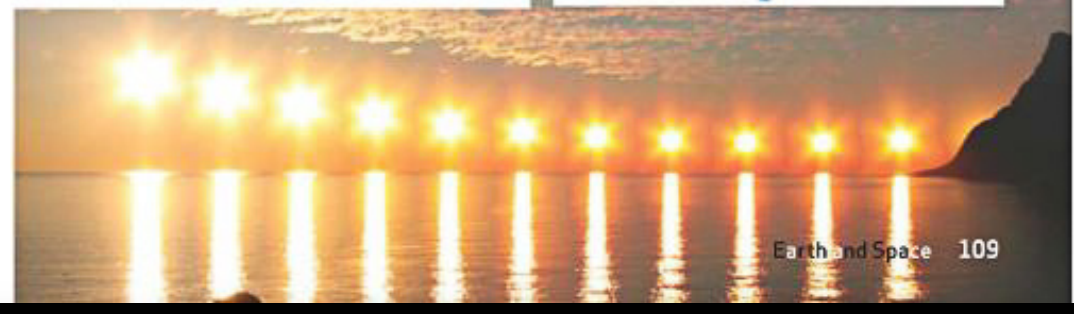
Read a Bar Graph
Macapá, Brazil, is very close to the equator. Minneapolis is 45° north of the equator. Fairbanks is near the North Pole. Note how distance from the equator changes the number of daylight hours.

Hours of Daylight





This time-lapse image was taken in the polar region of the Northern Hemisphere during winter. Note how low the Sun is in the sky, even at its highest point.



alonsaperi/E+/Getty Images