Introduction

As early humans began to study the sky, they believed Earth to be the center of the **universe**. Their observations were based solely upon the motion of the sun, moon, **planets**, and **stars** that their eyes could see—not an actual, scaled model. In time, the astronomers were able to develop more realistic models of our **solar system** with the sun as the center of the *universe*. Today, we know that even this model has changed. With new technologies, today's scientists are able to learn even more about space, enabling us to understand our world and even worlds beyond our own.

Astronomers have been able to develop a more realistic model of our solar system.

Origin of the Universe

Scientists have offered many **theories**, or educated guesses, on how the universe began. The *theory* that most scientists accept today is called the *Big Bang* theory.

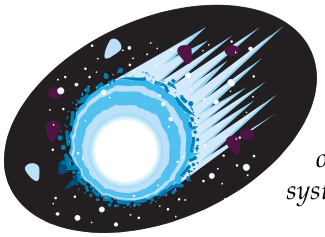
There are also many theories of how the solar system began.

According to this theory, all of the matter and energy found in the universe was once packed together in a single body. Between 15 and 20 billion years ago there was a huge explosion, and matter and energy spread outward in all directions. As the material cooled, gas formed and collected into expanding clouds. As the clouds moved away from the center of the explosion, they cooled and condensed to form **galaxies**. These *galaxies* continued to move away from each other and are still moving today. Within these galaxies today, *stars* form and die while the entire universe continues to expand.

Origin of the Solar System

There are also many theories of how the *solar system* began. Scientists think that about five million years ago, the force of gravity pulled together a large cloud of dust and gas. According to the *Dust Cloud theory*, also

known as the *nebular theory*, a slowly rotating cloud of dust and gas—a **nebula**—formed in one of the spiral arms of our galaxy, the Milky Way. As the cloud shrank, its center became so dense and hot that a star, the sun, was formed. Smaller fragments of remaining material began to **orbit** the sun. In time, gravity pulled these small bits of gas and dust together. These small bits then combined to make a few larger masses. These masses formed the *planets* and their **satellites**. When the sun began to shine, the remaining gas and dust were driven back into space, and only the material that had condensed into solid bodies remained.



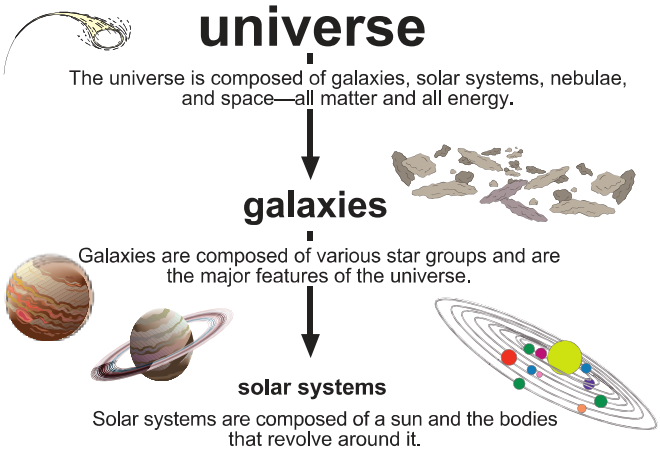
The Dust Cloud theory*, also know as the* nebular theory*, is one theory of the origin of the solar system.*

Another theory suggests that a star larger than the sun came very close to the sun. The closeness of the larger star caused explosions on the sun. The gases from these explosions condensed into particles which formed the planets.

The Universe

The universe is a system that contains many smaller parts. Galaxies, solar systems, *nebulae*, and space—all matter and energy—are the components that make up the universe.

Galaxies like our Milky Way are composed of various star groups and are the major features of the universe. Within galaxies, there are many different types of stars. Some of these stars are *orbited* by *satellites*. These star groups are called *solar systems*. Our sun is an example of a star with orbiting satellites. Only about one percent of all matter in the universe is found in galaxies.



The other 99 percent of matter in the universe is in *space*. Some matter is composed of nebulae, or dust and gas clouds, that are difficult to see without special instruments. The rest is called *dark matter* because we cannot see or detect it.

Measuring Distances

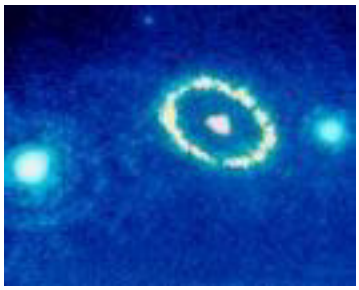
To measure distances in the universe scientists use a unit of distance called a **light-year**. A *light-year* is the distance light travels in one year. The three stars nearest to Earth besides the sun are 4.3 light-years away. When you see their light from Earth, you see light that left the stars 4.3 light-years ago.

Distances within the solar system are commonly given in AUs. AU stands for astronomical unit, the average distance between the sun and Earth. One AU equals 93 million miles or 150 million kilometers. The planet Mercury is .3 AUs from the sun and Earth is one AU from the sun.

The Stars, Planets, and Heavenly Bodies

In the universe, there are many groups of billions of stars called *galaxies*. Galaxies are classified according to their shape. One kind of galaxy is a **spiral galaxy**. It is disk-shaped and looks like a pinwheel with large arms that unwind from the center. Earth's galaxy, the Milky Way, is a *spiral galaxy*. Another common galaxy is an **elliptical galaxy**, which looks spherical to flattened or disklike in shape. They have no arms and very little dust and gas.

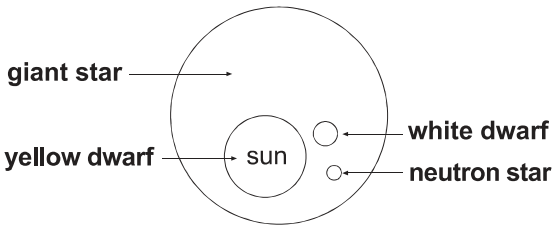
A spiral galaxy is disk-shaped and looks like a pinwheel with large arms that unwind from the center.



An elliptical galaxy looks spherical to flattened or disklike in shape.

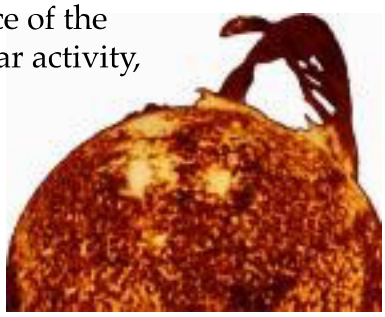
Stars

Stars differ in size, brightness, and temperature. Our sun is average in size for a star. Stars come in a variety of sizes and colors. They range from blue to red, from less than half the size of our sun to over 20 times the sun's size. The size and temperature of a star depends on how much gas and dust collects as the star forms. The color of the star depends on the surface temperature of the star. The more mass a star starts out with, the brighter and hotter it will be.



Sizes of Stars

Earth's sun is a medium-sized star and is called a *yellow dwarf*. There are many explosions on the surface of the star as the star uses its nuclear fuel. This nuclear activity, fusion, produces all the star's light and heat.



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Fusion is the joining of atoms to form new atoms. In a young star, such as our sun, four atoms of hydrogen join to form one atom of helium. This process releases the heat and light of the sun. As stars age, they use all their hydrogen. At this point, their fuel becomes the helium they produced earlier.

The fusion reactions in the core of the sun produce an outward force. This outward force balances the inward force due to gravity. With those two forces evenly balanced, the sun has maintained an equilibrium for five billion years.

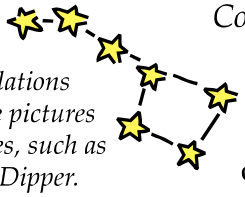
Medium-sized stars (such as our sun) use their fuel (helium) until they reach the red giant phase. In red giants, the outer layers expand, the core contracts, and helium atoms in the core fuse to form carbon. Once the carbon core is stabilized, the end is near. The star will shed its outer layers as a gaseous cloud called a *planetary nebula*. The star continues cooling and shrinking until it has become a white dwarf. The star then radiates its remaining heat into the coldness of space. In the end, it will be a cold dark mass sometimes referred to as a black dwarf. Our sun is expected to produce life-sustaining levels of light energy for about another five billion years.

Stars that are five or more times as massive as our sun follow a slightly different path. When they use up their hydrogen, they eventually grow into a red supergiant (i.e., a very big red giant) and begin to shrink, growing hotter and denser. When the core becomes essentially just iron, the star has nothing left to fuse. In less than a second, the star begins the final phase of its collapse. The core temperature rises to over 100 billion degrees as the iron atoms are crushed together. In one of the most spectacular events in the universe, the explosive shock of the collapsing core propels the material away from the star in a tremendous explosion called a *supernova*. The exploded material moves off into space possibly colliding with other cosmic debris to form new stars, planets, or moons.

If the core remains intact after the supernova, it is called a *neutron star*. However, if the original star was very massive (15 or more times the mass of our sun), a black hole might form. A black hole produces no light (hence it is *black*), but it is extremely massive. Black holes have so much gravity, even light falls into them.

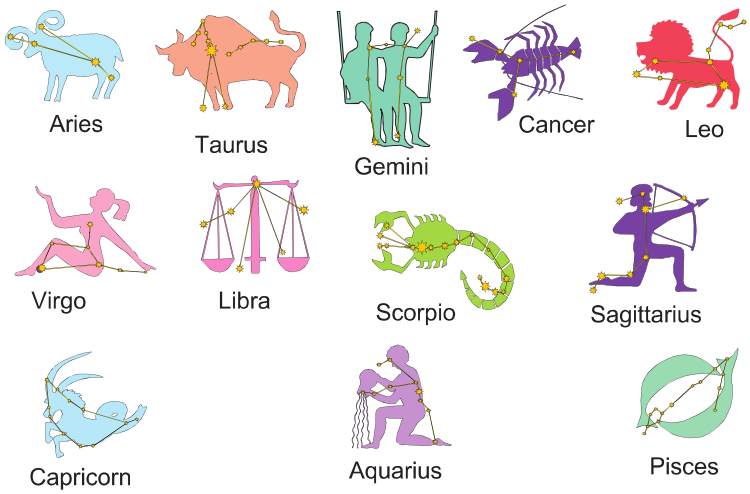
Stars maintain a balance between the great forces that produce radiation and fuel their nuclear fusion. This balance is called **stellar equilibrium**. As large stars grow older, they use up their remaining fuel, and this balance is thrown off, creating great explosions, or supernovas, and collapsing with great changes of gravity into neutron stars or black holes. In these changes, matter is neither created nor destroyed; it changes form and the remaining star particles and gases can now form new stars in the universe.

When people look at the universe, they often see smaller groups of stars called **constellations**.



Constellations look like pictures or shapes, such as the Big Dipper.

Constellations look like pictures or shapes. The Big Dipper and Little Dipper are constellations. The planets, sun, and moon all follow paths within a narrow belt across the sky. There are 12 constellations that appear in this belt. These constellations are called the signs of the Zodiac. The names of the signs of the Zodiac are Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius, and Pisces.



There are 12 constellations that are called the signs of the Zodiac.

Orbiting the sun are the nine planets of the solar system. *Planets* do not burn like stars but reflect the light of the sun.

Moons are satellites that orbit the planets. Some planets have no moons, and some have many moons. Earth has one moon. The moon accompanies Earth on its annual journey around the sun.

Masses of dust and ice with a gaseous tail, called **comets**, also revolve around the sun. Halley's Comet is the most well-known comet. It is seen from Earth every 76 years. Halley's Comet was last seen in 1986. It will not be seen again until the year 2062.

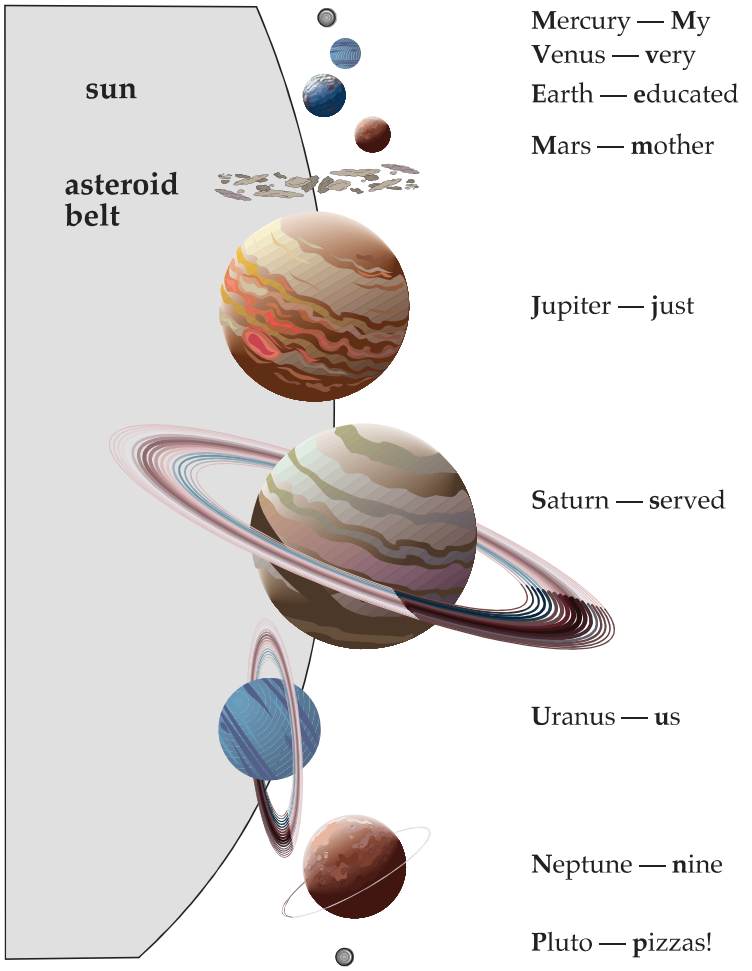
Meteors are small pieces of rocky material that sometimes enter Earth's atmosphere. When a meteor enters Earth's atmosphere, it begins to burn. This is called a *shooting star*, but it is not really a star. The rocky fragments of a meteor that hit the surface of Earth are called *meteorites*.

Asteroids are pieces of rock and metal that orbit the sun. Many are located in a belt between the planets Mars and Jupiter. These fragments of matter are similar to that from which planets were formed. They may be a broken-up planet or trapped debris. Asteroids range in size from tiny particles, too small to be seen, to masses 1,000 kilometers in diameter.

Planets

Our solar system consists of nine planets, their satellites, and many other small bodies such as asteroids, comets, and meteoroids. The planets in order from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

It is easy to remember the names of the planets in their order from the sun. Just remember this sentence: My very educated mother just served us nine pizzas!



My **v**ery **e**ducated **m**other **j**ust **s**erved **u**s **n**ine **p**izzas!

Mercury. Mercury is the planet closest to the sun. It rotates very slowly. The side facing the sun is very hot, while the side away from the sun is very cold. The spacecraft *Mariner 10* visited Mercury in 1974. It discovered a barren world with many craters. The craters have remained unchanged for billions of years because Mercury has no atmosphere or weather.

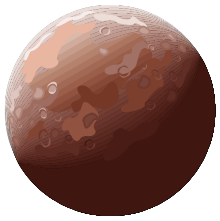
The planets in order from the sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto.

Venus. Venus is sometimes called Earth's *sister planet* because it is very similar in size, mass, and density. The atmosphere of Venus is very different from that of Earth. Venus' atmosphere is composed of carbon dioxide. It also has thick clouds of sulfuric acid. These clouds trap heat and create a greenhouse effect, causing extremely high surface temperatures. Venus is also covered by craters, but there is evidence that oceans once existed.

Earth is the third planet from the sun.

Earth. Earth is the third planet from the sun and is a bit larger than Venus. So far as we know, Earth is the only home of life in the solar system. It has one large moon but there are larger moons in the solar system. There are three main zones of Earth: the atmosphere; the hydrosphere (the world's water); and the lithosphere (the solid body of the world). Earth's solid body is divided into three regions: the core; the mantle; and the crust, the outermost layer of Earth and the one to which all human activity is confined.

Mars. Mars was examined by the *Viking* spacecraft in 1976 and revisited by the Mars *Pathfinder* in July of 1997. Its red soil, suspended by windstorms, gives it the name the *red planet*. Many large volcanoes and craters dot the surface of Mars, indicating that the planet was once very active. The solar system's largest known volcano, Mons Olympus, is found here. Mars also has large ice caps. The ice does not melt because the temperature of Mars is well below freezing. Mars has two small moons—Phobos and Deimos.



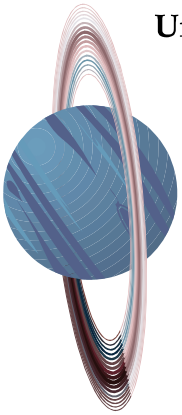
Many large volcanoes and craters dot the surface of Mars.

Jupiter is the largest planet in the solar system.

Jupiter. The largest planet in the solar system is the *gas giant*, Jupiter. Huge storm clouds cover the planet, including the giant red spot which is thought to be like a hurricane three times as large as Earth. In 1979, the *Voyager* spacecraft discovered a thin ring circling the planet. At least 63 moons are known to orbit Jupiter. The first four were discovered by Galileo Galilei in 1610.

Saturn. Saturn is very similar to Jupiter. It also has a dense atmosphere, storms, and rings. Saturn's rings, however, are composed of ice and form intricate patterns. There may be as many as 47 orbiting Saturn.

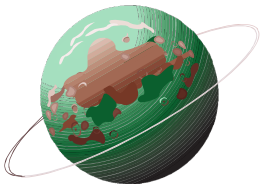
Saturn has a dense atmosphere, storms, and rings.



Uranus also has a ring system, but the rings encircle the planet from top to bottom.

Uranus. Uranus is also a *gas giant* like Jupiter and Saturn. The clouds that cover Uranus give it its characteristic greenish-blue color. Uranus also has a ring system, but the rings encircle the planet from top to bottom. This is because Uranus' axis is tilted at nearly a 90° angle, so it appears to have been knocked on its side. Twenty-seven moons orbit the planet.

Neptune. Neptune is considered Uranus' twin. It is about the same size and has a greenish-blue color. Two thin rings encircle the planet, and it has 13 moons.



Neptune is considered Uranus' twin.

Using Newton's law of gravitation, both the French astronomer Urbain Leverrier and the British mathematician John Couch Adams predicted the existence of a new planet that was causing the orbit of Uranus to be different than expected from Newton's law. Neptune was discovered in 1846 by German astronomer Johann Galle in an orbit close to its predicted position.

Pluto. The most distant planet in our solar system is Pluto. It was the last planet discovered, and due to its great distance from Earth its one moon was not discovered until 1978. Pluto is the smallest planet and may be composed entirely of frozen methane and ice.

Earth's moon

The planets orbit around the sun in our solar system just as the moon orbits Earth. What holds the planets in this orbit? Gravity does. It is the universal force of attraction between all objects that tends to pull them toward one another just as objects are pulled towards Earth's surface. Sir Isaac Newton proposed his law of gravity in 1687. Newton's law stated that every particle in the universe attracts every other particle with a force that is proportional to the masses and inversely proportional to the square of the distance between the objects. The force of attraction between any two objects depends upon their masses and the distance between them.

Summary

The nine planets—along with comets, meteoroids, asteroids, and other celestial objects—make up Earth's vast neighborhood. The planets and other heavenly bodies have at least one thing in common. They all share gravitational forces with the sun, forming a large system—the solar system. With the help of space probes, cameras, and other data-gathering equipment placed above Earth's atmosphere, scientists are able to find out more and more about our celestial neighborhood. These scientific studies are making our world seem smaller than we once imagined it to be and the universe more accessible.