Unit 12: The Universe and Solar System

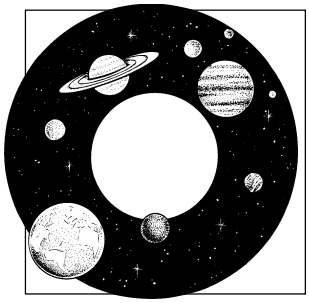
This unit focuses on the origin and composition of the universe and the solar system.

Student Goals

- Construct a model to show the relative distance from the sun to the planets.
- State the scientific theories on how the universe and solar system were formed.
- List the bodies within our solar system.
- Know some ways scientists collect data about our universe.
- Identify information about the universe.
- Know the stages in the development of stars.

Unit Focus

- Know that investigations are conducted to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories. (SC.H.1.4.1)
- Know that from time to time, major shifts occur in the scientific view of how the world works, but that more often, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. (SC.H.1.4.2)
- Understand that no matter how well one theory fits observations, a new theory might fit them as well or better, or might fit a wider range of observations, because in science, the testing, revising, and occasional discarding of theories, new and old, never ends and leads to an increasingly better understanding of how things work in the world, but not to absolute truth. (SC.H.1.4.3)



- Know how the characteristics of other planets and satellites are similar to and different from those on the Earth. (SC.E.1.4.2)
- Know that the stages in the development of three categories of stars are based on mass: stars that have the approximate mass of our Sun, stars that are two- to three-stellar masses and develop into neutron stars, and stars that are five- to six-stellar masses and develop into black holes. (SC.E.2.4.1)
- Identify the arrangement of bodies found within and outside our galaxy. (SC.E.2.4.2)
- Know astronomical distance and time. (SC.E.2.4.3)
- Understand stellar equilibrium. (SC.E.2.4.4)
- Know various scientific theories on how the universe was formed. (SC.E.2.4.5)
- Know the various ways in which scientists collect and generate data about our universe (e.g., X-ray telescopes, computer simulations of gravitational systems, nuclear reactions, space probes, and supercollider simulations). (SC.E.2.4.6)

Vocabulary

Use the vocabulary words and definitions below as a reference for this unit.

asteroids..... fragments of rock and metal that orbit the sun; many are in a belt between Mars and Jupiter

comet..... a mass of dust and ice with a bright gaseous tail that orbits the sun

constellation..... a small number of stars that appears to form a shape or image

elliptical galaxies..... galaxies that have a very bright center that contain very little dust and gas and are spherical to disklike in shape

galaxy..... millions or billions of stars in a system

light-year..... a unit of distance equal to the distance light travels in one year;
1 ly = 9.5×10^{15} m

meteors..... fragments of rocky material from space that burn as they fall through Earth's atmosphere; also known as meteoroids

nebula..... a cloud of interstellar gas and dust (*pl.* nebulae)

orbit..... (noun) the path of an object revolving around another object; (verb) to revolve in a path around another object

planets..... bodies that revolve around a sun and reflect its light

satellite..... an object that revolves around a larger object

solar system..... the sun and all the planets, their moons, asteroids, meteors, and comets; all objects that move around the sun

spiral galaxies..... disk-shaped galaxies that have a center of bright stars and flattened arms that swirl around the center, and look like a pinwheel; the solar system is part of a spiral galaxy

stars..... hot, bright bodies of gas constantly exploding in space

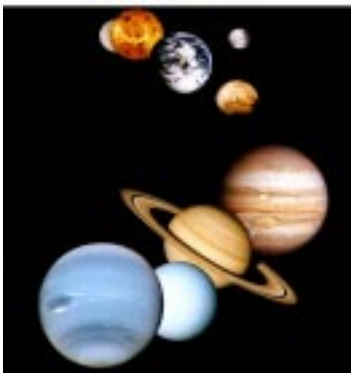
stellar equilibrium..... the balance between forces in a star including nuclear fusion, gravity, and the explosive force of the star

theory..... a hypothesis that has withstood the test of time

universe..... all bodies in space and all space between these bodies—all matter and all energy

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.

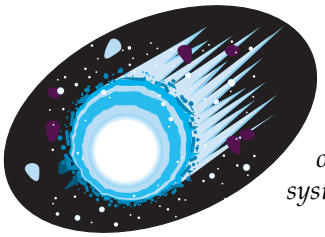
There are also many theories of how the solar system began.

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.

Practice

Use the list below to write the correct term for each definition on the line provided.

galaxy	**planets**	**stars**
nebula	**satellite**	**theory**
orbit	**solar system**	**universe**

_____ 1. a hypothesis that has withstood the test of time

_____ 2. millions or billions of stars in a system

_____ 3. hot, bright bodies of gas constantly exploding in space

_____ 4. all bodies in space and all space between these bodies—all matter and all energy

_____ 5. an object that revolves around a larger object

_____ 6. a cloud of interstellar gas and dust

_____ 7. bodies that revolve around a sun and reflect its light

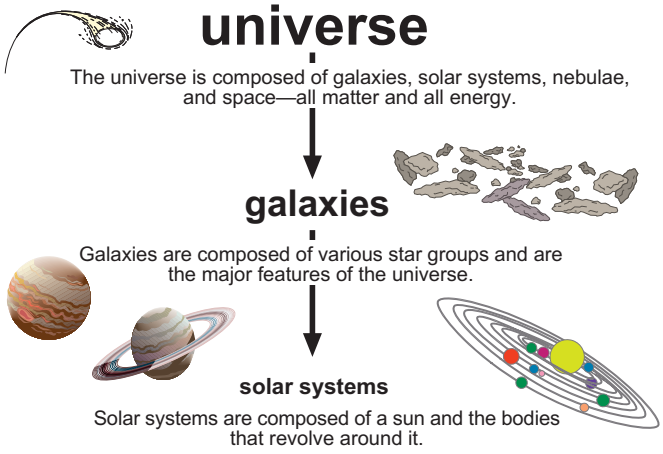
_____ 8. the path of an object revolving around another object; to revolve in a path around another object

_____ 9. the sun and all the planets, their moons, asteroids, meteors, and comets; all objects that move around the sun

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

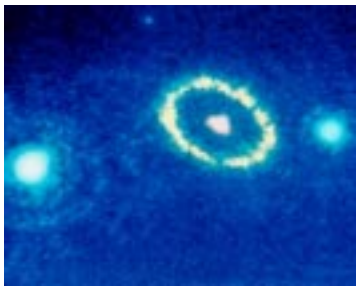
To measure distances in the universe scientists use a unit of distance called a **light-year**. A *light-year* is the distance light travels in one year. The three stars nearest to Earth besides the sun are 4.3 light-years away. When you see their light from Earth, you see light that left the stars 4.3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

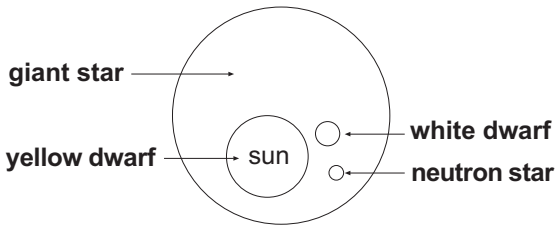
A spiral galaxy is disk-shaped and looks like a pinwheel with large arms that unwind from the center.



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.

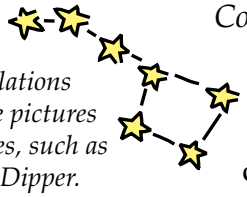
Medium-sized stars (such as our sun) use their fuel (helium) until they reach the red giant phase. In red giants, the outer layers expand, the core contracts, and helium atoms in the core fuse to form carbon. Once the carbon core is stabilized, the end is near. The star will shed its outer layers as 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.

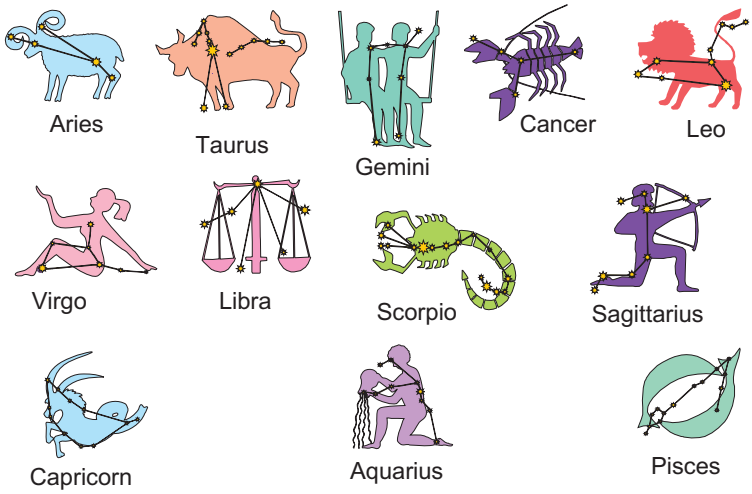
Stars maintain a balance between the great forces that produce radiation and fuel their nuclear fusion. This balance is called **stellar equilibrium**. As large stars grow older, they use up their remaining fuel, and this balance is thrown off, creating great explosions, or supernovas, and collapsing 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.