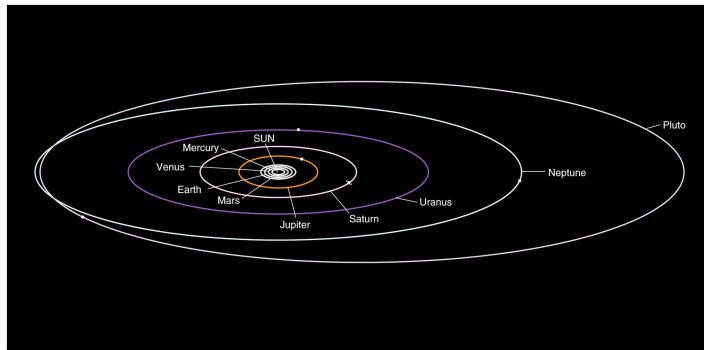


## INTRODUCTION

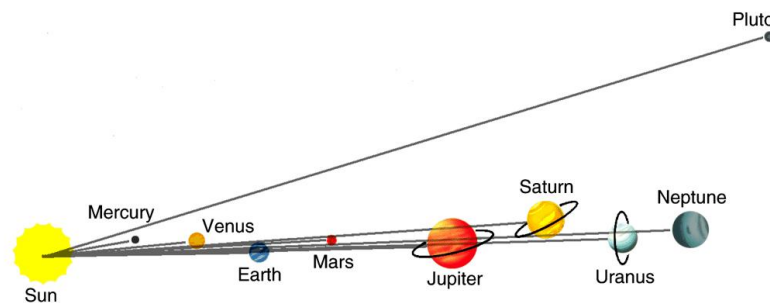
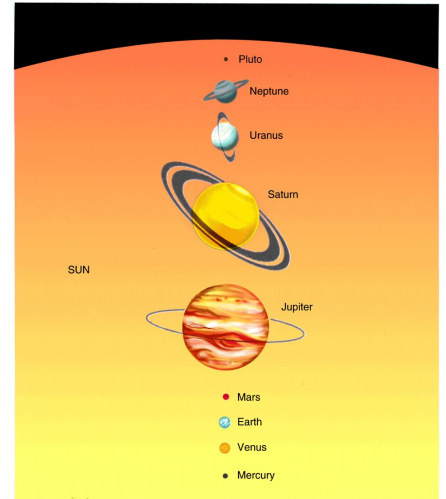
- Astronomy is the study of the universe, which includes all matter, energy, space and time.
- Although the universe is vast and almost beyond imagination, much is known about its make-up and origin.
- Less than 200 years ago it was thought that the Milky Way Galaxy constituted the entire universe. However, in the last century, with use of powerful telescopes, astronomers have discovered and identified at least a billion galaxies.
- A systematic study of the universe should begin with the Earth and its neighboring bodies which include the sun, eight planets, the moon and other satellites, commonly referred to as the ***Solar System***.



- Astronomers have long studied the motion of planets and originally believed the Earth was motionless and that the sun, moon and other planets revolved around it. This Earth-centered model of the solar system was called the ***geocentric model***.
- Nicolaus Copernicus, a Polish astronomer developed the theory of the Sun-centered model of the solar system that currently remains accepted as a planetary model. This model is called the ***heliocentric model***.
- The planets within the solar system can be divided into ***terrestrial planets*** consisting of Mercury, Venus, Earth and Mars, and the ***Jovian planets*** which consist of Jupiter, Saturn, Uranus and Neptune.
- A very small body at the outer edge of the solar system (Pluto) was recently declassified as a planet due to its dissimilarity with the other planets.

## THE SOLAR SYSTEM

- The sizes of the planets in the solar system vary greatly. Their relative size to that of the sun is shown below.
- The Jovian planets are much larger than the terrestrial ones.
- Jupiter is the largest planet, and Pluto is the smallest one.
- All planets *revolve* around the sun in a counter-clockwise motion, and have nearly circular orbits at nearly the same inclination, except Pluto.
- **Kepler's 1<sup>st</sup> Law** states that all planets move about the sun in elliptical orbits with the sun at one focus of the ellipse.
- Pluto has a very elliptical orbit with a very high inclination, as shown below.



- The time it takes a planet to orbit once around the sun is referred to as its year, and is commonly compared with Earth years. For example, Jupiter's year is 11.86 Earth years.
- The speed with which each planet revolves around the sun also varies greatly and is dependent on its distance from the sun at a particular time. The speed of the revolving planet will be greatest when it is closest to the sun (*perihelion*) and slowest when it is farthest from the sun (*aphelion*).
- **Kepler's 2<sup>nd</sup> law** relates the speed of the planets to their distance from the sun.

## TERRESTRIAL PLANETS

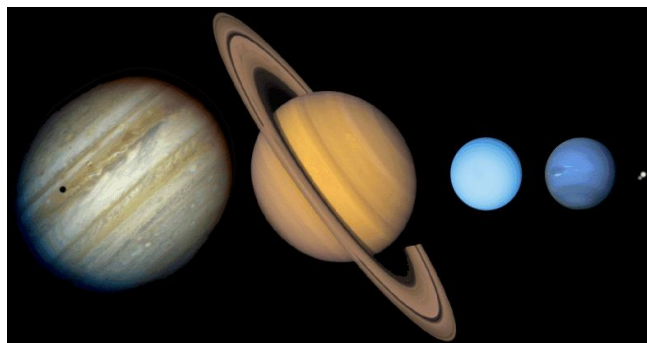
- Mercury, Venus, Earth and Mars are called the *terrestrial planets* because their physical and chemical characteristics resemble those of Earth.
- All four terrestrial planets are small in size and mass and are relatively dense. They are composed of rocky materials with metal cores.
- The orbits of these planets are nearly circular and very close together.
- Despite their similarities, the terrestrial planets also have some very distinct differences. Earth is the only one the four planets that has water present on its surface, and substantial amount of oxygen (21%) in its atmosphere.
- *Mercury* is the *closest* planet to the sun and has the *shortest period* of revolution (88 days). Since it is closest to the sun, it is the *fastest moving* planet. Temperature on the surface of Mercury can range from 467°C to -183°C. Because of its *high temperature* and relatively *small gravitational force*, Mercury has virtually *no atmosphere*.
- *Venus* is our closest planetary neighbor and therefore the *third-brightest* object in the sky. Venus and Earth have *similar densities, masses and gravitational forces*. However, Venus is covered with a *dense atmosphere* that is mostly carbon dioxide, and has very *high surface pressure* (90 atm) and *temperatures* (462°C).
- *Mars* is the fourth planet from the sun and appears reddish from the Earth. A Martian year is almost twice that of an Earth year, since Mars is 1.5 times further from the sun than the Earth and has a larger orbit. Since the axis of Mars is tilted like that of Earth, it also undergoes seasonal changes during the course of its year. Mars polar caps are easily seen from the Earth, and are composed of frozen CO<sub>2</sub>.



The terrestrial planets (with sizes to scale)

## JOVIAN PLANETS

- The four major gaseous planets – Jupiter, Saturn, Uranus and Neptune – are collectively known as the **Jovian planets** due to their similarity to the planet Jupiter. Pluto is separated from the Jovian planets because of its dissimilarity.
- The Jovian planets are **large** compared to the terrestrial planets. They possess **strong magnetic fields**, have **many moons and rings**. These planets are **very distant from the sun** and have **orbits far apart** from each other. Because these planets are composed mainly of hydrogen and helium gases, they have **very low densities**.
- These planets have rocky cores covered with layers of ice. Upper layers of gas surround these lower layers and apply high pressure to them. It is believed that during their formation, these more distant planets were able to keep their gaseous components. In contrast, the closer terrestrial planets lost their gaseous components due to the higher temperatures from the sun.
- Jupiter is the **largest** planet in the solar system, in both **volume and mass**. It is 11 times larger than Earth and nearly 320 times as much mass. It has a rocky core, a layer of ice, a layer of liquid hydrogen (at high pressure) and a cloud of gases consisting of hydrogen and several other gases. Its surface temperature is about  $-110^{\circ}\text{C}$ .
- An interesting feature of Jupiter is the **Great Red Spot**, which scientists believe to be a huge storm lasting hundreds of years. Jupiter has **many moons** (62) as well as a ring of particle matter near its equator.
- Saturn is most famous for its stunning **rings**, which are composed of particles of rock and ice ranging in size from dust grains to huge boulders. Saturn's composition is very similar to Jupiter (rocky core, ice layer, liquid  $\text{H}_2$ , gases), and its surface temperature is about  $-150^{\circ}\text{C}$ .



The Jovian planets (with sizes to scale)

## JOVIAN PLANETS

- Uranus was discovered in 1781, and is the *furthest planet* that can be seen from Earth *without the aid of a telescope*. Its atmosphere is composed of methane, a gas that absorbs the red end of sunlight. As a result, Uranus appears as blue-green color.
- Neptune was discovered in 1846 after calculations by two astronomers led them to expect a planet near Uranus that was disturbing its orbital rotation. In 1989 Voyager 2 obtained photographs from Neptune that showed the Great Dark Spot (similar to Jupiter's *Great Red Spot*), caused by storms on the planet. Neptune is very similar to Uranus in size and composition of atmosphere, and has several *satellites (13), five rings and a cloud of dust*. However, because of a *greater concentration of methane, Neptune appears bluer than Uranus*.
- The *smallest and most distant* body in the solar system is *Pluto*. It was considered to be the ninth planet until recently when it was declassified as a planet due to its small size and dissimilarity with the other planets. Little is known about Pluto's physical and chemical makeup since it is so far away. Recent data indicates that it is *covered with methane ice* and its temperature ranges from  $-230^{\circ}\text{C}$  to  $-210^{\circ}\text{C}$ .
- Recently another body was discovered to be orbiting the sun. This object, called a "*Planetoid*" is about  $\frac{3}{4}$  the size of Pluto and has a very *elongated orbit* that takes it as far as 81 billion miles from the sun. This planetoid has been named *Sedna*.

## PLANET EARTH

- The planet Earth is the most unique body in the solar system. It has *large bodies of surface water*, an *atmosphere with oxygen*, a *temperate climate* and *living organisms*.
- The Earth is not a perfect sphere, but rather an oblate spheroid – flattened at the pole and bulging at the equator. The difference between the diameter of the Earth at the poles and at the equator is small (27 miles) compared to the average diameter of the Earth (8000 miles).
- Earth rotates about its axis (like a spinning top) at an angle of  $23.5^\circ$  from the perpendicular. The Earth makes a complete rotation in 24 hours. The rotation of the Earth around its axis distributes the solar energy onto the planet's surface.
- The Earth revolves around the sun in a near circular orbit, and completes one revolution in 365 days. The Earth's revolution about the tilted axis gives rise to the seasons as shown below.

