# Topic Page: Solar System

Definition: **Solar System** from *The Penguin Dictionary of Science*

The Sun and the bodies that orbit it: the planets and their ➤satellites, ➤asteroids, ➤comets, ➤meteoroids and other interplanetary material.

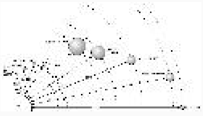

Image from: **solar system** in *The Macmillan Encyclopedia*

Summary Article: **solar system**
from *The Columbia Encyclopedia*

the sun and the surrounding planets, natural satellites, dwarf planets, asteroids, meteoroids, and comets that are bound by its gravity. The sun is by far the most massive part of the solar system, containing almost 99.9% of the system's total mass. The principal members of the sun's retinue are the eight major planets; other parts of the solar system are discussed in separate articles: see asteroid,comet, dwarf planet, and meteor.

## The Planets

In order of increasing average distance from the sun, the planets are Mercury, Venus, earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The planets orbiting nearer the sun than the earth are termed inferior planets; those whose orbits are larger are called superior planets. The unit for measuring distance in the solar system is the astronomical unit (AU), the average distance between the earth and the sun. The mean distances of the planets from the sun range from 0.39 AU for Mercury to 30.04 AU for Nepture.

Pluto, regarded for many years after its discovery as a planet, was reclassified in 2006 as a dwarf planet, which is a planetlike celestial body that does not clear or dominate the region of its orbit. In addition, Pluto is unlike the terrestrial planets—Mercury, Venus, Earth, and Mars—which are rocky, and it is unlike the gas giants—Jupiter, Saturn, Uranus, and Neptune. Its orbit, which is tilted from the plane in which the eight planets travel about the Sun, its size, and its composition more closely resemble those of the objects residing in the Kuiper belt (which were first discovered in 1992; see under comet) than those of a major planet, and Pluto is now recognized as a Kuiper belt, or transneptunian, object.

See the table entitled Major Planets of the Solar System.

### *Planetary Motion*

The motion of the planets was first described accurately by Johannes Kepler at the beginning of the 17th cent.; he showed that the planets move in nearly circular elliptical orbits. Isaac Newton later showed that the laws of planetary motion discovered by Kepler apply also to all other bodies in the solar system and are based on the force of gravitation. The sun's gravitational pull is the dominant force in the solar system; the forces exerted by the other celestial bodies on one another produce small shifts and variations, called perturbations, in their orbits. The planets orbit the sun in approximately the same plane (that of the ecliptic) and move in the same direction—counterclockwise as viewed from above the earth's North Pole. A planet's year, or sidereal period, is the time required for it to complete one full circuit around the sun. Mercury's year is 88 earth days, while Neptune's year is 165 earth years. All the planets rotate about their own axes as they revolve around the sun; their periods of rotation vary from just under 10 earth hours for Jupiter to 243 earth days for Venus. The rotation of Venus is from east to west (see retrograde motion). The equatorial planes of the planets are tilted to various degrees with respect to their orbital planes, giving rise to yearly seasons. The smallest tilt, that of Jupiter, is 3°, whereas that of Uranus is 98°, causing its axis of rotation to lie nearly in the plane of the planet's orbit. The tilt of the earth's equatorial plane is 23 1/2°.

### *Physical Properties*

The planets are grouped according to their physical properties. The inner planets (Mercury, Venus, Earth, and Mars), called the terrestrial, or earthlike, planets, are dense and small in size, with solid, rocky crusts and molten metallic interiors. Except for Mercury, they possess gaseous atmospheres from which lighter elements have escaped because of the low gravitational force. The Jovian planets (Jupiter, Saturn, Uranus, and Neptune) all have great volume and mass but relatively low density. Jupiter is heavier than all the other planets combined; it is 318 times as heavy as the earth and 1,300 times as large, making its density only about one fourth that of the earth. Saturn has a mass 95 times that of the earth and a density less than that of water. The atmospheres of the Jovian planets are very thick, merging imperceptibly with the bodies of the planets, and are rich in hydrogen, hydrogen compounds, and helium. Most of the major planets have one or more moons. See satellite, natural.

## Origin of the Solar System

Besides explaining the birth of the sun, planets, dwarf planets, moons, asteroids, and comets, a theory of the origin of the solar system must explain the chemical and physical differences of the planets; their orbital regularities, i.e., why they lie almost on the same plane and revolve in the same direction in nearly circular orbits; and also account for the relative angular momentum of the sun and planets arising from their rotational and orbital motions.

### *The Nebular Hypothesis*

The nebular hypothesis, developed by Immanuel Kant and given scientific form by P. S. Laplace at the end of the 18th cent., assumed that the solar system in its first state was a nebula, a hot, slowly rotating mass of rarefied matter, which gradually cooled and contracted, the rotation becoming more rapid, in turn giving the nebula a flattened, disklike shape. In time, rings of gaseous matter became separated from the outer part of the disk, until the diminished nebula at the center was surrounded by a series of rings. Out of the material of each ring a great ball was formed, which by shrinking eventually became a planet. The mass at the center of the system condensed to form the sun. The objections to this hypothesis were based on observations of angular momentum that conflicted with the theory.

### *The Planetesimal and Tidal Theories*

Encounter or collision theories, in which a star passes close by or actually collides with the sun, try to explain the distribution of angular momentum. According to the planetesimal theory developed by T. C. Chamberlin and F. R. Moulton in the early part of the 20th cent., a star passed close to the sun. Huge tides were raised on the surface; some of this erupted matter was torn free and, by a cross-pull from the star, was thrust into elliptical orbits around the sun. The smaller masses quickly cooled to become solid bodies, called planetesimals. As their orbits crossed, the larger bodies grew by absorbing the planetesimals, thus becoming planets.

The tidal theory, proposed by James Jeans and Harold Jeffreys in 1918, is a variation of the planetesimal concept: it suggests that a huge tidal wave, raised on the sun by a passing star, was drawn into a long filament and became detached from the principal mass. As the stream of gaseous material condensed, it separated into masses of various sizes, which, by further condensation, took the form of the planets. Serious objections against the encounter theories remain; the angular momentum problem is not fully explained.

### *Contemporary Theories*

Contemporary theories return to a form of the nebular hypothesis to explain the transfer of momentum from the central mass to the outer material. The nebula is seen as a dense nucleus, or protosun, surrounded by a thin shell of gaseous matter extending to the edges of the solar system. According to the theory of the protoplanets proposed by Gerard P. Kuiper, the nebula ceased to rotate uniformly and, under the influence of turbulence and tidal action, broke into whirlpools of gas, called protoplanets, within the rotating mass. In time the protoplanets condensed to form the planets. Although Kuiper's theory allows for the distribution of angular momentum, it does not explain adequately the chemical and physical differences of the planets.

Using a chemical approach, H. C. Urey has given evidence that the terrestrial planets were formed at low temperatures, less than 2,200 degrees Fahrenheit (1,200 degrees Celsius). He proposed that the temperatures were high enough to drive off most of the lighter substances, e.g., hydrogen and helium, but low enough to allow for the condensation of heavier substances, e.g., iron and silica, into solid particles, or planetesimals. Eventually, the planetesimals pulled together into protoplanets, the temperature increased, and the metals formed a molten core. At the distances of the Jovian planets the methane, water, and ammonia were frozen, preventing the earthy materials from condensing into small solids and resulting in the different composition of these planets and their great size and low density.

The discovery of extrasolar planetary systems, beginning with 51 Pegasi in 1995 and now numbering in the hundreds, have given planetary scientists pause. Because it was the only one known, all models of planetary systems were based on the characteristics of the solar system—several small planets close to the star, several large planets at greater distances, and nearly circular planetary orbits. However, all of the extrasolar planets are large, many much larger than Jupiter, the largest of the solar planets; many orbit their star at distances less than that of Mercury, the solar planet closest to the sun; and many have highly elliptical orbits. All of this has caused planetary scientists to revisit the contemporary theories of planetary formation.

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