

Planet

A **planet** is an astronomical body orbiting a star or stellar remnant that

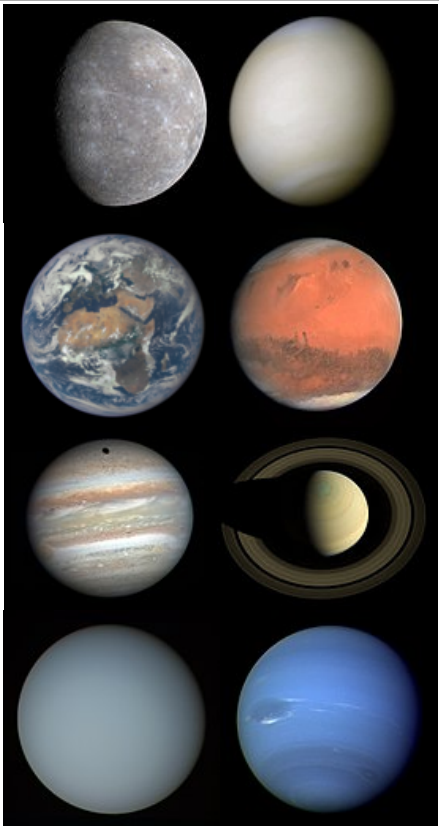
- is massive enough to be rounded by its own gravity,
- is not massive enough to cause thermonuclear fusion and
- has cleared its neighbouring region of planetesimals.^{[a][1][2]}

The term *planet* is ancient, with ties to history, astrology, science, mythology, and religion. Several planets in the Solar System can be seen with the naked eye. These were regarded by many early cultures as divine, or as emissaries of deities. As scientific knowledge advanced, human perception of the planets changed, incorporating a number of disparate objects. In 2006, the International Astronomical Union (IAU) officially adopted a resolution defining planets within the Solar System. This definition is controversial because it excludes many objects of planetary mass based on where or what they orbit. Although eight of the planetary bodies discovered before 1950 remain "planets" under the modern definition, some celestial bodies, such as Ceres, Pallas, Juno and Vesta (each an object in the solar asteroid belt), and Pluto (the first trans-Neptunian object discovered), that were once considered planets by the scientific community are no longer viewed as such.

The planets were thought by Ptolemy to orbit Earth in deferent and epicycle motions. Although the idea that the planets orbited the Sun had been suggested many times, it was not until the 17th century that this view was supported by evidence from the first telescopic astronomical observations, performed by Galileo Galilei. At about the same time, by careful analysis of pre-telescopic observation data collected by Tycho Brahe, Johannes Kepler found the planets' orbits were not circular but elliptical. As observational tools improved, astronomers saw that, like Earth, the planets rotated around tilted axes, and some shared such features as ice caps and seasons. Since the dawn of the Space Age, close observation by space probes has found that Earth and the other planets share characteristics such as volcanism, hurricanes, tectonics, and even hydrology.

Planets are generally divided into two main types: large low-density giant planets, and smaller rocky terrestrials. Under IAU definitions, there are eight planets in the Solar System. In order of increasing distance from the Sun, they are the four terrestrials, Mercury, Venus, Earth, and Mars, then the four giant planets, Jupiter, Saturn, Uranus, and Neptune. Six of the planets are orbited by one or more natural satellites.

Several thousands of planets around other stars ("extrasolar planets" or "exoplanets") have been discovered in the Milky Way. As of 1 April 2018, 3,758 known extrasolar planets in 2,808 planetary systems (including 627 multiple planetary systems), ranging in size from just above the size of the Moon to gas giants about twice as large as Jupiter have been discovered, out of which more than 100 planets are the same size as Earth, nine of which are at the same relative distance from their star as Earth from the Sun, i.e. in the habitable zone.^{[3][4]} On December 20, 2011, the Kepler Space Telescope team reported the discovery of the first Earth-sized extrasolar planets, Kepler-20e^[5] and Kepler-20f,^[6] orbiting a Sun-like star, Kepler-20.^{[7][8][9]} A 2012 study, analyzing gravitational microlensing data, estimates an average of at least 1.6 bound planets for every star in the Milky Way.^[10] Around one in five Sun-like^[b] stars is thought to have an Earth-sized^[c] planet in its habitable^[d] zone.



The eight planets of the Solar System

- The terrestrial planets
 - Mercury, Venus, Earth, and Mars
- The giant planets
 - Jupiter and Saturn (gas giants)
 - Uranus and Neptune (ice giants)

Shown in order from the Sun and in true color. Sizes are not to scale.

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History

The idea of planets has evolved over its history, from the divine lights of antiquity to the earthly objects of the scientific age. The concept has expanded to include worlds not only in the Solar System, but in hundreds of other extrasolar systems. The ambiguities inherent in defining planets have led to much scientific controversy

The five classical planets, being visible to the naked eye, have been known since ancient times and have had a significant impact on mythology, religious cosmology and ancient astronomy. In ancient times, astronomers noted how certain lights moved across the sky, as opposed to the "fixed stars", which maintained a constant relative position in the sky.^[11] Ancient Greeks called these lights *πλάνητες ἀστέρες* (*planētes asteres*, "wandering stars") or simply *πλανῆται* (*planētai*, "wanderers"),^[12] from which today's word "planet" was derived.^{[13][14][15]} In ancient Greece, China, Babylon, and indeed all pre-modern civilizations,^{[16][17]} it was almost universally believed that Earth was the center of the Universe and that all the "planets" circled Earth. The reasons for this perception were that stars and planets appeared to revolve around Earth each day^[18] and the apparently common-sense perceptions that Earth was solid and stable and that it was not moving but at rest.



Printed rendition of a geocentric cosmological model from *Cosmographia*, Antwerp, 1539

Babylon

The first civilization known to have a functional theory of the planets were the Babylonians, who lived in Mesopotamia in the first and second millennia BC. The oldest surviving planetary astronomical text is the Babylonian Venus tablet of Ammisaduqa, a 7th-century BC copy of a list of observations of the motions of the planet Venus, that probably dates as early as the second millennium BC.^[19] The MUL.APIN is a pair of cuneiform tablets dating from the 7th century BC that lays out the motions of the Sun, Moon, and planets over the course of the year.^[20] The Babylonian astrologers also laid the foundations of what would eventually become Western astrology.^[21] The *Enuma anu enlil*, written during the Neo-Assyrian period in the 7th century BC,^[22] comprises a list of omens and their relationships with various celestial phenomena including the motions of the planets.^{[23][24]} Venus, Mercury, and the outer planets Mars, Jupiter, and Saturn were all identified by Babylonian astronomers. These would remain the only known planets until the invention of the telescope in early modern times.^[25]

Greco-Roman astronomy

The ancient Greeks initially did not attach as much significance to the planets as the Babylonians. The Pythagoreans, in the 6th and 5th centuries BC appear to have developed their own independent planetary theory, which consisted of the Earth, Sun, Moon, and planets revolving around a "Central Fire" at the center of the Universe. Pythagoras or Parmenides is said to have been the first to identify the evening star (Hesperos) and morning star (Phosphoros) as one and the same (Aphrodite, Greek corresponding to Latin Venus).^[26] In the 3rd century BC, Aristarchus of Samos proposed a heliocentric system, according to which Earth and the planets revolved around the Sun. The geocentric system remained dominant until the Scientific Revolution

Ptolemy's 7 planetary spheres

1	2	3	4	5	6	7
Moon	Mercury	Venus	Sun	Mars	Jupiter	Saturn

By the 1st century BC, during the Hellenistic period, the Greeks had begun to develop their own mathematical schemes for predicting the positions of the planets. These schemes, which were based on geometry rather than the arithmetic of the Babylonians, would eventually eclipse the Babylonians' theories in complexity and comprehensiveness, and account for most of the astronomical movements observed from Earth with the naked eye. These theories would reach their fullest expression in the *Almagest* written by Ptolemy in the 2nd century CE. So complete was the domination of Ptolemy's model that it superseded all previous works on astronomy and

remained the definitive astronomical text in the Western world for 13 centuries.^{[19][27]} To the Greeks and Romans there were seven known planets, each presumed to be circling Earth according to the complex laws laid out by Ptolemy. They were, in increasing order from Earth (in Ptolemy's order): the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn.^{[15][27][28]}

India

In 499 CE, the Indian astronomer Aryabhata propounded a planetary model that explicitly incorporated Earth's rotation about its axis, which he explains as the cause of what appears to be an apparent westward motion of the stars. He also believed that the orbits of planets are elliptical.^[29] Aryabhata's followers were particularly strong in South India, where his principles of the diurnal rotation of Earth, among others, were followed and a number of secondary works were based on them.^[30]

In 1500, Nilakantha Somayaji of the Kerala school of astronomy and mathematics, in his *Tantrasangraha*, revised Aryabhata's model.^[31] In his *Aryabhatiyabhasya* a commentary on Aryabhata's *Aryabhatiya*, he developed a planetary model where Mercury/Venus, Mars, Jupiter and Saturn orbit the Sun, which in turn orbits Earth, similar to the Tychonic system later proposed by Tycho Brahe in the late 16th century. Most astronomers of the Kerala school who followed him accepted his planetary model.^{[31][32]}

Medieval Muslim astronomy

In the 11th century, the transit of Venus was observed by Avicenna, who established that Venus was, at least sometimes, below the Sun.^[33] In the 12th century, Ibn Bajjah observed "two planets as black spots on the face of the Sun", which was later identified as a transit of Mercury and Venus by the Maragha astronomer Qotb al-Din Shirazi in the 13th century.^[34] Ibn Bajjah could not have observed a transit of Venus, because none occurred in his lifetime.^[35]

European Renaissance

With the advent of the Scientific Revolution use of the term "planet" changed from something that moved across the sky (in relation to the star field); to a body that orbited Earth (or that was believed to do so at the time); and by the 18th century to something that directly orbited the Sun when the heliocentric model of Copernicus, Galileo and Kepler gained sway.

Renaissance planets,
c. 1543 to 1610 and c. 1680 to 1781

1 Mercury 	2 Venus 	3 Earth 	4 Mars 	5 Jupiter 	6 Saturn 
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Thus, Earth became included in the list of planets,^[36] whereas the Sun and Moon were excluded. At first, when the first satellites of Jupiter and Saturn were discovered in the 17th century, the terms "planet" and "satellite" were used interchangeably – although the latter would gradually become more prevalent in the following century.^[37] Until the mid-19th century, the number of "planets" rose rapidly because any newly discovered object directly orbiting the Sun was listed as a planet by the scientific community

19th century

In the 19th century astronomers began to realize that recently discovered bodies that had been classified as planets for almost half a century (such as Ceres, Pallas, Juno, and Vesta) were very different from the traditional ones. These bodies shared the same region of space between Mars and Jupiter (the asteroid belt), and had a much smaller mass; as a result they were reclassified as "asteroids". In the absence of any formal definition, a "planet" came to be understood as any "large" body that orbited the Sun. Because there was a dramatic size gap between the asteroids and the planets, and the spate of new discoveries seemed to have ended after the discovery of Neptune in 1846, there was no apparent need to have a formal definition.^[38]

Eleven planets, 1807–1845

1 Mercury 	2 Venus 	3 Earth 	4 Mars 	5 Vesta 	6 Juno 	7 Ceres 	8 Pallas 	9 Jupiter 	10 Saturn 	11 Uranus 
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20th century

In the 20th century, Pluto was discovered. After initial observations led to the belief that it was larger than Earth,^[39] the object was immediately accepted as the ninth planet. Further monitoring found the body was actually much smaller: in 1936, Ray Lyttleton suggested that Pluto may be an escaped satellite of Neptune,^[40] and Fred Whipple suggested in 1964 that Pluto may be a comet.^[41] As it was still larger than all known asteroids and seemingly did not exist within a larger population,^[42] it kept its status until 2006.

Planets 1854–1930, Solar planets 2006–present

1 Mercury 	2 Venus 	3 Earth 	4 Mars 	5 Jupiter 	6 Saturn 	7 Uranus 	8 Neptune 
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In 1992, astronomers Aleksander Wolszczan and Dale Frail announced the discovery of planets around a pulsar, PSR B1257+12.^[43] This discovery is generally considered to be the first definitive detection of a planetary system around another star. Then, on October 6, 1995, Michel Mayor and Didier Queloz of the Geneva Observatory announced the first definitive detection of an exoplanet orbiting an ordinary main-sequence star (51 Pegasi).^[44]

(Solar) planets 1930–2006

1 Mercury 	2 Venus 	3 Earth 	4 Mars 	5 Jupiter 	6 Saturn 	7 Uranus 	8 Neptune 	9 Pluto 
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The discovery of extrasolar planets led to another ambiguity in defining a planet: the point at which a planet becomes a star. Many known extrasolar planets are many times the mass of Jupiter, approaching that of stellar objects known as brown dwarfs. Brown dwarfs are generally considered stars due to their ability to fuse deuterium, a heavier isotope of hydrogen. Although objects more massive than 75 times that of Jupiter fuse hydrogen, objects of only 13 Jupiter masses can fuse deuterium. Deuterium is quite rare, and most brown dwarfs would have ceased fusing deuterium long before their discovery, making them effectively indistinguishable from supermassive planets.^[45]

21st century

With the discovery during the latter half of the 20th century of more objects within the Solar System and large objects around other stars, disputes arose over what should constitute a planet. There were particular disagreements over whether an object should be considered a planet if it was part of a distinct population such as a belt, or if it was large enough to generate energy by the thermonuclear fusion of deuterium.

A growing number of astronomers argued for Pluto to be declassified as a planet, because many similar objects approaching its size had been found in the same region of the Solar System (the Kuiper belt) during the 1990s and early 2000s. Pluto was found to be just one small body in a population of thousands.

Some of them, such as Quaoar, Sedna, and Eris, were heralded in the popular press as the tenth planet, failing to receive widespread scientific recognition. The announcement of Eris in 2005, an object then thought of as 27% more massive than Pluto, created the necessity and public desire for official definition of a planet.

Acknowledging the problem, the IAU set about creating the definition of planet, and produced one in August 2006. The number of planets dropped to the eight significantly larger bodies that had cleared their orbit (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune), and a new class of dwarf planets was created, initially containing three objects Ceres, Pluto and Eris).^[46]

Extrasolar planets

There is no official definition of extrasolar planets. In 2003, the International Astronomical Union (IAU) Working Group on Extrasolar Planets issued a position statement, but this position statement was never proposed as an official IAU resolution and was never voted on by IAU members. The position statement incorporates the following guidelines, mostly focused upon the boundary between planets and brown dwarfs.^[2]

1. Objects with true masses below the limiting mass for thermonuclear fusion of deuterium (currently calculated to be 13 times the mass of Jupiter for objects with the same isotopic abundance as the Sun^[47]) that orbit stars or stellar remnants are "planets" (no matter how they formed). The minimum mass and size required for an extrasolar object to be considered a planet should be the same as that used in the Solar System.
2. Substellar objects with true masses above the limiting mass for thermonuclear fusion of deuterium are "brown dwarfs", no matter how they formed or where they are located.
3. Free-floating objects in young star clusters with masses below the limiting mass for thermonuclear fusion of deuterium are not "planets", but are "sub-brown dwarfs" (or whatever name is most appropriate).

This working definition has since been widely used by astronomers when publishing discoveries of exoplanets in academic journals.^[48] Although temporary, it remains an effective working definition until a more permanent one is formally adopted. It does not address the dispute over the lower mass limit,^[49] and so it steered clear of the controversy regarding objects within the Solar System. This definition also makes no comment on the planetary status of objects orbiting brown dwarfs, such as 2M1207b.

One definition of a sub-brown dwarf is a planet-mass object that formed through cloud collapse rather than accretion. This formation distinction between a sub-brown dwarf and a planet is not universally agreed upon; astronomers are divided into two camps as whether to consider the formation process of a planet as part of its division in classification.^[50] One reason for the dissent is that often it may not be possible to determine the formation process. For example, a planet formed by accretion around a star may get ejected from the system to become free-floating, and likewise a sub-brown dwarf that formed on its own in a star cluster through cloud collapse may get captured into orbit around a star.

The 13 Jupiter-mass cutoff represents an average mass rather than a precise threshold value. Large objects will fuse most of their deuterium and smaller ones will fuse only a little, and the 13 M_J value is somewhere in between. In fact, calculations show that an object fuses 50% of its initial deuterium content when the total mass ranges between 12 and 14 M_J .^[51] The amount of deuterium fused depends not only on mass but also on the composition of the object, on the amount of helium and deuterium present.^[52] The Extrasolar Planets Encyclopaedia includes objects up to 25 Jupiter masses, saying, "The fact that there is no special feature around 13 M_J in the observed mass spectrum reinforces the choice to forget this mass limit."^[53] The Exoplanet Data Explorer includes objects up to 24 Jupiter masses with the advisory: "The 13 Jupiter mass distinction by the IAU Working Group is physically unmotivated for planets with rocky cores, and observationally problematic due to the sin i ambiguity."^[54] The NASA Exoplanet Archive includes objects with a mass (or minimum mass) equal to or less than 30 Jupiter masses.^[55]

Another criterion for separating planets and brown dwarfs, rather than deuterium fusion, formation process or location, is whether the core pressure is dominated by coulomb pressure or electron degeneracy pressure.^{[56][57]}

2006 IAU definition of planet

The matter of the lower limit was addressed during the 2006 meeting of the IAU's General Assembly. After much debate and one failed proposal, 232 members of the 10,000 member assembly, who nevertheless constituted a large majority of those remaining at the meeting, voted to pass a resolution. The 2006 resolution defines planets within the Solar System as follows:^[1]

A "planet" [1] is a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.

[1] The eight planets are: Mercury Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

Under this definition, the Solar System is considered to have eight planets. Bodies that fulfill the first two conditions but not the third (such as Ceres, Pluto, and Eris) are classified as dwarf planets, provided they are not also natural satellites of other planets. Originally an IAU committee had proposed a definition that would have included a much larger number of planets as it did not include (c) as a criterion.^[58] After much discussion, it was decided via a vote that those bodies should instead be classified as dwarf planets.^[59]

This definition is based in theories of planetary formation, in which planetary embryos initially clear their orbital neighborhood of other smaller objects. As described by astronomer Steven Soter.^[60]

"The end product of secondary disk accretion is a small number of relatively large bodies (planets) in either non-intersecting or resonant orbits, which prevent collisions between them. Minor planets and comets, including KBOs [Kuiper belt objects], differ from planets in that they can collide with each other and with planets."

The 2006 IAU definition presents some challenges for exoplanets because the language is specific to the Solar System and because the criteria of roundness and orbital zone clearance are not presently observable. Astronomer [Jean-Luc Margot](#) proposed a mathematical criterion that determines whether an object can clear its orbit during the lifetime of its host star, based on the mass of the planet, its semimajor axis, and the mass of its host star.^{[61][62]} This formula produces a value π that is greater than 1 for planets. The eight known planets and all known exoplanets have π values above 100, while Ceres, Pluto, and Eris have π values of 0.1 or less. Objects with π values of 1 or more are also expected to be approximately spherical, so that objects that fulfill the orbital zone clearance requirement automatically fulfill the roundness requirement.^[63]

Objects formerly considered planets

The table below lists [Solar System](#) bodies once considered to be planets.

Body	Current classification	Notes
Sun	Star	Classified as classical planets (Ancient Greek <i>πλανήται</i> , wanderers) in classical antiquity and medieval Europe, in accordance with the now-disproved geocentric model. ^[64]
Moon	Natural satellite	
Io , Europa , Ganymede , and Callisto	Natural satellites	The four largest moons of Jupiter, known as the Galilean moons after their discoverer Galileo Galilei . He referred to them as the "Medicean Planets" in honor of his patron, the Medici family . They were known as secondary planets. ^[65]
Titan , ^[e] Iapetus , ^[f] Rhea , ^[f] Tethys , ^[g] and Dione ^[g]	Natural satellites	Five of Saturn's larger moons discovered by Christiaan Huygens and Giovanni Domenico Cassini. As with Jupiter's major moons, they were known as secondary planets. ^[65]
Pallas , Juno , and Vesta	Asteroids	Regarded as planets from their discoveries between 1801 and 1807 until they were reclassified as asteroids during the 1850s. ^[67]
Ceres	Dwarf planet and asteroid	Ceres was subsequently classified as a dwarf planet in 2006.
Astraea , Hebe , Iris , Flora , Metis , Hygiea , Parthenope , Victoria , Egeria , Irene , Eunomia	Asteroids	More asteroids, discovered between 1845 and 1851. The rapidly expanding list of bodies between Mars and Jupiter prompted their reclassification as asteroids, which was widely accepted by 1854. ^[68]
Pluto	Dwarf planet and Kuiper belt object	The first known trans-Neptunian object (i.e. minor planet with a semi-major axis beyond Neptune). Regarded as a planet from its discovery in 1930 until it was reclassified as a dwarf planet in 2006.

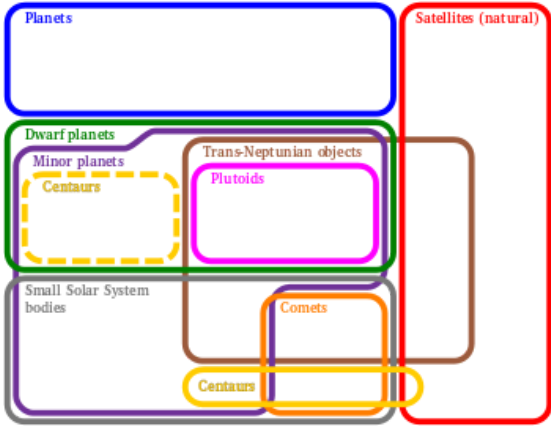
Beyond the scientific community, Pluto still holds cultural significance for many in the general public due to its historical classification as a planet from 1930 to 2006.^[69] A few astronomers, such as [Alan Stern](#), consider dwarf planets and the larger moons to be planets, based on a purely geophysical definition of planet.^[70]

Mythology and naming

The names for the planets in the Western world are derived from the naming practices of the Romans, which ultimately derive from those of the Greeks and the Babylonians. In ancient Greece, the two great luminaries the Sun and the Moon were called *Helios* and *Selene*; the farthest planet (Saturn) was called *Phainon*, the shiner; followed by *Phaethon* (Jupiter), "bright"; the red planet (Mars) was known as *Pyroeis*, the "fiery"; the brightest (Venus) was known as *Phosphoros*, the light bringer; and the fleeting final planet (Mercury) was called *Stilbon*, the gleamer. The Greeks also made each planet sacred to one among their pantheon of gods, the [Olympians](#): Helios and Selene were the names of both planets and gods; Phainon was sacred to [Cronus](#), the [Titan](#) who fathered the Olympians; Phaethon was sacred to [Zeus](#), Cronus's son who deposed him as king; Pyroeis was given to [Ares](#), son of Zeus and god of war; Phosphoros was ruled by [Aphrodite](#), the goddess of love; and [Hermes](#), messenger of the gods and god of learning and wit, ruled over Stilbon.^[19]

The Greek practice of grafting of their gods' names onto the planets was almost certainly borrowed from the Babylonians. The Babylonians named [Phosphoros](#) after their goddess of love, *Ishtar*; Pyroeis after their god of war, *Nergal*; Stilbon after their god of wisdom [Nabu](#), and Phaethon after their chief god, *Marduk*.^[71] There are too many concordances between Greek and Babylonian naming conventions for them to have arisen separately.^[19] The translation was not perfect. For instance, the Babylonian Nergal was a god of war, and thus the Greeks identified him with Ares. Unlike Ares, Nergal was also god of pestilence and the underworld.^[72]

Today, most people in the western world know the planets by names derived from the Olympian pantheon of gods. Although modern Greeks still use their ancient names for the planets, other European languages, because of the influence of the [Roman Empire](#) and, later, the [Catholic Church](#), use the Roman (Latin) names rather than the Greek ones. The Romans, who, like the Greeks, were [Indo-Europeans](#) shared with them a common pantheon under different names but lacked the rich narrative traditions that Greek poetic culture had given their gods. During the later period of the [Roman Republic](#), Roman writers borrowed much of the Greek narratives and applied them to their own pantheon, to the point where they became virtually indistinguishable.^[73] When the Romans studied Greek astronomy, they gave the planets their own gods'



Euler diagram showing the types of bodies in the Solar System.

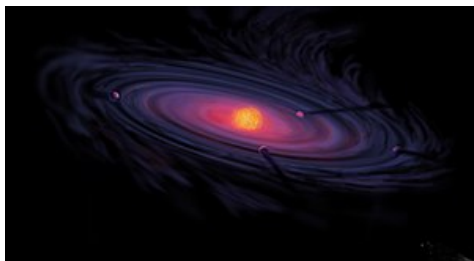
names: *Mercurius* (for Hermes), *Venus* (Aphrodite), *Mars* (Ares), *Iuppiter* (Zeus) and *Saturnus* (Cronus). When subsequent planets were discovered in the 18th and 19th centuries, the naming practice was retained with *Neptūnus* (Poseidon). Uranus is unique in that it is named for a Greek deity rather than his Roman counterpart

Some Romans, following a belief possibly originating in Mesopotamia but developed in Hellenistic Egypt, believed that the seven gods after whom the planets were named took hourly shifts in looking after affairs on Earth. The order of shifts went Saturn, Jupiter, Mars, Sun, Venus, Mercury, Moon (from the farthest to the closest planet).^[74] Therefore, the first day was started by Saturn (1st hour), second day by Sun (25th hour), followed by Moon (49th hour), Mars, Mercury, Jupiter and Venus. Because each day was named by the god that started it, this is also the order of the days of the week in the Roman calendar after the Nundinal cycle was rejected – and still preserved in many modern languages.^[75] In English, *Saturday*, *Sunday*, and *Monday* are straightforward translations of these Roman names. The other days were renamed after *Tiw* (Tuesday), *Wóden* (Wednesday), *Thunor* (Thursday), and *Fríge* (Friday), the Anglo-Saxon gods considered similar or equivalent to Mars, Mercury/Jupiter, and Venus, respectively

Earth is the only planet whose name in English is not derived from Greco-Roman mythology. Because it was only generally accepted as a planet in the 17th century^[36] there is no tradition of naming it after a god. (The same is true, in English at least, of the Sun and the Moon, though they are no longer generally considered planets.) The name originates from the 8th century Anglo-Saxon word *erda*, which means ground or soil and was first used in writing as the name of the sphere of Earth perhaps around 1300.^{[76][77]} As with its equivalents in the other Germanic languages it derives ultimately from the Proto-Germanic word *ertho*, "ground",^[77] as can be seen in the English *earth*, the German *Erde*, the Dutch *aarde*, and the Scandinavian *jord*. Many of the Romance languages retain the old Roman word *terra* (or some variation of it) that was used with the meaning of "dry land" as opposed to "sea".^[78] The non-Romance languages use their own native words. The Greeks retain their original name *Γῆ* (*Ge*).

Non-European cultures use other planetary-naming systems. India uses a system based on the Navagraha, which incorporates the seven traditional planets (Surya for the Sun, Chandra for the Moon, and Budha, Shukra, Mangala, *Brhaspati* and Shani for Mercury, Venus, Mars, Jupiter and Saturn) and the ascending and descending lunar nodes Rahu and Ketu. China and the countries of eastern Asia historically subject to Chinese cultural influence (such as Japan, Korea and Vietnam) use a naming system based on the five Chinese elements: water (Mercury), metal (Venus), fire (Mars), wood (Jupiter) and earth (Saturn).^[75] In traditional Hebrew astronomy, the seven traditional planets have (for the most part) descriptive names - the Sun is חמה *Ḥammah* or "the hot one," the Moon is לבנה *Levanah* or "the white one," Venus is כוכב נוגה *Kokhav Nogah* or "the bright planet," Mercury is כוכב *Kokhav* or "the planet" (given its lack of distinguishing features), Mars is מאדים *Ma'adim* or "the red one," and Saturn is שבתאי *Shabbatai* or "the resting one" (in reference to its slow movement compared to the other visible planets).^[79] The odd one out is Jupiter, called צדק *Tzedeq* or "justice." Steiglitz suggests that this may be a euphemism for the original name of כוכב בעל *Kokhav Ba'al* or "Baal's planet," seen as idolatrous and euphemized in a similar manner to Ishbosheth from II Samuel.^[79]

Formation



An artist's impression of protoplanetary disk

It is not known with certainty how planets are formed. The prevailing theory is that they are formed during the collapse of a nebula into a thin disk of gas and dust. A protostar forms at the core, surrounded by a rotating protoplanetary disk. Through accretion (a process of sticky collision) dust particles in the disk steadily accumulate mass to form ever-larger bodies. Local concentrations of mass known as planetesimals form, and these accelerate the accretion process by drawing in additional material by their gravitational attraction. These concentrations become ever denser until they collapse inward under gravity to form protoplanets.^[80] After a planet reaches a mass somewhat larger than Mars' mass, it begins to accumulate an extended atmosphere,^[81] greatly increasing the capture rate of the planetesimals by means of atmospheric drag.^{[82][83]} Depending on the accretion history of solids and gas, a giant planet, an ice giant, or a terrestrial planet may result.^{[84][85][86]}

When the protostar has grown such that it ignites to form a star, the surviving disk is removed from the inside outward by photoevaporation, the solar wind, Poynting–Robertson drag and other effects.^{[87][88]} Thereafter there still may be many protoplanets orbiting the star or each other, but over time many will collide, either to form a single larger planet or release material for other larger protoplanets or planets to absorb.^[89] Those objects that have become massive enough will capture most matter in their orbital neighbourhoods to become planets. Protoplanets that have avoided collisions may become natural satellites of planets through a process of gravitational capture, or remain in belts of other objects to become either dwarf planets or small bodies.

The energetic impacts of the smaller planetesimals (as well as radioactive decay) will heat up the growing planet, causing it to at least partially melt. The interior of the planet begins to differentiate by mass, developing a denser core.^[90] Smaller terrestrial planets lose most of their atmospheres because of this accretion, but the lost gases can be replaced by outgassing from the mantle and from the subsequent impact of comets.^[91] (Smaller planets will lose any atmosphere they gain through various escape mechanisms)

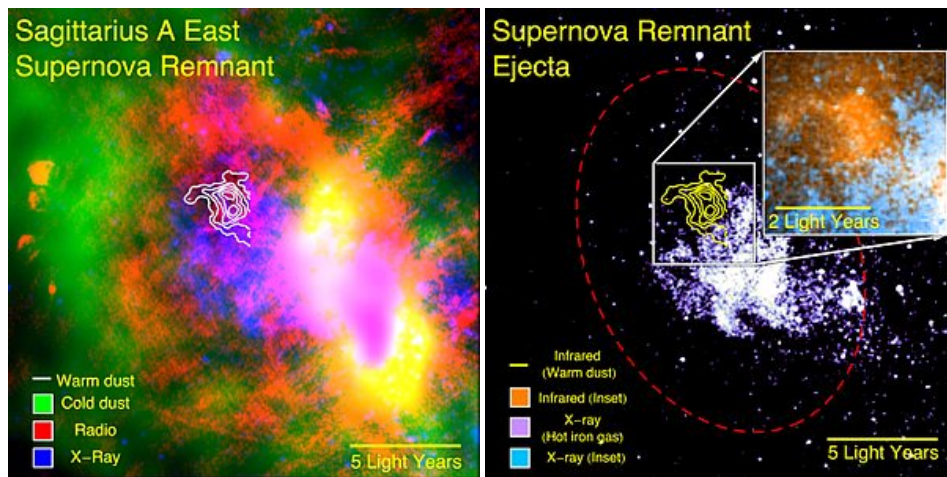
With the discovery and observation of planetary systems around stars other than the Sun, it is becoming possible to elaborate, revise or even replace this account. The level of metallicity—an astronomical term describing the abundance of chemical elements with an atomic number greater than 2 (helium)—is now thought to determine the likelihood that a star will have planets.^[92] Hence, it is thought that a metal-rich population I star will likely have a more substantial planetary system than a metal-poor, population II star.



The Greek gods of Olympus, after whom the Solar System's Roman names of the planets are derived



Asteroid collision - building planets (artist concept).



Supernova remnant ejecta producing planet-forming material.

Solar System

There are eight planets in the Solar System, which are in increasing distance from the Sun:

1. ☿ **Mercury**
2. ♀ **Venus**
3. ⊕ **Earth**
4. ♂ **Mars**
5. ♃ **Jupiter**
6. ♄ **Saturn**
7. ♅ **Uranus**
8. ♆ **Neptune**

Jupiter is the largest, at 318 Earth masses, whereas Mercury is the smallest, at 0.055 Earth masses.

The planets of the Solar System can be divided into categories based on their composition:

- **Terrestrials:** Planets that are similar to Earth, with bodies largely composed of rock: Mercury, Venus, Earth and Mars. At 0.055 Earth masses, Mercury is the smallest terrestrial planet (and smallest planet) in the Solar System. Earth is the largest terrestrial planet.
- **Giant planets (Jovians):** Massive planets significantly more massive than the terrestrials: Jupiter, Saturn, Uranus, Neptune.
 - **Gas giants,** Jupiter and Saturn, are giant planets primarily composed of hydrogen and helium and are the most massive planets in the Solar System. Jupiter at 318 Earth masses, is the largest planet in the Solar System, and Saturn is one third as massive, at 95 Earth masses.
 - **Ice giants,** Uranus and Neptune, are primarily composed of low-boiling-point materials such as water, methane, and ammonia, with thick atmospheres of hydrogen and helium. They have a significantly lower mass than the gas giants (only 14 and 17 Earth masses).

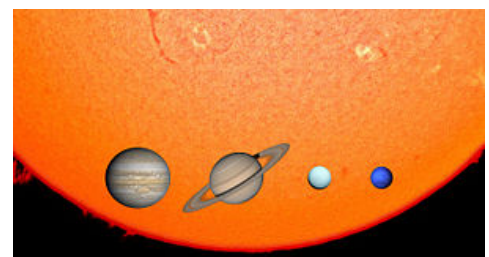
Solar System – sizes but not distances are to scale



The Sun and the eight planets of the Solar System



The inner planets, Mercury, Venus, Earth, and Mars



The four giant planets Jupiter, Saturn, Uranus, and Neptune against the Sun and some sunspots

Planetary attributes

	Name	Equatorial diameter ^[h]	Mass ^[h]	Semi-major axis (AU)	Orbital period (years) ^[h]	Inclination to Sun's equator (°)	Orbital eccentricity	Rotation period (days)	Confirmed moons ^[i]	Axial tilt (°)	Rings	Atmosphere
1.	<u>Mercury</u>	0.382	0.06	0.39	0.24	3.38	0.206	58.64	0	0.04	no	minimal
2.	<u>Venus</u>	0.949	0.82	0.72	0.62	3.86	0.007	−243.02	0	177.36	no	CO ₂ , N ₂
3.	<u>Earth</u> ^(a)	1.00	1.00	1.00	1.00	7.25	0.017	1.00	<u>1</u>	23.44	no	N ₂ , O ₂ , Ar
4.	<u>Mars</u>	0.532	0.11	1.52	1.88	5.65	0.093	1.03	<u>2</u>	25.19	no	CO ₂ , N ₂ , Ar
5.	<u>Jupiter</u>	11.209	317.8	5.20	11.86	6.09	0.048	0.41	<u>69</u>	3.13	yes	H ₂ , He
6.	<u>Saturn</u>	9.449	95.2	9.54	29.46	5.51	0.054	0.43	<u>62</u>	26.73	yes	H ₂ , He
7.	<u>Uranus</u>	4.007	14.6	19.22	84.01	6.48	0.047	−0.72	<u>27</u>	97.77	yes	H ₂ , He, CH ₄
8.	<u>Neptune</u>	3.883	17.2	30.06	164.8	6.43	0.009	0.67	<u>14</u>	28.32	yes	H ₂ , He, CH ₄

Color legend: terrestrial planets gas giants ice giants (both are giant planets). ^(a) Find absolute values in article Earth

Exoplanets

An exoplanet (extrasolar planet) is a planet outside the Solar System. As of 1 April 2018, there are 3,758 confirmed planets in 2,808 systems, with 627 systems having more than oneplanet.^{[94][95][96][97]}

In early 1992, radio astronomers Aleksander Wolszczan and Dale Frail announced the discovery of two planets orbiting the pulsar PSR 1257+12.^[43] This discovery was confirmed, and is generally considered to be the first definitive detection of exoplanets. These pulsar planets are believed to have formed from the unusual remnants of the supernova that produced the pulsar, in a second round of planet formation, or else to be the remaining rocky cores of giant planets that survived the supernova and then decayed into their current orbits.

The first confirmed discovery of an extrasolar planet orbiting an ordinary main-sequence star occurred on 6 October 1995, when Michel Mayor and Didier Queloz of the University of Geneva announced the detection of an exoplanet around 51 Pegasi. From then until the Kepler mission most known extrasolar planets were gas giants comparable in mass to Jupiter or larger as they were more easily detected. The catalog of Kepler candidate planets consists mostly of planets the size of Neptune and smaller, down to smaller than Mercury

There are types of planets that do not exist in the Solar System: super-Earths and mini-Neptunes, which could be rocky like Earth or a mixture of volatiles and gas like Neptune—a radius of 1.75 times that of Earth is a possible dividing line between the two types of planet.^[98] There are hot Jupiters that orbit very close to their star and may evaporate to become chthonian planets, which are the leftover cores. Another possible type of planet is carbon planets, which form in systems with a higher proportion of carbon than in the Solar System.

A 2012 study, analyzing gravitational microlensingdata, estimates an average of at least 1.6 bound planets for every star in the Milky Way.^[10]

On December 20, 2011, the Kepler Space Telescope team reported the discovery of the first Earth-size exoplanets, Kepler-20e^[5] and Kepler-20f,^[6] orbiting a Sun-like star, Kepler-20.^{[7][8][9]}

Around 1 in 5 Sun-like^[b] stars have an "Earth-sized"^[c] planet in the habitable^[d] zone, so the nearest would be expected to be within 12 light-years distance from Earth.^{[99][100]} The frequency of occurrence of such terrestrial planets is one of the variables in the Drake equation, which estimates the number ofintelligent, communicating civilizationsthat exist in the Milky Way.^[101]

There are exoplanets that are much closer to their parent star than any planet in the Solar System is to the Sun, and there are also exoplanets that are much farther from their star. Mercury, the closest planet to the Sun at 0.4 AU, takes 88 days for an orbit, but the shortest known orbits for exoplanets take only a few hours, e.g. Kepler-70b. The Kepler-11 system has five of its planets in shorter orbits than Mercury's, all of them much more massive than Mercury. Neptune is 30 AU from the Sun and takes 165 years to orbit, but there are exoplanets that are hundreds oAU from their star and take more than a thousand years to orbit, e.g.RXJ1609 b

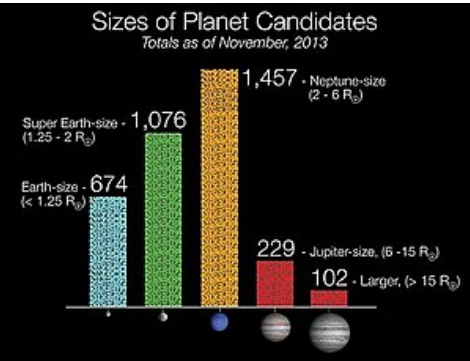
The next few space telescopes to study exoplanets are expected to be Gaia launched in December 2013, CHEOPS in 2018, TESS in 2018, and the James Webb Space Telescope in 2019.

Planetary-mass objects

A **planetary-mass object** (**PMO**), **planemo**,^[103] or **planetary body** is a celestial object with a mass that falls within the range of the definition of a planet: massive enough to achieve hydrostatic equilibrium (to be rounded under its own gravity), but not enough to sustain core fusion like a star.^{[104][105]} By definition, all planets are *planetary-mass objects* but the purpose of this term is to refer to objects that do not conform to typical expectations for a planet. These include dwarf planets, which are



Exoplanets, by year of discovery through September 2014.



Sizes of *Kepler* Planet Candidates – based on 2,740 candidates orbiting 2,036 stars as of 4 November 2013 (NASA).

rounded by their own gravity but not massive enough to clear their own orbit, the larger moons, and free-floating planemos, which may have been ejected from a system (rogue planets) or formed through cloud-collapse rather than accretion (sometimes called sub-brown dwarfs).

Rogue planets

Several computer simulations of stellar and planetary system formation have suggested that some objects of planetary mass would be ejected into interstellar space.^[106] Some scientists have argued that such objects found roaming in deep space should be classed as "planets", although others have suggested that they should be called low-mass brown dwarfs.^{[107][108]}

Sub-brown dwarfs

Stars form via the gravitational collapse of gas clouds, but smaller objects can also form via cloud-collapse. Planetary-mass objects formed this way are sometimes called sub-brown dwarfs. Sub-brown dwarfs may be free-floating such as Cha 110913-773444^[107] and OTS 44,^[109] or orbiting a larger object such as 2MASS J04414489+2301513

Binary systems of sub-brown dwarfs are theoretically possible; Oph 162225-240515 was initially thought to be a binary system of a brown dwarf of 14 Jupiter masses and a sub-brown dwarf of 7 Jupiter masses, but further observations revised the estimated masses upwards to greater than 13 Jupiter masses, making them brown dwarfs according to the IAU working definitions.^{[110][111][112]}

Former stars

In close binary star systems one of the stars can lose mass to a heavier companion. Accretion-powered pulsars may drive mass loss. The shrinking star can then become a planetary-mass object. An example is a Jupiter-mass object orbiting the pulsar PSR J1719-1438^[113]. These shrunken white dwarfs may become a helium planet or carbon planet.

Satellite planets and belt planets

Some large satellites are of similar size or larger than the planet Mercury, e.g. Jupiter's Galilean moons and Titan. Alan Stern has argued that location should not matter and that only geophysical attributes should be taken into account in the definition of a planet, and proposes the term *satellite planet* for a planet-sized satellite. Likewise, dwarf planets in the asteroid belt and Kuiper belt should be considered planets according to Stern.^[70]

Captured planets

Free-floating planets in stellar clusters have similar velocities to the stars and so can be recaptured. They are typically captured into wide orbits between 100 and 10^5 AU. The capture efficiency decreases with increasing cluster volume, and for a given cluster size it increases with the host/primary mass. It is almost independent of the planetary mass. Single and multiple planets could be captured into arbitrary unaligned orbits, non-coplanar with each other or with the stellar host spin, or pre-existing planetary system.^[114]

Attributes

Although each planet has unique physical characteristics, a number of broad commonalities do exist among them. Some of these characteristics, such as rings or natural satellites, have only as yet been observed in planets in the Solar System, whereas others are also commonly observed in extrasolar planets.

Dynamic characteristics

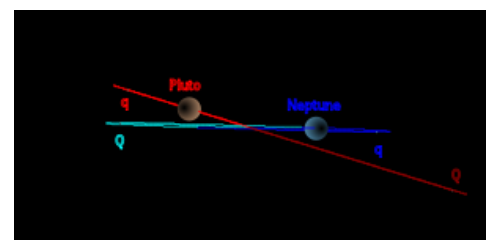
Orbit

According to current definitions, all planets must revolve around stars; thus, any potential "rogue planets" are excluded. In the Solar System, all the planets orbit the Sun in the same direction as the Sun rotates (counter-clockwise as seen from above the Sun's north pole). At least one extrasolar planet, WASP-17b, has been found to orbit in the opposite direction to its star's rotation.^[115] The period of one revolution of a planet's orbit is known as its sidereal period or year.^[116] A planet's year depends on its distance from its star; the farther a planet is from its star, not only the longer the distance it must travel, but also the slower its speed, because it is less affected by its star's gravity. No planet's orbit is perfectly circular, and hence the distance of each varies over the course of its year. The closest approach to its star is called its periastron (perihelion in the Solar System), whereas its farthest separation from the star is called its apastron (aphelion). As a planet approaches periastron, its speed increases as it trades gravitational potential energy for kinetic energy, just as a falling object on Earth accelerates as it falls; as the planet reaches apastron, its speed decreases, just as an object thrown upwards on Earth slows down as it reaches the apex of its trajectory.^[117]

Each planet's orbit is delineated by a set of elements:



Artist's impression of a super-Jupiter around the brown dwarf 2M1207.^[102]



The orbit of the planet Neptune compared to that of Pluto. Note the elongation of Pluto's orbit in relation to Neptune's (eccentricity), as well as its large angle to the ecliptic (inclination).

- The eccentricity of an orbit describes how elongated a planet's orbit is. Planets with low eccentricities have more circular orbits, whereas planets with high eccentricities have more elliptical orbits. The planets in the Solar System have very low eccentricities, and thus nearly circular orbits.^[116] Comets and Kuiper belt objects (as well as several extrasolar planets) have very high eccentricities, and thus exceedingly elliptical orbits.^[118]^[119]
- The semi-major axis is the distance from a planet to the half-way point along the longest diameter of its elliptical orbit (see image). This distance is not the same as its apastron, because no planet's orbit has its star at its exact centre!^[116]
- The inclination of a planet tells how far above or below an established reference plane its orbit lies. In the Solar System, the reference plane is the plane of Earth's orbit, called the ecliptic. For extrasolar planets, the plane, known as the sky plane or plane of the sky, is the plane perpendicular to the observer's line of sight from Earth.^[120] The eight planets of the Solar System all lie very close to the ecliptic; comets and Kuiper belt objects like Pluto are at far more extreme angles to it.^[121] The points at which a planet crosses above and below its reference plane are called its ascending and descending nodes.^[116] The longitude of the ascending node is the angle between the reference plane's 0 longitude and the planet's ascending node. The argument of periapsis (or perihelion in the Solar System) is the angle between a planet's ascending node and its closest approach to its star.^[116]

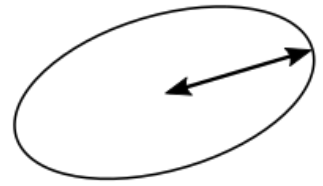
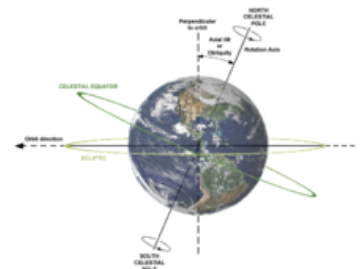


Illustration of the semi-major axis

Axial tilt

Planets also have varying degrees of axial tilt; they lie at an angle to the plane of their stars' equators. This causes the amount of light received by each hemisphere to vary over the course of its year; when the northern hemisphere points away from its star, the southern hemisphere points towards it, and vice versa. Each planet therefore has seasons, changes to the climate over the course of its year. The time at which each hemisphere points farthest or nearest from its star is known as its solstice. Each planet has two in the course of its orbit; when one hemisphere has its summer solstice, when its day is longest, the other has its winter solstice, when its day is shortest. The varying amount of light and heat received by each hemisphere creates annual changes in weather patterns for each half of the planet. Jupiter's axial tilt is very small, so its seasonal variation is minimal; Uranus, on the other hand, has an axial tilt so extreme it is virtually on its side, which means that its hemispheres are either perpetually in sunlight or perpetually in darkness around the time of its solstices.^[122] Among extrasolar planets, axial tilts are not known for certain, though most hot Jupiters are believed to have negligible to no axial tilt as a result of their proximity to their stars.^[123]



Earth's axial tilt is about 23.4°. It oscillates between 22.1° and 24.5° on a 41,000-year cycle and is currently decreasing.

Rotation

The planets rotate around invisible axes through their centres. A planet's rotation period is known as a stellar day. Most of the planets in the Solar System rotate in the same direction as they orbit the Sun, which is counter-clockwise as seen from above the Sun's north pole, the exceptions being Venus^[124] and Uranus,^[125] which rotate clockwise, though Uranus's extreme axial tilt means there are differing conventions on which of its poles is "north", and therefore whether it is rotating clockwise or anti-clockwise.^[126] Regardless of which convention is used, Uranus has retrograde rotation relative to its orbit.

The rotation of a planet can be induced by several factors during formation. A net angular momentum can be induced by the individual angular momentum contributions of accreted objects. The accretion of gas by the giant planets can also contribute to the angular momentum. Finally, during the last stages of planet building, a stochastic process of protoplanetary accretion can randomly alter the spin axis of the planet.^[127] There is great variation in the length of day between the planets, with Venus taking 243 days to rotate, and the giant planets only a few hours.^[128] The rotational periods of extrasolar planets are not known. However, for "hot" Jupiters, their proximity to their stars means that they are tidally locked (i.e., their orbits are in sync with their rotations). This means, they always show one face to their stars, with one side in perpetual day, the other in perpetual night.^[129]

Orbital clearing

The defining dynamic characteristic of a planet is that it has cleared its neighborhood. A planet that has cleared its neighborhood has accumulated enough mass to gather up or sweep away all the planetesimals in its orbit. In effect, it orbits its star in isolation, as opposed to sharing its orbit with a multitude of similar-sized objects. This characteristic was mandated as part of the IAU's official definition of a planet in August, 2006. This criterion excludes such planetary bodies as Pluto, Eris and Ceres from full-fledged planethood, making them instead dwarf planets.^[1] Although to date this criterion only applies to the Solar System, a number of young extrasolar systems have been found in which evidence suggests orbital clearing is taking place within their circumstellar discs.^[130]

Physical characteristics

Mass

A planet's defining physical characteristic is that it is massive enough for the force of its own gravity to dominate over the electromagnetic forces binding its physical structure, leading to a state of hydrostatic equilibrium. This effectively means that all planets are spherical or spheroidal. Up to a certain mass, an object can be irregular in shape, but beyond that point, which varies depending on the chemical makeup of the object, gravity begins to pull an object towards its own centre of mass until the object collapses into a sphere.^[131]

Mass is also the prime attribute by which planets are distinguished from stars. The upper mass limit for planethood is roughly 13 times Jupiter's mass for objects with solar type isotopic abundance, beyond which it achieves conditions suitable for nuclear fusion. Other than the Sun, no objects of such mass exist in the Solar System; but there are exoplanets of this size. The 13-Jupiter-mass limit is not universally agreed upon and the Extrasolar Planets Encyclopaedia includes objects up to 20 Jupiter masses,^[132] and the Exoplanet Data Explorer up to 24 Jupiter masses.^[133]

The smallest known planet is PSR B1257+12A, one of the first extrasolar planets discovered, which was found in 1992 in orbit around a pulsar. Its mass is roughly half that of the planet Mercury.^[4] The smallest known planet orbiting a main-sequence star other than the Sun is Kepler-37b, with a mass (and radius) slightly higher than that of the Moon.

Internal differentiation

Every planet began its existence in an entirely fluid state; in early formation, the denser heavier materials sank to the centre, leaving the lighter materials near the surface. Each therefore has a differentiated interior consisting of a dense planetary core surrounded by a mantle that either is or was a fluid. The terrestrial planets are sealed within hard crusts,^[134] but in the giant planets the mantle simply blends into the upper cloud layers. The terrestrial planets have cores of elements such as iron and nickel, and mantles of silicates. Jupiter and Saturn are believed to have cores of rock and metal surrounded by mantles of metallic hydrogen.^[135] Uranus and Neptune, which are smaller, have rocky cores surrounded by mantles of water, ammonia, methane and other ices.^[136] The fluid action within these planets' cores creates a geodynamo that generates a magnetic field.^[134]

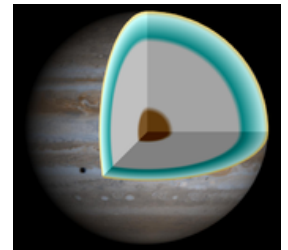


Illustration of the interior of Jupiter, with a rocky core overlaid by a deep layer of metallic hydrogen

Atmosphere



Earth's atmosphere

All of the Solar System planets except Mercury^[137] have substantial atmospheres because their gravity is strong enough to keep gases close to the surface. The larger giant planets are massive enough to keep large amounts of the light gases hydrogen and helium, whereas the smaller planets lose these gases into space.^[138] The composition of Earth's atmosphere is different from the other planets because the various life processes that have transpired on the planet have introduced free molecular oxygen.^[139]

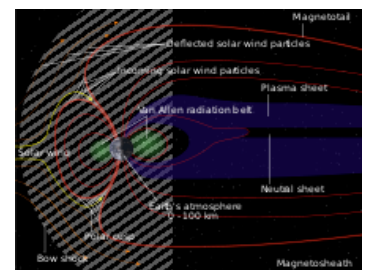
Planetary atmospheres are affected by the varying insolation or internal energy, leading to the formation of dynamic weather systems such as hurricanes, (on Earth), planet-wide dust storms (on Mars), a greater-than-Earth-sized anticyclone on Jupiter (called the Great Red Spot), and holes in the atmosphere (on Neptune).^[122] At least one extrasolar planet, HD 189733 b, has been claimed to have such a weather system, similar to the Great Red Spot but twice as large.^[140]

Hot Jupiters, due to their extreme proximities to their host stars, have been shown to be losing their atmospheres into space due to stellar radiation, much like the tails of comets.^{[141][142]} These planets may have vast differences in temperature between their day and night sides that produce supersonic winds,^[143] although the day and night sides of HD 189733 b appear to have very similar temperatures, indicating that that planet's atmosphere effectively redistributes the star's energy around the planet.^[140]

Magnetosphere

One important characteristic of the planets is their intrinsic magnetic moments which in turn give rise to magnetospheres. The presence of a magnetic field indicates that the planet is still geologically alive. In other words, magnetized planets have flows of electrically conducting material in their interiors, which generate their magnetic fields. These fields significantly change the interaction of the planet and solar wind. A magnetized planet creates a cavity in the solar wind around itself called the magnetosphere, which the wind cannot penetrate. The magnetosphere can be much larger than the planet itself. In contrast, non-magnetized planets have only small magnetospheres induced by interaction of the ionosphere with the solar wind, which cannot effectively protect the planet.^[144]

Of the eight planets in the Solar System, only Venus and Mars lack such a magnetic field.^[144] In addition, the moon of Jupiter Ganymede also has one. Of the magnetized planets the magnetic field of Mercury is the weakest, and is barely able to deflect the solar wind. Ganymede's magnetic field is several times larger, and Jupiter's is the strongest in the Solar System (so strong in fact that it poses a serious health risk to future manned missions to its moons). The magnetic fields of the other giant planets are roughly similar in strength to that of Earth, but their magnetic moments are significantly larger. The magnetic fields of Uranus and Neptune are strongly tilted relative the rotational axis and displaced from the centre of the planet.^[144]



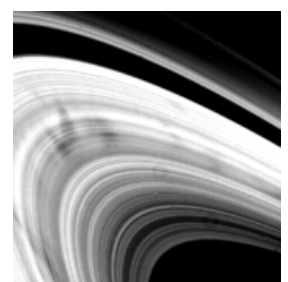
Earth's magnetosphere (diagram)

In 2004, a team of astronomers in Hawaii observed an extrasolar planet around the star HD 179949, which appeared to be creating a sunspot on the surface of its parent star. The team hypothesized that the planet's magnetosphere was transferring energy onto the star's surface, increasing its already high 7,760 °C temperature by an additional 400 °C.^[145]

Secondary characteristics

Several planets or dwarf planets in the Solar System (such as Neptune and Pluto) have orbital periods that are in resonance with each other or with smaller bodies (this is also common in satellite systems). All except Mercury and Venus have natural satellites, often called "moons". Earth has one, Mars has two, and the giant planets have numerous moons in complex planetary-type systems. Many moons of the giant planets have features similar to those on the terrestrial planets and dwarf planets, and some have been studied as possible abodes of life (especially Europa).^{[146][147][148]}

The four giant planets are also orbited by planetary rings of varying size and complexity. The rings are composed primarily of dust or particulate matter, but can host tiny 'moonlets' whose gravity shapes and maintains their structure. Although the origins of planetary rings is not precisely known, they are believed to be the result of natural satellites that fell below their parent planet's Roche limit and were torn apart by tidal forces.^{[149][150]}



The rings of Saturn

No secondary characteristics have been observed around extrasolar planets. The sub-brown dwarf [Cha 110913-773444](#), which has been described as a [rogue planet](#), is believed to be orbited by a tiny [protoplanetary disc](#)^[107] and the sub-brown dwarf [OTS 44](#) was shown to be surrounded by a substantial protoplanetary disk of at least 10 Earth masses.^[109]

See also

- [Double planet](#)– Two planetary mass objects orbiting each other
- [List of exoplanets](#)
- [List of hypothetical Solar System objects](#)
- [List of landings on extraterrestrial bodies](#)
- [Lists of planets](#)– A list of lists of planets sorted by diverse attributes
- [Mesoplanet](#)– A celestial body smaller than Mercury but larger than Ceres
- [Minor planet](#)– A celestial body smaller than a planet
- [Planetary habitability](#)– The measure of a planet's ability to sustain life
- [Planetary mnemonic](#)– A phrase used to remember the names of the planets
- [Planetary science](#)– The scientific study of planets
- [Planets in astrology](#)
- [Planets in science fiction](#)
- [Theoretical planetology](#)

Notes

- This [definition](#) is drawn from two separate [IAU](#) declarations; a formal definition agreed by the IAU in 2006, and an informal working definition established by the IAU in 2001/2003 for objects outside of the Solar System. The [fñcial 2006 definition](#) applies only to the Solar System, whereas the 2003 definition applies to planets around other stars. The extrasolar planet issue was deemed too complex to resolve at the 2006 IAU conference.
- For the purpose of this 1 in 5 statistic, "Sun-like" means [G-type star](#). Data for Sun-like stars wasn't available so this statistic is an extrapolation from data about [K-type stars](#)
- For the purpose of this 1 in 5 statistic, Earth-sized means 1–2 Earth radii
- For the purpose of this 1 in 5 statistic, "habitable zone" means the region with 0.25 to 4 times Earth's stellar flux (corresponding to 0.5–2 AU for the Sun).
- Referred to by Huygens as *aPlanetes novus* ("new planet") in his *Systema Saturnium* (<http://www.sil.si.edu/DigitalCollections/HST/Huygens/huygens-t-ext.htm>)
- Both labelled *nouvelles planètes* (new planets) by Cassini in his *Découverte de deux nouvelles planetes autour de Saturne*^[66]
- Both once referred to as "planets" by Cassini in his *An Extract of the Journal Des Scavans...* (<https://www.jstor.org/stable/101844>) The term "satellite" had already begun to be used to distinguish such bodies from those around which they orbited ("primary planets").
- Measured relative to Earth.
- Jupiter has the most verified satellites (69) in the Solar System.^[93]

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