



Asteroids

Asteroids, sometimes called minor planets, are rocky remnants left over from the early formation of the solar system about 4.6 billion years ago. Most of this ancient space rubble can be found orbiting the Sun between Mars and Jupiter within the main asteroid belt. Asteroids range in size from Ceres — the largest at about 950 kilometers (590 miles) in diameter and also identified as a dwarf planet — to bodies that are less than 1 kilometer (0.6 mile) across. The total mass of all the asteroids combined is less than that of Earth's Moon.

Most asteroids are irregularly shaped, though a few are nearly spherical, and they are often pitted or cratered. As they revolve around the Sun in elliptical orbits, the asteroids also rotate, sometimes quite erratically, tumbling as they go. More than 150 asteroids are known to have a small companion moon (some have two moons). There are also binary (double) asteroids, in which two rocky bodies of roughly equal size orbit each other, as well as triple asteroid systems.

The three broad composition classes of asteroids are C-, S-, and M-types. The C-type (chondrite) asteroids are most common, probably consist of clay and silicate rocks, and are dark in appearance. They are among the most ancient objects in the solar system. The S-types ("stony") are made up of silicate materials and nickel-iron. The M-types are metallic (nickel-iron). The asteroids' compositional differences are related to how far from the Sun they formed. Some experienced high temperatures after they formed and partly melted, with iron sinking to the center and forcing basaltic (volcanic) lava to the surface. Only one such asteroid, Vesta, survives to this day.

Jupiter's massive gravity and occasional close encounters with Mars or another object change the asteroids' orbits, knocking them out of the main belt and hurling them into space in all directions across the orbits of the other planets. Stray asteroids and asteroid fragments slammed into Earth and the other planets in the past, playing a major role in altering the geological history of the planets and in the evolution of life on Earth.

Scientists continuously monitor Earth-crossing asteroids, whose paths intersect Earth's orbit, and near-Earth asteroids that approach Earth's orbital distance to within about 45 million kilometers (28 million miles) and may pose an impact danger. Radar is a valuable tool in detecting and monitoring potential impact hazards. By reflecting transmitted signals off objects, images and other information can be derived from the echoes. Scientists can learn a great deal about an asteroid's orbit, rotation, size, shape, and metal concentration.

Several missions have flown by and observed asteroids. The Galileo spacecraft flew by asteroids Gaspra in 1991 and Ida in 1993; the Near-Earth Asteroid Rendezvous (NEAR) mission studied asteroids Mathilde and Eros; and the Rosetta mission encountered Steins in 2008 and Lutetia in 2010.

In 2005, the Japanese spacecraft Hayabusa landed on the near-Earth asteroid Itokawa and attempted to collect samples. On June 3, 2010, Hayabusa successfully returned to Earth a small amount of asteroid dust now being studied by scientists.

NASA's Dawn spacecraft, launched in 2007, orbited and explored asteroid Vesta for over a year. Once it left in September 2012, it headed towards dwarf planet Ceres, with a planned arrival of 2015. Vesta and Ceres are two of the largest surviving protoplanet bodies that almost became planets. By studying them with the same complement of instruments on board the same spacecraft, scientists will be able to compare and contrast the different evolutionary paths each object took to help understand the early solar system overall.

### SIGNIFICANT DATES

1801 — Giuseppe Piazzi discovers the first and largest asteroid, Ceres, orbiting between Mars and Jupiter.

1898 — Gustav Witt discovers Eros, one of the largest near-Earth asteroids.

1991–1994 — The Galileo spacecraft takes the first close-up images of an asteroid (Gaspra) and discovers the first moon (later named Dactyl) orbiting an asteroid (Ida).

1997–2000 — The NEAR spacecraft flies by Mathilde and orbits and lands on Eros.

1998 — NASA establishes the Near-Earth Object Program Office to detect, track, and characterize potentially hazardous asteroids and comets that could approach Earth.

### ASTEROID CLASSIFICATIONS

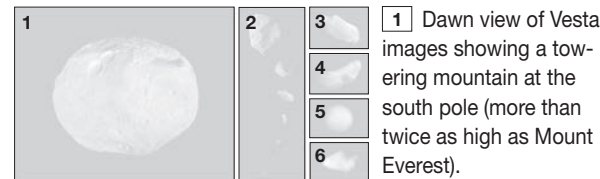
Main asteroid belt — The majority of known asteroids orbit within the asteroid belt between Mars and Jupiter, generally with not very elongated orbits. The belt is estimated to contain between 1.1 and 1.9 million asteroids larger than 1 kilometer (0.6 mile) in diameter, and millions of smaller ones. Early in the history of the solar system, the gravity of newly formed Jupiter brought an end to the formation of planetary bodies in this region and caused the small bodies to collide with one another, fragmenting them into the asteroids we observe today.

Trojans — These asteroids share an orbit with a larger planet, but do not collide with it because they gather around two special places in the orbit (called the L4 and L5 Lagrangian points). There, the gravitational pull from the Sun and the planet are balanced by a trojan's tendency to otherwise fly out of the orbit. The Jupiter trojans form the most significant population of trojan asteroids. It is thought that they are as numerous as the asteroids in the asteroid belt. There are Mars and Neptune trojans, and NASA announced the discovery of an Earth trojan in 2011.

Near-Earth asteroids — These objects have orbits that pass close by that of Earth. Asteroids that actually cross Earth's orbital path are known as Earth-crossers. As of June 19, 2013, 10,003 near-Earth asteroids are known and the number over 1 kilometer in diameter is thought to be 861, with 1,409 classified as potentially hazardous asteroids — those that could pose a threat to Earth.

2006 — Ceres attains a new classification, "dwarf planet," but retains its distinction as the largest known asteroid.  
2008 — The European spacecraft Rosetta, on its way to study a comet in 2014, flies by and photographs asteroid Steins, a rare type of asteroid composed of silicates and basalts.  
2010 — Rosetta flies by asteroid Lutetia, revealing a primitive survivor from the violent birth of our solar system.  
2011–2012 — Dawn studies Vesta. Dawn is the first spacecraft to orbit a main-belt asteroid and continues on to dwarf planet Ceres in 2015.

### ABOUT THE IMAGES



**1** Dawn view of Vesta images showing a towering mountain at the south pole (more than twice as high as Mount Everest).

**2** Asteroids compared to Vesta. From the top: Lutetia, Mathilde, Ida and moon Dactyl, Eros, Gaspra, Steins, and Itokawa (circled).

**3** A Galileo image of asteroid Ida and its moon Dactyl.

**4** NEAR gravity map of near-Earth asteroid Eros used to determine its shape and density.

**5** The Hubble Space Telescope provides our best view of dwarf planet Ceres until Dawn arrives there in 2015.

**6** Asteroid Annfrank was seen as an irregularly shaped, cratered body by NASA's Stardust spacecraft in 2002.

### FOR MORE INFORMATION

[solarsystem.nasa.gov/asteroids](http://solarsystem.nasa.gov/asteroids)