

Section 28.4

Objectives

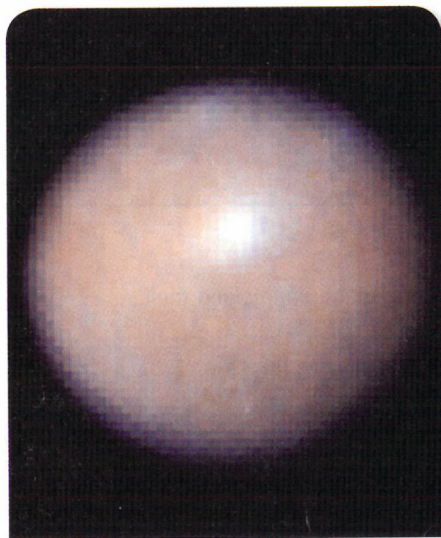
- ▶ **Distinguish** between planets and dwarf planets.
- ▶ **Identify** the oldest members of the solar system.
- ▶ **Describe** meteoroids, meteors, and meteorites.
- ▶ **Determine** the structure and behavior of comets.

Review Vocabulary

smog: air polluted with hydrocarbons and nitrogen oxides

New Vocabulary

dwarf planet
meteoroid
meteor
meteorite
Kuiper belt
comet
meteor shower



■ **Figure 28.26** Imaged from the *Hubble Space Telescope*, the newly described dwarf planet, Ceres, is the largest body in the asteroid belt.

Other Solar System Objects

MAIN Idea Rocks, dust, and ice compose the remaining 2 percent of the solar system.

Real-World Reading Link The radio might have been your favorite source of music until digital music players became available. Similarly, improvements in technology lead to a change in Pluto's rank as a planet when astronomers discovered many more objects that had similar characteristics to Pluto.

Dwarf Planets

In the early 2000s, astronomers began to detect large objects in the region of the planet Pluto, about 40 AU from the Sun, called the Kuiper belt. Then in 2003, one object, now known as Eris, was discovered that appeared to be the same size, or larger, than Pluto. At this time, the scientific community began to take a closer look at the planetary status of Pluto and other solar system objects.

Ceres In 1801, Giuseppe Piazzi discovered a large object in orbit between Mars and Jupiter. Scientists had predicted that there was a planet somewhere in that region, and it seemed that this discovery was it. However, Ceres, shown in **Figure 28.26**, was extremely small for a planet. In the following century, hundreds—now hundreds of thousands—of other objects were discovered in the same region. Therefore, Ceres was no longer thought of as a planet, but as the largest of the asteroids in what would be called the asteroid belt.

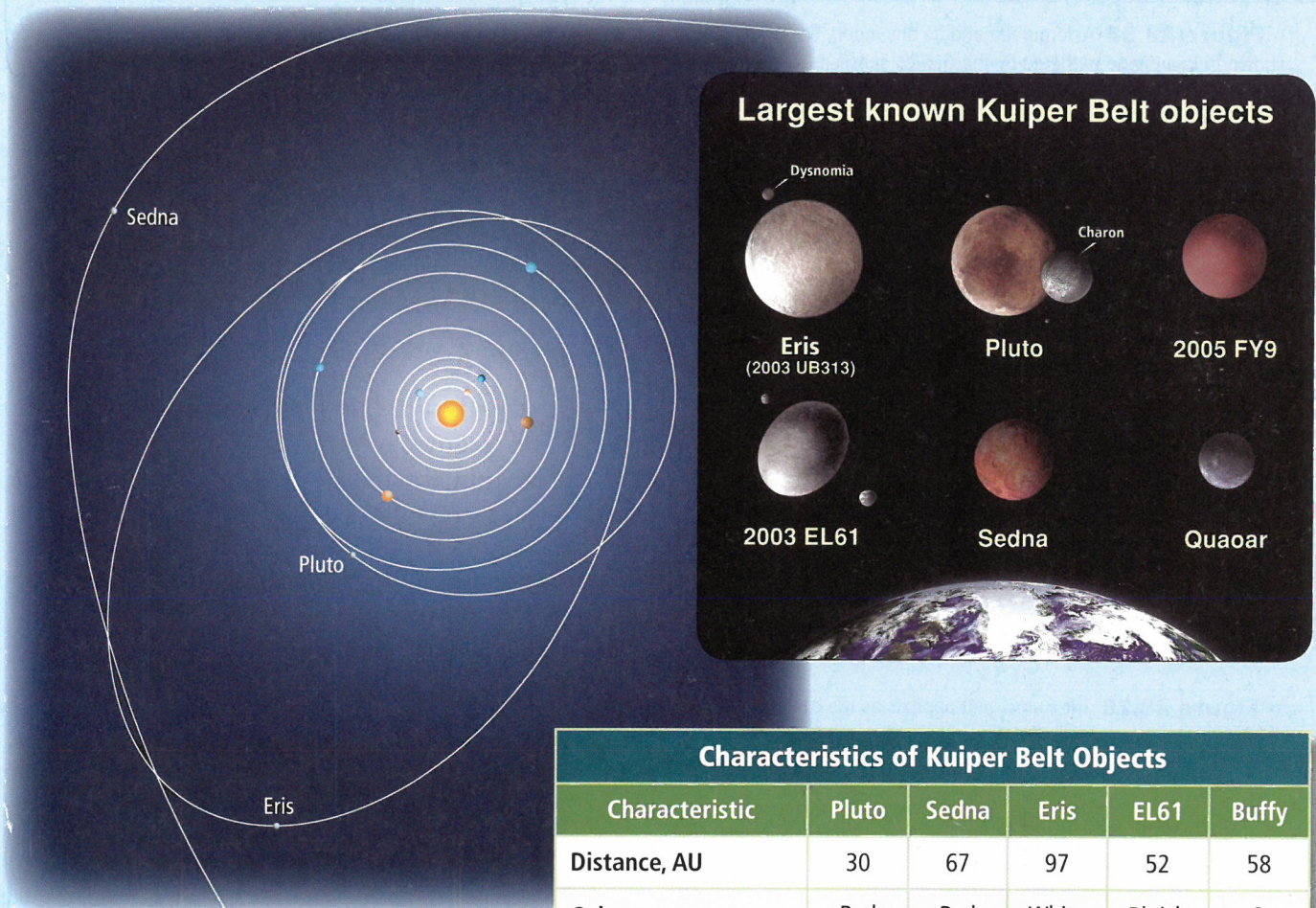
Pluto Since its discovery by Clyde Tombaugh in 1930, Pluto has been an unusual planet. It is not a terrestrial or gas planet; it is made of rock and ice. It does not have a circular orbit; its orbit is long, elliptical, and overlaps the orbit of Neptune. And it is smaller than Earth's Moon. It is one of many similar objects that exist outside of the orbit of Neptune. It has three moons, two of which orbit at widely odd angles from the plane of the ecliptic.

How many others? With the discovery of objects close to and larger than Pluto's size, the International Astronomical Union (IAU) faced a dilemma. Should Eris be named the tenth planet? Or should there be a change in the way these new objects are classified? For now, the answer is change. Pluto, Eris, and Ceres have been placed into a new classification of objects in space called dwarf planets. The IAU has defined a **dwarf planet** as an object that, due to its own gravity, is spherical in shape, orbits the Sun, is not a satellite, and has not cleared the area of its orbit of smaller debris. Currently the IAU has limited this classification to Pluto, Eris, and Ceres, but there are at least 12 other objects whose classifications are undecided, some of which are shown in **Figure 28.27**.

Visualizing the Kuiper Belt

Figure 28.27 Recent findings of objects beyond Pluto, in a vast disk called the Kuiper belt, have forced scientists to rethink what features define a planet.

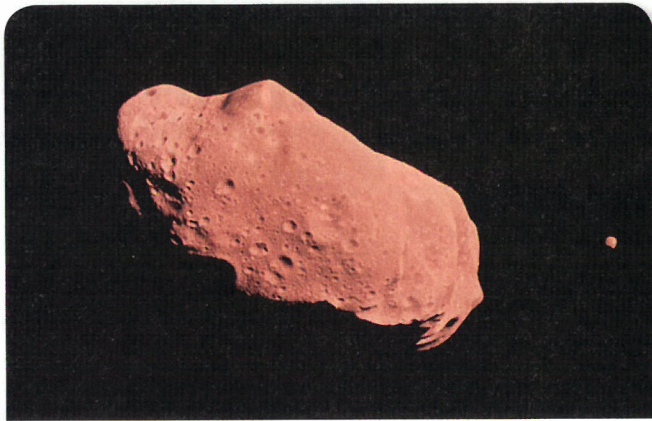
(Note: *Buffy (XR190)* is a nickname used by its discoverer. *EL61* is an official number assigned to an unnamed body.)



Characteristics of Kuiper Belt Objects					
Characteristic	Pluto	Sedna	Eris	EL61	Buffy
Distance, AU	30	67	97	52	58
Color	Red	Red	White	Bluish	?
Relative size	1	0.75	1.05	0.75	3
Moons	3	?	1	2	?
Orbital period, years	248	10,500	560	285	440
Orbital tilt, degrees	17	12	44	28	47
Orbital eccentricity	0.25	0.85	0.43	0.19	0

Concepts in Motion To explore more about the Kuiper belt objects, visit glencoe.com.

Earth Science online



■ **Figure 28.28** Asteroid Ida and its tiny moon, Dactyl, are shown in this image gathered by the *Galileo* spacecraft.

Small Solar System Bodies

Once the IAU defined planets and dwarf planets, they had to identify what was left. In the early 1800s, a name was given to the rocky planetesimals between Mars and Jupiter—the asteroid belt. Objects beyond the orbit of Neptune have been called trans-Neptunian objects (TNOs), Kuiper belt objects (KBOs), comets, and members of the Oort cloud. But what would the collective name for these objects be? The IAU calls them small solar system bodies.

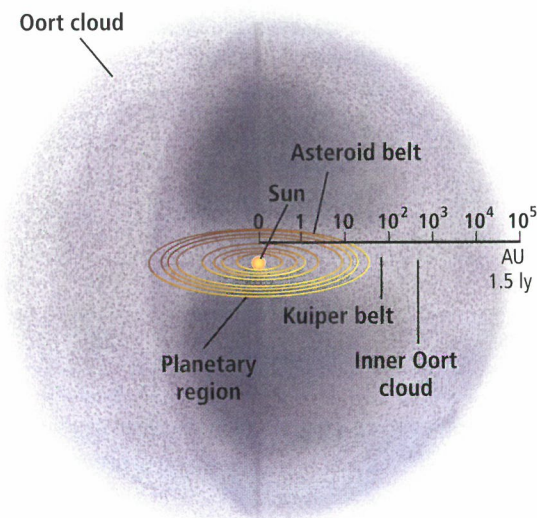
Asteroids There are thousands of asteroids orbiting the Sun between Mars and Jupiter. They are rocky bodies that vary in diameter and have pitted, irregular surfaces. Some asteroids have satellites of their own, such as the asteroid Ida, shown in **Figure 28.28**. Astronomers estimate that the total mass of all the known asteroids in the solar system is equivalent to only about 0.08 percent of Earth’s mass.

✓ **Reading Check Describe** the asteroid belt.

As asteroids orbit, they occasionally collide and break into fragments. When an asteroid fragment, or any other interplanetary material, enters Earth’s atmosphere it is called a **meteoroid**. As a meteoroid passes through the atmosphere, it is heated by friction and burns, producing a streak of light called a **meteor**. If the meteoroid does not burn up completely and part of it strikes the ground, the part that hits the ground is called a **meteorite**. When large meteorites strike Earth, they produce impact craters. Any craters visible on Earth must be young, otherwise they would have been erased by erosion.

Kuiper belt Like the rocky asteroid belt, another group of small solar system bodies that are mostly made of rock and ice lies outside the orbit of Neptune in the **Kuiper** (KI pur) **belt**. Most of these bodies probably formed in this region—30 to 50 AU from the Sun—from the material left over from the formation of the Sun and planets. Some, however, might have formed closer to the Sun and were knocked into this area by Jupiter and the other gas giant planets. Eris, Pluto, Pluto’s moon Charon, and an ever-growing list of objects are being detected within this band; however, none of them has been identified as a comet. Comets come from the farthest limits of the solar system, the Oort cloud, shown in **Figure 28.29**.

■ **Figure 28.29** The Kuiper belt appears as the outermost limit of the planetary disk. The Oort cloud surrounds the Sun, echoing its solar sphere.



The Solar System

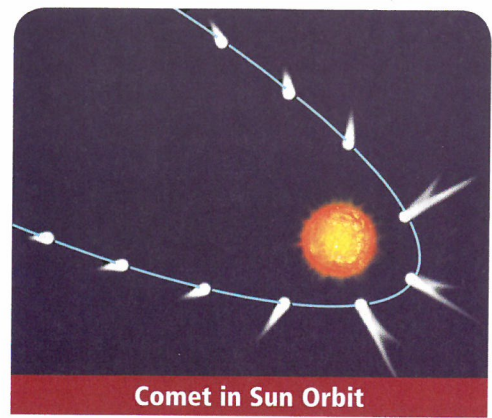
Comets

Comets are small, icy bodies that have highly eccentric orbits around the Sun. Ranging from 1 to 10 km in diameter, most comets orbit in a continuous distribution that extends from the Kuiper belt to 100,000 AU from the Sun. The outermost region is known as the Oort cloud and expands into a sphere surrounding the Sun. Occasionally, a comet is disturbed by the gravity of another object and is thrown into the inner solar system.

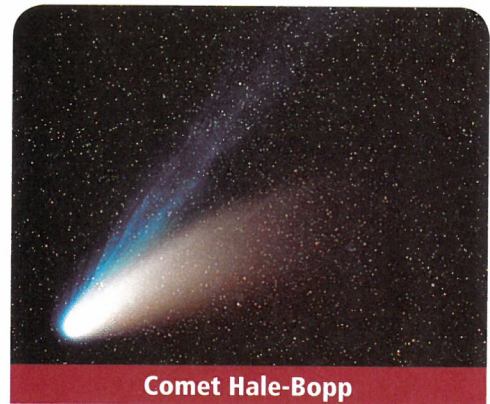
Comet structure When a comet comes within 3 AU of the Sun, it begins to evaporate. It forms a head and one or more tails. The head is surrounded by an envelope of glowing gas, and it has a small solid core. The tails form as gas and dust are pushed away from the comet by particles and radiation from the Sun. This is why comets' tails always point away from the Sun, as shown in

Figure 28.30.

Periodic comets Comets that repeatedly return to the inner solar system are known as periodic comets. One example is Halley's comet, which has a 76-year period—it appeared last in 1985, and is expected to appear again in 2061. Each time a periodic comet comes near the Sun, it loses some of its matter, leaving behind a trail of particles. When Earth crosses the trail of a comet, particles left in the trail burn in Earth's upper atmosphere producing bright streaks of light called a **meteor shower**. In fact, most meteors are caused by dust particles from comets.



Comet in Sun Orbit



Comet Hale-Bopp

■ **Figure 28.30** A comet's tail always points away from the Sun and is driven by a stream of particles and radiation. The comet Hale-Bopp was imaged when its orbit brought it close to the Sun in 1997.

Section 28.4 Assessment

Section Summary

- ▶ Dwarf planets, asteroids, and comets formed from the debris of the solar system formation.
- ▶ Meteoroids are planetesimals that enter Earth's atmosphere.
- ▶ Mostly rock and ice, the Kuiper belt objects are currently being detected and analyzed.
- ▶ Periodic comets are in regular, permanent orbit around the Sun, while others might pass this way only once.
- ▶ The outermost regions of the solar system house the comets in the Oort cloud.

Understand Main Ideas

1. **MAIN Idea** Identify the kinds of small solar system bodies and their compositions.
2. **Compare** planets and dwarf planets.
3. **Distinguish** among meteors, meteoroids, and meteorites.
4. **Explain** why a comet's tail always points away from the Sun.
5. **Compare and contrast** the asteroid belt and the Kuiper belt.

Think Critically

6. **Infer** why comets have highly eccentric orbits.

WRITING in Earth Science

7. Suppose you are traveling from the outer reaches of the solar system toward the Sun. Write a scientifically accurate description of the things you see.