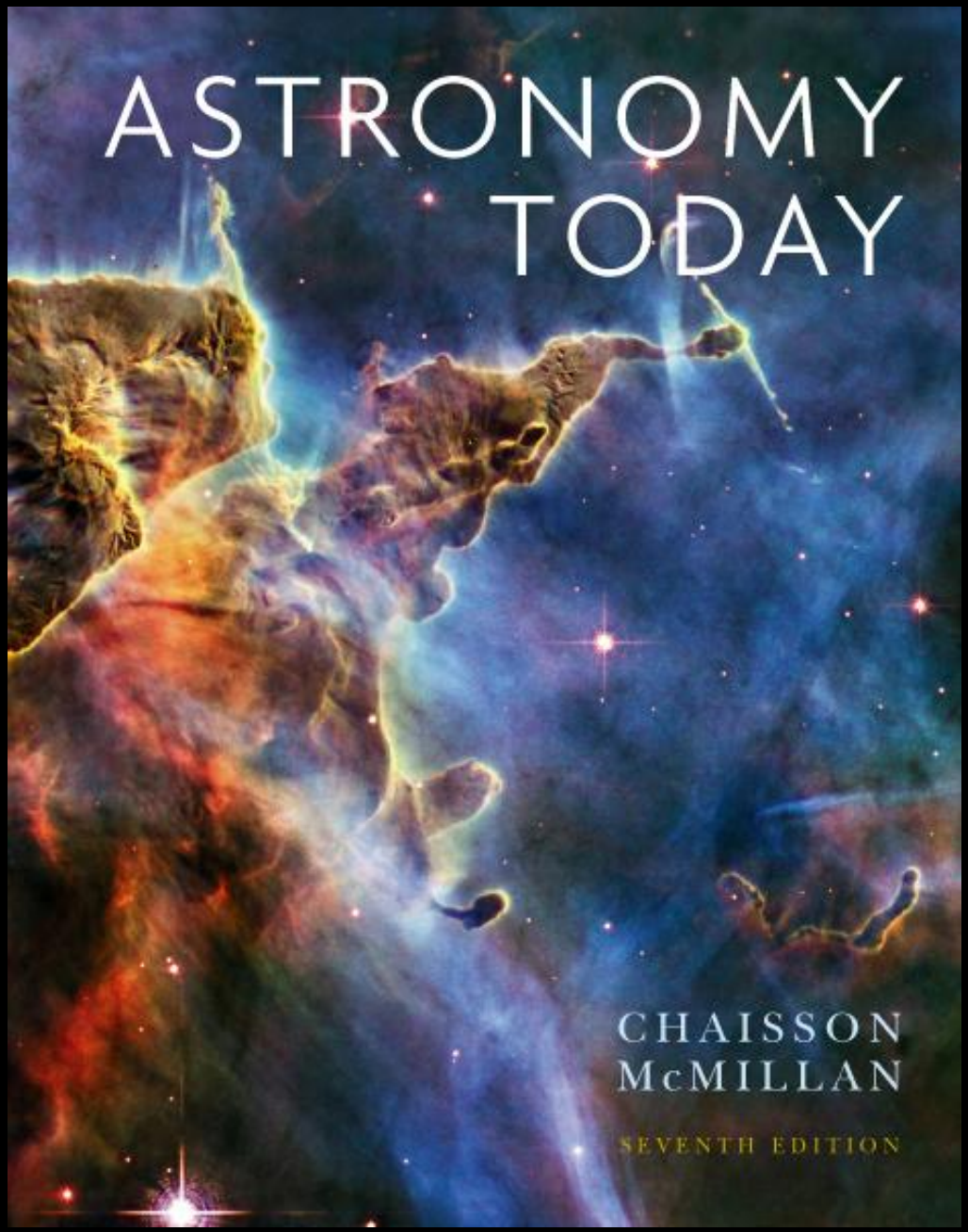


Lecture Outlines

Chapter 14

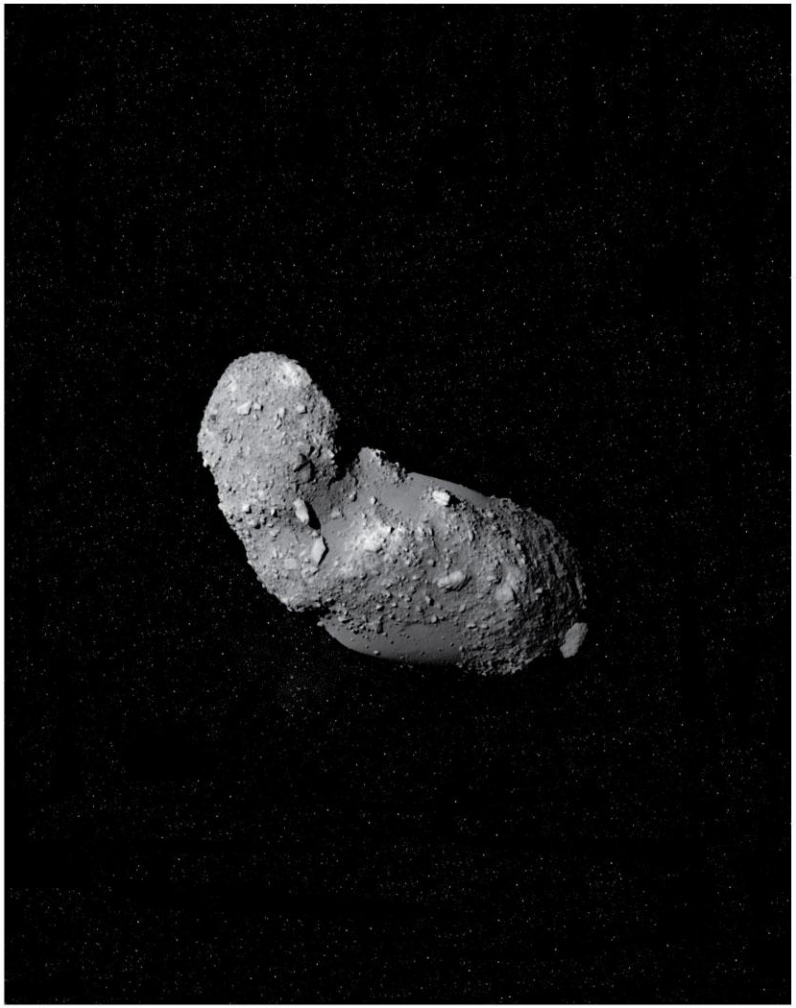
Astronomy Today

7th Edition

Chaisson/McMillan

© 2011 Pearson Education, Inc.

Chapter 14
Solar System Debris



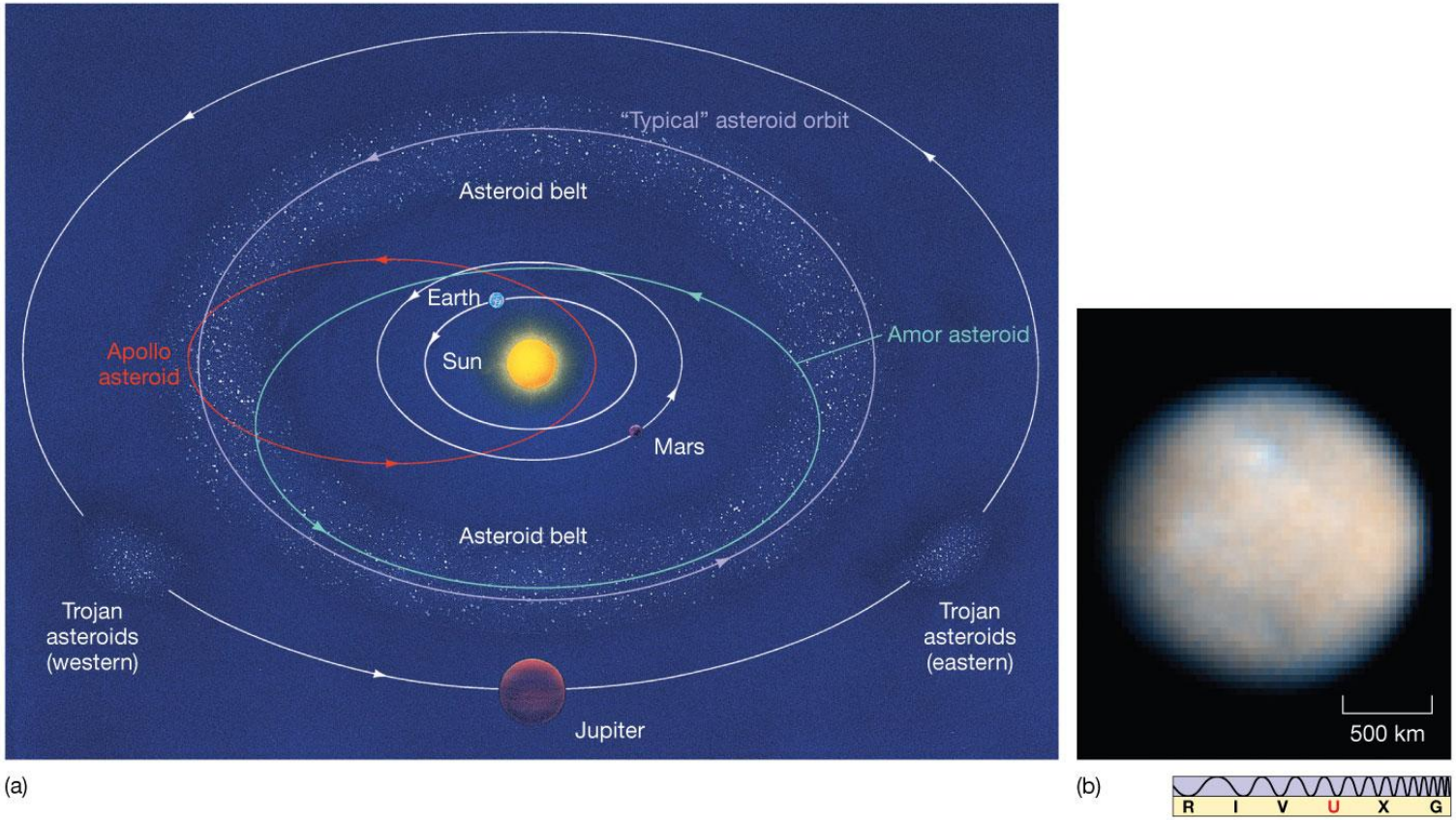
© 2011 Pearson Education, Inc.

Units of Chapter 14

© 2011 Pearson Education, Inc.

14.1 Asteroids

Asteroids are quite small, and most have eccentric orbits in the asteroid belt between Mars and Jupiter. The inset shows Ceres, the largest known asteroid.



© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.1 Asteroids

Asteroids are rocky; over 500,000 have been identified so far

Three largest	Diameter
Ceres	**940 km**
Pallas	**580 km**
Vesta	**540 km**

© 2011 Pearson Education, Inc.

14.1 Asteroids

Vesta shows evidence of volcanism; the reason is not understood

Asteroids are classified in types:

C-type: carbonaceous, dark

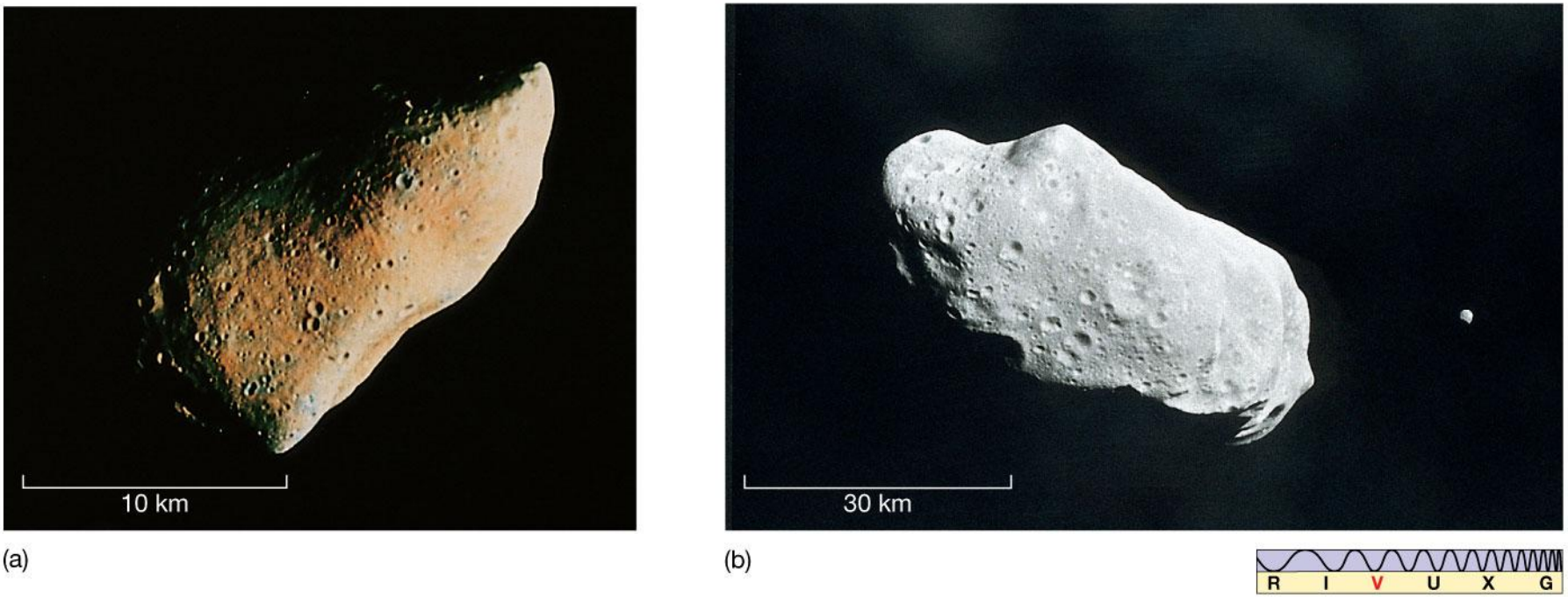
S-type: silicate (rocky)

M-type: metallic; iron and nickel

© 2011 Pearson Education, Inc.

14.1 Asteroids

Two small S-type asteroids, Gaspra and Ida, were visited by the *Galileo* probe. Gaspra (left) is in false color; it is really gray. Note that Ida (right) has a small moon, Dactyl.

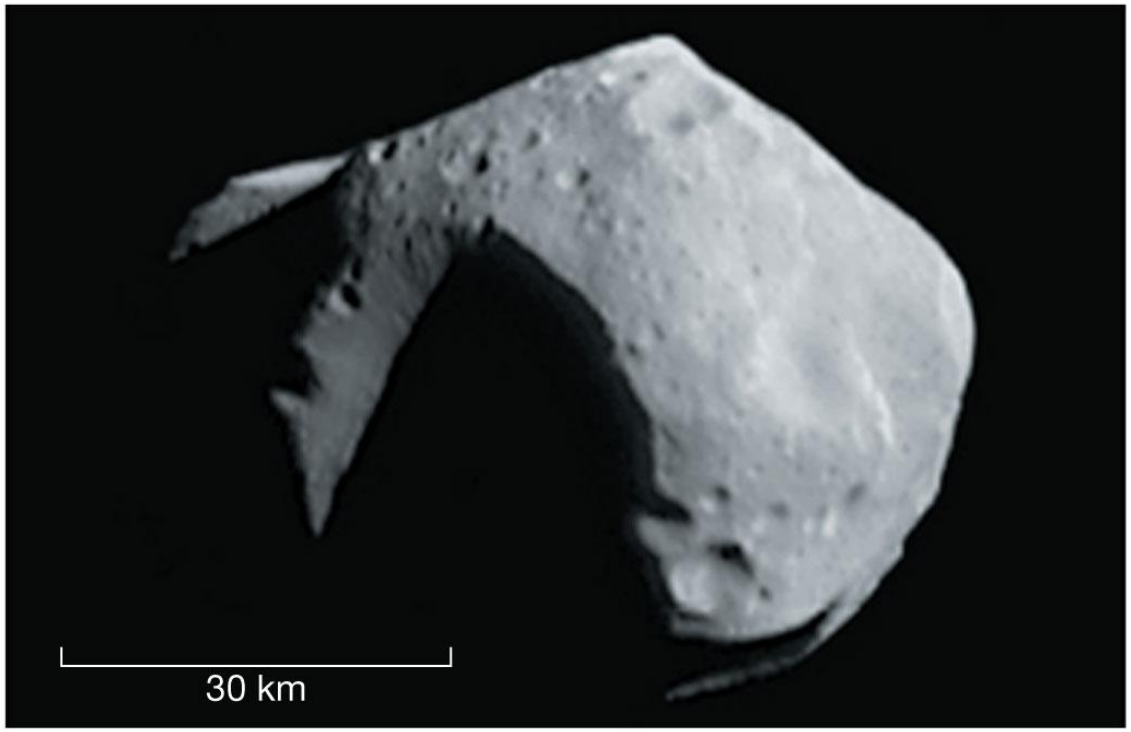


© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.1 Asteroids

The *NEAR* spacecraft visited the C-type asteroid Mathilde, on its way to its main target, Eros. Mathilde, like many other asteroids, has a very low density and is probably not solid.

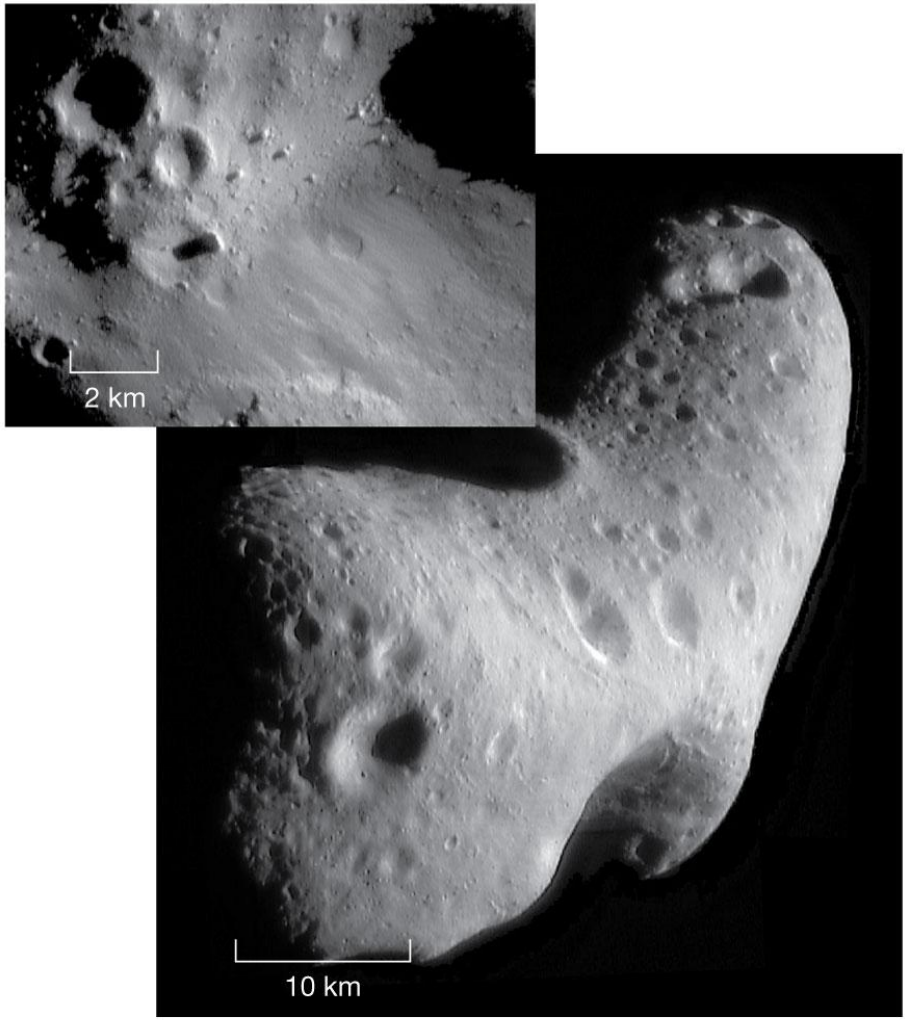


© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.1 Asteroids

Eros does seem to be solid



© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.1 Asteroids

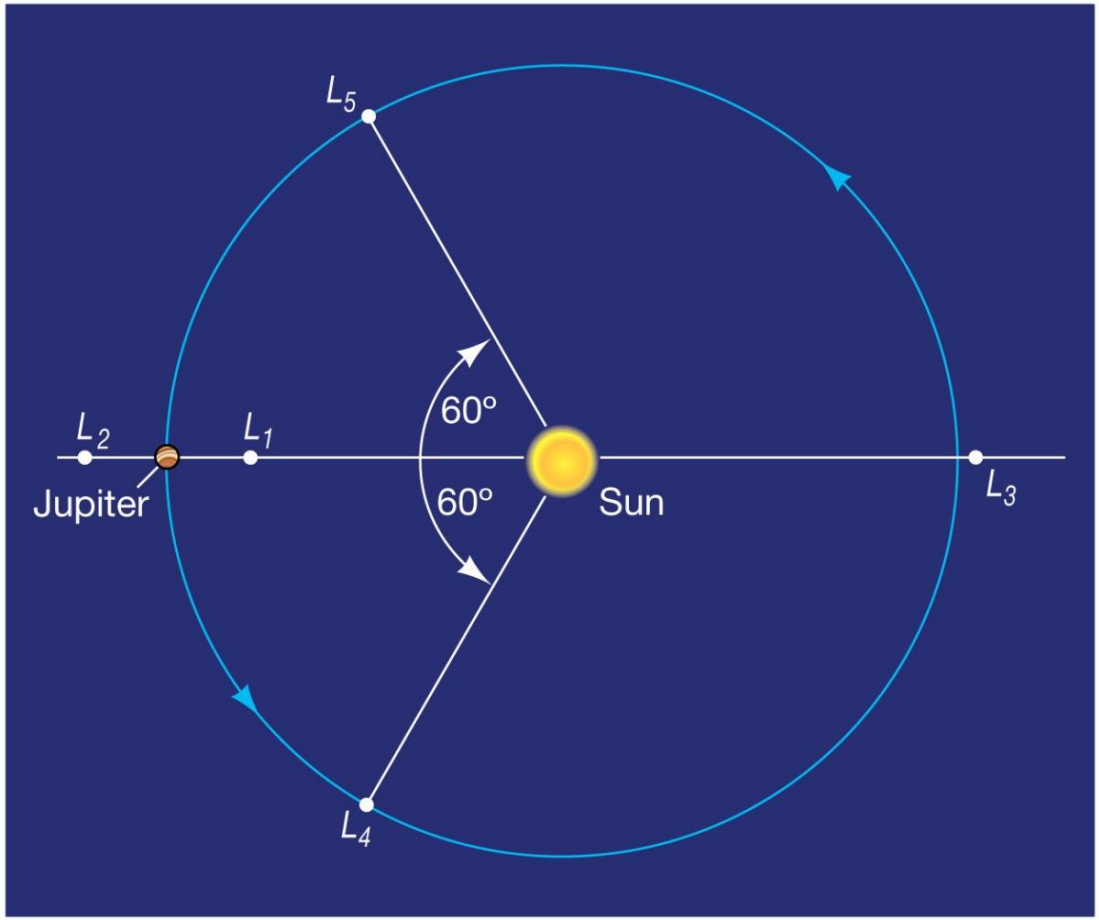
Some asteroids have orbits so eccentric that they cross Earth's orbit. They are called Apollo asteroids and raise the concern of a possible collision.

6500 such asteroids have been discovered so far, of which about 1000 have been designated as potentially hazardous, due to their size.

© 2011 Pearson Education, Inc.

14.1 Asteroids

Some asteroids, called Trojan asteroids, orbit at the L_4 and L_5 Lagrangian points of Jupiter's orbit



© 2011 Pearson Education, Inc.

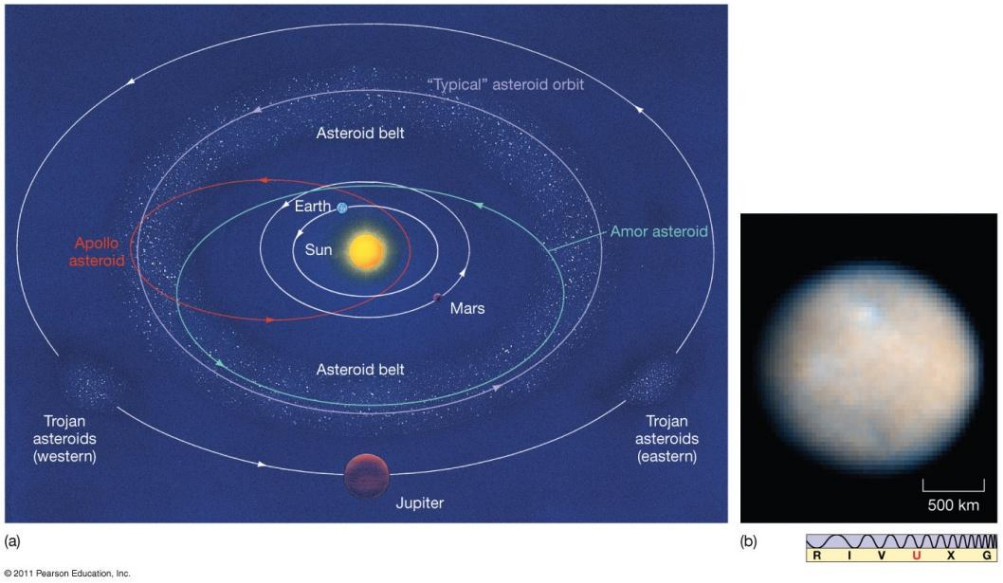
Discovery 14-1: What Killed the Dinosaurs?

Asteroid impact? Possibly…

Time scale is about right

Evidence exists for impact crater of proper age, and iridium layer indicates asteroid

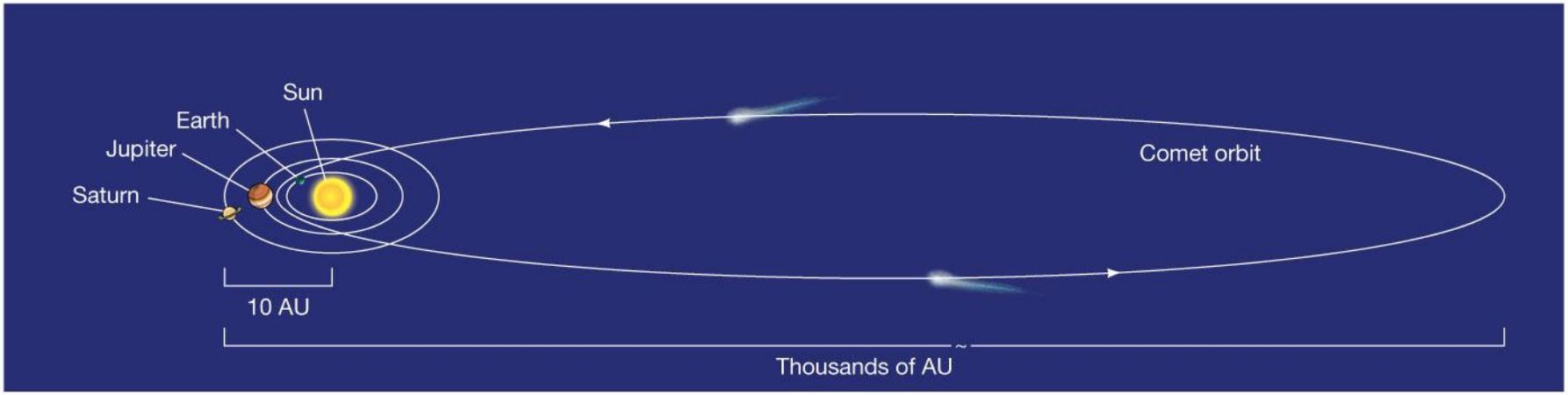
Did asteroid cause extinction out of the blue, accelerate ongoing extinction, or…?



© 2011 Pearson Education, Inc.

14.2 Comets

Comets that come close enough to the Sun to be detectable from Earth have very eccentric orbits

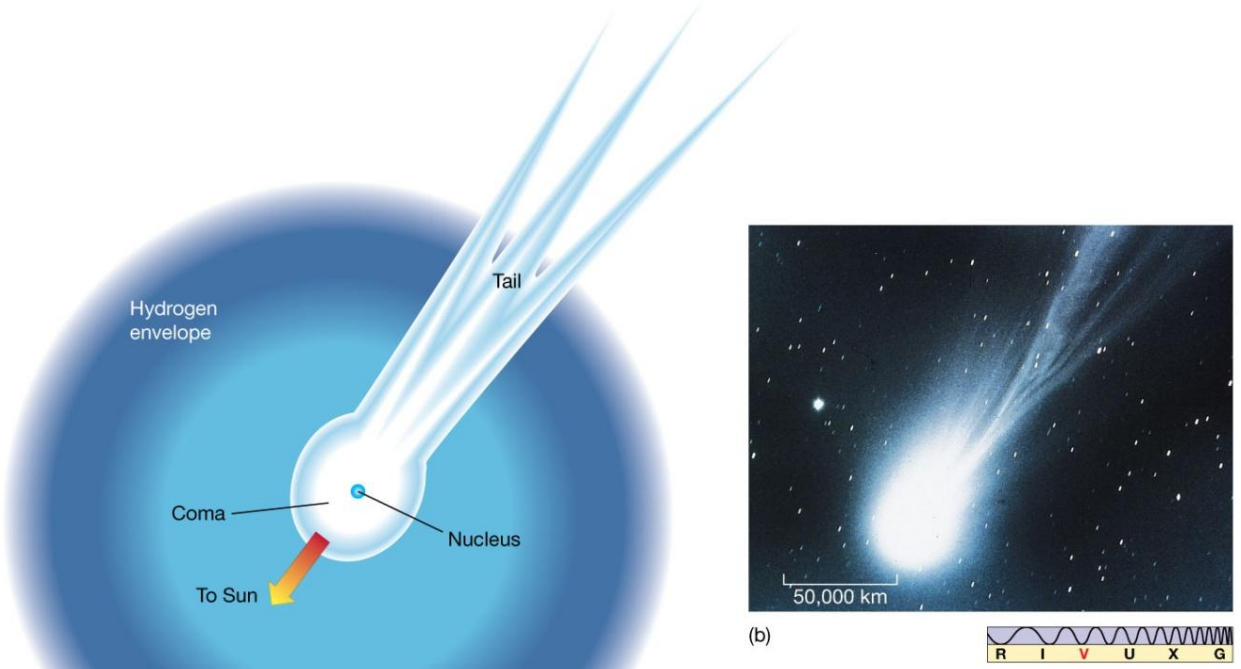


© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.2 Comets

Comets have a very small nucleus, a coma of gas and dust that is the most visible part and can be very large, a hydrogen envelope, a dust tail, and an ion tail



© 2011 Pearson Education, Inc.

14.2 Comets

The comet's tail always points away from the Sun, due to the solar wind. The ion tail is straighter than the dust tail.

(a)

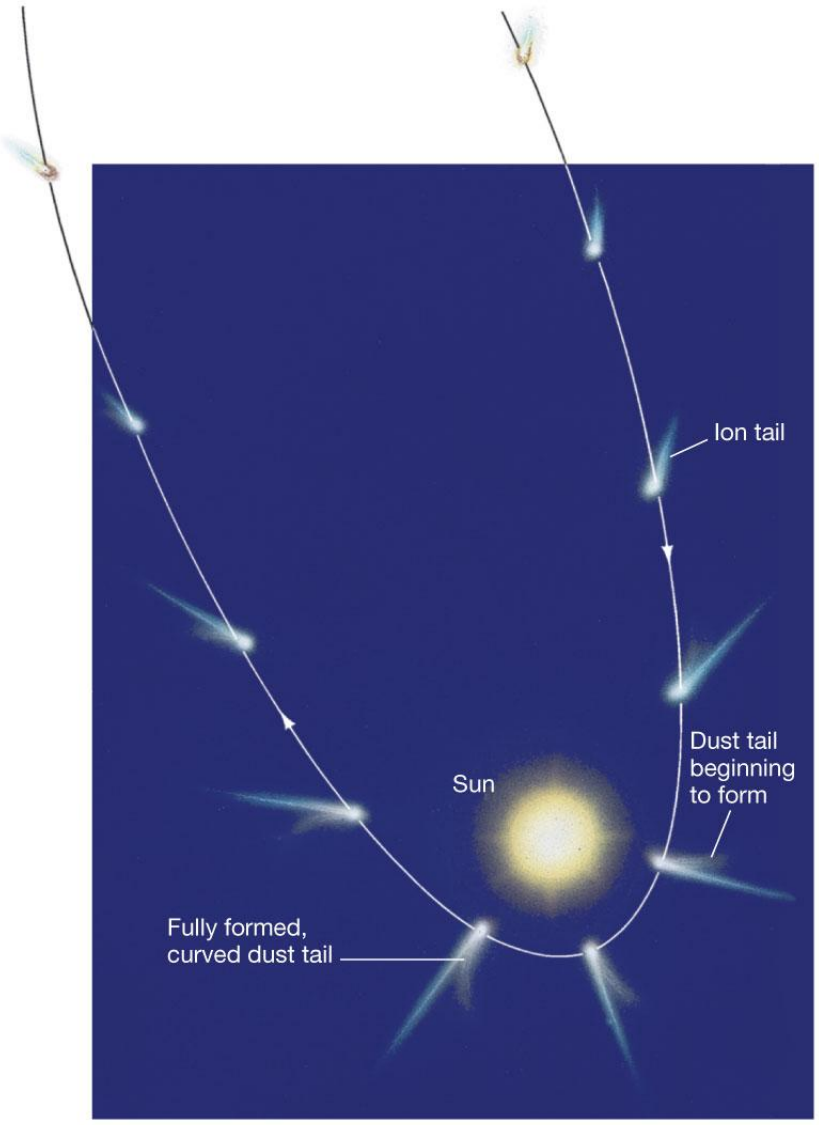
(b)

© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.2 Comets

The comet's tail develops as it approaches the Sun and disappears as it moves away from the Sun. The ion tail always points away from the Sun; the dust tail curves a bit as the comet gets ahead of it in its orbit.



© 2011 Pearson Education, Inc.

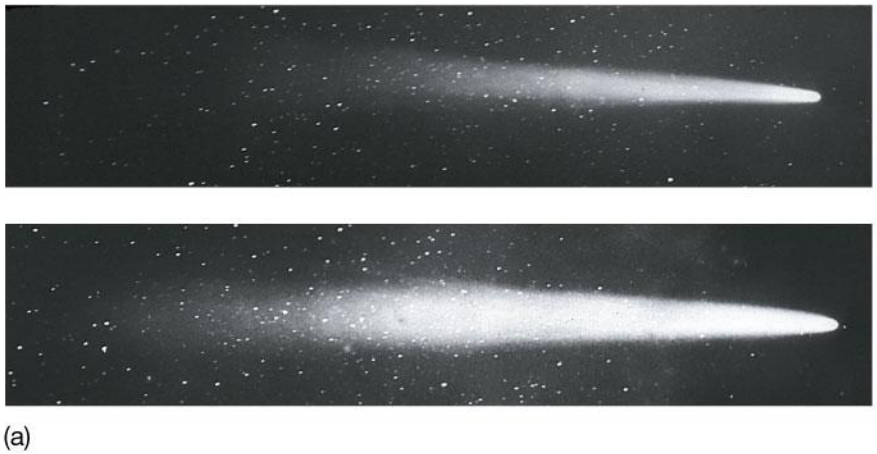
© 2011 Pearson Education, Inc.

14.2 Comets

Halley's Comet is one of the most famous; it has a period of 76 years and has been observed since antiquity. Its most recent visit, in 1986, was not spectacular.

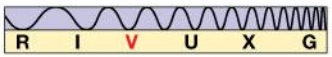
Left: The comet in 1910, as seen with the naked eye

Right: The comet in 1986, as seen through a telescope



(a)

(b)

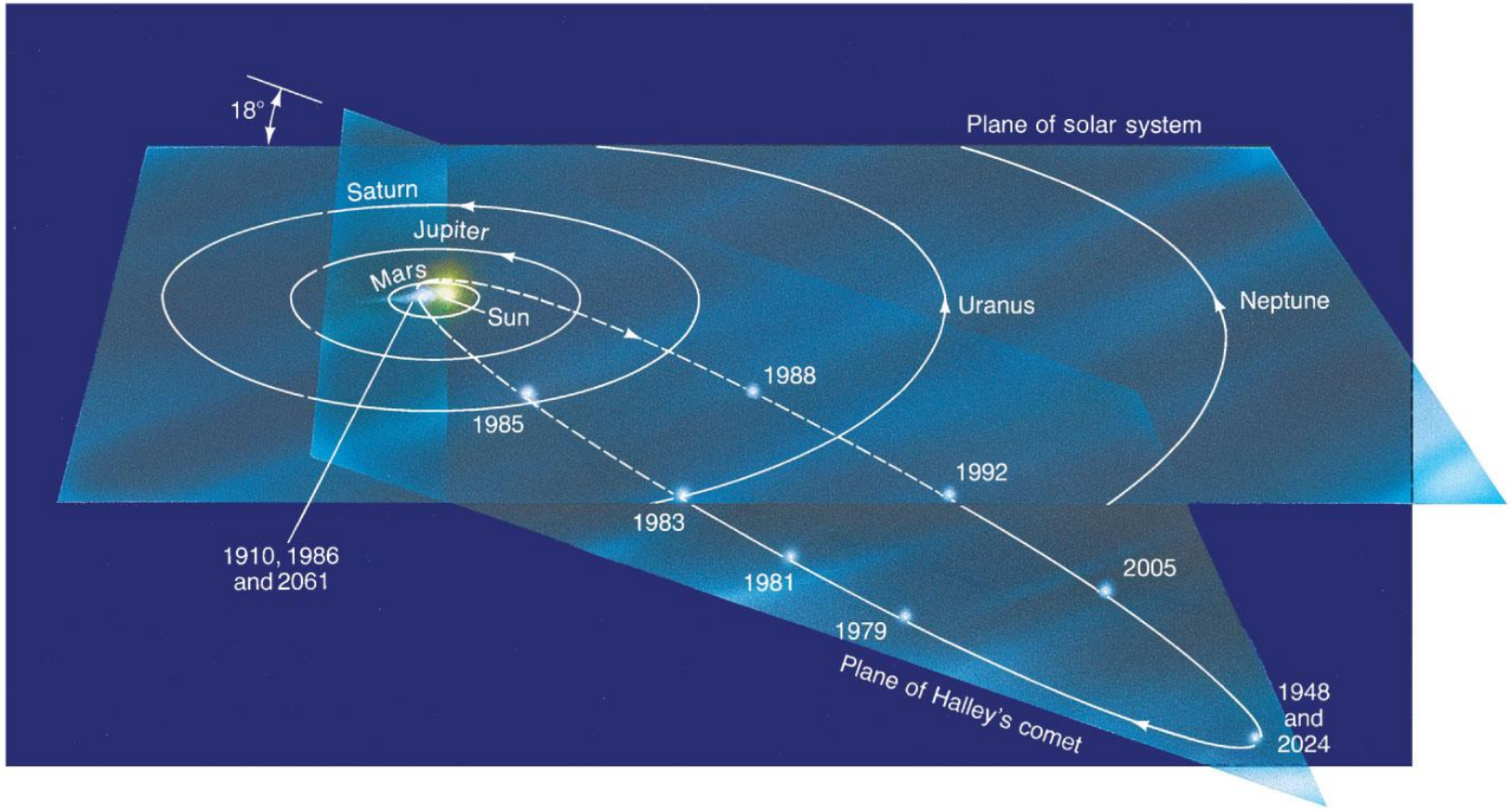


© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.2 Comets

Halley's Comet has a shorter period than most comets, but its orbit is not in the plane of the solar system, probably due to an encounter with a larger object



© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.2 Comets

Typical cometary mass: 10^{12} to 10^{16} kg

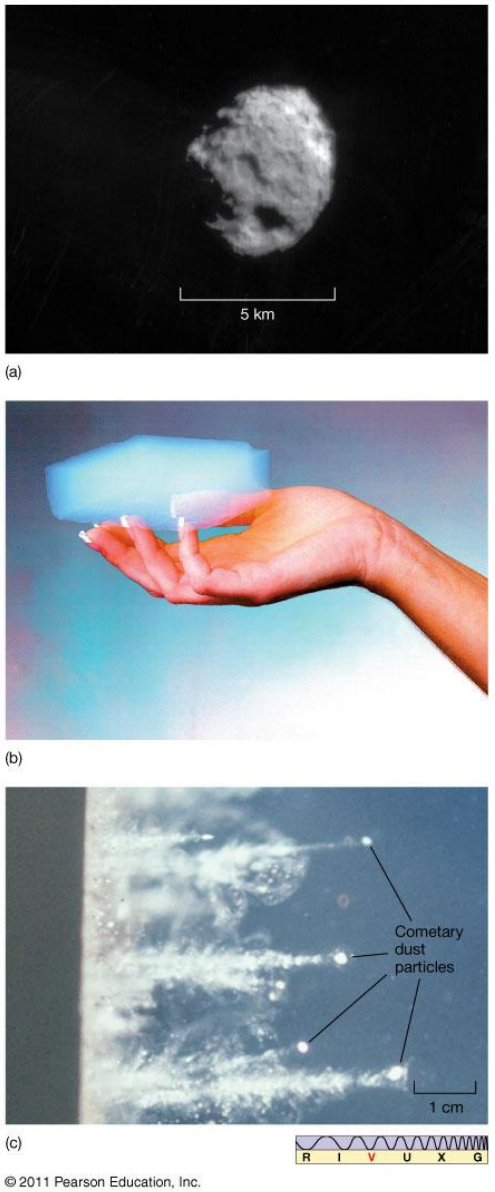
Each trip close to the Sun removes some material; Halley's Comet, for example, is expected to last about another 40,000 years

Sometimes a comet's nucleus can disintegrate violently

© 2011 Pearson Education, Inc.

14.2 Comets

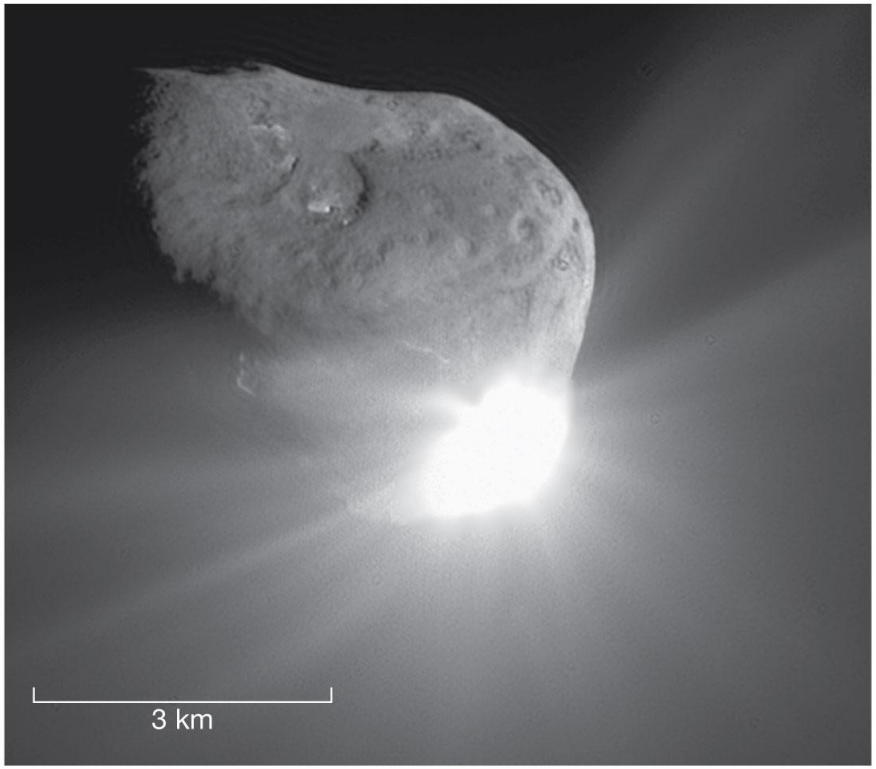
The *Stardust* mission flew through the tail of comet Wild-2, gathering dust particles in detectors made of aerogel and returning them to Earth for analysis



© 2011 Pearson Education, Inc.

14.2 Comets

The Deep Impact mission slammed a projectile into comet Tempel 1 and studied the material expelled in order to analyze the composition of the comet

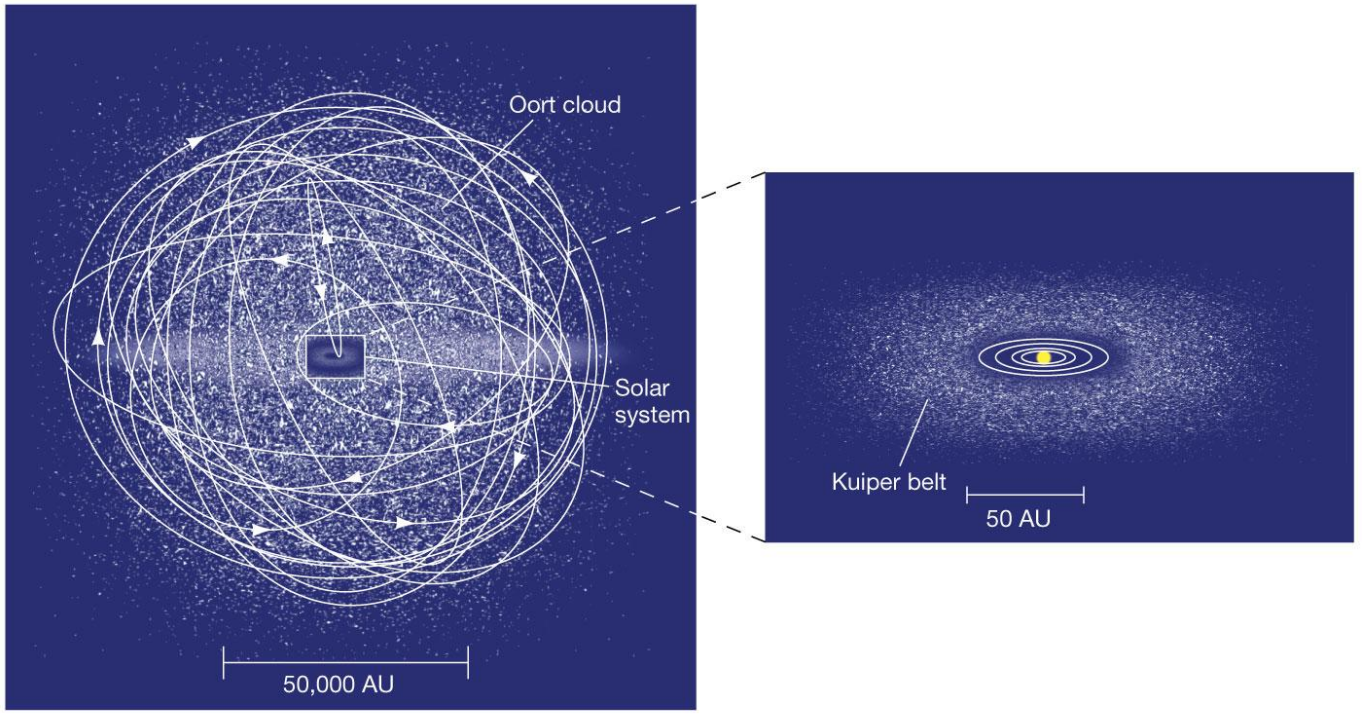


© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.2 Comets

Most comets that enter the inner solar system reside in the Kuiper belt outside the orbit of Neptune. Occasionally a comet from the far larger Oort cloud wanders into the inner solar system as well.



© 2011 Pearson Education, Inc.

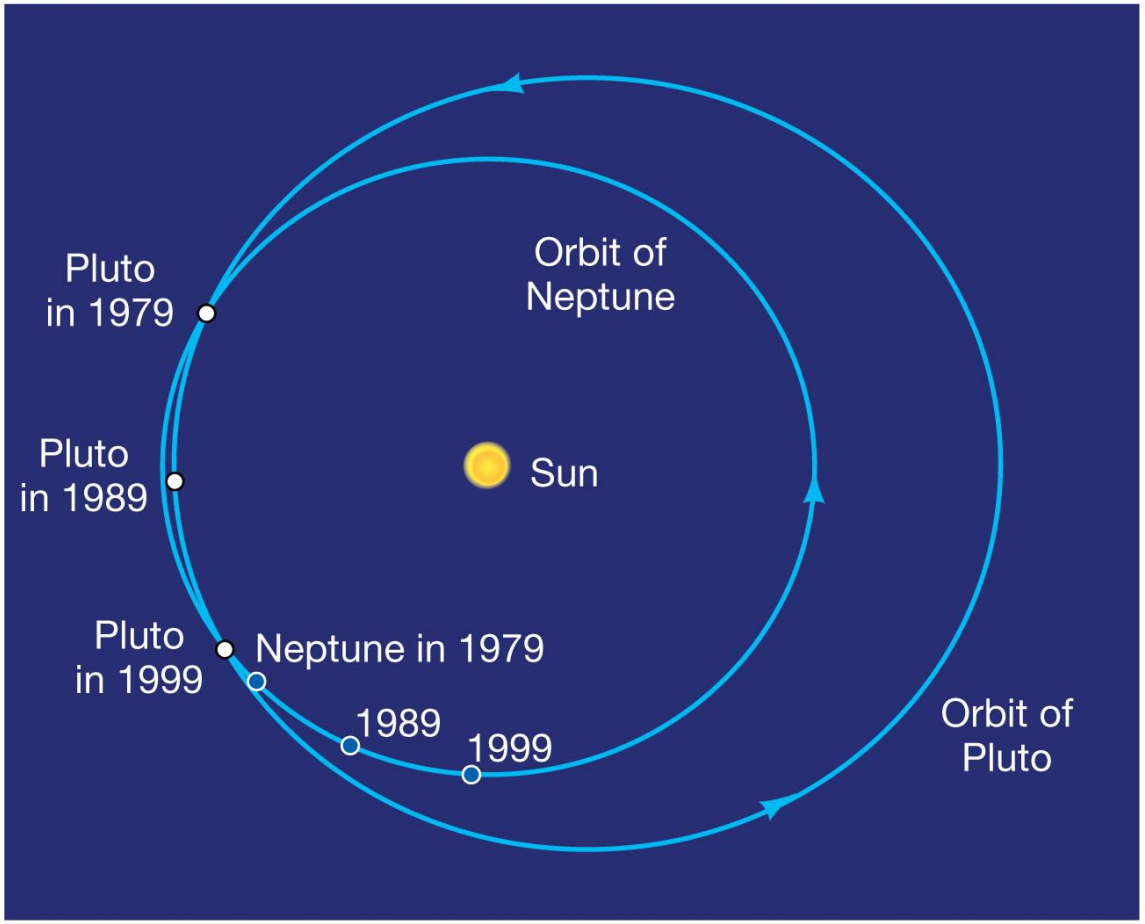
14.3 Beyond Neptune

Pluto was discovered in 1930. It was thought to be needed to explain irregularities in the orbits of Uranus and Neptune, but it turned out that there were no such irregularities.

© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

Pluto's orbit is eccentric and inclined to the plane of the ecliptic; it also crosses the orbit of Neptune

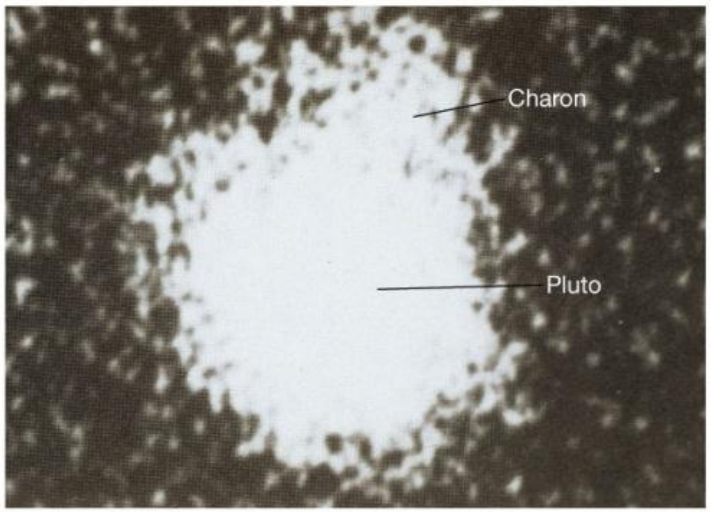


© 2011 Pearson Education, Inc.

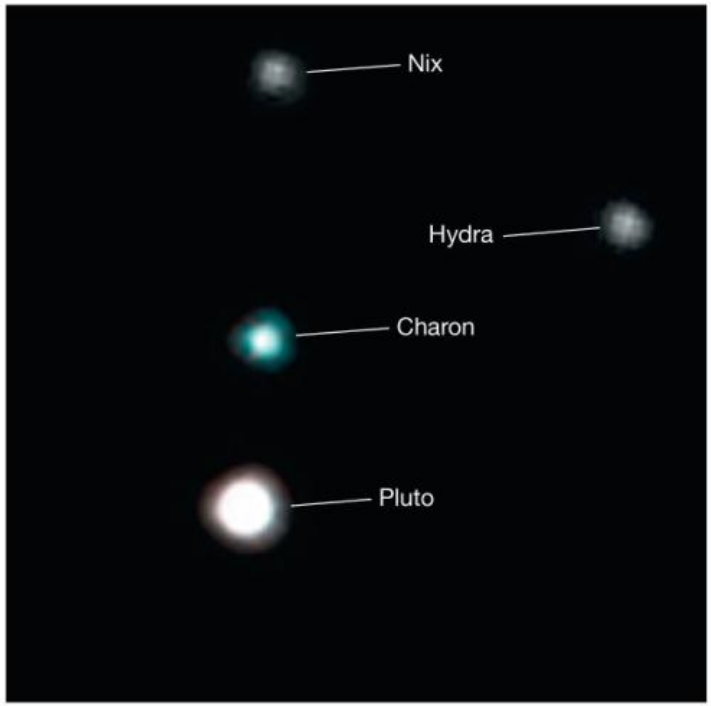
14.3 Beyond Neptune

Pluto's large moon, Charon, was discovered in 1978. It is orbitally locked to Pluto, and about a sixth as large.

The additional small moons are named Nix and Hydra.



(a)



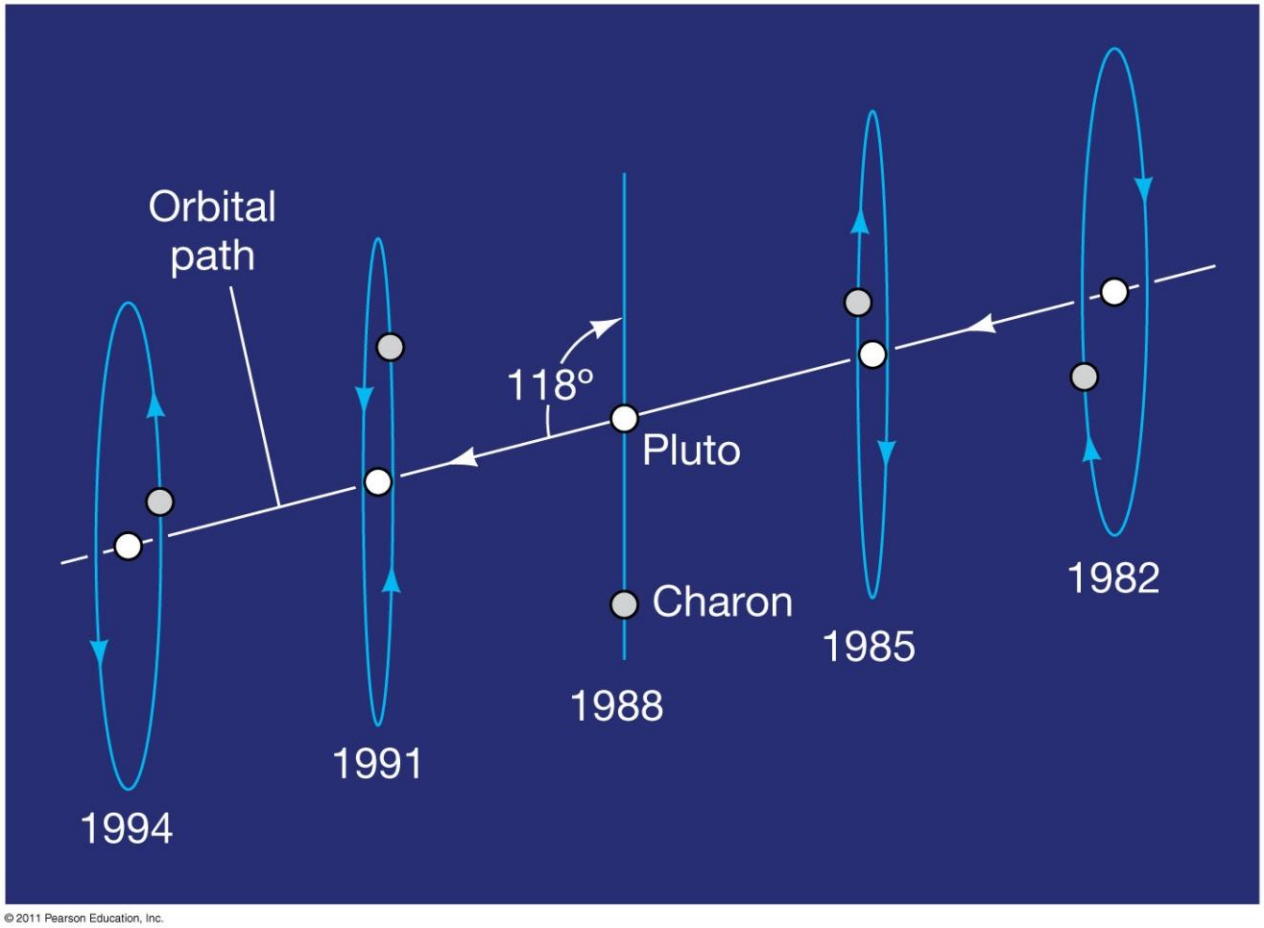
(b)

© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

Observations of eclipses of Pluto and Charon allowed measurement of orbital details

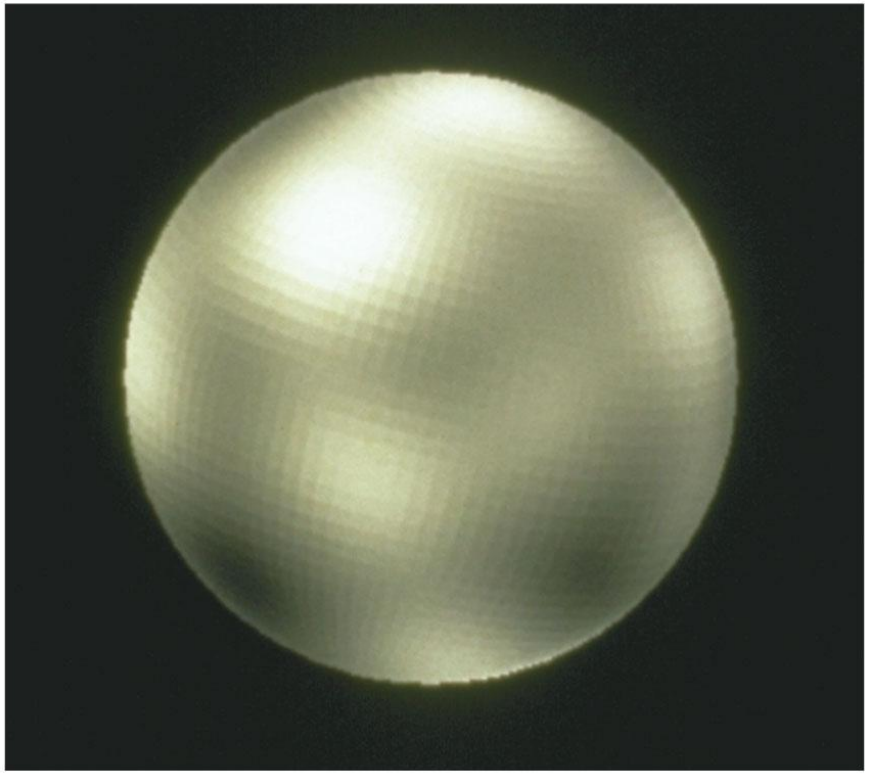


© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

The Kuiper belt is outside the orbit of Pluto and has many icy chunks

Current theory is that Pluto is the nearest, and largest, of these objects



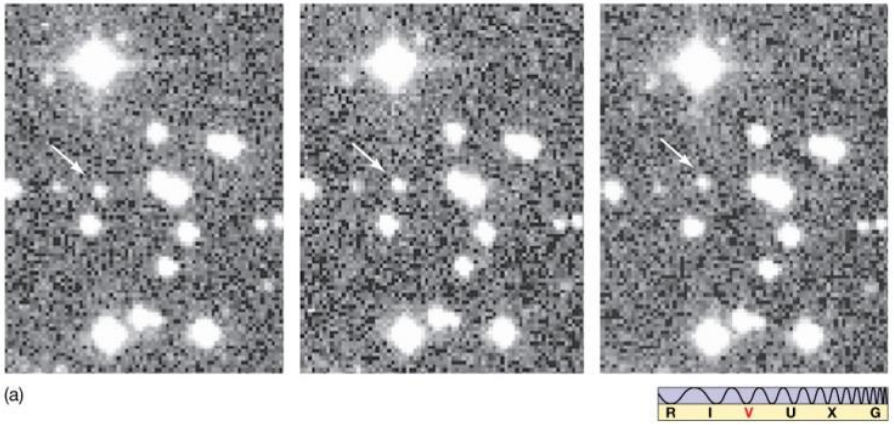
© 2011 Pearson Education, Inc.

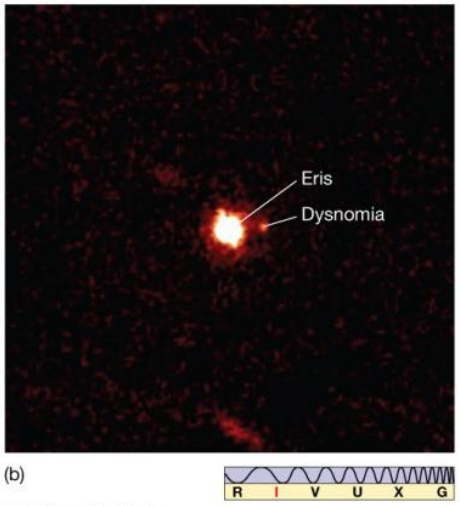
© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

No objects have been observed in the Oort cloud—it is simply too far away.

However, some Kuiper belt objects (KBOs) have been observed—over 1000 so far. Here are Pholus and Eris.

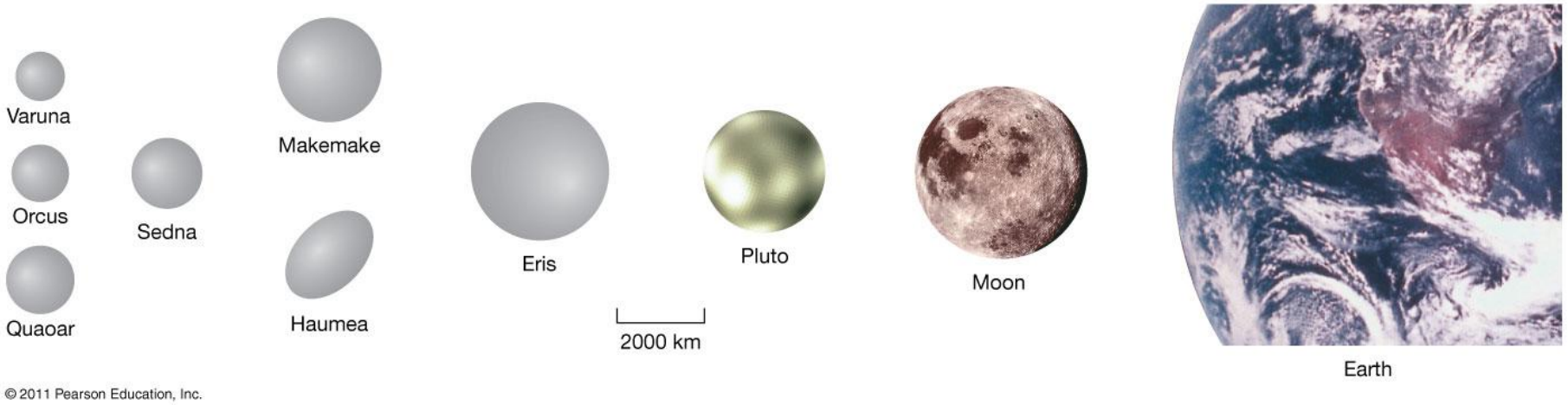




© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

Comparison of several trans-Neptunian objects with Earth and its moon



© 2011 Pearson Education, Inc.

14.3 Beyond Neptune

What happened to Pluto?

In 2006, the International Astronomical Union (IAU) adopted an official definition of “planet.” (There had not been an official definition before.) A planet must

1. Orbit the Sun
2. Be massive enough that its gravity keeps it spherical
3. Clear its orbit of other debris

Pluto does 1 and 2 but not 3.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

On an average dark night, you can see a few meteors every hour. The flash is caused by heating; most meteors do not survive to reach the ground.

(a)

(b)

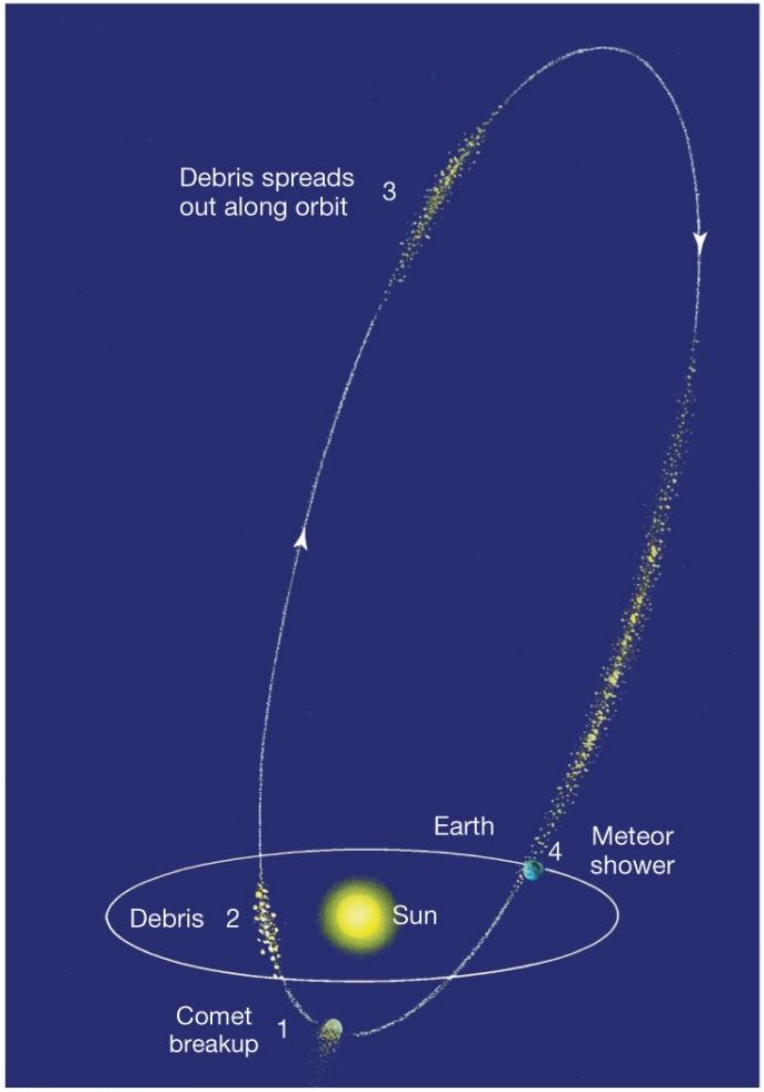
© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

Meteoroids are defined as being less than 100 m in diameter. Most of the smaller ones are the remnants of comets that have broken up.

If the Earth's orbit intersects the comet's, meteor showers will occur every year on the same date, until the meteoroids have burned out.



© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

Here are the major meteor showers

TABLE 14.1 Some Prominent Meteor Showers

Morning of Maximum Activity	Name of Shower	Rough Hourly Count	Parent Comet
Jan. 3	Quadrantid	40	—
Apr. 21	Lyrid	10	1861I (Thatcher)
May 4	Eta Aquarid	20	Halley
June 30	Beta Taurid	25‡	Encke
July 30	Delta Aquarid	20	—
Aug. 11	Perseid	50	1862III (Swift-Tuttle)
Oct. 9	Draconid	up to 500	Giacobini-Zinner
Oct. 20	Orionid	30	Halley
Nov. 7	Taurid	10	Encke
Nov. 16	Leonid	12*	1866I (Tuttle)
Dec. 13	Geminid	50	3200 (Phaeton)†

**Every 33 years, as Earth passes through the densest region of this meteoroid swarm, we see intense showers that can exceed 1000 meteors per minute for brief periods. This intense activity is next expected to occur in 2032.*

†Phaeton is actually an asteroid and shows no signs of cometary activity, but its orbit matches the meteoroid paths very well.

‡Meteor count peaks after sunrise.

© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

Larger meteoroids are usually loners from the asteroid belt and have produced most of the visible craters in the solar system.

The Earth has about 100 craters more than 0.1 km in diameter; erosion has made most of them hard to discern. One of the largest is in Canada.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

Meteoroids that burn up in the Earth's atmosphere have densities of 500 to 1000 kg/m^3 and are probably comet–like in composition.

Meteoroids that reach the surface have densities around 5000 kg/m^3 and are similar to asteroids.

(a)

(b)

© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

14.4 Meteoroids

Most meteorites are rocky (left); some are iron (right)

(a)

© 2011 Pearson Education, Inc.

(b)

© 2011 Pearson Education, Inc.

Summary of Chapter 14

- Most asteroids orbit in asteroid belt
- Total mass of all asteroids is less than mass of Earth's moon
- Asteroid types: S-type (silicate), M-type (metallic) and C-type (carbonaceous)
- A few asteroids are in Earth-crossing orbits
- Comets are icy and normally orbit far from the Sun

© 2011 Pearson Education, Inc.

Summary of Chapter 14 (cont.)

- Some comets have highly eccentric orbits and enter the inner solar system
- Most reside in the Oort cloud
- The Kuiper belt is just beyond the orbit of Neptune; a number of Kuiper belt objects have recently been observed
- Comets begin to vaporize as they approach the Sun
- Comet nucleus is tiny, but coma and tails can be enormous, covering 30–40° of the sky

© 2011 Pearson Education, Inc.

Summary of Chapter 14 (cont.)

- Meteors are the bright flashes of light from micrometeoroids hitting the atmosphere
- If a meteor lands on the Earth, it is called a meteorite
- Meteors that burn up in the atmosphere are mostly similar to comets; those that land are more like asteroids
- The gradual disintegration of a comet as it orbits the Sun leaves a meteoroid swarm; if the Earth encounters a swarm, we see a meteor shower

© 2011 Pearson Education, Inc.