

Observational Astronomy - Lecture 7

Solar System II - Moons, Comets, Asteroids

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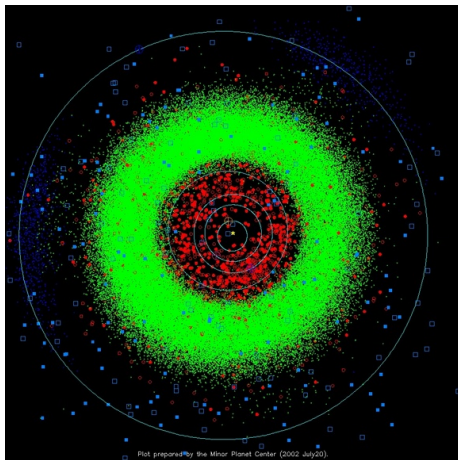
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Small Bodies in the Solar System

- Asteroids
 - Near-Earth Objects (NEOs)
- The Outer Solar System
 - Trans-Neptunian Objects (TNOs) and the Kuiper belt.
 - Comets and the Oort cloud.
- Moons

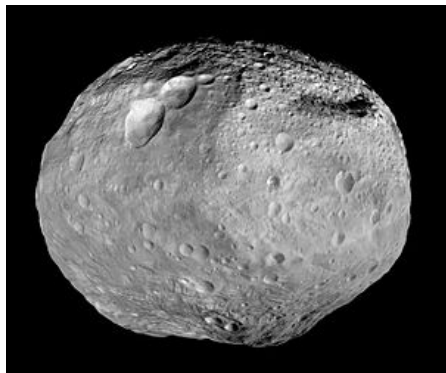
Snapshot of the Asteroid Belt



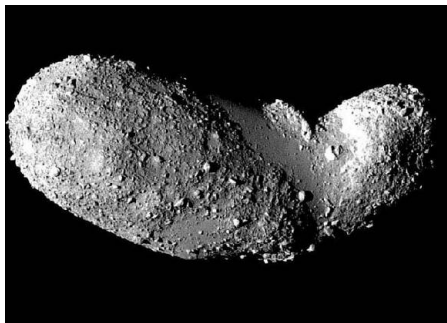
Over 100,000 objects are currently known.

Green: Main Belt Asteroids; Blue Dots: Jupiter Trojans
Red: Near-Earth Objects; Blue and Purple Squares: Comets

Asteroid Examples

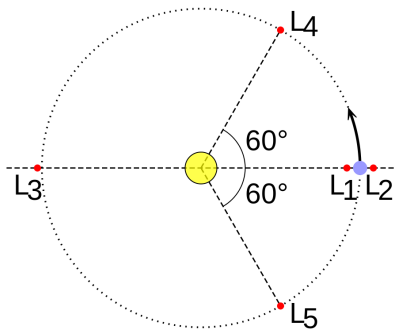


Large asteroids, like Vesta (≈ 500 km) are more or less round.

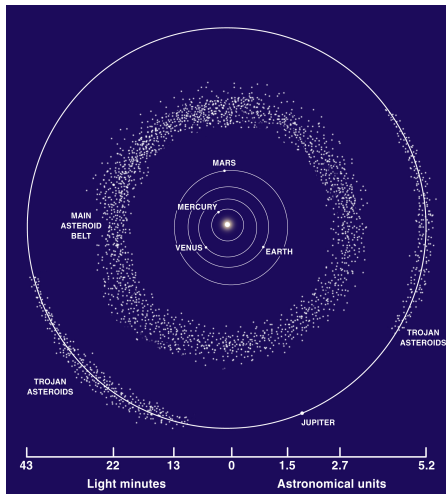


Itokawa, shown here (500m x 300m x 200m) is more of a "rubble pile".

LaGrange Points and Trojan Asteroids

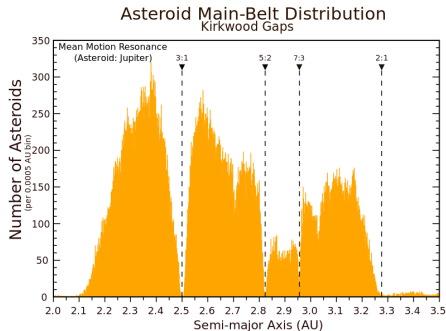


The Lagrange points of an orbit.

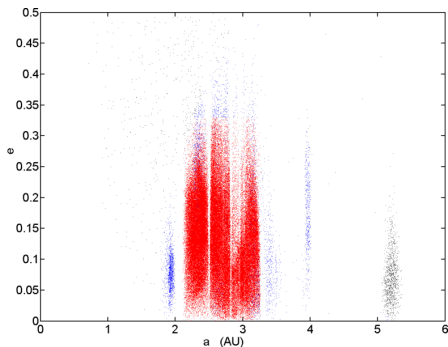


Jupiter's Trojan asteroids - named after the Trojans and the Greeks.

Asteroid Orbital Characteristics



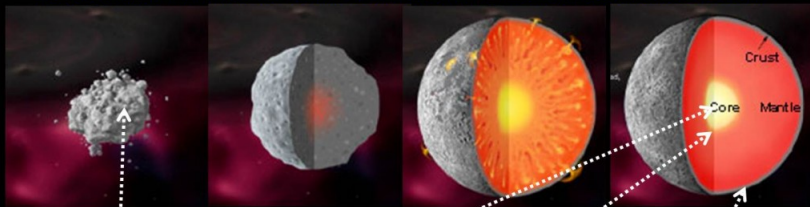
Jupiter's gravity sweeps out gaps in the asteroid belt.



The asteroids group into families.

Different Asteroid & Meteorite Types

Source: Smithsonian Museum of Natural History http://www.mnh.si.edu/earth/text/5_1_4_0.html



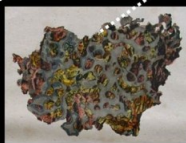
Chondritic Stony Meteorite

Asteroid Type C



Iron Meteorite

Asteroid Type M



Pallasite Meteorite

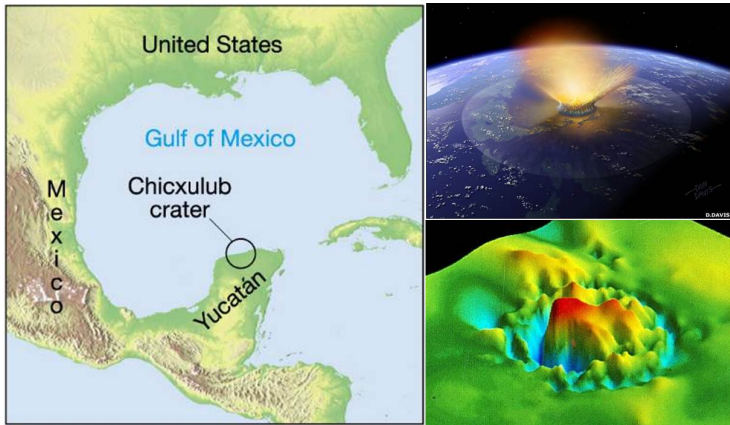


Achondritic Stony Meteorite

Asteroid Type S

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Did an Asteroid Kill the Dinosaurs?



The asteroid that formed this crater was about 10 km in diameter.

Carl Sagan, "If the dinosaurs had had a space program, they would not be extinct."

Near Earth Objects

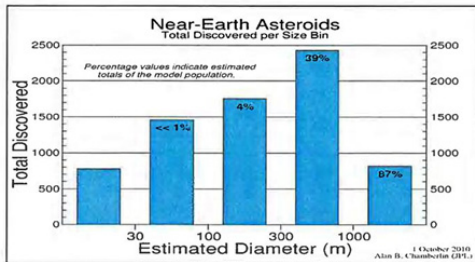
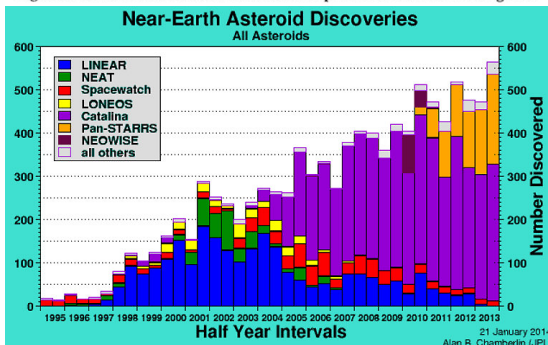
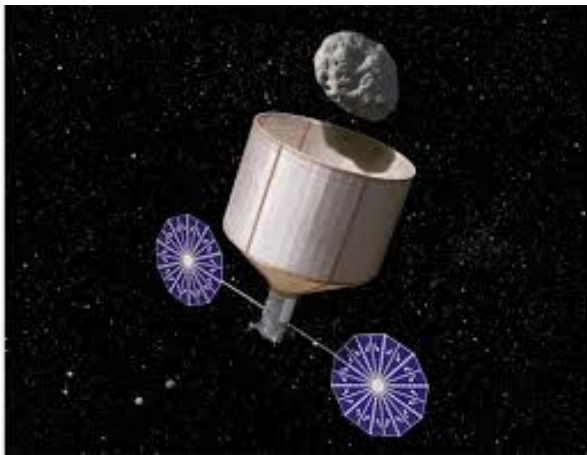


Figure 2. NEA discoveries and estimated completeness for five size categories



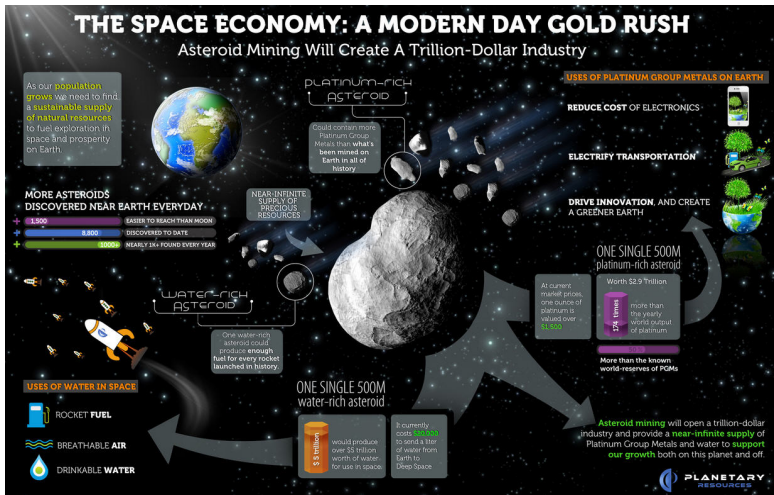
The Chelyabinsk meteor (Feb 15, 2013) was about 20 m in diameter.

Asteroid mining



NASA has a plan to capture a near-Earth object of 10-20 m in diameter and bring it back to Earth orbit. These objects represent both a threat and a resource.

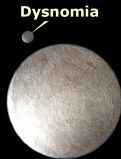
Planetary Resources Promotional Slide



Planetary Resources is a private company planning to mine to asteroids.

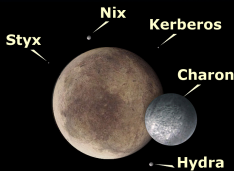
TransNeptunian Objects

Largest known trans-Neptunian objects (TNOs)



Dysnomia

Eris



Pluto



Makemake



Haumea



Sedna



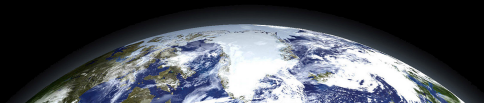
2007 OR₁₀



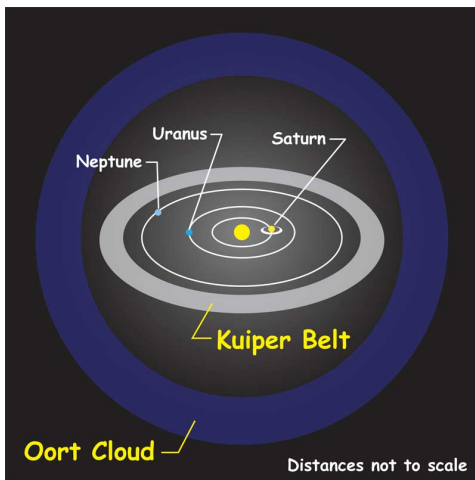
Quaoar



Orcus

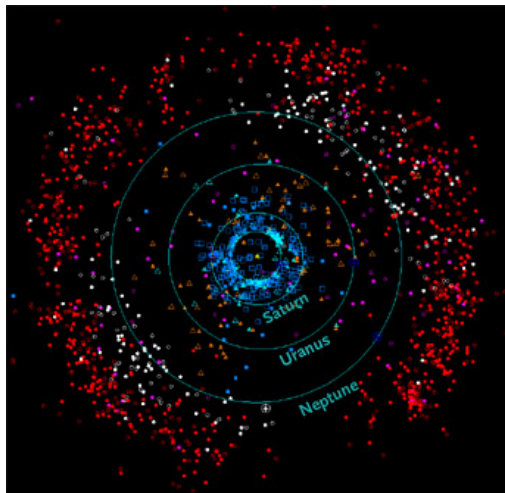


The Kuiper Belt and the Oort cloud



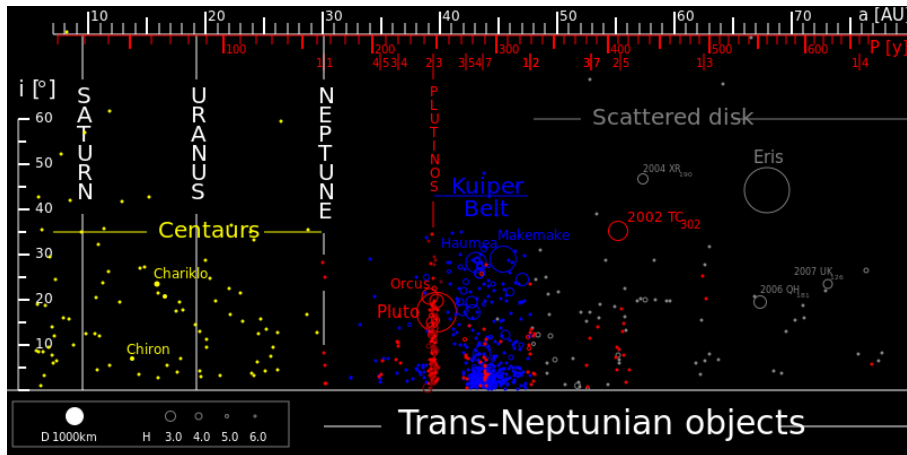
The Oort cloud is believed to extend out to very great distances - perhaps 0.5 light-year.

Snapshot of TransNeptunian Orbits

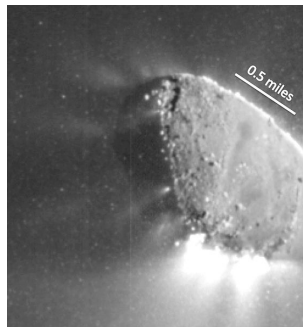
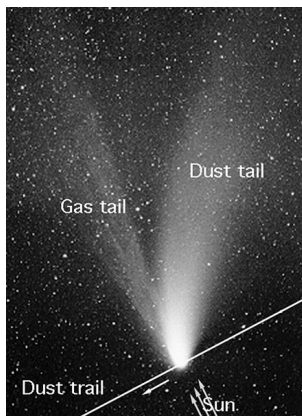
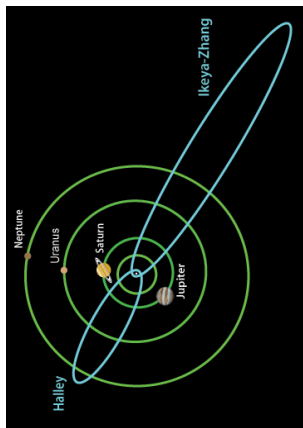


Red and white points are known Kuiper belt objects as of 2010.

TransNeptunian Object Orbits



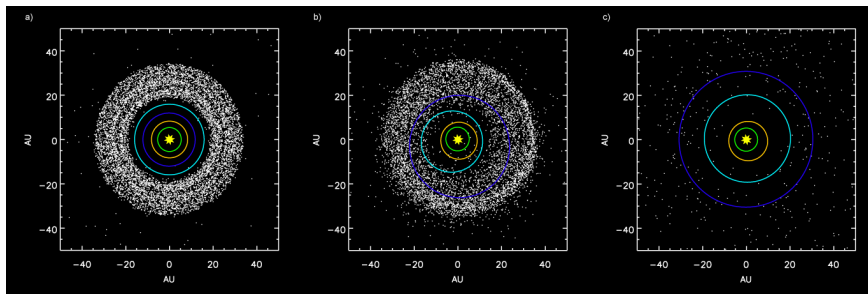
Comets



Jets from Comet Hartley.

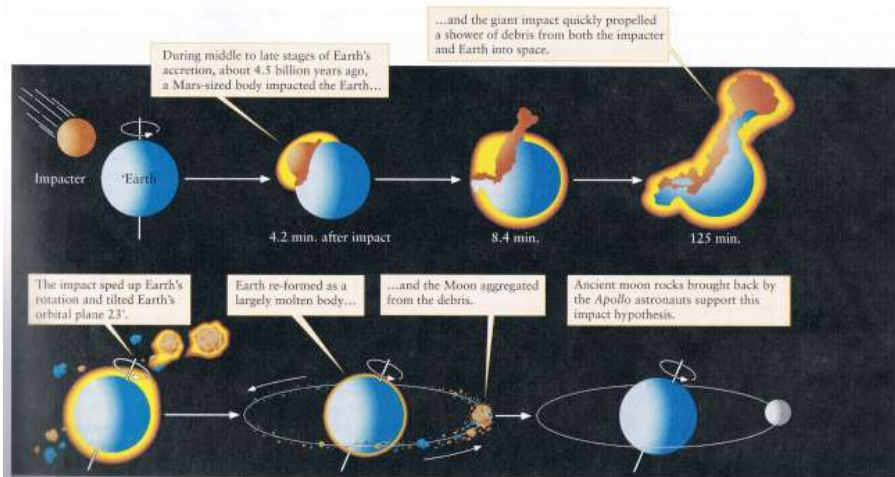
Comets are icy bodies that evaporate as they get close to the sun.

The Nice Hypothesis

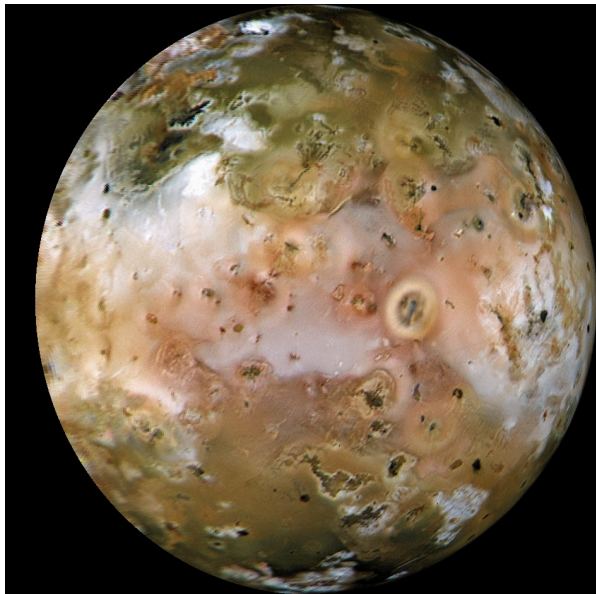


Jupiter (green) and Saturn (orange) entered into a 2:1 orbital resonance, causing Uranus (aqua) and Neptune (blue) to change places, and over 99% of the remaining small bodies to be ejected into much larger orbits. This caused the “Late Heavy Bombardment”, when many of the moon’s large craters were formed.

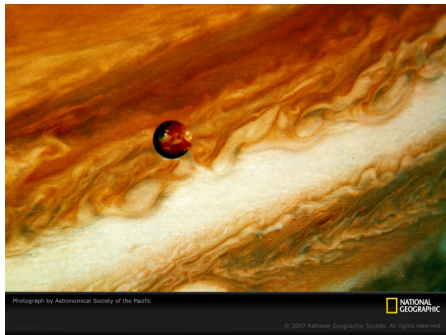
Possible Formation of Earth's Moon



Io

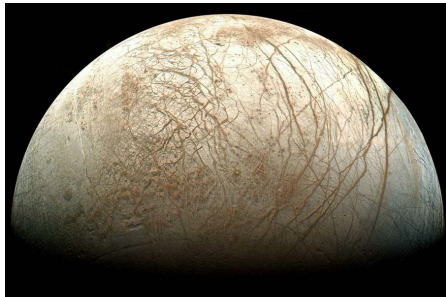
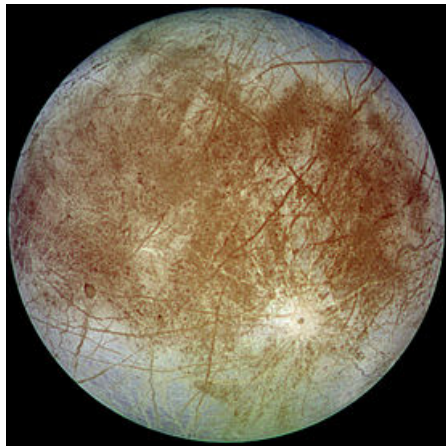


Io



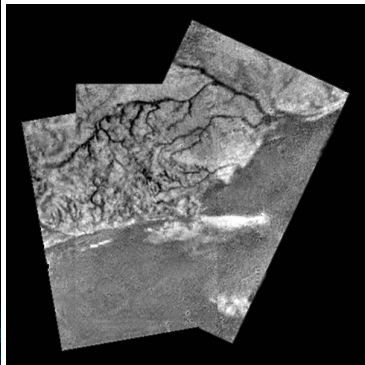
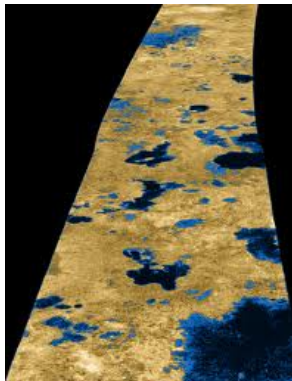
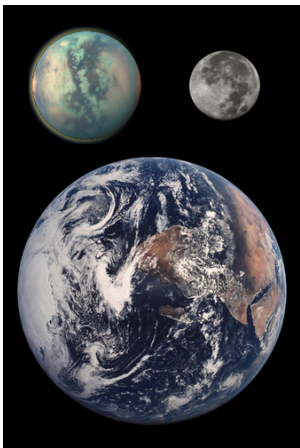
Io is heated by tidal heating in its orbit around Jupiter. It is the most volcanically active object in the Solar System.

Europa



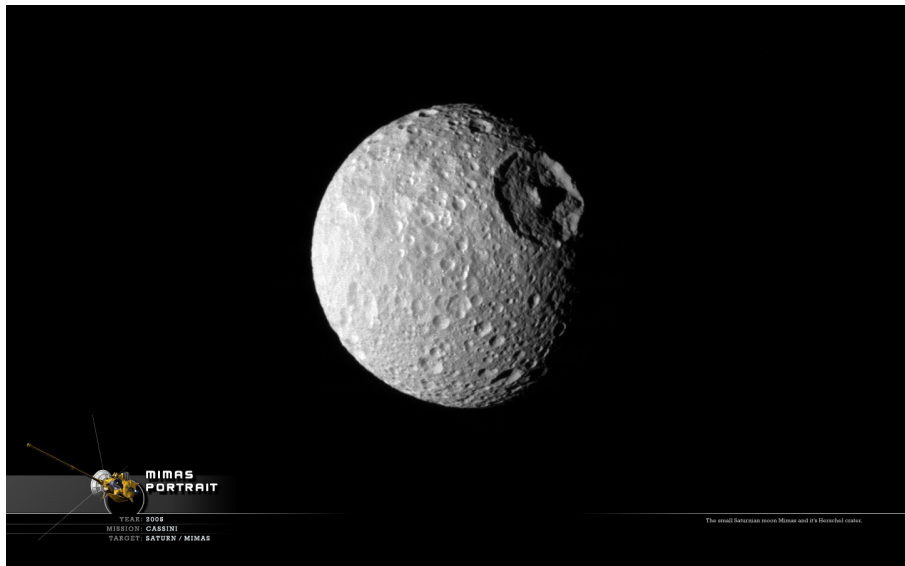
Europa may have an ocean of liquid water below its icy crust.

Titan



Titan has rivers and lakes of liquid methane (natural gas), ethane, or propane at -180°C

Mimas - "The Death Star"



Summary

- 1 There are huge numbers (billions?) of small bodies in the solar system.
- 2 We are just beginning to map out their locations and orbits.
- 3 These objects represent both a threat (Earth impacts) and a resource.
- 4 These objects are roughly divided into the inner asteroid belt, the Kuiper belt, and the Oort cloud.
- 5 The moons of the major planets show a fascinating diversity of structures.