Survey of the Solar System

The Sun

Giant Planets

Terrestrial Planets

Minor Planets

Satellite/Ring Systems
Definition of a dwarf planet

1. Orbits the sun
2. Is large enough to have become round due to the force of its own gravity
3. Is not a satellite
4. Must dominate the neighborhood around its orbit (cleared its orbital path)

Currently there are 5 recognized by the IAU: Ceres, Pluto, Haumea, Eris and Makemake

Though due to difficulties in confirming KBO roundness there are probably >100 known objects
Minor / Dwarf Planets

The new solar system

One dwarf planet in asteroid belt (Ceres)

Eight planets

Eris
Ceres
Pluto (& Charon)

Earth For Scale:

84 probable, 357 possible

http://www.gps.caltech.edu/~mbrown/dps.html

Image credit: M. Brown

Image credit: NASA
Asteroids

Minor planets with unconfirmed roundness and generally < 500 km in radius. Most reside in the asteroid belt (2.1–3.3 AU) between Mars’ and Jupiter’s orbits. Other populations include centaurs, Trojans, Kuiper belt objects (e.g., Pluto). They actually can, and several do, have confirmed satellites.
Vesta

July 24, 2011
Asteroids and Comets Visited

- Dactyl ([(243) Ida]): 1.6 x 1.2 km, Galileo, 1993
- 243 Ida: 58.8 x 25.4 x 18.6 km, Galileo, 1993
- 9969 Braille: 2.1 x 1 x 1 km, Deep Space 1, 1999
- 5535 Annefrank: 6.6 x 5.0 x 3.4 km, Stardust, 2002
- 2867 Steins: 5.9 x 4.0 km, Rosetta, 2008
- 433 Eros: 33 x 13 km, NEAR, 2000
- 25143 Itokawa: 0.5 x 0.3 x 0.2 km, Hayabusa, 2005
- 21 Lutetia: 132 x 101 x 76 km, Rosetta, 2010
- 253 Mathilde: 66 x 48 x 44 km, NEAR, 1997
- 951 Gaspra: 18.2 x 10.5 x 8.9 km, Galileo, 1991
- 103P/Hartley 2: 2.2 x 0.5 km, Deep Impact/EPOL, 2010
- 1P/Halley: 16 x 8 x 8 km, Vega 2, 1986
- 19P/Borrelly: 8 x 4 km, Deep Space 1, 2001
- 9P/Tempel 1: 7.6 x 4.9 km, Deep Impact, 2005
- 81P/Wild 2: 5.5 x 4.0 x 3.3 km, Stardust, 2004
Comets

Ice-rich objects that lose mass in the form of water vapor and ice/dust grains when exposed to sufficient solar heating. Mostly reside in the Oort Cloud (1-5 x 10^4 AU) and Kuiper Belt region.
Comets: Churyumov-Gerasimenko

August 3, 2014
Comets: Churyumov-Gerasimenko

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Satellites

All but two planets (Mercury & Venus) have satellites, as do several asteroids and minor planets.

The giant planets have tens of satellites each.

Have a broad spectrum of variability.
Satellites

Giant Planet Satellite Systems:
Inner moons in prograde orbits about planet and close to the equatorial plane with low eccentricity
Distant moons can orbit in any direction, at any inclination and with extreme eccentricity

Photo by Jan Sandberg
Not all moons carry equal weight...
Satellites

Giant Planet Satellite Systems:
Tidal forces due to orbital eccentricity and changing gravity from other moons can generate significant interior heat for moons
Satellites

Giant Planet Satellite Systems:
Tidal heat could potentially be translated to driving volcanic activity, heating a subsurface layer, etc.
Satellites

Giant Planet Satellite Systems:
Diffuse atmospheres have been detected at several moons, including: Io, Ganymede, Enceladus
Titan’s atmosphere is thicker than Earth’s
Satellites

Terrestrial Moons:
Earth’s moon thought to be from a large impactor early in the solar system’s history
Mars’s two moons appear to be captured asteroids likely from the nearby asteroid belt.

Deimos & Phobos
from MRO
Satellite Sizes

Pluto and Earth have largest moons relative to their size; both are likely formed from the impact of secondary planetesimals.

Ganymede and Titan are larger than Mercury.

Smallest moons are ~ km in size.

Earth and Moon
from Messenger spacecraft
Ring Systems

Only giant planets* have confirmed ring systems *and asteroid Chariklo

Generally thought to reside within a few radii of the planet (but recent observations show otherwise!)

Characteristics are quite variable between systems (e.g., Neptune arcs), raising many questions with respect to ring formation, life expectancy, and evolution.
Ring Systems – Chariklo! (largest centaur)
Ring Systems

Saturn:
Most observed and dynamic of the ring systems
Ring particles are made nearly entirely of water ice, with some dust and other chemicals

Sun eclipsed by Saturn from Cassini
Saturn:
Rings
dynamically shaped by moons causing waves, channels, gaps, etc.
Saturn:
E Ring sourced from cryovolcanism on the moon Enceladus
Ring Systems

Saturn:
Latest ring discovery by Spitzer Space Telescope: ring orbiting at $100 \, R_s$ and tilted $27^\circ$ from inner ring plane
Corresponds to orbit of irregular moon Phoebe