OUTER PLANETS
MINOR MEMBERS OF THE SOLAR SYSTEM
SUN

Jupiter
(Earth for Scale)

Jupiter’s bands are clouds

Hubble view of Jupiter
• Arrow shows entry point of Galileo probe, Dec. 1995

Galilean moons
• http://photojournal.jpl.nasa.gov/catalog/PIA00743

Io
• True color on top
• Enhanced color on bottom
• Surface covered with calderas (like Crater Lake…without the water!)

Volcanic Plume on Io

EUROPA – Surface-feature examples

Ganymede
Four Inner moons of Jupiter
- Metis, Adrastea, Amalthea, Thebe
- Amalthea is 247 km across
- Photos by Galileo probe, 1996-97

Jupiter’s outermost ring
- Discovered by Voyager I
- This photo by Galileo space probe--November 9, 1996

Saturn
- Voyager I, II went there in 1980, 81
- This photo by Cassini in 2004

Titan
- River system on Titan

Saturn and some of its moons
Enceladus

• http://pds.jpl.nasa.gov/planets/captions/saturn/encelads.htm

Neptune

Minor Members of Solar System

• Asteroids
• Meteoroids
• Comets
• Kuiper Belt Objects
• Dwarf Planets

“Planet”

• Orbits Sun
• Not a satellite
• Dominates its orbital path

“Dwarf Planet”

• is in orbit around Sun
• has sufficient mass for its self-gravity to pull itself into near-spherical shape
• has not cleared the neighborhood around its orbit
• is not a satellite

Pluto and Charon

Pluto and Charon

• Pluto does not dominate its orbit
• Pluto is the first discovered Kuiper Belt Object
• “Plutonian objects” of which it is the original example
• Pluto’s moon is Charon
Orbits of outer planets
- Notice Pluto is sometimes closer to Sun than Neptune

Inclination of Planetary orbits
- Notice Pluto's large inclination to Sun's equator

Kuiper Belt
- Donut shaped area containing numerous icy bodies of various sizes
- Eris is the largest discovered
- Pluto and Charon are some
- Triton, moon of Saturn, is likely one that was captured by Saturn's gravity
- Origin of numerous comets that orbit Sun in periods less than 200 years
- A division of Trans-Neptunian Objects

Eris
Kuiper Belt Object
Larger than Pluto
Discovered in 2003

Eris (2003 UB 313)

Orbit of Orcus (2004 DW)
Kuiper Belt Object
In red
Compare to Pluto in black

Inclination of Orbit of Orcus
- Pluto in red
- Neptune in gray
- Orcus in blue

Earth for scale
More Info:
http://solarsystem.nasa.gov/planets/profile.cfm/Object=TBOs&Display=OverviewLong

Largest known trans-Neptunian objects (TNOs)
Dwarf planets
• Large Kuiper Belt Objects
  º Pluto
  º Eris
  º Makemake
  º Haumea
• The asteroid Ceres
• Other KBOs likely to be discovered that are also dwarf planets

Ceres composition

Asteroids

Gaspra

Ida, Gaspra, Deimos, Phobos

Major Impact Structures
Meteor Crater, Arizona

Manicouagan, Quebec

Shoemaker-Levy 9

Electromagnetic Spectrum

Continuous Spectrum

Dark Line Spectrum

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength (nanometers)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>380–440</td>
</tr>
<tr>
<td>Blue</td>
<td>440–500</td>
</tr>
<tr>
<td>Green</td>
<td>500–560</td>
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<tr>
<td>Yellow</td>
<td>560–590</td>
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<tr>
<td>Orange</td>
<td>590–640</td>
</tr>
<tr>
<td>Red</td>
<td>640–750</td>
</tr>
</tbody>
</table>

*One nanometer is 10^-9 meter.
- Incandescent hot gas emits its elemental wavelength signature.
Solar wind blows comet tails

[Link](http://www.astro.uva.nl/demo/sun/inter.htm)

Solar Prominence

[Video](http://antwrp.gsfc.nasa.gov/apod/image/0109/sunplume_soho_big.gif)
[Video](http://antwrp.gsfc.nasa.gov/apod/ap030223.html)

Auroras

[Photo](http://www.astro.uva.nl/demo/sun/aarde.htm)

Surface Detail of Sun

- Nuclear Fusion of 4 Hydrogen to 1 Helium
- Difference in atomic mass is released as energy
- Released as photons—light particles
- Convection brings photons to photosphere
- Sun will last about another 5 billion years

Sun Structure

- Photosphere: most visible part—“Surface”
  - Hydrogen and helium
  - Granules, sunspots
- Chromosphere: lower atmosphere
  - Spicules from granules of photosphere
  - Prominences
- Corona: outer atmosphere
  - Ionized gases
  - Solar wind
- Solar flares
  - High pressure
  - Associated with sunspots

Solar Interior

Now: hot core + warm surface; small size.  
Future: very hot core + cool surface. Large size but less mass; very bright.