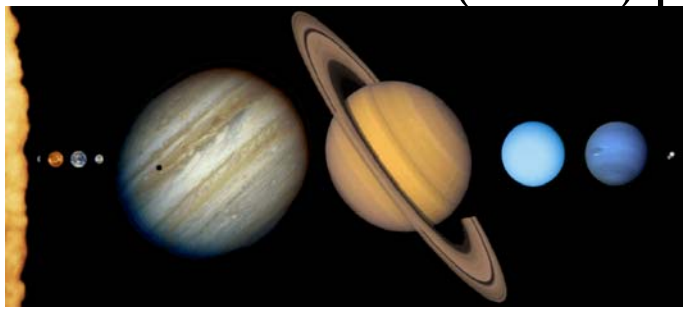
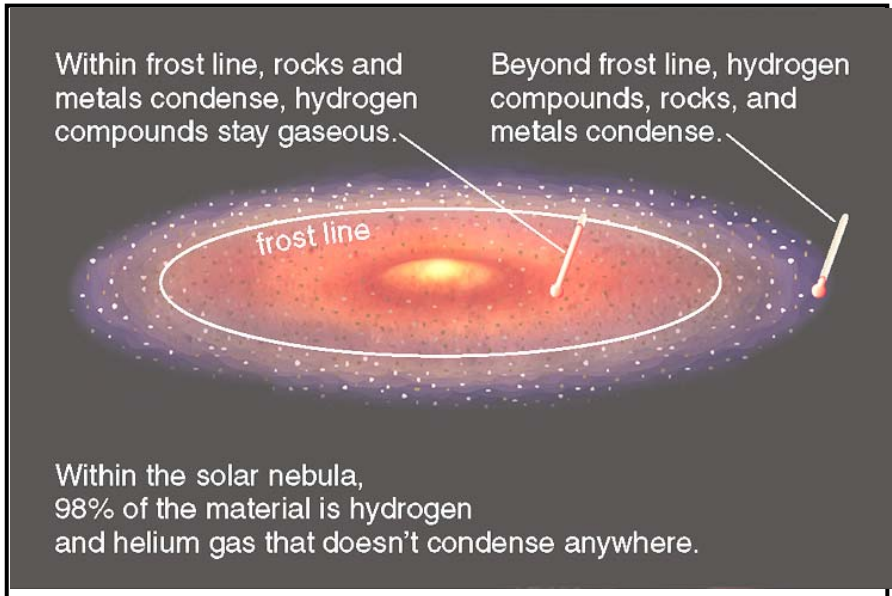
Overview of Solar System

- The solar system is a disk
  - Rotation of sun, orbits of planets all in same direction.
  - Most planets rotate in this same sense. (Venus, Uranus, Pluto are exceptions).
  - Angular momentum of pre-solar gas cloud.
- Terrestrial vs. Jovian (Giant) planets



  - High vs. low density
    - Rocks vs. mostly gas
  - Composition
    - heavy elements vs. primarily H/He
  - Difference due to distance from Sun.

Object	% Total Mass
Sun	99.8
Jupiter	0.1
Comets	0.05
All other planets	0.04
Satellites & rings	0.00005
Asteroids	0.000002
Cosmic dust	0.0000001



During planet formation in Solar Nebula:
Presence of ice

➔ **more material for core**

➔ **could gravitationally attract large masses of hydrogen & helium gas.**

Terrestrial Planets

- Earth
  - Differentiated:
    - Iron/nickel core
    - Mantle of lighter rock
    - Thin crust on top
  - Plate Tectonics
  - Evolution of atmosphere
    - Thick CO_2 ➔ life ➔ N_2, O_2
    - Current global warming
      - Greenhouse effect
      - Man-made CO_2
- (Moon)
  - Impact craters as clocks
  - Old highlands (4.1-4.4 billion yrs)
    - Heavily cratered
  - Maria (3.3- 3.8 billion yrs)
    - Fewer craters
  - Rocks from each brought back by Apollo astronauts.
    - Age dating
    - Chemical composition
  - Tidally locked to Earth
  - Formation of Moon
    - Giant Impact is current favorite theory… collision between Earth & Mars-sized object.
- Mercury
  - Closest to Sun, eccentric orbit.
  - Airless, heavily cratered.
  - Hot, but (slightly) colder than Hell.
  - Very dense - mostly iron-nickel core.
  - Geologically dead (probably)
    - But rupes ➔ shrinkage at early time.
  - Rotates in 2/3 of its orbital period
    - Tidal locking with a twist.

Terrestrial Planets (continued)

Venus

- Differentiated like Earth
  - But no tectonic plates.
- Surface mostly studied by radar
  - Large volcanoes
  - "Continents" pushed up by tectonic flows in mantle.
  - Recent lava flows, constant resurfacing.
  - Crater density ➔ very young surface
    - only 800 million yrs old.
- Thick CO_2 atmosphere
  - Result of runaway greenhouse effect.
  - Keeps surface very hot (900F).
    - Lead, brimstone (sulfer) are molten.
- Retrograde rotation
  - Probably due to giant impact.

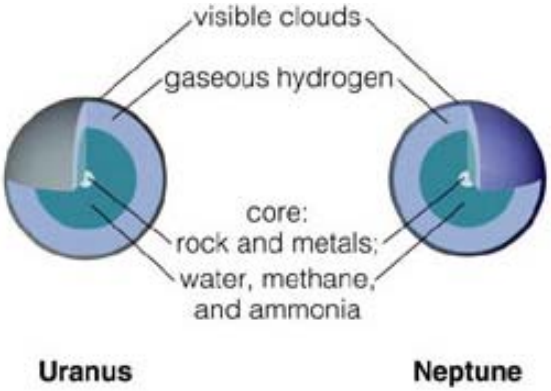
Mars

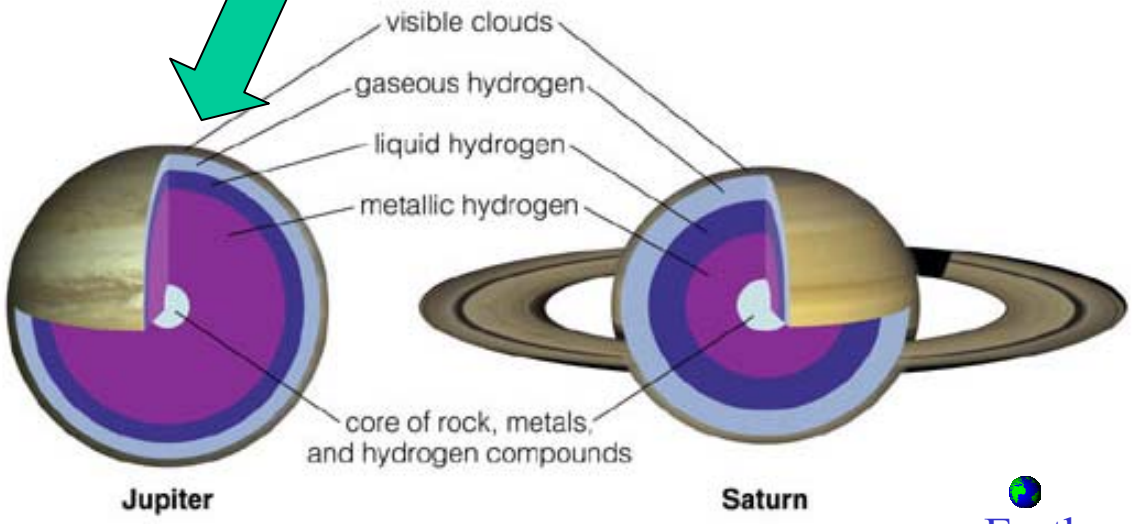
- 50% smaller diameter than Earth
- 1.5 times further from Sun.
- Gigantic volcanoes.
- 50% highland "continents"
  - Tharsis bulge.
  - Cracked open to form Valles Marineris.
- 50% low-lying lava plains.
- Atmosphere
  - CO_2, like Venus, but very thin.
  - Liquid water currently impossible.
- Climate change
  - Loss of atmosphere
    - Low escape velocity
    - Solar wind
  - Could not retain heat
  - Water froze out
    - even less heat retained
  - 2 Rovers currently searching for evidence of past water.
- Life?
  - Viking landers found no sign.
  - Questionable data in meteorite.

The Giant Planets

Jupiter – Saturn – Uranus - Neptune

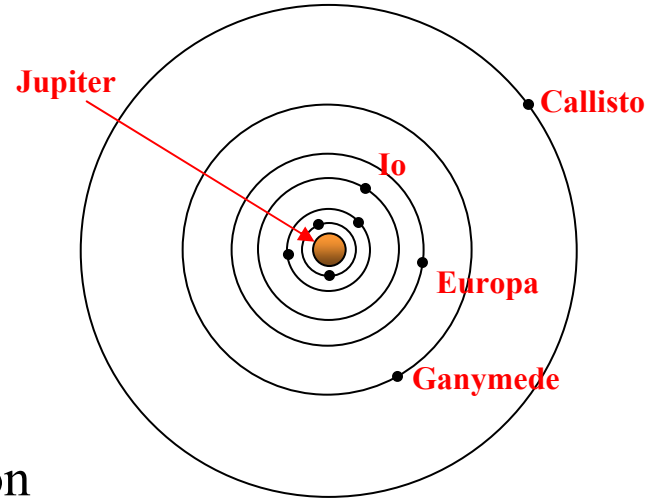
- 14-300 x more massive than Earth.
- Massive H, He atmospheres
  - By far the most abundant elements in the solar system.
- On top of rock/ice core with 10-15 x mass of Earth.
- Lots of weather on Jupiter
  - Ammonia (NH_3) clouds
  - Strong winds at differer latitudes.
    (differential rotation)
  - Cyclonic storms
    - Great Red Spot
      - 2 x size of Earth
      - 400 yrs so far
  - Investigated by Galileo probe.





Earth

Moons



- Jupiter's Galilean moons, as we get closer to Jupiter:
  - Callisto – ice, geologically dead.
  - Ganymede – ice, but geologically active.
  - Europa – rock, but covered by ice pack over liquid water.
  - Io – rock, extreme volcanic activity.
- Gradient of properties due to increased tidal effects & heating from Jupiter.
- Jupiter's 59 other moons are much smaller.
- Saturn: 33 known moons
  - largest is Titan
    - N_2 atmosphere.
    - Similar to Earth's, but very cold (ethane oceans).
    - Cassini/Huygens probe to land in 2004.
- Triton
  - Neptune's largest moon.
  - Retrograde orbit.
  - 75% rock, 25% ice.
  - Very thin N_2 atmosphere.
- Pluto (& Charon)
  - No spacecraft visits, so little is known
  - Pluto probably quite similar to Triton.
  - Charon is half as big as Pluto.
  - Pluto is probably just the largest Kuiper belt object.
    - Very low mass.
    - Eccentric, tilted orbit.
    - Similar to some comets.

Rings

- All 4 giant planets have rings.
- Rings form inside Roche limit:
  - $P^2 = a^3$ ➔ different parts of a moon try to move in orbits with different periods.
  - This tears bodies apart unless gravity (+ internal tensile strength) can hold them together.
  - For orbits inside Roche limit, prospective moons are torn apart.
- But rings constantly replenisheed by material abraded off small moons.
- Jupiter, Uranus, Neptune have very thin rings. Saturn has much larger rings.
- Shepherd satellites
  - moons sweep out divisions, contain rings through gravitational resonances.
- Rings made of ice and small bits of dust.

Comets

- Mostly ice
- Some on highly eccentric orbits
  - Spectacular tails when close to Sun.
  - Melted ice is driven off by solar radiation, solar wind.
- Most come from Oort Comet Cloud at edge of solar system.
  - Some from Kuiper Belt, just beyond Pluto.

Asteroids

- Small rocky bodies in orbit about sun.
  - Left over from formation of Solar System.
- Most, but not all, in asteroid belt.
  - Some cross Earth's orbit

Meteorites

- Asteroids that hit Earth and don't burn up in atmosphere.
- Analyzing them ➔
  - Age of solar system (4.5 billion yrs)
  - Initial chemical composition of solar system.