

# Review Sessions

Two choices:

- Monday: 7PM
- or Tuesday: 6PM
- Both in  
Plant & Soil Science (PSS)  
room A101  
(corner of Wilson & Bogue)

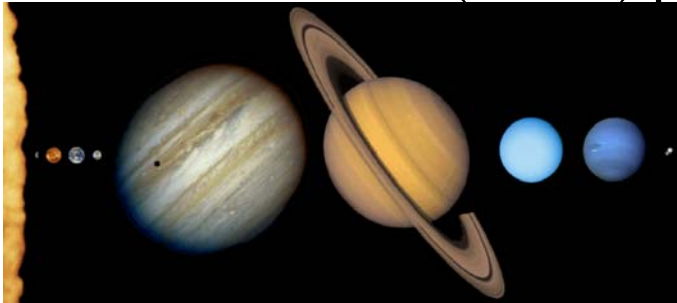


**Print & bring Study Guide**

- on course web site (reachable through Angel)

# Overview of Solar System

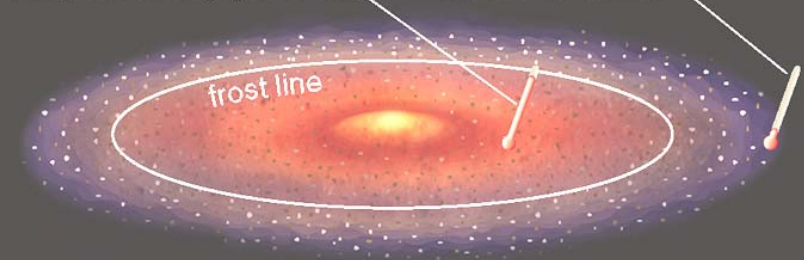
- The solar system is a disk
  - Rotation of sun, orbits of planets all in same direction.
  - Most planets rotate in this same sense. (Venus, Uranus, Pluto are exceptions).
  - Angular momentum of pre-solar gas cloud.
- Terrestrial vs. Jovian (Giant) planets



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

Within frost line, rocks and metals condense, hydrogen compounds stay gaseous.

Beyond frost line, hydrogen compounds, rocks, and metals condense.



Within the solar nebula, 98% of the material is hydrogen and helium gas that doesn't condense anywhere.

## During planet formation in Solar Nebula: Presence of ice

- ➔ more material for core
- ➔ could gravitationally attract large masses of hydrogen & helium gas.

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

# Terrestrial Planets

- Earth

- Differentiated:
  - Iron/nickel core
  - Mantle of lighter rock
  - Thin crust on top
- Plate Tectonics
- Evolution of atmosphere
  - Thick CO<sub>2</sub> → life → N<sub>2</sub>, O<sub>2</sub>
  - Current global warming
    - Greenhouse effect
    - Man-made CO<sub>2</sub>

- (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<sub>2</sub> atmosphere
  - Result of runaway greenhouse effect.
  - Keeps surface very hot (900F).
    - Lead, brimstone (sulfur) are molten.
- Retrograde rotation
  - Probably due to giant impact.

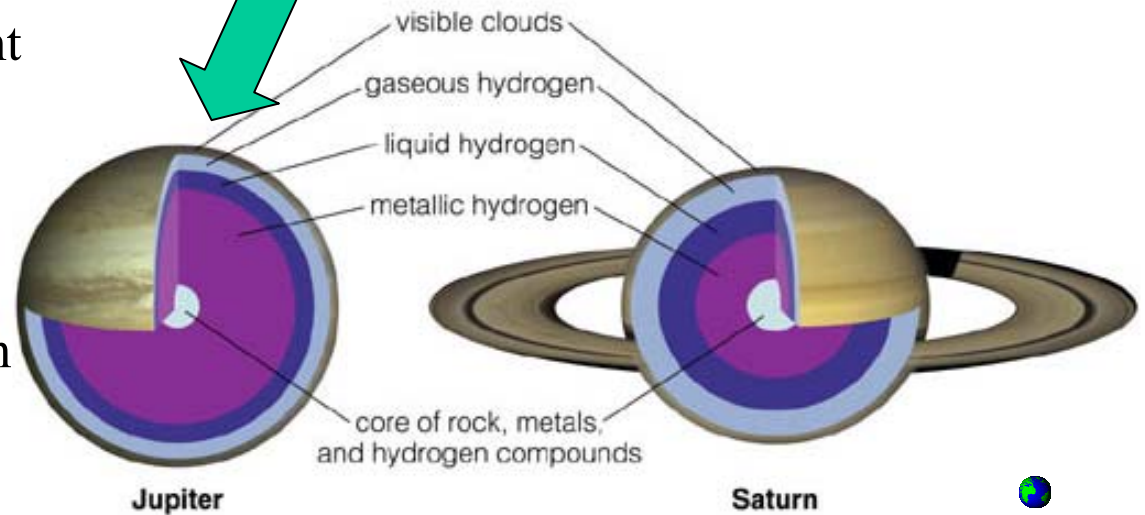
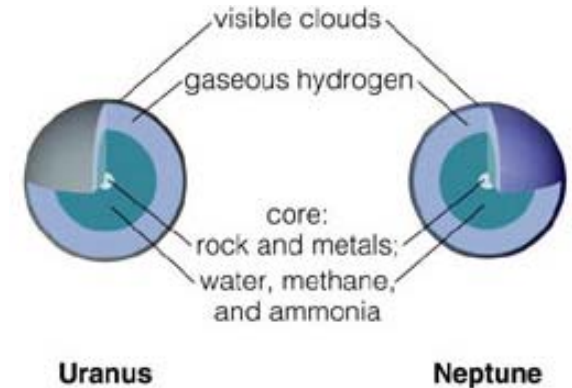
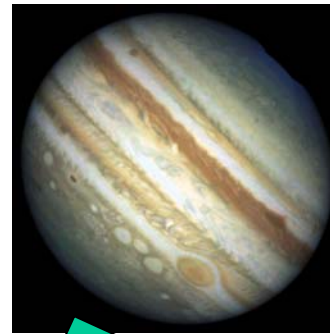
### Mars

- 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<sub>2</sub>, 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 are finding evidence of past water.
- Life?
  - Viking landers found no sign.
  - Questionable data in meteorite.

# The Giant Planets

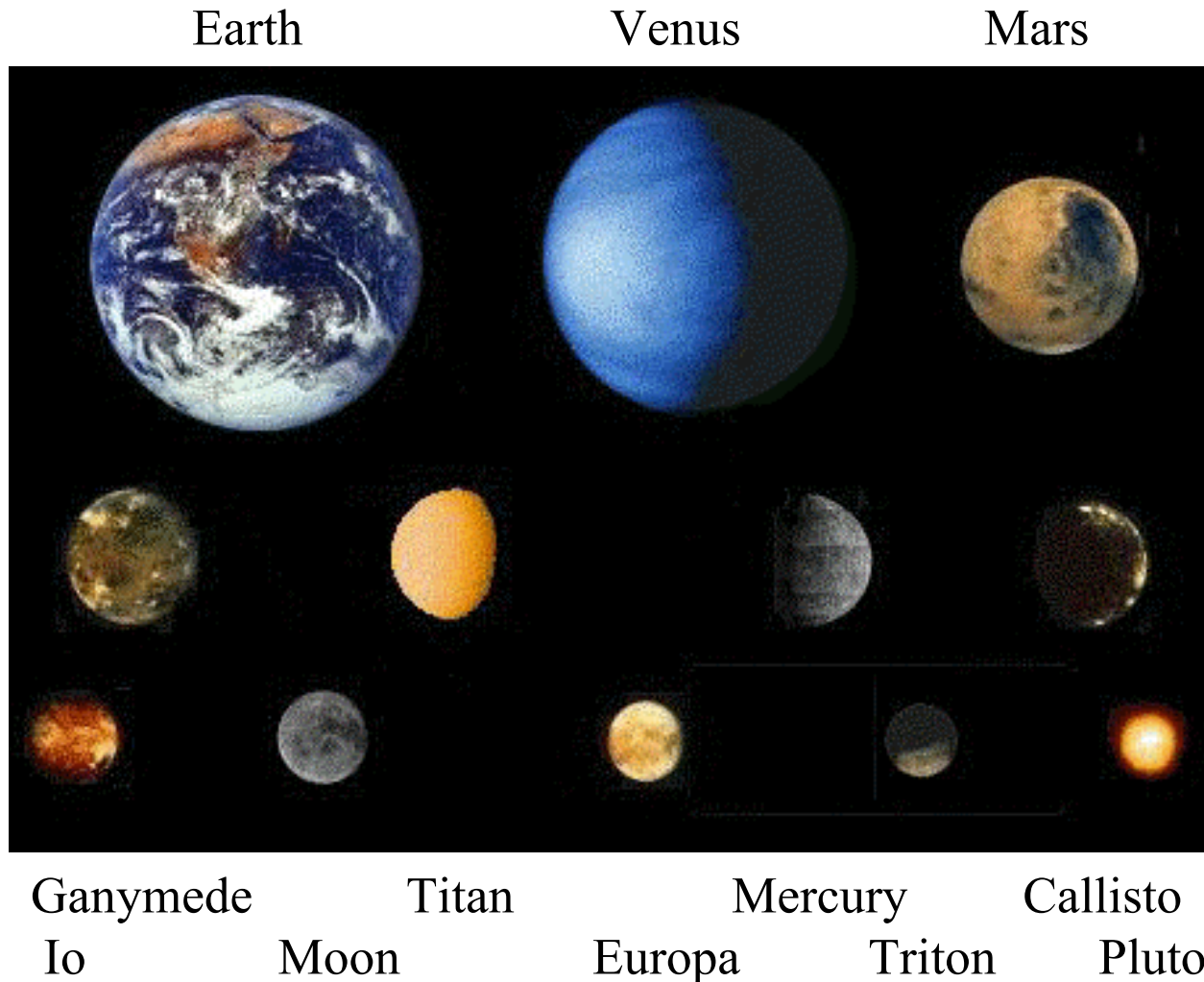
## Jupiter – Saturn – Uranus - Neptune

- 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<sub>3</sub>) clouds.
  - Strong winds at different latitudes.  
(differential rotation)
  - Cyclonic storms
    - Great Red Spot
      - 2 x size of Earth
      - 400 yrs so far
  - Investigated by Galileo probe.





# Some planets and moons shown in correct relative sizes



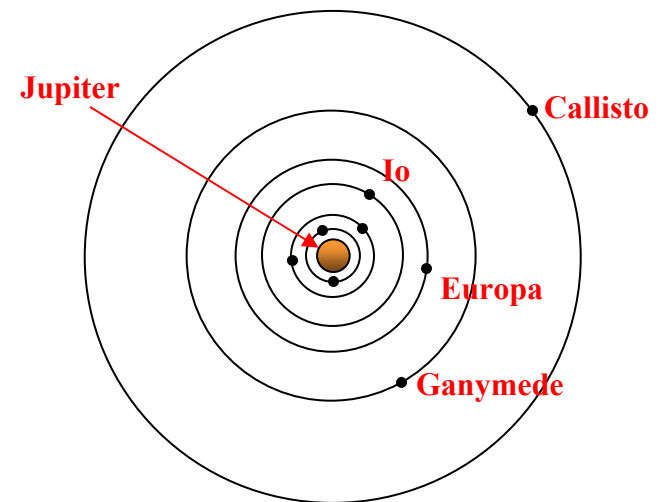
**Planets:**  
orbit around  
Sun

**Moons:**  
orbit around  
planets

**But...**  
asteroids,  
comets, dwarf  
planets =  
small bodies  
orbiting sun.

# 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<sub>2</sub> atmosphere.
    - Similar to Earth's, but very cold (methane lakes).
    - Cassini/Huygens visit.



# 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.

# Rings

- All 4 giant planets have rings.
- Rings form inside Roche limit:
  - $P^2 = a^3 \rightarrow$  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 replenished 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.
- Pluto (& Charon)
  - No spacecraft visits, so little is known
  - Pluto probably quite similar to Triton.
    - Triton is Neptune's largest moon.
      - Retrograde orbit around Neptune.
      - 75% rock, 25% ice.
      - Very thin  $N_2$  atmosphere.
    - Charon is half as big as Pluto.
    - Pluto now called a “Dwarf Planet”
    - Just one of several large Kuiper belt objects, all of which have:
      - Very low mass.
      - Eccentric, tilted orbits