Today’s Class: The Jovian Planets & Their Water Worlds

- Next Class: The Ice Giant Planets and Asteroids.
- Reading: Sections 11.2, 12.1, 12.2, 12.5 in Cosmic Perspective.

Clicker Question: What is the leading hypothesis for Venus’ lack of water?

a) It’s water molecules were broken apart, and hydrogen was lost to space.

b) Venus formed closer to the Sun and accreted very little water.

c) Its water is locked away in the crust along with carbon.

- Active volcanoes absorbed all the water early in the evolution of Venus.

Last Class

- The atmosphere of Venus.
- Greenhouse Effect on Venus & Earth.
- How did Earth’s atmosphere end up so different from Venus?
  - Effects of water and carbon
  - Dangers of human activity

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Today’s Class

- Inside Jupiter
  - Source of heat
  - Magnetosphere
- NASA's Juno mission
- The moons of Jupiter
  - Io: Active volcanoes
  - Europa: Possible ocean & life?
- The Saturn System
  - Titan
  - Enceladus
- NASA's Cassini mission

Jupiter

- Much farther from Sun than inner planets
- Mostly H/He; no solid surface
- 300 times more massive than Earth
- Many moons, rings
Jupiter’s moons can be as interesting as planets themselves, especially Jupiter’s four Galilean moons.

- Io (shown here): active volcanoes all over
- Europa: possible subsurface ocean
- Ganymede: largest moon in solar system
- Callisto: a large, cratered “ice ball”

Inside Jupiter

- High pressures inside Jupiter cause phase of hydrogen to change with depth.
- Hydrogen acts like a metal at great depths because its electrons move freely.

Jupiter’s Internal Heat

- Jupiter radiates twice as much energy as it receives from the Sun.
- Energy probably comes from slow contraction of interior (releasing potential energy).

Jupiter's Magnetosphere

- Jupiter's strong magnetic field (20,000 times Earth!) gives it an enormous magnetosphere.
- Gases escaping Io feed the donut-shaped Io torus.

Clicker Question: Jupiter does not have a large metal core like the Earth. How can it have a magnetic field?

a) The magnetic field is left over from when Jupiter accreted.
b) Its magnetic field comes from the Sun.
c) It has metallic hydrogen inside, which circulates and makes a magnetic field.
d) Its core creates a magnetic field, but it is very weak.
Juno
- Solar-powered, spinning spacecraft
- 8 Science instruments

Proposed/selected 2005
Launched Aug 5th 2011
Arrived Jul 4th 2016

The Juno Spacecraft
Juno’s key components:
- Solar arrays
  2m x 7.5m arrays producing ~300 W
  Sun-pointed, spinning 2 rpm

Spacecraft & Payload

Juno: Close Polar Orbit is Key

Why are Jupiter’s Galilean moons so geologically active?
Io's Volcanoes

- Volcanic eruptions continue to change Io's surface.

Tidal Heating

Io is squished and stretched as it orbits Jupiter.

Europa's Ocean: Waterworld?

Tidal stresses crack Europa's surface ice

Europa's interior also warmed by tidal heating

NASA Robotic Mission to Europa

**Goal:** JPL's Europa Clipper will investigate whether the icy moon could harbor conditions suitable for life. Mission will use a radiation-tolerant spacecraft with repeated close flybys of Europa from a long, looping orbit around Jupiter.
Saturn

• Giant and gaseous like Jupiter
• Spectacular rings
• Many moons, including cloudy Titan

Saturn

• Rings are NOT solid; they are made of countless small chunks of ice and rock, each orbiting like a tiny moon.

Medium and Large Moons

• Enough self-gravity to be spherical
• Have substantial amounts of ice
• Formed in orbit around jovian planets
• Circular orbits in same direction as planet rotation

Titan's Atmosphere

• Titan is the only moon in the solar system to have a thick atmosphere.
  • It consists mostly of nitrogen with some argon, methane, and ethane.

Titan's Surface

• Huygens probe on Cassini provided first look at Titan's surface in early 2005.
• It found liquid methane and "rocks" made of ice.

Dragonfly: Mission to Titan
**Enceladus – Geysers of Water**

- Ice fountains of Enceladus suggest it may have a subsurface ocean.

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**NASA's Cassini Mission: The End in 2017**

- Cassini's Final Hour
  - Measurements of:
    - Exosphere/Thermosphere
    - Ionosphere
    - "Ring rain"
    - Magnetic Field

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**Saturn's Atmosphere**

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**What did we learn Today?**

- **Inside Jupiter**
  - Source of heat
  - Magnetosphere
- **NASA's JUNO mission**
- **The moons of Jupiter**
  - Io: Active volcanoes
  - Europa: Possible ocean & life?
- **The Saturn System**
  - Titan
  - Enceladus
- **NASA's Cassini mission**