Astronomy 122

This Class (Lecture 10):

The Solar System

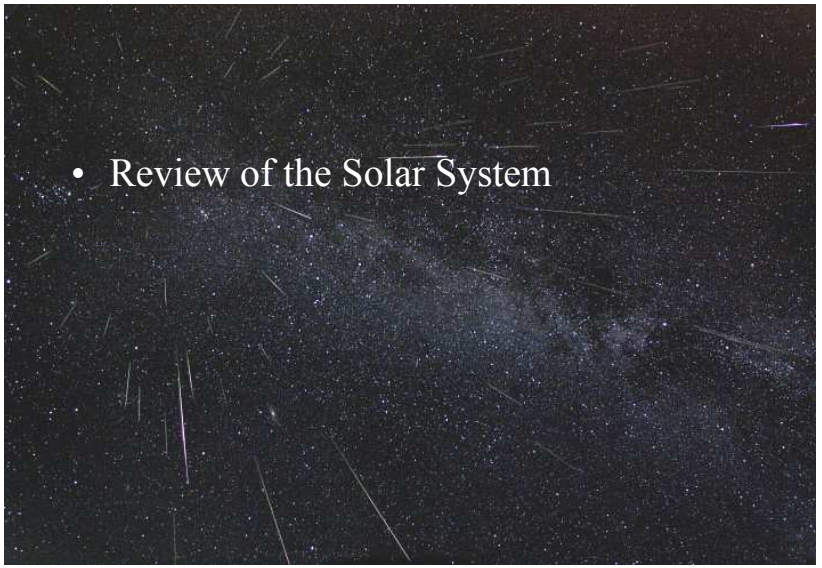
Homework #4 is posted.

Next Class:

The Sun

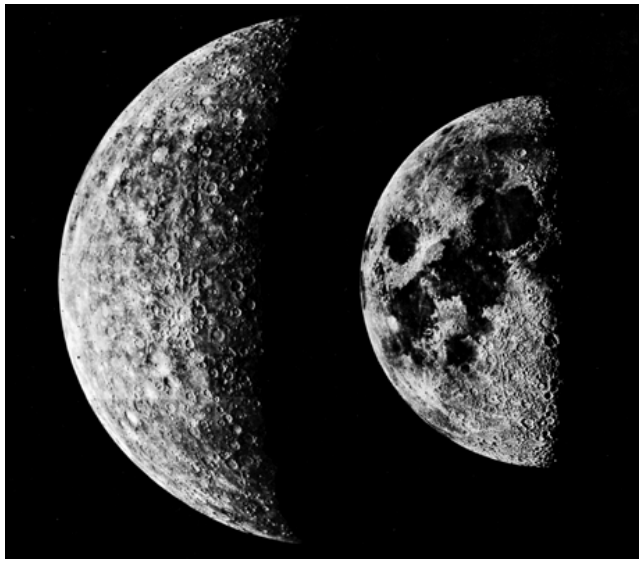
Music: *Venus* – Bjork

Outline



- Review of the Solar System

What's this Picture of?

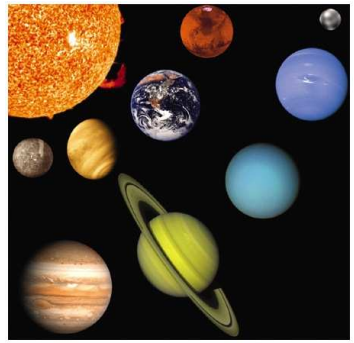


http://www.whfreeman.com/discovering/DTU/EXMOD36/F3609.HTM

It's not your parent's Solar System

The old style of teaching the Solar System

- Sun & 9 planets
- Separate section on each
- Mention asteroids and comets
- Lots of cool facts



Mercury Mary
Venus Vincent
Earth Eats
Mars Many
Jupiter Jelly
Saturn Sandwiches
Uranus Under
Neptune Neighbors
Pluto Porches

Mercury My
Venus Very
Earth Energetic
Mars Mother
Jupiter Just
Saturn Served
Uranus Us
Neptune Nine
Pluto Pizzas

21st Century View

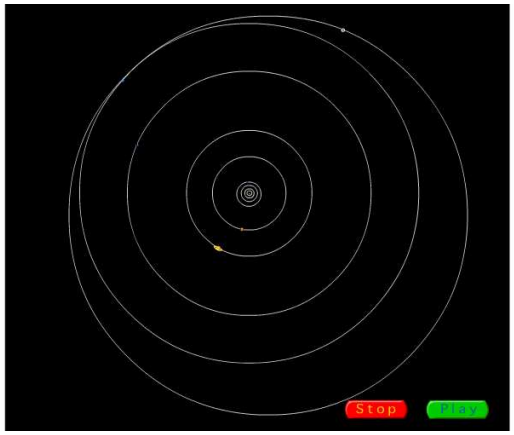
- Six families of the solar system
  - Star
  - Rocky planets
  - Asteroid belt
  - Gas giant planets
  - Kuiper belt
  - Oort cloud

Planets Dance

http://janus.astro.umd.edu/javadir/orbits/ssv.html

Planetary Orbits

- Orbital (and most rotational) motions in solar system are counter clock-wise in a flattened disk
- Orbits are actually close to circles, except Mercury and Pluto



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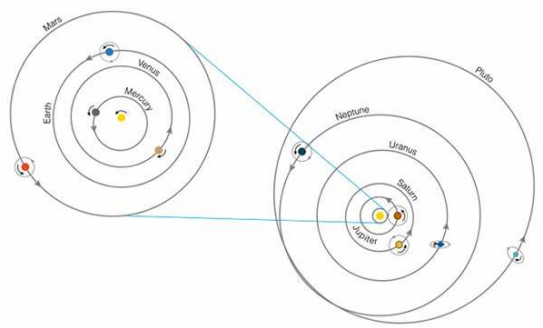
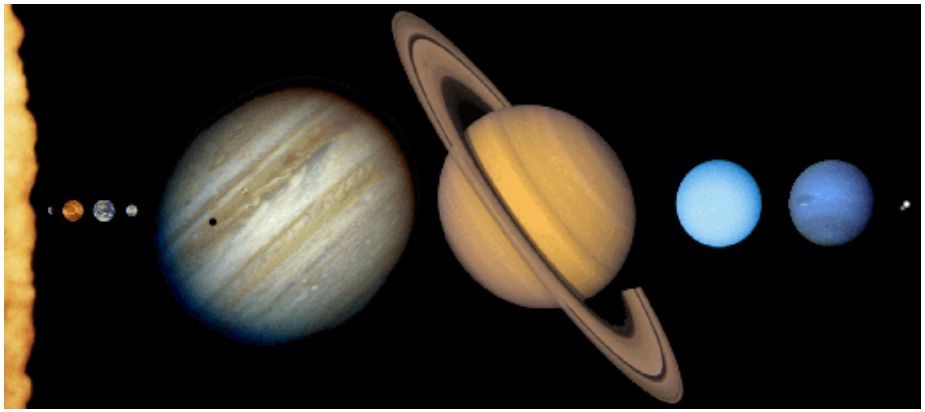


A Sense of Scale

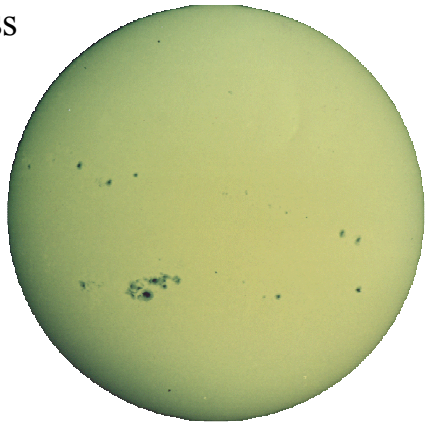
- Most pictures of the Solar System look something like this…



http://www.jpl.nasa.gov/galileo/sepo/education/nav/ss2.gif

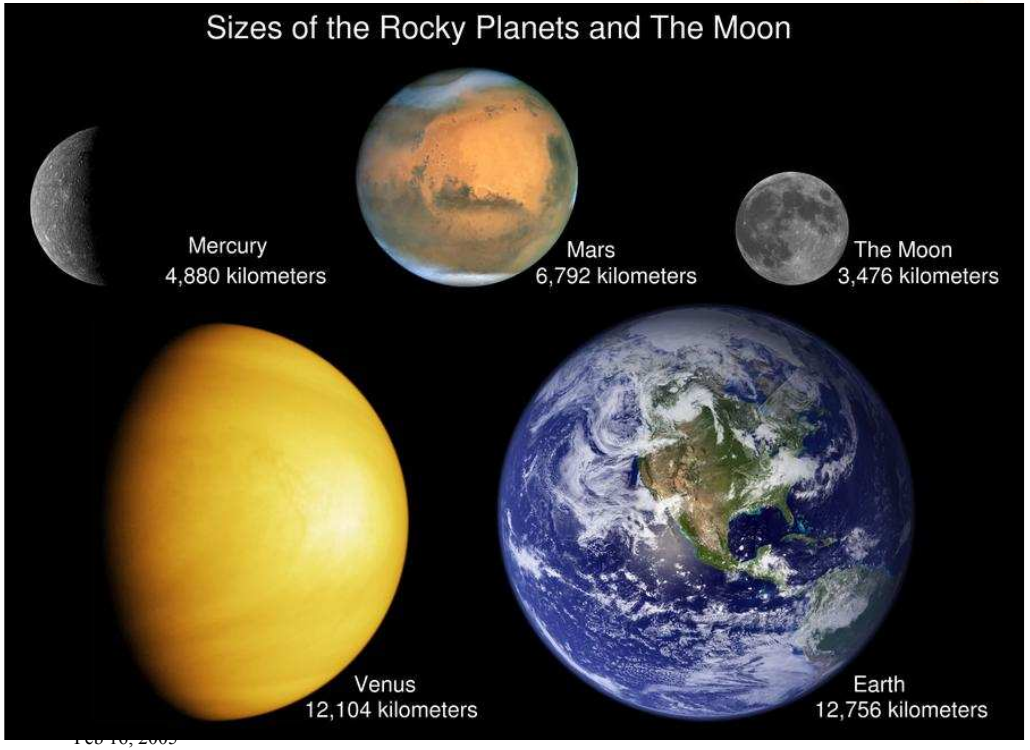
The Sun

- Dominates the solar system
  - 99.85% of the total mass
- Without the Sun's energy, life on Earth could not exist
- But the Sun is a fairly typical star
  - Understanding the Sun is vital to unlocking the secrets of the stars

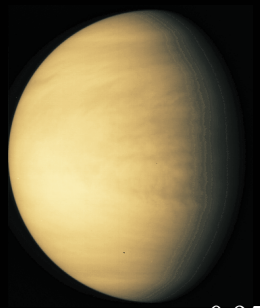


The Terrestrials

- Mercury, Venus, Earth, & Mars
  - Plus the Moon, if you want
- The closest planets to the Sun
- Small bodies, made mostly of rock and iron
- Very similar to each other in overall composition and structure
- Vastly differing surface conditions



Earth – Venus comparison



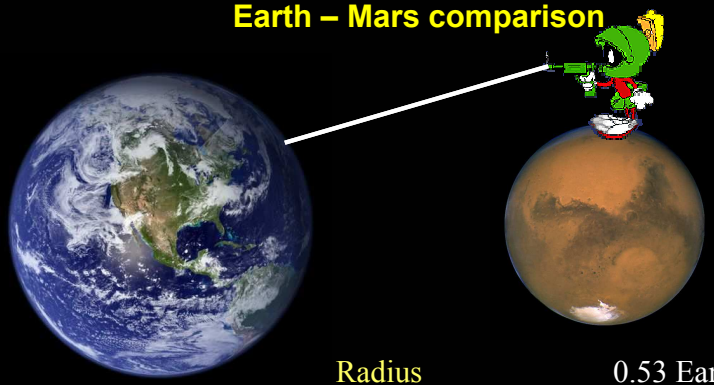
Venus is the hottest planet, the closest in size to Earth, the closest in distance to Earth, and the planet with the longest day.

Radius	0.95 Earth
Surface gravity	0.91 Earth
Mass	0.81 Earth
Distance from Sun	0.72 AU
Average Temp	475 C
Year	224.7 Earth days
Length of Day	116.8 Earth days
Atmosphere	96% CO_2

Turns Out that Venus is Hell

- The surface is hot enough to melt lead
- There is a runaway greenhouse effect
- There is almost no water
- There is sulfuric acid rain
- Not a place to visit for Spring Break.

Earth – Mars comparison

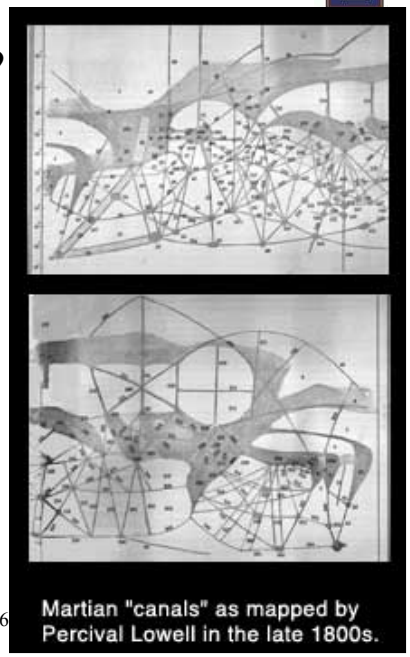


Mars has the Solar System's largest Volcano, Olympus Mons – 27 km tall.

Radius	0.53 Earth
Surface gravity	0.38 Earth
Mass	0.11 Earth
Distance from Sun	1.5 AU
Average Temp	-63 C
Max Temp	20 C
Year	687 Earth days
Length of Day	24 hours 39 minutes
Atmosphere	CO_2 95%

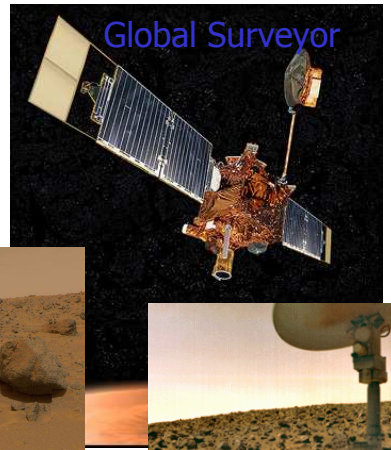
Percival Lowell's Canals

- Evidence for intelligent life?
- Mapped the civilization.
- Influenced culture.



Martian "canals" as mapped by Percival Lowell in the late 1800s.

Exploring Mars

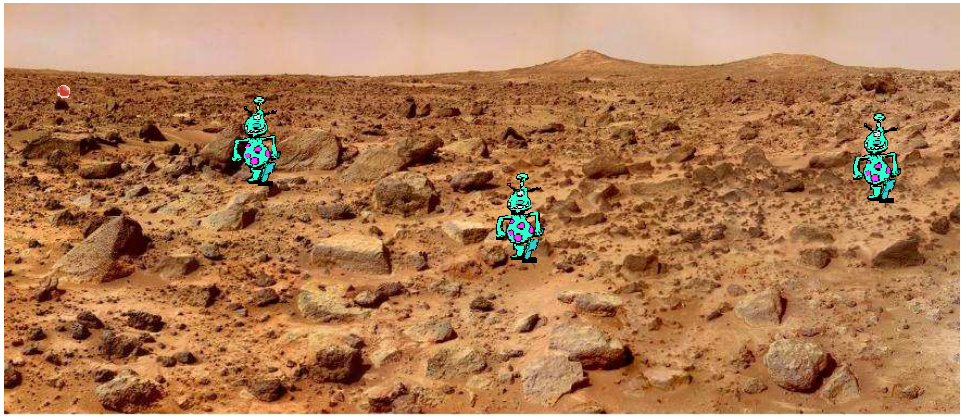


Missions to Mars

- Mankind has sent about 35 missions to explore Mars
  - More than any other planet
  - Mainly from the U.S. and Russia
- Only about 1/3 are successful in completing their missions (some are partly successful)
- We have learned a great deal from both the successes and failures

The Surface of Mars

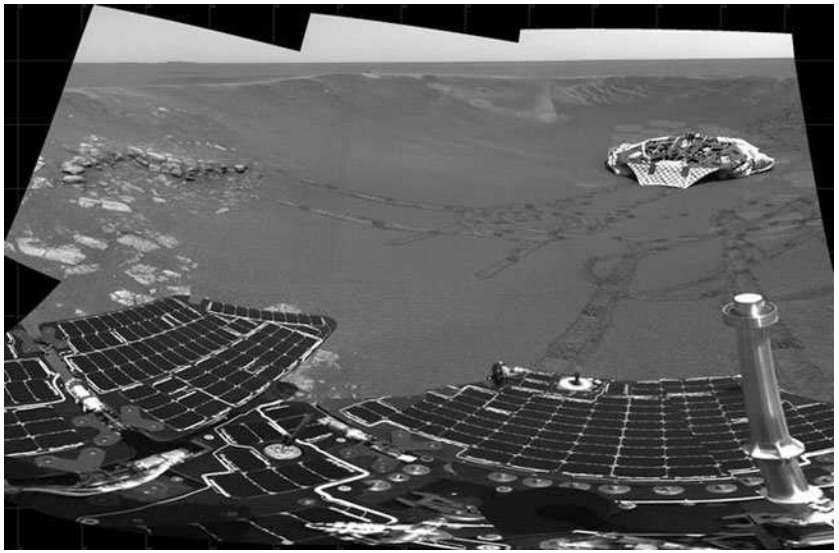
- Mars is a desert!
- Iron oxide in soil gives reddish cast.



View of "Twin Peaks" from Mars Pathfinder

 http://www.grc.nasa.gov/WWW/PAO/html/marspath.htm

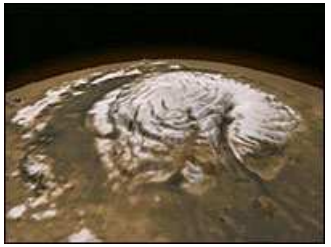
The Surface of Mars: Opportunity

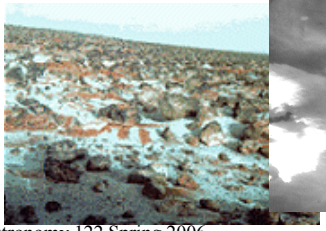


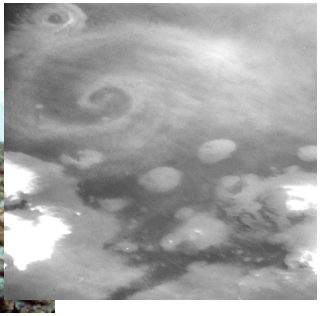
 http://antwrp.gsfc.nasa.gov/apod/ap040303.html

Water on Mars

- There **is** water on Mars
  - North and south polar caps (mostly CO_2)
  - Some water vapor in the air
  - Frost on rocks
  - Clouds (ice crystals)
- No *liquid* water now

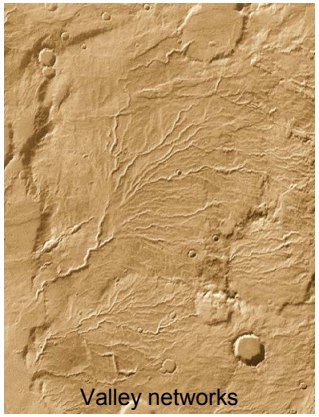


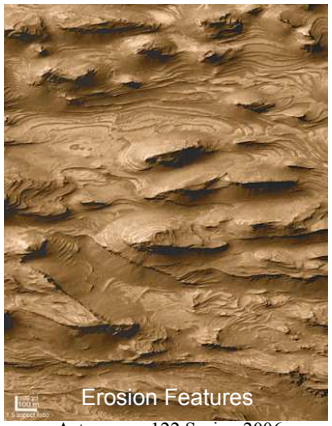


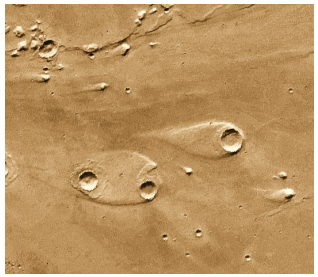


Liquid water on Mars?

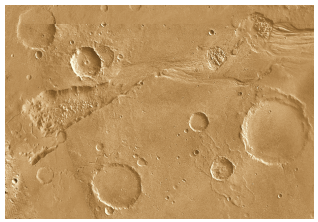
- Water erosion features visible from space
- Atmospheric pressure too low for liquid water to exist
- Perhaps at some point in the past?







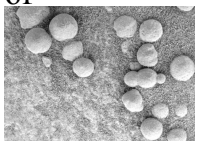
"Islands"

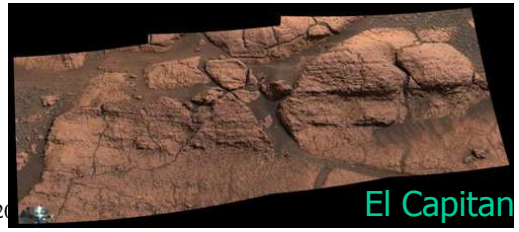


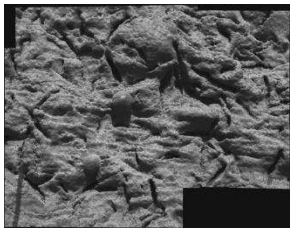
Flood erosion

Standing Water on Mars

- The new data from the rovers are highly suggestive of ancient standing water on the Meridiani Planum.
- 3 pieces of evidence:
  - Physical appearance of rocks
  - Rocks with niches where crystals appear to have grown
  - Rocks with sulfates left after the water evaporated
- Is it a former sea floor or just an area that had ground-water?



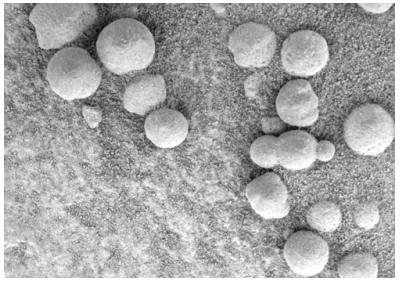


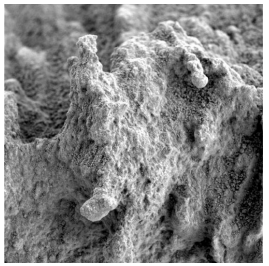


Mars' Watery Past

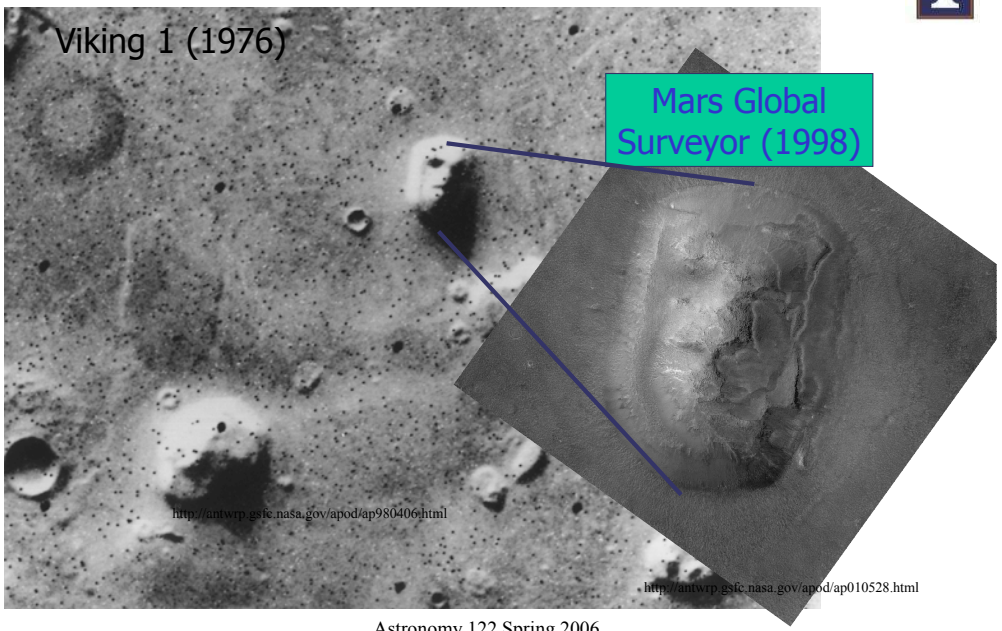
What Happened to the Water?

- That is the big question
  - Both Opportunity and Spirit have found evidence of water
  - Did the water escape to space with the air?
  - Is it frozen beneath the surface?
- The rovers are continuing their exploration
- More missions are planned





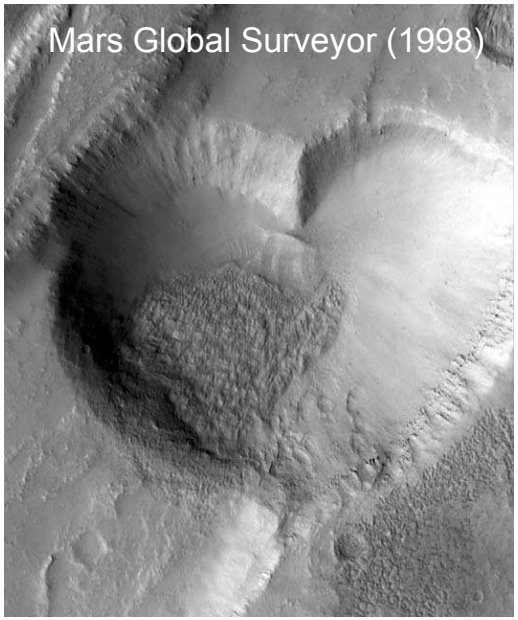
The "Face" of Mars?



Other Faces

http://antwrp.gsfc.nasa.gov/apod/ap990315.html

Other Places



http://www.solarviews.com/cap/mgs/heart.htm

Future Mars Missions

- Mars Reconnaissance Orbiter (2005)
  - Will study the geology and climate of Mars
  - Look for ancient sea shores
  - Survey potential landing sites

- Phoenix (2007)
  - Will analyze water ice at Mars' north pole

Manned Mars Exploration

- NASA's plans to send a manned expedition to Mars
- Timetable:
  - Complete Space Station by 2010
  - Return to Moon by 2020
  - Then, on to Mars (no date)
- No cost estimates
  - Some funds from to-be-retired shuttle fleet

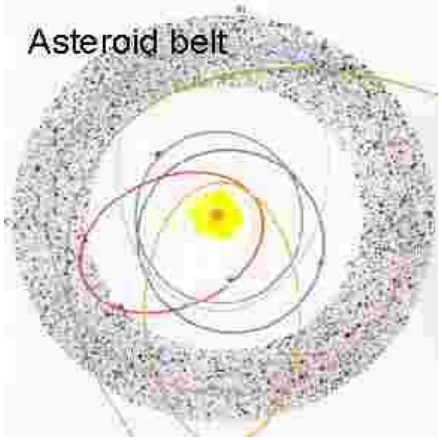
The Asteroids

- Mostly between the orbits of Mars and Jupiter
- Rocky debris left over from the formation of the solar system
- Some of the most ancient rocks in the solar system
- They hold the key to understanding its formation

Hollywood's View of the Asteroid Belt

The possibility of successfully navigating an asteroid field…

- Actually, NASA has sent many space probes into and through the Asteroid Belt
- Unlike in Star Wars, the Asteroid Belt is not that crowded
- Average separation between sizable asteroids is 10 million km!



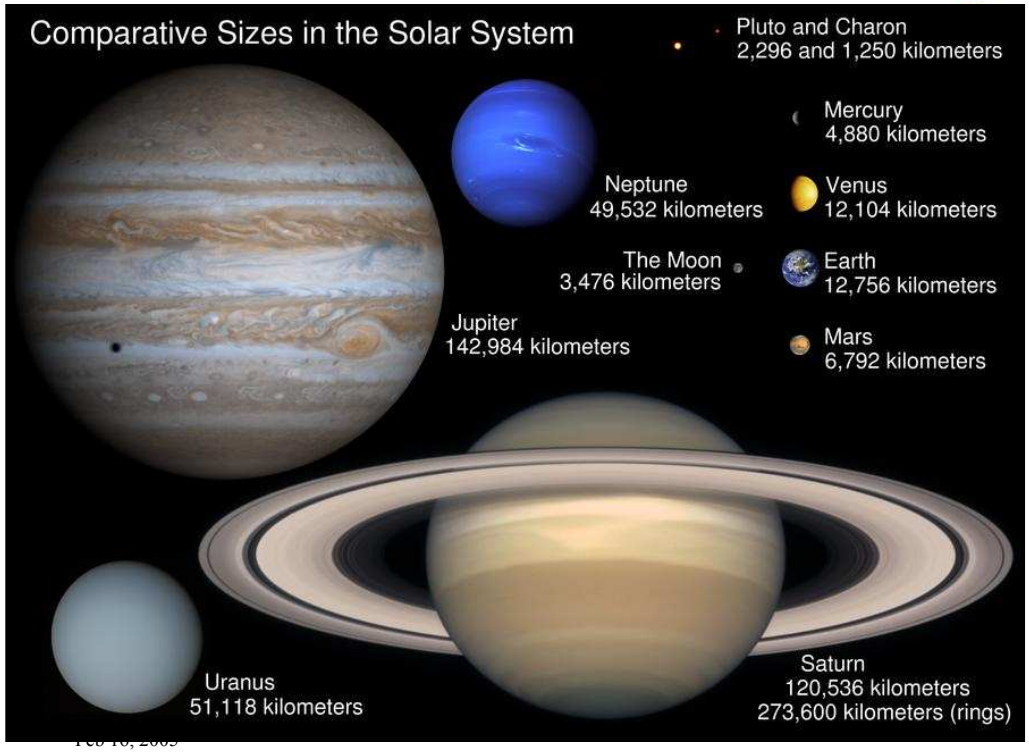
Thousands of asteroids …

On average, about a million miles apart!

Scientific View of the Asteroid Belt

Destroyed… by the Empire

- Are the asteroids a destroyed planet? **No**
  - Combined, the asteroids have a mass about 0.1% that of the Earth
  - Less than 10% that of our Moon
- The asteroids might be a *failed* planet
  - Jupiter's gravity kept the asteroids from coalescing into a planet
  - Jupiter probably ejected many asteroids from the Solar System



Earth – Jupiter comparison

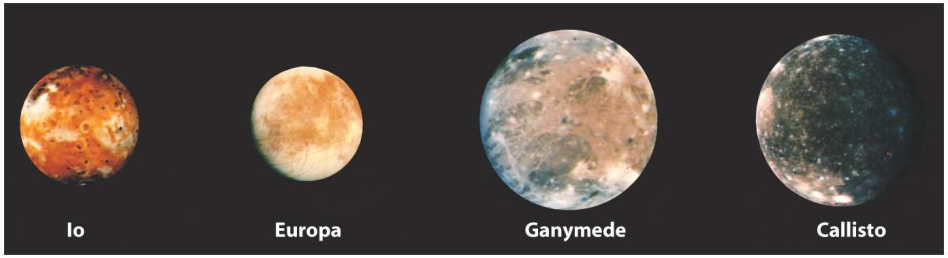
Biggest and most massive planet, has the largest gravity, has the largest number of moons (>61), yet has the shortest day in Solar System. Radiates more energy than it absorbs.

Radius	11.2 Earth
Cloud-top gravity	2.5 Earth
Mass	318 Earth
(more than 2.5 times the rest combined)	
Distance from Sun	5.2 AU
Year	11.88 Earth years
Solar day	9 hours 55 minutes

Causes a bulge at the equator.

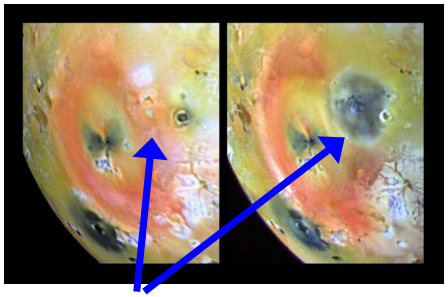
The Galilean Moons

- Europa is now thought to be the best option for life.
- But, Ganymede and Callisto are contenders.

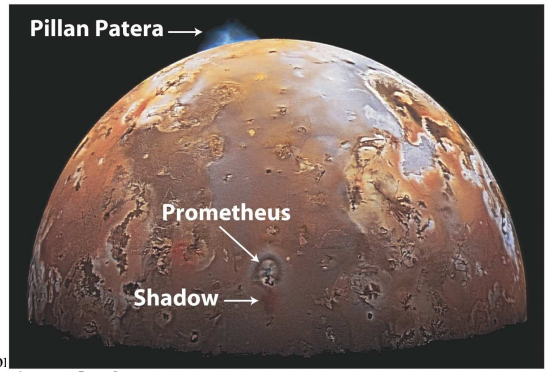


Io

- Innermost Galilean moon – the "pizza moon"
- The most volcanically active body in the solar system.
- Sulfur/sulfur dioxide on surface; silicate lava flows?
- Voyager 1 discovered presence of volcanoes
- Internal heating by Jupiter's tides
- Atmospheric gases ripped off by Jupiter's magnetic field.

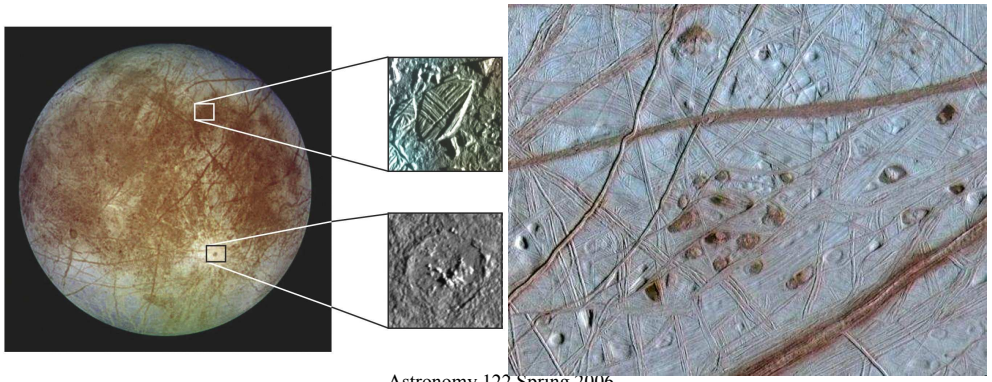


Pillan Patera eruption
Before & after



Europa

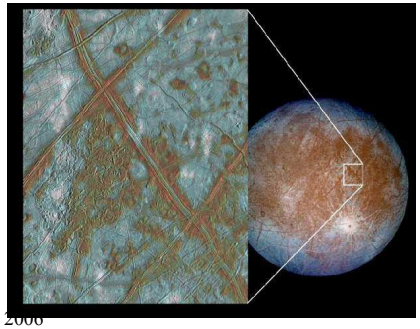
- Slightly smaller than our Moon.
- Icy crust 5 km thick. Can protect life against magnetic fields.
- Evidence for deep (50 km!) liquid water ocean beneath crust– remains liquid from tidal forces from Jupiter
- Cracks and fissures on surface – upwelling?



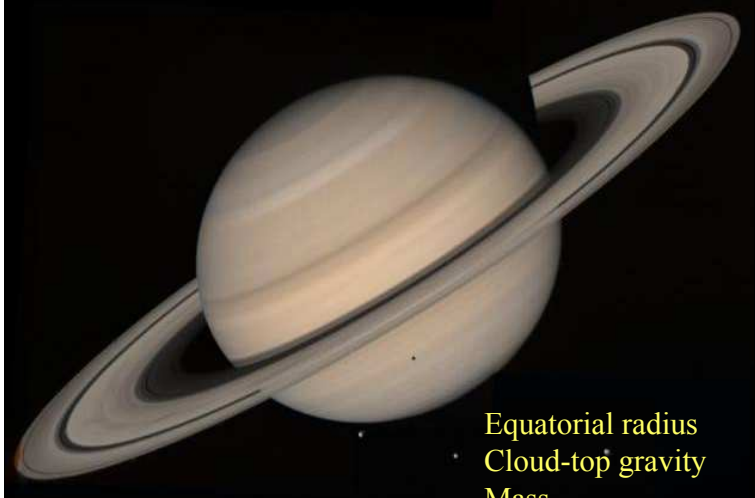
Galileo

Europa

- Few impact craters indicate recent resurfacing.
- Life would have to be below the surface, around hydrothermal vents.
- Like Io, it probably has strong tidal forces.
- Very encouraging, as early life on Earth, might have been formed around such vents.
- We don't how thick the ice is yet.
- To be continued.
- Future missions, will have to employ smash and dive spacecraft.



Earth – Saturn comparison



It floats. The least spherical planet.

Equatorial radius	9.45 Earth
Cloud-top gravity	1.07 Earth
Mass	95.2 Earth
Distance from Sun	9.53 AU
Year	29.5 Earth years
Solar day (equator)	10 hours 14 minutes

Jupiter-Saturn Comparison

Equatorial radius	0.84 Jupiter
Mass	0.30 Jupiter
Density	0.52 Jupiter

Almost as big as Jupiter, but Much less massive!

Saturn's Odd Moons

- **Mimas** - Crater two-thirds its own radius
- **Enceladus** - Fresh ice surface, water volcanoes?
- **Hyperion** – Irregularly shaped
- **Iapetus** - Half its surface is 10x darker than the other half
- **Pho** ts S back