

Astronomy 122



This Class (Lecture 6):

Our Solar System

Next Class:

Telescopes

Homework #2 due Sun!

Music: Venus as a Boy – Bjork

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TextBook



- TIS has the books in now.
- If you bought it earlier without the extras, you can bring in you receipt for iclicker rebate, planisphere, and Starry Night software.

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Outline



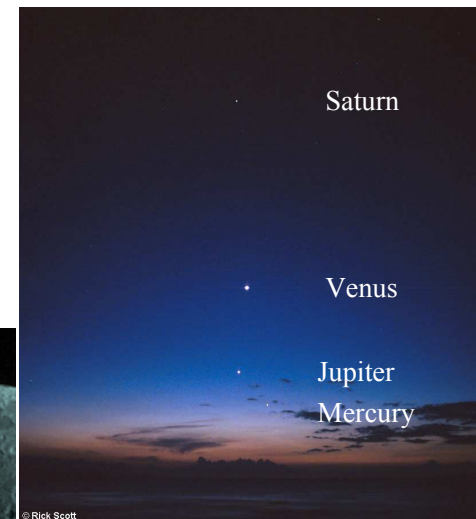
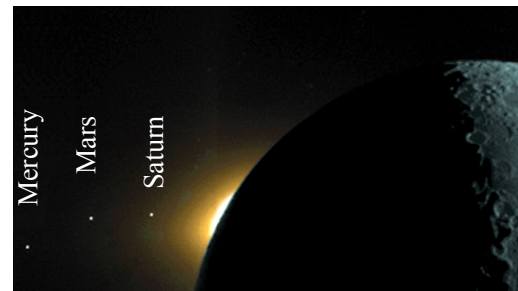
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The Planets



- In ancient times, people noted five bright “stars” that moved through the constellations of the Zodiac over time
- These “stars” were called *planets*, from Greek for “wanderers”



© Rick Scott

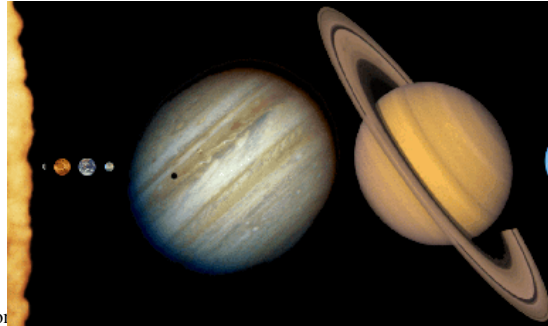
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<http://antwrp.gsfc.nasa.gov/apod/ap990325.html>
<http://antwrp.gsfc.nasa.gov/apod/ap001014.html>

Names of the Planets



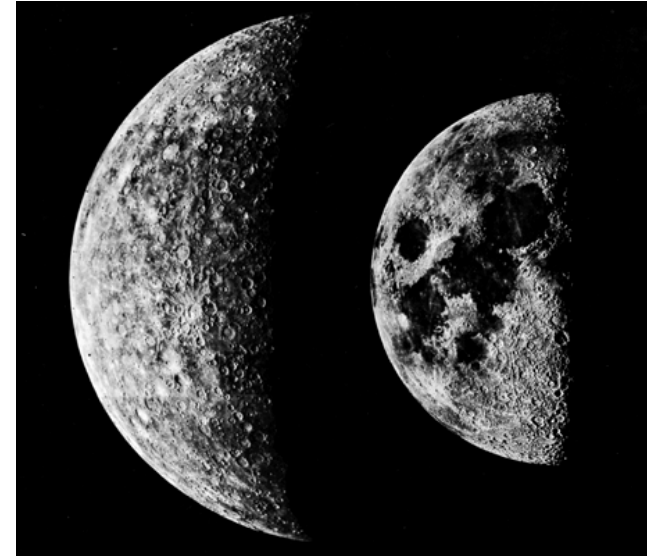
- Planets were given the names of Roman/Greek gods
 - Mercury (Hermes) – Messenger God (fast!)
 - Venus (Aphrodite) – Goddess of Beauty (brilliant!)
 - Mars (Ares) – God of War (red!)
 - Jupiter (Zeus) – King of the Gods
 - Saturn (Cronus)
 - Father of Zeus



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What's this Picture of?



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

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21st Century View



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

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Planetary Orbits



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



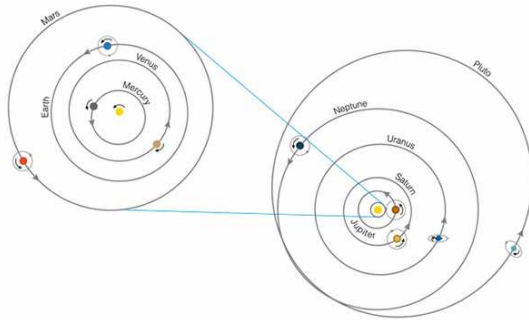
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Planetary Orbits



- Orbital (and most rotational) motions in solar system are counter clock-wise in a flattened disk
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Planets Dance



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

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Question



What do you think the orbit of planets tell us?

- Nothing
- It's just astronomical chance that they are going the same way.
- The planets and the asteroids may have been one single massive planet that broke up.
- Something fundamental about the origin of the Solar System.
- The Solar System is somehow related to a giant spinning top.

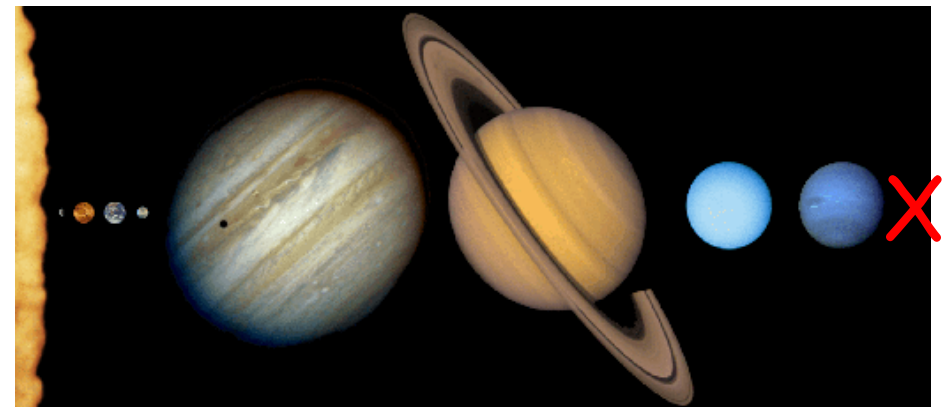
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A Sense of Scale



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



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

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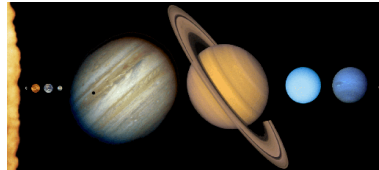
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Question



What was wrong with this picture?

- a) Earth is too big.
- b) The asteroids not included.
- c) The separations are not to scale.
- d) This conjunction of planets will destroy the Earth.
- e) Not drawn to scale.



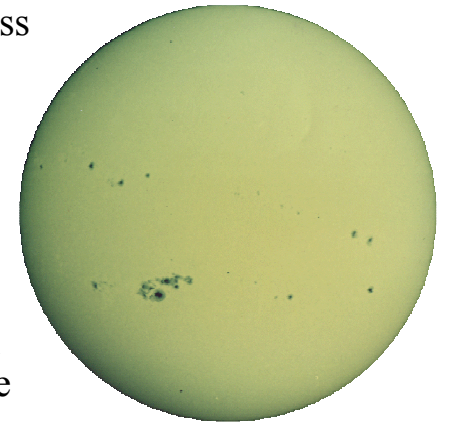
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The Sun



- 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



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The Terrestrials



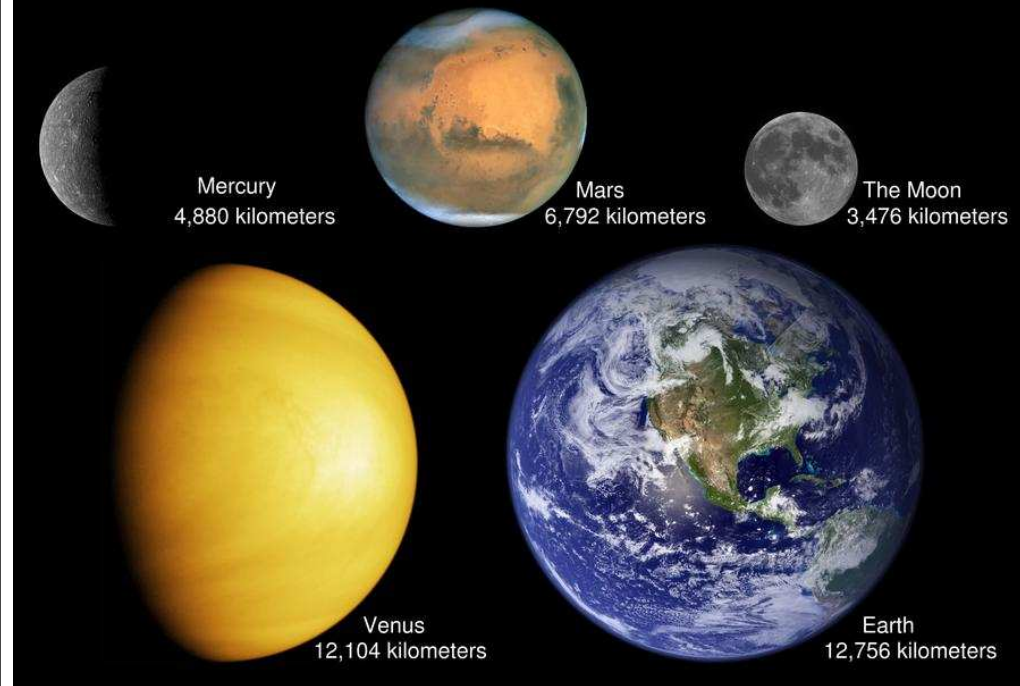
- Mercury, Venus, Earth, & Mars
 - Plus the Moon, if you want
- The closest planets to the Sun
- Small bodies, made mostly of rock and iron
- Very similar to each other in overall composition and structure
- Vastly differing surface conditions



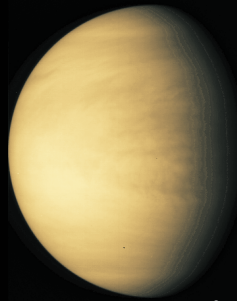
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Sizes of the Rocky Planets and The Moon



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



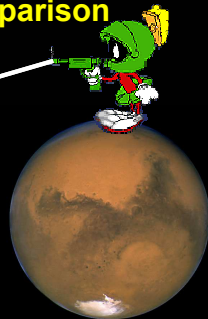
- The surface is hot enough to melt lead
- There is a runaway greenhouse effect
- There is almost no water
- There is sulfuric acid rain
- Not a place to visit for Spring Break.



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Earth – Mars comparison



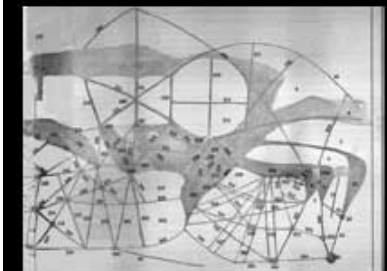
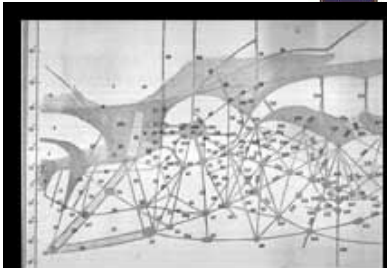
Mars has the Solar System's largest Volcano, Olympus Mons – 27 km tall.

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.

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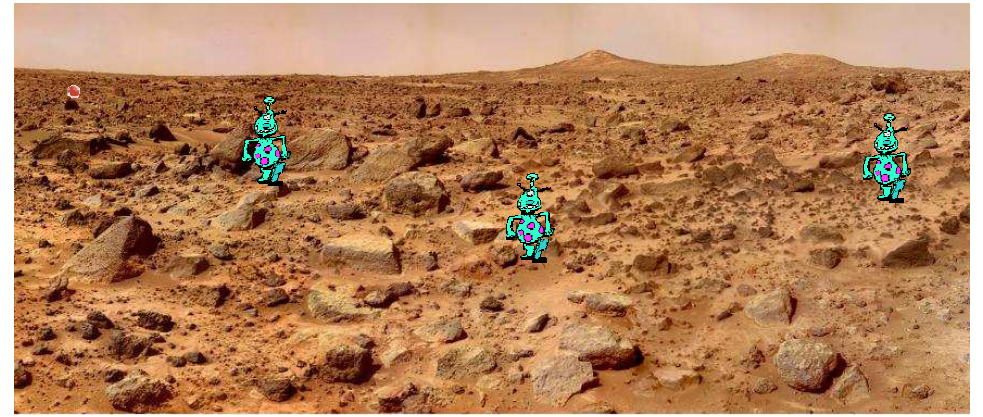
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The Surface of Mars



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

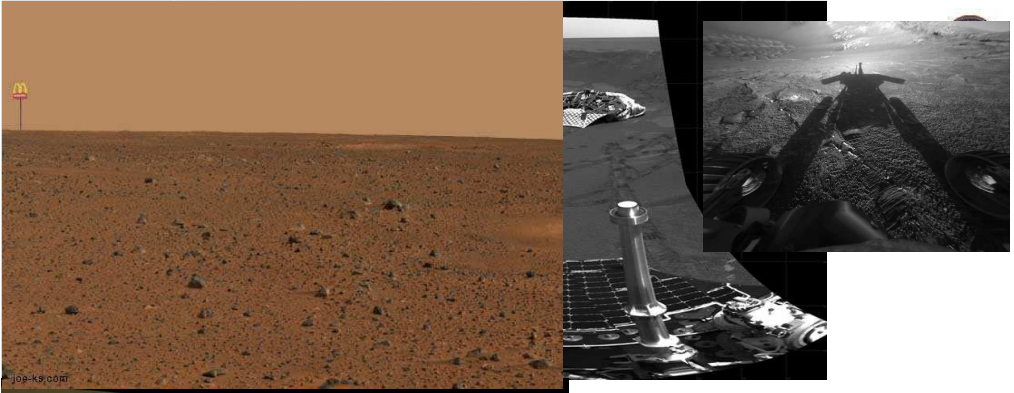


View of "Twin Peaks" from Mars Pathfinder

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



Roving on Mars: Spirit and Opportunity find evidence of water

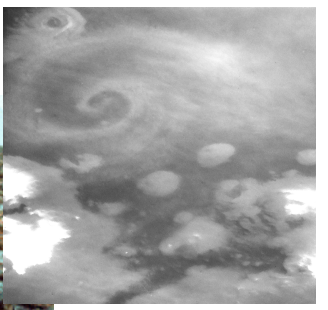
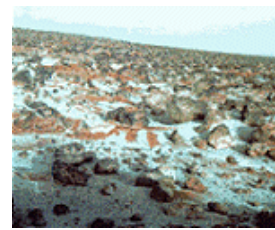
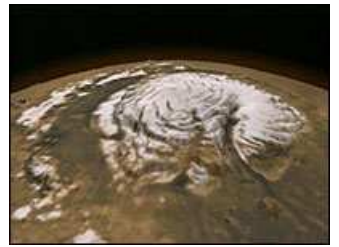
http://antwrp.gsfc.nasa.gov/apod/image/0403/emptynest_opportunity_big.jpg

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Water on Mars



- There **is** water on Mars
 - North and south polar caps (mostly CO₂)
 - Some water vapor in the air
 - Frost on rocks
 - Clouds (ice crystals)
- No *liquid* water now



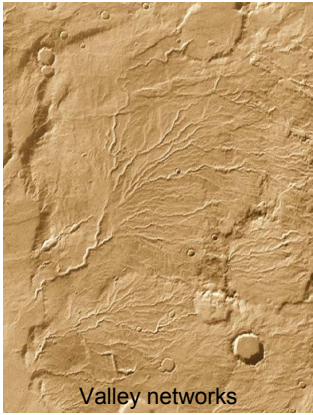
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Liquid water on Mars?

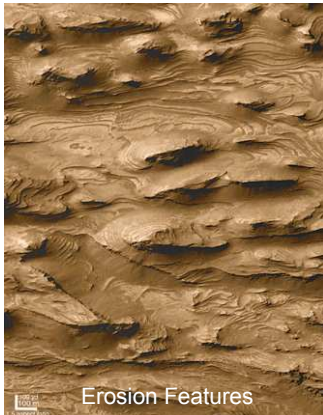


- Water erosion features visible from space
- Atmospheric pressure too low for liquid water to exist
- Perhaps at some point in the past?



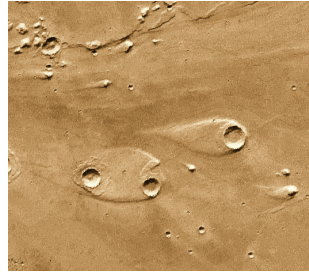
Valley networks

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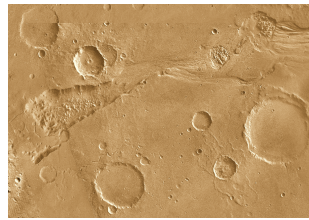


Erosion Features

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"Islands"



Flood erosion

Mars' Watery Past

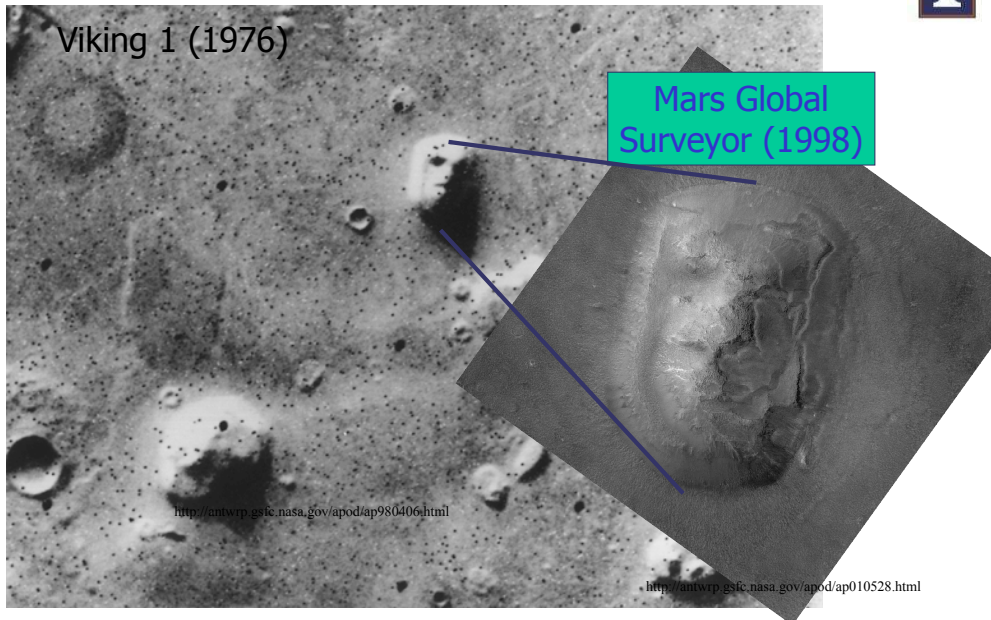


Image Courtesy of Kees Veenenbos

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The "Face" of Mars?



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Other Faces

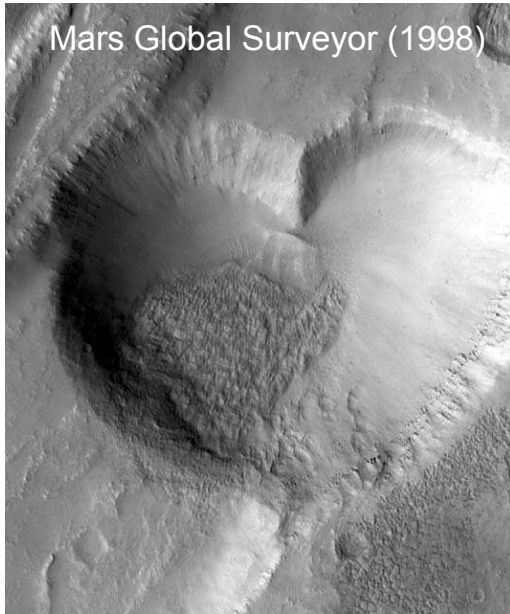


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<http://antwrp.gsfc.nasa.gov/apod/ap990315.html>

Other Places



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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



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Asteroid Gaspra



Hollywood's View of the Asteroid Belt

The possibility of successfully navigating an asteroid field...

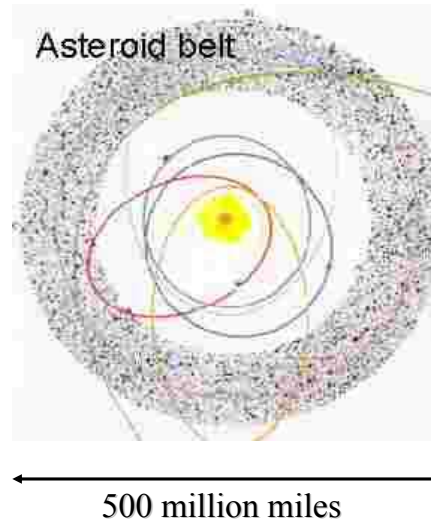


- Actually, NASA has sent many space probes into and through the Asteroid Belt
- Unlike in Star Wars, the Asteroid Belt is not that crowded
- Average separation between sizable asteroids is 10 million km!



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Thousands of asteroids ...

On average, about a million miles apart!



Scientific View of the Asteroid Belt

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Destroyed... by the Empire



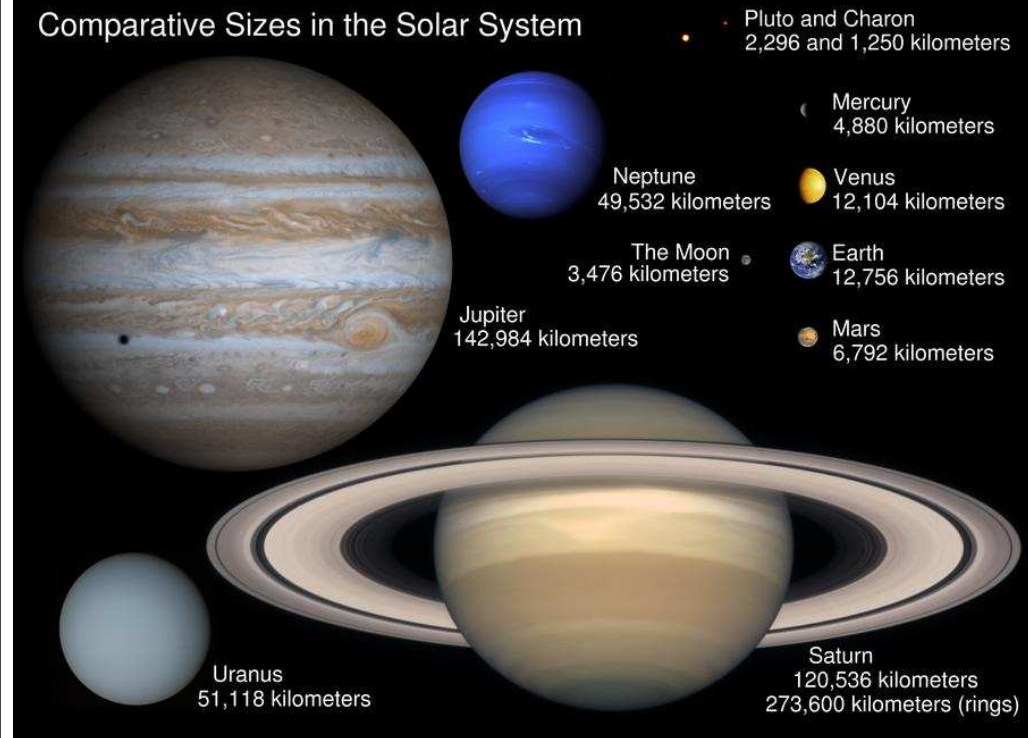
- Are the asteroids a destroyed planet? **No**
 - Combined, the asteroids have a mass about 0.1% that of the Earth
 - Less than 10% that of our Moon
- The asteroids might be a *failed* planet
 - Jupiter's gravity kept the asteroids from coalescing into a planet
 - Jupiter probably ejected many asteroids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



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Comparative Sizes in the Solar System



Earth – Jupiter comparison



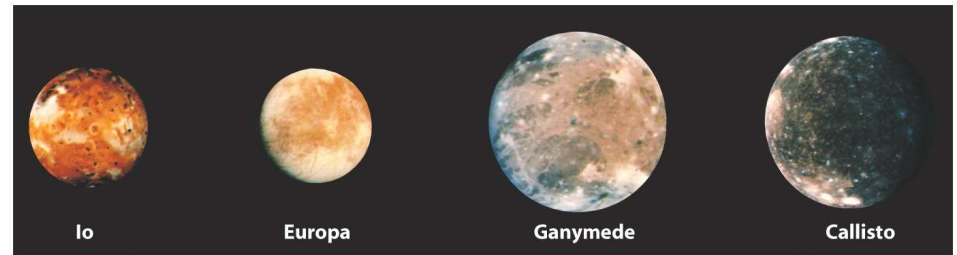
Biggest and most massive planet, has the largest gravity, has the largest number of moons (>61), yet has the shortest day in Solar System. Radiates more energy than it absorbs.

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 one of the best options for life in our Solar System.
- But, Ganymede and Callisto are contenders.



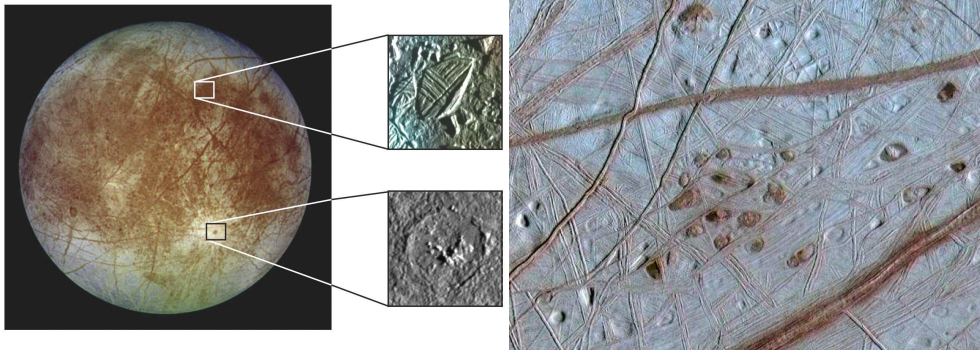
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Europa



- 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?



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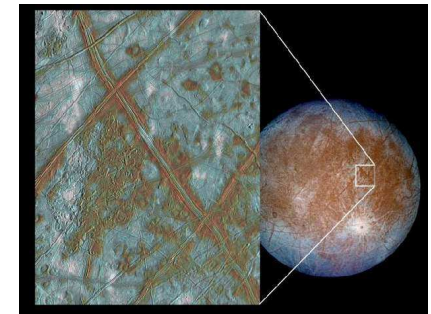
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Galileo

Europa



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



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Earth – Saturn comparison



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

It floats. The least spherical planet.

Jupiter-Saturn Comparison

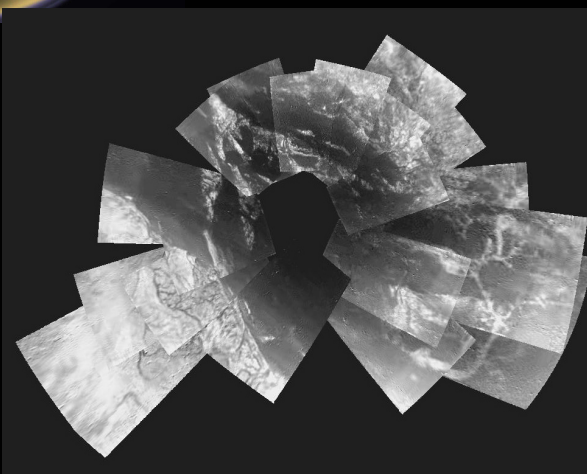


Equatorial radius	0.84 Jupiter
Mass	0.30 Jupiter
Density	0.52 Jupiter

Almost as big as Jupiter, but Much less massive!

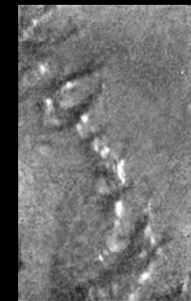
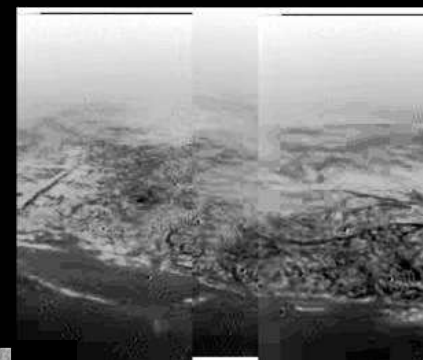
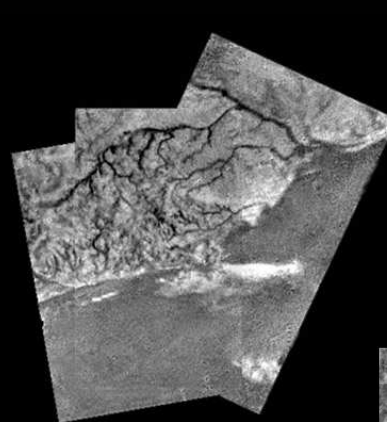


Cassini: Images of Titan

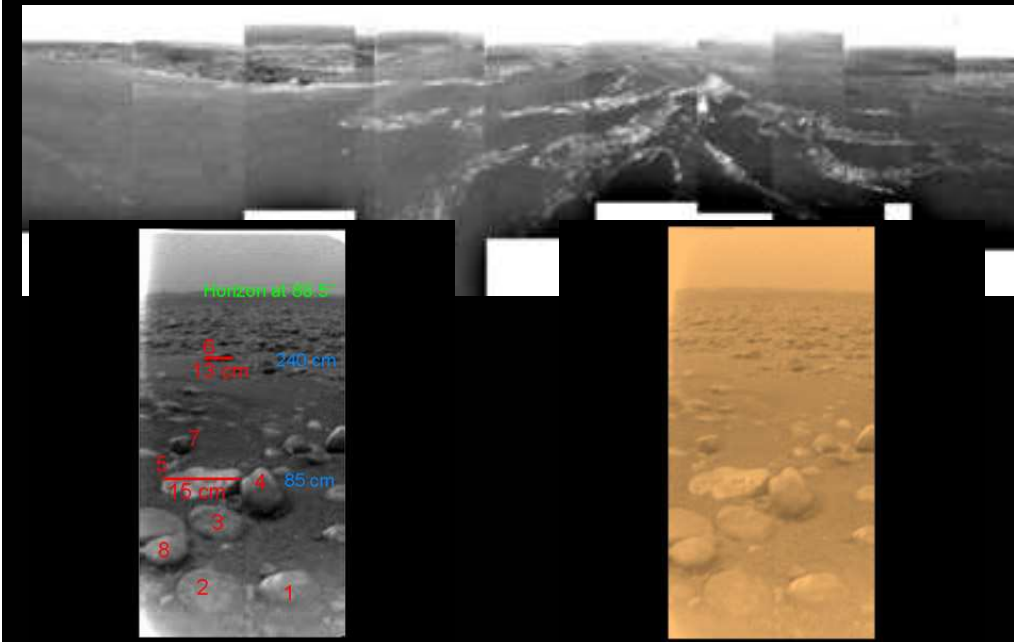


http://www.esa.int/SPECIALS/Cassini-Huygens/SEMC8Q71Y3E_0.html

Mapping Titan



Mapping Titan

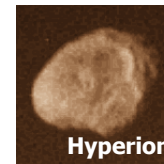
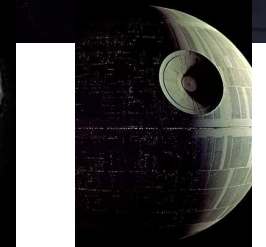


Saturn's Odd Moons

- **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
- **Phoebe** - Orbits Saturn backwards



Mimas



Hyperion



Phoebe



ENCELADUS
(DIAMETER = 500 km)

IAPETUS
(DIAMETER = 1440 km)

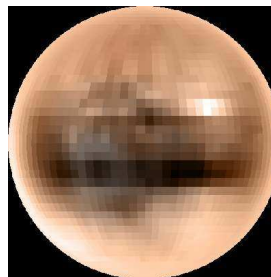
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The Outer Reaches



- Beyond the orbit of Neptune lie countless bodies of rock & ice
- Pluto is the largest of these bodies
 - Not a rocky planet
 - Not an ice giant



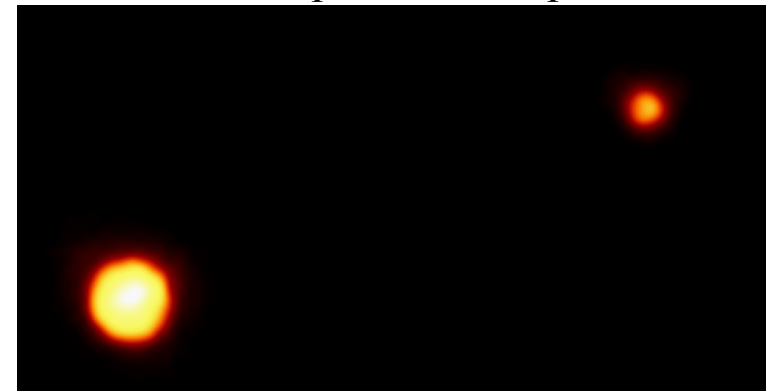
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First Pictures of Pluto/Charon



- 1995 – Hubble Space Telescope infrared
- 1996 – Hubble Space Telescope visible



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The Moons?



Ganymede
5262 km



Titan
5150 km



Mercury
4880 km



Callisto
4806 km



Io
3642 km



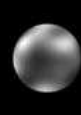
Moon
3476 km



Europa
3138 km



Triton
2706 km



Pluto
2300 km



Titania
1580 km

The Largest Moons and Smallest Planets

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Do we know of all of the Bodies in our Solar System?



- a) Yes.
- b) No.

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Do we know of all of the Bodies in our Solar System?

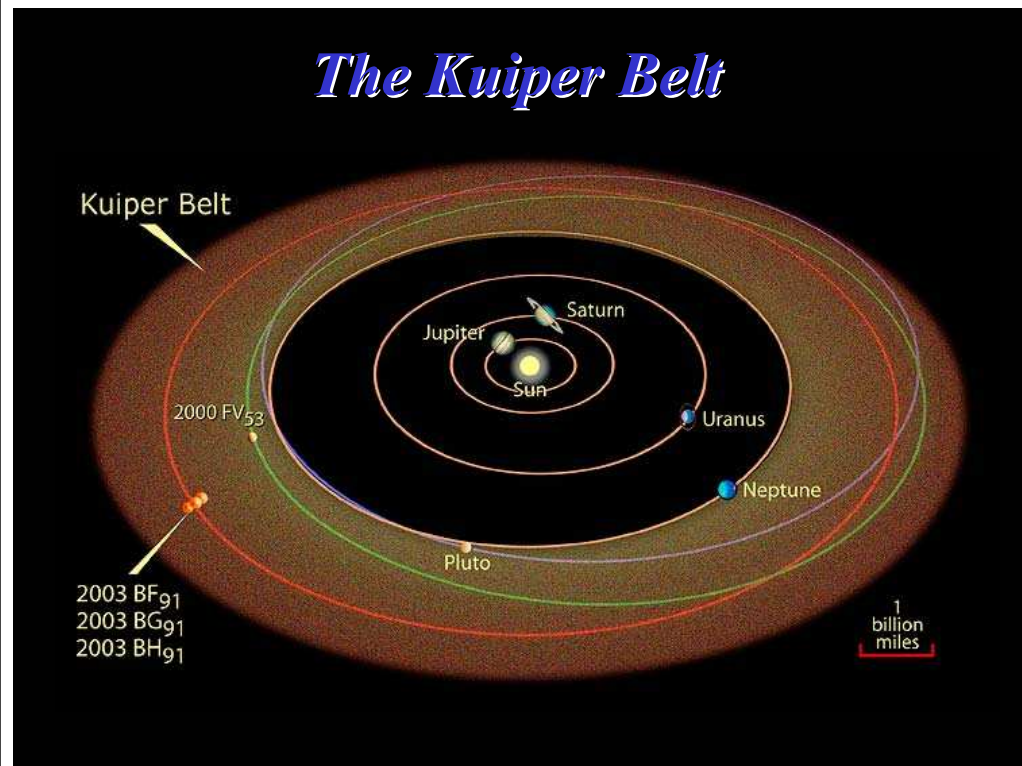


- **No.** Even at in the 21st century, we are still discovering new comets, or large asteroids, or even large planet-like objects?

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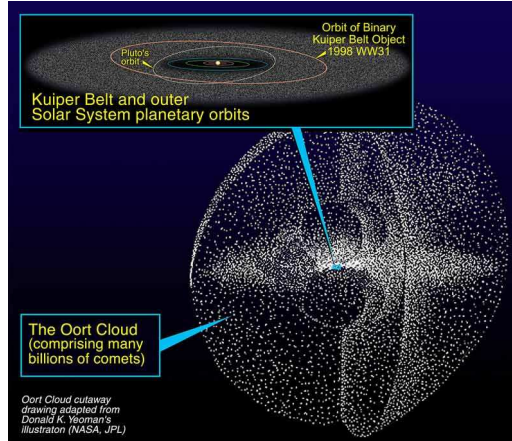
The Kuiper Belt



Oort Cloud



- Billions of icy minor planets – comet nuclei
- Roughly spherical out to 50,000 AU
- Predicted by Jan Oort
- Explains long-period comets
- No observations to date.

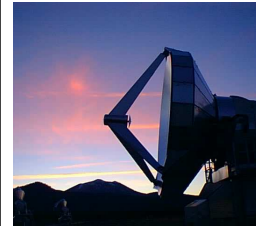


<http://www.solarviews.com/browse/comet/kuiper3.jpg>

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We need telescopes to observe Starlight



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Telescopes & Astronomy



- The single most important tool to astronomers is the telescope
 - They collect more light than the eye
 - Allow us to see heavenly objects more clearly and to greater distances
- Astronomers have been using telescopes for about 400 years to explore the Universe
- *Need telescopes which work at all wavelengths*



Johannes Hevelius observing with one of his telescopes (1647).

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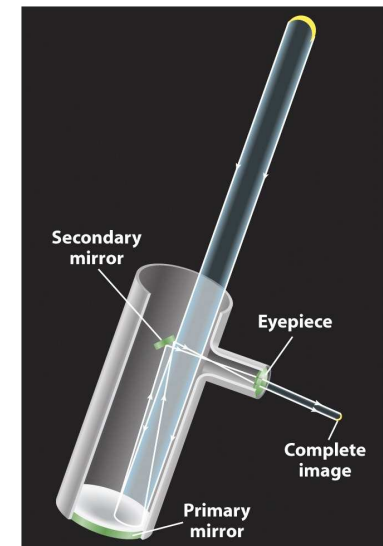
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Functions of a Telescope



- Telescope functions
 - Collect light over a large area
 - Resolve image onto an eyepiece or a scientific instrument
- Extract maximum possible information
 - Form image or take spectrum
- Can do this with either lenses (refracting) or mirrors (reflecting)
- Three priorities (in order)
 - Gathering light
 - Angular resolution
 - Magnification



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