Astronomy 330:

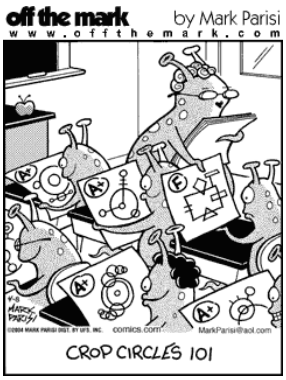
Extraterrestrial Life

This class (Lecture 15):

Life in the outer Solar System

Next Class:

Life in the Solar System
Anish Bhattacharya
Tyler Blum



HW#6 due Sunday
No Class March 19th

Music: Life on Mars— David Bowie

HW #2

Anish Bhattacharya
http://www.ufoevidence.org/
news articles: the majority is outdated; their grammar was fairly poor, site keeps boasting about the quantity, not the quality

John Ryan
http://www.bibliotecapleyades.net/vida_alien/alien_contact04.htm
Name-dropping page (Carl Sagan, Frank Drake, etc), and the webpage spends the majority of its length breaking down an alien bitmap message

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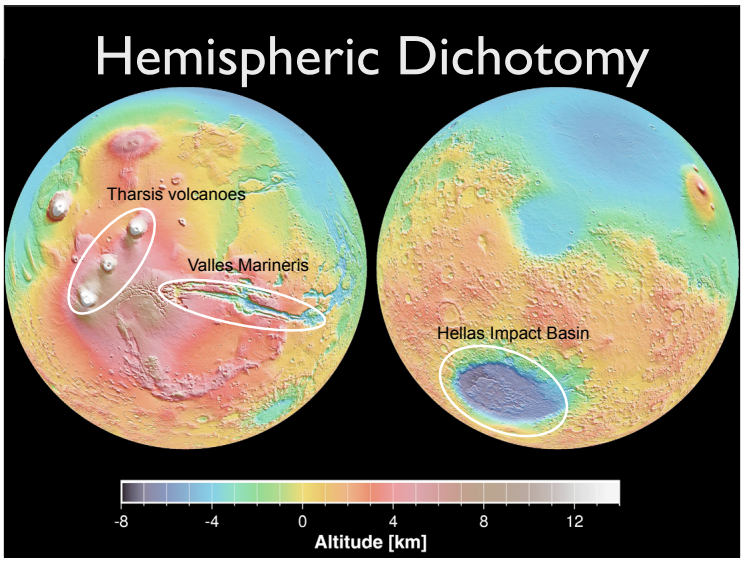
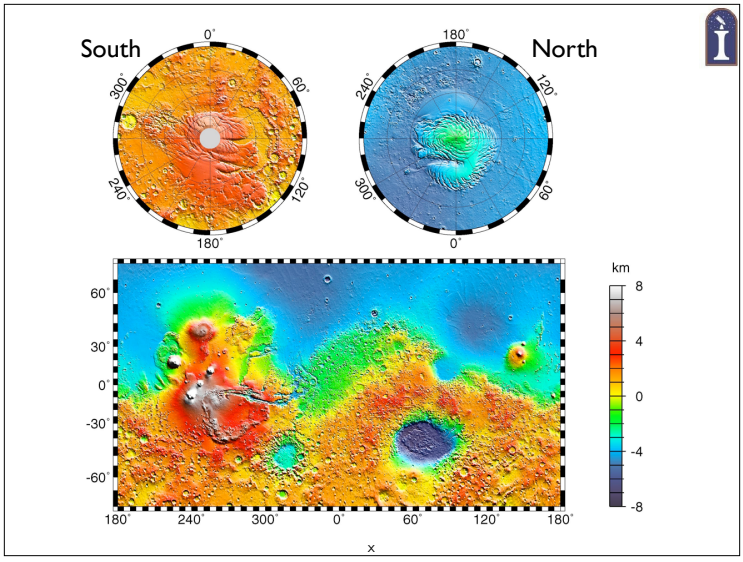
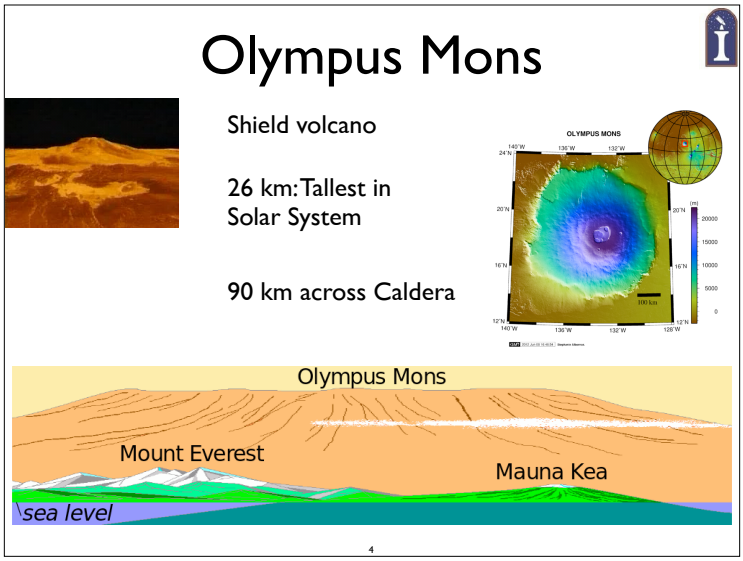
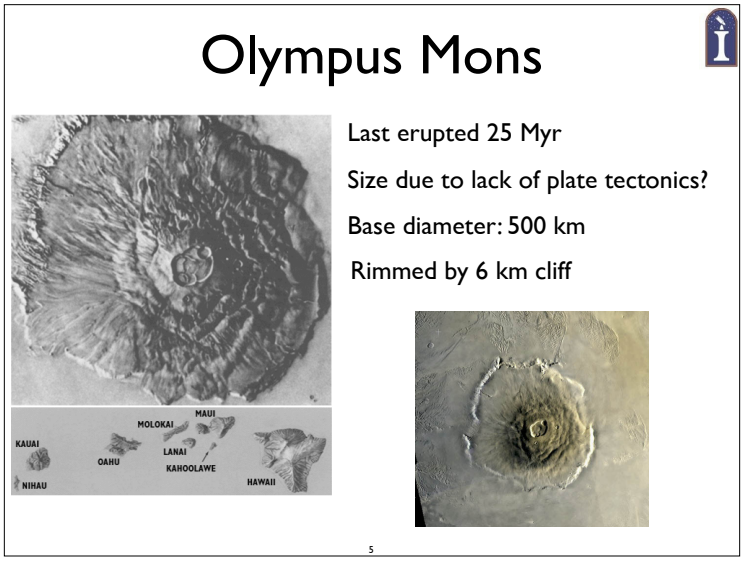


English: These maps are global false-color topographic views of Mars at different orientations from the Mars Orbiter Laser Altimeter (MOLA). The maps are orthographic projections that contain over 200,000,000 points and about 5,000,000 altimetric crossovers. The spatial resolution is about 15 kilometers at the equator and less at higher latitudes. The vertical accuracy is less than 5 meters. The right hand image view features the Hellas impact basin (in purple, with red annulus of high standing material). The left hand features the Tharsis topographic rise (in red and white). Note also the subtle textures associated with resurfacing of the northern hemisphere lowlands in the vicinity of the Utopia impact basin. This data was compiled by the Mars Orbiter Laser Altimeter (MOLA) Team, led by David Smith at the Goddard Space Flight Center in Greenbelt, MD.

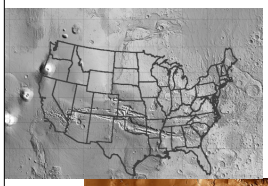


Maps of Mars' global topography. The projections are Mercator to 70° latitude and stereographic at the poles with the south pole at left and north pole at right. Note the elevation difference between the northern and southern hemispheres. The Tharsis volcano-tectonic province is centered near the equator in the longitude range 220° E to 300° E and contains the vast east-west trending Valles Marineris canyon system and several major volcanic shields including Olympus Mons (18° N, 225° E), Alba Patera (42° N, 252° E), Ascraeus Mons (12° N, 248° E), Pavonis Mons (0°, 247° E), and Arsia Mons (9° S, 239° E). Regions and structures discussed in the text include Solis Planum (25° S, 270° E), Lunae Planum (10° N, 290° E), and Claritas Fossae (30° S, 255° E). Major impact basins include Hellas (45° S, 70° E), Argyre (50° S, 320° E), Isidis (12° N, 88° E), and Utopia (45° N, 110° E). This analysis uses an areocentric coordinate convention with east longitude positive.





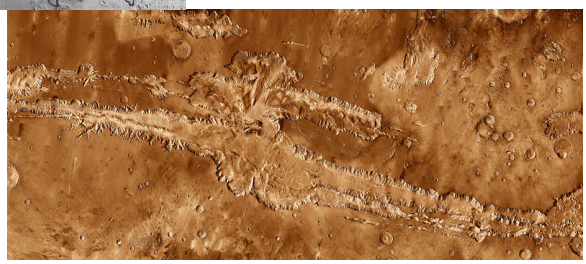
Valles Marineris



Series of fault canyons: 5000 km long

Giant crack in the crust of Mars.

Formed as Mars cooled, expanded by water



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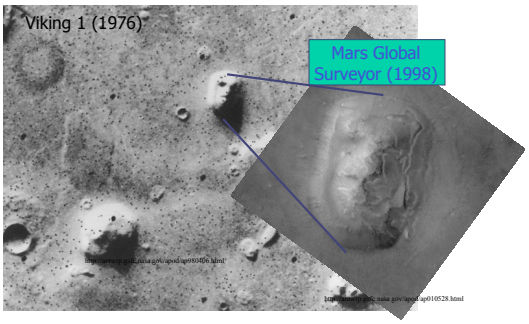
Valles Marineris in mosaic of THEMIS infrared images from *2001 Mars Odyssey*

Pareidolia



psychological phenomenon involving a vague and random stimulus (often an image or sound) being perceived as significant

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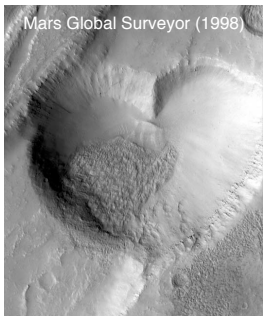
Pareidolia



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Manned Missions?

NASA planning manned mission?

Europe?

Russia?

China?

Inspiration MARS

MARS ONE

http://en.wikipedia.org/wiki/Manned_mission_to_Mars

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Inspiration Mars will seek astronaut couple to spend 501 days in a space capsule in 2018, but likely delayed until 2021.

Mars One— one way ticket for colonization in 2024. Recently chose candidates

Goodbye Mars

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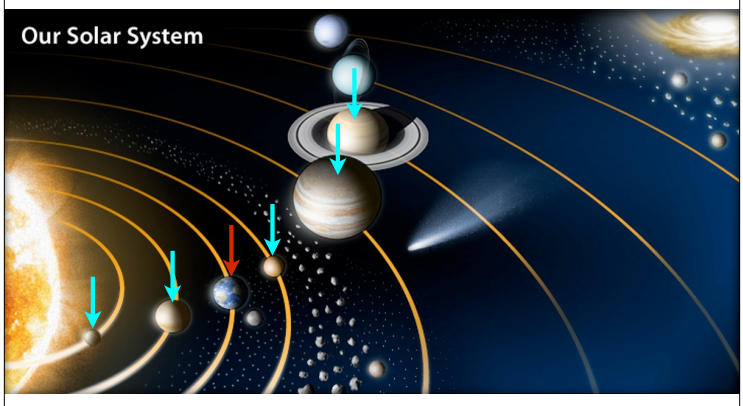
Life in the Solar System?



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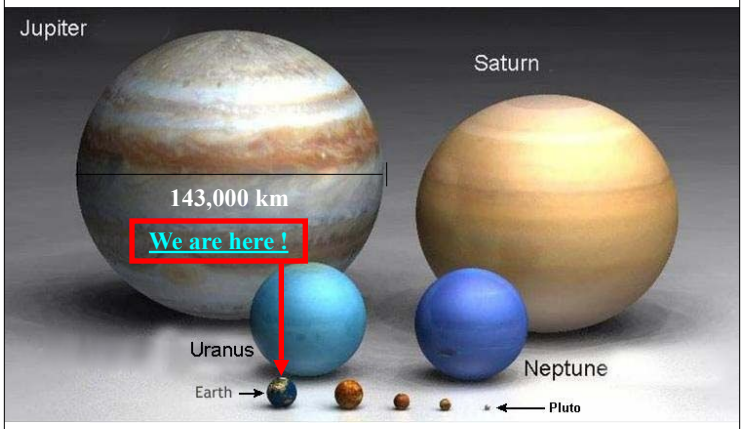
Jupiter is Huge



Earth – Jupiter comparison

Biggest and most massive planet, has the largest gravity, has the largest number of moons (>63), 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.

Jupiter's Interior

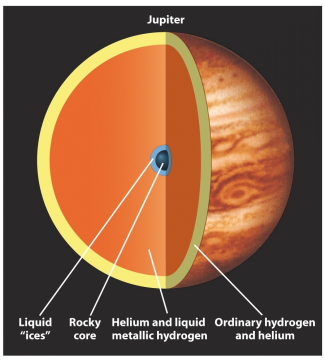
Average density only 30% greater than water

25% of the Earth's density

By 20,000 km down, the pressure is 3 million times that on the Earth's surface!

Hydrogen becomes a liquid metal

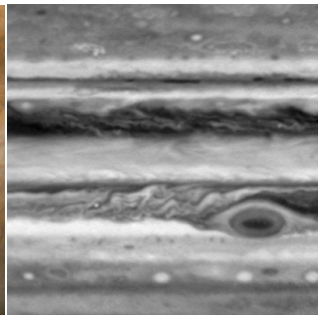
Core of rock & "ice"
10-12 Earth masses



The Great Red Spot

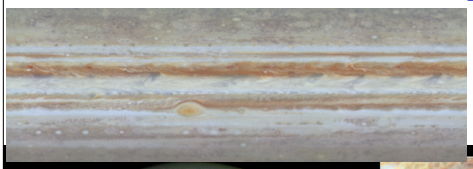
- A huge storm 25,000 km across – twice size of the Earth!
- First observed > 300 years ago!

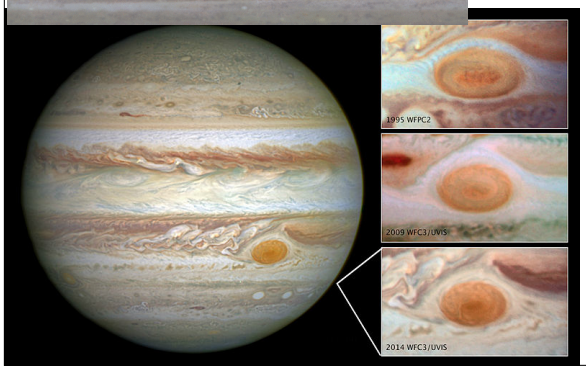
Voyager 1 image



Cassini images

The Great Red Spot



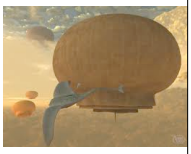


Great Red Spot is shrinking …

between 1996 and 2006 the spot lost 15 percent of its diameter along its major axis

Jupiter Life

Life in the clouds?



Science Fiction from Scientists?

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Carl Sagan and Edwin Salpeter devised a scheme for life in the clouds of Jupiter. They argued that the atmosphere must be rich in organic chemistry, so why not expect Earth-like life?

Floating Life

They proposed a simple life form like oceanic plankton called “sinkers”.

Small (0.1 cm) life that grew and fell, but then replicated by “splitting-up” and getting circulated back into the upper atmosphere.

http://www.wackerbaits.com/sf/media/bellsinker.jpg
http://www.mantapacific.org/mantapacific/information/images/plankton.jpg

The problem is that any life in the clouds that sank too far down would be destroyed by the temperature or pressure.

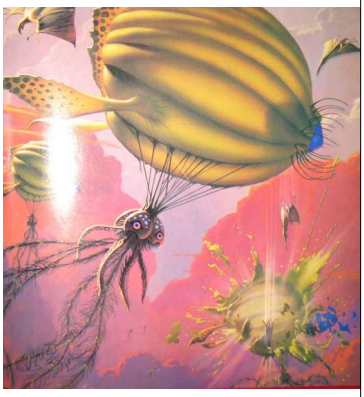
Floating Life

The sinkers— basis of a proposed ecology.

“floaters”– large hydrogen balloon-like life that could “swim” in the Jovian atmosphere.

Floating Life

They could be huge creatures, as large as 1 to 2 km in diameter.



Maybe similar to whales– mixture between jellyfish and birds?

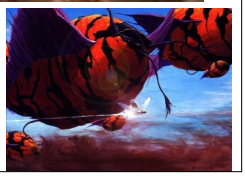
Big bags of hydrogen gas.

Floating Life

Maybe there are also "hunters" that fed on the floaters?

Of course, this is all speculative, and there is no way to detect such life.

Science fiction from scientists really.

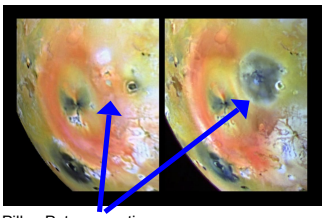


Io

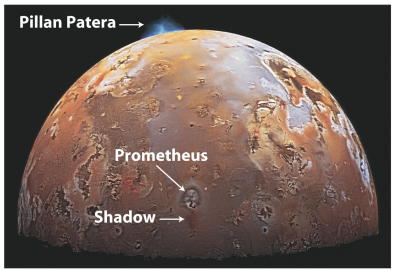
Innermost Galilean moon – the "pizza moon"

The most volcanically active body in the solar system.

Internal heating by Jupiter's tides



Pillan Patera eruption
Before & after



Voyager 1 discovered presence of volcanoes.

Atmospheric gases ripped off by Jupiter's magnetic field – ion torus

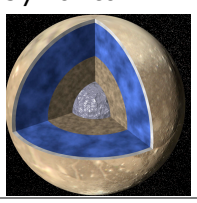
Ganymede Life

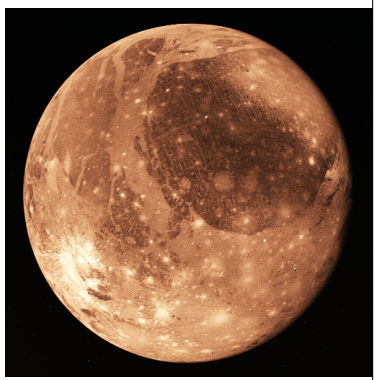
Largest moon of Jupiter

Ancient/Young surface

Water ocean under surface?

Probably Iron core



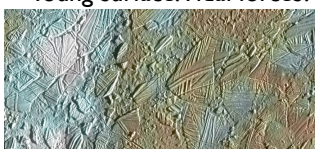


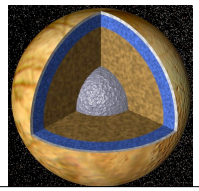
50% larger than Luna

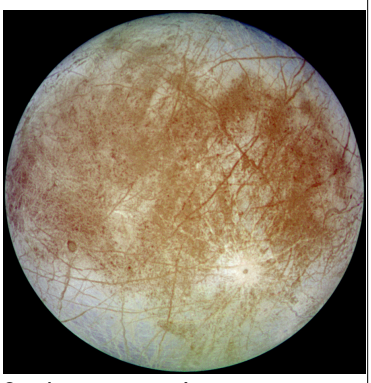
Life in oceans?

Europa

Young surface:Tidal forces?







Similar in size to Luna

Life in oceans?

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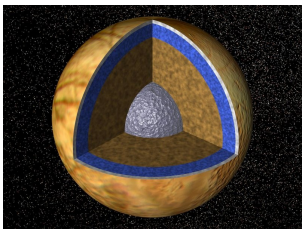
Slightly smaller than our Moon.
Icy crust 5 km thick. Can protect life against magnetic fields.
Evidence for deep (50 km!) liquid water ocean beneath crust–remains liquid from tidal forces from Jupiter
Cracks and fissures on surface – upwelling?

Europa

Life would have to be below the surface, around hydrothermal vents.

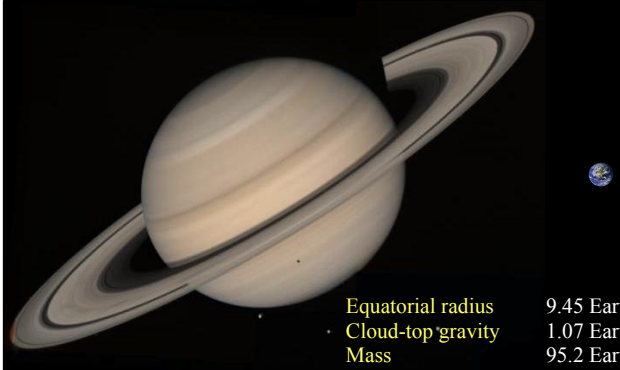
We don't how thick the ice is yet.

Future missions, will have to employ melting or smash and dive spacecraft.



Very encouraging, as early life on Earth, might have been formed around such vents.

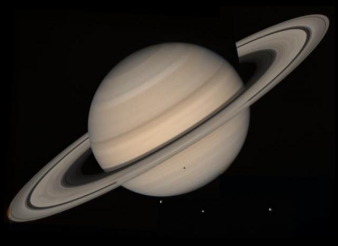
Earth – Saturn comparison



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

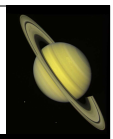
Jupiter-Saturn Comparison



Equatorial radius	0.84 Jupiter
Mass	0.30 Jupiter
Density	0.52 Jupiter

Almost as big as Jupiter, but
Much less massive!

Saturn



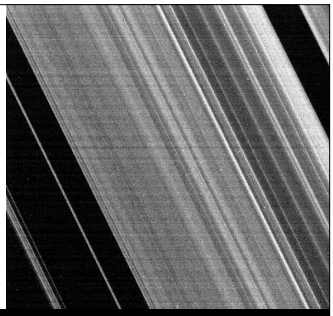
Saturn is very similar to Jupiter

- Large planet
  - Mostly liquid hydrogen
- Has a mini-solar system
  - At least 60 moons
  - Most are small

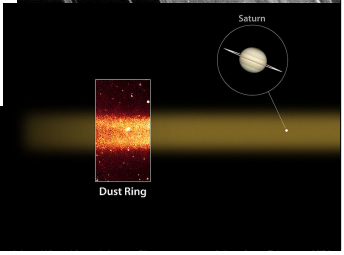
Named for the father of the Roman gods

Saturn's Rings

Two main rings
- Several fainter rings
- Each ring is divided into *ringlets*



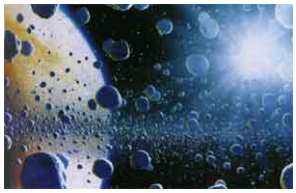
The rings are **thin**
- Only a few tens of meters thick– razor thin!



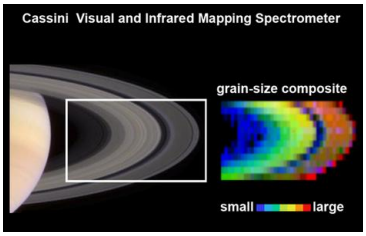
Less mass than the moon Mimas (50 billionths of Saturn's mass).

Makeup of the Rings

The rings of Saturn are **not** solid rings
- Made of icy rocks
- 1cm to 10m across

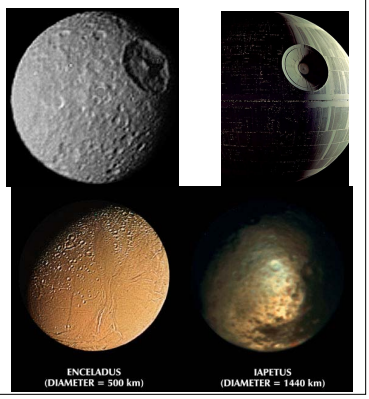


Cassini data shows ring particle size varies with distance from Saturn
- Note the gap is filled with small particles



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

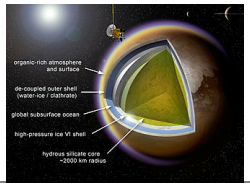


Titan

Largest moon of Saturn

Atmosphere: 95% N

Atmospheric pressure is 1.5x Earth



50% larger than Luna

Much like ancient Earth?

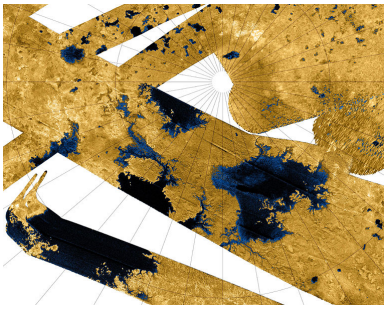
Saturn's largest moon– bigger than Mercury. 2nd largest moon in the solar system after Ganymede. Discovered in 1655 by Christiaan Huygens. Only moon to have a dense atmosphere. Dense nitrogen atmosphere. Small greenhouse effect 98% nitrogen. Only Earth is comparable. Methane (something producing it). Much like ancient Earth!

Surface Liquid

Now confirmed to have liquid on surface— likely ethane and/or methane

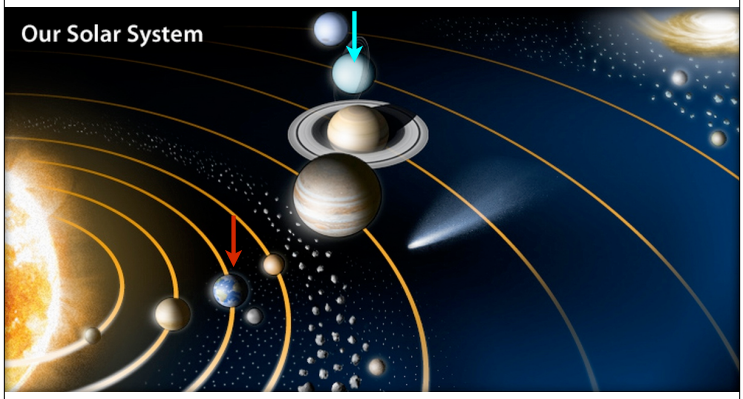
Only body besides the Earth with this feature!

Chemistry would be slow— like ancient Earth?

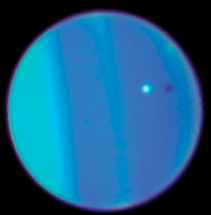


http://photojournal.jpl.nasa.gov/catalog/?IDNumber=PIA10008

Life in the Solar System?



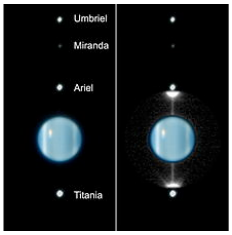
Earth-Uranus Comparison



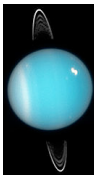
Uranus has the coldest atmosphere in Solar System and the core is colder than expected. Uranus is rotating on its side (98 degree tilt) and orbits the sun like a ball.rolling.

Radius	3.98 Earth
Surface gravity	.91 Earth
Mass	14.5 Earth
Distance from Sun	19.2 AU
Effective Temp	57 K
Year	30,687 Earth days
Length of Day	-17 hours 14 minutes
Atmosphere	H_2, He, & CH_4

Uranus

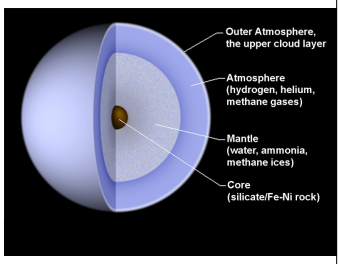


William Herschel
1781 *Georgium Sidus*



Coldest planet
Core smaller than Earth
- 55% Mass
- 20% Radius

Model Uncertainties



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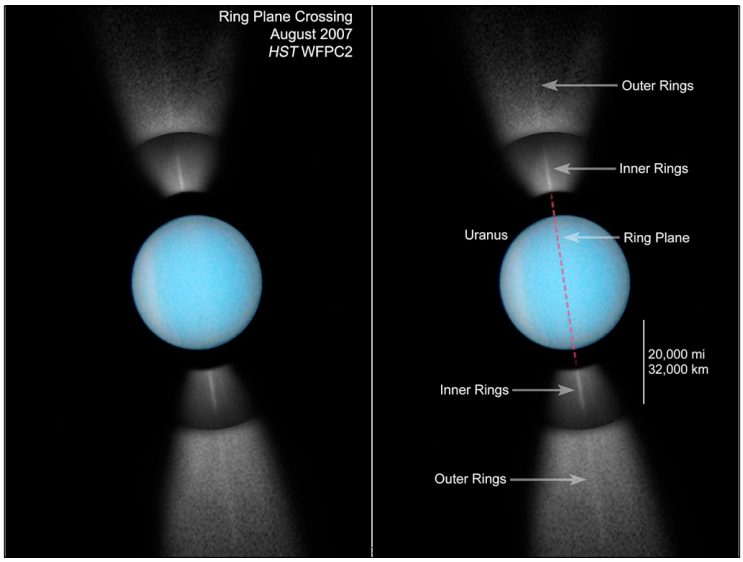
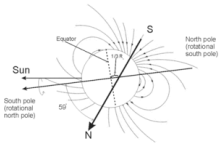
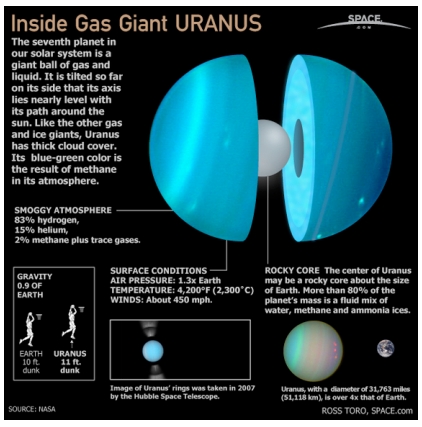
First planet detected with a telescope! Wanted to name it Georgium Sidus (George's Star), or the "Georgian Planet" in honor of his new patron, King George III, but that name did not catch on.



Uranus

Peculiar Magnetic Field





x

Question

Which of the following is not a true statement about Uranus?

a) Radiates less energy than it receives

b) Tidally locked with Sun

c) Rotates nearly on its side

d) Odd magnetic field

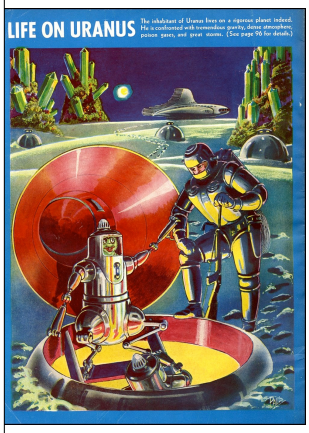
e) Has a solid core

iClicker

x

B

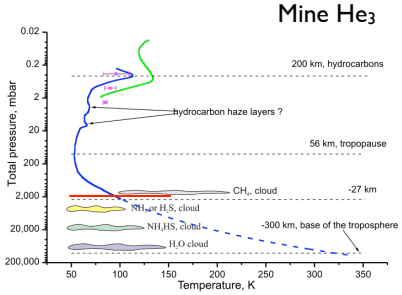
Uranus



Hard to imagine life existing, but primitive conditions?

Liquid Water Ocean?

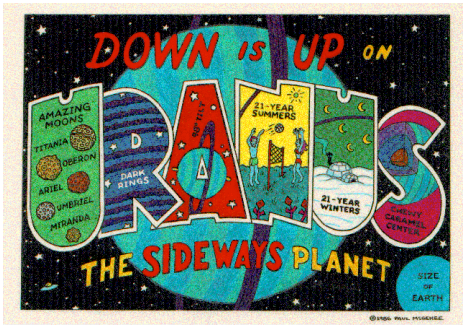
Mine He_3



38

Superheated water

Goodbye Uranus



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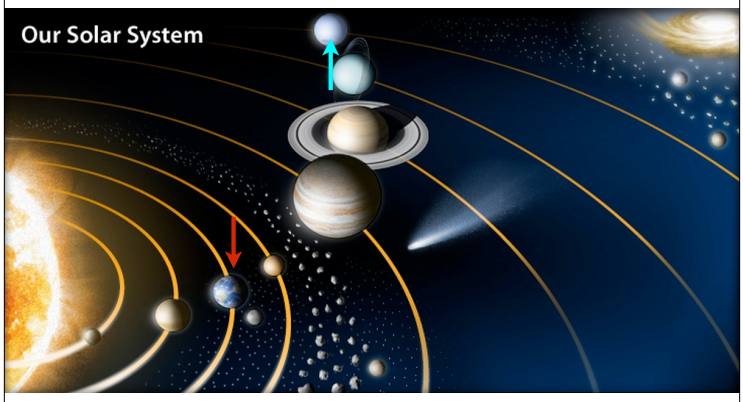
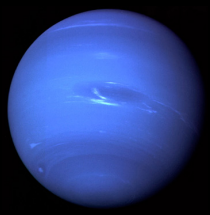
Life in the Solar System?



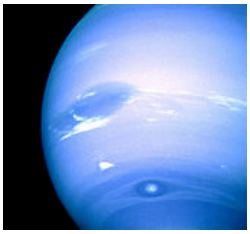
Earth-Neptune Comparison



Neptune is the most distant planet and the coldest, has the strongest winds, and was discovered because it was *dark matter* affecting the orbit of Uranus.

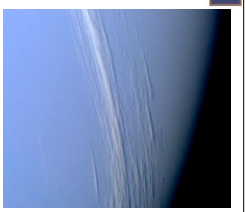
Radius	3.86 Earth
Surface gravity	1.14 Earth
Mass	17.1 Earth
Distance from Sun	30 AU
Effective Temp	59 K
Year	60,190 Earth days
Length of Day	16 hours 7 minutes
Atmosphere	H_2 & He, CH_4

Neptune

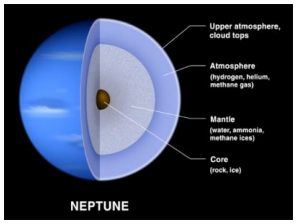


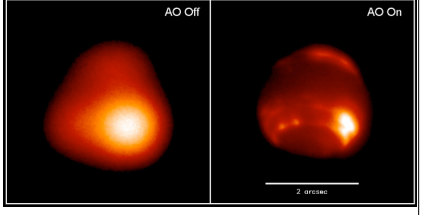
Internal Heat

Driving weather

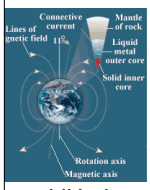


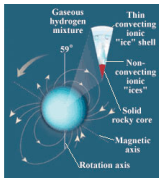
2x Radiates



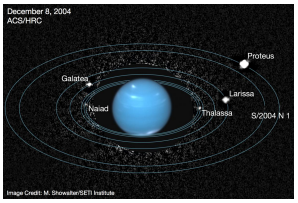


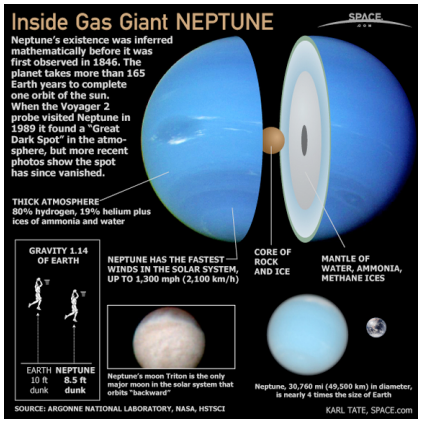
Neptune





NH_3 driven magnetic field?
Unstable?





Question

Which of the following is not a true statement about Neptune?

a) Fast motion in atmosphere

b) No magnetic field

c) Multiple moons

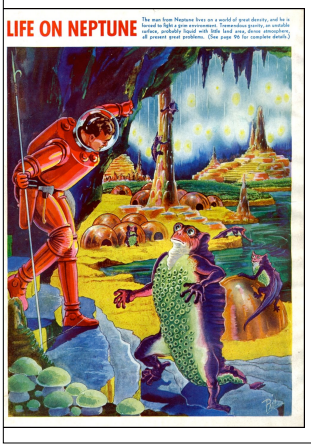
d) Radiates more energy than it receives

e) Has a solid core

iClicker

B

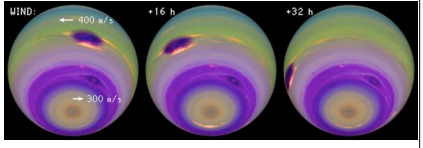
Neptune



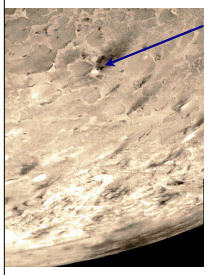
Hard to imagine life existing, but primitive conditions?.

Liquid water ocean?

Problem: Fast winds in atmosphere



Triton



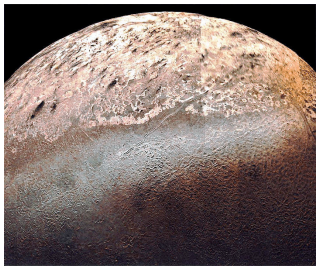
Ice Volcanoes?

Cryovolcanoes

Rocky Core

Water Mantle?

Life?

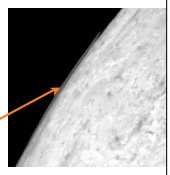


55% Frozen N_2
15-30% Frozen O_2
10-20% Frozen CO_2

Larger than Pluto and Eris

Retrograde Orbit

Captured KBO or dwarf Planet?

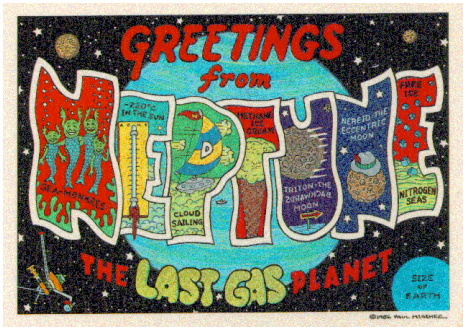


Atmosphere
(Voyager 2)

45

Getting warmer?

Goodbye Neptune



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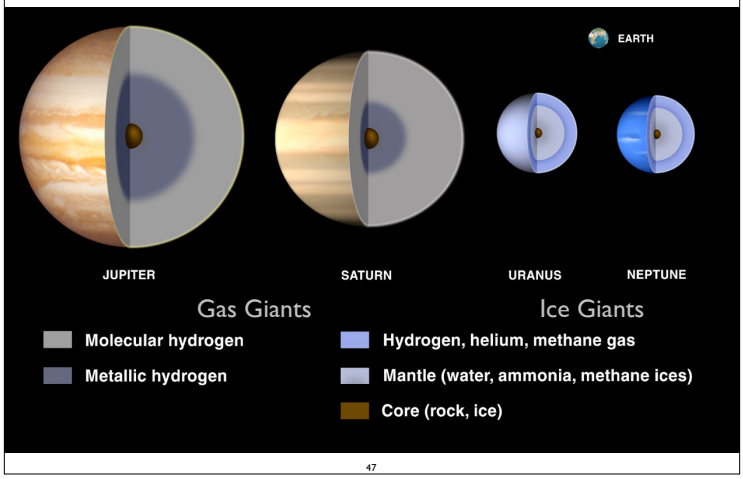
Outer Planet Comparison



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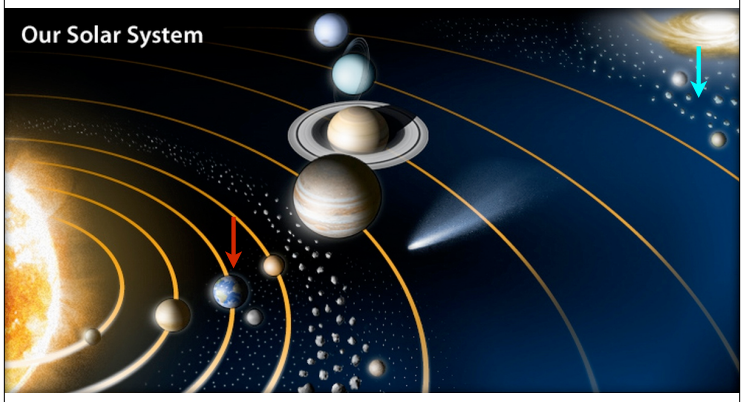
http://hendrix2.uoregon.edu/~imamura/121/images/JSUR_interiors.jpg

Life in the Solar System?

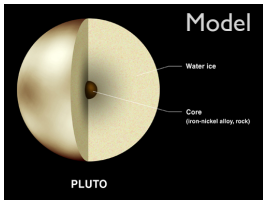


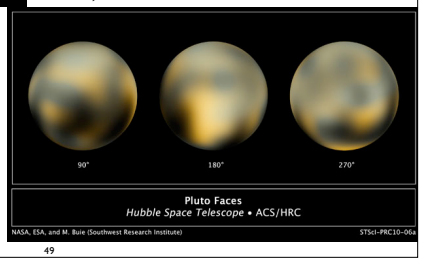
Pluto

Clyde Tombaugh (Illinois)

Hydrocarbons detected in spectra?

Thin atmosphere containing N, CH_4, CO





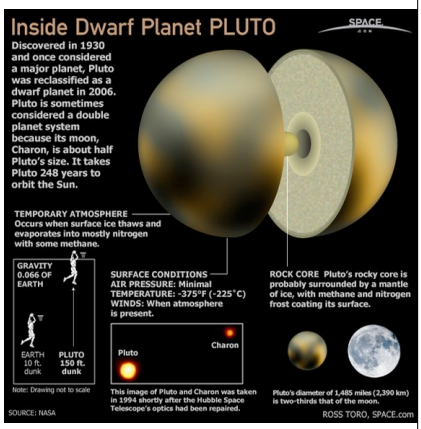
Pluto

2:3 Resonance with Neptune

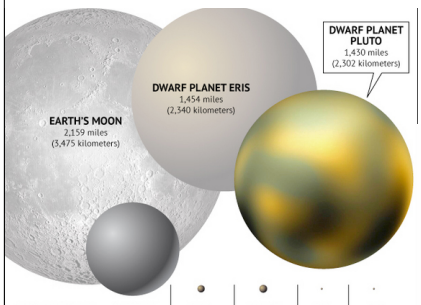
~120 degree axial tilt

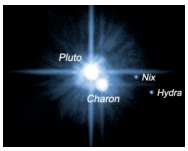
Highly contrastive surface

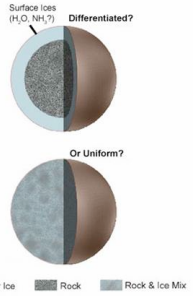
Surface changes color & luminosity



Pluto & Charon







PLUTO'S MOONS:	CHARON	NIX	HYDRA	P4	P5
Year of discovery	1978	2005	2005	2011	2012
Diameter	648 miles (1,043 km)	31-62 miles (50-100 km)	31-62 miles (50-100 km)	8-21 miles (13-34 km)	6-15 miles (10-25 km)
Orbital period (Earth days)	6.4	24.9	38.2	32.1	not available

SOURCE: HUBBLE SPACE TELESCOPE SCIENCE INSTITUTE

KARL TATE / © SPACE.com

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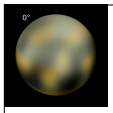
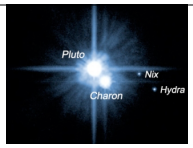
Pluto





Very Cold: Frozen surface

Hydrocarbons: Sunlight or cosmic rays interacting with methane ices

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http://en.wikipedia.org/wiki/File:ESO-L._Calçada_-_Pluto_(by).jpg

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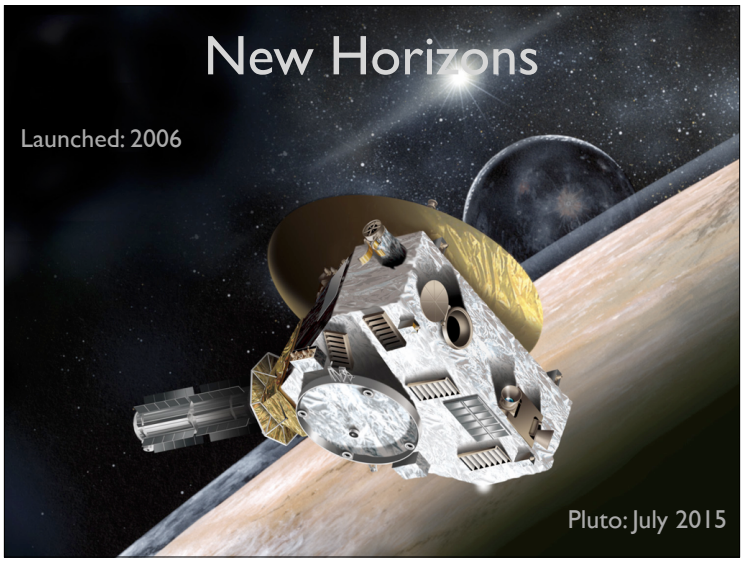
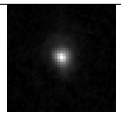


Eris

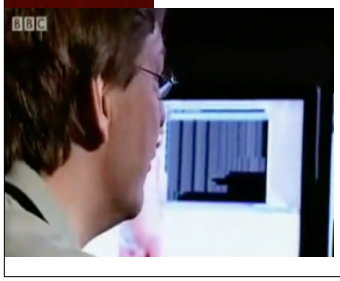


HST

Orbit: 557 Years

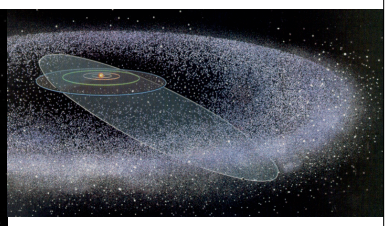
~97 AU from Sun

37-50K



Most massive dwarf planet

Trans-Neptunian Objects

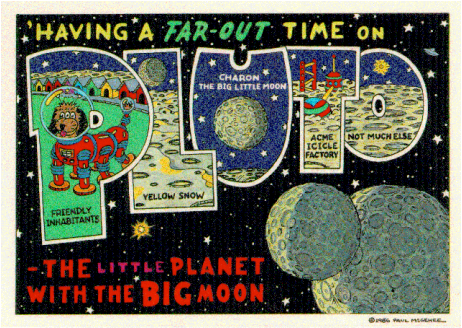


Methane Ice

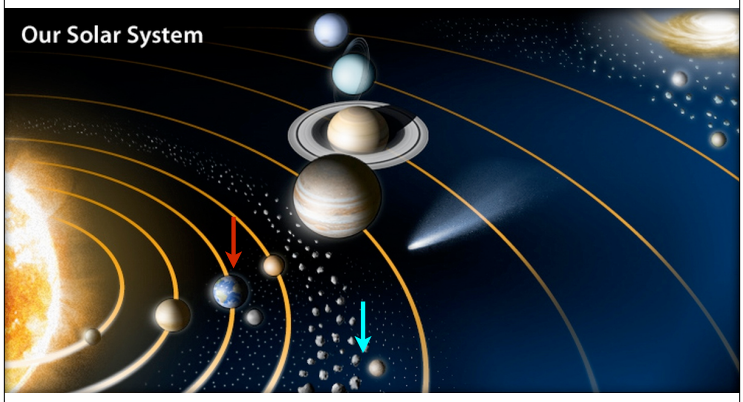
Ruddy color signature of complex organics?

Icy surfaces

Goodbye KB



Life in the Solar System?



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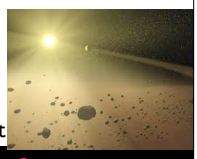
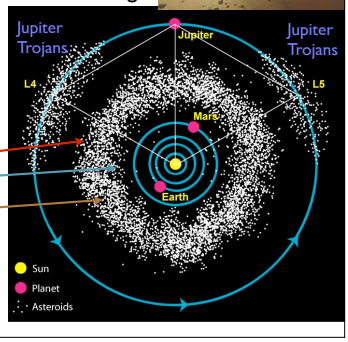
Asteroid Belt

Ceres
Vesta
Pallas
Hygiea

Zodiacal Light



3 Types:
- Carbonaceous
- Silicate
- Metal-rich



Asteroid Belt is mostly empty!
1:10^9 chance of spacecraft collision

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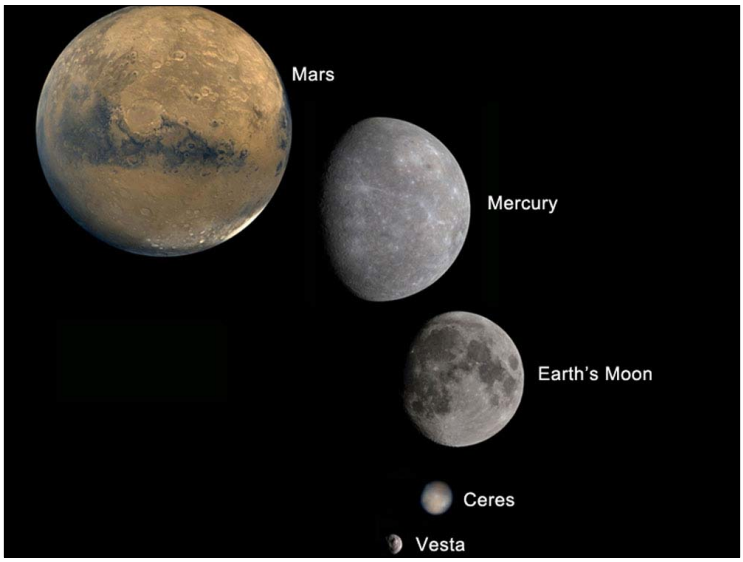
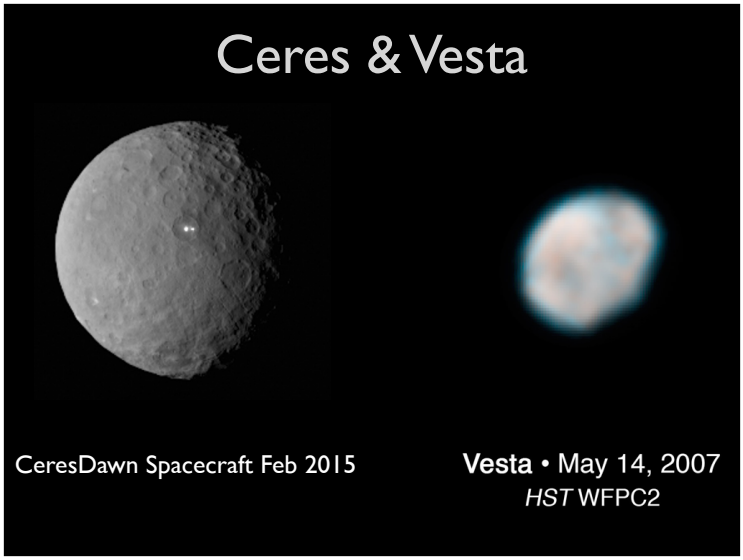


There is a growing chorus of researchers that believe life can be basically on every rock that has ice/water and an energy source. Ceres apparently has both ingredients.



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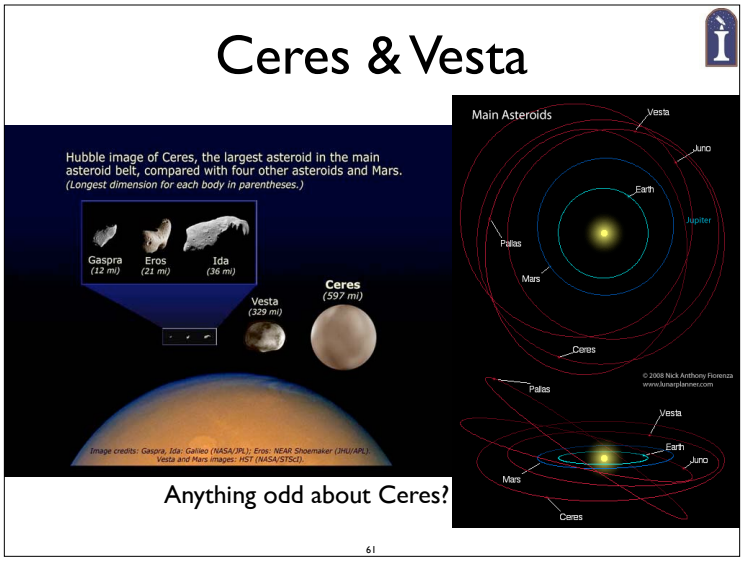

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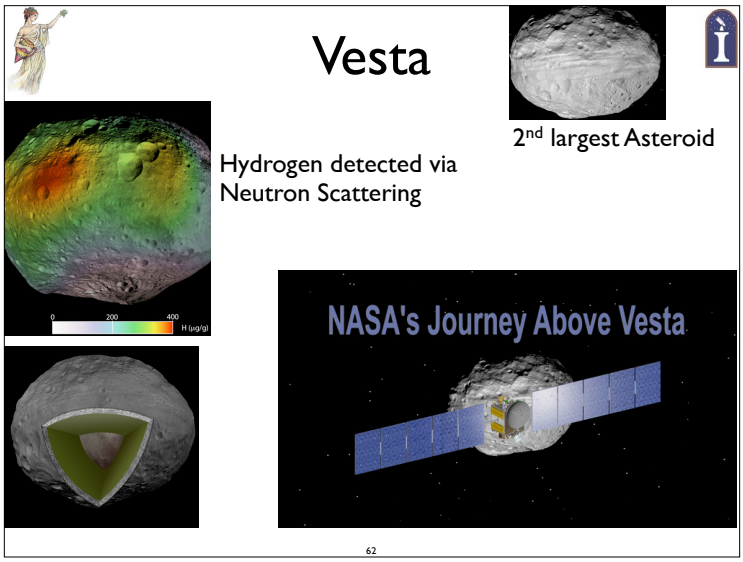

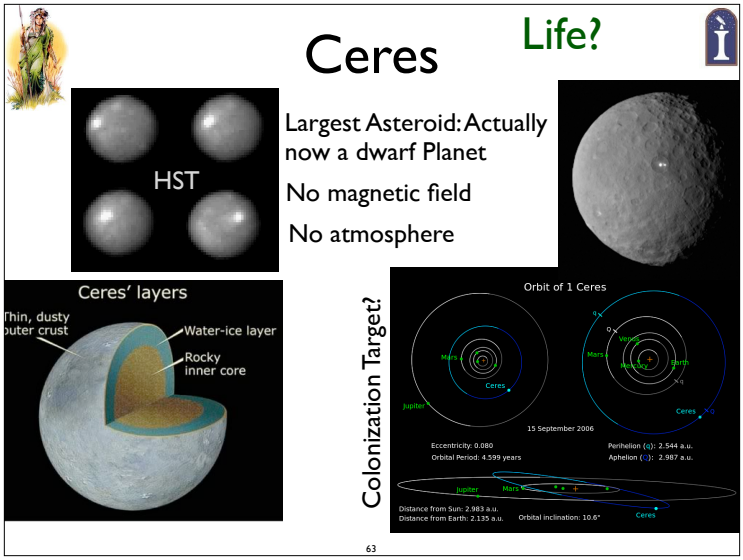

There is a growing chorus of researchers that believe life can be basically on every rock that has ice/water and an energy source. Ceres apparently has both ingredients.

A demoted planet (before Pluto!)