Astronomy 230

Section 1– MWF 1400-1450

106 B6 Eng Hall

This Class (Lecture 16):

Life in the Solar System

Midterm is March 12!

The Exam will be in the Astronomy Building Classroom, room number 134.

Next Class:

Life in the Solar System– Part II

Outline

- Midterm Discussion
- Venus
  - Hot
  - Live in the clouds?
- Mars
  - YAMR?
  - Water in Mars's past.
  - Martian microbes?

Midterm

- 1 hour exam in Astronomy classroom.
- It will cover material up to, but not including, "Life in the Solar System"
- Will consist of 20 multiple choice/ true-false questions (worth 2 points each) and 2 essay questions (one worth 40 points and one worth 25 points) .
- A total of 105 points, so 5 extra credit points.
- You can bring a normal-sized sheet of paper with notes on both sides.

Review I

- What are the five biological attributes of life, and what do they mean?
- Compare the chemical composition of life to the chemical composition of: a) the crust of the Earth; b) Earth's oceans; and c) the Sun.
- What is the Drake Equation, and what do the terms mean?
- What is the origin and use of the four main biological elements H, O, C, and N?
- Describe the Early Universe. Why do we believe in the Big Bang?
- What are the properties of a first generation star? In particular, describe which heavy elements they made and how they did it.
- What are the properties of a second generation star? In particular, describe which heavy elements they made and how they did it.
- What does the presence of complex molecules in interstellar space tell us?
- Describe the techniques that astronomers use to search for planets around stars?

Review I

- Describe the processes for forming a star and its planets.
- The planets and the Sun formed from the same interstellar cloud. Discuss reasons why the chemical abundances of the inner planets are different than the outer planets.
- What determines if a planet is in the Habitable Zone?
- Discuss DNA and RNA. How do they function to assemble proteins that carry the genetic code?
- What was the Miller-Urey experiment and why is it thought to be important for life? Include the role of a reducing atmosphere in your discussion.
- What is one possible scenario for the synthesis of polymers on the early Earth? Include the probability of getting 200 of the 20 relevant amino acids in the correct order for constructing a protein.

Drake Equation

Frank Drake





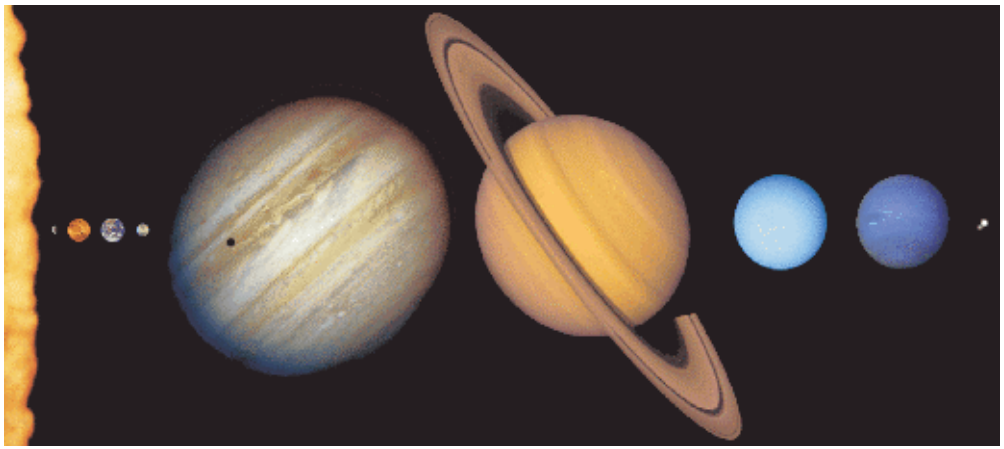



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

N	R_*	f_p	n_e	f_l	f_i	f_c	L
# of advanced civilizations we can contact	Rate of formation of Sun-like stars	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun-icate	Lifetime of advanced civilizations
	10	**0.34**	**0.208**	**0.235**			**= 1.66**
	Stars/year	Planetary System/star	Livable Planets /Planetary System	Evolved Life /Livable Planet			Evolved Life /decade

Life in the Solar System?

- We want to examine in more detail the backyard of humans.
- What we find may change our estimates of n_e or even f_l.

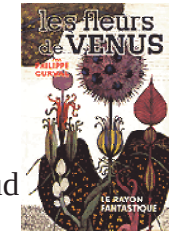


Earth – Venus comparison

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	0.949 Earth
Surface gravity	0.905 Earth
Mass	0.815 Earth
Distance from Sun	0.723 AU
Average Temp	475 C
Year	224.7 Earth days
Length of Day	116.8 Earth days
Atmosphere	96% CO_2

What We Used to Think



Venus must be hotter, as it is closer the Sun, but the cloud cover must reflect back a large amount of the heat.

In 1918, a Swedish chemist and Nobel laureate concluded:

"…everything on Venus is dripping wet.... A very great part of the surface ... is no doubt covered with swamps corresponding to those on the Earth in which the coal deposits were formed.... The constantly uniform climatic conditions, which exist everywhere, result in an entire absence of adaptation to changing exterior conditions. Only low forms of life are therefore represented, mostly no doubt, belonging to the vegetable kingdom; and the organisms are nearly of the same kind all over the planet. "

http://www.daviddarling.info/encyclopedia/V/Venuslife.html

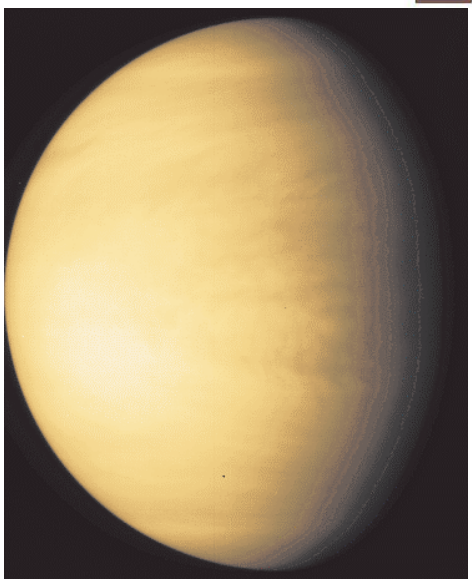
Turns Out that Venus is Hell

- 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.

Venus

- Always covered in thick clouds of CO_2, which make it the hottest planet in the Solar System.
- Pressure on surface is 90 times that on Earth– like 1 km under the sea

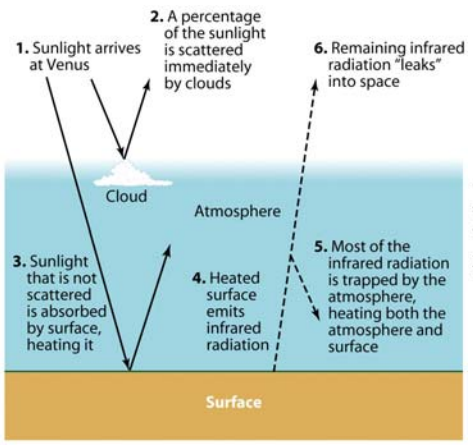
- Often called the morning star or the evening star. 3rd brightest object in the sky. Often mistaken for UFO.
- Retrograde rotation – Sun rises in west
- No moons, no magnetic field

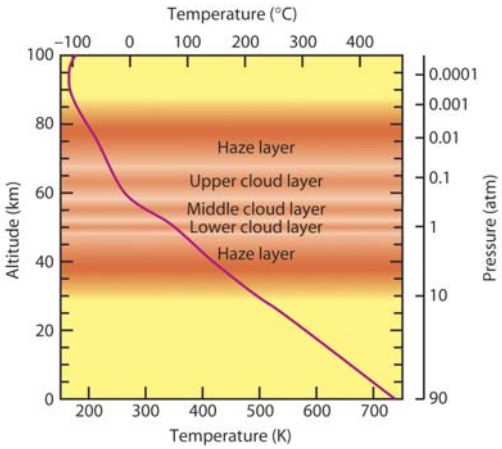


http://antwrp.gsfc.nasa.gov/apod/ap960923.html

The Greenhouse Effect

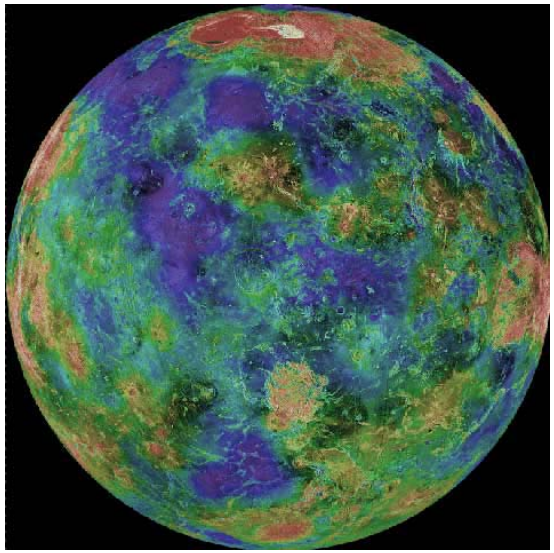
- Surface completely covered by clouds
- Atmosphere mostly carbon dioxide and nitrogen
- Sulfuric acid clouds
- Runaway greenhouse effect – surface temperature > 700 K





Venus: Surface

- Blue is lowest and Red is highest– there is trace amounts of water
- Most of surface is smooth lava flows
- Many (> 1,000) large volcanoes
- Probable ongoing volcanism
- Slow wind erosion of impact craters
- Craters are clustered



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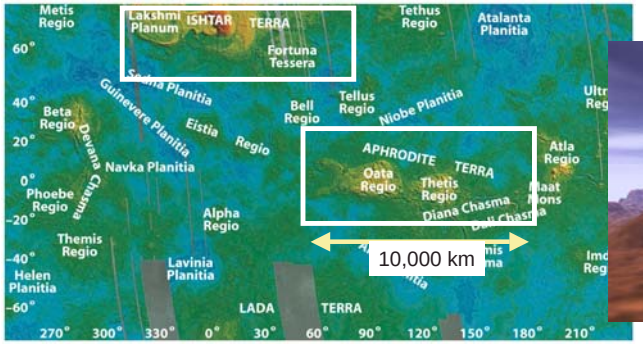
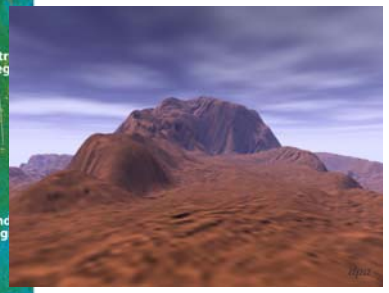
Venus: surface features



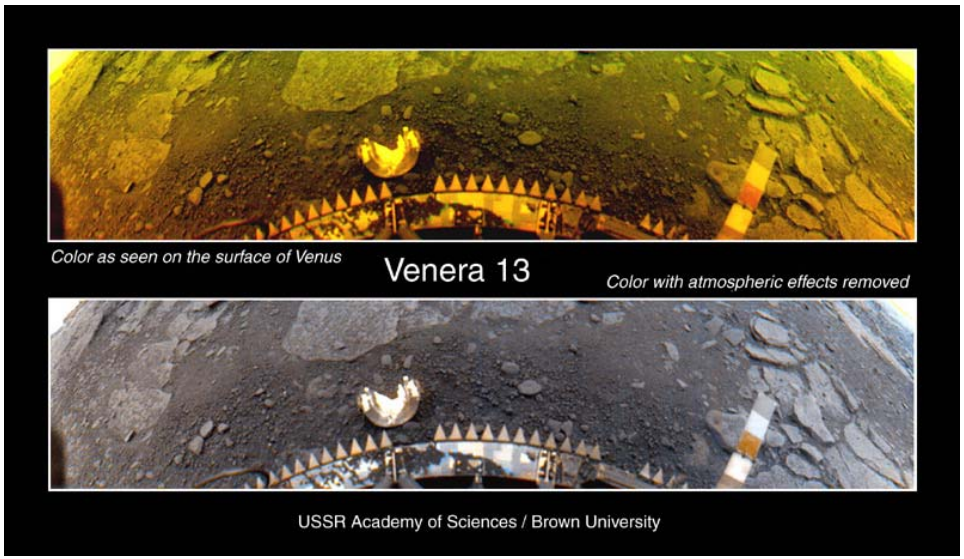


Maxwell Montes (65N 5E)
(Highest mountain range in the solar system
11km high– Everest is 8km)

http://www.solarviews.com/raw/venus/vidven2.mpg

http://www.geology.smu.edu/~dpa-www/venus/mpeg/max.mpg

Images from the Surface of Venus (Soviet Venera probes)

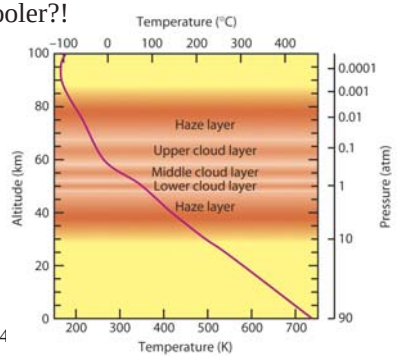


What Happened to Venus?

- It really should have been more like Earth, but the atmosphere is much different.
- Earth's atmosphere is mostly O_2 from life.
- Venus has some N,and if the CO_2 was buried in sediments like it is on Earth, then N_2 would have dominated its atmosphere too.
- Apparently Venus lost its H_2O– no oceans and no sediments.
- Probably the atmospheric temperature was hot enough for water to travel high enough to be broken apart by UV radiation, the H was lost and the O reacted with something else.
- The Earth traps water vapor in the cool tropopause at 14km.

Life on Venus?

- Surface is far too hot
  - If lead is liquid, think of what heat would do to complex organic polymers
  - No cooler polar regions exist
    - Heat is uniform!
    - But, high in the clouds it should be cooler?!



Life on Venus?

- Maybe life can still exist in the clouds?
- High clouds in the atmosphere contain chemicals that hint at the presence of some kind of biological activity.
- They found hydrogen sulfide and sulfur dioxide - two gases that react with each other. So something is probably producing them.
- Hardly any carbon monoxide. So something is perhaps removing the gas.
- One possibility is that microbes living in the clouds could be combining sulfur dioxide with carbon monoxide and possibly hydrogen sulphide or carbonyl sulphide in a metabolism similar to that of some early terrestrial microorganisms.
- Given that the temperature on Venus was once much cooler, there may once have been oceans on the planet. Life could have started there and retreated to stable niches once the runaway greenhouse effect began.
- Maybe a mission to scoop up some atmosphere?

http://www.daviddarling.info/encyclopedia/V/Venuslife.html

Earth – Mars comparison

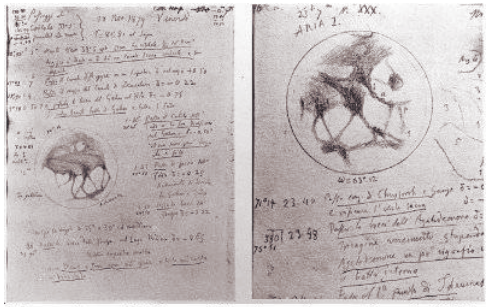
Mars has the Solar System's largest Volcano, Olympus Mons – 27 km tall.

Radius	0.532 Earth
Surface gravity	0.378 Earth
Mass	0.107 Earth
Distance from Sun	1.52 AU
Average Temp	-63 C
Max Temp	20 C
Year	687 Earth days
Length of Day	24 hours 39 minutes
Atmosphere	CO_2 95%

What used to think.

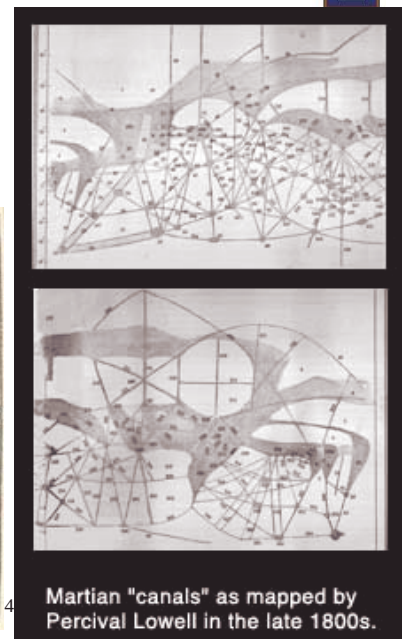

Giovanni Virginio Schiaparelli

- Was thought to be similar to the Earth in many ways.
- Life was argued to exist on Mars by many astronomers.
- The astronomer Schiaparelli announced that he saw regular linear markings on the surface, which he named *canali*.
- Technically, in Italian means channels, but it was mistranslated to canals.


Pages from Schiaparelli's observing notebook, 1879

Percival Lowell's Canals

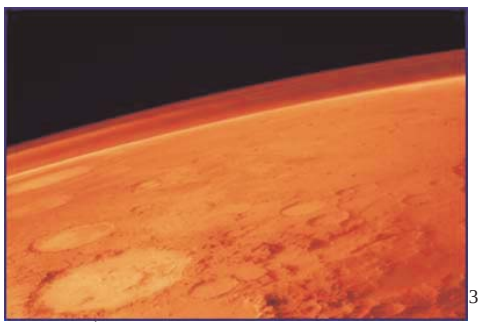
- Evidence for intelligent life?
- Mapped the civilization.
- Influenced culture.

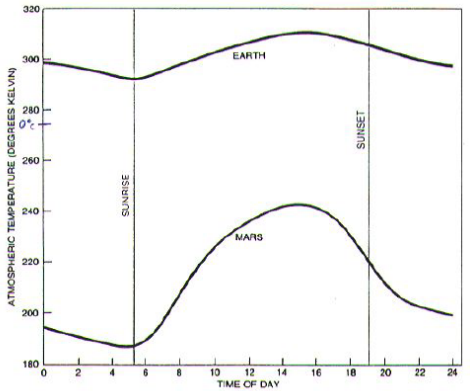


Martian "canals" as mapped by Percival Lowell in the late 1800s.

The Martian Atmosphere

- 95% carbon dioxide
- Atmospheric pressure 0.6% of Earth's – like 40 km altitude on Earth
- But too thin for significant greenhouse effect.
- Pressure is too low for liquid water.
- Not protected by a global magnetosphere like Earth's
- Large daily and seasonal swings in surface temperature

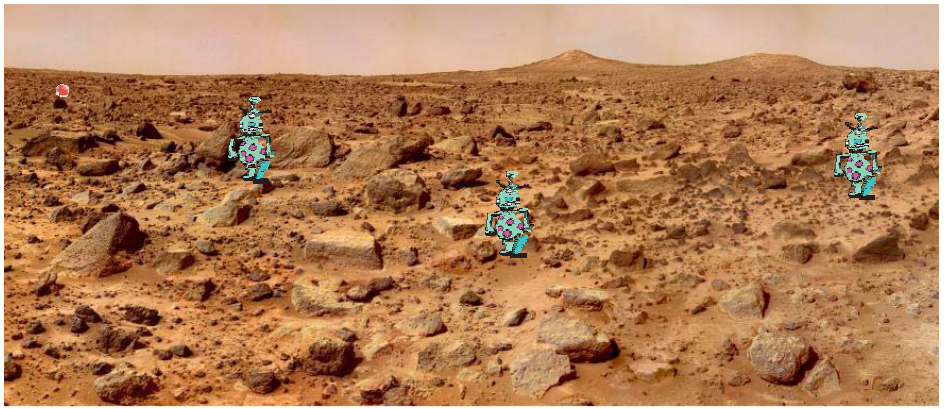




DAILY VARIATIONS IN ATMOSPHERIC TEMPERATURE at the *Viking 1* landing site (*color*) are qualitatively similar to those at China Lake, Calif., a desert site (*black*). In both cases the temperature touches a minimum around sunrise and reaches a peak about 10 hours later. The daily range, however, is about three times greater on Mars than it is on the earth. At Viking site range is 55 degrees, from about 187 to 242 degrees Kelvin (−86 to −31 degrees Celsius). At China Lake range is 18 degrees, from 292 to 310 degrees K. (19 to 37 degrees C).

The Surface of Mars

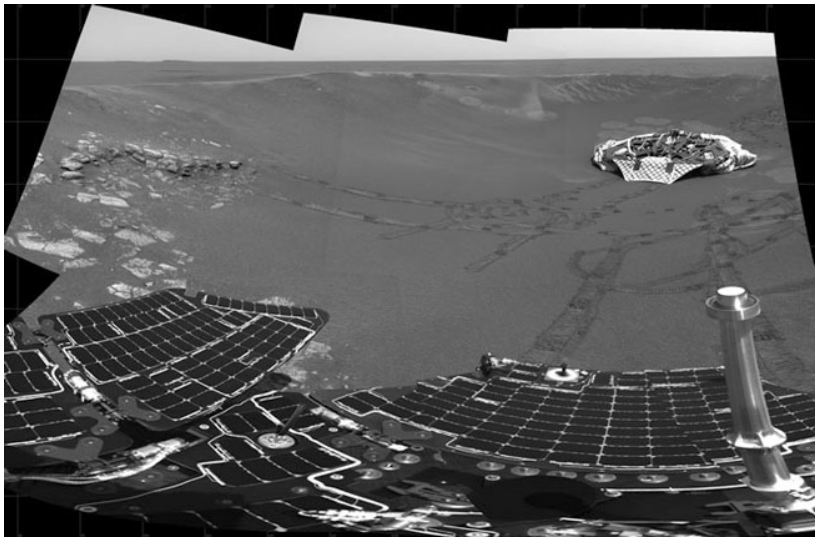
- Mars is a desert!
- Iron oxide in soil gives reddish cast.



View of "Twin Peaks" from Mars Pathfinder

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

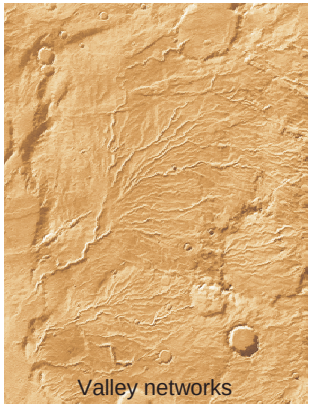
The Surface of Mars: Opportunity

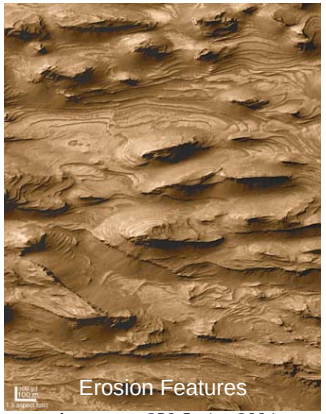


http://antwrp.gsfc.nasa.gov/apod/ap040303.html

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?



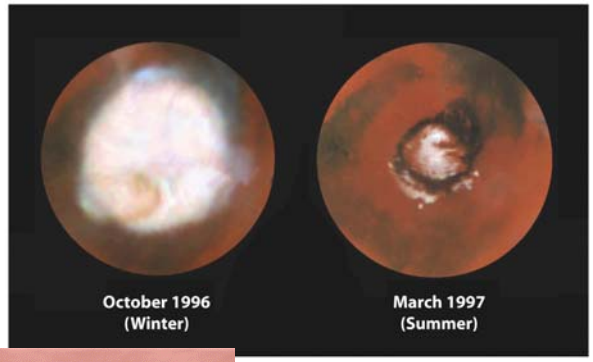


"Islands"

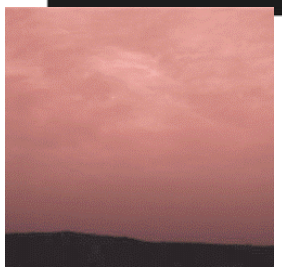
Flood erosion

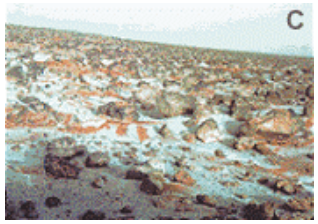
Water on Mars

- North and south polar caps is mostly frozen CO_2, but maybe some ice water too.
- Frost
- Clouds (ice crystals)



http://www.solarviews.com/eng/marscld.htm

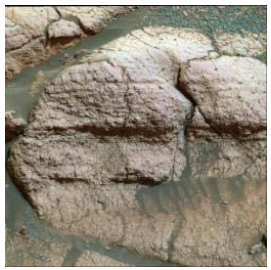




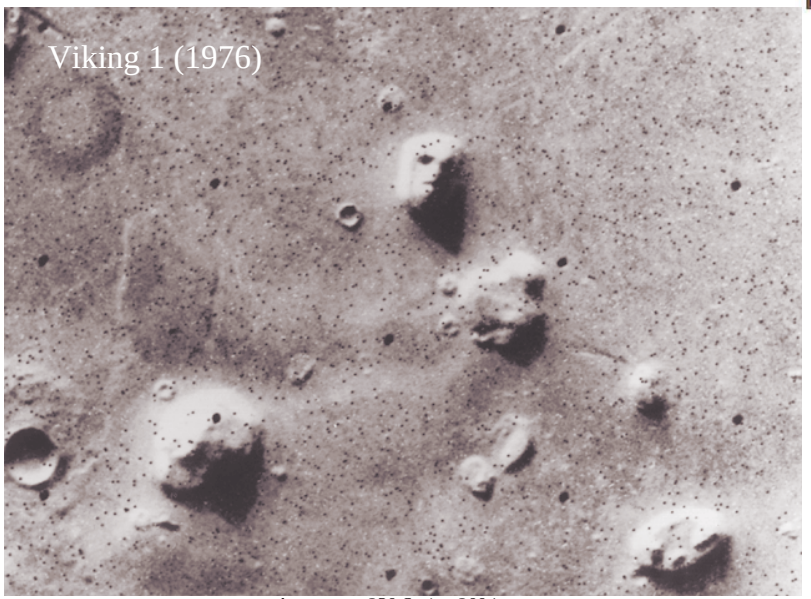
NASA Spacelink

Standing Water on Mars

- The new data from the rover Opportunity 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.
- Does not mean there was necessarily a standing ocean. But maybe.



The Surface of Mars



The Surface of Mars

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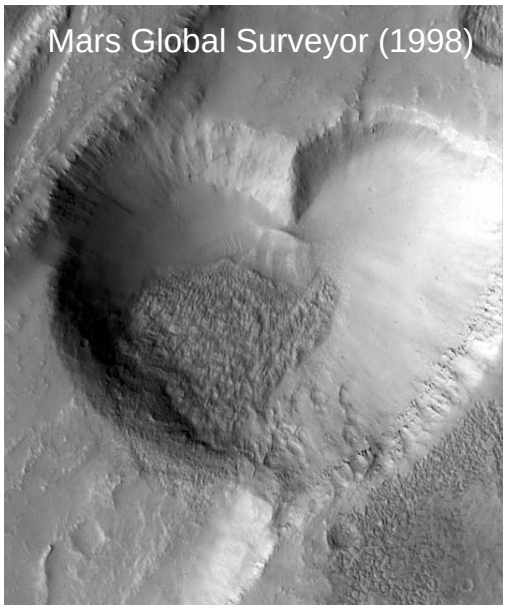
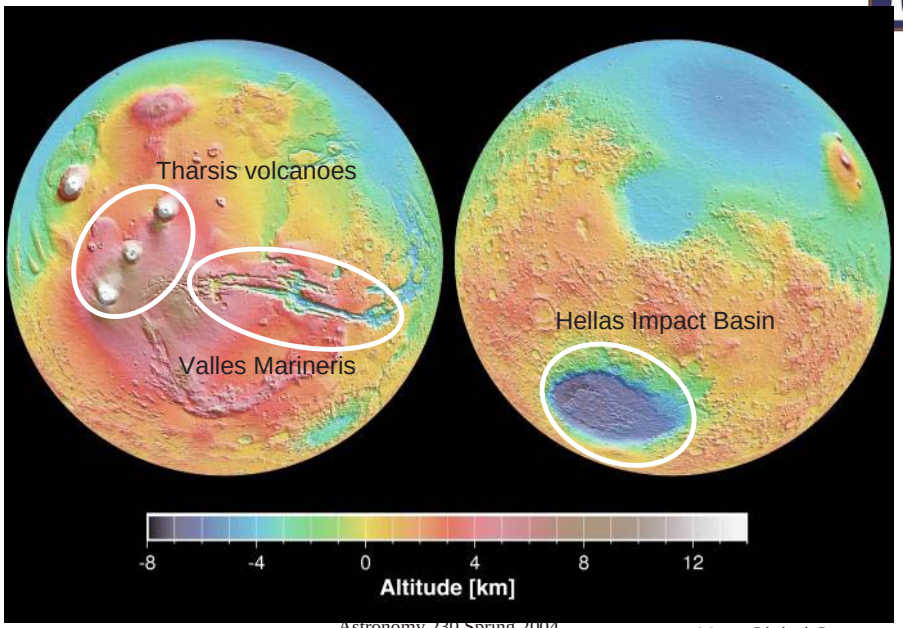


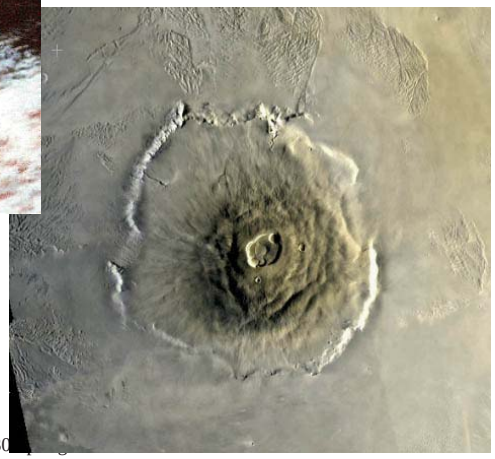
The Surface of Mars



Mars Global Surveyor

Olympus Mons

- The largest mountain in the Solar System rising 24 km (78,000 ft.).

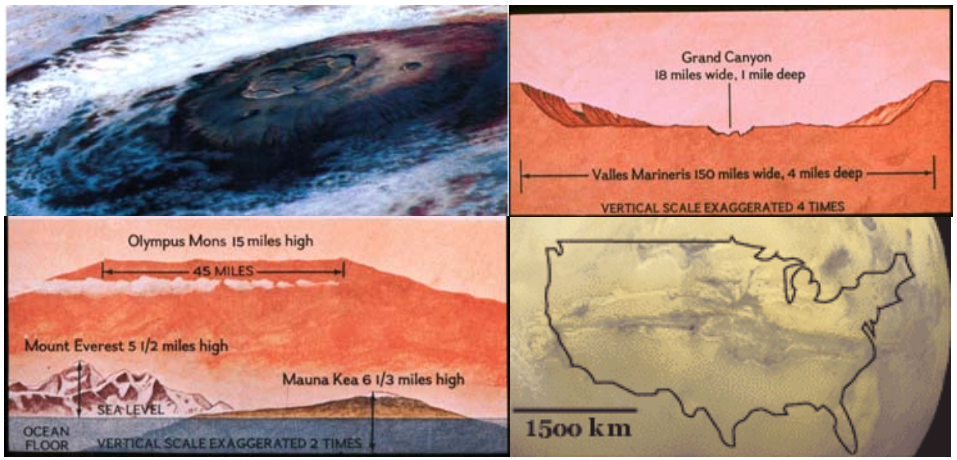


- Its base is more than 500 km in diameter and is rimmed by a cliff 6 km (20,000 ft) high (right).
- Last erupted 200+ years ago.

http://hyperphysics.phy-astr.gsu.edu/hbase/solar/marsoly.html

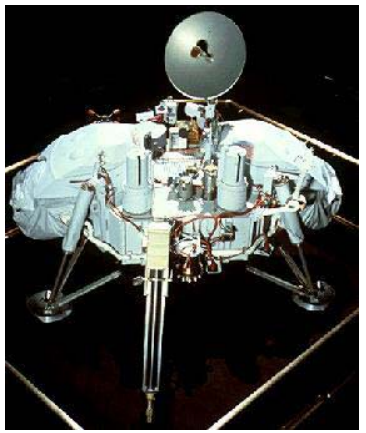
Volcanoes and Chasms

Olympus Mons Valles Marineris



The Search for Mars Life

- Viking 1 and 2 carried several experiments to detect life
- The results were ambiguous. The soil reacted vigorously with the Viking nutrients, then tapered off in activity.
- The conclusion of most scientists is that the reactions were due to inorganic chemical reactions.



Martians?

- In August 1996, evidence for microbial life was found in a Martian meteorite.
  - ALH84001: Found in Antarctica, composition suggests it was knocked from Mars
  - About 14 such Mars rocks have been found on Earth
- David McKay *et al.* suggested that there was fossil evidence for bacteria in the meteorite.

Martian Microbe Fossils?

- Microscopic shapes that resemble living and fossil bacteria on Earth– nanobacteria.
- Microscopic mineral grains like some produced by living and fossil bacteria on Earth
- Organic chemical compounds that resemble the decay products of bacteria on Earth.
- In the end, not impelling enough. Non-biological processes can produce the observed features