

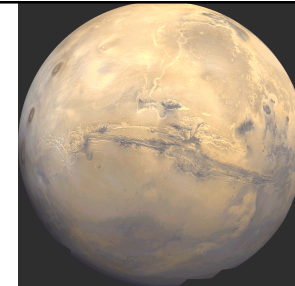
Mars–February 14

- No office hours today

- Description
- What happened to Mars' greenhouse?
- What happened to Mars' atmosphere
- Mars Odyssey/ Search for water

Mars

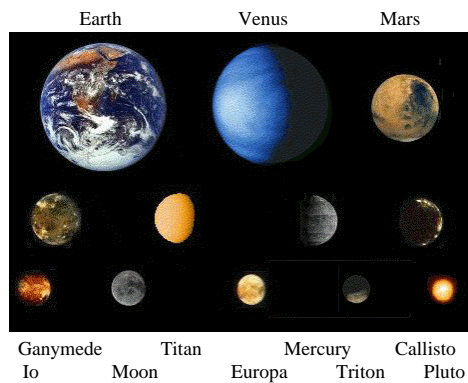
	Venus	Earth	Mars
Diameter	0.95	1	0.53
Mass	0.81	1	0.11
Semi-major axis	0.72	1	1.52
Density	0.96	1	0.71
Rotation (days)	-243	1	1.026
Orbit period (days)	224	365	687



- Some of the 16 spacecraft that have gone to Mars:
 - **Mariner 9** orbiter (1971-72)
 - **Viking 1,2** landers (1976-80)
 - **Pathfinder** lander + rover (1997)
 - **Climate Orbiter, Polar lander** (crashed, 1999).
 - **Mars Global Surveyor**: orbiting Mars since March 1999.
 - **Odyssey**: orbiting Mars since October 2001.

[Rotating Mars](#)

Some planets and moons shown in correct relative sizes

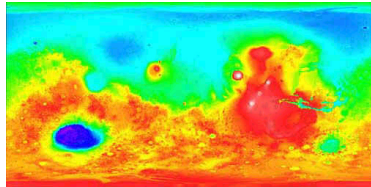


Geology

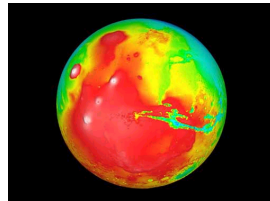
- Density suggests mostly silicates, but small metal core
- No detectable magnetic field
- Continental highlands
 - cover ~ 50% of planet.
- Low-lying lava plains
 - average of 4 km lower than continents.
 - Same age as lunar maria - 3-4 billion yrs old.

Topographic Map

From Mars Global Surveyor orbiter

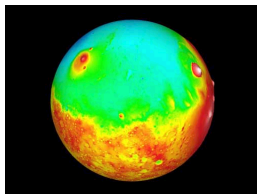


Red = high areas.
Blue = low areas.



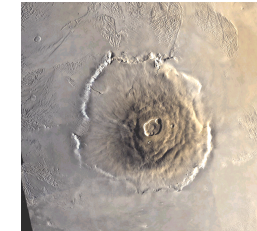
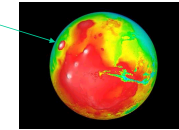
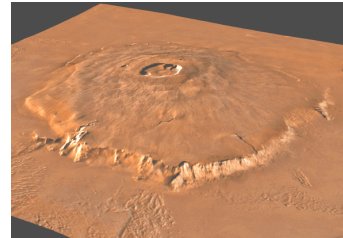
Tharsis bulge

- uplifted continent 10 km high.
- has 4 huge volcanoes, 15 km high.



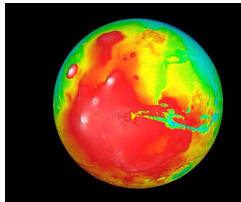
Rotating Mars

Olympus Mons



- 500 km diameter
 - would cover MI lower peninsula
- 25 km above surrounding plains
- largest mountain in Solar System.
 - 100 x volume of Mauna Loa
- < 100 million yrs old (impact crater counts)
 - so Mars is still geologically active.

Valles Marineris



- 5000 km long
 - 1/4 way around Mars
 - would stretch clear across US.
- Huge tectonic crack in Tharsis bulge
 - 8-10 km deep
 - no outlet for water
 - but some minor role of water erosion in side canyons.

The Martian Atmosphere

	Venus	Earth	Mars
Surface temperature	482° C	20° C	-100° C
Surface Air Pressure	92	1	0.007
CO ₂	96%	0.03%	95%
N ₂	3.5%	78%	2.7%

- Little air
- Very cold
- (almost) no liquid water.
 - At Mars' low atmospheric pressure, water should go straight from ice to vapor.
- No Greenhouse effect because there is so little atmosphere.

Polar Ice Caps

Mars - February 1995 HST - WFPC2
Mars - October 1996 HST - WFPC2
Mars - January 1997 HST - WFPC2
Mars - March 1997 HST - WFPC2

Northern Cap

Southern Cap

- Always below 150° K (-279°F), so CO₂ frozen all year.
- Unknown mix of CO₂ and H₂O ice.

Frozen CO₂ layer in winter

Only underlying H₂O ice left in summer, 3 km thick

Rotating Mars

Climate change

Used to be *lots* of running water

- Runoff channels.
 - From rainstorms billions of years ago.

10 km

[Fig. 7.22]

What happened to Mars' greenhouse

- At one time Mars was warm enough for liquid water.
- CO₂ reacts with silicate rocks to convert to carbonate rocks.
 - Q Why is sequestering of carbon in rocks not fatal on earth?
 - a. The rocks are protected by vegetation.
 - b. Because of plate tectonics, the carbon is released again.
 - c. On earth, this does not happen as much because of the oceans
- CO₂ produced by volcanoes & meteors
 - Meteor bombardment ceased
 - Being smaller, Mars cools faster & volcanoes decrease more rapidly
- CO₂ clouds cool Mars > more clouds form > cool

What happened to Mars' atmosphere

Mars did have H₂O & CO₂. Where did H₂O go?

	Venus	Earth	Mars
Escape velocity	0.93	1	0.45
Surface temperature	482° C	20° C	-100° C
Surface Air Pressure	92	1	0.007

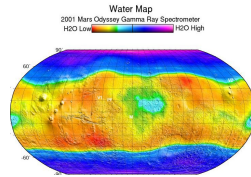
- H₂O dissociates to O₂ & H₂ by UV light
 - Hydrogen escapes
 - Oxygen reacts with rock
- Stripping by solar wind
 - Core solidified → magnetic field went away → stripping of gas by solar wind particles.
- Low temperature freezes water

Early Mars **Mars Today**

[Fig. 7.27]

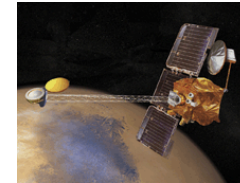
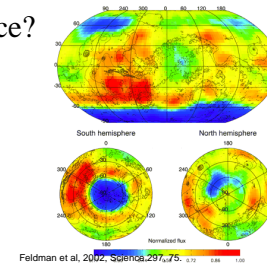
Gamma Ray Spectrometer & Neutron Spectrometer on Mars Odyssey

- "We have found that in the regions north and south of 60 degrees latitude, the surface is well over 50 percent water ice by volume. If just the top meter of ice deposits around the martian north pole were melted, there would be enough liquid water to fill Lake Michigan." Boynton (<http://marsprogram.jpl.nasa.gov/spotlight/odyssey-mission-success.html>)



How could Odyssey see below the Martian surface?

- Cosmic rays hit Mars b/c there is no protecting magnetic field & atmosphere. Produce neutrons and gamma rays.
- Hydrogen (in top meter) absorbs energy of neutrons efficiently.
 - Energy of neutrons is transferred to hydrogen b/c masses are same.
 - Mass of Silicon, etc is much greater than that of neutron. Energy loss is small when neutron hits silicon.



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