Red Planet Mars

Chapter Thirteen

Introduction To Modern Astronomy I

Introducing Astronomy
(chap. 1-6)

Planets and Moons
(chap. 7-17)

Ch7: Comparative Planetology I
Ch8: Comparative Planetology II
Ch9: The Living Earth
Ch10: Our Barren Moon
Ch11: Sun-Scorched Mercury

Ch12: Cloud-covered Venus
Ch13: Red Planet Mars

Ch14: Jupiter and Saturn
Ch15: Satellites of Jup. & Saturn
Ch16: Outer World
Ch17: Vagabonds of Solar System

Guiding Questions

1. When is the best to see Mars in the night sky?
2. Why was it once thought that there are canals on Mars?
3. How are the northern and southern hemispheres of Mars different from each other?
4. What is the evidence that there was once liquid water on Mars?
5. Why is the Martian atmosphere so thin?
6. What have we learned about Mars by sending spacecraft to land on its surface?
7. What causes the seasonal color changes on Mars?
8. As seen from Mars, how do the Martian moons move across the sky?

Mars Data

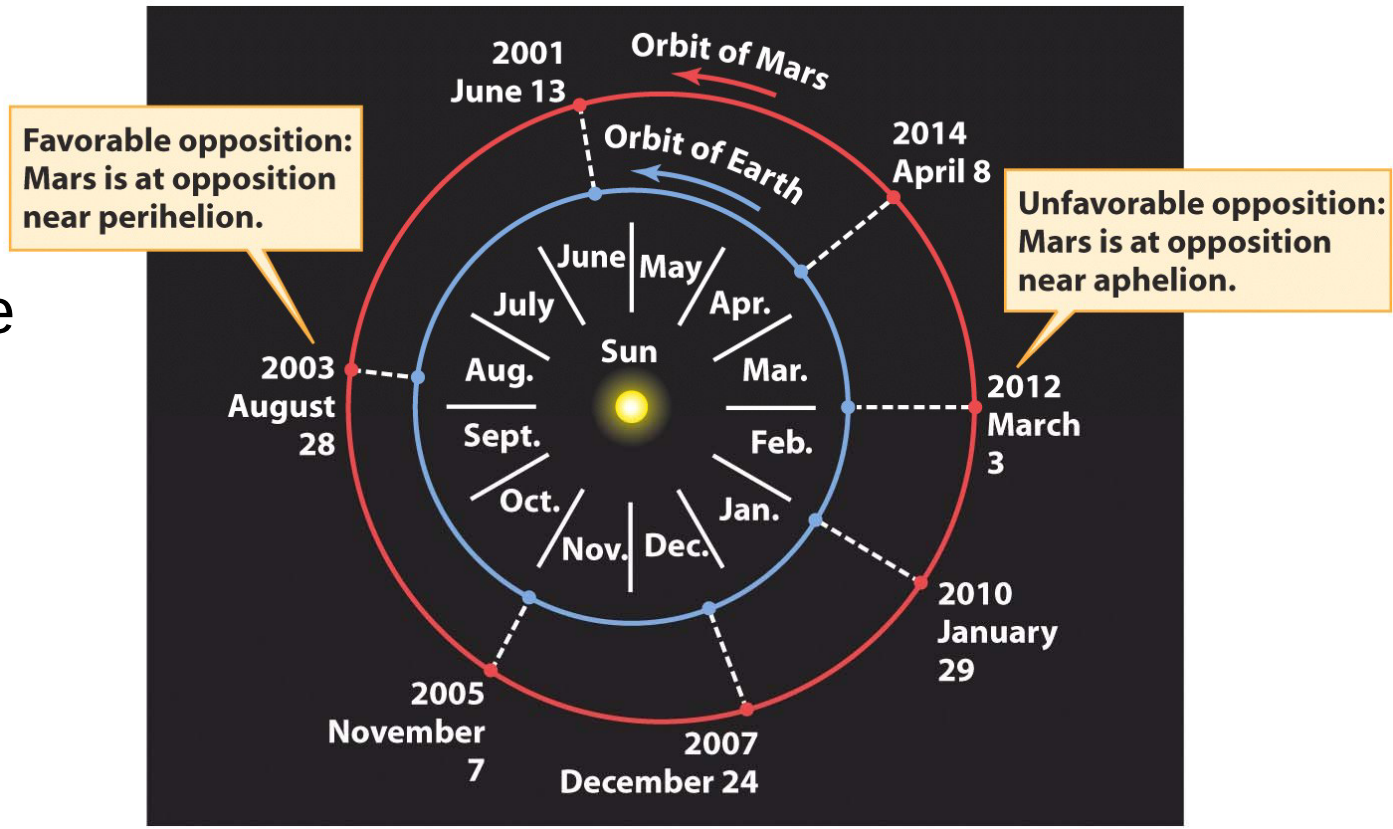
table 13-1 | Mars Data

Average distance from Sun:	1.524 AU = 2.279×10^8 km
Maximum distance from Sun:	1.666 AU = 2.492×10^8 km
Minimum distance from Sun:	1.381 AU = 2.067×10^8 km
Eccentricity of orbit:	0.093
Average orbital speed:	24.1 km/s
Orbital period:	686.98 days = 1.88 years
Rotation period:	$24^h\ 37^m\ 22^s$
Inclination of equator to orbit:	25.19°
Inclination of orbit to ecliptic:	1.85°
Diameter (equatorial):	6794 km = 0.533 Earth diameter
Mass:	6.418×10^{23} kg = 0.107 Earth mass
Average density:	3934 kg/m^3
Escape speed:	5.0 km/s
Surface gravity (Earth = 1):	0.38
Albedo:	0.15
Surface temperatures:	Maximum: 20°C = 70°F = 293 K Mean: −53°C = −63°F = 220 K Minimum: −140°C = −220°F = 133 K
Atmospheric composition (by number of molecules):	95.3% carbon dioxide (CO_2) 2.7% nitrogen (N_2) 0.03% water vapor (H_2O) 2% other gases

Earth-based observations

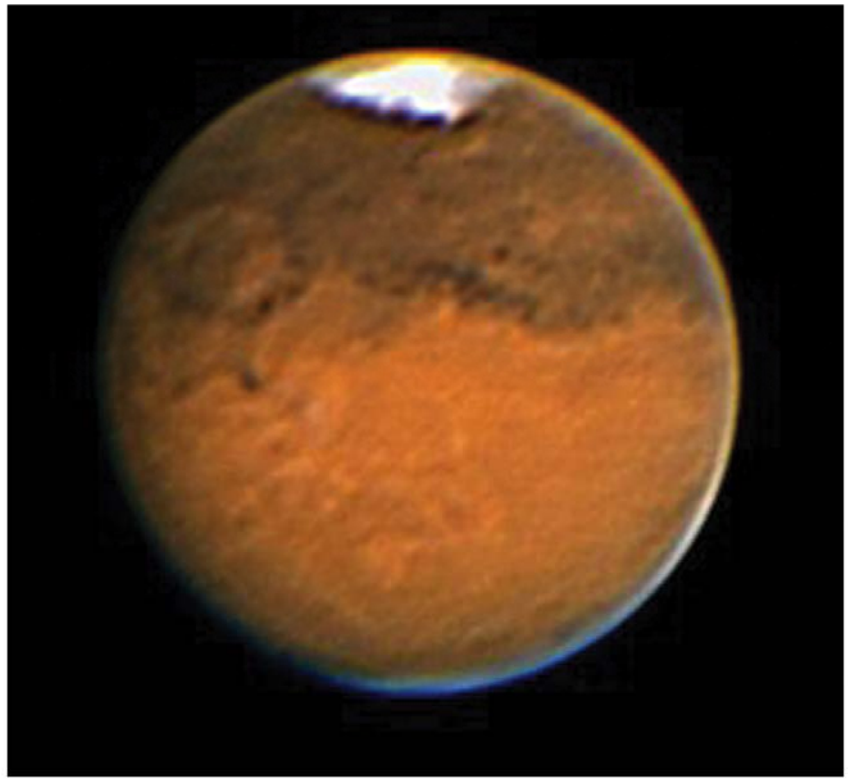
- The best Earth-based views of Mars are obtained when Mars is simultaneously at
  1. opposition and
  2. near perihelion

- At favorable opposition, the Earth-Mars distance can be as small as 0.37 AU, and angular diameter can be as large as 25 arcsec



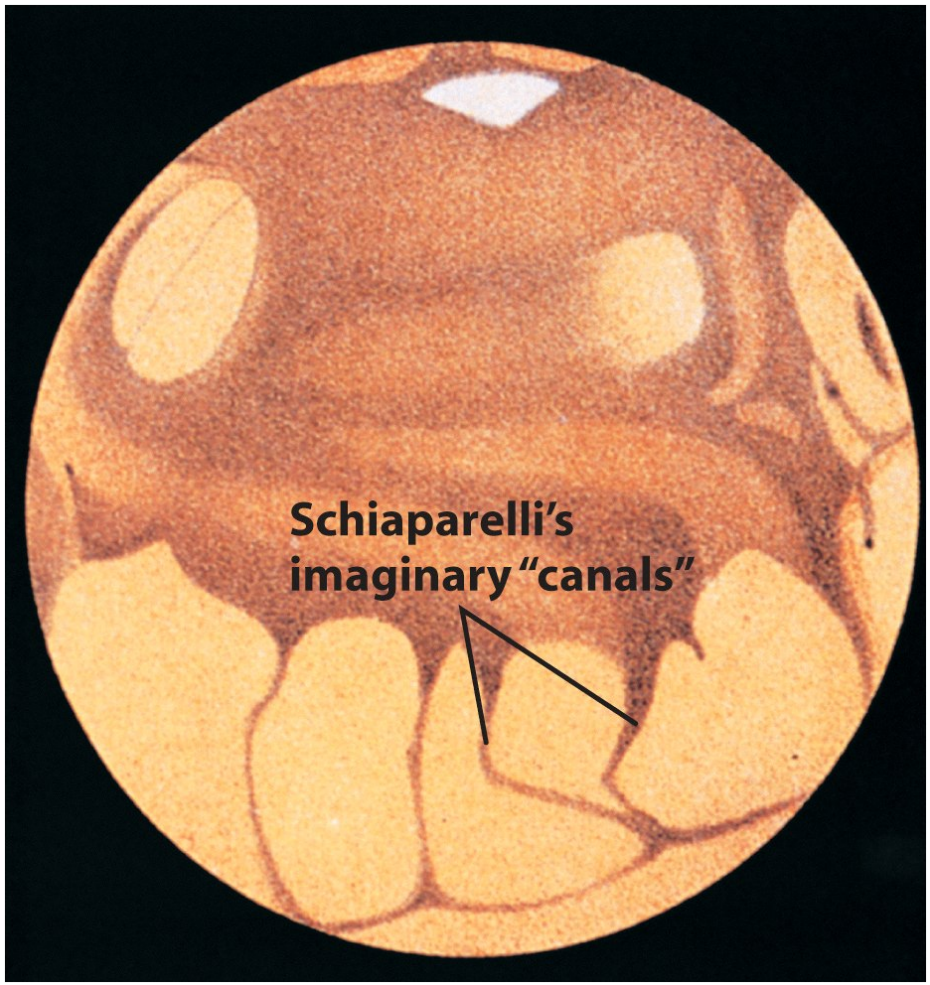
Earth-based Observations

- Mars has a thin, almost cloudless atmosphere that permits a clear view of the Surface
- A solar day on Mars is nearly the same length as on Earth
- Mars has polar caps that expand and shrink with the seasons
- The Martian surface undergoes seasonal color changes



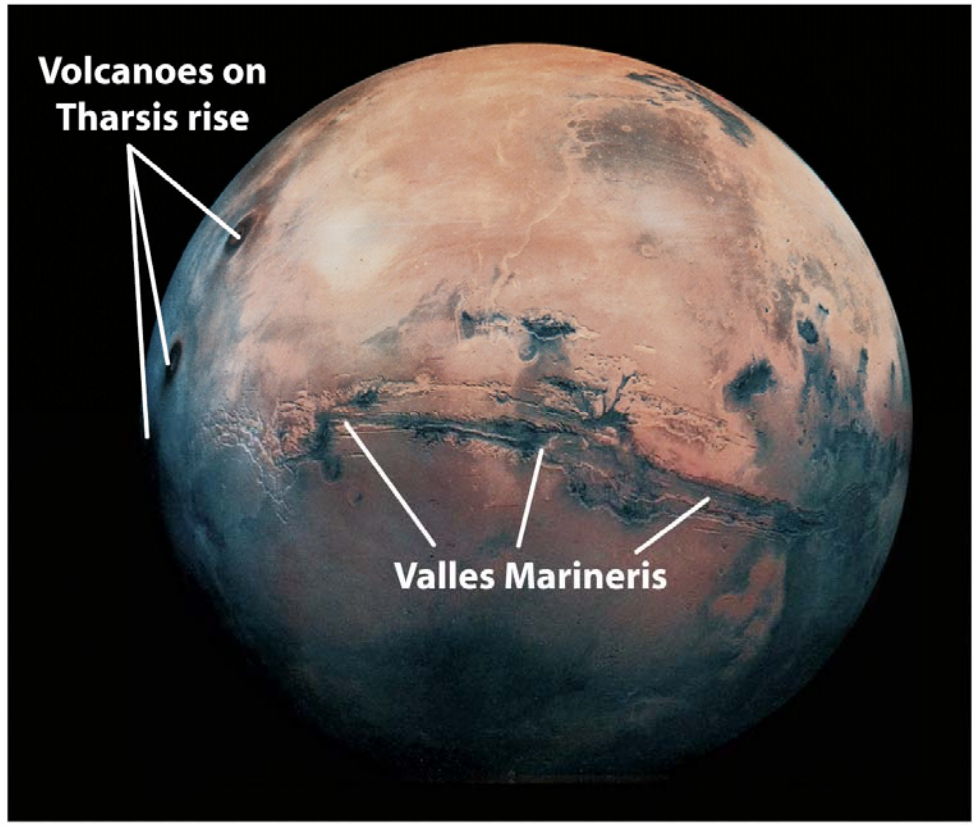
Earth-based observations

- A few observers, in 19th century, reported a network of linear features called canals
- These observations, led to many speculations about Martian life
- However, it is proven that the canals are illusion.



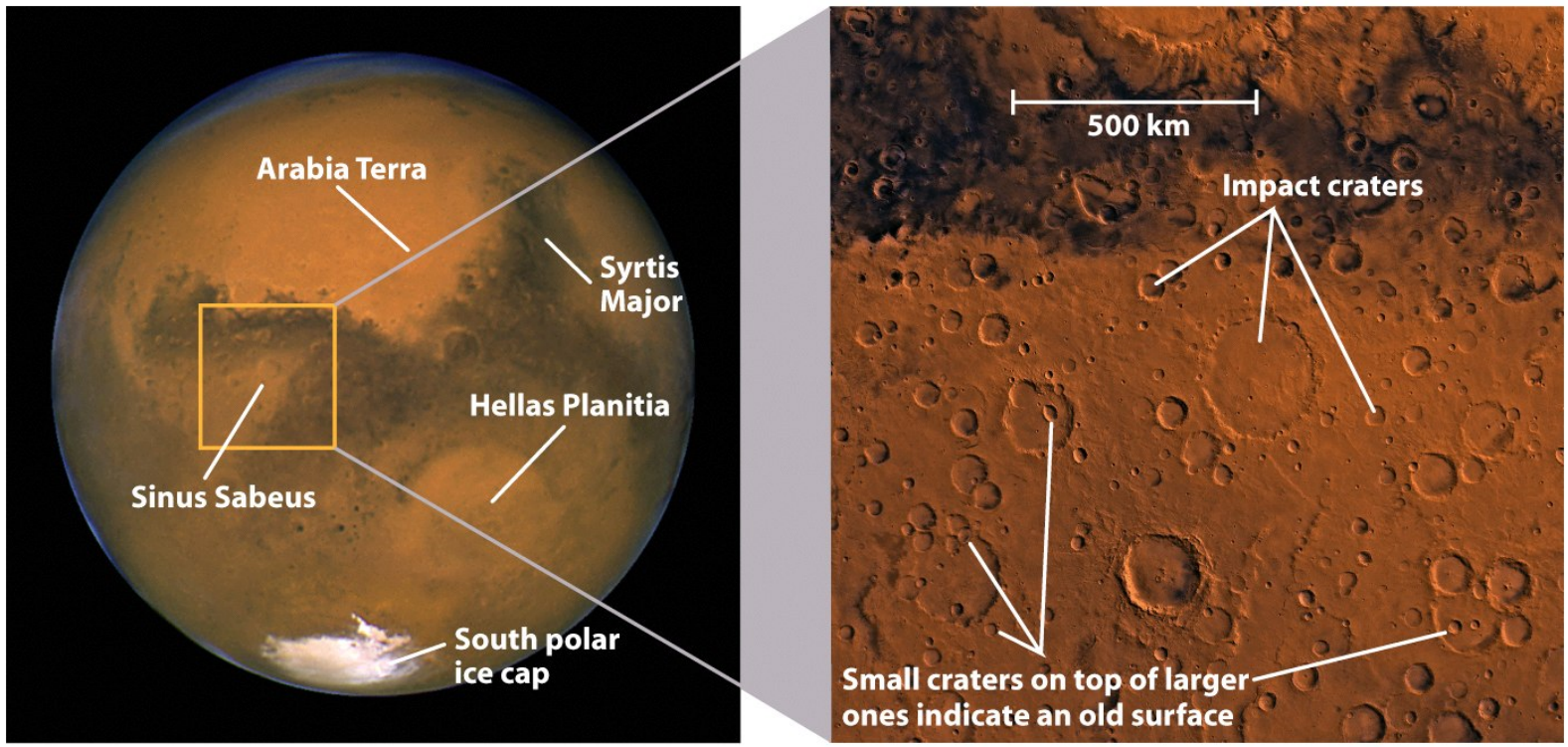
Surface

- Since 1960s, Mars have been regularly visited by unmanned spacecraft and their landing modules.
- The Martian surface has numerous craters, several huge volcanoes, a vast rift valley, and dried-up riverbeds— but no canals



Surface

- Martian surface is largely covered by craters
- Some martial surface must be extremely ancient



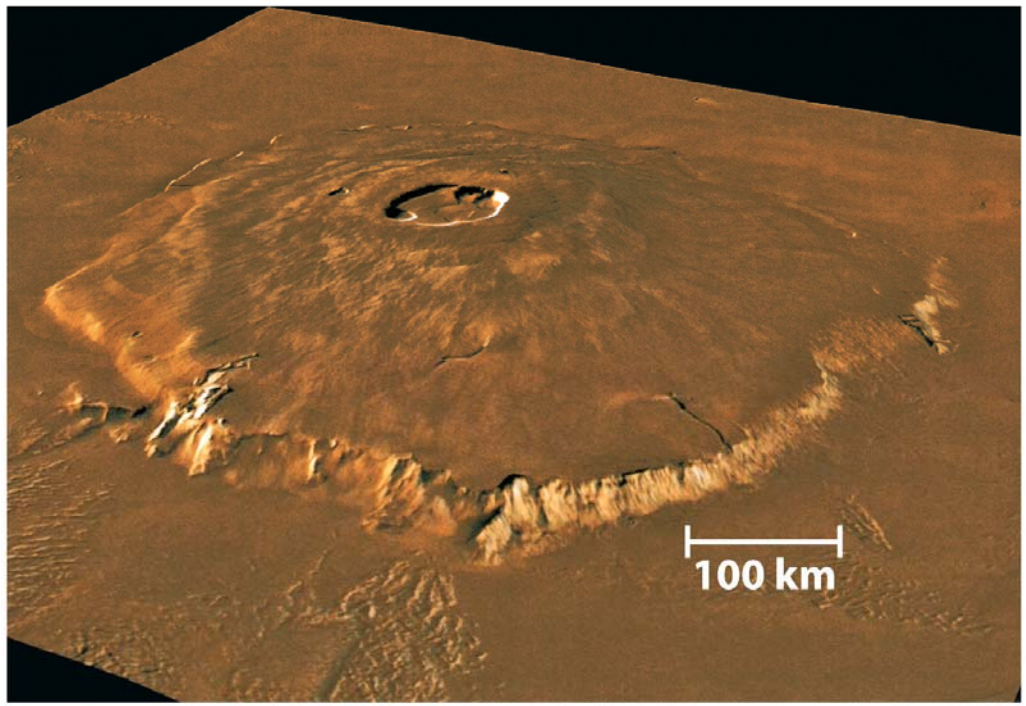
(a) Mars from the Hubble Space Telescope

(b) Closeup of Sinus Sabeus region

Surface

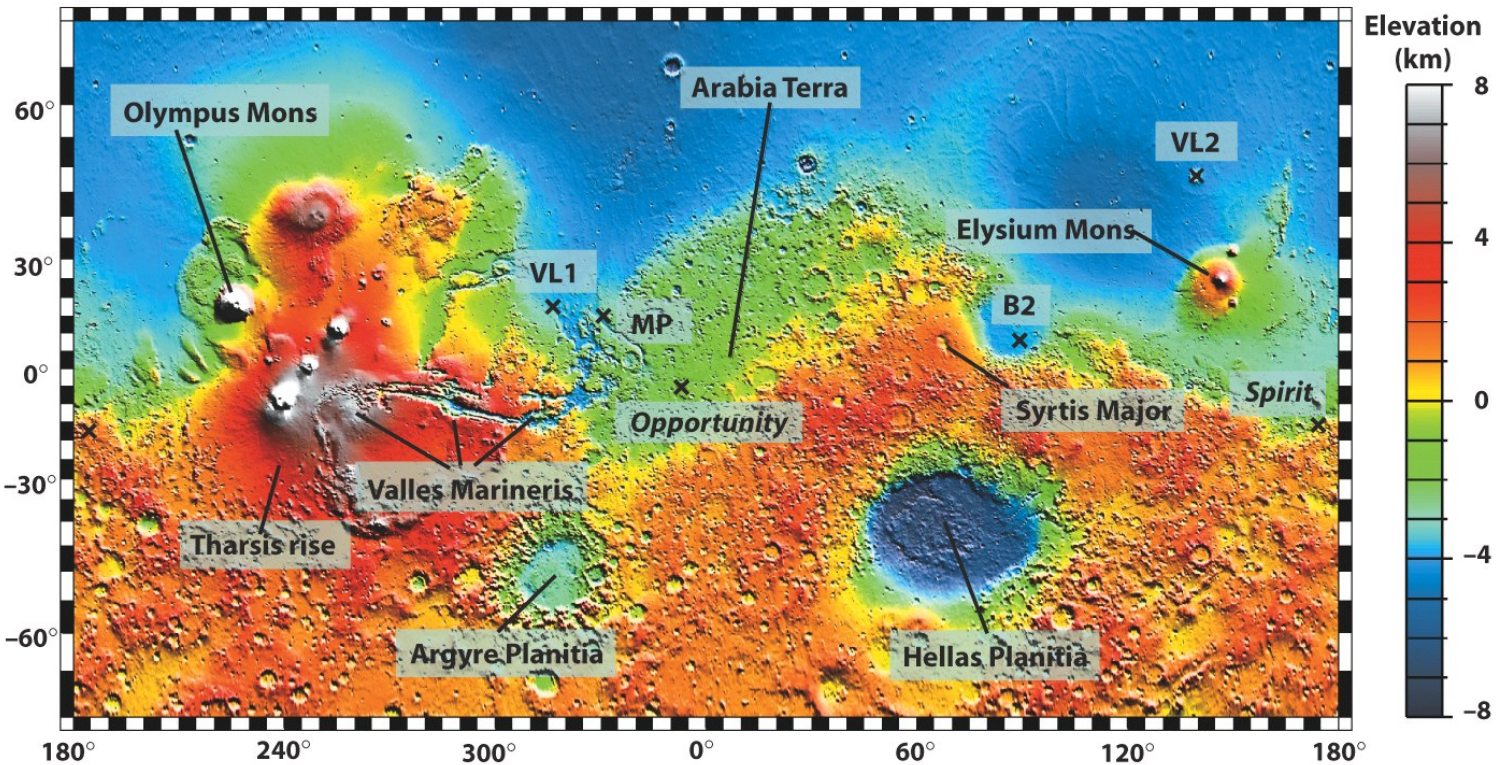
- Olympus Mons: the largest volcano in the solar system, 600 km across, 24 km above the surrounding plains, the scarps (or cliffs) 6 km high

- It was probably formed by hot-spot volcanism: magma wells up from a hot spot in a planet's mantle over a long time, e.g., millions of years
- The huge size of Olympus Mons, instead a chain, indicates the absence of planet tectonics.



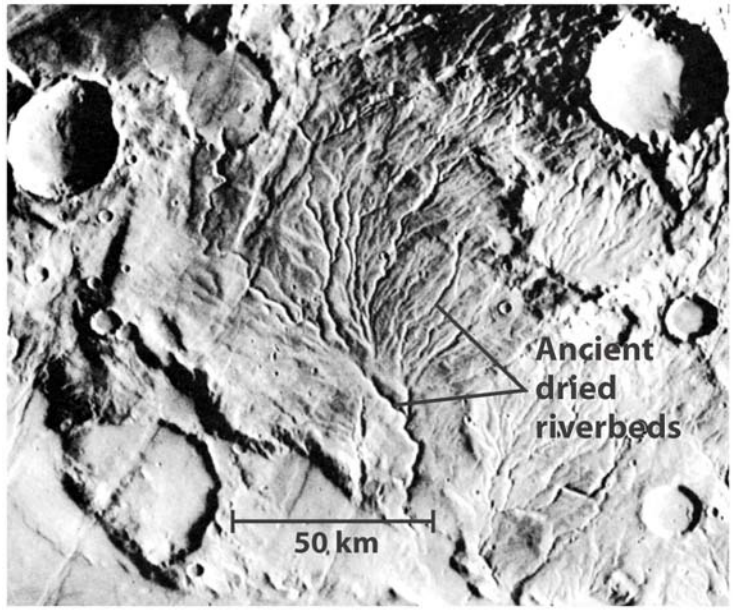
Surface

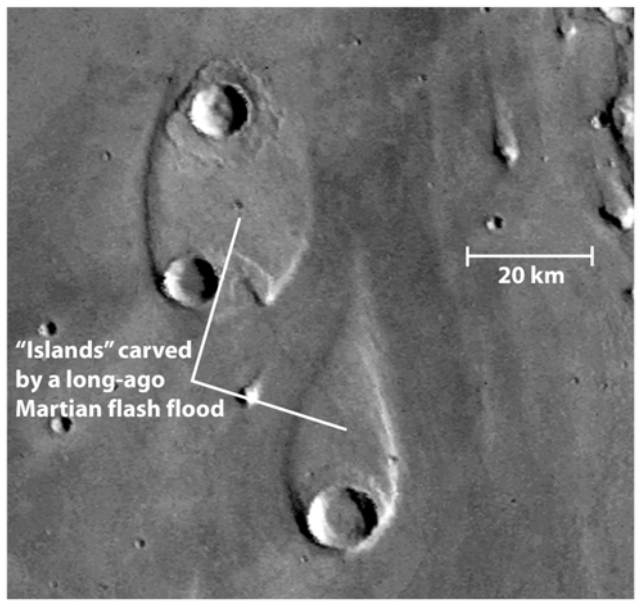
- Southern highlands versus northern lowlands: dichotomy
  - The average elevation of southern highlands is about 5 km higher than that of northern lowlands
  - Surface in the south is relatively older, because of numerous craters
  - Surface in the north is smooth and free of craters



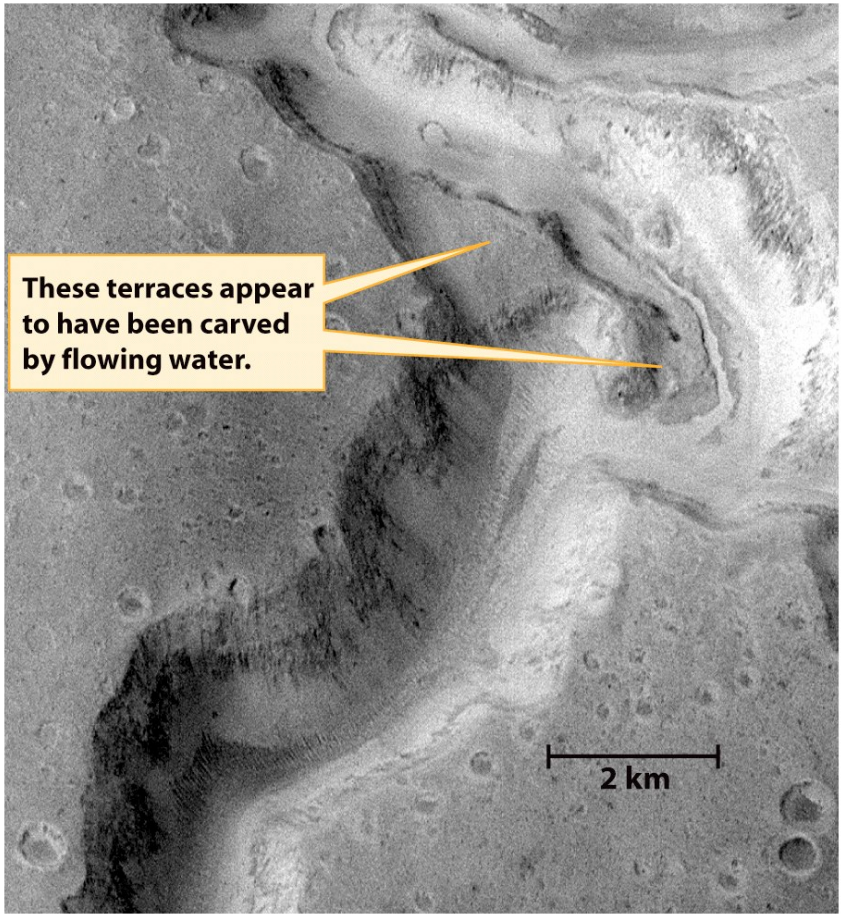
Water on Mars

- No liquid water or rainfall on the planet's surface today
- Liquid water once flowed on March, as evident in many surface features
- E.g., dried riverbeds on the Martian surface
- "Island" carved by flash flood

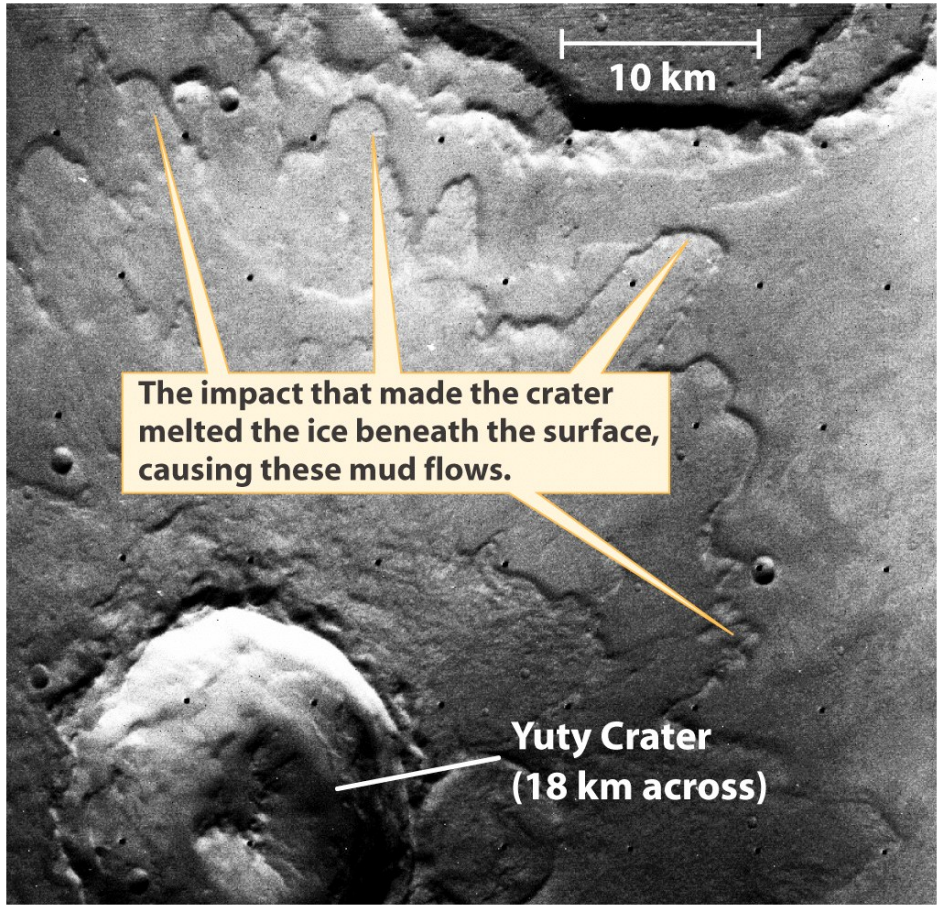




Water on Mars



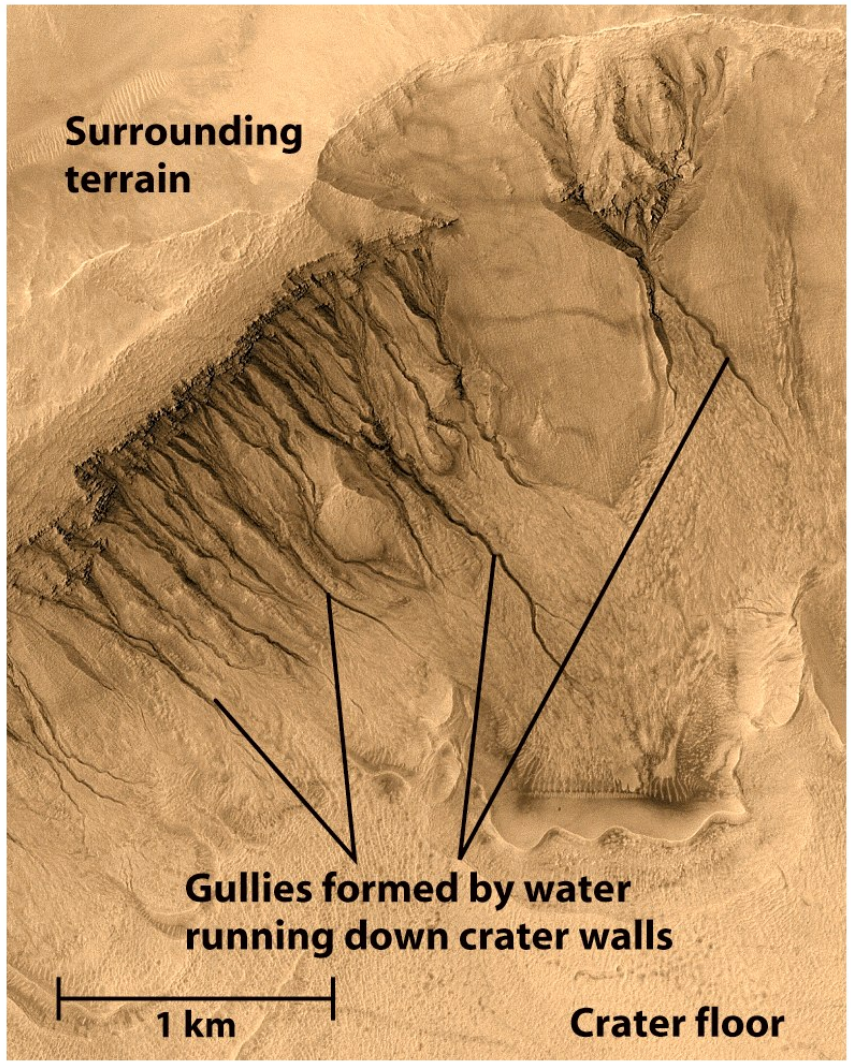
Sustained water carved out canyons



Mud flow feature indicates a subsurface layer of water ice

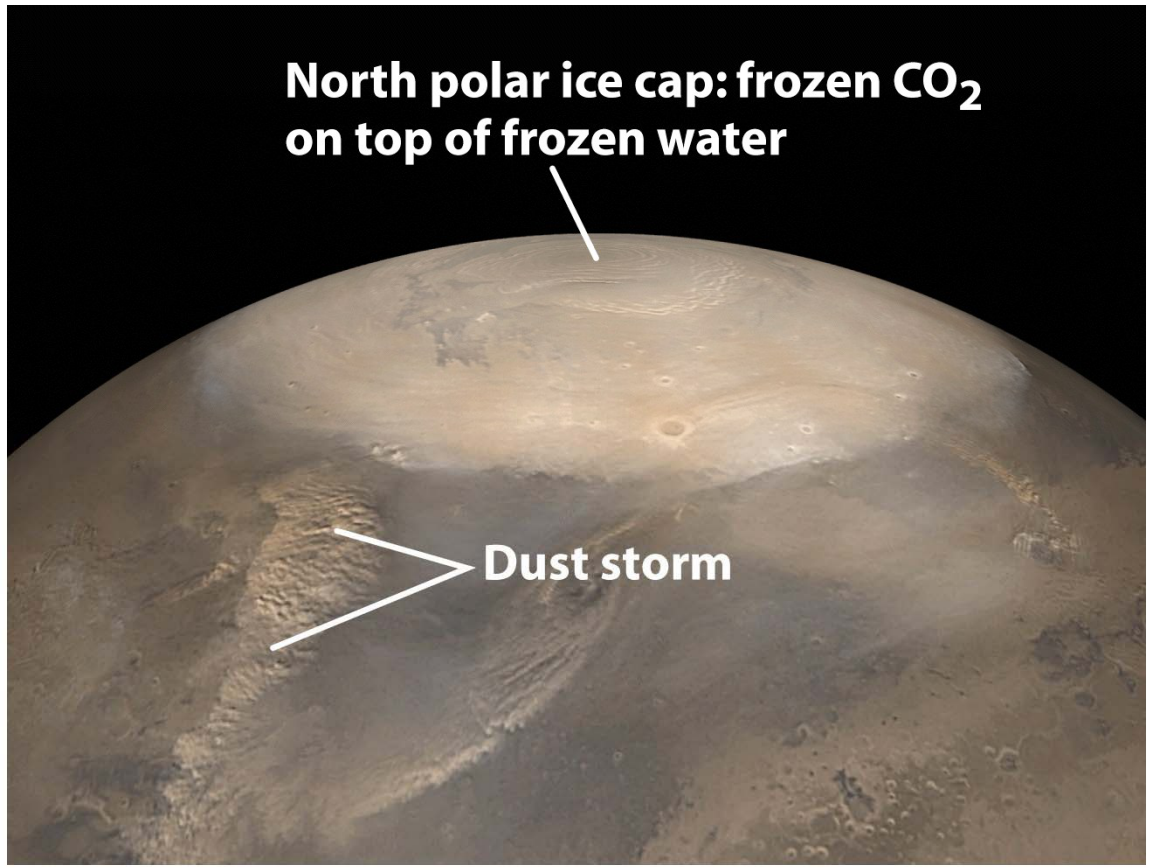
Water on Mars

- Gullies have formed by subsurface water seeping out to the surface



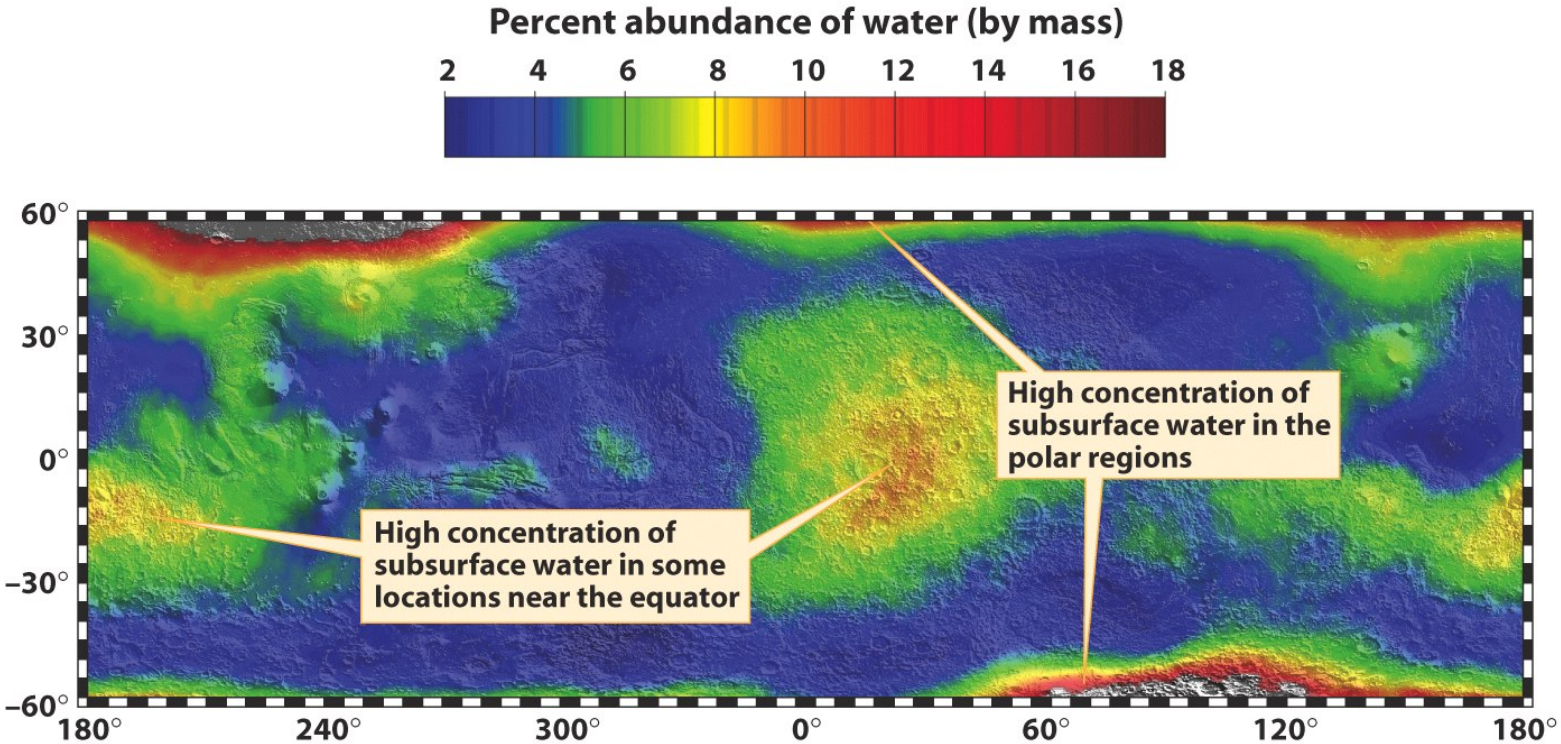
Water on Mars

- Mars's polar caps contain frozen water
- The Martian polar caps expand in winter as a thin layer of frozen carbon dioxide (dry ice) is deposited from the atmosphere



Water on Mars

- Frozen water is contained in polar caps
- Frozen water is stored in permafrost under the Martian surface
- There might be enough water to cover the planet to a depth of 500 meters



Water Measurement from Mars Odyssey Spacecraft

Atmosphere

- The present Martian atmosphere is composed mostly of carbon dioxide
- The atmospheric pressure on the surface is less than 1% that of the Earth and shows seasonal variations as carbon dioxide freezes onto and evaporates from the poles

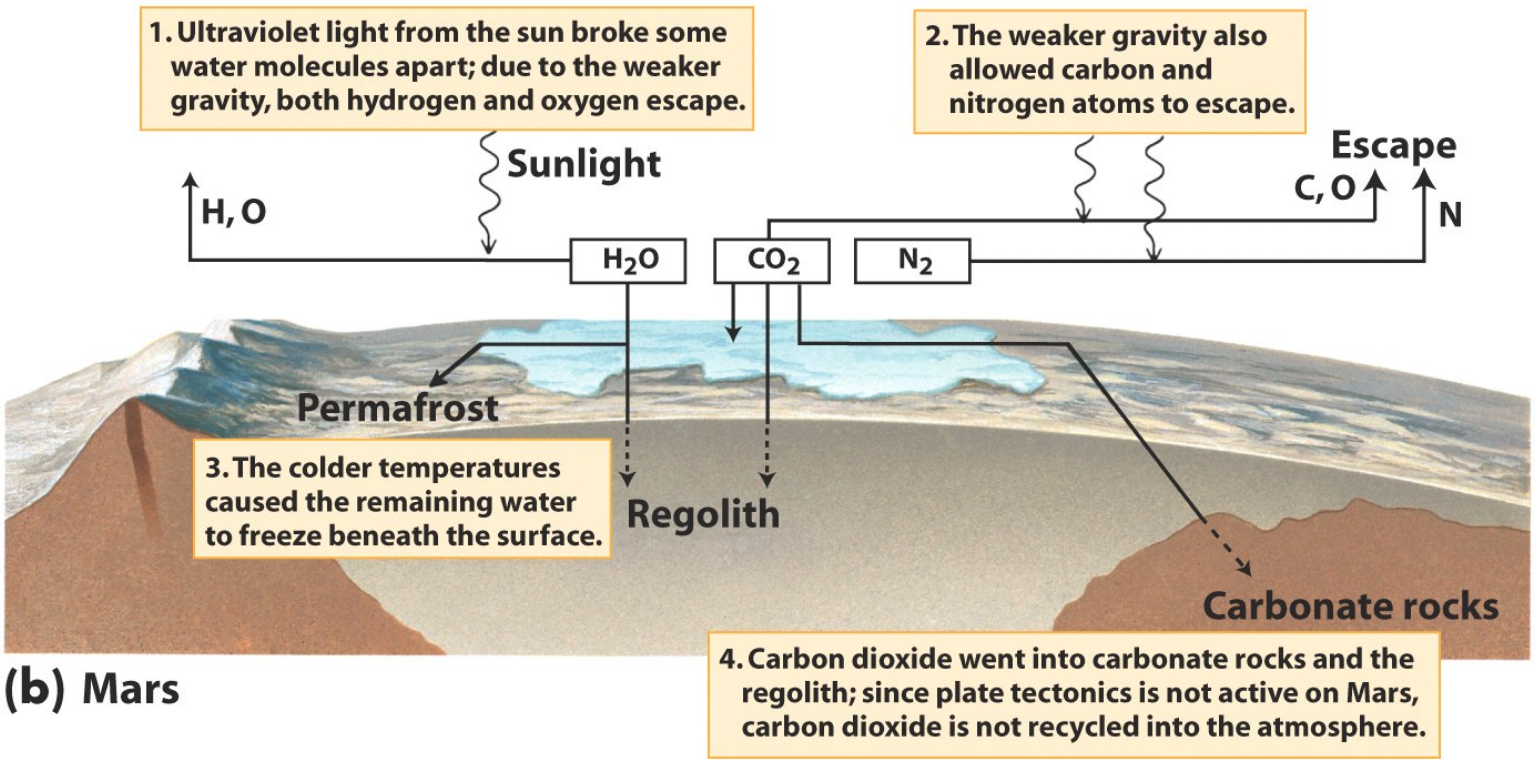
- Mars and Earth began with similar primordial atmosphere that evolved differently
  - Mars has relatively weaker gravity
  - Mars is geologically inactive

Atmosphere

- Water and carbon dioxide molecules are broken into atoms, which then escape into space, thanks to the weaker gravity of the Mars
- This weakened the greenhouse effect, and caused the temperature to drop
- A lower temperature caused more water vapor to condense to the surface, carrying carbon dioxide
- This further reduced the temperature, caused a **runaway icehouse effect, opposite to the runaway greenhouse effect occurred on Venus**
- The remaining water is frozen underneath the surface
- The remaining CO_2 is locked in the rocks; it is not recycles into the atmosphere, thanks to the inactivity

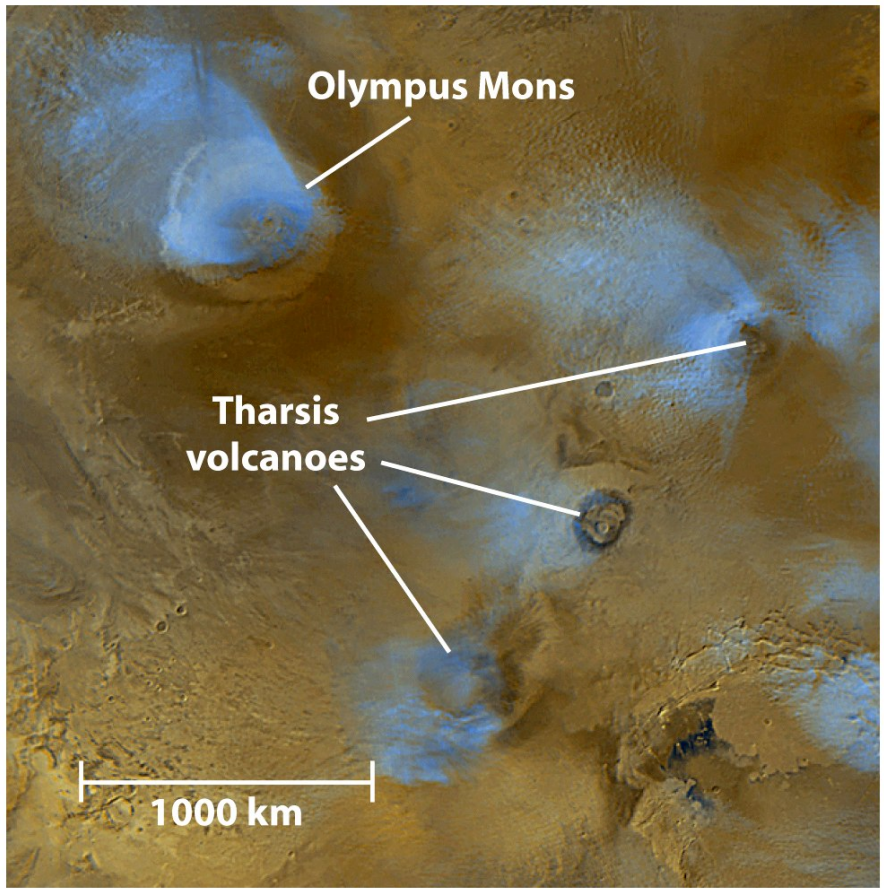
Atmosphere

- The remaining water is frozen underneath the surface
- The remaining CO_2 is locked in the rocks; it is not recycles into the atmosphere, thanks to the inactivity
- This resulted in a thin Martian atmosphere



Atmosphere

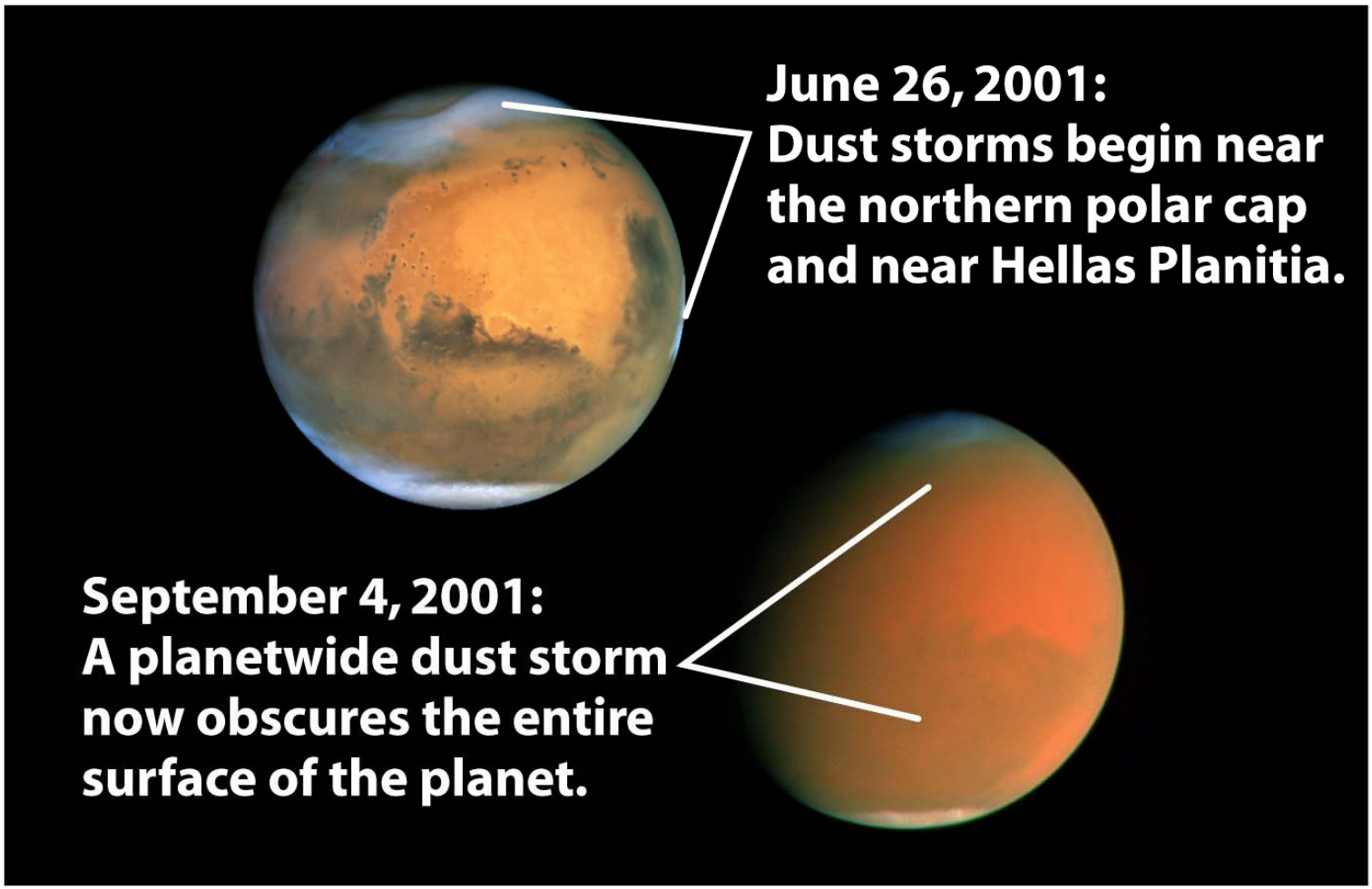
- Clouds are made of tiny water ice crystals as well as crystal of carbon dioxide ice (dry ice)



Clouds Above Mars' Mountains

Atmosphere

- When temperature rises during the spring, CO_2 frost evaporates, and trigger the dust storm

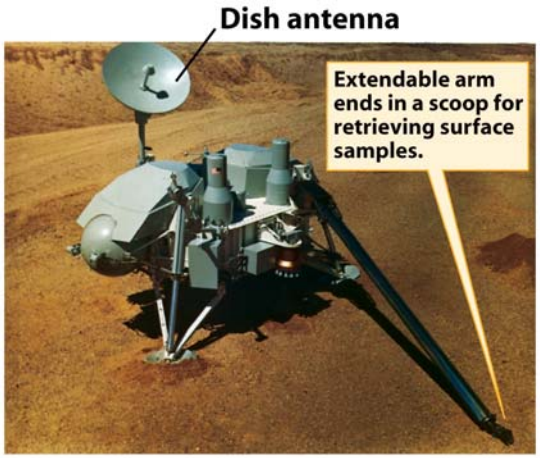


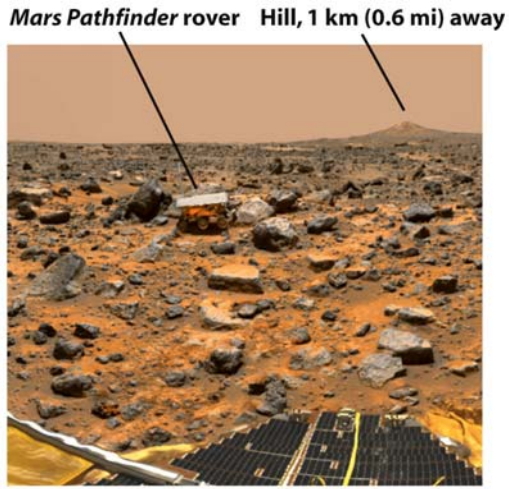
Atmosphere

- When temperature decreases during the winter, freezing CO_2 adheres to water ice and dust grain in the air, causing them to fall to the ground

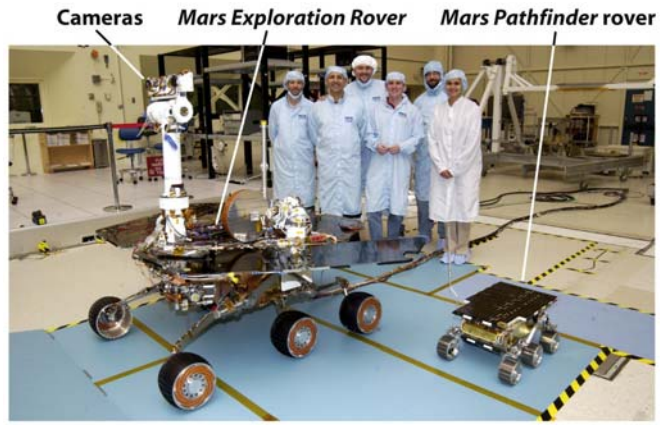
Exploration

- Many spacecraft have been sent to study the Mars, including both orbiting and landing spacecraft
- In 1970s, Viking 1 and Viking 2 Landers
- In 1997, Mars Pathfinder Lander called Sojourner
- In 2004, Mars Exploration Rovers: Spirit and Opportunity
- Human exploration on Mars is now under development



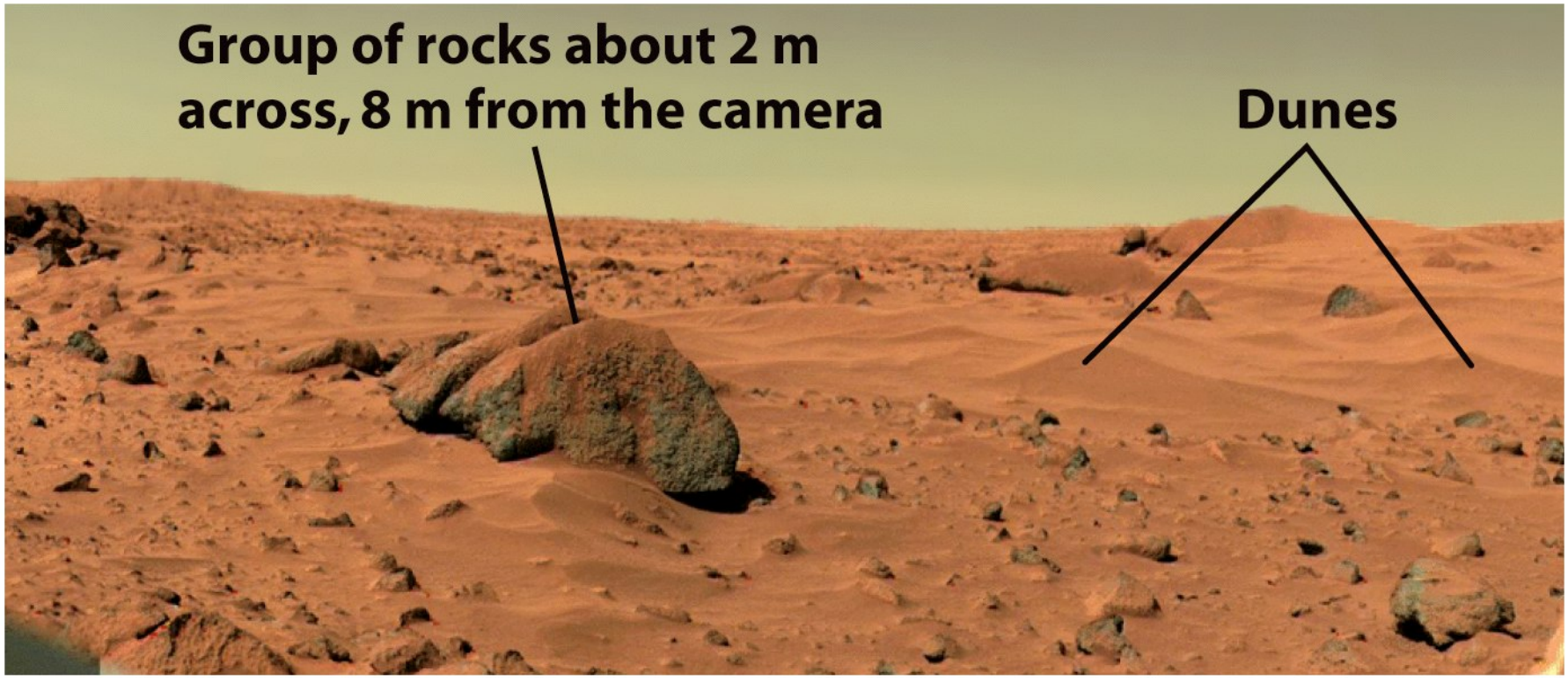


(a) A rover on Mars



Two generations of rovers

Exploration



Final Notes on Chap. 13

- There are 8 sections in total.
- Section 13-7 (on seasons) and 17-8 (on Moons) are not studied