Mars vs. Earth

- Mars is about 2/3 the size of the Earth.
  - This smaller size has implications for
    - geologic history - a quicker cooling and geologic death
    - atmosphere - weaker gravity and greater difficulty holding on to gas.
- Despite these differences Mars may be the planet with the most in common with the Earth.
Mars as Seen from Earth

• Historically, more than Venus, Mars was an object of keen telescopic interest from Earth.
  – Venus is a featureless disk. Mars shows terrain, polar caps, rotation, clouds...
Mars as Seen from Earth

- Even before the telescope Mars attracted considerable attention because of its red/orange color and its substantially changing brightness.
Mars as Seen from Earth

- Even before the telescope, Mars attracted considerable attention because of its red/orange color and its substantially changing brightness.
  - Mars is much much closer at opposition than at conjunction.
  - Some oppositions are much closer than others due to Mars' elliptical orbit.
A Shimmering Mars and the Imagination

- Mars' small angular size and Earth's atmospheric distortion left much to early observer's imagination.
  - Among the obvious (and suggestive) observations
    - Mars has a day roughly equal to an Earth day.
    - Mars has a tilt almost the same as Earth tilt (although it's elliptical orbit is a significant factor in its seasons unlike Earth).
    - Mars has polar caps (were they made of water?)
    - Clouds come and go.
    - Dark patches have a greenish hue (vegetation?)
  - Could Mars be inhabited???
Martians

• Early last century, an inhabited Mars was very much in the public consciousness.
  – so much so that a 1938 radio dramatization of H. G. Wells “War of the Worlds” created widespread panic amongst those who missed the beginning of the program.
Reality Sets In

• More detailed telescopic observations revealed a less hospitable world – and disposed of the myth of “canals”.
Reality Sets In

- More detailed telescopic observations revealed a less hospitable world – and disposed of the myth of “canals”.
Martian Properties

• A thin carbon dioxide atmosphere - $1/100^{th}$ the surface pressure of Earth's (96% CO$_2$, 4% Nitrogen, just like Venus)
  - Despite being made of a greenhouse gas, the thin atmosphere makes for poor blanket and it is below freezing most everywhere, all of the time
  • much colder at night and at the poles.
Martian Properties

• A thin carbon dioxide atmosphere - 1/100\textsuperscript{th} the surface pressure of Earth's
  
  - In winter the temperature drops so much at the poles that the atmosphere freezes out to form the changing polar caps.
  
  - The residual “summer caps” ARE made of water ice, however.

Mars
North Polar Cap

PRC97-15b • ST Sci OPO • May 20, 1997
P. James (Univ. Toledo), T. Clancy (Space Science Inst.), S. Lee (Univ. Colorado) and NASA
Martian Properties

• A thin carbon dioxide atmosphere - $1/100^{th}$ the surface pressure of Earth's
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Martian Properties

• A thin carbon dioxide atmosphere - 1/100\textsuperscript{th} the surface pressure of Earth's
  - In winter the temperature drops so much at the poles that the atmosphere freezes out to form the changing polar caps.
  - The atmospheric pressure on Mars actually changes as the polar caps come and go.
Spacecraft Exploration of Mars

- The first spacecraft flybys in the early 1960's made Mars look quite inhospitable.
  - Maybe no surprise given Mars' small size relative to Earth.
Spacecraft Exploration of Mars

• As it turned out, these early missions imaged the “boring” side of Mars.
Spacecraft Exploration of Mars

- Orbiters and Landers in the 1970's painted a different picture.
Spacecraft Exploration of Mars

- Mars was big enough to have had a geologically interesting past
Spacecraft Exploration of Mars

- Immense volcanoes

Olympus Mons
Spacecraft Exploration of Mars

• A start at plate tectonics?
Spacecraft Exploration of Mars

• A start at plate tectonics?
Evidence for Water on Mars

• Many lines of evidence point to abundant liquid water being present on the surface of Mars early in Martian history.

Evidence for Water on Mars (today)

- Water locked in the surface
Evidence for Water on Mars (today)

- Glacial activity?
Evidence for Water on Mars (today)

- Glacial activity in buried ice...
Evidence for Water on Mars (today)

- Fresh ice on and below the surface

http://phoenix.lpl.arizona.edu/index.php
Evidence for Water on Mars (today)

- Fresh ice on and below the surface
Mars in Context

- Mars is 2/3 the size of Earth and Venus
- Today its atmosphere is quite thin
  - But... substantial outgassing early on produced a thick CO2 atmosphere and a significant greenhouse (and abundant water in liquid form).
  - Significant geologic activity came to a halt early on.
  - Loss of atmosphere over time led to a cold, frozen world.
Mars as a Laboratory for Understanding the Earth

• The Earth is geologically quite active and its surface is young.
  - Most of the information regarding the first billion years of Earth's history has been destroyed.
Mars as a Laboratory for Understanding the Earth

• Mars apparently was briefly Earthlike during its first billion years.
  – Being smaller, Mars' geological activity came to a halt in the same first billion years that has been erased here on Earth.
  – Clues to the early evolution of the Earth's crust, the origin of life, and maybe even life itself, may be found on Mars.
Robotic Exploration of Mars

- The fact that Mars may provide clues to the early Earth and the emergence of life has led, in large part, to aggressive investigation of Mars.

1976 – Viking 1 and 2.
Robotic Exploration of Mars

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http://www.jpl.nasa.gov/missions/mer/
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http://www.jpl.nasa.gov/missions/mer/
Robotic Exploration of Mars

- The fact that Mars may provide clues to the early Earth and the emergence of life has led, in large part, to aggressive investigation of Mars from orbit and on the surface.
Robotic Exploration of Mars

• Seek out craters to examine the geological record
Robotic Exploration of Mars

- Seek out craters to examine the geological record
Robotic Exploration of Mars

• These observations confirm that Mars was once warmer with bodies of liquid water on its surface.
Mars Science Laboratory
Every two years a low-energy launch window to Mars opens. The trip requires about 8 months.
Mars Science Laboratory

Arriving at Mars in August!
Mars Sample Return?

- Further investigation requires analyzing Mars rocks in detail.
- Returning rocks from the Martian surface will be challenging, expensive, and at least a decade away.
Samples for Free!

• Fortunately we already have Mars rocks here on Earth – probably almost a billion tons!
  − Impacts can launch rocks into interplanetary space. Some Martian rocks have found their way to Earth.
  − We've only found a few kilograms, however.
Mars Rocks on Earth

• A few dozen meteorites have characteristics that strongly (or in some cases definitively) indicate they are from Mars.
Mars Rocks on Earth

- A few contain Martian air!

The meteorites in the table below are grouped by their pairings and listed roughly in the order that they were found.

<table>
<thead>
<tr>
<th>Meteorite Name</th>
<th>Location Found</th>
<th>Date Found</th>
<th>Mass (g)</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassigny</td>
<td>France, Haute-Marne province, village of Chassigny</td>
<td>October 3, 1815</td>
<td>~4,000</td>
<td>dunite (chassignite)</td>
</tr>
<tr>
<td>Shergotty</td>
<td>India, Bihar State, town of Shergahti</td>
<td>August 25, 1865</td>
<td>~5,000</td>
<td>basaltic shergottite</td>
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<tr>
<td>Nakhlá</td>
<td>Egypt, El-Baharnya, village of El-Nakhla</td>
<td>June 28, 1911</td>
<td>~10,000</td>
<td>clinopyroxeneite (nakhlite)</td>
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<tr>
<td>Lafayette</td>
<td>United States, Indiana, Lafayette</td>
<td>1931</td>
<td>~800</td>
<td>clinopyroxeneite (nakhlite)</td>
</tr>
<tr>
<td>Governor Valadares</td>
<td>Brazil, state of Minas Gerais, city of Governor Valadares</td>
<td>1958</td>
<td>158</td>
<td>clinopyroxeneite (nakhlite)</td>
</tr>
<tr>
<td>Zagami</td>
<td>Nigeria, Katsina Province, Zagami Rock</td>
<td>October 3, 1962</td>
<td>~18,000</td>
<td>basaltic shergottite</td>
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<tr>
<td>ALHA 77005</td>
<td>Antarctica, Victoria Land, Allan Hills</td>
<td>December 29, 1977</td>
<td>482</td>
<td>peridotite (herzolitic shergottite)</td>
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<td>Yamato 793605</td>
<td>Antarctica, Victoria Land, Yamato Mountains</td>
<td>1979</td>
<td>16</td>
<td>peridotite (herzolitic shergottite)</td>
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<tr>
<td>EETA 79001</td>
<td>Antarctica, Victoria Land, Elephant Moraine</td>
<td>January 13, 1980</td>
<td>7,900</td>
<td>olivine-phryic shergottite</td>
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<tr>
<td>ALH 84001</td>
<td>Antarctica, Victoria Land, Allan Hills</td>
<td>December 27, 1984</td>
<td>1,939.9</td>
<td>orthopyroxene</td>
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<tr>
<td>LEW 88516</td>
<td>Antarctica, Victoria Land, Lewis Cliff</td>
<td>December 22, 1988</td>
<td>13.2</td>
<td>peridotite (herzolitic shergottite)</td>
</tr>
<tr>
<td>QUE 94201</td>
<td>Antarctica, Victoria Land, Queen Alexandra Range</td>
<td>December 16, 1994</td>
<td>12.0</td>
<td>basaltic shergottite</td>
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<tr>
<td>Dar al Gani 476</td>
<td>Libya, Sahara Desert</td>
<td>May 1, 1998</td>
<td>2,015</td>
<td>olivine-phryic shergottite</td>
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<tr>
<td>Dar al Gani 489</td>
<td></td>
<td>1997</td>
<td>2,146</td>
<td></td>
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<td>Dar al Gani 735</td>
<td></td>
<td>1996-1997</td>
<td>588</td>
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<td>Dar al Gani 620</td>
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<td>1998-1999</td>
<td>1,619</td>
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<td>Dar al Gani 876</td>
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<td>May 7, 1998</td>
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<td>Dar al Gani 975</td>
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<td>August 21, 1999</td>
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<td>Dar al Gani 1037</td>
<td></td>
<td>1999</td>
<td>4012.4</td>
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<tr>
<td>Yamato 980459</td>
<td>Antarctica, Yamato Mountains</td>
<td>December 4, 1998</td>
<td>82.46</td>
<td>basaltic shergottite</td>
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<tr>
<td>Los Angeles 001</td>
<td>United States, California, Mojave Desert</td>
<td>October 30, 1999</td>
<td>452.6</td>
<td>basaltic shergottite</td>
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<tr>
<td>Los Angeles 002</td>
<td></td>
<td>October 30, 1999</td>
<td>245.4</td>
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<tr>
<td>Sayh al Uhaymir 005</td>
<td>Oman, Sayh al Uhaymir</td>
<td>November 26, 1999</td>
<td>1,344</td>
<td>olivine-phryic shergottite</td>
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<tr>
<td>Sayh al Uhaymir 008</td>
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<td>November 26, 1999</td>
<td>8,579</td>
<td></td>
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<tr>
<td>Sayh al Uhaymir 051</td>
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<td>August 1, 2000</td>
<td>436</td>
<td></td>
</tr>
<tr>
<td>Sayh al Uhaymir 094</td>
<td></td>
<td>February 8, 2001</td>
<td>233.3</td>
<td></td>
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</tbody>
</table>
Meet Your Ancestors?

- An extremely controversial study, published in 1996, suggested that one particular Martian meteorite contained chemical (and fossil!) signatures of ancient Martian microbial life.
Meet Your Ancestors?

- Subsequent studies have shown that the chemistry and structures seen here can all be produced naturally and without biology.
There is NO scientific evidence for life of any sort on Mars.

- But it could be, and likely is, there.
  - It could have evolved independently from life on Earth.
  - Impact debris from Earth could have carried life to Mars.
  - We certainly have contaminated Mars with our landings despite our best efforts to the contrary.
Transport of Life via Impact Debris

- Ridiculous!?, I couldn't survive 30 seconds in the vacuum of space..., BUT... bacteria can!

- Parts returned to the Earth from the Moon from the Surveyor lander had viable bacteria after 3 years of exposure to the harsh lunar environment.