Lecture 25:
Is/Was Mars Habitable?

Astro 202
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But first...

- Paper 7 is due at start of class on Thursday
- Poster session is Thursday May 1
- That's your final exam!
- No extensions!
- Be Ready!
- I will have poster boards for you today or Thursday
- A few more words about your posters...

Common Poster “Blunders”

- Title is larger than necessary
- Titles that are too wordy and line spacing that is too large
- Author’s names/affiliations/contact information are too small to read from afar
- The text is overly wordy
- Text type is too small or too large
- Poster has a general lack of unity of style
- Directional flow of information is not clear
- Poster has poor composition (alignment, lines, flow,...)
- Poster uses too many small elements or too many small parts
- Inadequate use of blank space (perhaps nonintuitive...)
- Overpowering/distracting use of background graphics
- Overzealous use of color
- Poster elements mounted in unreadable positions
- Use of unnecessary material
- Poster is too big, too small, or the wrong shape for display board
- Lack of attention once initially mounted

[Mann Library: Q179.94 G67x 1999]

see also Purrington, C., “Advice on designing scientific posters,” Department of Biology, Swarthmore College, online at http://www.swarthmore.edu/HaStro/cpurrin1/posteradvice.htm

Layout Ideas

- Poster should have a logical “flow” to it
- Flow should be logical, like left to right, and/or top to bottom
- Should be easy to “navigate”
- Number/Letter various sections and/or use arrows, pointers, or other “linkage elements” if you anticipate any potential confusion

[Mann Library: Q179.94 G67x 1999]

Figure 6.4 Some variations in layout based on demarcating the poster in to two vertical strips. These layouts demonstrate some frequently used poster formats. There are a wide number of variations that may be adopted. These examples show the importance of maintaining some clear space or flow in the poster design.
NASA's Astrobiology Focus

- Searching for evidence of life in our solar system and beyond has become one of NASA's most important goals.
- It's not just words, it's actions...
  - Current Mars exploration program
  - Cassini/Huygens Titan entry probe
  - Europa Orbiter? Titan Orbiter? Enceladus?
  - Continued study of extreme life on Earth

Exobiology has a major role in Mars exploration

<table>
<thead>
<tr>
<th>The Common Thread</th>
<th>Primary Goals</th>
<th>Resulting Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>LIFE</td>
<td>Understand the Potential for Life Elsewhere in the Universe</td>
</tr>
<tr>
<td></td>
<td>CLIMATE</td>
<td>Understand the Relationship to Earth's Climate Change Processes</td>
</tr>
<tr>
<td></td>
<td>RESOURCES</td>
<td>Understand the Solid Planet: How It Evolved and its Resources for Future Exploration</td>
</tr>
</tbody>
</table>

Focus on Mars...

The “Old” Mars...
Is Mars just “the Moon with an atmosphere” – or –
Was Mars like Earth long ago?

Life on Mars?

- Mars preserves clues that its climate may once have been very different...
- ...and that there is still a substantial (?) inventory of water at or near the surface...
- ...and that there is evidence for fairly recent volcanism and/or geothermal heat sources...

Evidence for Life on Mars from a meteorite?

- A small number (~20) of meteorites are thought to have come from Mars
- Special one: ALH8400, found in Antarctica in 1984
- Thought to be a sample of ancient Martian crust: radiometric age around 3.5 billion years
- Cosmic ray exposure indicates ejection from Mars around 15 million to 20 million years ago
- Outer chemical evidence indicates that it fell to Earth about 13,000 years ago
Evidence for Life on Mars from a meteorite?

- Four pieces of evidence presented by scientists that ALH84001 preserves signs of past life on Mars:
  - Carbonate minerals: precipitated from a once thicker, warmer, atmosphere?
  - Magnetite grains: similar in shape to magnetite formed bacterially
  - Complex organic molecules: specifically PAH molecules
  - Segmented, "bacterial?" shapes

Landmark paper published by McKay et al. (1996) Science, 273, p. 924

But much skepticism!

- Is the rock from Mars?
- Was it contaminated by Earth life while sitting in Antarctica for 13,000+ years?
- There have been abiologic explanations proposed for each piece of "biologic" evidence
- No "controls" on some new methods used
- "Extraordinary claims require extraordinary evidence" — Carl Sagan
- Proponents remain steadfast, despite criticism...

The real message of ALH84001

- Whether or not ancient fossil microbes actually exist in this Mars meteorite may be secondary
- ALH84001 and data from telescopes and space missions appear to show that:
  - liquid water existed in the Martian subsurface
  - complex organic molecules were there too
  - energy was provided by volcanoes, impacts, geothermal
- The ingredients for life all appear to have existed at one time on Mars. Do they still exist today??

The New Mars...
Sinus Meridiani Sedimentary Rocks

- more diverse than at MER-B site
- erosional expression
- bedding properties
- relative albedo

Crater in Meridiani near 8°N, 7°W

Exhumed Delta
Discovery of hematite in Meridiani Planum

Mars Pathfinder

5 km

Mars Exploration Program
Mars Exploration Time Line

NASA Odyssey
...and most recently, Spirit & Opportunity

51+ months of traverse by the Spirit rover...
• Total distance: 7528 meters

Jan. '04
Bonneville
Columbia Hills
Husband Hill
Summit
Today: Sol 1530
Home Plate
El Dorado
Water-related mineral deposits!

El Dorado
Spirit Sol 708
Dec. 30, 2005

Southern Basin, on to Home Plate
and then unexpected silica-rich soils!

Spirit’s stuck wheel reveals unexpected sulfur-rich soils!

50 months of traversing by the Opportunity rover...
• Total distance: 11,692 meters

Exploring “Home Plate”
We found millions of “Blueberries” in the sand...

And we found hundreds and hundreds of thin layers in salty rocks!
Is Mars just “the Moon with an atmosphere” – or – Was Mars like Earth long ago?

- The New Mars is not just “the Moon with an atmosphere”
- Craters and surfaces have been buried, exhumed, and re-buried many times
- Sedimentary rocks are common on Mars, and some were water-lain
- At least some of early Mars was wet, active, and perhaps even **habitable** long ago

Looking ahead...

- **2001**
  - NASA Mars Odyssey
  - X
  - Japanese Mro Orbiter

- **2003**
  - NASA Mars Express
  - ✓
  - Italian 1-Mercury Telecom Orbiter

- **2005**
  - NASA Mars Reconnaissance Orbiter
  - ✓
  - Phoenix Lander Mission (Phoenix)

- **2007**
  - X
  - Italian O-Marsc Telecom Orbiter
  - X

- **2009**
  - Mars Reconnaissance Orbiter
  - X

- **2013**
  - X
  - ESA Mars Express

- **2020**
  - X
  - ESA Mars Express

- **2025**
  - X
  - ESA Mars Express

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Mars Reconnaissance Orbiter

- Explore local diversity
- Life inference
- Science pathways responsive to discovery
This Memorial Day Weekend: NASA “Phoenix” Lander

Mission Goals:
• Study the history of water on Mars by searching for and examining water ice in the high-latitude subsurface
• Determine if the Martian arctic soil could support life

Instruments:
• Cameras (high-res and microscopic)
• Robotic arm
• Mass Spectrometer to study isotopes, organics
• Chemical composition
• Meteorology

Mars Science Laboratory: Next Rover on the Red Planet
Launch: Late Summer 2009
Landing: Fall, 2010
Thinking about landing sites...

Beyond 2010...

- The next big leap may be *Mars Sample Return*
  - First attempt could be launched in late 2010’s
  - Entirely robotic mission, using next-generation rovers
  - Goal to bring back a few kg of well-selected samples

- Beyond that...
  - More sample returns from other sites
  - *Human Exploration*
    - Substantial increase in cost and complexity
    - But substantial gain in scientific capabilities...
    - Maybe 2020’s to 2030’s?
39 years ago...
...yesterday...
...and tomorrow...

Summary

- NASA and other space agencies are focusing more and more on Astrobiology and the search for habitable environments beyond Earth...
- Mars is at the top of that search list!
- An extensive program of Mars exploration by orbiters, landers, and rovers has revealed that Mars was once habitable by any reasonable definition
- Did life form on Mars?
- Is there any life there today?
- Are we alone?
- ... Let’s Find Out!

- We must not cease from exploration. And the end of all our exploring will be to arrive where we began and to know the place for the first time.”
  - T.S. Eliot

Next Lecture...

- SETI: The Search for Extraterrestrial Intelligence
- Turn in Paper 7!