Life in Universe

ASTRON 1141 – Chapter 8 Water on Mars, Life on Mars, Jovian Planets

Water on Mars

1. The present atmosphere of Mars is breezy, cold & dry
2. The present surface of Mars is rusty desert, with signs of past volcanic activity
3. Evidence of past water flows indicates that Mars was once warmer and wetter

- **Mars is a smallish planet**
  - Mars is relatively easy to observe from Earth
  - Rotation period = 24 hours, 37 minutes
  - Orbital period = 1.88 years
- Martian seasons are similar to Earth seasons (only longer)

- **Martian atmosphere: thin & dry**
  - Only traces of water vapor
  - Average air pressure is 0.7% of Earth's

- **Martian weather: breezy & cold**
  - Average temperature = -50 C
  - Gusty winds lead to dust devils

- **The polar caps of Mars are a mixture of frozen H_2O (ice) and frozen CO_2 (dry ice)**
  - The surface of Mars looks like a desert
  - By Earthly standards, it **is** a desert

- **Why the reddish-brown colors?**
  - Mars is **rusty** (Martian dust consists largely of iron oxide)
  - Mars is divided between old crater highlands & younger smooth lowlands

- **Olympus Mons: largest volcano in the Solar system**
  - It's located over a hot spot in the Martian Mantle
  - Few impact craters are seen on its flanks: it has been recently "repaved" by lava
- **Valles Marineris: biggest valley in the Solar System**
  - It's a rift valley over 4000 kilometers long (about the width of the continental U.S.)

- Deep, broad outflow channels are evidence for catastrophic floods in the past
- **Narrow, dried riverbeds are evidence for sustained flow billions of years ago**
  - Flow patterns are strong evidence for liquid water in the past
- **Lack of impact craters on top of some flows shows they are young**
  - Some narrow gullies are a few million years old – or less
  - Layered sedimentary rocks contain hydrated minerals like hematite

- **Mars was once warmer and wetter**
  - Large Martian seas existed only during the first billion years of its existence

Life on Mars

1. Speculation about intelligent life on Mars lasted well into the 20th century
2. Evidence for past or present simple life on Mars has been inconclusive so far
3. We're still looking!

- **The idea of intelligent life on Mars is common in popular culture**
  - Why Mars?

- In 1877, Giovanni Schiaparelli (an Italian astronomer) observed linear features on Mars that he called canali (channels or canals)
- He thought they were probably natural channels; others saw them as artificial canals

- Percival Lowell was among those who thought canali were artificial canals
- In 1894, he built an observatory in Arizona, where he spent nearly 20 years mapping Mars

- **Lowell mapped extensive canal systems that he thought were present on Mars**
  - Lowell's books popularized the idea of intelligent life on Mars; most professional astronomers thought he was mistaken
- July 1965: Mariner 4, the first spacecraft to visit Mars, found a desert planet with no canals

- **The Martian atmosphere proved to be too low in pressure for liquid water to exist**
  - Liquid water is unstable in Mars

- What were the canals? Optical illusions, probably
- The human brain is good at picking out patterns - even patterns that aren't there

- **One patter humans are very good at detecting is the human face**
  - This explains the infamous "face on Mars"

- The two Viking landers (1976) were designed to look for simple life on Mars
- Martian soil was scooped up and subjected to three biology experiments

- **Experiment #1: soil was exposed to carbon dioxide "tagged" with carbon-14.**
  - Was C-14 incorporated into soil?
- **Experiment #2: soil was mixed with sterile broth.**
  - Did soil emit gases such as O2 or CO2?
- **Experiment #3: soil was mixed with sterile broth tagged with carbon-14.**

- **Results from the Viking landers were conflicting**
  - Scientists were confused
  - Results could have come either biological or non-biological activity

- ALH84001 is a meteorite that was found in the Allan Hills of Antarctica in 1984
- It has the same composition as Martian rocks, contains bubbles full of Martian air, & has a radiometric age younger than most meteorites
- Conclusion: it was blasted from the surface of Mars by an asteroid impact

- **Evidence for possible biological activity in ALH 84001:**
  - The presence of polycyclic aromatic hydrocarbons and amino acids
  - Magnetite crystals like those produced by Earth bacteria
  - Shapes resembling Earth bacteria (only smaller)

- On the other hand...
- **The meteorite sat in Antarctica for 13,000 years; contamination can't be ruled out**
  - Complex carbon compounds & non-biological processes can make magnetite crystals
  - If something is shaped like a bacterium, that doesn't mean that it is a bacterium

- Curiosity looks for the spectra of complex carbon compounds in the scooped soil
- Analysis of isotope ratios gives information about the history of Martian air and oceans

Jovian Planets

1. Jupiter & Saturn are gas giants, with thick atmosphere over metallic hydrogen mantles
2. Uranus & Neptune are ice giants, with thinner atmospheres over slushy ice mantles
3. All the Jovian planets have extensive moon systems, including several giant moons

- **Jovian planets: bigger than terrestrial planets, farther from the Sun than terrestrial planets**
  - Jupiter: 5 AU
  - Saturn: 10 AU
  - Uranus: 19 AU
  - Neptune: 30 AU

- Jupiter and Saturn are gas giants, with deep atmosphere and metallic hydrogen mantles
- **What is "Metallic Hydrogen"?**
  - Metal: shiny, malleable, electrical conductor; containing free electrons
  - Hydrogen becomes a metal at very high pressures (1.4 million atmospheres)
  - Like the Earth, Jupiter & Saturn have a layer of liquid metal where a magnetic field is generated
- **Jupiter's magnetic field traps energetic electrons protons (a.k.a. ionizing radiation) in a belt above its equator**
  - Life *near* Jupiter would have to be shielded, or be very radio resistant
- Jupiter & Saturn have strong winds (with updrafts & downdrafts) that make their atmospheres inhospitable

- **Uranus & Neptune are ice giants, with deep slushy mantles of water, ammonia & methane ices**
  - Neptune & Uranus are blue because their atmospheres contain methane (CH_4), which absorbs red light

- Jovian planets have H- and He-rich atmospheres because they're large & cool enough to hold on to them

- **Jupiter has 67 known moons: four are the giant Galilean moons**
  - 4 Galilean moons:
    a) Large (>3000 km)
    b) Spherical
    c) Differentiated
  - 63 small moons:
    a) Small (<200 km)
    b) Irregular
    c) Undifferentiated

- The four Galilean moons of Jupiter: