

## Topics

- ◆ today, next time Mars, Chapter 9
- ◆ Course grades posted on web site
- ◆ Final exams:
  - Sec 1 (Dec 11), Sec 2 (Dec 14); both 8AM
  - Review Monday Dec 10, 5-6PM, this room
  - 100 questions, worth 200 points
  - 50% review, 50% last quarter of course

## Life's beginnings on Earth

- ◆ Organic molecules => amino acids => proteins => living cells
- ◆ microscopic life
  - microfossils found in ancient rocks
  - life started 3.7 to 3.9 billion years ago,
  - as soon as stable crust had formed
  - symmetry of amino acids suggest may have been a single origin
- ◆ large animal life, fossils, begin with “Cambrian explosion” 0.6 billion years ago

## Origins of life

- ◆ organic molecules, amino acids, were in solar nebula
  - Ices in cold traps will reveal constituents
- ◆ Earth
  - life began as soon as it possibly could
  - may have been destroyed and reborn several times
- ◆ Mars
  - conditions may have been more favorable, since farther from brighter protosun
  - Did life start in Mars' Middle Period?

## Is life inevitable or a miracle??

- ◆ Earth: life began as soon as possible
  - when epoch of heavy bombardment ended
  - sample of 1 does not tell us whether life is rare or common
- ◆ if 2 independent samples of life are found, then life probably easy to start
- ◆ if Mars had life, then the universe is teeming with life

## Conditions in Mars' Middle Period

- ◆ dense CO<sub>2</sub> atmosphere with greenhouse effect
  - atmospheric pressure about 2x Earth's
- ◆ Earthlike surface temperatures
  - CO<sub>2</sub> is excellent greenhouse effect gas
  - early sun brighter than now
- ◆ rainfall, gently flowing rivers, lakes, oceans
- ◆ similar to Earth at the same time

## Microscopic life on Mars (???)

- ◆ several dozen Mars meteorites now known
  - solidification ages 1 to 3 billion years
  - minerals similar to those detected in Martian soil by Viking landers
  - trapped gas bubbles contain Martian air
- ◆ Circumstantial evidence for life
  - minerals suggest rock wet for long time
  - chemical residue of biological activity
  - possible microscopic fossils seen
- ◆ But other interpretations possible

## The Fermi Paradox

- ◆ few 100 billion solar systems in Galaxy
  - Many 100 millions of Earth-like planets
- ◆ Life an inevitable part consequence if liquid water exists?
- ◆ Galaxy 10 billion years old
- ◆ Life on other planets would be billion years ahead or behind us
- ◆ if our SS has been visited it was probably 100's millions to billions years ago
  - Search on ancient surfaces reveals nothing

## Search for Extraterrestrial Artifacts

- ◆ few 100 billion solar systems in galaxy
- ◆ galaxy 10 billion years old
- ◆ if our SS has been visited it was probably 100's millions to billions years ago
- ◆ careful search of ancient surfaces should reveal evidence of prehistoric visits to our solar system
  - anything left on moon or Mercury will remain undisturbed for billions of years
- ◆ no evidence of alien visits known today