

Astrobiology

April 7, 2009

Agenda

- Announce:
 - Project Part II's due
 - Project Presentations start in two weeks
 - Observation April 21
- Astrobiology
- Movie: Universe: Search for ET

Known Life

- Only on Earth
- Fossil algae and bacteria in 3.5 billion year old rocks
- Took life just 1 billion years old
- 600 million years ago – Cambrian Explosion
- 250 million years ago—Dinosaurs and mamalls
- 65 million years ago—Dinosaurs wiped out
- 6 million years ago—Early Hominids
- 0.5 million years ago—us

Universality of Life on Earth

- Same elements used in their chemistry: hydrogen, oxygen, carbon, nitrogen, iron
- Same materials abundant on Earth
- Common structures:
 - Amino acids—basic structural units containing hydrogen, carbon, nitrogen, oxygen
 - Proteins—long molecules made up of amino acids (e.g. fish scales→keratin, cartilage→collagen)
 - Energy source for cells: ATP
- Information storage: DNA

Implications of Universality

- Indicates common origin of life
- Suggests life develops from complex molecules

Theory: Life arose from chemical reactions

- 1953: water, hydrogen, methane, ammonia and electric spark
 - Generated 5 amino acids and complex organic molecules
- Later developments:
 - Found "droplets" similar to cells
 - Created ATP
- Why no "life development" now?
 - Presence of oxygen, attacks organic molecules (early Earth lacked oxygen..shown by analysis of rocks)
 - Existing life consumes such materials
- Possible sources of organic material:
 - Deep sea vents...minerals, energy, low oxygen
 - Earth birth
 - Bombardments of planetesimals

Development of Life

- Early cell-like structures must be able to reproduce
- Earliest may have developed using RNA replication...much simpler than using DNA
- Earliest cells: prokaryotes
 - No nucleus
 - Merger of such cells could have created cells with nuclei (replacation and energy storage)
- Eukaryotes
 - Complex cells
 - Nucleus stores information and powers the cell
 - Complicated cell membrane (in/out processes)
- Evolution from simple beginnings to complicated life
 - Random genetic mutations
 - Changing environment
 - Natural selection:
 - Changes which prove beneficial more likely to produce offspring

Panspermia

- Life developed elsewhere, arrived on Earth
- Dust particles, comet, etc carries life form to Earth
- Criticisms:
 - Shifts problem of how life arose elsewhere
 - Must explain how life form survived in space

Relevant Questions

- Can there be artificial life? (Kurzweil's Singularity)
- Is there life outside our planet? (SETI)
- If so, is it related to us (panspermia) or not?
- Is there life on Earth not related to us?

Many Worlds

- Many habitable planets, means chances high of ET life
- How many habitable planets? (Goldilocks)
 - Sunlike star...too big burns too quickly, too small and planet has to be too close) 10%
 - Earthlike planet...rocky not gaseous, stable temps ..10%
 - Probability of Life forming...1%
 - Probability of advanced civilization...need lots of time, and no selfdestruction...0.1%
- Drake Equations...fill in probabilities to determine number of possible civilizations in galaxy:
 - 10^{11} stars $\cdot 0.1 \cdot 0.1 \cdot 0.01 \cdot 0.001 = 10,000$
 - Civilizations still likely very far apart (maybe as much as 1000 lightyears between them)

Rare Earth

- Life's development on Earth suggests continued growth and development
- Colonization and communication with rest of galaxy
- Conclude: we're alone in galaxy

Fermi paradox

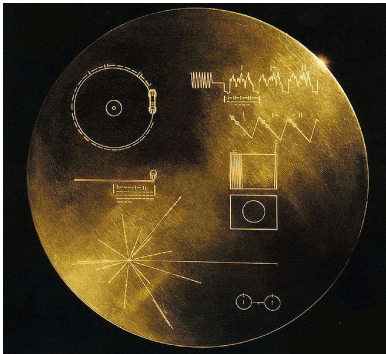
- Enrico Fermi:
 - "Where are they?" referring to ET life
- If ET life exist, why haven't we heard from or seen evidence of them?

What to expect of life elsewhere?

- Carbon based?
- Requires water? Some liquid?
- Sun as energy source?

Searches

- Mars...probes, landers, rovers
 - Evidence of water in past
 - Evidence of organic molecules from Martian meteorites
- Extra-solar system searches:
 - SETI—listen for radio transmissions
 - Choice of frequency...likely near 21 cm (longer overwhelmed by galaxy, shorter blocked by molecules in atmosphere)
 - Transmissions to them: Voyager probes containing "Golden Record"



Anthropic Reasoning

- Must be careful to avoid extrapolating from coincidence...
- Hard to establish probabilities on life elsewhere since the fact that life is supported here could be extremely rare...but that we are here is because we had to find ourselves in a place that supported life!