

Outline 21: Origin of Life

Better Living Through Chemistry

What is Life?

- Internal chemical activity providing growth, repair, and generation of energy.
- The ability to reproduce.
- The capacity to respond to outside stimuli.

Components of Life

5 Principal components for all life:

Water

Carbohydrates: starches and sugars for energy

Fats: for energy storage

Proteins: structural tissues

Nucleic acids: for reproduction

6 Dominant Elements of Life

H, hydrogen

O, oxygen

C, carbon

N, nitrogen

P, phosphorous (in rocks)

S, sulfur

Combining Elements into complex Organic compounds

- Miller's 1953 experiment:

Combine gases of the early atmosphere in a sealed system with no oxygen.

Heat the gases, add electrical sparks, cool the mixture.

Amino acids formed after several days. They are the building blocks of protein.

Combining Elements into complex Organic compounds

Several variations of Miller's experiment have been run. These experiments have produced carbohydrates, fats, simple proteins, and the building blocks of nucleic acids: sugars, phosphates, and nitrogenous bases (ATCG).

How did life begin?

No one has yet been able to create life in the lab. However, scientists have had only 50 years. Nature had hundreds of millions of years.

What was earliest life like?

- Certainly it was single celled.
- Single celled life today, 3 domains:

Archaea - prokaryotic cells

Bacteria - prokaryotic cells

Eukarya - eukaryotic cells

Prokaryotes vs. Eukaryotes

- Prokaryotes - simple, single-celled organisms lacking a nucleus, organelles, and sexual reproduction. Many are anaerobic.
- Eukaryotes - single (protists) or multi-celled (plants and animals), have a nucleus, organelles, sex, and are strictly aerobic.

Archaea, the most primitive forms of life

- Archaea use to be included with bacteria, but geneticists have separated them on the basis of their unique genetic composition.
- Living archaea are all anaerobic and they can tolerate extremes of heat and chemistry.

Archaea

- Retain evidence for life on early earth.
- Tolerate:
 - boiling water
 - poisonous gases: e.g., hydrogen sulfide, carbon monoxide, etc.
 - high doses of UV radiation

Archaea

Living archaea include:

- fermenters: eat sugars
- methane producers: energy from CO₂ and hydrogen
- chemoautotrophs: make their food from chemicals in their environment

Where on earth did it happen?

- Darwin's "warm little pond?"
 - concentrated "organic soup" (+)
 - no protection from UV radiation (-)

- Deep-sea volcanic vents?
 protection from UV radiation (+)
 heat destroys amino acids (-)

The 5 Major Biochemical Steps in the Evolution of Life

- Fermentation - archaea
 Sugar fermented = ethyl alcohol + 2 units of energy
- Methane production - archaea
 $\text{CO}_2 + 4\text{H}_2 = \text{CH}_4$ (methane) + $2\text{H}_2\text{O}$ + 1 unit of energy
- Anaerobic photosynthesis - bacteria
 $\text{H}_2\text{S} + \text{CO}_2 + \text{sunlight} = \text{C}_6\text{H}_{12}\text{O}_6$ (sugar) + H_2O + 12S (sulphur)
- Aerobic photosynthesis - bacteria, 3.5 BY
 $\text{H}_2\text{O} + \text{CO}_2 + \text{sunlight} = \text{sugar} + \text{O}_2$
- Aerobic respiration - bacteria and eukarya
 $\text{Sugar} + \text{O}_2 = \text{H}_2\text{O} + \text{CO}_2 + 36$ units of energy