

Introduction to Biology. Lecture 8

Alexey Shipunov

Minot State University

September 19, 2014



Outline

1 Where we are?

2 Origin of life

- Alternatives and amendments to abiogenesis

3 First life

- Hadean and Archean eons
- First cells



Outline

- 1 Where we are?
- 2 Origin of life
 - Alternatives and amendments to abiogenesis
- 3 First life
 - Hadean and Archean eons
 - First cells



Outline

- 1 Where we are?
- 2 Origin of life
 - Alternatives and amendments to abiogenesis
- 3 First life
 - Hadean and Archean eons
 - First cells



Four types of biomolecules form biological polymers

- Lipids
- Sugars and polysaccharides
- Amino acids and proteins
- Nucleotides and nucleic acids



Abiogenesis is the most feasible theory of life origin

- Primordial soup
- RNA world
- Proteins
- Cells: last universal common ancestor (LUCA)



Origin of life

Alternatives and amendments to abiogenesis

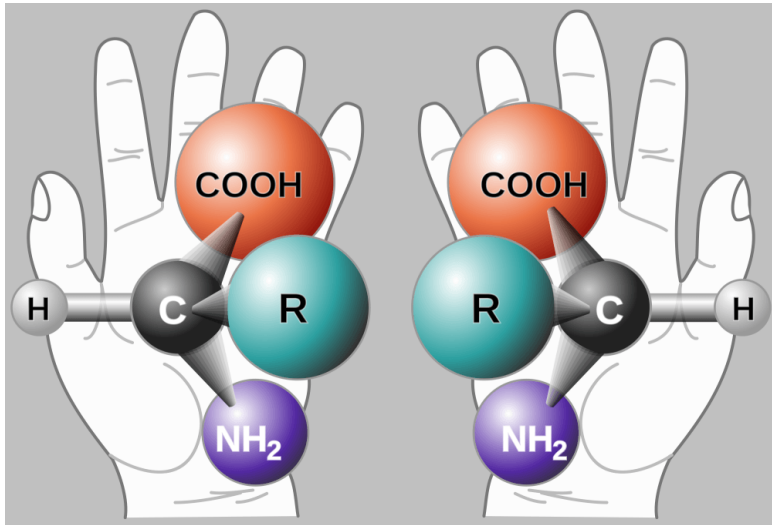


Problems of abiogenesis: chiral purity of life

- Most of amino acids are chiral: they have “left” and “right” forms
- *All proteins from living organisms contain only “left” amino acids*
- Sugars (carbohydrates) could also be “left” and “right”
- *Nucleic acids contain only “right” sugars*



“Left” and “right” amino acids



Panspermia theory

- Life is a fundamental feature of Universe
- It always exists and constantly spreading



Self-organization

- Lovelock's (1982) Gaia hypothesis: Earth is a living being
- Life is a way of stabilizing geological cycles on Earth
- Self-organization was based on the principles of Prigogine's **non-equilibrium thermodynamics**
- Life first, organisms second



First life

Hadean and Archean eons



First evidences of life

- Earth age is usually estimated as 4600 Mya (million years ago), Hadean eon was the first epoch
- First minerals are ≈ 4000 Mya, they mark Archean eon



Oldest evidences of life and photosynthesis

- The oldest organic carbon is ≈ 3800 Mya (Greenland, Mesoarchean)
- Organic carbon: carbon with $^{13}\text{C}/^{14}\text{C}$ ratio like in living plants
- Oldest remnants of chlorophyll: 3100 Mya (Mesoarchean)



Photosynthesis

- $\text{CO}_2 + \text{H}_2\text{O} \xrightarrow{\text{light, chlorophyll}} \text{carbohydrates} + \text{O}_2$
- Two stages:
 - Ⓐ Light-dependent: production of energy (ATP) and photolysis of water
 - Ⓑ Light-independent: assimilation of CO_2 into carbohydrates
- Then carbohydrates are partly converting into lipids; with addition of N—into amino acids; with addition of N and P—into nucleotides



ATP

- Universal energy source in the cell, “universal currency”
- $\text{ATP} \rightarrow \text{ADP} + \text{P} + \text{energy}$



Oxygen and iron

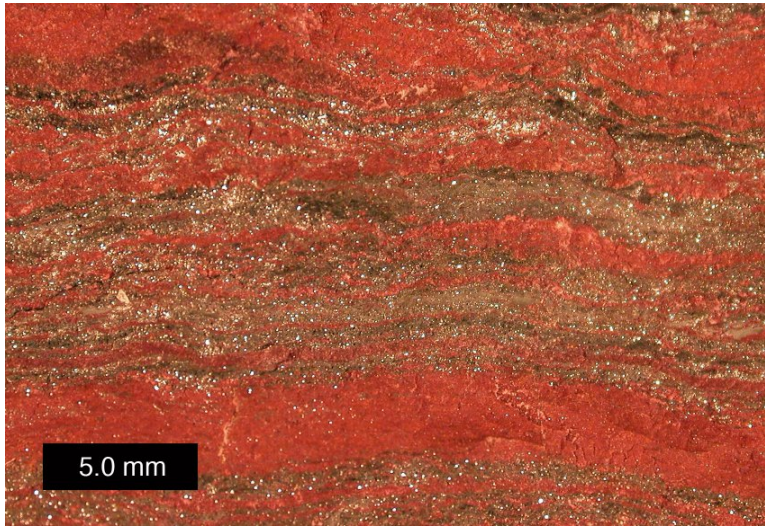
- Initially, Earth atmosphere contained no oxygen
- Photosynthetic oxygen oxidized free iron into quartzite-like rocks contained hematite and other iron minerals
- New iron was always replenished from ocean water
- However, ≈ 2000 Mya, when Proterozoic eon started, almost all iron went deeper into mantle and core



Wheeler Peak, NV



Hematite



From oxygen oases to oxygen revolution

- In Archean, photosynthesis could only produce local “oxygen oases”
- But when no free iron was available anymore, atmosphere started to accumulate oxygen
- When oxygen reached 1% (Pasteur point), aerobic life started
- This was the oxygen revolution which allowed cells to obtain energy via respiration



Fermentation *versus* respiration

- carbohydrates \rightarrow CO_2 + ethanol + 2 ATP
- carbohydrates + $\text{O}_2 \rightarrow \text{CO}_2$ + H_2O + 38 (!!!) ATP



First life

First cells



Who was first?

- Stromatolites: microbial mats from (mostly) cyanobacteria (photosynthetic bacteria)
- *Metallogenium* and others: proteobacteria (e.g., aerobic metal-oxidizing bacteria)



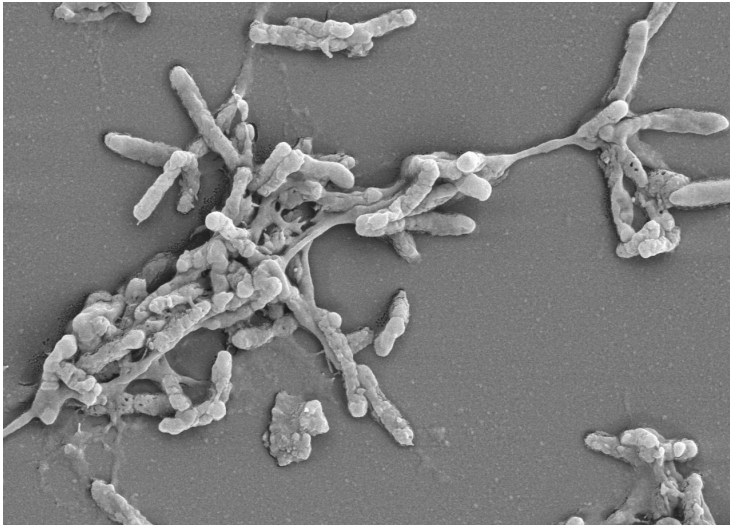
Fossil stromatolite



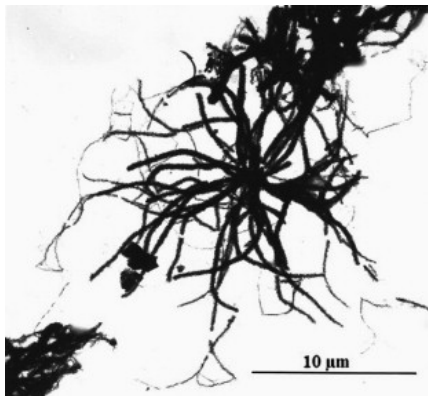
Present-day stromatolite (Shark Bay, Australia)



Present-day iron-oxidizing bacteria



Fossil *Metallogenium*



Summary

- Bacteria were first
- Photosynthesis changed the atmosphere
- Aerobic life respire to obtain more ATP



For Further Reading



Photosynthesis.

<http://en.wikipedia.org/wiki/Photosynthesis>
(introduction)



Cellular respiration.

http://en.wikipedia.org/wiki/Cellular_respiration
(introduction)

