Origin of Life

Pieces of Model

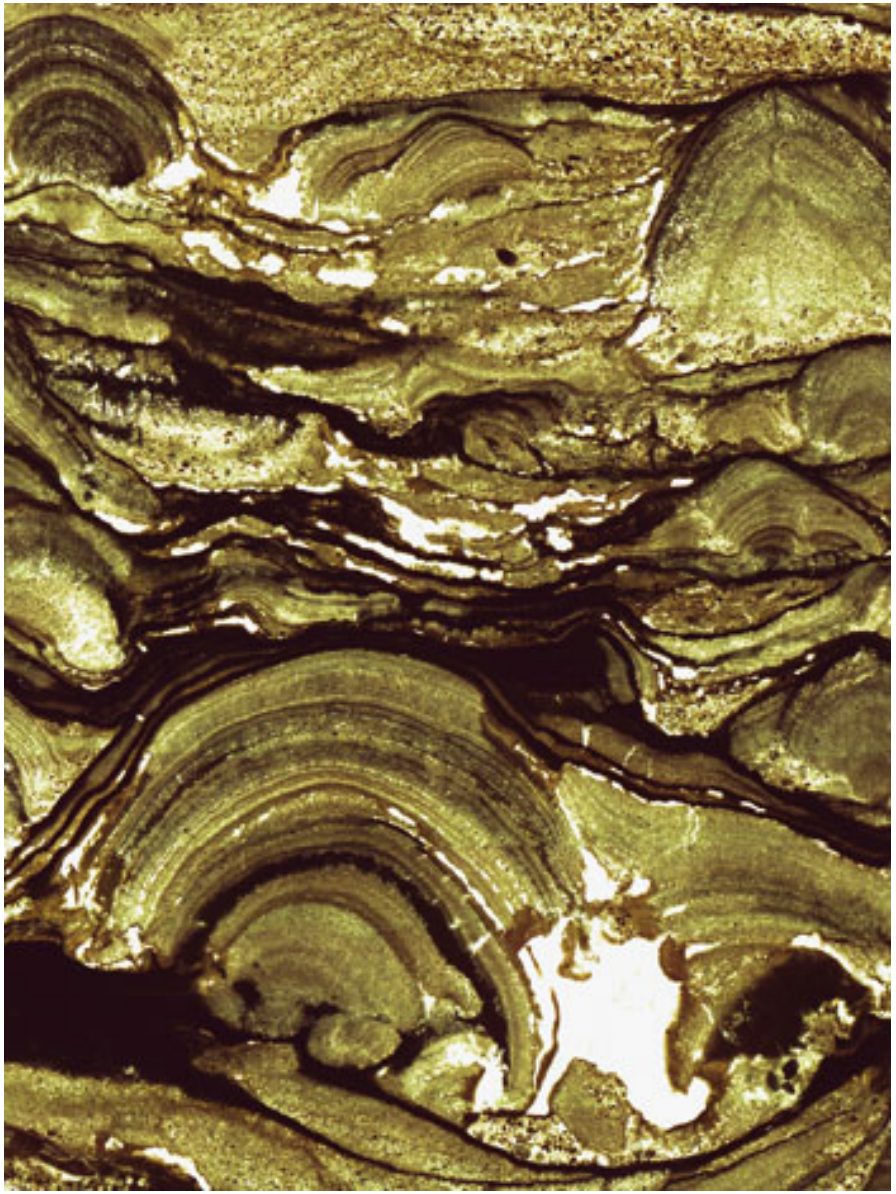
- Evidence for age of earliest life
- Where did life originate?
- How does life arise from non-life?
- How did cells arise?
- Development of more complex organisms

Evidence for age of origin of life

- Evidence of ancient life:
  - Stromatolites: 3.2 billion
  - Layers of sediment left by cyanobacterial mats

http://www.rockhounds.com/grand_hikes/hikes/stromatolites_in_the_hakatai/

http://www.geology.sdsu.edu/seminars/fall08/10_29_08.html



Are stromatolites evidence of life or non-organic origin?

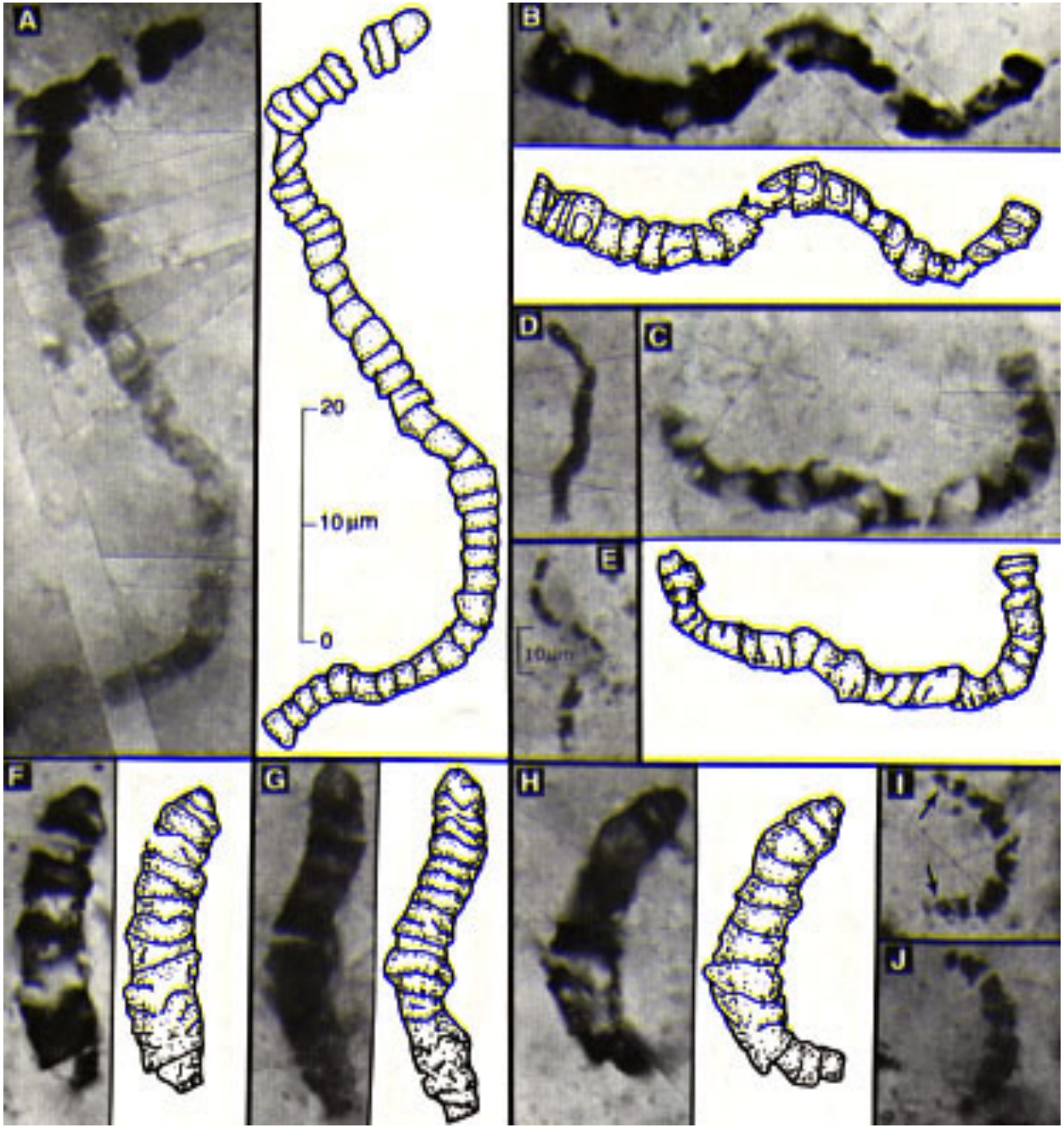
2008 study of 2.7 Gy stromatolites:
Found shapes similar to bacteria, associated with the kind of nanocrystals in modern bacteria-grown stromatolites.

K. Lepot et al., "Microbially influenced formation of 2,724-million-year-old stromatolites," Nature Geosciences, 2008. 1: 118-21.

http://www.nature.com/news/2008/080125/full/news.2008.529.html

Evidence for age of origin of life

- Evidence of ancient life:
  - Stromatolites: 3.2+ billion
  - Cyanobacteria themselves: 3.5 Gy
    - Contested fossils



Originally thought to contain carbon, new analysis suggests they are hematite deposits in microfractures.

Marshall, C.P., J.R. Emry & A.O. Marshall, "Haematite pseudomicrofossils present in the 3.5-billion-year-old Apex Chert", Nature Geosciences, 2011. 4:240-243.

Evidence for age of origin of life

- Evidence of ancient life:
  - Stromatolites: 3.2+ billion
  - Cyanobacteria: 3.5 Gy?
  - Carbon isotope ratios: photosynthetic-like ratios 3.8 Gy

Where did life originate?

- It came from the swamp: “primordial ooze” model.
  - Early oceans full of organic material
  - Methane-ammonia atmosphere
  - Most widely accepted model

Where did life originate?

- It came from the swamp: “primordial ooze” model.
- It came from outer space: arrived on a comet
  - Organic molecules in interstellar molecular clouds
  - Organic molecules in comets, including amino acids

Where did life originate?

- It came from the swamp: “primordial ooze” model.
- It came from outer space: arrived on a comet
- It came from the center of the Earth: evolved in hydrothermal waters
  - Bacteria found in deep wells (10 km +)

How did life arise from non-life?

- Abiotic production of replication – things that can reproduce themselves without being made by living things.

How did life arise from non-life?

- Abiotic production of replication
  - DNA/RNA made of bases and sugars

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    - Bases can be formed from cyanide, found in comets and at deep-sea vents
    - Sugars can form from formaldehyde present in early atmosphere and “primordial soup”

How did life arise from non-life?

- Abiotic production of replication
  - DNA/RNA made of bases and sugars
    - Bases can be formed from cyanide, found in comets and at deep-sea vents
    - Sugars can form from formaldehyde present in early atmosphere and “primordial soup”
  - How do they organize into DNA/RNA?
    - Clay templates (more later)

How did life arise from non-life?

- Abiotic production of amino acids – building blocks of proteins not made by living things
  - Urey-Miller experiment

How did life arise from non-life?

- Abiotic production of amino acids
  - Urey-Miller experiment
    - Methane, ammonia, water, hydrogen
    - Heat
    - Lightning (electrical spark)

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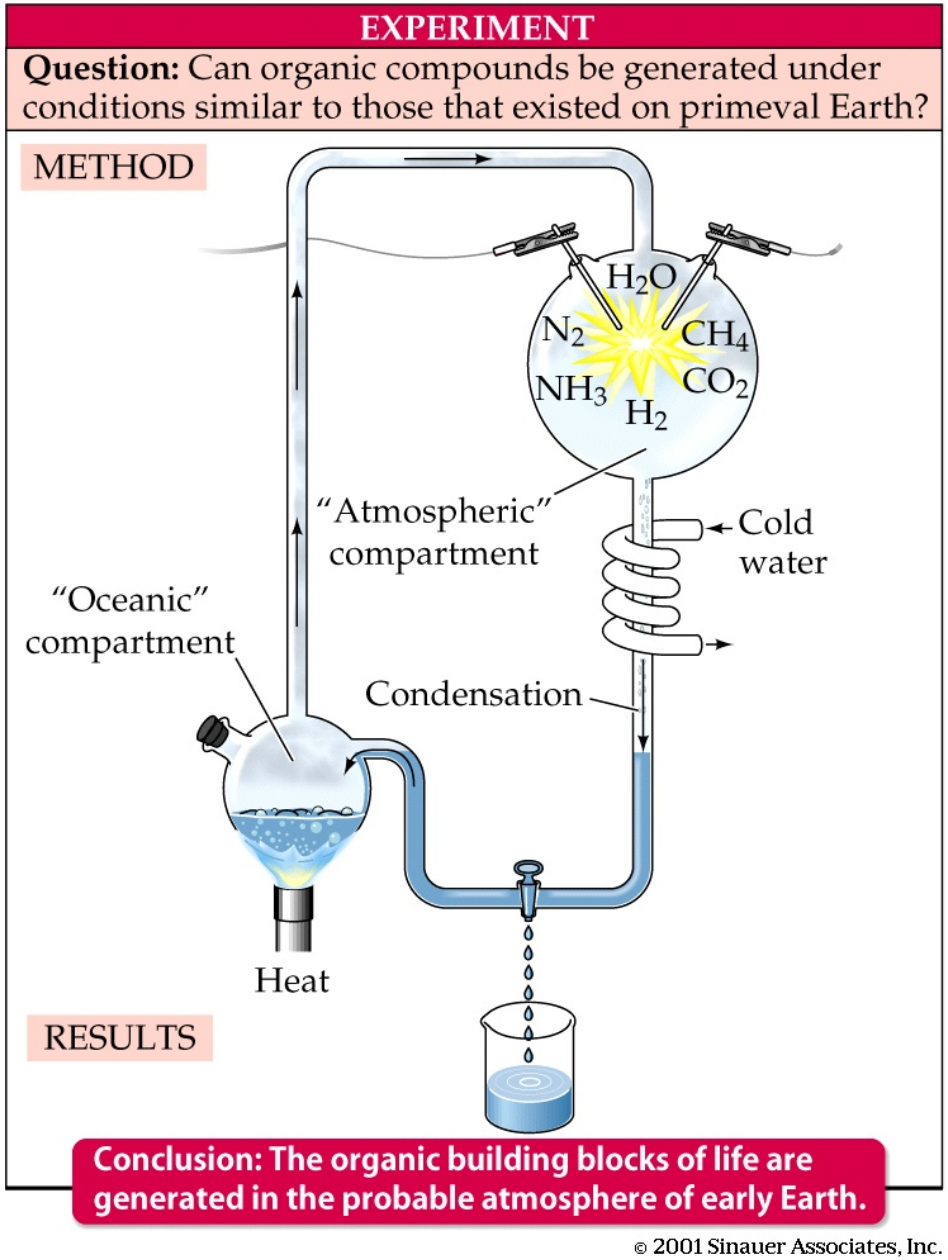
    - Result: 13 of 22 amino acids used in living systems



http://www.blc.arizona.edu/courses/schaffer/182/Urey-Miller.htm

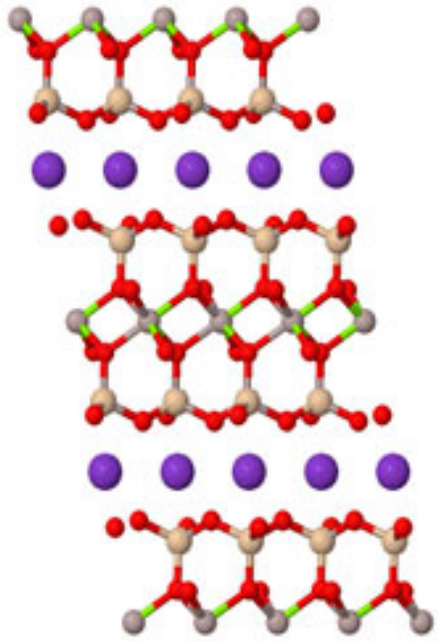
How did life arise from non-life?

- Abiotic production of amino acids
  - Urey-Miller experiment
  - We know it must happen, since amino acids come to Earth on comets

How did life arise from non-life?

- Organization of amino acids into proteins
  - Clay templates
    - Clays are made of flat, tightly bound layers, loosely bound to other layers
    - Each layer has unbonded ions, hence lots of attractive charges

This is a model of a clay mineral. Notice how it has tightly bonded layers, held together by the attraction of the positive ions in between the layers. If the layers are peeled apart, the negative ions on the surface of each layer can attract other positive ions and serve as an organizer for complex molecules.



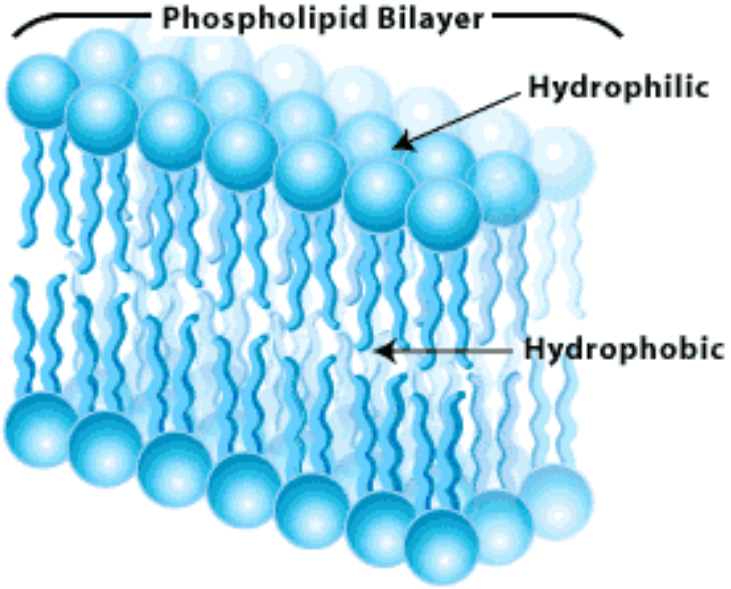
http://www.claysandminerals.com/minerals/clayminerals

How did life arise from non-life?

- Organization of amino acids into proteins
  - Clay templates
    - clays are made of flat, tightly bound layers, loosely bound to other layers
    - Each layer has unbonded ions, hence lots of attractive charges
  - In experiment where amino acid-rich solution was splashed onto clays and allowed to dry, amino acids organized themselves into protein fragments

Organization of cells

- Cells are simply replicating stuff inside a membrane – so the membrane makes it a cell.
- Cell membrane made of fatty acids (lipids)
  - In water, they self-organize into bilayer membranes



One end of the fatty acids is attracted to water: the other end is repelled by water. So they self-organize with the water-attracting parts on the outside.

http://physio1.wikispaces.com/Cell+Membrane

Organization of cells

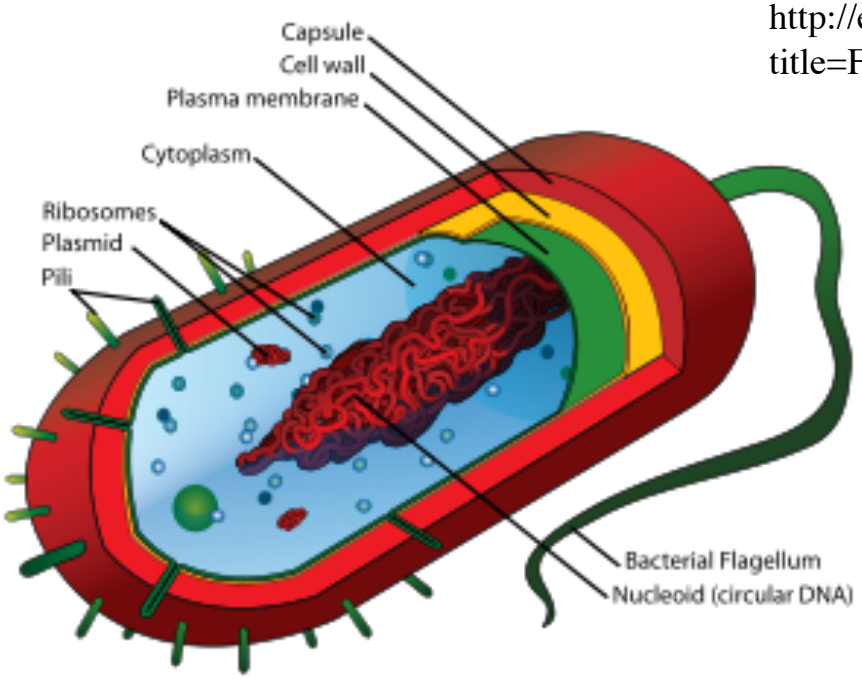
- Cell membrane made of fatty acids (lipids)
  - In water, they self-organize into bilayer membranes
  - If replicating molecules were caught in between, it would be a primitive cell

Origin of more complex life

- Eukaryote v. Prokaryote

Origin of more complex life

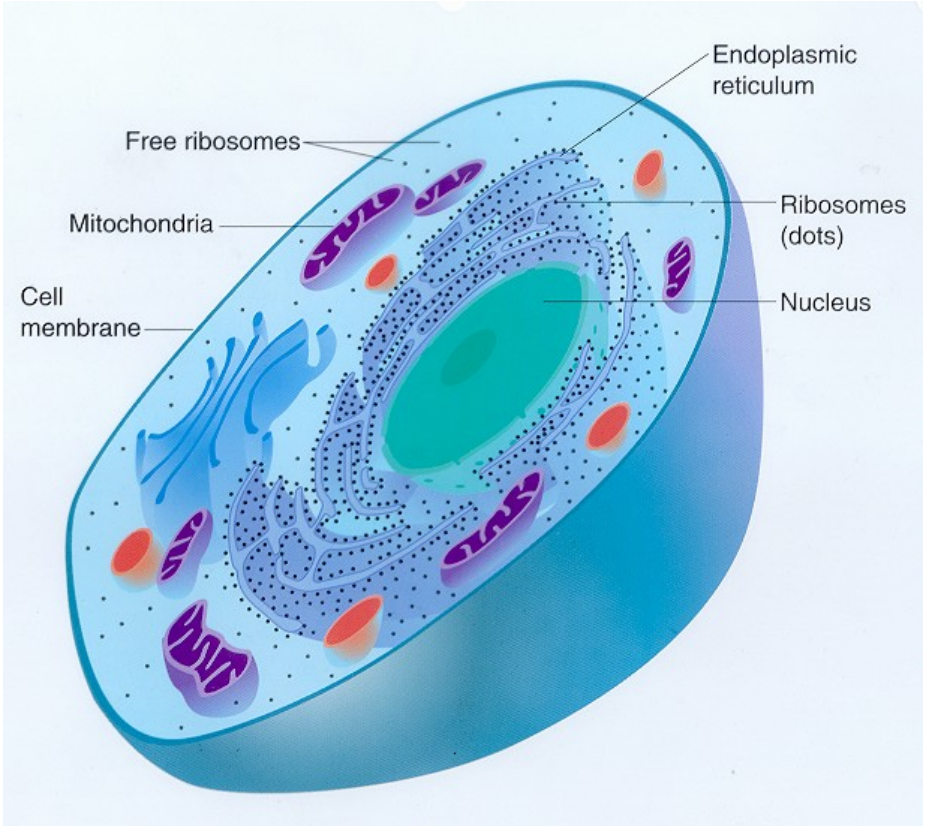
- Eukaryote v. Prokaryote
  - Prokaryote: small, no nucleus, limited organelles, simple ring chromosome with few genes
  - Eukaryote: large, organelles, nucleus, complex chromosomes with many genes



http://en.wikipedia.org/w/index.php?title=File:Average_prokaryote_cell-_en.svg&page=1

Prokaryote

Eukaryote



http://medicalpicturesinfo.com/eukaryotic/

Origin of more complex life

- Eukaryote v. Prokaryote
  - Prokaryote: small, no organelles, simple ring chromosome with few genes
  - Eukaryote: large, organelles, nucleus, complex chromosomes with many genes
- Organelles resemble prokaryotes, some even have DNA or RNA

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  - Prokaryote: small, no organelles, simple ring chromosome with few genes
  - Eukaryote: large, organelles, nucleus, complex chromosomes with many genes
- Organelles resemble prokaryotes, some even have RNA
- Evolution of eukaryotes from symbiosis of prokaryotes