Biology 10

Chapter 19-3

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“Earth’s Early History”

Objectives

- Describe the hypotheses scientists have about early Earth, and the origin of life.
- Describe the theory of how eukaryotic cells formed.
- Explain the evolutionary significance of sexual reproduction.

Chemical Evolution

- **chemical evolution**- theory that states the first life forms evolved from organic molecules
- requires several conditions
  - 1) absence of free oxygen
  - 2) energy
  - 3) proper chemicals present
  - 4) time
- According to evidence gathered, these four conditions existed early in Earth's history

Early Earth's Atmosphere

- atmosphere contained CO_2, H_2O, N_2, H_2, some NH_3, H_2S, and HCN
  - satisfies conditions 1 and 3
  - early atmosphere was probably pinkish-orange!
- As Earth cooled, water vapor condensed in the atmosphere, and torrential rainfalls appeared
  formed oceans- salt due to erosion of land
  - lots of iron in the water, oceans were probably brown!

Energy Requirement

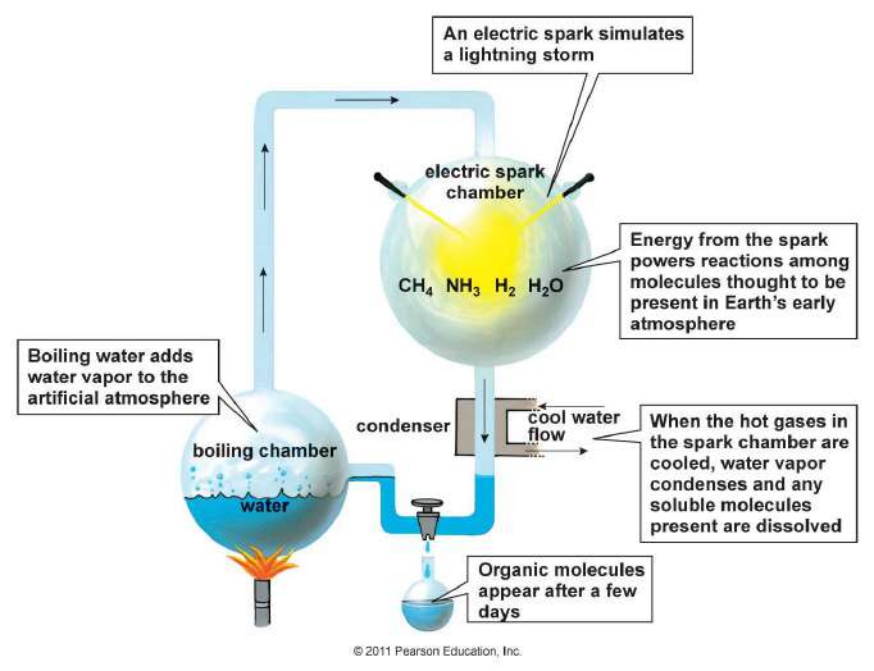
- Energy existed in several forms—satisfied condition 2
- solar radiation (much more UV than present—no ozone layer!)
- volcanic activity
- thunderstorms

Time Requirement

- Earth estimated to be 4.6 billion years old
  - satisfies condition 4

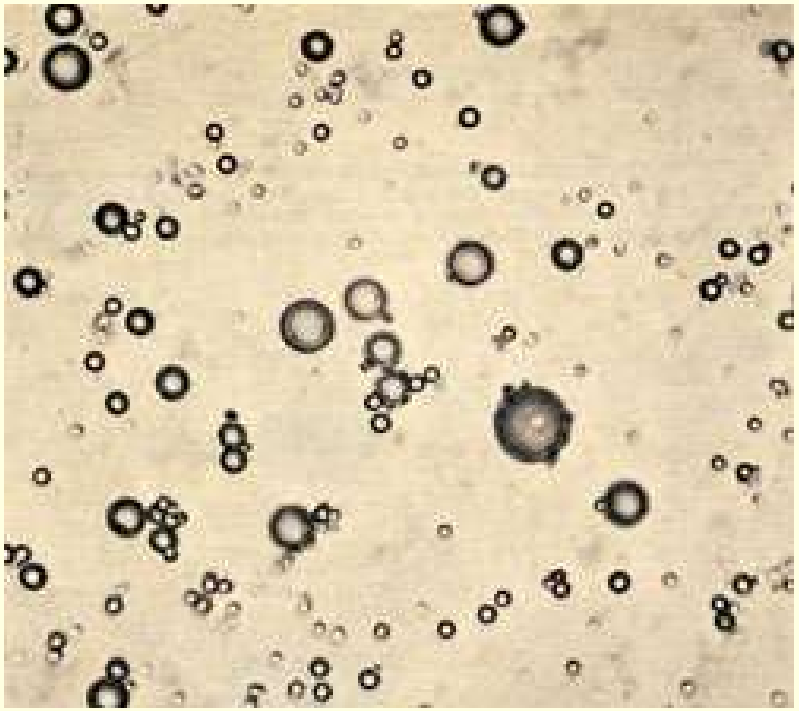
First Organic Molecules

- 1950's- Urey and Miller designed an apparatus which simulated atmospheric conditions of early Earth
  - after zapping "atmosphere" with electricity, amino acids and other organic molecules formed
  - subsequent experiments with different mixtures of gasses have yielded a great variety of organic molecules, including cytosine and uracil
  - Belief is that more complex organic molecules (polymers) may have been formed on rock or clay substrates at the bottom of the ocean



Formation of Microspheres

- Experiments with **proteinoid microspheres** clusters of organic polymers, indicate that groups of polymers organize into tiny spheres
- can divide, store energy, and are selectively permeable
- hypotheses suggest may have formed living cells 3.8 billion years ago



Evolution of RNA and DNA

- Scientists still aren't sure, but hypothesize that RNA formed first
- RNA has the ability to
  - 1) store information
  - 2) direct protein synthesis
  - 3) catalyze DNA synthesis reactions
- Since DNA is more stable, it may have formed in order to store information more reliably
- Lots of questions left to answer here!

First cells

- Fossil evidence indicate cells arose 3.8 billion years ago
- First cells were prokaryotic **anaerobes**- do not use oxygen for metabolism
- also heterotrophic, fermenting organic molecules (sugars, amino acids, nucleic acids) as food

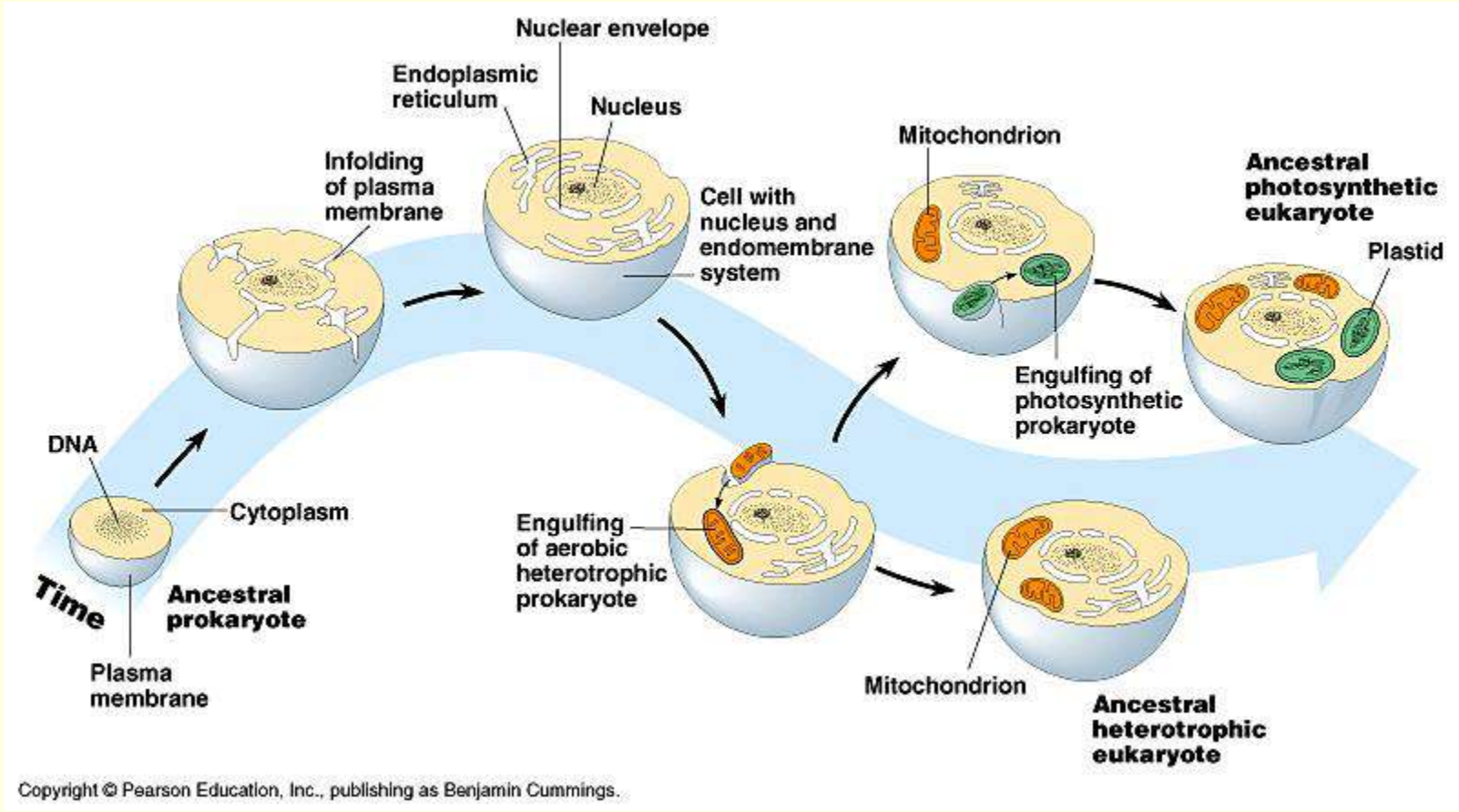
First cells

- **stromatolites**- columns of fossilized prokaryotic cells 3.5 billion years old
- Next, some cells evolved the ability to harness sunlight for energy (became autotrophs)
  - produced free oxygen, which reacted with iron in the water to form rust bands
  - turned the water from brown to blue
  - eventually began to collect in the atmosphere
  - formed ozone layer, protecting Earth from UV radiation
  - free oxygen also poisoned many of the first cells, but others were able to adapt and use the oxygen for metabolism (respiration)

Eukaryotic cells

- occurred between 2 and 1.5 billion years ago
- **endosymbiont theory**- suggests that the first eukaryotic cells arose as a result of symbiosis between primitive eukaryotic cells and the prokaryotic cells within
- prokaryotic cells ingested or invaded by heterotrophic cells, but not destroyed
- some could use oxygen to produce ATP, eventually evolved into mitochondria
- later, photosynthetic prokaryotes were ingested, and evolved into chloroplasts
- Evidence:
  - chloroplasts and mitochondria resemble prokaryotic cells
  - contain their own nucleic acids, prokaryotic ribosomes, and can conduct independent protein synthesis

Endosymbiotic Theory Image



Evolution of Sexual Reproduction

- After eukaryotic cells evolved, sexual reproduction evolved
- HUGE step in evolutionary history!
  - sexual reproduction greatly increases variety in individuals
    - without it, you only have mutations to introduce new variants
  - gives natural selection more “raw material” to work on
  - increases the chances a species will survive, as natural variations may be more fit for their changing environments

Evolution of Multicellularity

- Occurred shortly after evolution of sexual reproduction
- Being multicellular was another HUGE advantage!
  - easier to find food, cells working together!
  - easier to avoid predation, you're bigger now!
- Led to rapid adaptive radiation, greater diversity