HISTORY OF LIFE ON EARTH

Objectives

1. Describe the steps and experiments that created the precursors of life.
2. Explain how oxygen was introduced into the environment and how it affected life on earth.
3. Describe the evolution of eukaryotes and the endosymbiont theory.
4. List the causes and consequences of mass extinctions.

Outline

A. Possible Origin of Life
   1. Creation of Organic Compounds
   2. Synthesis of Macromolecules
   3. Protocells
   4. Self-Replicating RNA
   5. Best Scenario

B. Key Events in History of Life
   1. Introduction of Oxygen
   2. Evolution of Eukaryotes
   3. Origin of Multicellularity
   4. Colonization of Land

C. Mass Extinctions
   1. Permian Extinction
   2. Cretaceous Extinction
   3. Consequences

A. Possible Origin of Life

- Current (oxidizing) atmosphere
  - 78% N_2
  - 21% O_2
  - 0.03% CO_2

- Early (reducing) atmosphere
    - 4000 mya
    - N_2, NO_x
    - H_2O
    - H_2
    - H_2S
    - CH_4
    - NH_3
    - O_2 missing (key factor)
        - Highly reactive and corrosive
        - Quickly oxidizes other molecules
        - Dangerous to life

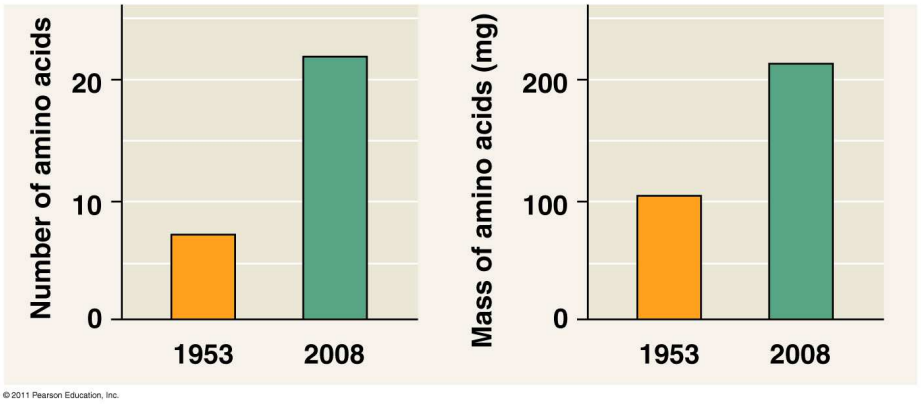
1. Creation of Organic Compounds

- Reducing atmosphere
- Large amounts of energy
    - Lightning
    - Volcanic Activity
    - Bombardment of Asteroids
    - High Pressure

- Amino acids, Nucleotides made

  - Monosaccharides also made

  - Primordial Soup

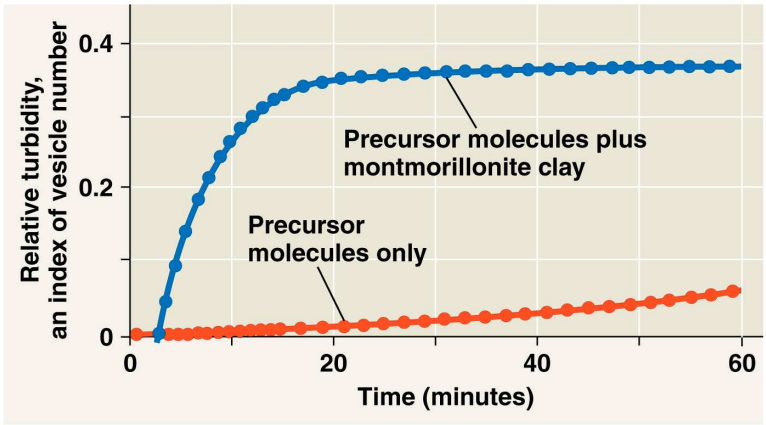


2. Synthesis of Macromolecules

- Formation of RNA spontaneously

- Energy from hot rocks (esp. clay)

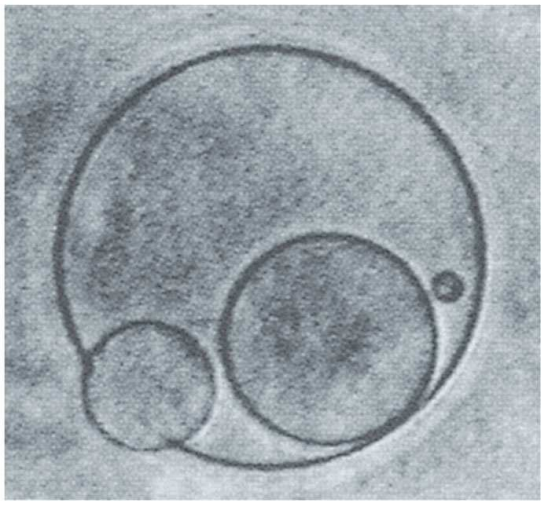
  - Make RNA and polypeptides



(a) Self-assembly

3. Protocells

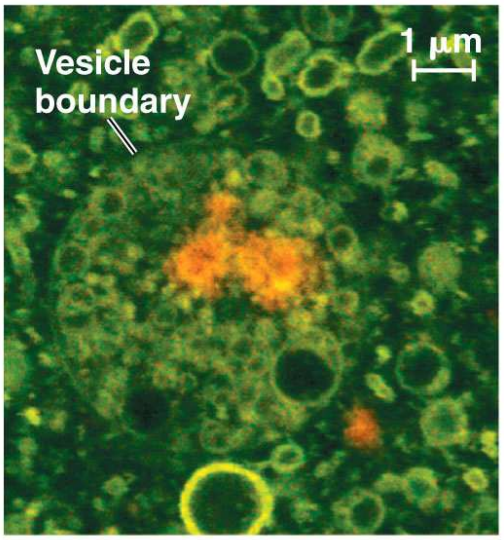
- Vesicles
    - Naturally formed by phospholipids
    - Occurs more quickly with montmorillionite clay
- Grow by absorbing each other
    - "Ingest" other clay particles
    - Selectively permeable
- Fragment when too large



(b) Reproduction

4. Self-Replicating RNA

- Can carry genetic information
- Can act as catalyst
- RNA is primer for DNA synthesis
    - DNA more stable
    - DNA more accurate



(c) Absorption of RNA

5. Best Scenario

- Vesicles absorb molecules
    - Molecules form a complement
- Complementary polymers separate, begin producing new chains
- RNA fits scenario best
    - Naturally produced on clay
    - Act as catalyst
    - Acts as genetic material
- Successful vesicles
    - Able to absorb new material
    - Able to divide
    - Able to pass on traits
    - Reproduce more

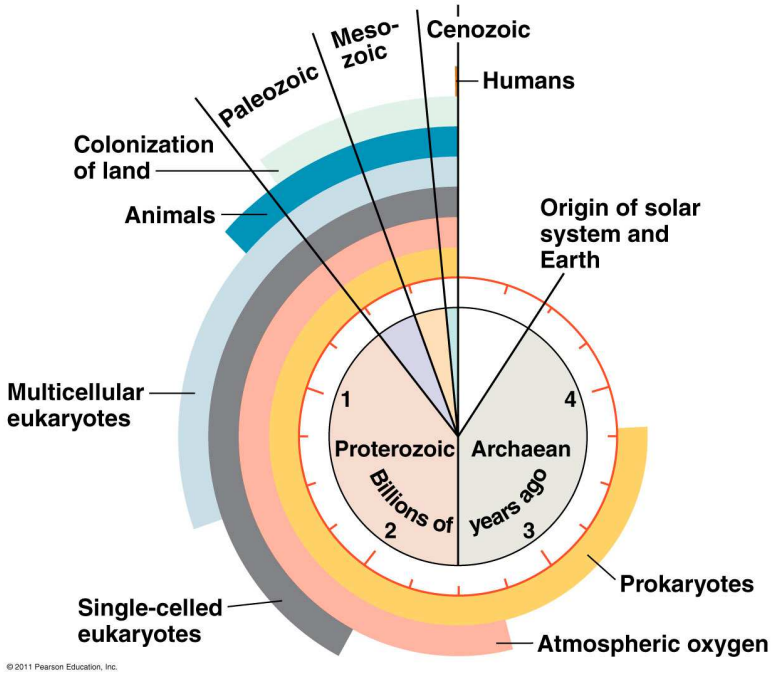
B. Key Events in History of Life

- Oldest evidence of life – 3500 mya
  - Fossils of bacterial stromatolites
    - Complex pads of bacteria

▲ Stromatolites

▲ Fossilized stromatolite

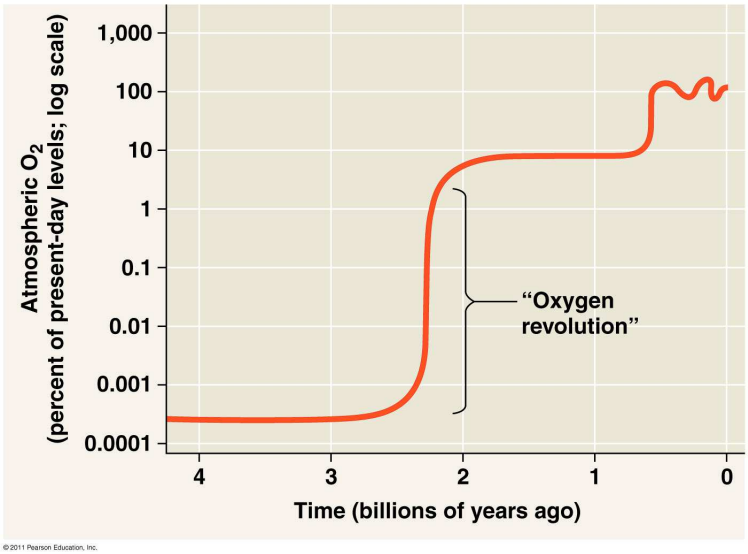
- Suggests life began much earlier
  - ~3800 – 3900 mya?



- Prokaryotes only form of life

1. Introduction of Oxygen

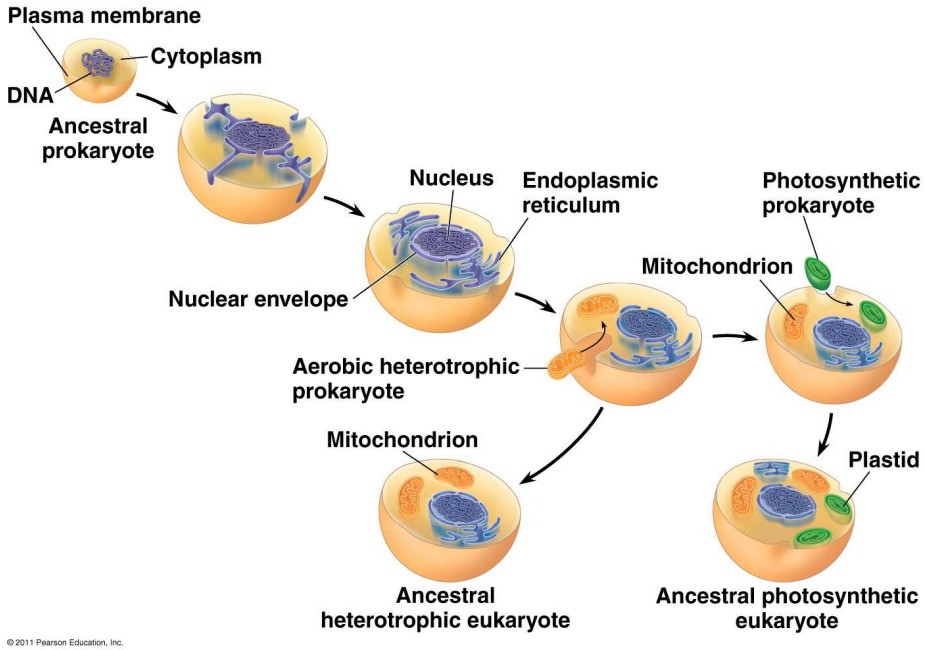
- Due to oxygenic photosynthesis
    - Most likely cyanobacteria
    - First measurable change – 2700 mya
- Signaled by presence of iron (III) oxide



- "Oxygen Revolution" – 2300 mya
    - Oxygen concentration rockets to 10%
    - Probably due to eukaryotes
    - Likely caused first major extinctions
        - Oxygen reactive and toxic
        - Forms free radicals
- Formed ozone (O_3)
    - Protects DNA from UV radiation
    - Life could live on surface
        - Before lived under 5-10 m of water
- Ended reducing atmosphere
- Allowed for highly efficient respiration
- Geological History of Oxygen

2. Evolution of Eukaryotes

- Fossil evidence ~ 2100 mya
    - Likely invagination of membrane
    - Allowed for larger size
- Endosymbiont theory
    - Descendents of bacteria
    - Oxygen more efficient for respiration
    - Photosynthesis provides nutrition



3. Origin of Multicellularity

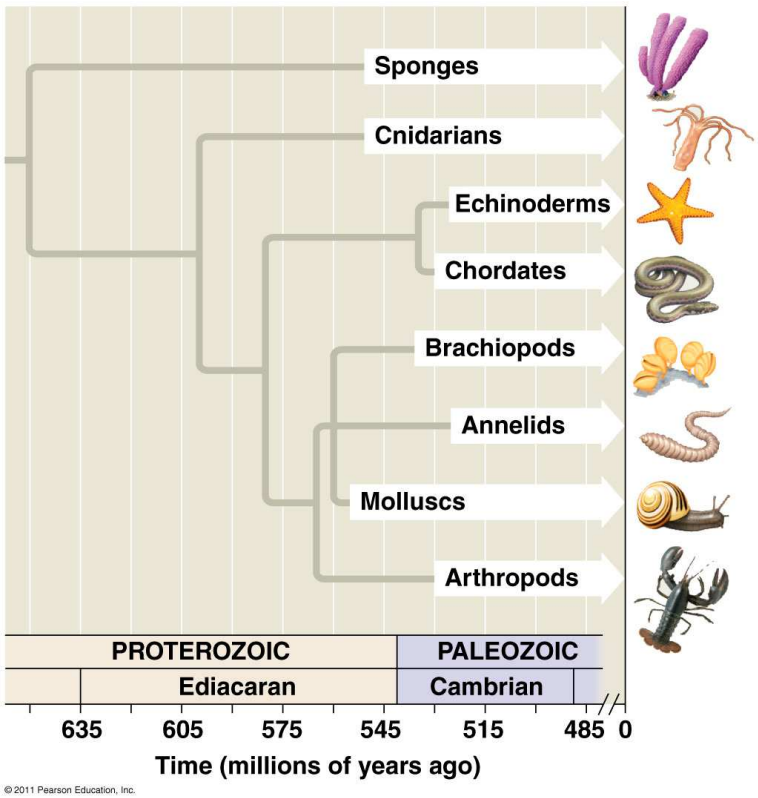
- Fossil samples of algae ~1200 mya
  - Originated ~ 1500 mya?

- Most small

- Cambrian explosion

  - Evidence of many new animal phyla

  - Explosion of predators and defenses

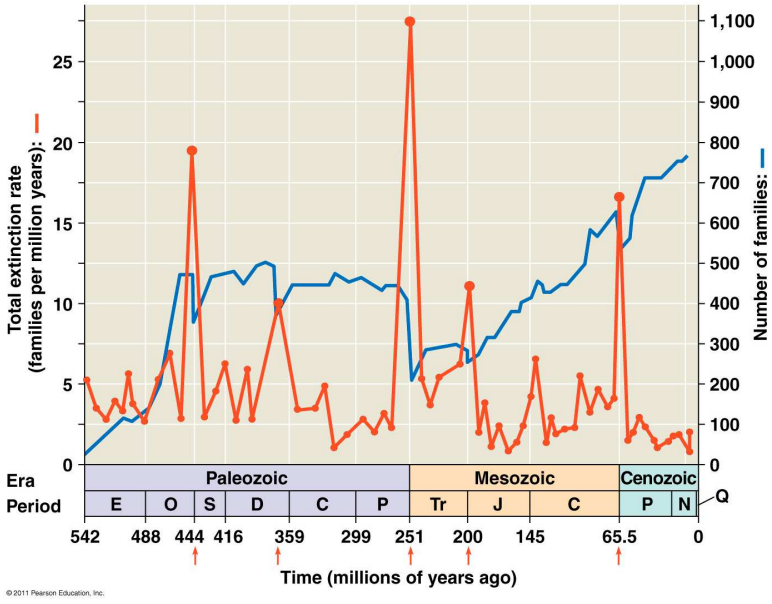


4. Colonization of Land

- Bacteria ~ 1000 mya
- Multicellular organisms ~ 500 mya
- Plant-Fungal symbiosis
- Crustacean Fossils ~ 420 mya
- Tetrapod Fossils ~ 365 mya

C. Mass Extinctions

- Loss of > 50% of species
- Due to severe climatic change
- Borders of geologic eras



1. Permian Extinction

- Paleozoic – Mesozoic boundary
- c. 250 mya
- Due to volcanic activity
    - Land covered with lava and ash
    - Warmed earth by ~6°C
    - Reduced oxygen levels
    - Poisoning with H_2S
    - Damaged ozone layer
- Lost 96% of marine animal species

2. Cretaceous Extinction

- Mesozoic – Cenozoic boundary
- c. 65.5 mya
- Due to asteroid strike
  - Indicated by iridium-enriched clay
  - Cooled earth
  - Slowed photosynthesis

3. Consequences

- 5-10 million years to recover
- Increase frequency of predators
- Chance for new groups to proliferate
- Adaptive Radiation