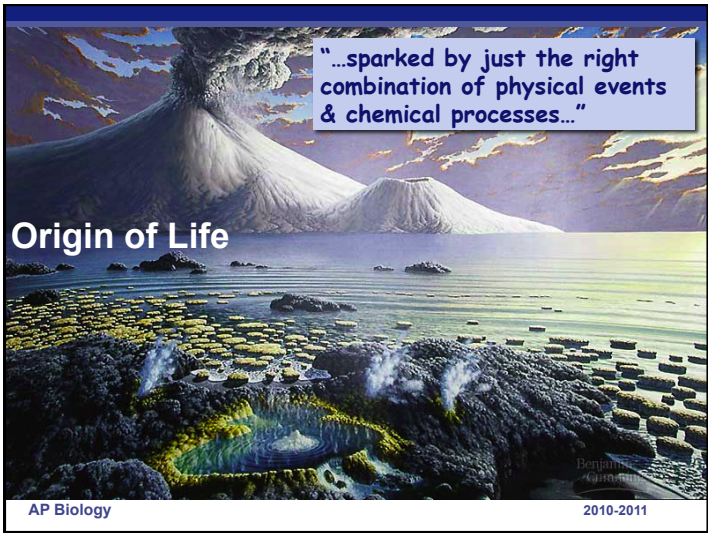
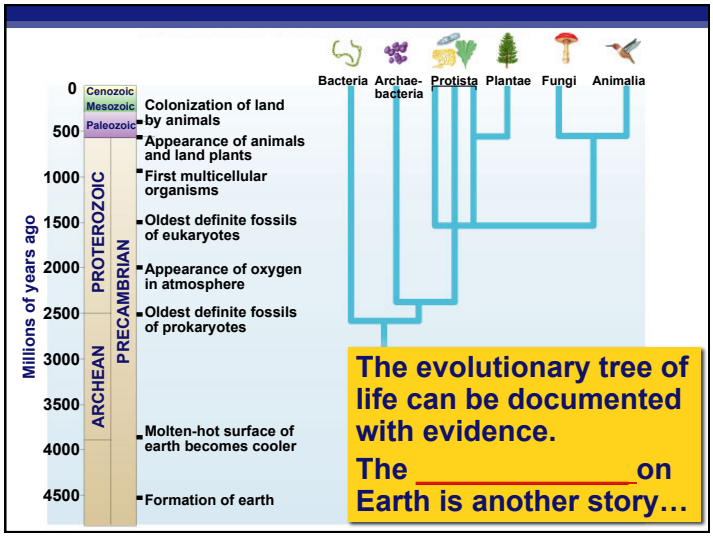




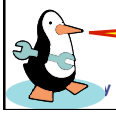
The Origin of Life is _____

- _____
  - *Was life created by a supernatural or divine force?*
  - not testable
- _____
  - *Was the original source of organic (carbon) materials comets & meteorites striking early Earth?*
  - testable
- _____
  - *Did life evolve spontaneously from inorganic molecules?*
  - testable

Conditions on early Earth

- _____
  - water vapor (H_2O), CO_2, N_2, NO_x, H_2, NH_3, CH_4, H_2S
  - lots of available H & its electron
  - no free oxygen
- **Energy source**
  - lightning, UV radiation, volcanic

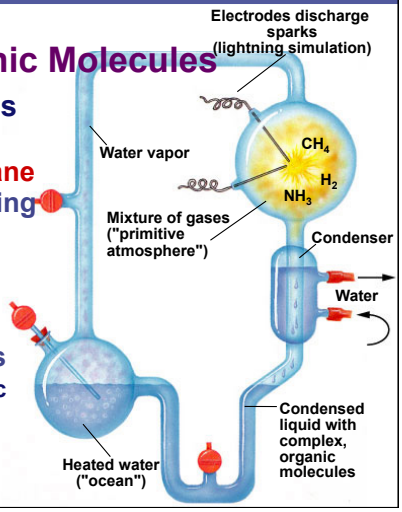
low O_2 = organic molecules do not breakdown as quickly



What's missing from that atmosphere?

Origin of Organic Molecules

- **Abiotic synthesis**
  - 1920 **Oparin & Haldane** propose reducing atmosphere hypothesis
  - 1953 **Miller & Urey** test hypothesis
    - formed organic compounds
      - amino acids
      - adenine



Stanley Miller

University of Chicago

produced
-amino acids
-hydrocarbons
-nitrogen bases
-other organics

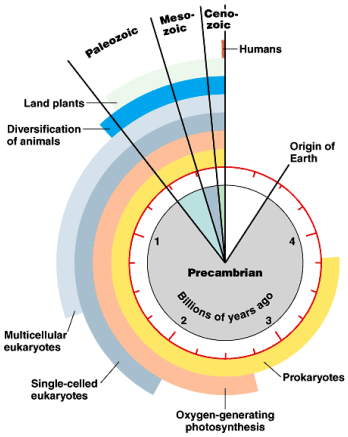
Why was this experiment important??!

Key Events in Origin of Life

- _____
  - lipid bubbles → separate inside from outside
    → metabolism & reproduction
- _____
  - RNA is likely first genetic material
  - multiple functions: encodes information (self-replicating), enzyme, regulatory molecule, transport molecule (tRNA, mRNA)
    - makes inheritance possible
    - makes natural selection & evolution possible
- _____
  - endosymbiosis

Timeline

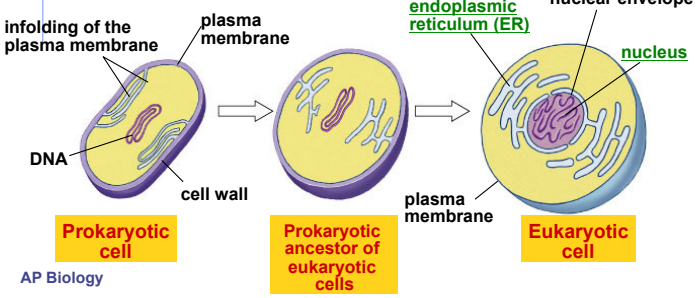
- Key events in evolutionary history of life on Earth
  - 3.5–4.0 bya: life originated
  - 2.7 bya: free O_2 = photosynthetic bacteria
  - 2 bya: first eukaryotes



First Eukaryotes

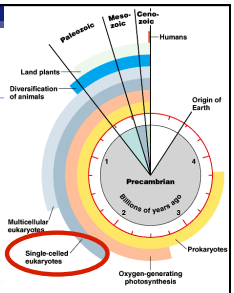
~2 bya

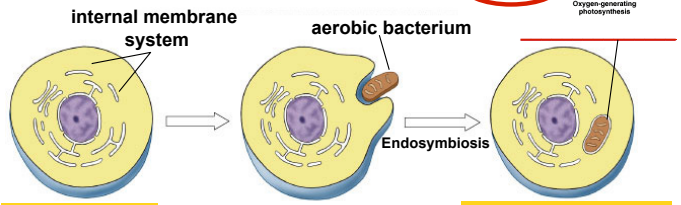
- Development of internal membranes
  - create internal micro-environments
  - advantage: specialization = increase efficiency
    - natural selection!



1st Endosymbiosis

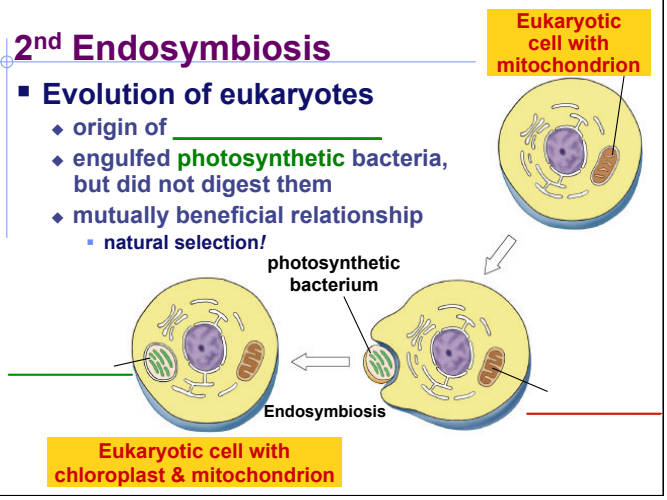
- Evolution of eukaryotes
  - origin of _____
  - engulfed aerobic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection!





2nd Endosymbiosis

- Evolution of eukaryotes
  - origin of _____
  - engulfed photosynthetic bacteria, but did not digest them
  - mutually beneficial relationship
    - natural selection!



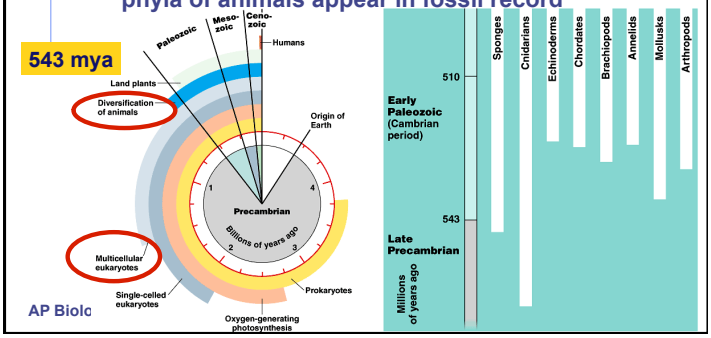
Theory of Endosymbiosis

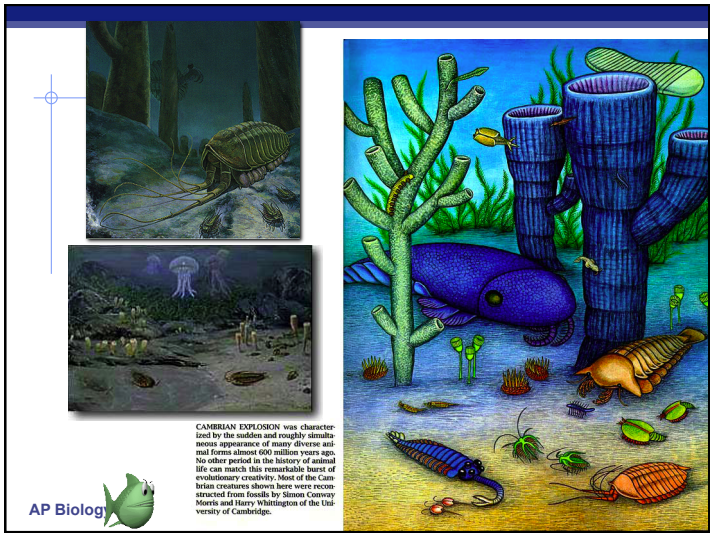
- Evidence
  - _____
    - mitochondria & chloroplasts resemble bacterial structure
  - _____
    - mitochondria & chloroplasts have their own circular DNA, like bacteria
  - _____
    - mitochondria & chloroplasts move freely within the cell
    - mitochondria & chloroplasts reproduce independently from the cell

Lynn Margulis

Cambrian explosion

- **Diversification of Animals**
  - within 10–20 million years most of the major phyla of animals appear in fossil record

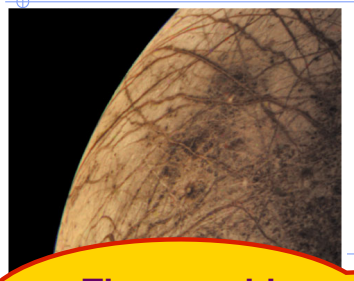




CAMBRIAN EXPLOSION was characterized by the sudden and roughly simultaneous appearance of many diverse animal forms almost 600 million years ago. No other period in the history of animal life can match this remarkable burst of evolutionary creativity. Most of the Cambrian creatures shown here were reconstructed from fossils by Simon Conway Morris and Harry Whittington of the University of Cambridge.

Is there life elsewhere?

Does it look like life on Earth?



They would Ask Questions!