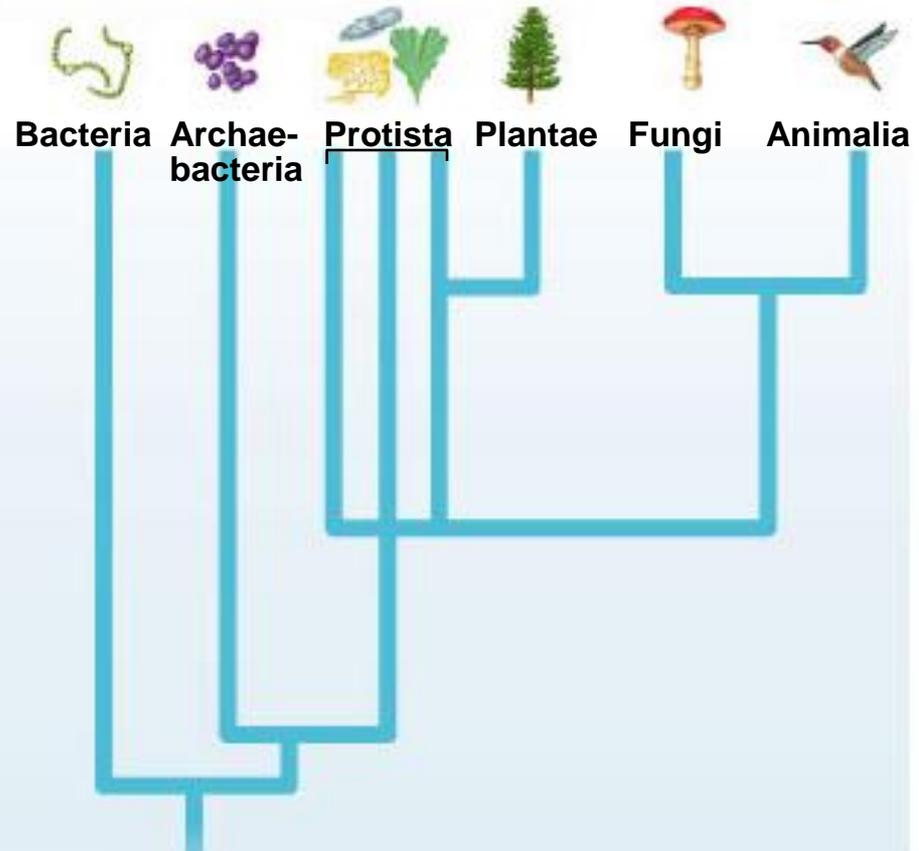
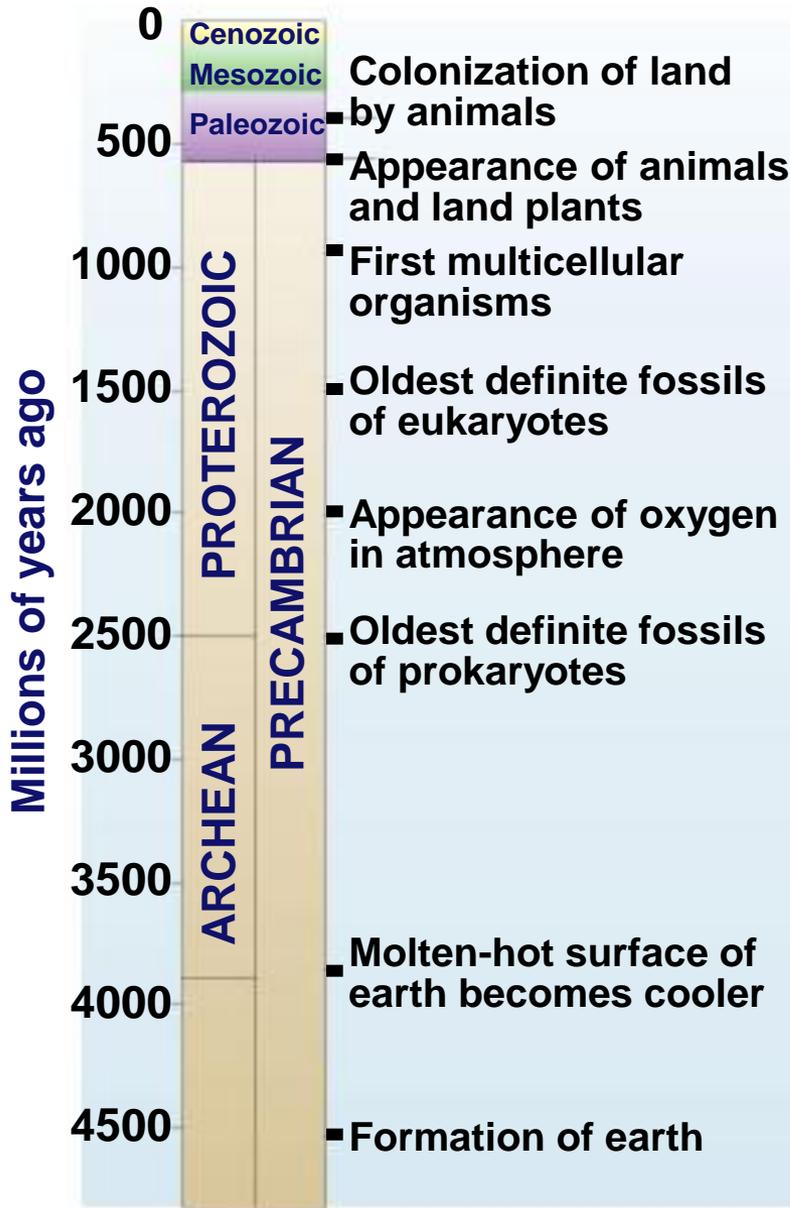


“...sparked by just the right combination of physical events & chemical processes...”

Origin of Life

Benjamin
Ginn



The evolutionary tree of life can be documented with evidence.

The Origin of Life on Earth is another story...

The Origin of Life is Hypothesis

- Special Creation
 - ◆ *Was life created by a supernatural or divine force?*
 - ◆ **not testable**
- Extra-terrestrial Origin
 - ◆ *Was the original source of organic (carbon) materials comets & meteorites striking early Earth?*
 - ◆ **testable**
- Spontaneous Abiotic Origin
 - ◆ *Did life evolve spontaneously from inorganic molecules?*



Conditions on early Earth

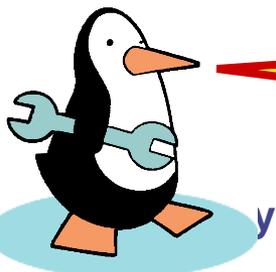
■ Reducing atmosphere

- ◆ 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

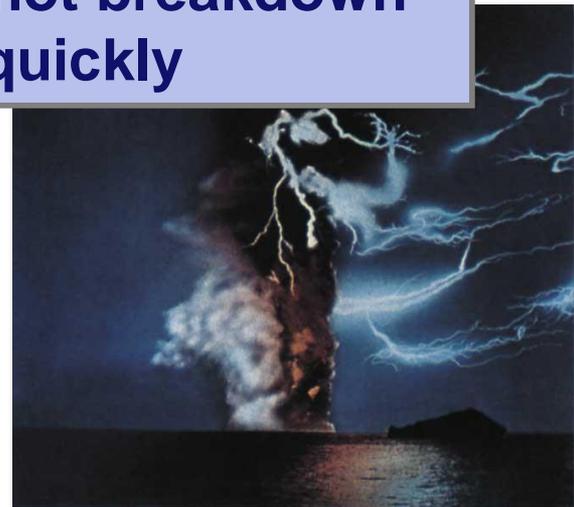
■ Energy source

- ◆ 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

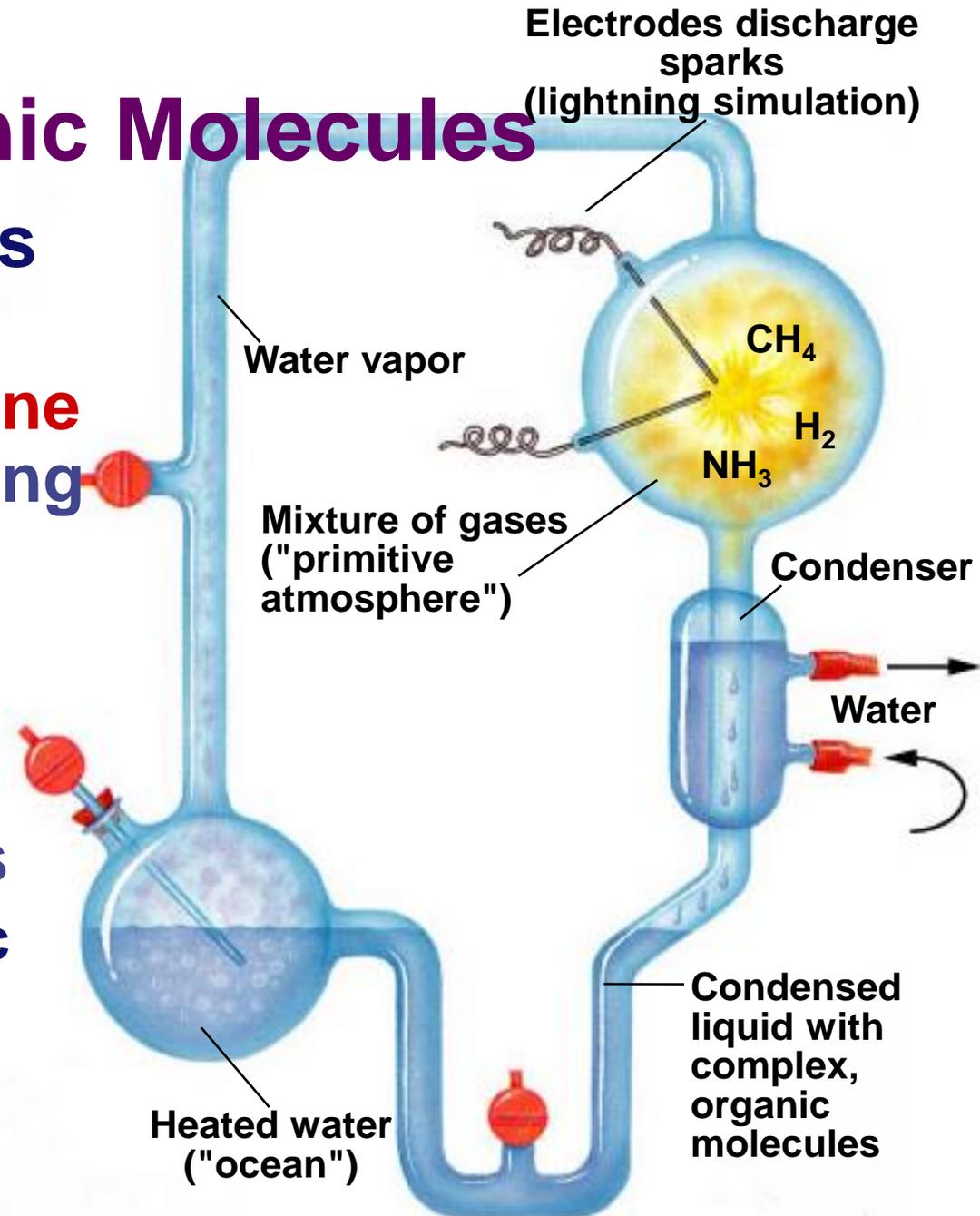
Oparin & Haldane
propose reducing
atmosphere
hypothesis

◆ 1953

Miller & Urey
test hypothesis

■ formed organic
compounds

- ◆ amino acids
- ◆ adenine



Stanley Miller

University of Chicago

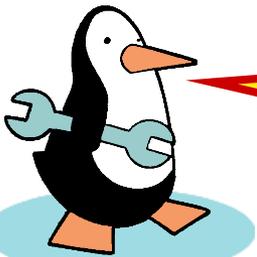


produced

- amino acids
- hydrocarbons
- nitrogen bases
- other organics



Why was
this experiment
important??!



Key Events in Origin of Life

■ Origin of Cells (Protobionts)

- ◆ lipid bubbles → separate inside from outside
→ metabolism & reproduction

■ Origin of Genetics

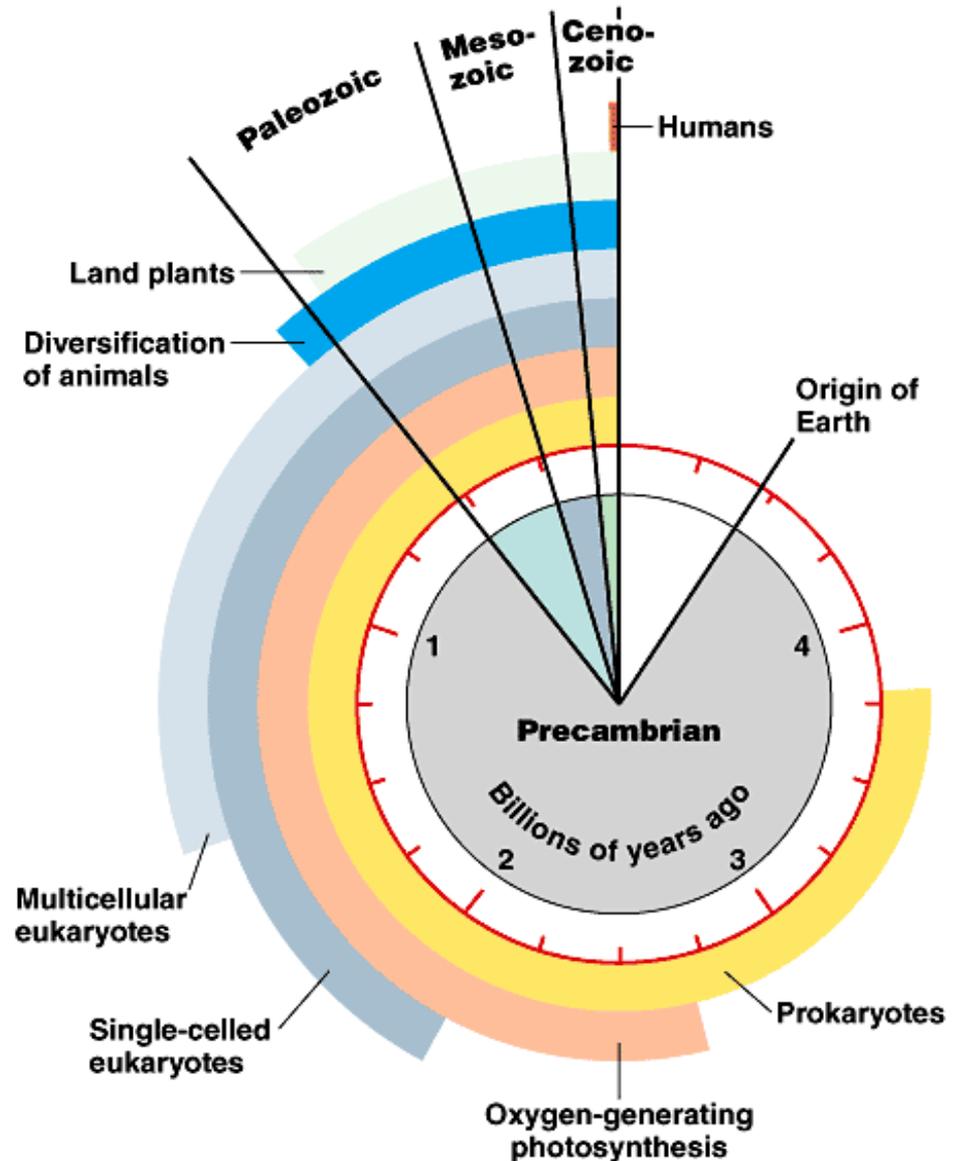
- ◆ RNA is likely first genetic material
- ◆ multiple functions: encodes information (self-replicating), enzyme, regulatory molecule, transport molecule (tRNA, mRNA)
 - makes inheritance possible
 - makes natural selection & evolution possible

■ Origin of Eukaryotes

- ◆ 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

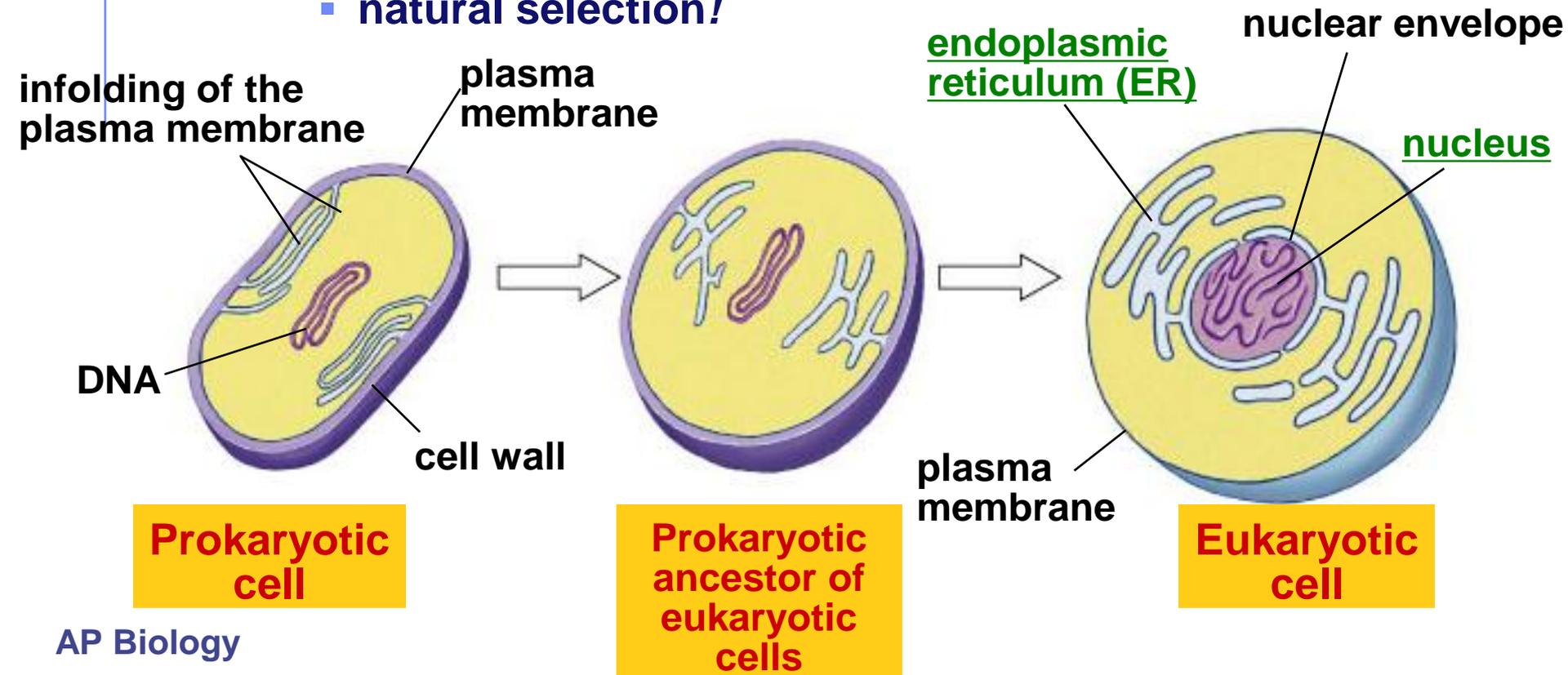


~2 bya

First Eukaryotes

Development of internal membranes

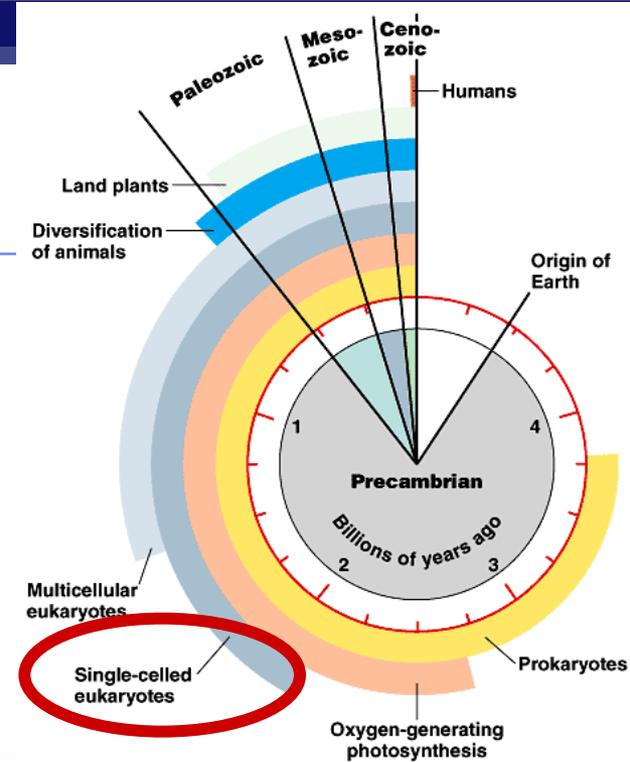
- ◆ create internal micro-environments
- ◆ advantage: specialization = increase efficiency
 - natural selection!



1st Endosymbiosis

Evolution of eukaryotes

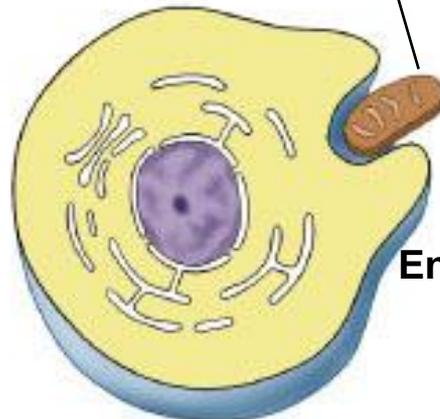
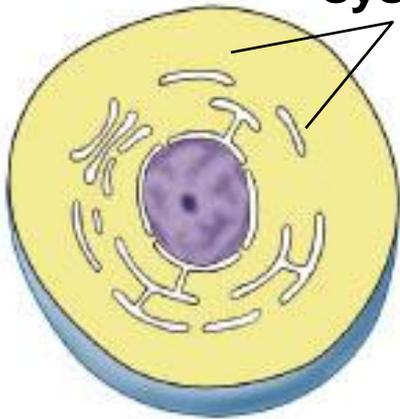
- ♦ origin of **mitochondria**
- ♦ engulfed aerobic bacteria, but did not digest them
- ♦ mutually beneficial relationship
 - natural selection!



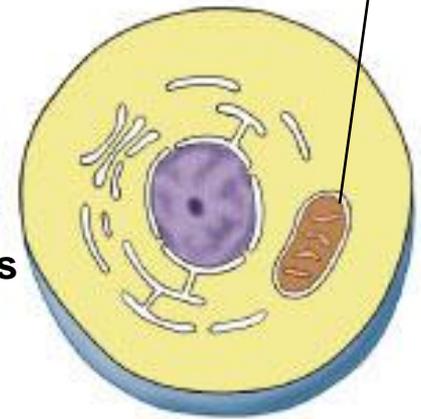
internal membrane system

aerobic bacterium

mitochondrion



Endosymbiosis



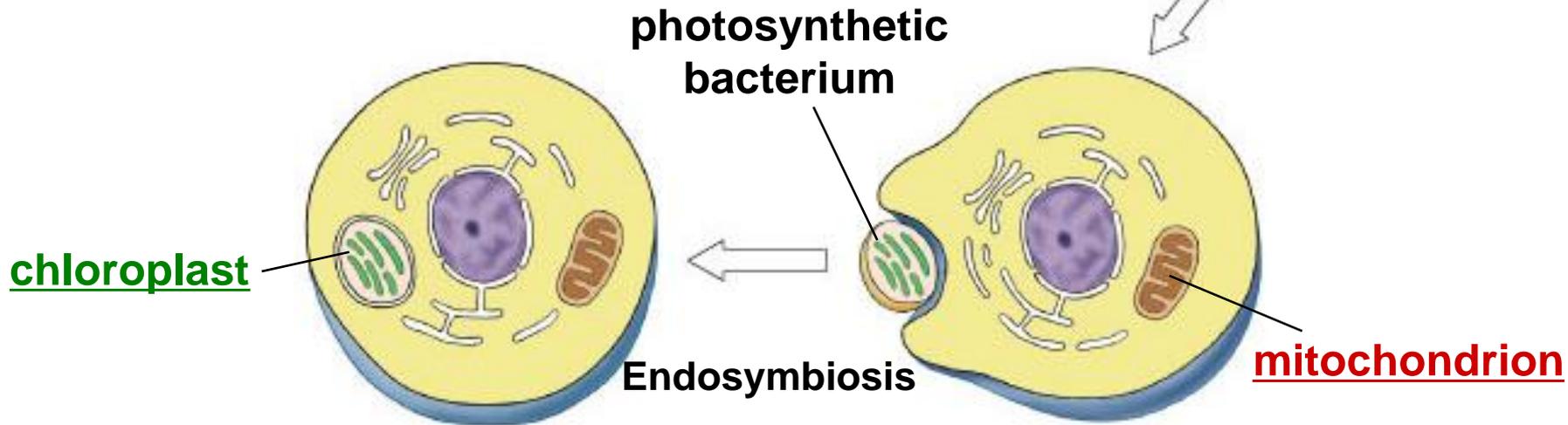
Ancestral eukaryotic cell

Eukaryotic cell with mitochondrion

2nd Endosymbiosis

Evolution of eukaryotes

- ◆ origin of chloroplasts
- ◆ engulfed photosynthetic bacteria, but did not digest them
- ◆ mutually beneficial relationship
 - natural selection!



Eukaryotic cell with mitochondrion

Eukaryotic cell with chloroplast & mitochondrion

Theory of Endosymbiosis

■ Evidence

◆ structural

- mitochondria & chloroplasts resemble bacterial structure

◆ genetic

- mitochondria & chloroplasts have their own circular DNA, like bacteria

◆ functional

- mitochondria & chloroplasts move freely within the cell
- mitochondria & chloroplasts reproduce independently from the cell



Lynn Margulis

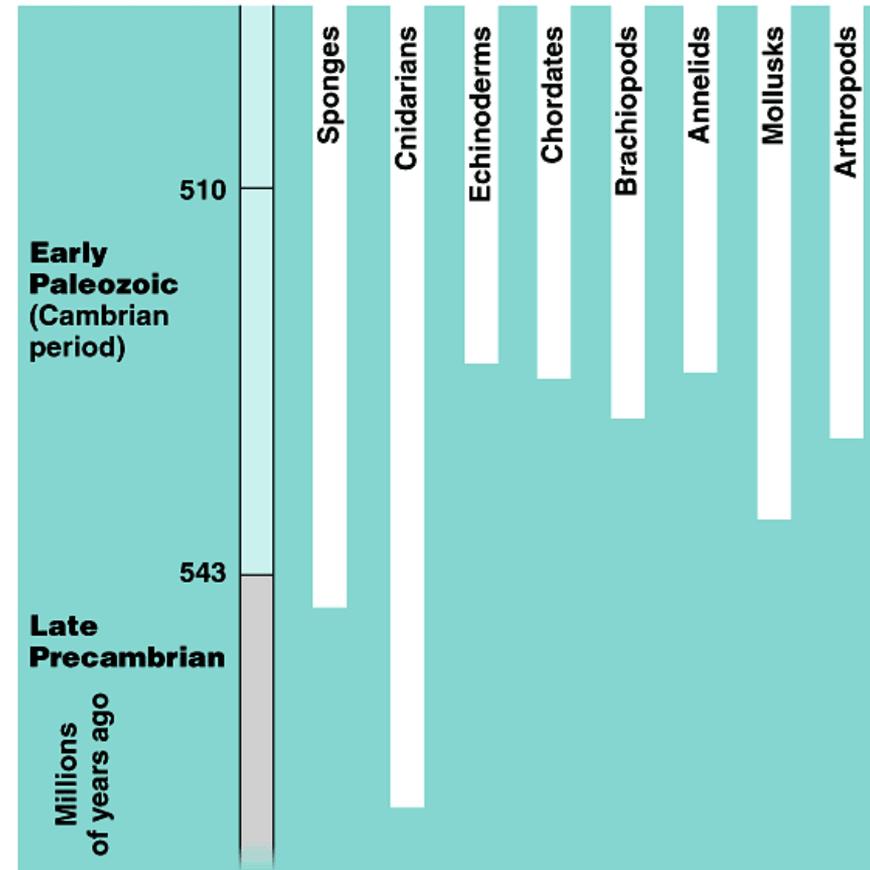
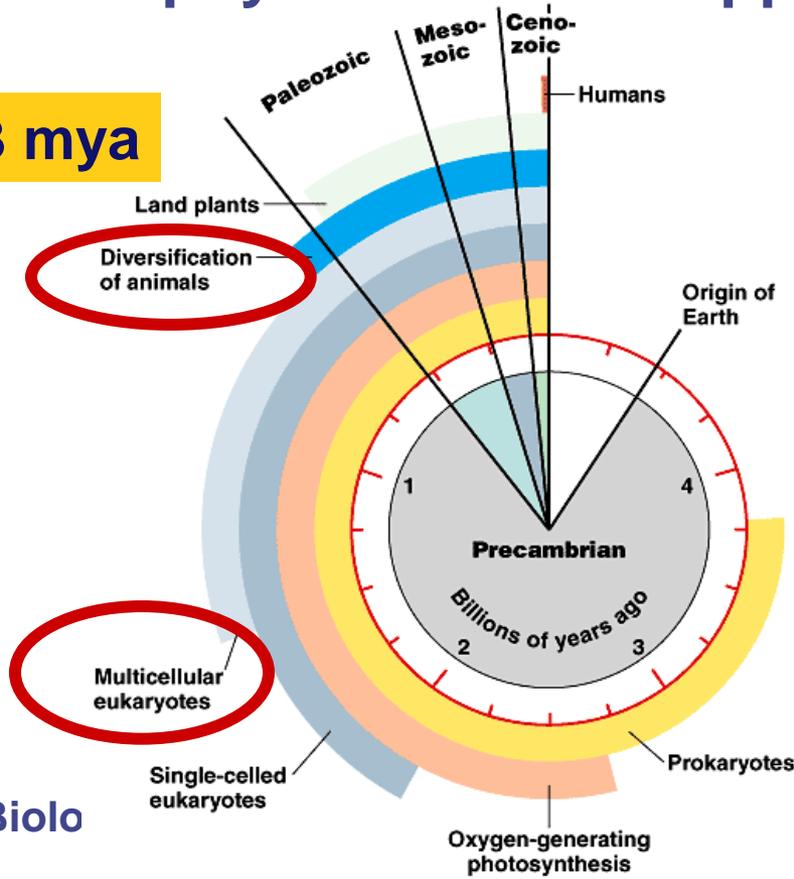


Cambrian explosion

■ Diversification of Animals

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

543 mya





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!**

