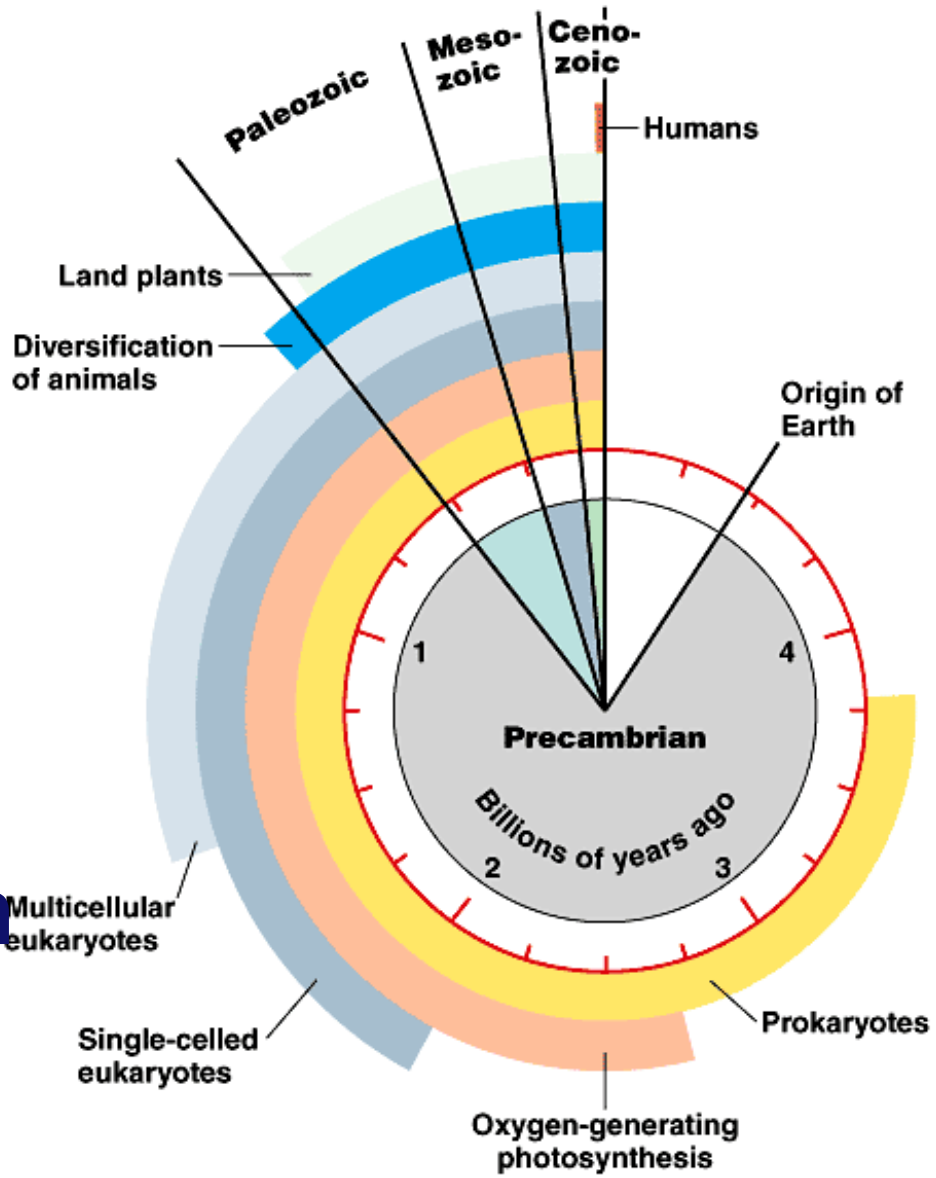
Origin of Eukaryotic Cells

- Earth is 4.6 byo
- Life originated 3.5–4.0 bya
- Prokaryotes dominated earth for about 1by



Cyanobacteria

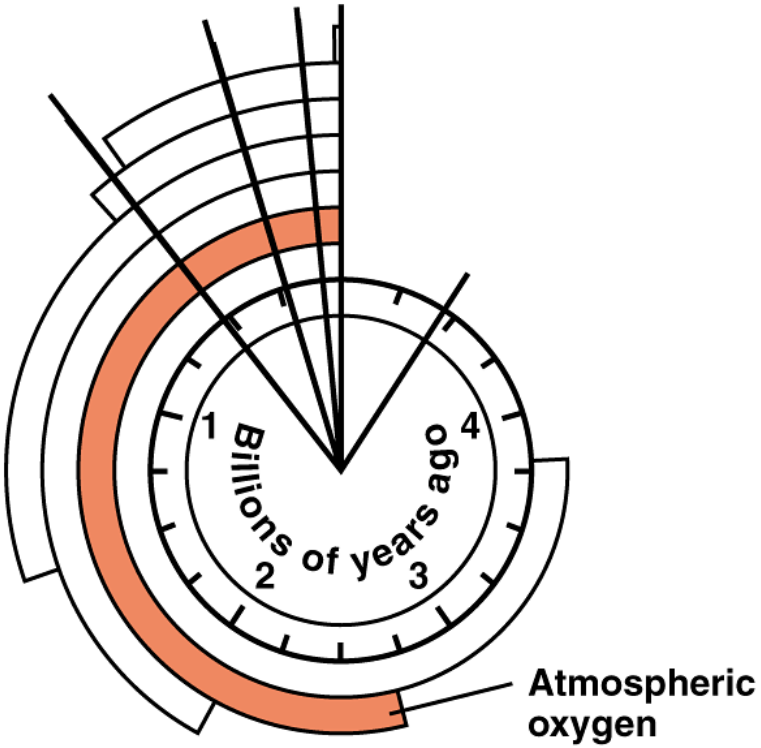
- A type of prokaryote with much infolding of the cell membrane

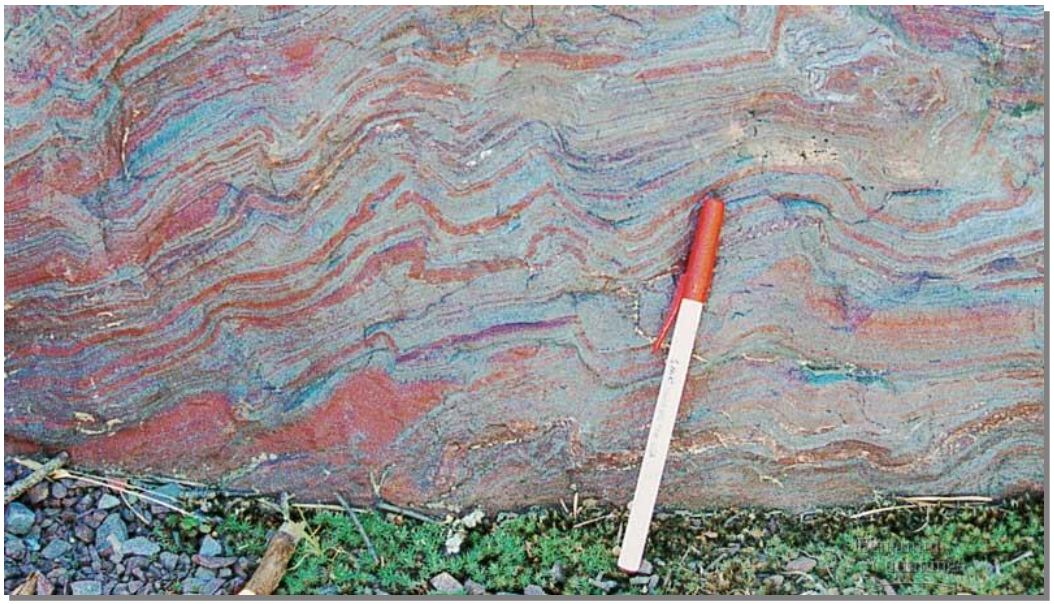
- Capable of performing photosynthesis, which releases oxygen into the atmosphere

Cyanobacterium heterocyst

Oxygen atmosphere

- Oxygen begins to accumulate 2.7 bya
  - evidence in banded iron in rocks (rusting)
  - makes aerobic respiration possible

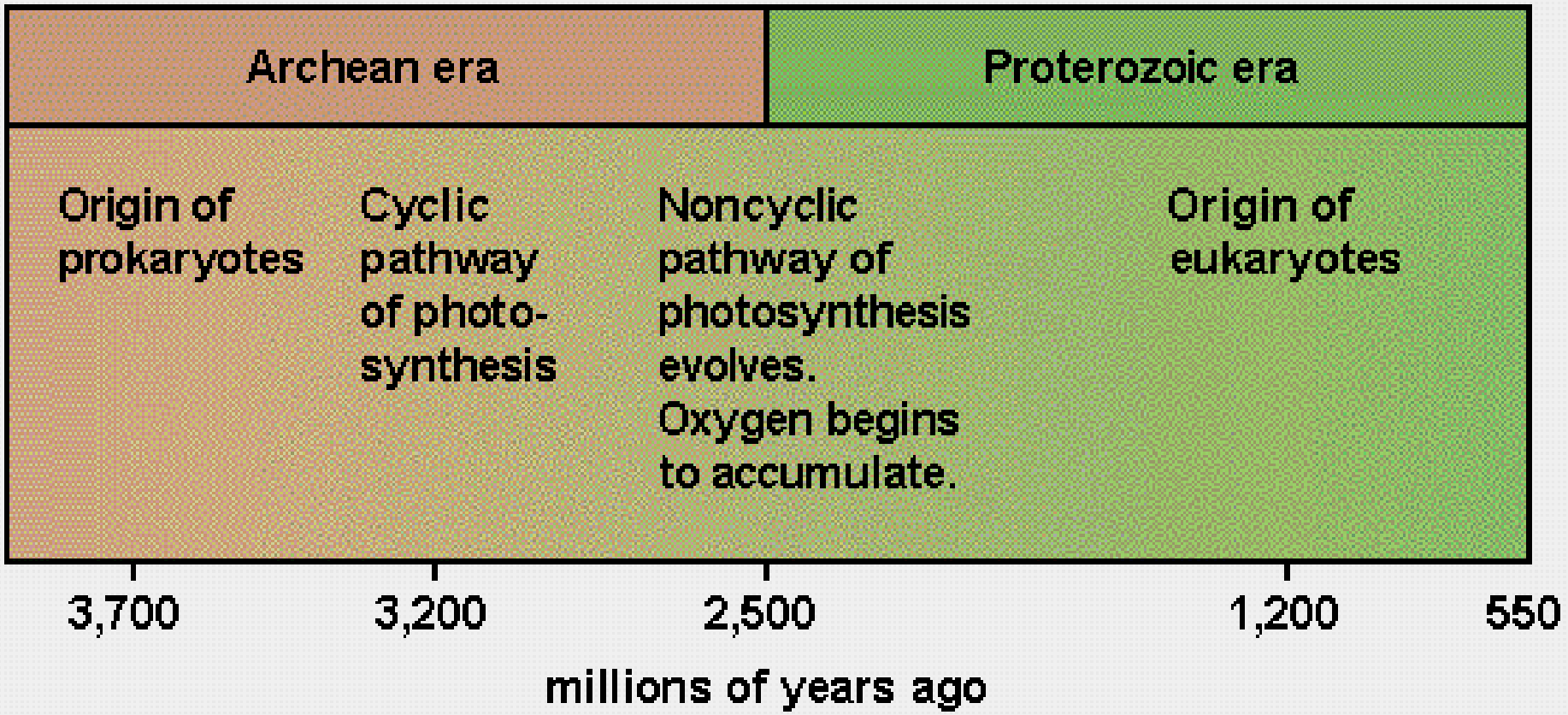




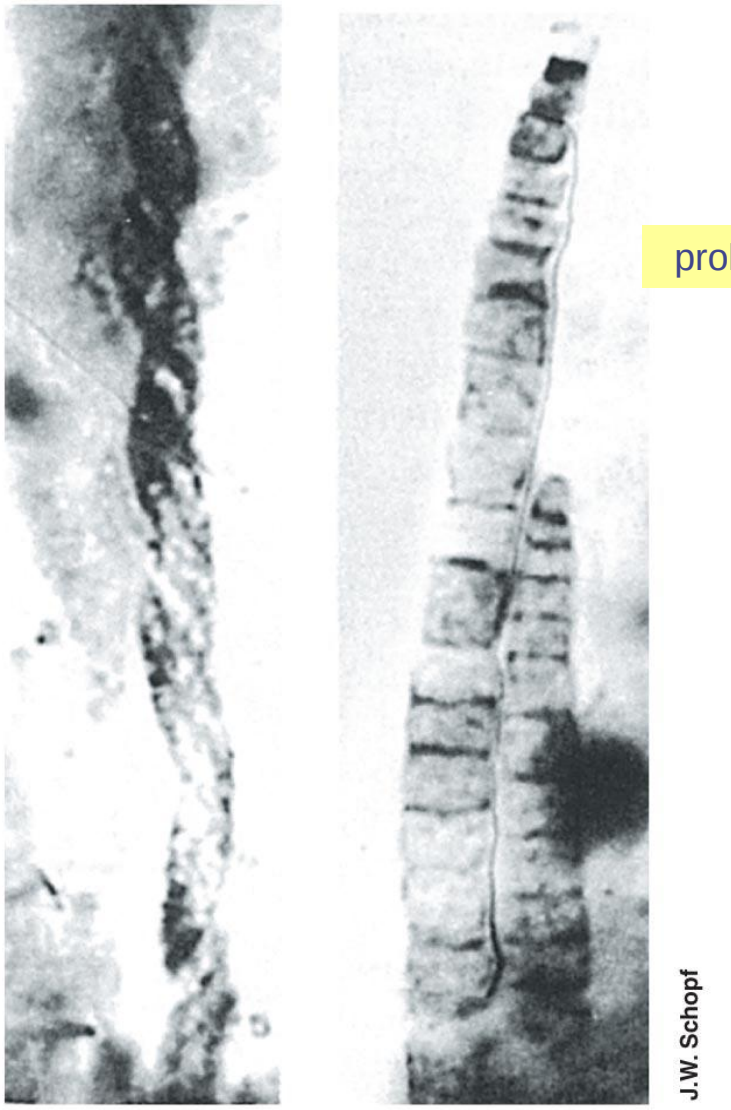
Eukaryotes

- **nearly all are *aerobic*,**
  - **they depend on free oxygen to carry out their metabolic processes**

- **Accordingly, they could not have evolved before at least some free oxygen was present in the atmosphere**


Archean era
Proterozoic era
Origin of prokaryotes
Cyclic pathway of photo-synthesis
Noncyclic pathway of photosynthesis evolves. Oxygen begins to accumulate.
Origin of eukaryotes
3,700
3,200
2,500
1,200
550
millions of years ago

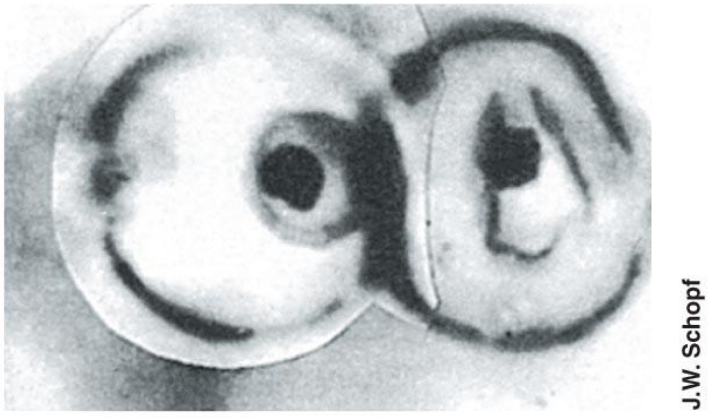
More Recent Fossil Bacteria and Eukaryotes



1 billion yrs old rocks

prokaryotes

eukaryotic cells



Two processes are thought to have led to the origin of eukaryotes….

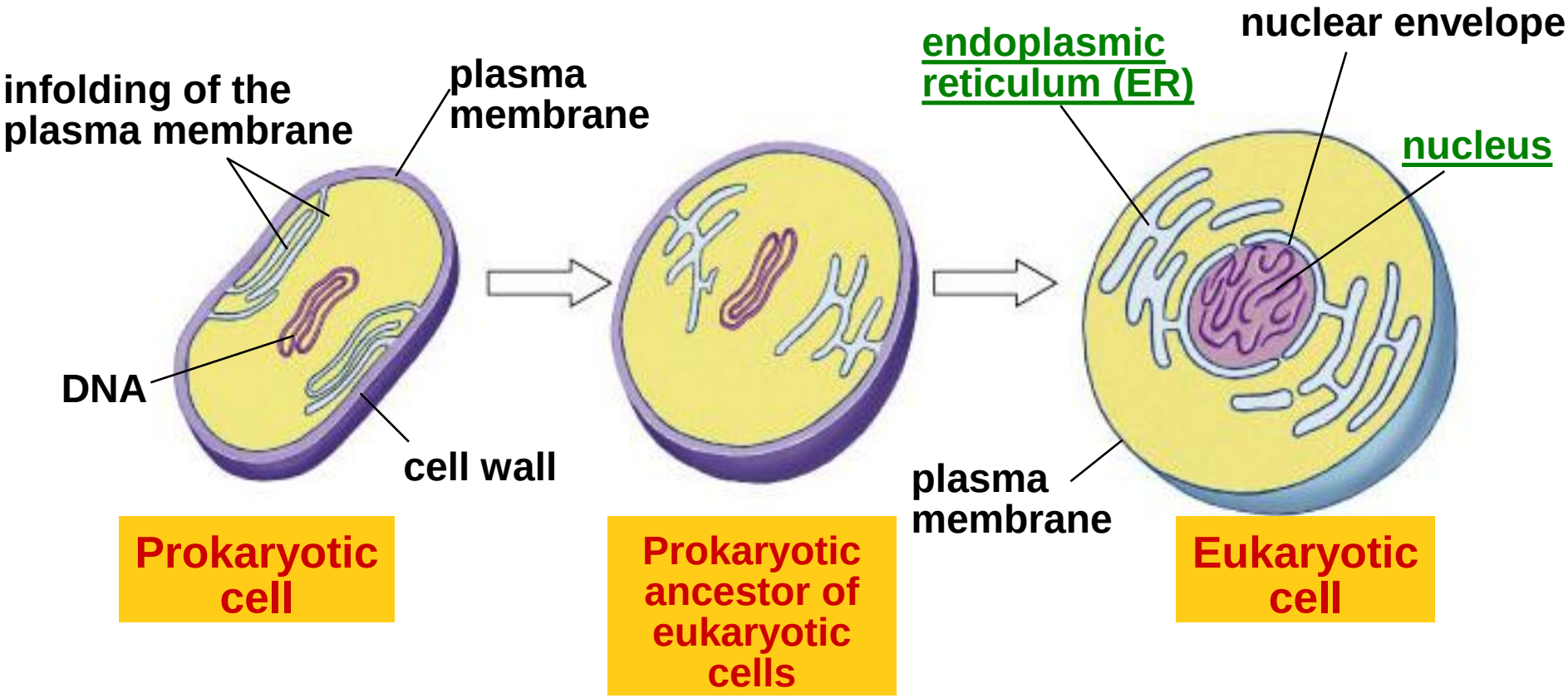
1. **Infoldings of the prokaryotic cell membrane**

2. **Endosymbiosis**

Development of internal membranes

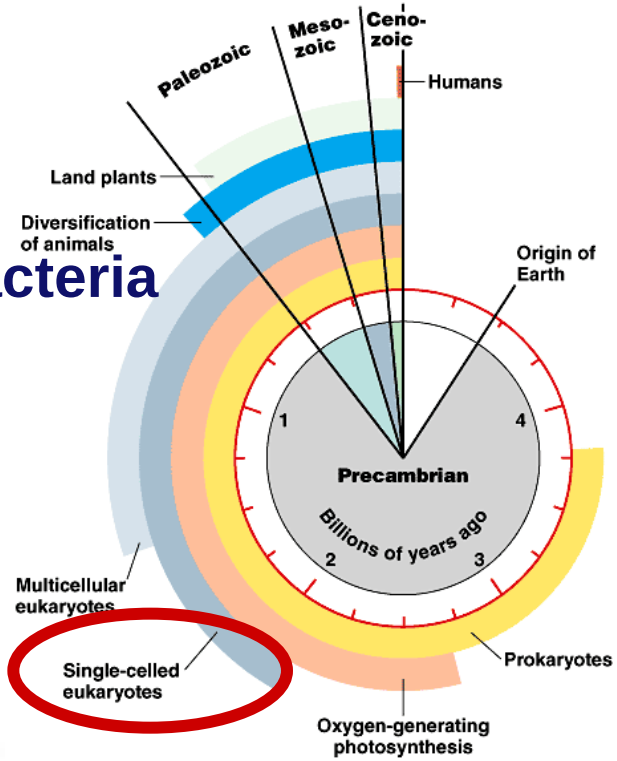
- create internal micro-environments
- advantage = increase efficiency
  - natural selection!

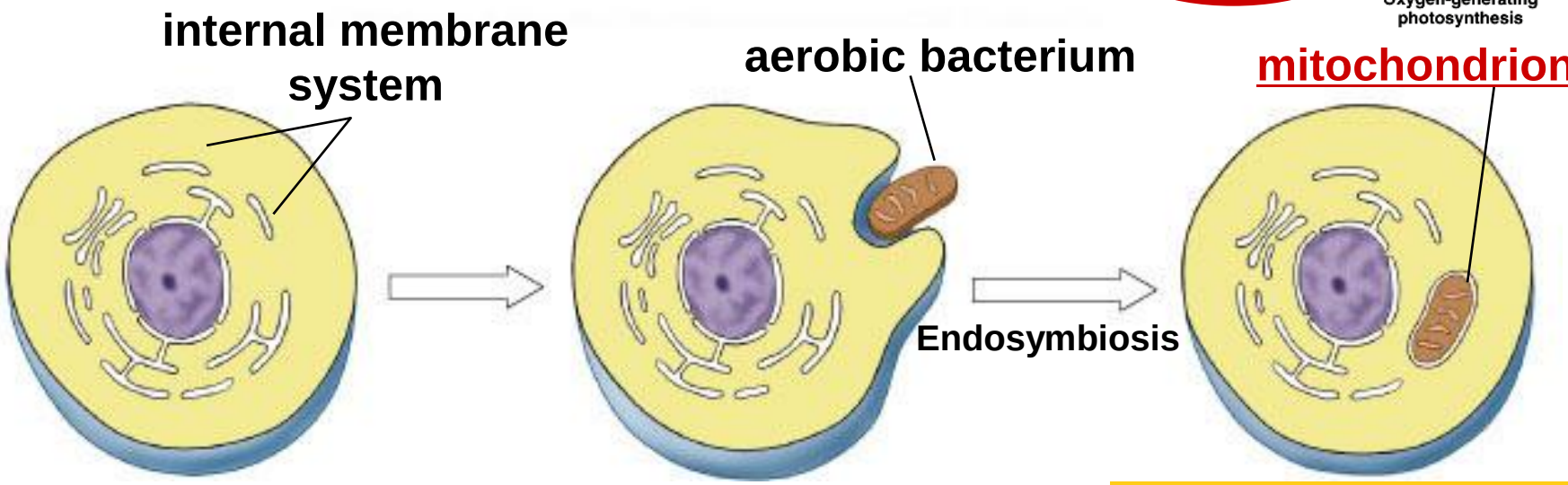
~2 bya



Endosymbiosis

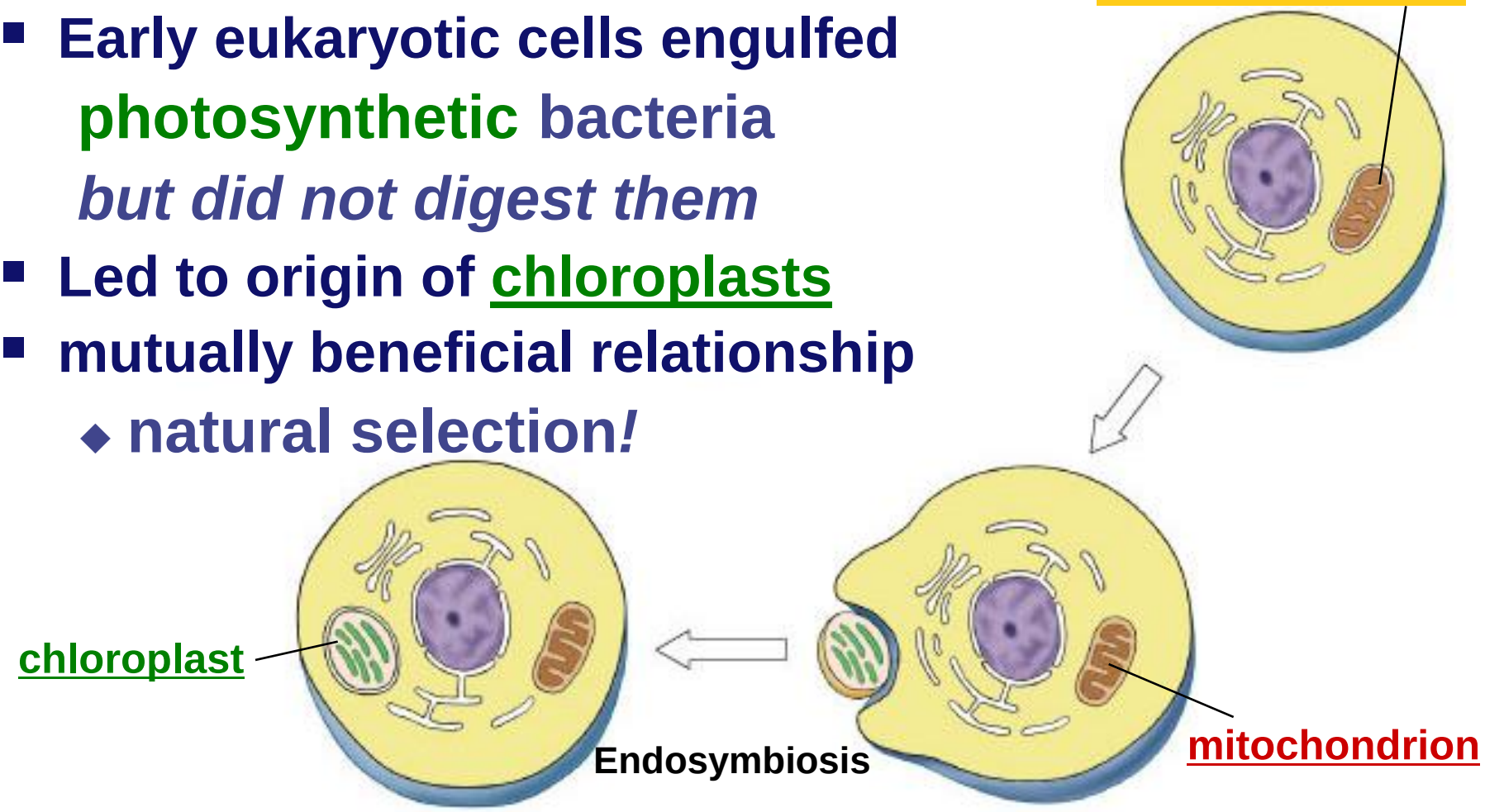
- Early eukaryotic cells engulfed aerobic bacteria
  but did not digest them
- Led to the origin of mitochondria
- Mutually beneficial relationship
  - natural selection*!*





Endosymbiosis

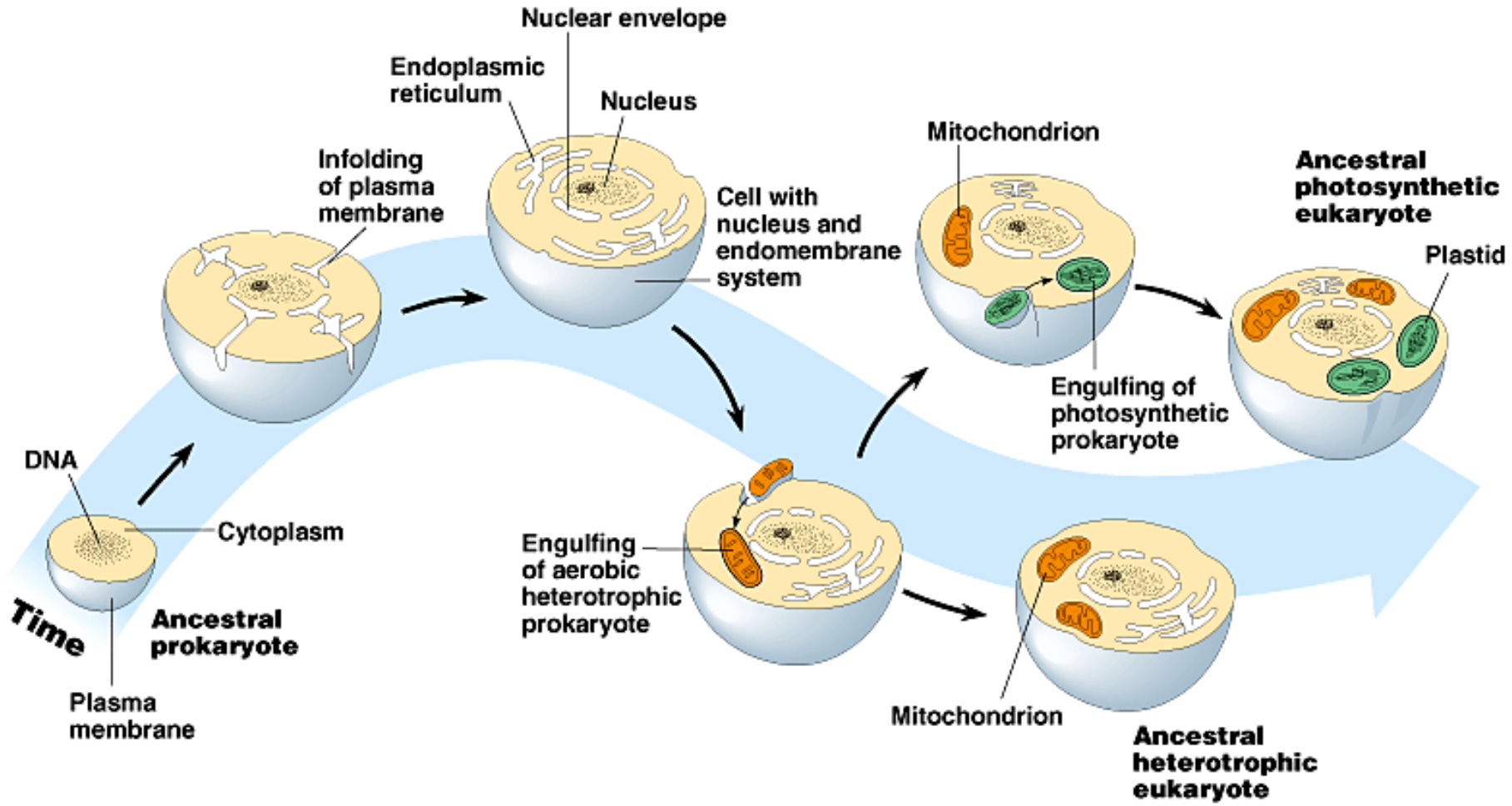
- Early eukaryotic cells engulfed
  photosynthetic bacteria
  but did not digest them
- Led to origin of **chloroplasts**
- mutually beneficial relationship
  - natural selection*!*



Endosymbiosis

- **In this relationship one symbiont lived within the other, which is a special type of symbiosis called endosymbiosis**
- **in some cases of a symbiotic relationship, one symbiont cannot live independently of the other**
- **This may have been the case early symbiotic prokaryotes that became increasingly interdependent until the unit could exist only as a whole**

A model of the origin of eukaryotes



Theory of Endosymbiosis

Lynn Margulis

Structural Evidence

Both mitochondria & chloroplasts

- **Resemble bacterial structure**
- **Are found in membranous envelopes *(like a cell membrane)***
- **are the same approximate size as prokaryotes**
- **have 70s ribosomes**

Genetic Evidence

Both mitochondria & chloroplasts

- **have circular naked DNA**
- **DNA shares common sequences with modern prokaryotes**

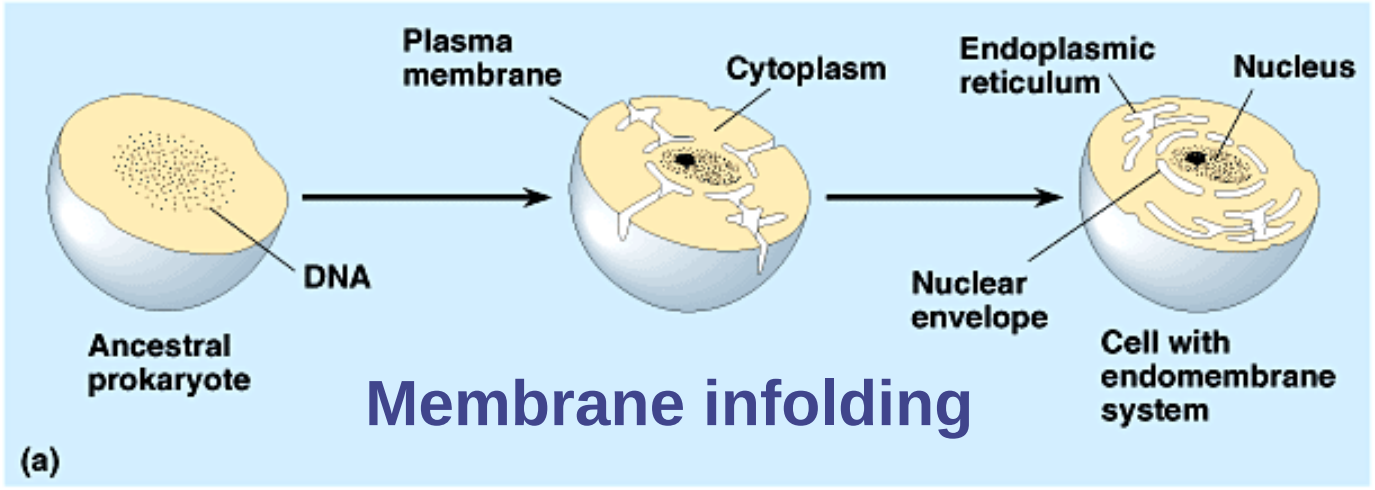
Functional Evidence

Both mitochondria & chloroplasts

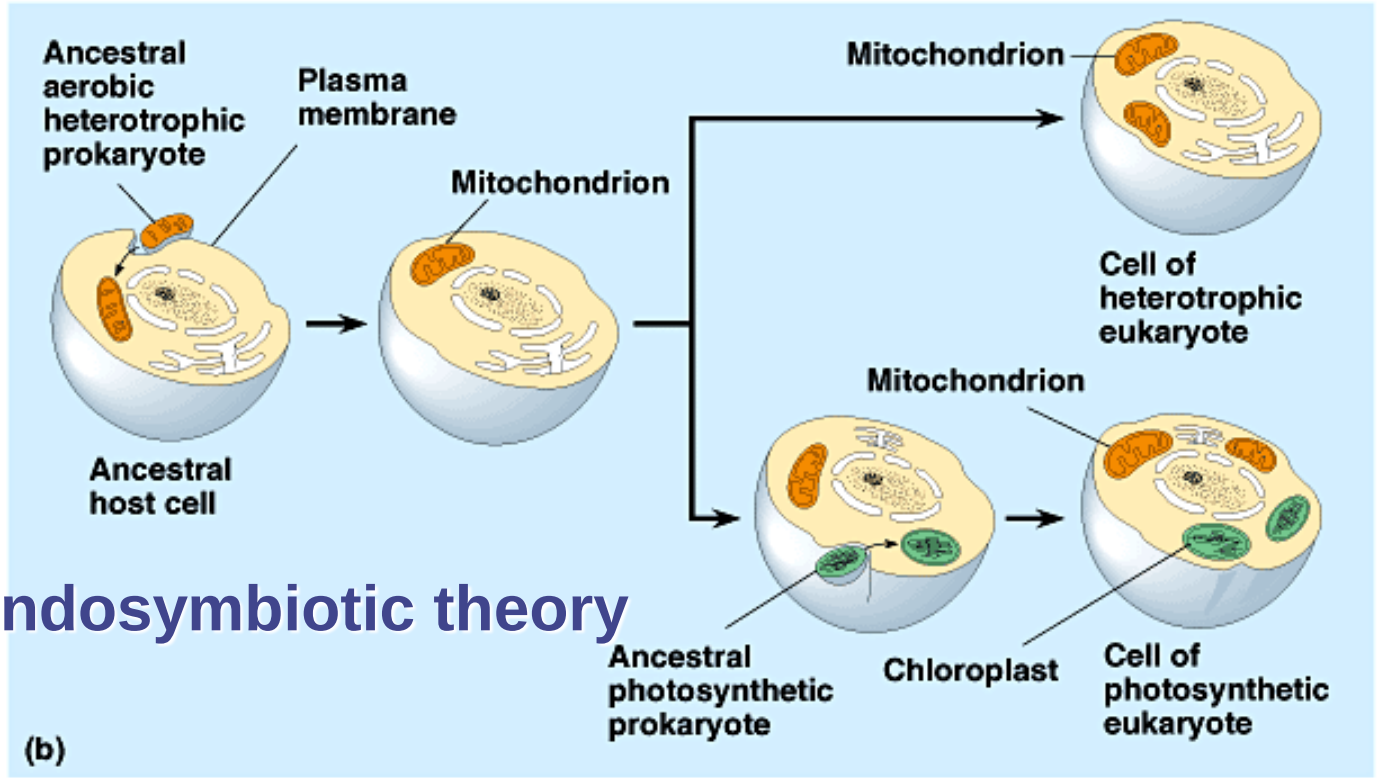
- **move freely within the cell**
- **reproduce independently from the cell through binary fission**
- **are inhibited by antibiotics**

Where Did Organelles Come From ?

- **Membranous infoldings**
  - Nucleus
  - ER
  - Golgi
  - Lysosomes
  - Vesicles
- **Endosymbiosis**
  - Mitochondria
  - Chloroplasts



Membrane infolding



Endosymbiotic theory