17-2 Earth's Early History

Formation of Earth

Hypotheses about Earth’s early history are based on a relatively small amount of evidence.

Gaps and uncertainties make it likely that scientific ideas about the origin of life will change.

Evidence shows that Earth was not “born” in a single event.

Pieces of cosmic debris were probably attracted to one another over the course of 100 million years.

While Earth was young, it was struck by one or more objects, producing enough heat to melt the entire globe.

Once Earth melted, its elements rearranged themselves according to density.

The most dense elements formed the planet’s core.

Moderately dense elements floated to the surface, cooled, and formed a solid crust.

The least dense elements formed the first atmosphere.

What substances made up Earth's early atmosphere?

Earth's early atmosphere probably contained hydrogen cyanide, carbon dioxide, carbon monoxide, nitrogen, hydrogen sulfide, and water.

Scientists infer that about four billion years ago, Earth cooled and solid rocks formed on its surface.

Millions of years later, volcanic activity shook Earth’s crust.

About 3.8 billion years ago, Earth’s surface cooled enough for water to remain a liquid, and oceans covered much of the surface.

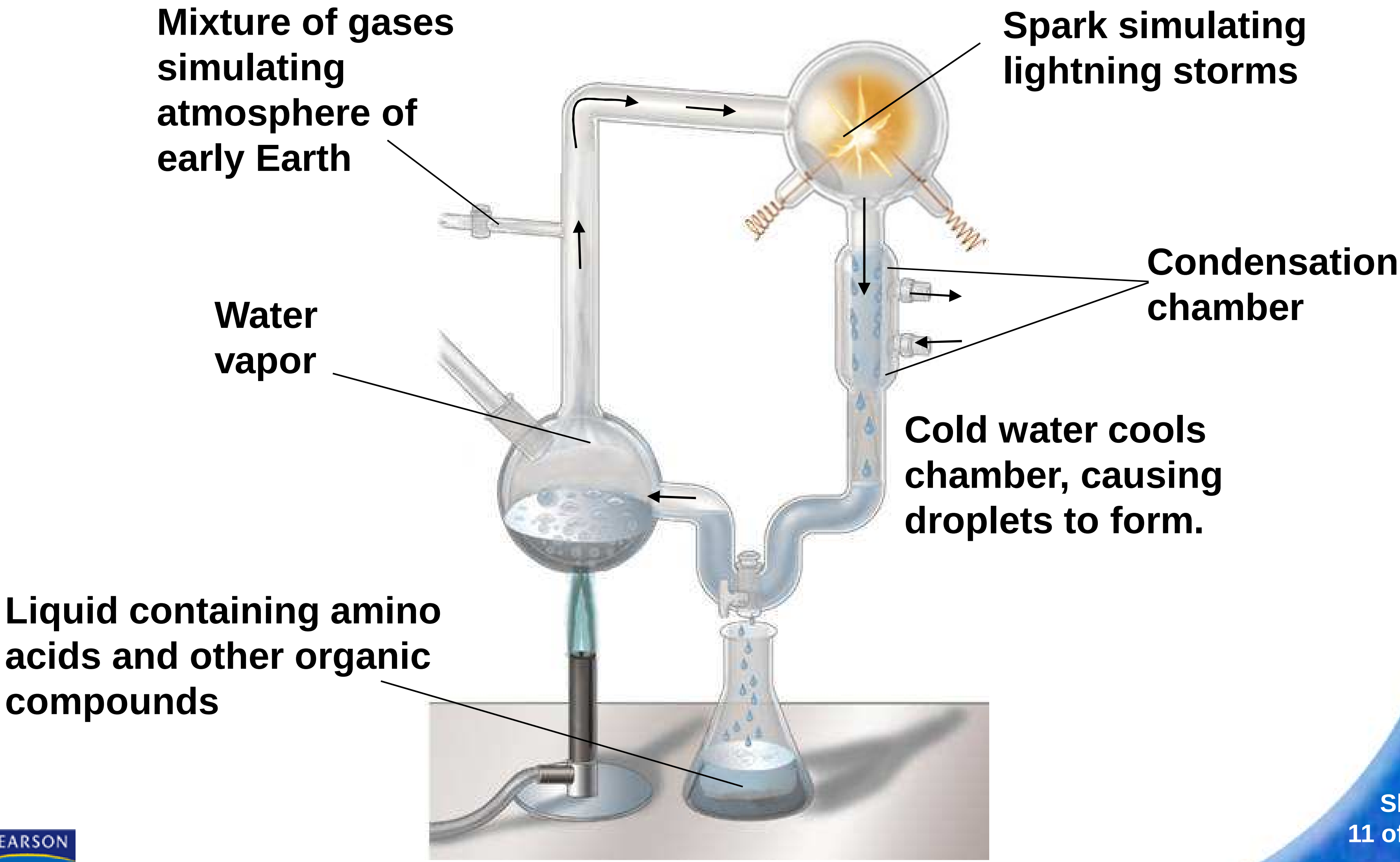
The First Organic Molecules

Could organic molecules have evolved under conditions on early Earth?

In the 1950s, Stanley Miller and Harold Urey tried to answer that question by simulating conditions on the early Earth in a laboratory setting.

What did Miller and Urey's experiments show?

Miller and Urey's Experiment



Miller and Urey's experiments suggested how mixtures of the organic compounds necessary for life could have arisen from simpler compounds present on a primitive Earth.

Although their simulations of early Earth were not accurate, experiments with current knowledge yielded similar results.

The Puzzle of Life's Origins

Evidence suggests that 200–300 million years after Earth had liquid water, cells similar to modern bacteria were common.

Formation of Microspheres

In certain conditions, large organic molecules form tiny bubbles called **proteinoid microspheres**.

Microspheres are not cells, but they have selectively permeable membranes and can store and release energy.

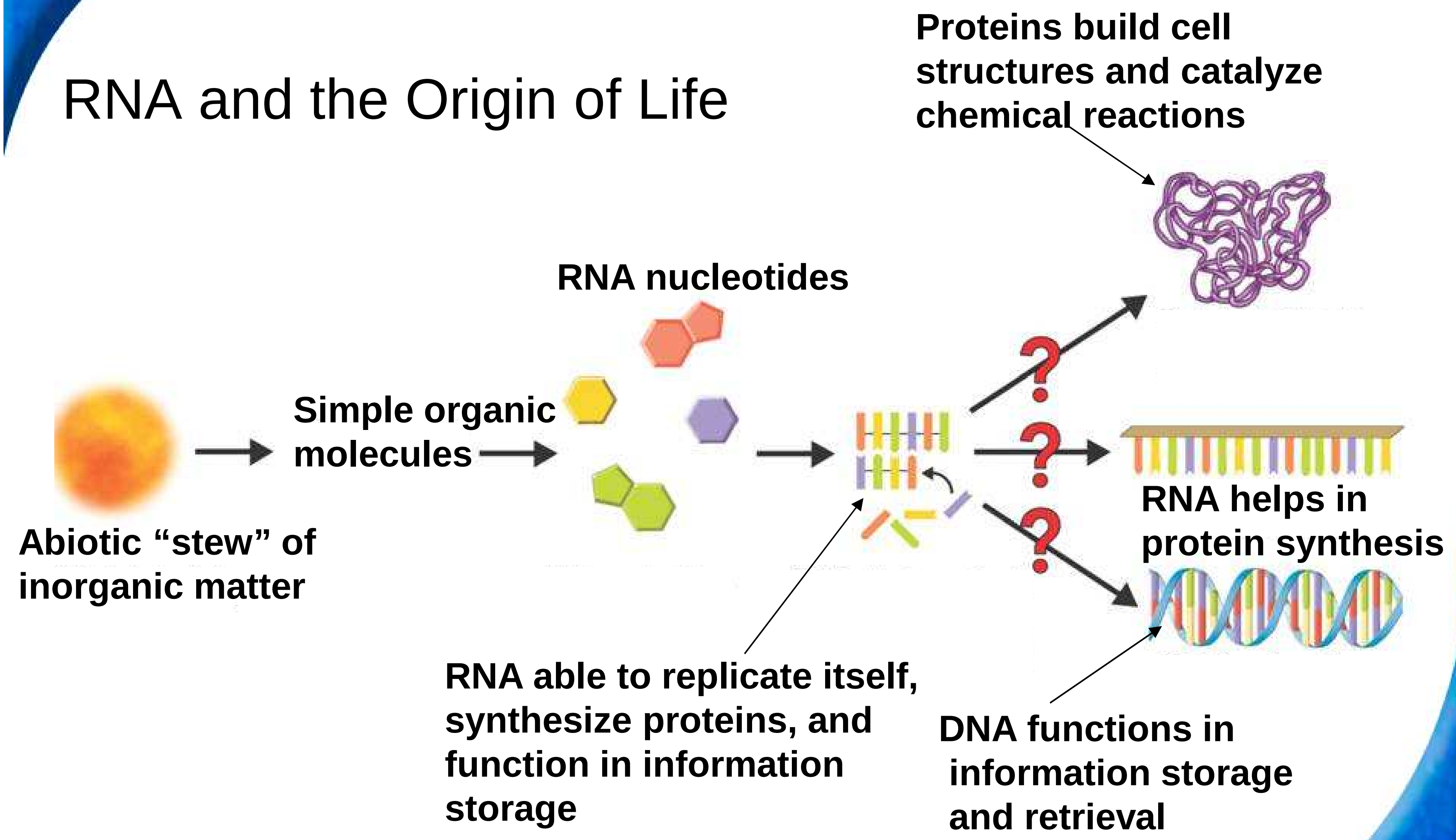
Hypotheses suggest that structures similar to microspheres might have acquired more characteristics of living cells.

Evolution of RNA and DNA

How could DNA and RNA have evolved? Several hypotheses suggest:

- Some RNA sequences can help DNA replicate under the right conditions.
- Some RNA molecules can even grow and duplicate themselves suggesting RNA might have existed before DNA.

RNA and the Origin of Life



Free Oxygen

Microscopic fossils, or **microfossils**, of unicellular prokaryotic organisms resembling modern bacteria have been found in rocks over 3.5 billion years old.

These first life-forms evolved without oxygen.

About 2.2 billion years ago, photosynthetic bacteria began to pump oxygen into the oceans.

Next, oxygen gas accumulated in the atmosphere.

What occurred when oxygen was added to Earth's atmosphere?

The rise of oxygen in the atmosphere drove some life forms to extinction, while other life forms evolved new, more efficient metabolic pathways that used oxygen for respiration.

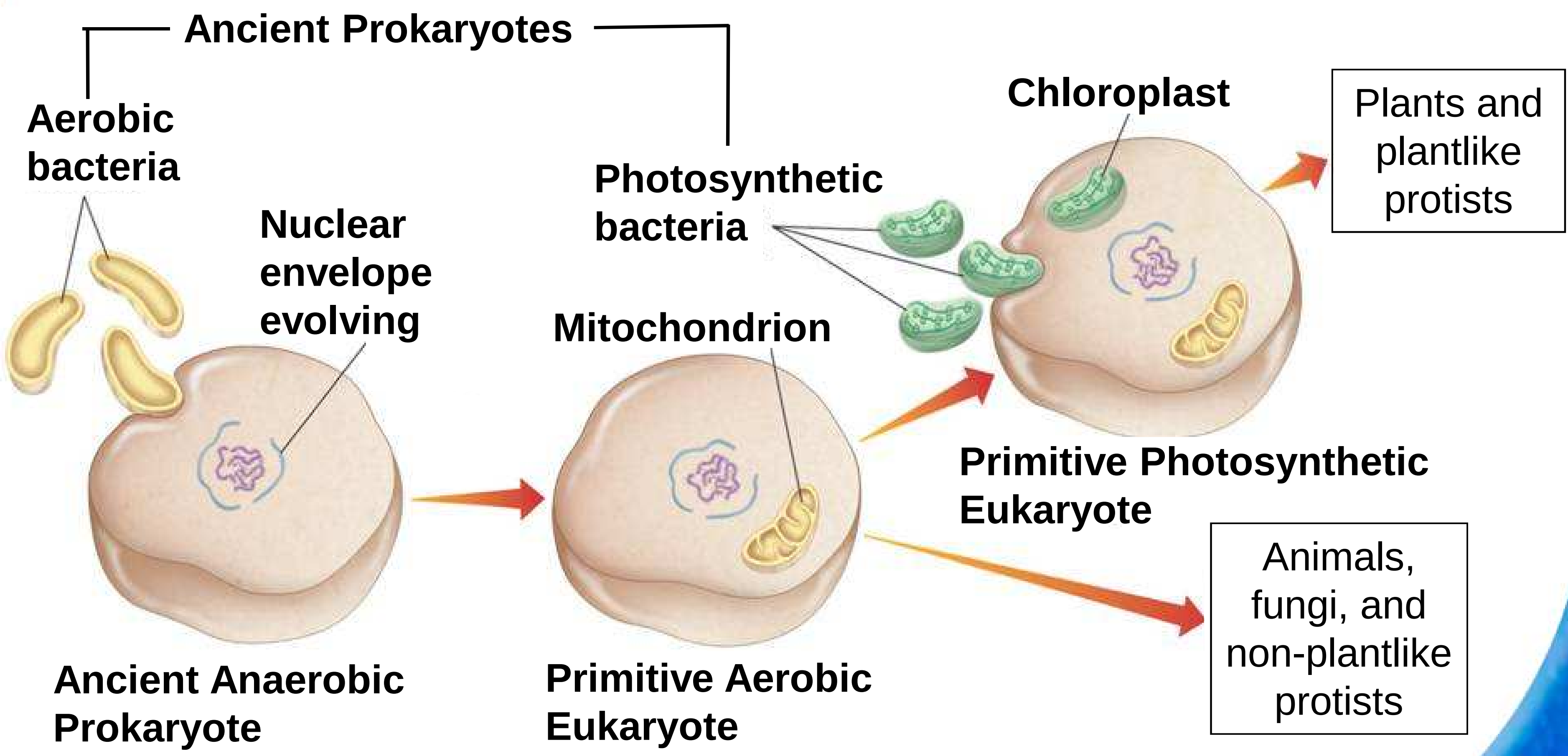
Origin of Eukaryotic Cells

What hypothesis explains the origin of eukaryotic cells?

The Endosymbiotic Theory

The endosymbiotic theory proposes that eukaryotic cells arose from living communities formed by prokaryotic organisms.

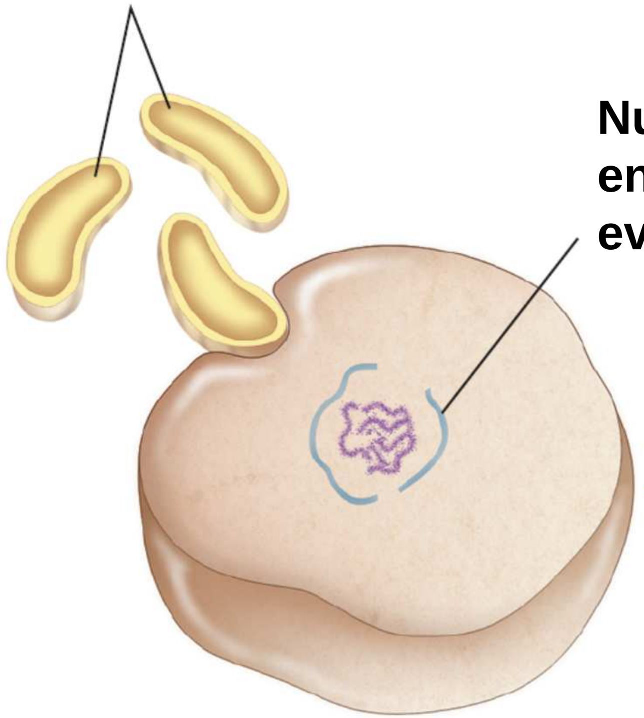
Endosymbiotic Theory



About 2 billion years ago, prokaryotic cells began evolving internal cell membranes.

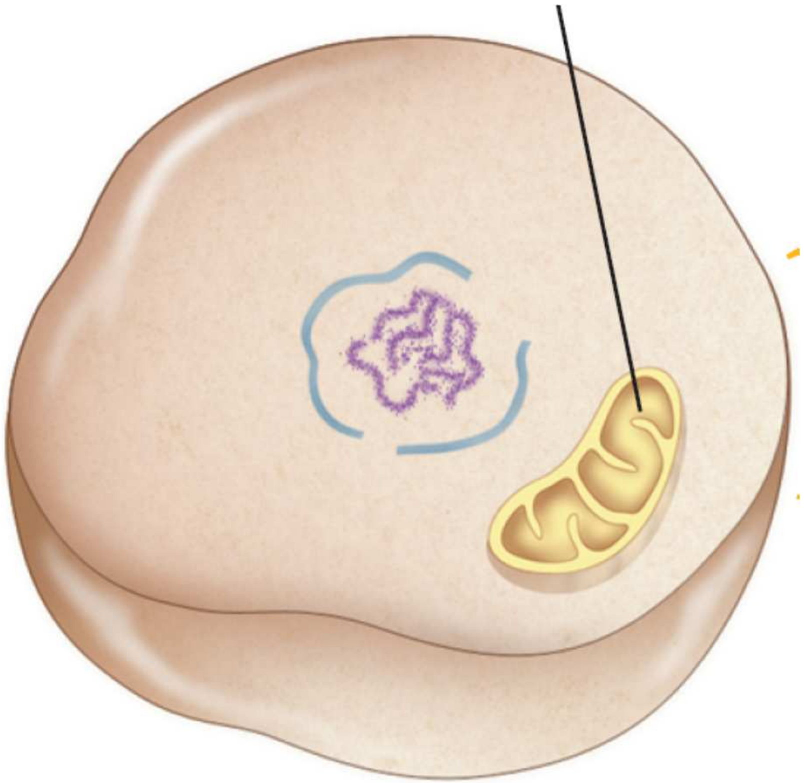
The result was the ancestor of all eukaryotic cells.

According to the endosymbiotic theory, eukaryotic cells formed from a symbiosis among several different prokaryotes.



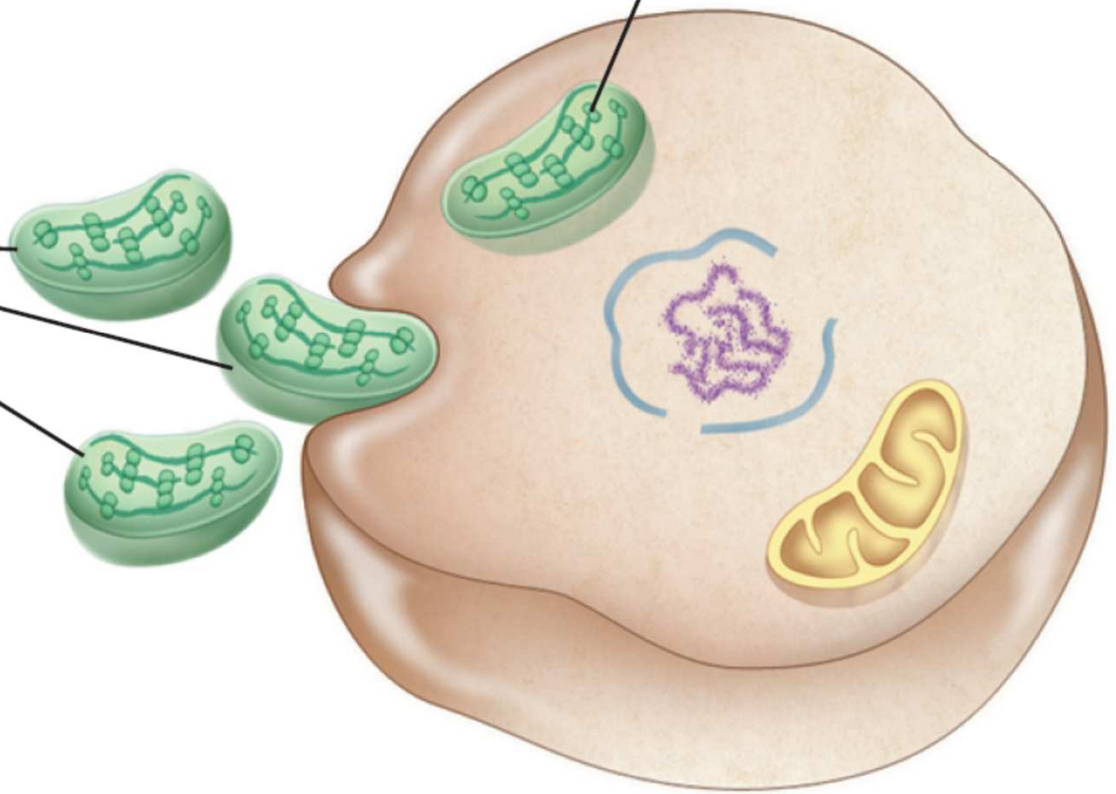
Ancient Anaerobic Prokaryote

Prokaryotes that use oxygen to generate energy-rich molecules of ATP evolved into mitochondria.



Primitive Aerobic Eukaryote

Prokaryotes that carried out photosynthesis evolved into chloroplasts.



Primitive Photosynthetic Eukaryote

Sexual Reproduction and Multicellularity

Most prokaryotes reproduce asexually. Asexual reproduction:

- yields daughter cells that are exact copies of the parent cell.
- restricts genetic variation to mutations in DNA.

Sexual reproduction shuffles genes in each generation. In sexual reproduction:

- offspring never resemble parents exactly
- there is an increased probability that favorable combinations will be produced
- there is an increased chance of evolutionary change due to natural selection