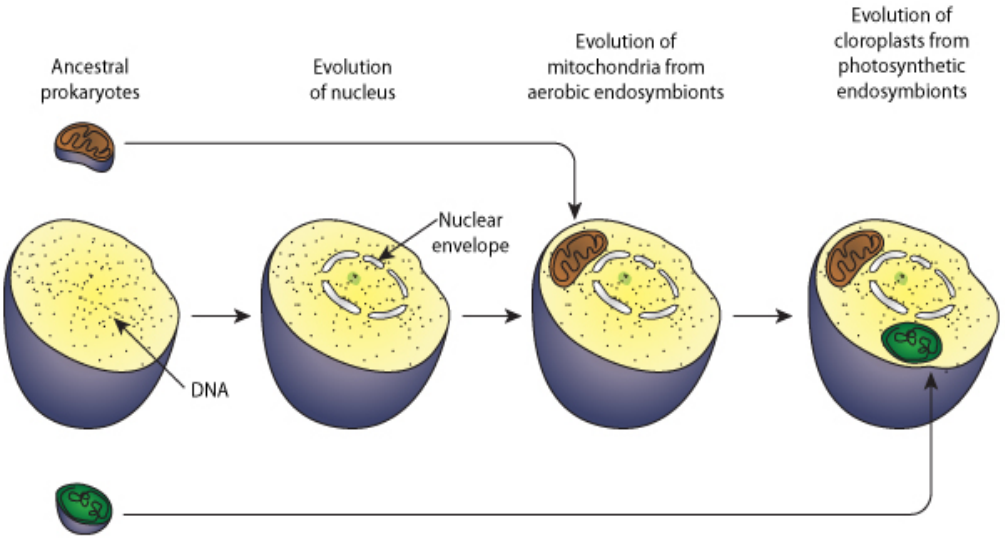
Name: _____ Date: _____ Group: _____

Endosymbiotic Theory

(Lexile 990L)



1 Geologists have found rocks containing fossil evidence of cellular organisms that lived on the Earth approximately 3.5 billion years ago. The fossils show that the early cells resembled modern prokaryotes. Prokaryotes have a cell wall, a cell membrane, and a fluid interior containing deoxyribonucleic acid (DNA) and other organic molecules. Some of the ancient cellular organisms are thought to have obtained nutrients by consuming organic compounds in the environment. Others are thought to have obtained nutrients through chemosynthesis: the synthesis of organic compounds from inorganic molecules such as methane, ammonia, and carbon dioxide.

2 The first photosynthetic organisms, ancestors of the modern cyanobacteria, appear in the fossil record about a billion years after the first cellular organisms appeared. Cyanobacteria are bacteria that perform photosynthesis, a series of chemical reactions that utilizes energy from the sun to synthesize nutrients, in the form of glucose, from water and carbon dioxide. Molecular oxygen is a byproduct of photosynthesis. The proliferation of photosynthetic organisms in the fossil record suggests that the ability to perform photosynthesis was a great advantage, because sunlight, water, and carbon dioxide were abundant and easy to obtain. Geological, isotopic, and chemical evidence suggests that as the photosynthetic organisms became more and more abundant, they produced more and more oxygen, which began to accumulate in the atmosphere about 200 million years after the first photosynthetic organisms appeared. The accumulation of oxygen changed the nature of the atmosphere from a reducing atmosphere to the oxidizing atmosphere that exists on Earth today. The oxidizing atmosphere was toxic to many organisms. Organisms that were not wiped out by the oxidizing atmosphere began to use the oxygen for metabolic processes (e.g. cellular respiration) that increased their metabolic efficiency.

3 The fossil record indicates a dramatic change approximately two billion years ago, nearly 1.5 billion years after the first cells appeared in the fossil record. The diversity of prokaryotes increased greatly and the first eukaryotes appeared. The eukaryotes differed from the prokaryotes, because the eukaryotes had internal membranes.

4 Unlike prokaryotic cells, eukaryotic cells enclose their DNA within a membrane-bound nucleus. Prokaryotic cells do not have a nucleus or other membrane-bound organelles. Modern eukaryotic cells have other membrane-bound organelles, including the endoplasmic reticulum, Golgi body, and vacuoles, which form an interconnected endomembrane system. Each membrane has structural and functional specializations that help the organelle perform its functions. Each organelle in the endomembrane system is enclosed within a single-layered membrane. Mitochondria and chloroplasts, however, differ from the organelles of the endomembrane system, because they have a double-layered membrane.

3. The endosymbiotic theory states that eukaryotic cells originated from endosymbyotic interactions among prokaryotic cells. Endosymbiosis is an interaction where one organism lives inside the body of another organism, and both organisms benefit from the relationship. The endosymbiotic theory got its start more than 100 years ago, in the late 1800s. Scientists observed that the membranes of mitochondria and chloroplasts are similar to those of prokaryotes. The scientists hypothesized that the ancestors of the eukaryotes ingested smaller prokaryotes for food. Some of the smaller prokaryotes survived being eaten, however, and began living inside the larger cells. Some of the ingested prokaryotes were able to use oxygen to produce chemical energy via respiration. If a larger cell ingested a smaller cell that could perform respiration, the larger cell could benefit from the energy that the smaller cell produced. If the smaller cell could survive inside the cytoplasm of the larger cell, it would be protected from the external environment. The endosymbiotic theory states that mitochondria were once free-living prokaryotes that could perform respiration; they were ingested by larger cells and survived inside the cytoplasm, providing energy to the larger cells through respiration. Similarly, the endosymbiotic theory states that chloroplasts were once free-living prokaryotes that could perform photosynthesis; they were ingested by larger cells and survived inside the cytoplasm, providing food in the form of glucose to the larger cells through photosynthesis. Not much attention was paid to the endosymbiotic theory until Lynn Margulis published a book entitled *Origin of Eukaryotic Cells* in 1971.

4. Margulis argued for the endosymbiotic theory using observational and experimental evidence. She showed that some present-day prokaryotes are similar in size and appearance to mitochondria and chloroplasts. Experimental evidence revealed that chloroplasts and mitochondria both contain ribosomes. The ribosomes within mitochondria and chloroplasts are more similar to those of prokaryotes than they are to those of eukaryotes. Mitochondria and chloroplasts contain their own DNA, which is similar to that of prokaryotes. Mitochondrial replication and chloroplast replication are similar to prokaryotic binary fission, and their enzymes also resemble those of prokaryotes. Overall, there is a considerable amount of evidence supporting the endosymbiotic theory.

1 A process by which organisms create carbohydrates from sunlight, carbon dioxide, and water is called -

A photosynthesis.

B biogenesis.

C chemosynthesis.

D metamorphosis.

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2 Why did cyanobacteria gain an advantage over their chemosynthetic competitors?

A Chemosynthetic bacteria are too large and unable to diffuse organic compounds across their membranes.

B Cyanobacteria rely on ammonia and methane for photosynthesis.

C Chemosynthetic bacteria require oxygen for survival.

D Cyanobacteria are able to produce glucose using abundant and easily obtained materials.

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3 Which type of cell does not contain membrane-bound organelles?

A Animal cells

B Prokaryotic cells

C Eukaryotic cells

D Plant cells

4 Which of the following characteristics make mitochondria and chloroplasts different from other organelles?

A They are part of the endomembrane system.

B They are found in both prokaryotic and eukaryotic cells.

C They have a double-layered membrane.

D None of the above

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5 The endosymbiotic theory states that early eukaryotic cells ingested prokaryotic cells called endosymbionts. This lead to a symbiotic relationship between the larger and smaller cells. Endosymbiotic relationships may have led to mitochondria and chloroplasts. Which of the following statements is NOT true of mitochondria?

A They replicate by binary fission.

B They are independent and can survive on their own.

C They have their own unique DNA.

D They have ribosomes similar to other prokaryotes.

6 Which of the following is evidence to support the endosymbiotic theory?

A Prokaryotes have the same numbers and types of enzymes as eukaryotes.

B Mitochondria and chloroplasts have their own DNA, which is similar to prokaryotic DNA.

C All eukaryotic cells have a double-layered membrane composed of phospholipids and proteins.

D Fossil evidence shows that the first forms of life were prokaryotic cells.