Name Date Class

Section 14.2

The Origin of Life

SC.D.1.4.3 The student knows that changes in Earth's climate, geological activity, and life forms may be traced and compared. SC.D.1.4.4 The student knows that Earth's systems and organisms are the result of a long, continuous change over time.

Before You Read

In this section, you will explore hypotheses that scientists have developed to explain how life on Earth began. Scientists develop experiments that help them test hypotheses. On the lines below, list something in biology that you would like to learn more about. Then write a sentence explaining an experiment that you could use to learn more about the topic.

Read to Learn

STUDY COACH

Mark the Text **Identify Key People** Underline the name of each scientist introduced in this section. Say the name aloud. Then highlight the sentence that explains the main contribution the person made to understanding the origin of life.

Reading Check

1. What did Francesco Redi's experiment prove?

Origins: The Early Ideas

Before the invention of microscopes and modern scientific equipment, ideas about the origin of life came from what people saw in the world they lived in. When people noticed maggots on meat, it was easy to assume that the maggots came from the meat. Likewise, when people found baby mice in sacks of grain, they thought that the grain produced the mice. These types of observations led people to believe in spontaneous generation. **Spontaneous generation** is the idea that something that is not alive can produce living things.

How was spontaneous generation disproved?

An experiment, performed in 1668, showed that maggots were not produced by decaying meat. An Italian doctor, Francesco Redi, put meat into different jars. He covered some of the jars, and left the other jars open. Flies buzzed around the tops of the covered jars but could not get to the meat. However, the meat in the open jars attracted many flies. Maggots were soon growing in those jars. The maggots developed into flies. No maggots or flies appeared in the covered jars. It was easy to conclude from this experiment that maggots do not come from spontaneous generation. Flies produce maggots, which become flies.

What did Pasteur's experiments prove?

With the development of the microscope, scientists could see that microorganisms live everywhere. They wondered if microorganisms came from the air. Was there some vital force in the air that caused microorganisms to arise spontaneously?

This was a more difficult idea to prove false. However, in the mid-1880s, Louis Pasteur designed an experiment that disproved the spontaneous generation of microorganisms.

Pasteur used a specially designed glass bottle that allowed air to enter the bottle, but kept microorganisms out. There was a broth with nutrients in the bottle. As long as Pasteur kept the microorganisms out, the broth remained clear.

Pasteur's experiment showed that microorganisms come from other microorganisms. This led to the concept of **biogenesis** (bi oh JEN uh sus), the idea that living things come only from other living things.

Origins: The Modern Ideas

For more than 100 years biologists have accepted the idea of biogenesis. But that still does not answer the question: How did life begin on Earth? There are many theories, none of which have been proven scientifically. Scientists continue to look into theories and test hypotheses about what conditions existed on early Earth.

How did simple organic molecules form?

Scientists hypothesize that two things happened before life could appear on Earth. The first is that there had to be organic molecules—molecules containing carbon. The second is that the organic molecules must have formed into more complex molecules such as proteins, carbohydrates, and nucleic acids. These are the materials that are absolutely necessary for life.

Scientists think that the early atmosphere of Earth did not contain any free oxygen. Instead, the atmosphere was made of water vapor, carbon dioxide, nitrogen, methane, and ammonia. How did this mixture combine and form the organic molecules that are found in all living things today?

In the 1930s, a Russian scientist named Alexander Oparin suggested that lightning striking Earth, heat from the sun, and Earth's own heat started chemical reactions using substances in Earth's atmosphere. The chemical reactions made small organic molecules that ended up in the ocean when it rained. This turned the ocean into an environment in which life could start. This hypothesis is illustrated in the figure at the top of page 160.

How was Oparin's hypothesis tested?

In 1953, two American scientists, Stanley Miller and Harold Urey, tested Oparin's hypothesis. They mixed the elements

Think it Over

2. **Describe** How did Pasteur develop the concept of biogenesis?

Reading Check

3. What two things had to happen before life could appear on Earth?

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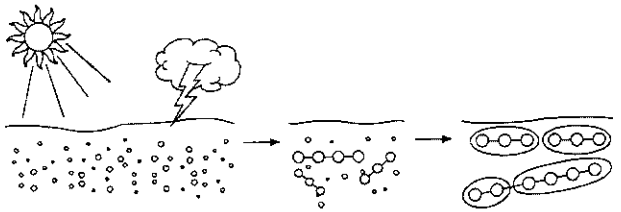

Energy from the sun and lightning strikes molecules in the sea.

Molecules combine to form simple organic molecules.

Larger molecules continue to form, making simple amino acids.

Think it Over

4. **Analyze** What happens when amino acids are heated? (Circle your choice.)
   a. They become protocells.
   b. They become proteins.
   c. They melt.

thought to be in Earth's early atmosphere—water vapor, ammonia, methane, and hydrogen gases—and added electricity. It became hot. When the mixture cooled, it contained organic molecules such as amino acids and sugars. This result provides support for Oparin's hypothesis.

Scientists then tested whether it was possible for more complex molecules to form from the organic molecules. Many experiments were performed. Scientists discovered that when amino acids are heated, they turn into proteins. Many scientists were convinced that complex organic molecules had formed in small pools of warm water on Earth.

What is a protocell?

In 1992, Sidney Fox caused complex molecules to turn into protocells. A **protocell** is a large, organized structure, surrounded by a membrane. It is able to grow and divide. Growth and division are considered life activities.

The Evolution of Cells

In an earlier chapter you learned that prokaryotes are one-celled organisms that do not have internal membrane-bound structures. The first life-forms may have been prokaryotes that evolved from protocells. There was no oxygen available in the atmosphere at this time. So the first life-forms were able to survive without it. That means they were anaerobic. They probably were not able to make their own food but survived on the organic material in the ocean. Gradually they changed into organisms similar to present-day archaebacteria, which do make their own food. **Archaebacteria** (ar kee bac TEER ee uh) live in harsh environments such as

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deep-sea vents or hot springs. They make their food by chemosynthesis. In chemosynthesis, organisms turn compounds, such as sulfur compounds, into food.

What changes did photosynthesis cause?

The next organisms to develop may have been prokaryotes that could undergo photosynthesis. Photosynthesis releases oxygen. Oxygen began to enter the atmosphere. Organisms that use oxygen began to develop. The fossil record shows that 2.8 billion years ago there was an increase in the variety of prokaryotes.

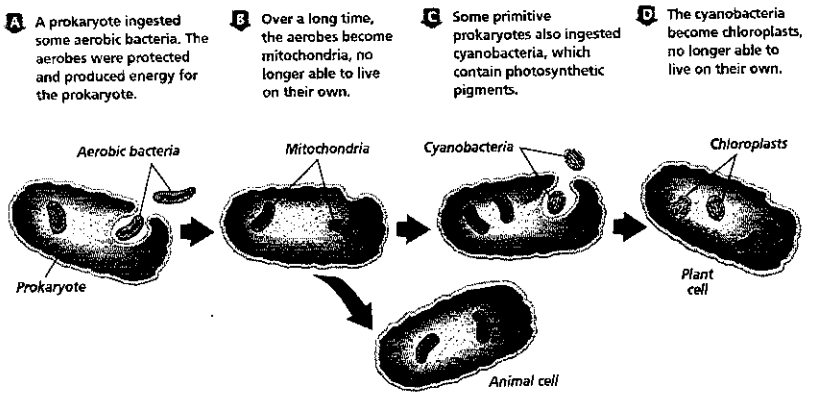
Oxygen in the atmosphere had another effect. The sun's rays converted the oxygen to ozone molecules. This ozone layer shielded organisms from harmful ultraviolet radiation. That made it possible for even more complex organisms to evolve.

Reading Check

5. What were two results of oxygen in the atmosphere?

What new organisms evolved?

The more complex organism that evolved was a eukaryote. A scientist named Lynn Margulis has a theory about how eukaryotic cells may have evolved. According to this theory, prokaryotes may have consumed bacteria. Some of these bacteria evolved into mitochondria, which released energy for the cell. Other types evolved into chloroplasts. Present day mitochondria and chloroplasts share similarities with bacteria. The DNA of chloroplasts and mitochondria resembles the DNA of prokaryotes instead of eukaryotes. The figure below illustrates this process.



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After You Read

Mini Glossary

archaebacteria (ar kee bac TEER ee uh): chemosynthetic prokaryotes that live in deep sea vents and hot springs

biogenesis (bi oh JEN uh sus): idea that living things come only from other living things

protocell: large, ordered structure, enclosed by a membrane that carries out some life activities, such as growth and division

spontaneous generation: mistaken idea that living things can arise from nonliving materials

1. Read the key terms and definitions in the Mini Glossary above. Highlight the two key terms that describe ideas about the origin of living things. On the lines below, explain which idea came first and why it was replaced by the other idea.

2. Place the following events in the order in which they occurred on the vertical time line. The first event and the last event have already been entered on the time line.

Ozone layer develops
Protocells develop
Organisms use photosynthesis
Complex organic molecules form
Prokaryotes appear
Organisms use chemosynthesis

Oceans contain organic molecules

Eukaryotes develop

3. Select one of the time line events. On a separate sheet of paper, write three sentences explaining the importance of this event.

Visit the Glencoe Science Web site at **science.glencoe.com** to find your biology book and learn more about the origin of life.