The Origin of Life

Reading Preview

Key Concepts

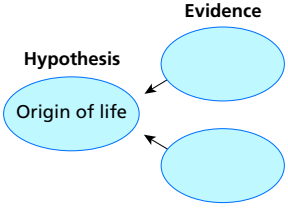
- How was the atmosphere of early Earth different from today's atmosphere?
- How do scientists hypothesize that life arose on early Earth?

Key Term

- fossil

Target Reading Skill

Identifying Supporting Evidence As you read, identify the evidence that supports scientists' hypothesis of how life arose on Earth. Write the evidence in a graphic organizer like the one below.



Lab zone Discover Activity

How Can the Composition of Air Change?

1. Your teacher will give you two covered plastic jars. One contains a plant, and one contains an animal.
2. Observe the organisms in each jar. Talk with a partner about how you think each organism affects the composition of the air in its jar.
3. Predict how the amount of oxygen in each jar would change over time if left undisturbed.
4. Return the jars to your teacher.

Think It Over

Inferring Scientists hypothesize that Earth's early atmosphere was different from today's atmosphere. What role might early organisms have played in bringing about those changes?

You stare out the window of your time machine. You have traveled more than 3.5 billion years back in time, to an early point in Earth's history. The landscape is unfamiliar—rugged, with bare, jagged rocks and little soil. You search for a hint of green, but there is none. You see only blacks, browns, and grays. Lightning flashes all around you. You hear the rumble of thunder, howling winds, and waves pounding the shore.

You neither see nor hear any living things. However, you know that this is the time period when scientists hypothesize that early life forms arose on Earth. You decide to explore. To be safe, you put on your oxygen mask. Stepping outside, you wonder what kinds of organisms could ever live in such a place.

The Atmosphere of Early Earth

You were smart to put on your oxygen mask before exploring early Earth! You would not have been able to breathe because there was little oxygen in the air. Scientists think that conditions on early Earth were very different than they are today. **On ancient Earth, nitrogen, water vapor, carbon dioxide, and methane were probably the most abundant gases in the atmosphere.** In contrast, the major gases in the atmosphere today are nitrogen and oxygen.

Life on Early Earth Evidence suggests that the earliest forms of life appeared on Earth some time between 3.5 and 4.0 billion years ago. Because there was no oxygen, you, like most of today's organisms, could not have lived on Earth back then.

No one can ever be sure what the first life forms were like, but scientists have formed hypotheses about them. First, early life forms did not need oxygen to survive. Second, they were probably unicellular organisms. Third, they probably lived in the oceans. The first organisms probably resembled the archaea that live today in extreme environments, such as in polar ice caps, hot springs, and the mud of ocean bottoms.

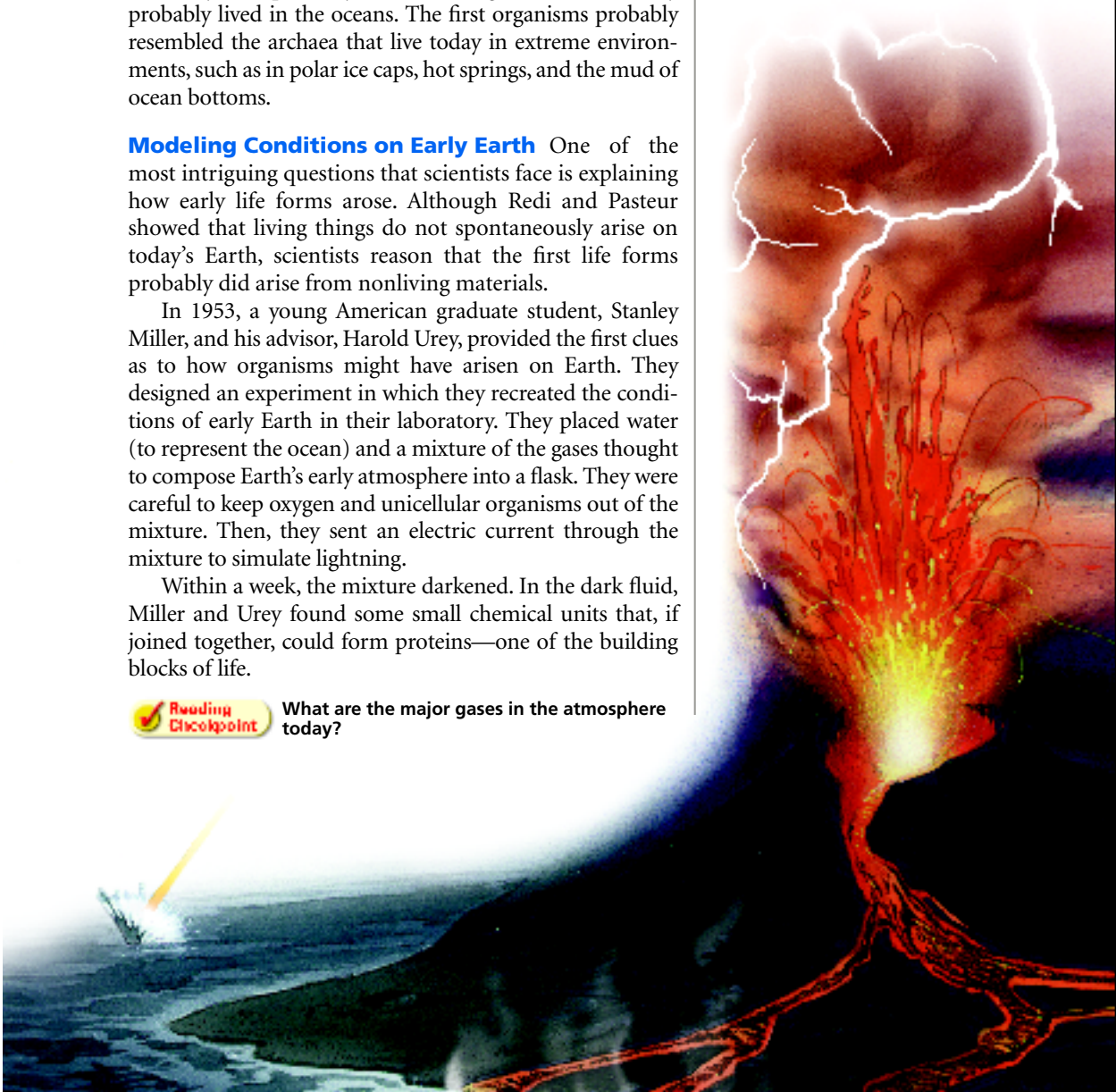
Modeling Conditions on Early Earth One of the most intriguing questions that scientists face is explaining how early life forms arose. Although Redi and Pasteur showed that living things do not spontaneously arise on today's Earth, scientists reason that the first life forms probably did arise from nonliving materials.

In 1953, a young American graduate student, Stanley Miller, and his advisor, Harold Urey, provided the first clues as to how organisms might have arisen on Earth. They designed an experiment in which they recreated the conditions of early Earth in their laboratory. They placed water (to represent the ocean) and a mixture of the gases thought to compose Earth's early atmosphere into a flask. They were careful to keep oxygen and unicellular organisms out of the mixture. Then, they sent an electric current through the mixture to simulate lightning.

Within a week, the mixture darkened. In the dark fluid, Miller and Urey found some small chemical units that, if joined together, could form proteins—one of the building blocks of life.

Reading Checkpoint **What are the major gases in the atmosphere today?**

FIGURE 21
Early Earth
The atmosphere of early Earth had little oxygen. There were frequent volcanic eruptions, earthquakes, and violent storms. **Inferring** *Could modern organisms have survived on ancient Earth? Why or why not?*



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The First Cells

In experiments similar to Miller and Urey's, other scientists succeeded in producing chemical units that make up carbohydrates and nucleic acids. The experimental results led scientists to formulate a hypothesis about how life arose on Earth.

Scientists hypothesize that the small chemical units of life formed gradually over millions of years in Earth's waters. Some of these chemical units joined to form the large chemical building blocks found in cells. Eventually, some of these large chemicals joined together and became the forerunners of the first cells.

Support From Fossil Evidence This hypothesis is consistent with fossil evidence. A **fossil** is a trace of an ancient organism that has been preserved in rock or another substance. Scientists have discovered fossils of what appear to have been archaea-like organisms. These ancient fossils have been dated to be between 3.4 and 3.5 billion years old. Therefore, these fossils support the idea that cells may have existed back then.

The first cells could not have needed oxygen to survive. They were probably heterotrophs that used the chemicals in their surroundings for energy. As the cells grew and reproduced, their numbers increased. In turn, the amount of chemicals available to them decreased.

At some point much later, some of the cells may have developed the ability to make their own food. These early ancestors of today's autotrophs had an important effect on the atmosphere. As they made their own food, they produced oxygen as a waste product. As the autotrophs thrived, oxygen accumulated in Earth's atmosphere. Over hundreds of millions of years, the amount of oxygen increased to its current level.

Reading Checkpoint **What is a fossil?**

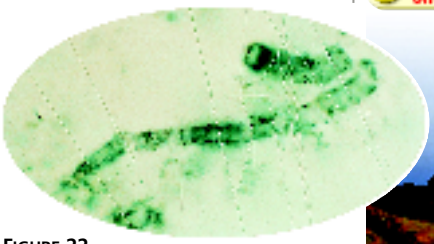

FIGURE 22
Fossil Evidence
These cell-like fossils were found in the rugged terrain of western Australia. They are the oldest fossils known—about 3.5 billion years old.

FIGURE 23
Unanswered Questions
Scientists continue to search for clues about the origin of life.
Applying Concepts *What kind of evidence might be found in rocks?*

Unanswered Questions Many scientists today continue to explore the question of how and where life first arose on Earth. Laboratory experiments, like those by Miller and Urey, can never prove how life first appeared on Earth. Such experiments can only test hypotheses about how life forms could have arisen. No one will ever know for certain how and when life first appeared on Earth. However, scientists will continue to ask questions, test their models, and look for experimental and fossil evidence about the origin of life on Earth.

Section 4 Assessment

Target Reading Skill **Identifying Supporting Evidence** Refer to your graphic organizer as you answer the questions below.

Reviewing Key Concepts

1. **a.** **Naming** Which gases were probably most abundant in Earth's early atmosphere?
   b. **Describing** How did Miller and Urey model the conditions in Earth's early atmosphere?
   c. **Inferring** What can be inferred from the results of Miller and Urey's experiment?
2. **a.** **Reviewing** What experiments in addition to Miller and Urey's helped scientists hypothesize about how life arose on Earth?
   b. **Sequencing** Place these events in the proper sequence according to the hypothesis about how life arose on Earth: small chemical units form, cells make their own food, the first cells form, oxygen levels increase in the atmosphere, large chemical building blocks form.
   c. **Inferring** How is the existence of organisms in hot springs today consistent with the scientific hypothesis of how life forms arose on Earth?

Writing in Science

Advertisement You are in charge of exhibits at a science museum. The museum is building an exhibit that models early Earth. Write an ad for the museum to attract visitors to see the new exhibit. Clearly describe to visitors what they will see and hear.