First Life

By Kirsten Weir

How did Earth's earliest life-forms evolve out of ancient raw materials?

Robert Hazen builds bombs. He's not a weapons manufacturer or a criminal, though. He's a scientist at the Carnegie Institution for Science in Washington, D.C.

© Amanda Lucidon/Lucid Pix
Robert Hazen looks into the pressure bomb that he uses to simulate the chemical environment that might have given rise to life on Earth.

Hazen uses small metal cylinders called pressure bombs to blast minerals with insanely high pressures and temperatures. It's all done in the hopes of answering one of the biggest questions in science: How did life begin on Earth?

Hazen's background is studying *minerals*—solid, crystalline materials that form naturally through geological processes and make up rocks. He's using that knowledge to figure out how ancient minerals might have been involved in the evolution of the first primitive life-forms.

Back-In-Time Capsule

Earth's first life-forms, says Hazen, could have arisen almost anywhere on the planet—at least any place where there is *energy.* Energy is the capacity to do work, and all living things need it to function.

Solar energy bathes Earth's surface. Chemical energy from rocks and minerals pulses beneath Earth's crust. At the bottom of the oceans, heat energy flows from *hydrothermal vents.* Hydrothermal vents are cracks in the seafloor where superheated, mineral-rich water gushes upward. The undersea hot springs are homes to bizarre life-forms that exist nowhere else.

Ralph White/Corbis
A hydrothermal vent

As an expert in minerals, Hazen is intrigued by the mineral-rich worlds around deep-sea vents. Did ancient hydrothermal vents spawn the first living things? To test that idea, he dropped the bomb.

First, he combined a few basic ingredients that were present during Earth's early days: carbon, water, and several other simple compounds. Next, he put the ingredients in a pressure bomb to recreate the conditions around hydrothermal vents. Then, he cranked up the heat to a scorching 249 degrees Celsius (480 degrees Fahrenheit) and squeezed the contents to a pressure 2,000 times greater than atmospheric pressure at sea level. "We let those high-temperature, high-pressure conditions work their magic," he says.

After a few hours, he cracked open his back-in-time capsule. Inside he found thousands of newly made compounds, including many *organic* ones. Organic compounds contain one or more carbon atoms. All life is based on them. The

most interesting organic compounds that Hazen found were simple sugars, amino acids, and lipids. Those three materials are necessary for life as we know it. “Depending on the conditions and what minerals you use,” Hazen notes, “you can make all the building blocks of life.”

Getting Together

Hazen’s research showed that the unique conditions around hydrothermal vents could have created the basic ingredients of living things. But how, in the vast ocean, did a handful of new molecules and compounds get together to form the more complex chemicals that led to life? That’s the question Hazen is working on now.

Some molecules seek one another naturally, he says. Lipids are one example. A lipid molecule is long and skinny. One end is naturally attracted to water, and the other end is repelled by it. When lipids are underwater, they bunch together to form a little ball. Their water-loving heads face outward, giving them contact with the fluid. Their water-hating tails poke into the center of the ball, away from the wet stuff. Simply because of their chemical properties, Hazen says, “they self-assemble into spherical structures that look like little cells.”

Other organic molecules like to cling to the surface of certain minerals. Life’s earliest molecules might have been attracted to rocks and minerals on the ocean floor. Once they began meeting up on those surfaces in large numbers, they could have joined together to create bigger molecules and, eventually, the first living things on the planet.

Hazen’s research doesn’t apply just to life on Earth. Scientists have found amino acids and other molecular building blocks of life inside space rocks. What happened here might be happening on moons and planets throughout the universe, he says.

Earth First

For now, Hazen is concentrating his efforts here on Earth, trying to work out how young, organic molecules might have found one another in the big, lonely ocean. In other labs across the country, scientists are looking at how those molecules might have joined together and started copying themselves.

The researchers are all inspired by a common goal. “One of the great human motivations, in science and the arts, is to understand who we are and where we came from,” Hazen says. “Studying the origin of life is part of that exploration—it’s part of what it is to be human.”

Life's Building Blocks

Robert Hazen's pressure-bomb experiments created a number of organic molecules, including simple sugars, amino acids, and lipids—the main building blocks of life. All three are found in every living organism on Earth.

- **Simple sugars** are relatively small molecules that contain carbon, hydrogen, and oxygen. *Carbohydrates* are made from simple sugars. Carbohydrates provide structure to cells and are an essential component of DNA. They also provide energy to living things.
- **Amino acids** are compounds that contain carbon, hydrogen, oxygen, and nitrogen. *Proteins* are made from amino acids. Proteins are complex substances that perform many crucial jobs in living organisms, such as transporting oxygen in the blood and controlling chemical reactions inside cells.
- **Lipids** are a group of fatty molecules that contain carbon, hydrogen, and oxygen. *Cell membranes* are made from lipids. Cell membranes are the barriers that surround living cells and *organelles,* the specialized structures inside cells.

Shutterstock

Name: _____ Date: _____

1. Why is scientist Robert Hazen using pressure bombs to blow up minerals?

A He is doing experiments to see how big of an explosion he can create.
B He is doing experiments to see how life may have begun on earth.
C He is a weapons manufacturer trying to build a better bomb.
D He is doing experiments to see how combustible minerals are.

2. Read these two sentences from the passage: "How, in the vast ocean, did a handful of new molecules and compounds get together to form the more complex chemicals that led to life? That's the question Hazen is working on now."

Which of the following describes the relationship between these two sentences?

A The sentences make a comparison.
B The sentences argue about a topic.
C The second sentence adds information to the first sentence.
D The second sentence shows the effect of the first sentence.

3. Which of the following conclusions about Robert Hazen's experiments are supported by the passage?

A His experiments have shown how life began on earth.
B His experiments haven't found out anything important.
C Scientists have decided that the best thing to do about Hazen's experiments is ignore them.
D Scientists are exploring ideas from his research in their own experiments.

4. Read this sentence: "The undersea hot springs are homes to bizarre life-forms that exist nowhere else."

In this sentence, what does **bizarre** mean?

A new
B large
C strange
D attractive

5. What is the main idea of this passage?

A Life may exist on other planets and moons.
B Blowing up minerals is a good way to learn about science.
C Robert Hazen is an important American scientist who has lived an interesting life.
D Robert Hazen's experiments may help show how life began on earth.

6. According to the passage, how might simple molecules find each other and combine to make more complex molecules?

_____

_____

_____

7. What might be some implications of Robert Hazen's experiments and research? Cite evidence from the text to support your answer.

_____

_____

_____

8. The question below is an incomplete sentence. Choose the word that best completes the sentence.

Scientists find Robert Hazen's experiments to be valuable _____ they point to signs of life that may have begun beneath the surface of the oceans.

A yet
B because
C however
D after

9. Answer the following questions based on the sentence below.

For the immediate future, scientist Robert Hazen is concentrating his efforts to work out how life might have begun.

Who? scientist Robert Hazen

(is doing) What? _____

When? _____

Why? _____

10. **Vocabulary Word**: vents: openings in a surface, often where gas or liquid comes out.

Use the vocabulary word in a sentence: _____

_____

_____