1 The Science of Biology

Science as a Way of Knowing

q: What role does science play in the study of life?

<table>
<thead>
<tr>
<th>WHAT I KNOW</th>
<th>WHAT I LEARNED</th>
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<tr>
<td><strong>1.1</strong> How do we find explanations for events in the natural world?</td>
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<td><strong>1.2</strong> How do the scientific community and society influence the process of science?</td>
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<td><strong>1.3</strong> What is biology?</td>
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1.1 What Is Science?

Lesson Objectives

- State the goals of science.
- Describe the steps used in scientific methodology.

Lesson Summary

What Science Is and Is Not

Science is an organized way of gathering and analyzing evidence about the natural world. The goals of science are to provide natural explanations for events in the natural world and to use those explanations to make useful predictions. Science is different from other human works in the following ways:

- Science deals only with the natural world.
- Scientists collect and organize information about the natural world in an orderly way.
- Scientists propose explanations that are based on evidence, not belief.
- They test those explanations with more evidence.

Scientific Methodology: The Heart of Science

Methodology for scientific investigation involves:

- Making an observation. Observation involves the act of noticing and describing events or processes in a careful, orderly way. Scientists use their observations to make inferences. An inference is a logical interpretation based on what scientists already know.

- Suggesting hypotheses. A hypothesis is a scientific explanation for a set of observations that can be tested in ways that support or reject it.

- Testing the hypothesis. Testing a hypothesis often involves designing an experiment. Whenever possible, a hypothesis should be tested by a controlled experiment—an experiment in which only one variable (the independent variable, or manipulated variable) is changed. The variable that can change in response to the independent variable is called the dependent variable, or responding variable. The control group is exposed to the same conditions as the experimental group except for one independent variable.

- Collecting, recording, and analyzing data, or information gathered during the experiment.

- Drawing conclusions based on data.

What Science Is and Is Not

1. What is science?

2. What are the goals of science?
Questions 3–10 refer to spontaneous generation, the idea that life can arise from nonliving matter. Spontaneous generation was accepted by many in the scientific community up until the mid-nineteenth century. A series of simple experiments tested the validity of this idea.

3. Evidence used to support spontaneous generation was the observation that foods over time become covered in maggots or fungal and bacterial growth. The inference behind spontaneous generation is that there is no “parent” organism. Write this inference as a hypothesis using an if–then sentence that suggests a way of testing it.

4. In 1668, Francesco Redi proposed a different hypothesis to explain the specific example of maggots that appear on spoiled food. He had observed that maggots appear on meat a few days after flies have been seen on the food. He inferred that the flies had left behind eggs too small to see. Redi’s experiment is shown below. What conclusion can you draw from Redi’s experiment?

5. In the late 1700s, Lazzaro Spallanzani designed a different experiment to show that life did not arise spontaneously from food. He inferred that some foods spoil because of growing populations of microorganisms. Fill in the information requested below.

   Independent variable: ____________________________
   Dependent variable: ____________________________
   Controlled variables (identify three): ____________________________
6. THINK VISUALLY Critics of Spallanzani said that he showed only that organisms cannot live without air. In 1859 Louis Pasteur designed an experiment to address that criticism, an experiment that reproduced Spallanzani's results.

Draw in the third and final steps in the experiment. Use an arrow to show the path of travel of the microorganisms. Shade the broth in the flask(s) in which microorganisms grew.

Boiled meat broth

Boiled meat broth

7. How did Pasteur solve Spallanzani's problem of limiting exposure to air?

8. What purpose did boiling the meat broth serve in both the Spallanzani and Pasteur experiments?

9. How do the Redi, Spallanzani, and Pasteur experiments disprove the hypothesis you wrote in Question 3?

10. Today, we use a process of heating liquids to prevent spoiling by bacteria and other microorganisms, pioneered by one of the three scientists mentioned above. What is that process called and for what food is it used?

11. What facts did Redi's, Spallanzani's, and Pasteur's experiments establish? What broader scientific understanding about life did the experiments explore? How does the example of these experiments demonstrate science as a way of knowing?
Lesson Objectives

- Explain how scientific attitudes generate new ideas.
- Describe the importance of peer review.
- Explain what a scientific theory is.
- Explain the relationship between science and society.

Lesson Summary

Scientific methodology is closely linked to exploration and discovery. Good scientists share scientific attitudes, or habits of mind, that lead them to exploration and discovery. New ideas are generated by curiosity, skepticism, open-mindedness, and creativity. Ideas for exploration can arise from practical problems. Discoveries in one field of science can lead to new technologies; the new technologies give rise to new questions for exploration.

Communication and Sharing Ideas

Sharing ideas and sharing of ideas are vital to modern science. Scientists share their findings with the scientific community by publishing articles that undergo peer review. In peer review, scientific papers are reviewed by anonymous, independent experts. Publishing peer-reviewed articles in scientific journals allows scientists to share ideas, test and evaluate each other's work.

Once research has been published, it enters the dynamic marketplace of scientific ideas. New ideas fit into scientific understanding by leading to new hypotheses that must be independently confirmed by controlled experiments.

In science, the word theory applies to a well-tested explanation that unifies a broad range of observations and hypotheses and that enables scientists to make accurate predictions about new situations.

- No theory is considered absolute truth.
- Science is always changing; as new evidence is uncovered, a theory may be reviewed or replaced by a more useful explanation.

Science and Society

Using science involves understanding its context in society and its limitations. Understanding science helps people make decisions that also involve cultural customs, values, and ethical standards.

- can help people predict the consequences of their actions and plan the future. Scientists strive to be objective, but when science is applied in society, it can be affected by bias, a point of view that is personal rather than scientific.
1. Describe how new ideas are generated.

2. How are science and technology related?

3. It took hundreds of years of discussion and the experiments of Louis Pasteur in the nineteenth century for the larger scientific community to accept that spontaneous generation of life was not a valid scientific concept. Referring to the diagram, describe how modern methods of communication have changed the scientific process.

4. THINK VISUALLY! Use lesson concepts to complete the diagram to show the outcome of communication among scientists. Why are “New Ideas” placed at the center of the diagram?

5. Of the four types of communication you added, identify the one that is critical to ensuring communication among the scientific community.
6. A typical dictionary will have different definitions for the word *theory*. It will include a definition that describes how scientists use the term, but it will also define *theory* as speculation, or an assumption, or a belief. Are these common definitions of *theory* synonyms (words similar in meaning) or antonyms (words opposite in meaning) to the definition of a scientific theory? Explain your thinking.

For Questions 7–11, identify whether each statement is a hypothesis or a theory. For a hypothesis, write an “H” on the line. For a theory, write a “T.”

- 7. The rate that grass grows is related to the amount of light it receives.
- 8. All life is related and descended from a common ancestor.
- 9. The universe began about 15 billion years ago.
- 10. New tennis balls bounce higher than old tennis balls.
- 11. Caffeine raises blood pressure.

12. How can bias affect the application of science in society? What role does a good understanding of science play in this phenomenon?

Apply the Big idea

13. What is it about science, as a way of knowing, that makes it self-correcting?
10. Biology is made up of many overlapping fields, each of which uses different tools to gather information about living things. Fill out the table below with information about two fields of biology—one that appeals to you, and one that does not. Include a description of each field and the tools scientists in the field use, as well as your impressions of each.

<table>
<thead>
<tr>
<th>Field Description</th>
<th>Why It Does or Does Not Appeal to Me</th>
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11. Describe the system of measurement most scientists use when collecting data and doing experiments.

12. Why do scientists need a common system of measurement?

13. What is the most important safety rule for you to follow in the laboratory?

14. Your teacher is doing a long-term experiment by having you and your classmates grow plants at home. You are testing the hypothesis that plant growth is affected by the amount of water a plant receives. All the data will be compiled in three weeks. Why isn’t it a good idea to use the 8-ounce measuring cup from your kitchen or the 12-inch ruler you have on your desk?
Chapter Vocabulary Review

For Questions 1–8, complete each statement by writing the correct word.

1. The act of noticing and describing events or processes in a careful, orderly way is called _____________.

2. The information gathered during an experiment is called _____________.

3. A(n) ____________ is a logical interpretation based on what scientists already know.

4. A(n) ____________ is a scientific explanation for a set of observations that can be tested in ways that support or reject it.

5. A(n) ____________ is a well-tested explanation that unifies a broad range of observations and hypotheses.

6. In ____________ reproduction, the new organism has a single parent.

7. A(n) ____________ is a signal to which an organism responds.

8. ____________ is an organized way of gathering and analyzing evidence about the natural world.

For Questions 9–17, write the letter of the definition that best matches each term on the line provided.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>9. biology</td>
<td>A. in an experiment, the group exposed to the same conditions as the experimental group except for one independent variable</td>
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<td>10. bias</td>
<td>B. the study of life</td>
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<td>11. homeostasis</td>
<td>C. living things maintaining a relatively stable internal environment</td>
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<tr>
<td>12. metabolism</td>
<td>D. a molecule containing the universal genetic code</td>
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<td>13. DNA</td>
<td>E. a point of view that is personal rather than scientific</td>
</tr>
<tr>
<td>14. control group</td>
<td>F. a living planet</td>
</tr>
<tr>
<td>15. independent variable</td>
<td>G. the combination of chemical reactions through which an organism builds up or breaks down materials</td>
</tr>
<tr>
<td>16. dependent variable</td>
<td>H. in an experiment, the variable that is manipulated</td>
</tr>
<tr>
<td>17. biosphere</td>
<td>I. in an experiment, the responding variable</td>
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