



# 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?

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2. What are the goals of science?

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## Scientific Methodology: The Heart 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.

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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?

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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:

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Dependent variable:

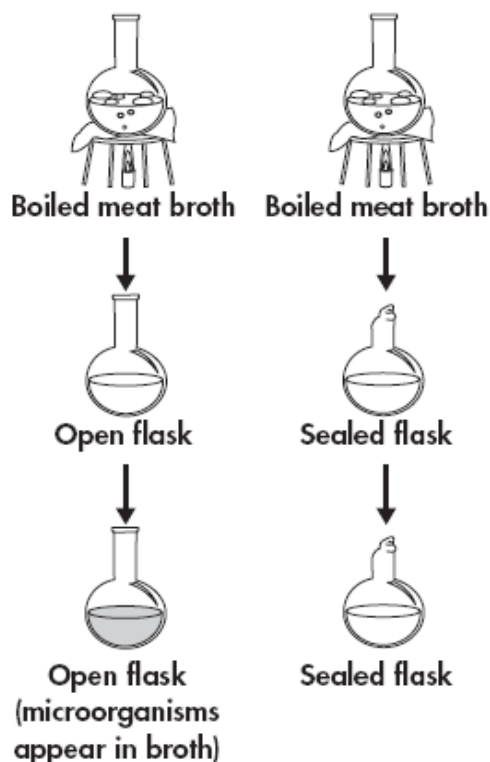
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Controlled variables (identify three):

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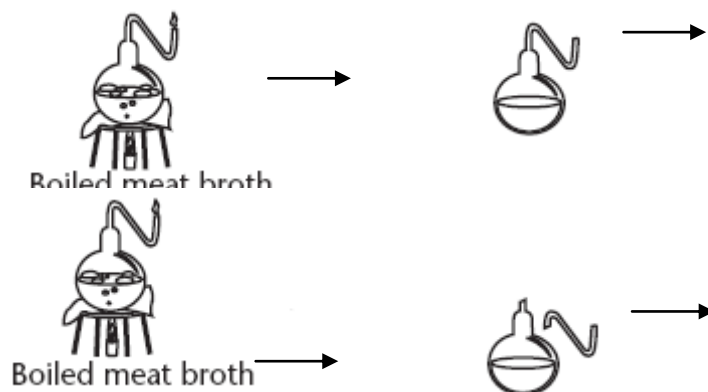


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6. **THINK VISUALLY** Critics of Spallanzini said that he showed only that organisms cannot live without air. In 1859 Louis Pasteur designed an experiment to address that criticism, an experiment that reproduced Spallanzani's results.

*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.*



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 it is used?
- \_\_\_\_\_

### Apply the Big idea

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?

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## 1.2 Science in Context

### 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

**Exploration and Discovery: Where Ideas Come From** 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.

**Communicating Results: Reviewing and Sharing Ideas** Communication 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.

**Scientific Theories** 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.

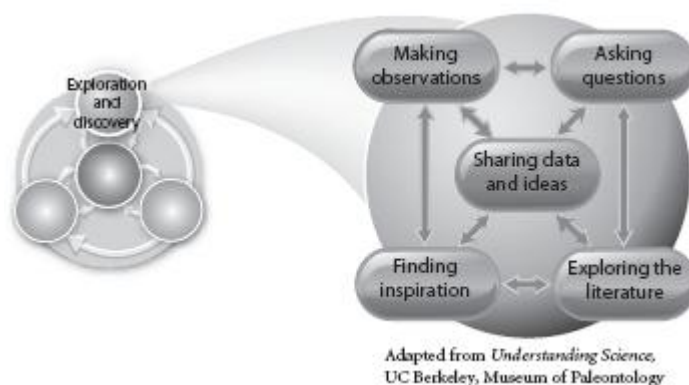
**Science and Society** Using science involves understanding its context in society and its limitations. Understanding science

- ▶ 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.

## Exploration and Discovery: Where Ideas Come From

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.  
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## Communicating Results: Reviewing and Sharing Ideas

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.  
\_\_\_\_\_



## Scientific Theories

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.

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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.

## Science and Society

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

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### Apply the Big idea

13. What is it about science, as a way of knowing, that makes it self-correcting?

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## 1.3 Studying Life

### Lesson Objectives

-  List the characteristics of living things.
-  Identify the central themes of biology.
-  Explain how life can be studied at different levels.
-  Discuss the importance of a universal system of measurement.

### Lesson Summary

**Characteristics of Living Things** **Biology** is the study of life. Living things share these characteristics: They are made of cells and have a universal genetic code; they obtain and use materials and energy to grow and develop; they reproduce; they respond to signals in their environment (**stimuli**) and maintain a stable internal environment; they change over time.

**Big Ideas in Biology** The study of biology revolves around several interlocking big ideas:

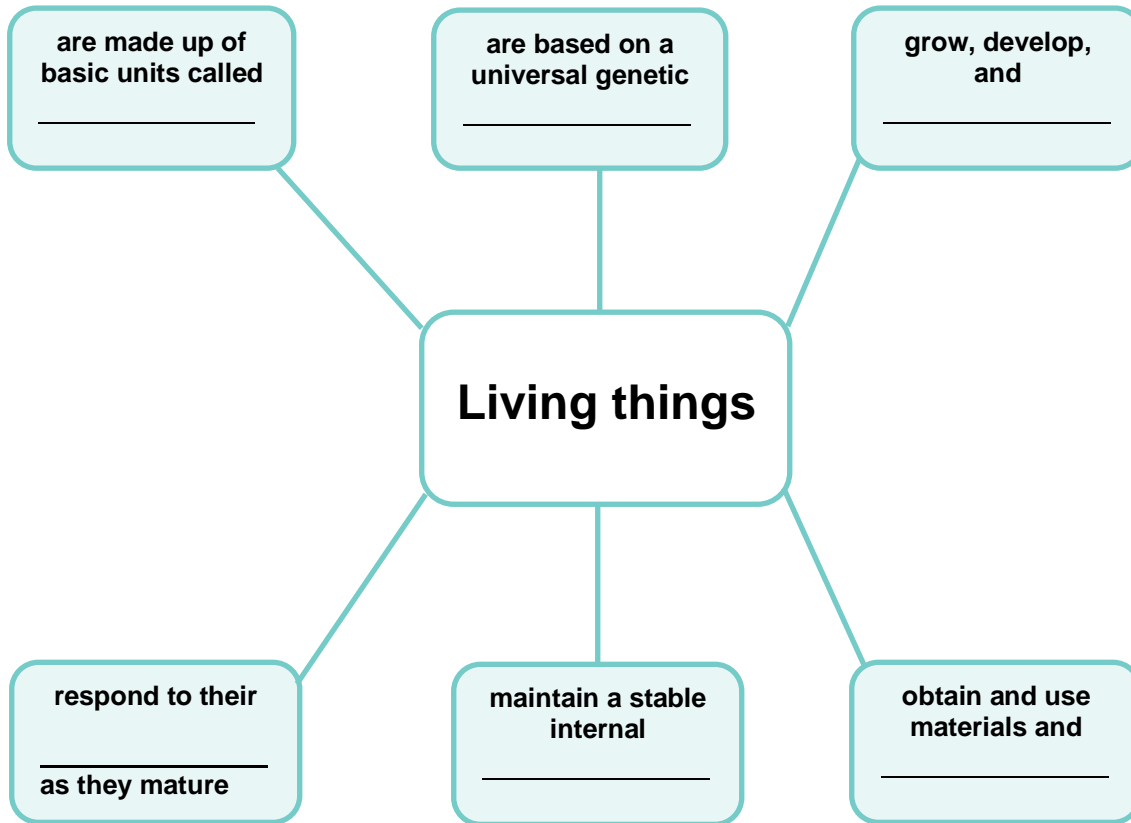
- ▶ **Cellular basis of life.** Living things are made of cells.
- ▶ **Information and heredity.** Living things are based on a universal genetic code written in a molecule called DNA.
- ▶ **Matter and energy.** Life requires matter that provides raw material, nutrients, and energy. The combination of chemical reactions through which an organism builds up or breaks down materials is called **metabolism**.
- ▶ **Growth, development, and reproduction.** All living things reproduce. In **sexual reproduction**, cells from two parents unite to form the first cell of a new organism. In **asexual reproduction**, a single organism produces offspring identical to itself. Organisms grow and develop as they mature.
- ▶ **Homeostasis.** Living things maintain a relatively stable internal environment.
- ▶ **Evolution.** Taken as a group, living things evolve, linked to a common origin.
- ▶ **Structure and function.** Each major group of organisms has evolved structures that make particular functions possible.
- ▶ **Unity and diversity of life.** All living things are fundamentally similar at the molecular level.
- ▶ **Interdependence in nature.** All forms of life on Earth are connected into a **biosphere**—a living planet.
- ▶ **Science as a way of knowing.** Science is not a list of facts but “a way of knowing.”

**Fields of Biology** Biology includes many overlapping fields that use different tools to study life. These include biotechnology, global ecology, and molecular biology.

**Performing Biological Investigations** Most scientists use the metric system as a way to share quantitative data. They are trained in safe laboratory procedures. To remain safe when you are doing investigations, the most important rule is to follow your teacher’s instructions.

## Characteristics of Living Things

1. Complete the graphic organizer to show the characteristics living things share.



- The genetic molecule common to all living things is \_\_\_\_\_.
- The internal process of \_\_\_\_\_ enables living things to survive changing conditions.
- Living things are capable of responding to different types of \_\_\_\_\_.
- Living things have a long history of \_\_\_\_\_ change.
- The continuation of life depends of both \_\_\_\_\_ and \_\_\_\_\_.
- The combination of chemical reactions that make up an organism's \_\_\_\_\_ help to organize raw materials into living matter.



Name \_\_\_\_\_ Class \_\_\_\_\_ Date \_\_\_\_\_

## Big Ideas in Biology

8. Complete the table of Big Ideas in Biology. The first row is filled in for you.

Big Idea	Description
Cellular basis of life	Living things are made of cells.
Information and heredity	
	Life requires matter that provides raw materials, nutrients, and energy.
Growth, development, and reproduction	
	Living things maintain a relatively stable internal environment.
Evolution	
	Each major group of organisms has evolved structures that make particular functions possible.
	All living things are fundamentally similar at the molecular level.
	All forms of life on Earth are connected into a biosphere—a living planet.
Science as a way of knowing	

9. Pick two of the big ideas from the chart and describe how the ideas interlock.

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## Fields of Biology

- 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.

Field of Biology	Description of Field	Why It Does or Does Not Appeal to Me

## Performing Biological Investigations

- 11.** Describe the system of measurement most scientists use when collecting data and doing experiments.

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

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

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### Apply the Big idea

- 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?

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## 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.

### Term

- \_\_\_\_\_ 9. biology
- \_\_\_\_\_ 10. bias
- \_\_\_\_\_ 11. homeostasis
- \_\_\_\_\_ 12. metabolism
- \_\_\_\_\_ 13. DNA
- \_\_\_\_\_ 14. control group
- \_\_\_\_\_ 15. independent variable
- \_\_\_\_\_ 16. dependent variable
- \_\_\_\_\_ 17. biosphere

### Definition

- A.** in an experiment, the group exposed to the same conditions as the experimental group except for one independent variable
- B.** the study of life
- C.** living things maintaining a relatively stable internal environment
- D.** a molecule containing the universal genetic code
- E.** a point of view that is personal rather than scientific
- F.** a living planet
- G.** the combination of chemical reactions through which an organism builds up or breaks down materials
- H.** in an experiment, the variable that is manipulated
- I.** in an experiment, the responding variable

