

# Chapter 1

# Biology and You

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Characteristics of Living Things

## Why It Matters

Biology, the study of life, directly applies to your health, life, and future in ways as simple as making daily food choices or as complex as deciding which career to pursue.

Biologists are curious about living things. This biologist was curious enough about seabirds to climb to the top of this high cliff.

This scientist is taking measurements of a puffin chick to estimate its age. This information will help the scientist predict when the chick will leave its burrow and head out to sea.

One mystery that biologists have yet to solve about puffins is how the chicks, who leave their burrow when they are only 50 days old, are able to return to the same spot many years later to have their own chicks.

# The Nature of Science

## Key Ideas

- How can someone practice scientific thought?
- What are universal laws in science?
- How do ethics apply to science?
- Why should someone who is not planning to become a scientist study science?

## Key Terms

skepticism

## Why It Matters

Thinking like a scientist helps you solve problems and think critically about the world around you.

The goal of science is to help us understand the natural world and improve people's lives. Thinking like a scientist can help you solve problems and think critically about your world.

## Scientific Thought

➤ Scientific thought involves making observations, using evidence to draw conclusions, being skeptical about ideas, and being open to change when new discoveries are made.

**Questioning Ideas** Scientists carefully observe the world. They then ask questions about what they observe. Often, the questions that they ask lead to even more questions. This process is the cornerstone of scientific thought. Scientific thought also requires **skepticism**—a questioning and often doubtful attitude. Scientists question everything. They require evidence, not opinions, to support ideas. Many great discoveries have been made when scientists doubted conventional wisdom. For example, people once thought that stress caused stomach ulcers. However, a group of researchers found the bacteria *Helicobacter pylori* in the stomachs of people with ulcers. Studies confirmed that the bacteria, shown in **Figure 1**, caused ulcers.

**Discovery and Change** As scientists challenge old claims and make new discoveries, they change the way that people view the world. Many scientific discoveries lead to new technologies and medical treatments. For example, discovering that bacteria cause stomach ulcers led to prescribing antibiotics for patients with ulcers. Through the ongoing cycle of challenge and discovery, scientific knowledge grows.

*Helicobacter pylori* bacterium



**Figure 1** Doctors once thought that stress caused stomach ulcers. However, in 1982, scientists discovered that *Helicobacter pylori* bacteria were the actual cause.



**skepticism** a habit of mind in which a person questions the validity of accepted ideas



**Figure 2** All objects in the universe, from birds to stars, are affected by gravity. Birds must overcome gravity to fly. Stars are formed when gravity pulls a mass of gases together.

### ACADEMIC VOCABULARY

**aspect** the way in which an idea or situation is viewed



## Universal Laws

► Science is governed by truths that are valid everywhere in the universe. These truths are called *universal laws*. Though branches of science address different aspects of the natural world, universal laws such as the law of gravity, the law of conservation of energy, and the laws of planetary motion apply to all branches of science and to every person. A biologist studying the flight of the bird in **Figure 2** is studying how animals have adapted to overcome the force of gravity. A biologist studying the habits of nocturnal animals is studying the way that animal behavior has adapted to take advantage of the regular pattern of day and night caused by Earth's rotation on its axis.

## Science and Ethics

Ethics are a system of moral principles and values. ► Because scientific experimentation and discovery can have serious ethical implications, scientific investigations require ethical behavior. Scientists performing investigations must report only accurate data and be willing to allow their peers to review their work. All scientists rely on the work of other scientists. If the data or claims of one scientist are misleading or false, many other scientists may waste time and resources conducting investigations that are based on that unethical work.

Many other people also rely on scientists to be ethical. For example, if a scientist falsely claims to have discovered a cure for diabetes, people with diabetes may change how they manage their condition to take advantage of the discovery. Because the findings are false, the people relying on the discovery could be in danger.

Scientists must also obey laws and behave ethically with people involved in scientific investigations. Ethical scientists adhere to strict guidelines to ensure that no one involved in medical experiments is coerced, exploited, or involuntarily exposed to a known danger.

► **Reading Check** *Why is it important that scientific investigations be done ethically? (See the Appendix for answers to Reading Checks.)*





## Evaluate a Scientific Claim

As a consumer, you need to make wise decisions. Often, your buying choices depend on evaluating claims made by the manufacturer. Are the claims accurate? What can you really expect from the products?

### Analysis

1. **CRITICAL THINKING Evaluating Conclusions** Suppose that two television commercials claim that their own product is the fastest-acting acne medicine. Design a strategy that could be used to compare the brands. How would you compare their effectiveness?
2. **CRITICAL THINKING Determining the Validity of a Claim** New automobiles are sold with a window sticker displaying the expected miles per gallon. Are these manufacturers' estimates realistic and repeatable by consumers? How would you find out?

## Why Study Science?

Scientific thinking is not just for scientists. The same critical-thinking process that scientists use is a tool that you can use in your everyday life. ➤ **An understanding of science can help you take better care of your health, be a wiser consumer, and become a better-informed citizen.** For example, you may read an article claiming that riding a bike for 30 minutes a week can lower your blood pressure. How will you know if the claim is accurate? You can investigate the claim by using scientific thought. Ask questions about the claim, be skeptical about what you read, and be ready for discovery and change.

You can also use science to improve the world around you. You may see a problem in your town, such as a struggling recycling program or a dangerous crosswalk. You can investigate these problems with skepticism and creativity to discover helpful solutions. By applying scientific thinking to these problems, you can help yourself and your community.

### READING TOOLBOX

**Everyday Words in Science** In your own words, write the everyday meaning for the word *law*. How does the everyday meaning compare to the science meaning of *law*?

### Section

# 1

## Review

### ➤ KEY IDEAS

1. **Describe** the processes involved in practicing good scientific thought.
2. **Identify** two universal laws.
3. **Explain** how ethics apply to science.
4. **Relate** how science has already helped you in your everyday life.

### CRITICAL THINKING

5. **Making Inferences** Most animals have solid bones. However, most birds have bones with hollow spaces. Explain how this feature of birds is related to one of the universal laws.
6. **Evaluating Claims** Two brands of yeast claim to produce a fast-rising dough. Design a strategy that could be used to compare the brands. What would you measure?

### WRITING FOR SCIENCE

7. **Persuasive Writing** Write a letter to a younger brother or sister explaining the importance of studying science. Give at least three reasons to support your explanation.

# Scientific Methods

Key Ideas	Key Terms	Why It Matters
<ul style="list-style-type: none"> <li>➤ How do scientific investigations begin?</li> <li>➤ What are two types of experiments that scientists can use to test hypotheses?</li> <li>➤ What is the difference between a theory and a hypothesis?</li> </ul>	observation hypothesis experiment control group theory	Scientific thinking can help you understand and analyze information that you come across in your daily life.

All scientists have a certain way of investigating the world. Studying an actual scientific investigation is an exciting way to learn how science is done. Our story begins with a population of Canada geese.

## Beginning a Scientific Investigation

For many years, the number of Canada geese around Chicago, shown in **Figure 3**, had been rising rapidly. Scientist Charles Paine of the Max McGraw Wildlife Foundation was studying this population growth when he noticed that the number of geese was no longer increasing. Why was the population boom over?

**Making Observations** ➤ Most scientific investigations begin with observations that lead to questions. **Observation** is the act of noting or perceiving objects or events by using the senses. Scientists must use both direct and indirect observation to study the world around them. Many things, like the Canada geese, can be seen. This means they can be directly observed. Other things, like the force of gravity, cannot be seen. Gravity is observed indirectly by observing the effects of gravity on objects that can be directly observed.



**Formulating a Hypothesis** To find out what was happening to the population of Canada geese, Paine needed to form a hypothesis. A **hypothesis** is a possible explanation that can be tested by observation or experimentation. Hypotheses are not guesses. Possible hypotheses to explain Paine's observations included these:

- The geese were being killed by predators.
- Many of the geese had become infertile.
- The geese were migrating out of the area.

**Figure 3** Chicago's Canada goose population had risen rapidly for several years. After making observations, Charles Paine discovered that the population was now increasing by only about 1% per year.



## The pH of Common Substances

You can use pH indicator paper to determine the pH of various solutions. The pH indicator paper changes color when it is exposed to a solution. The change in color indicates how acidic or basic the solution is.

### Procedure

1. Make a data table with three columns. Add these headings: "Solution," "Predicted pH," and "Measured pH." Make a row for **five solutions** to be tested.
2. Predict the pH (acid or base) of each solution, and record your predictions in your data table.
3. **Test** each solution with **pH paper**, and record the results in the appropriate row in your data table.



### Analysis

1. **Summarize** your findings in two sentences.
2. **Compare** your results with those of the rest of the class. Explain any differences.
3. **List** the scientific methods that you followed in doing this activity.
4. **CRITICAL THINKING Analyzing Results** Were the predictions that you made correct? Explain any differences between your predictions and your results.

## Scientific Experiments

An **experiment** is a procedure that is carried out under controlled conditions to test a hypothesis. ➤ **Scientists conduct controlled experiments or perform studies in order to test a hypothesis.**

**Controlled Experiments** A controlled experiment is a procedure that tests one factor at a time and that uses a control group and an experimental group. A **control group** serves as a standard of comparison because the group receives no experimental treatment. Experimental groups are identical to the control group except for one factor, or *variable*. The single factor that scientists change in an experiment is called the *independent variable*. Factors that may change in response to the independent variable are called *dependent variables*. Scientists analyze changes to the dependent variables to understand how the independent variable affects the system that they are studying.

**Study Without Experimentation** There are often cases in which experiments are not possible or not ethical. For example, researchers are trying to find out if the bacteria that cause dental plaque also contribute to heart disease. It is not ethical to ask a group of people not to brush their teeth for years in order to find out if they will develop heart disease. Instead, researchers look for connections in data gathered from patients who have heart disease. However, many factors can contribute to heart disease. Researchers try to reduce the number of variables that may affect their data. For example, smoking leads to heart disease. If a person who has heart disease smokes and has dental plaque, determining which factor caused the patient's heart disease is impossible.

**observation** the process of obtaining information by using the senses

**hypothesis** a testable idea or explanation that leads to scientific investigation

**experiment** a procedure that is carried out under controlled conditions to discover, demonstrate, or test a fact, theory, or general truth

**control group** in an experiment, a group that serves as a standard of comparison with another group to which the control group is identical except for one factor

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Topic: Scientific Investigations

Code: HX81358

**theory** a system of ideas that explains many related observations and is supported by a large body of evidence acquired through scientific investigation

### READING TOOLBOX

**Hypothesis or Theory?** List the hypotheses that were proposed to explain the decrease in Canada geese in Chicago. Identify which hypothesis was supported by evidence.

**Analyzing Results** To test his hypothesis, Paine put radio collars on the adult Canada geese. He tracked the geese and learned that very few of the adult geese were being killed by predators. The results of an experiment may support a hypothesis or prove that a hypothesis is not true. After Paine analyzed his results, he had to change his hypothesis. Paine now hypothesized that the eggs, not the adult geese, were being eaten by predators. He discussed his ideas with his colleague Stan Gehrt, who was studying predators in the Chicago area. Gehrt had recently discovered an amazing fact: Chicago was home to about 2,000 coyotes! Gehrt had observed that coyotes, such as the one in **Figure 4**, sometimes ate the eggs of Canada geese.

**Drawing Conclusions and Verifying Results** Scientists draw conclusions that explain the results of their experiments. Working together, Paine and Gehrt concluded that urban coyotes were controlling the Canada goose population by eating the eggs. How could Paine and Gehrt verify their conclusions? Scientists verify their conclusions by conducting experiments and studies many times. They also check to see if other scientists have found similar results. In this case, urban coyotes have been found in many large cities. Paine and Gehrt could try to find out if these coyotes also eat goose eggs.

**Considering Bias** Scientists are human and have particular points of view, or biases. Scientists work hard to prevent bias from affecting their work, but bias can still influence an experiment. Also, a conflict of interest could affect a scientific study. For example, an investigation funded by a company may be biased in favor of that company's products or services. For this reason, you should view all scientific claims in their context and question them. Remember that skepticism is an important part of scientific thought, even when considering research done by qualified scientists.

**Figure 4** Coyotes like this one have adapted to city life. ➤ How do coyotes most likely control Chicago's Canada goose population?



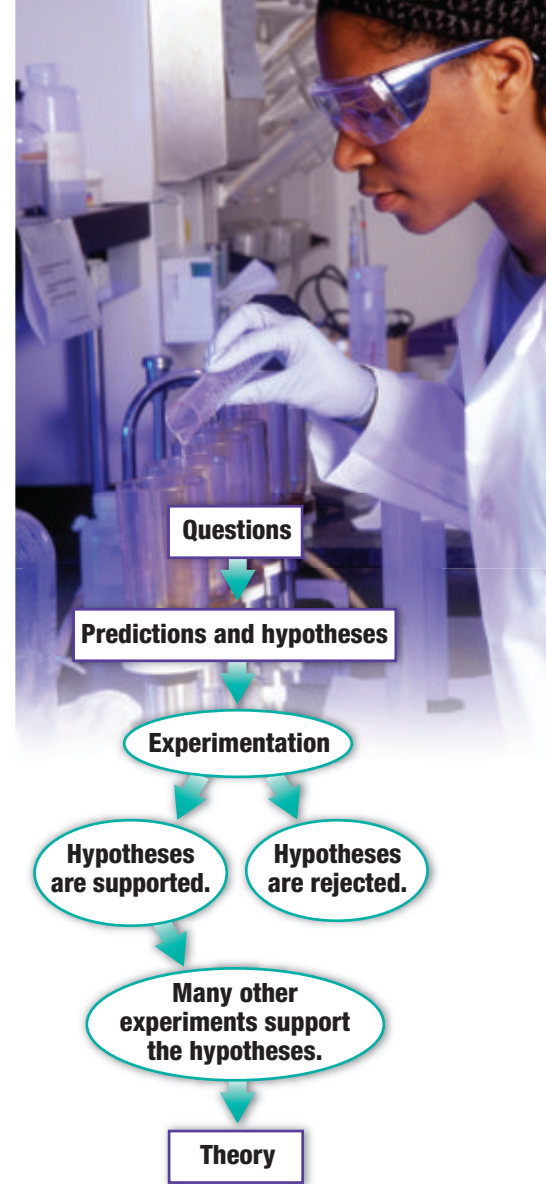
## Scientific Theories

When related hypotheses are well supported and explain a great amount of data, these hypotheses may be put together to form a **theory**. ➤ The main difference between a theory and a hypothesis is that a hypothesis is a specific, testable prediction for a limited set of conditions and a theory is a general explanation for a broad range of data. Some examples of scientific theories include the quantum theory, the cell theory, and the theory of evolution. As you study science, remember that the word *theory* is used very differently by scientists and by the general public. People may say, “It’s just a theory,” suggesting that an idea is untested, but scientists view a theory as a highly tested, generally accepted principle that explains a vast number of observations and experimental data.

**Constructing a Theory** Figure 5 summarizes the steps in the development of a theory. Constructing a theory often involves considering contrasting ideas and conflicting hypotheses. Argument, disagreement, and unresolved questions are a healthy part of scientific research. Scientists routinely evaluate and critique one another’s work. Once a scientist completes an investigation, he or she often writes a report for publication in a scientific journal. Before publication, the research report is reviewed by other scientists. These reviewers ensure that the investigation was carried out with the appropriate controls, methods, and data analysis. The reviewers also check that the conclusions reached by the author are justified by the data obtained. Publishing an investigation allows other scientists to use the information to form their hypotheses. They can also repeat the investigations and confirm the validity of the conclusions.

If the results of an experiment can be reproduced many times, the scientific research may help develop a new theory. However, the possibility always remains that future evidence will cause a scientific theory to be revised or even rejected. Challenging old theories is how scientific understanding grows.

➤ **Reading Check** *How does the scientific use of the word theory differ from how it is used by the general public?*



**Figure 5** Scientists build theories from questions, predictions, hypotheses, and experimental results. ➤ How can an experiment lead to a theory?

### Section

## 2

## Review

### ➤ KEY IDEAS

1. **Summarize** the processes that scientists often use when beginning scientific investigations.
2. **Describe** two ways that scientists test hypotheses.
3. **Explain** the difference between a hypothesis and a theory.

### CRITICAL THINKING

4. **Analyzing Methods** Provide one example of a case in which an experiment would not be possible and one example in which an experiment would not be ethical.
5. **Forming Hypotheses** A friend notices that her dog is getting thinner even though she has not changed how much she feeds him. Propose three testable hypotheses to explain the dog’s weight loss.

### METHODS OF SCIENCE

6. **Designing an Experiment** Suppose that Paine had hypothesized that the Canada geese in Chicago were not reproducing at a normal rate. What experiment could he use to test whether the geese in Chicago were less fertile than geese elsewhere?



# Tools and Techniques

Key Ideas	Key Terms	Why It Matters
<ul style="list-style-type: none"> <li>Why do scientists use SI units for measurement?</li> <li>What are some tools and techniques that scientists use in the laboratory?</li> <li>What can you do to stay safe during an investigation?</li> </ul>	SI	Understanding the tools and techniques that scientists use can help you work safely and effectively in the lab.

Scientists use various units of measurements, tools, and lab techniques to help them make observations and gather and record data.

## Measurement Systems

Measurements taken by scientists are expressed in the International System of Units (**SI**), which is the official name of the metric system.

▶ The International System of Units is used by all scientists because scientists need to share a common measurement system. SI is also preferred by scientists because it is scaled in multiples of 10, which makes the system easy to use. Like the U.S. monetary system, SI is a decimal system, so all relationships between SI units are based on powers of 10. Most SI units have a prefix that indicates the relationship of that unit to a base unit. For example, the SI base unit for length is the meter. The prefix *kilo-* means 1,000. Thus, a kilometer is equal to 1,000 meters. **Figure 6** shows other common SI units.

▶ **Reading Check** *How are prefixes used in names of SI units?*



**Figure 6** How many dimes are in a dollar? The question is easy to answer because our monetary system, like SI, is built on powers of 10. ▶ How many pennies are there in \$10?



0.01



0.1



1



10

### Common SI Units

Prefix	Factor	Volume	Length	Mass
<i>kilo-</i>	1,000	1 kiloliter = 1,000 L	1 kilometer = 1,000 m	1 kilogram = 1,000 g
—	<b>1</b>	<b>1 liter (L)</b>	<b>1 meter (m)</b>	<b>1 gram (g)</b>
<i>centi-</i>	0.01	1 centiliter = 0.01 L	1 centimeter = 0.01 m	1 centigram = 0.01 g
<i>milli-</i>	0.001	1 milliliter = 0.001 L	1 millimeter = 0.001 m	1 milligram = 0.001 g



## Practice Staining Techniques

The parts (organelles) of a typical cell are mostly transparent. In a technique called *staining*, color is added to cell parts to help identify and distinguish them.

### Procedure

- 1 Use **forceps** to remove a thin layer of **onion skin**, and place it in the center of a **glass slide**. Add a **drop of water**, and place a **coverslip** over the specimen.
- 2 Examine the onion skin with a **light microscope**. Draw what you see.
- 3 Place a **drop of iodine stain** along one edge of the coverslip. Touch a piece of **paper towel** to the opposite edge to draw the water. When the skin is stained, examine it with the microscope.



### Analysis

1. **Describe** how the stain affected the onion skin.
2. **CRITICAL THINKING Analyzing Information** What is the advantage of using the paper to draw the stain across the field of view?

## Lab Techniques

➤ In the lab, scientists always keep detailed and accurate notes and perform precise measurements. Many scientists also use specialized tools, such as microscopes, and specialized procedures, such as sterile technique.

**Microscopy** Many organisms, such as bacteria, are too small to see with the unaided eye. Microscopes help magnify these organisms. Two common kinds of microscopes are light microscopes and electron microscopes. In a light microscope, light passes through one or more lenses to produce an enlarged image of an object. An electron microscope forms an image of an object by using a beam of electrons to magnify extremely small objects.

**Sterile Technique** Scientists who study cells need to be able to grow cells in a controlled setting. Because bacteria live everywhere on Earth, scientists must use sterile technique when growing cells. Sterile technique is a method of keeping unwanted microorganisms out of a lab to minimize the risk of contamination. The tools of sterile technique include an autoclave for sterilizing equipment, sterilized dishes and pipets, a laminar-flow hood, and latex gloves.

**Collecting Data Remotely** As electronic technology has advanced, more tools have become available for scientists to use. Remote tracking devices to attach to released animals, data collected from satellites, and technology based on the global positioning system (GPS) have enabled scientists to conduct investigations that would have been impossible just a few decades ago.

➤ **Reading Check** *When might sterile technique be used in a lab?*

**SI** the International System of Units, which is the measurement system that is accepted by scientists worldwide

### ACADEMIC VOCABULARY

**technique** a way of doing something

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Topic: History of Standard Units

Code: HX80747



**Figure 7** Using proper safety equipment is necessary during every scientific investigation. For example, this scientist must use a special suit to protect his skin from the extreme heat coming from this volcano vent.

## READING TOOLBOX

**Idea Wheel** Complete the idea wheel that you started at the beginning of the chapter. Fill in the outer sections of the wheel with details about the tools and techniques used in science.

## Safety

As you can see in **Figure 7**, studying science is exciting, but it can also be dangerous. ➤ Scientists must use caution when working in the lab or doing field research to avoid dangers such as chemical burns, exposure to radiation, exposure to infectious disease, animal bites, or poisonous plants. Here are some guidelines for working safely in the lab:

- Listen carefully to your teacher, and follow all instructions.
- Read your lab procedure carefully before beginning the lab.
- Do not take any shortcuts in your lab procedure.
- Always wear your safety goggles and any other needed safety equipment when working in the lab.
- Measure chemicals precisely.
- Never taste or smell any materials or chemicals that you use in a lab unless your teacher instructs you to do so.
- Do not use any damaged or defective equipment.
- Keep your lab area clean and free from clutter.
- When you place something onto the lab bench, make sure that the object sits securely on the bench and will not fall or tip over.
- Pay attention to where you are walking.
- If you are working outside, be aware of your surroundings. Avoid poisonous plants and animals that live in the area. Wear sunscreen and a hat that shades your neck and ears.

**Accidents** If an accident does occur, remain calm. Make sure that you are safe and that no one else is in danger. Then, inform your teacher right away. Follow all of the instructions that your teacher gives you. Know the location and proper operation of all lab safety equipment before it is needed. A review of lab safety equipment before labs begin can save valuable time if an accident happens in your lab. For more information about lab safety and how to respond to accidents in the lab, read *Lab Safety* at the front of this book.

➤ **Reading Check** List at least five actions that you can take in the laboratory to ensure your safety.

### Section

## 3

## Review

### ➤ KEY IDEAS

1. **Explain** why scientists use SI units for measurement.
2. **Describe** two kinds of microscopes.
3. **Summarize** the steps that you should take if an accident occurs in the lab.

### CRITICAL THINKING

4. **Inferring Conclusions** In general, measurement systems that are based on powers of 10 are the easiest for people to use. Infer why these systems are easiest to use.
5. **Analyzing Information** Why is reading the lab procedure before starting an experiment considered an important part of lab safety?

### MATH SKILLS

6. **Performing Conversions** A scientist pours 3.48 milliliters (mL) of hydrochloric acid into a beaker. How many liters of hydrochloric acid did the scientist pour into the beaker?

# What Is Biology?

Key Ideas	Key Terms	Why It Matters	
<ul style="list-style-type: none"> <li>▶ What are some of the branches of biology?</li> <li>▶ What are seven characteristics that all living things share?</li> </ul>	biology cell homeostasis metabolism	reproduction heredity evolution	All living things on Earth are tied together by common traits and rely on one another for their common survival.

The giant sequoia shown in **Figure 8** is very different from the man standing below it. But both organisms have much in common. Studying living organisms is what the science of biology is all about.

## The Study of Life

**Biology** is the study of life. Life is extremely diverse. It would be impossible for one person to become an expert in all aspects of biology, so scientists specialize. There are many branches of biology.

▶ **Biology includes biochemistry, ecology, cell biology, genetics, evolutionary theory, microbiology, botany, zoology, and physiology.** Biochemistry is the study of the chemistry of life. Ecology is the study of how organisms interact with each other and with their environment. The study of life on the cellular level is called cell biology. Genetics is the study of how organisms pass traits to their offspring. Evolutionary theory is the study of changes in types of organisms over time. The study of microscopic organisms is called microbiology. The study of plants is called botany. Zoology is the study of animals. Physiology is the study of the human body. As you read, you will learn about each of these fields. You will also have the opportunity to practice techniques that are used in careers in each of these fields.

**biology** the scientific study of living organisms and their interactions with the environment



**Figure 8** Both the man and the sequoia tree that he is standing on are living organisms.

▶ Which branches of biology would study both humans and trees?

## Properties of Life

All living organisms share certain properties. ▶ The seven properties of life are cellular organization, homeostasis, metabolism, responsiveness, reproduction, heredity, and growth. Life is characterized by the presence of all seven properties at some stage in an organism's life.

**Cellular Organization** A cell is the smallest unit capable of all life functions. A **cell** is a highly organized, tiny structure that is enclosed in a thin covering called a *membrane*. The basic structure of cells is the same in all organisms.

### Why It Matters

# Biology in the Wild

A biologist who studies organisms in their natural habitat is called a field biologist. These scientists study life in every kind of habitat. They may tag polar bears near the North Pole or climb into caves deep underground. By studying organisms in their natural habitat, field biologists can learn about life in the wild.

### Hanging Around for Science

Sometimes, field biologists hang around in interesting places. Scientists who study the biology of cave-dwelling organisms are called speleologists. This scientist is hanging over a cave called the Well of the Birds. This sinkhole is more than 200 meters deep and growing.



**Life Under Water** This marine biologist has to go underwater to study manatees in their habitat. Manatees are an endangered species. Scientists hope that by learning about manatees, we may be able to prevent the extinction of this species.

**Research** Use library or Internet sources to learn more about jobs that are available for field biologists.

**Homeostasis** All living organisms must maintain a stable internal environment in order to function properly. The maintenance of stable internal conditions in spite of changes in the external environment is called **homeostasis**.

**Metabolism** Living things carry out many chemical reactions in order to obtain energy. **Metabolism** is the sum of all of the chemical reactions carried out in an organism. Almost all of the energy used by living things originally comes from sunlight. Plants, algae, and some bacteria capture this energy and use it to make molecules. These molecules serve as the source of energy, or food, for other organisms.

**Responsiveness** In addition to maintaining a stable internal environment, living organisms also respond to their external environment. Plants bend toward sunlight. Birds fluff their feathers to insulate their bodies during cold weather. Students, shown in **Figure 9**, also respond to their environment.

**Reproduction** Most living things can reproduce. **Reproduction** is the process by which organisms make more of their own kind from one generation to the next. Because no organism lives forever, reproduction is an essential part of life.

**Heredity** When an organism reproduces, it passes on its own traits to its offspring in a process known as **heredity**. Heredity is the reason that children tend to look like their parents. Inherited characteristics change over generations. This process is called **evolution**.

**Growth** All living organisms grow. Some one-celled organisms only grow briefly, during the time that they are reproducing. Other living things, like the giant sequoia, grow for thousands of years and reach an enormous size. As organisms grow, many change. This process is called *development*. Frogs begin as eggs, develop into tadpoles, and eventually develop into frogs. Development differs from evolution because development refers to change in a single individual during that individual's life.

► **Reading Check** *How is heredity related to evolution?*



**Figure 9** These students are responding to the rain by using raincoats. ► Can you think of a way that you have responded to your environment today?

**cell** in biology, the smallest unit that can perform all life processes

**homeostasis** the maintenance of a constant internal state in a changing environment

**metabolism** the sum of all chemical processes that occur in an organism

**reproduction** the process of producing offspring

**heredity** the passing of genetic traits from parent to offspring

**evolution** the development of new types of organisms from preexisting types of organisms over time

## Section

# 4

## Review

### ► KEY IDEAS

1. **Explain** what biology is.
2. **Describe** nine fields that are part of the science of biology.
3. **Name** the basic unit of life.
4. **Discuss** the seven properties all living organisms share.
5. **Define** homeostasis.

### CRITICAL THINKING

6. **Recognizing Verifiable Facts** If you find an object that seems alive, how might you determine if the object is indeed an organism?
7. **Elaborating** Give an example of one way that you are interdependent on another type of organism.
8. **Analyzing Information** Relate five of the characteristics of life to an organism familiar to you.

### ALTERNATIVE ASSESSMENT

9. **Interview a Biologist** Choose a field of biology that interests you. Locate a biologist working in that field, and conduct an interview by phone or e-mail. Ask the biologist how he or she became interested in his or her field and what the scientist's work is like. Report your findings to the class.

## Key Ideas

## Key Terms

### 1 The Nature of Science

- Scientific thought involves making observations, using evidence to draw conclusions, being skeptical about ideas, and being open to change when new discoveries are made.
- Science is governed by truths that are valid everywhere in the universe. These truths are called *universal laws*.
- Scientific investigations require ethical behavior.
- An understanding of science can help you take better care of your health, be a wiser consumer, and become a better-informed citizen.

skepticism (4)



### 2 Scientific Methods

- Most scientific investigations begin with observations that lead to questions.
- Scientists can conduct controlled experiments and qualitative studies in order to test a hypothesis.
- The main difference between a theory and a hypothesis is that a hypothesis is a specific, testable prediction for a limited set of conditions and a theory is a general explanation for a broad range of data.

observation (10)  
 hypothesis (10)  
 experiment (11)  
 control group (11)  
 theory (13)

### 3 Tools and Techniques

- The International System of Units (SI) is used by all scientists because scientists need to share a common measurement system. SI is scaled in multiples of 10, which makes the system easy to use.
- In the lab, scientists always keep detailed and accurate notes and perform precise measurements. Many scientists also use specialized tools, such as microscopes, and specialized procedures, such as sterile technique.
- Scientists must use caution when working in the lab or doing field research to avoid dangers such as chemical burns, exposure to radiation, exposure to infectious disease, animal bites, or poisonous plants.

SI (14)



### 4 What Is Biology?

- Biology includes biochemistry, ecology, cell biology, genetics, evolutionary theory, microbiology, botany, zoology, and physiology.
- The seven properties of life are cellular organization, homeostasis, metabolism, responsiveness, reproduction, heredity, and growth.



biology (17)  
 cell (18)  
 homeostasis (19)  
 metabolism (19)  
 reproduction (19)  
 heredity (19)  
 evolution (19)