Dear Colleague,

 Trying to cover all of biology in a single textbook is a terrifying, exhilarating, humbling, and sometimes overwhelming experience. But, if we had to pick a single word to describe our experience in writing this book, both of us would say “amazing.”

 Why? Because the more we learn about biology, the more we are astonished at how much science has progressed since our student days, and how much more we have yet to learn about the natural world. We wrote this book because we want to share with you and your students our amazement at scientific progress, our awe at the wonder of nature, and our delight with the way science works.

 It’s easy for students to get overwhelmed by the amount of information presented in an intro bio course. From molecules to the biosphere, there’s an awful lot of stuff to learn. All this “stuff” can give students the impression that biology “is done”—that everything has been figured out. Scientists, a student once told us, are ashamed to admit that there’s anything they don’t know.

 That student was dead wrong, and we wrote this book to help you correct that kind of misunderstanding. Scientists aren’t interested in just memorizing what is known, but in using scientific methodology to explore what is not known. Beginning with Chapter 1, we’ve tried to present the “stuff” your students are required to know in a context that helps them share in the excitement that scientists feel as we investigate unsolved problems and unexplored territory in the living world.

 If you find this book useful, we’ll be happy. As teachers, you are the most important part of the scientific community. You are the nurturers of new talent, the caretakers of youthful curiosity. You can help invigorate the scientific enterprise with hope, energy, and vigor. We hope you’ll share your thoughts, suggestions, and criticisms of this textbook with us, because we know we’ll learn from them. And, most especially, we thank you for the honor of sharing your classroom with us.
Connect to the Big Idea

Use the photograph of the paleontologists to start a class discussion of the methods scientists use to gather data. Ask students how these scientists are learning about this species of dinosaur. (Sample answer: They are observing the dinosaur’s skeleton.) Challenge students to describe other methods scientists use to learn about the natural world. (Students may identify methods such as experimentation or describe the use of technology to gather information.) Then, ask students to identify some of the topics that scientists study. Guide students to anticipate the answer to the question, What role does science play in the study of life?

Have students read over the Chapter Mystery and discuss the use of human growth hormone (HGH) in individuals who are short but otherwise healthy. Then, ask students to explain how the Chapter Mystery illustrates the connection between science and society. Help them relate the discussion to the Chapter 1 Big Idea of Science as a Way of Knowing.

Have students preview the chapter vocabulary using the Flash Cards.

CHAPTER 1

The Science of Biology

Science as a Way of Knowing

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

Understanding by Design

Chapter 1 describes science, explains the relationship between science and society, and introduces the study of life. The graphic organizer at the right shows how these concepts are framed by the chapter Big Idea, Essential Question, and Guiding Questions. The idea and questions help students begin to explore the Unit 1 Enduring Understanding of how the process of science helps biologists investigate how nature works at all levels, from the molecules in cells to the biosphere.

PERFORMANCE GOALS

In Chapter 1, students explore the process of science and the study of biology by reviewing detailed figures. They also preview the Big Ideas that run through biology and this textbook. They synthesize chapter concepts by writing a letter to Aristotle explaining how science has changed over time and an editorial encouraging all students to take a science course.
A doctor injects a chemical into the body of an eight-year-old boy named David. This healthy boy shows no signs of disease. The “condition” for which he is being treated is quite common—David is short for his age. The medication he is taking is human growth hormone, or HGH.

HGH, together with genes and diet, controls growth during childhood. People who produce little or no HGH are abnormally short and may have other related health problems. But David has normal HGH levels. He is short simply because his parents are both healthy, short people.

But if David isn’t sick, why does his doctor prescribe HGH? Where does medicinal HGH come from? Is it safe? What does this case say about science and society? As you read this chapter, look for clues about the nature of science, the role of technology in our modern world, and the relationship between science and society. Then, solve the mystery.

Never Stop Exploring Your World.
Finding the solution to the growth hormone mystery is only the beginning. Follow the Untamed Science crew in the video What Do Biologists Look Like? as they find the answers to the question “What is biology?” and dispel misconceptions about biologists.

These paleontologists—biologists who study ancient life—are working to reconstruct the skeleton of Carcharodontosaurus, a giant dinosaur that lived over 90 million years ago. By using scientific skills such as observation and inference, scientists can learn how ancient animals lived. The huge teeth of this dinosaur are sharp and serrated like a knife, suited for eating meat—a lot of it!
Getting Started

Objectives
1.1.1 State the goals of science.
1.1.2 Describe the steps used in scientific methodology.

Student Resources
Study Workbooks A and B, 1.1 Worksheets
Spanish Study Workbook, 1.1 Worksheets
Lab Manual B, 1.1 Data Analysis Worksheet, 1.1 Hands-On Activity Worksheet

ACTIVATE PRIOR KNOWLEDGE
Write the title of Lesson 1.1, What Is Science?, on the board. Ask students to write a one-sentence response to the question. Have several students share their responses with the class, and use students’ responses to spark a class discussion of what is—and what is not—science.

NATIONAL SCIENCE EDUCATION STANDARDS
UNIFYING CONCEPTS AND PROCESSES
I, II, III

CONTENT
F.6, G.1, G.2, G.3

INQUIRY
A.2.a, A.2.b, A.2.c, A.2.d, A.2.e, A.2.f

LESSON 1.1

What Is Science?

THINK ABOUT IT
One day long ago, someone looked around and wondered: Where did plants and animals come from? How did I come to be? Since then, humans have tried to answer those questions in different ways. Some ways of explaining the world have stayed the same over time. Science, however, is always changing.

What Science Is and Is Not
What are the goals of science?
This book contains lots of facts and ideas about living things. Many of those facts are important, and you will be tested on them! But you shouldn’t think that biology, or any science, is just a collection of never-changing facts. For one thing, you can be sure that some “facts” presented in this book will change soon—if they haven’t changed already. What’s more, science is not a collection of unchanging beliefs about the world. Scientific ideas are open to testing, discussion, and revision. So, some ideas presented in this book will also change.

These statements may puzzle you. If “facts” and ideas in science change, why should you bother learning them? And if science is neither a list of facts nor a collection of unchanging beliefs, what is it?
Science as a Way of Knowing  
Science is an organized way of gathering and analyzing evidence about the natural world. It is a way of observing, a way of thinking, and “a way of knowing” about the world. In other words, science is a process, not a “thing.” The word science also refers to the body of knowledge that scientific studies have gathered over the years.

Several features make science different from other human endeavors. First, science deals only with the natural world. Scientific endeavors never concern, in any way, supernatural phenomena of any kind. Second, scientists collect and organize information in an orderly way, looking for patterns and connections among events. Third, scientists propose explanations that are based on evidence, not belief. Then they test those explanations with more evidence.

The Goals of Science  
The scientific way of knowing includes the view that the physical universe is a system composed of parts and processes that interact. From a scientific perspective, all objects in the universe, and all interactions among those objects, are governed by universal natural laws. The same natural laws apply whether the objects or events are large or small.

Aristotle and other Greek philosophers were among the first to try to view the universe in this way. They aimed to explain the world around them in terms of events and processes they could observe. Modern scientists continue that tradition. One goal of science is to provide natural explanations for events in the natural world. Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.

Science, Change, and Uncertainty  
Over the centuries, scientists have gathered an enormous amount of information about the natural world. Scientific knowledge helps us cure diseases, place satellites in orbit, and send instantaneous electronic communications. Yet, despite all we know, much of nature remains a mystery. It is a mystery because science never stands still; almost every major scientific discovery raises more questions than it answers. Often, research yields surprises that point future studies in new and unexpected directions. This constant change doesn’t mean science has failed. On the contrary, it shows that science continues to advance.

That’s why learning about science means more than just understanding what we know. It also means understanding what we don’t know. You may be surprised to hear this, but science rarely “proves” anything in absolute terms. Scientists aim for the best understanding of the natural world that current methods can reveal. Uncertainty is part of the scientific process and part of what makes science exciting! Happily, as you’ll learn in later chapters, science has allowed us to build enough understanding to make useful predictions about the natural world.

How Science Works  

THE SCIENCE OF BIOLOGY IN ANCIENT GREECE  
Although the word biology was not used until the early nineteenth century, the scientific study of life has a history of thousands of years. Alcmaeon, a Greek physician born about 535 B.C., is thought to be one of the first persons to have studied human anatomy. He discovered the optic nerve and speculated that the brain was the center of intellectual activity. The Greek philosopher Aristotle, born in 384 B.C., was a meticulous observer of living things, classifying over 500 animal species in a strict hierarchy. He even proposed a theory of progressive change among animals—an early suggestion of evolution.
Use Visuals

Have students use Figure 1–3 to learn about scientific methodology. Point out to students that this figure continues through page 8. Have students make an outline that includes the following main topics: observing and asking questions, inferring and hypothesizing, designing controlled experiments, collecting and analyzing data, and drawing conclusions. As students read the detailed descriptions of these processes, have them add details to their outlines.

Address Misconceptions

The Scientific Method A common misconception among students is that the “scientific method” is a set of five or six simple steps performed by all scientists, always in the same order. The text on this page can be used to address this misconception. Point out the sentences that refer to the dynamic nature of scientific investigations—how there is not any single, rigid set of steps called the scientific method. Tell students scientific methodology describes a general style of investigation and it applies across all the branches of science.

Scientific Methodology: The Heart of Science

What procedures are at the core of scientific methodology?

You might think that science is a mysterious process, used only by certain people under special circumstances. But that’s not true, because you use scientific thinking all the time. Suppose your family’s car won’t start. What do you do? You use what you know about cars to come up with ideas to test. At first, you might think the battery is dead. So you test that idea by turning the key in the ignition. If the starter motor works but the engine doesn’t start, you reject the dead-battery idea. You might guess next that the car is out of gas. A glance at the fuel gauge tests that idea. Again and again, you apply scientific thinking until the problem is solved—or until you run out of ideas and call a mechanic!

Scientists approach research in pretty much the same way. There isn’t any single, cut-and-dried “scientific method.” There is, however, a general style of investigation that we can call scientific methodology.

Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions. Figure 1–3 shows how one research team used scientific methodology in its study of New England salt marshes.

Observing and Asking Questions Scientific investigations begin with observation, the act of noticing and describing events or processes in a careful, orderly way. Of course, scientific observation involves more than just looking at things. A good scientist can, as the philosopher Arthur Schopenhauer put it, “Think something that nobody has thought yet, while looking at something that everybody sees.” That kind of observation leads to questions that no one has asked before.

How Science Works

AN EMPHASIS ON EXPERIMENTATION

Galileo Galilei (1564–1642) is generally considered to have established modern scientific methodology, as demonstrated in his investigations. Some stories about Galileo cannot be verified, but his approach to the study of nature is beyond question. His emphasis on experimentation as the way to prove the validity of ideas was part of the broader movement of free thought and skepticism that was characteristic of the European Renaissance. Galileo’s scientific legacy includes the challenge to Aristotle’s view that the natural state of a body is at rest—a view that had been accepted for 2000 years; and the discovery of Jupiter’s moons, which supported the Copernican model of the solar system.
Inferring and Forming a Hypothesis After posing questions, scientists use further observations to make inferences. An inference is a logical interpretation based on what scientists already know. Inference, combined with a creative imagination, can lead to a hypothesis. A hypothesis is a scientific explanation for a set of observations that can be tested in ways that support or reject it.

Designing Controlled Experiments Testing a scientific hypothesis often involves designing an experiment that keeps track of various factors that can change, or variables. Examples of variables include temperature, light, time, and availability of nutrients. Whenever possible, a hypothesis should be tested by an experiment in which only one variable is changed. All other variables should be kept unchanged, or controlled. This type of experiment is called a controlled experiment.

Controlling Variables Why is it important to control variables? The reason is that if several variables are changed in the experiment, researchers can't easily tell which variable is responsible for any results they observe. The variable that is deliberately changed is called the independent variable (also called the manipulated variable). The variable that is observed and that changes in response to the independent variable is called the dependent variable (also called the responding variable).

Control and Experimental Groups Typically, an experiment is divided into control and experimental groups. A control group is exposed to the same conditions as the experimental group except for one independent variable. Scientists always try to reproduce or replicate their observations. Therefore, they set up several sets of control and experimental groups, rather than just a single pair.

In Your Notebook What is the difference between an observation and an inference? List three examples of each.

Building Science Skills

Divide the class into small groups, and have each group consider this question: Does the amount of sleep a student gets affect how well that student does in school? Ask each group to design an experiment that would address the question. Have each group write a short summary of the procedure it would follow. Then, have groups share their experimental designs with the class.

Differentiated Instruction

Struggling Students Help students understand the meaning of the terms independent variable and dependent variable in the context of a controlled experiment. Describe a simple experimental scenario to students, for example, giving several plants differing amounts of water to see how their growth is affected. Help students identify the independent variable and dependent variable in the experiment. Describe a simple experimental scenario until they can reliably identify the independent and dependent variables. Then, have them apply this knowledge to the activity described above.

Advanced Students Ask students to use reliable resources to find out about studies of the amount of sleep teens receive and how their school performance is affected. Help students identify the independent and dependent variables in the experiment. Continue describing scenarios until they can reliably identify the independent and dependent variables. Then, have them apply this knowledge to the activity described above.

Have students access Art in Motion: Experimental Design to manipulate the variables in the experiment in Figure 3–1. Students can also use the Interactive Art: Redi and Pasteur’s Experiments to explore the idea of spontaneous generation through experimentation.

Check for Understanding

Hand Signals

Present students with the following questions, and ask them to show a thumbs-up sign if they can definitely answer the question, a thumbs-down sign if they cannot, or a waving-hand sign if they are not sure.

• Why is science sometimes referred to as a “way of knowing”?
• What are the goals of science?
• How is a controlled experiment designed?

Adjust Instruction

If students are confused by a question, write it on the board and have small groups write a short response. Then, have volunteers from each group post their responses on the board.

Answers

In Your Notebook Students should explain that an observation, which is something noticed using the senses, is different from an inference, which is a logical interpretation of an observation. Students should list three examples of each.
**LESSON 1.1**

**COLLECTING AND ANALYZING DATA**

**Control Group**

**Experimental Group**

The researchers sampled all the plots throughout the growing season. They measured growth rates and plant sizes, and analyzed the chemical composition of living leaves.

**Drawing Conclusions**

Data from all plots were compared and evaluated by statistical tests. Data analysis confirmed that marsh grasses in experimental plots with additional nitrogen did, in fact, grow taller and larger than controls. The hypothesis and its predictions were supported.

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**How Science Works**

**THE USE OF STATISTICS IN SCIENCE**

Data analysis in science often relies on the use of statistics. Although some statistical calculations are very sophisticated, calculations as basic as finding the mean, median, and mode of a set of values are ways to analyze data using statistics. Statistical tools such as range and standard deviation can be used to assess the variability of data. Statistics can also be used to calculate the percent error of experimental data. Percent error is calculated by obtaining the absolute value of the difference between the accepted value and the experimental value, dividing by the accepted value, and multiplying by 100.

\[
\% \text{ error} = \frac{|\text{experimental value} - \text{accepted value}|}{\text{accepted value}} \times 100
\]
**Drawing Conclusions** Scientists use experimental data as evidence to support, refute, or revise the hypothesis being tested, and to draw a valid conclusion. Hypotheses are often not fully supported or refuted by one set of experiments. Rather, new data may indicate that the researchers have the right general idea but are wrong about a few particulars. In that case, the original hypothesis is reevaluated and revised; new predictions are made, and new experiments are designed. Those new experiments might suggest changes in the experimental treatment or better control of more variables. As shown in Figure 1–4, many circuits around this loop are often necessary before a final hypothesis is supported and conclusions can be drawn.

**When Experiments Are Not Possible** It is not always possible to test a hypothesis with an experiment. In some of these cases, researchers devise hypotheses that can be tested by observations. Animal behavior researchers, for example, might want to learn how animal groups interact in the wild. Investigating this kind of natural behavior requires field observations that disturb the animals as little as possible. When researchers analyze data from these observations, they may devise hypotheses that can be tested in different ways.

Sometimes, ethics prevents certain types of experiments—especially on human subjects. Medical researchers who suspect that a chemical causes cancer, for example, would not intentionally expose people to it! Instead, they search for volunteers who have already been exposed to the chemical. For controls, they study people who have not been exposed to the chemical. The researchers still try to control as many variables as possible. For example, they might exclude volunteers who have serious health problems or known genetic conditions. Medical researchers always try to study large groups of subjects so that individual genetic differences do not produce misleading results.

**Assessment Answers**

1a. Science is an organized way of gathering and analyzing evidence gathered about the natural world.

1b. Science provides explanations for events in the natural world, an understanding of patterns in nature, and predictions about natural events.

1c. Sample answer: I don’t think that scientists will ever run out of things to study because every discovery raises new questions. Also, as technology improves, there will be new ways to investigate things.

2a. Scientific methodology involves observing and asking questions, inferring and hypothesizing, designing controlled experiments, collecting and analyzing data, and drawing conclusions.

2b. Hypotheses are so important to controlled experiments because they are testable explanations for a set of observations.

3. A few hundred years ago, observations seemed to indicate that some living things could just suddenly appear: maggots showed up on meat; mice were found on grain; and beetles turned up on cow dung. Those observations led to the incorrect idea of spontaneous generation—the notion that life could arise from nonliving matter. Write a paragraph for a history magazine evaluating the spontaneous generation hypothesis. Why did it seem logical at the time? What evidence was overlooked or ignored?

**Assess and Remediate**

**EVALUATE UNDERSTANDING**

Have each student write a sentence that uses two of the lesson vocabulary terms and clearly shows the relationship between the two terms. Call on students to share their sentences with the class. Then, have students complete the 1.1 Assessment.

**REMEDICATION SUGGESTION**

**Struggling Students** If students have trouble with Question 2b, remind them that all experiments begin with a statement to be tested. Ask students what this statement is called. (hypothesis)

Students can check their understanding of lesson concepts with the Self-Test assessment. They can then take an online version of the Lesson Assessment.


### Getting Started

**Objectives**

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

**Student Resources**

Study Workbooks A and B, 1.2 Worksheets
Spanish Study Workbook, 1.2 Worksheets

For corresponding lesson in the Foundation Edition, see pages 9–12.

**Build Background**

Before class, write a message on the board using a random arrangement of letters rather than recognizable words. When students ask you about the message, point out that they are demonstrating curiosity, one of the scientific habits of mind.

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**Science in Context**

**THINK ABOUT IT** Scientific methodology is the heart of science. But that vital “heart” is only part of the full “body” of science. Science and scientists operate in the context of the scientific community and society at large.

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

**What scientific attitudes help generate new ideas?**

Scientific methodology is closely linked to exploration and discovery, as shown in Figure 1–5. Recall that scientific methodology starts with observations and questions. But where do those observations and questions come from in the first place? They may be inspired by scientific attitudes, practical problems, and new technology.

**Scientific Attitudes** Good scientists share scientific attitudes, or habits of mind, that lead them to exploration and discovery. **Curiosity, skepticism, open-mindedness, and creativity help scientists generate new ideas.**

- **Curiosity** A curious researcher, for example, may look at a salt marsh and immediately ask, “What’s that plant? Why is it growing here?” Often, results from previous studies also spark curiosity and lead to new questions.

- **Skepticism** Good scientists are skeptics, which means that they question existing ideas and hypotheses, and they refuse to accept explanations without evidence. Scientists who disagree with hypotheses design experiments to test them. Supporters of hypotheses also undertake rigorous testing of their ideas to confirm them and to address any valid questions raised.

- **Open-Mindedness** Scientists must remain open-minded, meaning that they are willing to accept different ideas that may not agree with their hypothesis.

- **Creativity** Researchers also need to think creatively to design experiments that yield accurate data.

**FIGURE 1–5 The Process of Science** As the arrows indicate, the different aspects of science are interconnected—making the process of science dynamic, flexible, and unpredictable.

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### NATIONAL SCIENCE EDUCATION STANDARDS

**UNIFYING CONCEPTS AND PROCESSES**

**CONTENT**

E.2, F.6, G.1, G.2, G.3

**INQUIRY**

A.1.b, A.2.b, A.2.c, A.2.e, A.2.f

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**Teach for Understanding**

**ENDURING UNDERSTANDING** The process of science helps biologists investigate how nature works at all levels, from the molecules in cells to the biosphere.

**GUIDING QUESTION** How do the scientific community and society influence the process of science?

**EVIDENCE OF UNDERSTANDING** After completing the lesson, give students the following assessment to show their understanding of scientific attitudes. Have students work with a small group to write and perform a skit that demonstrates how a scientist would employ each of the scientific habits of mind discussed (curiosity, skepticism, open-mindedness, and creativity) when exploring a scientific problem. Have each group perform its skit for the class.
Practical Problems  Sometimes, ideas for scientific investigations arise from practical problems. Salt marshes, for example, play vital roles in the lives of many ecologically and commercially important organisms, as you will learn in the next unit. Yet they are under intense pressure from industrial and housing development. Should marshes be protected from development? If new houses or farms are located near salt marshes, can they be designed to protect the marshes? These practical questions and issues inspire scientific questions, hypotheses, and experiments.

The Role of Technology  Technology, science, and society are closely linked. Discoveries in one field of science may lead to new technologies. Those technologies, in turn, enable scientists in other fields to ask new questions or to gather data in new ways. For example, the development of new portable, remote data-collecting equipment enables field researchers to monitor environmental conditions around the clock, in several locations at once. This capability allows researchers to pose and test new hypotheses. Technological advances can also have big impacts on daily life. In the field of genetics and biotechnology, for instance, it is now possible to mass-produce complex substances—such as vitamins, antibiotics, and hormones—that were once available naturally.

In Your Notebook  Describe a situation where you were skeptical of a “fact” you had seen or heard.

How Science Works

APPLYING SCIENCE TO PRACTICAL PROBLEMS

The Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) are examples of government agencies that apply science to practical problems. The EPA helps develop and enforce regulations that protect the environment. The results of scientific studies, carried out either in EPA laboratories or by other researchers, are used when regulations are developed. The FDA applies science to help maintain public health. This agency is responsible for the safety of cosmetics, medical devices, and several other categories of products. Both the EPA and FDA also provide scientifically accurate information to the public for individuals to use as they make decisions about the environment and various products.

Teach

Connect to Social Studies

Have students work in groups to identify a practical problem in their community, such as pollution, to which scientific investigation could be applied. Have students prepare a report describing the problem, how scientific attitudes could be used to learn more about it, and at least one way technology could be applied to solving it. Have each group share its report with the class.

DIFFERENTIATED INSTRUCTION

EL Advanced Students  Have students research actual examples of how science has been applied to a practical problem in their community or state. Have each student prepare a poster or slideshow with presentation software to share the findings.

Focus on ELL: Access Content

INTERMEDIATE AND ADVANCED SPEAKERS  Have students create a Two-Column Table as they work through the lesson. Have them write down any new concepts they learn in the first column. In the second column, have them label each concept with a “+” if they understand it fully, or a “?” if they are confused about it. At the end of the lesson, suggest students work in pairs to discuss any concepts labeled with a question mark.

Study Wkbks A/B, Appendix S31, Two-Column Table. Transparencies, GO16.

Guide students to understand that the ability to produce artificial HGH increases its availability and the number of individuals who can receive treatment. It enables people to grow taller than they would naturally. Students can go online to Biology.com to gather their evidence.

Answers

FIGURE 1–7  Sample answer: Can vegetation be used to control flooding on the inlet?

IN YOUR NOTEBOOK  Students’ notebook entries should identify questionable facts they have encountered, such as unrealistic product claims.
Teach continued

Use Visuals

Have students use Figure 1–8 to learn more about the role of communication in science.

Ask Why is the term “new ideas” found in the center of the diagram in Figure 1–8? (Each of the four processes in the corners of the diagram can lead to new ideas in science.)

Ask When a scientific paper is published, does that mean research about that topic is complete? Why or why not? (Sample answer: Publication of a paper does not mean that research about a topic is complete; it may open doors for many new studies about the same topic.)

DIFFERENTIATED INSTRUCTION

Struggling Students Use the following sentence prompts to help students understand the information in Figure 1–8.

• Peer review can lead to new ideas by . . .
• Replication of results can lead to new ideas by . . .
• Discussion with colleagues can lead to new ideas by . . .
• Publication can lead to new ideas by . . .

Have students complete the sentences verbally or in written form. Discuss the completed sentences with students to be sure they understand how each process contributes to the formation of new ideas in science.

Communicating Results: Reviewing and Sharing Ideas

Why is peer review important?

Data collection and analysis can be a long process. Scientists may focus intensely on a single study for months or even years. Then, the exciting time comes when researchers communicate their experiments and observations to the scientific community. Communication and sharing of ideas are vital to modern science.

Peer Review Scientists share their findings with the scientific community by publishing articles that have undergone peer review. In peer review, scientific papers are reviewed by anonymous, independent experts. Publishing peer-reviewed articles in scientific journals allows researchers to share ideas and to test and evaluate each other’s work. Scientific articles are like high-powered versions of your high school lab reports. They contain details about experimental conditions, controls, data, analysis, and conclusions. Reviewers read them looking for oversights, unfair influences, fraud, or mistakes in techniques or reasoning. They provide expert assessment of the work to ensure that the highest standards of quality are met. Peer review does not guarantee that a piece of work is correct, but it does certify that the work meets standards set by the scientific community.

Sharing Knowledge and New Ideas Once research has been published, it enters the dynamic marketplace of scientific ideas, as shown in Figure 1–8. How do new findings fit into existing scientific understanding? Perhaps they spark new questions. For example, the finding that growth of salt marsh grasses is limited by available nitrogen suggests other hypotheses: Is the growth of other plants in the same habitat also limited by nitrogen? What about the growth of different plants in similar environments, such as the mangrove swamp shown in Figure 1–9? Each of these logical and important questions leads to new hypotheses that must be independently confirmed by controlled experiments.

In Your Notebook Predict what might happen if an article is published without undergoing peer review.

Answers

FIGURE 1–9 Sample answer: I would set up a controlled experiment in which extra nitrogen was supplied to a group of mangrove seedlings. I would then compare the growth of these seedlings over time to the growth of mangrove seedlings grown using the same concentration of nitrogen as in the salt marsh.

IN YOUR NOTEBOOK An article published without undergoing peer review might contain oversights or mistakes in techniques or reasoning. The research could also be fraudulent or biased.

ONE-MINUTE RESPONSE

Give students about a minute to write a quick response to the following:

• Why is peer review an important part of communicating scientific results?

ADJUST INSTRUCTION

If students do not understand the importance of peer review, discuss the consequences of inaccurate or fraudulent scientific papers being published. Then, have them write a sentence that summarizes the impact this would have on the advancement of science.
Lead a Discussion
Have students discuss the difference between the everyday use of the word *theory* and the scientific use of the word *theory*.

**Ask** How does the everyday use of the word *theory* influence how people think about scientific theories? (Sample answer: Many people perceive scientific theories to be simply ideas or hunches, based on the everyday use of the word *theory.*)

**Ask** In your own words, how would you explain to a friend that a scientific theory is more than a hunch or an idea? (Sample answer: When the word *theory* is used in science, it refers to an idea that has been thoroughly tested and is supported by a great deal of evidence.)

**DIFFERENTIATED INSTRUCTION**

**Less Proficient Readers** Have students fill out a Main Ideas and Details Chart to help them organize the information about scientific theories. Write the following main ideas on the board:

- The scientific use of the word *theory* is different from its everyday use.
- In science, a theory is a well-tested explanation.
- Theories can be revised or replaced.

Have students write these main ideas on their chart. Then, ask them to add at least two details for each main idea in the chart. Call on volunteers to share some of their details with the class.

**Study Wkbs A/B, Appendix S28, Main Ideas and Details Chart. Transparencies, GO13.**

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**Quick Lab**

**Purpose** Students will explain why the replication of scientific procedures depends on clear, detailed instructions.

**Materials** screen, blocks

**Planning** Set up the classroom so that students can work on their structures out of sight. Possible “screens” include cardboard boxes and posterboards.

**Replicating Procedures**

1. Working with a partner behind a screen, assemble ten blocks into an unusual structure. Write directions that others can use to replicate that structure without seeing it.

2. Exchange directions with another team. Replicate the team’s structure by following its directions.

3. Compare each replicated structure to the original. Identify which parts of the directions were clear and accurate, and which were unclear or misleading.

**Scientific Theories**

1. **What is a scientific theory?**

   Evidence from many scientific studies may support several related hypotheses in a way that inspires researchers to propose a scientific theory that ties those hypotheses together. As you read this book, you will often come across terms that will be new to you because they are used only in science. But the word *theory* is used both in science and in everyday life. It is important to understand that the meaning you give the word *theory* in daily life is very different from its meaning in science. When you say, “I have a theory,” you may mean, “I have a hunch.” When a friend says, “That’s just a theory” she may mean, “People aren’t too certain about that idea.” In those same situations, a scientist would probably use the word *hypothesis*. But when scientists talk about gravitational theory or evolutionary theory, they mean something very different from hunch or hypothesis.

2. **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.** Charles Darwin’s early observations and hypotheses about change over time in nature, for example, grew and expanded for years before he collected them into a theory of evolution by natural selection. Today, evolutionary theory is the central organizing principle of all biological and biomedical science. It makes such a wide range of predictions about organisms—from bacteria to whales to humans—that it is mentioned throughout this book.

   A useful theory that has been thoroughly tested and supported by many lines of evidence may become the dominant view among the majority of scientists, but no theory is considered absolute truth. Science is always changing; as new evidence is uncovered, a theory may be revised or replaced by a more useful explanation.

**ANALYZE AND CONCLUDE**

1. **Answers will vary.** Students should identify additional details or more precise language that would have improved the directions provided to their partners.

2. Scientists would not be able to verify findings if they could not replicate an experiment. Results of scientific studies must be replicable to be accepted. Replication would not be possible without carefully written directions.
Connect to the Real World

Use several of the topics relating to social issues raised in the first paragraph to start a discussion of the role science plays in personal/public health and environmental issues.

Ask How does science influence society? (Sample answer: Scientific data helps provide answers to questions that affect everyday lives.)

Help students understand that scientists do not work in a vacuum. Instead, their research is strongly influenced by society.

Ask How does society influence science? (Sample answer: Society can limit the application of scientific ideas, especially if new scientific ideas conflict with prevailing cultural beliefs.)

DIFFERENTIATED INSTRUCTION

Advanced Students Have students research a historical example of how scientific advancement was impeded by the society in which a scientist lived. For example, students might research Galileo, Copernicus, Wegener, or Darwin to find out how the acceptance of ideas was influenced by prevailing social beliefs and attitudes. Ask students to discuss their research and describe how—or if—this same situation applies today.

Science and Society

What is the relationship between science and society?

Make a list of health-related things that you need to understand to protect your life and the lives of others close to you. Your list may include drugs and alcohol, smoking and lung disease, AIDS, cancer, and heart disease. Other topics focus on social issues and the environment. How much of the information in your genes should be kept private? Should communities produce electricity using fossil fuels, nuclear power, solar power, wind power, or hydroelectric dams? How should chemical wastes be disposed of?

All these questions require scientific information to answer, and many have inspired important research. But none of these questions can be answered by science alone. These questions involve the society in which we live, our economy, and our laws and moral principles.

Using science involves understanding its context in society and its limitations. Figure 1–10 shows the role science plays in society.

Science, Ethics, and Morality When scientists explain “why” something happens, their explanation involves only natural phenomena. Pure science does not include ethical or moral viewpoints. For example, biologists try to explain in scientific terms what life is, how life operates, and how life has changed over time. But science cannot answer questions about why life exists or what the meaning of life is.

Similarly, science can tell us how technology and scientific knowledge can be applied but not whether it should be applied in particular ways. Remember these limitations when you study and evaluate science.

Avoiding Bias The way that science is applied in society can be affected by bias. A bias is a particular preference or point of view that is personal, rather than scientific. Examples of biases include personal taste, preferences for someone or something, and societal standards of beauty.

Science aims to be objective, but scientists are human, too. They have likes, dislikes, and occasional biases. So, it shouldn’t surprise you to discover that scientific data can be misinterpreted or misapplied by scientists who want to prove a particular point. Recommendations made by scientists with personal biases may or may not be in the public interest. But if enough of us understand science, we can help make certain that science is applied in ways that benefit humanity.

Answers

Figure 1–10 Sample answer: Yes, I think shellfish should be routinely screened for toxins because shellfish are an important source of food for many people. Without routine screening to check for toxins, many people could get sick or even die.
Understanding and Using Science  Science will keep changing as long as humans keep wondering about nature. We invite you to join us in that wonder and exploration as you read this book. Think of this text, not as an encyclopedia, but as a “user’s guide” to the study of life. Don’t just memorize today’s scientific facts and ideas. And please don’t believe them! Instead, try to understand how scientists developed those ideas. Try to see the thinking behind experiments we describe. Try to pose the kinds of questions scientists ask.

If you learn to think as scientists think, you will understand the process of science and be comfortable in a world that will keep changing throughout your life. Understanding science will help you make complex decisions that also involve cultural customs, values, and ethical standards.

Furthermore, understanding biology will help you realize that we humans can predict the consequences of our actions and take an active role in directing our future and that of our planet. In our society, scientists make recommendations about big public policy decisions, but they don’t make the decisions. Who makes the decisions? Citizens of our democracy do. In a few years, you will be able to exercise the rights of a voting citizen, influencing public policy by the ballots you cast and the messages you send public officials. That’s why it is important that you understand how science works and appreciate both the power and the limitations of science.

1.2 Assessment

Review Key Concepts  

1. a. **Review** List the attitudes that lead scientists to explore and discover.
   b. **Explain** What does it mean to describe a scientist as skeptical? Why is skepticism an important quality in a scientist?

2. a. **Review** What is peer review?
   b. **Apply Concepts** An advertisement claims that studies of a new sports drink show it boosts energy. You discover that none of the study results have been peer-reviewed. What would you tell consumers who are considering buying this product?

3. a. **Review** What is a scientific theory?
   b. **Compare and Contrast** How does use of the word *theory* differ in science and in daily life?

4. a. **Review** How is the use of science related to its context in society?
   b. **Explain** Describe some of the limitations of science.
   c. **Apply Concepts** A study shows that a new pesticide is safe for use on food crops. The researcher who conducted the study works for the pesticide company. What potential biases may have affected the study?

5. **Big Idea** *Science as a Way of Knowing*
   
   **Apply the Big Idea**
   
   **Question 1b,** have them review their answer to the In Your Notebook question on page 11.

   **Sample answer:** Science does not include ethical or moral viewpoints. It may also be influenced by bias.

   **Sample answer:** The scientist might be biased by ties to the pesticide company.

   **Sample answer:** It is important to know what questions science cannot answer.

   **Sample answer:** It helps you assess the validity of the ideas.

**Lead a Discussion**

Discuss why science is important for all individuals. Ask students why it is important to understand how scientific ideas are developed. (Sample answer: It helps you assess the validity of the ideas.) Discuss why knowing the limitations of science is also important. (Sample answer: It is important to know what questions science cannot answer.)

**Assess and RemEDIATE**

**Evaluate Understanding**

Have each student choose a main topic from the lesson and prepare a brief summary of it. Call on students to share their summaries with the class. Then, have them complete the 1.2 Assessment.

**Remediation Suggestion**

**Struggling Students** If students are struggling with Question 1b, have them review their answer to the In Your Notebook question on page 11.

**Sample answer:** Science does not include ethical or moral viewpoints. It may also be influenced by bias.

**Sample answer:** The scientist might be biased by ties to the pesticide company.

**Sample answer:** It is important to know what questions science cannot answer.

**Sample answer:** It helps you assess the validity of the ideas.

**Sample answer:** It is important to know what questions science cannot answer.

**Sample answer:** It helps you assess the validity of the ideas.
CHAPTER FEATURE

Lead a Discussion

After students have read the feature, discuss their opinions about the funding of product safety studies.

Ask What is an advantage of having independent organizations fund product safety studies? (Sample answer: Independent organizations are less likely to be biased about a product’s safety.)

Ask What is an advantage of having private industry fund product safety studies? (Sample answer: Companies would do a better job testing their products than an independent agency, because their company’s reputation is at stake.)

Ask How does knowledge of scientific attitudes and methodology affect the way you evaluate product safety information? (Sample answer: Scientific attitudes, especially open-mindedness and skepticism, are vital when evaluating information about product safety. Knowledge of scientific methodology allows me to evaluate the studies performed on products.)

Who Should Fund Product Safety Studies?

Biology plays a major role in the research, development, and production of food, medicine, and other consumer items. Companies that make these items profit by selling reliable and useful products in the marketplace. For example, the plastics industry provides countless products for everyday use.

But sometimes questions arise concerning product safety. Bisphenol-A (BPA), for instance, is a chemical found in hard plastics. Those plastics are used to make baby bottles, reusable water bottles, and the linings of many food and soft drink cans. Is BPA safe? This type of question can be posed as a scientific hypothesis to be tested. But who does the testing? Who funds the studies and analyzes the results?

Ideally, independent scientists test products for safety and usefulness. That way, the people who gather and analyze data can remain objective—they have nothing to gain by exaggerating the positive effects of products and nothing to lose by stating any risks. However, scientists are often hired by private companies to develop or test their products.

Often, test results are clear: A product is safe or it isn’t. Based on these results, the Food and Drug Administration (FDA) or another government agency makes recommendations to protect and promote public health. Sometimes, though, results are tough to interpret.

More than 100 studies have been done on BPA—some funded by the government, some funded by the plastics industry. Most of the independent studies found that low doses of BPA could have negative health effects on laboratory animals. A few studies, mostly funded by the plastics industry, concluded that BPA is safe. In this case, the FDA ultimately declared BPA to be safe. When the issue of BPA safety hit the mass media, government investigations began. So, who should sponsor product safety studies?

Research and Decide

1. Analyze the Viewpoints  To make an informed decision, research the current status of the controversy over BPA by using the Internet and other resources. Compare this situation with the history of safety studies on cigarette smoke and the chemical Teflon.

2. Form an Opinion  Should private industries be able to pay scientists to perform their product safety studies? How would you deal with the issue of potential bias in interpreting results?

The Viewpoints

Independent Organizations Should Fund Safety Studies

Scientists performing safety studies should have no affiliation with private industries, because conflict of interest seems unavoidable. A company, such as a BPA manufacturer, would naturally benefit if its product is declared to be safe. Rather, safety tests should be funded by independent organizations such as universities and government agencies, which should be as independent as possible. This way, recommendations for public health can remain free of biases.

Private Industries Should Fund Safety Studies

There are an awful lot of products out there! Who would pay scientists to test all those products? There are simply too many potentially useful and valuable products being developed by private industry for the government to keep track of and test adequately. Public funds are not available. It is in a company’s best interest to produce safe products, so it would be inclined to maintain high standards and perform rigorous tests.

Quick Facts

WHAT IS THE U.S. CONSUMER PRODUCT SAFETY COMMISSION?

The U.S. Consumer Product Safety Commission is an agency of the U.S. government that deals with the safety of many products that people use every day. It is an independent agency within the government. Its responsibilities include helping develop voluntary standards that can be followed by manufacturers, collecting information about injuries and other harm caused by consumer products, researching potentially hazardous products, and issuing recalls for products that are hazardous. Individuals who have been harmed by a consumer product can contact the U.S. Consumer Product Safety Commission to report the incident. The agency’s Web site offers updated information about product recalls and safety issues.
1.3 Studying Life

THINK ABOUT IT Think about important and exciting news stories you’ve seen or heard. Bird flu spreads around the world, killing thousands of birds and threatening a human epidemic. Users of certain illegal drugs experience permanent damage to their brains and other parts of their nervous systems. Reports surface about efforts to clone human cells to grow new organs to replace those lost to disease or injury. These and many other stories involve biology—the science that employs scientific methodology to study living things. (The Greek word bios means “life,” and -logy means “study of.”)

Characteristics of Living Things

What characteristics do all living things share?

Biology is the study of life. But what is life? What distinguishes living things from nonliving matter? Surprisingly, it isn’t as simple as you might think to describe what makes something alive. No single characteristic is enough to describe a living thing. Also, some nonliving things share one or more traits with organisms. For example, a firefly and fire both give off light, and each moves in its own way. Mechanical toys, automobiles, and clouds (which are not alive) move around, while mushrooms and trees (which are alive) stay in one spot. To make matters more complicated, some things, such as viruses, exist at the border between organisms and nonliving things.

Despite these difficulties, we can list characteristics that most living things have in common. Living things are made up of basic units called cells, are based on a universal genetic code, obtain and use materials and energy, grow and develop, reproduce, respond to their environment, maintain a stable internal environment, and change over time.

FIGURE 1–12 Is It Alive? The fish are clearly alive, but what about the colorful structure above them? Is it alive? As a matter of fact, it is. The anemone-like structure is actually a marine animal called elkhorn coral. Corals show all the characteristics common to living things.

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THE CHARACTERISTICS OF LIVING THINGS

FIGURE 1–13

Apple trees share certain characteristics with other living things. Compare and Contrast How are the apple tree and the grass growing below similar? How are they different?

Living things are based on a universal genetic code. All organisms store the complex information they need to live, grow, and reproduce in a genetic code written in a molecule called DNA. That information is copied and passed from parent to offspring. With a few minor variations, life's genetic code is almost identical in every organism on Earth.

Living things grow and develop. Every organism has a particular pattern of growth and development. During development, a single fertilized egg divides again and again. As these cells divide, they differentiate, which means they begin to look different from one another and to perform different functions.

Living things respond to their environment. Organisms detect and respond to stimuli from their environment. A stimulus is a signal to which an organism responds.

Answers

FIGURE 1–13 Sample answer: The apple tree and the grass are similar in that both contain DNA, are made of cells, reproduce, grow and develop, use materials and energy, respond to their environment, and maintain a stable environment; they differ in that an apple tree contains many more cells than an individual grass plant.

How Science Works

A CONSTANT “INTERNAL MILIEU”

In 1851, French physiologist Claude Bernard discovered that nerves in an animal’s body control the dilation and constriction of blood vessels. He observed that on hot days the blood vessels of the skin become dilated, whereas on cold days those same blood vessels become constricted. Bernard explained that these changes functioned to regulate body temperature. He concluded that, even when the external environment changes, an animal has a way of maintaining a constant “internal milieu.” His concept of the maintenance of an internal balance within an organism is incorporated in the modern concept of homeostasis, which literally means “same condition.”
**Expand Vocabulary**

Point out that the paragraphs describing the characteristics of living things in Figure 1–13 contain the majority of this lesson’s vocabulary terms. Have students work with a partner to make a flash card for each vocabulary term found on these two pages. Then, have students use the flash cards to review the definitions of the terms with their partner.

**DIFFERENTIATED INSTRUCTION**

**ELL English Language Learners** Pair students learning English with native English speakers for the activity described above. Encourage these pairs to focus on proper pronunciation of the terms in addition to their definitions. Circulate among pairs, and ask English language learners to share words and definitions with you.

**ELL Advanced Students** Those students who can easily learn the definitions of the vocabulary terms on these pages should be encouraged to use the index of this book to find out what chapters will further explore each of the vocabulary terms. For example, if a student looks up the term DNA in the index, he or she will note that DNA will be further discussed in chapters relating to the chemistry of life, genetics, biotechnology, and classification. Ask students to anticipate some of the topics related to each vocabulary term that they will learn about as they read the book.

**ELL Focus on ELL: Build Background**

**ALL SPEAKERS** Have students use the information in Figure 1–13 to develop a class bulletin board on the characteristics of living things. Suggest that beginning and intermediate speakers draw or find visuals that represent each of the eight characteristics. Have these students work with advanced and advanced high speakers to write captions for each visual. The caption should explain how the visual showcases a particular characteristic of life. Ask advanced high students to write short summaries of each characteristic to help organize the bulletin board.

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**Check for Understanding**

**USE VOCABULARY**

Have students make a crossword puzzle that includes each of the lesson vocabulary terms included in Figure 1–13. The clues for each term should be scientifically accurate and based on the definitions given in the text.

**ADJUST INSTRUCTION**

Collect the crossword puzzles and redistribute them at random. Ask students to complete the crossword puzzle they have been given. Then, have students return the crossword puzzle to the student who made it and talk about any clues they had difficulty matching a term with.
LESSON 1.3

Build Study Skills

Explain that the ten Big Ideas, or central themes, in the study of biology are the overarching ideas found throughout this book. Point out to students that an understanding of these Big Ideas will allow them to relate the specific information in each chapter to a larger, more general concept. Divide the class into ten groups, and assign each group one of the Big Ideas. Have groups prepare a short, creative, memorable presentation to share the information with the rest of the class. Each presentation should include a reference to one or more of the later chapters in the book that are related to the group’s Big Idea. Point out that each chapter’s Big Idea is listed on the first page of the chapter. Have groups make their presentations to the class.

DIFFERENTIATED INSTRUCTION

Less Proficient Readers Students who struggle to read the text associated with each Big Idea should be encouraged to work in pairs to understand the description of each Big Idea. Suggest that pairs work through the Big Ideas one by one, taking the time to discuss each one before moving on to the next.

Answers

IN YOUR NOTEBOOK Sample answer: As a baby grows and develops, generalized cells become more different and specialized for particular functions.

Big Ideas in Biology

What are the central themes of biology?

The units of this book seem to cover different subjects. But we’ll let you in on a secret: That’s not how biology works. All biological sciences are tied together by themes and methods of study that cut across disciplines. These “big ideas” overlap and interlock, and crop up again and again throughout the book. You’ll also notice that several of these big ideas overlap with the characteristics of life or the nature of science.

The study of biology revolves around several interlocking big ideas: The cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; evolution; structure and function; unity and diversity of life; interdependence in nature; and science as a way of knowing.

Big Idea Cellular Basis of Life Living things are made of cells. Many living things consist of only a single cell; they are called unicellular organisms. Plants and animals are multicellular. Cells in multicellular organisms display many different sizes, shapes, and functions. The human body contains 200 or more different cell types.

Big Idea Information and Heredity Living things are based on a universal genetic code. The information coded in DNA forms an unbroken chain that stretches back roughly 3.5 billion years. Yet, the DNA inside your cells right now can influence your future—your risk of getting cancer, the amount of cholesterol in your blood, and the color of your children’s hair.

Big Idea Matter and Energy Living things obtain and use material and energy. Life requires matter that serves as nutrients to build body structures, and energy that fuels life’s processes. Some organisms, such as plants, obtain energy from sunlight and take up nutrients from air, water, and soil. Other organisms, including most animals, eat plants or other animals to obtain both nutrients and energy. The need for matter and energy link all living things on Earth in a web of interdependent relationships.

Big Idea Growth, Development, and Reproduction All living things reproduce. Newly produced individuals are virtually always smaller than adults, so they grow and develop as they mature. During growth and development, generalized cells typically become more and more different and specialized for particular functions. Specialized cells build tissues, such as brains, muscles, and digestive organs, that serve various functions.

Big Idea Homeostasis Living things maintain a relatively stable internal environment, a process known as homeostasis. For most organisms, any breakdown of homeostasis may have serious or even fatal consequences.

In Your Notebook Describe what happens at the cellular level as a baby grows and develops.

Answers

1. leaves

2. Sample answer: Siamang gibbons are dependent on the trees in the rainforest, because most of their diet is made up of plant material. Therefore, these animals would not be able to get the food they need if the rainforest were cut down.
Evolutionary theory is the central organizing principle of all biological sciences. Evolutionary change links all forms of life to a common origin more than 3.5 billion years ago. Evidence of this shared history is found in all aspects of living and fossil organisms, from physical features to structures of proteins to sequences of information in DNA. Evolutionary theory is the central organizing principle of all biological and biomedical sciences.

Each major group of organisms has evolved its own particular body part “tool kit,”—a collection of structures that have evolved in ways that make particular functions possible. From capturing food to digesting it, and from reproducing to breathing, organisms use structures that have evolved into different forms as species have adapted to life in different environments. The structures of wings, for example, enable birds and insects to fly. The structures of legs enable horses to gallop and kangaroos to hop.

Although life takes an almost unbelievable variety of forms, all living things are fundamentally similar at the molecular level. All organisms are composed of a common set of carbon-based molecules, store information in a common genetic code, and use proteins to build their structures and carry out their functions. One great contribution of evolutionary theory is that it explains both this unity of life and its diversity.

All forms of life on Earth are connected into a biosphere, which literally means “living planet.” Within the biosphere, organisms are linked to one another and to the land, water, and air around them. Relationships between organisms and their environments depend on the cycling of matter and the flow of energy. Human life and the economies of human societies also require matter and energy, so human life depends directly on nature.

Science is not a list of facts, but “a way of knowing.” The job of science is to use observations, questions, and experiments to explain the natural world in terms of natural forces and events. Successful scientific research reveals rules and patterns that can explain and predict at least some events in nature. Science enables us to take actions that affect events in the world around us. To make certain that scientific knowledge is used for the benefit of society, all of us must understand the nature of science—its strengths, its limitations, and its interactions with our culture.

**Figure 1–14 Different But Similar**
The colorful keel-billed toucan is clearly different from the plant on which it perches. Yet, the two organisms are fundamentally similar at the molecular level. Unity and diversity of life is an important theme in biology.

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**Build Reading Skills**
Suggest students use an outline to organize the information in **Big Ideas in Biology**. Model this for students by writing Cellular Basis of Life on the board. Under this, write the most important details from the paragraph in the text, such as “Living things are made of cells,” and “Some organisms consist of a single cell; others are made up of many cells.” Have students outline the remaining nine big ideas using the same format.

**Differentiated Instruction**

- **Struggling Students** Provide students with a prepared outline that includes the ten Big Ideas with several blank write-on lines below each one. Tell them to write important details about each Big Idea on the lines. Encourage students to rephrase information in their own words rather than copying information directly from the text.

- **Advanced Students** After students have completed their outlines, suggest they consider a topic of personal interest in biology, for example, biotechnology or insects. Then, have them write a paragraph identifying how at least two of the Big Ideas are related to their topic of interest. Have students share their paragraphs with the class.

**Mystery Clue**
Talk about how values and biases are part of the decision to give healthy children HGH. Students’ responses should reflect an understanding of the term bias. When talking about the role of science in this decision, guide students to understand that, while the role of pure science is to determine what can be done, considering what should be done is an important step. Students can go online to Biology.com to gather their evidence.

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**Check for Understanding**

**INDEX CARD SUMMARIES/QUESTIONS**
Give each student an index card. Ask them to identify and describe one of the Big Ideas in biology that they understand on the front of the card. Then, have them identify one Big Idea they do not understand and write it on the back of the card in the form of a question.

**ADJUST INSTRUCTION**
Note the Big Ideas that are causing confusion for most students. Select those Big Ideas as the topic of a review discussion in which a volunteer reads aloud information about the Big Idea and students are encouraged to ask questions they have about that Big Idea.
Global Ecology
Life on Earth is shaped by weather patterns and processes in the atmosphere so large that we are just beginning to understand them. We are also learning that activities of living organisms—including humans—profoundly affect both the atmosphere and climate. Humans now move more matter and use more energy than any other multicellular species on Earth. Global ecological studies, aided by satellite technology and supercomputers, are enabling us to learn about our global impact, which affects all life on Earth.

An ecologist studies lichens on Douglas fir. Many lichens are extremely sensitive to nitrogen- and sulfur-based air pollution. Thus, researchers often monitor lichens in efforts to study the effects of air pollution on forest health.

Fields of Biology
How do different fields of biology differ in their approach to studying life?
Living systems range from groups of molecules that make up cells to collections of organisms that make up the biosphere. Biology includes many overlapping fields that use different tools to study life from the level of molecules to the entire planet. Here’s a peek into a few of the smallest and largest branches of biology.

Connect to the Real World
Use the information on these two pages to encourage students’ exploration of careers in biology or science in general. Challenge them to think beyond the stereotype of scientists in white coats working in a laboratory setting. Invite a school guidance counselor to speak to the class about careers in science. Encourage students to prepare questions for the guidance counselor about science careers and the required educational preparation for those careers.

DIFFERENTIATED INSTRUCTION

Special Needs Help special needs students learn about biology careers in various fields, including ecology, plant biology, paleontology, wildlife biology, and molecular biology. Make a matching activity in which students match these careers with their descriptions. Write the name of each career on a separate index card. Then, write a description of each career on another set of index cards. Have students match the careers and their descriptions. Finally, ask them to brainstorm a list of other careers in science.

English Language Learners Suggest students read the information on the different fields of biology one by one. Discuss each field with them before moving on to the next. Ask them what aspects of these fields they are most curious about. Then, have them generate one or two written questions they would like to ask a guidance counselor about careers in these fields. Encourage students to practice asking their questions aloud before the guidance counselor’s visit.

Quick Facts
BRANCHES OF BIOLOGY
The branches of biology are numerous. Zoologists, botanists, paleontologists, and ethologists are just a few of the great variety of biologists. Other biologists include biochemists, geneticists, cytologists, ecologists, and microbiologists. Biochemists study the chemistry of living things. Geneticists study heredity and variation among organisms. Cytologists, or cell biologists, study the structure and function of cells. Ecologists study the interactions of organisms in ecosystems. Microbiologists study the structure and function of microorganisms. The list goes on, and those mentioned are just the biologists who pursue knowledge in what is sometimes called theoretical science. There are also many biologists who work in applied or practical science, including physicians, medical researchers, wildlife managers, foresters, and agricultural researchers, to name just a few.
Biotechnology  This field, created by the molecular revolution, is based on our ability to “edit” and rewrite the genetic code—in a sense, redesigning the living world to order. We may soon learn to correct or replace damaged genes that cause inherited diseases. Other research seeks to genetically engineer bacteria to clean up toxic wastes. Biotechnology also raises enormous ethical, legal, and social questions. Dare we tamper with the fundamental biological information that makes us human?

- A plant biologist analyzes genetically modified rice plants.

Building the Tree of Life  Biologists have discovered and identified roughly 1.8 million different kinds of living organisms. That may seem like an incredible number, but researchers estimate that somewhere between 2 and 100 million more forms of life are waiting to be discovered around the globe—from caves deep beneath the surface, to tropical rainforests, to coral reefs and the depths of the sea. Identifying and cataloguing all these life forms is enough work by itself, but biologists aim to do much more. They want to combine the latest genetic information with computer technology to organize all living things into a single universal “Tree of All Life”—and put the results on the Web in a form that anyone can access.

- A paleontologist studies signs of ancient life—fossilized dinosaur dung!

Ecology and Evolution of Infectious Diseases  HIV, bird flu, and drug-resistant bacteria seem to have appeared out of nowhere, but the science behind their stories shows that relationships between hosts and pathogens are dynamic and constantly changing. Organisms that cause human disease have their own ecology, which involves our bodies, medicines we take, and our interactions with each other and the environment. Over time, disease-causing organisms engage in an “evolutionary arms race” with humans that creates constant challenges to public health around the world. Understanding these interactions is crucial to safeguarding our future.

- A wildlife biologist studies a group of wild gelada baboons. Pathogens in wild animal populations may evolve in ways that enable them to infect humans.

Genomics and Molecular Biology  These fields focus on studies of DNA and other molecules inside cells. The “molecular revolution” of the 1980s created the field of genomics, which is now looking at the entire sets of DNA code contained in a wide range of organisms. Evermore-powerful computer analyses enable researchers to compare vast databases of genetic information in a fascinating search for keys to the mysteries of growth, development, aging, cancer, and the history of life on Earth.

- A molecular biologist analyzes a DNA sequence.

Lead a Discussion

Point out that some fields of biology described on these pages, such as genomics and molecular biology, did not exist until relatively recently. The development of new technology was instrumental in their creation. Other fields of biology described here, such as paleontology, have existed for many years, although they have been changed dramatically by new technology, as well.

Ask  What are some ways that scientists in the fields of biology described on these pages use technology? (Sample answers: Molecular biologists use computers to analyze DNA sequences. Global ecologists use satellites to gather data.) Then, have students consider how the fields of biology described here are interconnected.

Ask  How could a wildlife biologist use information generated by a molecular biologist? (Sample answer: A wildlife biologist could use information generated by a molecular biologist to find out if two similar-appearing species are genetically related.)

DIFFERENTIATED INSTRUCTION

- Less Proficient Readers  Use the photos on these pages to launch a discussion of fields of biology. Call on students to describe what they see in each picture. After students describe what they see, have them read the italicized sentence related to the photo. Then, ask them to use the picture, discussion, and sentence to write a sentence in their own words about each field of biology.

**Check for Understanding**

**QUESTION BOARD**

Establish a section of a bulletin board or white board in the classroom to be used by students to post anonymous questions about careers in biology or identify fields of biology about which they would like to learn more.

**ADJUST INSTRUCTION**

Read over students’ questions to identify common questions or topics of interest. Select several of these as topics for class discussion. Carefully examine the questions to determine if students have any misconceptions about the fields of biology described in the text. If so, address those by helping students review the correct information in the text.
**Build Math Skills**

Tell students that using the metric system often involves conversions between metric units. For example, a measurement made in centimeters might need to be expressed in meters. To reinforce students’ ability to convert between units, write the following problems on the board:

- 1 kilometer = ? meters (1000)
- 0.45 liter = ? milliliters (450)
- 5000 milligrams = ? grams (5)
- 130 meters = ? kilometers (0.13)
- 2500 milliliters = ? liters (2.5)
- 0.017 grams = ? milligrams (17)

Challenge students to calculate the answers to these conversion problems.

**DIFFERENTIATED INSTRUCTION**

**ELL Special Needs** Have students fold a piece of paper in half horizontally and then vertically to form four equal-sized squares. In each of the four squares, have them write one of the following terms: length, mass, volume, and temperature. Then, have them write the name of the metric unit used for each quantity in the appropriate box. Students can add pictures of tools used to measure each quantity or other visual reminders that help them remember this information.

**ELL English Language Learners** Students who have recently moved to the U.S. may be more familiar with the metric system than students who have received most of their education in the U.S. Encourage these students to be the class “experts” on the metric system, by teaching a short lesson about it or by helping other students with the conversion problems listed above.

Have students access Data Analysis: Adventures in Measurement to explore strategies used by scientists when direct measurement is difficult.

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**Answers**

**FIGURE 1–15** The polar bear’s mass would be expressed in kilograms.

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**Performing Biological Investigations**

**How is the metric system important in science?**

During your study of biology, you will have the opportunity to perform scientific investigations. Biologists, like other scientists, rely on a common system of measurement and practice safety procedures when conducting studies. As you study and experiment, you will become familiar with scientific measurement and safety procedures.

**Scientific Measurement** Because researchers need to replicate one another’s experiments, and because many experiments involve gathering quantitative data, scientists need a common system of measurement. **Most scientists use the metric system when collecting data and performing experiments.** The metric system is a decimal system of measurement whose units are based on certain physical standards and are scaled on multiples of 10. A revised version of the original metric system is called the International System of Units, or SI. The abbreviation SI comes from the French *Le Système International d’Unités*.

Because the metric system is based on multiples of 10, it is easy to use. Notice in **Figure 1–15** how the basic unit of length, the meter, can be multiplied or divided to measure objects and distances much larger or smaller than a meter. The same process can be used when measuring volume and mass. You can learn more about the metric system in Appendix B.

**Quick Facts**

**THE INTERNATIONAL SYSTEM OF UNITS**

The International Bureau of Weights and Measures, located near Paris, France, oversees the SI system of measurement. The Bureau recognizes seven official base units—meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (temperature), candela (luminous intensity), and mole (amount of substance). Derived units are those that involve more than one base unit. For example, force is expressed in newtons, a unit derived using meters, kilograms, and seconds. Like all aspects of science, the base units and derived units recognized by the International Bureau of Weights and Measures are subject to additions and modifications as new technology and fields of scientific inquiry emerge.
Safety  Scientists working in a laboratory or in the field are trained to use safe procedures when carrying out investigations. Laboratory work may involve flames or heating elements, electricity, chemicals, hot liquids, sharp instruments, and breakable glassware. Laboratory work and fieldwork may involve contact with living or dead organisms—not just potentially poisonous plants and venomous animals but also disease-carrying mosquitoes and water contaminated with dangerous microorganisms.

Whenever you work in your biology laboratory, you must follow safe practices as well. Careful preparation is the key to staying safe during scientific activities. Before performing any activity in this course, study the safety rules in Appendix B. Before you start each activity, read all the steps and make sure that you understand the entire procedure, including any safety precautions.

The single most important safety rule is to always follow your teacher's instructions and directions in this textbook. Any time you are in doubt about any part of an activity, ask your teacher for an explanation. And because you may come in contact with organisms you cannot see, it is essential that you wash your hands thoroughly after every scientific activity. Remember that you are responsible for your own safety and that of your teacher and classmates. If you are handling live animals, you are responsible for their safety too.

Assessment Answers

1a. Living things are made up of one or more basic units called cells, are based on a universal genetic code, obtain and use material and energy, grow and develop, reproduce, respond to their environment, maintain a stable internal environment, and, as a group, change over time.

1b. A stimulus is a signal to which an organism responds. In this case, hunger is an internal stimulus, and the sight of the plum is an external stimulus.

2a. the cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; evolution; structure and function; unity and diversity of life; interdependence in nature; and science as a way of knowing

2b. Like all organisms, this newly discovered organism would consist of cells.

3a. Biologists study life from the level of molecules to the entire planet.

3b. Acceptable answers include ecology and wildlife biology.

4a. Scientists use a common system of measurement because they need to be able to replicate each other's work, and many experiments involve quantitative data.

4b. Sample answer: If these scientists did not use a common system of measurement, they could inadvertently mix the wrong quantities of chemicals, which could potentially be dangerous.

5. 2.5 kg
Pre-Lab
Introduce students to the concepts they will explore in the chapter lab by assigning the Pre-Lab questions.

Lab
Tell students they will perform the chapter lab Using a Microscope to Estimate Size described in Lab Manual A.

Struggling Students
A simpler version of the chapter lab is provided in Lab Manual B.

SAFETY
Students should use caution when handling the microscope slides.

Look online for Editable Lab Worksheets.

For corresponding pre-lab in the Foundation Edition, see page 20.

NATIONAL SCIENCE EDUCATION STANDARDS
UCP III INQUIRY A.1.c, A.2.c, A.2.d

Pre-Lab: Using a Microscope to Estimate Size

Problem How can you use a microscope to estimate the size of an object?

Materials compound microscope, transparent 15-cm plastic ruler, prepared slide of plant root or stem, prepared slide of bacteria

Lab Manual Chapter 1 Lab
Skills Focus Observe, Measure, Calculate, Predict

Connect to the Big idea: Science provides a way of knowing the world. The use of technology to gather data is a central part of modern science. In biology, the compound microscope is a vital tool. With a microscope, you can observe objects that are too tiny to see with the unaided eye. These objects include cells, which are the basis for all life.

In this lab, you will explore another important use of the microscope. You will use the microscope to estimate the size of cells.

Background Questions
a. Explain How did the invention of the microscope help scientists know the natural world?
b. Explain How can a microscope help a scientist use scientific methodology?
c. Infer List one important fact about life that scientists would not know without microscopes. Hint: Review the characteristics of living things.

Pre-Lab Questions
Preview the procedure in the lab manual.

1. Review Which lens provides more magnification—a low-power lens or a high-power lens? Which lens provides the larger field of view?

2. Use Analogies A photographer may take wide views and close-ups of the same scene. How are these views similar to the low-power and high-power lenses on a microscope? What is an advantage of each view?

3. Calculate Eight cells fit across a field of view of 160 μm. What is the width of each cell?

4. Predict Which cell do you think will be larger, the plant cell or the bacterial cell? Give a reason for your answer.

PRE-LAB QUESTIONS
1. The high-power lens provides more magnification. The low-power lens provides the larger field of view.

2. A wide view and low power can show the relationship between objects in space. A close-up and high-power can reveal more details about an object’s structure.

3. 20 μm

4. Accept any answer for which a student provides a reason. For example, some students may predict that plant cells are smaller because a plant has more than one cell.

Pre-Lab Answers

BACKGROUND QUESTIONS
a. Sample answer: Microscopes allowed scientists to gather information about parts of the natural world that they could not previously observe.

b. Most students will say that microscopes help scientists observe and collect data. Some may know that microscopes can be used to conduct experiments.

c. Sample answer: Living things are made up of units called cells.
1 Study Guide

**Big Idea** Science as a Way of Knowing

By applying scientific methodology, biologists can find answers to questions that arise in the study of life.

### 1.1 What Is Science?

- One goal of science is to provide natural explanations for events in the natural world. Science also aims to use those explanations to understand patterns in nature and to make useful predictions about natural events.

- Scientific methodology involves observing and asking questions, making inferences and forming hypotheses, conducting controlled experiments, collecting and analyzing data, and drawing conclusions.

<table>
<thead>
<tr>
<th>science</th>
<th>observation</th>
<th>inference</th>
<th>hypothesis</th>
<th>controlled experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(7)</td>
<td>(7)</td>
</tr>
</tbody>
</table>

### 1.2 Science in Context

- Curiosity, skepticism, open-mindedness, and creativity help scientists generate new ideas.

- Publishing peer-reviewed articles in scientific journals allows researchers to share ideas and to test and evaluate each other’s work.

- 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.

- Using science involves understanding its context in society and its limitations.

**theory (13) bias (14)**

### 1.3 Studying Life

- Living things are made up of units called cells, are based on a universal genetic code, obtain and use materials and energy, grow and develop, reproduce, respond to their environment, maintain a stable internal environment, and change over time.

- The study of biology revolves around several interlocking big ideas: the cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; evolution; structure and function; unity and diversity of life; interdependence in nature; and science as a way of knowing.

- Biology includes many overlapping fields that use different tools to study life from the level of molecules to the entire planet.

- Most scientists use the metric system when collecting data and performing experiments.

**biology (17) DNA (18) stimulus (18) sexual reproduction (19) biosphere (21)**

**Think Visually** Using the information in this chapter, complete the following concept map:

- **Scientists** make observations that can lead to inferences.
  - Inferences can be tested by controlled experiments.

- Questions 1 can be answered by controlled experiments and hypotheses that can be tested by field studies.

- Field studies can lead to observations and can be tested by controlled experiments.

### Performance Tasks

**SUMMATIVE TASK** Have students recall from the first lesson of this chapter how Aristotle aimed to explain the world around him in terms of events and processes he could observe. Ask them to write a letter to Aristotle describing how science has changed and how it has stayed the same since his time. Challenge students to consider scientific methodology, available technology, and current fields of biology when writing their letters. Remind them to use the proper format for a friendly letter.

**TRANSFER TASK** Have students write an editorial for the school newspaper that encourages all students to take a science class, regardless of their anticipated career. In their editorial, students should explain how an informed public can make better decisions about issues involving science, and why a knowledge of science has become increasingly important in the society in which we live. Encourage students to submit their editorials to be considered for publication.

**Answers**

**THINK VISUALLY**

1. Hypotheses
2. Observations
3. Field studies
Lesson 1.1

UNDERSTAND KEY CONCEPTS

1. c 2. a 3. b
4. c 5. b

6. The goals of science are to investigate and understand the natural world, to explain events in the natural world, and to use those explanations to make useful predictions.

7. An observation is made using senses to gather information; an inference is a logical interpretation based on prior knowledge and experience.

8. A hypothesis helps scientists understand the natural world by suggesting a testable explanation for a set of observations, which provides the starting point for discovering new information.

9. It makes sense for scientists to test just one variable at a time so that they can tell which variable is responsible for the results they observe.

10. In a controlled experiment, the experimental group is set up to test the effects of different variables (one variable at a time). The control group is exposed to the same conditions as the experimental group except for one independent variable.

11. When drawing a conclusion, scientists use data to support, refute, or revise their hypothesis. If the data indicate the researchers are generally correct but have a few of the details wrong, they may revise their hypothesis and retest it.

12. A graph can make patterns and trends in data easier to recognize and understand.

THINK CRITICALLY

13. Answers will vary. Students’ suggested experiments should include one independent variable and a control group. For example, find two young animals of the same species whose weight is approximately the same. Feed each animal a different food, and weigh the animals at intervals to find out which animal grows more quickly.

14. If other key variables are not controlled, there is no way of knowing which variable caused the observed results.

Lesson 1.2

UNDERSTAND KEY CONCEPTS

15. c 16. d 17. b

18. Scientific theories are useful because they unify a broad range of observations and enable scientists to make accurate predictions about many new situations.

19. While theories are supported by large amounts of evidence, they aren’t considered absolute truths because science is always changing—and there is always the possibility that new evidence will require that a theory be modified or even discarded.

THINK CRITICALLY

20. Science is a process, or way of learning about the world, rather than a collection of unchanging facts.

21. Sample answer: Curiosity leads you to ask questions about the new skill; skepticism keeps you from accepting explanations without evidence; open-mindedness enables you to accept different ideas about how the skill could be learned; and creativity helps you explore different ways the skill could be learned.

22. Sample answer: I would look to see whether the researchers who wrote it showed any bias in their conclusions or made any mistakes in their techniques or reasoning. I would make sure their data supported their conclusions.
Lesson 1.3

UNDERSTAND KEY CONCEPTS

23. The process in which two cells from different parents unite to produce the first cell of a new organism is called
a. homeostasis.
b. development.
c. asexual reproduction.
d. sexual reproduction.

24. The process by which organisms keep their internal conditions relatively stable is called
a. metabolism.
b. a genome.
c. evolution.
d. homeostasis.

25. How are unicellular and multicellular organisms alike? How are they different?

26. Give an example of changes that take place as cells in a multicellular organism differentiate.

27. List three examples of stimuli that a bird responds to.

Think Critically

28. Measure Use a ruler to find the precise length and width of this book in millimeters.

29. Interpret Visuals Each of the following safety symbols might appear in a laboratory activity in this book. Describe what each symbol stands for. (Hint: Refer to Appendix B.)

1. 2. 3. 4.

HEIGHT BY PRESCRIPTION

Although scientific studies have not proved that HGH treatment significantly increases adult height, they do suggest that extra HGH may help some short kids grow taller sooner. Parents who learn about this possibility may want treatment for their children. David’s doctor prescribed HGH to avoid criticism for not presenting it as an option.

This situation is new. Many years ago, HGH was available only from cadavers, and it was prescribed only for people with severe medical problems. Then, genetic engineering made it possible to mass-produce safe, artificial HGH for medical use—safe medicine for sick people. However, many people who are shorter than average often face prejudice in our society. This led drug companies to begin marketing HGH to parents of healthy, short kids. The message: “Help your child grow taller!”

As David’s case illustrates, science has the powerful potential to change lives, but new scientific knowledge and advances may raise more questions than they answer. Just because science makes something possible, does that mean it’s right to do it? This question is difficult to answer. When considering how science should be applied, we must consider both its limitations and its context in society.

1. Relate Cause and Effect Search the Internet for the latest data on HGH treatment of healthy children. What effect does early HGH treatment have on adult height?

2. Predict HGH was among the first products of the biotechnology revolution. Many more are in the pipeline. As products become available that could change other inherited traits, what challenges await society?

3. Connect to the Big Idea Why would it be important for scientists to communicate clearly the results of HGH studies? How might parents benefit by understanding the science behind the results?

THINK CRITICALLY

28. Check that students have reported their answers in centimeters. Students’ measurements should be close to the following: 220 mm × 283 mm.

29. (1) This symbol warns that the lab includes glassware that could be hazardous if broken. (2) This symbol is used to indicate the possibility of electric shock. (3) This symbol means that the lab involves the use of sharp objects that could cause injury. (4) This symbol is a reminder to use heat-resistant gloves when handling hot materials.
Connecting Concepts

USE SCIENCE GRAPHICS

30. Graph 1 shows the number of organisms in the population increasing over time. Graph 2 shows an increase in the number of individuals in the population followed by a decrease, which results in no net change in the size of the population. Graph 3 shows several rapid increases in the number of individuals, each followed by a decrease in the number of individuals, resulting in no net change in the size of the population. Graph 4 shows a population that does not change in size over the time period represented in the graph.

31. Numerical values indicating time elapsed on the x-axis and number of organisms on the y-axis are needed.

32. Sample answer: The shape of Graph 1 could represent a chemical reaction in which a product accumulates, or it could represent the height of a plant over time.

WRITE ABOUT SCIENCE

33. Answers will vary. Students’ responses should describe how to use scientific methodology to determine what type of food a cat prefers. Students should include the following steps: observing and asking questions, inferring and hypothesizing, designing a controlled experiment, collecting and analyzing data, and drawing conclusions.

34. Students’ responses should include a testable hypothesis and a description of a controlled experiment in which the independent variable and the variables to be controlled are identified.

31. Interpret Graphs Before any of the graphs could be used to make direct comparisons among the populations, what additional information would be necessary?

32. Compare and Contrast Graphs of completely different events can have the same appearance. Select one of the graphs and explain how the shape of the graph could apply to a different set of events.

Write About Science

33. Explanation Suppose you have a pet cat and want to determine which type of cat food it prefers. Write an explanation of how you could use scientific methodology to determine the answer. (Hint: Before you start writing, list the steps you might take, and then arrange them in order beginning with the first step.)

34. Assess the Many people add fertilizer to their house and garden plants. Make a hypothesis about whether you think fertilizers really help plants grow. Next, design an experiment to test your hypothesis. Include in your plan what variable you will test and what variables you will control.

35. Interpret Graphs The independent variable in the controlled experiment was the a. number of flies. b. number of groups studied. c. number of days. d. size of the containers.

36. Infer Which of the following is a logical inference based on the content of the graph?

a. The flies in Group B were healthier than those in Group A.
b. A fly population with more available space will grow larger than a population with less space.
c. If Group B was observed for 40 more days, the size of the population would double.
d. In 40 more days, the size of both populations would decrease at the same rate.
Standardized Test Prep

Multiple Choice

1. To ensure that a scientific work is free of bias and meets standards set by the scientific community, a research group’s work is peer reviewed by
   A. anonymous scientific experts.
   B. the general public.
   C. the researchers’ friends.
   D. lawmakers.

2. Which of the following characteristics is NOT shared by both a horse and the grass it eats?
   A. uses energy
   B. response to stimulus
   C. movement from place to place
   D. stable internal environment

3. Which of the following statements about a scientific theory is NOT true?
   A. It has the same meaning in science as it does in daily life.
   B. It enables scientists to make accurate predictions about new situations.
   C. Scientific theories tie many hypotheses together.
   D. It is based on a large body of evidence.

4. A bird-watcher sees an unusual bird at a feeder. He takes careful notes on the bird’s color, shape, and other physical features and then goes to a reference book to see if he can identify the species. What aspect of scientific thinking is most apparent in this situation?
   A. observation
   B. inference
   C. hypothesis formation
   D. controlled experimentation

5. Unlike sexual reproduction, asexual reproduction involves
   A. two cells.    C. one parent.
   B. two parents. D. one nonliving thing.

6. One meter is equal to
   A. 1000 millimeters.
   B. 1 millimeter.
   C. 10 kilometers.
   D. 1 milliliter.

Questions 7–8

Once a month, a pet owner recorded the mass of her puppy in a table. When the puppy was 3 months old, she started to feed it a “special puppy food” she saw advertised on TV.

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Mass at Start of Month (kg)</th>
<th>Change in Mass per Month (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>5</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>+3</td>
</tr>
<tr>
<td>4</td>
<td>13</td>
<td>+5</td>
</tr>
</tbody>
</table>

7. According to the table, which statement is true?
   A. The puppy’s mass increased at the same rate for each month shown.
   B. The puppy’s mass was less than 5 kg at the start of the new diet.
   C. The puppy gained 5 kg between age 3 and 4 months.
   D. The puppy had gained 13 kg as a result of the new diet.

8. All of the following statements about the pet owner’s study are true EXCEPT
   A. The owner used the metric system.
   B. The owner recorded data.
   C. The owner could graph the data.
   D. The owner conducted a controlled experiment.

Open-Ended Response

9. Explain how a controlled experiment works.

Test-Taking Tip

READ ALL THE ANSWER CHOICES

Tell students to be sure to read all of the answer choices on multiple-choice tests, even if the first choice seems to be correct. Remind them that a more-complete or better answer choice may be present among the remaining choices. By reading all of the answer choices, they are more likely to choose the best one.