The Nature of Life

UNIT 1

Chapters

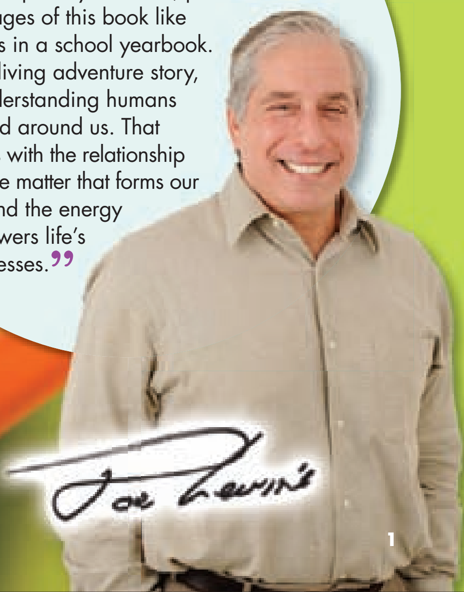
1 The Science of Biology

2 The Chemistry of Life

INTRODUCE the **Big ideas**

- **Science as a Way of Knowing**
- **Matter and Energy**

"Science is 'a way of knowing'— a way of explaining the natural world through observations, questions, and experiments. But science isn't just dry old data, pressed between pages of this book like prom flowers in a school yearbook. Science is a living adventure story, aimed at understanding humans and the world around us. That story begins with the relationship between the matter that forms our bodies and the energy that powers life's processes."



1 The Science of Biology

Big idea

Science as a Way of Knowing

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

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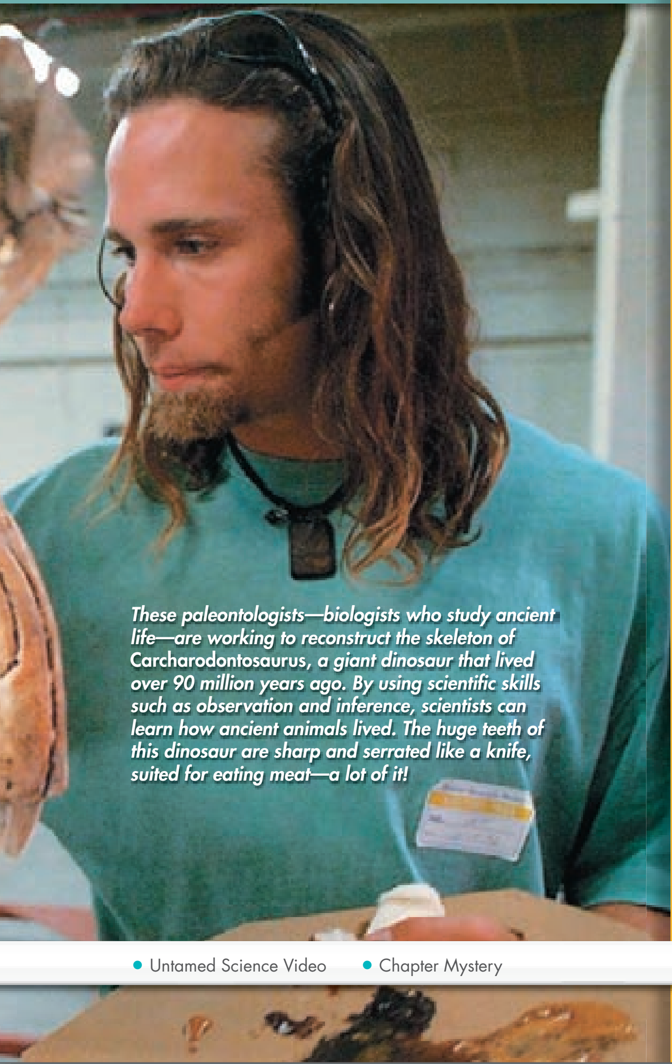
INSIDE:



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!

- Untamed Science Video
- Chapter Mystery

CHAPTER **MYSTERY**

HEIGHT BY PRESCRIPTION

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. Take a video field trip with the ecogeeks of Untamed Science to see where this mystery leads.

UntamedScience

1.1 What Is Science?

Key Questions

What are the goals of science?

What procedures are at the core of scientific methodology?

Vocabulary

science • observation • inference • hypothesis • controlled experiment • independent variable • dependent variable • control group • data

Taking Notes

Flowchart As you read, create a flowchart showing the steps scientists use to answer questions about the natural world.

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?

FIGURE 1–1 Studying the Natural World How do whales communicate? How far do they travel? How are they affected by environmental changes? These are questions whale researchers can use science to answer.

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.

FIGURE 1–2 Science in Action These marine scientists are recording information as they study whales in Alaska.

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.

BUILD Vocabulary

WORD ORIGINS The word **science** derives from the Latin word *scientia,* which means "knowledge." Science represents knowledge that has been gathered over time.

In Your Notebook *Explain in your own words why there is uncertainty in 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!

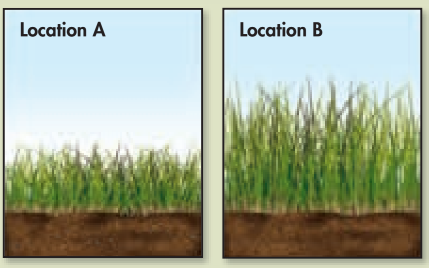
Scientists approach research in pretty much the same way. There isn't any single, cut-and-dried "scientific method." There is, however, a general style of investigation that we can call scientific methodology. **Scientific methodology involves observing and asking questions, making inferences and forming 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.

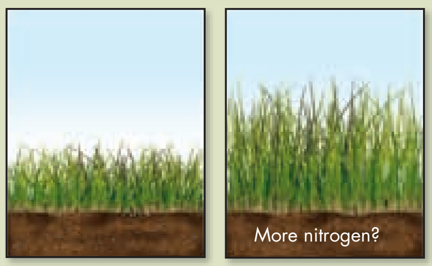
FIGURE 1–3 Salt Marsh Experiment Salt marshes are coastal environments often found where rivers meet the sea. Researchers made an interesting observation on the way marsh grasses grow. Then, they applied scientific methodology to answer questions that arose from their observation.

OBSERVING AND ASKING QUESTIONS



Researchers observed that marsh grass grows taller in some places than others. This observation led to a question: *Why do marsh grasses grow to different heights in different places?*

INFERRING AND HYPOTHESIZING



The researchers inferred that something limits grass growth in some places. It could be any environmental factor—temperature, sunlight, water, or nutrients. Based on their knowledge of salt marshes, they proposed a hypothesis: *Marsh grass growth is limited by available nitrogen.*

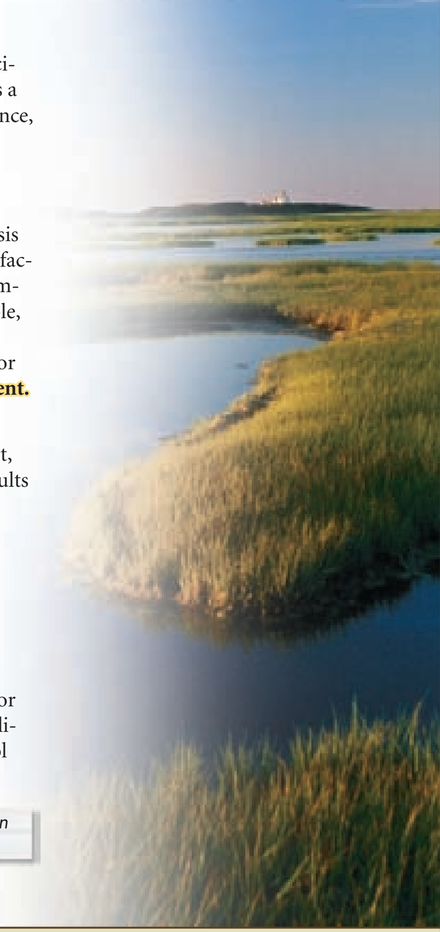
Inferring and Forming a Hypothesis After posing questions, scientists use further observations to make inferences. An **inference** is a logical interpretation based on what scientists already know. Inference, combined with a creative imagination, can lead to a hypothesis. A **hypothesis** is a scientific 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.*



DESIGNING CONTROLLED EXPERIMENTS

The researchers selected similar plots of marsh grass. All plots had similar plant density, soil type, input of freshwater, and height above average tide level. The plots were divided into control and experimental groups.

The researchers added nitrogen fertilizer (the independent variable) to the experimental plots. They then observed the growth of marsh grass (the dependent variable) in both experimental and control plots.

Collecting and Analyzing Data Scientists make detailed records of experimental observations, gathering information called **data.** There are two main types of data. Quantitative data are numbers obtained by counting or measuring. In the marsh grass experiment, quantitative data could include the number of plants per plot, the length, width, and weight of each blade of grass, and so on. Qualitative data are descriptive and involve characteristics that cannot usually be counted. Qualitative data in the marsh grass experiment might include notes about foreign objects in the sample plots or information on whether the grass was growing upright or sideways.

▶ ***Research Tools*** Scientists choose appropriate tools for collecting and analyzing data. The tools may range from simple devices such as metersticks and calculators to sophisticated equipment such as machines that measure nitrogen content in plants and soil. Charts and graphs are also tools that help scientists organize their data. In the past, data were recorded by hand, often in notebooks or personal journals. Today, researchers typically enter data into computers, which make organizing and analyzing data easier. Many kinds of data are now gathered directly by computer-controlled equipment.

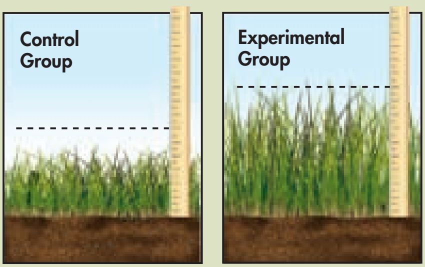
▶ ***Sources of Error*** Researchers must be careful to avoid errors in data collection and analysis. Tools used to measure the size and weight of marsh grasses, for example, have limited accuracy. Data analysis and sample size must be chosen carefully. In medical studies, for example, both experimental and control groups should be quite large. Why? Because there is always variation among individuals in control and experimental groups. The larger the sample size, the more reliably researchers can analyze that variation and evaluate the differences between experimental and control groups.

MYSTERY CLUE

Describe a controlled experiment that can be designed to test the hypothesis that extra HGH helps children grow taller. What ethical issues can you imagine in actually carrying out such a study?

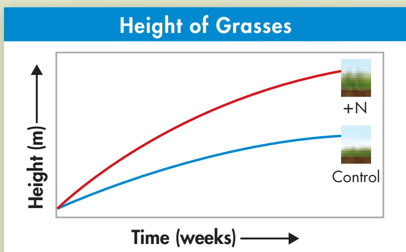
FIGURE 1–3 Continued

COLLECTING AND ANALYZING DATA



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.

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.

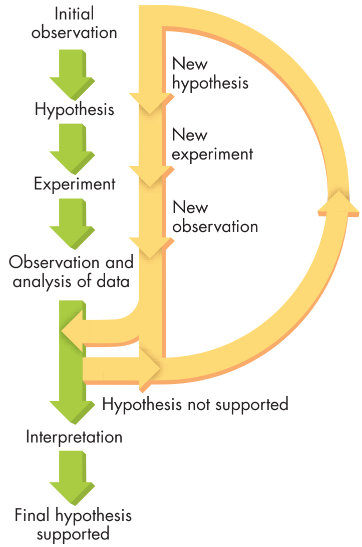


FIGURE 1–4 Revising Hypotheses During the course of an investigation, hypotheses may have to be revised and experiments redone several times.

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.

1.1 Assessment

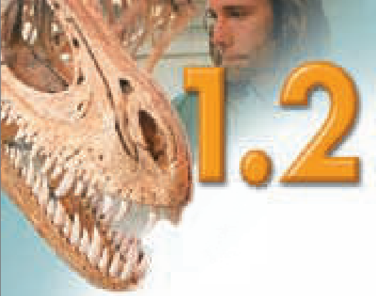
Review Key Concepts

1. a. **Review** What is science?
   b. **Explain** What kinds of understandings does science contribute about the natural world?
   c. **Form an Opinion** Do you think that scientists will ever run out of things to study? Explain your reasoning.
2. a. **Review** What does scientific methodology involve?
   b. **Explain** Why are hypotheses so important to controlled experiments?

WRITE ABOUT SCIENCE

Creative Writing

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?



1.2 Science in Context

Key Questions

What scientific attitudes help generate new ideas?

Why is peer review important?

What is a scientific theory?

What is the relationship between science and society?

Vocabulary

theory • bias

Taking Notes

Preview Visuals Before you read, study **Figure 1–10.** As you read, use the figure to describe the role science plays in society.

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?

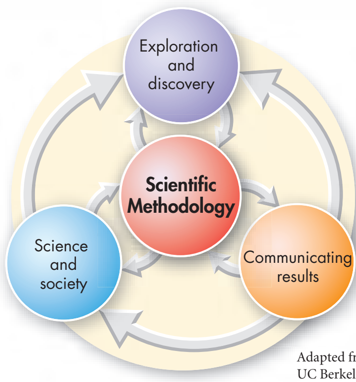
Scientific methodology is closely linked to exploration and discovery, as shown in **Figure 1–5.** Recall that scientific methodology starts with observations and questions. But where do those observations and questions come from in the first place? They may be inspired by scientific attitudes, practical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



Adapted from *Understanding Science,* UC Berkeley, Museum of Paleontology

FIGURE 1–6 Exploration and Discovery Ideas in science can arise in many ways—from simple curiosity or from the need to solve a particular problem. Scientists often begin investigations by making observations, asking questions, talking with colleagues, and reading about previous experiments.

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.

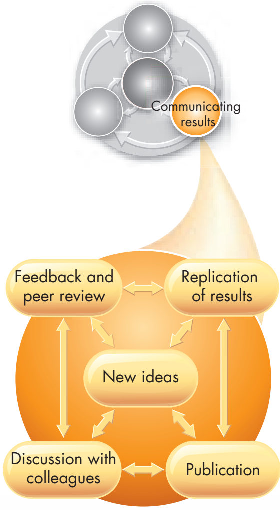
The Role of Technology Technology, science, and society are closely linked. Discoveries in one field of science may lead to new technologies. Those technologies, in turn, enable scientists in other fields to ask new questions or to gather data in new ways. For example, the development of new portable, 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 before were only available naturally.

MYSTERY CLUE

How does the ability to produce artificial HGH impact human life?

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

FIGURE 1–7 Ideas From Practical Problems People living on a strip of land like this one in Murrells Inlet, South Carolina, may face flooding and other problems. **Pose Questions** ***What are some scientific questions that can arise from a situation like this one?***



Adapted from *Understanding Science*, UC Berkeley, Museum of Paleontology

FIGURE 1–8 Communicating Results Communication is an important part of science. Scientists review and evaluate one another's work to ensure accuracy. Results from one study may lead to new ideas and further studies.

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.*

FIGURE 1–9 Mangrove Swamp In tropical areas, mangrove swamps serve as the ecological equivalents of temperate salt marshes. The results of the salt marsh experiment suggest that nitrogen might be a limiting nutrient for mangroves and other plants in these similar habitats.
Design an Experiment ***How would you test this hypothesis?***

Quick Lab
GUIDED INQUIRY

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.

Analyze and Conclude

1. **Evaluate** How could you have written better directions?
2. **Infer** Why is it important that scientists write procedures that can be replicated?

Scientific Theories

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*.

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.

BUILD Vocabulary

ACADEMIC WORDS The adjective **dominant** means "having the most authority or influence." After an idea has been thoroughly tested, confirmed repeatedly, and is accepted by the majority of scientists, it may become the dominant explanation for a particular phenomenon.

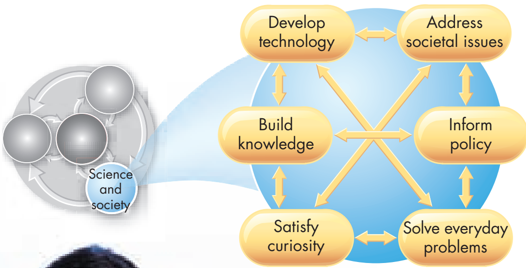
Science and Society

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.

FIGURE 1–10 Science and Society Science both influences society and is influenced by society. The researcher below tests shellfish for toxins that can poison humans. **Form an Opinion** *Should shellfish be routinely screened for toxins?*



Adapted from *Understanding Science*, UC Berkeley, Museum of Paleontology

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.

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.

FIGURE 1–11 Using Science in Everyday Life These student volunteers are planting mangrove saplings as part of a mangrove restoration project.

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?

Apply the Big idea

Science as a Way of Knowing

5. Explain in your own words why science is considered a "way of knowing."

BIOLOGY.com Search Lesson 1.2 GO • Self-Test • Lesson Assessment

Biology & Society

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?

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 with public funds. 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.

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?

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.")

Key Questions

What characteristics do all living things share?

What are the central themes of biology?

How do different fields of biology differ in their approach to studying life?

How is the metric system important in science?

Vocabulary

biology • DNA • stimulus • sexual reproduction • asexual reproduction • homeostasis • metabolism • biosphere

Taking Notes

Concept Map As you read, draw a concept map showing the big ideas in biology.

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 antlerlike structure is actually a marine animal called elkhorn coral. Corals show all the characteristics common to living things.

VISUAL SUMMARY

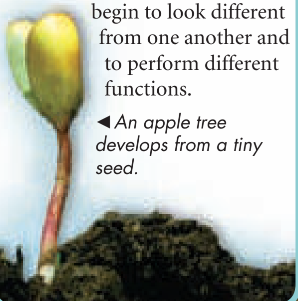
THE CHARACTERISTICS OF LIVING THINGS

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.

◀ The growth, form, and structure of an apple tree are determined by information in its DNA.

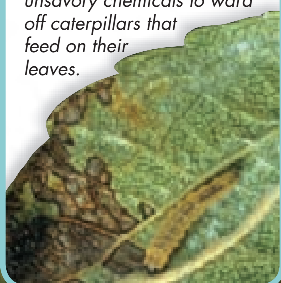
Living things grow and develop. Every organism has a particular pattern of growth and development. During development, a single fertilized egg divides again and again. As these cells divide, they differentiate, which means they begin to look different from one another and to perform different functions.

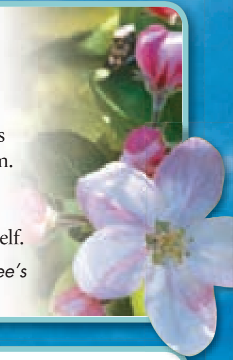


◀ An apple tree develops from a tiny seed.

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.

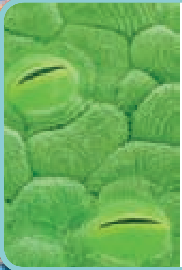
▼ Some plants can produce unsavory chemicals to ward off caterpillars that feed on their leaves.





Living things reproduce. All organisms reproduce, which means that they produce new similar organisms. Most plants and animals engage in sexual reproduction. In **sexual reproduction,** cells from two parents unite to form the first cell of a new organism. Other organisms reproduce through **asexual reproduction,** in which a single organism produces offspring identical to itself.

▶ *Beautiful blossoms are part of the apple tree's cycle of sexual reproduction.*

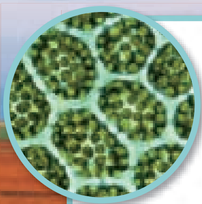


Living things maintain a stable internal environment. All organisms need to keep their internal environment relatively stable, even when external conditions change dramatically. This condition is called **homeostasis.**

◀ *These specialized cells help leaves regulate gases that enter and leave the plant.* SEM 1200×

Living things obtain and use material and energy. All organisms must take in materials and energy to grow, develop, and reproduce. The combination of chemical reactions through which an organism builds up or breaks down materials is called **metabolism.**

▶ *Various metabolic reactions occur in leaves.*



Living things are made up of cells. Organisms are composed of one or more cells—the smallest units considered fully alive. Cells can grow, respond to their surroundings, and reproduce. Despite their small size, cells are complex and highly organized.

▲ *A single branch of an apple tree contains millions of cells.* LM 800×

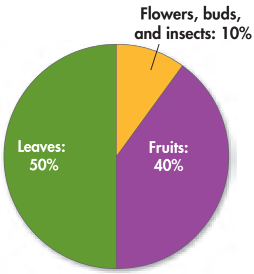
Taken as a group, living things evolve. Over generations, groups of organisms evolve, or change over time. Evolutionary change links all forms of life to a common origin more than 3.5 billion years ago. Evidence of this shared history is found in all aspects of living and fossil organisms, from physical features to structures of proteins to sequences of information in DNA.

▶ *Signs of one of the first land plants, Cooksonia, are preserved in rock over 400 million years old.*

Analyzing Data

What's in a Diet?

The circle graph shows the diet of the siamang gibbon, a type of ape found in the rainforests of Southeast Asia.



Analyze and Conclude

1. Interpret Graphs Which plant parts do siamangs rely on most as a source of their matter and energy?

2. Predict How would siamangs be affected if the rainforests they live in were cut down?

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.*

Big idea **Evolution** Taken as a group, living things evolve. 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.

Big idea **Structure and Function** 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.

Big idea **Unity and Diversity of Life** 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.

Big idea **Interdependence in Nature** 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.

Big idea **Science as a Way of Knowing** 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.

MYSTERY CLUE

What human values or biases are involved in the case of giving HGH to healthy children? What role does science play in this case?

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.

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.

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.*

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.*

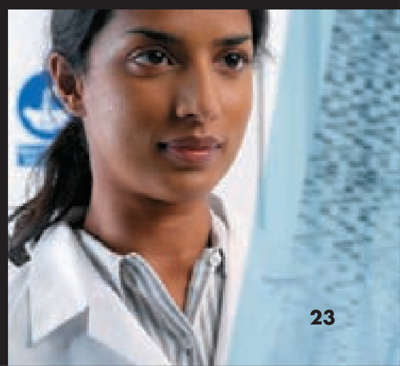
Building the Tree of Life Biologists have discovered and identified roughly 1.8 million different kinds of living organisms. That may seem like an incredible number, but researchers estimate that somewhere between 2 and 100 million more forms of life are waiting to be discovered around the globe—from 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. Ever-more-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.*

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.

BUILD Vocabulary

PREFIXES The SI prefix *milli-* means "thousandth." Therefore, 1 millimeter is one-thousandth of a meter, and 1 milligram is one-thousandth of a gram.

Common Metric Units

Length	Mass
1 meter (m) = 100 centimeters (cm) 1 meter = 1000 millimeters (mm) 1000 meters = 1 kilometer (km)	1 kilogram (kg) = 1000 grams (g) 1 gram = 1000 milligrams (mg) 1000 kilograms = 1 metric ton (t)
Volume	**Temperature**
1 liter (L) = 1000 milliliters (mL) 1 liter = 1000 cubic centimeters (cm^3)	0°C = freezing point of water 100°C = boiling point of water

FIGURE 1–15 The Metric System Scientists usually use the metric system in their work. This system is easy to use because it is based on multiples of 10. In the photo, biologists in Alaska weigh a small polar bear. **Predict** ***What unit of measurement would you use to express the bear's mass?***

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.

FIGURE 1–16 Science Safety Wearing appropriate protective gear is important while working in a laboratory.

1.3 Assessment

Review Key Concepts

1. a. Review List the characteristics that define life.

b. Applying Concepts Suppose you feel hungry, so you reach for a plum you see in a fruit bowl. Explain how both external and internal stimuli are involved in your action.

2. a. Review What are the themes in biology that come up again and again?

b. Predict Suppose you discover a new organism. What would you expect to see if you studied it under a microscope?

3. a. Review At what levels do biologists study life?

b. Classify A researcher studies why frogs are disappearing in the wild. What field of biology does the research fall into?

4. a. Review Why do scientists use a common system of measurement?

b. Relate Cause and Effect Suppose two scientists are trying to perform an experiment that involves dangerous chemicals. How might their safety be affected by not using a common measurement?

PRACTICE PROBLEM

5. In an experiment, you need 250 grams of potting soil for each of 10 plant samples. How many kilograms of soil in total do you need? MATH

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Skills Lab

GUIDED INQUIRY

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? MATH

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

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Untamed Science Video Be prepared for some surprise answers as the Untamed Science crew hit the streets to ask people basic questions about science and biology.

Art in Motion Learn about the steps scientists use to solve problems. Change the variables, and watch what happens!

Art Review Review your understanding of the various steps of experimental processes.

InterActive Art Design your own experiment to test Redi's and Pasteur's spontaneous generation experiments.

Data Analysis Investigate the different strategies scientists use for measurement.

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.

science (5)
observation (6)
inference (7)
hypothesis (7)
controlled experiment (7)
independent variable (7)
dependent variable (7)
control group (7)
data (8)

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.

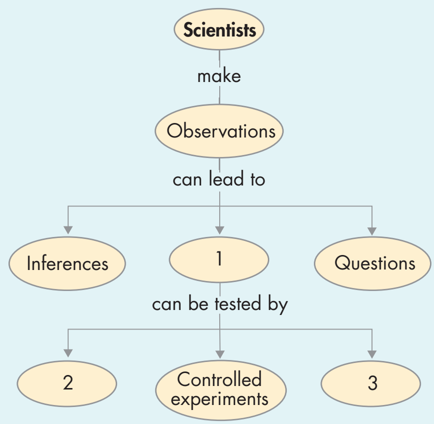
The study of biology revolves around several interlocking big ideas: the cellular basis of life; information and heredity; matter and energy; growth, development, and reproduction; homeostasis; evolution; structure and function; unity and diversity of life; interdependence in nature; and science as a 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)
asexual reproduction (19)
homeostasis (19)
metabolism (19)
biosphere (21)

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

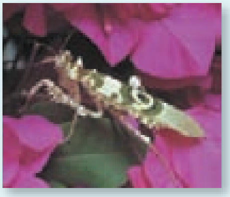


1 Assessment

1.1 What Is Science?

Understand Key Concepts

1. Which of the following statements about the image shown below is NOT an observation?
   a. The insect has three legs on the left side.
   b. The insect has a pattern on its back.
   c. The insect's pattern shows that it is poisonous.
   d. The insect is green, white, and black.



2. The statement "The worm is 2 centimeters long" is a(n)
   a. observation.
   b. theory.
   c. inference.
   d. hypothesis.

3. An inference is
   a. the same as an observation.
   b. a logical interpretation of an observation.
   c. a statement involving numbers.
   d. a way to avoid bias.

4. To be useful in science, a hypothesis must be
   a. measurable.
   b. observable.
   c. testable.
   d. correct.

5. Which of the following statements about a controlled experiment is true?
   a. All the variables must be kept the same.
   b. Only one variable is tested at a time.
   c. Everything can be studied by setting up a controlled experiment.
   d. Controlled experiments cannot be performed on living things.

6. What are the goals of science?
7. How does an observation about an object differ from an inference about that object?
8. How does a hypothesis help scientists understand the natural world?
9. Why does it make sense for scientists to test just one variable at a time in an experiment?
10. Distinguish between an experimental group and a control group.
11. What steps are involved in drawing a conclusion?
12. How can a graph of data be more informative than a table of the same data?

Think Critically

13. **Design an Experiment** Suggest an experiment that would show whether one food is better than another at speeding an animal's growth.
14. **Control Variables** Explain why you cannot draw a conclusion about the effect of one variable in an investigation when the other key variables are not controlled.

1.2 Science in Context

Understand Key Concepts

15. A skeptical attitude in science
    a. prevents scientists from accepting new ideas.
    b. encourages scientists to readily accept new ideas.
    c. means a new idea will only be accepted if it is backed by evidence.
    d. is unimportant.

16. The purpose of peer review in science is to ensure that
    a. all scientific research is funded.
    b. the results of experiments are correct.
    c. all scientific results are published.
    d. published results meet standards set by the scientific community.

17. A scientific theory is
    a. the same as a hypothesis.
    b. a well-tested explanation that unifies a broad range of observations.
    c. the same as the conclusion of an experiment.
    d. the first step in a controlled experiment.

18. Why are scientific theories useful?
19. Why aren't theories considered absolute truths?

Think Critically

20. Evaluate Why is it misleading to describe science as a collection of facts?

21. Propose a Solution How would having a scientific attitude help you in everyday activities, for example, in trying to learn a new skill?

22. Conduct Peer Review If you were one of the anonymous reviewers of a paper submitted for publication, what criteria would you use to determine whether or not the paper should be published?

1.3 Studying Life

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?

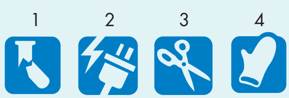
26. Give an example of changes that take place as cells in a multicellular organism differentiate.

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.)



solve the CHAPTER MYSTERY

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?

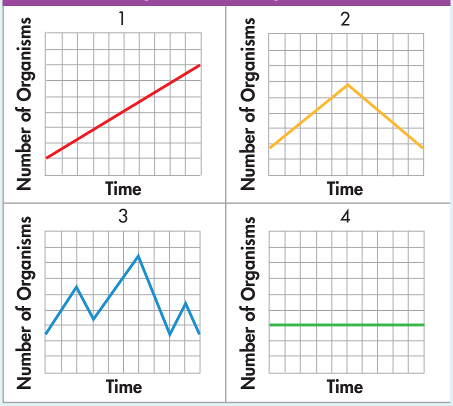
3. Connect to the Big idea Why would it be important for scientists to communicate clearly the results of HGH studies? How might parents benefit by understanding the science behind the results?

Connecting Concepts

Use Science Graphics

The following graphs show the size of four different populations over a period of time. Use the graphs to answer questions 30–32.

Changes in Four Populations



30. **Analyze Data** Write a sentence summarizing what each graph shows.

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

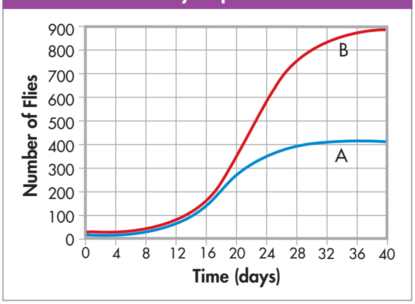
33. **Explanation** Suppose you have a pet cat and want to determine which type of cat food it prefers. Write an explanation of how you could use scientific methodology to determine the answer. (*Hint*: Before you start writing, list the steps you might take, and then arrange them in order beginning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

34. **Assess the Big idea** 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.

Analyzing Data

A researcher studied two groups of fruit flies: Population A was kept in a 0.5 L container; Population B was kept in a 1 L container.

Fruit Fly Population



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.
B two parents.
C one parent.
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.

Change in a Puppy's Mass Over Time

Age (months)	Mass at Start of Month (kg)	Change in Mass per Month (kg)
2	5	—
3	8	+3
4	13	+5

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.

If You Have Trouble With . . .

Question	1	2	3	4	5	6	7	8	9
See Lesson	1.2	1.3	1.2	1.1	1.3	1.3	1.1	1.1	1.1