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.**

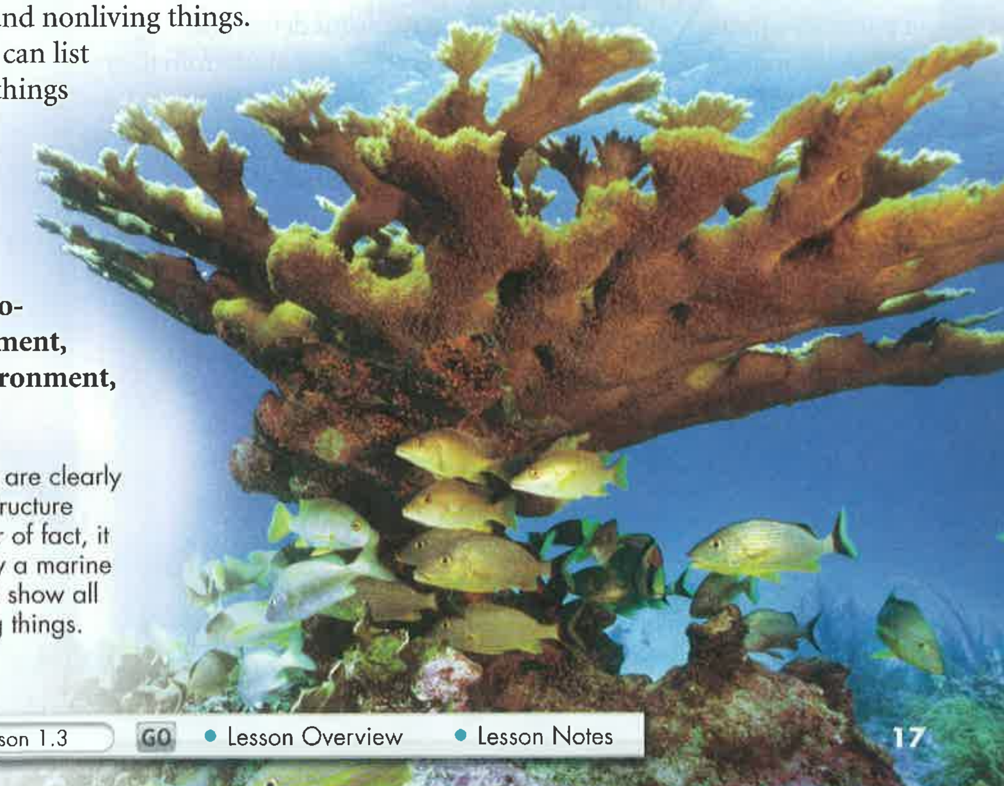


FIGURE 1–12 Is It Alive? The fish are clearly alive, but what about the colorful structure above them? Is it alive? As a matter of fact, it is. The antlerlike structure is actually a marine animal called elkhorn coral. Corals show all the characteristics common to living things.

VISUAL SUMMARY

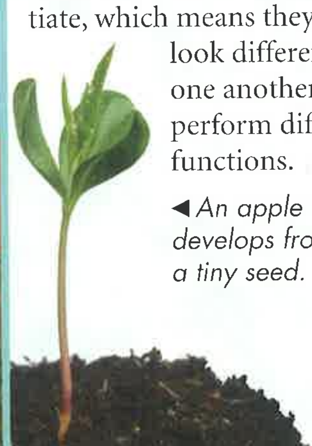
THE CHARACTERISTICS OF LIVING THINGS

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.



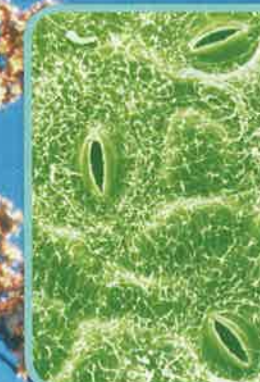
◀ *An apple tree develops from a tiny seed.*

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 250×

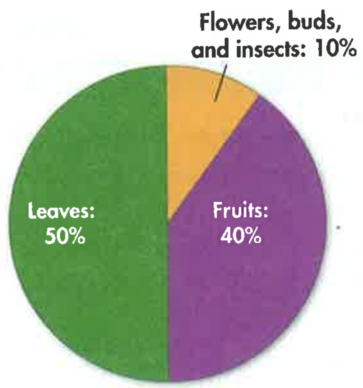
Taken as a group, living things evolve. Over generations, groups of organisms evolve, or change over time. Evolutionary change links all forms of life to a common origin more than 3.5 billion years ago. Evidence of this shared history is found in all aspects of living and fossil organisms, from physical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

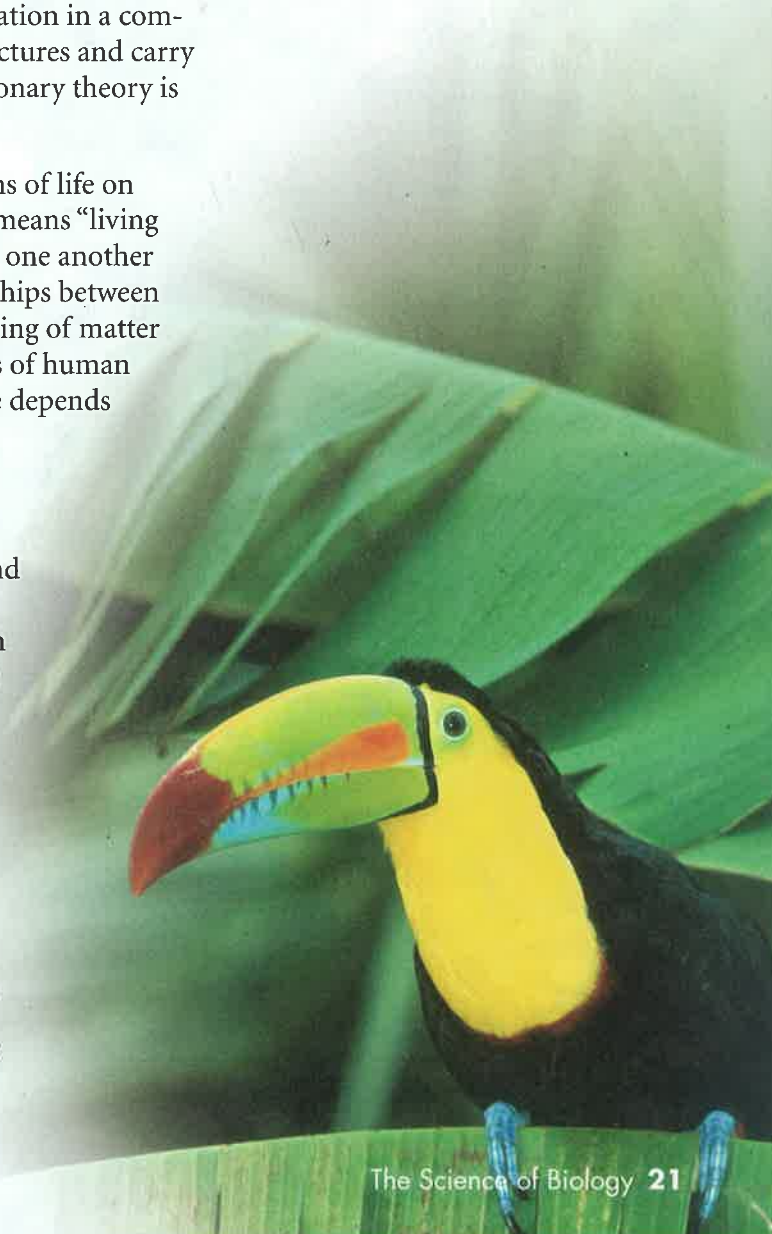


FIGURE 1–14 Different But Similar The colorful keel-billed toucan is clearly different from the plant on which it perches. Yet, the two organisms are fundamentally similar at the molecular level. Unity and diversity of life is an important theme in biology.

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.

▶ *Scientists in Brazil record data to understand how environmental factors affect tree growth.*

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.

▶ *Paleontologists study the fossilized bones of dinosaurs.*

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.

▶ *An entomologist (center) and other researchers inspect mosquito traps lining an area between a neighborhood and a mosquito breeding area in Florida.*

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

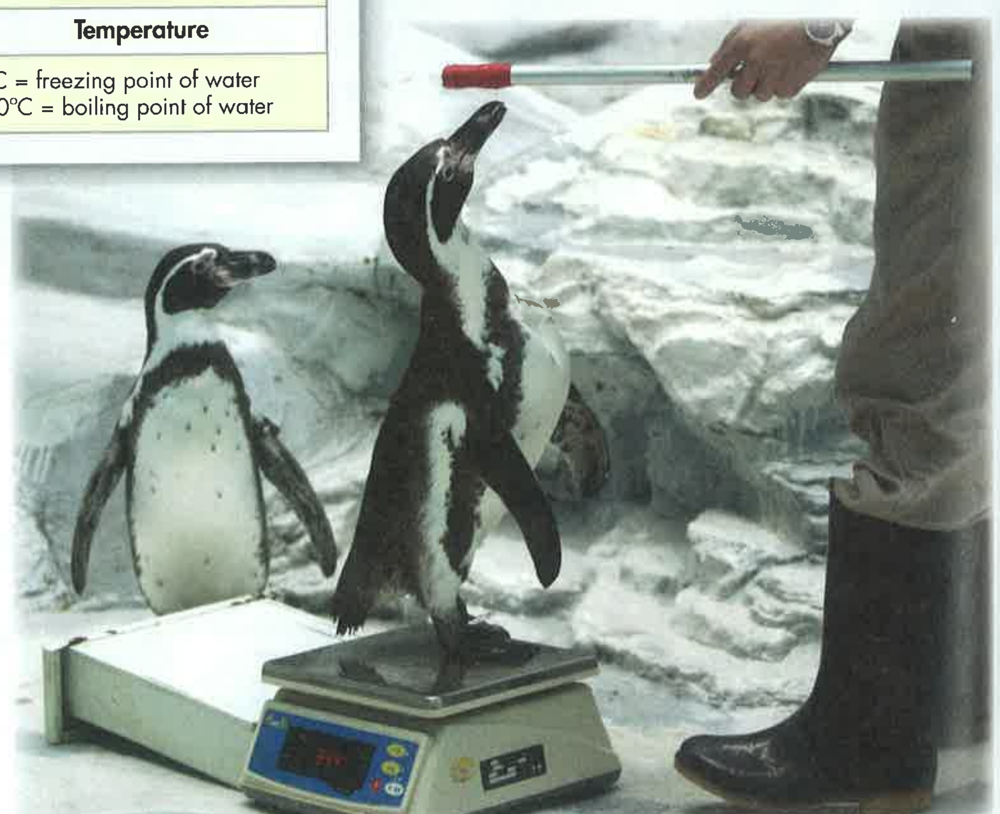


FIGURE 1–15 The Metric System Scientists usually use the metric system in their work. This system is easy to use because it is based on multiples of 10. This penguin in China has been trained to hop onto the scale to be weighed. Predict ***What unit of measurement would you use to express the penguin's 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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