1.1 The Study of Life

KEY CONCEPT Biologists study life in all its forms.

MAIN IDEAS

- Earth is home to an incredible diversity of life.
- All organisms share certain characteristics.

VOCABULARY

biosphere, p. 4
biodiversity, p. 5
species, p. 5
biology, p. 5
organism, p. 5
cell, p. 5
metabolism, p. 6
DNA, p. 6

REVIEW AT CLASSZONE.COM

Connect It's a warm summer evening. Maybe you're laughing and joking while waiting to eat at a family barbecue. As you sit down for dinner, mosquitoes flying around have the same idea. But their dinner is you, not the barbecue. Probably the most attention that you pay to mosquitoes is when you take careful aim before smacking them. Biologists have a somewhat different view of mosquitoes, unless of course they are the ones being bitten. But in those times of logic and reason, a biologist can see a mosquito as just one example of the great diversity of life found on Earth.

MAIN IDEA

Earth is home to an incredible diversity of life.

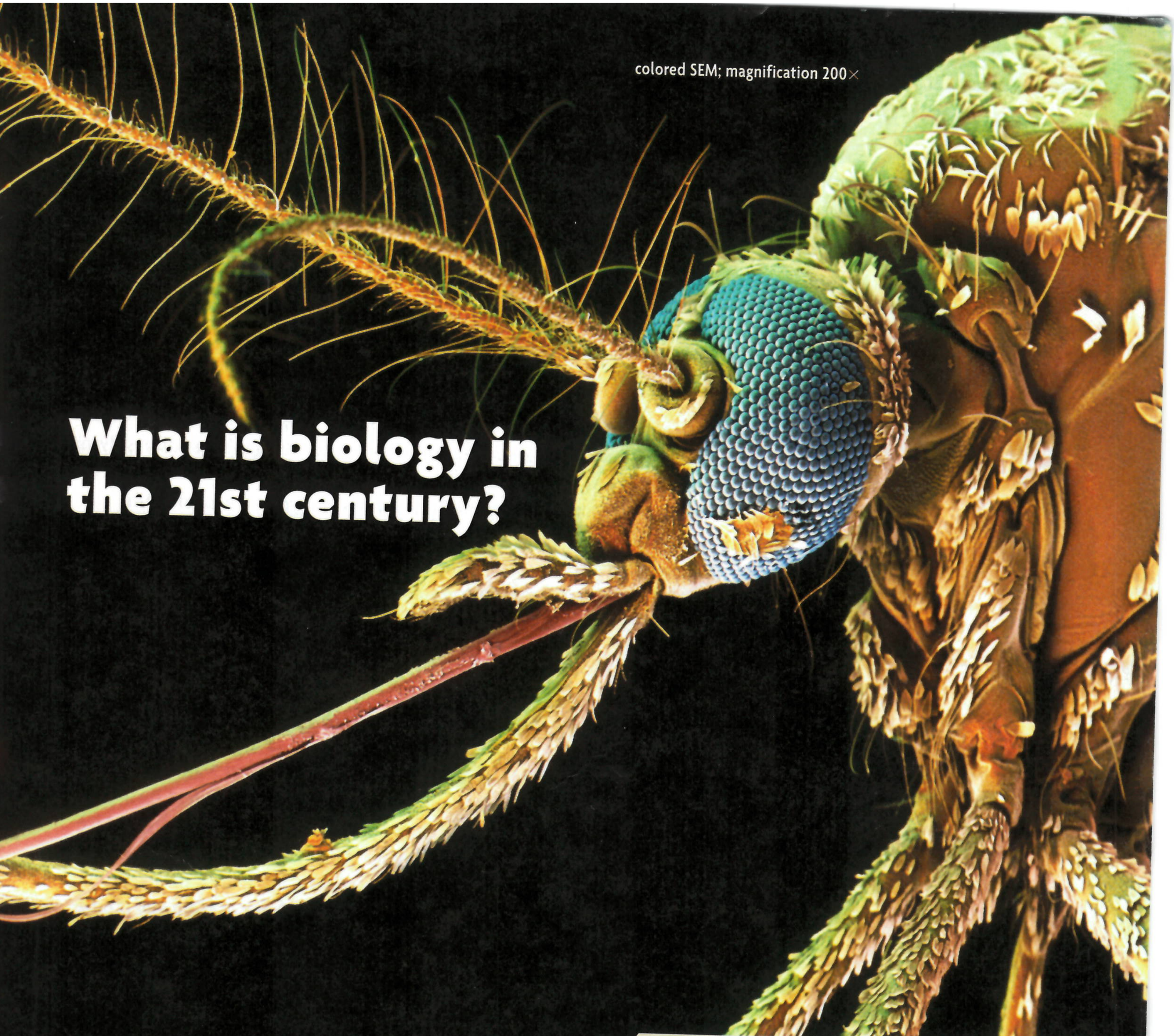
In Yellowstone National Park, there are pools of hot water as acidic as vinegar. It might be difficult to believe, but those pools are also full of life. Life is found in the darkness at the deepest ocean floors and in thousands-of-years-old ice in Antarctica. Not only are living things found just about anywhere on Earth but they also come in a huge variety of shapes and sizes. Plants, for example, include tiny mosses and giant redwood trees on which moss can grow. There are massive animals such as the blue whale, which is the largest animal living on Earth. There are tiny animals such as the honeypot ant in **FIGURE 1.1**, which can store so much food for other ants that it swells to the size of a grape.

FIGURE 1.1 Honeypot ants live in deserts where food and water are scarce. Some of the ants in the colony act as storage tanks for other ants in the colony.

The Biosphere

All living things and all the places they are found on Earth make up the **biosphere.** Every part of the biosphere is connected, however distantly, with every other part of the biosphere. The biosphere includes land environments such as deserts, grasslands, and different types of forests. The biosphere also includes saltwater and freshwater environments, as well as portions of the atmosphere. And different types of plants, animals, and other living things are found in different areas of the biosphere. Even the inside of your nose, which is home to bacteria and fungi, is a part of the biosphere.

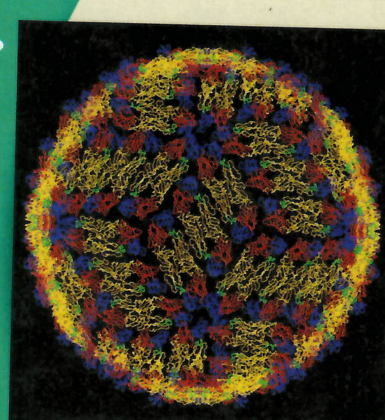
What is biology in the 21st century?



colored SEM; magnification 200×

Biology has always been the study of life, but our knowledge of living things and our use of technology to study them is always changing. For example, the above image of a yellow fever mosquito was made with a scanning electron microscope. Why bother with a mosquito? Because even in the 21st century, mosquitoes can carry viruses for which we have no defense.

Connecting CONCEPTS



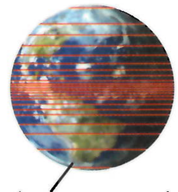
Computer Models Scientists use computer models, such as the virus model shown in the image to the left, to study things that could not otherwise be investigated. For example, the chemical structure of a virus's outer coat cannot be seen, even with an electron microscope. But by using computer models, scientists can better understand viruses and how to attack them.

Biodiversity

Across the biosphere, the variety of life is called biological diversity, or **biodiversity.** Biodiversity generally increases from Earth's poles to the equator. This means that greater biodiversity is found in warmer areas. Why is biodiversity greater closer to the equator? More living things are able to survive in consistently warm temperatures than in areas that have large temperature changes during a year. Because more living things, especially plants, can survive in warm areas, those areas provide a larger, more consistent food supply for more species.

VISUAL VOCAB

Across the **biosphere,** the variety of life is called **biodiversity.**



There are several different ways *species* can be defined. One definition of **species** is a particular type of living things that can reproduce by interbreeding among themselves. About 2 million different living species have been identified, but biologists estimate that tens of millions of species remain to be discovered. Over half of the known species are insects, but no one knows how many insect species actually exist.

Every year, biologists discover about 10,000 new species. In contrast, some scientists estimate that over 50,000 species die out, or become extinct, every year. Occasionally, however, a species thought to be extinct is found again. For example, the ivory-billed woodpecker was thought to have become extinct in 1944, but a team of scientists reported seeing it in Arkansas in 2004.

TAKING NOTES

Use a two-column chart to help you summarize vocabulary terms and concepts.

term or concept	*meaning*

Apply **Describe biodiversity in terms of species.**

MAIN IDEA

All organisms share certain characteristics.

Biology is the scientific study of all forms of life, or all types of organisms. An **organism** is any individual living thing. All organisms on Earth share certain characteristics, but an actual definition of life is not simple. Why? The categories of living and nonliving are constructed by humans, and they are not perfect. For example, some things, such as viruses, fall into a middle range between living and nonliving. They show some, but not all, of the characteristics of living things.

Cells All organisms are made up of one or more cells. A **cell** is the basic unit of life. In fact, microscopic, single-celled organisms are the most common forms of life on Earth. A single-celled, or unicellular, organism carries out all of the functions of life, just as you do. Larger organisms that you see every day are made of many cells, and are called multicellular organisms. Different types of cells in a multicellular organism have specialized functions, as shown in **FIGURE 1.2.** Your muscle cells contract and relax, your stomach cells secrete digestive juices, and your brain cells interpret sensory information. Together, specialized cells make you a complete organism.

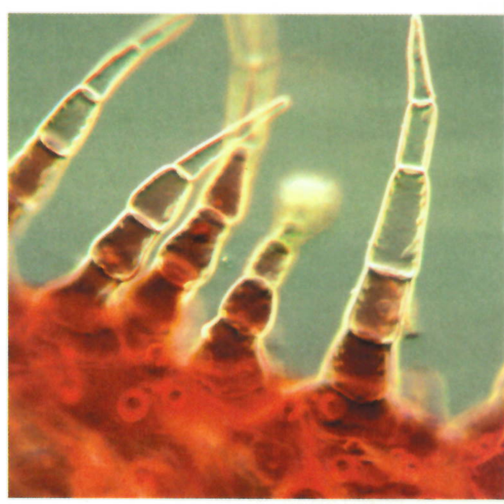


FIGURE 1.2 Cells can work together in specialized structures, such as these leaf hairs that protect a leaf from insects. (LM; magnification 700×)

Connecting CONCEPTS

Cells and Energy You will read in **Chapter 4** about different processes used by cells to capture and release energy—photosynthesis, chemosynthesis, and cellular respiration.

Need for energy All organisms need a source of energy for their life processes. Energy is the ability to cause a change or to do work. The form of energy used by all living things, from bacteria to ferrets to ferns, is chemical energy. Some organisms use chemicals from their environment to make their own source of chemical energy. Some organisms, such as plants, algae, and some bacteria, absorb energy from sunlight and store some of it in chemicals that can be used later as a source of energy. Animals get their source of energy by eating other organisms. In all organisms, energy is important for **metabolism,** or all of the chemical processes that build up or break down materials.

Response to environment All organisms must react to their environment to survive. Light, temperature, and touch are just a few of the physical factors, called stimuli, to which organisms must respond. Think about how you respond to light when you leave a dimly lit room and go into bright sunlight. One of your body's responses is to contract the pupils of your eyes. Your behavior might also change. You might put on sunglasses or raise your hand to shade your eyes. Other organisms also respond to changes in light. For example, plants grow toward light. Some fungi need light to form the structures that you know as mushrooms.

Reproduction and development Members of a species must have the ability to produce new individuals, or reproduce. When organisms reproduce, they pass their genetic material to their offspring. In all organisms, the genetic material is a molecule called deoxyribonucleic acid (dee-AHK-see-RY-boh-noo-KLEE-ihk), or **DNA.**

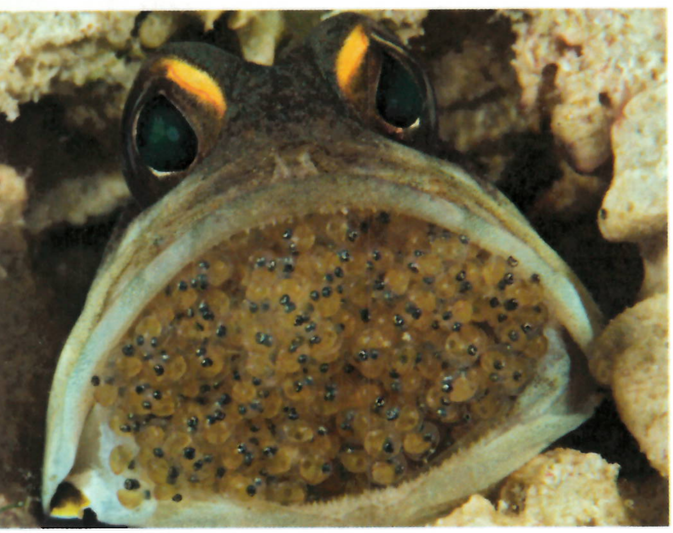


FIGURE 1.3 Reproductive strategies differ among species. The male gold-specs jawfish protects unhatched eggs by holding them in his mouth.

Single-celled organisms can reproduce when one cell divides into two cells. Both new cells have genetic information that is identical to the original cell. Many multicellular organisms, such as the gold-specs jawfish in **FIGURE 1.3**, reproduce by combining the genetic information from two parents. In both cases, the instructions for growth and development of organisms, from bacteria to people, are carried by the same chemicals—DNA and ribonucleic acid (RNA). The process of development allows organisms to mature and gain the ability to reproduce.

Summarize **What characteristics are shared by all living things?**

1.1 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING ▶ MAIN IDEAS

1. How are **species** related to the concept of **biodiversity**?
2. How do the characteristics of living things contribute to an **organism's** survival?

CRITICAL THINKING

3. **Apply** Describe the relationship between **cells** and organisms.
4. **Synthesize** How does biodiversity depend on a species' ability to reproduce?

Connecting CONCEPTS

5. **Human Biology** You respond automatically to many different stimuli, such as loud noises. Why might a quick response to a sound be important?

1.2 Unifying Themes of Biology

KEY CONCEPT Unifying themes connect concepts from many fields of biology.

MAIN IDEAS

- All levels of life have systems of related parts.
- Structure and function are related in biology.
- Organisms must maintain homeostasis to survive in diverse environments.
- Evolution explains the unity and diversity of life.

VOCABULARY

system, p. 7
ecosystem, p. 7
homeostasis, p. 9
evolution, p. 10
adaptation, p. 10

REVIEW AT CLASSZONE.COM

Connect What do you think about when you hear the term *theme*? Maybe you think about the music at the start of your favorite TV show. Maybe you think about the colors and organization of a computer desktop. In both cases, that theme shows up over and over again. In biology, you will see something similar. That is, some concepts come up time after time, even in topics that might seem to be completely unrelated. Understanding these themes, or concepts, can help you to connect the different areas of biology.

MAIN IDEA

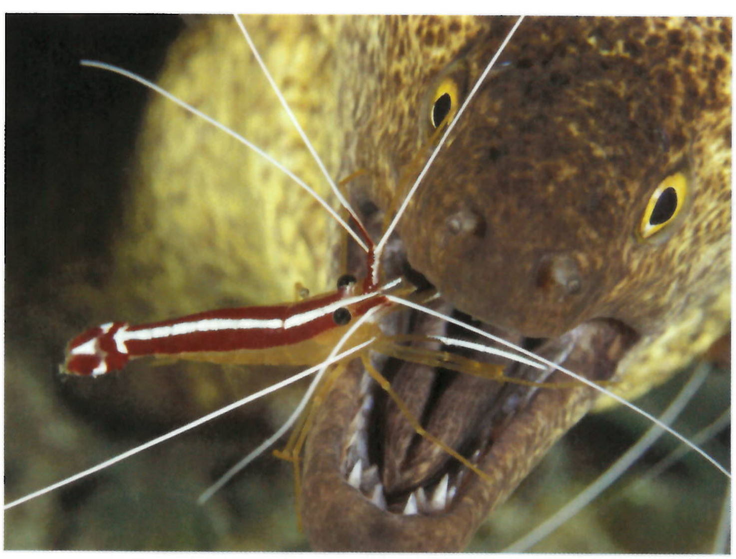
All levels of life have systems of related parts.

Think about the separate parts of a car—tires, engine, seats, and so on. Even if you have a complete set of car parts, you might not have a functioning car. Only when all of the parts that make up a car are put together in the correct way do you have a working car. A car is a system. A **system** is an organized group of related parts that interact to form a whole. Like any other system, a car's characteristics come from the arrangement and interaction of its parts.

Systems exist on all scales in biology, from molecules that cannot be seen, to cells that can be seen only with a microscope, to the entire biosphere. In just one heart muscle cell, for example, many chemicals and processes interact in a precise way so that the cell has energy to do its work. Moving up a level, heart muscle, valves, arteries, and veins help form a system in your body—the circulatory system.

Two organisms that interact can also be a system, as you can see in **FIGURE 1.4.** On a larger scale, you are a part of a biological system—an ecosystem—that has living and nonliving parts. An **ecosystem** is a physical environment with different species that interact with one another and with nonliving things. When you hear the term *ecosystem*, you might think about a large region, such as a desert, a coral reef, or a forest. But an ecosystem can also be a very small area, such as an individual tree.

FIGURE 1.4 The moray eel and the cleaner shrimp are parts of a system in which both organisms benefit. The shrimp cleans the eel's mouth and gets food and protection in return.



Often, different biologists study different systems. For example, a person studying DNA might focus on very specific chemical interactions that take place in a cell. A person studying behavior in birds might focus on predator–prey relationships in an ecosystem. However, more and more biologists are working across different system levels. For example, some scientists study how chemicals in the brain affect social interactions.

Connect **Describe how your biology class could be considered a system.**

MAIN IDEA

Structure and function are related in biology.

Think about a car again. In a car, different parts have different structures. The structure of a car part gives the part a specific function. For example, a tire's function is directly related to its structure. No other part of the car can perform that function. Structure and function are also related in living things. What something does in an organism is directly related to its shape or form. For example, when you eat, you probably bite into food with your sharp front teeth. Then you probably chew it mostly with your grinding molars. All of your teeth help you eat, but different types of teeth have different functions.

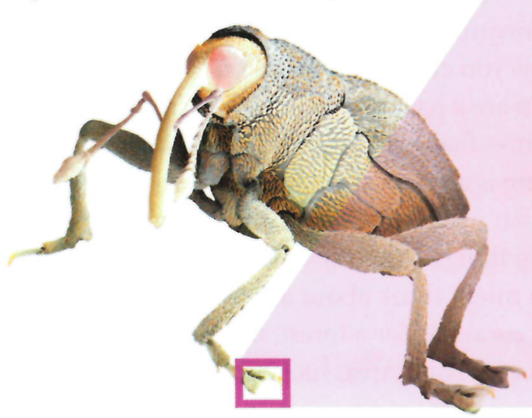
Structure and function are related at the level of chemicals in cells. For example, membrane channels and enzymes are both proteins, but they have very different structures and functions. A channel is a protein molecule that extends through the membrane, or outer layer, of a cell. It has a structure like a tube that allows specific chemicals to pass into and out of a cell. Enzymes are protein molecules that make chemical processes possible in living things. These proteins have shapes that allow them to attach to only certain chemicals and then cause the chemicals to react with each other.

Different types of cells also have different functions that depend on their specialized structures. For example, cells in your brain process information. They have many branches that receive information from other cells. They also have long extensions that allow them to send messages to other cells. Red blood cells are very different. They are much smaller, disk-shaped, and are

Connecting **CONCEPTS**

Biochemistry Proteins are a type of molecule found in all living things. Proteins have many different functions, which you will read about in **Chapter 2**.

FIGURE 1.5 The snout beetle (below) has specialized prongs and pads on its tarsi (right) that allow it to easily walk on both smooth and rough surfaces. (colored SEMs; magnifications: beetle 20×; tarsus 100×)



specialized to carry oxygen. Their structure allows them to fit through even the smallest blood vessels to deliver oxygen throughout your body. Of course, a cell from your brain cannot take the place of one of your red blood cells.

Structure and function are also related on the level of the organism. For example, your foot structure allows you to walk easily on rough, fairly level surfaces. Walking on a surface such as ice is more difficult, and walking up a wall is impossible for you. The beetle in **FIGURE 1.5** is different. Its tarsi, or "feet," have sharp prongs that can grip smooth or vertical surfaces, as well as soft pads for walking on rough surfaces. The beetle's tarsus has a different structure and function than your foot has, but both are specialized for walking.

Infer Do you think heart muscle has the same structure as arm muscle? Explain.

MAIN IDEA

Organisms must maintain homeostasis to survive in diverse environments.

Temperature and other environmental conditions are always changing, but the conditions inside organisms usually stay quite stable. How does the polar bear in **FIGURE 1.6** live in the arctic? How can people be outside when the temperature is below freezing, but still have a stable body temperature around 37°C (98.6°F)? Why do you shiver when you are cold, sweat when you are hot, and feel thirsty when you need water?

Homeostasis (HOH-mee-oh-STAY-sihs) is the maintenance of constant internal conditions in an organism. Homeostasis is important because cells function best within a limited range of conditions. Temperature, blood sugar, acidity, and other conditions must be controlled. Breakdowns in homeostasis are often life-threatening.

Homeostasis is usually maintained through a process called negative feedback. In negative feedback, a change in a system causes a response that tends to return that system to its original state. For example, think about how a car's cruise control keeps a car moving at a constant set speed. A cruise control system has sensors that monitor the car's speed and then send that information to a computer. If the car begins to go faster than the set speed, the computer tells the car to slow down. If the car slows below the set speed, the computer tells the car to speed up. Similarly, if your body temperature drops below normal, systems in your body act to return your temperature to normal. Your muscles cause you to shiver, and blood vessels near your skin's surface constrict. If your body temperature rises above normal, different responses cool your body.

Behavior is also involved in homeostasis. For example, animals regulate their temperature through behavior. If you feel cold, you may put on a jacket. Reptiles sit on a warm rock in sunlight if they get too cold, and they move into shade if they get too warm.

Summarize What is homeostasis, and why is it important?

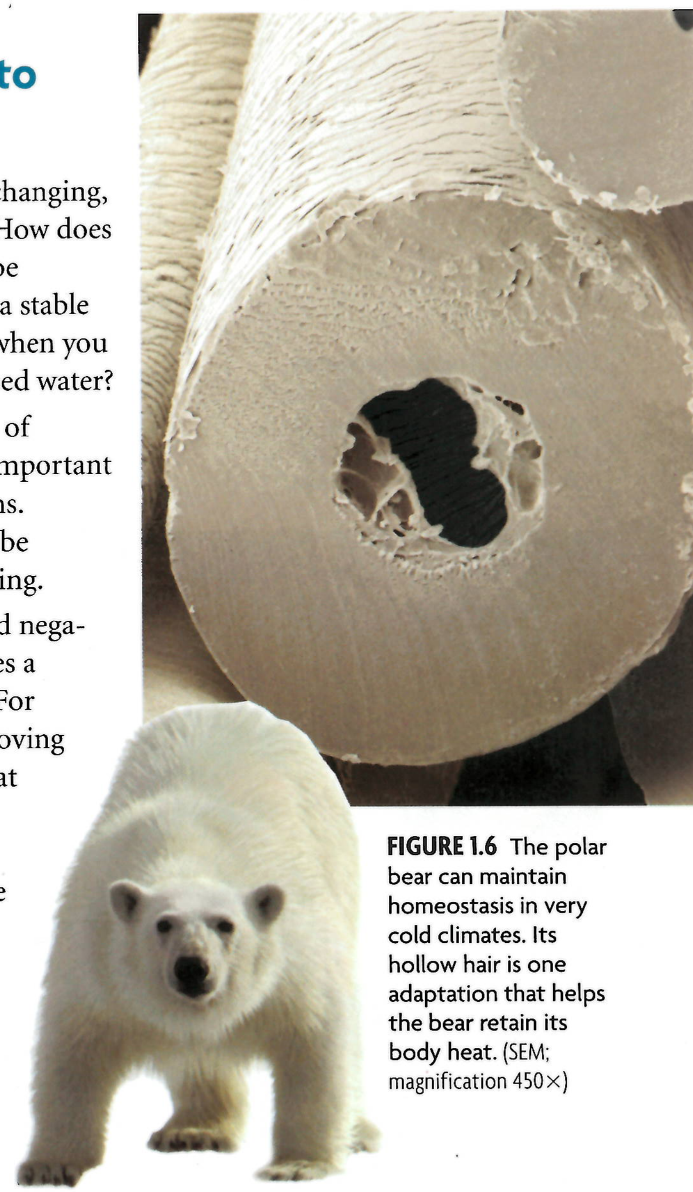


FIGURE 1.6 The polar bear can maintain homeostasis in very cold climates. Its hollow hair is one adaptation that helps the bear retain its body heat. (SEM; magnification 450×)

MAIN IDEA

Evolution explains the unity and diversity of life.

Connecting CONCEPTS

Evolution The processes of evolution, natural selection, and adaptation are described in more detail in **Unit 4**.

Evolution is the change in living things over time. More specifically, evolution is a change in the genetic makeup of a subgroup, or population, of a species. The concept of evolution links observations from all levels of biology, from cells to the biosphere. A wide range of scientific evidence, including the fossil record and genetic comparisons of species, show that evolution is continuing today.

Adaptation

One way evolution occurs is through natural selection of adaptations. In natural selection, a genetic, or inherited, trait helps some individuals of a species survive and reproduce more successfully than other individuals in a particular environment. An inherited trait that gives an advantage to individual organisms and is passed on to future generations is an **adaptation.** Over time, the makeup of a population changes because more individuals have the adaptation. Two different populations of the same species might have different adaptations in different environments. The two populations may continue to evolve to the point at which they are different species.

Consider the orchid and the thorn bug in **FIGURE 1.7.** Both organisms have adapted in ways that make them resemble other organisms. The orchid that looks like an insect lures other insects to it. The insects that are attracted to the orchid can pollinate the flower, helping the orchid to reproduce. The thorn bug's appearance is an adaptation that makes predators less likely to see and eat it.

FIGURE 1.7 Through evolution, some orchids (left) have flowers that look like insects and some insects, such as the thorn bug (right), look like parts of plants.

This adaptation allows the thorn bug to survive and reproduce. In different environments, however, you would find other orchid and insect species that have different adaptations.

Adaptation in evolution is different from the common meaning of adaptation. For example, if you say that you are adapting to a new classroom or to a new town, you are not talking about evolution. Instead, you are talking about consciously getting used to something new. Evolutionary adaptations are changes in a species that occur over many generations due to environmental pressures, not through choices made by organisms. Evolution is simply a long-term response to the environment. The process does not necessarily lead to more complex organisms, and it does not have any special end point. Evolution continues today, and it will continue as long as life exists on Earth.

Unity and Diversity

Evolution is a unifying theme of biology because it accounts for both the diversity and the similarities, or the unity, of life. As you study biology, you will see time after time that organisms are related to one another. When you read about cells in Unit 2 and genetics in Unit 3, you will see that all organisms have similar cell structures and chemical processes. These shared characteristics result from a common evolutionary descent.

Humans and bacteria have much more in common than you may think. Both human and bacterial genetics are based on the same molecules—DNA and RNA. Both human and bacterial cells rely upon the same sources of energy, and they have similar cell structures. Both human and bacterial cells have membranes made mostly of fats that protect the inside of the cell from the environment outside the cell.

Now think about the vast number of different types of organisms. All of the species now alive are the result of billions of years of evolution and adaptation to the environment. How? Natural selection of genetic traits can lead to the evolution of a new species. In the end, this genetic diversity is responsible for the diversity of life on Earth.

Analyze How does evolution lead to both the diversity and the unity of life?

1.2 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING MAIN IDEAS

1. Describe a biological system.
2. Give an example of how structure is related to function in living things.
3. Why is homeostasis essential for living things?
4. What is the relationship between adaptation and natural selection?

CRITICAL THINKING

5. **Analyze** How are structure and function related to adaptation?
6. **Apply** How is the process of natural selection involved in evolution?

Connecting CONCEPTS

7. **Cells** Do you think homeostasis is necessary at the level of a single cell? Explain.

DATA ANALYSIS ClassZone.com

Types of Data

Scientists collect two different types of data: qualitative data and quantitative data.

Qualitative data Qualitative data are descriptions in words of what is being observed. They are based on some quality of an observation, such as color, odor, or texture.

Quantitative data Quantitative data are numeric measurements. The data are objective—they are the same no matter who measures them. They include measurements such as mass, volume, temperature, distance, concentration, time, or frequency.

EXAMPLE

Suppose that a marine biologist observes the behavior and activities of dolphins. She identifies different dolphins within the group and observes them every day for a month. She records detailed observations about their behaviors. Some of her observations are qualitative data, and some are quantitative data.

Qualitative data examples

- Dolphin colors range from gray to white.
- Dolphins in a pod engage in play behavior.
- Dolphins have smooth skin.

Quantitative data examples

- There are nine dolphins in this pod.
- Dolphins eat the equivalent of 4–5 percent of their body mass each day.
- The sonar frequency most often used by the dolphins is around 100 kHz.

Notice that the qualitative data are descriptions. The quantitative data are objective numerical measurements.

IDENTIFY DATA TYPES

Suppose that you are a biologist studying jackals in their natural habitat in Africa. You observe their behaviors and interactions, and take photographs of their interactions to study later. Examine the photograph of the jackals shown to the right.

1. **Analyze** Give three examples of qualitative data that could be obtained from the photograph of the jackals.
2. **Analyze** Give three examples of quantitative data that could be obtained from the photograph of the jackals.

1.3 Scientific Thinking and Processes

KEY CONCEPT Science is a way of thinking, questioning, and gathering evidence.

MAIN IDEAS

- Like all science, biology is a process of inquiry.
- Biologists use experiments to test hypotheses.
- A theory explains a wide range of observations.

VOCABULARY

observation, p. 13
data, p. 14
hypothesis, p. 14
experiment, p. 16
independent variable, p. 16
dependent variable, p. 16
constant, p. 16
theory, p. 16

REVIEW AT CLASSZONE.COM

Connect What does the study of fungus have in common with the study of human heart disease? How is research in a laboratory similar to research in a rain forest? Biologists, like all scientists, ask questions about the world and try to find answers through observation and experimentation. How do your daily observations help answer questions that you have about the world?

MAIN IDEA

Like all science, biology is a process of inquiry.

Science is a human process of trying to understand the world around us. There is no one method used by all scientists, but all scientific inquiry is based on the same principles. Scientific thinking is based on both curiosity and skepticism. Skepticism is the use of critical and logical thinking to evaluate results and conclusions. Scientific inquiry also requires evidence. One of the most important points of science is that scientific evidence may support or even overturn long-standing ideas. To improve our understanding of the world, scientists share their findings with each other. The open and honest exchange of data is extremely important in science.

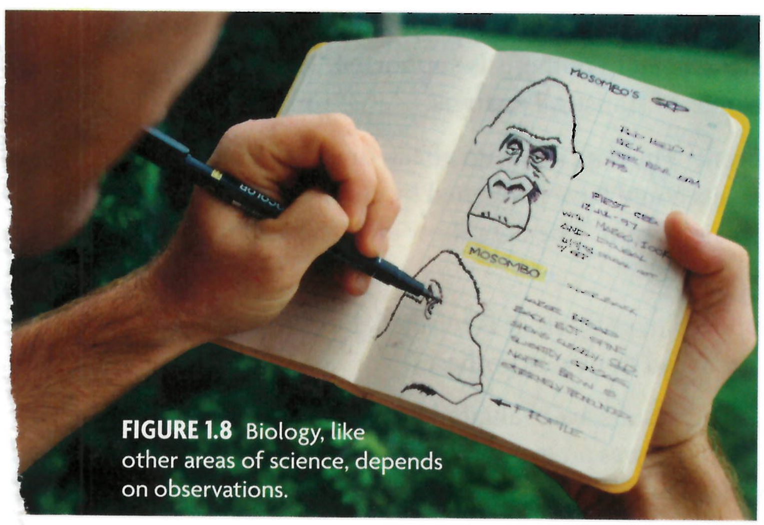


FIGURE 1.8 Biology, like other areas of science, depends on observations.

Observations, Data, and Hypotheses

All scientific inquiry begins with careful and systematic observations. Of course, **observation** includes using our senses to study the world, but it may also involve other tools. For example, scientists use computers to collect measurements or to examine past research results. Much early biological research was based on observing, describing, and categorizing the living world. By themselves, description and categorization are not as common in research today due to advances in technology, but they are still very important in biology. For example, how could someone study the interactions of gorillas without observing and describing their behavior, as in **FIGURE 1.8**?

Connecting CONCEPTS

Data Analysis Biology relies on the analysis of scientific data. Use the Data Analysis activities in each chapter in this book to build your data analysis skills.

Scientific questions often come from observations, whether the observations are one's own or someone else's. Observations can also be recorded as **data** that can be analyzed. Scientists collect two general types of data: qualitative data and quantitative data. As you learned on page 12, qualitative data are descriptions of a phenomenon that can include sights, sounds, and smells. This type of data is often useful to report what happens but not how it happens. In contrast, quantitative data are characteristics that can be measured or counted, such as mass, volume, and temperature. Anything that is expressed as a number, from time to a rating scale on a survey, is quantitative data that can be used to explore how something happens.

Scientists use observations and data to form a hypothesis. A **hypothesis** (plural, *hypotheses*) is a proposed answer for a scientific question. A hypothesis must be specific and testable. You probably form and test many hypotheses every day, even though you may not be aware of it. Suppose you oversleep. You needed to get up at 7 A.M., but when you wake up you observe that it is 8 A.M. What happened? Did the alarm not go off? Was it set for the wrong time? Did it go off but you slept through it? You just made three hypotheses to explain why you overslept—the alarm did not go off, the alarm was set for the wrong time, or the alarm went off but you did not hear it.

Testing Hypotheses

A hypothesis leads to testable predictions of what would happen if the hypothesis is valid. How could you use scientific thinking to test a hypothesis about oversleeping? If you slept late because the alarm was set for the wrong time, you could check the alarm to find out the time for which it was set. Suppose the alarm was actually set for 7 P.M. In this case, your hypothesis would be supported by your data, and you could be certain that the alarm was set for the wrong time.

For scientists, just one test of a hypothesis is usually not enough. Most of the time, it is only by repeating tests that scientists can be more certain that their results are not mistaken or due to chance. Why? Biological systems are highly variable. By repeating tests, scientists take this variability into account and try to decrease its effects on the experimental results.

After scientists collect data, they use statistics to mathematically analyze whether a hypothesis is supported. There are two possible outcomes of statistical analysis.

- **Nonsignificant** The data show no effect, or an effect so small that the results could have happened by chance.
- **Statistically significant** The data show an effect that is likely not due to chance.

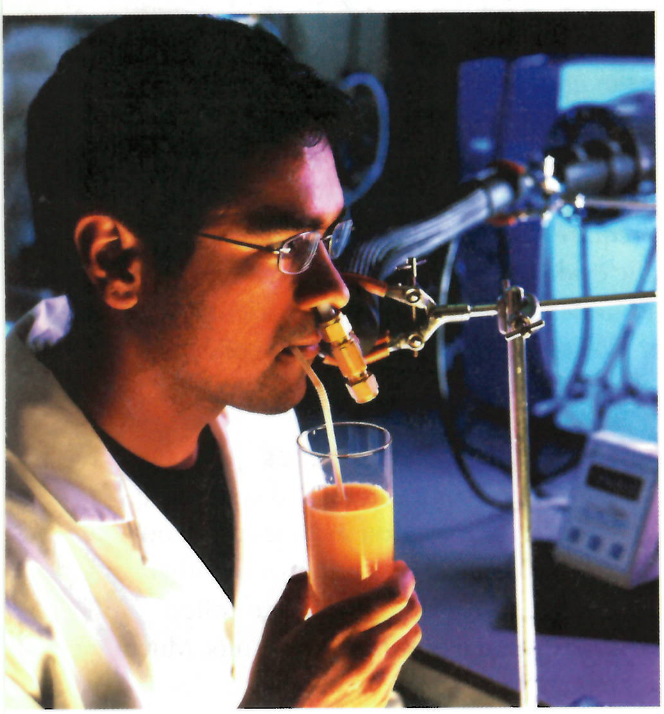


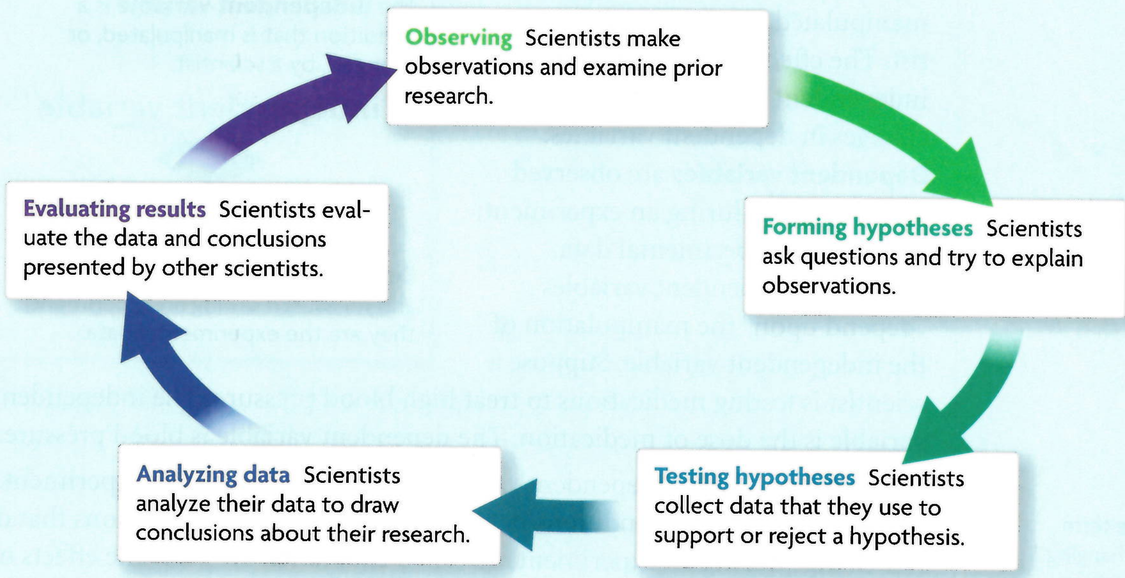
FIGURE 1.9 In this experiment, a scientist studies how chemicals are detected in the mouth and nose to produce taste.

When data do not support a hypothesis, it is rejected. But these data are still useful because they often lead to new hypotheses.

Experimental methods and results are evaluated by other scientists in a process called peer review. How was an experiment done and how were the data analyzed? Do the data support the conclusions of the experiment?

FIGURE 1.10 Scientific Thinking

Science is a cycle. The steps are shown in a certain order, but the cycle does not begin or end at any one point, and the steps may take place in various orders.



Synthesize Where in the cycle would retesting a hypothesis fit? Explain.

Is there bias in the experimental design or in the conclusions? Only after this review process is complete are research results accepted. Whether the results support an existing theory or disagree with earlier research, they are often used as a starting point for new questions. In **FIGURE 1.10**, you see the cycle of observing, forming hypotheses, testing hypotheses, analyzing data, and evaluating results that keeps scientific inquiry going.

Synthesize Why is there no one correct process of scientific investigation?

MAIN IDEA

Biologists use experiments to test hypotheses.

You have read about the importance of observations in science. Observational studies help biologists describe and explain something in the world. But in observational studies, scientists try not to interfere with what happens. They try to simply observe a phenomenon. One example involves the endangered white stork. The number of white storks has decreased sharply over the last 50 years. To help protect the storks, biologists have studied the migration patterns of the birds. What can observational studies tell a biologist about stork populations and migration? The studies can show changes in migration path and distance. They can show where storks breed and how many eggs they lay. Observational studies can answer all of these questions. But there is one question that observations cannot answer: What causes any changes that might be observed? The only way to answer that question is through an experiment.

Scientific experiments allow scientists to test hypotheses and find out how something happens. In **experiments,** scientists study factors called independent variables and dependent variables to find cause-and-effect relationships. The **independent variable** in an experiment is a condition that is manipulated, or changed, by a scientist. The effects of manipulating an independent variable are measured by changes in dependent variables. **Dependent variables** are observed and measured during an experiment; they are the experimental data. Changes in dependent variables "depend upon" the manipulation of the independent variable. Suppose a scientist is testing medications to treat high blood pressure. The independent variable is the dose of medication. The dependent variable is blood pressure.

VISUAL VOCAB

The **independent variable** is a condition that is manipulated, or changed, by a scientist.

independent variable

affects

dependent variable

Dependent variables are observed and measured during an experiment; they are the experimental data.

Ideally, only one independent variable should be tested in an experiment. Thus, all of the other conditions have to stay the same. The conditions that do not change during an experiment are called **constants.** To study the effects of an independent variable, a scientist uses a control group or control condition. Subjects in a control group are treated exactly like experimental subjects except for the independent variable being studied. The independent variable is manipulated in experimental groups or experimental conditions.

VOCABULARY

In common usage, the term *constant* means "unchanging." In experimental research, a constant is a condition or factor that is controlled so that it does not change.

Constants in the blood pressure medication experiment include how often the medication is given, and how the medication is taken. To control the experiment, these factors must remain the same, or be held constant. For example, the medication could be tested with 0, 25, 50, or 100 milligram doses, twice a day, taken by swallowing a pill. By changing only one variable at a time—the amount of medication—a scientist can be more confident that the results are due to that variable.

Infer How do experiments show cause-and-effect relationships?

MAIN IDEA

A theory explains a wide range of observations.

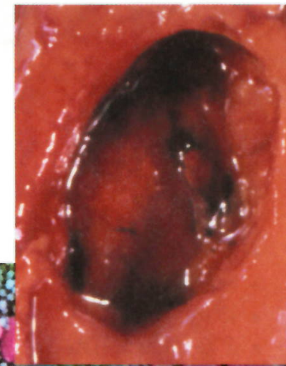
Many words have several different meanings. Depending on the context in which a word is used, its meaning can change completely. For example, the word *right* could mean "correct," or it could refer to a direction. Similarly, the word *theory* has different meanings. Usually, the word *theory* in everyday conversation means a speculation, or something that is imagined to be true. In science, the meaning of *theory* is very different.

Recall that a hypothesis is a proposed answer for a scientific question. A **theory** is a proposed explanation for a wide range of observations and experimental results that is supported by a wide range of evidence. Eventually, a theory may be broadly accepted by the scientific community. Natural selection is a scientific theory. It is supported by a large amount of data, and it explains many observations of life on Earth. Theories are not easily accepted in science, and by definition they are never proved. Scientific hypotheses and theories may be supported or refuted, and they are always subject to change. New theories that better explain observations and experimental results can replace older theories.

Theories can change based on new evidence. One example of how scientific understanding can change involves the cause of disease. Until the mid 1800s, illnesses were thought to be related to supernatural causes or to imbalances of the body's "humours," or fluids. Then scientific research suggested that diseases were caused by microscopic organisms, such as bacteria. The germ theory of disease was born, but it has changed over the years. For example, an early addition to the germ theory stated that it must be possible to grow a disease-causing microorganism in a laboratory.

Now, we know that viruses and prions do not completely fit the germ theory of disease because they are not living organisms. A virus has some of the characteristics of life, but it cannot reproduce itself without infecting a living cell. Prions are even less like organisms—they are just misfolded proteins. The link between prions and disease was not even suggested until the early 1980s, but much evidence points to prions as the cause of mad cow disease and, in humans, Creutzfeldt–Jakob disease.

The details of germ theory have changed as our knowledge of biology has grown, but the basic theory is still accepted. Scientists must always be willing to revise theories and conclusions as new evidence about the living world is gathered. Science is an ongoing process. New experiments and observations refine and expand scientific knowledge, as you can see in **FIGURE 1.11.** Our understanding of the world around us has changed dramatically over the past few decades, and the study of biology has changed and expanded as well.



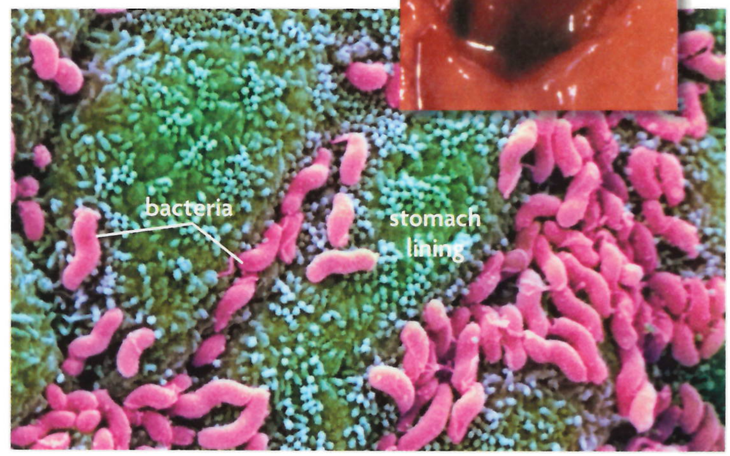


FIGURE 1.11 For many years, scientific evidence indicated that stomach ulcers (top) were caused by stress. Then, new evidence showed that the ulcers are actually caused by a type of bacteria called *Helicobacter pylori* (bottom). (colored SEM; magnification 4000×)

NSTA SCILINKS scilinks.org
To learn more about scientific methods, go to scilinks.org.
Keycode: MLB001

Summarize **What is a scientific theory?**

1.3 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What role do **hypotheses** play in scientific inquiry?
2. What is the difference between an **independent variable** and a **dependent variable**?
3. How is the meaning of **theory** in science different from the everyday use of the term?

CRITICAL THINKING

4. **Compare and Contrast** How are hypotheses and theories related?
5. **Apply** Give examples of different ways in which **observations** are used in scientific inquiry.

Connecting CONCEPTS

6. **Scientific Process** Why is the statement "All life is made of cells" an example of a theory? Explain.

MATERIALS

- 4 graduated cylinders with gelatin
- 4 marbles
- metric ruler
- 10 mL water
- 2 10-mL graduated cylinders
- 10 mL detergent (10%)
- 10 mL detergent (30%)
- 10 mL detergent (50%)

OR

- 10 mL detergent (pH 4)
- 10 mL detergent (pH 7)
- 10 mL detergent (pH 10)

PROCESS SKILLS

- **Measuring**
- **Modeling**

Manipulating Independent Variables

Some chemicals, called enzymes, help break down substances into smaller molecules. Some laundry detergents contain enzymes that help break down protein stains in clothing. In this investigation, you will test how different conditions affect the activity of the enzymes in laundry detergent.

PROBLEM How is enzyme activity affected by changes in conditions?

PROCEDURE

1. Obtain four graduated cylinders filled with gelatin. One of the cylinders is for the control condition. The other three are for the experimental conditions.
2. Decide which variable you would like to test.
   - pH (pH is a measurement of acidity, and a lower pH means that a substance is more acidic)
   - detergent concentration
3. The dependent variable is the amount of gelatin broken down by the enzyme in the detergent. Measure the dependent variable by placing a marble on top of the gelatin and measuring how far the marble sinks into the gelatin.
4. Identify the independent variable in your experiment. Form a hypothesis that explains the effect of the independent variable on the dependent variable.
5. Pour 10 mL of water onto the gelatin in one graduated cylinder. This graduated cylinder represents the control condition. Pour 10 mL of each different detergent solution into each of the other graduated cylinders. These graduated cylinders represent the experimental conditions.
6. Place a marble on the top of the gelatin in each graduated cylinder. Wait five minutes, then measure the distance that the marble has sunk into the gelatin.
7. Construct a data table like the one shown below, and record your data.

TABLE 1. EFFECT OF DETERGENT ON GELATIN

Condition	Distance (cm)
Water	
Solution 1	
Solution 2	
Solution 3	

ANALYZE AND CONCLUDE

1. **Analyze** Use a bar graph to plot your data. What trends exist in your data? Explain whether your results supported your hypothesis.
2. **Communicate** Share the results of your experiment with other groups in your class. Did other groups that manipulated the same independent variable obtain similar results? Why or why not?

EXTEND YOUR INVESTIGATION

Some areas have "hard" water, or water with a high mineral content. Other areas have "soft" water, or water with a low mineral content. Design an experiment to test the effect of the mineral content of water on detergent activity.

1.4 Biologists' Tools and Technology

KEY CONCEPT Technology continually changes the way biologists work.

MAIN IDEAS

- Imaging technologies provide new views of life.
- Complex systems are modeled on computers.
- The tools of molecular genetics give rise to new biological studies.

VOCABULARY

microscope, p. 19
gene, p. 23
molecular genetics, p. 23
genomics, p. 23

REVIEW AT CLASSZONE.COM

Connect Can you imagine life without cars, computers, or cell phones? Technology changes the way we live and work. Technology also plays a major part in the rapid increase of biological knowledge. Today, technology allows biologists to view tiny structures within cells and activity within a human brain. Technology allows biologists to study and change genes. What will technology allow next?

MAIN IDEA

Imaging technologies provide new views of life.

Until the late 1600s, no one knew about cells or single-celled organisms. Then the microscope was invented. Scientists suddenly had the ability to study living things at a level they never knew existed. Thus, the microscope was the first in a long line of technologies that have changed the study of biology.

Microscopes

A **microscope** provides an enlarged image of an object. Some of the most basic concepts of biology—such as the fact that cells make up all organisms—were not even imaginable before microscopes. The first microscopes magnified objects but did not produce clear images. By the 1800s, most microscopes had combinations of lenses that provided clearer images. Today's light microscopes, such as the one in **FIGURE 1.12** that you might use, are still based on the same principles. They are used to see living or preserved specimens, and they provide clear images of cells as small as bacteria. Light microscopes clearly magnify specimens up to about 1500 times their actual size, and samples are often stained with chemicals to make details stand out.

FIGURE 1.12 Biologists use microscopes to study cells, which are too small to be seen with the naked eye.

Electron microscopes, developed in the 1950s, use beams of electrons instead of light to magnify objects. These microscopes can be used to see cells, but they produce much higher magnifications, so they can also show much smaller things. Electron microscopes can clearly magnify specimens more than 100,000 times their actual size. They can even be used to directly study individual protein molecules. However, electron microscopes, unlike light microscopes, cannot be used to study living organisms because the specimens being studied have to be in a vacuum.

There are two main types of electron microscopes.

- A scanning electron microscope (SEM) scans the surface of a specimen with a beam of electrons. Usually, the specimen's surface is coated with a very thin layer of a metal that deflects the electrons. A computer forms a three-dimensional image from measurements of the deflected electrons.
- A transmission electron microscope (TEM) transmits electrons through a thin slice of a specimen. The TEM makes a two-dimensional image similar to that of a light microscope, but a TEM has a much higher magnification.

Often, SEM and TEM images are colorized with computers so that certain details are easier to see, as shown in **FIGURE 1.14.** Any time you see an SEM or TEM image in color, it has been given that color artificially.

Connecting CONCEPTS

Imaging Biologists use several types of micrographs, or images from microscopes. Whenever you see a micrograph in this book, LM stands for "light micrograph," SEM stands for "scanning electron micrograph," and TEM stands for "transmission electron micrograph."

Medical Imaging

Imaging technology is not limited to microscopes. In fact, technology used to study tissues inside living humans is commonly used in research and medicine. For example, doctors or dentists have probably taken x-ray images of you several times. An x-ray image is formed by x-rays, which pass through soft tissues, such as skin and muscle, but are absorbed by bones and teeth. Thus, x-ray images are very useful for looking at the skeleton but not so useful for examining soft tissues such as ligaments, cartilage, or the brain.

What if a doctor wants to examine ligaments in a person's knee? Another imaging technology called magnetic resonance imaging (MRI) is used. MRI uses a strong magnetic field to produce a cross-section image of a part of the body. A series of MRI images can be put together to give a complete view of all of the tissues in that area, as you can see in **FIGURE 1.13.** Advances in technology have led to new uses for MRI. For example, a technique called functional MRI (fMRI) can show which areas of the brain are active while a person is doing a particular task.

Compare and Contrast How do SEMs and TEMs produce different images of the same specimen?

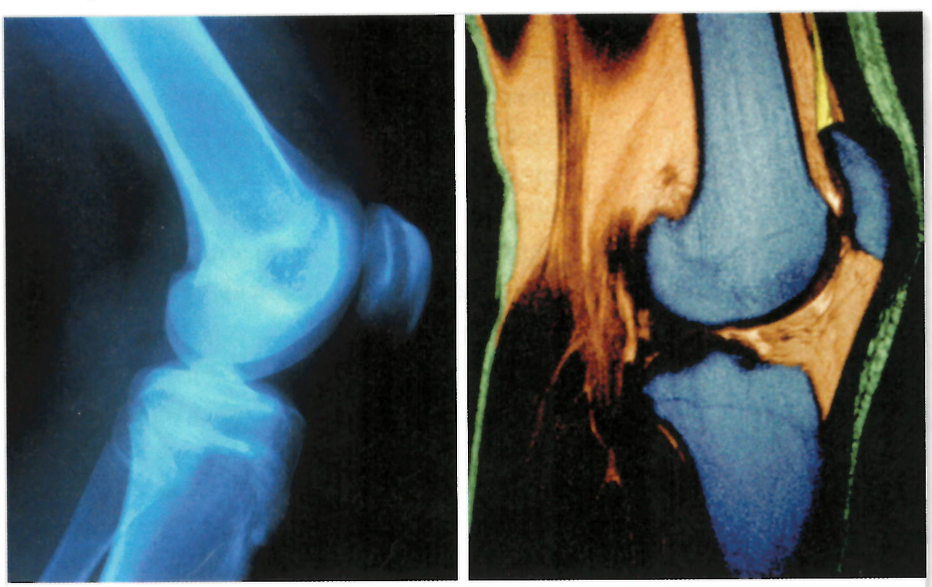


FIGURE 1.13 An x-ray of the human knee (left) shows dense tissues, such as bone, in detail. An MRI of the human knee (right) shows both soft and dense tissues in detail.

FIGURE 1.14 Comparing Micrographs

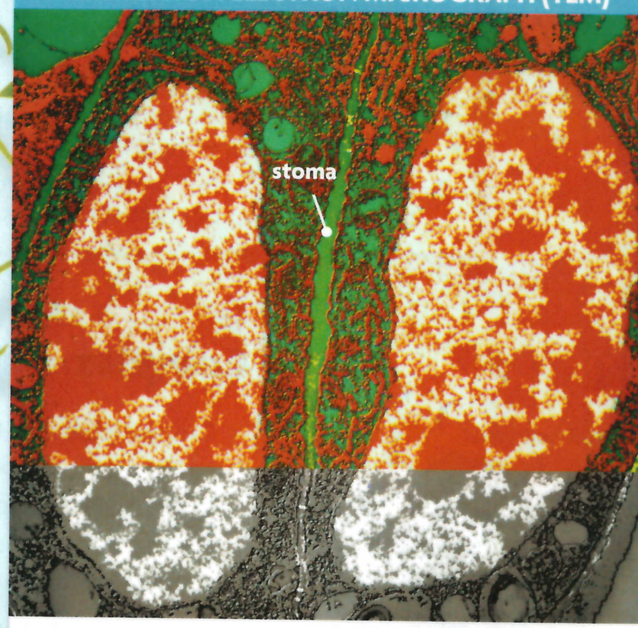
Different types of microscopes provide different views and magnifications, such as in these images of guard cells surrounding a stoma, or pore, in a leaf.

Animated BIOLOGY
View a set of cells through different microscopes at ClassZone.com.

LIGHT MICROGRAPH (LM)

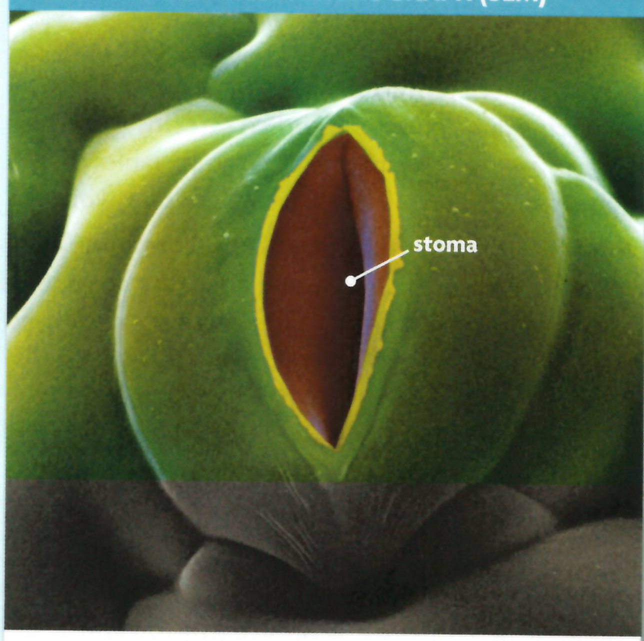
A light micrograph shows a two-dimensional image of a specimen. This light micrograph shows the actual color of the specimen. (LM; magnification 2000×)

TRANSMISSION ELECTRON MICROGRAPH (TEM)



A TEM shows a two-dimensional image of a thin slice of a specimen. A TEM is colorized by computer. The bottom part of the image shows the original black-and-white image. (colored TEM; magnification 5000×)

SCANNING ELECTRON MICROGRAPH (SEM)



An SEM shows a three-dimensional image of a specimen's surface. An SEM is colorized by computer. The bottom part of the image shows the original black-and-white image. (colored SEM; magnification 1500×)

CRITICAL VIEWING **What type of microscope would be best for showing details inside a cell? Why?**

QUICK LAB **OBSERVING**

Life Under a Microscope

Using a microscope properly is an important skill for many biologists. In this lab, you will review microscope skills by examining a drop of water from the surface of a local pond.

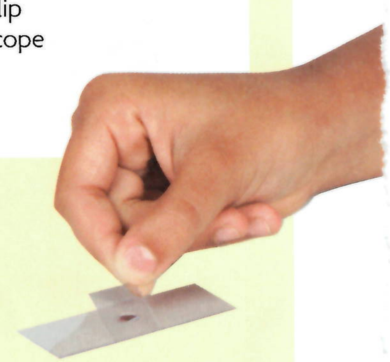
PROBLEM What types of organisms can be found in pond water?

PROCEDURE

1. Make a wet mount slide. Place a drop of pond water in the center of a microscope slide and carefully put a cover slip over the water. For more information on making a wet mount, see page R8.
2. View the pond water sample under low power on the microscope. Use the coarse focus knob to bring the sample into focus. Draw and label any organisms that you see in the sample.
3. View the slide under high power. Use the fine focus knob to bring portions of the sample into focus. Draw and label any organisms, including details of their structures, that you see in the sample.

MATERIALS

- 1 drop pond water
- eyedropper
- microscope slide
- cover slip
- microscope



ANALYZE AND CONCLUDE

1. **Connect** Describe how organisms in the sample exhibit the characteristics of living things.
2. **Compare and Contrast** Make a table to compare and contrast the characteristics of organisms in the sample of pond water.

MAIN IDEA

Complex systems are modeled on computers.

Computer-based technology has greatly expanded biological research. As computers have become faster and more powerful, biologists have found ways to use them to model living systems that cannot be studied directly. A computer model simulates the interactions among many different variables to provide scientists with a general idea of how a biological system may work.

Computers can model complex systems within organisms. For example, computer models are used to study how medicines might affect the body or, as you can see in **FIGURE 1.15**, the effects of a heart attack. Scientists have even used computer models to find out how water molecules travel into and out of cells. The scientists made a computer program that took into account more than 50,000 virtual atoms in a virtual cell. The computer model showed that water molecules must spin around in the middle of a channel, or a passage into the cell, to fit through the channel. Water molecules had a specific fit that other molecules could not match.

Computer models can also help biologists study complex systems on a much larger scale. Epidemiology, which is the study of how diseases spread, depends on computer models. For example, computer models can predict how fast and how far the flu might spread in a city. A model can calculate the number of people who might get sick, and suggest where in the city the illness began. This study cannot be done with people and cities. Computer models are used when actual experiments are not safe, ethical, or practical.

Infer What are some reasons why biologists use computer models?

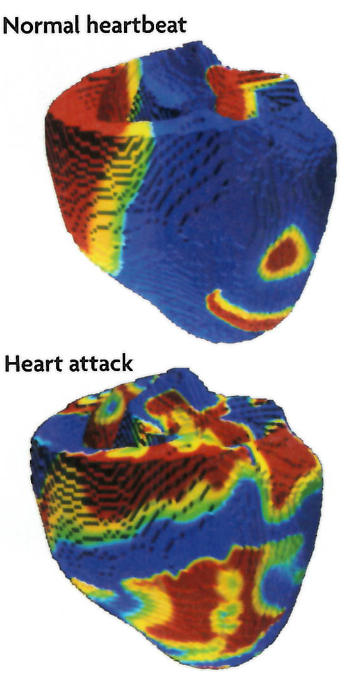


FIGURE 1.15 This computer-generated model shows that heart activity (red) is tightly regulated during a normal heartbeat. During a heart attack, heart activity is widespread and disorganized.

MAIN IDEA

The tools of molecular genetics give rise to new biological studies.

Computer-based technologies, such as those shown in **FIGURE 1.16**, have led to major changes in biology. But perhaps the greatest leap forward in our knowledge of life has happened in genetics. In just 40 years, we have gone from learning how the genetic code works, to changing genes, to implanting genes from one species into another. What is a gene? A **gene** is nothing more than a segment of DNA that stores genetic information. Our understanding of the DNA molecule has led to many technologies that were unimaginable when your parents were in high school—genetically modified foods, transgenic plants and animals, even replacement of faulty genes. These advances come from molecular genetics. **Molecular genetics** is the study and manipulation of DNA on a molecular level. Molecular genetics is used to study evolution, ecology, biochemistry, and many other areas of biology.

Entirely new areas of biology have arisen from combining molecular genetics with computer technology. For example, computers are used to quickly find DNA sequences. Through the use of computers, the entire DNA sequences, or genomes, of humans and other organisms have been found. **Genomics** (juh-NOH-mihks) is the study and comparison of genomes both within and across species. Here again, biologists need to use computers.

All of the information from genomics is managed by computer databases. By searching computer databases, a process called data mining, a biologist can find patterns, similarities, and differences in biological data. Suppose a biologist identifies a molecule that prevents the growth of cancerous tumors. The biologist could use computer databases to search for similar molecules.

This is the cutting edge of biology today. Where will biology be when your children are in high school?

Connect **What does the term *genetics* mean to you? Why?**

FIGURE 1.16 Robots are used to speed up research into the human genome (top). Computers are used to sequence human DNA (bottom).

Connecting CONCEPTS

Genetics You will learn much more about these and other genetics topics in **Unit 3**.

1.4 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. How do light **microscopes** differ from electron microscopes?
2. Why is computer modeling used in biological studies?
3. How does **molecular genetics** add to our understanding of **genes**?

CRITICAL THINKING

4. **Apply** Viruses are smaller than cells. What types of microscopes could be used to study them? Explain.
5. **Synthesize** Provide an example of how technology has helped biologists gain a better understanding of life.

Connecting CONCEPTS

6. **Evolution** **Genomics** can be used to study the genetic relationships among species. Why might genomics be important for evolution research? Explain.

1.5 Biology and Your Future

KEY CONCEPT Understanding biology can help you make informed decisions.

MAIN IDEAS

- Your health and the health of the environment depend on your knowledge of biology.
- Biotechnology offers great promise but also raises many issues.
- Biology presents many unanswered questions.

VOCABULARY

biotechnology, p. 26
transgenic, p. 26

REVIEW AT CLASSZONE.COM

Connect Should brain imaging technology be used to tell if someone is lying? Is an endangered moth's habitat more important than a new highway? Would you vote for or against the pursuit of stem cell research? An informed answer to any of these questions requires an understanding of biology and scientific thinking. And although science alone cannot answer these questions, gathering evidence and analyzing data can help every decision maker.

MAIN IDEA

Your health and the health of the environment depend on your knowledge of biology.

Decisions are based on opinions, emotions, education, experiences, values, and logic. Many of your decisions, now and in the future, at both personal and societal levels, involve biology. Your knowledge of biology can help you make informed decisions about issues involving endangered species, biotechnology, medical research, and pollution control, to name a few. How will your decisions affect the future of yourself and others?

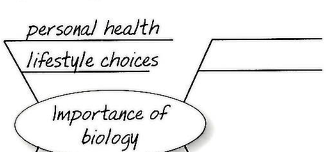
Biology and Your Health

What you eat and drink is directly related to your health. But you may not think twice about the possibility of contaminated food or water, or a lack of vitamins in your diet. Not long ago, diseases caused by vitamin deficiencies were still fairly common. The first vitamins were identified less than 100 years ago, but today the vitamins found in foods are printed on labels.

Even today we still face food-related causes of illness. For example, you might hear about an outbreak of food poisoning, and mad cow disease was only recognized in the late 1980s. Of perhaps greater concern to you are food allergies. Many people suffer from severe, even life-threatening, allergies to foods such as peanuts and shellfish. Beyond questions about the sources of food are questions and concerns about what people eat and how much they eat. For example, scientists estimate that more than 60 percent of adults in the United States are overweight or obese. The health consequences of obesity include increased risks of diabetes, stroke, heart disease, breast cancer, colon cancer, and other health problems. Biology can help you to better understand all of these health-related issues.

TAKING NOTES

Use a mind map to take notes about the importance of studying biology.



An understanding of biology on many different levels—genetic, chemical, and cellular, for example—can help you make any number of lifestyle choices that affect your health. Why is it important to use sunscreen? What are the benefits of exercise? What are the effects of using alcohol, illegal drugs, and tobacco? Cigarette smoke does not just affect the lungs; it can also change a person's body chemistry, as you can see in **FIGURE 1.17.** Lower levels of monoamine oxidase in the brain can affect mood, and lower levels in the liver could contribute to high blood pressure.

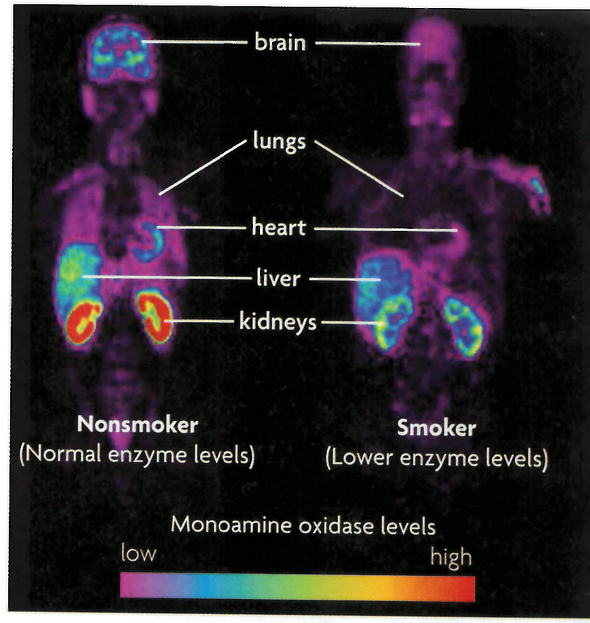


FIGURE 1.17 As compared with nonsmokers, smokers have much lower levels of an enzyme called monoamine oxidase throughout their bodies.

Biology and the World Around You

In 1995, some middle school students from Minnesota were walking through a wetland and collecting frogs for a school project. The students stopped to look at the frogs, and what they saw shocked them. Many of the frogs had deformities, including missing legs, extra legs, and missing eyes. What caused the deformities? Scientists investigated that question by testing several hypotheses. They studied whether the deformities could have been caused by factors such as a chemical in the water, ultraviolet radiation, or some type of infection.

Why would frog deformities such as that in **FIGURE 1.18** provoke such scientific interest? The frogs are a part of an ecosystem, so whatever affected them could affect other species in the area. If the deformities were caused by a chemical in the water, might the chemical pose a risk to people living in the area? In other regions of the United States, parasites caused similar deformities in frogs. Might that parasite also be present in Minnesota? If so, did it pose a risk to other species?

Scientists still do not know for sure what caused the frog deformities in Minnesota. No parasitic infection was found, so that hypothesis was rejected. However, evidence indicates that the water contained a chemical very similar to a chemical in frogs that helps control limb development. It is not known whether the chemical is the result of pollution or if it occurs naturally.

FIGURE 1.18 Deformities in frogs can be an indication of chemical pollution in an ecosystem.

Suppose that the chemical comes from a factory in the area. Is it reasonable to ban the chemical? Should the factory be closed or fined? In any instance like this, political, legal, economic, and biological concerns have to be considered. What is the economic impact of the factory on the area? Is there any evidence of human health problems in the area? Is there a different chemical that could be used? Without an understanding of biology, how could you make an informed decision related to any of these questions?

These are the types of questions that people try to answer every day. Biologists and other scientists research environmental issues such as pollution, biodiversity, habitat preservation, land conservation, and natural resource use, but decisions about the future are not in the hands of scientists. It is up to everyone to make decisions based on evidence and conclusions from many different sources.

Connect How might biology help you to better understand environmental issues?

MAIN IDEA

Biotechnology offers great promise but also raises many issues.

FIGURE 1.19 Biotechnology is being used in the search for alternative energy sources, as shown in this bioreactor that uses algae (inset) to produce hydrogen gas. (LM; magnification 400×)

Biotechnology is the use and application of living things and biological processes. Biotechnology includes a very broad range of products, processes, and techniques. In fact, some forms of biotechnology have been around for centuries, such as the use of microorganisms to make bread and cheese. Today, biotechnology is used in medicine, agriculture, forensic science, and many other fields. For example, people wrongly convicted of crimes have been freed from prison when DNA testing has shown that their DNA did not match DNA found at crime scenes. Biotechnology has great potential to help solve a variety of modern problems, such as the search for alternative energy sources like the algae shown in **FIGURE 1.19**. However, along with the advances in biotechnology come questions about its uses.

Benefits and Biological Risks

All domestic plants and animals are the result of centuries of genetic manipulation through selective breeding. Today, genetic manipulation can mean the transfer of genetic information from one organism to a very different organism. Organisms that have genes from more than one species, or have altered copies of their own genes, are called **transgenic** organisms. Transgenic bacteria can make human insulin to treat people with diabetes. Transgenic sheep and cows can make human antibodies and proteins. When you hear about genetically modified foods, you are hearing about transgenic organisms.

Genetically modified foods have many potential benefits. Crop plants are changed to increase the nutrients and yield of the plants and to resist insects. Insect-resistant crops could reduce or end the need for chemical pesticides. However, the long-term effects of genetically modified crops are not fully known. Is it safe to eat foods with genetically modified insect resistance? What if genetically modified plants spread undesirable genes, such as those for herbicide resistance, to wild plants? Around the world, the benefits and risks of biotechnology are debated. Understanding these benefits and risks requires knowledge of ecosystems, genetic principles, and even the functions of genes.

Connecting CONCEPTS

Genetics You will learn more about genetic screening and how it is used in **Chapter 9**.

Benefits and Ethical Considerations

Another form of biotechnology is human genetic screening, which is the analysis of a person's genes to identify genetic variations. Genetic screening can indicate whether individuals or their potential offspring may be at risk for certain diseases or genetic disorders. Genetic screening has the potential for early diagnosis of conditions that can be treated before an illness occurs.

Genetic screening also raises ethical concerns. For example, who should have access to a person's genetic information? Some people are concerned that insurance companies might refuse health insurance to someone with a gene that might cause a disease. Suppose genetic screening reveals that a child might have a genetic disorder. How should that information be used? Genetic screening has the potential to eliminate some disorders, but what should be considered a disorder? Of greater concern is the possibility that people might use genetic screening to choose the characteristics of their children. Is it ethical to allow people to choose to have only brown-eyed male children who would be at least six feet tall?

Predict How might genetically modified crops affect biodiversity?

MAIN IDEA

Biology presents many unanswered questions.

About 50 years ago, the structure of DNA was discovered. By 2003, the entire human DNA sequence was known. Over the last 50 years, our biological knowledge has exploded. But even today there are more questions than answers. Can cancer be prevented or cured? How do viruses mutate? How are memories stored in the brain? One of the most interesting questions is whether life exists on planets other than Earth. Extreme environments on Earth are home to living things like the methane worms in **FIGURE 1.20.** Thus, it is logical to suspect that other planets may also support life. But even if life exists elsewhere in the universe, it may be completely different from life on Earth. How might biological theories change to take into account the characteristics of those organisms?

FIGURE 1.20 Methane worms live in frozen methane gas at the bottom of the Gulf of Mexico. Because some organisms can live in such extreme environments, some scientists hypothesize that life exists, or once existed, on the planet Mars. (SEM; magnification 20×)

A huge number of questions in biology are not just unanswered—they are unasked. Before the microscope was developed, no one investigated anything microscopic. Before the middle of the 20th century, biologists did not know for sure what the genetic material in organisms was made of. As technology and biology advance, who knows what will be discovered in the next 20 years?

Evaluate Do you think technology can help answer all biological questions? Explain your views.

1.5 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING MAIN IDEAS

1. Give three examples of ways in which biology can help inform everyday decisions.
2. What are some of the potential benefits and potential risks of biotechnology?
3. What are some of the unanswered questions in biology?

CRITICAL THINKING

4. **Synthesize** Scientists disagree on whether genetically modified foods are safe to eat. What type of scientific evidence would be needed to show that a genetically modified food is unsafe?
5. **Connect** How might your study of biology help inform you about your lifestyle choices?

Connecting CONCEPTS

6. **Ecology** What effects might genetically modified plants and animals have on an ecosystem if they breed with wild plants and animals?

CHAPTER 1

OPTIONS FOR INQUIRY

Use these inquiry-based labs and online activities to deepen your understanding of biology and scientific experiments.

DESIGN YOUR OWN INVESTIGATION

Manipulating Plant Growth

The direction in which plants grow is affected by conditions such as light, gravity, and contact with an object. In this lab, you will design your own experiment to determine how changing an independent variable affects a dependent variable.

MATERIALS

- 3 bean plants
- 10 cm masking tape
- permanent marker
- light source
- 3 wooden sticks
- 1 m string
- metric ruler
- water
- 250-mL beaker

SKILLS **Designing Experiments, Observing, Collecting Data, Analyzing Data, Inferring**

PROBLEM How does changing an external condition affect plant growth?

PROCEDURE

1. Label three bean plants A, B, and C.
2. Decide which condition you will test: light, gravity, or contact with an object.
3. Design your experiment and identify your independent variable. Use one plant as the control condition. Use the other two plants as experimental conditions. For example, gravity can be tested by placing an experimental plant on its side.
4. Identify the constants in your experiment, such as the amount of water you will give the plants.
5. Determine the operational definition for the dependent variable; that is, decide how you will measure the dependent variable. For example, it could be the number of leaves facing in a certain direction each day.
6. Record your observations once a day for five days in a table like the one shown below. Remember to wash your hands after handling the plants.
7. Have your teacher approve your procedure. Carry out your experiment.

TABLE 1. EFFECT OF ______ ON PLANT GROWTH

Day	Plant A Growth (mm)	Plant B Growth (mm)	Plant C Growth (mm)
1			
2			

ANALYZE AND CONCLUDE

1. **Analyze** How did your independent variable affect plant growth? How did you measure the dependent variable? Do the data support your hypothesis? Explain.
2. **Infer** Why is it important to have control groups and constants in an experiment?
3. **Communicate** Share your results with other groups. How did different independent variables affect plant growth? Did your results agree with the results of other groups that tested the same variable? If not, what might have caused that difference?
4. **Design Experiments** Review the design of your experiment. What changes could you make to the procedure to reduce the variability in your data?
5. **Ask Questions** From your data, what new questions do you have about plant growth?