UNIT 1 Introduction

Researcher with Nassau grouper

Giant panda cub with caretaker at Wolong Nature Reserve in China

UNIT 1

Ecological survey of mountain eucalyptus

DISCOVERIES IN SCIENCE

Milestones in Biology

1489

Leonardo da Vinci applies architectural techniques to anatomical drawing. His detailed drawings of the human skull revolutionize scientific illustration.

Statue of Leonardo da Vinci in Italy

1811

At 12 years old, Mary Anning, a British fossil collector, discovers the first complete fossil skeleton of an ichthyosaur. Other scientists use her discoveries to support the theory that fossils are evidence of extinct species.

1898

Marie Curie, a scientist born in Poland, demonstrates that isotopes of certain elements, such as radium and polonium, are the source of radioactive energy in radioactive rocks.

Marie Curie in her laboratory

1910

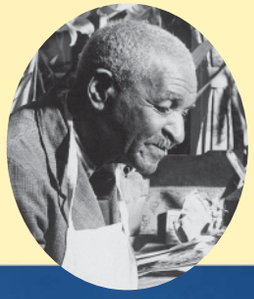
Alex Carrel publishes a paper reporting his success in using cold storage to preserve blood vessels for long periods of time before transplanting them. His work, related to developing organ-transplant processes, earns him the Nobel Prize in physiology or medicine in 1912.

1918–1919

An influenza epidemic kills between 20 million and 40 million people worldwide. In less than a year, about 675,000 Americans die of the disease, 10 times the number of Americans who died in World War I.

1927

George Washington Carver, American inventor and botanist, patents a process for making paints from soybean extracts.



George Washington Carver

1971

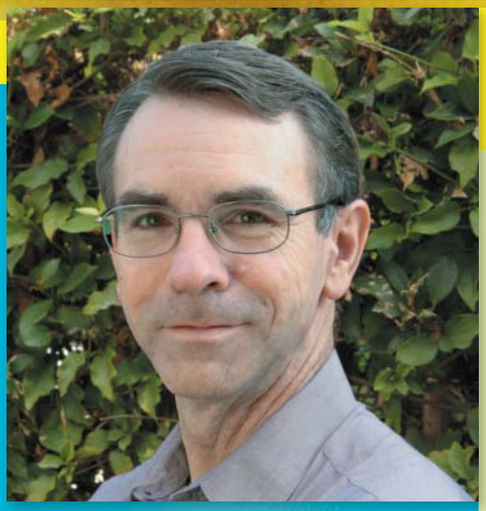
Louis Leaky sponsors Biruté Mary Galdikas to study the orangutans of Borneo. In 1975, Galdikas begins publishing articles about her observations of orangutan behavior. Many articles and lectures follow. Her work helps educate the public about the need to preserve wild habitats.

1996

David Ho is recognized as *Time* magazine's Man of the Year for his pioneering work developing "cocktails" of medicines that fight HIV.

David Ho

Mason wasp with prey



BIOLOGY CAREER

Forensic Scientist

Wayne Moorehead

Wayne Moorehead is a forensic scientist. Forensic scientists use scientific processes to investigate legal matters. Moorehead works with the Trace Evidence and Fire Division of the Orange County Sheriff–Coroner Crime Laboratory in California. He specializes in forensic microscopy, trace evidence, and the analysis of explosives, fire debris, and unusual evidence. Moorehead enjoys his work, especially using critical thinking to answer questions about crimes.

Moorehead traces his interest in forensic science back to his childhood, when he enjoyed using a chemistry set and microscope and reading forensic science books. He still collects books in his field.

Moorehead enjoys using forensic science in criminal investigations but considers his greatest accomplishment to be teaching forensic science to high school students, college students, professors, and the public.

Yellow crinoid and reef fish on a coral reef

Chapter Planner 2

Applications of Biology

		Standards	Teach Key Ideas
CHAPTER OPENER, pp. 26–27	15 min.	*National Science Education Standards*	
SECTION 1 Health in the 21st Century, pp. 29–32 › Meeting the Challenge › Disease in a Changing World › Biology and Human Potential	90 min.	SI2, ST2, SPSP1, SPSP6, HNS1, HNS2	**Bellringer Transparency** **Transparencies** F6 Important Bacterial Diseases • J37 The Immune Response **Visual Concepts** Pathogen • Vaccine
SECTION 2 Biology, Technology, and Society, pp. 33–37 › Biotechnology Around Us › Applications of Biological Research › Biology, Forensics, and Public Safety › The Ethics of Biotechnology	60 min.	ST2, SPSP1, SPSP5, SPSP6, HNS1, HNS2	**Bellringer Transparency** **Transparencies** A29 How Telescopes Work • C34 Genetic Engineering • C35 Genetically Engineered Medicine • C38 Making a Genetically Engineered Vaccine **Visual Concepts** Genetic Engineering • Using Plasmids to Produce Insulin • Genetically Engineered Vaccines • DNA Fingerprint • Making a DNA Fingerprint
SECTION 3 Biology and the Environment, pp. 38–43 › A Lost World › Technology In Environmental Science › Citizen Scientists	30 min.	LSInter 5, SPSP1, SPSP3, SPSP4, SPSP6, HNS1, HNS2	**Bellringer Transparency** **Transparencies** E27 Earth's Major Biomes **Visual Concepts** Species • Biodiversity • Conservation • Recycling
			See also PowerPoint® Resources

Chapter Review and Assessment Resources

- SE Super Summary, p. 44
- SE Chapter Review, p. 45
- SE Standardized Test Prep, p. 47
- Review Resources
- Chapter Tests A and B
- Holt Online Assessment

CHAPTER FastTrack

It is best to cover all of the material in this chapter because it supports science process and technology curriculum objectives.

Basic Learners

- TE Vaccination Model, p. 31
- TE Word Parts, p. 34
- TE Lost World Species, p. 38
- Directed Reading Worksheets*
- Active Reading Worksheets*
- Lab Manuals, Level A*
- Study Guide* ■
- Note-taking Workbook*
- Special Needs Activities and Modified Tests*

Advanced Learners

- TE Be the Expert, p. 35
- TE DNA Evidence, p. 36
- Critical Thinking Worksheets*
- Concept Mapping Worksheets*
- Science Skills Worksheets*
- Lab Datasheets, Level C*

Key

SE Student Edition
TE Teacher's Edition

Chapter Resource File
Workbook
Transparency

CD or CD-ROM
* Datasheet or blackline master available

■ Also available in Spanish

All resources listed below are also available on the Teacher's One-Stop Planner.

Why It Matters	Hands-On	Skills Development	Assessment
Build student motivation with resources about high-interest applications.	SE **Inquiry Lab** Artificial Shark Skin, p. 27*■	TE **Reading Toolbox** Assessing Prior Knowledge, p. 26 SE **Reading Toolbox,** p. 28	
	SE **Quick Lab** Model a Low-Tech Solution, p. 31*■ SE **Skills Practice Lab** Microbe Growth, p. 42*■	SE **Reading Toolbox** Predictions, p. 31 TE **Reading Toolbox** Predictions, p. 31	SE **Section Review** TE **Formative Assessment Spanish Assessment***■ **Section Quiz**■
TE **Synthetic Hormones,** p. 34	SE **Quick Lab** Biomimetic Engineering, p. 34*■ **Quick Lab** Using Bacteria to Make Food*	SE **Reading Toolbox** Word Parts, p. 35 TE **Reading Toolbox** Word Parts, p. 35	SE **Section Review** TE **Formative Assessment Spanish Assessment***■ **Section Quiz**■
TE **Rainforest Medicines,** p. 38 SE **Bio Bots,** p. 41	**Inquiry Lab** Collecting Data Through a Survey*	SE **Reading Toolbox** Three-Panel Flip Chart, p. 39 TE **Reading Toolbox** Three-Panel Flip Chart, p. 39 TE **Reading Toolbox** Visual Literacy, p. 41	SE **Section Review** TE **Formative Assessment Spanish Assessment***■ **Section Quiz**■
	See also Lab Generator		**See also Holt Online Assessment Resources**

Resources for Differentiated Instruction

English Learners

TE New Terms, p. 30
TE Word Origins, p. 39
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*
Multilingual Glossary

Struggling Readers

TE New Terms, p. 30
TE Sequencing Events, p. 31
TE Vaccination Model, p. 31
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Special Education Students

TE Biological Research, p. 35
TE Modeling GIS, p. 39
Directed Reading Worksheets*
Active Reading Worksheets*
Lab Manuals, Level A*
Study Guide*■
Note-taking Workbook*
Special Needs Activities and Modified Tests*

Alternative Assessment

TE Understanding Ethics, p. 36
Science Skills Worksheets*
Section Quizzes*■
Chapter Tests A, B, and C*■

Chapter 2

Overview

This chapter describes how research connects biology to our everyday lives. This chapter illustrates how knowledge helps us better understand ourselves and the world around us.

READING TOOLBOX

Assessing Prior Knowledge Students should understand the following concepts:
- characteristics of life
- nature of scientific thinking

Visual Literacy Ask students what characteristics of living things can be attributed to a robot. (Sample answers: ability to move, ability to communicate, require energy, and the ability to process information) What characteristics of living things are not exhibited by a robot? (Sample answers: ability to reproduce, ability to grow and develop)

Biology is on the verge of creating tools that can target specific cells and deliver therapy. This technique would minimize damage to surrounding cells while maximizing therapeutic efficiency. LS Visual

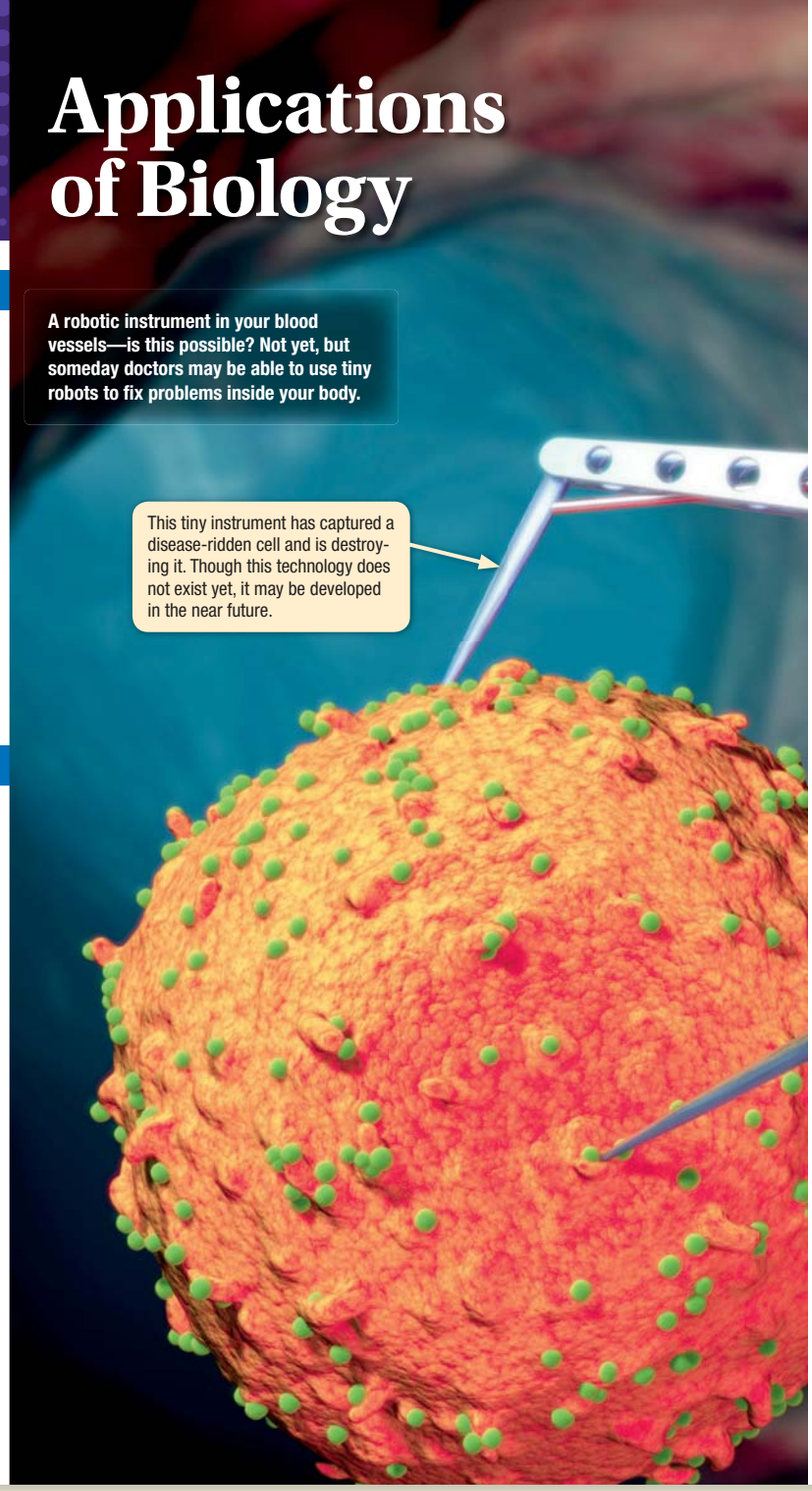
Chapter 2

Applications of Biology

Preview

Why It Matters

Biological research affects many aspects of our lives. Many of the products we use, the food we eat, and the medicine we take have been improved through applications of biology.

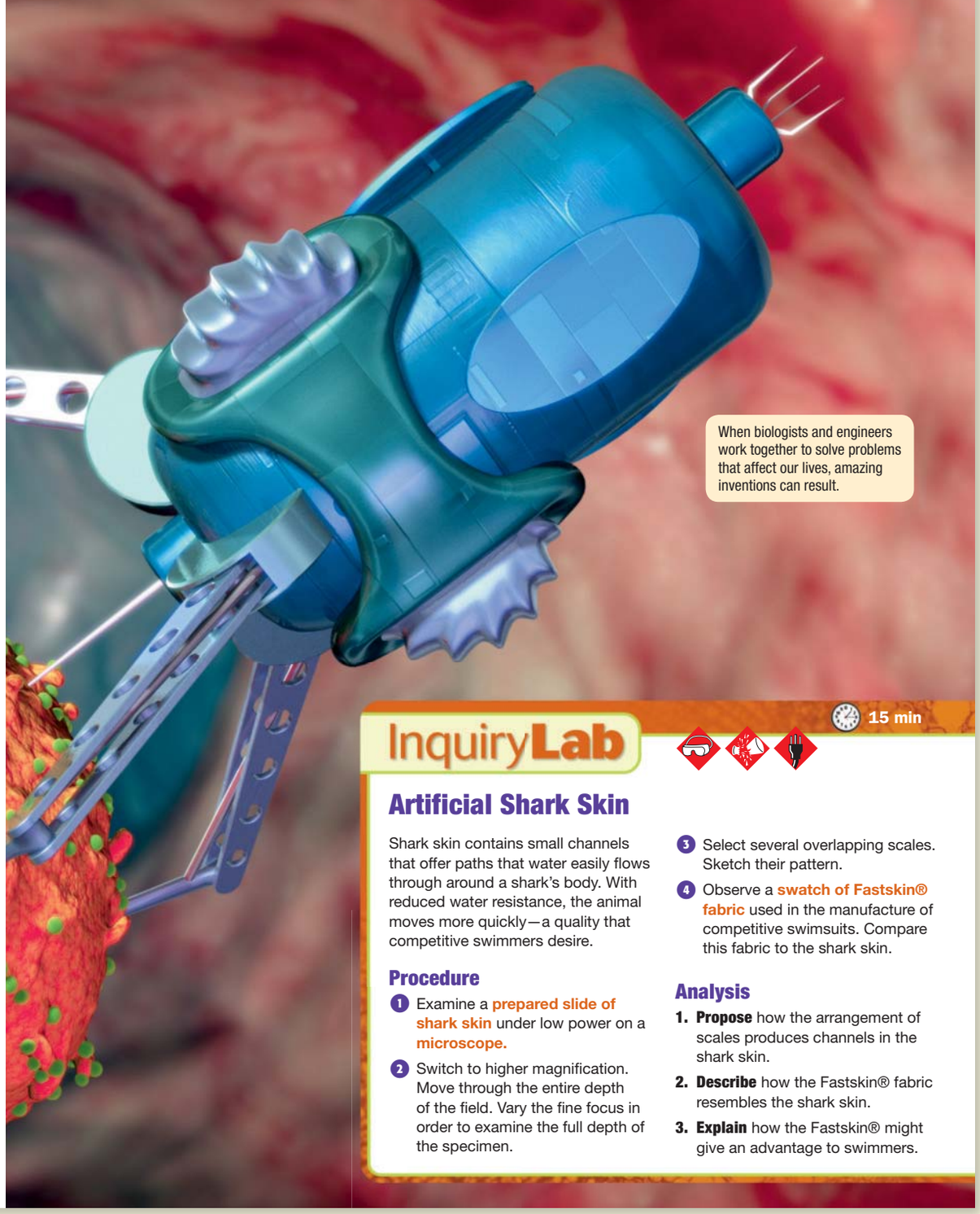


A robotic instrument in your blood vessels—is this possible? Not yet, but someday doctors may be able to use tiny robots to fix problems inside your body.

This tiny instrument has captured a disease-ridden cell and is destroying it. Though this technology does not exist yet, it may be developed in the near future.

Chapter Correlations — *National Science Education Standards*

LSInter 5 Human beings live within the world's ecosystems.
SI2 Understandings about scientific inquiry
ST2 Understandings about science and technology
SPSP1 Personal and community health
SPSP3 Natural resources
SPSP4 Environmental quality
SPSP5 Natural and human-induced hazards
SPSP6 Science and technology in local, national, and global challenges
HNS1 Science as a human endeavor
HNS2 Nature of scientific knowledge



When biologists and engineers work together to solve problems that affect our lives, amazing inventions can result.

InquiryLab

15 min

Artificial Shark Skin

Shark skin contains small channels that offer paths that water easily flows through around a shark's body. With reduced water resistance, the animal moves more quickly—a quality that competitive swimmers desire.

Procedure

1. Examine a **prepared slide of shark skin** under low power on a **microscope.**
2. Switch to higher magnification. Move through the entire depth of the field. Vary the fine focus in order to examine the full depth of the specimen.
3. Select several overlapping scales. Sketch their pattern.
4. Observe a **swatch of Fastskin® fabric** used in the manufacture of competitive swimsuits. Compare this fabric to the shark skin.

Analysis

1. **Propose** how the arrangement of scales produces channels in the shark skin.
2. **Describe** how the Fastskin® fabric resembles the shark skin.
3. **Explain** how the Fastskin® might give an advantage to swimmers.

InquiryLab

Teacher's Notes Have students work in pairs. Students should wear eye protection except when viewing slides. Review proper techniques using microscope. Fastskin® is a product of Speedo, and can be purchased at sporting goods stores.

Materials

- prepared slide of sharkskin
- microscope
- swatch of Fastskin® fabric

Answers to Analysis

1. The pattern of the overlap resulted in ridges and gaps that formed the surface's channel-like features.
2. It had a raised pattern that produced a series of channels along its surface.
3. Swimmers would go faster since the water would more easily flow around their body as directed by the sharkskin pattern.

READING TOOLBOX

Using Words

1. life measurement
2. having to do with genes
3. all parts of something to do with life
4. all parts of something to do with genes

Using Language

1. The newly gathered evidence suggests that the bird is not actually extinct.
2. Humans will travel to Mars, assuming that resources become available.

Using FoldNotes

The three-panel flip chart aids the organization of students' thoughts around a single idea. Many flip charts can be made throughout a chapter depending on the number of ideas the student needs to organize. Students can modify the flip chart to have as few as two and as many as six panels, depending on the complexity of the topic. LS Verbal

READING TOOLBOX

These reading tools can help you learn the material in this chapter. For more information on how to use these and other tools, see **Appendix: Reading and Study Skills.**

Using Words

Word Parts You can tell a lot about a word by taking it apart and examining its prefix, root, and suffix.

Your Turn Use the table to hypothesize the meanings of the following words.

1. *biometrics*
2. *genetics*
3. *biome*
4. *genome*

Word Parts

Part	Type	Meaning
bio-	prefix	life
metric	root	measurement
-ic	suffix	having to do with
-ome	suffix	all parts of something
gen	root	born; to become; to produce

Using Language

Predictions A prediction is a statement about what might happen in the future. You can identify predictions in the material you read by locating terms such as *might, impossible,* and *likely*.

Your Turn Read the following sentences, and write the author's prediction.

1. Scientists agree that the birdcall heard on the tape is likely a bird thought to be extinct.
2. With enough funding and effort, humans might travel to Mars one day.

Using FoldNotes

Three-Panel Flip Chart A three-panel flip chart is useful when you want to compare the characteristics of three topics. The three-panel flip chart can help you organize the characteristics of the three topics side by side under the flaps. Similarities and differences between the three topics can then be easily identified.

Your Turn Create a flip chart that compares areas of biological research such as epidemiology, genetics, and environmental science.

1. Fold a piece of paper in half from the top to the bottom.
2. Fold the paper in thirds from side to side. Then, unfold the paper so that you can see the three sections.
3. From the top of the paper, cut along each of the vertical fold lines to the fold in the middle of the paper. You now have three flaps.

Section 1

Health in the 21st Century

Key Ideas	Key Terms	Why It Matters
How are biologists working to eliminate major diseases that affect human populations? How has our understanding of the biological nature of disease changed over time? How might medical advances improve and extend human lives?	epidemiology vaccination genetics genome	Studying how diseases spread and developing ways to prevent and treat diseases can help reduce human suffering.

Biological research in the 20th century led to incredible advances in the prevention and treatment of disease. Yet, despite this progress, we still have more to learn and understand about how diseases affect humans. One of the great challenges of biology is to apply our understanding of the natural world to these issues.

Meeting the Challenge

Biologists combine research and data from many different fields of science to help reduce the spread of disease. For example, biologist Rita Colwell has applied biological research, data from the ocean, and chemistry to reduce the number of outbreaks of cholera. Cholera is a disease that is caused by ingesting food or water that contains the cholera bacterium. This bacterium is a *pathogen,* that is, an agent that causes disease. Normally, a person must ingest millions of cholera bacteria to contract the disease. However, Colwell and her students found that tiny animals called *copepods* give the bacteria an advantage. The bacteria cluster around the mouthparts and egg casings of female copepods, which are shown in **Figure 1.** The copepods benefit from this behavior because the bacteria help burst the copepods' egg casings and release the copepod eggs. Then, the bacteria feed on the broken egg casings. Copepods feed on plankton—microscopic plant and animal life—in ocean water. When the amount of plankton in the water increases, the number of copepods (and, thus, bacteria) in the water increases and a cholera outbreak could occur.

SCILINKS
www.scilinks.org
Topic: Disease Prevention
Code: HX80414

Reading Check ***Why is the cholera bacterium a pathogen? (See the Appendix for answers to Reading Checks.)***

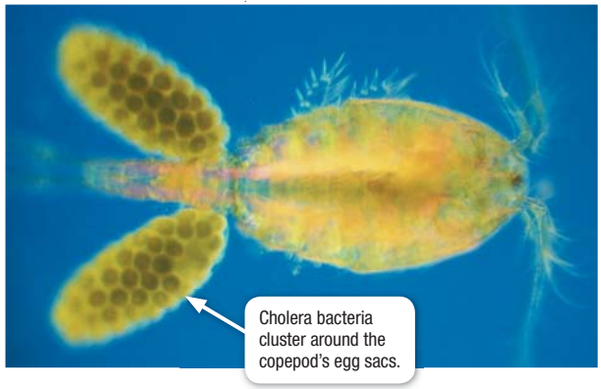


Figure 1 This micrograph illustrates two egg sacs (left, dark yellow) that are attached to a copepod (right, light yellow). The cholera bacteria is spread in part when the egg sacs rupture.

Key Resources

Transparencies
F6 Important Bacterial Diseases
J37 The Immune Response

Visual Concepts
Pathogen
Vaccination

Section 1

Focus

This section explains the role biology played in improving human health during the last one hundred years and explores where research is leading us in the future.

Bellringer
Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

Parasites Ask students for other examples of parasites that can make humans extremely ill. (Some examples are malaria virus *Plasmodia* carried by *Anopheles* mosquitoes; *Rikettesia* which causes Rocky Mountain Spotted Fever, carried by ticks in the eastern United States and Lyme disease, carried by deer ticks.)
LS Visual

Teach, *continued*

Teaching Key Ideas

Integrating the Sciences The cholera example shows how science is an integrated field of study. Researchers must understand the organism, its environment and biochemistry, and the geography of the area. Emphasize that educated citizens integrate many fields of study including geography, computer science, and mathematics. Challenge students to research other discoveries that illustrate the integration of the sciences. (For example, any cellular research requires an in-depth knowledge of chemistry. Prosthesis research requires an understanding of physics.) LS Verbal

Teaching Key Ideas

Scientific Models Explain that the use of models to make predictions is an important aspect of science. Just like an automobile engineer builds a small version of the car they are designing to see how it will be affected by environmental factors, biologists build models to predict how a bacteria will spread in an environment. Often, the scientific models include complex mathematical relationships between variables in the environment and how they affect the organism under research.

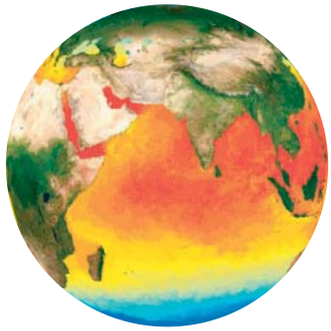


Figure 2 Colwell analyzed satellite data of the ocean to predict cholera outbreaks. In this image, warm colors such as red represent warmer water temperatures.

Solving the Riddle After Colwell established a link between cholera and copepods, she focused on some interesting data. Cholera outbreaks occurred regularly in water that tested negative for cholera bacteria. As a result, researchers assumed that the bacteria were not present in the water. However, Colwell was convinced that the bacteria existed in a form that could not be detected by the tests.

Colwell developed a more sensitive test that relied on the chemical properties of the bacteria's cell wall. She used this new test to detect cholera bacteria in water that had previously tested negative for the bacteria. This research suggested that cholera bacteria exist in a dormant state in cold water and that they become active when water temperature increases.

Using Models Colwell was able to predict cholera outbreaks with much greater accuracy because she now understood the role of water temperature in the cholera life cycle. She used satellite data, shown in **Figure 2,** to study the characteristics of ocean water and to predict cholera outbreaks. These predictions allowed health workers to anticipate cholera outbreaks and save lives. Even so, warm water is only one of many factors that play a role in cholera outbreaks.

A Low-Tech Solution Although researchers could predict cholera outbreaks, it was still difficult to prevent the spread of the disease. So Colwell focused on a low-tech solution to reduce the spread of cholera. Cholera bacteria attach to copepods that are much larger by comparison. The researchers demonstrated that the copepods could be filtered from water by using a folded piece of cotton cloth, such as a *sari.* A sari is a traditional garment worn by Indian woman and is shown in **Figure 3.** In some areas, these simple filters have reduced cases of cholera by almost 50%. Colwell's work is just one example of how biological research can make a huge difference in people's lives.

Reading Check ***Relate water temperature to cholera outbreaks.***

Figure 3 Today, many people use saris to filter water. This low-tech solution has greatly reduced the frequency of cholera outbreaks.

Differentiated Instruction

Struggling Readers/English Learners

New Terms Key vocabulary is highlighted for students. However, you will need to help students with unfamiliar terms in this section by writing them on the board and working with students to construct definitions. Accept drawings and simple memory aids in addition to verbal definitions. Have students copy this information to index cards, or in their notebooks for use while reading. Have them classify each by its part of speech. (Most will be nouns, but not all.) The list should include the following words: *cholera, gastrointestinal, bacterium, pathogen, copepod, plankton, dormant, sari, immune system, expression, assistive technology.* Encourage students to add their own words to the list as needed and to use this strategy throughout the year to help them with the reading. LS Verbal

Hands-On

QuickLab

15 min

Model a Low-Tech Solution

Procedure

1. Put on **gloves, a lab apron, and goggles.** Use an **eyedropper** to put a copepod from a **copepod culture** onto a **well slide.** Examine the specimen under a **microscope.** Record your observations.
2. Stretch a **piece of dark cotton cloth** over the mouth of a **beaker.** Secure the fabric with a **rubber band.**
3. Pour the copepod culture onto the fabric. Examine a sample of the strained liquid under the microscope, and record your observations. Return any strained copepods and the culture solution to the culture jar.
4. Repeat steps 2 and 3, but replace the cloth with a **funnel** lined with **filter paper.**

Analysis

1. **Compare** the pore size of the cotton cloth with that of the filter paper.
2. **Determine** which filter(s) strains out the copepods.
3. CRITICAL THINKING **Inferring Relationships** From your observation, is the filter with the smallest pore size the most practical to use for obtaining drinking water? Explain.

Disease in a Changing World

Rita Colwell's work is an example of **epidemiology**—the study of how diseases spread. **As scientists learn more about the nature of disease, our ability to prevent and treat diseases has improved.**

Disease "Conquered" by Biology In 1979, scientists announced that they had destroyed the smallpox virus. Smallpox is a disease that causes terrible scarring and even death. Vaccination, a technique first developed during the 1800s, played an important role in getting rid of smallpox. A **vaccination** is a medical procedure that allows a person to resist infection by a disease. During this procedure, genetic information from a dead or weakened pathogen is introduced into the body. As a result, the body's immune system "learns" to fight the pathogen. Today, the development of vaccinations and global health programs have nearly succeeded in getting rid of many other diseases.

New Insights into Disease Discoveries in the field of genetics have produced many new tools to study and treat diseases that are caused by abnormalities in a person's genes. **Genetics** is the science of heredity and the study of how traits are passed on to offspring. Genetics research will benefit greatly from discoveries made by the Human Genome Project. In 2003, the project finished sequencing the entire human genome. A **genome** is the complete set of genetic information for an organism. Now, researchers can begin to study single genes in order to understand their role in genetic diseases.

Reading Check *How do vaccination programs prevent diseases?*

READING TOOLBOX

Predictions Scientists use observations to make predictions. Make a list of the predictions in this section and the hypotheses that they address.

epidemiology (EP uh DEE mee AHL uh jee) the study of the distribution of diseases in populations and the study of factors that influence the occurrence and spread of disease

vaccination (VAK suh NAY shuhn) the administration of treated microorganisms into humans or animals to induce an immune response

genetics (juh NET iks) the science of heredity and of the mechanisms by which traits are passed from parents to offspring

genome (JEE NOHM) the complete genetic material contained in an individual or species

Differentiated Instruction

Basic Learners/Struggling Readers

Vaccination Model Draw a diagram on the board to help students understand how vaccinations work. Show that a dead or weakened sample of the pathogen is injected or ingested by the person being vaccinated. Then, refer students to the immune response diagram in **Chapter 37** to see how the body reacts to the pathogen. They do not need to understand the process at this point. The purpose is to give students a visual model for the concept in the text.

Struggling Readers

Sequencing Events Have students list the main events in Dr. Colwell's quest to control the cholera outbreaks. Put these events on index cards and have students put them in the correct order. (discovery of the role of copepods in an outbreak, conditions that cause a copepod population to increase, discovery of a new test for cholera bacteria, discovery of conditions that activate the bacteria, prediction of the conditions for an outbreak, discovery of method to remove the bacteria) LS Verbal

QuickLab

Teacher's Notes Students should wear gloves, a lab apron, and safety goggles for this lab. Students will note that both materials are good filters. However, one is faster than the other.

Materials
- disposable gloves
- lab apron
- safety goggles
- beaker
- copepod culture
- cotton cloth, dark color
- elastic
- eyedropper
- filter paper
- funnel
- microscope
- rubber band
- well slide

Answers to Analysis

1. The cotton cloth had much larger pores.
2. Both the cloth and the filter paper strained the copepods.
3. No, because it takes too long for the water to pass through the filter paper.

READING TOOLBOX

Predictions Sample prediction: Cholera outbreaks can be predicted by monitoring water temperature. Sample hypothesis: If cholera bacteria become active in warm water, satellite imagery can be used to pinpoint potential outbreak sites. LS Verbal

Teach, *continued*

Teaching Key Ideas

Life Expectancy Have students research the life expectancy of people in countries like the United States and England over the past 100 years. Compare those values with life expectancies of people living in countries such as Bangledesh and Somolia. What diseases are most prevalent in developing countries such as these and how do they compare with diseases in developed countries? (Students will find greater life expectancies in economically stable countries. They will also note major differences in the most prevalent diseases. Lifestyle diseases such as diabetes are more prevalent in the U.S. and England.) LS Verbal

Close

Formative Assessment

Monitoring the spread of flu each winter would be an example of ___.

A. geography (Incorrect. Geography would play a role in the data analysis, but it is not the study of the spread of disease.)

B. immunity (Incorrect. Immunity is the body's response to a previously introduced pathogen.)

C. epidemiology (Correct! Monitoring flu outbreaks is an example of epidemiology.)

D. copepod biology (Incorrect. Copepods are a factor in the spread of cholera.)

Figure 4 Advances in battlefield medicine include remote surgery. The doctor on the left is performing a surgery from a remote site. The surgery is aided by nurses, such as those on the right.

ACADEMIC VOCABULARY

device a piece of equipment made for a specific use

Biology and Human Potential

The length of human lives in developed countries has nearly doubled in the past century. **› As our understanding of medicine, biology, and science in general increases, humans will live longer and healthier lives.**

Assistive Technologies People who have injuries, diseases, or disabilities can use assistive technology products to help them accomplish everyday tasks. These products include bionic limbs and computer interfaces, and can help a person speak, see, or hear. They can also help a person coordinate his or her movements.

Battlefield Medicine Battlefield medicine is a new field of medicine which includes remote surgery, as shown in **Figure 4.** This field also includes new products designed for use in battle. For example, heavy blood loss is a common cause of death in war zones. Researchers have developed a bandage that can stop the flow of blood from serious wounds in a short period of time, before massive blood loss occurs. This device might eventually be used in hospitals to treat patients with gunshot wounds and other injuries.

› Reading Check ***Give an example of an assistive technology.***

Section 1 **Review**

KEY IDEAS

1. **Describe** ways in which biologists are "meeting the challenge" to reduce the spread of diseases.
2. **Describe** how our understanding of the nature of disease has changed over time.
3. **Explain** how advances in biology have improved human potential.

CRITICAL THINKING

4. **Forming Hypotheses** Rita Colwell's success in tracking cholera outbreaks was due to her open-minded approach to the available data. What were her assumptions, and how did they differ from assumptions of other scientists? Explain your answer.
5. **Expressing an Opinion** What is the future of battlefield medicine? Explain your answer.

WRITING FOR SCIENCE

6. **Writing an Essay** Write an essay that explains your thoughts on why humans would be able to live longer, healthier lives as our understanding of biology increases. Include examples of technologies that would enable humans to live longer lives.

Answers to Section Review

1. Students' answers may include as an example the work of Rita Colwell because she applied biological research oceanographic data, and chemistry to discover methods for reducing outbreaks of cholera.
2. We better understand how diseases are transmitted and treated. In addition, we have learned how to prevent diseases through breakthroughs such as vaccination and the eradication of pathogens.
3. The ability to conquer diseases and feed the world's population increases life expectancies.
4. Colwell knew that the bacteria had to be in the water even though it had tested negative. Her work involved the development of a more sensitive test that relied on chemical properties.
5. Students may mention that the extreme conditions of the battlefield call for new medical solutions. Many of the medical discoveries that increase the survival rates of the wounded might aid patients outside war zones.
6. Answers will vary but may include how addressing disease, illness, and aging, and research into debilitating injuries or illnesses will extend and improve the quality of life.

Section 2

Biology, Technology, and Society

Key Ideas	Key Terms	Why It Matters
❯ What is one way that genetic engineering affects our lives? ❯ How has biotechnology provided new tools for scientists to understand biological processes? ❯ How are biological factors used to verify an individual's identity and to ensure public safety? ❯ What ethical issues are raised by the use of biotechnology?	genetic engineering biometrics	Understanding the potential applications of biotechnology will help you make ethical decisions about its use.

What do hook-and-loop fasteners, a database of fingerprints, and a pet fish that glows in the dark have in common? They are all examples of how biological research affects society.

Biotechnology Around Us

Biotechnology affects many aspects of our lives, including our food sources. Genetic engineering is one of the most common examples of biotechnology. **Genetic engineering** is a technology in which the genetic material of a living cell is changed. ❯ **In agriculture, genetic engineering is used to create crops that yield more product or are resistant to pests.** For example, **Figure 5** shows a genetically modified type of corn called Bt corn. Bt corn has been altered to contain a gene from a naturally occurring soil bacterium called *Bacillus thuringiensis*. This gene allows the corn to make a toxin that kills a crop pest called the European corn borer. The use of Bt corn has raised crop yields and lowered the amount of pesticides that farmers use to control European corn borers.

genetic engineering (juh NET ik EN juh NIR ing) a technology in which the genome of a living cell is modified for medical or industrial use

Figure 5 The use of Bt corn reduces the amount of pesticides that farmers use to control pests. However, its use is controversial.

Key Resources

Transparencies

A29 How Telescopes Work
C34 Genetic Engineering
C35 Genetically Engineered Medicine
C38 Making a Genetically Engineered Vaccine

Visual Concepts

Genetic Engineering
Using Plasmids to Produce Insulin
Genetically Engineered Vaccines
DNA Fingerprint
Making a DNA Fingerprint

Section 2

Focus

This section introduces biotechnology—the relationship between biology and technology and its application in our every day lives. It also raises ethical issues on the appropriate use of these new technologies.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Teaching Key Ideas

Technological Drawbacks The controversy over Bt corn concerns evidence that the pollen from this strain of corn is toxic to Monarch butterfly larvae. Thus, an agricultural breakthrough has the potential to destroy wildlife. Ask students to name some technological advances that concern them or someone they know. (Responses may include: genetically engineered foods that could cause illness or mutations, cloning of organisms, genetic screenings for diseases, stem-cell research, cosmetic surgery, food additives, and drug development.) Start a discussion about the importance of understanding these technologies before forming opinions. Talk to students about finding unbiased sources of information to learn more about technological advances that concern them. LS Interpersonal

Teach, *continued*

QuickLab

Teacher's Notes Make sure that your water basin is at least twice as deep as the cup is wide. Tape the spoon to the outside of the cup. Duct tape works well. When constructing the model make sure there is an air-tight seal between the straw and balloon.

Materials
- balloon, large
- basin
- duct tape
- soda straws, plastic (6)
- spoon, metal
- water

Safety Caution Make sure that the balloons have been stretched out before you attempt to blow them up through the straw "pipe."

Answers to Analysis

1. When the model bladder is inflated, the cup rises to the surface. When air escapes, the model bladder sinks.
2. As the volume of the inflated bag increases, the buoyancy increases. As the volume of the inflated bag decreases, the buoyancy decreases.
3. The cup is the hull of the submarine. The metal spoon is the equipment and personnel. The balloon is the ballast tanks that fill with air when the submarine rises and with water when it dives.

Hands-On

QuickLab

15 min

Biomimetic Engineering

Bony fishes have a swim bladder that controls their buoyancy. This structure fills with gas to make the fish more buoyant. To become less buoyant, gas is released from the bladder. Engineers modeled submarines after this principle. In this lab, you will model a swim bladder and relate its structure and function to that of a submarine.

Procedure

1. Fill a **basin** about two-thirds full with **water.** Use **tape** to secure a **metal spoon** to a **cup.** Put the cup in the water (the cup should sink).
2. Link **three straws** together to form a long tube. Tape the straw "pipe" inside the mouth of a **large balloon.**
3. Secure the balloon in the cup, and put the cup in the water. Blow into the straws to add air to the balloon.

Analysis

1. **Describe** what happens when you blow air into the model bladder and when you let air escape.
2. **Assess** how the volume of the inflated balloon affects the overall buoyancy of the model.
3. CRITICAL THINKING **Relating Concepts** What structures of the swim bladder relate to the parts of a submarine?

Applications of Biological Research

Biotechnology is also used to produce medicines, to perform scientific research, and to develop new materials. **Tools such as genetic engineering, nanotechnology, and computer models have expanded the potential applications of biological research.**

ACADEMIC VOCABULARY

process a set of steps, events, or changes

Biotechnology and Scientific Research Scientists often use genetic engineering tools to study biological processes. For example, Nigel Atkinson is a biologist who studies the effects of alcohol and other compounds on fruit flies. To do this, he uses genetically modified fruit flies to determine if certain genes help the flies form resistance to the effects of alcohol. This research may help other scientists develop new methods of treating alcoholism in humans.

Scientists also take advantage of gene technology to make vaccines and medical products such as insulin. Insulin is a hormone that controls the metabolism of sugar as well as carbohydrates, fats, and proteins from the diet. Some people who have diabetes must take regular doses of insulin because their bodies cannot produce enough of the hormone. Before genetic engineering, insulin was obtained from pigs and cows. Now, it is made from bacteria that are changed so that they contain the human gene that produces insulin.

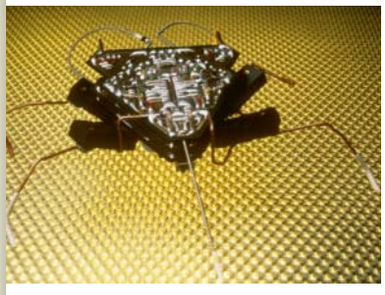


Figure 6 Nanotechnology often takes the form of tiny robotic items that look like animals. This robot was formed from a computer microchip.

Nanotechnology Biological research has also gained from advances in nanotechnology. One application of this technology is shown in **Figure 6.** Nanotechnology is the science of creating products by changing individual atoms or molecules. For example, the release of a drug can be controlled by putting the drug compound inside a shell of atoms. Nanotechnology can also help repair damaged body tissue. For example, researchers are developing a very small, biodegradable template that may help damaged brain cells grow back after an injury.

Why It Matters

Synthetic Hormones Scientists today produce dozens of products by employing biotechnology. For example, human growth hormone can be synthetically produced to treat people with growth hormone deficiencies. Before biotechnology, it took the pituitary glands from fifty cadavers to produce one dose. Tissue plasminogen activator, which dissolves blood clots in heart attack victims, is produced through biotechnology, too.

Differentiated Instruction

Basic Learners

Word Parts Have students research the meaning of the prefix *nano-*. (one billionth, or 10^{-9}) Ask them how the prefix relates to the definition given. (Nanotechnology is the science of creating products that are at the sizes of atoms and molecules. Sizes of atoms are expressed in nanometers, 1×10^{-9}.) Ask students for definitions of *nanosecond* and *nanogram.* (1×10^{-9} second and 1×10^{-9} gram) LS Verbal

Biomolecular Materials Some cells and organisms have amazing ways of putting together organic compounds, or *biomolecules.* These methods inspire scientists to develop new, synthetic, biomolecular materials. For example, new types of ceramics are based on the process that clams use to form their own shells. Scientists are trying to create a stronger glue by studying how bacteria stick to rocks in fast-moving streams. Artificial spider silk is being used to make a new lightweight, strong fabric.

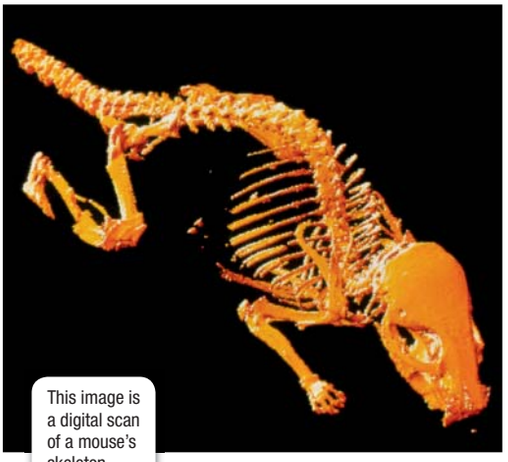
Biomimetics New products are also based on larger-scale biological structures and processes. *Biomimetics* (BIE oh muh ME tiks) is the application of biological processes and systems to solve design and engineering problems. Hook-and-loop fasteners, originally made by the company Velcro®, are one of the most familiar biomimetic products. These fasteners were modeled after prickly burrs that attach to animal fur or clothing. Another example is the submarine, which was modeled after the swimbladder of bony fishes. Studies of animal eyes have helped astronomers design new telescopes such as the lobster-eye telescope, which collects and focuses X-rays. Other amazing products are being developed every day!

Adapting Tools and Methods Tools and methods that are developed for one purpose are often adapted for other uses. For example, computerized axial tomography (CAT) scanning technology was originally developed to help doctors make detailed three-dimensional images of internal organs. Biologists can now use CAT scans to create models of fossils and of living organisms. **Figure 7** shows one of these kinds of models. Now, scientists can study specimens without dissecting them.

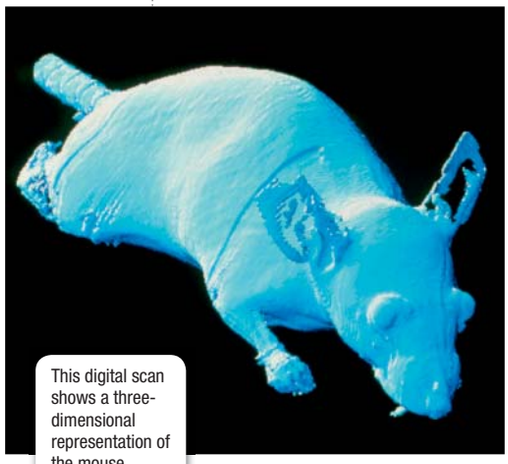
Reading Check ***How is the lobster-eye telescope unique from other types of telescopes?***

READING TOOLBOX

Word Parts Using your knowledge of word parts, write a definition in your own words for *nanotechnology, biotechnology,* and *biomolecules.*



This image is a digital scan of a mouse's skeleton.



This digital scan shows a three-dimensional representation of the mouse.

Figure 7 Digital scanning technology combines CAT scans and digital imaging to create three-dimensional models of organisms.

READING TOOLBOX

Using Words Students should show evidence of breaking down the following words into their prefixes and roots.
nano on the order of 10^{-9}
technology newly developed materials or techniques that give additional capacity to the user
nanotechnology materials or techniques on the order of one billionth that give additional capacity to the user
bio- of or relating to life
molecular on the scale of molecules, structures composed of atoms
biomolecular life at a molecular scale
biotechnology newly developed materials or techniques relating to living things

Teaching Key Ideas

Biomimetics Ask students for other biomimetics examples. Here are some clues: How has a bird's ability to fly influenced engineering? (airplane design) How has a bat's ability to communicate influenced communication? (sonar) How has the shape of a maple seed influenced engineering? (helicopter design)
LS **Logical**

Differentiated Instruction

Advanced Learners/GATE

Be the Expert Assign students to groups of three. Assign one student as the biotechnology expert, another the biomolecular materials expert, and the third student as the biomimetics expert. Have the students conduct research and make a timeline for major developments in each of their fields. Have the groups present their timelines to the class. LS **Interpersonal**

Special Education Students

Biological Research List the different applications of biological research on the board or chart paper: biotechnology, nanotechnology, biomolecules, biomimetics, and adapted tools. Have students list examples from the text or your discussions of each application on large self-sticking notes. Then, have students place their notes under the appropriate heading. Review each list with the class and reclassify examples as needed.

Teach, *continued*

Teaching Key Ideas

DNA Fingerprinting Restriction Fragment Length Polymorphism, or RFLP, analysis is the method by which a DNA fingerprint is made. Special enzymes, called restriction enzymes are mixed with a person's DNA. These enzymes cut DNA along specific sequences. Because everyone's DNA is different, restriction enzymes will cut at different places, leaving a unique combination of DNA fragments. The pattern of these fragments produces the "fingerprint" of a person's DNA. Just as everyone's fingerprints have loops, whirls, and swirls, people also have a specific set of DNA fragments.

Biology, Forensics, and Public Safety

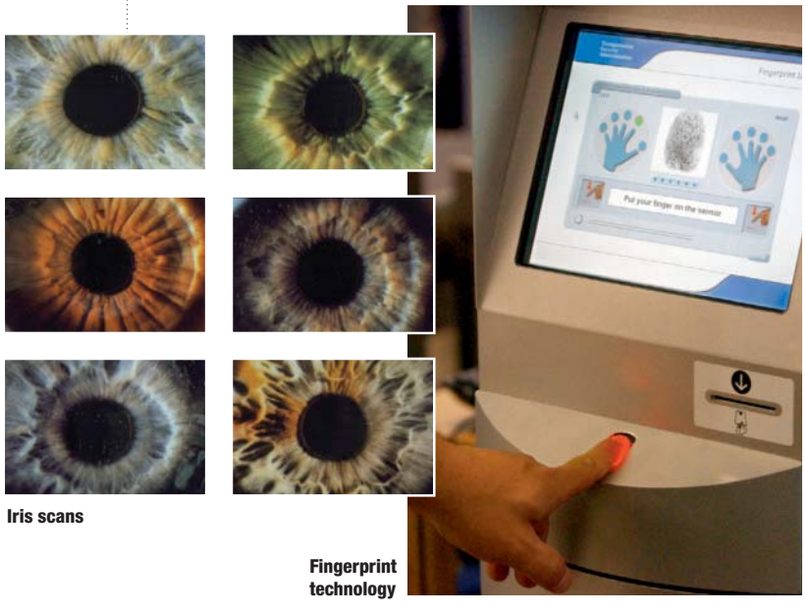
Biological research is also used in criminal investigations and to make sure that the public is safe. **Because biological factors such as fingerprints, iris patterns, and genetic material are unique, they can be used to identify individuals.** The use of biological traits to determine a person's identity is called **biometrics.**

biometrics (BIE oh ME triks) the statistical analysis of biological data; the measurement and analysis of unique physical or behavioral characteristics to verify the identity of a person

Two Types of Fingerprinting Fingerprints are one of the most common forms of evidence used in criminal investigations. For example, the FBI fingerprint database is the largest database of its kind in the world. A fingerprint scanner is shown in **Figure 8.** Another method of identification is called *DNA fingerprinting.* A DNA fingerprint has nothing to do with a person's actual finger but rather is a unique pattern of DNA that represents the total of a person's genetic material. Evidence such as hair or skin cells that are left behind at a crime scene can be identified by using DNA fingerprinting.

Other Forms of Biometric Identification Improved computer processing power has led to the development of many new biometric technologies. For example, **Figure 8** shows examples of different iris patterns. Iris scans are very fast and reliable, and are as unique as a fingerprint. These scans can also detect changes in a person's iris. Other software programs can tell the difference between human faces, or can analyze brain waves and speech patterns.

Reading Check ***What is DNA fingerprinting, and how is it used to identify someone?***



Iris scans

Fingerprint technology

Figure 8 Iris scans (left) show ridges, strings of tissue, and tiny pits in the iris. These features make every person's iris unique. The fingerprint scan (right) is also used to identify people.

Differentiated Instruction

Alternative Assessment

Understanding Ethics Ask the class why they should be concerned about ethical practices in biotechnology. Then, ask each student to submit anonymously a short paragraph on an application that could have ethical implications. Their paragraphs should identify the application, describe possible benefits and drawbacks, and the steps that would aid an informed opinion on the ethics related to the application. Provide a closed shoebox to hold the paragraphs. Give general feedback to the class after reviewing the submissions.

Advanced Learners/GATE

DNA Evidence Biotechnology has aided the justice system convicting criminals and setting the innocent free. Have students research the use of biotechnology in the criminal justice system. Students should seek information on both pros and cons of biotechnology use. LS Verbal

Preventing Bioterrorism Biologists and other scientists are working to develop new ways to detect and prevent the use of biological agents by terrorists. After the events of September 11, 2001, people have become more concerned about the possibility of a bioterrorist attack. Drills such as the one shown in **Figure 9** help people prepare for such an event. Handheld probes have been developed that can quickly detect common biological agents. Other research focuses on making vaccines and new antibiotic treatments for victims of anthrax or other biological weapons.

Figure 9 Bioterrorism drills such as this one can help populations prepare for bioterrorist attacks.

The Ethics of Biotechnology

Although biotechnology has great potential to improve our lives, its use also raises many ethical concerns. **Advances in biotechnology raise ethical concerns that must be addressed, both by individuals and by society.**

Manipulating DNA People have many concerns about genetic engineering. Some people worry that putting genetically engineered organisms into an ecosystem could harm the environment. Others worry that eating food that is made from genetically modified organisms might be harmful to their health. Some people object to the idea of changing an organism's DNA, or to techniques such as cloning, or to the use of human stem cells in research. Others feel that limiting the kinds of scientific research that might save lives and cure diseases is unethical.

Personal Security Putting biometric identification methods to use also raises ethical issues. Many people feel that databases of personal, biological information represents an invasion of privacy. The concern is that governments or other organizations could use this information improperly.

Reading Check ***What are some ethical concerns faced by society that relate to genetically modified organisms?***

SCILINKS
www.scilinks.org
Topic: Biological Weapons
Code: HX81692

Section 2 Review

KEY IDEA

1. **Describe** briefly how genetic engineering has improved agricultural crops.
2. **Explain** how biotechnology research has affected modern life.
3. **Describe** the biological features that are considered to be unique to an individual's identity.
4. **State** an example of an ethical issue that is brought up by advances in biotechnology.

CRITICAL THINKING

5. **Applying Information** Explain how crime investigators use biometrics to determine who is and who is not the perpetrator of a crime.
6. **Applying Information** Why should both individuals and society address ethical concerns? Explain your reasoning.

ALTERNATIVE ASSESSMENT

7. **Product Design** Biomimetics is described as "the abstraction of good design from nature." What does *biomimetics* mean? Describe an example of the type of product that would exemplify the abstraction of good design from nature. Be specific in your example.

Teaching Key Ideas

Debate Hold a class debate on biometric identification versus personal freedoms. The following are some questions teams that could debate: How does a country manage public safety in a global economy? When do security measures compromise the rights of citizens? How have these questions influenced politics within the United States? LS **Logical**

Close

Formative Assessment

Advances in biotechnology have resulted in all of the following, except the ____.

A. development of synthetic hormones that help regulate sugar metabolism (Incorrect. Insulin, for example, has been synthesized.)

B. development of iris scanning to establish identity (Incorrect. This technology is available and is more accurate than fingerprinting.)

C. cloning of animals (Incorrect. Animals have been cloned.)

D. cloning of humans. (Correct! This issue raises too many ethical concerns for individuals and society as a whole.)

Answers to Section Review

1. Genetic engineering is used to create crops that are more productive or that are resistant to pests.
2. Sample answer: The design of new tools used by scientists in genetic engineering, nanotechnology, and computer modeling, by the creation of new ways to produce medicines and materials, and new techniqes in scientific research.
3. Biological features such as fingerprints, iris patterns, and DNA are considered unique.
4. ethical concerns such as the invasion of privacy; reduction of personal freedoms; potential adverse health effects from new foods, drugs, or treatments; use of living cells and organisms for research
5. Biological factors such as fingerprints, iris patterns, and genetic materials are unique to individuals. Therefore, they can be used to determine an individual's identity.
6. To be scientifically literate, individuals should be aware of ethical questions or standards for research. Society has to decide whether the benefits of research outweigh the potential harm.
7. Biomimetics is the application of biological processes and systems to solve design and engineering problems. Hook-and-loop fasteners are an outcome of studying seeds that have tiny hooks that attach to animal fur. This adaptation allows the seeds to be dispersed.

Section 3

Biology and the Environment

Key Ideas	Key Terms	Why It Matters
How does biological research help protect the environment? How do new technologies help us study the environment? How do biologists rely on the contributions of community members to develop solutions for environmental problems?	ecology environmental science	Studying the environment will help us make wise choices about the conservation and protection of natural resources.

Focus

This section focuses on the role of biological research and its effect on the environment as well as the role of individuals in environmental conservation.

Bellringer

Use the Bellringer transparency to prepare students for this section.

Teach

Why It Matters

Rainforest Medicines Tropical rainforests contain plants that are sources of compounds and that can be used to treat diseases. For example, Madagascar rosy periwinkle, *Catharanthus roseus*, endemic to Madagascar, has compounds that are used to treat childhood leukemia. With the destruction of rainforests globally, an uncertain number of undiscovered therapies will be lost forever.

Teaching Key Ideas

What Is a Species? Introduce the scientific meaning of *species*. Many students will look at **Figure 10** and wonder about why the "lost world" discovery is important. To them, the organisms shown are just an owl and a flower. Tell them that every discovery adds to our understanding of the how, when, and where of evolution.

The study of the interactions of living organisms with one another and with their environment is called **ecology.** The study of ecology and the environment, or **environmental science,** is one of the most important applications of biology.

A Lost World

In February 2006, an international team of biologists announced an amazing discovery. In a mountainous region of western New Guinea, the researchers discovered a "lost world" that appeared untouched by humans. During just two weeks of fieldwork, the team discovered more than 40 species of plants and animals. **Figure 10** shows a few of the species that were discovered by the team.

The discovery of the lost world stresses the fact that parts of the world still exist that we know little about. Therefore, the need to study and protect these areas is very important. **Biological research helps us understand, value, and protect the environment. We learn how to protect the environment by learning more about what affects it.** The environment provides natural resources such as water, food, and energy sources that are vital to human societies and to all organisms. Biologists are working to protect areas such as the lost world in New Guinea and to find ways that Earth's resources can continue to meet the needs of growing human populations.

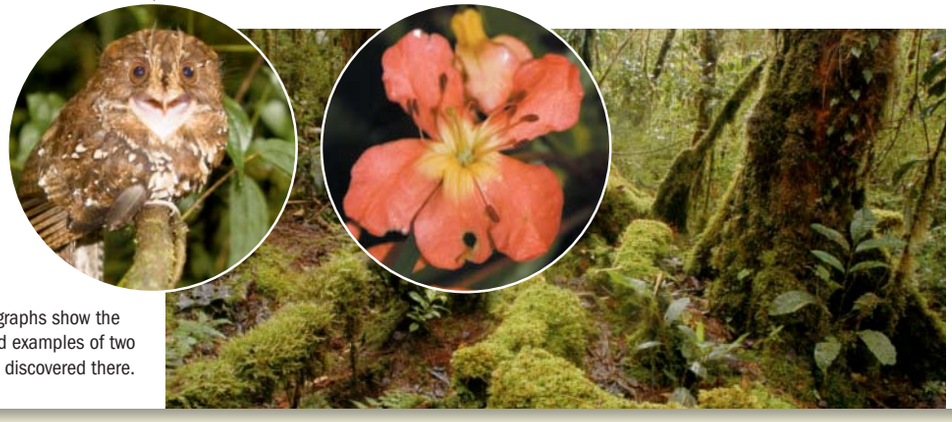


Figure 10 These photographs show the habitat of New Guinea and examples of two species that were recently discovered there.

Key Resources

Transparencies
E27 Earth's Major Biomes

Visual Concepts
Species
Biodiversity
Conservation
Recycling

Differentiated Instruction

Basic Learners

Lost World Species Have students research the lost world discovery. Then, have them create a poster or brochure describing the environment and the characteristics of the new species that were found there. The descriptions should include what makes each unique. LS Visual

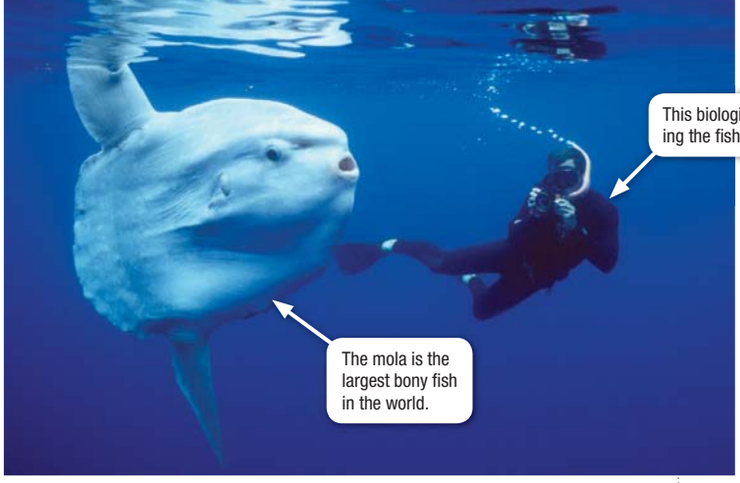


Figure 11 Biologists use satellite tagging to help protect the mola. **What information can you learn about a fish by tracking its location?**

Technology in Environmental Science

Biologists are using many new technologies to study the environment. **Tools such as satellite tagging, geographic information systems (GISs), and genetics are used to study and protect the environment.**

Satellite Tagging The scientist in **Figure 11** is part of a research team that is tracking the movements of molas, some of the largest fish in the world. In this study, molas are tagged with a transmitter that sends data about the fish's movements to a satellite. The data will help the team understand the mola's behavior, such as its role in ocean food webs. By keeping track of individual fish, the team also hopes to find out if the molas are overfished. Satellite tagging is used in many other kinds of wildlife studies, such as to track polar bears and sea turtles. This technology gives scientists the information they need to plan conservation strategies.

Geographic Information Systems Satellite data can be used in computer modeling programs called *geographic information systems* (GIS). A GIS is a powerful tool in environmental research because it allows biologists to compare different kinds of data. For example, mola researchers could use a GIS to map the relationship between ocean temperature, the location of food sources, and the movement of the mola. A GIS also allows researchers to have access to data from many different studies so that they can work together.

Genetic Tools Scientists use genetics in many ways to study and protect the environment. For example, many species of endangered wildlife are killed for their body parts. Wildlife agents are using DNA fingerprinting to identify the remains of endangered animals and to identify the people who killed the animals. Biologists are also collecting DNA samples from endangered animals so that they can still be studied if the animals become extinct. In the future, DNA samples could possibly be used to clone extinct animals.

Reading Check *How does a GIS allow scientists to work together?*

READING TOOLBOX

Three-panel Flip Chart Construct a three-panel flip chart to compare satellite tagging, GIS technology, and genetic tools in the study of environmental science.

ecology (ee KAHL uh jee) the study of the interactions of living organisms with one another and with their environment

environmental science (en VIE ruhn MENT'l) the study of the air, water, and land surrounding an organism or a community, which ranges from a small area to Earth's entire biosphere

Answer to Caption Question

Figure 11: By tracking a fish, its behavior can be learned, including what it eats, where it lives, and what its habits are.

READING TOOLBOX

Three-Panel Flip Chart Satellite tagging allows scientists to follow the paths of individual organisms. This information tells scientists about the location of potential food sources, energy budgets, and group dynamics.

GIS technologies allow scientists to analyze sets of geographic data to find relationships. For example, scientists can plot an individual's path against specific geographic characteristics, such as mountains, valleys, or rivers. If botanical surveys have been conducted, scientists can plot the animal's path against the types of resources present in an area.

Genetic tools allow scientists to catalog genetic samples from animals around the world. Studies could lead to information on common ancestry or immunity against certain diseases based on genetic disposition.

Differentiated Instruction

English Learners

Word Origins Tell students that the prefix *eco-* is from the Greek word *oikos* meaning "house." Have students look up the definitions of ecology, ecosphere, and ecosystem and tell how they are related to the meaning of the Greek prefix. (All have to do with the "house" of living things.) LS Verbal

Special Education Students

Modeling GIS Give students three scenarios and ask them to move within the room in response. Take a photo of the room each time students are in their final positions. For example: 1: The room is hot. (Most students will move apart,) 2: A breeze is coming in the window. (Some students may stand close and others farther away.) 3: Someone is shouting at the front of the room. (Students may move to the back.) Have students compare their movements when two of the factors are in effect, and then when all three of the factors occur.

Close

Formative Assessment

The "lost world" discovery is important to science because ____.

A. there's a new place to shoot reality TV shows (Incorrect. Visitors who are not scientists would likely need special clearance.)

B. there's a new area for people to live (Incorrect. The area is very remote and not suitable for large numbers of new inhabitants.)

C. new species enhance our understanding of data collected from all over the world (Correct! Discoveries of unknown species increase the knowledge base.)

D. it provides more funding for GIS research (Incorrect. Discoveries do not generate funds by themselves.)

Figure 12 The Raptor Rehabilitation Center is one of the most exciting projects that the students of the SWCC take part in. At the center, students help care for injured and orphaned birds of prey such as eagles, hawks, and owls.

ACADEMIC VOCABULARY

contribution a part given toward a whole

Citizen Scientists

Biologists rely on the contributions of individuals and communities to help develop solutions for environmental problems. These "citizen scientists" make valuable contributions to biological research and environmental conservation.

Environmental Clubs Many high schools have clubs that involve students in environmental research and conservation. For example, **Figure 12** shows members of the Southwestern High School Conservation Club (SWCC) in Somerset, Kentucky. SWCC's mission is to help other students understand the natural world through hands-on activities. This project is just one example of how biology students can become involved in environmental science.

Getting Involved If your school does not have an environmental club, find a teacher who can help you start one. Begin by working with other students to create a list of local environmental issues. Then, discuss some ways that your science class can learn more about these issues. You never know where environmental research can lead you, so keep an open mind and get involved!

Reading Check *What is the mission of the SWCC?*

SCILINKS
www.scilinks.org
Topic: Environmental Decision Making
Code: HX80525

Section 3 Review

KEY IDEA

1. **Evaluate** how the study of biology protects the environment.
2. **State** some tools that are used to protect the environment.
3. **Explain** why biologists rely on citizens to develop solutions to environmental problems.

CRITICAL THINKING

4. **Forming Reasoned Opinions** Why should biologists work on solutions that both protect fragile areas and support human needs? Explain your answer.
5. **Analyzing Methods** How can information gained from GIS technology aid environmental research? Explain your answer.

ALTERNATIVE ASSESSMENT

6. **New Species Table** Conduct Internet research on the "lost world" recently discovered by scientists in New Guinea. Make a table that includes at least five new species. Name each organism, and describe its characteristics. Why is the discovery of new species important in biology?

Answers to Section Review

1. Biological research helps us understand, value, and protect the environment.
2. Tools such as satellite tagging, GIS, and DNA collections are used to study and protect the environment.
3. Citizen scientists are considered valuable to scientific researchers because they are able to contribute information from wider areas than one biologist can cover. For example, many universities conduct bird studies and ask citizens to record bird sightings. This information becomes part of larger database so that documented migratory patterns, nesting habits, and other changes may be studied.
4. Fragile areas contain natural resources that support human needs. For example, fragile areas are pollution free and may contain unique forms of life that can provide clues or materials in the treatment of diseases.
5. GIS is able to collect data from multiple areas through satellite tagging. Using various forms of analysis, scientists can better predict trends and changes in an environment.
6. Answers are acceptable as long as they include five species that were discovered in the lost world. Examples include: the golden-mantled tree kangaroo, smoky honeyeater bird, golden-fronted bowerbird, giant echidna, or Berlepsch's six-wired bird of paradise. The discovery of new species is important to biology because it adds to the overall body of knowledge of living things.

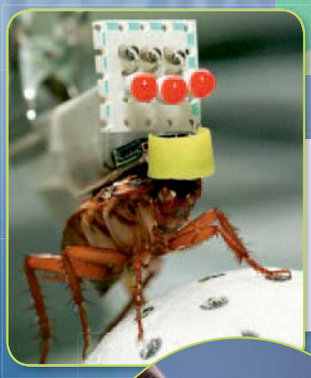
Why It Matters

Bio Bots

A robot that can play miniature golf? The boundary between living things and mechanical devices is not as clear as it used to be. These boundaries are being tested at every level, from biochemistry to intelligent behavior. Many fields of science and technology have been brought together to develop *bionics* (combinations of biological organisms and electronic devices) and *artificial intelligence* (computers that can learn and make decisions).

Bugs in the Machine

Insects are particularly popular subjects for bionic and artificial-intelligence work. One reason is because insects are easy to study in terms of both anatomy and behavior. Another reason is that many insects have "swarm" behaviors, which means that group behaviors emerge from the independent decisions of individuals. Scientists are using computer software to study and model these kinds of behaviors, and this software is being used in applications that range from environmental management to computer games.



Bug Bots A wide variety of "bug bots" have been developed. Some bug bots can be remotely controlled by insects, such as this roach.

Bionics Robotic limbs, such as this model of a human hand, almost eliminate the need for more traditional prosthetic limbs.

Quick Project Ask 10 people to define what being "alive" and being "intelligent" mean. (Do not tell them your reason for asking until after you record their answers.) Make a graphic organizer that compares the responses, and then write your own response.

Why It Matters

Teacher's Notes The term *artificial intelligence* was first coined in 1955 in a study carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. Today's artificial intelligence ranges from washing machines whose settings automatically adjust based on the types of clothes present to face recognition systems and e-mail filters. Artificial intelligence is closing the gap between "alive" and "intelligent."

READING TOOLBOX

Visual Literacy Describe the characteristics of the robots on this page that correspond to characteristics of living organisms. How do you know that they are not alive? (They neither reproduce nor develop.) Is there a difference between being alive and being intelligent? (Answers will vary.) Explain.

Answer to Quick Project

Use students' work as the starting point to discuss the public's perception of intelligence.

Lab

Skills Practice

Chapter 2 Lab

Microbe Growth

To prepare for field research, Rita Colwell, a biologist, read that cholera, like other infectious diseases, was caused by a particular microbe. Thus, a person would need to be exposed to the disease-causing microbe to become infected with cholera. Colwell developed a low-tech method of sterilization, in which living organisms are removed, to prevent disease.

There are millions of different microbes. Not all of them cause disease, but many can interfere with scientific experiments. How do scientists keep laboratories free of such organisms? Sterile techniques, though common today, were not always common in the laboratory. Scientists such as Francesco Redi, Lazzaro Spallanzani, and Louis Pasteur demonstrated the importance of sterilization in preventing the growth of the microbes. In this lab, you will explore conditions under which microbes grow, and you will ask questions about the variables that might affect the microbes' growth.

Objectives

- Observe the effect of sterile and nonsterile conditions on the growth of microbes.
- Make daily observations, and organize data.
- Hypothesize about the conditions under which microbes grow.

Materials

- test tubes, sterile (4)
- pencil, wax
- test-tube rack
- broth, nutrient
- rubber stoppers, sterile (4)
- water, sterilized
- test-tube holder
- gloves, heat-resistant
- water bath, boiling

Safety

Procedure

Prepare the Lab Materials

1. Work with a partner. Review all safety procedures, including sterile techniques and safe handling of microbe cultures, with your teacher.
2. Put on a lab apron, safety goggles, and disposable gloves.
3. **CAUTION: Handle glass test tubes carefully.** Obtain four sterilized test tubes and a test-tube rack. Use a wax pencil to label the tubes "A" through "D," and place the tubes in the test-tube rack.

Observations of Microbe Growth

	Tube Contents	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Tube A	sterile broth							
Tube B	broth exposed to air							
Tube C	exposed broth, then sterilized							
Tube D	sterilized water, exposed to air							

Time Required

30 to 45 minutes are needed for the initial setup and review of safety procedures associated with sterile technique. The second day follow-up session requires 15 to 30 minutes depending on who sets up the boiling-water bath. If you manage this step, day 2 will take less time. Each successive day of observation requires about 5 to 10 minutes. Be sure to schedule time for hand-washing, which is essential after each part of the experiment.

Ratings

EASY — HARD

Teacher Prep
Student Setup
Concept Level
Cleanup

Safety Cautions

- Review safety procedures associated with sterile technique and the growth of microbes in the classroom.
- Remind students that they may not open the sealed tubes. The stoppers must remain in place throughout the activity.
- All students must be supplied with a lab apron, safety goggles, and disposable and heat-resistant gloves for use during all parts of this investigation.
- All students must thoroughly wash their hands and wipe the desk surfaces when they are finished with each part of this investigation. Remind them to keep their hands away from their faces. There should be no eating during this or any investigation.
- Review safety rules associated with the use of boiling water. If the use of a boiling water bath is inappropriate or impractical do this step as a demonstration.

Tips and Tricks

You can obtain sterile nutrient solution locally by using commercial chicken broth, available at any grocery store. Make sure to sterilize the test tubes and stoppers before adding the broth. Alternatively, dehydrated broth may be used. Follow the rehydration instructions included with the product. Any stopper or lid can be used for the test (e.g., a screw-top lid), provided that an air-tight seal is established and maintained. For example, screw-top lids can only be used with corresponding test tubes. Remember that once the container is opened, the sterility is compromised. You can boil broth that is exposed to air, which will destroy most of the microbes that might have infected it. To insure sterility, use an autoclave or pressure cooker. Review the manufacturer's instructions before using the device.

Culture Disposal The cultures must be disposed of in a safe manner as outlined by local and school safety protocol. Often this protocol involves sterilization of the used glassware in an autoclave.

4. Fill tubes A, B, and C halfway with sterile nutrient broth solution.
5. Insert a sterile rubber stopper into the mouth of tube A. For now, leave the other broth-filled tubes unsealed.
6. Fill tube D halfway with sterilized water and add the tube to the test-tube rack.
7. Make a table for your observations of microbe growth. Observe the appearance of the broth in all four test tubes, and record your observations in the column labeled "Day 1."
8. Once you have recorded your observations, place the test-tube rack in an area where it will not be disturbed for 24 hours.

Make Observations on Day Two

9. Put on a lab apron, safety goggles, and disposable gloves.
10. Observe the appearance of the solution in each of the four test tubes. Record your observations in the column labeled "Day 2."
11. **CAUTION: Review the safety procedures associated with heating and electrical safety.** Put on heat-resistant gloves. With your teacher's guidance, use a test-tube holder to move tube C into a boiling water bath. Keep the test tube in the bath for 10 min.
12. Use the test tube holder to remove tube C from the water. Allow the tube to cool, and return it to the test-tube rack.
13. Insert a sterile rubber stopper into the mouth of tubes B, C, and D.
14. Place the rack with all four sealed test tubes in an area where it will not be disturbed for several days.

Make Continued Observations

15. Each day for the next 5 days, put on safety goggles and gloves. Carefully examine the contents of each tube. (Note: Make sure that the stopper remains in place, sealing the tube's opening.)
16. Write down your observations of the broth. Note any changes in the clarity of the solution. Also, look for changes in the appearance of the broth surface.
17. Clean up your materials according to your teacher's instructions. Wash your hands before leaving the lab.

Analyze and Conclude

1. **Summarizing Data** Did you observe any changes in the appearance of the tube contents over time? Describe your results for each of the four test tubes.
2. **Using Evidence to Make Explanations** If any of the tubes remained unchanged, explain why they did not support microbe growth.
3. SCIENTIFIC METHODS **Formulating Scientific Questions** Why was keeping all of the tubes sealed throughout the experiment essential?

SCILINKS
www.scilinks.org
Topic: Microbes
Code: HX80956

Extensions

4. **Further Inquiry** Does temperature affect microbe growth? How could you find out? Based on this investigation, design an experiment that would uncover any relationship between microbe growth and temperature. Share your experimental design with your teacher. With your teacher's permission, perform the investigation.

Answers to Analyze and Conclude

1. Yes, the solution in tube B turned cloudy and the surface had a mat of growing microbes. The solution in the other tubes should be clear.
2. In tube A, no airborne microbes were introduced to the solution. In tube C, boiling killed airborne microbes in the broth. In tube D, there were no nutrients to support microbe growth.
3. Sealing the tubes prevented contamination of the sterilized tubes with microbes.

Answers to Extensions

4. Answers will vary but should reflect a step-by-step procedure focusing on how microbes grow in various temperatures.

Key Resources

- Holt Lab Generator
- Lab Datasheet (Levels A, B, C)
- Holt Science Biology Video Labs
- Virtual Investigations

Chapter 2 Summary

go.hrw.com
SUPER SUMMARY
Keyword: HX8APBS

SUPER SUMMARY

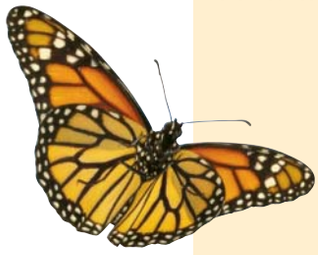
Have students connect the major concepts in this chapter through an interactive Super Summary. Visit **go.hrw.com** and type in the key word **HX8APBS** to access the Super Summary for this chapter.

Reteaching Key Ideas

Healthcare Advances Have students describe the advancements in healthcare in the 20th century and how those advancements were spurred by biology. LS Logical

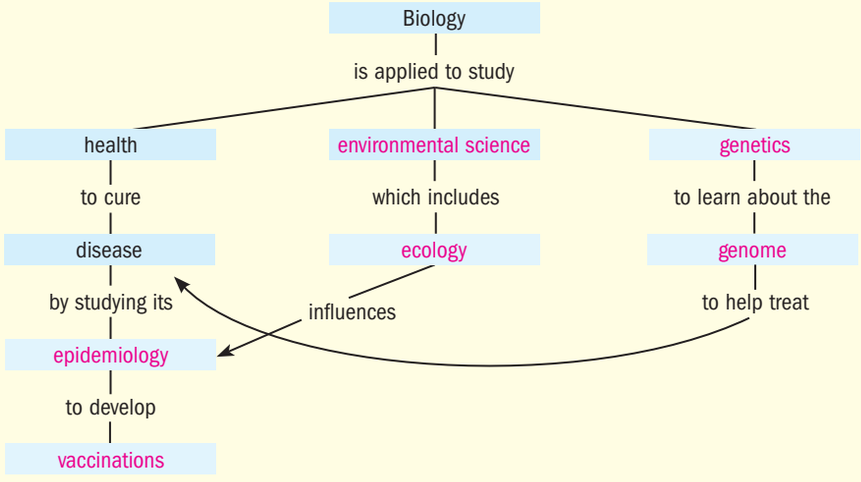
Biotechnology Have students describe five applications of biotechnology to their every day lives. LS Logical

Environmental Issues Have students identify local environmental concerns that could be addressed by a local community group. Help students organize an action plan that will involve local leaders and politicians in addressing local environmental concerns. LS Interpersonal

Key Ideas	Key Terms
1 Health in the 21st Century › Biologists combine research and data from many different fields to help reduce the spread of disease. › As scientists learn more about the nature of disease, our ability to prevent and treat diseases has improved. › As our understanding of medicine,biology, and science in general increases, humans will live longer and healthier lives. 	**epidemiology** (31) **vaccination** (31) **genetics** (31) **genome** (31)
2 Biology, Technology, and Society › Genetic engineering is used to create crops that yield more product or are resistant to pests. › Tools such as genetic engineering, nanotechnology, and computer models have expanded the potential applications of biological research. › Because biological factors such as fingerprints, iris patterns, and genetic material are unique, they can be used to determine an individual's identity. › Advances in biotechnology raise ethical concerns that must be addressed by individuals and by society. 	**genetic engineering** (33) **biometrics** (36)
3 Biology and the Environment › Biological research helps us understand, value, and protect the environment. We learn how to protect the environment by learning more about what affects it. › Tools such as satellite tagging, geographic information systems, and genetics are used to study and protect the environment. › Biologists rely on the contributions of individuals and communities to help develop solutions for environmental problems. 	**ecology** (38) **environmental science** (38)

Answer to Concept Map

The following is one possible answer to Chapter Review question 2.



Chapter 2 Review

READING TOOLBOX

1. **Three-panel Flip Chart** Organize three examples of ethical issues that face society today in a three-panel flip chart.
2. **Concept Map** Construct a concept map that describes some applications of biology. Try to include the following terms in your concept map: *genetics, ecology, environmental science, vaccination, epidemiology,* and *genome.*

Using Key Terms

Use each of the following terms in a separate sentence.

3. *environmental science*
4. *genetic engineering*

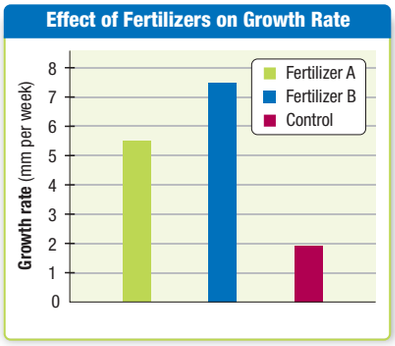
Write a definition for each of the following terms.

5. *vaccination*
6. *ecology*

Understanding Key Ideas

7. Cholera bacteria cluster
   - **a.** around the plankton where the copepods feed in the ocean water.
   - **b.** throughout the shells of both the male and female copepods.
   - **c.** only around the mouthparts of both male and female copepods.
   - **d.** around the mouthparts and egg casings of female copepods.
8. Define *battlefield medicine.*
   - **a.** amputation during surgery
   - **b.** the treatment of soldiers in or near an area of combat
   - **c.** the vaccination of soldiers prior to being deployed to a battlefield
   - **d.** the term used for military hospitals
9. What area of biology applications does genetic engineering *not* represent?
   - **a.** bioscience
   - **b.** biotechnology
   - **c.** biometrics
   - **d.** bioagriculture
10. Criminal investigators use biological factors for all of the following *except*
    - **a.** to determine a person's identity.
    - **b.** to determine how to keep the public safe.
    - **c.** to make detailed three-dimensional images of internal organs.
    - **d.** to determine the pattern of bands that would result in a fingerprint.

Use the graph to answer the following question.



11. Which of the following is the dependent variable in the experiment?
    - **a.** control
    - **b.** fertilizer A
    - **c.** fertilizer B
    - **d.** growth rate

Explaining Key Ideas

12. **Describe** why Rita Colwell focused on a low-tech solution to reduce the spread of cholera.
13. **Explain** the function of a vaccination in the human body.
14. **Investigate** the purpose for assistive technology.
15. **Describe** how biomolecular materials have influenced research studies.
16. **Describe** how to get an environmental club started at your school.
17. **Describe** how genetics is used to study and protect endangered animals.
18. **Describe** the impact of Bt corn when the corn is grown by farmers.

Assignment Guide

Section	Questions
1	5, 7, 8, 12, 13, 14, 19, 20, 26, 30
2	4, 9, 10, 11, 15, 18, 21, 22, 23, 25, 27, 28
3	3, 6, 16, 17, 24, 29

Review

Reading Toolbox

1. Check students' definitions for accuracy.
2. See previous page for Answer to Concept Map.

Using Key Terms

3. *Environmental science* includes principles from ecology.
4. The ability to alter genes is called *genetic engineering.*
5. *Vaccination* is the administration of all or a part of weakened or dead microbes or viruses to stimulate the immune response.
6. *Ecology* is the study of the interactions of livings things with each other and with their environment.

Understanding Key Ideas

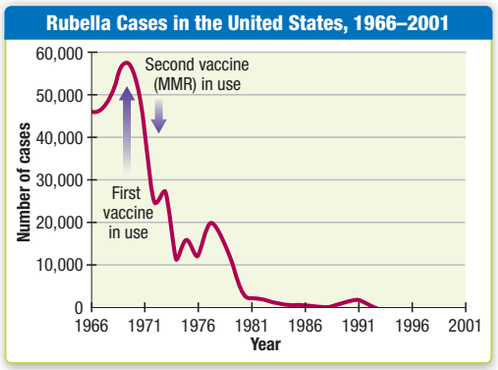
7. d 8. b 9. c 10. c 11. d

Explaining Key Ideas

12. A low-tech solution is easier to implement in regions of the world where poverty is prevalent.
13. All or part of a dead or weak pathogen is introduced to the human body so that the immune system can learn to fight it.
14. to help people with debilitating injuries, diseases, or disabilities to accomplish everyday tasks.
15. Scientists are using this knowledge in creating new materials for human use.
16. Students might identify a list of local environmental issues and discuss this list with a science teacher or club sponsor. Then, develop a plan of how to entice members and become involved in identifying an issue and finding a solution.
17. Wildlife agents are using DNA fingerprinting to identify poachers. Biologists are also collecting the DNA of endangered animals for study if the animals become extinct. Some believe that the DNA samples could be used to clone extinct animals.
18. The use of Bt corn enables farmers to use less chemicals on the crops to control pests. However, the pollen from this corn has a negative impact on Monarch butterflies.

Using Science Graphics

Use the graph to answer the following question.



19. What happened after the second vaccine license became a triple vaccination for mumps, measles, and rubella (MMR)?

Critical Thinking

20. Explaining Relationships Which areas of the world should scientists focus on in order to identify and prevent cholera epidemics? Explain why you think this is the case.

21. Predicting Consequences Future breakthroughs in science may alter the genes that affect aging in humans, and might allow some people to live longer lives. What are some possible environmental consequences if this type of technology is developed? What are some possible social consequences of this technology?

22. Logical Reasoning Insect populations may develop resistance to pesticides or other chemical compounds. When a population is resistant, the chemical can no longer kill the insect pest. Could insect populations develop resistance to Bt corn? If so, what could scientists do to control the resistant populations?

23. Finding Evidence What kind of scientific experiments would you want to perform in order to ensure that a genetically modified crop was safe for people and the environment?

24. Applying Information Describe how new technologies could be used to manage and protect an endangered species like the timber wolf.

25. Forming Hypotheses Describe how iris scans are considered a more reliable form of biometric identification than fingerprint analysis is. Explain your reasoning.

26. Cholera and Technology What kind of new technology would be most useful for studying the connection between cholera and ocean temperatures? Explain your answer.

Alternative Assessment

27. Design a Product Develop a new product that is based on one aspect of an organism or biological system. Create a brochure that describes the product and shows how it works. In the brochure, also describe how the product's design is inspired by nature.

Writing for Science

28. Outline Ethical Issues Create an outline that summarizes the many ethical issues surrounding the use of biometric technology for public safety. Then, write a letter to your congressperson to express your concerns about or support for this technology.

Methods of Science

29. Forming Models A geographic information system (GIS) uses computerized map layers to compare data. Construct a paper model that shows how a GIS would compare the areas that are important to you (such as your house, school, natural areas, and shopping areas) to the areas that are important to a friend and the areas that are important to one of your caregivers.

Math Skills

30. Using Percentages Filtering water through a few layers of sari cloth can reduce the number of cholera bacteria by 99%. If a sample of water contained 2.5 million cholera bacteria, how many bacteria would be left in the water after filtration?

Using Science Graphics

19. The greatest decrease in rubella cases came after the second vaccine, the MMR, was licensed.

Critical Thinking

20. Scientists should focus on preventing cholera epidemics in coastal areas of the world that are close to the equator.

21. If people live longer, human populations will increase. More people means a greater demand for natural resources. Increased resource use could damage Earth's environment. Longer lives might lead to greater overcrowding or changing social structures.

22. Insects could develop resistance to the toxic properties of the corn. Controlling resistant populations would require additional research to develop a different pesticide.

23. Lab tests would be needed to determine whether the food caused any adverse effects in mammals. The crop's soil and runoff from that soil should be examined to check for toxins. Lab tests should also be run to see if the crop was toxic to any beneficial insects.

24. Satellite tagging could be used to track wolf movements. GIS could be used to overlay those movements with maps of vegetation to discover and protect the best wolf habitat. DNA fingerprinting could be used to identify poachers.

25. Iris scans are considered more reliable because they can detect any changes or alterations to a person's iris.

26. GIS technology could help scientists overlay maps of ocean temperatures with maps of cholera concentrations to see if there is a connection.

Alternative Assessment

27. Student brochures should describe how the product works and how it is based on an organism or biological system.

Writing for Science

28. Answers will vary.

Methods of Science

29. The model should show three layers that map the same area. The model could be constructed from three sheets of tracing paper so that connections can be seen between the data layers.

Math Skills

30. 1% = 0.01; 0.01 × 2,500,000 = 25,000 cholera bacteria

Chapter 2

Standardized Test Prep

TEST TIP Carefully read the instructions, the question, and the answer options before choosing an answer.

Science Concepts

1. Which of the following is the study of how diseases spread?
- **A** epidemiology
- **B** biology
- **C** genetics
- **D** Human Genome Project

2. What is the area of science that creates products by manipulating individual atoms or molecules?
- **F** biodegradable
- **G** biotechnology
- **H** nanotechnology
- **J** nanodegradable

3. What is the most commonly used form of biometric evidence?
- **A** skin cells
- **B** fingerprints
- **C** hair follicles
- **D** DNA fragments

4. What three natural resources does the environment provide to all organisms?
- **F** water, food, and air
- **G** soil, food, and energy sources
- **H** water, food, and energy sources
- **J** food, energy sources, and minerals

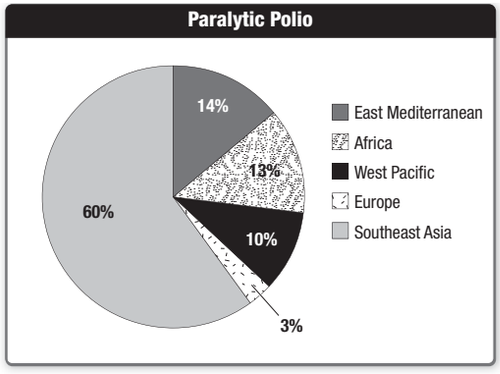
5. What are members of the public called when they give observations to professional scientists?
- **A** citizen scientists
- **B** biological researchers
- **C** environmental scientists
- **D** environmental conservationists

6. In 1979, scientists announced that they had successfully eliminated a disease. Which of the following diseases was eliminated?
- **F** chicken pox
- **G** German pox
- **H** smallpox
- **J** polio

7. What is another term for genetic engineering?
- **A** ecosystem DNA
- **B** studying DNA structures
- **C** manipulating DNA structures
- **D** biological research of DNA strands

Using Science Graphics

The following diagram depicts the global distribution of paralytic polio cases in 1994. Use the diagram to answer the following questions.



Source: Centers for Disease Control and Prevention, 1994.

8. Where were the greatest number of paralytic polio cases in the world?
- **F** Africa
- **G** Europe
- **H** West Pacific
- **J** Southeast Asia

9. Where were the least number of paralytic polio cases in the world?
- **A** Africa
- **B** West Pacific
- **C** Southeast Asia
- **D** Europe

10. If the number of paralytic polio cases in Southeast Asia were 1,950, what would be the number of cases in the East Mediterranean?
- **F** 164
- **G** 437
- **H** 455
- **J** 273

Writing Skills

11. Short Response Write an essay to describe why the study of ecology is considered an important application of biology.

State Resources

For specific resources for your state, visit go.hrw.com and type in the keyword **HSHSTR**.

Test Practice with Guided Reading Development

Answers

1. A **2.** H **3.** B
4. H **5.** A **6.** H
7. C **8.** J **9.** D
10. H

11. Essays should reflect an understanding that ecology is the study of the interactions of living organisms with one another and with their environment, and that the field includes the interactions of humans as well as other organisms.

TEST DOCTOR

Question 1 **A** is correct. Epidemiology specializes in studying how diseases spread. **B** is incorrect. Biology is the very general study of all living organisms. **C** is incorrect. The study of genetics focuses specifically on the patterns of heredity between generations of organisms. **D** is incorrect. The Human Genome Project focuses on the complete sequencing of the DNA in the human genome.

Question 2 **F** is incorrect. *Biodegradable* refers to the capability of being broken down by ecological processes. **G** is incorrect. *Biotechnology* refers to the use of genetic manipulation. **H** is correct because *nano-* refers to the scale of atoms and technology refers to the increased capacity to manipulate objects. **J** is incorrect. Though *nano-* refers to the scale of atoms, degradable refers to the breaking down of an object.

Question 3 **A** is incorrect. Skin cells have only recently been able to be used as biometric evidence. **B** is correct. Fingerprints have been recorded and catalogued for decades as biometric evidence. **C** is incorrect. Hair follicles have only recently been used as biometric evidence. **D** is incorrect. DNA fragments are useful, but not a common form of biometric evidence.