

Chapter 2

Applications of Biology

Preview

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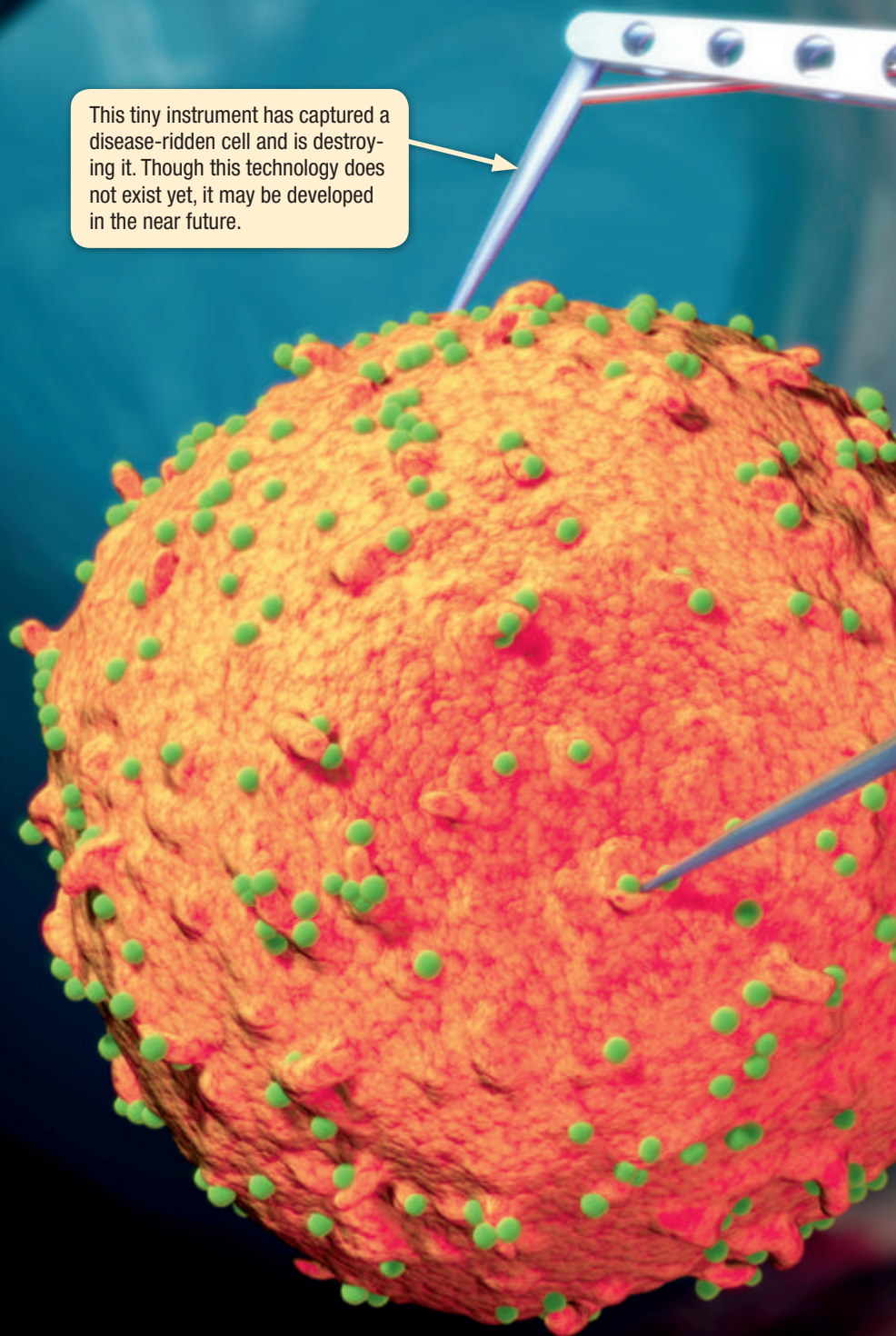
A Lost World
Technology in Environmental Science
Citizen Scientists

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.



Biology, Technology, and Society

Key Ideas

- ▶ 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?

Key Terms

genetic
engineering
biometrics

Why It Matters

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.

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?

ACADEMIC VOCABULARY

process a set of steps, events, or changes

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.

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.

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.

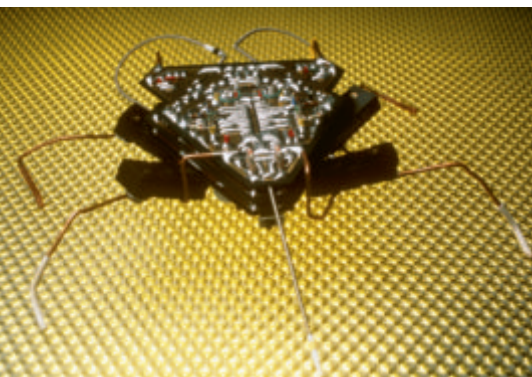


Figure 6 Nanotechnology often takes the form of tiny robotic items that look like animals. This robot was formed from a computer microchip.

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!

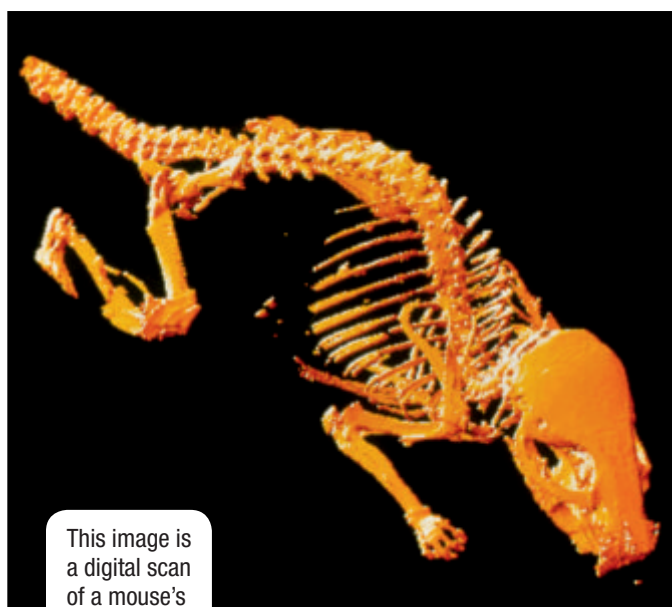
Adapting Tools and Methods Tools and methods that are developed for one purpose are often adapted for other uses. For example, computerized axial tomography (CAT) scanning technology was originally developed to help doctors make detailed three-dimensional images of internal organs. Biologists can now 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?*

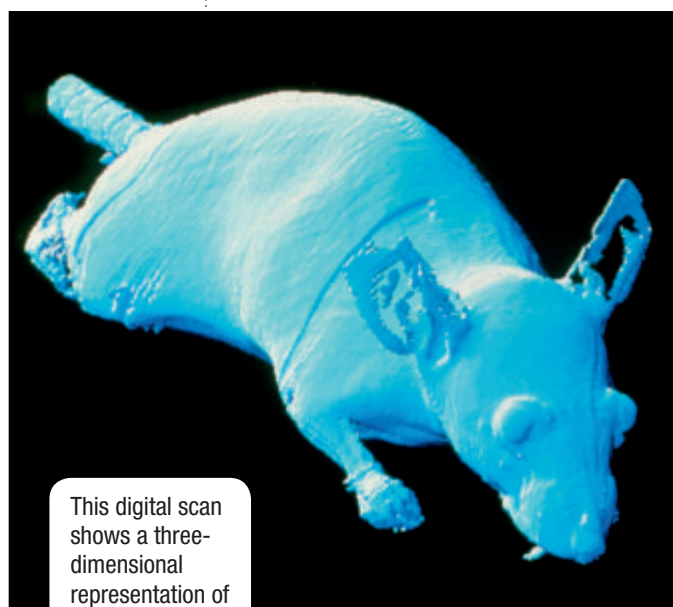
**READING
TOOLBOX**

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

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



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



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

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**.

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?*

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

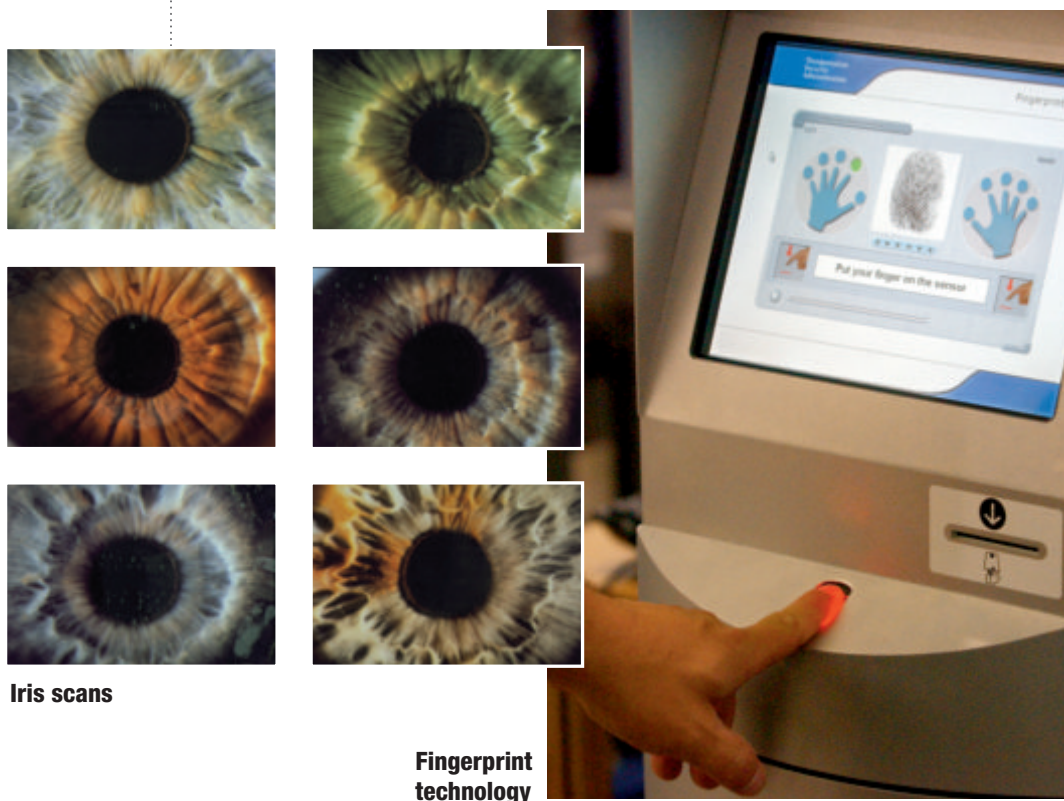


Figure 8 Iris scans (left) show ridges, strings of tissue, and tiny pits in the iris. These features make every person's iris unique. The fingerprint scan (right) is also used to identify people.

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.

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?*



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

SCILINKS.

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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.

Biology and the Environment

Key Ideas

- 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?

Key Terms

ecology
environmental
science

Why It Matters

Studying the environment will help us make wise choices about the conservation and protection of natural resources.

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.

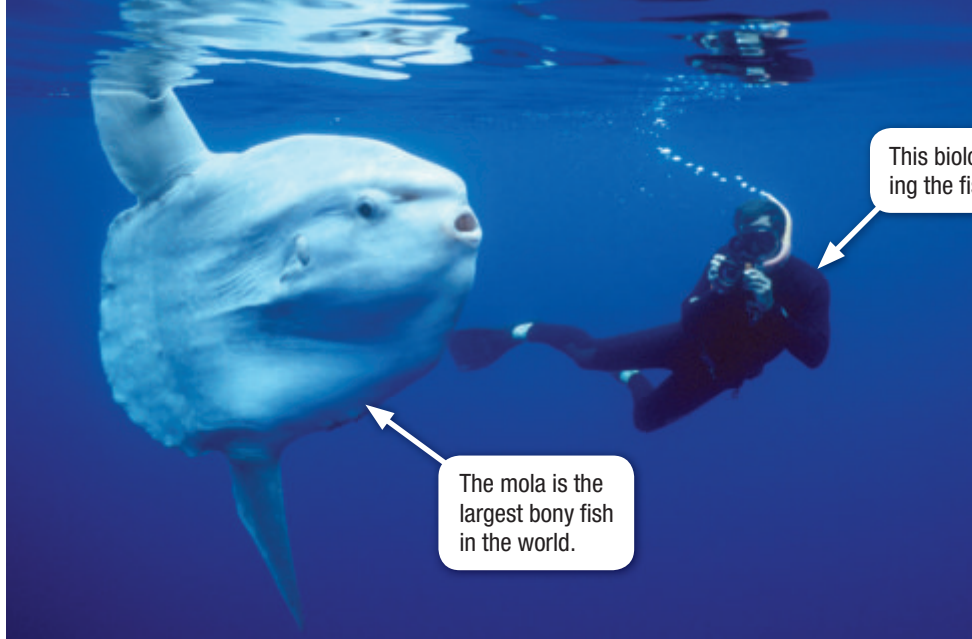


Figure 11 Biologists use satellite tagging to help protect the mola. ➤ **What information can you learn about a fish by tracking its location?**

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'!) 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

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

SCILINKS
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 Topic: Environmental Decision Making
 Code: HX80525

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?*

Section

3

Review

► KEY IDEA

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

CRITICAL THINKING

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

ALTERNATIVE ASSESSMENT

- 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?

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

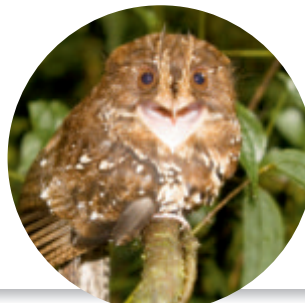
- Genetic engineering is used to create crops that yield more product or are resistant to pests.
- Tools such as genetic engineering, nanotechnology, and computer models have expanded the potential applications of biological research.
- Because biological factors such as fingerprints, iris patterns, 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)