How might information and communication technology change our idea of what an office should be? What effects might this have on businesses, the environment, and society in general?

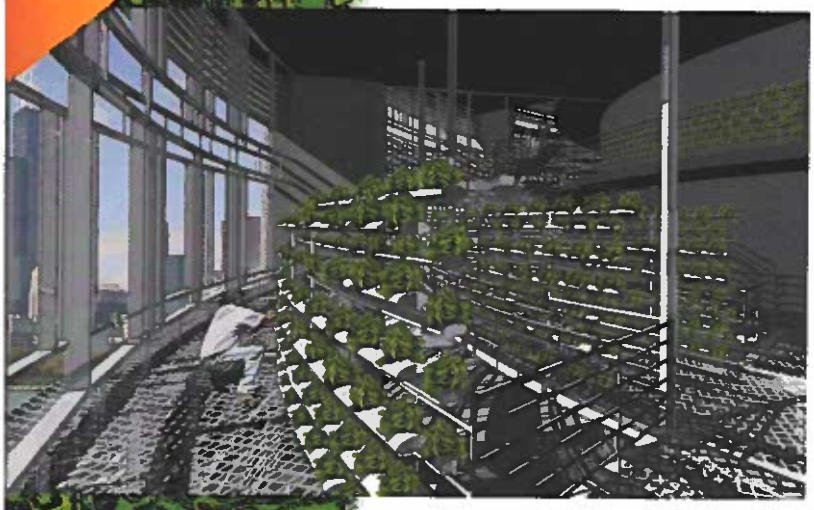
CHAPTER 14

Agricultural, Medical, and Biotechnology

Better by Design

Dickson Despommier and Blake Kurasek design vertical farms

What if you could eat food grown only a few blocks from where you live? Dr. Dickson Despommier has proposed building vertical farms in cities. Crops would be grown using mineral nutrient solutions without soil (hydroponics). Some crops could also be grown in air by spraying the plant's roots with a nutrient-rich solution (aeroponics). Vertical farms have many advantages. For example, crops could be grown year-round. Crops would not fail because of bad weather. Vertical farms would also require less land. Building on Dickson's scientific work, Blake Kurasek has designed "living skyscrapers." In these buildings, produce grown in the building can supply its occupants and a surrounding population.



Shipping food over long distances can be avoided by growing food near the consumer.

"Over the next 50 years, population growth will require an additional area the size of Brazil to grow sufficient food. This amount of high-quality land is simply not available."

Reading Target

Creating an Outline

An *outline* is an orderly statement of the main ideas and major details of a text passage. Each main idea or detail is written on a separate line. Creating an outline can help you understand and remember what you read. Read each section of this chapter carefully. Then use the Reading Target graphic organizer at the end of the chapter to create an outline of the chapter.

Key Terms

antibodies
aquaculture
biotechnology
cloning
deoxyribonucleic acid (DNA)
gene
genetic code
genetic engineering
greenhouse
hydroponics
implants
irradiation
laparoscopic surgery
minimally invasive surgery
monoculture
precision farming
prosthetic devices
reproductive cloning
telemedicine
transplants
vaccines

Objectives

After reading this chapter, you will be able to:

- Describe how food is grown, harvested, and processed.
- List medical technology and devices that can improve quality of life.
- Discuss the use of biotechnology in foods, medicines, and other products.
- Debate the implications of biotechnology.

Useful Web sites:
www.verticalfarm.com
www.blakekurasek.com

Several types of technology affect our health and wellness either directly or indirectly. Agricultural technology, for example, is responsible for producing the foods we eat to remain healthy. Medical technology includes surgical procedures, implants, and prosthetics (artificial limbs) that keep us healthy and make our lives better. A related field, biotechnology, works hand-in-hand with agricultural and medical technologies to improve our health.

Agricultural Technology

Farmers own and operate farms that grow plants that provide us with food and many other products. They prepare the land, plant seeds, and care for the plants. When the crop is mature, they harvest the food. In some cases, they also package and sell the products they grow. Other farmers and ranchers raise animals such as cows, sheep, and poultry. They care for the animals and shelter them in barns or other farm buildings.

Many other agricultural specialties also exist. For example, some agricultural specialists grow plants in greenhouses. A *greenhouse* is a building made mostly of glass or transparent plastic. It helps control conditions such as humidity and temperature. Greenhouses provide an artificial ecosystem that mimics the climate necessary for growing specific plants.

Hydroponics is a type of agriculture in which plants are grown in a water-based system, without soil. See **Figure 14-1**. *Aquaculture* farmers raise fish and shellfish. They raise the animals in ponds, floating net pens, or other systems in which they can feed and protect them. See **Figure 14-2**.

Farming is hard work, and crop growth is unpredictable due to weather conditions. Having too much rain can cause as much damage as having too little. An early frost in autumn or a late frost in spring can destroy an entire crop. Weeds sometimes grow faster than the crops. The farmer also has to fight insects and plant diseases.

Figure 14-1. In hydroponic farming, the plant roots are bathed in a water solution that contains the nutrients they need.

Figure 14-2. Aquaculture farmers often protect their stock by enclosing them with nets or fences in their native habitat.

The prices farmers can get for their crops may also vary from year to year. Many farmers plant more than one type of crop. If prices drop for one crop, the farmer may be able to make up the difference with another type of crop. This practice also helps farmers avoid weather-related crop failures. While too much rain might destroy one crop, another crop may survive or even thrive in the additional rainfall.

Much of modern farming is automated. Specialized machinery helps reduce some of the work. See **Figure 14-3**. It is used to till the soil, spray fertilizers and insecticides, irrigate fields, and harvest crops. These techniques allow farmers to produce a larger crop using less time and fewer resources. As world population increases, these improvements become more important on a global scale.

Farming and Computer Technology

Today, farmers use computers for many tasks. For example, by using a database on the Internet, they can learn about weather forecasts. They can connect with the board of trade to see the current price of corn or other crops. This information helps them decide the best time to plant or to sell their crops.

Some farmers now use *precision farming* methods. They gather data from satellites to locate problems in their fields. For example, they can find an area that is not draining correctly or that is being destroyed by insects. They can then target that specific area for repairs or pest control. This helps farmers use less pesticide, which is better for the environment. It also decreases the amount of time they spend working in the field.

Food Processing

The foods we eat include both natural or processed foods. Natural foods include the corn, tomatoes, and peppers you see on the shelves of supermarkets. Processed foods are produced synthetically. Margarine, candies, pies, and many drinks are processed using both chemicals and natural ingredients. See **Figure 14-4**.

Figure 14-3. Automatic irrigation systems water crops on a large scale.

Figure 14-4. A—Natural foods include many items you can find in the produce section of a grocery store. B—Cheese is an example of a processed food. Other examples include breakfast cereals, canned soups, and many types of meat products.

To process food, wastes such as skins, bones, cobs, and shells, are removed first. The food might be cut, crushed, or ground. It is then sorted, and any substandard products are removed. Next, it is mixed and blended with additives, such as colorings, spices, and preservatives. For example, sausage can be made from a combination of pork, fat, spices, applesauce, corn syrup, and water. Heating, pickling, dehydrating, refrigerating, or freezing may be used to help preserve the food.

These processes, along with irradiation, help provide food with safe long-term storage capability and minimize the risks associated with eating spoiled food. *Irradiation* is a method of exposing foods to a low level of radiation to kill bacteria and other parasites. After many studies, scientists have concluded that this is a safe method of keeping food safe from bacteria for an extended time.

Finally, foods might be formed into a certain shape, such as forming chocolate into bars or pasta into uniform shapes. Foods are then packed to both protect them and keep them clean. See **Figure 14-5**.

Figure 14-5. Pasta is formed into many different shapes before it is packaged.

Math Application

Food and Calories

You have probably heard the old saying, "You are what you eat." This is true in many ways. If you eat foods that are good for you and maintain a balanced diet, you will feel better than if you eat junk food routinely. If you eat too much or fail to get enough exercise, you will gain weight. If you do not eat enough to supply your daily needs, you will lose weight. Balancing the calories you eat with your level of physical activity can help you maintain a desirable weight.

The United States Department of Agriculture has created a tool you can use to find out what foods are best for your health and how much of each food you should eat. You can find this tool at www.mypyramid.gov. You can find the number of calories in almost any food using several sites on the Internet.

Math Activity

In this activity, you can find out if your diet is appropriate for your needs. Follow these steps:

1. Determine the number of calories you need every day. The number depends on your current weight and your level of activity. Use the following chart to find the ideal number of calories for you.

Activities	80 lb.	100 lb.	120 lb.	140 lb.	160 lb.	180 lb.
None	960	1200	1440	1680	1920	2160
A few activities	1280	1600	1920	2240	2560	2880
Many activities	1600	2000	2400	2800	3200	3600

2. Keep a record of the foods you eat in one day.
3. Find the number of calories for each portion of food you eat. One way to do this is to refer to the Nutritional Facts listing on the packages of the food you eat. Another method is to search the Internet. For example, the Web sites for most fast food restaurants now list the calories in their foods. You can also go to one of the many "calorie counter" sites. Add up the number of calories you consumed in one day to find your total calorie intake.
4. Compare the number of calories you ate with the chart above. If there is a big difference between your ideal calorie needs and the amount you consume, make a plan to change your eating or exercise habits.
5. Go to www.mypyramid.gov and review the recommended amount of each food group. Compare this with the list of foods you ate in one day. How healthy is your diet? How can you improve it?
6. Use MyPyramid to plan an entire week of healthy meals that meet your calorie requirements. Show the number of calories in each food you choose, and add the calories for each day to make sure you are planning the correct number of calories.

Medical Technology

What are the requirements to remain healthy? It helps to have comfortable surroundings, quiet moments for ourselves, and people who love and support us. In addition, fresh air, water, sunshine, rest and sleep, are vital for a healthy body. We know that smoking is very harmful to our health and that too much exposure to the sun can be dangerous. We understand the importance of proper nutrition and exercise.

Sometimes, however, we have to depend on technology to keep us healthy. We need medicines to cure diseases or ease symptoms. Surgical techniques are sometimes necessary to repair injuries or remove cancers. Other devices, such as hearing aids, eyeglasses, and artificial body parts, are also part of medical technology. See **Figure 14-6**.

Medicine

Medicines, or drugs, act in many different ways to fight disease. *Vaccines* stimulate the body's immune system to develop special proteins called *antibodies*. Other medicines, such as penicillin, stop the growth of bacteria. Still others work with our bodies to lower blood pressure or cholesterol levels.

Some of the most widely used medicines were originally derived from plants. For example, aspirin was first extracted from the bark of white willow trees. Today, like many other medicines, aspirin is made synthetically. Still, natural plant material is important in medical research. The search for new medicines is often concentrated in areas, such as rainforests, that have many plants whose properties have not yet been explored. See **Figure 14-7**.

Figure 14-6. X-rays and other diagnostic tools are other examples of medical technology we use on a regular basis.

Figure 14-7. Our search for new medicines often takes place in rainforests because of their many as yet unknown plant and animal species. What impacts might this have on the environment? How can we search these areas responsibly?

Repairing the Damage

Medical technology is not just about treating diseases. It also helps when we are injured, or when our natural body parts begin to wear out.

Surgical Techniques

For many procedures, patients used to spend several hours in surgery, a week in the hospital, and a month recuperating at home. With the latest technologies, however, these times are being reduced. Surgeons can do procedures in a fraction of the time, and recovery time is minimal.

One reason is that new procedures are less invasive. Many types of abdominal surgery can be done through small incisions instead of the large incisions used by surgeons in the past. This type of surgery is known as *laparoscopic surgery*, or *minimally invasive surgery*.

Robotic surgery is another example of technological improvements in surgical techniques. For example, heart surgery has traditionally required the surgeon to saw through the patient's sternum and crack open ribs to create a space wide enough for hands to reach inside.

Today, a thin, remotely controlled robotic arm can be inserted between a patient's ribs through tiny incisions. The surgeon sits at a computer to control the instruments at the ends of the robotic arm. The instruments include tiny surgical tools, a light, and a camera. The camera sends views of the internal organs to a video monitor. The surgeon controls the instruments while watching the images shown on the monitor. See **Figure 14-8**.

Robotic surgery has become routine because it can be more precise than traditional surgery. The technique is now used for many major and minor operations, including gall bladder removals and pacemaker operations. Patients are exposed to less risk because the incisions are very small. Less tissue has to heal, so the patient recovers more quickly. The surgery is also less painful.

Figure 14-8. This surgeon is using a foot switch and special headband to control a robot, which holds and directs the tiny camera inside the patient's body.

Prosthetic Devices

Doctors use replacement surgery when parts of the body wear out. They replace natural parts with artificial parts. *Prosthetic devices* are implants or replacement body parts that mimic the original human body part. These devices can reduce the pain from arthritis, injuries, or simply years of use. Hips and knees are examples of human joints that wear out over time. These joints also frequently suffer from arthritis as our bodies age.

Prosthetic devices must be made from certain metals and plastics that do not react with the body's chemistry. See **Figure 14-9**. For example, an artificial hip uses a ball-and-socket joint. The artificial ball is often made of stainless steel or ceramic. The ball fits into a cup made of a high grade polyethylene. The stem that holds the ball in place is inserted into a space that has been drilled into the femur (thigh bone).

Most artificial replacement parts are successful, if only for a period of time. For example, the amount of wear of the cup against the ball in a knee or hip joint is a major factor in how long the parts will last. Titanium is generally used for artificial hip joints. Carbon fiber is often used for artificial legs. Artificial eyes are made of acrylic plastic. Various types of silicone can be molded into shapes for reconstructing a face or replacing a finger. See **Figure 14-10**.

Through medical technology, artificial parts can be made to replace natural ones, but are they better than natural ones? This has been debated at length. Newer prosthetic devices come very close to allowing people to function as well or better than they did using their natural body parts.

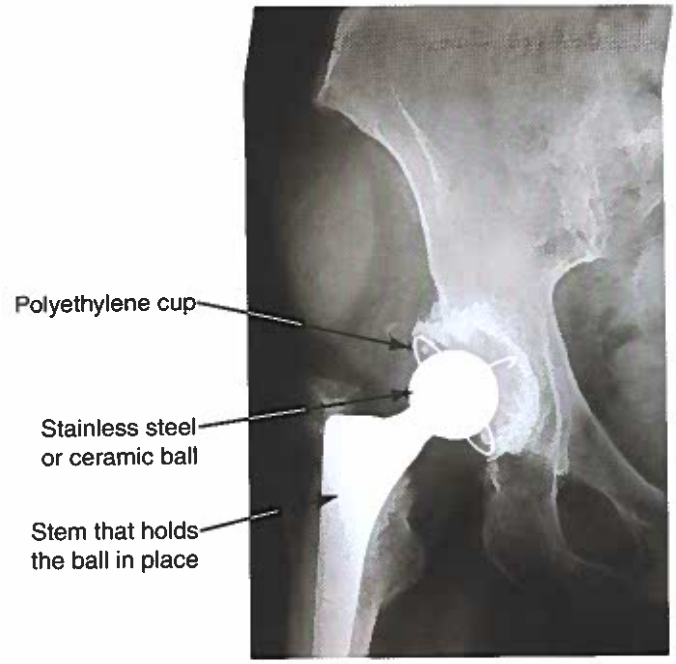


Figure 14-9. *A hip replacement can improve the mobility of an older person* whose hip joint has begun to fail.

This is especially important in sporting events. For example, does a runner with carbon-fiber prosthetic legs have a better chance of winning a race? Experts have studied the question, but so far, they have not been able to give a clear answer. Some people think the prosthetics give the athlete an unfair advantage. Others think the athlete is at a disadvantage. As medical technology continues to improve, this question may become very important in sports and other areas.

Transplants and Implants

Replacement body parts can be mechanical, electronic, or organic. Mechanical transplants such as metal hip joints, plastic valves, or electronic pacemakers are called ***implants***. Living organs that replace faulty ones are called ***transplants*** and are usually from another human donor. Some

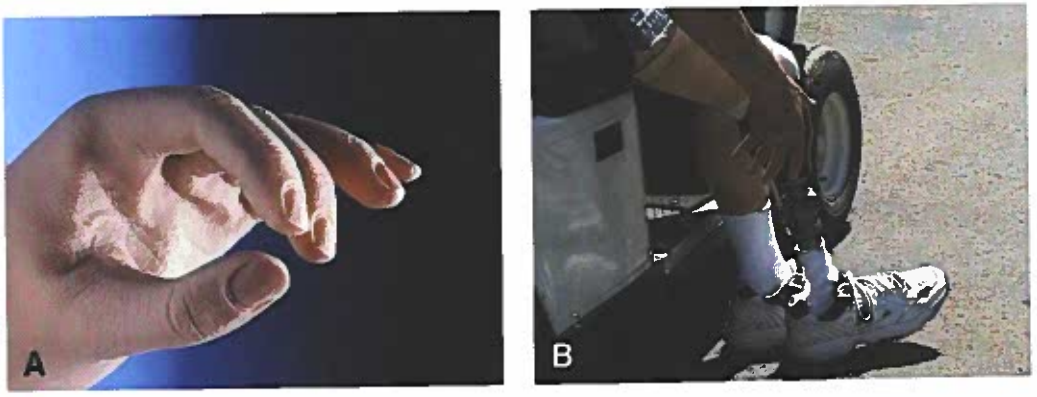


Figure 14-10. Prosthetics may or may not look like the original human body part. Some, such as the hand in A, look natural. Others, like the artificial leg shown in B, are built more for function than style.

body parts, such as the heart and kidneys, are far too complex for artificial parts to be made at a reasonable cost. These organs are transplanted. See **Figure 14-11**. Other body parts are now routinely transplanted or implanted, including:

- Heart pacemakers
- Heart valves
- Hearing aids
- Speech devices
- Lenses to correct eye cataracts
- Knee and hip joints
- Dentures
- Artificial limbs

Other Advances in Medical Technology

Would you swallow a pill that contains a camera? A new camera-in-a-pill has been invented that, when swallowed, can move or stop, according to what a doctor needs to see. The pill is radio-controlled and can be used to replace a colonoscopy, a procedure that can be very uncomfortable.

Technology is helping millions of people stay in touch with their doctors and nurses using *telemedicine*. Patients can use the Internet and other communication devices to transmit data from their homes to a database containing their medical files. Satellite-Internet connections from remote areas to 24-hour emergency medical centers allow patients to consult specialists using video links. Using telemedicine, a nurse can ask a patient health questions, receive information, and give advice.

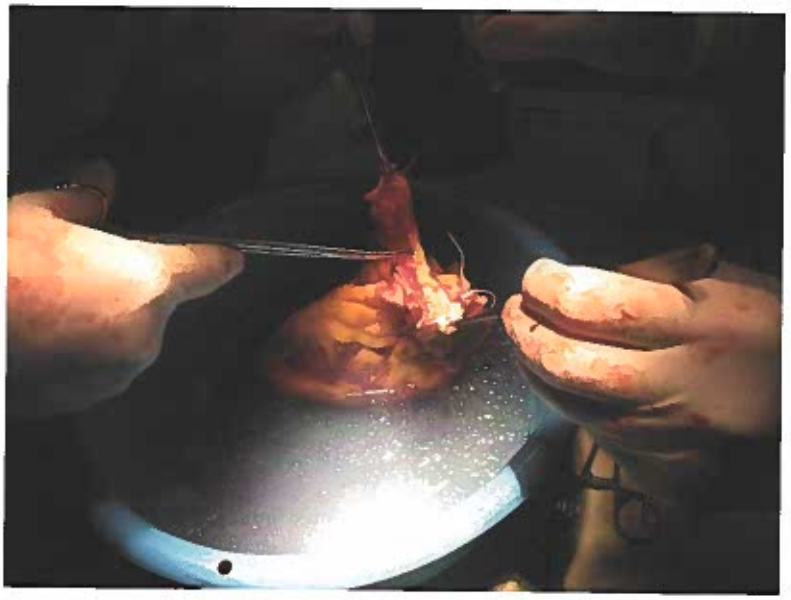


Figure 14-11. This heart is being prepared for transplant. The human heart is too complex to be created artificially with our current knowledge and tools.

Think Green

Medical Technology and the Environment

Have you ever thought about what happens to used medical supplies? We know that blood and other body fluids can spread disease. Every day, clinics and hospitals use a huge amount of disposable supplies, such as gauze. What happens to the gauze that is used to clean blood from an injured arm, for example?

Blood and other body fluids are considered hazardous waste. Gauze, needles, and other disposable supplies that come in contact with these fluids are collected separately from other trash. They are disposed of according to strict government guidelines. This helps prevent other people from coming in contact with contaminated material and possibly catching the disease. For more information about hazardous waste, refer to Chapter 16 and **Appendix B** at the end of this textbook.

Biotechnology

Biotechnology is the use of living organisms to produce new foods, medicines, and other products. It is closely related to both agricultural and medical technology.

The modern age of biotechnology started in 1953 when James Watson and Francis Crick announced the discovery of *deoxyribonucleic acid (DNA)*. See **Figure 14-12**. Strands of DNA are considered the basic building blocks of life. This discovery opened the way for a more precise understanding of how living things work. Scientists and technologists started to take the basic blocks of living creatures apart and put them back together in new ways.

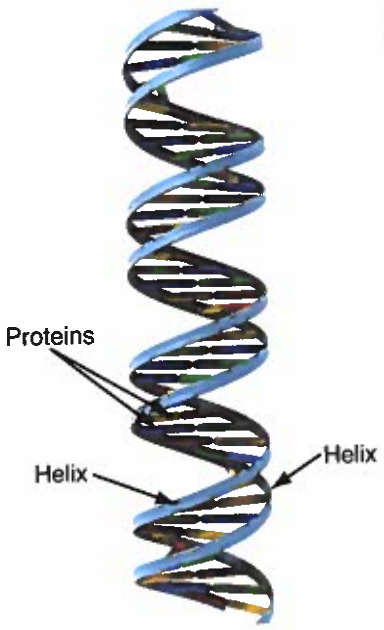


Figure 14-12. DNA is made up of two helixes, or spirals, bound together by proteins. Notice the different colors used for the proteins in this model. Each color represents one of four proteins. The arrangement, or sequence, of the proteins defines the traits of all living things.

Genetic Engineering

In the past, improvements in animals and plants occurred over hundreds of years. For example, to increase the yield of soybeans, a farmer would crossbreed plants. The farmer might cross plants with the highest yield with another variety of the same species that had a resistance to drought. This method of improving crops took generations to produce results. Hardier plants and animals are now possible in a single generation by recombining genes in a process known as *genetic engineering*. A *gene* is a sequence of DNA that defines a specific trait, such as hair color or eye color.

Agricultural Applications

Every living thing, from the smallest beetle to the tallest oak tree, has a set of genes, which we call a *genetic code*. This code determines precisely what traits it will have. In agriculture, biotechnologists look for the most beneficial traits in plants and animals. For example, they may try to increase nutrition, flavor, and disease resistance by moving traits from one organism to another.

Genetically Engineered Animals

The Enviropig™ is one example of genetic engineering. See **Figure 14-13**. Manure from normal pigs has a high phosphorous content that pollutes rivers and lakes. Phosphorous increases the amount of algae in water. Algae rob fish and other organisms of oxygen. That is why reducing pig pollution is very important. Genes from other organisms have been introduced in the Enviropig to allow it to process its food more efficiently. This reduces the amount of phosphorous in its manure, which helps protect water supplies.

Figure 14-13. The saliva of genetically engineered pigs contains phytase, an enzyme that allows the pigs to digest phosphorus more completely.

Cloning is another example of genetic engineering. Technically, *cloning* is the process of creating an exact copy of any kind of biological material. Scientists in research laboratories have been cloning DNA segments into bacterial host cells for more than 30 years.

The type of cloning that you may have heard most about is *reproductive cloning*. This is the process of creating a genetic "twin" of an existing animal or microorganism. Reproductive cloning first came into the spotlight in 1997 when Scottish scientists created "Dolly," a cloned sheep. The controversy over this type of cloning continues. Many people are concerned about the ethical implications of cloning.

Genetically Modified Crops

Genetically modified crops are another example of the use of genetic engineering. The crops are modified to be more resistant to insects and other pests. These crops are being used on many farms in the United States and around the world. We can produce fortified vegetables, or crops that are less affected by frost. See **Figure 14-14.**

Many genetically engineered products are highly controversial, however. In the past, the diversity of genes and species has provided a variety from which the best combinations of seeds have been drawn. Some people question whether *monoculture*, the spreading of a single species over a large area, will result from genetically engineered seeds. Monocultures are extremely vulnerable to new parasites and diseases.

Figure 14-14. Genetically engineered corn may produce larger, disease-resistant crops. What are the disadvantages of using genetically engineered plants as food sources?

Many questions remain about genetically modified products. Some questions include:

- What effect will genetically modified organisms have on wild animals and plants? Are the risks greater than the benefits?
- Are we sure that it is safe to mix genetic material from different life forms? Have the tests been carried out over an adequate period of time?
- Could transferring genes across natural boundaries cause epidemics of diseases such as mad cow disease?
- Could there be pressure to change less desirable genetic traits in humans?
- What effect will the higher cost of genetically modified seeds have on farmers?
- Will the smaller number of varieties be a source of increased risk for farmers because monocultural fields are more vulnerable to disease and pest attacks?

Biotechnology and Humans

Biotechnology and genetic engineering also affect humans directly. The Human Genome Project (HGP) was finished in 2003 and shows the complete genetic blueprint for building a human being. It was found that humans possess only about 20,000 genes. Identifying this genetic information became possible only recently, when computers became powerful enough to process the data. Billions of pieces of data are needed to describe a single human.

Scientists are working to discover which human genes are responsible for certain hereditary disorders. They hope to be able to test for specific genetic diseases and perhaps even cure them using genetic engineering.

Like many technologies, genetic medicine has both good and bad sides. If doctors can screen people for the likelihood that they will develop heart disease or cancer, they can take steps to prevent the diseases. This information would also allow people to make good lifestyle choices. They could select the right diets or exercise levels to increase their chance of remaining healthy.

This knowledge, however, could also result in genetic discrimination. For example, will a person, family, or group be treated differently because tests show they have a reduced life span or a tendency toward certain behavior?

Some questions that might have to be answered in the future include:

- Should people be forced to undergo genetic testing?
- Should third parties have access to the genetic information of others?

While certain defects could be removed and attractive features added, as far as we know, no gene gives us the important characteristics that make us human. No particular genes make a human being kind-hearted, law-abiding, or capable of loving. Also, keep in mind that no one can guess exactly what effect genetically engineered changes might have on humans in the future.

The Future of Biotechnology

You have probably noticed that much of the material in the agricultural and medical sections of this chapter could also have been placed in the biotechnology section. As scientists and technologists continue to improve medical and agricultural technologies, these technologies will become even more linked to biotechnology.

Improvements in biotechnology can help people live fuller, healthier lives. See Figure 14-15. Improvements to prosthetic devices will allow more and more people with missing limbs to do things they would normally be unable to do. A retina implant is being developed to give sight to people who are blind. Cochlear (ear) implants may help deaf people hear. Many medical procedures will be possible, but they may also be controversial. Many advances will have ethical and moral implications.

As discussed in Chapter 1, technology itself is neither good nor bad. Remember that all technology can be used for good purposes or bad purposes. In biotechnology as in other areas of technology, we must use technological advances wisely. We must think of both intended and unintended consequences. Information is the key to making wise technology decisions.

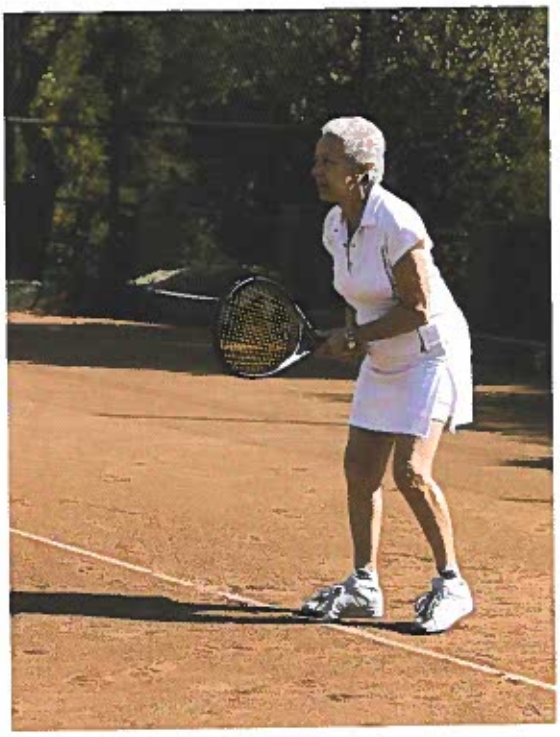


Figure 14-15. With the help of various medical and biotechnologies, seniors can participate in activities that were once reserved for younger people.

End Note

For thousands of years, farmers have been improving their crops. They have saved seeds from the best plants in this year's harvest to use next year. They used trial and error to find the best crops and the best methods for growing them. Medical technology, too, has advanced largely by trial and error. Someone accidentally discovered that aloe soothes burns and that the bark of the white willow tree can ease pain.

Today, technology has dramatically speeded up the development of new crops, drugs, and processes. We grow larger crops and have the opportunity to live longer and healthier lives. These advances come at a price, though. Many chemicals that are used to increase food production they can cause danger to other creatures. For example, some agricultural runoff can spawn a deadly oxygen-eating bacterium that kills fish and other species living in or around lakes and streams. Can we develop technology to fix these effects?

As new technologies such as genetic engineering are developed and improved, they will raise even more pressing questions. Will humans experience increased genetic uniformity, a narrowing of the gene pool, and a loss of genetic diversity? Will human efforts cause other species to become extinct? Who will make the decisions as to what is a "good" gene and what is a "bad" gene that should be eliminated? These and similar questions may need to be answered not once, but on a continuing basis now and in the future.

Summary

- Agricultural technology is responsible not only for growing foods and other products, but also for processing and packaging them.
- Medical technology provides medicines, surgical techniques, and even prosthetics to help us stay healthy and to treat injuries and illnesses.
- Biotechnology, which is based on the use of living organisms, is becoming increasingly connected to both agricultural technology and medical technology.
- As these technologies continue to advance, we must keep informed about new ideas and consider both the potential good and the potential harm they may do.

Reading Target

Creating an Outline

Use a graphic organizer similar to the one below to create an outline. Write your outline on a separate sheet of paper. Remember to use Roman numerals for the main ideas and letters for supporting ideas. Try to supply at least two supporting details for each main section. Add more detail lines if necessary to describe all of a section's important details.

I. Agricultural technology includes growing, harvesting, and processing food and other items we use every day.
   A.
   B.
   C.
   D.

II.
   A.
   B.
   C.
   D.

III.
   A.
   B.
   C.
   D.

Test Your Knowledge

Write your answers to these review questions on a separate sheet of paper.

1. Name at least two types of farming specialties and explain what these farmers do.
2. What are the advantages of precision farming?
3. What is irradiation?
4. How do vaccines help people fight disease?
5. What are the two basic sources of new medicines?
6. Name at least two advantages of robotic surgery over manual surgery.
7. What is a prosthetic device?
8. What is the difference between an implant and a transplant?
9. What is biotechnology, and how is it related to agricultural and medical technologies?
10. Briefly describe the process of genetic engineering.

Critical Thinking

1. In your own words, explain why is genetic engineering such a hotly debated topic.
2. If biotechnology could produce a robot that truly thinks, would it be ethical to "pull the plug" on such a robot? Explain.
3. One possible use of genetic engineering is in the field of law enforcement. How can genetic engineering help police and crime labs? Do you think this is a good idea? Explain.

Apply Your Knowledge

1. Choose a crop that is commonly grown in the United States, such as soybeans, corn, or wheat. Research to find out the average price farmers have received for this crop each year for the last 10 years. Make a graph to show the results. Note any trends that you see and suggest possible reasons for them.
2. Investigate the process of making cheese. Prepare a multimedia presentation to share your findings with the class.
3. Use the Internet to investigate new techniques and methods that are being used to prevent or cure a currently incurable illness of your choice. Prepare a three-minute speech on the subject and deliver the speech to your class.
4. Find out more about what happens to hazardous medical waste after it is collected. How is it processed? How does this keep it from harming other humans and animals?
5. Research the latest advances in genetic engineering and choose one topic that seems controversial. As a class, debate the pros and cons of the new product or technique.
6. Research one career related to the information you have studied in this chapter. Create a report that states the following:
   - The occupation you selected
   - The education requirements to enter this occupation
   - The possibilities for promotion to a higher level
   - What someone with this career does on a daily basis
   - The earning potential for someone with this career

   You might find this information on the Internet or in your library. If possible, interview a person who already works in this field to answer the five points. Finally, state why you might or might not be interested in pursuing this occupation when you finish school.

STEM Applications

1. **ENGINEERING** Design and make a hydroponics unit for a location that needs attractive plants without continuous maintenance. Document your design and include it in your portfolio.
2. **TECHNOLOGY** Find a recipe for making applesauce from apples. With your parent or guardian's permission, follow the recipe. Record the technology you used in the course of preparing the applesauce. Brainstorm technological improvements that might make the process easier, faster, or more fun.
3. **SCIENCE** Research the construction of a greenhouse. Individually or as a class, design and make a greenhouse that will allow you to grow a type of plant that does not ordinarily grow in your location. Test the greenhouse by using it to grow the specified plants from seeds. Document your design and record the results of your growing efforts. Did the plants sprout? Did they flourish? What kind of care did they require? At the end of the growing season, publish your results in a scientific reporting format.

CHAPTER 15

Manufacturing and Production

Better by Design

Metaphase Design Group develops user-centered designs

Work gloves provide important protection, but often they make handling objects more difficult. At Metaphase Design Group, a team of designers explored how work gloves are used. They then designed a range of gloves for specific tasks. Constructors' gloves have a small magnet in one finger. The magnet is strong enough to pick up one nail, but weak enough to prevent picking up more than one. People who work in shipping, receiving, and delivery need bare fingertips to use their electronic tracking devices. Their gloves have fingertip "hats" that can be flipped back and held with Velcro®. The wedge-like thumb design slides easily under boxes for handling.

A small magnet in the index fingers of these gloves allows carpenters to pick up one nail at a time.

The tips of these gloves can be folded back and secured by Velcro when employees are working with electronic equipment.

"The best way to find out what a product should do is by watching people use it in the real world."