Objective: 8.L.5.2

Chapter 4 • Lesson 13

Human Health

Key Words • nervous system • digestive system • circulatory system • respiratory system • toxic • addiction • experiment • variable • independent variable • dependent variable • controlled variable

Getting the Idea

You are an organism made up of trillions of cells. These cells work together to carry out the functions that keep you alive. To perform these functions, the cells of the body are organized in specific ways. Understanding how your body functions can help you make choices that will keep you healthy.

Systems Working Together

The body is organized into systems, each of which has its own functions. No system could survive on its own. The systems of the human body work together and depend on each other.

Recall from Lesson 11 that cells get the energy they need from the process of cellular respiration. In the body, several systems work together to transport food and oxygen, the materials for cellular respiration, to cells. The **nervous system**, which includes the brain and sense organs, gathers and responds to information about the environment. It uses information such as signals from the eyes and nose to locate food. The nervous system also directs many body functions, such as movement. It helps move the hands and arms to bring food to the mouth. This is also made possible by the muscular and skeletal systems.

The **digestive system**, which includes the mouth and stomach, takes in food and breaks it down into smaller molecules that can be used by cells. The **circulatory system** then delivers those molecules to all the cells of the body. The heart and blood are parts of the circulatory system.

Cells also need oxygen to perform cellular respiration. The **respiratory system**, which includes the lungs, takes in oxygen from the air and passes it to the circulatory system. The circulatory system then transports oxygen to cells.

Both the circulatory and respiratory systems help cells get rid of materials they no longer need. The circulatory system carries carbon dioxide and wastes away from cells. The respiratory system releases carbon dioxide and water vapor to the air.

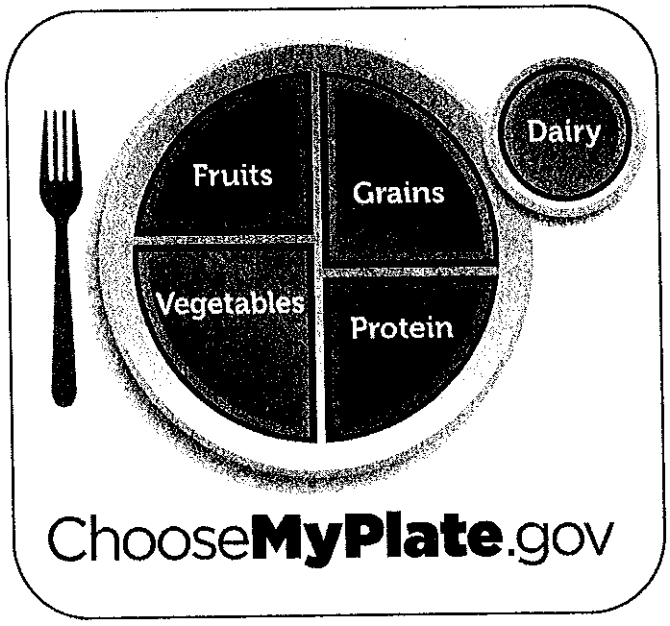
Food and Health

You may have heard the expression "You are what you eat." This is not exactly true. No matter how many potato chips you eat, you will not turn into a potato chip. But the expression is worth thinking about because what you eat affects your health.

The food you eat contains a variety of nutrients. Some of these, such as starches and sugars, are used for energy. Potatoes, pasta, and bread contain starches. Candy and other sweets contain sugars. Other nutrients, such as proteins, are used for building materials in your body. You get protein from meat, fish, cheese, eggs, beans, milk, and other dairy products. Vitamins and minerals are nutrients. They help the body function properly and are found in a variety of fruits and vegetables. Lipids are nutrients that provide energy and some materials for growth. Lipids, which include fats and oils, are often found combined with other nutrients. Many sources of protein, such as meat and cheese, also contain fats. Foods fried in oil or butter also contain large amounts of lipids.

Eating a diet that has a good variety of nutrients will give you the energy you need. It will also give you the materials you need to grow and maintain healthy life processes. Eating a diet that is not balanced can lead to health problems. Often, people eat more starches, sugars, and fats than are needed. If a person eats more of these energy sources than are needed, the body stores the extra energy as fat. The person gains weight. Being overweight can cause damage to the heart and other health problems.

The diagram below shows the proportions of each type of food in a healthy diet. Fruits and vegetables should make up the largest part of your diet. Grains and proteins such as lean meats and cheese should make up less. Drink water or milk instead of sweetened soft drinks. Also, regular exercise is important to health. It keeps your heart and muscles strong. Exercise uses energy from the food you eat, which can help you maintain a healthy weight.



Source: USDA

Tobacco and Health

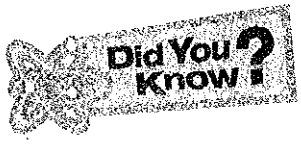
Tobacco products are **toxic**, or harmful to the body. Cigarette smoke contains several toxic substances. One of these substances is a gas called carbon monoxide. When smoke is inhaled, carbon monoxide enters the blood. It interferes with the ability of the blood to carry oxygen throughout the body.

Cigarette smoke also contains a dark, sticky material called tar. Tar from cigarette smoke affects the lining of the respiratory system, making it difficult for the body to get rid of dust, pollen, and other matter in the air that is inhaled. Tar and tobacco contain chemicals called *carcinogens*, substances that cause cancer. These chemicals are the reason smoking causes lung cancer and cancers that affect the mouth, throat, and stomach. Other methods of tobacco use, including chewing tobacco, can also lead to cancer.

Smoking has many long-term effects in addition to cancer. Smoking causes emphysema, a disease that reduces the ability of the lungs to absorb oxygen. Smoking also contributes to the development of heart disease. Choosing not to smoke reduces a person's risk of developing these diseases.

Using tobacco causes the body to absorb nicotine, which is a kind of drug called a stimulant. Like carbon monoxide, nicotine increases heart rate. It also increases blood pressure. People who smoke or chew tobacco become addicted to nicotine. An **addiction** is a physical dependence on a substance. People who are addicted to nicotine have cravings for it. These cravings are very strong and make it difficult for users of tobacco to quit the habit.

Some people feel pressured by friends or classmates to smoke or chew tobacco. However, deciding not to use tobacco is one of the best choices you can make for your health. It is also important to avoid secondhand smoke. This is smoke you inhale from people who are smoking nearby. Secondhand smoke has many of the long-term effects of smoking. It is especially harmful to children. Children who are exposed to secondhand smoke are more likely to have asthma and respiratory infections. To reduce the danger of secondhand smoke, many towns and cities have banned smoking in restaurants and other public places.



When a person quits smoking, the body can take many years to repair all the damage caused by smoking. But some of the benefits of quitting smoking happen almost right away. Carbon monoxide levels in the blood return to normal 12 hours after a person's last cigarette.

Alcohol, Drugs, and Health

A *drug* is a substance that causes a change in a person's body or behavior. Some drugs are used as medicines. Pain relievers can make a headache or backache go away. Allergy medicines are used to clear up symptoms such as a runny nose or sneezing. However, not all drugs are medicines. Recall that the nicotine in tobacco is a drug.

Some drugs are useful substances when used correctly. But they can be used in harmful ways, too. The use of a drug in a way that is not helpful is called *drug abuse*. The use of illegal drugs, such as heroin and cocaine, is a form of drug abuse. The use of someone else's prescription medicine is also drug abuse. Choosing not to abuse drugs is very important to staying safe and healthy.

Drugs affect the body in many ways. Most illegal drugs affect the nervous system. Some can cause nervousness and loss of appetite. Other drugs may cause decreased alertness, poor reflexes, and reduced muscle coordination.

Drug abuse has many long-term effects. Many drugs cause brain damage, which can result in mental confusion and memory loss. Long-term use of drugs can cause heart and liver damage. Another long-term effect of drug use is addiction.

Alcohol is a drug. Because it can be purchased legally by adults, alcohol is often abused. Alcohol use affects judgment. When thought processes and judgment are slowed, people react slowly. They are not able to make fast decisions such as those required to drive a car. When people drink alcohol and drive, they are likely to have an accident. Alcohol is involved in almost one-third of the deaths caused by car accidents.

Lesson Review

1. Which systems work together to deliver oxygen to the cells of the body?

   A. muscular and circulatory

   B. skeletal and digestive

   C. respiratory and circulatory

   D. digestive and respiratory

2. Which of these foods is a major source of both protein and fat?

   A. peas

   B. bread

   C. cheese

   D. oil

3. Which is the **best** definition of *addiction*?

   A. a physical dependence on a substance

   B. a dependence on an illegal substance

   C. any behavior that is harmful to health

   D. an unavoidable side effect of taking medicine

4. Which of these **best** explains why driving after drinking alcohol is dangerous behavior?

   A. Drinking alcohol can cause nervousness and agitation.

   B. Drinking alcohol can affect thought processes and slow reaction time.

   C. Drinking alcohol can lead to liver damage.

   D. Drinking alcohol can speed up heart rate and breathing rate.

Chapter 4 • Lesson 14

Objective: 8.L.1.1

Diseases

Key Words • microorganism • microbiology • pathogen • fungus • parasite • virus • bacteria • antibiotic

Getting the Idea

A disease is a condition that prevents the body from functioning normally. Many diseases that affect humans are infectious. An infectious disease can be transmitted, or spread from one organism to another.

Agents of Disease

Many diseases in humans and other organisms are caused by microorganisms. A **microorganism** is a living thing that cannot be seen without a microscope. The study of these microscopic organisms is **microbiology**. Microbiology includes the study of viruses, bacteria, protists, and some fungi. Any microorganism that causes disease is a **pathogen**.

A **fungus** (plural: *fungi*) may be either a one-celled or a many-celled organism. Most fungi that cause disease are one-celled. Yeasts, molds, and mildews are examples of one-celled fungi. Mushrooms and shelf fungi are many-celled fungi and do not cause disease. Like plant and animal cells, the cells of fungi include a nucleus and organelles surrounded by membranes.

Some microorganisms that cause disease in humans are parasites. A **parasite** is an organism that lives on or in another organism and benefits at the other organism's expense. A parasite uses the tissues or fluids of its host, the organism on which it lives, as a source of food. Over time, this may weaken or sicken the host.

Viruses are other common agents of disease in humans. A **virus** is a microscopic core of genetic material surrounded by a protein coating. A virus causes illness when it infects a living cell. Though it may seem surprising, viruses are not usually considered to be living things. Unlike living things, viruses are not made up of cells. Also, viruses do not carry out any of the functions of life except reproduction. Viruses cannot reproduce without infecting a living cell. You will read more about this later in the lesson.

Many pathogens are bacteria. **Bacteria** (singular: *bacterium*) are one-celled organisms. Recall from Lesson 10 that bacteria are prokaryotes. The cell of a bacterium does not have a nucleus contained in a nuclear membrane. A bacterium also lacks the other organelles of plant and animal cells.

Bacteria are grouped according to their shapes. Bacteria have rigid cell walls that give them their shape. As shown in the diagram, bacteria have three common shapes—spiral, rod, and sphere. Each type of bacterium is described below.

Spirilla Bacilli Cocci

- A spirillum (plural: *spirilla*) is a bacterium that has a spiral shape. This shape is sometimes described as a corkscrew.
- A bacillus (plural: *bacilli*) is a rod-shaped bacterium.
- A coccus (plural: *cocci*) is a round or spherical bacterium.

Fungi and Disease

Most fungi that cause disease in humans are made up of only one cell. For example, *Candida* is a group of yeasts. These microorganisms can invade many parts of the body. They cause problems ranging from skin infections to more severe infections of the bones, lungs, and heart.

Ringworm is a common skin infection caused by a fungus. It often affects the neck, scalp, groin, or feet. A ringworm infection of the feet is more commonly called athlete's foot. The fungus that causes athlete's foot is picked up from the environment. The fungus spreads easily in wet places where many people go barefoot, such as the showers in locker rooms. It most often grows between the toes, where the skin is likely to be warm and moist. It causes itching and flaky skin. Athlete's foot can be difficult to cure.

Molds are another type of one-celled fungi. Many molds cause problems for humans who inhale the molds or their spores (reproductive cells). Once in the lungs, molds can cause a variety of problems, including allergic reactions, asthma attacks, and pneumonia.

Diseases Caused by Parasites

Recall that a parasite is an organism that lives on or in another organism. In most cases, parasites do not kill their host—the organism on which they live. If they did, the parasites would lose the benefits that they gain from that organism.

When parasites use their host for nourishment, they can sicken and weaken the host. For example, the parasite that causes African sleeping sickness destroys red blood cells. Red blood cells carry oxygen to all parts of the body. When the parasite destroys these cells, other cells do not get enough oxygen. Therefore, a person with African sleeping sickness is lethargic and tires easily. You will learn more about parasites in Lesson 15.

Bacteria and Disease

Bacteria can be found everywhere. They are in water and soil. They are on the surfaces people touch every day. Bacteria live on and inside other organisms. Many bacteria are useful. For example, some bacteria help break down the remains of dead organisms. Bacteria that live in the intestines of animals aid in digestion.

Many bacteria are pathogens. For a bacterium to cause disease, it must enter your body. Bacteria often enter the body in food and water, or through cuts in the skin. Once inside the body, most bacteria reproduce very quickly. In fact, some bacteria can divide to produce two new bacteria as often as every 20 to 30 minutes. At that rate, in only 16 hours, a population that began as two bacteria can grow to more than 8.5 billion bacteria.

Bacteria in the body can act as parasites by using nutrients needed by the body's own cells. However, most bacteria that cause disease produce toxins, or poisons, that disrupt normal cell functions. Some diseases caused by bacteria are cholera, *Salmonella* food poisoning, pneumonia, and typhoid fever. The table lists some other diseases caused by bacteria, along with their effects on the body.

Diseases Caused by Bacteria

Disease	Bacterium	Effect on Body
Lyme disease	*Borrelia burgdorferi*	"Bulls-eye" rash at site of tick bite, fever, fatigue, muscle aches, joint aches
Tetanus	*Clostridium tetani*	Muscle spasms, paralysis, death
Tuberculosis	*Mycobacterium tuberculosis*	Fatigue, weight loss, mild fever, cough, death
Strep throat	*Streptococcus pyogenes*	Fever, sore throat, swollen glands
Hansen's disease (leprosy)	*Mycobacterium leprae*	Skin sores, thickening of skin, nasal congestion

Meningitis is a disease that can be caused by several different kinds of bacteria and one kind of virus. Viral meningitis is a mild disease, but bacterial meningitis is a serious infection. The bacteria infect the fluid and membranes that surround the brain and spinal cord. The first signs of the infection are a fever, headache, and a stiff neck. The person may also be very sensitive to light. If the infection is not treated quickly, the person may have seizures or go into a coma. Sometimes people die from bacterial meningitis.

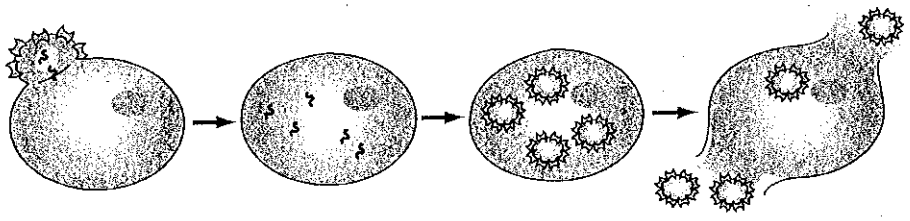
Bacterial meningitis is spread from person to person, usually through coughing, sneezing, or kissing. It can spread through groups of people who are close together for much of the time. It tends to spread more quickly among children than adults. This is because small children may not be careful about sneezing and coughing on others. But the infection does not spread as easily as the common cold or the flu.

Many diseases caused by bacteria have been brought under control by antibiotics. **Antibiotics** are drugs that kill bacteria or slow their growth. However, misuse of antibiotics has allowed some bacteria to become resistant to their effects. The antibiotics do not harm the resistant bacteria. Antibiotic resistance has made it difficult to treat some bacterial diseases.

Viruses and Disease

Some diseases caused by viruses include viral meningitis, smallpox, yellow fever, chickenpox, measles, and AIDS. Influenza, or flu, and the common cold are also caused by viruses. Scientists have found a link between viruses and some types of cancer. For example, cervical cancer is associated with the human papilloma virus (HPV).

To reproduce, a virus attaches itself to a healthy cell. It injects its genetic material into the cell. Once its genetic material is inside the cell, the virus uses the cell's structures to make new viruses. Eventually, the new viruses cause the host cell to burst open. The host cell dies and releases the viruses. These new viruses can infect and kill more cells.



A virus attacks and inserts genetic material into a cell.

New genetic material for the virus is created.

Complete viruses are made in the cell.

The cell is destroyed, releasing new viruses.

Diseases caused by viruses often produce aches and fever. In some diseases, there is a cycle to the aches and fever. During a period when many viruses are breaking out of host cells, fever goes up and the aches get worse. In between these periods, the fever is lower and the aches may go away.

Antibiotics are not effective against viruses. However, scientists are developing drugs that can be used against viruses. For example, drugs have been produced to treat people with a certain type of influenza. These antiviral substances slow down the rate at which the virus reproduces. This makes it easier for the body's immune system to fight the virus. Also, the spread of some diseases caused by viruses or other pathogens can be prevented with vaccines. You will learn more about vaccines in the next lesson.

Discussion Question

Should antibiotics be used to treat diseases such as African sleeping sickness, the common cold, and the flu? Why or why not?

Lesson Review

1. Which of these diseases can be treated with antibiotics?
   - **A.** Lyme disease
   - **B.** the common cold
   - **C.** influenza
   - **D.** AIDS

2. Which type of pathogen causes athlete's foot?
   - **A.** bacterium
   - **B.** insect
   - **C.** fungus
   - **D.** virus

3. Which of the following reproduces by injecting its genetic material into a host cell?
   - **A.** parasite
   - **B.** virus
   - **C.** bacterium
   - **D.** microorganism

4. Which of the following are likely to be either spherical, rod-shaped, or spiral-shaped?
   - **A.** bacteria
   - **B.** viruses
   - **C.** eukaryotes
   - **D.** parasites

Chapter 4 • Lesson 15

Objectives: 8.L.1.1; 8.L.1.2

Public Health

Key Words • infectious disease • epidemic • pandemic • vector • vaccine

Getting the Idea

Have you ever watched a movie or played a video game in which scientists race to stop a spreading disease? Think about what usually happens in this kind of story. First, the scientists find the cause of the disease. Then they find a way to kill the pathogen and save the world! This does not happen just in movies and games. Real-life scientists work to control the spread of diseases. They work in a field called public health.

Keeping People Healthy

Public health is the science that deals with protecting and improving the health of the people in a community. Public health scientists make sure that food, water, and medicines are safe. Public health workers inspect restaurants and factories where foods are processed. They check that the places are clean and that the food does not contain bacteria or other disease-causing organisms. Drinking water is tested to make sure it does not contain harmful organisms or dangerous chemicals.

Scientists are always working to develop new medicines. Before these medicines can be used, they must be tested to make sure they are safe. They are also tested to make sure that they are effective. New medicines are tested in clinical trials. In these tests, patients with a disease take a new medicine to see if it can cure the disease. It can take many years of testing before a medicine is approved for use.

Some public health scientists are disease detectives. They research diseases and look for ways to prevent them. To stop the spread of a disease, public health scientists study the pathogen that causes the disease. It is important to understand how pathogens function. One way to study pathogens is to grow them in a laboratory. Cells grown in a laboratory culture can be tested to see which medicines can kill them or slow their growth. This testing helps scientists learn which medicines to use to treat someone who has a certain disease.

It is also important to learn how pathogens are passed from one person to another. This knowledge helps scientists find ways to stop the spread of pathogens. When scientists know how pathogens are spread, they can use computer models to predict where a disease may spread next.

Widespread Diseases

Diseases that can be passed from one organism to another are called **infectious diseases**. An infection is a condition caused by the presence of pathogens in the body. Infectious diseases that are passed from one person to another include the common cold, tuberculosis, measles, chickenpox, smallpox, and AIDS.

Some infectious diseases spread more easily than others. People get influenza, or the flu, when virus particles enter their noses or mouths. Virus particles are usually spread from person to person through coughing and sneezing. Every winter there is an outbreak of flu. In some years it affects a small part of the population. In other years, many people are infected. An **epidemic** is an outbreak of a disease that affects many people in an area.

If an epidemic spreads over a larger area, or throughout the world, it is called a **pandemic**. In 2009, a type of flu called H1N1 was first identified in Mexico. Soon after that, cases were reported in the United States and then in other countries around the world. The H1N1 flu was considered a pandemic.

Some pandemics last for several years. Others last for a shorter time. The H1N1 pandemic in 2009 lasted about a year. Pandemics end for several reasons. First, some infected people die. They can no longer spread the infection. Scientists estimate that up to 18,000 people died in the H1N1 pandemic. A second reason pandemics end is that people recover. Often, after people have had an infection, they cannot get it a second time. Finally, many people may be resistant to a disease. Even if they are exposed to the pathogen, they do not get sick. For all these reasons, a virus can run out of people to infect.

Epidemics and pandemics are not new, as the history of smallpox shows. Smallpox, which is caused by a virus, produces high fever, fatigue, and a rash. There were smallpox epidemics in ancient Egypt and India, and later in Europe. The disease traveled to North America with early European settlers. In the late 1700s, smallpox spread rapidly throughout populations in North America. Smallpox reached as far as Alaska, Canada, and Mexico.

Stopping the spread of an epidemic is very difficult. Infectious diseases spread from one person to another. If everyone stayed home, diseases would not spread much. But people travel all over the world, and some of them carry diseases with them. During the H1N1 epidemic in Mexico, many countries warned their citizens not to travel to Mexico. But by the time this warning was issued, the disease had already made its way around the world.

Infectious Diseases in Plants and Animals

Humans are not the only organisms affected by infectious diseases. Infectious diseases can affect the health of plants and other animals, too. Many diseases in plants are caused by fungi. These include wheat rust and corn smut. Hoof-and-mouth disease is caused by a virus and affects cattle. Diseases of crops and farm animals can cost farmers large amounts of money. An epidemic of one of these diseases can also reduce food supplies.

Vectors

Some diseases are spread from one person to another by vectors. A **vector** is an organism that transmits a disease. Malaria is a disease caused by a parasite in the blood. Mosquitoes are vectors of malaria. A mosquito bites a person who has malaria. Later, when the mosquito bites another person, the disease is passed to that person. Yellow fever and West Nile disease, both of which are caused by viruses, are also spread by mosquitoes. You cannot catch these diseases simply by being near or touching someone who is sick.

Ticks can be vectors of disease. Lyme disease is a bacterial disease carried by ticks. The infection causes fever, headaches, muscle aches, joint aches, and swollen lymph nodes. In most cases, a few days after the tick bite, a ring-shaped rash forms around the bite. This does not always happen, so the best way to be sure if you have Lyme disease is to have a blood test.

Diseases that are carried by insect vectors can be avoided if you can avoid the vector. If you are going to be in an area where the vectors are found, you should use insect repellent. It is also a good idea to wear long pants and a shirt with long sleeves.

Preventing Infectious Diseases

One important way to avoid infectious diseases is good hygiene. Hygiene refers to keeping yourself clean. Good hygiene habits include washing your hands frequently and bathing regularly. These practices remove pathogens you may have come in contact with. Because flu, colds, and other infectious diseases can be spread by touching objects that have pathogens on them, hand washing is especially important.

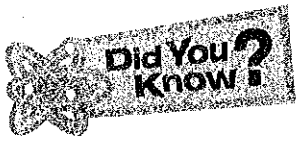
Hygiene also includes covering your mouth when you cough or sneeze to avoid spreading disease. Do not use your hands to cover your mouth and nose. Instead, you should sneeze into your arm, as shown in the image on the right. This keeps pathogens off your hands so you do not transfer them to objects you touch. Avoid touching your face, especially your eyes and nose. The viruses that cause flu and colds can enter the body that way.

Another way to stop the spread of infectious diseases is to kill the pathogens. Recall from Lesson 14 that antibiotics kill bacteria. Antibiotics do not kill viruses. However, there are some antiviral drugs. These drugs reduce the number of viruses that are produced during an infection. This can help slow the spread of the disease.

Your body is able to kill many pathogens. People recover from infections because of the body's immune system. White blood cells and proteins called antibodies attack pathogens. Usually, after you have had an infectious disease, your body still has antibodies to protect against the pathogen. This provides immunity to the disease, so you will not get it a second time. The reason you can catch a cold or flu more than once is that there are many viruses that cause these diseases. Different antibodies are needed to fight each one.

Vaccines can prevent some diseases, including many caused by viruses. You have probably been vaccinated against diseases such as measles, chickenpox, and polio. A **vaccine** contains a weakened or dead form of a pathogen. Because the pathogen in the vaccine is weakened, it does not cause disease. The vaccine stimulates your immune system to make antibodies that destroy the pathogen. As a result, your immune system knows how to respond to the pathogen. If you are later exposed to a form of the pathogen that could make you ill, your body will make antibodies to destroy the pathogen.

The development of vaccines has made many infectious diseases less common than they once were. Vaccination programs around the world have wiped out smallpox. The last known case of smallpox in the United States was in 1949. The last case in the world was in Somalia in 1977. Polio, a viral disease that can cause paralysis, has been wiped out in the United States. There have been no new polio cases in the United States since 1993. Public health groups around the world are working to wipe out the disease everywhere.



In 1959, North Carolina became the first state to require that all children be vaccinated against polio.

Discussion Question

Your mother is worried because she heard that the chickenpox vaccine your younger brother is going to receive is actually a weakened form of the virus that causes chickenpox. How do you explain to her that being injected with the disease will actually help protect your brother?

Lesson Review

1. An event in which a disease spreads to many regions of the world is called

   A. an epidemic.

   B. an outbreak.

   C. a pandemic.

   D. a pathogen.

2. A mosquito that transmits malaria from one person to another is

   A. a bacterium.

   B. a parasite.

   C. an infection.

   D. a vector.

3. A vaccine is made from

   A. proteins produced by the body's immune system.

   B. a weakened or dead form of a pathogen.

   C. body cells that are immune to a disease.

   D. an antibiotic used to treat an infectious disease.

Chapter 4 • Lesson 16

Objective: 8.L.2.1

Biotechnology

Key Words • biotechnology • genetic modification • genome • cloning

Getting the Idea

You may have eaten pluots. These fruits have only been available for about 30 years. They were developed from plums and apricots. For thousands of years, people have changed plants and animals for human use. But scientists today have new technologies for doing so.

Crossbreeding and Selective Breeding

Biotechnology is the manipulation of living things to make useful products. The use of biotechnology causes changes in organisms. Some of the earliest forms of biotechnology involved breeding plants and animals.

In crossbreeding, two different kinds of organisms are bred together. Pluots were developed by breeding plums and apricots together. Loganberries were developed from blackberries and red raspberries.

Selective breeding is the intentional mating of organisms to produce offspring with specific traits. In this process, organisms with desired traits are bred, in the hope that the traits will be passed to their offspring. Once grown, offspring with the desired traits are bred, continuing the process. Offspring without the desired traits are not bred. This process is repeated over many generations until all offspring consistently show the desired trait. Over time, new varieties of organisms that always show the traits are produced. Many breeds of dogs have been produced in this way.

Genetic Modification

Many traits of organisms are now produced through genetic modification. **Genetic modification** changes the genetic material of a living organism. This practice is used to make medicines and treat diseases. It is also used to improve crops and to produce organisms used in scientific research.

Gene splicing is one form of genetic modification. In gene splicing, a gene from one organism is inserted into the DNA of another organism. For example, scientists have spliced the human gene for making a substance called insulin into the DNA of bacteria. This causes the bacteria to make human insulin. This insulin can be used

by some people with diabetes. Their bodies do not produce enough insulin, so they must use insulin from other sources. At one time, insulin for people with diabetes came from the organs of cows or pigs. Now, people can use human insulin manufactured by genetically modified bacteria. Gene splicing has also been used to create bacteria that produce substances such as vitamins and vaccines.

Genetic modification has also been used to develop corn that is resistant to some herbicides. An herbicide is a product used to kill weeds. Farmers who plant this corn can spray their fields with the herbicide to kill weeds, without harming the corn. Scientists are also using genetic modification to develop fruits and vegetables that taste better and stay fresher from farm to market.

To use genetic modification, scientists need to know as much as possible about an organism's DNA. Scientists have developed techniques for mapping an organism's genome. A **genome** is the complete sequence of an organism's DNA. When scientists map a genome, they identify the sequence of certain repeating units in the DNA. They also try to identify all the organism's genes and figure out where on the DNA they are located.

Several sites in North Carolina are involved in genome research, or genomics. North Carolina State University has the Genomic Sciences Laboratory. Its work includes DNA sequencing. The University of North Carolina's Center for Integrated Systems Genetics has performed studies involving genomics and human health. Genome research is carried out at Duke University's Institute for Genomic Sciences and Policy. North Carolina is also home to many corporations that are working in the field of genomics.

DNA Fingerprinting

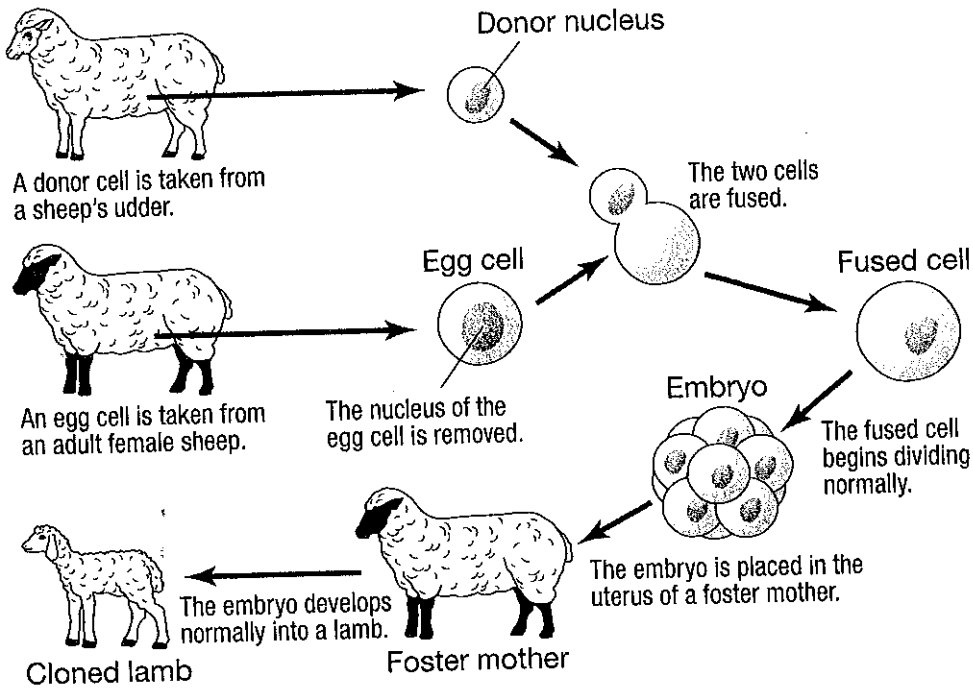
Scientists have worked out the sequence of the human genome. Much of the DNA of all humans is the same. But there are some sections that are different in each person. The sequence of repeating units in these sections can be used as a sort of "fingerprint" to solve crimes.

In DNA fingerprinting, DNA is collected at a crime scene. Even small amounts of blood or other body fluids left at the crime scene may be enough to provide a sample of DNA. Cells attached to the root of a hair can also provide a DNA sample. When a suspect is found, a DNA sample is taken from the suspect. The sequences of the DNA samples are compared. If the DNA from the crime scene matches the DNA of the suspect, this may be evidence that the suspect was at the crime scene. If the sequences are not the same, it shows that the DNA came from someone else.

Animal Cloning

The chromosomes in the nucleus of a fertilized egg cell have all the information needed to produce an entire organism. A single fertilized egg can develop into an adult. Scientists wondered if a body cell could do the same thing. To find out, they used a technique called cloning. **Cloning** produces an organism that is an exact genetic copy of another.

In one experiment, scientists took the nucleus from an adult sheep cell. They put that nucleus into a sheep egg cell, replacing the original nucleus. When the cell started dividing, it was implanted into a female sheep. The dividing cell grew into a lamb named Dolly. Born in 1997, Dolly was genetically identical to the adult whose chromosomes were used to create her. Therefore, Dolly was a clone. The diagram shows how Dolly was cloned.



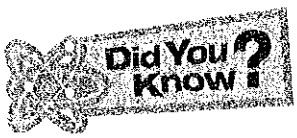
Since Dolly was created, scientists have cloned other animals. Cloning animals is difficult and expensive. It often takes many tries to create one clone. However, cloning might be used to duplicate animals with desirable traits. For example, scientists might clone cows that give a lot of milk. Or scientists might clone animals to help preserve endangered species. Clones can give birth normally. So, like other animals, they pass their desirable traits to their offspring.

Bioremediation

Some forms of biotechnology do not change an organism's genes. Bioremediation uses existing kinds of bacteria to clean up the environment. After a large oil spill in 1989, workers saw that some areas were becoming cleaner on their own. They discovered that bacteria were consuming the oil. These bacteria were not added by anyone. They were in the water naturally. The fact that they could consume oil was unknown before this. Scientists found that the bacteria need nitrogen to function. So now, nitrogen-containing fertilizers are added to oil spills to help the bacteria clean up.

Other microorganisms have been used to clean up toxic wastes in soil and water. Different kinds of bacteria work on different substances. Bioremediation scientists know which bacteria to use for each kind of chemical spill. They also know what nutrients must be supplied to keep the bacteria working.

So far, bioremediation has used naturally occurring bacteria. Researchers are working to develop genetically modified bacteria that can clean up chemical spills even faster.



Not all uses of one-celled organisms are new. For example, yeasts have been used for thousands of years in making bread. Yeasts are also used to make some fermented drinks. Bacteria are used in making yogurt. Molds are often used to add flavoring to cheese.

Risks of Biotechnology

Biotechnology has been very beneficial to humans. However, some people have concerns about its use. For example, the entire human genome has been mapped. This new knowledge may lead to treatments or cures for some diseases. But some people worry about how information about an individual's genes could be used. For example, a health insurance company might refuse to cover a person who carries a gene for a specific disease. Cloning is also a controversial issue. Some people worry that scientists might try to clone humans.

Another concern is that genetically modified organisms could spread to places where they are not wanted. Such organisms might cause disease or have unexpected and negative effects on the environment. Crop plants that are genetically modified to resist herbicides could spread beyond the fields where they are planted. These plants could be difficult to remove. Genes bred into some crop plants may also cross over into wild populations.

Genetically engineered food plants may come with other risks. One risk is that genes moved from one species to another may cause allergic reactions. Genetically engineered foods are not currently labeled in ways that would let people avoid this danger. Some crops, such as corn, are used in many different foods. Altering those crops could affect millions of people.

Discussion Question

Not everyone agrees that biotechnology should be used to modify crop plants. What is your opinion? Explain your reasoning.

Lesson Review

1. A genome is
   - **A.** a sequence of units in a short segment of DNA.
   - **B.** a gene inserted into a bacterial chromosome.
   - **C.** the complete sequence of an organism's DNA.
   - **D.** part of a chromosome.

2. Which of these is an example of genetic modification?
   - **A.** use of herbicides
   - **B.** crossbreeding
   - **C.** heart surgery
   - **D.** gene splicing

3. Which process uses a body cell to create a new organism?
   - **A.** crossbreeding
   - **B.** cloning
   - **C.** genetic modification
   - **D.** gene splicing

4. Which of these is **not** a way in which biotechnology can benefit agriculture?
   - **A.** increasing crop production
   - **B.** reducing the loss of crops to insects
   - **C.** producing better-tasting fruits
   - **D.** improving farm machinery