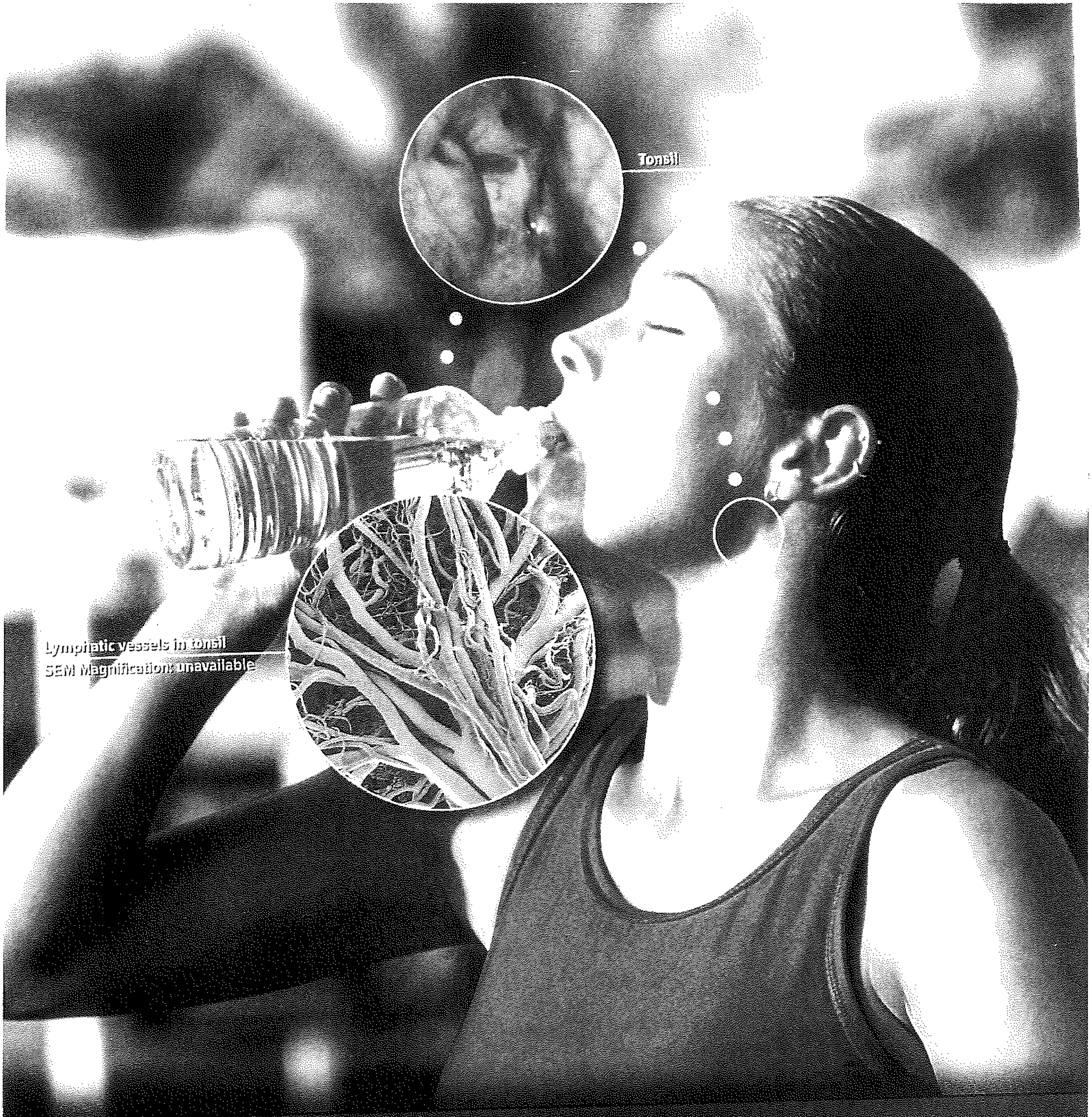


THEME FOCUS Cause and Effect

The human body uses specific and nonspecific immunities to maintain a healthy balance.

BIG Idea The immune system attempts to protect the body from contracting an infection through pathogens.

Section 1

Reading Preview

Essential Questions

- What are Koch's postulates?
- How are diseases transmitted and how do reservoirs play a role in disease dispersal?
- What are the symptoms and treatment of infectious diseases?
- What are disease patterns?

Review Vocabulary

protozoan: unicellular, heterotrophic, animal-like protist

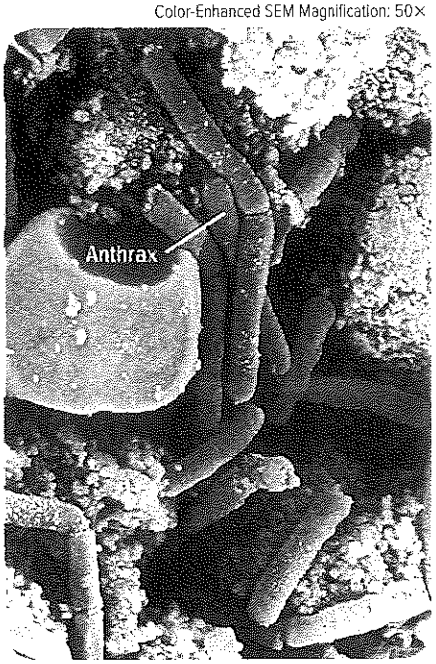
New Vocabulary

infectious disease
pathogen
Koch's postulates
reservoir
endemic disease
epidemic
pandemic
antibiotic

Multilingual eGlossary

Figure 1 These rodlike bacteria cause the disease anthrax.

Color-Enhanced SEM Magnification: 50×



Infectious Diseases

MAIN Idea **Pathogens are dispersed by people, other animals, and objects.**

Real-World Reading Link Have you ever gotten something sticky on your hands? As you touched other objects, they too became sticky. In a similar manner, viruses transfer to objects that you touch. When these objects are touched by someone else, the virus can be picked up by another person.

Pathogens Cause Infectious Disease

What do a cold and athlete's foot have in common? They are both examples of an infectious disease. An **infectious disease** is a disease that is caused by a pathogen passed from one organism to another, disrupting homeostasis in the organism's body. Agents called **pathogens** are the cause of infectious diseases. Some but not all types of bacteria, viruses, protozoans, fungi, and parasites are pathogens.

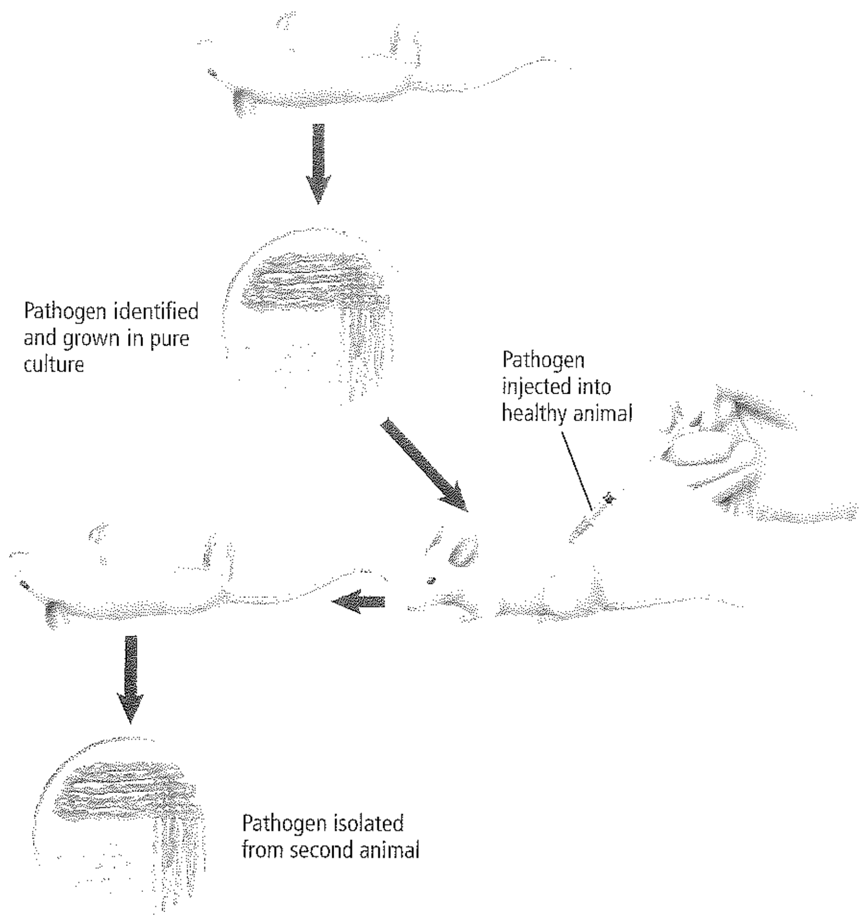
Many types of these organisms are present in the world around us without causing infectious diseases. Your body benefits from organisms, such as certain types of bacteria and protozoans, that normally live in your intestinal and reproductive tracts. Other bacteria live on your skin, especially in the shafts of your hair follicles. These organisms keep pathogens from thriving and multiplying on your body.

Germ Theory and Koch's Experiments

Before the invention of the microscope, people thought "something" passed from a sick person to a well person to cause an illness. Then, scientists discovered microorganisms and Louis Pasteur demonstrated that microorganisms from the air are able to grow in nutrient solutions. With the knowledge gained from these and other discoveries, doctors and scientists began to develop the germ theory. The germ theory states that some microorganisms are pathogens. However, scientists were not able to clearly demonstrate this theory until Robert Koch developed his postulates.

Identification of the first disease pathogen In the late 1800s, Robert Koch, a German physician, was studying anthrax (AN thraks)–a deadly disease that affects cattle and sheep and can also affect people. Koch isolated bacteria, like those in **Figure 1,** from the blood of cattle that had died from anthrax. After growing the bacteria in the laboratory, Koch injected the bacteria into healthy cattle. These animals developed the disease anthrax. He then isolated bacteria from the blood of newly infected cattle and grew the bacteria in the laboratory. The characteristics of the two sets of cultures were identical, indicating that the same type of bacteria caused the illness in both sets of cattle. Thus, Koch demonstrated that the bacteria he originally isolated were the cause of anthrax.

Reading Check **Explain** how Koch proved the germ theory correct.



Postulate 1

The suspected pathogen must be isolated from the diseased host in every case of the disease.

Postulate 2

The suspected pathogen must be grown in pure culture on artificial media in the laboratory.

Postulate 3

The suspected pathogen from the pure culture must cause the same disease when placed in a healthy new host.

Postulate 4

The suspected pathogen must be isolated from the new host, grown again in pure culture, and shown to have the same characteristics as the original pathogen.

Figure 2 Koch's postulates demonstrate that a specific pathogen causes a specific disease.

Infer ***what Koch demonstrated when he isolated the same bacteria from the cattle the second time.***

Koch's postulates Koch established and published experimental steps known as **Koch's postulates,** which are rules for demonstrating that an organism causes a disease. These steps are followed today to identify a specific pathogen as the agent of a specific disease. Follow the steps in **Figure 2** as you read each of the four postulates.

Postulate 1: The suspected pathogen must be isolated from the diseased host in every case of the disease.

Postulate 2: The suspected pathogen must be grown in pure culture on artificial media in the laboratory. A pure culture is a culture that contains no other types of microorganisms—only the suspected pathogen.

Postulate 3: The suspected pathogen from the pure culture must cause the disease when placed in a healthy new host.

Postulate 4: The suspected pathogen must be isolated from the new host, grown again in pure culture, and shown to have the same characteristics as the original pathogen.

Some exceptions to Koch's postulates do exist. Some pathogens, such as the pathogen that is thought to cause syphilis (SIH fuh lus), cannot be grown in pure culture on artificial media. Artificial media are the nutrients that the bacteria need to survive and reproduce. Pathogens are grown on this media in the laboratory. Also, in the case of viruses, cultured cells are needed because viruses cannot be grown on artificial media.

Study Tip

Purposeful Reading Before reading, predict how the information you learn about diseases can be applied to your daily life. Scan the chapter and focus on the boldfaced headings to get an idea about what you will study. Record your ideas. Refer to the list as you study the chapter.

Table 1 Human Infectious Diseases   Interactive Table

Disease	Cause	Affected Organ System	How Disease is Spread
Tetanus	Bacterium	Nervous system	Soil in deep puncture wound
Strep throat	Bacterium	Respiratory system	Droplets/direct contact
Tuberculosis	Bacterium	Respiratory system	Droplets
Lyme disease	Bacterium	Skeletal and nervous system	Vector (tick)
Chicken pox	Virus	Skin	Droplets/direct contact
Rabies	Virus	Nervous system	Animal bite
Common cold	Virus	Respiratory system	Droplets/direct contact
Influenza	Virus	Respiratory system	Droplets/direct contact
Hepatitis B	Virus	Liver	Direct contact with exchange of body fluids
West Nile	Virus	Nervous system	Vector (mosquito)
Giardia	Protozoan	Digestive tract	Contaminated water
Malaria	Protozoan	Blood and liver	Vector (mosquito)
Athlete's foot	Fungus	Skin	Direct contact or contaminated objects

Spread of Disease

Of the large number of microorganisms that coexist with humans, only a few cause disease. The pathogens vary as much as the diseases themselves. Some might cause mild diseases, such as the common cold. Others cause serious diseases, such as meningitis (men in JI tus), an infection of the coverings of the brain and spinal cord. **Table 1** lists some of the human infectious diseases you might know.

For a pathogen to spread, it must have both a reservoir and a way to spread. A disease **reservoir** is a source of the pathogen in the environment. Reservoirs might be animals, people, or inanimate objects, such as soil.

Human reservoirs Humans are the main reservoir for pathogens that affect humans. They might pass the pathogen directly or indirectly to other humans. Many pathogens might be passed on to other hosts before the person even knows he or she has the disease. An individual that is symptom-free but capable of passing the pathogen is called a carrier. Pathogens that cause colds, influenza (commonly referred to as the flu), and sexually transmitted diseases, such as human immunodeficiency (ih MYEWN noh dih fih shun see) virus (HIV), can be passed on without the person knowing he or she is infected.

VOCABULARY

SCIENCE USAGE V. COMMON USAGE

Carrier

Science usage: person who spreads germs while remaining well

Typhoid fever was spread by a carrier known as "Typhoid Mary."

Common usage: a person or corpor-ation in the transportation business *Freight is shipped by carriers.*

Animal reservoirs Other animals also are reservoirs of pathogens that can be passed to humans. Influenza and rabies are examples of human diseases listed in **Table 1** that are caused by pathogens passed to humans from other animals. Influenza can infect pigs and various types of birds. Rabies is found in domestic dogs and many wild animals, such as bats, foxes, skunks, and raccoons.

Other reservoirs Some bacteria normally found in the soil, such as tetanus bacteria, can cause disease in humans. The tetanus bacteria can cause a serious infection if it contaminates a deep wound in the body. Contamination of wounds by bacteria was a major cause of death during wars before the development of antibiotics and vaccinations.

Contaminated water or food is another reservoir of pathogens for human disease. One of the main purposes of sewage treatment plants is the safe disposal of human feces, which prevents contamination of the water supply by pathogens. Contaminated water used in growing or preparing food can transfer pathogens. Food also can become contaminated through contact with humans or insects such as flies.

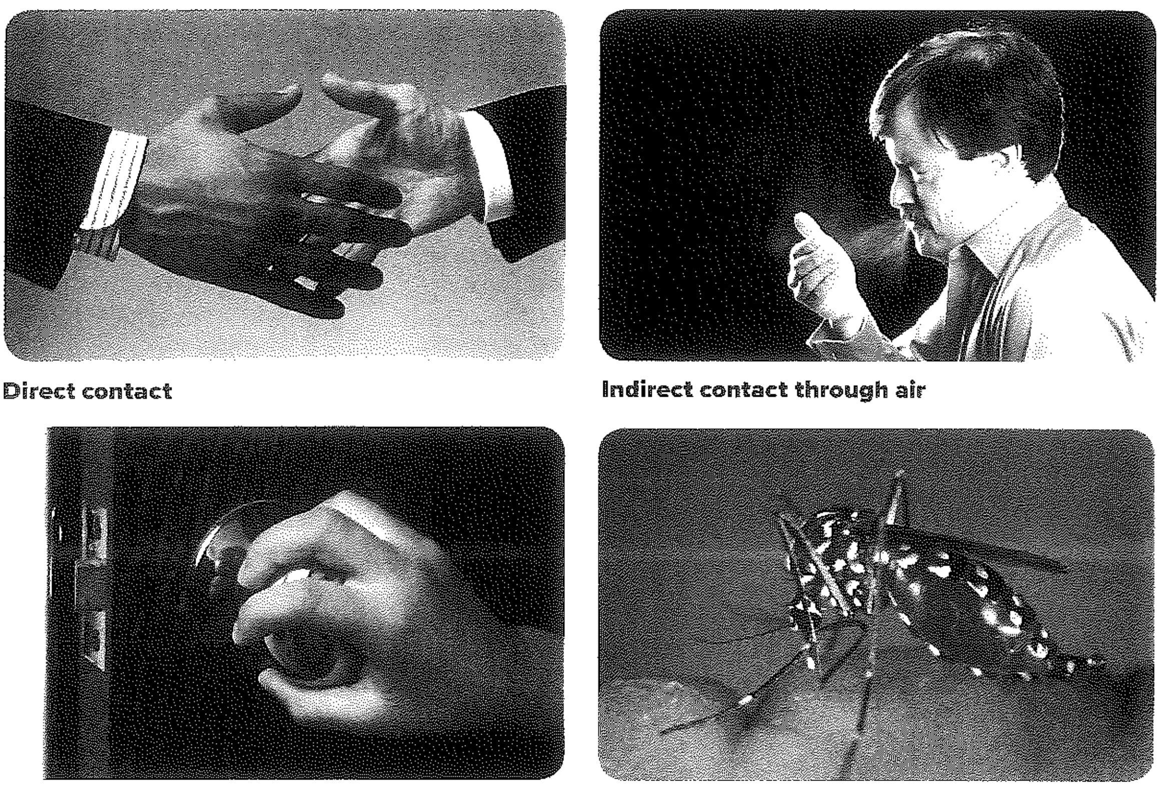
Transmission of pathogens Pathogens mainly are transmitted to humans in four ways: direct contact, indirectly through the air, indirectly through touching contaminated objects, or by organisms called vectors that carry pathogens. **Figure 3** illustrates some of the ways pathogens can be transmitted to humans.

Direct Contact Direct contact with other humans is one of the major modes of transmission of pathogens. Diseases such as colds, infectious mononucleosis (mah noh new klee OH sus)(commonly referred to as mono, or the "kissing disease"), herpes (HUR peez), and sexually transmitted diseases are caused by pathogens passed through direct contact.

CAREERS IN BIOLOGY

Epidemiologist An epidemiologist studies disease patterns to help prevent and control the spread of diseases. An epidemiologist might track the spread of a new strain of influenza and advise the public on safety concerns.

Figure 3 Diseases can be transmitted to humans in various ways.
Identify *ways to prevent contracting diseases if contact cannot be avoided.*



Direct contact

Indirect contact through air

Indirect contact by objects

Vectors

Indirect contact Some pathogens can be passed through the air. When a person with an infectious disease sneezes or coughs, pathogens can be passed along with the tiny mucus droplets. These droplets then can spread pathogens to another person or to an object.

Many organisms can survive on objects handled by humans. Cleansing of dishes, utensils, and countertops with detergents as well as careful hand-washing help prevent the spread of diseases that are passed in this manner. As a result, there are various food rules that restaurants must abide by that are based on preventing the spread of disease.

Vectors Certain diseases can be transmitted by vectors. The most common vectors are arthropods, which include biting insects such as mosquitoes and ticks. Recall from **Table 1** that Lyme disease, malaria, and West Nile virus are diseases that are passed to humans by vectors. The West Nile virus, which is currently spreading across the United States, is transmitted from horses and other mammals to humans by mosquitoes. Flies can transmit pathogens by landing on infected materials, such as feces, and then landing on materials handled or eaten by humans.

Launch Lab

Review **Based on what you have read about the spread of disease, how would you now answer the analysis questions?**

Reading Check **Describe** how diseases are spread to humans.

Symptoms of Disease

When you become ill with a disease such as the flu, why do you feel aches and pains, and why do you cough and sneeze? The pathogen, such as an influenza virus or bacteria, has invaded some of the cells of your body. The virus multiplies in the cells and leaves the cells either by exocytosis or by causing the cell to burst. Thus, the virus damages tissues and even kills some cells. When pathogenic bacteria invade the body, harmful chemicals or toxins might be produced. The toxins can be carried throughout the body via the bloodstream and damage various parts of the body.

Figure 4

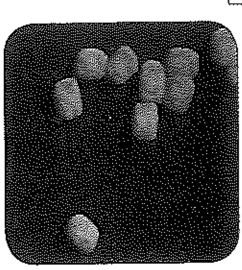
Immunology Through Time

For centuries, scientists have struggled to learn about the human immune system. Today, scientists are working to stop HIV, a virus that has attacked the immune system of over 40 million people worldwide.

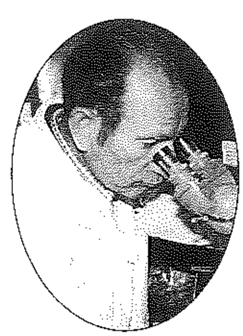
1908 Elie Metchnikoff observes phagocytosis, and Paul Ehrlich describes antibodies. They share a Nobel Prize for their discoveries.

1981 The first clinical description of acquired immunodeficiency syndrome (AIDS) is established.

1800 — 1900 — 1970



1796 Edward Jenner discovers that a patient vaccinated with the cowpox virus is immune to smallpox.



1975 César Milstein and his research team develop a technique to clone a specific antibody.

Toxins produced by pathogens can affect specific organ systems. The tetanus bacteria produce a potent toxin that causes spasms in the voluntary muscles. The disease botulism (BAH chuh lih zum) usually is caused when a person consumes food in which the botulism bacteria have grown and produced a toxin. This toxin paralyzes nerves. The toxin from the botulism bacteria can cause disease in humans even when no bacteria are present.

Some types of bacteria, some protozoans, and all viruses invade and live inside cells, causing damage. Because the cells are damaged, they might die, causing symptoms in the host. Some disease symptoms, such as coughing and sneezing, are triggered by the immune system, as discussed later in this chapter. For a closer look at research on the immune system, examine **Figure 4.**

Disease Patterns

As outbreaks of diseases spread, certain patterns are observed. Agencies such as community health departments, the Centers for Disease Control and Prevention (CDC), and the World Health Organization (WHO) continually monitor disease patterns to help control the spread of diseases. The CDC, with headquarters in Atlanta, Georgia, receives information from doctors and medical clinics and publishes a weekly report about the incidence of specific diseases, as shown in **Figure 5.** The WHO similarly watches disease incidence throughout the world.

Some diseases, such as the common cold, are known as **endemic diseases** because they continually are found in small amounts within the population. Sometimes, a particular disease will have a large outbreak in an area and afflict many people, causing an **epidemic.** If an epidemic is widespread throughout a large region, such as a country, continent, or the entire globe, it is described as **pandemic.**

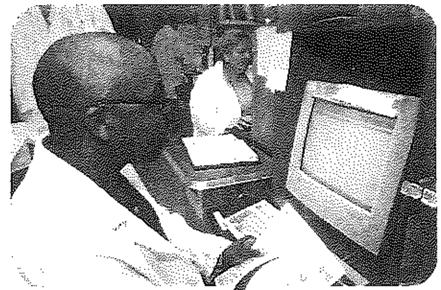


TABLE 2. Reported cases of notifiable diseases,* by geographic division and area — United States, 2003

Area	Total resident population (in thousands)	AIDS†
UNITED STATES	287,974	44,232**
NEW ENGLAND	14,134	1,697
Maine	1,295	52
N.H.	1,274	37
Vt.	616	16
Mass.	6,422	757
R.I.	1,068	102
Conn.	3,459	733
MID. ATLANTIC	40,038	10,142
Upstate N.Y.	11,385	1,589
N.Y. City	7,749	5,133
N.J.	8,575	1,514
Pa.	12,329	1,906
E.N. CENTRAL	45,635	3,875
Ohio	11,409	775
Ind.	6,157	506
Ill.	12,586	1,734
Mich.	10,043	676
Wis.	5,440	184
W.N. CENTRAL	19,464	844
Minn.	5,025	179
Iowa	2,936	75
Mo.	5,670	404
N. Dak.	634	2
S. Dak.	760	13
Nebr.	1,728	60
Kans.	2,712	111
S. ATLANTIC	53,564	12,191
Del.	806	216
Md.	5,451	1,572
D.C.	[illegible]	961

Figure 5 The Centers for Disease Control and Prevention publish reports on the incidence of certain diseases.
Infer *how these reports are helpful in understanding disease patterns.*

1985 Flossie Wong-Staal and her team clone HIV, enabling scientists to create a test to determine whether or not a person has HIV.

2004 HIV infection is pandemic in sub-Saharan Africa, where 10 percent of the world's population has 60 percent of the world's HIV infections.

1980 — 1990 — 2000

1984 Luc Montagnier and Robert Gallo independently announce the discovery of the virus that causes AIDS.

1999 Dr. Beatrice Hahn hypothesizes that humans most likely were exposed to HIV from a chimp species found in west equatorial Africa.

2009 Treatments for HIV/AIDS that use a combination of targeted chemotherapy and highly active retroviral treatments seek out and destroy HIV/AIDS-infected cells.

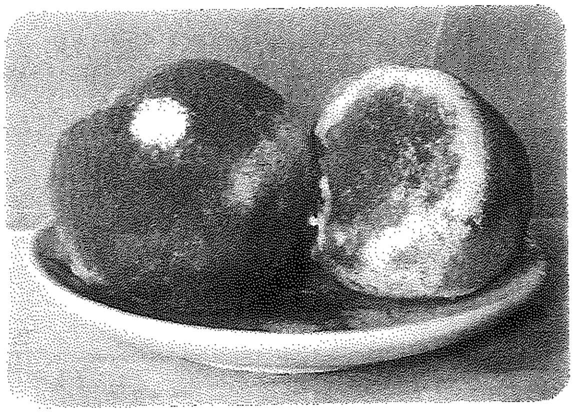


Figure 6 Penicillin, a widely used antibiotic, is secreted by the mold called *Penicillium*, shown growing on these oranges.
Determine ***why many strengths and varieties of penicillin and other antibiotics are needed.***

Treating and Fighting Diseases

A medical professional may prescribe a drug to help the body fight a disease. One type of prescription drug is an **antibiotic** (an ti bi AH tihk), which is a substance that can kill or inhibit the growth of microorganisms. Penicillin is secreted by the fungus *Penicillium,* which is shown in **Figure 6.** This fungus secretes the chemical penicillin to kill competing bacteria that grow on the fungal food source. Penicillin was isolated, purified, and first used in humans during World War II. Many other fungal secretions are used as antibiotics, such as erythromycin, neomycin, and gentamicin. Synthetic antibiotics also have been developed by pharmaceutical companies.

Chemical agents also are used in the treatment of protozoan and fungal diseases. Some antiviral drugs are used to treat herpes infections, influenza in the elderly, and HIV infections. Most viral diseases are handled by the body's built-in defense system–the immune system.

Connection to Over the last 60 years, the widespread use of antibiotics has caused many bacteria to become resistant to particular antibiotics. Natural selection occurs when organisms with favorable variations survive, reproduce, and pass their variations to the next generation. Bacteria in a population might have a trait that enables them to survive when a particular antibiotic is present. These bacteria can reproduce quickly and pass on the variation. Because reproduction can occur so rapidly in bacteria, the number of antibiotic-resistant bacteria in a population can increase quickly, too.

MiniLab 1

MiniLab

Evaluate the Spread of Pathogens

How can you evaluate the spread of disease? Investigate what possible diseases might be transmitted by common items.

Procedure

1. Read and complete the lab safety form.
2. Observe all the items given to you by your teacher.
3. Infer the types of diseases each item could pass on to a human (if any).
4. Evaluate the likelihood of each item transmitting a disease to a human and devise a scale for assessing each item's probability for transmitting an infectious disease.

Analysis

1. **Identify** the types of pathogens that might be transmitted by the items you were given and the methods of transmission of each pathogen.
2. **Infer** the items most likely to be disease reservoirs.
3. **Describe** possible disease patterns of each pathogen.
4. **Infer** how you could prevent getting diseases from these possible pathogens.

age fotostock/SuperStock

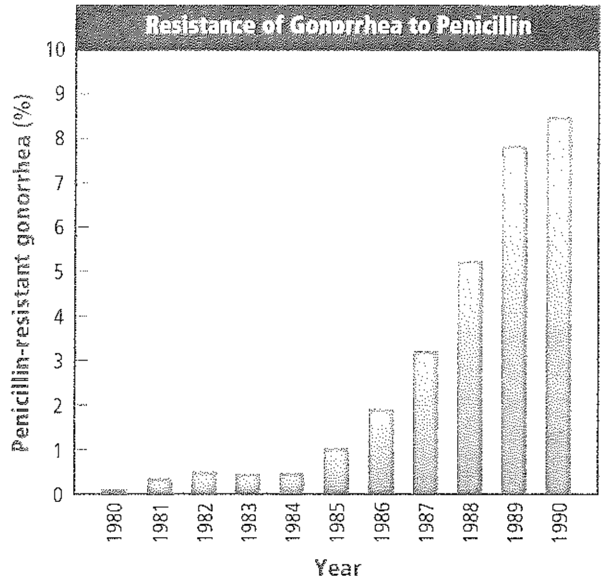


Figure 7 The graph shows the reported incidence of penicillin-resistant gonorrhea in the United States from 1980–1990.

Analyze *What is the percentage increase from 1980 to 1990?*

Antibiotic resistance of bacteria has presented the medical community with some problems with treating certain diseases. For example, penicillin was used effectively for many years to treat gonorrhea (gah nuh REE uh), a sexually transmitted disease, but now most strains of gonorrhea bacteria are resistant to penicillin. As a result, new drug therapies are needed to treat gonorrhea. **Figure 7** shows the increase in gonorrhea resistance as the bacteria have gained resistance to treatment with antibiotics.

Another treatment problem is with staphylococcal disease–it is acquired in high-density living conditions, which can result in skin infections, pneumonia (noo MOH nyuh), or meningitis. These staphylococci are often strains of bacteria that are resistant to many current antibiotics and can be difficult to treat.

Section 1 Assessment

Section Summary

- Pathogens, such as bacteria, viruses, protozoans, and fungi, cause infectious diseases.
- Koch's postulates demonstrate how a particular pathogen causes a certain disease.
- Pathogens are found in disease reservoirs and are transmitted to humans by direct and indirect methods.
- The symptoms of disease are caused by invasion of the pathogen and the response of the host immune system.
- Treatment of infectious disease includes the use of antibiotics and antiviral drugs.

Understand Main Ideas

1. MAIN Idea **Compare** the mode of transmission of the common cold with that of malaria.
2. **Summarize** some symptoms of bacterial infectious disease.
3. **Define** *infectious disease* and give three examples of infectious diseases.
4. **Illustrate** Koch's postulates for a bacterial infectious disease in a rabbit by drawing a graphic organizer or a concept map.
5. **Infer** why a person might be exposed to tetanus bacteria after stepping on a dirty nail.

Think Critically

6. **Evaluate** the following scenario: Two days after visiting a pet shop and observing green parrots in a display cage and fish in an aquarium, a student developed a fever, became ill, and was diagnosed with parrot fever. What might be the disease reservoir and possible transmission method?
7. **Evaluate** how the practice of medicating animal feed with a low level of antiobiotics might play a role in the development of antibiotic-resistant bacteria.

Online Quiz

Section 2

Reading Preview

Essential Questions

- What are the similarities and differences between nonspecific and specific immunity?
- What is the structure and function of the lymphatic system?
- What is the importance of B cells and T cells?
- What are the differences between passive and active immunity?

Review Vocabulary

white blood cells: large, nucleated blood cells that play a major role in protecting the body from foreign substances and microorganisms

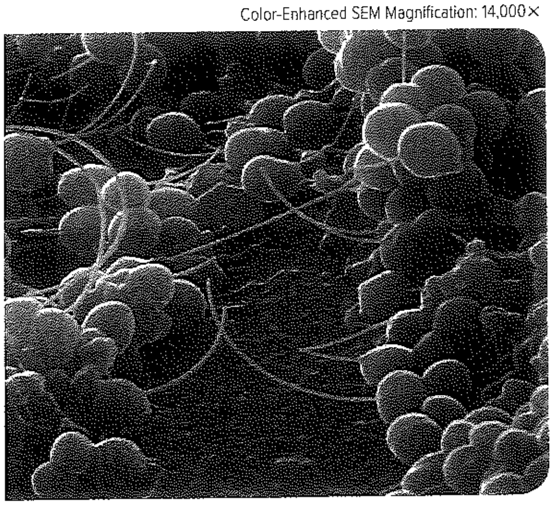
New Vocabulary

complement protein
interferon
lymphocyte
antibody
B cell
helper T cell
cytotoxic T cell
memory cell
immunization

Multilingual eGlossary

Figure 8 These bacteria normally are found on human skin and provide protection from pathogens.

Color-Enhanced SEM Magnification: 14,000×



The Immune System

MAIN Idea **The immune system has two main components: nonspecific immunity and specific immunity.**

Real-World Reading Link We live with a number of potential pathogens such as bacteria and viruses that can cause disease. Like a fort protecting a city from attack, the immune system protects the body against these and other disease-causing organisms.

Nonspecific Immunity

At the time of birth, the body has a number of defenses in the immune system that fight off pathogens. These defenses are nonspecific because they are not aimed at a specific pathogen. They protect the body from any pathogen that the body encounters.

The nonspecific immunity provided by the body helps to prevent disease. Nonspecific immunity also helps to slow the progression of the disease while the specific immunity begins to develop its defenses. Specific immunity is the most effective immune response, but nonspecific immunity is the first line of defense.

Barriers Like the strong walls of a fort, barriers are used by the body to protect against pathogens. These barriers are found in areas of the body where pathogens might enter.

Skin barrier The first major line of defense is the unbroken skin and its secretions. Skin contains layers of living cells covered by many layers of dead skin cells. By forming a barrier, the layers of dead skin cells help protect against invasion by microorganisms. Many of the bacteria that live symbiotically on the skin digest skin oils to produce acids that inhibit many pathogens. **Figure 8** shows some normal bacteria found on the skin that protect the skin from attack.

Chemical barriers Saliva, tears, and nasal secretions contain the enzyme lysozyme. Lysozyme breaks down bacterial cell walls, which kills pathogens.

Another chemical defense is mucus, which is secreted by many inner surfaces of the body. It acts as a protective barrier, blocking bac-teria from sticking to the inner epithelial cells. Cilia also line the airway. Their beating motion sends any bacteria caught in the mucus away from the lungs. When the airway becomes infected, extra mucus is secreted, which triggers coughing and sneezing to help move the infected mucus out of the body.

A third chemical defense is the hydrochloric acid secreted in your stomach. In addition to digestion, stomach acid kills many microorganisms found in food that could cause disease.

Reading Check **Compare and contrast** the different types of barriers of the immune system.

Nonspecific responses to invasion Even if an enemy gets through the walls of a town's fort, defense doesn't end. Similarly, the body has nonspecific immune responses to pathogens that get beyond its barriers.

Cellular defense If foreign microorganisms enter the body, the cells of the immune system, shown in **Table 2,** defend the body. One method of defense is phagocytosis. White blood cells, especially neutrophils and macrophages, are phagocytic. Recall that phagocytosis is the process by which phagocytic cells surround and internalize the foreign microorganisms. The phagocytes then release digestive enzymes and other harmful chemicals from their lysosomes, destroying the microorganism.

A series of about 20 proteins that are found in the blood plasma are called complement proteins. **Complement proteins** enhance phagocytosis by helping the phagocytic cells bind better to pathogens and activating the phagocytes. Some complement proteins can form a complex in the plasma membrane of a pathogen. This complex forms a pore, which aids in the destruction of the pathogen, as shown in **Figure 9.**

Interferon When a virus enters the body, another cellular defense helps prevent the virus from spreading. Virus-infected cells secrete a protein called **interferon.** Interferon binds to neighboring cells and stimulates these cells to produce antiviral proteins which can prevent viral replication in these cells.

Inflammatory response Another nonspecific response, the inflammatory response, is a complex series of events that involves many chemicals and immune cells that help enhance the overall immune response. When pathogens damage tissue, chemicals are released by both the invader and cells of the body. These chemicals attract phagocytes to the area, increase blood flow to the infected area, and make blood vessels more permeable to allow white blood cells to escape into the infected area. This response aids in the accumulation of white blood cells in the area. Some of the pain, heat, and redness experienced during an infectious disease are the result of the inflammatory response.

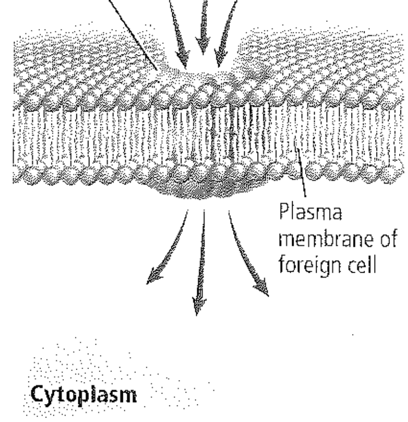
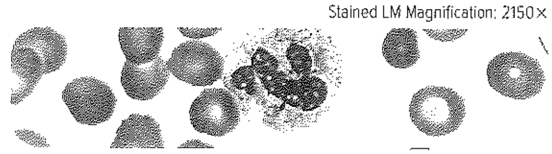


Figure 9 For some pathogens, complement proteins can form a pore in the plasma membrane of the invading cell.

Animation

Table 2 Cells of the Immune System

Interactive Table

Type of Cell	Example	Function
Neutrophils	Stained LM Magnification: 2150× 	Phagocytosis: blood cells that ingest bacteria
Macrophages	Color-Enhanced LM Magnification: 380× 	Phagocytosis: blood cells that ingest bacteria and remove dead neutrophils and other debris
Lymphocytes	Stained LM Magnification: 1600× 	Specific immunity (antibodies and killing of pathogens): blood cells that produce antibodies and other chemicals

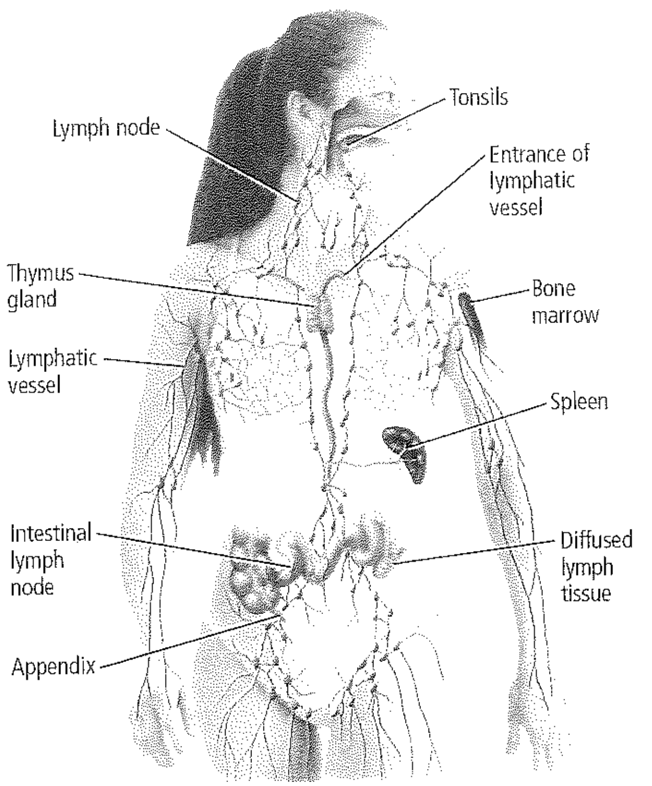


Figure 10 The lymphatic system contains the organs involved in the specific immune response.
***Identify** the lymphatic organ where T cells mature.*

BrainPOP

Specific Immunity

Pathogens sometimes get past the nonspecific defense mechanisms. The body has a second line of defense that attacks these pathogens. Specific immunity is more effective, but takes time to develop. This specific response involves the tissues and organs found in the lymphatic system.

Lymphatic system The lymphatic (lim FA tihk) system, illustrated in **Figure 10,** includes organs and cells that filter lymph and blood, destroy foreign microorganisms, and absorb fat. Lymph is the fluid that leaks out of capillaries to bathe body cells. This fluid circulates among the tissue cells, is collected by lymphatic vessels, and is returned to the veins near the heart.

Lymphatic organs The organs of the lymphatic system contain lymphatic tissue, lymphocytes, a few other cell types, and connective tissue. **Lymphocytes** are a type of white blood cell that is produced in red bone marrow. These lymphatic organs include the lymph nodes, tonsils, spleen, thymus (THI mus) gland, and diffused lymphatic tissue found in mucous membranes of the intestinal, respiratory, urinary, and genital tracts.

The lymph nodes filter the lymph and remove foreign materials from the lymph. The tonsils form a protective ring of lymphatic tissue between the nasal and oral cavities. This helps protect against bacteria and other harmful materials in the nose and mouth. The spleen stores blood and destroys damaged red blood cells. It also contains lymphatic tissue that responds to foreign substances in the blood. The thymus gland, which is located above the heart, plays a role in activating a special kind of lymphocyte called T cells. T cells are produced in the bone marrow, but they mature in the thymus gland.

VOCABULARY

WORD ORIGIN

Thymus
comes from the Greek word *thymos,* meaning *warty excrescence*

B Cell Response

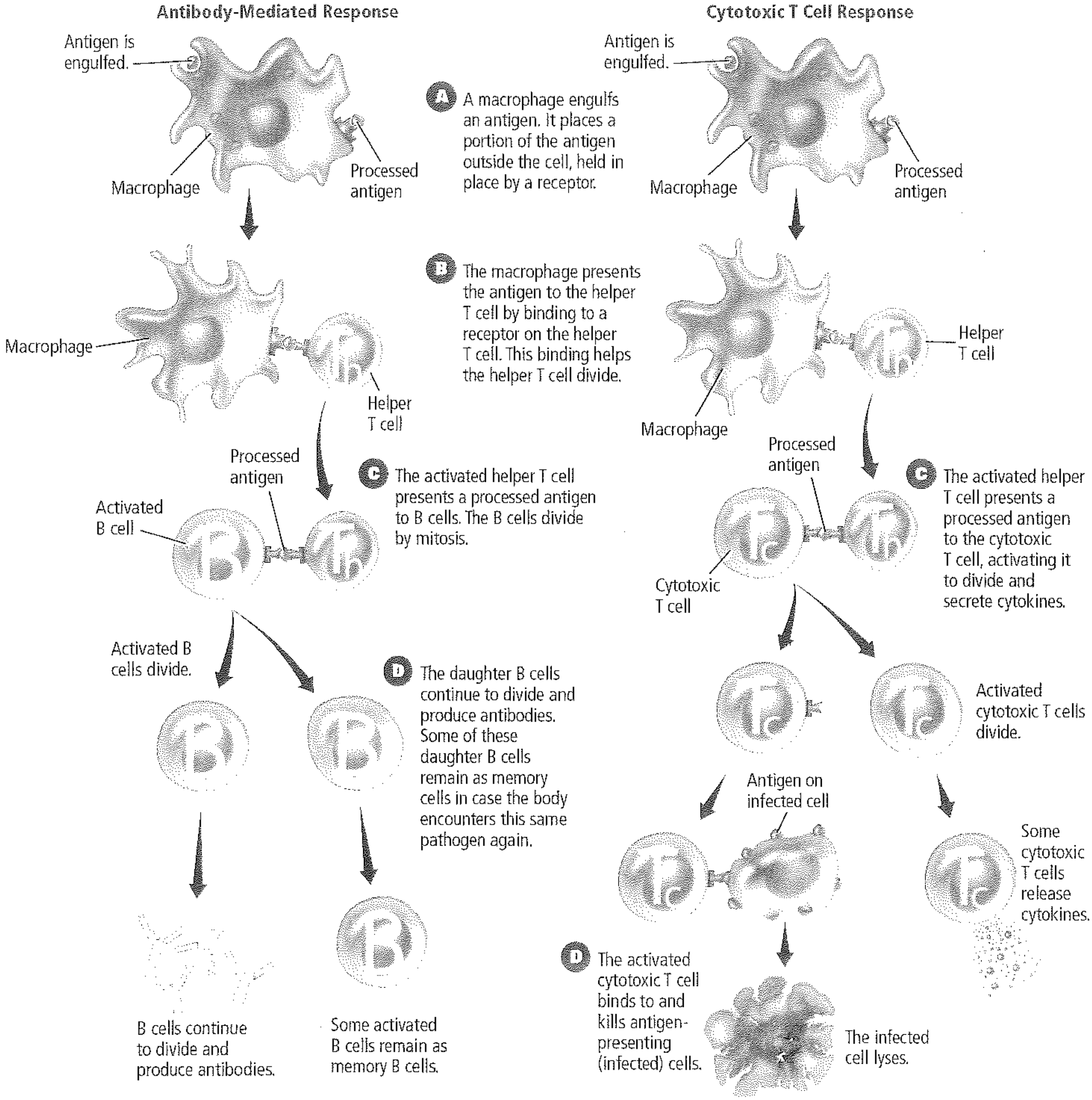
Antibodies are proteins produced by B lymphocytes that specifically react with a foreign antigen. An antigen is a substance foreign to the body that causes an immune response; it can bind to an antibody or T cell. B lymphocytes, often called **B cells,** are located in all lymphatic tissues and can be thought of as antibody factories. When a portion of a pathogen is presented by a macrophage, B cells produce antibodies. Follow along in **Figure 11,** as you learn about how B cells are activated to produce antibodies.

Tim Fuller

Visualizing Specific Immune Responses

Figure 11

Specific immune responses involve antigens, phagocytes, B cells, helper T cells, and cytotoxic T cells. The antibody-mediated response involves antibodies produced by B cells and memory B cells. The cytotoxic T cell response results in cytotoxic T cell activation.



Animation

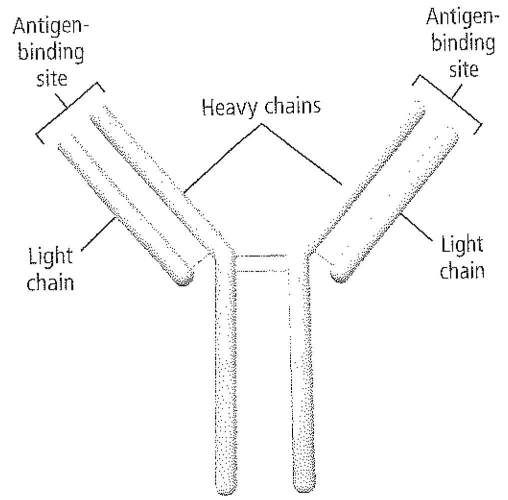


Figure 12 Antibodies are made up of two types of protein chains—heavy and light chains.
Summarize *which cells produce antibodies.*

When a macrophage surrounds, internalizes, and digests a pathogen, it takes a piece of the pathogen, which is called a processed antigen, and displays it on its membrane, as illustrated in **Figure 11.** In the lymphatic tissues, such as the lymph nodes, the macrophage, with the processed antigen on its surface, binds to a type of lymphocyte called a **helper T cell.** This process activates the helper T cell. This lymphocyte is called a "helper" because it activates antibody secretion in B cells and another type of T cell, which will be discussed later, that aids in killing microorganisms:

- The activated helper T cell reproduces, binds processed antigens, and attaches to a B cell.
- The new helper T cells continue the process of binding antigens, attaching to B cells, and reproducing.
- Once an activated helper T cell binds to a B cell holding an antigen, the B cell begins to manufacture antibodies that specifically bind to the antigen.
- The antibodies can enhance the immune response by binding to microorganisms, making them more susceptible to phagocytosis and by initiating the inflammatory response, helping promote the nonspecific response.

B cells make many combinations of antibodies by using DNA that codes for the production of various heavy and light protein chains that make up antibodies as shown in **Figure 12.** Any heavy chain can combine with any light chain. If a B cell can make 16,000 different kinds of heavy chains and 1200 kinds of light chains, it can make 19,200,000 different types of antibodies ($1200 \times 16{,}000$).

T Cell Response

Once helper T cells are activated by the presentation of an antigen by macrophages, helper T cells can also bind to and activate a group of lymphocytes called cytotoxic T cells. Activated **cytotoxic T cells** destroy pathogens and release chemicals called cytokines. Cytokines stimulate the cells of the immune system to divide and recruit immune cells to an area of infection. Cytotoxic T cells bind to pathogens, release a chemical attack, and destroy the pathogens. Multiple target cells can be destroyed by a single cytotoxic T cell. **Figure 11** summarizes the activation of cytotoxic T cells.

Reading Check **Summarize** the role that lymphocytes play in immunity.

Passive and Active Immunity

The body's first response to an invasion by a pathogen is called the primary response. For example, if the viral pathogen that causes chicken pox enters the body, nonspecific and specific immune responses eventually defeat the foreign virus and the body is cleared of the pathogen.

One result of the specific immune response is the production of memory B and T cells. **Memory cells** are long-living cells that are exposed to the antigen during the primary immune response. These cells are ready to respond rapidly if the body encounters the same pathogen later. Memory cells protect the body by reducing the likelihood of developing the disease if exposed again to the same pathogen.

Passive immunity Sometimes temporary protection against an infectious disease is needed. This type of temporary protection occurs when antibodies are made by other people or animals and are transferred or injected into the body. For example, passive immunity occurs between a mother and her child. Antibodies produced by the mother are passed through the placenta to the developing fetus and through breast milk to the infant child. These antibodies can protect the child until the infant's immune system matures.

Antibodies developed in humans and animals that are already immune to a specific infectious disease are used to treat some infectious diseases in others. These antibodies are injected into people who have been exposed to that particular infectious disease. Passive immune therapy is available for people who have been exposed to hepatitis A and B, tetanus, and rabies. Antibodies also are available to inactivate snake and scorpion venoms.

Active immunity Active immunity occurs after the immune system is exposed to disease antigens and memory cells are produced. Active immunity can result from having an infectious disease or immunization. **Immunization,** also called vaccination, is the deliberate exposure of the body to an antigen so that a primary response and immune memory cells will develop. **Table 3** lists some of the common immunizations offered in the United States. Immunizations contain killed or weakened pathogens, which are incapable of causing the disease.

Most immunizations include more than one stimulus to the immune system, given after the first immunization. These booster shots increase the immune response, providing further protection from the disease-causing organism.

VOCABULARY

ACADEMIC VOCABULARY

Passive
not active; acted upon
The passive monkey stared lazily at the zoo visitors.

Table 3 **Common Immunizations** Interactive Table

Immunization	Disease	Contents
DPT	Diphtheria (D), tetanus (T), pertussis (P) (whooping cough)	D: inactivated toxin, T: inactivated toxin, P: inactivated bacteria
Inactivated polio	Poliomyelitis	Inactivated virus
MMR	Measles, mumps, rubella	All three inactivated viruses
Varicella	Chicken pox	Inactivated virus
HIB	Haemophilus influenzae (flu) type b	Portions of bacteria cell wall covering
HBV	Hepatitis B	Subunit of virus

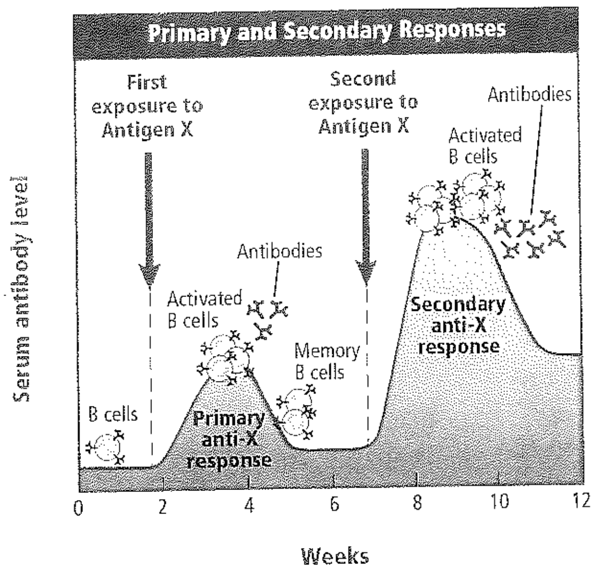


Figure 13 This graph shows the difference between the primary and secondary immune responses to exposure to an antigen.
***Analyze** the differences between the primary and secondary immune responses.*

Personal Tutor

Virtual Lab

Why are immunizations effective in preventing disease? The characteristics of the secondary immune response, which is the response to a second exposure to an antigen, enable immunizations to be effective in preventing disease. Study the graph in **Figure 13.** Note that the secondary response to the antigen has a number of different characteristics. First, the response is more rapid than the primary response, as shown by the greater steepness in the portion of the curves plotted in red. Second, the overall response, both B and T cell response, is greater during the second exposure. Lastly, the overall memory lasts longer after the second exposure.

Immune System Failure

Defects in the immune system can result in an increased likelihood of developing infectious diseases as well as certain types of cancers. Some diseases can affect the immune system's effectiveness. One such disease called acquired immunodeficiency syndrome (AIDS) results from an infection by human immunodeficiency virus (HIV). AIDS is a serious health problem worldwide.

In 2006, approximately 36,828 AIDS cases were diagnosed in the U.S. In 2006, 14,016 people died of AIDS in the U.S. In 2007, an estimated 33 million people globally were living with HIV infection.

DATA ANALYSIS LAB 1

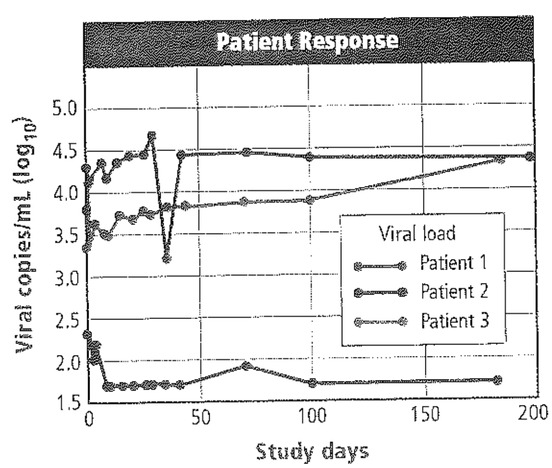
Based on Real Data*

Draw a Conclusion

Is passive immune therapy effective for HIV infection? The standard treatment for a patient with an HIV infection is antiviral drug therapy. Unfortunately, the side effects and increasing prevalence of drug-resistant viruses create a need for additional therapies. One area being studied is passive immune therapy.

Data and Observations

The graph shows HIV patient responses to passive immune therapy. The number of viral copies/mL is a measure of the amount of virus in the patient's blood.



Think Critically

1. **Compare** the patient responses to passive immune therapy.
2. **Explain** whether the researchers can conclude if passive immune therapy is effective.

*Data obtained from: Stiegler G., et al. 2002. Antiviral activity of the neutralizing antibodies 2F5 and 2F12 in asymptomatic HIV-1-infected humans: a phase I evaluation. *AIDS* 16: 2019-2025.

Recall the important role that helper T cells play in specific immunity. HIV infects mainly helper T cells, also called $CD4^+$ cells because these cells have a receptor on the outside of their plasma membrane. This $CD4^+$ receptor is used by medical professionals to identify these cells, as illustrated in **Figure 14.**

HIV is an RNA virus that infects helper T cells. The helper T cells become HIV factories, producing new viruses that are released and infect other helper T cells. Over time, the number of helper T cells in an infected person decreases, making the person less able to fight disease. HIV infection usually has an early phase during the first six to twelve weeks while viruses are replicating in helper T cells.

The patient suffers symptoms such as night sweats and fever, but these symptoms are reduced after about eight to ten weeks. Then, the patient exhibits few symptoms for a period of time as long as ten years but is capable of passing the infection through sexual intercourse or blood products. HIV is a secondary immunodeficiency disease, which means that the immune system of a previously healthy person fails. Without antiviral drug therapy, the patient usually dies from a secondary infection from another pathogen after about ten years of being infected with HIV. Current antiviral drug therapy is aimed at controlling the replication of HIV in the body. Resistant strains, expensive drugs, and side effects are all issues that patients face. Researchers and health care providers are working to meet these needs and continue the search for a cure.

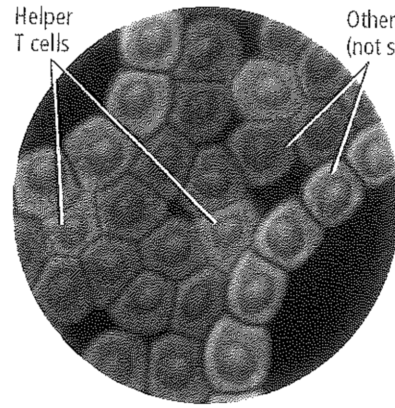


Figure 14 Helper T cells have receptors on the surface that are used to identify them in the laboratory.

Section 2 Assessment

Section Summary

- The nonspecific immune response includes the skin barrier, secreted chemicals, and cellular pathways that activate phagocytosis.
- The specific immune response involves the activation of B cells, which produce antibodies, and T cells, which include helper T cells and cytotoxic T cells.
- Passive immunity involves receiving antibodies against a disease.
- Active immunity results in immune memory against a disease.
- HIV attacks helper T cells, causing an immune system failure.

Understand Main Ideas

1. MAIN Idea **Compare** specific and nonspecific immune responses.
2. **Describe** the steps involved in activating an antibody response to an antigen.
3. **Identify** ways passive and active immunity can be acquired.
4. **Describe** the structure and function of the lymphatic system.
5. **Infer** why the destruction of helper T cells in HIV infection is so devastating to specific immunity.

Think Critically

6. **Hypothesize** what happens when an HIV strain mutates such that viral-replication drugs are no longer effective.
7. **Evaluate** the effects of severe combined immune deficiency on a child born without T cell immunity.

MATH in Biology

8. Antibodies are made of two light protein chains and two heavy protein chains. If the molecular weight of a light chain is 25,000 and the molecular weight of a heavy chain is 50,000, what is the molecular weight of an antibody?

Online Quiz

Section 3

Reading Preview

Essential Questions

- What are the five categories of noninfectious diseases?
- What is the role of allergens in allergies?
- What is the difference between allergies and anaphylactic shock?

Review Vocabulary

cancer: uncontrolled cell division that can be caused by environmental factors or changes in enzyme production in the cell cycle

New Vocabulary

degenerative disease
metabolic disease
allergy
anaphylactic shock

Multilingual eGlossary

Noninfectious Disorders

MAIN Idea **Noninfectious disorders include genetic disorders, degenerative diseases, metabolic diseases, cancer, and inflammatory diseases.**

Real-World Reading Link Maybe you have heard your parents or grand-parents complain about their arthritis, which causes achy bones and joints. Perhaps some of your relatives have diabetes or have survived cancer. You or a friend might have an allergy to dust, plant pollens, or other environmental substances. These disorders are different from infectious diseases caused by pathogens.

Genetic Disorders

Not all diseases or body disorders are caused by pathogens. Some diseases are caused by the inheritance of genes that do not function properly in the body, such as albinism, sickle cell anemia, Huntington disease, and hemophilia. There are also chromosomal disorders that result from abnormal chromosome numbers, such as Down syndrome. Many diseases are complex and have both an environmental and a genetic cause.

Coronary artery disease (CAD) is an example of a condition with environmental and genetic origins. This cardiovascular disease can result in blockage of arteries, shown in **Figure 15,** that deliver oxygenated blood to the heart muscle. There is a genetic component that increases a person's risk of developing CAD. Environmental factors such as diet contribute to the development of this complex disease. Families with a history of CAD have a two to seven times greater risk of having CAD than families without a history of CAD. The exact genetic factors, however, are not known.

Figure 15 When blood cannot flow through a coronary artery, such as the the diseased artery shown here, a heart attack or sudden death can result.

Stained LM Magnification: 25×

Reading Check **Summarize** the factors that cause coronary artery disease.

Degenerative Diseases

Some diseases called **degenerative** (dih JEH nuh ruh tihv) **diseases** are the result of a part of the body wearing out. This can be due to the natural aging process. However, a degenerative condition, such as degenerative arthritis, could occur sooner than would be expected if the person is genetically predisposed to the disease or if the person's joints have experienced an increased amount of wear and tear. Degenerative arthritis is common; most people have it by age 70. It is found in almost all vertebrate animals. Arteriosclerosis (ar tir ee oh skluh ROH sus), which is a hardening of the arteries, is another example of a degenerative disease. Because degenerative diseases also have a genetic component, some individuals might be more likely to develop a degenerative disease because of their genetic makeup.

Metabolic Diseases

Metabolic disease results from an error in a biochemical pathway. Some metabolic diseases result in the inability to digest specific amino acids or to regulate body processes. When the pancreas does not make the proper amount of insulin and glucose does not enter body cells normally, the condition is known as Type 2 diabetes. This results in high glucose levels in the bloodstream, which causes damage to many organs including the kidneys and the retinas of the eyes. Metabolic diseases can have a genetic component but also can involve environmental factors such as diet.

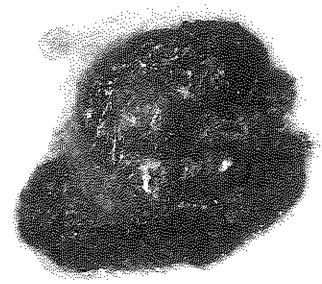


Figure 16 Cancer is due to an abnormal increase in cell division in the body, resulting in a tumor such as this skin tumor.
Infer *why this large growth is so life-threatening.*

Cancer

Cancer is characterized by abnormal cell growth. Normally, certain regulatory molecules in the body control the beginning and end of the cell cycle. If this control is lost, abnormal cell growth results that could lead to various types of tumors, as shown in **Figure 16.** The abnormal cells can interfere with normal body functions and can travel throughout the body. Cancer can develop in any body tissue or organ, including the blood cells. Cancer in the blood cells is called leukemia. Both genetic and environmental factors have been shown to cause cancer.

Connection to History Cancer has been a disease that affects humans since ancient times. Egyptian mummies show evidence of bone cancer, and ancient Greek scientists described different kinds of cancer. Medieval manuscripts have reported details about cancer.

MiniLab 2

Compare Cancerous and Healthy Cells

MiniLab

How do cancerous cells and healthy cells differ in appearance? Observe and compare liver cells afflicted with this common noninfectious disease to healthy liver cells.

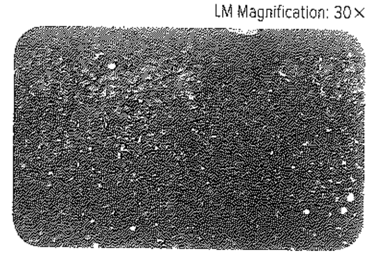
Procedure

1. Read and complete the lab safety form.
2. Place a prepared **slide of healthy human liver cells** on a **microscope.**
WARNING: *Never touch broken microscope slides or other broken glass materials.*
3. Observe the healthy liver cells under several different magnifications.
4. Sketch a diagram of several healthy liver cells.
5. Repeat steps 2–4 with a prepared **slide of cancerous human liver cells.**

Analysis

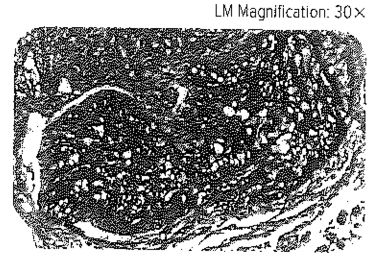
1. **Compare and contrast** the features of healthy liver cells with those of cancerous liver cells.
2. **Infer** why it would not be dangerous to handle an object that was handled by a patient with liver cancer.
3. **Describe** how cancer disrupts the body's homeostasis.

LM Magnification: 30×



Healthy cells

LM Magnification: 30×



Cancerous cells

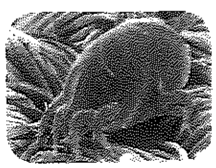
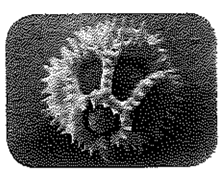
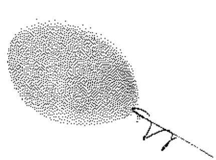
Inflammatory Diseases

Inflammatory diseases, such as allergies and autoimmunity, are diseases in which the body produces an inflammatory response to a common substance. Recall from Section 2 that infectious diseases also result in an inflammatory response. However, the inflammatory response in an infectious disease enhances the overall immune response. This inflammatory response is a result of the immune system removing bacteria or other microorganisms from the body. In inflammatory disease, the inflammatory response is not helpful to the body.

Allergies Certain individuals might have an abnormal reaction to environmental antigens. A response to environmental antigens is called an **allergy.** These antigens are called allergens and include things such as plant pollens, dust, dust mites, and various foods, as illustrated in **Table 4.** An individual becomes sensitized to the allergen and has localized inflammatory response with swollen itchy eyes, stuffy nose, sneezing, and sometimes a skin rash. These symptoms are the result of a chemical called histamine that is released by certain white blood cells. Antihistamine medications can help alleviate some of these symptoms.

✓ Reading Check **Explain** how allergies are related to the immune system.

Table 4 Common Allergens — Interactive Table

Allergen	Example	Description
Dust mite	 Color-Enhanced SEM Magnification: 170×	Dust mites are found in mattresses, pillows, and carpets. Mites and mite feces are allergens.
Plant pollen	 Color-Enhanced SEM Magnification: 2300×	Different parts of the country have very different pollen seasons; people can react to one or more pollens, and a person's pollen allergy season might be from early spring to late fall.
Animal dander	 Color-Enhanced SEM Magnification:1175×	Dander is skin flakes; cat and dog allergies are the most common, but people also are allergic to pets such as birds, hamsters, rabbits, mice, and gerbils.
Peanut		Allergic reaction to peanuts can result in anaphylaxis. Peanut allergy is responsible for more fatalities than any other type of allergy.
Latex		Latex comes from the milky sap of the rubber tree, found in Africa and Southeast Asia; the exact cause of latex allergy is unknown.

(1)Andrew Syred/Photo Researchers; (2)Eye of Science/Photo Researchers; (3)Biophoto Associates/Photo Researchers; (4)C Squared Studios/Getty Images; (5)Brian G. Green/Getty Images

Severe allergic reactions to particular allergens can result in **anaphylactic** (an uh fuh LAK tik) **shock**, which causes a massive release of histamine. In anaphylactic shock, the smooth muscles in the bronchioles contract, which restricts air flow into and out of the lungs.

Common allergens that cause severe allergic reactions are bee stings, penicillin, peanuts, and latex, which is used to make balloons and surgical gloves. People who are extremely sensitive to these allergens require prompt medical treatment if exposed to these agents because anaphylactic reactions are life-threatening. Allergies and anaphylactic reactions are known to have an inherited component.

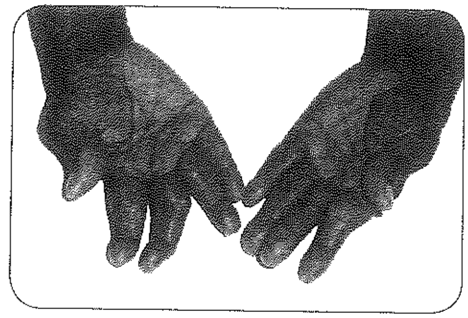


Figure 17 The large knobs and deformaties of these fingers are due to rheumatoid arthritis, an autoimmune disease.

Autoimmunity During the development of the immune system, the immune system learns not to attack proteins produced by the body. However, some people develop autoimmunity (aw toh ih MYOON ih tee) and do form antibodies to their own proteins, which injures their cells.

Figure 17 shows the hands of a person with rheumatoid arthritis–a form of arthritis in which antibodies attack the joints. Degenerative arthritis, the form of arthritis that you read about earlier in the section on degenerative diseases, is not caused by autoimmunity.

Rheumatic fever and lupus (LEW pus) are other examples of autoimmune disorders. Rheumatic fever is an inflammation in which antibodies attack the valves of the heart. This can lead to damage to the heart valves and cause the valves to leak or not close properly as blood moves through the heart. Lupus is a disorder in which autoantibodies are formed and attack healthy tissue. As a result, many organs are vulnerable to attack by the body's own immune system.

Section 3 Assessment

Section Summary

- Noninfectious disorders often have both a genetic and an environmental component.
- The inflammatory response to an infectious disease enhances the immune response, but the inflammatory response to an inflammatory disease is not helpful to the body.
- Allergies are due to an overactive immune response to allergens found in the environment.
- Anaphylactic shock is a severe hypersensitivity to particular allergens.
- Autoimmunity results in an immune attack on body cells.

Understand Main Ideas

1. MAIN Idea **Identify** the type of noninfectious disease shown in **Figure 15.**
2. **Explain** the role of allergens in allergies.
3. **Create** a diagram demonstrating the process of anaphylactic shock.
4. **Categorize** the following diseases into the categories used in this section: sickle cell disease, diabetes, vertebral degeneration, autoimmunity, and leukemia.

Think Critically

5. **Hypothesize** several causes of chronic bronchitis (inflammation of the bronchioles) found in coal miners.
6. **Create** a plan that limits a child's exposure to cat dander when the child is found to be allergic to that allergen.

WRITING in Biology

7. Create a pamphlet explaining the symptoms of allergies and listing common allergens.

Online Quiz

CUTTING-EDGE BIOLOGY

Buckyballs: A Cure for Allergies?

If you have ever had a sneezing fit after smelling flowers or become sick after eating shellfish, you might have had an allergic reaction. Many people have some type of allergy.

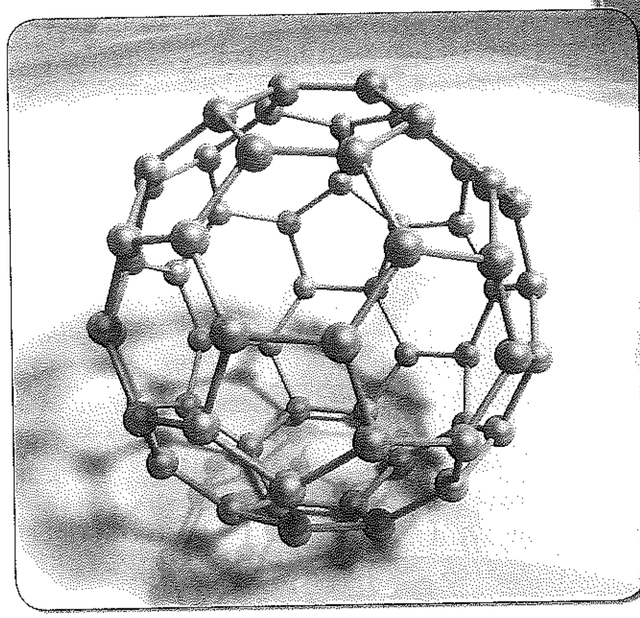
A Common Ailment Each year in the United States, consumers spend millions of dollars on nose sprays, pills, shots, doctor visits, and allergen avoidance in the fight against allergies. Common allergens include food, medications, animal venom and dander, and latex. Allergies, particularly food allergies, are increasingly common in the United States.

A Study A recent study gives hope to allergy sufferers in the form of a tiny, carbon ball. Buckminsterfullerenes (nicknamed buckyballs) are spherical cages about 1–10 nanometers in size made up of 60 carbon atoms. They were discovered in 1985 by scientists who vaporized graphite with a laser.

In 2007, a study revealed that buckyballs prevent allergic responses in tissue cultures and in mice. Your immune system reacts to allergens by releasing histamines and other chemicals. It is thought that buckyballs can prevent allergens from activating the histamine response.

Some buckyballs were modified by adding chemical side groups to increase their solubility. Some human immune cells called mast cells grown in tissue cultures were treated with the buckyballs while others were not.

When scientists exposed the cultures to allergenlike molecules, the buckyball-treated cultures released 50 times less histamine and inhibited 30 to 40 other chemicals involved in allergic reactions.



Soccer ball-shaped spheres of carbon atoms called buckyballs might provide relief for allergy sufferers in the future.

Mice injected with buckyballs also released less histamine when exposed to allergens. What scientists do not know is exactly what triggers mast cells to produce histamine and how buckyballs block that reaction.

WRITING in Biology

Research buckyballs and other new treatments for allergies. Work with a partner to develop a creative way to share your findings with the class. Ideas include a public service announcement, news article, poster, or presentation.

WebQuest

BIOLAB

FORENSICS: HOW DO YOU FIND PATIENT ZERO?

Background: Imagine that a new disease—"cellphonitis"—has invaded your school. One of the symptoms of this disease is the urge to use a cell phone during class. Cellphonitis is easily transferred from person to person by direct contact and there is no natural immunity to the disease. A student in your class has the disease, and is Patient Zero. The disease is spreading in your class and you need to track the disease to prevent the spread of an epidemic.

Question: *Is it possible to track a disease and determine the identity of Patient Zero?*

Materials

Pasteur pipets (1 per group)
numbered test tubes of water, one infected with simulated "cellphonitis" (1 per group)
test tube racks (1 per group)
small paper cups (1 per group)
pencil and paper
testing indicator

Safety Precautions

Procedure

1. Read and complete the lab safety form.
2. Prepare a table to keep track of the contacts you make. Select a test tube and record the number of the test tube.
3. Use a Pasteur pipet and move a small amount of the fluid from the test tube to a paper cup.
4. Your teacher will divide your class into groups. When your group is called, you will simulate the sharing of saliva during drinking water by using your pipets to exchange the fluid in your test tubes with another member of your group.
5. Record who you exchanged with in your tables.
6. Roll the test tube gently between your hands to mix and repeat Step 4 every time your group is told to exchange. Be sure to pick someone different to exchange with each time.
7. When the exchanges are complete, your teacher will act as the epidemiologist and use the testing indicator to see who has the disease.
8. Share the information and work together as groups to see if you can determine the identity of Patient Zero.
9. Once each group has made their hypothesis, test the original fluid in each cup to see who really was Patient Zero.
10. Return the test tubes. Dispose of the other materials you used as instructed by your teacher.

Analyze and Conclude

1. **Analyze** Use your data and draw a diagram for each possible Patient Zero. Use arrows to show who should be infected with each possible Patient Zero.
2. **Compare and Contrast** How was the spread of "cellphonitis" in this simulation similar to the spread of disease in real life? How was it different?
3. **Think Critically** If this simulation were run in a large class, why might the disease not be passed in later exchanges?
4. **Error Analysis** What problems did you run into as you tried to determine the identity of Patient Zero?

COMMUNICATE

Newscast Research a current disease epidemic. Prepare a newscast about how epidemiologists are searching for the source of disease and present it to your class.

William Fritsch/Brand X Pictures

Chapter 37 Study Guide

THEME FOCUS Cause and Effect The human body uses specific and nonspecific immunities to maintain a healthy balance.

BIG Idea The immune system attempts to protect the body from contracting an infection through pathogens.

Section 1 Infectious Diseases

infectious disease (p. 1076)
pathogen (p. 1076)
Koch's postulates (p. 1077)
reservoir (p. 1078)
endemic disease (p. 1081)
epidemic (p. 1081)
pandemic (p. 1081)
antibiotic (p. 1082)

MAIN Idea Pathogens are dispersed by people, other animals, and objects.

- Pathogens, such as bacteria, viruses, protozoans, and fungi, cause infectious diseases.
- Koch's postulates demonstrate how a particular pathogen causes a certain disease.
- Pathogens are found in disease reservoirs and are transmitted to humans by direct and indirect methods.
- The symptoms of disease are caused by invasion of the pathogen and the response of the host immune system.
- Treatment of infectious disease includes the use of antibiotics and antiviral drugs.

Section 2 The Immune System

complement protein (p. 1085)
interferon (p. 1085)
lymphocyte (p. 1086)
antibody (p. 1086)
B cell (p. 1086)
helper T cell (p. 1088)
cytotoxic T cell (p. 1088)
memory cell (p. 1089)
immunization (p. 1089)

MAIN Idea The immune system has two main components: nonspecific immunity and specific immunity.

- The nonspecific immune response includes the skin barrier, secreted chemicals, and cellular pathways that activate phagocytosis.
- The specific immune response involves the activation of B cells, which produce antibodies, and T cells, which include helper T cells and cytotoxic T cells.
- Passive immunity involves receiving antibodies against a disease.
- Active immunity results in immune memory against a disease.
- HIV attacks helper T cells, causing an immune system failure.

Section 3 Noninfectious Disorders

degenerative disease (p. 1092)
metabolic disease (p. 1093)
allergy (p. 1094)
anaphylactic shock (p. 1095)

MAIN Idea Noninfectious disorders include genetic disorders, degenerative diseases, metabolic diseases, cancer, and inflammatory diseases.

- Noninfectious disorders often have both a genetic and an environmental component.
- The inflammatory response to an infectious disease enhances the immune response, but the inflammatory response to an inflammatory disease is not helpful to the body.
- Allergies are due to an overactive immune response to allergens found in the environment.
- Anaphylactic shock is a severe hypersensitivity to particular allergens.
- Autoimmunity results in an immune attack on body cells.

Vocabulary eGames

Chapter 37 Assessment

Section 1

Vocabulary Review

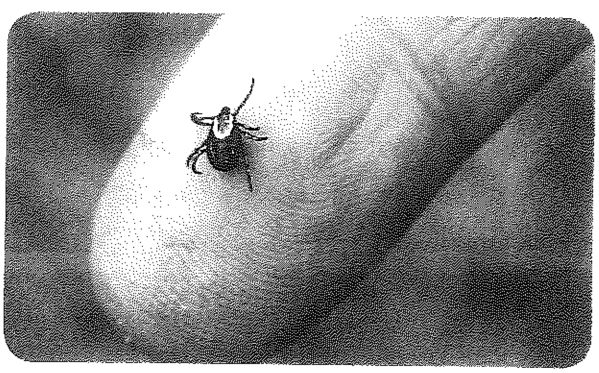
Match the definitions below with a vocabulary term from the Study Guide page.

1. A(n) __________ is an agent that causes an infectious disease.
2. When a disease becomes widespread in a particular area, it is called a/an __________.
3. A source of disease organisms is called a __________.

Understand Main Ideas

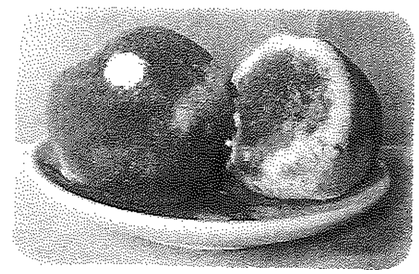
4. Which national organization tracks disease patterns in the United States?
   A. The Centers for Disease Control and Prevention
   B. National Disease Center
   C. World Health Organization
   D. United Nations
5. Which scientist established a method for determining whether a microorganism caused a specific disease?
   A. Koch
   B. Hooke
   C. Sagan
   D. Mendel
6. Which is the most common way that humans acquire an infectious disease?
   A. contaminated water
   B. mosquito bites
   C. sick animals
   D. infected humans

Use the photo below to answer question 7.



7. Which type of disease transmission is shown above?
   A. direct contact
   B. air transmission
   C. object transmission
   D. vector transmission

Use the photo below to answer question 8.



8. Which substance is secreted by the organism shown above?
   A. anthrax
   B. influenza
   C. gentamicin
   D. penicillin

Constructed Response

9. **THEME FOCUS Cause and Effect** Explain how you could prove that a particular bacteria was causing an infectious disease in a mouse population.
10. **Open Ended** Explain how the Centers for Disease Control and Prevention would be able to determine if an epidemic was occurring in your city.
11. **CAREERS IN BIOLOGY** Imagine you are the school nurse. Describe to students more than one way the cold virus could be transmitted from one person to another.

Think Critically

12. **MAIN Idea** Design a feasible plan that could decrease the spread of infectious disease within your school.
13. **Evaluate** why growing viruses in cell cultures would be an exception to Koch's postulates.

Section 2

Vocabulary Review

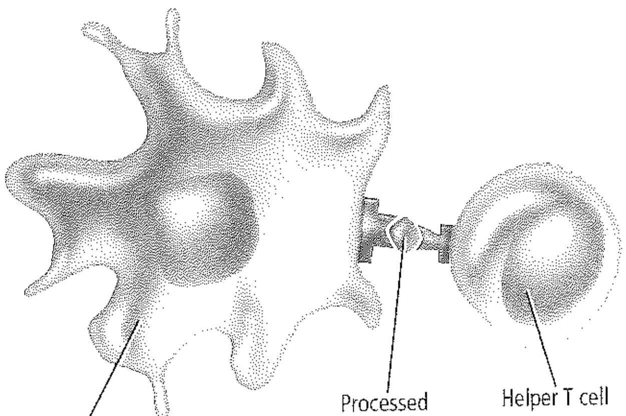
For questions 14–16, match each definition with a vocabulary term from the Study Guide page.

14. a chemical produced by B cells in response to antigen stimulation
15. a cell that activates B cells and cytotoxic T cells
16. a type of white blood cell produced in the bone marrow that includes B and T cells

Chapter 37 Assessment

Understand Main Ideas

Use the diagram below to answer questions 17 and 18.



17. What kind of immune response is demonstrated in the diagram above?
   A. genetic **C.** specific
   B. nonspecific **D.** hormonal

18. To which does the activated helper T cell present its antigen?
   A. a pathogen **C.** a B cell
   B. bone marrow **D.** the thymus gland

19. Which is the first defense your body has against infectious disease?
   A. the helper T cell **C.** your skin
   B. an antibody **D.** phagocytosis

20. What is the role of complement proteins, found in the plasma, in the immune response?
   A. enhance phagocytosis
   B. activate phagocytes
   C. enhance destruction of a pathogen
   D. all of the above

21. Where are lymphocytes produced?
   A. bone marrow **C.** spleen
   B. thymus gland **D.** lymph nodes

Constructed Response

22. **Short Answer** Describe how the thymus gland is involved in the development of immunity.

23. BIG Idea Evaluate why the body needs both a nonspecific and a specific immune response.

24. **Open Ended** Form a hypothesis as to why the proportion of unvaccinated Americans is increasing.

Think Critically

25. **Organize** the sequence of events that occurs to activate an antibody response to tetanus bacteria.

26. **Compare** the role of helper T cells and cytotoxic T cells in the specific immune response.

Section 3

Vocabulary Review

Use a vocabulary term from the Study Guide page to answer questions 27–29.

27. What type of reaction is a hypersensitivity to an allergen such as a bee sting?

28. Which type of disease occurs when people abnormally respond to environmental antigens?

29. Which type of disease is caused by a body part wearing out?

Understand Main Ideas

Use the photo below to answer question 30.

Publiphoto/Photo Researchers

30. The above photo demonstrates which disease?
   A. tetanus **C.** rheumatoid arthritis
   B. sickle-cell disease **D.** allergy

31. Which type of noninfectious disease is defined as a problem in a biochemical pathway in the body?
   A. inflammatory disease
   B. metabolic disease
   C. degenerative disease
   D. cancer

Online Test Practice

32. Which of the following substances is released in the body to cause most of the symptoms of allergies?
A. insulin
B. allergens
C. histamine
D. acetylcholine

33. Individuals can have a dangerous response to particular allergens, such as latex, and go into anaphylactic shock. What will be the result?
A. breathing problems
B. epileptic seizures
C. atherosclerosis
D. arthritis

34. In autoimmunity, which attacks the body's own proteins?
A. antigens
B. allergens
C. antibodies
D. antihistamines

Constructed Response

35. **Short Answer** Describe how an allergy differs from a common cold, considering that the symptoms are similar.

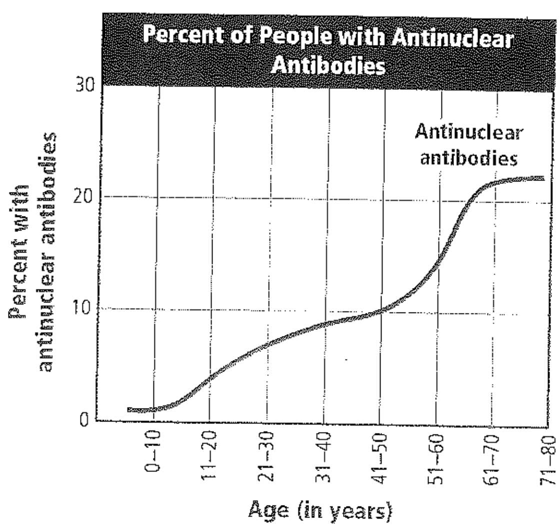
36. **Short Answer** Discuss the effects on the organs of the body when the smooth muscles in the bronchioles constrict, causing breathing to be difficult.

37. **Short Answer** Evaluate why lupus causes systemic problems in the body.

Think Critically

38. MAIN Idea Construct a table listing each of the types of non-infectious disease and give an example of each type.

Use the graph below to answer question 39.



39. **Summarize** the relationship between antinuclear antibodies and age.

Online Test Practice

Summative Assessment

40. BIG Idea A friend of yours has been diagnosed with chicken pox. Describe how your body protects itself from infection and what you can do to lessen your chances of contracting the disease.

41. Choose a pathogen and make a sequence diagram showing the steps of how each type of immunity is involved in preventing or fighting infection.

42. WRITING in Biology Construct an analogy comparing the immune system to a castle being attacked by invaders from a neighboring territory.

DBQ Document-Based Questions

The table below illustrates the effectiveness of using vaccinations to prevent the contraction of disease. There was a large decrease in cases of the diseases listed after the use of vaccinations.

Data obtained from: Mandell, G. L., et al. 1995. Principles and Practice of Infectious Diseases, 4th ed. Churchill Livingstone, and Centers for Disease Control and Prevention. 2000. Morbidity and Mortality Weekly Report 48: 1162-1192.

Disease	Maximum Number of Cases in a Year	Number of Cases in 1999 in U.S.	Percent Change
Measles	894,134	60	–99.99
Mumps	152,209	352	–99.77
Polio (paralytic)	21,269	0	–100.0
Tetanus	1560	33	–97.88
Hepatitis B	26,611	6495	–75.59

43. Which disease has shown the greatest change in occurrence since the year of its maximum number of cases?

44. Tetanus has shown a large decline since the United States started vaccinating. Explain why this disease will not be completely eradicated.

45. Create a bar graph showing the percent change in number of cases as a result of vaccination for each disease.

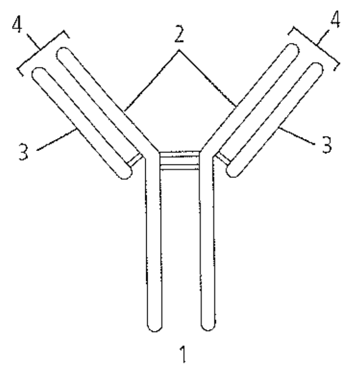
Standardized Test Practice

Cumulative

Multiple Choice

1. In the digestive system, complex carbohydrates are broken down into which substance?
   A. amino acids
   B. fatty acids
   C. simple sugars
   D. starches

Use the diagram below to answer questions 2 and 3.



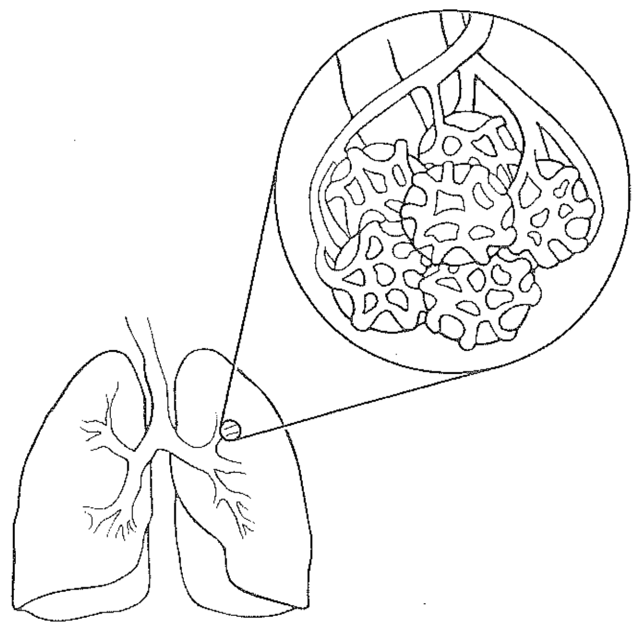
2. The diagram above shows the basic structure of an antibody. Which part of the diagram corresponds to the antigen binding site?
   A. 1
   B. 2
   C. 3
   D. 4

3. Why are parts 2 and 3 of the diagram above important for the formation of antibodies?
   A. They allow for an enormous number of possible antibodies to form.
   B. They are created by the T cells in the immune system.
   C. They help reduce the number of antibodies that form.
   D. They help stimulate the inflammatory response.

4. Which is the role of estrogen during puberty in females?
   A. It causes development of the female body.
   B. It causes eggs to begin to mature in the ovaries.
   C. It causes meiosis to start to produce an egg.
   D. It causes ovaries to release mature eggs.

5. Which is true of the appendix?
   A. It absorbs sodium hydrogen carbonate to neutralize acid.
   B. It has no known function in the digestive system.
   C. It helps break down fats.
   D. It secretes acids to help break down foods.

Use the diagram below to answer question 6.



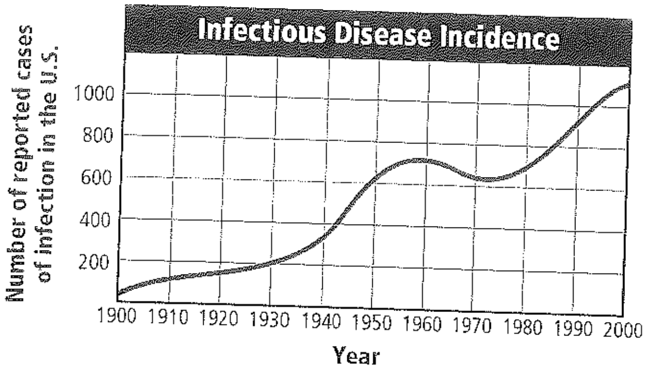
6. Which happens in the blood in these structures?
   A. Carbon dioxide and oxygen are exchanged.
   B. Carbon dioxide and oxygen remain constant.
   C. Nitrogen and carbon dioxide are exchanged.
   D. Nitrogen and carbon dioxide remain constant.

7. Puberty takes place during which transition in life?
   A. adolescence to adulthood
   B. childhood to adolescence
   C. fetus to infant
   D. zygote to fetus

8. What is the role of hormones in the body?
   A. to act as reaction catalysts
   B. to control breathing process
   C. to help synthesize proteins
   D. to regulate many body functions

Short Answer

Use the graph below to answer questions 9 and 10.



9. What is the overall trend shown in the above graph?

10. What are two possible explanations for the pattern in the above graph?

11. What characteristics are used to classify protists into three groups?

12. Describe the process of dilation during birthing. Assess why it is important.

13. Identify the function of the large intestine.

14. Assess how the respiratory system of most reptiles is adapted for life on land.

15. Free-living flatworms have some unique body structures: eyespots, a ganglion, and auricles that detect chemical stimuli. How are these body structures related to each other?

Extended Response

16. Arthropods first moved onto land about 400 million years ago and have survived several mass extinctions. Propose a hypothesis about why arthropods have been so successful.

17. Compare the production of sperm cells and egg cells during meiosis.

Essay Question

Scientist Marc Lappé wrote the following in 1981 in a book called *Germs That Won't Die.*

"Unfortunately, we played a trick on the natural world by seizing control of these [natural] chemicals, making them more perfect in a way that has changed the whole microbial constitution of the developing countries. We have organisms now proliferating that never existed before in nature. We have selected them. We have organisms that probably caused a tenth of a percent of human disease in the past that now cause twenty, thirty percent of the diseases that we're seeing. We have changed the whole face of the earth by the use of antibiotics."

Using the information in the paragraph above, answer the following question in essay format.

18. As Lappé predicted in 1981, many diseases have emerged in forms that are resistant to treatment by antibiotics and other powerful drugs. Have antibiotics "changed the whole face of the earth" for the better or for the worse? In an organized essay, discuss the advantages and disadvantages of antibiotics as they are used today.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Review Section . . .	35.2	37.2	37.2	36.2	35.1	34.2	36.2	35.2	37.1	37.1	19.1	36.2	35.1	29.1	25.1	26.1	36.1	37.1