Chapter 39 Organizer

Refer to pages 45-50 of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section | Objectives | Activities/Features
--- | --- | ---
**Section 39.1**
**The Nature of Disease**
National Science Education Standards UCP1-1, UCP5, UCP6; A.1, A.2; C.4, C.5, C.6; F.1, F.5, G.1-3 (1 session)
1. Outline the steps of Koch's postulates.  
2. Describe how infections are transmitted.  
3. Explain what causes the symptoms of a disease.
5. Compare innate and acquired immune responses.  
6. Distinguish between antibody and cellular immunity.

**Problem-Solving Lab 39-1**, p. 1059
MiniLab 39-1: Testing How Diseases are Spread, p. 1060

**Internet BioLab**: Getting On-line for Information on Diseases, p. 1074

**Inside Story**: Lines of Defense, p. 1066
MiniLab 39-2: Distinguishing Types of White Blood Cells, p. 1067

**Problem-Solving Lab 39-2**, p. 1072
BioTechnology: New Vaccines, p. 1076

**Section 39.2**
**Defense Against Infectious Diseases**
National Science Education Standards UCP1-3, UCP5; A.1, A.2, C.1, C.4, C.5, C.6; E.1, E.2, E.1, E.5, E.e, G.1-3 (3 sessions)

BioLab
p. 1074 Internet access, paper, pencil

MiniLabs
p. 1060 fresh apples (4), rotting apple, zipper-lock plastic bags (4), cotton ball, ethanol
p. 1067 microscope, prepared slide of blood cells, paper, pencil

**Alternative Lab**
p. 1064 E. coli culture, antibiotic disks (3 types), sterile untreated dishes, petri dish with sterile nutrient agar, cotton swabs, forceps, ethanol, transparent tape, marking pen, incubator

**Quick Demos**
p. 1056 petri dish with sterile nutrient agar, incubator
p. 1064 microprojector, prepared slides of red and white blood cells

**Materials List**

**Key to Teaching Strategies**

**MATERIALS LIST**

**BioLab**
p. 1074 Internet access, paper, pencil

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**Teacher Classroom Resources**

**Section 39.1**
**The Nature of Disease**

**Reinforcement and Study Guide**, p. 171
**BioLab** and **MiniLab Worksheets**, p. 173
**Laboratory Manual**, pp. 285-292
**Content Mastery**, pp. 189-190, 192

**Section 39.2**
**Defense Against Infectious Diseases**

**Reinforcement and Study Guide**, pp. 172-174
**Concept Mapping**, p. 39
**Critical Thinking/Problem Solving**, p. 39
**BioLab and MiniLab Worksheets**, pp. 174-176
**Content Mastery**, pp. 189, 191-192

**Assessment Resources**

Chapter Assessment, pp. 229-234
MindJogger Videozipes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 39 quiz

**Additional Resources**

Spanish Resources
English/Spanish Audiocassettes
Cooperative Learning in the Science Classroom
Lesson Plans/Block Scheduling

**GLENCO TECHNOLOGY**

The following multimedia resources are available from Glencoe.

**Biology: The Dynamics of Life**

- **CD-ROM**
- Video: Lymphocytes
- Animation: Antibody Immunity
- Animation: Cellular Immunity

**Videodisc Program**

- Lymphocytes
- Antibody Immunity
- Cellular Immunity

**The Secret of Life Series**

- Tinkering With Our Genes: Genetic Medicine
- Nothing to Sneeze At: Viruses

**GLENCOE TECHNOLOGY**

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**Teacher’s Corner**

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- **CD-ROM**
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- Animation: Antibody Immunity
- Animation: Cellular Immunity

**Videodisc Program**

- Lymphocytes
- Antibody Immunity
- Cellular Immunity

**The Secret of Life Series**

- Tinkering With Our Genes: Genetic Medicine
- Nothing to Sneeze At: Viruses

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551
or at http://www.carolina.com
Immunity from Disease

What You’ll Learn
- You will describe how infections are transmitted and what causes the symptoms of disease.
- You will explain the various types of innate and acquired immune responses.
- You will compare antibody and cellular immunity.

Why It’s Important
Your body constantly faces attack from disease-causing organisms. A knowledge of your immune system will help you understand how your body defends itself.

What Is an Infectious Disease?
The cold virus causes a disease—a change that disrupts the homeostasis of your cells. Soon you have a sore throat, stuffy nose, headache, and mild fever. Has diet the infection cause these symptoms?

Section 39.1 The Nature of Disease

Everyone occasionally gets a cold. Cold viruses enter your body by way of your nose and are set up by the back of your throat by a bivalve cell. Some are washed down your esophagus and destroyed by your digestive system. Others become lodged in your nasal passages. These viruses enter cells that line your nasal cavity. Once inside, the viruses unleash their genes, taking over the DNA of your cell. Soon you have a sore throat, stuffy nose, headache, and mild fever. Has diet the infection cause these symptoms?

The immune system, like a castle, protects the body against invasion. Like the knight protecting his castle, the neutrophil shown here is on constant surveillance against foreign invaders.

E comforting: The immune system, lower urinary and reproductive tract, and lower intestinal tract. Figure 39.1 shows some common bacteria that live on your skin. They have a symbiotic relationship with system.
Diseases and Their Causes

Table 39.1 Human infectious diseases

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Disease</th>
<th>Affected organ system</th>
<th>Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smear</td>
<td>Virus</td>
<td>Skin</td>
<td>Droplet</td>
</tr>
<tr>
<td>Chickens pox</td>
<td>Virus</td>
<td>Skin</td>
<td>Droplet</td>
</tr>
<tr>
<td>Cold sores</td>
<td>Virus</td>
<td>Skin</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Rabies</td>
<td>Virus</td>
<td>Nervous system</td>
<td>Animal bite</td>
</tr>
<tr>
<td>Poliovirus</td>
<td>Virus</td>
<td>Nervous system</td>
<td>Contaminated water</td>
</tr>
<tr>
<td>Infectious mononucleosis</td>
<td>Virus</td>
<td>Salivary glands</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Glanders</td>
<td>Virus</td>
<td>Respiratory system</td>
<td>Droplet</td>
</tr>
<tr>
<td>Anthrax</td>
<td>Spore</td>
<td>Respiration system</td>
<td>Droplet</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>Virus</td>
<td>Immune system</td>
<td>Exchange of body fluids</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>Virus</td>
<td>Liver</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Measles</td>
<td>Virus</td>
<td>Skin</td>
<td>Droplet</td>
</tr>
<tr>
<td>Mumps</td>
<td>Virus</td>
<td>Salivary glands</td>
<td>Droplet</td>
</tr>
<tr>
<td>Tetanus</td>
<td>Bacteria</td>
<td>Nervous system</td>
<td>Deep wound</td>
</tr>
<tr>
<td>Food poisoning</td>
<td>Bacteria</td>
<td>Gastrointestinal system</td>
<td>Contaminated food</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Bacteria</td>
<td>Respiratory system</td>
<td>Droplet</td>
</tr>
<tr>
<td>Whooping-cough</td>
<td>Bacteria</td>
<td>Respiratory system</td>
<td>Droplet</td>
</tr>
<tr>
<td>Pertussis</td>
<td>Bacteria</td>
<td>Respiratory system</td>
<td>Droplet</td>
</tr>
</tbody>
</table>

Pathogens cause infectious diseases and some cancers. In fact, about half of all human diseases are infectious. In order to determine which pathogen causes a specific disease, scientists follow a standard set of procedures.

Determining What Causes a Disease

One of the first problems scientists face when studying a disease is finding out what causes the disease. Not all diseases are caused by pathogens. Disorders such as hemophilia (hee mai FEE uh), which is caused by a recessive allele on the X chromosome, and sickle cell anemia are inherited. Others, such as osteoarthritis (ohs tee ah AR thritis), may be caused by wear and tear on the body as it ages. Pathogens cause infectious diseases and some cancers. In fact, about half of all human diseases are infectious. In order to determine which pathogen causes a specific disease, scientists follow a standard set of procedures.

First pathogen identified

Koch established experimental steps, shown in Figure 39.2, for directly relating a specific pathogen to a specific disease. These steps, first published in 1884, are known today as Koch's postulates:

1. The pathogen must be found in the host in every case of the disease.
2. The pathogen must be isolated from the host and grown in a pure culture—that is, a culture containing no other organisms.
3. When the pathogen from the pure culture is placed in a healthy host, it must cause the disease.
4. The pathogen must be isolated from the new host and be shown to be the original pathogen.

Koch's postulates are useful in determining the cause of most diseases, some exceptions exist. Some organisms, such as the pathogenic bacterium that causes the sexually transmitted disease syphilis (SIEF ih lis), have never been grown on an artificial medium. Viral pathogens also cannot be cultured this way because they multiply only within cells. As a result, living tissue must be used as a culture medium for viruses.

The Spread of Infectious Diseases

For a disease to continue and spread, there must be a continual source of the disease organisms. This source can be either a living organism or an inanimate object on which the pathogen can survive.

**Table 39.2**

<table>
<thead>
<tr>
<th>Source of Pathogen</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct contact</td>
<td>Hands, clothing, saliva</td>
</tr>
<tr>
<td>Droplet</td>
<td>Inhaled air, contaminated food, water</td>
</tr>
<tr>
<td>Contaminated water</td>
<td>Swimming pools, drinking water</td>
</tr>
</tbody>
</table>

Koch's postulates are steps used to identify an infectious pathogen.
Reservoirs of pathogens

The main source of human disease pathogens is the human body itself. In fact, the body can be a reservoir of disease-causing organisms. People may transmit pathogens directly or indirectly to other people. Sometimes, people can harbor pathogens without exhibiting any signs of the illness and unknowingly transmit the pathogens to others. These people are called carriers and are a significant reservoir of infectious diseases.

Other people may unknowingly pass on a disease during its first stage, before they begin to experience symptoms. This symptom-free period, while the pathogens are multiplying within the body, is called an incubation period. Humans can unknowingly pass on the pathogens that cause colds, streptococcal throat infections, and sexually transmitted diseases (STDs) such as gonorrhea and AIDS during the incubation periods of these diseases.

Animals are other living reservoirs of microorganisms that cause disease in humans. For example, some types of influenza, commonly known as the flu, and rabies are often transmitted to humans from animals. The major nonliving reservoirs of infectious diseases are soil and water. Soil harbors pathogens such as fungi and the bacterium that causes botulism, a type of food poisoning. Water contaminated by fishes of humans and other animals is a reservoir for several pathogens, especially those responsible for intestinal diseases.

Transmission of disease

How are pathogens transmitted from a reservoir to a human host? Pathogens can be transmitted from reservoirs in four main ways: by direct contact, by an object, through the air, or by an intermediate organism called a vector. Figure 39.9 illustrates each of these.

- **Direct contact**: This is the most common way that pathogens are transmitted. For example, contact with contaminated hands can transmit bacteria, viruses, and parasites from one person to another. Direct contact can also occur through bodily fluids, especially during sexual intercourse.

- **Indirect transmission**: Pathogens can be transmitted indirectly through contaminated objects or surfaces. For example, food poisoning can be caused by eating food contaminated with harmful bacteria or viruses. Other examples include the transmission of diseases through kissing, and sexual contact.

- **Airborne transmission**: Pathogens can also be transmitted through the air. For example, the influenza virus is spread through droplets of water or dust that contain the virus. These droplets can be inhaled by another person and infect their respiratory system.

- **Vector transmission**: Pathogens can be transmitted by vectors, which are disease-carrying organisms. Examples of vectors include insects and arthropods. These vectors can transmit diseases such as malaria, which is transmitted by mosquitoes, and Lyme disease, which is transmitted by ticks.

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MiniLab 39-1

Experimenting

Testing How Diseases Spread

Most of the damage done to host cells by bacteria is inflicted by toxins.
Toxins are poisonous substances that are sometimes produced by microorgan-
isms. These poisons are transported by the blood and can cause serious and sometimes fatal effects.
Some toxins produce fever and cardiovascular disturbances. Toxins can also inhibit protein synthesis in the host cell, destroy blood cells and blood vessels, or cause spasms by dis-
rupting the nervous system.

For example, the toxin produced by tetanus bacteria affects nerve cells and produces uncontrollable muscle contractions. If the condition is left untreated, paralysis and death occur.

Tetanus bacteria are normally present in soil, as Figure 39.4 illustrates. If dirt
transfers the bacteria into a deep wound on your body, the bacteria begin to produce the toxin in the wounded area. A remnant of this toxin, about the same amount as the ink used to make a period on this page, could kill 30 people. That is why you should be vaccinated for tetanus.

Patterns of Diseases

In today's highly mobile world, diseases can spread rapidly. Contami-
nated water, for example, can affect many thousands of people quickly.

Therefore, identifying a pathogen, its method of transmission, and the geo-
graphic distribution of the disease it causes are major concerns of govern-
ment health departments.

The Centers for Disease Control and Prevention, the central source of dis-
ease information in the United States, publishes a weekly report about the incidence of specific diseases.

Some diseases, such as typhoid fever, occur only occasionally in the
United States. These periodic outbreaks often occur because someone traveling in a foreign country has
brought the disease back home. On the other hand, many diseases are constantly present in the population.
Such a disease is called an endemic disease. The common cold is an endemic disease.

Sometimes, an epidemic breaks out. An epidemic occurs when many
people in a given area are afflicted with the same disease at about the same time.
Influenza is a disease that often achieves epidemic status, some-
times spreading to many parts of the world. During the 1950s, a polio epi-
demic spread across the United States. Victims of this disease were paralyzed or died when the polio virus attacked the nerve cells of the brain and spinal cord. Many survived only after being placed in an iron lung—a machine that allowed the patient to continue to breathe, as shown in Figure 39.5.

Treating Diseases

A person who becomes sick often can be treated with medicinal drugs, such as antibiotics. An antibiotic is a substance produced by a microorgan-
ism that, in small amounts, will kill or inhibit the growth and reproduc-
tion of other microorganisms, espe-
cially bacteria. Antibiotics are pro-
duced naturally by various species of
bacteria and fungi. Although antibiot-
cics can be used to cure some bacte-
rial infections, antibiotics do not affect viruses.
3 Assess
Check for Understanding

1. Has your school housefly and other insects that carry disease.
2. Most bacteria cannot survive outside their host. Viruses also depend on a host to live.

Extension
Ask students to research the history of the development of antibiotics.

4 Close
Discussion
Discuss the kinds of precautions school cafeterias must take to avoid disease transmission.

A problem that sometimes occurs with the continued use of antibiotics is that the bacteria become resistant to the drugs. That means the drugs become ineffective. Penicillin, an antibiotic produced by a fungus, was used for the first time in the 1940s and is still one of the most effective antibiotics known. However, penicillin has now been in use for more than 50 years, and more and more types of bacteria have evolved that are resistant to it. Bacteria that are resistant to penicillin produce an enzyme that breaks down this antibiotic. In certain infections, such as the STD gonorrhea, this resistance is a problem because, until now, penicillin has been the most successful drug in treating the infection. The increase in penicillin-resistant gonorrhea is graphed in Figure 39.6. The use of antibiotics is only one way to fight infections. Your body also has its own built-in defense system—the immune system—that is continually working to keep you healthy.

Innate Immunity
Your body produces a variety of white blood cells that defend it against invasion by pathogens that are constantly bombarding you. No matter what pathogens are present, your body is always ready. The body's earliest lines of defense against any and all pathogens make up your non-specific, innate immunity.

Skin and body secretions
When a potential pathogen contacts your body, often the first barrier it must penetrate is your skin. Like the walls of a castle, intact skin is a formidable physical barrier to the entrance of microorganisms.

In addition to the skin, pathogens also encounter your body's secretions of mucus, sweat, tears, and saliva. The main function of mucus is to prevent various areas of the body from drying out. Because mucus is slightly viscous (thick), it traps many microorganisms and other foreign substances that enter the respiratory and digestive tracts. Mucus is continually swallowed and passed to the stomach, where acidic gastric juice (made of hydrochloric acid and other fluids) destroys most bacteria and their toxins. Sweat, tears, and saliva all contain the enzyme lysozyme, which is capable of breaking down the cell walls of some bacteria.

Figure 39.6
This graph shows the occurrence of penicillin-resistant gonorrhea. Notice the increase in the number of reported cases of gonorrhea in the United States.

Cases of Penicillin-Resistant Gonorrhea

<table>
<thead>
<tr>
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<td>1950</td>
<td>25</td>
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1062 IMMUNITY FROM DISEASE

Section 39.2
Defense Against Infectious Diseases

You can't win it, but a war is going on around these teenagers. In fact, the same sort of war is occurring around you. Hordes of unseen enemies are present everywhere—on the air, on the ground, even on your clothes. Defenders ready to protect you from the onset of attack are inside your body. How does your body save you from the microscopic foes that cause infectious disease? How do the body's defenses protect you from these unseen enemies?

**Innate Immunity**
- Your body produces a variety of white blood cells that defend it against invasion by pathogens that are constantly bombarding you.
- No matter what pathogens are present, your body is always ready.
- The body's earliest lines of defense against any and all pathogens make up your non-specific, innate immunity.

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<tr>
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</tr>
</tbody>
</table>
Phagocytes

Figure 39.8 When tissues become infected, histamine release causes blood vessels to dilate. Tissue fluid leaks out of the vessels into the injured area, causing swelling.

Inflammation of body tissues

If a pathogen manages to get past the skin and body secretions, the body has several other nonspecific defense mechanisms that can destroy the invader and restore homeostasis. Think about what happens when you get a splinter. When bacteria or other pathogens damage body tissues, inflammation (ihn fluh MAY shun) may result. Inflammation is characterized by four symptoms—redness, swelling, pain, and heat. As Figure 39.8 shows, inflammation begins when damaged tissue cells, and white blood cells called basophils, release histamine (汀提 tub meen). Histamine causes blood vessels in the injured area to dilate, which makes them more permeable to tissue fluid. These dilated blood vessels cause the redness of an inflamed area. Fluid that leaks from the vessels into the injured tissue helps the body destroy toxic agents and restore homeostasis. This increase in tissue fluid causes swelling and pain, and may also cause a local temperature increase. Inflammation can occur as a reaction to other types of injury as well as infections. Physical force, chemical substances, extreme temperatures, and radiation may also inflame body tissues.

Phagocytosis of pathogens

Pathogens that enter your body may encounter cells that carry on tissue macrophages. They then begin consuming pathogens and dead neutrophils by phagocytosis. Once the infection is over, some monocytes mature into tissue macrophages that engulf and digest them.

Protection against inflammation

When an infection is caused by a virus, your body faces a problem. Phagocytes cannot destroy viruses. Recall that a virus multiplies within a host cell. A phagocyte that engulfs a virus will still be destroyed if the virus multiplies within it. One way your body fights viruses is through inflammation. The inflamed area acts as a barrier. The pus at the site of a bacterial infection is an example of inflammation. Many important antibodies are produced in the bloodstream. They provide a way for the immune system to quickly respond to a pathogen.

Assessment

Knowledge Ask students to describe similarities between a macrophage and an amoeba. Recall engulf particles by phagocytosis.

Assessment

Performance Have students design and perform another lab procedure using disks treated with antibiotics. Use the Performance Task Assessment List for Designing an Experiment in PASG, p. 23.

Alternative Lab

Antibiotics and Bacteria

Purpose

Students will determine which antibiotics are most effective in inhibiting bacterial growth.

Materials

E. coli bacterial culture, 3 types of antibiotic disks, sterile untreated disks, cotton swabs, forceps, ethanol, transparent tape, plates of nutrient agar, marking pen, incubator

Procedure

Gives students the following directions:
CAUTION: Wear lab aprons, safety goggles, and disposable latex gloves. Do not open petri dishes after they have been sealed. Wash hands after inoculating petri dishes and after making observations. Used petri dishes and toothpicks should be autoclaved before disposal.

1. Use the marking pen to make a cross on the bottom of an agar plate, dividing it into four sections.
2. Using a cotton swab, gently transfer some of the bacterial culture onto the agar plate.
3. Spread the culture evenly over the surface of the agar plate using the cotton swab.
4. Dip the forceps into alcohol and allow them to air dry without touching any surface.
5. Use the forceps to transfer two antibiotic disks into each of three sections of the plate. Label the bottom with the type of antibiotic used in each section.
6. Use the forceps to transfer two untreated disks to the fourth section of the agar plate.
7. Tape the plates closed and incubate for 48 hours at 37°C.
8. Look for regions of inhibition near the disks.

Analysis

1. Why were untreated disks placed in one section? This section was the control.
2. Did any of the antibiotics inhibit the growth of the bacteria? Answers will vary.

Learning Objectives

Students will:
1. Use antibodies to kill bacteria.
2. Use macrophages to fight bacteria.
3. Explain the importance of inflammation in fighting infections.

Performance Assessment

Have students orally make an analogy between the reaction of the immune system and a battle scene. Ask them who or what might represent the skin, tissue macrophages, neutrophils, and monocytes.

Reinforcement

Work on students’ table of defense against infections diseases.

Workbook

1. Define “defense against infectious diseases.”
2. Explain the difference between cell-mediated and humoral immunity.
3. Explain the importance of inflammation in fighting infections.
4. Describe the role of phagocytosis in the immune system.

Workbook

1. List four symptoms of inflammation.
2. Explain how inflammation helps fight infections.
3. Describe how phagocytes and macrophages fight infections.
4. Explain how inflammation helps fight infections.

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3. Explain the importance of inflammation in fighting infections.
4. Describe the role of phagocytosis in the immune system.
White blood cells play a major role in protecting your body against disease. Many of these cells leave the bloodstream to fight disease organisms in the tissues.

Acquired Immunity

The cells of your innate immune system continually survey your body for foreign invaders. When a pathogen is detected, these cells begin defending your body right away. Meanwhile, as the infection continues, another type of immune response that counteracts the invading pathogen is also mobilized. Certain white blood cells gradually develop the ability to recognize a specific foreign substance. This acquired immune response enables these white blood cells to inactivate or destroy the pathogen. Defending against a specific pathogen by gradually building up a resistance to it is called acquired immunity.

Acquired immune response

Normally, the immune system recognizes components of the body as self, and foreign substances, called antigens, as nonself. Antigens are usually proteins present on the surfaces of whole organisms, such as bacteria, or on parts of organisms, such as the pollen grains of plants. An acquired immune response occurs when the immune system recognizes an antigen and responds to it by producing antibodies against it. Antibodies are foreign substances that stimulate your body to counteract viral infections with interferons. Interferons are proteins that protect cells from viruses. They are host-cell specific, that is, human interferons will protect human cells from viruses but will do little to protect cells of other species from the same virus.

Interferon is produced by a body cell that has been infected by the virus. The interferon diffuses into uninfected neighboring cells, which then produce antiviral proteins that can prevent the virus from multiplying.

Distinguishing Types of White Blood Cells

The human immune system includes five types of white blood cells found in the bloodstream: basophils, neutrophils, monocytes, eosinophils, and lymphocytes.

Procedure

1. Copy the data table below.
2. Mount a prepared slide of white blood cells on the microscope and focus on low-power. Turn to high power and look for white blood cells. CAUTION: Use care when working with microscope slides.
3. Find a neutrophil, monocyte, eosinophil, and lymphocyte.
4. Count a total of 50 white blood cells, and record how many of each cell type.
5. Calculate the percentage by multiplying the number of each cell type by two. Record the percentages. Diagram each type.

<table>
<thead>
<tr>
<th>Data Table</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of white blood cell</td>
<td>Number counted</td>
</tr>
<tr>
<td>Neutrophil</td>
<td></td>
</tr>
<tr>
<td>Monocyte</td>
<td></td>
</tr>
<tr>
<td>Basophil</td>
<td></td>
</tr>
<tr>
<td>Lymphocyte</td>
<td></td>
</tr>
<tr>
<td>Eosinophil</td>
<td></td>
</tr>
</tbody>
</table>

Analysis

1. Which type of white blood cell was most common?
2. Second most common?
3. How do red and white blood cells differ?

Susumu Tonagawa and Immunity

Students will determine the percentages of different kinds of white blood cells.

Process Skills
classify, observe and infer, compare and contrast, collect and organize data

Safety Precautions
Caution students to use care when working with prepared slides and microscopes. Special care should be taken when viewing slides under high power as the objective does not break the slide.

Teaching Strategies
It would be helpful for student identification to set up a prepared microscope slide showing both an eosinophil and a basophil.

Expected Results
The common percentages of white blood cells are: neutrophils, 60-70%; lymphocytes, 20-25%; monocytes, 1-3%; eosinophils, 2-4%; and basophils, 0.5-1.0%.

Analysis
1. neutrophils, lymphocytes
2. White blood cells have a nucleus; red blood cells don't.

Assessment
Performance Have students include summaries of the lab, their data tables, and their answers to the Analysis questions in their Biology Journals. Use the Performance Task Assessment List for Lab Report in PASC, p. 47.
Each plasma cell secretes more than 2000 anti-
body molecules that make up the lymphatic system. Your body’s cells are constantly bathed with fluid. This tissue fluid forms when water and dissolved sub-
stances diffuse from the blood into the spaces between the cells that make up the surrounding tissues. This tissue fluid collects in open-
ended lymph capillaries. Once the tissue fluid enters the lymph vessels, it is called lymph. Figure 39.10 shows the major glands and vessels that make up the lymphatic system.

Glands of the lymphatic system

At locations along the lymphatic pathways, the lymph vessels pass through lymph nodes. A lymph node is a small mass of tissue that contains lymphocytes and filters pathogens from the lymph, as shown in Figure 39.11. Lymph nodes are made of an interlaced network of connective tissue fibers that holds lymphocytes. A lymphocyte (lymf uh site) is a type of white blood cell that enters your nose and mouth. The lymph nodes filter the lymph and the blood to protect the body from pathogens.

Antibody Immunity

Acquired immunity involves the production of two kinds of immune responses: antibody immunity and cellular immunity. Antibody immunity is a type of chemical warfare within your body that involves several types of cells. Follow the steps of antibody immunity illustrated in Figure 39.12.

When a pathogen invades your body, it is first attacked by the cells of your innate immune system, as shown in Figure 39.12A, B, and C. If the infection is not controlled, then your body builds up acquired immunity to the antigen by producing antibodies to it. A type of lym-
phocyte called a T cell becomes involved. A T cell is a lymphocyte that is produced in bone marrow and processed in the thymus gland. Two kinds of T cells play different roles in immunity.

Visual Learning

Figure 39.12 Ask students to write a summary of what is hap-
ening in this figure.

Reinforcement

Compare the antigen-antibody reaction to the lock-and-key fit of enzymes and substrates.

Assessment

Performance Assessment in the Biology Classroom, p. 45. Vaccine Models and the Common Cold. Have students carry out this activity to find out why a single vaccine will not combat the com-
mon cold.

Concept Development

Explain to students that normally the body’s immune response helps maintain homeostasis. However, sometimes the body loses its ability to discriminate between self and nonself, which leads to autoimmunity. Auto-

Antibody Immunity

immunity is a response by anti-

bodies or sensitized T cells against a person’s own tissue anti-
gens. It is involved in multiple sclerosis, Graves’ disease of the thyroid, rheumatic fever (in which antibodies are formed against the heart), and juvenile diabetes (in which antibodies are formed against the pancreas).

To view this animation, see the Interactive CD-ROM. She is a type of white blood cell that enters your nose and mouth. The lymph nodes filter the lymph and the blood to protect the body from pathogens.

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To view this animation, see the Interactive CD-ROM. She is a type of white blood cell that enters your nose and mouth. The lymph nodes filter the lymph and the blood to protect the body from pathogens.
One kind of T cell, called a helper T cell, interacts with B cells, shown in Figure 39.12D, E, and F. A B cell is a lymphocyte that, when activated by a T cell, becomes a plasma cell and produces antibodies. B cells are produced in the bone marrow. Plasma cells, shown in Figure 39.12G and H, release antibodies into the bloodstream and tissue spaces. Sometimes B cells do not become plasma cells but remain in the bloodstream as memory B cells. Memory B cells are ready and armed to respond rapidly if the same pathogen invades the body at a later time. The response to a second invasion is immediate and rapid, usually without any symptoms.

Cellular Immunity

Like antibody immunity, cellular immunity also involves T cells with antibodies on their surfaces. The T cells involved in cellular immunity are cytotoxic, or killer, T cells. T cells stored in the lymph nodes, spleen, and tonsils transform into cytotoxic T cells that are specific for a single antigen. However, unlike B cells, they do not form antibodies. Cytotoxic T cells differentiate and produce identical clones. They travel to the infection site and release enzymes directly into the pathogens, causing them to lyse and die. The steps in cellular immunity are illustrated in Figure 39.13.

Passive and Active Immunity

Perhaps you had chicken pox as a child. Many children have had chicken pox by the time they enter school. Most people don’t have chicken pox a second time because they have become immune to the chicken pox virus. Acquired immunity to many pathogens is directly exposed to antigens and produces antibodies in response to those antigens. Passive immunity is acquired indirectly. Passive acquired immunity involves injecting into the body antibodies that come from an animal or a human who is already immune to the disease. For example, a person who is bitten by a snake might be injected with antibodies from a horse that is immune to the snake venom. Active immunity is obtained naturally when a person is exposed to antigens. The body produces antibodies that correspond specifically to these antigens. Once the person recovers from the infection, he or she will be immune if exposed to the pathogen again. Active immunity can be induced artificially by vaccines. A vaccine is a substance consisting of weakened, dead, or incomplete portions of pathogens or antigens that, when injected into the body, cause an immune response. Vaccines produce immunity because they prompt the body to react as if it were naturally infected. Table 39.2 lists some common vaccines.

In 1798, Edward Jenner, an English country doctor, demonstrated the first safe vaccination procedure. Jenner knew that dairymen workers who acquired cowpox from infected cows were resistant to catching smallpox. He reasoned that cowpox also caused immunity to smallpox. Jenner infected a young boy with cowpox. The boy developed a mild cowpox infection. Six weeks later, Jenner scratched the skin of the boy with viruses from a smallpox victim, as depicted in Figure 39.14. For example, at birth, a human infant acquires passive immunity to disease from its mother. Active acquired immunity develops when your body is directly exposed to antigens and produces antibodies in response to those antigens.

Table 39.2 Recommended childhood immunizations

<table>
<thead>
<tr>
<th>Immunization Agent Protection against</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acellular DPT or Tetramune Bacteria Diphtheria, pertussis (whooping cough), tetanus (diph)</td>
</tr>
<tr>
<td>MMR</td>
</tr>
<tr>
<td>OPV</td>
</tr>
<tr>
<td>HIB</td>
</tr>
<tr>
<td>HB or Tetramune</td>
</tr>
</tbody>
</table>

Passive immunity involves injecting into the body antibodies that correspond specifically to these antigens. Once the person recovers from the infection, he or she will be immune if exposed to the pathogen again. Active immunity can be induced artificially by vaccines. A vaccine is a substance consisting of weakened, dead, or incomplete portions of pathogens or antigens that, when injected into the body, cause an immune response. Vaccines produce immunity because they prompt the body to react as if it were naturally infected. Table 39.2 lists some common vaccines. In 1798, Edward Jenner, an English country doctor, demonstrated the first safe vaccination procedure. Jenner knew that dairymen workers who acquired cowpox from infected cows were resistant to catching smallpox. He reasoned that cowpox also caused immunity to smallpox. Jenner infected a young boy with cowpox. The boy developed a mild cowpox infection. Six weeks later, Jenner scratched the skin of the boy with viruses from a smallpox victim, as depicted in Figure 39.14.
**AIDS and the Immune System**

In 1983, an unusual cluster of cases of a rare pneumonia caused by a pneumonia virus appeared in the San Francisco area. Medical investigators soon related the appearance of this disease with the incidence of a rare form of skin cancer called Kaposi’s sarcoma. Both diseases seemed associated with a general lack of function of the body’s immune system. By 1988, the pathogen causing this immune system disease had been identified as a retrovirus, now known as Human Immunodeficiency (HIV).

**Vaccination**

- **Diphtheria toxoid** is a modified form of the toxin produced by the bacterium Corynebacterium diphtheriae. It causes the symptoms associated with the disease diphtheria. When injected into your body, the toxoid prompts the immune system to respond as if it were being attacked by the diphtheria toxin. The graph below shows the human body’s response to receiving an immunization shot of the diphtheria toxoid and then to being infected later on by the diphtheria bacterium.

**Antibody Response to Diphtheria Antigens**

- **Antigen**
- **Vaccination**
- **Time in days**
- **Natural infection with diphtheria bacterium**
- **Diphtheria toxoid**
- **No vaccine**

**Antibodies**

- Protamine, B cells, and T cells.
- The immunity process by which the body adapts to a specific antigen by forming antibodies against it.
- A toxin is a poison released by a pathogen to cause disease symptoms. A toxoid is a treated form of the toxin that does not harm the body but stimulates the immune system to form antibodies against the toxin.
- Line A-B involves macrophages, T cells, and B cells. Line B-C probably involves memory B cells and plasma cells.

**Protein**

- **Antigen**
- **Protein**
- **Antibody**
- **Antigen-Antibody complex**

**The viruses for cowpox and smallpox are so similar that the immune system cannot tell them apart.**

**The boy, therefore, did not get sick because he had artificially acquired active immunity to the disease. To learn more about how vaccines work, try the Problem-Solving Lab here.**

**Problem-Solving Lab 39.2**

**Analyzing Information**

**Scenario:**

- **You have had personal experience with injections for immunization. You know that these shots prevent you from catching a particular disease.**
- **How do you actually work? Why are you protected against a specific disease when you receive a vaccination for that disease?**

**Analysis:**

- **Diphtheria toxoid** is a modified form of the toxin produced by the bacterium Corynebacterium diphtheriae. It causes the symptoms associated with the disease diphtheria. When injected into your body, the toxoid prompts the immune system to respond as if it were being attacked by the diphtheria toxin. The graph below shows the human body’s response to receiving an immunization shot of the diphtheria toxoid and then to being infected later on by the diphtheria bacterium.

**Thinking Critically**

1. What is the difference between a toxin and a toxoid?
2. Which cells associated with the immune system are most likely involved with line A-B? With line B-C?
3. Are the events in the graph illustrating innate or acquired immunity?
4. How does the virus reproduce and infects an increasing number of T-cells? The virus then penetrates the cell, where it may remain inactive for months. HIV contains the enzyme reverse transcriptase, which allows the virus to use its RNA to synthesize viral DNA in the host cell.

**Understanding Main Ideas**

1. What role do phagocytes play in defending the body against disease?
2. What role does the body play in defending the body against microorganisms?
3. What is the difference between naturally acquired passive immunity and naturally acquired active immunity?
4. How does histamine release lead to inflammation of a wound?

**Thinking Critically**

- Why is it adaptive for memory cells to remain in the immune system after an invasion by pathogens?

- Sequence the events that occur in the formation of antibody immunity. For more help, refer to Organizing Information in the Skill Handbook.

**Portfolio**

**Types of Immunity**

- **Passive immunity** and **active immunity**.

- **Concept maps** that identify the different types of immunity and describe how they develop. Have students complete their concept maps with the terms Passive Immunity and Active Immunity.

**Forecasting the World**

- **Phagocytes** are white blood cells that ingest and destroy pathogens by surrounding and engulfing them.
- **A lymph node is a small mass of tissue that filters lymph and traps and destroys microorganisms.**
- **Naturally acquired passive immunity** involves a mother passing antibodies to her baby through the placenta or in breast milk. Naturally acquired active immunity involves the disease and forming your own antibodies.
- **Histamine causes blood vessels in the injured area to dilate, making them more permeable to tissue fluid, which leaks out, causing swelling.**
- **Memory cells remain in case the body encounters the same antigen again.**

**Section Assessment**

- **Check for Understanding**
- **Visual-Spatial**
  - Ask students to create a flowchart of B cell and T cell immune reactions.

- **Extension**
  - Ask students to find out the current status of an AIDS vaccine. Have them look in the latest issues of medical and scientific journals.

- **Assessment Skill**
  - Have students explain how the AIDS virus overcome both nonspecific and specific immunity.

**Discussion**

- Ask students to summarize the role of B and T cells in immune reactions.

**4 Close**

- Provide students with a variety of antigen shapes and have students model in proteins, then further wrapped in a lipid coat. The knolllike outer proteins of the virus attach to a receptor on a helper T-cell. The virus can then penetrate the cell, where it may remain inactive for months. HIV contains the enzyme reverse transcriptase, which allows the virus to use its RNA to synthesize viral DNA in the host cell.

- The first symptoms of AIDS may not appear for eight to ten years after initial HIV infection. During this time, the virus reproduces and inflicts an increasing number of T cells.

- Infected persons may eventually develop AIDS. During the early stages of the disease, symptoms may include swollen lymph nodes, a loss of appetite and weight, fever, rashes, night sweats, and fatigue.

- It is not known what percentage of persons infected with HIV will develop AIDS, but present indications are that the majority will. Almost all who develop AIDS die, usually because of infectious diseases or some form of cancer that takes advantage of the body’s weakened immune system.
Getting On-line for Information on Diseases

There are two main categories of disease, infectious and noninfectious. Infectious diseases are caused by pathogens. These diseases, like the common cold or AIDS, are said to be communicable because they can be passed from one person to another. Noninfectious diseases are not caused by a pathogen. These diseases, like cancer or arthritis, are said to be noncommunicable because they are not passed from one person to another.

1. Defining What is a pathogen? Provide several examples.
2. Comparing Describe the difference between a communicable and a noncommunicable disease. Provide several examples of each.
3. Thinking Critically What are vectors? Are they associated with communicable or noncommunicable diseases? Explain your answer.
4. Applying Concepts Explain why the table for noncommunicable diseases does not have a column for organism responsible or method of transmission.
5. Using the Internet What is one advantage of getting information on disease research by way of the Internet rather than from textbooks or an encyclopedia?

Data Table 1

<table>
<thead>
<tr>
<th>Communicable diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease name</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Data Table 2

<table>
<thead>
<tr>
<th>Noncommunicable diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease name</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Definite Strategy
- You may wish to have students complete all or part of this activity at home if they have access to computers, or in the school library or computer center.
- Point out to students that their data tables will have to be expanded in size to accommodate all the information they obtain.
- Have students share their findings with classmates at the conclusion of the activity.

Data and Observations
- Student data and observations will vary, depending on the diseases selected and the information resources used.

Note Internet addresses that you find useful in the space below for quick reference.

Internet Address Book

1075

1. A pathogen is a disease-producing agent. Pathogens include bacteria, viruses, parasites, and fungi.
2. Communicable diseases, such as flu, TB, AIDS can be passed from one person to another while noncommunicable diseases (such as cancer, arthritis) cannot.
3. Vectors are carriers of a pathogen. Since noncommunicable diseases are not caused by pathogens, there are no vectors involved in their transmission.
4. Noncommunicable diseases are not caused by an organism or pathogen.
5. Internet information can be updated more frequently than information printed in textbooks and encyclopedias.

Teaching Strategies
- Collect data on the ten diseases and record in a table.
- Materials access to the Internet
- Use the Internet skill handbook.
- Use the Internet to gather information.

Preparing
- Collect data on the ten diseases and record in a table.
- Materials access to the Internet
- Use the Internet skill handbook.

Procedure
1. Copy the two data tables below.
2. Choose five communicable and five noncommunicable diseases you wish to investigate.
3. List the diseases in your data tables. Try to make your disease choices as specific as possible. For example, cancer as a topic is too broad. Instead, limit your choice to a specific type of cancer, such as breast cancer, prostate cancer, or Hodgkin’s disease.
4. Go to the Glencoe Science Web Site to find links that will provide you with information for this BioLab.
5. Be sure to complete the last two rows asking for current research findings and your sources of information.

Assessment
- Skill: Have students combine their lists of communicable and noncommunicable diseases so that a total of at least 20 diseases are included. Have students use the list to compare characteristics of viral versus bacterial diseases. Use the Performance Task Assessment List for Analyzing the Data in PASC, p. 27.

Sharing Your Data
- Find this BioLab on the Glencoe Science Web Site at www.glencoe.com/sec/science. Post your findings in the data table provided for this activity. Add additional data from other students to your data table. Analyze the data to help you answer the problem posed for this BioLab.

Sharing Your Data
- Internet Address Book
- Internet addresses that you find useful in the space below for quick reference.
New Vaccines

Greater understanding of how the immune system works and rapid advances in gene technology have paved the way for the development of new types of vaccines that offer hope in the fight against some of the world’s most deadly and widespread diseases.

Traditional vaccines have been made from weakened or killed forms of a disease-causing virus or bacterium, or from some of its cellular components or toxins. Although these types of vaccines have helped to prevent disease, they sometimes cause severe side effects. Furthermore, it hasn’t been possible to create vaccines for diseases such as malaria and AIDS using traditional methods. With the help of genetic engineering technology, researchers can now manipulate microbe genes to create entirely new kinds of vaccines.

Recombinant vaccines One revolutionary approach to developing vaccines uses recombinant DNA technology, a process in which genes from one organism are inserted into another organism. The hepatitis B virus vaccine was the first genetically engineered vaccine to be produced in this way. Researchers isolated the gene in the hepatitis virus that codes for the production of the antigen protein that stimulates an immune response. Then they inserted that gene into yeast cells. Like tiny microbial machines, the genetically altered yeast cells produce great quantities of pure hepatitis B antigen, which is then used to make a vaccine.

Applications for the Future An antigen-coding gene from a disease-causing virus such as HIV can be inserted into a non-disease-causing virus such as canarypox virus. When a vaccine made from a carrier virus is injected into a host, the virus replicates and in the process produces the antigen protein, which causes an immune response. This type of vaccine, called a live vector vaccine, shows promise against AIDS.

DNA Vaccines DNA vaccines differ from other vaccines in that only the cloned segment of DNA that codes for a disease-causing antigen is injected into a host—the DNA itself is the vaccine. The DNA can be injected through a hypodermic needle into muscle tissue, or tiny DNA-coated metal beads can be fired into muscle cells using a “gene gun.” Once in the cells, the foreign DNA is expressed as antigen protein that induces an immune response. Researchers currently are working on DNA vaccines for cancer and tuberculosis.

BIO Technology

Purpose
Students learn that genetic engineering technology can be used to develop new vaccines.

Background
Traditional vaccines against rubies, measles, mumps, and many other diseases are made from live, attenuated (weakened) viruses. The virus is grown in laboratory cultures of nonhuman cells and allowed to mutate over several generations. Then a strain is selected that does not produce the disease but does induce an immune response. This strain is used to make the vaccine. There is a danger that the virus could mutate back into the form that produces disease. The advantage of using recombinant DNA to make attenuated vaccines is that mutations in the viral genome can be engineered to ensure that reverse mutation back to a pathogenic form is virtually impossible.

Teaching Strategies
■ Have students research their own vaccination histories and make a chart that lists each vac- cine they have received since birth and approximately when they received it.

Investigating the Technology

A person could be vaccinated against a number of diseases with a single inoculation.
A burn patient loses protective T helper cell acquired immunity in lysozyme, cell walls tissue, lymph...

10. How is malaria transmitted?

a. by Aedes aegypti mosquitoes
b. by the bite of infected ticks
c. by contact with infected body fluids
d. by drinking water infected with the parasite

21. If the bacteria that cause tetanus are easily exposed to air, their ability to grow is______.

a. reduced
b. increased
c. unaffected
d. inhibited

A burn patient loses protective T helper cell acquired immunity in lysozyme, cell walls tissue, lymph...

11. Any disease caused by microorganisms in the body is known as an______ disease.

a. infective
b. toxic

c. allergic

d. infectious

12. Diseases that are constantly present in the population are ________ diseases.

a. endemic
b. epidemic

c. infectious

d. communicable

13. ________ is a body response to an injury characterized by redness, swelling, pain, and heat.

a. vasodilation
b. inflammation

c. infection

d. phagocytosis

14. When ________ fluid collects in open-ended vessels, it is called ________.

a. lymph
b. blood
c. serum

d. pus

15. A(n) ________ is a type of white blood cell that secretes histamine.

a. neutrophil
b. lymphocyte

c. phagocyte

d. mast cell

16. ________ is an enzyme produced in sweat, tears, and saliva, which can break down the ________ of some bacteria.

a. antibody
b. histamine

c. lysozyme

d. interferon

17. ________ is a body response to an injury characterized by reduced blood flow, swelling, pain, and heat.

a. vasodilation
b. inflammation

c. infection

d. phagocytosis

18. Building up resistance to a specific pathogen is called ________.

a. vaccination
b. vaccination

c. immunization

d. immune system

19. A tissue ________ combats invading pathogens by engulfing them.

a. phagocyte
b. lymphocyte

c. plasma cell

d. mast cell

20. ________ is a type of lymphocyte destroyed by HIV.

a. B cell
b. CD4 T cell

c. CD8 T cell

d. plasma cell

23. While building a tree house, you get a tiny splinter in your finger. Two days later, the area is swollen and pus leaks out. Why is there pus around the splinter?

a. fluid collects in open-ended blood vessels
b. fluid collects in open-ended lymph vessels

c. fluid collects in open-ended lymph vessels

d. fluid collects in open-ended vessels and damages the skin

24. A month after buying a new pet parakeet, Susan experienced pains in her legs, followed by chills, fever, diarrhea, and a headache. She recovered after two weeks of antibiotics. When she next visited the pet store, many of the parakeets were ill. How could researchers find out if Susan had the same disease as the birds?

a. check for antibodies to the virus that causes the disease
b. test for histamine levels in the blood

c. test for phagocytes in the lymph

d. test for enteric pathogens in the stool

The graph below shows the progress of a typical HIV infection with signs of the various stages of the AIDS disease.

**Integrating Information** Use the graph to answer these questions.

1. Which variable is the dependent variable?

a. time
b. symptoms
c. antibody level in blood
d. plasma level

2. When does the antibody level begin to rise?

a. at about 4 weeks
b. at about 8 weeks
c. during the AIDS symptom stage
d. at death

3. The HIV virus attacks ________.

a. red blood cells
b. T cells
c. epithelial cells

4. What type of molecule are antibodies?

a. carbohydrates
b. proteins
c. fats
d. nucleic acids

5. Observing and Inferring Explain why AIDS is considered a syndrome rather than a single disease.

**CD-ROM** For additional review, use the assessment options for this chapter found on the Biology: The Dynamics of Life interactive CD-ROM and on the Glencoe Science Web Site: www.glencoe.com/sec/science
How do the human body systems function together? When an Olympic ice-skater performs on the ice, the cells, tissues, organs, and organ systems of the skater’s body function together to help the athlete perform at his or her best and perhaps win a gold medal. All body systems must work together to make an award-winning performance possible.

Levels of Organization

All organisms are made of cells. In complex organisms, such as humans, most cells are organized into functional units called tissues. The four basic tissues of the human body are epithelial, muscle, connective, and nervous tissues. Epithelium covers the body and lines organs, vessels, and body cavities. Muscles are contractile and are found attached to bones and in the walls of organs, such as the heart. Connective tissue is widely distributed throughout the body. It produces blood and provides support, binding, and storage. Nervous tissue transmits impulses that coordinate, regulate, and integrate body systems.

Tissues to Systems

Groups of tissues that perform specialized functions are called organs. Your stomach and eyes are examples of organs. Most organs contain all four basic tissue types. Each of the body’s organs is part of an organ system. An organ system consists of a group of organs that work together to carry out a major life function. The eleven major organ systems of the human body are described in this BioDigest.

SKIN

The skin and its associated structures, including hair, nails, sweat glands, and oil glands, are important in maintaining homeostasis in the body. The skin protects tissues and organs, helps regulate body temperature, produces vitamin D, and contains sensory receptors.

SKELETAL SYSTEM

The skeletal system consists of the axial skeleton and appendicular skeleton. The axial skeleton supports the head and includes the skull and the bones of the back and chest. The appendicular skeleton contains the bones associated with the limbs. The entire skeleton, which is made up of 206 bones, has many functions. It provides support for the softer, underlying tissues; provides a place for muscle attachment; protects vital organs; manufactures blood cells; and serves as a reservoir for calcium and phosphorus.

JOINTS: WHERE BONES MEET

The place where two bones meet is called a joint. Joints can be immovable, such as the joints in the skull; or movable, such as the shoulder joints. The shoulder joint is called a ball-and-socket joint; the elbow joint is a hinge joint. The wrists have gliding joints, and the neck has pivot joints.

Skin

Skin structure varies somewhat from place to place on the body.
**Muscular System**

The muscular system includes three types of muscles: smooth, cardiac, and skeletal.

**Smooth Muscle**

Smooth muscles are found in the walls of hollow internal organs, such as the stomach or blood vessels. These muscles are not under conscious control and are called involuntary muscles. Smooth muscle cells are spindle shaped and contain a single nucleus.

**Skeletal Muscle**

Skeletal muscles can be involved, either voluntarily or by reflex actions.

**Heart Muscle**

Cardiac muscle tissue is found only in the heart. These cells contain a single nucleus and striations made up of organized protein filaments that are involved in contraction of the muscle. Like smooth muscle, cardiac muscle is involuntary muscle. Cardiac muscle has the unique ability to contract without first being stimulated by nerve tissue.

**Digestive System**

The digestive system receives food and breaks it down so it can be absorbed by the body’s cells. The digestive system also eliminates food materials that are not digested or absorbed. Foods are broken down into simpler molecules that can move through cell membranes and be transported to all parts of the body by the bloodstream or the lymphatic vessels. The digestive system includes the mouth, tongue, teeth, salivary glands, pharynx, esophagus, stomach, liver, gallbladder, pancreas, and small and large intestines.

**Blood Glucose Levels**

L evels of glucose in the blood are maintained all day long by hormones secreted by the pancreas. After a meal, the sugars from the food are transported into the blood, raising the blood glucose level. The pancreas secretes insulin, which helps the body take up the sugar or convert it to glycogen in the liver to be stored for later use. The pancreas secretes glucose-lowering hormones that would increase blood glucose levels. Discuss what happens in terms of insulin after the body takes in sugar.

**Meeting Individual Needs**

**Hearing Impaired/Learning Disabled**

Visual-Spatial: Have hearing impaired students make flash cards with a body system named on one side of the card and its functions on the other side. Students can use the cards as a study aid.

**PROJECT**

**Photo Essay of Body Systems**

Visual-Spatial: Have students become familiar with the different body systems by asking groups of two or three students to use pictures from magazines to prepare a photo essay representing one body system. They should present their essays to the class and learn about the systems through oral explanation.

**PROJECT**

**Daily Calorie Intake**

Logical-Mathematical: Have students keep track of what they eat and all of their activities (including resting, sleeping, watching TV, etc.) for 48 hours. Students can use a calorie guide to estimate their daily calorie intake and an activity guide to calculate their calorie usage.

**Quick Demo**

X rays of the skeletal system and barium X rays of the digestive system can be viewed by hanging them on classroom windows or projecting them with an overhead projector. Use the X rays to discuss the parts and functions of each of these systems.

**Enrichment**

Have a doctor from a sports medicine clinic speak to the class concerning fitness and the effects of sports injuries on the muscular system and other body systems.

**Chalkboard Activity**

Make a list of the items students have eaten in the last two days that would increase blood glucose levels. Discuss what happens in terms of insulin after the body takes in sugar.
The endocrine system controls all of the metabolic activities of body structures. This system includes all of the glands in the body that secrete chemical messengers called hormones. Hormones travel in the bloodstream to target tissues, where they alter the metabolism of the target tissue. Some of the major endocrine glands include the pituitary, thyroid, parathyroid, adrenals, pancreas, ovaries, and testes.

Nervous System

The organs of the nervous system include the brain, spinal cord, nerves, and sensory receptors. These organs contain nerve cells, called neurons, that conduct impulses. Nerve impulses allow the neurons to communicate with each other and with the cells of muscles and glands. Each impulse consists of an electrical charge that travels the length of a neuron’s cell membrane. Between two neurons there is a small gap called a synapse. When one neuron is stimulated, it releases chemicals called neurotransmitters into the synapse, which stimulates a change in electrical charge in the next neuron. Nerve impulses travel through the body this way, from neuron to neuron.

The major glands of the endocrine system secrete hormones that regulate body functions.

Sensory Receptors

Some nerve cells act as sensory receptors that detect changes inside and outside of the body. These neurons carry impulses to the spinal cord and brain. The brain and spinal cord then send impulses to muscles or glands, stimulating them to contract or secrete hormones. This interconnection provides coordination between the nervous system and the endocrine system.

Respiratory System

The organs of the respiratory system exchange gases between blood and the air. During inhalation, oxygen in the air passes into the blood from small air sacs called alveoli in the lungs. Body cells use oxygen to break down glucose to make ATP needed for metabolism. Carbon dioxide (CO₂) is produced by the breakdown of glucose and is transported to the lungs by the blood. In the lungs, carbon dioxide diffuses out of the blood and into the alveoli. It is forced out of the lungs during exhalation. The major organs of the respiratory system are the nasal cavity in the nose, the pharynx, larynx, trachea, bronchi, and lungs.

The respiratory system filters the air as it passes into the nose, down the air passages, and into the lungs.

The lungs

The lungs contain many small sacs called alveoli, where gas exchange with the blood occurs.

Respiration

Breathing: At rest, humans inhale and exhale about 12 to 20 times per minute, moving about 15 L of air per minute, and inhaling 21.6 cubic meters of air each day. Lungs: Lung weight about 2.3 kg each. The right lung has three lobes and the left lung has two lobes. There are 300 million alveoli in the lungs. Flattened out, they would cover 360 square meters. Sneeze: A sneeze ejects particles at 165.76 km/hr.

VITAL STATISTICS

Interpreting and acting on information sent to the central nervous system (brain and spinal cord) is the major job of the nervous system.

Quick Demo

Kinesthetic: To demonstrate a protective reflex, have a student hold up a piece of Plexiglas in front of his or her face. Have another student throw a soft ball, such as Nerf ball, at the student’s face. Have another student of Plexiglas in front of his or her face. Have another student hold up a piece of Plexiglas in front of the student’s face. Have another student throw a soft ball, such as Nerf ball, at the student.

Enrichment

Have students choose a disease (infectious or noninfectious) of the respiratory system to research in the library or on the Internet.
**Urinary System**

Metabolic waste products are created during the breakdown of amino acids. The urinary system removes these metabolic wastes from the body. Kidney transplants.

- **Kidney**
- **Ureter**
- **Bladder**
- **Urethra**

The urinary system filters the blood, collects urine, and excretes urine from the body.

**Reproductive System**

The reproductive system is involved in the production of gametes. The male reproductive system produces and maintains sperm cells and transfers them into the female reproductive tract. The female reproductive system produces and maintains egg cells, receives and transports sperm cells, and supports the development of the fetus.

- **Testis**
- **Sperm ducts**
- **Seminal vesicles**
- **Prostate gland**

The male reproductive system.

- **Ovary**
- **Fallopian tube**
- **Uterus**
- **Vagina**

The female reproductive system.

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**Urinary**

1. **Kidney**
2. **Ureter**
3. **Bladder**
4. **Urethra**

The urinary system filters the blood, collects urine, and excretes urine from the body.

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**Reproductive**

1. **Testis**
2. **Sperm ducts**
3. **Seminal vesicles**
4. **Prostate gland**

The male reproductive system.

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**VITAL STATISTICS**

**Reproduction**

- **Testes**: The testes contain 244 m of tubules in which sperm cells are continually produced by meiosis.
- **Ovaries**: At birth, a female already has about 2 million eggs. About 300,000 survive to puberty, but only 450 or so mature and are expelled from the ovary during her lifetime.

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**Circulatory System**

The circulatory system includes the heart, blood vessels (arteries, veins, and capillaries), and blood. The muscular heart pumps blood through the blood vessels. The blood carries oxygen and nutrients to the body cells and other waste products to the excretory system.

**Systolic Pressure**

When the rapid rush of blood through the arteries slows, the gauge measures a pressure called the systolic pressure. This is the highest pressure in the vessels, just before the two ventricles contract. Blood pressure readings give both the systolic and the diastolic pressure. The systolic pressure is used to evaluate artery condition.

**Diastolic Pressure**

When the force of the heart and blood vessels. Blood pressure measurements give an indication of the health of the heart and blood vessels.

**Systolic Pressure**

When the cuff of the blood pressure machine squeezes the arm, it blocks the blood flow in an artery. At the pressure in the cuff is released, a gauge attached to the cuff measures the pressure in the artery as blood flows back into the body. This is the systolic pressure, which is a measure of the pressure when the right and left ventricles contract.

**Diastolic Pressure**

When the first rush of blood through the arteries slow, the gauge measures a pressure called the diastolic pressure. This is the lowest pressure in the vessels, just before the two ventricles contract. Blood pressure readings give both the systolic and the diastolic pressure of the arteries. Blood pressure is used to evaluate artery condition.

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**Your Blood Pressure**

Blood pressure measurements give an indication of the health of the heart and blood vessels.

- **Systolic Pressure**
- **Diastolic Pressure**

**Assessment**

Knowledge: Assign each student one component of a body system. Have students write a description of their assigned component and how it interacts with the body system and the entire organism.

**Extension**

Have students interested in a career in sports medicine visit with a trainer from their high school or local college team to find out what type of education is needed to become an athletic trainer.

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**BiQuest: Reproductive Systems**

Unit 2, Side 2, 19 min. 57 sec.

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**Gifted**

Linguistic. Have gifted students research the factors involved in the development of arteriosclerosis and its treatment.

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**Meeting Individual Needs**

GLOMEN

**Quick Demo**

Ask the school nurse to demonstrate measuring blood pressure on a few students in the class.
A lymphocyte attacks pathogens

The lymphatic system

Lymphatic System

Fluids leak out of capillaries and bathe body tissues. The lymphatic system, also known as the immune system, transports this tissue fluid back into the bloodstream. As tissue fluids pass through lymphatic vessels and lymph nodes, disease-causing pathogens and other foreign substances are filtered out and destroyed. Immune immunity involves the action of several types of white blood cells that protect the body against any type of pathogen. Macrophages and neutrophils engulf foreign substances that enter the body. If the infection persists, the lymphatic system becomes involved. The body develops an acquired immune response that defends against the specific pathogen. Acquired immunity involves helper T cells that pass on chemical information about the pathogen to B cells. B cells produce antibodies that disarm or destroy the invaders. Some B cells remain in the body as memory B cells that recognize the antigens if they ever invade the body again. This process provides the body with acquired natural immunity against disease.

The lymphatic system includes lymph nodes, tonsils, the thymus gland, and spleen. T cells mature in the thymus. The spleen stores both T cells and B cells.

Understanding Main Ideas

1. Which of the following is NOT one of the levels of organization of cells in the human body?
   a. tissue  c. organ system  b. organ  d. receptor

2. Which of the following systemsmanufactures blood cells?
   a. skin  b. circulatory system  c. skeletal system  d. respiratory system

3. Which type of muscle fibers line hollow internal organs?
   a. smooth  b. skeletal  c. cardiac  d. voluntary

4. Which of the following organs is NOT a part of the digestive system?
   a. tongue  b. spleen  c. liver  d. pancreas

5. Oxygen is needed by your body cells to
   a. produce carbon dioxide in the cells
   b. break down glucose to make ATP
   c. exchange gas in the alveoli of the lungs
   d. provide muscles with energy to contract

6. What type of event occurs at the synapse between two neurons?
   a. Calcium passes from one cell to another cell.
   b. A neurotransmitter passes from one neuron to the next neuron.
   c. A wave of electrical charges passes from one cell to the next cell.
   d. Sensory receptors detect changes inside the body.

7. Which system secretes hormones to control the metabolic activities of the body structures?
   a. endocrine system  b. nervous system  c. circulatory system  d. excretory system

8. Which type of immune cell creates antibodies against foreign invaders?
   a. red blood cells  b. spleen cells  c. B cells  d. T cells

9. Urine contains the metabolic waste products from the digestion of
   a. glucose  b. amino acids  c. water  d. fat

10. The highest blood pressure, systolic pressure, is the force created by
    a. the lungs  b. the atroventricular valves  c. the atroventricular valves  d. the arteries

Thinking Critically

1. The nervous system receives information from the inside and outside of the body, interprets it, and acts on the information by stimulating muscles or glands. The endocrine system secretes hormones that regulate metabolic activities of body structures.

2. The disease destroys T cells, thereby removing the very immune cells capable of killing agents that cause infections.

3. Digestive, respiratory, and urinary systems

4. The respiratory system delivers oxygen, which is transported by the circulatory system to the body cells. The circulatory system delivers carbon dioxide from the body cells to the lungs for elimination from the body.

5. Breaking a bone will disrupt capillaries, causing bleeding. Blood clots must be formed until the capillaries can be healed. Breaking a bone could also disrupt blood cell production from that area until healing restores the bone.