Name Date Class

Section 39.2

Defense Against Infectious Diseases

Before You Read

Have you ever been around someone who was sneezing and coughing? Did you later get sick, or were you able to fight off the infection? Why do you think that you sometimes catch other people's *bugs* and other times you do not? On the lines below, write a sentence about the last time you got sick. Then explain why you think your body was unable to defend itself.

Read to Learn

STUDY COACH

Mark the Text **Identify Main Ideas** As you read this section, highlight the main ideas. Then study the ideas and restate them in your own words.

Reading Check

1. What is your body's first barrier against pathogens?

Innate Immunity

Your body produces a variety of white blood cells. These cells defend your body against invasion by pathogens. No matter what pathogens are present, a healthy immune system is always ready. The body's **innate immunity** is always present and defends the body against any and all pathogens.

How do skin and body secretions protect you?

When a potential pathogen comes in contact with your body, often the first barrier it meets is your skin. Skin keeps many microorganisms from entering the body.

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

What causes inflammation of body tissues?

If a pathogen gets past the skin and body secretions, your body has several other nonspecific defense mechanisms. These can

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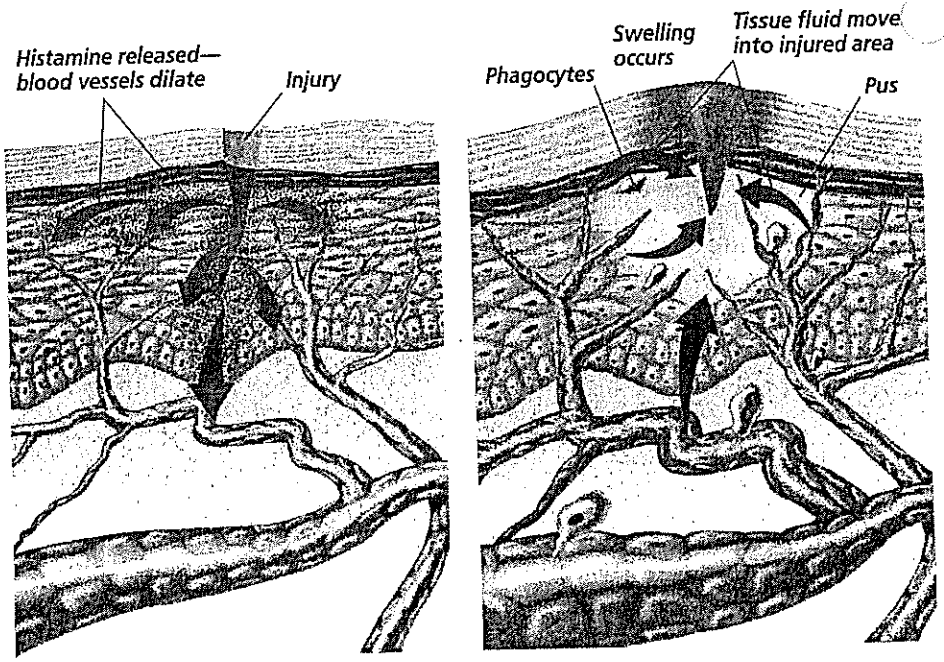
destroy the invader and restore homeostasis. Think about what happens when you get a splinter. If bacteria or other pathogens enter and damage body tissues, inflammation (ihn fluh MAY shun) results. Inflammation has four symptoms—redness, swelling, pain, and heat. The figure to the right shows what happens when inflammation begins. First, damaged tissue cells called mast cells and white blood cells called basophils release histamine (HIHS tuh meen).



Histamine causes blood vessels in the injured area to dilate, or enlarge. 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 helps restore homeostasis. This increase in tissue fluid causes swelling and pain, and may also cause the area to become warmer. Inflammation can occur with other types of injuries as well as infections. Physical force, chemical substances, extreme temperatures, and radiation can cause inflammation.

Reading Check

2. What causes blood vessels in an injured area to dilate?

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What is phagocytosis of pathogens?

Pathogens that enter your body may encounter cells that engulf and destroy them, a process known as phagocytosis. **Phagocytes** (FA guh sites) are white blood cells that destroy pathogens by surrounding and engulfing them. They are like fighter cells attacking and devouring the invaders they encounter. Phagocytes include monocytes. Monocytes develop into macrophages. Phagocytes also include neutrophils and eosinophils.

Macrophages are white blood cells that provide the first defense against pathogens that have entered the tissues. Macrophages are sometimes called giant scavengers or big eaters because of the manner in which they engulf pathogens or damaged cells. They will attack anything they recognize as foreign. Enzymes inside the macrophage digest the particles it has engulfed.

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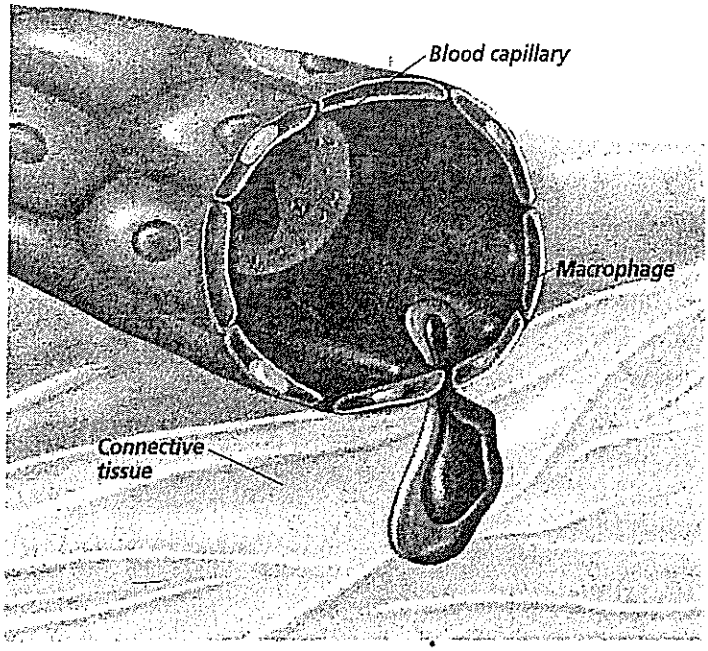

If the macrophages do not stop the infection, another type of phagocyte, called a neutrophil, is attracted to the site. Neutrophils also destroy pathogens by engulfing and digesting them.

If the infection is still not stopped, a third type of phagocyte arrives on the scene. Monocytes are small, immature macrophages that circulate in the bloodstream. These cells squeeze through blood vessel walls to move into the infected area. Once they reach the site of the infection, they mature into macrophages. They begin consuming pathogens and dead neutrophils. Once the infection is over, some monocytes mature into tissue macrophages. They remain in the area and prepare to guard against new infections.

Reading Check

3. What clears away pus?

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After a macrophage has destroyed large numbers of pathogens, dead neutrophils, and damaged tissue cells, it eventually dies. After a few days, infected tissue develops a substance called pus. **Pus** consists of living and dead white blood cells, living and dead pathogens, and body fluids. Pus formation usually continues until the infection subsides. Eventually, the pus is cleared away by macrophages.

What are protective proteins?

When an infection is caused by a virus, the body faces a problem. Phagocytes alone cannot destroy viruses. Recall that a virus multiplies within a host cell. A phagocyte that engulfs a virus will be destroyed if the virus multiplies within it. One way your body can counteract viral infections is with interferons. **Interferons** are proteins that protect cells from viruses. Interferons are host-cell specific. This means that human interferons will protect human cells from viruses but cannot protect cells of other species from the same virus.

Acquired Immunity

The cells of your innate immune system continually check your body for foreign invaders. When a pathogen is detected, these cells defend your body. As the infection continues, another type

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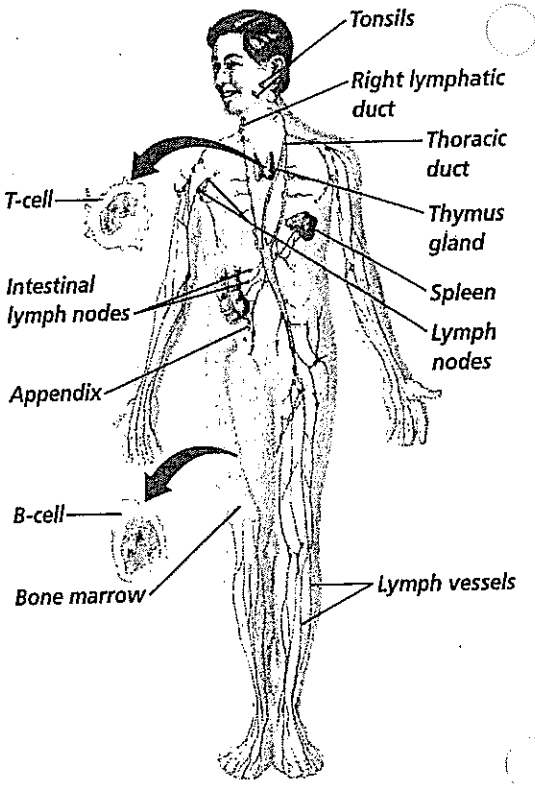
of immune response that fights the invading pathogen is activated. Certain white blood cells gradually develop the ability to recognize a specific foreign substance. This acquired immune response causes these white blood cells to destroy the pathogen. Defending against a specific pathogen by gradually building up a resistance to it is called **acquired immunity.**

Normally, the immune system recognizes components of the body as something that belongs to the body. It recognizes foreign substances, called antigens, as not belonging. An acquired immune response begins when the immune system recognizes an antigen. It responds by producing antibodies against it. Antigens are foreign substances that stimulate an immune response. Antibodies are proteins in the blood that correspond specifically to each antigen. The development of acquired immunity is the job of the lymphatic system. The process of acquiring immunity to a specific disease can take days or weeks. The illustration at right shows the lymphatic system.



What is the lymphatic system?

Your lymphatic (lihm FA tihk) system not only helps the body defend itself against disease, but also maintains homeostasis by keeping body fluids at a constant level.

Body cells are constantly bathed in fluid. This **tissue fluid** is composed of water and dissolved substances that 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.**

What are the glands of the lymphatic system?

At locations along the lymphatic system, the lymph vessels pass through lymph nodes. A **lymph node** is a small mass of tissue that contains lymphocytes. It filters pathogens from the lymph. A **lymphocyte** (LIHM fuh site) is a type of white blood cell that defends the body against foreign substances.

Tonsils are large clusters of lymph tissue located at the back of the mouth cavity and at the back of the throat. They form a protective ring around the openings of the nasal and oral cavities. Tonsils protect against bacteria and other pathogens that enter your nose and throat.

Reading Check

4. What function do lymph nodes serve?

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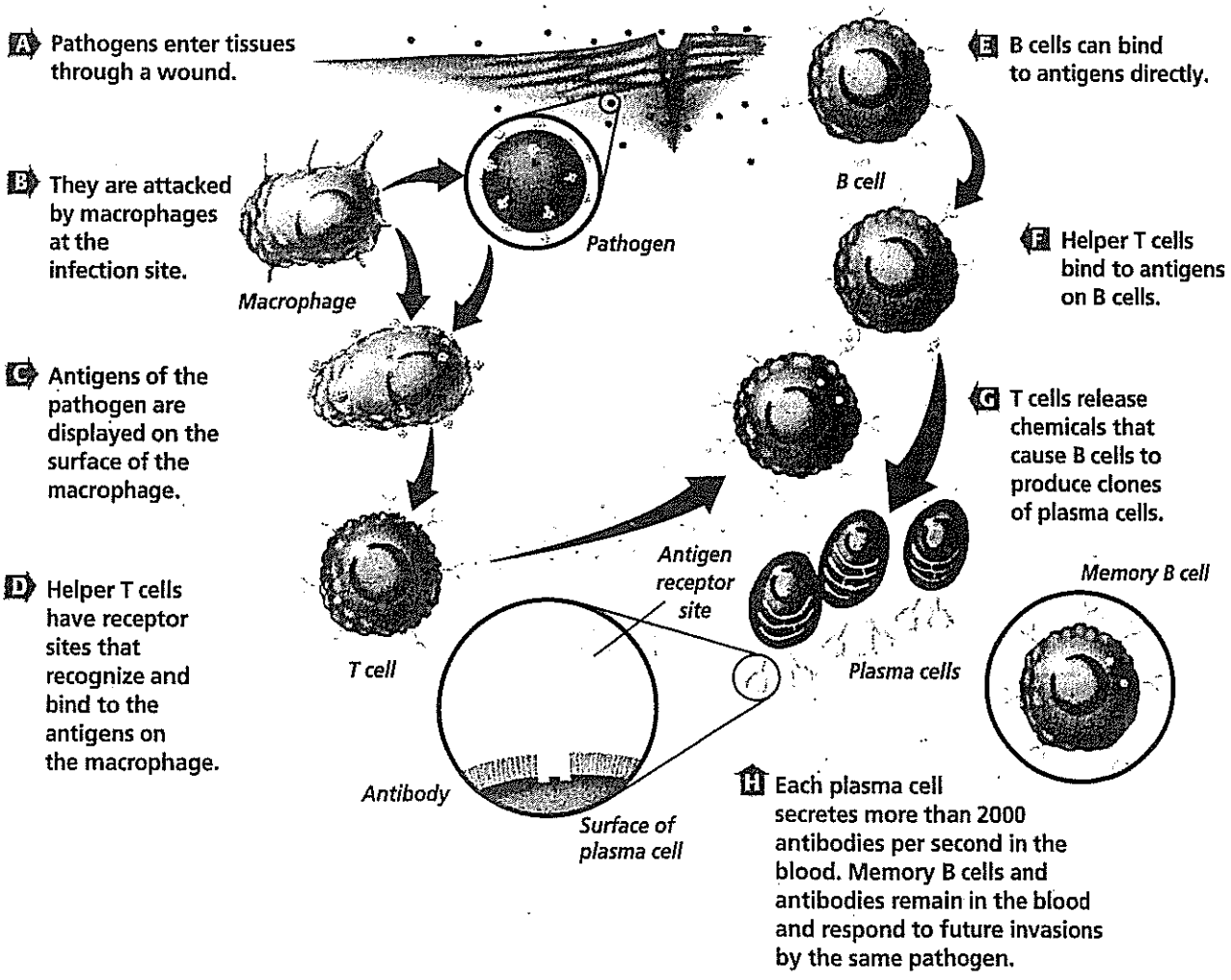
The spleen is an organ that stores certain types of lymphocytes. It also filters and destroys bacteria and worn-out red blood cells. The spleen does not filter lymph.

Another important part of the lymphatic system is the thymus gland. It is located above the heart. The thymus gland stores immature lymphocytes until they mature and are released into the body's defense system.

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 in your body that involves several types of cells. The illustration below shows how antibody immunity defends your body against pathogens.



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When a pathogen invades the body, it is attacked by the cells of your innate immune system. If the infection is not controlled, then your body builds up acquired immunity. It produces antibodies to use against the antigen. A type of lymphocyte 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.

One kind of T cell, a helper T cell, interacts with B cells. A **B cell** is a lymphocyte that becomes a plasma cell and makes antibodies when activated by a T cell. B cells are made in the bone marrow. Plasma cells release antibodies into the bloodstream and tissue spaces. Some activated B cells do not become plasma cells but remain in the bloodstream as memory B cells. Memory B cells are ready to respond if the same pathogen invades the body again.

Cellular Immunity

Cellular immunity also involves T cells with antigens 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. They are specific for a single antigen. However, unlike B cells, they do not form antibodies. Cytotoxic T cells produce identical clones. They travel to the infection site and release enzymes directly into the pathogens, which die.

The cells that protect the body against pathogens sometimes can cause problems within the body. The immune system may overreact to a harmless substance such as pollen. Mast cells release histamines in large amounts. This causes the symptoms of an allergic reaction: sneezing, increased mucus production in the nasal passages, and redness. The immune system also can attack its own cells. This attack of the body's own tissue is called an autoimmune disorder. Lupus and rheumatoid arthritis are autoimmune disorders. T cells and antibodies also can attack transplanted tissue, such as a kidney or heart, which comes from outside the body.

Passive and Active Immunity

Acquired immunity to a disease may be passive or active. Passive acquired immunity develops by acquiring antibodies that are generated in another host. Active acquired immunity develops when your body produces antibodies in response to being exposed to antigens.

Reading Check

5. What happens when the immune system overreacts to a harmless substance such as pollen?

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How does passive immunity develop?

Passive immunity may develop in two ways. Natural passive immunity develops when antibodies are transferred from a mother to her unborn baby through the placenta or to a newborn infant through the mother's milk. Artificial passive immunity occurs when a human is injected with antibodies from a person or animal who is already immune.

How does active immunity develop?

Active immunity can be gained naturally. When a person is exposed to particular antigens, the body produces antibodies that correspond to these antigens. When a person recovers from the infection, that person will usually be immune to the pathogen for the rest of his or her life.

Active immunity can be created artificially. This is done through vaccinations, usually a shot or injection, with a particular vaccine. A **vaccine** is a substance that consists of weakened, dead, or incomplete portions of pathogens or antigens. When a vaccine is injected into the body, it causes an immune response. Vaccines produce immunity because the body reacts as if it were infected with the disease.

In the late 1790s an English doctor named Edward Jenner demonstrated the first safe vaccination procedure. Dr. Jenner knew that people who worked with dairy cows sometimes acquired cowpox from cows that had the disease. Cowpox is similar to smallpox but is a much milder disease. Dairy workers who had had cowpox did not catch smallpox.

Jenner decided to test whether immunity to cowpox would create immunity to smallpox. Jenner infected a young boy with cowpox. The boy developed a mild cowpox infection. Six weeks later, Jenner scratched the boy's skin with smallpox viruses. The boy did not get sick. He had acquired active immunity to smallpox from the cowpox vaccination. The viruses for cowpox and smallpox are so similar that the immune system can't tell them apart.

AIDS and the Immune System

In 1981, a number of cases of a rare pneumonia appeared in the San Francisco, California, area. The pneumonia was caused by a protozoan. Medical investigators noticed a relationship between this pneumonia and a rare form of skin cancer called Kaposi's sarcoma. The pneumonia and the skin cancer seemed to be associated with a failure throughout the body's immune system.

Think it Over

6. Compare How do humans develop active immunity by artificial and natural means?

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Reading Check

7. Why did dairy workers who had cowpox not get smallpox during smallpox epidemics?

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By 1983, the pathogen that caused this immune system disease had been identified. It is a retrovirus. The disease is now known as Human Immunodeficiency (ih myew noh dih FIH shun see) Virus, or HIV. HIV kills helper T cells in the body. HIV leads to Acquired Immune Deficiency Syndrome, or AIDS.

How is HIV spread?

The disease HIV is spread from an infected person through blood or body fluids. This can occur through direct contact with the infected blood or body fluids. It also can occur through contact with objects that have been contaminated by infected blood or body fluids. Intimate sexual contact and use of contaminated intravenous needles are known methods of disease transmission. HIV also can be transmitted by blood transfusion if the blood is contaminated. A pregnant woman who has HIV can transmit it to her fetus. The virus also can be transmitted through breast milk.

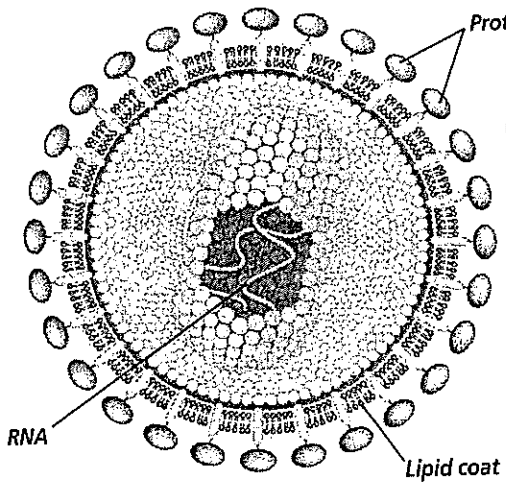
Since 1985, blood banks in the United States have carefully screened donated blood. This has helped to prevent HIV-infected blood from being used during blood transfusions.

Abstinence from intimate sexual contact protects against HIV and other sexually transmitted diseases. HIV transmission can be prevented among users of illegal drugs if they do not share needles.

The HIV virus is two copies of RNA wrapped in proteins. They are wrapped again in a lipid coat. The knoblike outer proteins of the virus attach to a receptor on a helper T cell. Once attached, the virus can penetrate the cell. The virus may remain inactive for months. HIV contains the enzyme reverse transcriptase. This enzyme allows the virus to use its RNA to synthesize viral DNA in the host cell.

Reading Check

8. How does a person become infected with HIV?



What are the symptoms of AIDS?

The first symptoms of AIDS may not appear for as many as ten years after a person is infected. During this time, the HIV virus reproduces, infecting more and more T cells. People infected with HIV may develop AIDS. Early symptoms of AIDS may include swollen lymph nodes, loss of appetite, weight loss, fever, rashes, night sweats, and fatigue.

It is not known how many people who are infected with HIV will develop AIDS. AIDS weakens the body's immune system and the body cannot fight off other infectious diseases or certain forms of cancer.

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After You Read

Mini Glossary

acquired immunity: the body's defense against a specific pathogen by gradually building up a resistance to that pathogen

B cell: a lymphocyte that, when activated by a T cell, becomes a plasma cell and produces antibodies

innate immunity: the ability of your immune system to defend the body against any and all pathogens; white blood cells play a significant role in providing innate immunity for your body

interferon: a host-cell-specific protein that protects cells of one species from viruses

lymph: tissue fluids composed of water and dissolved substances from the blood that have collected and entered the lymph vessels

lymph node: small mass of tissue made of an interlaced network of connective tissue fibers that contains lymphocytes. It filters pathogens from the lymph.

lymphocyte (LIHM fuh site): type of white blood cell that defends the body against foreign substances

macrophage: white blood cell that provides first defense against pathogens that have entered body tissues; giant cells that surround and engulf pathogens, and lysosomal enzymes inside the macrophage digest the engulfed particle

phagocyte (FAG uh site): white blood cell that destroys pathogens by surrounding and engulfing them

pus: a collection of living and dead white blood cells, living and dead pathogens, and body fluids

T cell: lymphocyte produced in bone marrow and processed in the thymus gland

tissue fluid: composed of water and dissolved substances that diffuse from the blood into the spaces between the cells that make up the surrounding tissues

vaccine: a substance consisting of weakened, dead, or incomplete portions of pathogens or antigens that, when injected into the body, causes an immune response

1. Review the terms and their definitions in the Mini Glossary above. On the lines below, use at least three terms to describe how the lymphatic system works and how it helps protect the human body from infection.

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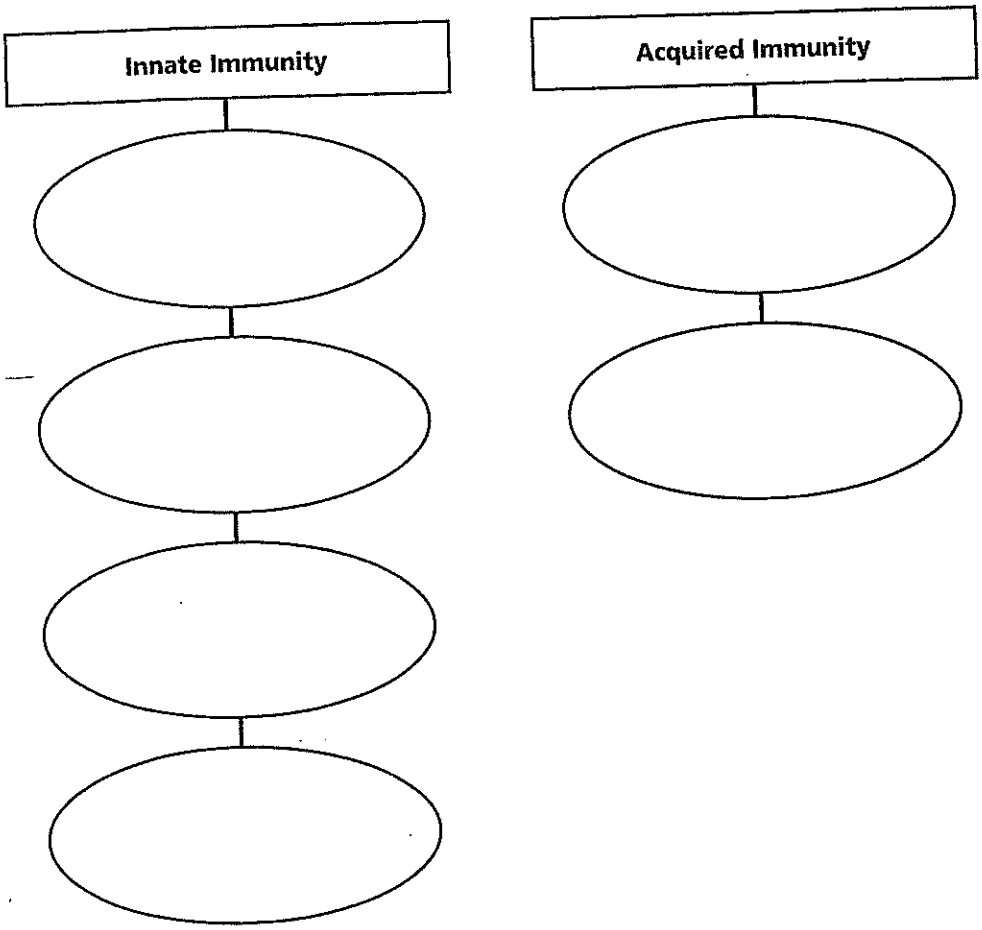
2. Fill in items from the list below to complete the diagram.

the lymphatic system
skin and body secretions
phagocytosis of pathogens
inflammation of body tissue
glands of the lymphatic system
protective proteins



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