

14

The Lymphatic System and Immunity

FOCUS: The lymphatic system includes lymph, lymphocytes, lymphatic vessels, lymph nodes, tonsils, the spleen and the thymus gland. The lymphatic system helps maintain fluid

balance in the tissues, absorbs fats and other substances from the digestive tract, and is part of the body's defense system.

CONTENT LEARNING ACTIVITY

Lymphatic Capillaries and Vessels

“The lymphatic system, unlike the circulatory system, only removes fluid from tissues.”

Match these terms with the correct statement or definition:

Lymphatic capillaries
Lymphatic vessels

Right lymphatic duct
Thoracic duct

1. Tiny, closed-ended vessels consisting of simple squamous epithelium.
2. One-way valves present; lymphatic capillaries branch from these.
3. Large lymphatic vessel that empties into the left subclavian vein; drains all but right head, neck, chest and upper arm.



Contraction of surrounding skeletal muscle, contraction of smooth muscle in lymphatic vessel walls, and pressure changes in the thorax during respiration are factors that assist the movement of lymph through lymphatic vessels.

Lymphatic Organs

“Lymphatic organs contain lymphatic tissue, which consists of lymphocytes and other cells.”

Using the terms provided, complete these statements:

Divide
Immune
Lymphatic organs

Microorganisms
Red bone marrow
Reticular

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Lymphocytes originate from (1) and are carried by the blood to (2). When the body is exposed to microorganisms or foreign substances, the lymphocytes (3) and increase in number. Lymphocytes are part of the (4) response that destroys microorganisms and foreign substances. In addition to cells, lymphatic tissue has very fine (5) fibers. This fiber network holds lymphocytes and other cells in place, and when blood or lymph filters through, traps (6) and other items in the fluid.

Tonsils

“There are three groups of tonsils.”

A. Match these terms with the correct statement or definition:

Lingual tonsils
Palatine tonsils

Pharyngeal tonsils

- _____
- _____
- _____

1. "The tonsils" located on each side of the posterior opening of the oral cavity.
2. Located near the internal opening of the nasal cavity; also called the adenoid.
3. Located on the posterior surface of the tongue.

B. Match these terms with the correct parts labeled in figure 14.1:

Lingual tonsil
Palatine tonsil
Pharyngeal tonsil

1. _____
2. _____
3. _____

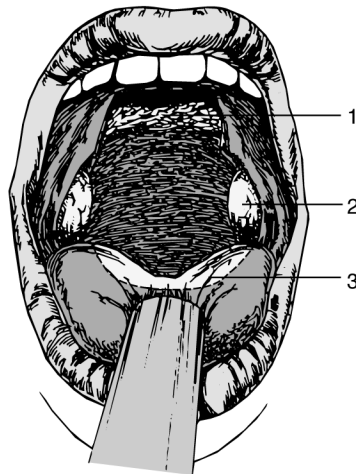


Figure 14.1

Lymph Nodes

““ *Lymph nodes are small, round structures distributed along various lymphatic vessels.* ””

A. Match these terms with the correct statement or definition:

Germinal centers
Lymph nodules

Lymph sinus

1. Lymphocytes and other cells that form dense aggregations of tissue in a lymph node.
2. A space between lymphatic tissue in the lymph node; contains macrophages on a network of fibers.
3. Areas of rapidly dividing lymphocytes within a lymph node.

B. Match these aggregations of lymph nodes with the correct location:

Axillary
Cervical

Inguinal

1. Lymph nodes in the groin area.
2. Lymph nodes in the armpit area.
3. Lymph nodes in the neck area.



As lymph moves through the lymph nodes, two things happen: the immune system is activated, and microorganisms and foreign substances are removed from the lymph by macrophages.

Spleen

““ *The spleen filters blood instead of lymph, and has two types of lymphoid tissue.* ””

Using the terms provided, complete these statements:

Blood
Erythrocytes
Foreign substances
Lymphocytes

Macrophages
Red pulp
White pulp

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

The spleen filters (1) instead of lymph. The spleen contains (2), which surrounds arteries within the spleen, and (3), which is associated with veins. The spleen detects and responds to (4) in the blood, destroys worn out (5), and acts as a (6) reservoir. (7) in the white pulp can be stimulated in the same manner as in lymph nodes, and (8) in the red pulp remove foreign substances and worn out erythrocytes through phagocytosis.

Thymus

“The thymus is a bilobed gland located in the superior mediastinum.”

Using the terms provided, complete these statements:

Blood
Decreases
Degenerate
Foreign substances

Increases
Lymphocytes
Thymic tissues

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

In a newborn, the thymus is large. It continues to grow slowly until puberty, but after puberty the thymus (1) in size. The thymus functions as a site for the production and maturation of (2). Large numbers of lymphocytes are produced in the thymus, but for unknown reasons, most (3). While in the thymus, lymphocytes do not respond to (4). After the lymphocytes have matured, they enter the (5) and travel to other (6), where they help to protect against microorganisms and other foreign substances

Immunity

“Immunity is the ability to resist damage from foreign substances such as microorganisms and harmful chemicals.”

Match these terms with the correct statement or definition:

Innate immunity
Adaptive immunity

1. Identical response occurs each time the body is exposed to a given substance.
2. Response to a substance during the second exposure is faster and stronger than during the first exposure; exhibits specificity and memory.
3. Response results in a person being immune to harmful effects of a bacteria or virus.

Innate Immunity

“Innate immunity includes mechanical means, chemicals, cells, and the inflammatory response.”

A. Match these chemicals with the correct description or example:

Cell surface chemicals
Complement
Inflammatory chemicals

Mechanical mechanisms
Viral protection chemical

1. Prevent the entry of microorganisms into the body; e.g., skin, mucous membranes, tears, saliva, and urine.
2. Lysozyme and mucus.
3. Histamine, complement, leukotrienes, and prostaglandins.
4. Cause vasodilation, increase vascular permeability, and stimulate phagocytosis.
5. A group of plasma proteins activated by foreign substances or antibodies; promote inflammation, phagocytosis, and lysis.
6. Interferons.

B. Match these terms with the correct statement or definition:

Macrophages
Mononuclear phagocytic system

Phagocytes
Neutrophils

1. General term for cells that are capable of ingestion and destruction of particles.
2. Small phagocytic leukocytes that are usually the first cells to enter infected tissue.
3. Monocytes that leave the blood, enter tissues, and enlarge fivefold.
4. Group name for monocytes and macrophages.



Leukocytes are produced in red bone marrow and lymphatic tissue and are released into the blood. Leukocytes detect and move toward chemicals (chemotaxis) such as complement, leukotrienes, kinins, and histamine, which are released from damaged cells.

C. Match these terms with the correct statement or definition:

Eosinophils
Basophils and mast cells

Natural killer cells

1. Cells that release inflammatory chemicals such as histamines and leukotrienes.
2. Cells that release enzymes that break down chemicals released by basophils and mast cells.
3. Lymphocytes produced in red bone marrow that kill tumor and virus-infected cells, but have no memory response.

Inflammatory Response

“The inflammatory response is a complex sequence of events involving both chemicals and cells.”

A. Using the terms provided, complete these statements:

Chemical mediators
Chemotactic
Complement
Fibrin

Vascular
permeability
Vasodilation

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

Most inflammatory responses are similar. The microorganism itself or damage to tissues causes the release or activation of (1), such as histamine, prostaglandins, leukotrienes, complement, and kinins. The chemicals produce several effects: (2), which increases blood flow and brings phagocytes and other leukocytes to the area; (3) attraction of phagocytes, which leave the blood and enter tissues; and increased (4), allowing fibrinogen and complement to enter tissues from the blood. Fibrinogen is converted to (5), which prevents the spread of infection by walling off the infected area. (6) further enhances the inflammatory response and attracts additional phagocytes.



Symptoms of local inflammation include redness, heat, swelling, pain, and loss of function.

B. Using the terms provided, complete these statements:

Local inflammation
Neutrophils
Pyrogens

Systemic
inflammation
Vascular
permeability

1. _____
2. _____
3. _____
4. _____
5. _____

An inflammatory response confined to a specific area of the body is a (1). An inflammatory response that occurs in many parts of the body is a (2). In addition to local symptoms, additional features may be present in systemic inflammation. First, the red bone marrow produces and releases large numbers of (3), which promote phagocytosis. Second, (4), chemicals released by microorganisms, neutrophils, and other cells, induce fever. Third, in severe cases, there may be a great increase in (5) resulting in a large amount of fluid loss.

Adaptive Immunity

“Adaptive immunity involves the ability to recognize, respond to, and remember a particular substance.”

A. Match these terms with the correct statement or definition:

Allergic reaction
Antigens

Foreign antigens
Self antigens

1. General term for substances that stimulate adaptive immunity responses.
2. Antigens introduced from outside the body.
3. Overreaction of the immune system to foreign antigens such as pollen, animal hairs, food, and drugs.
4. Molecules produced by the body that stimulate an immune system response; stimulate autoimmune disease.



Autoimmune disease results when self antigens stimulate unwanted destruction of normal tissue, e.g., rheumatoid arthritis.

B. Match these terms with the correct statement or definition:

Antibody-mediated
immunity
B cells

Cell-mediated
immunity
T cells

1. Lymphocytes that produce proteins called antibodies.
2. Lymphocytes responsible for cell-mediated immunity and involved in regulating cell-mediated and antibody-mediated immunity.
3. Immunity produced by antibodies in plasma; humoral immunity.

Origin and Development of Lymphocytes

“All blood cells, including lymphocytes, are derived from stem cells in red bone marrow.”

Match these terms with the correct statement or definition:

Clones
Red bone marrow

Stem cells
Thymus

1. Cells in red bone marrow that give rise to all blood cells.
2. Location where pre-B cells are processed into B cells.
3. Location where pre-T cells are processed into T cells.
4. Small groups of identical lymphocytes produced during embryonic development.



A specific clone can respond only to a specific antigen. Clones that can act against self-antigens are normally eliminated or suppressed.

Activation and Multiplication of Lymphocytes

“For an adaptive immune system response to occur, lymphocytes must be activated by an antigen.”

A. Using the terms provided, complete these statements:

Antigen-binding receptors	Cytokines
B or T cells	Endocytosis
Clone	Helper T cell
Costimulation	Interleukin-1
Major histocompatibility complex (MHC) proteins	Interleukin-2

(1) are proteins on the surface of a lymphocyte that bind with a specific type of antigen. Each (2) consists of a group of lymphocytes with identical antigen-binding receptors. The adaptive immune response begins with (3) of an antigen by an antigen-presenting cell such as a macrophage. Once inside the antigen-presenting cell, the antigen is broken down, and pieces of the antigen are returned to the cell surface bound to (4). Next, the macrophage presents the processed antigen to a (5). Often, to produce a response from a B or T cell, (6) by a second signal is also required. Costimulation can be achieved by (7), a general term for proteins or peptides secreted by one cell to regulate other cells. For example, when a macrophage comes into contact with the processed antigen and the MHC protein on the helper T cell, the macrophage secretes (8), which stimulates the helper T cell. The helper T cell responds by producing (9) and interleukin-2 receptors. Interleukin-2 causes helper T cells to divide, producing many helper T cells. Helper T cells can then stimulate (10).

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

B. Using the terms provided, complete these statements:

Antibodies	Interleukins
Antigen	MHC molecule
Helper T cells	

Most B cells do not respond to antigens without stimulation from (1). This process begins when a B cell takes in the same kind of (2) that stimulated the helper T cell. The antigen is processed by the B cell and presented to the helper T cell using a(n) (3). There is also costimulation involving (4). The result is the division of a B cell into two cells. The division process continues, producing many cells that are capable of producing (5). Thus, many cells produce sufficient antibodies to destroy all of the (6).

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____



Lymphocytes have other surface molecules besides MHC molecules that help to bind cells together and stimulate a response. For example, CD4 is a glycoprotein on helper T cells that can bind to the MHC molecule on macrophages.

Antibody-Mediated Immunity

“Antibodies are proteins produced in response to an antigen.”

A. Match these terms with the correct statement or definition:

Constant region
Variable region

Gamma globulins
or immunoglobulins

1. Part of the antibody that combines with the antigen.

2. Part of the antibody that activates complement or attaches to cells such as macrophages, basophils, and mast cells.

3. Other terms used for antibodies.



Antibody-mediated immunity is effective against extracellular antigens such as bacteria, viruses (when they are outside of cells), toxins, and certain allergic reactions.

B. Match these terms with the correct parts labeled in figure 14.2:

Antigen-binding site
Constant region
Variable region

1. _____

2. _____

3. _____

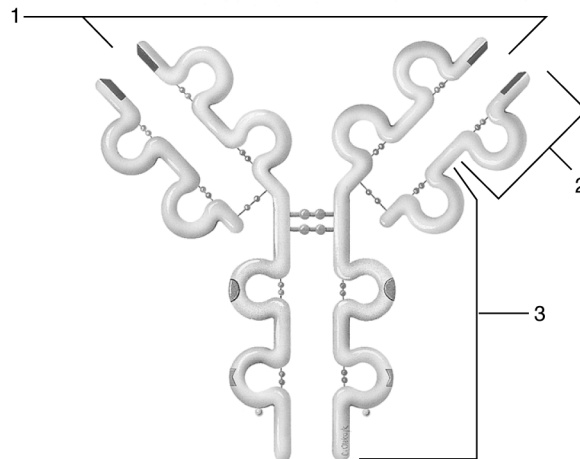


Figure 14.2

Effects of Antibodies

“Antibodies can affect antigens either directly or indirectly.”

Match these terms with the correct statement or definition:

Direct effects
Indirect effects

1. Antibody binds to antigen or antigens and inactivates them.
2. Macrophages attach to constant region and phagocytize the antigen; complement is activated; inflammatory chemicals are released by mast cells.

Antibody Production

“The production of antibodies after the first exposure to an antigen is different from that following a second or subsequent exposure.”

Match these terms with the correct statement or definition:

Memory B cells
Plasma cells

Primary response
Secondary, or memory response

1. Results from the first exposure of a B cell to an antigen.
2. Lymphocytes that produce antibodies.
3. Lymphocytes responsible for the secondary (memory) response.
4. Response to an antigen that is faster and produces larger quantities of antibodies.

Cell-Mediated Immunity

“Cell-mediated immunity is a function of T cells and is most effective against microorganisms that live inside the cells of the body.”

Match these terms with the correct statement or definition:

Cytotoxic T cells
Cytokines

Memory T cells

1. Cells responsible for the cell-mediated immunity response; foreign antigen stimulates these cells to lyse virus-infected cells, tumor cells, or tissue transplant cells.
2. Chemicals that are released by cytotoxic T cells and attract macrophages, or activate additional T cells.
3. T cells that provide a secondary response and long-lasting immunity.



Cytotoxic T cells are sometimes called CD8 cells because they have the CD8 glycoprotein on their surface. The CD8 molecule helps attach the cytotoxic T cell to MHC molecules.

Immunotherapy

“Immunotherapy treats disease by altering immune system function or by directly attacking harmful cells.”

Using the terms provided, complete these statements:

- | | |
|-----------------------|----------------|
| Antigen | MHC molecules |
| Autoimmune | Myelin |
| Cytokines | Neuroendocrine |
| Monoclonal antibodies | |

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

Some approaches to immunotherapy attempt to boost immune system function in general. For example, administering (1) or other agents promote inflammation and activation of immune cells, which can help in the destruction of tumor cells. Other cytokines inhibit the immune system. For example, in (2) diseases the immune system treats self-antigens as foreign antigens. In multiple sclerosis, this results in the destruction of the (3) that covers axons. Interferon beta, which is a cytokine, blocks the expression of (4) that display the self-antigens. In a more specific approach, the ability to produce (5) may result in therapies useful for treating tumors. If a(n) (6) specific to tumor cells can be found, monoclonal antibodies could deliver radioactive isotopes, drugs, toxins, enzymes, or cytokines to kill the tumor cell. Another possibility for curing or reducing the severity of disease is to use (7) regulation of the immune system, because we know that the nervous system regulates the secretion of many hormones, for which lymphocytes have receptors.

Acquired Immunity

“There are four ways to acquire immunity: active natural, active artificial, passive natural, and passive artificial.”

Match these terms with the correct statement or definition:

- | | |
|----------------------------|-----------------------------|
| Active artificial immunity | Passive artificial immunity |
| Active natural immunity | Passive natural immunity |
| Antiserum | |

- | | |
|-------|---|
| _____ | 1. Results from natural exposure to an antigen that causes the body's immune system to respond against the antigen. |
| _____ | 2. Results when an antigen is deliberately introduced into an individual to stimulate his immune system; also called vaccination. |
| _____ | 3. Results from the transfer of antibodies from a mother to her child across the placenta. |
| _____ | 4. Results when antibodies are removed from a human or another animal and injected into an individual requiring immunity. |
| _____ | 5. General term used for antibodies that provide passive artificial immunity. |

QUICK RECALL

1. List three basic functions of the lymphatic system.
2. List three factors that compress lymphatic vessels and move lymph toward the circulatory system.
3. List the functions of the lymph nodes, spleen, and thymus.
4. List the two cell types responsible for most of the phagocytosis in the body.
5. Name the cell type that produces antibodies (antibody-mediated immunity) and the cell type that produces cytokines (cell-mediated immunity).
6. Give the two basic ways that antibody-mediated immunity (antibodies) act against an antigen, and the two basic ways that cell-mediated immunity acts against an antigen.

WORD PARTS

Give an example of a new vocabulary word that contains each word part.

WORD PART	MEANING	EXAMPLE
-gen	to bear	1. _____
phag-	eat	2. _____
macro-	large	3. _____
inflam-	burn; set on fire	4. _____
immun-	safe; free	5. _____
auto-	self	6. _____

MASTERY LEARNING ACTIVITY

Place the letter corresponding to the correct answer in the space provided.

- _____ 1. The lymphatic system
 - a. removes excess fluid from tissues.
 - b. absorbs fats from the digestive tract.
 - c. defends the body against microorganisms and other foreign substances.
 - d. all of the above
- _____ 2. Lymphatic vessels
 - a. do not have valves.
 - b. pass through at least one lymph node.
 - c. from the right upper limb join the thoracic duct.
 - d. all of the above
- _____ 3. Lymph is moved through lymphatic vessels because of
 - a. blood pressure.
 - b. pressure changes in the digestive tract.
 - c. contraction of surrounding skeletal muscle.
 - d. all of the above
- _____ 4. The tonsils
 - a. form a protective ring of lymphatic tissue between the mouth, nose, and pharynx.
 - b. increase in size in adults.
 - c. consist of four groups.
 - d. all of the above
- _____ 5. Lymph nodes
 - a. produce lymphocytes.
 - b. remove microorganisms and foreign substances from lymph.
 - c. contain macrophages on a network of fibers.
 - d. all of the above
- _____ 6. The spleen
 - a. detects and responds to foreign substances in the blood.
 - b. serves as a reservoir for lymph.
 - c. produces new erythrocytes.
 - d. all of the above

- _____ 7. The thymus
- increases in size in adults.
 - produces lymphocytes that move to other lymph tissue.
 - responds to foreign substances in the blood.
 - all of the above
- _____ 8. A group of chemicals that is activated by a series of reactions, in which each component of the series activates the next component, and the activated chemicals promote inflammation and phagocytosis, is called
- histamine.
 - antibodies.
 - complement.
 - kinins.
 - lysozyme.
- _____ 9. A substance produced by cells in response to infection by viruses and prevents viral replication in other cells is
- interferon.
 - complement.
 - fibrin.
 - antibodies.
 - histamine.
- _____ 10. Neutrophils
- enlarge to become macrophages.
 - account for most of the dead cells in pus.
 - are usually the last cell type to enter infected tissues.
 - are involved in the cleanup work in the late stages of an infection.
 - all of the above
- _____ 11. In addition to leukocytes, some cells found in connective tissue release inflammatory chemicals. These cells are called
- macrophages.
 - eosinophils.
 - neutrophils.
 - mast cells.
 - monocytes.
- _____ 12. During the inflammatory response
- histamine and other chemical mediators are released.
 - chemotaxis of phagocytes occurs.
 - fibrinogen enters tissue from the blood.
 - blood vessels vasodilate.
 - all of the above
- _____ 13. Antigens
- are foreign substances introduced into the body.
 - are molecules produced by the body.
 - stimulate a specific immune system response.
 - all of the above
- _____ 14. B cells
- are processed in the thymus.
 - originate in red bone marrow.
 - once released in the blood, stay in the blood.
 - all of the above
- _____ 15. Helper T cells
- release a chemical hormone called interleukin 2.
 - regulate the immune system.
 - produce antibodies.
 - both a and b
- _____ 16. The variable region on the arms of the antibody molecule
- is the part of the antibody that combines with the antigen.
 - activates complement.
 - attaches the antibody to macrophages.
 - all of the above
- _____ 17. Antibodies
- prevent antigens from binding together.
 - promote phagocytosis.
 - inhibit inflammation.
 - block the activation of complement.

- _____ 18. The secondary antibody response
- is slower than the primary response.
 - produces less antibodies than the primary response.
 - prevents the appearance of disease symptoms.
 - a and b
- _____ 19. The type of lymphocyte responsible for the secondary antibody response?
- memory cell
 - plasma cell
 - cytotoxic T cell
 - T helper cell
 - mast cell
- _____ 20. The type of immunity produced by vaccination would be
- active natural immunity.
 - passive natural immunity.
 - active artificial immunity.
 - passive artificial immunity.



FINAL CHALLENGES



Use a separate sheet of paper to complete this section.

- The central nervous system and bone marrow do not have lymphatic vessels. Why doesn't edema occur in these tissues?
- In some areas of the world, a disease is caused by small worms that enter the body and become lodged inside lymphatic vessels. What effect would this have on the lower limbs?
- Ivy Hurtt developed a poison ivy rash after a camping trip. Her doctor prescribed a cortisol ointment to relieve the inflammation. A few weeks later Ivy scraped her elbow, which became inflamed. Because she had some of the cortisol ointment left over, she applied it to the scrape. Explain why the ointment was or was not a good idea for the poison ivy and for the scrape.
- Suzy Withitt has just had her ears pierced. To her dismay, she finds that, when she wears inexpensive (but tasteful) jewelry, by the end of the day there is an inflammatory (allergic) reaction to the metal in the jewelry. Is this because of antibodies or cytokines?