

# The Lymphatic System and Body Defenses

## CHAPTER 12 SUMMARY

One of the least recognized of the body systems, the lymphatic system has been gaining ground in recognition and understanding over the past decade or so, largely due to research into AIDS, cancer, and autoimmune disorders. Its importance in fighting disease and keeping us healthy cannot be overstated. Although at first unfamiliar to students, this system quickly piques their interest as a lifesaving system that deserves their attention.

The two semi-independent parts of the lymphatic system are presented first, beginning with the lymphatic vessels and followed by the lymphoid tissues and organs. Next is a full description of body defenses, beginning with an explanation of the nonspecific defenses such as fever and the inflammatory response, and followed by the specific defenses regulated by the immune system, with special focus on the antigen-antibody response. The cells of the immune system are also outlined and explained.

The next section of the chapter discusses the two types of immune response. Humoral (antibody-mediated) immunity is described first, highlighting the various roles of B cells and explaining the differences between active and passive types of humoral immunity. Cellular (cell-mediated) immunity is presented next, along with a description of the role T cells play in this type of immune response.

The final section of this chapter discusses homeostatic imbalances of the immune system. Organ transplantation and its associated risk of rejection are explained, along with allergies, immunodeficiencies, and autoimmune diseases. Finally, in discussing the developmental aspects of the lymphatic system, there is an explanation that our immune system begins to wane in later life, making us more prone to cancer, as well as autoimmune and immunodeficiency diseases.

### I. LYMPHATIC SYSTEM (pp. 370–374)

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#### A. Nonspecific Body Defenses (pp. 375–380)

##### 1. Surface Membrane Barriers

##### 2. Cells and Chemicals

###### a. Phagocytes

b. Natural Killer Cells

c. Inflammatory Response

d. Antimicrobial Chemicals

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e. Fever

B. Specific Body Defenses: The Immune System (pp. 380–398)

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3. Humoral (Antibody-Mediated) Immunity

a. Active and Passive Humoral Immunity

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ii. Antibody Classes

iii. Antibody Function

4. Cellular (Cell-Mediated) Immune Response

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6. Disorders of Immunity

a. Allergies

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III. DEVELOPMENTAL ASPECTS OF BODY DEFENSES (pp. 398–400)

## KEY TERMS

active immunity  
antibody  
antigen  
appendix  
autoimmune  
B cells  
cellular immunity  
humoral immunity  
hypersensitivity  
immunocompetent  
immunodeficiencies  
immunoglobulins  
inflammatory response  
lymph  
lymph nodes  
lymph vessels  
macrophages  
nonspecific defenses  
passive immunity  
Peyer's patches  
phagocytes  
specific defenses  
T cells  
tonsils

## Key Points

Compare and contrast lymph vessels and blood vessels.

Blood vessels form a closed loop or circuit whereas lymph vessels are an open, one-way system. Blood vessels have a pump (the heart) behind them helping to push fluids along, whereas lymph vessels are pumpless. Veins and lymph vessels are similar in that they are both thin walled and have valves, and both rely on the milking action of muscles and pressure changes in the thorax to move fluids along.

Outline the location and origin of lymph fluid, starting with blood plasma. Describe how it is called interstitial fluid once it is pushed out of the blood vessels, that it becomes lymph fluid when picked up by the lymph vessels, and finally, that it is again called blood plasma upon its return to the cardiovascular system.

Point out that this is *all the same fluid*, but that it is called different things depending upon its location at any given time.

Reinforce that the right lymphatic duct drains one-fourth of the body (the upper right quadrant) and the thoracic duct drains the remaining three-fourths of the body.

Describe edema as an excess of interstitial fluid and identify some of the common types, including pitting edema and anasarca (generalized edema). Explain that there are numerous causes resulting from homeostatic imbalance of many of the systems, including the renal, pulmonary, and cardiovascular systems.

Approximately 24 liters of fluid per day are pushed out of the capillaries to bathe the cells, and if all 24 liters are not reabsorbed, the fluid left behind leads to edema.

Discuss post-mastectomy lymphedema and describe exercises and treatments that can help with interstitial fluid return. Also discuss the lymphedema of elephantiasis, usually caused by obstruction of the lymph vessels by an infestation of filarial parasites (a condition most common in the tropics), and explain treatment options for this condition.

Removal of the tonsils and adenoids following repeated upper respiratory infections is still practiced, although not to the degree it was in generations past. Increased awareness of the role of the lymph system in fighting disease has made it less desirable to remove lymph tissue than in previous years.

List the numerous functions of the spleen, as well as the causes and consequences of splenomegaly. Explain the theories behind splenectomy.

The spleen's numerous cleansing functions include control of encapsulated bacteria in the blood and destruction of old RBCs. Cirrhosis and heart failure can lead to spleen enlargement. In thrombocytopenia, the spleen eliminates platelets at a rate faster than they can be replaced, and one treatment option is removal of the spleen to prevent further platelet destruction.

List redness, heat, swelling, and pain as the four cardinal signs of the inflammatory response, and emphasize that fever and heat are not the same thing. Note that fever is NOT a symptom of this response. Also note that although inflammation is sometimes painful, students need to understand that the response is a beneficial, essential defense mechanism that paves the way for proper tissue repair.

Fever is a separate nonspecific defense mechanism. A fifth sign is occasionally listed as part of the inflammatory response, and that sign is decreased joint movement resulting from swelling.

Note that complement proteins represent a nonspecific defense, even though they may be activated as part of a specific response to an antigen. Also point out that complement fixation represents another example of positive feedback.

The mechanism of complement fixation is often poorly understood by students and warrants extra time for discussion.

10. Emphasize that immunoglobulins are antibodies, and that the two words are synonymous.

Discuss antihistamines and explain when and why they are taken, as well as the role of IgE in necessitating their use.

Antihistamines are used to treat allergies, hives, and other hypersensitivity reactions brought about by IgE.

Explain the symptoms of anaphylactic shock and the necessary treatment for this lifethreatening condition.

Anaphylactic shock is a reaction between allergic antigens and IgE. It can only occur following previous exposure to the specific allergic antigen, and it results in bronchospasm, laryngeal edema, and circulatory collapse. Untreated, it can be fatal.

Discuss autoantibodies as the basis for autoimmune diseases such as rheumatoid arthritis, myasthenia gravis, and Graves' disease. Use the example of anti-sperm antibodies produced following vasectomy, and note that after 7 to 10 years, there is such an abundance of the antibodies circulating in the bloodstream that attempts at vasectomy reversal after that length of time are usually unsuccessful.

Autoantibodies are produced by B cells in response to altered autoantigens, or "self-antigens," although the reasons for this reaction are still being researched.

## ANSWERS TO END OF CHAPTER REVIEW QUESTIONS

*Questions appear on pp. 400–401*

### Multiple Choice

1. c
2. a
3. b
4. a, c, d
5. a
6. b, d
7. c
8. a, c
11. d
12. a, b, c, d
13. a

### Short Answer Essay

1. Lymphatic vessels collect excess tissue fluid (lymph) and return it to the bloodstream. Lymph nodes remove foreign material such as bacteria and tumor cells from lymph and produce lymphocytes.
2. Lymph nodes are most dense in the cervical, axillary and inguinal areas.
3. The tonsils are particularly important in preventing bacterial and other foreign pathogens from entering the body via the pharynx. The spleen functions primarily as an RBC "graveyard," i.e. it destroys worn-out RBCs. It also produces lymphocytes and acts as a blood reservoir.
4. Mucus provides a mechanical barrier for pathogens by trapping them. Mucosae are found on the outer surface of the eye, in the linings of all body cavities open to the exterior, that is, the digestive, respiratory, urinary, and reproductive tracts. Lysozyme, an enzyme that destroys bacteria, is found in saliva and lacrimal fluid.

Keratin, a protein in epithelial membranes, presents a physical barrier to microorganisms on the skin, as well as being resistant to most weak acids and bases and to bacterial enzymes and toxins.

Acid pH of skin secretions inhibits bacterial growth. Vaginal secretions are also very acidic. Hydrochloric acid is secreted by the stomach mucosa and acts to kill pathogens.

Ciliated mucosa of the upper respiratory tract sweep dust- and bacteria-laden mucus superiorly toward the mouth, restraining it from entering the lower respiratory passages.

5. Complement is a group of 20 blood proteins that, when activated, causes lysis of the cell to which the antibodies are attached. Other roles of complement include opsonization, inflammatory actions such as stimulating mast cells and basophils to release histamine (which increases vascular permeability), and attracting neutrophils and other inflammatory cells to the area.

6. Interferons are secreted by virus-infected cells. They diffuse to nearby cells and bind to their membrane receptors, interfering with the ability of viruses to multiply within these cells.

7. The immune response is the response of the body to foreign substances.

8. Antigen is a foreign substance (nonself) that is capable of activating an immune response and of interacting with the products (cells and antibodies of that response).

An incomplete antigen is a small molecule that connects with our own proteins, unlike a complete antigen which does not.

9. Humoral immunity is that portion of the immune system that reflects the work of antibodies produced by B cells or their progeny plasma cells. Cell-mediated immunity reflects a cell-mounted attack against antigens that is mediated by T cells.

10. T cells, notably the helper T cells, regulate not only cell-mediated immunity but humoral immunity as well by interacting directly (or indirectly) with B cells.

11. Immunocompetence is the capability of mounting an immune response against a particular antigen. The appearance of antigen-specific receptors on the surface of a B cell or T cell signals that it has developed immunocompetence. T cells are programmed in the thymus; B cells are programmed in the bursa-equivalent organ, probably red bone marrow in humans.

12. Clonal selection involves the rapid cell division of the antigen-activated lymphocyte to produce a "family" or clone of identical cells, all bearing the same antigen-specific receptors. The macrophage is important in clonal selection because it "presents" the antigens to the immunocompetent cells.

13. Members of a B cell clone include B memory cells and plasma cells, which are antibody-producing "factories."

14. Helper T cells are the major regulatory cells; they activate the cytotoxic T cells and are the population disabled by HIV. Killer T cells interact directly with virus-infected (or foreign) cells to kill (lyse) them. Suppressor T cells cause the immune response to wind down when the enemy (antigen) has been destroyed or inactivated.

15. The primary immune response occurs on the first meeting with the antigen; the secondary response is the second and subsequent meeting with the same antigen. The secondary response is faster because all the preparations (clonal selection and memory cells) have been made and immunological memory has been established.

16. An antibody is basically Y-shaped. It consists of two heavy chains and two light chains, each with a constant region and a variable region. The constant regions determine antibody class and where and how the antibody acts in the body. The variable regions form the antigen-binding sites.

17. The five classes of immunoglobulins are IgM, IgG, IgE, IgA, and IgD. IgD is attached to B cell membranes; IgG is most abundant in plasma and crosses placental barriers; IgE is involved in allergic responses; IgM is the first antibody released in the primary response and some are bound to B cell membranes. IgG and IgM bind complement. IgA is present in body secretions that bathe membranes, that is, in tears, saliva, and mucus.

18. Antibodies defend the body by fixing complement and by neutralizing, agglutinating, and precipitating antigens.

19. An allergy is an abnormally vigorous immune response to an otherwise harmless antigen. Acute allergic responses occur and resolve within minutes and are mediated by IgE antibodies bound to mast cells. The mast cells release histamine upon antigen-antibody binding, and histamine causes blood vessels to become leaky. Typical symptoms are runny nose (or asthma), watery eyes, and hives. Delayed-reaction allergies are mediated by T cells and occur hours to days after exposure to the allergen.

20. An autoimmune disease may result from a change in self-antigens, the appearance of self-antigens not previously recognized by the immune system, or the cross-reaction of antibodies produced against foreign antigens with self-antigens.

## ANSWERS TO AT THE CLINIC QUESTIONS

1. The infant will develop artificially acquired active immunity.

2. IgA is found primarily in mucus and other secretions that bathe body surfaces. It plays an important role in preventing pathogens from entering the body. Lack of IgA would result in frequent major/minor infections of the sinuses or respiratory tract infections.

3. Actively acquired immunity to previous flu virus antigens will not protect against new proteins (antigens) on the viral coat.

4. Lymph nodes and vessels help to return fluid to the circulatory system. Removal results in severe localized edema. She can expect chronic edema along the arm although some lymphatic drainage is eventually reestablished by regrowth of lymph vessels from veins.

5. Lymphocyte circulation is important because it greatly increases the chance of the lymphocytes coming into contact with antigens.