Lymphatic System

chapter 20

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Key Terms

lymph (p. 373)
lymph nodes (p. 375)
lymphatic ducts (p. 374)
lymphatic vessels (p. 373)
spleen (p. 378)
thymus gland (p. 376)
tonsils (p. 376)

Objective

1. List three functions of the lymphatic system.
2. Describe the composition and flow of lymph.
3. Describe the lymph nodes, and state the location of the cervical nodes, axillary nodes, and inguinal nodes.
4. Describe the other lymphoid organs: tonsils, thymus gland, and spleen.

The woman in Figure 20-1 has a condition called *elephantiasis*. The name is an obvious reference to the size and shape of her leg. Elephantiasis is caused by the invasion and blockage of the lymphatic vessels by small worms called *filariae*. The amount of swelling illustrates the importance of the lymphatic system, which drains fluid from our tissue spaces.

The lymphatic system contains lymph, lymphatic vessels, lymphoid organs, and lymphoid tissue, which are widely scattered throughout the body. The three main functions of the lymphatic system are as follows:

- The lymphatic vessels return tissue fluid to the blood.
- Specialized lymphatic vessels play an important role in the intestinal absorption of fats and fat-soluble vitamins.
- Lymphoid tissue helps the body defend itself against disease.

FIGURE 20-1 Elephantiasis, a form of lymphedema.

THE LYMPHATIC SYSTEM

LYMPH: WHAT IT IS, WHERE IT COMES FROM

Lymph (limf) is a clear fluid that resembles plasma. Lymph is composed primarily of water, electrolytes, waste from metabolizing cells, and some protein that leaks out of the capillaries of the systemic circulation. Where does lymph come from? It is formed from the plasma during capillary exchange. About 20 L/day of lymph is filtered from the blood into the interstitium, or tissue spaces. It leaves the interstitium through the lymphatic vessels, which then carry the lymph toward the heart and eventually empty it into the blood.

Water and dissolved substances are continuously filtered out of the blood capillaries into the interstitium to form tissue fluid. Approximately 85% of this tissue fluid moves back into the blood capillaries and is carried away as part of the venous blood. What about the 15% of the tissue fluid that does not re-enter the blood capillaries? This fluid is drained by the lymphatic capillaries that surround the blood capillaries (Figure 20-2). The tissue fluid entering the lymphatic vessels is the lymph.

LYMPHATIC VESSELS

The **lymphatic vessels** include lymphatic capillaries and several larger lymphatic vessels. Like the blood

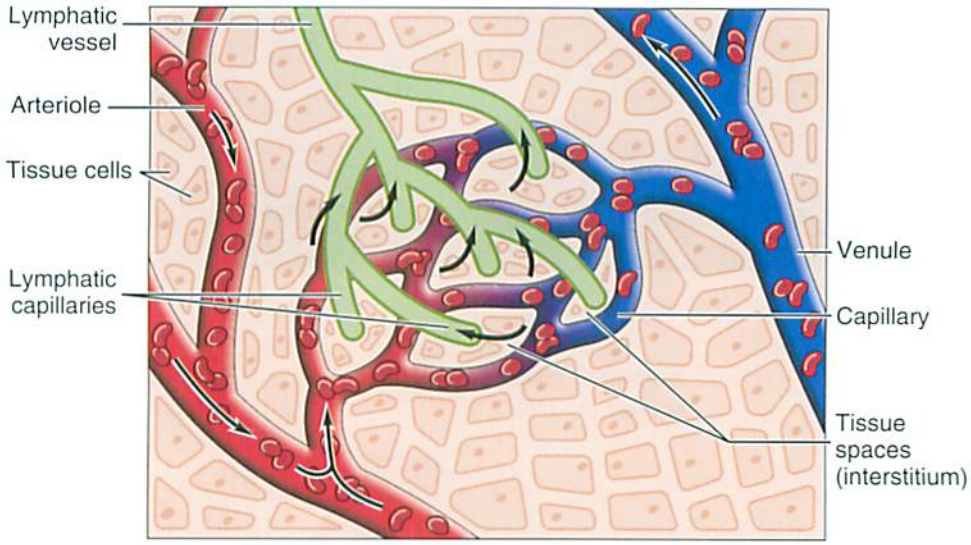


FIGURE 20-2 Lymph capillaries and blood capillaries.

vessels, the lymphatic vessels form an extensive network. The distribution of lymphatic vessels is similar to the distribution of veins. With the exception of the CNS, every organ in the body has a rich supply of lymphatic vessels. These pick up tissue fluid and transport it toward the heart. Figure 20-3 shows the relationship between the circulatory system and the lymphatic system. Note especially the close relationship of the lymphatic vessels with the veins.

The walls of the lymphatic capillaries are made up of a single layer of epithelium and have large pores. This large-pore structure allows the lymphatic capillaries to drain tissue fluid and proteins, thereby forming lymph. Once absorbed by the lymphatic capillaries, the lymph flows toward the heart through a series of larger and larger lymphatic vessels until it reaches the large **lymphatic ducts**.

For example, lymph from the right arm and right side of the head and thorax drains into the right lymphatic duct. Lymph from the rest of the body drains into the thoracic duct (Figure 20-4). Both ducts empty the lymph into the subclavian veins. The right lymphatic duct drains lymph into the right subclavian vein; the thoracic duct drains lymph into the left subclavian vein.

MOVEMENT THROUGH THE LYMPHATIC VESSELS

Whereas blood moves because it is pumped by the heart, lymph depends on other means for movement. Lymph moves in response to the following:

- The "milking" action of the skeletal muscles. As the skeletal muscles contract, they squeeze the surrounding lymphatic vessels, thereby pushing lymph toward the heart.
- The movement of the chest during respiration. Contraction and relaxation of the chest muscles cause changes in the pressure within the thorax. The changes in intrathoracic pressure increase the flow of lymph.
- The rhythmic contraction of the smooth muscle in the lymphatic vessels. The alternating contraction and relaxation of the smooth muscle cause lymph to flow.
- The presence of valves. Like the veins, the lymphatic vessels contain valves. Valves prevent any backflow of lymph; if lymph moves at all, it must move toward the heart.

? Re-Think

1. A patient has had a radical mastectomy (removal of the breast) with lymph node dissection. Why might she develop edema in the affected arm?
2. What is the function of the right lymphatic and thoracic ducts?

2+2 Sum It Up!

Lymphatic vessels accompany venous blood vessels throughout the body. They drain fluid and protein from tissue spaces; the lymph drains into the main lymphatic ducts (right lymphatic duct and thoracic duct). The main lymphatic ducts drain into the general circulation through the subclavian veins. Lymph is not pumped by the heart; it moves in response to skeletal and smooth muscle activity.

LYMPHOID ORGANS

The lymphoid organs include the lymph nodes, tonsils, thymus gland, and spleen (Figure 20-5, *A*). Lymphoid tissue is also found scattered throughout the body in many other organs and particularly in mucous membranes, where it is referred to as *MALT* (*m*ucosal-*a*ssociated *l*ymphoid *t*issue). In general, the lymphoid organs and lymphoid tissue help defend the body

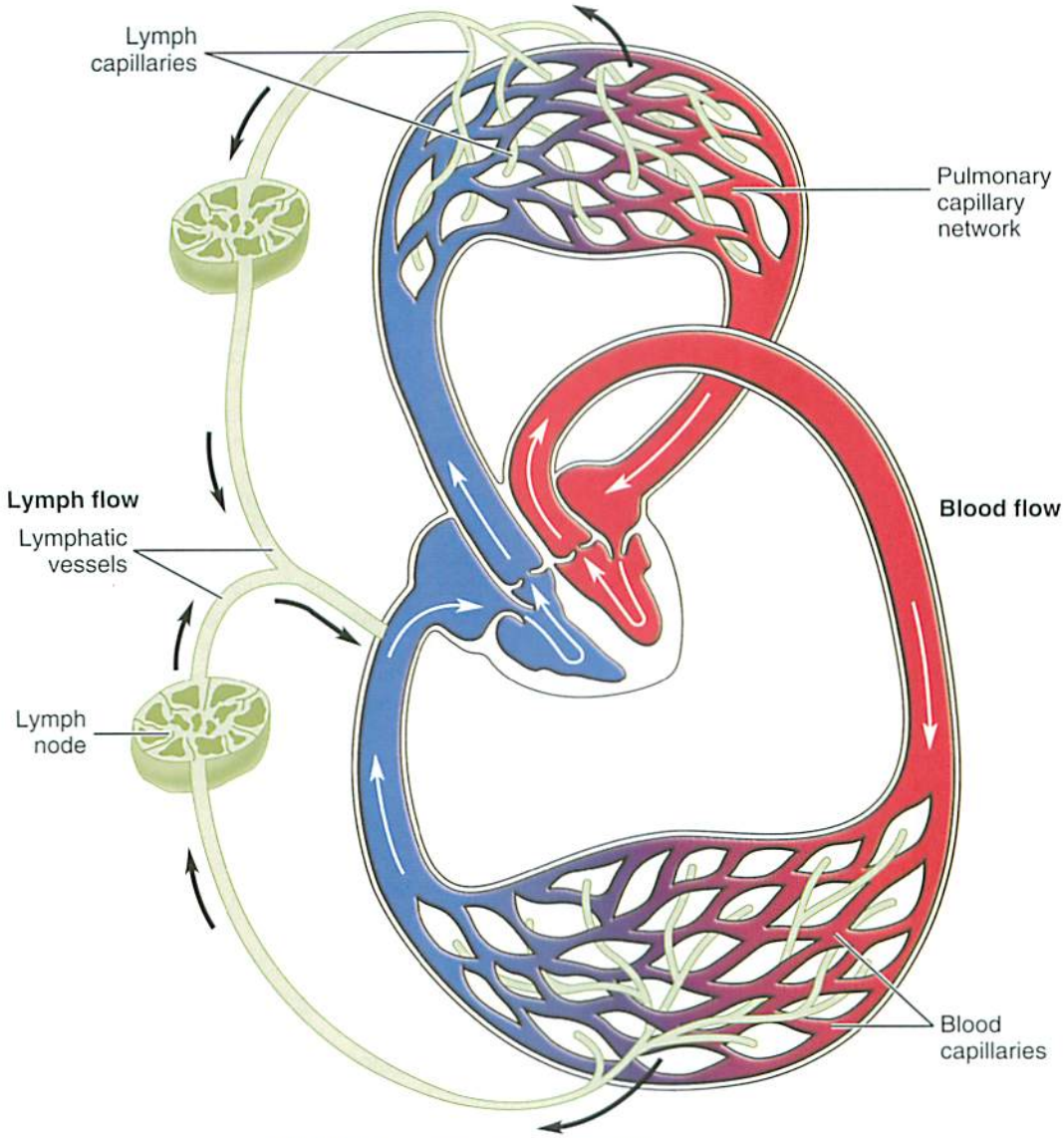


FIGURE 20-3 Lymphatic vessels accompany the veins.

against disease by filtering particles such as pathogens and cancer cells from the lymph, tissue fluid, and blood and by supporting the activities of the lymphocytes, which provide immunity against disease.

LYMPH NODES

Lymph nodes are small pea-shaped patches of lymphatic tissue strategically located to filter the lymph as it flows through the lymphatic vessels. Lymph nodes tend to appear in clusters (see Figure 20-5, *B*). The larger clusters include the following:

- *Cervical lymph nodes* drain and cleanse lymph coming from the head and neck areas. Enlarged, tender cervical lymph nodes often accompany upper respiratory infections.
- *Axillary lymph nodes* are located in the axillary area, or armpit. These nodes drain and cleanse lymph coming from the upper extremities, shoulders, and breast area. Cancer cells that escape from the breast are often found in the axillary lymph nodes.
- *Inguinal lymph nodes* are located in the groin region. These nodes drain and cleanse lymph from the lower extremities and external genitalia.

What does a lymph node look like? A lymph node contains several compartments, called *lymph nodules*, that are separated by lymph sinuses (Figure 20-6). The lymph nodules are masses of lymphocytes and macrophages. These cells are defensive cells and are concerned with immunity and phagocytosis; they protect the body against disease. The lymph nodules are separated by lymph sinuses; these are lymph-filled spaces. Afferent lymphatic vessels carry lymph into the node

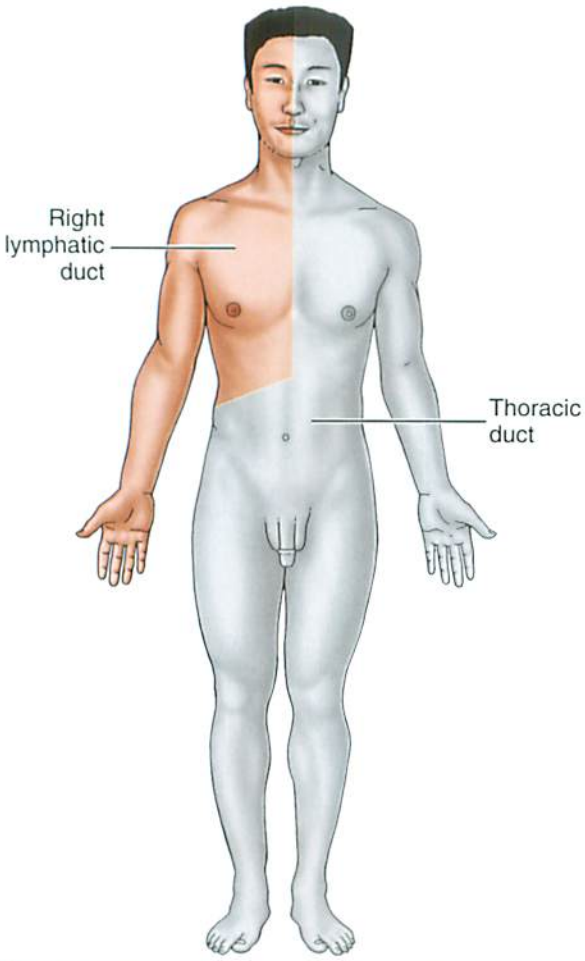


FIGURE 20-4 Main lymphatic ducts: right lymphatic duct and thoracic duct.

for cleansing. The lymph leaves the node through the efferent lymphatic vessels as it continues its journey toward the heart.

TONSILS

Tonsils are partially encapsulated lymph nodes in the throat area (see Figure 20-5, *A* and *C*). They filter tissue fluid contaminated by pathogens that enter the body through the nose, mouth, or both. The three sets of tonsils are as follows:

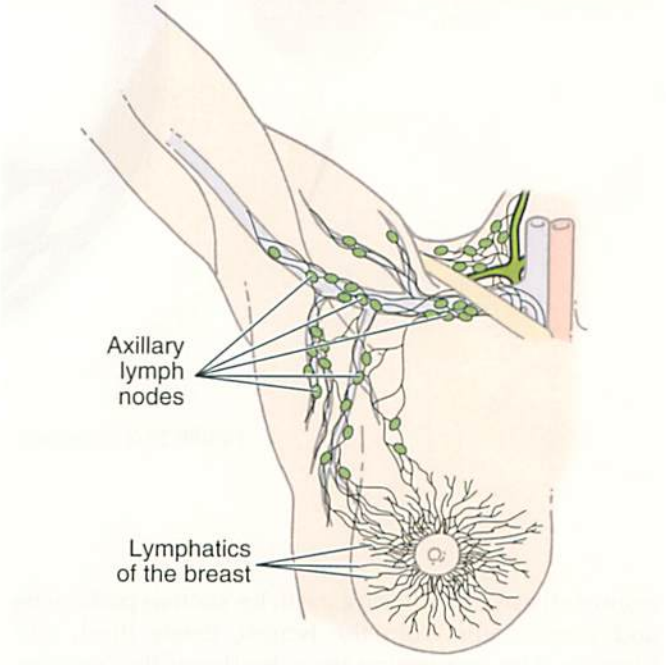
- *Palatine tonsils* are small masses of lymphoid tissue located at the opening of the oral cavity into the pharynx. A tonsillectomy is most often performed on this particular set of tonsils.
- *Pharyngeal tonsils* are also called the *adenoids*. They are located near the opening of the nasal cavity in the upper pharynx. The adenoids atrophy during adolescence. Enlargement of the adenoids may interfere with breathing and may require surgical removal, a procedure known as *adenoidectomy*.
- *Lingual tonsils* are located at the back of the tongue.

Do You Know...

Why the Axillary Lymph Nodes Are Removed during a Mastectomy (Surgical Breast Removal)?

Many cancers metastasize, or spread, by way of the lymphatic vessels. Cancer of the breast commonly metastasizes to the axillary lymph nodes. In an attempt to rid the body of all cancer cells, the surgeon removes the breast and associated axillary lymph nodes. Each lymph node is then biopsied; further treatment often depends on how many of the lymph nodes are positive (i.e., are cancerous, or malignant). Removal of the axillary lymph nodes frequently impairs lymphatic drainage. Consequently, the woman may develop edema of the affected arm and shoulder. Because the edema develops in response to impaired drainage of lymph, it is called *lymphedema*.

A new technique is the sentinel node biopsy. The procedure was developed to determine if a cancer has spread without doing the traditional lymph node dissection. It is based on the following observation. Lymph ducts of the breast usually drain to one lymph node first and then to the others in the axillary region. The lymph node that receives the initial drainage is called the *sentinel lymph node* and is identified by the injection of dye. If the sentinel node biopsy is negative, it is assumed that the cancer has not spread to the axillary lymph nodes.



THYMUS GLAND

The **thymus gland** is located in the mediastinum of the thoracic cavity (see Figure 20-5, *A*). The thymus gland plays a crucial role in the development of the immune system before birth and in the first few months after birth. After puberty, the gland shrinks or involutes, but remains active throughout life.

The thymus gland secretes hormones called *thymosins*. Thymosins promote the proliferation and maturation of special lymphocytes (T cells) in lymphoid tissue throughout the body (see Chapter 21).

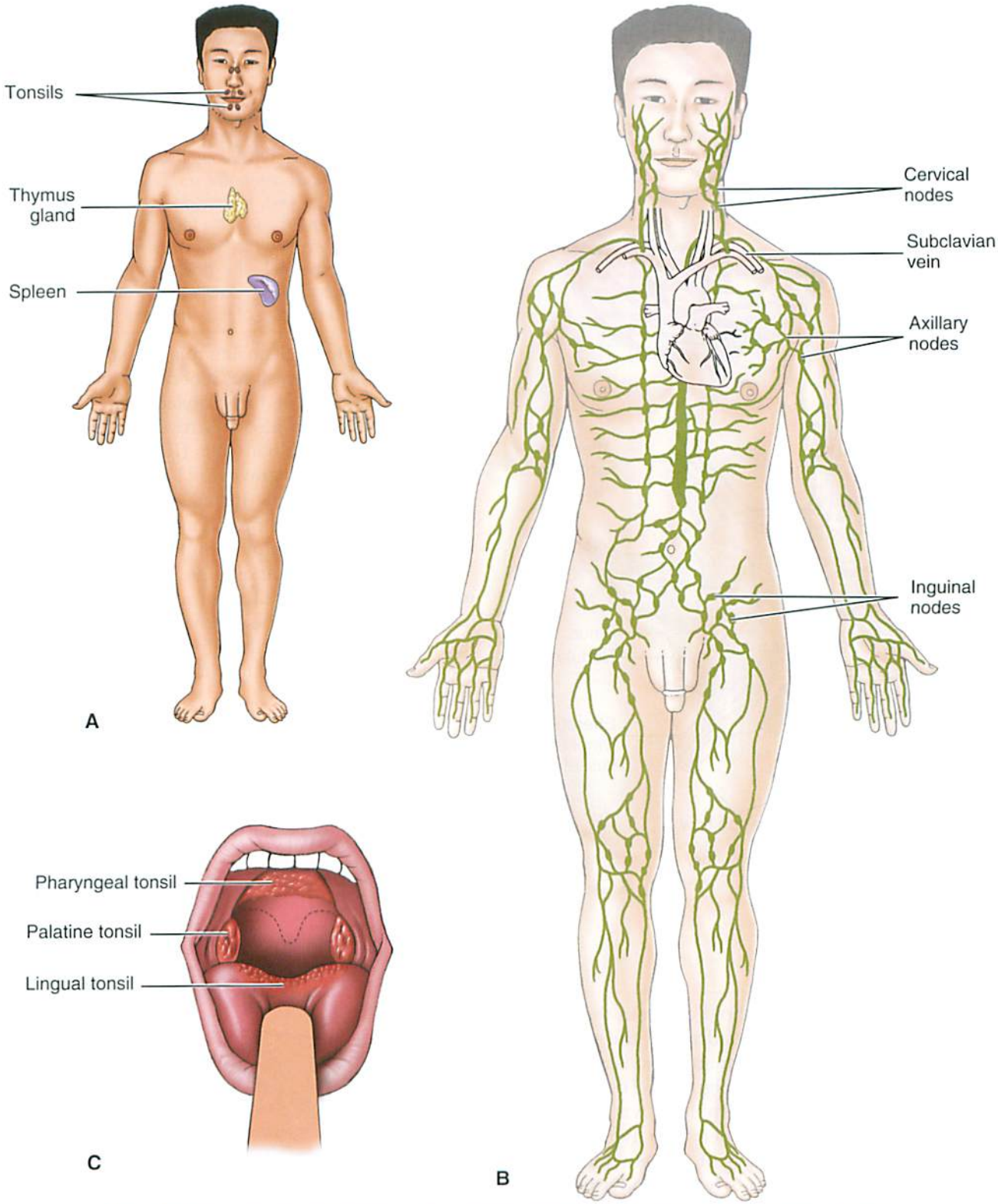


FIGURE 20-5 Location of lymphoid tissue. **A,** Lymphoid organs. **B,** Distribution of lymph nodes. **C,** Tonsils.

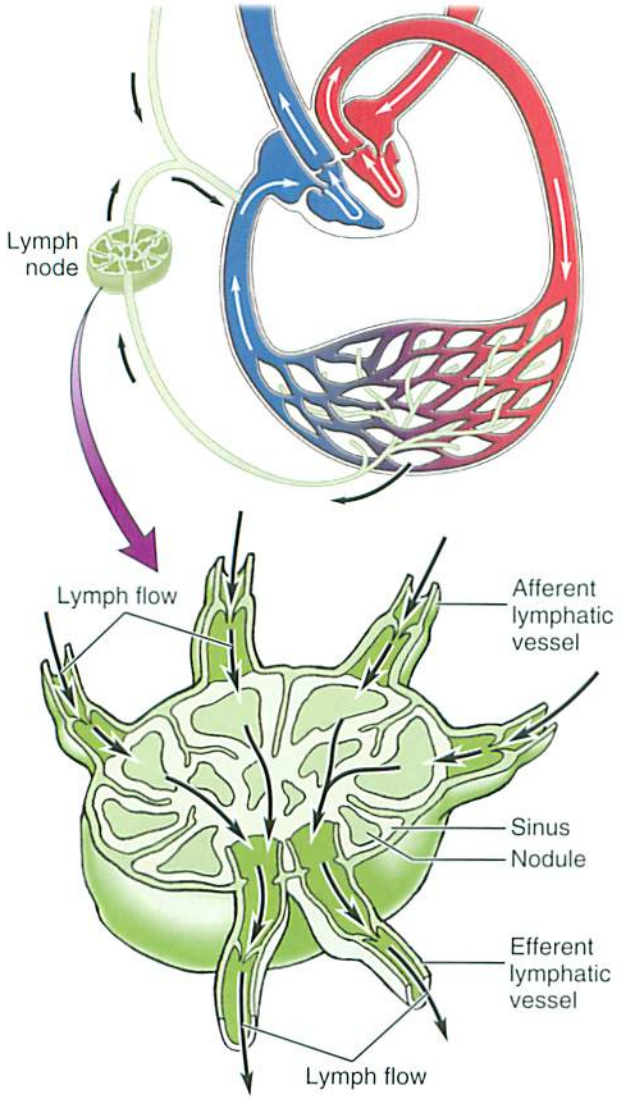


FIGURE 20-6 Cross-section of a lymph node.

SPLEEN

The **spleen** is the largest lymphoid organ in the body. It is located in the left upper quadrant of the abdominal cavity, just beneath the diaphragm, and is normally protected by the lower rib cage (Figure 20-7). Although the spleen is much larger, it resembles a lymph node.

The spleen filters blood rather than lymph. The spleen is composed of two types of tissue: white pulp and red pulp. The white pulp is lymphoid tissue consisting primarily of lymphocytes surrounding arteries. The red pulp contains venous sinuses filled with blood and disease-preventing cells such as lymphocytes and macrophages. Blood enters the spleen through the splenic artery. The blood is cleansed as it slowly flows through the spleen. Microorganisms trapped by the spleen are destroyed by the leukocytes in the spleen. The cleansed blood leaves the spleen through the splenic vein.

Do You Know...

Why "Lose That Spleen" Was a Slogan for Ancient Roman Marathoners?

In ancient Roman times, the rumor in marathon circles was that removal of the spleen would make a person a faster runner. The spleen was removed surgically or burnt out with a hot iron—ouch! Unfortunately, the rumor was based on a misreading of a biblical text, which does indeed say that the removal of the spleen made for a faster runner. The misreading? The shrinkage of the biblical spleen was achieved by an oral medicine concocted by the priests and not by surgery or a hot poker. Fortunately, the practice died out quickly...unfortunately, so did the victims of this "misreading."

In addition to its cleansing role, the spleen has other functions. The spleen stores blood, especially platelets. (As much as 30% of the platelets are stored in the spleen.) The spleen also destroys and phagocytoses old, worn-out red blood cells (RBCs). Therefore, the spleen is called the "graveyard" of the RBCs. Finally, the spleen plays a role in fetal erythropoiesis. After birth, the spleen stops producing RBCs but continues its lifelong production of lymphocytes.

Because of its location, the spleen is commonly injured. Because it is difficult to repair and prone to bleed, the spleen may be removed surgically. The splenectomized patient can live quite well without a spleen but may be more prone to infection.

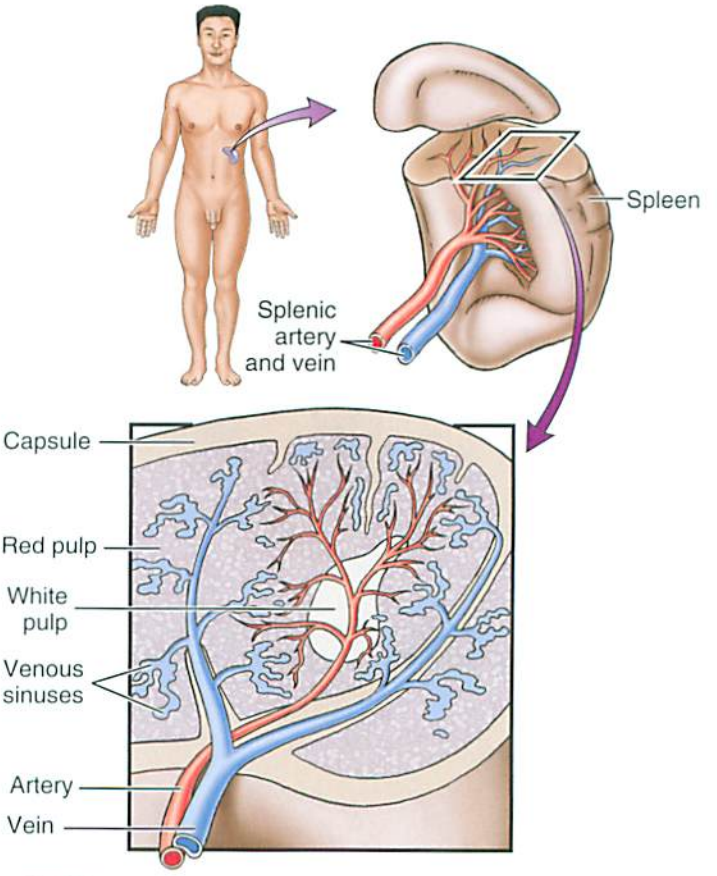


FIGURE 20-7 Spleen, composed of white pulp and red pulp.

Re-Think

1. List four lymphoid organs.
2. List three functions of the spleen.

2+2 Sum It Up!

Lymphocyte-containing organs, called *lymphoid organs,* include the lymph nodes, tonsils, thymus gland, and spleen. Lymph nodes are scattered throughout the body; some are clustered as the cervical, axillary, and inguinal lymph nodes. Three sets of tonsils (partially encapsulated lymph nodes) are the palatine, pharyngeal (adenoids), and lingual tonsils. Lymphoid tissue, in general, plays a crucial role in the prevention of disease. The spleen also acts as a storage site for RBCs and platelets.

As You Age

1. Lymphoid tissue reaches its peak development at puberty and then progressively shrinks with age.
2. After puberty, the thymus gland involutes, or shrivels up, and is replaced by connective tissue. This process involves a decrease in the amount of thymosins produced. Because of these changes, the defense mechanisms of the body diminish with age.

MEDICAL TERMINOLOGY AND DISORDERS Disorders of the Lymphatic System

Medical Term	Word Parts	Word Part Meaning or Derivation	Description
Words			
hypersplenism	hyper-	excessive	**Hypersplenism** is *a disorder in which an overactive spleen prematurely destroys red blood cells, white blood cells, and platelets, thereby causing anemia, leukopenia, and thrombocytopenia.*
	-splen/o-	spleen	
	-ism	condition of	
lingual	lingul/o-	tongue	There are three pairs of tonsils: the palatine, the pharyngeal, and the **lingual,** located on the posterior tongue.
	-al	pertaining to	
splenomegaly	splen/o-	spleen	**Splenomegaly** is *an enlarged spleen; it usually accompanies hypersplenism and the excessive destruction of blood cells.*
	-megaly	enlargement	
tonsillectomy	tonsil/o-	tonsil	A **tonsillectomy** is *the removal of the tonsils,* usually the palatine tonsils.
	-ectomy	removal of	
Disorders			
lymphadenopathy	lymph/o-	lymph	Means *disease of the lymph nodes, but is used synonymously with "swollen or enlarged lymph nodes."* Lymph nodes swell in response to a number of conditions, both localized and systemic (infectious mononucleosis), autoimmune diseases and malignancies. Rarely is the distinction made between lymphadenopathy and **lymphadenitis,** *an inflammation of the lymph nodes.*
	-aden/o-	gland	
	-pathy	disease	
lymphedema	lymph/o-	lymph	Also called **lymphatic obstruction;** it is *a condition in which there is localized tissue swelling caused by damaged lymphatic vessels and poor drainage of tissue fluid.* The most common cause of lymphedema in the United States is related to the treatment of cancer: lymph node dissection, cancer surgery, and radiation therapy. In tropical regions of the world a common cause of severe lymphedema is filariasis, a parasitic infection.
	-edema	From a Greek word meaning a "swelling tumor"	
lymphoma	lymph/o-	lymph	*A solid malignant tumor of lymphoid cells, specifically the lymphocytes.* Abnormal lymphocytes collect and grow in lymph nodes or in lymphoid organs such as the spleen and tonsils, forming tumors that eventually metastasize throughout the body. There are two main categories of lymphomas: Hodgkin lymphoma (HL) and non-Hodgkin lymphoma (NHL).
	-oma	tumor	

Get Ready for Exams!

Summary Outline

The main functions of the lymphatic system are defense of the body against infection, return of fluid from the tissue spaces to the blood, and absorption of fat and fat-soluble vitamins from the digestive tract.

I. The Lymphatic System

A. Lymph
1. Lymph is a clear fluid containing water, electrolytes, waste, and some protein.
2. Water and electrolytes are filtered from the plasma into the tissue spaces. Tissue fluid leaves the interstitium by way of the lymphatic vessels; in the lymphatic vessels, the fluid is known as *lymph*.

B. Lymphatic vessels
1. Lymphatic vessels are similar to the blood capillaries and the veins. The large holes in the lymphatic capillaries absorb fluid and protein from the tissue spaces.
2. Lymph drains into the right lymphatic duct and thoracic duct; both ducts drain into the subclavian veins.

C. Movement of lymph
1. Lymph is not pumped by the heart like blood.
2. Lymph moves in response to skeletal muscle contraction (through milking action), chest movement, and contraction of smooth muscle in the lymphatic vessels.

II. Lymphoid Organs

A. Lymph nodes
1. The major clusters of lymph nodes are the cervical, axillary, and inguinal nodes.
2. Lymph nodes help protect the body against infection.

B. Tonsils
1. Tonsils are encapsulated lymph nodes.
2. The tonsils are the palatine, pharyngeal (adenoids), and lingual tonsils.

C. Thymus gland
1. The thymus gland produces and helps differentiate T lymphocytes.
2. The thymus gland secretes thymosins.

D. Spleen
1. It functions as a large lymph node.
2. It has a store of WBCs that phagocytose microorganisms and participate in the immune process.
3. It stores blood and removes worn-out red blood cells and platelets.
4. It engages in fetal erythropoiesis.

Review Your Knowledge

Matching: Lymph Terms

Directions: Match the following words with their descriptions below.

a. lymph nodes
b. subclavian veins
c. thoracic duct
d. spleen
e. tonsils

1. ___ Pharyngeal, lingual, palatine
2. ___ Most of the lymph drains into this large duct.
3. ___ The large lymphatic ducts empty lymph into these blood vessels.
4. ___ Contains red pulp and white pulp; it is the largest lymphoid organ in the body
5. ___ Small, pea-shaped lymphoid structures that filter lymph as it flows through the lymphatic vessels

Multiple Choice

1. Which of the following is least characteristic of adenoids?
   a. They are considered lymphoid organs.
   b. They are tonsils.
   c. They cannot be surgically removed.
   d. They contain cells that fight infection.
2. The spleen
   a. is located in the right upper quadrant.
   b. cannot be removed without causing death.
   c. removes worn-out RBCs and platelets from the circulation.
   d. is avascular.
3. An overly active spleen may prematurely remove platelets from the circulation, thereby
   a. making the person hypertensive.
   b. predisposing the person to infection.
   c. predisposing the person to bleeding.
   d. causing hyperbilirubinemia and jaundice.
4. Which complication is most apt to develop in the patient who has had a breast removed (mastectomy) and lymph node dissection?
   a. Infectious mononucleosis
   b. Bleeding
   c. Lymphedema
   d. Jaundice
5. Which of the following statements is true about tonsils?
   a. Tonsils are nonlymphoid tissue.
   b. The pharyngeal tonsils are called *adenoids*.
   c. The lingual tonsils are the tonsils most often removed surgically.
   d. The pharyngeal tonsils may enlarge but never get infected.
6. The right lymphatic duct and the thoracic duct deliver
   a. blood to the lymphoid organs.
   b. venous blood to the right heart.
   c. lymph to the subclavian veins.
   d. lymph to the axillary lymph nodes.