Selected Key Terms

The following terms and other boldface terms in the chapter are defined in the Glossary.

- adenoids
- chyle
- lacteal
- lymph
- lymphadenitis
- lymphadenopathy
- lymphangitis
- lymphatic duct
- lymph node
- spleen
- thymus
- tonsil

Learning Outcomes

After careful study of this chapter, you should be able to:

1. List the functions of the lymphatic system.
2. Explain how lymphatic capillaries differ from blood capillaries.
3. Name the two main lymphatic ducts and describe the area drained by each.
4. List the major structures of the lymphatic system and give the locations and functions of each.
5. Describe the composition and function of the reticuloendothelial system.
6. Describe the major lymphatic system disorders.
7. Show how word parts are used to build words related to the lymphatic system (see Word Anatomy at the end of the chapter).
Chapter 16

The Lymphatic System and Lymphoid Tissue
The Lymphatic System

The lymphatic system is a widespread system of tissues and vessels. Its organs are not in continuous order, but are scattered throughout the body, and it services almost all regions. Only bone tissue, cartilage, epithelium and the central nervous system are not in direct communication with this system.

Functions of the Lymphatic System

The functions of the lymphatic system are just as varied as its locations. These functions fall into three categories:

- **Fluid balance.** As blood circulates through the capillaries in the tissues, water and dissolved substances are constantly exchanged between the bloodstream and the interstitial (in-ter-STISH-al) fluids that bathe the cells. Ideally, the volume of fluid that leaves the blood should be matched by the amount that returns to the blood. However, there is always a slight excess of fluid left behind in the tissues. In addition, some proteins escape from the blood capillaries and are left behind. This fluid and protein would accumulate in the tissues if not for a second drainage pathway through lymphatic vessels (Fig. 16-1).

  In addition to the blood-carrying capillaries, the tissues also contain microscopic lymphatic capillaries. These small vessels pick up excess fluid and protein left behind in the tissues (Fig. 16-2). The capillaries then drain into larger vessels, which eventually return these materials to the venous system near the heart.

- **Protection from infection.** The lymphatic system is an important component of the immune system, which fights infection. One group of white blood cells, the lymphocytes, can live and multiply in the lymphatic system, where they attack and destroy foreign organisms. Lymphoid tissue scattered throughout the body filters out pathogens, other foreign matter and cellular debris in body fluids. More will be said about the lymphocytes and immunity in Chapter 17.

- **Absorption of fats.** Following the chemical and mechanical breakdown of food in the digestive tract, most nutrients are absorbed into the blood through intestinal capillaries. Many digested fats, however, are too large to enter the blood capillaries and are instead absorbed into lymphatic capillaries. These fats are added to the blood when lymph joins the bloodstream. The topic of digestion is covered in Chapter 19.

The fluid that circulates in the lymphatic system is called lymph (limf), a clear fluid similar in composition to interstitial fluid. Although lymph is formed from the components of blood plasma, it differs from the plasma in that it has much less protein.

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**Figure 16-1** The lymphatic system in relation to the cardiovascular system. Lymphatic vessels pick up fluid in the tissues and return it to the blood in vessels near the heart. ZOOMING IN What type of blood vessel receives lymph collected from the body?

**Checkpoint 16-1** What are three functions of the lymphatic system?

**Lymphatic Circulation**

Lymph travels through a network of small and large channels that are in some ways similar to the blood vessels.
However, the system is not a complete circuit. It is a one-way system that begins in the tissues and ends when the lymph joins the blood (see Fig. 16-1).

**Lymphatic Capillaries**

The walls of the lymphatic capillaries resemble those of the blood capillaries in that they are made of one layer of flattened (squamous) epithelial cells. This thin layer, also called endothelium, allows for easy passage of soluble materials and water (Fig. 16-3). The gaps between the endothelial cells in the lymphatic capillaries are larger than those of the blood capillaries. The lymphatic capillaries are thus more permeable, allowing for easier entrance of relatively large protein particles. The proteins do not move back out of the vessels because the endothelial cells overlap slightly, forming one-way valves to block their return.

Unlike the blood capillaries, the lymphatic capillaries arise blindly; that is, they are closed at one end and do not form a bridge between two larger vessels. Instead, one end simply lies within a lake of tissue fluid, and the other communicates with a larger lymphatic vessel that transports the lymph toward the heart (see Figs. 16-1 and 16-2).

Some specialized lymphatic capillaries located in the lining of the small intestine absorb digested fats. Fats taken into these lacteals (LAK-te-als) are transported in the lymphatic vessels until the lymph is added to the blood. More information on the role of the lymphatic system in digestion is found in Chapter 19.

**Checkpoint 16-2** What are two differences between blood capillaries and lymphatic capillaries?

**Lymphatic Vessels**

The lymphatic vessels are thin walled and delicate and have a beaded appearance because of indentations where valves are located (see Fig. 16-1). These valves prevent back flow in the same way as do those found in some veins.

Lymphatic vessels (Fig. 16-4) include superficial and deep sets. The surface lymphatics are immediately below the skin, often lying near the superficial veins. The deep vessels are usually larger and accompany the deep veins.

Lymphatic vessels are named according to location. For example, those in the breast are called mammary lymphatic vessels, those in the thigh are called femoral lymphatic vessels, and those in the leg are called tibial lymphatic vessels. At certain points, the vessels drain through lymph nodes, small masses of lymphatic tissue that filter the lymph. The nodes are in groups that serve a particular region. For example, nearly all the lymph from the upper extremity and the breast passes through the axillary lymph nodes, whereas lymph from the lower extremity passes through the inguinal nodes. Lymphatic vessels carrying lymph away from the regional nodes eventually drain into one of two terminal vessels, the right lymphatic duct or the thoracic duct, both of which empty into the bloodstream.

**The Right Lymphatic Duct** The right lymphatic duct is a short vessel, approximately 1.25 cm (1/2 inch) long, that receives only the lymph that comes from the superior right quadrant of the body: the right side of the head, neck, and thorax, as well as the right upper extremity. It empties into the right subclavian vein near the heart (see Fig. 16-4 B). Its opening into this vein is
guarded by two pocket-like semilunar valves to prevent blood from entering the duct. The rest of the body is drained by the thoracic duct.

**The Thoracic Duct**  The thoracic duct, or left lymphatic duct, is the larger of the two terminal vessels, measuring approximately 40 cm (16 inches) in length. As shown in Figure 16-4, the thoracic duct receives lymph from all parts of the body except those superior to the diaphragm on the right side. This duct begins in the posterior part of the abdominal cavity, inferior to the attachment of the diaphragm. The first part of the duct is enlarged to form a cistern, or temporary storage pouch, called the cisterna chyli (sis-TER-nah KI-li). Chyle (kile) is the milky fluid that drains from the intestinal lacteals, and is formed by the combination of fat globules and lymph. Chyle passes through the intestinal lymphatic vessels and the lymph nodes of the mesentery (membrane around the intestines), finally entering the cisterna chyli. In addition to chyle, all the lymph from below the diaphragm empties into the cisterna chyli, passing through the various clusters of lymph nodes. The thoracic duct then carries this lymph into the bloodstream.

The thoracic duct extends upward through the diaphragm and along the posterior wall of the thorax into
the base of the neck on the left side. Here, it receives the left jugular lymphatic vessels from the head and neck, the left subclavian vessels from the left upper extremity, and other lymphatic vessels from the thorax and its parts. In addition to the valves along the duct, there are two valves at its opening into the left subclavian vein to prevent the passage of blood into the duct.

**Lymph Nodes**

The lymph nodes, as noted, are designed to filter the lymph once it is drained from the tissues (Fig. 16-5). They are also sites where lymphocytes of the immune system multiply and work to combat foreign organisms. The lymph nodes are small, rounded masses varying from pinhead size to as long as 2.5 cm (1 inch). Each has a fibrous connective tissue capsule from which partitions (trabeculae) extend into the substance of the node. At various points in the node's surface, afferent lymphatic vessels pierce the capsule to carry lymph into the node. An indented area called the **hilum** (HI-lum) is the exit point for efferent lymphatic vessels carrying lymph out of the node. At this region, other structures, including blood vessels and nerves, connect with the node.

Each node is subdivided into lymph-filled spaces (sinuses) and cords of lymphatic tissue. Pulplike nodules in the outer region, or cortex, have germinal centers where certain immune lymphocytes multiply. The inner region, the medulla, has populations of immune cells, including lymphocytes and macrophages (phagocytes) along open channels that lead into the efferent vessels.

Lymph nodes are seldom isolated. As a rule, they are massed together in groups, varying in number from 2 or 3 to well over 100. Some of these groups are placed deeply, whereas others are superficial. The main groups include the following:

- **Cervical nodes**, located in the neck in deep and superficial groups, drain various parts of the head and neck. They often become enlarged during upper respiratory infections.
- **Axillary nodes**, located in the axillae (armpits), may become enlarged after infections of the upper extremi-

**Movement of Lymph**

The segments of lymphatic vessels located between the valves contract rhythmically, propelling the lymph along. The contraction rate is related to the volume of fluid in the vessel—the more fluid, the more rapid the contractions.

Lymph is also moved by the same mechanisms that promote venous return of blood to the heart. As skeletal muscles contract during movement, they compress the lymphatic vessels and drive lymph forward. Changes in pressures within the abdominal and thoracic cavities caused by breathing aid the movement of lymph during passage through these body cavities. Box 16-1 describes what happens when lymph does not flow properly.

**Lymphoid Tissue**

Lymphoid (LIM-loyd) tissue is distributed throughout the body and makes up the specialized organs of the lymphatic system. The lymph nodes have already been described relative to describing lymphatic circulation, but these tissues and other components of the lymphatic system are discussed in greater detail in the next section.

**Box 16-1**

### Clinical Perspectives

**Lymphedema: When Lymph Stops Flowing**

Fluid balance in the body requires appropriate distribution of fluid among the cardiovascular system, lymphatic system, and the tissues. Edema occurs when the balance is tipped toward excess fluid in the tissues. Often, edema is due to heart failure. However, blockage of lymphatic vessels (and the resulting fluid accumulation in the subcutaneous tissues) can cause another form of edema called **lymphedema**. The clinical hallmark of lymphedema is chronic swelling of an arm or leg, whereas heart failure usually causes swelling of both legs.

Lymphedema may be either primary or secondary. Primary lymphedema is a rare congenital condition caused by abnormal development of lymphatic vessels. Secondary lymphedema, or acquired lymphedema, can develop as a result of trauma to a limb, surgery, radiation therapy, or infection of the lymphatic vessels (lymphangitis). One of the most common causes of lymphedema is the removal of axillary lymph nodes during mastectomy (breast removal), which disrupts lymph flow from the adjacent arm. Lymphedema may also occur following prostate surgery.

Therapies that encourage the flow of fluid through the lymphatic vessels are useful in treating lymphedema. These therapies may include elevation of the affected limb, manual lymphatic drainage through massage, light exercise, and firm wrapping of the limb to apply compression. In addition, changes in daily habits can lessen the effects of lymphedema. For example, further blockage of lymph drainage can be prevented by wearing loose clothing and jewelry, carrying a purse or handbag on the unaffected arm, and sitting with legs uncrossed. Lymphangitis requires the use of appropriate antibiotics. Prompt treatment is necessary because, in addition to swelling, other complications include poor wound healing, skin ulcers, and increased risk of infection.
ties and the breasts. Cancer cells from the breasts often metastasize (spread) to the axillary nodes.

- **Tracheobronchial** (tra-ke-o-BRONG-ke-al) nodes are found near the trachea and around the larger bronchial tubes. In people living in highly polluted areas, these nodes become so filled with carbon particles that they are solid black masses resembling pieces of coal.

- **Mesenteric** (mes-en-TER-ik) nodes are found between the two layers of peritoneum that form the mesentery. There are some 100 to 150 of these nodes.
- **Inguinal nodes**, located in the groin region, receive lymph drainage from the lower extremities and from the external genital organs. When they become enlarged, they are often referred to as **buboes** (BU-bose), from which bubonic plague got its name.

Box 16-2 explains the role as lymph node biopsy in the treatment of cancer.

**Checkpoint 16-4:** What is the function of the lymph nodes?

The spleen is an organ that contains lymphoid tissue designed to filter blood. It is located in the superior left hypochondriac region of the abdomen, high up under the dome of the diaphragm, and normally is protected by the lower part of the rib cage (Fig. 16-6). The spleen is a soft, purplish, and somewhat flattened organ, measuring approximately 12.5 to 16 cm (5 to 6 inches) long and 5 to 7.5 cm (2 to 3 inches) wide. The capsule of the spleen, as well as its framework, is more elastic than that of the lymph nodes. It contains involuntary muscle, which enables the splenic capsule to contract and also to withstand some swelling.

Considering its size, the spleen has an unusually large blood supply. The organ is filled with a soft pulp that filters the blood. It also harbors phagocytes and lymphocytes, which are active in immunity. The spleen is classified as part of the lymphatic system because it contains prominent masses of lymphoid tissue. However, it has wider functions than other lymphatic structures, including the following:

- Cleansing the blood of impurities and cellular debris by filtration and phagocytosis.
- Destroying old, worn-out red blood cells. The iron and other breakdown products of hemoglobin are carried to
Ordinarily, the lymphatic system is one of the body's primary defenses against disease. In cancer, though, it can be a vehicle for the spread (metastasis) of disease. When cancer cells enter the lymphatic vessels, they travel to other parts of the body, where they may establish new tumors. Along the way, some cancer cells become lodged in the lymph nodes.

In breast cancer, the degree of invasion of nearby lymph nodes helps determine what treatments are required after surgical removal of the tumor. Until recently, a mastectomy often included the removal of nearby lymphatic vessels and nodes (a procedure called axillary lymph node dissection). Biopsy of the nodes determined whether or not they contained cancerous cells, and if they did, radiation treatment or chemotherapy was required. In many women with early-stage breast cancer, however, the axillary nodes do not contain cancerous cells. In addition, about 20 percent of the women whose lymphatic vessels and nodes have been removed suffer impaired lymph flow. Resulting in lymphedema, pain, disability, and an increased risk of infection.

Sentinel node biopsy is a new diagnostic procedure that may minimize the need to perform axillary lymph node dissection, while still detecting metastasis. Surgeons use radioactive tracers to identify the first nodes that receive lymph from the area of a tumor. Biopsy of only these "sentinel nodes" reveals whether tumor cells are present, providing the earliest indication of metastasis. Research shows that sentinel lymph node biopsy is associated with less pain, fewer complications, and faster recovery than axillary lymph node dissection. However, because the procedure is relatively new, more clinical trials are required to determine whether sentinel node biopsy is as successful as axillary dissection in finding cancer before it spreads.

**Checkpoint 16-5** What is filtered by the spleen?

**The Thymus**

Because of its appearance under a microscope, the thymus (THI-mus), located in the superior thorax beneath the sternum, traditionally has been considered part of the lymphoid system (see Fig. 16-6). Recent studies, however, suggest that this structure has a much wider function than other lymphoid tissue. It appears that the thymus plays a key role in immune system development before birth and during the first few months of infancy. Certain lymphocytes must mature in the thymus gland before they can perform their functions in the immune system (see Chapter 17). These T cells (T lymphocytes) develop under the effects of the thymus gland hormone called thymosin (THI-mo-sin), which also promotes lymphocyte growth and activity in lymphoid tissue throughout the body. Removal of the thymus causes a decrease in the production of T cells, as well as a decrease in the size of the spleen and of lymph nodes throughout the body.

The thymus is most active during early life. After puberty, the tissue undergoes changes; it shrinks in size and is replaced by connective tissue and fat.

**Checkpoint 16-6** What kind of immune system cells develop in the thymus?
The Tonsils

The tonsils are masses of lymphoid tissue located in the vicinity of the pharynx (throat) where they remove contaminants from materials that are inhaled or swallowed (Fig. 16-7). The tonsils have deep grooves lined with lymphatic nodules. Lymphocytes attack pathogens trapped in these grooves. The tonsils are located in three areas:

- The palatine (PAL-ah-tine) tonsils are oval bodies located at each side of the soft palate. These are generally what is meant when one refers to “the tonsils.”
- The single pharyngeal (ah-PEN-diks) tonsils are a fingerlike tube of lymphatic tissue, measuring about approximately 8 cm (3 in.) long, and is attached, or “appended” to the first portion of the large intestine (see Fig. 16-6). Like the tonsils, it seems to be noticed only when it becomes infected, causing appendicitis. The appendix may, however, figure in the development of immunity, as do the tonsils.
- The single pharyngeal (ah-PEN-diks) tonsils are a fingerlike tube of lymphatic tissue, measuring about approximately 8 cm (3 in.) long, and is attached, or “appended” to the first portion of the large intestine (see Fig. 16-6). Like the tonsils, it seems to be noticed only when it becomes infected, causing appendicitis. The appendix may, however, figure in the development of immunity, as do the tonsils.

Any of these tonsils may become so loaded with bacteria that they become reservoirs for repeated infections and their removal is advisable. In children, a slight enlargement of any of them is not an indication for surgery, however, because all lymphoid tissue masses tend to be larger in childhood. A physician must determine whether these masses are abnormally enlarged, taking the patient’s age into account, because the tonsils function in immunity during early childhood. The surgery to remove the palatine tonsils is a tonsillectomy; an adenoidectomy is removal of the adenoids. Often these two procedures are done together and abbreviated as T & A (see Box 16-3, Tonsillectomy: A Procedure Reconsidered).

Figure 16-7 Location of the tonsils. All are in the vicinity of the pharynx (throat).

Other Lymphoid Tissue

The appendix (ah-PEN-diks) is a fingerlike tube of lymphatic tissue, measuring about approximately 8 cm (3 in.) long, and is attached, or “appended” to the first portion of the large intestine (see Fig. 16-6). Like the tonsils, it seems to be noticed only when it becomes infected, causing appendicitis. The appendix may, however, figure in the development of immunity, as do the tonsils.

In the mucous membranes lining portions of the digestive, respiratory, and urogenital tracts there are areas of lymphatic tissue that help destroy outside contaminants. By means of phagocytosis and production of anti-
bodies, substances that counteract infectious agents, this mucosal-associated lymphoid tissue, or MALT, prevents microorganisms from invading deeper tissues.

**Peyer (PI-er) patches** are part of the MALT system. These clusters of lymphatic nodules are located in the mucous membranes lining the small intestine’s distal portion. Peyer patches, along with the tonsils and appendix, are included in the specific network known as GALT, or gut-associated lymphoid tissue. All of these lymphatic tissues associated with mucous membranes are now recognized as an important first barrier against invading microorganisms.

### The Reticuloendothelial System

The reticuloendothelial (reh-tik-u-lo-en-do-THE-le-al) system consists of related cells responsible for the destruction of worn-out blood cells, bacteria, cancer cells, and other foreign substances that are potentially harmful to the body. Included among these cells are monocytes, relatively large white blood cells (see Fig. 13-4 E in Chapter 13) that are formed in the bone marrow and then circulate in the bloodstream to various parts of the body. Upon entering the tissues, monocytes develop into macrophages (MAK-ro-faj-ez), a term that means “big eaters.”

Macrophages in some organs are given special names; Kupffer (KOOP-fer) cells, for example, are located in the lining of the liver sinusoids (blood channels). Other parts of the reticuloendothelial system are found in the spleen, bone marrow, lymph nodes, and brain. Some macrophages are located in the lungs, where they are called dust cells because they ingest solid particles that enter the lungs; others are found in soft connective tissues all over the body.

This widely distributed protective system has been called by several other names, including tissue macrophage system, mononuclear phagocyte system, and monocyte-macrophage system. These names describe the type of cells found within this system.

### Disorders of the Lymphatic System and Lymphoid Tissue

**Lymphangitis** (lim-fan-JI-tis), which is inflammation of lymphatic vessels, usually begins in the region of an infected and neglected injury and can be seen as red streaks extending along an extremity. Such inflamed vessels are a sign that bacteria have spread into the lymphatic system. If the lymph nodes are not able to stop the infection, pathogens may enter the bloodstream, causing septicemia (sep-thih-SE-me-ah), or blood poisoning. Streptococci often are the invading organisms in such cases.

In **lymphadenitis** (lim-fad-en-I-tis), or inflammation of the lymph nodes, the nodes become enlarged and tender. This condition reflects the body’s attempt to combat an infection. Cervical lymphadenitis occurs during measles, scarlet fever, septic sore throat, diphtheria, and, frequently, the common cold. Chronic lymphadenitis may be caused by the bacillus that causes tuberculosis. Infections of the upper extremities cause enlarged axillary nodes, as does cancer of the breast. Infections of the external genitals or the lower extremities may cause enlargement of the inguinal lymph nodes.

### Lymphedema

Edema is tissue swelling due to excess fluid. The condition has a variety of causes, but edema due to obstruction of lymph flow is called lymphedema (lim-feh-DE-mah). Possible causes of lymphedema include infection of the lymphatic vessels, a malignant growth that obstructs lymph flow, or loss of lymphatic vessels and nodes as a result of injury or surgery. Areas affected by lymphedema are more prone to infection because the filtering activity of the lymphatic system is diminished. Mechanical methods to improve drainage and drugs to promote water loss are possible treatments for lymphedema (see Box 16-1).

As mentioned in Chapter 5, **elephantiasis** is a great enlargement of the lower extremities resulting from lymphatic vessel blockage by small worms called *filariae* (fi-LA-re-e). These tiny parasites, carried by insects such as flies and mosquitoes, invade the tissues as embryos or immature forms. They then grow in the lymph channels and obstruct lymphatic flow. The swelling of the legs or, as sometimes happens in men, the scrotum, may be so great that the victim becomes incapacitated. This disease is especially common in certain parts of Asia and in some of the Pacific islands. No cure is known.

**Lymphadenopathy**

Lymphadenopathy (lim-fad-en-OP-ah-the) is a term meaning “disease of the lymph nodes.” Enlarged lymph nodes are a common symptom in a number of infectious and cancerous diseases. For example, generalized lymphadenopathy is an early sign of infection with human immunodeficiency virus (HIV), the virus that causes acquired immunodeficiency syndrome (AIDS). **Infectious mononucleosis** (mon-o-nu-kle-O-sis) is an acute viral infection, the hallmark of which is a marked enlargement of the cervical lymph nodes. Mononucleosis is fairly common among college students. Enlarged lymph nodes are commonly referred to as glands, as in “swollen glands.” However, they do not produce secretions and are not glands.

**Splenomegaly**

Enlargement of the spleen, known as splenomegaly (spleno-MEG-ah-le), accompanies certain acute infectious diseases, including scarlet fever, typhus fever, typhoid fever, and syphilis. Many tropical parasitic diseases cause
splenomegaly. A certain blood fluke (flatworm) that is fairly common among workers in Japan and other parts of Asia causes marked splenic enlargement.

Splenomegaly is characterized by enlargement of the spleen, hemorrhages from the stomach, and fluid accumulation in the abdomen. In this and other similar diseases, splenectomy appears to constitute a cure.

**Lymphoma**

Lymphoma (lim-FO-mah) is any tumor, benign or malignant, that occurs in lymphoid tissue. Two examples of malignant lymphoma are described next.

Hodgkin disease is a chronic malignant disease of lymphoid tissue, especially the lymph nodes. The incidence of this disease rises in two age groups: in the early 20s among both men and women, and again after age 50, more commonly among men. The cause is unknown, but in some cases may involve a viral infection. Hodgkin disease appears as painless enlargement of a lymph node or close group of nodes, often in the neck, but also in the armpit, thorax, and groin. It may spread throughout the lymphatic system and eventually to other systems if not controlled by treatment. Early signs are weight loss, fever, night sweats, fatigue, anemia and decline in immune defenses. A clear sign of the disease is the presence of Reed-Sternberg cells in lymph node biopsy tissue (Fig. 16-8). Chemotherapy and radiotherapy, either separately or in combination, have been used with good results, affording patients many years of life.

Non-Hodgkin lymphoma is more common than Hodgkin disease. It appears mostly in older adults and patients with deficient immune systems, such as those with AIDS. Enlargement of the lymph nodes (lymphadenopa-

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**Word Anatomy**

Medical terms are built from standardized word parts (prefixes, roots, and suffixes). Learning the meanings of these parts can help you remember words and interpret unfamiliar terms.

<table>
<thead>
<tr>
<th>WORD PART</th>
<th>MEANING</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphoid Tissue</td>
<td>-oid</td>
<td>like, resembling</td>
</tr>
<tr>
<td>-oad</td>
<td>gland</td>
<td>mysterious pathy</td>
</tr>
<tr>
<td>-megaly</td>
<td></td>
<td>excessive enlargement</td>
</tr>
</tbody>
</table>

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**Figure 16-8** Reed-Sternberg cell characteristic of Hodgkin disease. A typical cell has two nuclei with large, dark-staining nucleoli. (Reprinted with permission from Rubin E, Farber JL. Pathology 3e. Philadelphia: Lippincott Williams & Wilkins, 1999.)

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**Checkpoint 16-8** What is lymphadenopathy?

**Checkpoint 16-9** What is lymphoma and what are two examples of malignant lymphoma?
Summary

I. Lymphatic system
A. Functions
1. Fluid balance—drains excess fluid and proteins from the tissues and returns them to the blood
2. Protection from infection
   a. Lymphocytes fight foreign organisms
   b. Lymphoid tissue filters body fluids
3. Absorption of fats—lacteals absorb digested fats from small intestine

II. Lymphatic circulation
A. Lymphatic capillaries
1. Made of endothelium (simple squamous epithelium)
2. More permeable than blood capillaries
3. Overlapping cells form one-way valves
B. Lymphatic vessels
1. Superficial and deep sets
2. Right lymphatic duct
   a. Drains upper right part of body
   b. Empties into right subclavian vein
3. Thoracic duct
   a. Drains remainder of body
   b. Empties into left subclavian vein
C. Movement of lymph
1. Valves in vessels
2. Contraction of vessels
3. Skeletal muscle contraction
4. Breathing

III. Lymphoid tissue—distributed throughout body
A. Lymph nodes
1. Along path of lymphatic vessels
2. Filter lymph
B. Spleen
1. Filtration of blood
2. Destruction of old red cells
3. Production of red cells before birth
4. Storage of blood
C. Thymus
1. Processing of T lymphocytes (T cells)
2. Secretion of thymosin—stimulates T lymphocytes in lymphoid tissue
D. Tonsils
1. Filter swallowed and inhaled material
2. Located near pharynx (throat)
   a. Palatine—near soft palate
   b. Pharyngeal (adenoids)—behind nose
   c. Lingual—back of tongue
E. Other
1. Appendix—attached to large intestine
2. Mucosal—associated lymphoid tissue (MALT)
   a. Gut-associated lymphoid tissue (GALT)
      (1) Example—Feyer patches in lining of small intestine

IV. The reticuloendothelial system
1. Cells throughout body that remove impurities
2. Macrophages
   a. From monocytes
   b. Localize and given special names—e.g., Kupffer cells, dust cells

V. Disorders of the lymphatic system and lymphoid tissue
A. Lymphangitis—inflammation of lymphatic vessels
B. Lymphadenitis—inflammation of lymph nodes that occurs during infection
1. Lymphedema—swelling due to obstruction of lymph flow
   a. Removal of lymph nodes and vessels by injury, surgery
   b. Infection—e.g., elephantiasis caused by filariae (parasitic worms)
2. Lymphadenopathy—disease of lymph nodes
3. Splenomegaly—enlargement of the spleen
4. Lymphoma—tumor of lymphoid tissue
   a. Hodgkin disease—chronic malignancy with enlarged lymph nodes
   b. Non-Hodgkin lymphoma—more common in older adults

Questions for Study and Review

Building Understanding
Fill in the blanks
1. The fluid that circulates in the lymphatic system is called ______.
2. Digested fats enter the lymphatic circulation through vessels called______.
3. Fat globules and lymph combine to form a milky fluid called ______.
4. Surgical removal of the spleen is termed ______.
5. When filariae block lymphatic vessels they cause the disease called ______.
Matching
Match each numbered item with the most closely related lettered item.

___ 6. Inflammation of lymphatic vessels
   a. lymphoma
   b. lymphangitis
   c. lymphedema
   d. lymphadenitis

___ 7. Inflammation of lymph nodes
___ 8. Fluid retention due to obstruction of lymph vessels
___ 9. Tumor that occurs in lymphoid tissue

Multiple choice
___ 10. Compared to plasma, lymph contains much less
   a. fat
   b. protein
   c. carbohydrate
   d. water
___ 11. Lymph from the lower extremities returns to
   the cardiovascular system via the
   a. cisterna chyli
   b. right lymphatic duct
   c. thymus
   d. thoracic duct
___ 12. Macrophages and monocytes found throughout
   the body make up the
   a. tonsils
   b. Peyer patches
   c. reticuloendothelial system
   d. appendix
___ 13. The hallmark clinical sign of infectious
   mononucleosis is:
   a. splenomegaly
   b. lymphadenopathy
   c. lymphangitis
   d. edema

Understanding Concepts
14. How does the structure of lymphatic capillaries correlate with their function? List some differences between lymphatic and blood capillaries.
15. Describe three mechanisms that propel lymph through the lymphatic vessels.
16. Trace a globule of fat from a lacteal in the small intestine to the right atrium.
17. Describe the structure of a typical lymph node.
18. State the location of the spleen and list several of its functions.
19. Describe two forms of lymphoma.

Conceptual Thinking
20. Explain the absence of arteries in the lymphatic circulatory system.