Blood, Lymph, and Immune Systems

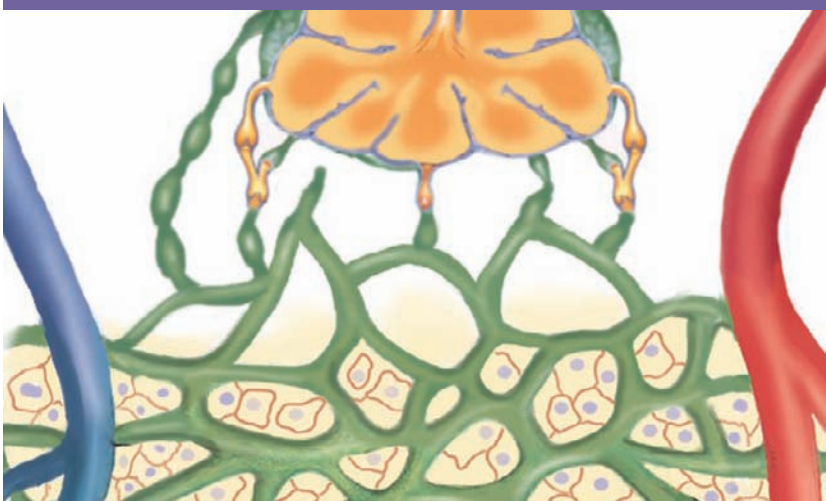
CHAPTER 9

Chapter Outline

Objectives

Upon completion of this chapter, you will be able to:

- Identify and describe the components of blood.
- Locate and identify the structures associated with the lymphatic system.
- List the cells associated with the acquired immune response and describe their function.
- Describe the functional relationship between the blood, lymph, and immune systems and other body systems.
- Recognize, pronounce, spell, and build words related to the blood, lymph, and immune systems.
- Describe pathological conditions, diagnostic and therapeutic procedures, and other terms related to the blood, lymph, and immune systems.
- Explain pharmacology related to the treatment of blood, lymph, and immune disorders.
- Demonstrate your knowledge of this chapter by completing the learning and medical record activities.



Anatomy and Physiology

The blood, lymph, and immune systems share common cells, structures, and functions. Blood provides immune cells that locate, identify, and destroy disease-causing agents. These immune cells actively engage in the destruction of the invading agent or produce substances that seek out and tag the agent for destruction. Immune cells rely on lymph vessels and blood vessels to deliver their protective devices to the entire body. Furthermore, immune cells use lymph structures (the spleen and lymph nodes) for permanent or temporary lodging sites. They also use these structures to monitor the **extracellular fluid** of the body as it filters through the nodes. When immune cells identify disease-causing agents passing through the nodes, they destroy them before they cause disease in the **host.** The lymph system returns extracellular fluid, lymph, and immune substances back to the circulatory system as plasma to be ready once again for redelivery to the entire body. Although blood, lymph, and immune systems are discussed separately, their functions and structures overlap.

Blood

Blood is connective tissue composed of a liquid medium called ***plasma*** in which solid components are suspended. It accounts for approximately 8% of the total weight of the body. The solid components of blood include:

- red blood cells (**erythrocytes**)
- white blood cells (**leukocytes**)
- platelets (**thrombocytes**). (See Figure 9–1.)

Anatomy and Physiology Key Terms

This section introduces important blood, lymph, and immune system terms and their definitions. Word analyses for selected terms are also provided.

Term	Definition
antibody ĂN-tĭ-bŏd-ē	Protective protein produced by B lymphocytes in response to presence of a foreign substance called an *antigen*
antigen ĂN-tĭ-jĕn	Substance recognized as harmful to the host and stimulates formation of antibodies in an immunocompetent individual
bile pigments BĪL	Substances derived from the breakdown of hemoglobin, produced by the liver, and excreted in the form of bile ***Interference with the excretion of bile may lead to jaundice.***
cytokines SĪ-tō-kīnz	Chemical substances produced by certain cells that initiate, inhibit, increase, or decrease activity in other cells ***Cytokines are important chemical communicators in the immune response, regulating many activities associated with immunity and inflammation.***
extracellular fluid ĕks-tră-SĔL-ū-lăr	All body fluids found outside cells, including interstitial fluid, plasma, lymph, and cerebrospinal fluid ***Extracellular fluid provides a stable external environment for body cells.***
host	Organism that maintains or harbors another organism
immunocompetent ĭm-ū-nō-KŎM-pĕ-tĕnt	Ability to develop an immune response, or the ability to recognize antigens and respond to them
natural killer cells	Specialized lymphocytes that kill abnormal cells by releasing chemicals that destroy the cell membrane causing its intercellular fluids to leak out ***Natural killer (NK) cells destroy virally infected cells and tumor cells.***

Pronunciation Help

Long Sound	ā—rate	ē—rebirth	ī—isle	ō—over	ū—unite
Short Sound	ă—alone	ĕ—ever	ĭ—it	ŏ—not	ŭ—cut

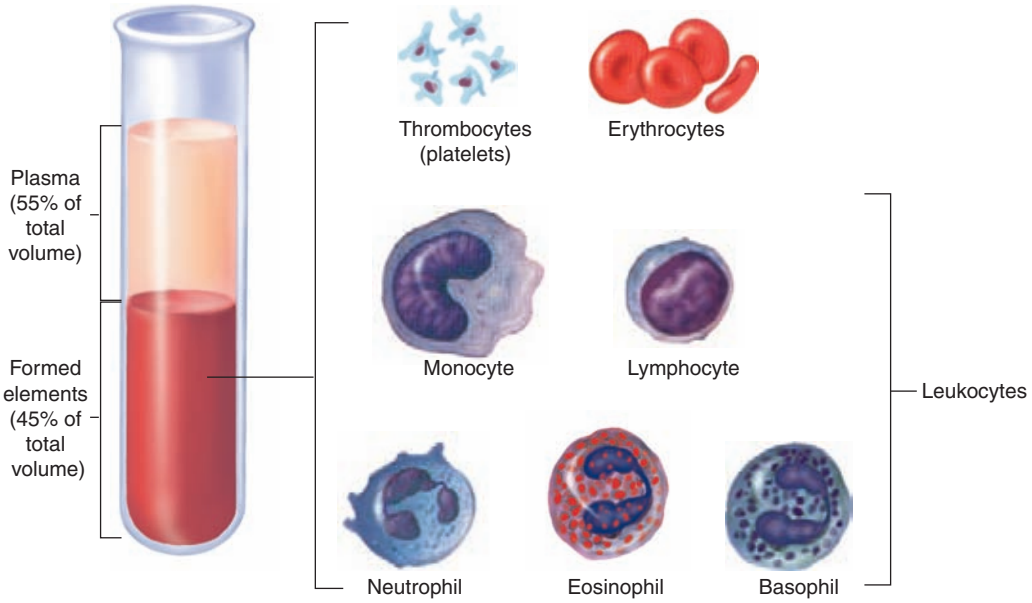


Figure 9-1. Blood composition.

In adults, blood cells are formed in the bone marrow of the skull, ribs, sternum, vertebrae, pelvis and the ends of the long bones of the arms and legs. Blood cells develop from an undifferentiated cell called a ***stem cell.*** The development and maturation of blood cells is called ***hematopoiesis,*** or ***hemopoiesis.*** (See Figure 9–2.) Red blood cell development is called ***erythropoiesis;*** white blood cell development, ***leukopoiesis;*** and platelet development, ***thrombopoiesis.*** After blood cells mature, they leave the bone marrow and enter the circulatory system.

Red blood cells transport oxygen and carbon dioxide. White blood cells provide defenses against diseases and other harmful substances and aid in tissue repair. Platelets provide mechanisms for blood coagulation. Although blood makes up only about 8% of all body tissues, it is essential to life.

Red Blood Cells

Red blood cells (RBCs), or **erythrocytes,** are the most numerous of the circulating blood cells. During erythropoiesis, RBCs decrease in size and, just before reaching maturity, the nucleus is extruded. Small fragments of nuclear material may remain in the immature RBC and appear as a fine, lacy net. This immature RBC is called a ***reticulocyte.*** Although some reticulocytes are found in circulation, most lose their nuclear material prior to entering the circulatory system as mature erythrocytes. During erythropoiesis, RBCs develop a specialized iron-containing compound called ***hemoglobin*** that gives them their red color. Hemoglobin carries oxygen to body tissues and exchanges it for carbon dioxide. When mature, RBCs are shaped like biconcave disks.

RBCs live about 120 days and then rupture, releasing hemoglobin and cell fragments. Hemoglobin breaks down into an iron compound called ***hemosiderin*** and several **bile pigments.** Most hemosiderin returns to the bone marrow and is reused in a different form to manufacture new blood cells. The liver eventually excretes bile pigments.

White Blood Cells

White blood cells (WBCs), or **leukocytes,** protect the body against invasion by pathogens and foreign substances, remove debris from injured tissue, and aid in the healing process. While RBCs remain in the bloodstream, WBCs migrate through endothelial walls of capillaries and venules and enter tissue spaces by a process called ***diapedesis.*** (See Figure 9–3.) There they initiate inflammation and the immune response if they encounter sites of injury or infection. WBCs are divided into two groups: granulocytes and agranulocytes depending on the presence or absence of granules in the cytoplasm.

Granulocytes

There are three types of **granulocytes:** neutrophils, eosinophils, and basophils. Their names are derived from the type of dye that stains their

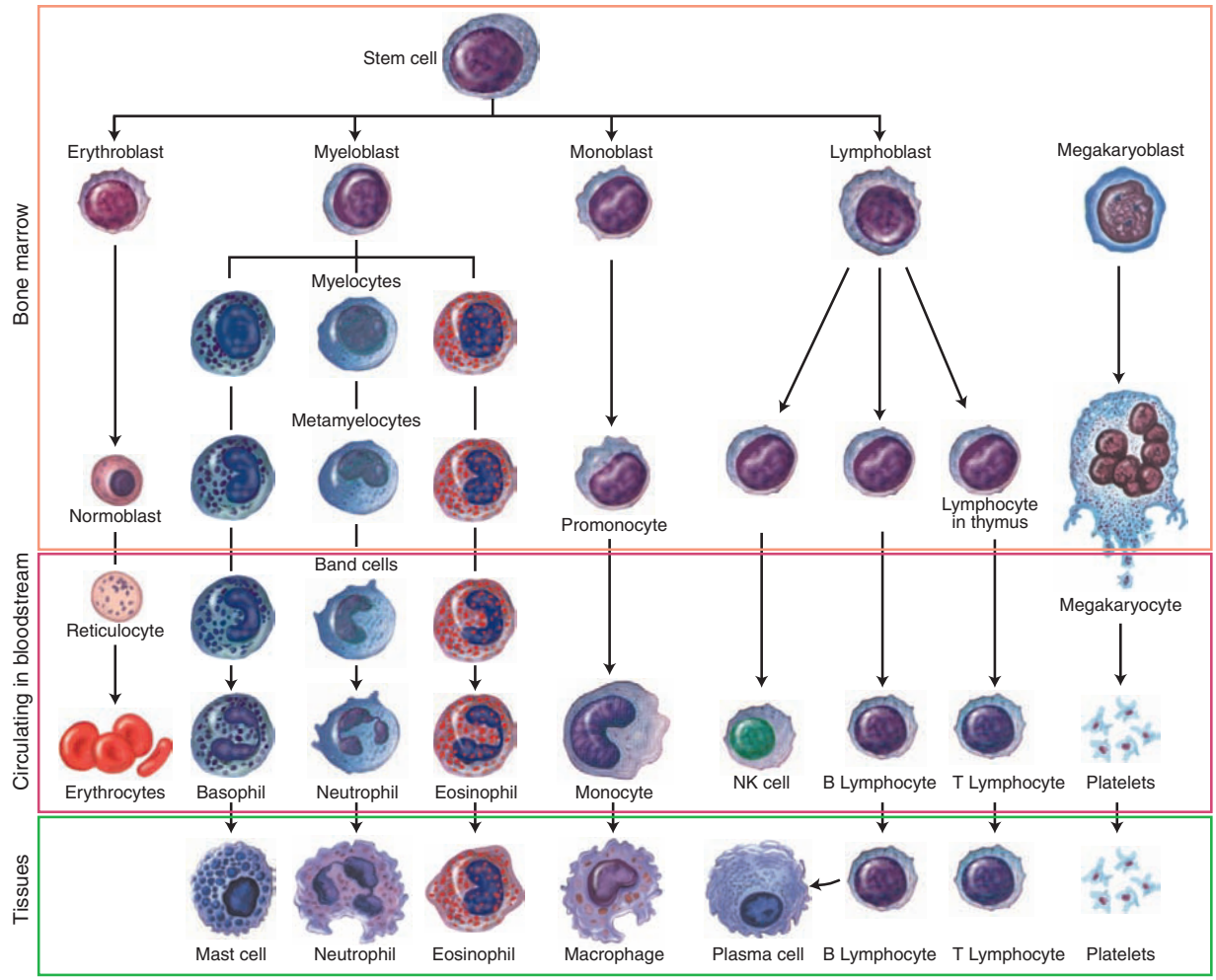


Figure 9-2. Hematopoiesis.

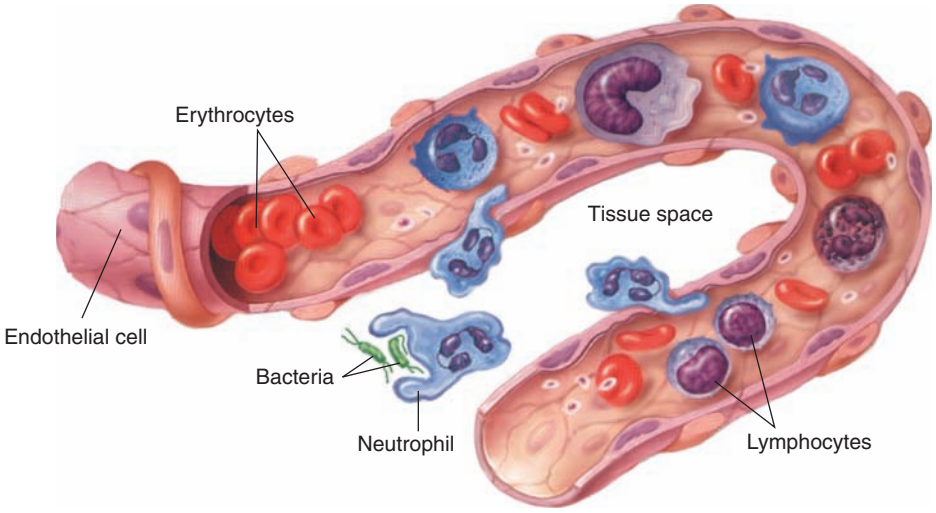


Figure 9-3. Diapedesis.

cytoplasmic granules when a blood smear is prepared in the laboratory for examination:

- **Neutrophils** are the most numerous circulating leukocyte. Their granules stain with a neutral dye, giving them their lilac color. Neutrophils are motile and highly phagocytic, permitting them to ingest and devour bacteria and other particulate matter. They are the first cell to appear at a site of injury or infection to begin the work of phagocytizing foreign material. (See Figure 9–4.) Their importance in body protection cannot be underestimated. A person with a serious deficiency of this blood cell type will die despite protective attempts by other body defences.
- **Eosinophils** contain granules that stain with a red acidic dye called ***eosin***. Eosinophils protect the body by releasing many substances that neutralize toxic compounds, especially of a chemical nature. Eosinophils increase in number during allergic reactions and animal parasite infestations.
- **Basophils** contain granules that readily stain with a purple alkaline (basic) dye. Basophils release histamines and heparin when tissue is damaged. **Histamines** initiate the inflammatory process by increasing blood flow. As more blood flows to the damaged area, it carries with it additional nutrients, immune substances, and immune cells that help in damage containment and tissue repair. **Heparin** is an anticoagulant and acts to prevent blood from clotting at the injury site.

In their mature forms, all three types of granulocytes commonly exhibit a nucleus with at least two lobes, and in neutrophils, sometimes as many as six lobes (**polymorphonuclear**).

Agranulocytes

Agranulocytes arise in the bone marrow from stem cells. Their nuclei do not form lobes. Thus, they are commonly called ***mononuclear leukocytes*****.** There are two types of agranulocytes: monocytes and lymphocytes.

- **Monocytes** are mildly phagocytic when found within blood vessels. However, they remain in the vascular channels only a short time. When they exit, they transform into **macrophages,** avid phagocytes

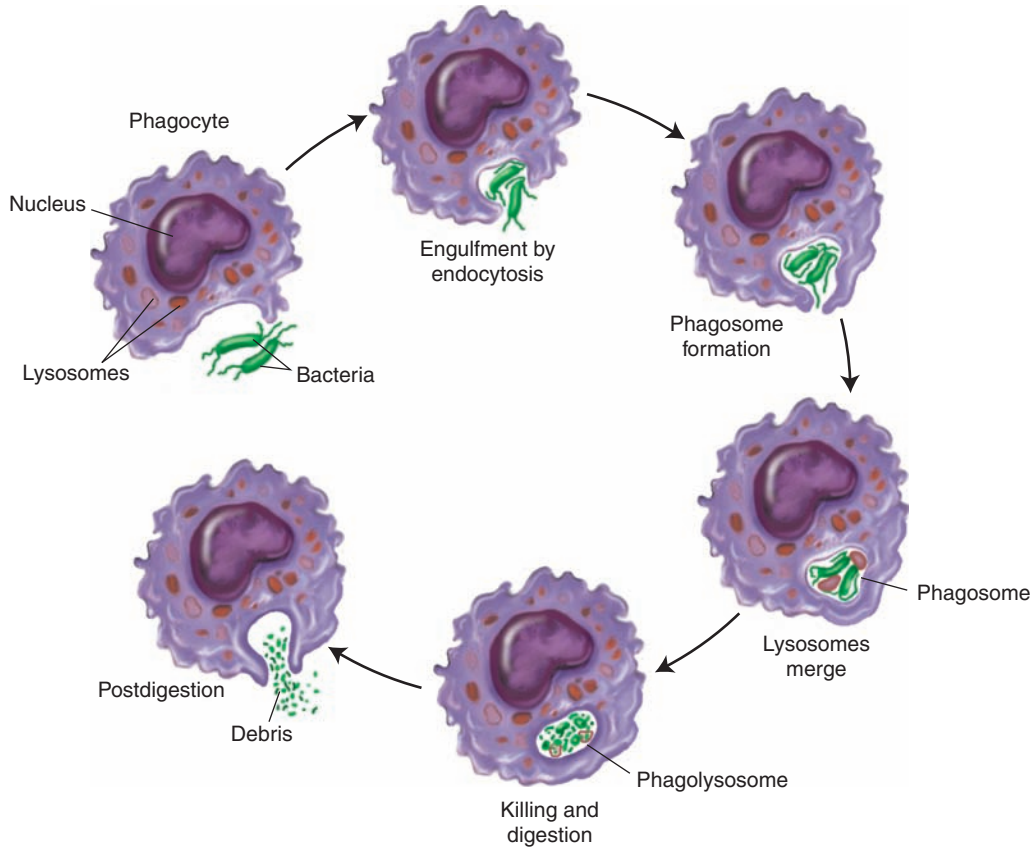


Figure 9-4. Phagocytosis.

capable of ingesting pathogens, dead cells, and other debris found at sites of inflammation. Macrophages play a chief role in many activities associated with specific immunity.

- **Lymphocytes** include B cells, T cells, and natural killer cells. B cells and T cells provide a specialized type of defence called the ***specific immune response.*** This mode of protection is custom-made and aimed at a specific antigen. Its dual action includes humoral immunity and cellular immunity. **Natural killer (NK) cells** provide a generalized defence and respond whenever a potentially dangerous or abnormal cell is encountered. They "kill" by releasing potent chemicals that rupture the cell membrane of abnormal cells. NK cells are highly effective against cancer cells and cells harboring pathogens. These cells have the ability to kill over and over again before they die. (See Table 9-1.)

Platelets

Platelets are the smallest formed elements found in blood. Although they are sometimes called ***thrombocytes,*** they are not true cells, as this term erroneously suggests, but merely fragments of cells. Platelets initiate blood clotting (**hemostasis**) when injury occurs. Hemostasis is not a single reaction, but a series of interlinked reactions, each requiring a specific factor. If any one of the factors is absent, a clot will not form. Initially, the damaged blood vessel constricts and platelets become "sticky." They aggregate at the injury site and provide a barrier to contain blood loss. Clotting factors in platelets and injured tissue release **thromboplastin,** a substance that initiates clot formation. In the final step of coagulation, **fibrinogen** (a soluble blood protein) becomes insoluble and forms fibrin strands that act as a net, entrapping blood cells. This jellylike mass of blood cells and fibrin is called a ***thrombus*** or ***blood clot***.

Plasma

Plasma is the liquid portion of blood in which blood cells are suspended. When blood cells are removed, plasma appears as a thin, almost colorless fluid. It is composed of about 92% water and contains such products as **plasma proteins** (albumins, globulins, and fibrinogen), gases, nutrients, salts, hormones, and waste materials. Plasma makes possible the chemical communication between body cells by transporting body products throughout the body.

Blood serum is a product of blood plasma. If fibrinogen and clotting elements are removed from plasma, the resulting fluid is called ***serum.*** If a blood sample clots in a test tube, the resulting fluid that remains after the clot is removed is serum, because fibrinogen and other clotting elements have been expended to form the clot.

Blood Groups

Human blood is divided into four groups, A, B, AB, and O, based on the presence or absence of specific **antigens** on the surface of RBCs. (See Table 9–2.) In each of these four blood groups, the plasma does not contain the **antibody** against the antigen that is present on the RBCs. Rather, the plasma contains the opposite antibodies. These

Table 9-1 Protective Actions of White Blood

This chart lists the two main categories of white blood cells along with their cellular components and their protective actions.

Cell Type	Protective Action
Granulocytes	
Neutrophils	Phagocytosis
Eosinophils	Allergy, animal parasites
Basophils	Inflammation mediators, anticoagulant properties
Agranulocytes	
Monocytes	Phagocytosis
Lymphocytes	
• B cells	Humoral immunity
• T cells	Cellular immunity
• Natural killer cells	Destruction without specificity

Table 9-2 ABO System

The table below lists the four blood types along with their respective antigens and antibodies and the percentage of the population that have each type.

Blood Type	Antigen (RBC)	Antibody (plasma)	% Population
A	A	anti-B	41
B	B	anti-A	10
AB	A and B	none	4
O	neither A nor B	anti-A and anti-B	45

antibodies occur naturally; that is, they are present or develop shortly after birth even though there has been no previous exposure to the antigen.

In addition to antigens of the four blood groups, there are numerous other antigens that may be present on RBCs. One such antigen group includes the Rh blood factor. This particular factor is implicated in **hemolytic disease of the newborn (HDN)**, caused by an incompatibility between maternal and fetal blood.

Blood groups are medically important in transfusions, transplants, and maternal-fetal incompatibilities. Although **hematologists** have identified more than 300 different blood antigens, most of these are not of medical concern.

Lymph System

The lymph system consists of a fluid called ***lymph*** (in which lymphocytes and monocytes are suspended), a network of transporting vessels called ***lymph vessels***, and a multiplicity of other structures, including nodes, spleen, thymus, and tonsils. Functions of the lymph system include:

- maintaining fluid balance of the body by draining extracellular fluid from tissue spaces and returning it to the blood
- transporting lipids away from the digestive organs for use by body tissues
- filtering and removing unwanted or infectious products in lymph nodes. (See Figure 9–5.)

Lymph vessels begin as closed-ended capillaries in tissue spaces and terminate at the right lymphatic duct and the thoracic duct in the chest cavity. As whole blood circulates, a small amount of plasma seeps from (1) **blood capillaries**. This fluid, now called ***extracellular (interstitial* or *tissue) fluid***, resembles plasma but contains slightly less protein. Extracellular fluid carries needed products to tissue cells while removing their wastes. As extra cellular fluid moves through tissues, it also collects cellular debris, bacteria, and particulate matter. Extracellular fluid returns to blood capillaries to become plasma or enters (2) **lymph capillaries** to become lymph. Lymph passes into larger and larger vessels on its return trip to the bloodstream. Before it reaches its final destination, it first enters (3) **lymph nodes**. These nodes serve as depositories for cellular debris. In the node, macrophages phagocytize bacteria and other harmful material while T cells and B cells exert their protective influence. When a local infection exists, the number of bacteria entering a node is so great and the destruction by T cells and B cells so powerful that the node commonly enlarges and becomes tender.

Lymph vessels from the right chest and arm join the (4) **right lymphatic duct.** This duct drains into the (5) **right subclavian vein,** a major vessel in the cardiovascular system. Lymph from all other areas of the body enters the (6) **thoracic duct** and drains into the (7) **left subclavian vein.** Lymph is redeposited into the circulating blood and becomes plasma. This cycle continually repeats itself.

The (8) **spleen** resembles lymph nodes because it acts like a filter removing cellular debris, bacteria, parasites, and other infectious agents. However, the spleen also destroys old RBCs and serves as a repository for healthy blood cells. The (9) **thymus** is located in the upper part of the chest (**mediastinum**). It partially controls the immune system by transforming certain lymphocytes into T cells, the lymphocytes responsible for cellular immunity. The (10) **tonsils** are masses of lymphatic tissue located in the pharynx. They act as filters to protect the upper respiratory structures from invasion by pathogens.

Immune System

Although exposed to a vast number of harmful substances, most people suffer relatively few diseases throughout their lifetime. Numerous body

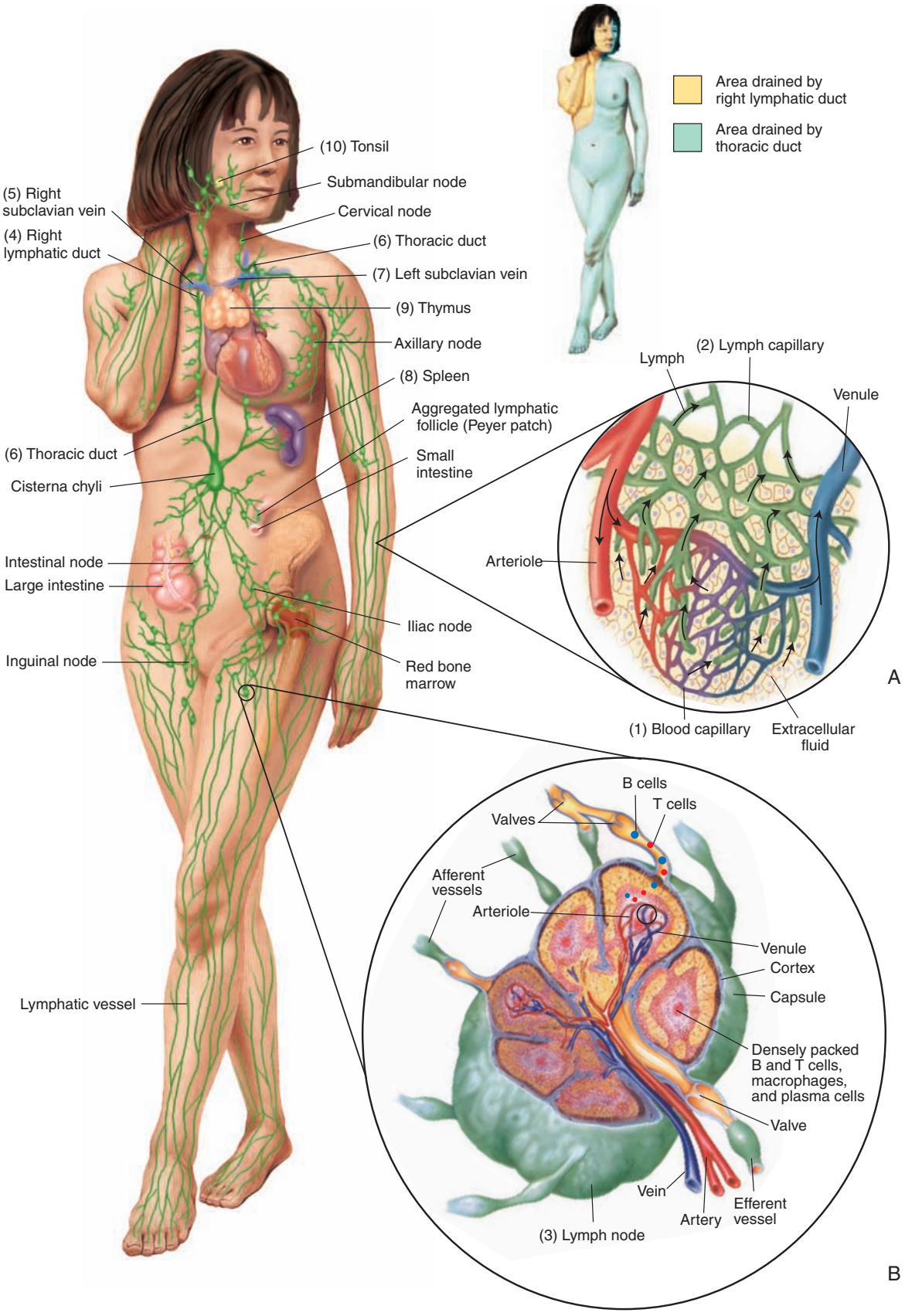


Figure 9-5. Lymph system. (A) Capillary. (B) Lymph node.

defenses called ***resistance*** work together to protect against disease. Resistance includes physical barriers (skin and mucous membranes) and chemical and cellular barriers (tears, saliva, gastric juices, and neutrophils). Because these barriers are present at birth, they are said to be ***innate*** barriers. Another form of resistance called the ***acquired immune response*** develops after birth. This form of resistance is by far the most complex in structure and function. It continuously develops throughout life as a result of exposure to one disease after another. With each exposure, the immune system of an **immunocompetent** individual identifies the invading antigen, musters a unique response to destroy it, and then retreats with a memory of both the invader and the method of destruction. In the event of a second encounter by the same invader, the immune system is armed and ready to destroy it before it can cause disease. The WBCs responsible for the specific immune response include monocytes and lymphocytes.

Monocytes

After a brief stay in the vascular system, monocytes enter tissue spaces and become highly phagocytic **macrophages.** In this form, they consume large numbers of pathogens, including bacteria and viruses. After macrophages engulf a pathogen, they process it in such a way that the highly specific antigenic properties of the pathogen are placed on the cell surface of the macrophage. Thus, the macrophage becomes an **antigen-presenting cell (APC).** The APC awaits an encounter with a lymphocyte capable of responding to that specific antigen. When this occurs, the specific immune system begins the operations required for the systematic destruction of the antigen.

Lymphocytes

Two types of **lymphocytes**, T cells and B cells, are the active cells of the acquired immune response. Each cell type mediates a specific type of immunity, either humoral or cellular.

Humoral Immunity

Humoral immunity is the component of the specific immune system that protects primarily against extracellular antigens, such as bacteria and viruses that have not yet entered a cell. Humoral immunity is mediated by B cells, which originate and mature in the bone marrow. During maturation, each B cell develops receptors for a specific antigen and then enters the circulatory system. Upon an encounter with its specific antigen, the B cell produces a clone of cells called ***plasma cells.*** Plasma cells produce highly specific proteins called ***antibodies.*** Antibodies travel throughout the body in plasma, tissue fluid, and lymph. When an antibody encounters its specific antigen, it attaches to it and forms an **antigen-antibody complex.** Once the antigen-antibody complex is formed, the antigen is inactivated, neutralized, or tagged for destruction. After all antigens have been destroyed, memory B cells migrate to lymph tissue and remain available for immediate recall if that same antigen is encountered again.

Cellular Immunity

Cellular immunity is the component of the specific immune system that protects primarily against intracellular antigens such as viruses and cancer cells. Cellular immunity is mediated by T cells. These cells originate in the bone marrow but migrate and mature in the thymus. The four types of T cells include the cytotoxic T cell (T_C), helper T cell (T_H), suppressor T cell (T_S), and memory T cell (T_M). The **cytotoxic T cell** is the cell that actually destroys the invading antigen. It determines the antigen's specific weakness and uses this weakness as a point of attack to destroy it. The **helper T cell** is essential to the proper functioning of both humoral and cellular immunity. It uses chemical messengers called **cytokines** to activate, direct, and regulate the activity of most of the other components of the immune system, especially B cells. If the number of helper T cells is deficient, the immune system essentially shuts down and the patient becomes a victim of even the most harmless organisms. The **suppressor T cell** monitors the progression of infection. When infection resolves, the suppressor T cell "shuts down" the immune response. Finally, like the humoral response, the cellular response also produces memory cells. These **memory T cells** find their way to the lymph system and remain there long after the encounter with the antigen, ready for combat if the antigen reappears. (See Table 9–3.)

The memory component is unique to the acquired immune response. Memory B and T cells are able to "recall" how they previously disposed of a particular antigen and are able to repeat the process. The repeat performance is immediate, powerful, and sustained. Disposing of the antigen during the second and all subsequent exposures is extremely rapid and much more effective than it was during the first exposure. This "repeat performance" is called the ***anamnestic response.***

Table 9-3 Lymphocytes and Immune Response

The chart below lists the lymphocytes involved in humoral and cellular immunity along with their functions and sites of origin and maturation.

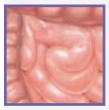
Lymphocyte	Function	Origin	Maturation
Humoral immunity			
B lymphocytes		Bone marrow	Bone marrow
• Plasma cells	• Antibody formation for destruction of extracellular antigens		
• Memory cells	• Provides active immunity		
Cellular immunity			
T lymphocytes		Bone marrow	Thymus, immune system
• Cytotoxic T cell (T_C)	• Destruction of infected cells and cancer cells		
• Helper T cell (T_H)	• Assistance for B cells, cytotoxic T cells and other components of the immune system		
• Suppressor T cell (T_S)	• Suppression (shutting down) of humoral and cellular response when infection resolves		
• Memory T cell (T_M)	• Active immunity		

Connecting Body Systems-Blood, Lymph, and Immune Systems

The main functions of the blood, lymph, and immune systems are to provide a medium for the transport and exchange of products throughout the body and to protect and repair cells that are damaged by disease or trauma. Specific functional relationships between the blood, lymph, and immune systems and other body systems are summarized below.

Cardiovascular

- Blood delivers oxygen to the heart needed for contraction.
- Lymphatic system returns interstitial fluid to the vascular system to maintain blood volume.
- Immune system protects against infections.

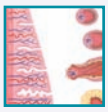


Digestive

- Blood transports products of digestion to nourish body cells.
- Immune system provides surveillance mechanisms to detect and destroy cancer cells in the digestive tract.
- An innate component of the immune system, the acidic environment of the stomach helps control pathogens of the digestive tract.

Endocrine

- Blood and lymph systems transport hormones to target organs.
- Immune system protects against infection in endocrine glands.



Female reproductive

- Blood, lymph, and immune systems transport nourishing and defensive products across the placental barrier for the developing fetus.
- Immune system provides specific defense against pathogens that enter the body through the reproductive tract.
- Immune system supplies antibodies for breast milk that protect the baby until its immune system is established.

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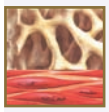
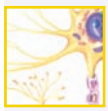
Connecting Body Systems-Blood, Lymph, and Immune Systems—cont'd



Musculoskeletal

- Blood removes lactic acid that accumulates in muscles during strenuous exercise.
- Blood transports calcium to bones for strength and healing.
- Lymph system maintains interstitial fluid balance in muscle tissue.
- Immune system aids in repair of muscle tissue following trauma.



Nervous

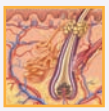
- Immune system responds to nervous stimuli in order to identify injury or infection sites and initiate tissue defense and repair.
- Plasma and lymph provide the medium in which nervous stimuli cross from one neuron to another.
- Lymph system removes excess interstitial fluid from tissues surrounding nerves.

Respiratory

- Red blood cells transport respiratory gases to and from the lungs.
- Tonsils harbor immune cells that combat pathogens that enter through the nose and mouth.

Genitourinary

- Immune system provides surveillance against cancer cells.
- Blood transports waste products, especially urea, to the kidneys for removal via the production of urine.
- Blood in peritubular capillaries recaptures essential products that have been filtered by the nephron.



Integumentary

- Blood provides leukocytes, especially neutrophils, to the integumentary system when breaches or injury occur in the skin.
- Lymph system supplies antibodies to the dermis for defense against pathogens.
- Blood found in the skin, the largest organ of the body, helps maintain temperature homeostasis.

It is time to review lymph structures by completing Learning Activity 9–1.

Medical Word Elements

This section introduces combining forms, suffixes, and prefixes related to the blood, lymph, and immune systems. Word analyses are also provided.

Element	Meaning	Word Analysis
Combining Forms		
aden/o	gland	**aden/**oid (ĂD-ĕ-noyd): resembling a gland *-oid:* resembling
agglutin/o	clumping, gluing	**agglutin/**ation (ă-gloo-tĭ-NĀ-shŭn): process of clumping *-ation:* process (of)
bas/o	base (alkaline, opposite of acid)	**bas/o/**phil (BĀ-sō-fĭl): attraction to base (alkaline dyes) *-phil:* attraction for ***The granules of the basophil appear dark blue when stained with a dye used in hematology.***
blast/o	embryonic cell	erythr/o/**blast/**osis (ĕ-rĭth-rō-blăs-TŌ-sĭs): abnormal increase of embryonic red (cells) *erythr/o:* red *-osis:* abnormal condition; increase (used primarily with blood cells) ***Erythroblastosis fetalis is a potentially fatal disease of newborns occurring when a blood incompatibility exists between mother and fetus.***

(continued)

Medical Word Elements—cont'd

Element	Meaning	Word Analysis
chrom/o	color	hypo/**chrom**/ic (hī-pō-KRŌM-ĭk): under coloration *hypo-:* under, below *-ic:* pertaining to ***Hypochromic cells are erythrocytes that contain inadequate hemoglobin. These cells are commonly associated with iron-deficiency anemia.***
eosin/o	dawn (rose-colored)	**eosin/o**/phil (ē-ō-SĬN-ō-fĭl): attraction for rose colored (dye) *-phil:* attraction for ***The granules of an eosinophil appear rose-colored when stained with eosin, a dye used in hematology.***
erythr/o	red	**erythr/o**/cyte (ĕ-RĬTH-rō-sīt): red cell *-cyte:* cell ***An erythrocyte is a red blood cell.***
granul/o	granule	**granul/o**/cyte (GRĂN-ū-lō-sīt): cell (containing) granulocytes (in the cytoplasm) *-cyte:* cell
hem/o	blood	**hem/o**/phobia (hē-mō-FŌ-bē-ă): fear of blood *-phobia:* fear ***People who suffer from hemophobia commonly faint at the sight of blood.***
hemat/o		**hemat**/oma (hē-mă-TŌ-mă): blood tumor *-oma:* tumor ***A hematoma is a mass of extravasated, usually clotted blood caused by a break or leak in a blood vessel. It may be found in any organ, tissue, or space within the body.***
immun/o	immune, immunity, safe	**immun/o**/logy (ĭm-ū-NŎL-ō-jē): study of immunity *-logy:* study of ***Immunology includes the study of autoimmune diseases, hypersensitivities, and immune deficiencies.***
kary/o	nucleus	**kary/o**/lysis (kăr-ē-ŎL-ĭ-sĭs): destruction of the nucleus *-lysis:* separation; destruction; loosening ***Karyolysis results in cell death.***
nucle/o		mono/**nucle**/ar (mŏn-ō-NŪ-klē-ăr): pertaining to a single nucleus *mono-:* one *-ar:* pertaining to
leuk/o	white	**leuk**/emia (loo-KĒ-mē-ă): white blood condition *-emia:* blood condition ***Leukemia causes a profoundly elevated white blood cell count and a very low red blood cell count.***
lymphaden/o	lymph gland (node)	**lymphaden/o**/pathy (lĭm-făd-ĕ-NŎP-ă-thē): disease of lymph nodes *-pathy:* disease ***Lymphadenopathy is characterized by changes in the size, consistency, or number of lymph nodes.***

Medical Word Elements—cont'd

Element	Meaning	Word Analysis
lymph/o	lymph	**lymph/**oid (LĬM-foyd): resembling lymph *-oid:* resembling
lymphangi/o	lymph vessel	**lymphangi/**oma (lĭm-făn-jē-Ō-mă): tumor (composed of) lymph vessels *-oma:* tumor
morph/o	form, shape, structure	**morph/o/**logy (mor-FŎL-ō-jē): study of form, shape, and structure *-logy:* study of
myel/o	bone marrow; spinal cord	**myel/o/**gen/ic (mī-ĕ-lō-JĔN-ĭk): relating to the origin in bone marrow *gen:* forming, producing, origin *-ic:* pertaining to ***Granulocytes are formed in the bone marrow and are thus considered*** **myelogenic.**
neutr/o	neutral, neither	**neutr/o/**phil/ic (nū-trō-FĬL-ĭk): pertaining to an attraction for neutral dyes *-phil:* attraction for *-ic:* pertaining to, relating to ***A neutrophil is a leukocyte whose granules stain easily with neutral dyes.***
phag/o	swallowing, eating	**phag/o/**cyte (FĂG-ō-sīt): cell that eats (foreign material) *-cyte:* cell ***The neutrophil is phagocytic and protects the body by consuming foreign substances that may cause disease or injury.***
plas/o	formation, growth	a/**plas/**tic (ā-PLĂS-tĭk): pertaining to a failure to form *a-:* without, not *-tic:* pertaining to ***Aplastic anemia is a failure of the bone marrow to produce adequate blood cells.***
poikil/o	varied, irregular	**poikil/o/**cyte (POY-kĭl-ō-sīt): cell that is irregular or varied (in shape) *cyte:* cell
reticul/o	net, mesh	**reticul/o/**cyte (rĕ-TĬK-ū-lō-sīt): cell (that contains a) net or meshwork *-cyte:* cell ***A reticulocyte is an immature erythrocyte that contains strands of nuclear material. This material appears as a tiny net when observed microscopically.***
ser/o	serum	**ser/o/**logy (sē-RŎL-ō-jē): study of serum *-logy:* study of ***Serology includes the study of antigens and antibodies in serum as well as sources other than serum, including plasma, saliva, and urine.***
sider/o	iron	**sider/o/**penia (sĭd-ĕr-ō-PĒ-nē-ă): deficiency of iron *-penia:* decrease, deficiency ***Sideropenia usually results from inadequate iron uptake or from hemorrhage.***
splen/o	spleen	**splen/o/**rrhagia (splē-nō-RĀ-jē-ă): bursting forth of the spleen *-rrhagia:* bursting forth ***Splenorrhagia is a hemorrhage from a ruptured spleen.***

(continued)

Medical Word Elements—cont'd

Element	Meaning	Word Analysis
Combining Forms		
thromb/o	blood clot	**thromb/**osis (thrŏm-BŌ-sĭs): abnormal condition of a blood clot *-osis:* abnormal condition; increase (used primarily with blood cells) ***Thrombosis is the formation of blood clots in the blood vessels.***
thym/o	thymus gland	**thym/o/**pathy (thī-MŎP-ă-thē): disease of the thymus gland *-pathy:* disease
xen/o	foreign, strange	**xen/o/**graft (ZĔN-ō-grăft): foreign transplantation, also called *heterograft* *-graft:* transplantation ***A xenograft is a cross-species transplant, such as a pig heart valve to a human recipient. A xenograft is used as a temporary measure when there is insufficient tissue available from the patient or other human donors.***
Suffixes		
-blast	embryonic cell	erythr/o/**blast** (ĕ-RĬTH-rō-blăst): embryonic red cell *erythr/o:* red
-emia	blood condition	an/**emia** (ă-NĒ-mē-ă): without blood *an-:* without, not ***Anemia is any condition characterized by a reduction in the number of red blood cells or a deficiency in their hemoglobin.***
-globin	protein	hem/o/**globin** (HĒ-mō-glō-bĭn): blood protein *hem/o:* blood ***Hemoglobin is an iron-containing protein found in RBCs that transports oxygen and gives blood its red color.***
-graft	transplantation	auto/**graft** (AW-tō-grăft): self transplantation *auto-:* self, own ***An autograft is a surgical transplantation of tissue from one location of the body to another in the same individual.***
-osis	abnormal condition; increase (used primarily with blood cells)	leuk/o/cyt/**osis** (loo-kō-sī-TŌ-sĭs): abnormal increase in white (blood) cells *leuk/o:* white *cyt:* cell
-penia	decrease, deficiency	erythr/o/**penia** (ĕ-rĭth-rō-PĒ-nē-ă): abnormal decrease in red (blood cells) *erythr/o:* red
-phil	attraction for	neutr/o/**phil** (NŪ-trō-fĭl): attraction for a neutral (dye) *neutr/o:* neutral, neither ***Neutrophils are the most numerous type of leukocyte. They provide phagocytic protection for the body.***
-phoresis	carrying, transmission	electr/o/**phoresis** (ē-lĕk-trō-fō-RĒ-sĭs): carrying an electric (charge) *electr/o:* electricity ***Electrophoresis is a laboratory technique used to separate proteins based on their electrical charge, size, and shape. It is a commonly employed technique used in deoxyribonucleic acid (DNA) testing.***

Medical Word Elements—cont'd

Element	Meaning	Word Analysis
-phylaxis	protection	ana/**phylaxis** (ăn-ă-fĭ-LĂK-sĭs): against protection *ana-:* against, up, back ***Anaphylaxis is an exaggerated, life-threatening hypersensitivity reaction to a previously encountered antigen. It is treated as a medical emergency.***
-poiesis	formation, production	hem/o/**poiesis** (hē-mō-poy-Ē-sĭs): formation of blood *hem/o:* blood
-stasis	standing still	hem/o/**stasis** (hē-mō-STĀ-sĭs): standing still of blood *hem/o:* blood ***Hemostasis is the control or arrest of bleeding, commonly using chemical agents.***
Prefixes		
a-	without, not	**a**/morph/ic (ā-MOR-fĭk): without a (definite) form *morph:* form, shape, structure *ic:* pertaining to
allo-	other, differing from the normal	**allo**/graft (ĂL-ō-grăft): transplantation differing from the normal; also called *homograft* *-graft:* transplantation ***An allograft is a transplant between two individuals who are not identical twins but are genetically compatible.***
aniso-	unequal, dissimilar	**aniso**/cyt/osis (ăn-ī-sō-sĭ-TŌ-sĭs): abnormal increase in cells that are unequal *cyt:* cell *-osis:* abnormal condition; increase (used primarily with blood cells) ***Anisocytosis generally refers to red blood cells that vary is size from normal (normocytic) to abnormally large (macrocytic) or abnormally small (microcytic).***
iso-	same, equal	**iso**/chrom/ic (ī-sō-KRŌM-ĭk): pertaining to the same color *chrom:* color *ic:* pertaining to
macro-	large	**macro**/cyte (MĂK-rō-sīt): large (red) cell *-cyte:* cell
micro-	small	**micro**/cyte (MĪ-krō-sīt): small (red) cell *-cyte:* cell
mono-	one	**mono**/nucle/osis (mŏn-ō-nū-klē-Ō-sĭs): abnormal increase of mononuclear (cells) *nucle:* nucleus *-osis:* abnormal condition; increase (used primarily with blood cells) ***In infectious mononucleosis, there is an increase in monocytes and lymphocytes.***
poly-	many, much	**poly**/morph/ic (pŏl-ē-MOR-fĭk): pertaining to many forms or shapes *morph:* form, shape, structure *-ic:* pertaining to

It is time to review medical word elements by completing Learning Activity 9–2. For audio pronunciations of the above-listed key terms, you can visit www.davisplus.fadavis.com/gylys/systems *to download this chapter's* Listen and Learn! *exercises or use the book's audio CD (if included).*

Pathology

Pathology associated with blood includes anemias, leukemias, and coagulation disorders. These groups of disorders typically share common signs and symptoms that generally include paleness, weakness, shortness of breath, and heart palpitations. Lymphatic disorders are commonly associated with edema and lymphadenopathy. In these disorders, tissues are swollen with enlarged, tender nodes. Immunopathies include abnormally heightened immune responses to antigens (allergies, hypersensitivities, and autoimmune disorders) or abnormally depressed responses (immunodeficiencies and cancers). Many immunological disorders are manifested in other body systems. For example, asthma and hay fever are immunological disorders that affect the respiratory system; atopic dermatitis and eczema are immunological disorders that affect the integumentary system. Some of the most devastating diseases, such as rheumatoid arthritis, and AIDS, are caused by disordered immunity.

For diagnosis, treatment, and management of diseases that affect blood and blood-forming organs, the medical services of a specialist may be warranted. **Hematology** is the branch of medicine that studies blood cells, blood-clotting mechanisms, bone marrow, and lymph nodes. The physician who specializes in this branch of medicine is called a ***hematologist.*** **Allergy and immunology** is the branch of medicine involving disorders of the immune system, including asthma and anaphylaxis, adverse reactions to drugs, autoimmune diseases, organ transplantations, and malignancies of the immune system. The physician who specializes in this combined branch of medicine is called an ***allergist*** and ***immunologist.***

Anemias

Anemia is any condition in which the oxygen-carrying capacity of blood is deficient. It is not a disease but rather a symptom of various diseases. It results when there is a decrease in the number of circulating RBCs (**erythropenia**), the amount of hemoglobin (**hypochromasia**) within them, or in the volume of packed erythrocytes (**hematocrit**). Some of the causes of anemias include excessive blood loss, excessive blood-cell destruction, decreased blood formation, and faulty hemoglobin production.

Anemia commonly causes changes in the appearance of RBCs when observed microscopically. In healthy individuals, RBCs fall within a normal range for size (**normocytic**) and amount of hemoglobin (**normochromic**). Variations in these normal values include RBCs that are excessively large (**macrocytic**), are excessively small (**microcytic**), or have decreased amounts of hemoglobin (**hypochromic**). Signs and symptoms associated with most anemias include difficulty breathing (**dyspnea**), weakness, rapid heartbeat (**tachycardia**), paleness (**pallor**), low blood pressure (**hypotension**) and, commonly, a slight fever. (See Table 9–4.)

Acquired Immune Deficiency Syndrome (AIDS)

Acquired immune deficiency syndrome (AIDS) is an infectious disease caused by the human immunodeficiency virus (HIV), which slowly destroys the immune system. The immune system becomes so weak (**immunocompromised**) that, in the final stage of the disease, the patient falls victim to infections that usually do not affect healthy individuals (**opportunistic infections**). Symptoms of AIDS begin to appear gradually, and include swollen lymph glands (**lymphadenopathy**), malaise, fever, night sweats, and weight loss. **Kaposi sarcoma,** a neoplastic disorder, and ***Pneumocystis*** **pneumonia** (PCP) are two diseases closely associated with AIDS.

Transmission of HIV occurs primarily through body fluids—mostly blood, semen, and vaginal secretions. The virus attacks the most important cell in the immune system, the helper T cell. Once infected by HIV, the helper T cell becomes a "mini-factory" for the replication of the virus. More importantly, the virus destroys the helper T cell, which impacts the effective functioning of the humoral and cellular arms of the immune system, ultimately causing the patient's death.

Although there is no cure for HIV, treatments are available that can slow the development of the virus and the progression of the disease. These medications have serious adverse effects; however, once the decision for medical management is made, the patient should continue treatment. Failure to do so causes the virus to become highly resistant to current treatment options.

Allergy

An **allergy** is an acquired abnormal immune response. It requires initial exposure (**sensitization**) to an allergen (**antigen**). Subsequent exposures to the allergen produce increasing allergic reactions that cause a broad range of inflammatory changes.

Table 9-4 Common Anemias

This table lists various types of anemia along with descriptions and causes for each.

Type of Anemia	Description	Causes
Aplastic (hypoplastic)	• Associated with bone marrow failure • Diminished numbers of red blood cells (RBCs), white blood cells (WBCs), and platelets due to bone marrow suppression • Serious form of anemia that may be fatal	Commonly caused by exposure to cytotoxic agents, radiation, hepatitis virus, and certain medications
Folic-acid deficiency anemia	• RBCs are large and deformed with a diminished production rate and life span	Caused by insufficient folic acid intake due to poor diet, impaired absorption, prolonged drug therapy, or increased requirements (pregnancy or rapid growth as seen in children)
Hemolytic	• Associated with premature destruction of RBCs • Usually accompanied by jaundice	Caused by the excessive destruction of red blood cells or such disorders as erythroblastosis and sickle cell anemia
Hemorrhagic	• Associated with loss of blood volume • Normal levels achieved with correction of the underlying disorder	Commonly caused by acute blood loss (as in trauma), childbirth, or chronic blood loss (as in bleeding ulcers)
Iron-deficiency anemia	• Most common type of anemia worldwide	Caused by a greater demand on stored iron than can be supplied, commonly as a result of inadequate dietary iron intake or malabsorption of iron
Pernicious anemia	• Chronic, progressive disorder found mostly in people older than age 50 • Treated with B_{12} injections	Caused by low levels of vitamin B_{12} in peripheral red blood cells that may be the result of a lack of intrinsic factor in the stomach, which then inhibits absorption of vitamin B_{12}
Sickle cell anemia	• Most common genetic disorder in people of African descent • Characterized by RBCs that become crescent and irregularly shaped when oxygen levels are low, thus preventing cells from entering capillaries and resulting in severe pain and internal bleeding	Caused by a defect in the gene responsible for hemoglobin synthesis (A person must have both genes for the disease to manifest. Those with only one gene for the trait are carriers of the disease.)

Common signs and symptoms include hives (**urticaria**), eczema, allergic rhinitis, asthma and, in the extreme, **anaphylactic shock,** a life-threatening condition.

The offending allergens are identified by allergy sensitivity tests. In one such test, small scratches are made on the patient's back and a liquid suspension of the allergen is introduced into the scratch. If antibodies to the allergen are present in the patient, the scratch becomes red, swollen, and hardened (**indurated**).

A treatment called ***desensitization*** reduces the sensitivity of the patient to the offending allergen. This treatment involves repeated injections of highly diluted solutions containing the allergen. The initial concentration of the solution is too weak to cause symptoms. Additional exposure to higher concentrations promotes tolerance of the allergen.

Autoimmune Disease

Autoimmunity is the failure of the body to distinguish accurately between "self" and "nonself." In this abnormal response, the immune system attacks the antigens found on its own cells to such an extent that tissue injury results. Types of autoimmune disorders range from those that affect only a single organ to those that affect many organs and tissues (**multisystemic**).

Myasthenia gravis is an autoimmune disorder that affects the neuromuscular junction. Muscles of the limbs and eyes and those affecting speech and swallowing are usually involved. Other autoimmune diseases include rheumatoid arthritis (RA), idiopathic thrombocytopenic purpura (ITP), vasculitis, and systemic lupus erythematosus (SLE).

Treatment consists of attempting to reach a balance between suppressing the immune response to avoid tissue damage, while still maintaining the immune mechanism sufficiently to protect against disease. Most autoimmune diseases have periods of flare-up (**exacerbations**) and latency (**remissions**). Autoimmune diseases are usually chronic, requiring lifelong care and monitoring, even when the person may look or feel well. Currently, few autoimmune diseases can be cured; however, with treatment, those afflicted can live relatively normal lives.

Edema

Edema is an abnormal accumulation of fluids in the intercellular spaces of the body. A major cause of edema is a decrease in the blood protein level (**hypoproteinemia**), especially albumin, which controls the amount of plasma leaving the vascular channels. Other causes of edema include poor lymph drainage, high sodium intake, increased capillary permeability, and heart failure.

Edema limited to a specific area (**localized**) may be relieved by elevation of that body part and application of cold packs. Systemic edema may be treated with medications that promote urination (**diuretics**).

Closely associated with edema is a condition called **ascites,** in which fluid collects within the peritoneal or pleural cavity. The chief causes of ascites are interference in venous return in cardiac disease, obstruction of lymphatic flow, disturbances in electrolyte balance, and liver disease.

Hemophilia

Hemophilia is a hereditary disorder in which the blood-clotting mechanism is impaired. There are two main types of hemophilia: **hemophilia A,** a deficiency in clotting factor VIII, and **hemophilia B**, a deficiency in clotting factor IX. The degree of deficiency varies from mild to severe. The disease is sex-linked and found most commonly in men. Women are carriers of the trait but generally do not have symptoms of the disease.

Mild symptoms include nosebleeds, easy bruising, and bleeding from the gums. Severe symptoms produce areas of blood seepage (**hematomas**) deep within muscles. If blood enters joints (**hemarthrosis**), it is associated with pain and, possibly, permanent deformity. Uncontrolled bleeding in the body may lead to shock and death. Treatment consists of intravenous administration of the deficient factor. The amount of factor replaced depends on the seriousness of the hemorrhage and the amount of blood lost.

Infectious Mononucleosis

Infectious mononucleosis is one of the acute infections caused by the Epstein-Barr virus (EBV). It is usually found in young adults and tends to appear in early spring and fall. Saliva and respiratory secretions have been implicated as significant infectious agents, hence the name "kissing disease." Sore throat, fever, and enlarged cervical lymph nodes characterize this disease. Other signs and symptoms include gum infection (**gingivitis**), headache, tiredness, loss of appetite (**anorexia**), and general malaise. In most cases, the disease resolves spontaneously and without complications. In some cases, however, the liver and spleen enlarge (**hepatomegaly/splenomegaly**). Less common clinical findings include hemolytic anemia with jaundice and thrombocytopenia. Recovery usually ensures a lasting immunity.

Oncology

Oncological disorders associated with the blood, lymph, and immune systems include leukemia, Hodgkin disease, and Kaposi sarcoma.

Leukemia

Leukemia is an oncological disorder of the blood-forming organs, characterized by an overgrowth (**proliferation**) of blood cells. With this condition, malignant cells replace healthy bone marrow cells. The disease is generally categorized by the type of leukocyte population affected: granulocytic (**myelogenous**) or lymphocytic.

The various types of leukemia may be further classified as **chronic** or **acute**. In the acute form, the cells are highly embryonic (**blastic**) with few

mature forms, resulting in severe anemia, infections, and bleeding disorders. This form of leukemia is life threatening. Although there is a proliferation of blastic cells in chronic forms of leukemia, there are usually enough mature cells to carry on the functions of the various cell types.

Although the causes of leukemia are unknown, viruses, environmental conditions, high-dose radiation, and genetic factors have been implicated. Bone marrow aspiration and bone marrow biopsy are used to diagnose leukemia. Treatment includes chemotherapy, radiation, biological therapy, bone marrow transplant, or a combination of these modalities. Left untreated, leukemias are fatal.

Hodgkin Disease

Hodgkin disease, also called ***Hodgkin lymphoma,*** is a malignant disease of the lymph system, primarily the lymph nodes. Although malignancy usually remains only in neighboring nodes, it may spread to the spleen, GI tract, liver, or bone marrow.

Hodgkin disease usually begins with a painless enlargement of lymph nodes, typically on one side of the neck, chest, or underarm. Other symptoms include severe itching (**pruritus**), weight loss, progressive anemia, and fever. If nodes in the neck become excessively large, they may press on the trachea, causing difficulty in breathing (**dyspnea**), or on the esophagus, causing difficulty in swallowing (**dysphagia**).

Radiation and chemotherapy are important methods of controlling the disease. Newer methods of treatment include bone marrow transplants. Treatment is highly effective.

Kaposi Sarcoma

Kaposi sarcoma is a malignancy of connective tissue, including bone, fat, muscle, and fibrous tissue. It is closely associated with AIDS and is commonly fatal because the tumors readily metastasize to other organs. Its close association with HIV has resulted in this disorder being classified as one of several "AIDS-defining conditions." The lesions emerge as purplish brown macules and develop into plaques and nodules. The lesions initially appear over the lower extremities and tend to spread symmetrically over the upper body, particularly the face and oral mucosa. Treatment for AIDS-related Kaposi sarcoma is usually palliative, relieving the pain and discomfort that accompany the lesions, but there is little evidence that it prolongs life.

Diagnostic, Symptomatic, and Related Terms

This section introduces diagnostic, symptomatic, and related terms and their meanings. Word analyses for selected terms are also provided.

Term	Definition
anisocytosis ăn-ī-sō-sī-TŌ-sĭs *an-:* without, not *iso-:* same, equal *cyt:* cell *-osis:* abnormal condition; increase (used primarily with blood cells)	Condition of marked variation in the size of erythrocytes when observed on a blood smear ***With anisocytosis, the blood smear shows macrocytes (large RBCs) and microcytes (small RBCs) as well as normocytes (normal-size RBCs).***
ascites ă-SĪ-tēz	Accumulation of serous fluid in the peritoneal or pleural cavity
bacteremia băk-tĕr-Ē-mē-ă *bacter:* bacteria *-emia:* blood condition	Presence of viable bacteria circulating in the bloodstream usually transient in nature
graft rejection grăft	Destruction of a transplanted organ or tissue by the recipient's immune system

Diagnostic, Symptomatic, and Related Terms—cont'd

Term	Definition
graft-versus-host disease (GVHD) GRĂFT	Condition that occurs following bone marrow transplant in which the immune cells in the transplanted marrow produce antibodies against the host's tissues ***GVHD can be acute or chronic. The acute form appears within 2 months of the transplant; the chronic form usually appears within 3 months. GVHD may also occur as a reaction to blood transfusion.***
hematoma hēm-ă-TŌ-mă *hemat:* blood *-oma:* tumor	Localized accumulation of blood, usually clotted, in an organ, space, or tissue due to a break in or severing of a blood vessel
hemoglobinopathy hē-mō-glō-bĭ-NŎP-ă-thē *hem/o:* blood *globin/o:* protein *-pathy:* disease	Any disorder caused by abnormalities in the hemoglobin molecule ***One of the most common hemoglobinopathies is sickle cell anemia.***
hemolysis hē-MŎL-ĭ-sĭs *hem/o:* blood *-lysis:* separation; destruction; loosening	Destruction of RBCs with a release of hemoglobin that diffuses into the surrounding fluid
hemostasis hē-mō-STĀ-sĭs *hem/o:* blood *-stasis:* standing still	Arrest of bleeding or circulation
immunity ĭ-MŪ-nĭ-tē	State of being protected against infectious diseases
active	Immunity produced by the person's own immune system ***Active immunity is generally long lived because memory cells are formed. Its two types include natural active immunity, resulting from recovery from a disease, and artificial active immunity, resulting from an immunizing vaccination.***
passive	Immunity in which antibodies or other immune substances formed in one individual are transferred to another individual to provide immediate, temporary immunity ***Passive immunity is short lived because memory cells are not transferred to the recipient. Two types of passive immunity include natural passive immunity, where medical intervention is not required (infant receiving antibodies through breast milk) and artificial passive immunity, where antibodies, antitoxins, or toxoids (generally produced in sheep or horses) are transfused or injected into the patient to provide immediate protection.***
lymphadenopathy lĭm-făd-ĕ-NŎP-ă-thē *lymph:* lymph *aden/o:* gland *-pathy:* disease	Any disease of the lymph nodes ***In localized lymphadenopathy, only one area of the body is affected. In systemic lymphadenopathy, two or more noncontiguous areas of the body are affected.***

Diagnostic, Symptomatic, and Related Terms—cont'd

Term	Definition
lymphosarcoma lĭm-fō-săr-KŌ-mă *lymph/o:* lymph *sarc:* flesh (connective tissue) *-oma:* tumor	Malignant neoplastic disorder of lymphatic tissue (not related to Hodgkin disease)
septicemia sĕp-tĭ-SĒ-mē-ă	Serious, life-threatening bloodstream infection that may arise from other infections throughout the body, such as pneumonia, urinary tract infection, meningitis, or infections of the bone or GI tract; also called *blood infection* or *blood poisoning* ***Septicemia is characterized by chills, fever, tachycardia, tachypnea, confusion, hypotension, and ecchymoses. If left untreated, it may lead to shock and death.***
serology sē-RŎL-ō-jē *ser/o:* serum *-logy:* study of	Laboratory test to detect the presence of antibodies, antigens, or immune substances
titer TĪ-tĕr	Blood test that measures the amount of antibodies in blood; commonly used as an indicator of immune status

It is time to review pathological, diagnostic, symptomatic, and related terms by completing Learning Activity 9–3.

Diagnostic and Therapeutic Procedures

This section introduces procedures used to diagnose and treat blood, lymph, and immune disorders. Descriptions are provided as well as pronunciations and word analyses for selected terms.

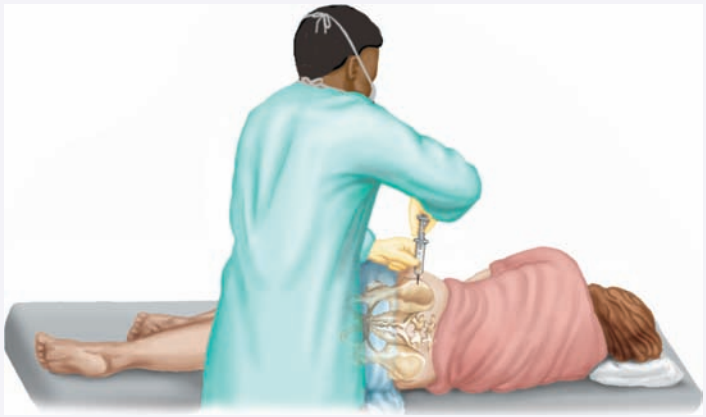
Procedure	Description
Diagnostic Procedures	
Laboratory	
blood culture	Test to determine the presence of pathogens in the bloodstream
complete blood count (CBC)	Series of tests that includes hemoglobin; hematocrit; RBC, WBC, and platelet counts; differential WBC count; RBC indices; and RBC and WBC morphology
differential count (diff) dĭf-ĕr-ĔN-shăl	Test that enumerates the distribution of WBCs in a stained blood smear by counting the different kinds of WBCs and reporting each as a percentage of the total examined ***Because differential values change considerably in pathology, this test is commonly used as a first step in diagnosing a disease.***
erythrocyte sedimentation rate (ESR) ĕ-RĬTH-rō-sīt sĕd-ĭ-mĕn-TĀ-shŭn *erythr/o:* red *-cyte:* cell	Measurement of the distance RBCs settle to the bottom of a test tube under standardized condition; also called *sed rate* ***Elevated ESR is associated with inflammatory diseases, cancer, and pregnancy, but decreases in liver disease. The more elevated the sed rate, the more severe is the inflammation.***

(continued)

Diagnostic and Therapeutic Procedures—cont'd

Procedure	Description
hemoglobin (Hgb) value HĒ-mō-glō-bĭn *hem/o:* blood *-globin:* protein	Measurement of the amount of hemoglobin found in a whole blood sample ***Hgb values decrease in anemia and increase in dehydration, polycythemia vera, and thrombocytopenia purpura.***
hematocrit (Hct) hē-MĂT-ō-krĭt	Measurement of the percentage of RBCs in a whole blood sample
Monospot	Non specific rapid serological test for infectious mononucleosis; also called *the heterophile antibody test*
partial thromboplastin time (PTT) thrŏm-bō-PLĂS-tĭn	Test that measures the length of time it takes blood to clot. It screens for deficiencies of some clotting factors and monitors the effectiveness of anticoagulant (heparin) therapy; also called *activated partial thromboplastin time (APTT)* ***PTT is valuable for preoperative screening of bleeding tendencies.***
prothrombin time (PT) prō-THRŎM-bĭn	Test that measures the time it takes for the plasma portion of blood to clot. It is used to evaluate portions of the coagulation system; also called *pro time* ***PT is commonly used to manage patients receiving the anticoagulant warfarin (Coumadin).***
red blood cell (RBC) indices	Mathematical calculation of the size, volume, and concentration of hemoglobin for an RBC
Schilling test	Test used to assess the absorption of radioactive vitamin B_{12} by the digestive system ***Schilling test is the definitive test for diagnosing pernicious anemia because vitamin B_{12} is not absorbed in this disorder and passes from the body by way of stool.***
Radiographic	
lymphadenography lĭm-făd-ĕ-NŎG-ră-fē *lymph:* lymph *aden/o:* gland *-graphy:* process of recording	Radiographic examination of lymph nodes after injection of a contrast medium
lymphangiography lĭm-făn-jē-ŎG-ră-fē *lymph:* lymph *angi/o:* vessel *-graphy:* process of recording	Radiographic examination of lymph vessels or tissues after injection of contrast medium
Surgical	
aspiration ăs-pĭ-RĀ-shŭn bone marrow bōn MĂR-ō	Drawing in or out by suction Procedure using a syringe with a thin aspirating needle inserted (usually in the pelvic bone and rarely the sternum) to withdraw a small sample of bone marrow fluid for microscopic evaluation (See Figure 9–6.)

Diagnostic and Therapeutic Procedures—cont'd

Procedure	Description
	
	Figure 9-6. Bone marrow aspiration.
biopsy (bx) BĪ-ŏp-sē	Representative tissue sample removed from a body site for microscopic examination, usually to establish a diagnosis
bone marrow bōn MĂR-ō	Removal of a small core sample of tissue from bone marrow for examination under a microscope and, possibly, for analysis using other tests
sentinel node SĔNT-ĭ-nĕl NŌD	Removal of the first lymph node (the *sentinel node*) that receives drainage from cancer-containing areas and the one most likely to contain malignant cells ***If the sentinel node does not contain malignant cells, there may be no need to remove additional lymph nodes.***
Therapeutic Procedures	
Surgical	
lymphangiectomy lĭm-făn-jē-ĔK-tō-mē *lymph:* lymph *angi:* vessel *-ectomy:* excision	Removal of a lymph vessel
transfusion trănz-FŪ-zhŭn	Infusion of blood or blood components into the bloodstream
autologous aw-TŎL-ō-gŭs	Transfusion prepared from the recipient's own blood
homologous hō-MŎL-ō-gŭs	Transfusion prepared from another individual whose blood is compatible with that of the recipient
transplantation	Grafting of living tissue from its normal position to another site or from one person to another
autologous bone marrow aw-TŎL-ō-gŭs bōn MĂR-ō	Harvesting, freezing (cryopreserving), and reinfusing the patient's own bone marrow to treat bone marrow hypoplasia following cancer therapy
homologous bone marrow hō-MŎL-ō-gŭs bōn MĂR-ō	Transplantation of bone marrow from one individual to another to treat aplastic anemia, leukemia, and immunodeficiency disorders

Pharmacology

Various drugs are prescribed to treat blood, lymph, and immune systems disorders. (See Table 9–5.) These drugs act directly on individual components of each system. For example, anticoagulants are used to prevent clot formation but are ineffective in destroying formed clots. Instead, thrombolytics are used to dissolve clots that obstruct coronary, cerebral, or pulmonary arteries and, conversely, hemostatics are used to prevent or control hemorrhage. In addition, chemotherapy and radiation are commonly used to treat diseases of the blood and immune system. For example, antineoplastics prevent cellular replication to halt the spread of cancer in the body; antivirals prevent viral replication within cells and have been effective in slowing the progression of HIV and AIDS.

Table 9-5 Drugs used to Treat Blood, Lymph, and Immune Disorders

This table lists common drug classifications used to treat blood, lymph, and immune disorders, their therapeutic actions, and selected generic and trade names.

Classification	Therapeutic Action	Generic and Trade Names
anticoagulants	Prevent blood clot formation by inhibiting the synthesis or inactivating one or more clotting factors *These drugs prevent deep vein thrombosis (DVT) and postoperative clot formation and decrease the risk of stroke.*	**heparin** HĔP-ă-rĭn heparin sodium **warfarin** WĂR-făr-ĭn Coumadin
antifibrinolytics	Neutralize fibrinolytic chemicals in the mucous membranes of the mouth, nose, and urinary tract to prevent the breakdown of blood clots *Antifibrinolytics are commonly used to treat serious bleeding following certain surgeries and dental procedures especially in patients with medical problems such as hemophilia*	**aminocaproic acid** ă-mē-nō-kă-PRŌ-ĭk ĂS-ĭd Amicar
antimicrobials	Destroy bacteria, fungi, and protozoa, depending on the particular drug, generally by interfering with the functions of their cell membrane or their reproductive cycle *HIV patients are commonly treated prophylactically with antimicrobials to prevent development of Pneumocystis carinii pneumonia (PCP).*	**trimethoprim, sulfamethoxazole** trĭ-MĔTH-ō-prĭm, sŭl-fă-mĕth-ŎK-să-zōl Bactrim, Septra **pentamidine** pĕn-TĂM-ĭ-dēn NebuPent, Pentam-300
antivirals	Prevent replication of viruses within host cells *Antivirals are used in treatment of HIV infection and AIDS.*	**nelfinavir** nĕl-FĬN-ă-vēr Viracept **lamivudine/zidovudine** lă-MĪV-ū-dēn- zī-DŌ-vū-dēn Combivir

Table 9-5 Drugs used to Treat Blood, Lymph, and Immune Disorders—cont'd

Classification	Therapeutic Action	Generic and Trade Names
fat-soluble vitamins	Prevent and treat bleeding disorders resulting from a lack of prothrombin, which is commonly caused by vitamin K deficiency	**phytonadione** fī-tō-nă-DĪ-ōn Vitamin K1 Mephyton
thrombolytics	Dissolve blood clots by destroying their fibrin strands *Thrombolytics are used to break apart, or lyse, thrombi, especially those that obstruct coronary, pulmonary, and cerebral arteries.*	**alteplase** ĂL-tĕ-plās Activase, t-PA **streptokinase** strĕp-tō-KĪ-nās Streptase

Abbreviations

This section introduces blood, lymph, and immune system abbreviations and their meanings.

Abbreviation	Meaning	Abbreviation	Meaning
AB, Ab, ab	antibody, abortion	**EBV**	Epstein-Barr virus
A, B, AB, O	blood types in ABO blood group	**eos**	eosinophil (type of white blood cell)
AIDS	acquired immune deficiency syndrome	**ESR**	erythrocyte sedimentation rate
ALL	acute lymphocytic leukemia	**Hb, Hgb**	hemoglobin
AML	acute myelogenous leukemia	**HCT, Hct**	hematocrit
APC	Antigen-presenting cell	**HDN**	hemolytic disease of the newborn
APTT	activated partial thromboplastin time	**HIV**	human immunodeficiency virus
baso	basophil (type of white blood cell)	**Igs**	immunoglobulins
CBC	complete blood count	**ITP**	idiopathic thrombocytopenic purpura
CLL	chronic lymphocytic leukemia	**IV**	intravenous
CML	chronic myelogenous leukemia	**lymphos**	lymphocytes
diff	differential count (white blood cells)	**MCH**	mean cell hemoglobin (average amount of hemoglobin per cell)

Abbreviations—cont'd

Abbreviation	Meaning	Abbreviation	Meaning
MCHC	mean cell hemoglobin concentration (average concentration of hemoglobin in a single red cell)	**PT**	prothrombin time, physical therapy
MCV	mean cell volume (average volume or size of a single red blood cell)	**PTT**	partial thromboplastin time
ml, mL	milliliter (1/1000 of a liter)	**RA**	right atrium; rheumatoid arthritis
NK cell	natural killer cell	**RBC, rbc**	red blood cell
PA	posteroanterior; pernicious anemia; pulmonary artery	**sed**	sedimentation
PCP	*Pneumocystis* pneumonia; primary care physician; phencyclidine (hallucinogen)	**segs**	segmented neutrophils
PCV	packed cell volume	**SLE**	systemic lupus erythematosus
poly, PMN, PMNL	polymorphonuclear leukocyte	**WBC, wbc**	white blood cell

It is time to review procedures, pharmacology, and abbreviations by completing Learning Activity 9–4.

LEARNING ACTIVITIES

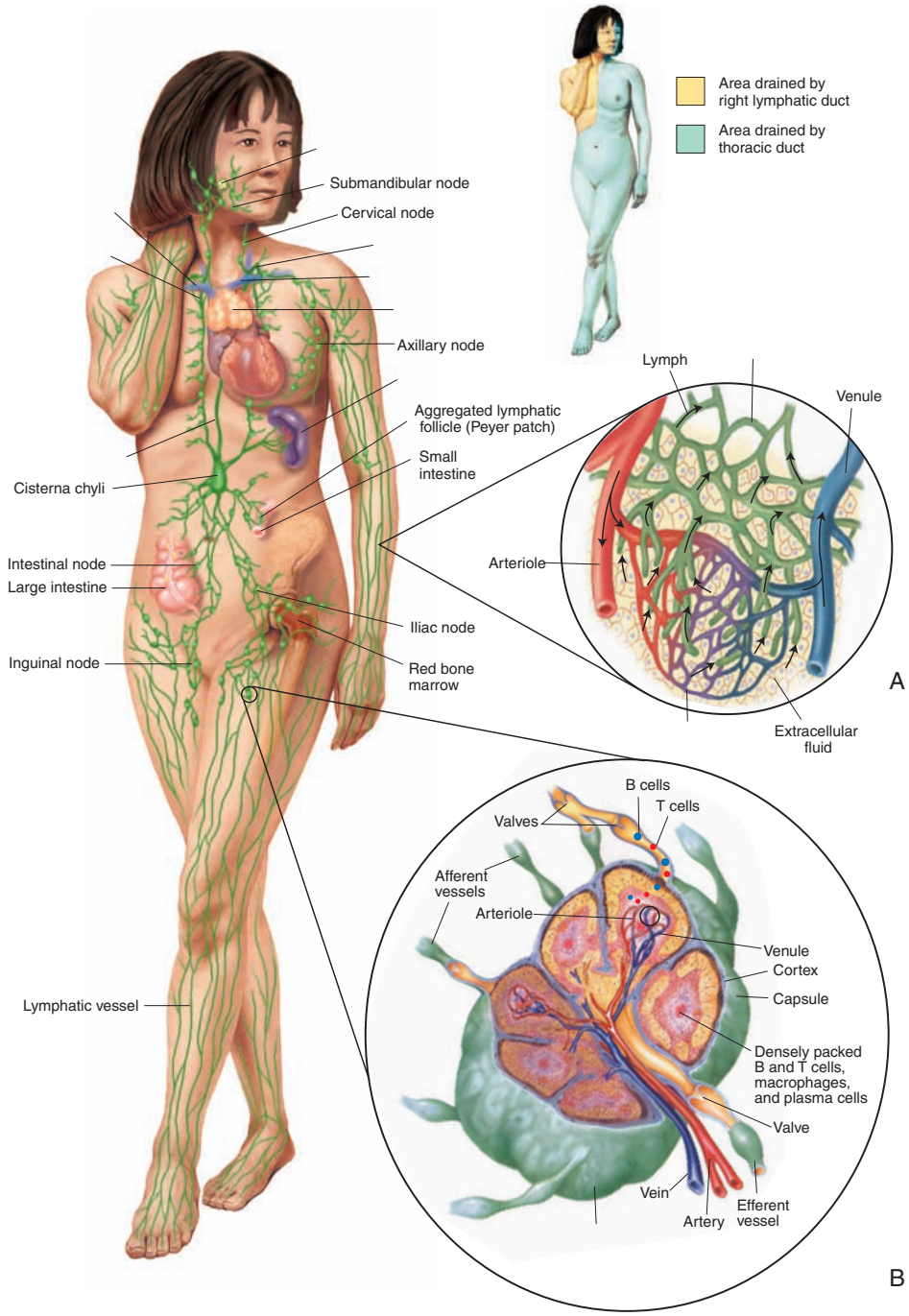
The following activities provide review of the blood, lymph, and immune system terms introduced in this chapter. Complete each activity and review your answers to evaluate your understanding of the chapter.

Learning Activity 9-1

Identifying Lymph Structures

Label the following illustration using the terms listed below.

blood capillary	*lymph node*	*spleen*	*tonsil*
left subclavian vein	*right lymphatic duct*	*thoracic duct*	
lymph capillary	*right subclavian vein*	*thymus*	



Check your answers by referring to Figure 9–5 on page 234. Review material that you did not answer correctly.

DavisPlus.fadavis.com

Enhance your study and reinforcement of word elements with the power of DavisPlus. Visit www.davisplus.fadavis.com/gylys/systems *for this chapter's flash-card activity. We recommend you complete the flash-card activity before completing activity 9–2 below.*

Learning Activity 9-2

Building Medical Words

Use *-osis* (abnormal condition; increase [used primarily with blood cells]) to build words that mean:

1. abnormal increase in erythrocytes _____
2. abnormal increase in leukocytes _____
3. abnormal increase in lymphocytes _____
4. abnormal increase in reticulocytes _____

Use *-penia* (deficiency, decrease) to build words that mean:

5. decrease in leukocytes _____
6. decrease in erythrocytes _____
7. decrease in thrombocytes _____
8. decrease in lymphocytes _____

Use *-poiesis* (formation, production) to build words that mean:

9. production of blood _____
10. production of white cells _____
11. production of thormbocytes _____

Use *immun/o* (immune, immunity, safe) to build words that mean:

12. specialist in study of immunity _____
13. study of immunity _____

Use *splen/o* (spleen) to build words that mean:

14. herniation of the spleen _____
15. destruction of the spleen _____

Build surgical words that mean:

16. excision of the spleen _____
17. removal of the thymus _____
18. destruction of the thymus _____
19. incision of the spleen _____
20. fixation of (a displaced) spleen _____

Check your answers in Appendix A. Review any material that you did not answer correctly.

Correct Answers _____ × 5 = _____ % Score

Learning Activity 9-3

Matching Pathological, Diagnostic, Symptomatic, and Related Terms

Match the following terms with the definitions in the numbered list.

active	*exacerbations*	*hemophilia*	*myelogenous*
anisocytosis	*graft rejection*	*immunocompromised*	*normocytic*
aplastic anemia	*hematoma*	*infectious mononucleosis*	*opportunistic infection*
artificial	*hemoglobinopathy*	*Kaposi sarcoma*	*passive*
bacteremia	*hemolysis*	*lymphadenopathy*	*septicemia*

1. _____ periods of flare-up
2. _____ any disorder due to abnormalities in the hemoglobin molecule
3. _____ presence of bacteria in blood
4. _____ associated with bone marrow failure
5. _____ type of immunity where memory cells are formed
6. _____ malignancy of connective tissue commonly associated with HIV
7. _____ used to denote an erythrocyte that is normal in size
8. _____ swollen or diseased lymph glands
9. _____ term that denotes a weakened immune system
10. _____ blood-clotting disorder
11. _____ common viral disorder caused by the Epstein-Barr virus
12. _____ leukemia that affects granulocytes
13. _____ type of immunity where memory cells are not transferred to the recipient
14. _____ type of passive immunity where medical intervention is required
15. _____ destruction of erythrocytes with the release of hemoglobin
16. _____ localized accumulation of blood in tissue; blood clot
17. _____ destruction of a transplanted organ or tissue by the recipient's immune system
18. _____ condition of marked variation in the size of erythrocytes
19. _____ disease that normally does not infect a healthy individual
20. _____ blood infection

Check your answers in Appendix A. Review any material that you did not answer correctly.

Correct Answers _____ × 5 = _____ % Score

Learning Activity 9-4

Matching Procedures, Pharmacology, and Abbreviations

Match the following terms with the definitions in the numbered list.

anticoagulants	*homologous*	*RBC indices*
aspiration	*lymphadenography*	*sentinel*
autologous	*lymphangiectomy*	*Shilling*
differential	*Monospot*	*thrombolytics*
hematocrit	*RBC*	*WBC*

1. _____ drawing in or out by suction
2. _____ measurement of erythrocytes expressed as a percentage in a whole blood sample
3. _____ serologic test for infectious mononucleosis
4. _____ used to prevent blood clot formation
5. _____ leukocyte
6. _____ term used to describe a transplantation from another individual
7. _____ removal of a lymph vessel
8. _____ mathematical calculation of the size, volume, and concentration of hemoglobin for an average RBC
9. _____ definitive test for pernicious anemia
10. _____ radiographic examination of lymph nodes
11. _____ term used to describe a transfusion from the recipient's own blood
12. _____ first lymph node that receives drainage from cancer containing areas
13. _____ erythrocyte
14. _____ used to dissolve blood clots
15. _____ test to enumerate the distribution of WBCs in a stained blood smear

Check your answers in Appendix A. Review any material that you did not answer correctly.

Correct Answers _____ × 6.67 = _____ % Score

MEDICAL RECORD ACTIVITIES

The two medical records included in the following activities use common clinical scenarios to show how medical terminology is used to document patient care. Complete the terminology and analysis sections for each activity to help you recognize and understand terms related to the blood, lymph, and immune systems.

Medical Record Activity 9-1

Discharge Summary: Sickle Cell Crisis

Terms listed in the following table are taken from *Discharge Summary: Sickle Cell Crisis* that follows. Use a medical dictionary such as *Taber's Cyclopedic Medical Dictionary,* the appendices of this book, or other resources to define each term. Then review the pronunciations for each term and practice by reading the medical record aloud.

Term	Definition
ambulating ĂM-bū-lāt-ĭng	
analgesia ăn-ăl-JĒ-zē-ă	
anemia ă-NĒ-mē-ă	
crisis KRĪ-sĭs	
CT	
hemoglobin HĒ-mō-glō-bĭn	
ileus ĬL-ē-ŭs	
infarction ĭn-FĂRK-shŭn	
morphine MOR-fēn	
sickle cell SĬK-ăl SĔL	
splenectomy splē-NĔK-tō-mē	
Vicodin VĪ-kō-dĭn	

Listen and Learn Online! *will help you master the pronunciation of selected medical words from this medical record activity. Visit* www.davisplus.com/gylys/systems *to find instructions on completing the* Listen and Learn Online! *exercise for this section and to practice pronunciations.*

DISCHARGE SUMMARY: SICKLE CELL CRISIS

General Hospital

1511 Ninth Avenue ■■ Sun City, USA 12345 ■■ (555) 802-1887

DISCHARGE SUMMARY

July 6, 20xx

ADMISSION DATE: June 21, 20xx DISCHARGE DATE: June 23, 20xx

ADMITTING AND DISCHARGE DIAGNOSES:
1. Sickle cell crisis.
2. Abdominal pain.

PROCEDURES: Two units of packed red blood cells and CT scan of the abdomen.

REASON FOR ADMISSION: This is a 46-year-old African American man who reports a history of sickle cell anemia, which results in abdominal cramping when he is in crisis. His hemoglobin was 6 upon admission. He says his baseline runs 7 to 8. The patient states that he has not had a splenectomy. He describes the pain as mid abdominal and cramplike. He denied any chills, fevers, or sweats.

HOSPITAL COURSE BY PROBLEM:
Problem 1. Sickle cell crisis. Patient was admitted to a medical/surgical bed, and placed on oxygen and IV fluids. He received morphine for analgesia, as well as Vicodin. At discharge, his abdominal pain had resolved; however, he reported weakness. He was kept for an additional day for observation.

Problem 2. CT scan was performed on the belly and showed evidence of ileus in the small bowel with somewhat dilated small-bowel loops and also an abnormal enhancement pattern in the kidney. The patient has had no nausea or vomiting. He is moving his bowels without any difficulty. He is ambulating. He even goes outside to smoke cigarettes, which he has been advised not to do. Certainly, we should obtain some information on his renal function and have his regular doctor assess this problem.

DISCHARGE INSTRUCTIONS: Patient advised to stop smoking and to see his regular doctor for follow-up on renal function.

Michael R. Saadi, MD
Michael R. Saadi, MD

MRS:dp

D: 6-21-20xx
T: 6-21-20xx

Patient: Evans, Joshua
Room #: 609 P

Physician: Michael R. Saadi, MD
Patient ID#: 532657

Analysis

Review the medical record *Discharge Summary: Sickle Cell Crisis* to answer the following questions.

1. What blood product was administered to the patient?

2. Why was this blood product given to the patient?

3. Why was a CT scan performed on the patient?

4. What were the three findings of the CT scan?

5. Why should the patient see his regular doctor?

Medical Record Activity 9-2

Discharge Summary: PCP and HIV

Terminology

Terms listed in the following table are taken from *Discharge Summary: PCP and HIV* that follows. Use a medical dictionary such as *Taber's Cyclopedic Medical Dictionary*, the appendices of this book, or other resources to define each term. Then review the pronunciations for each term and practice by reading the medical record aloud.

Term	Definition
alveolar lavage ăl-VĒ-ō-lăr lă-VĂZH	
Bactrim BĂK-trĭm	
bronchoscopy brŏng-KŎS-kō-pē	
diffuse dĭ-FŪS	
HIV	
human immunodeficiency virus ĭm-ū-nō-dē-FĬSH-ĕn-sē	
infiltrate ĬN-fĭl-trāt	

Term	Definition
Kaposi sarcoma KĂP-ō-sē săr-KŌ-mă	
leukoencephalopathy loo-kō-ĕn-sĕf-ă-LŎP-ă-thē	
multifocal mŭl-tĭ-FŌ-kăl	
PCP	
PMN	
Pneumocystis pneumonia nū-mō-SĬS-tĭs nū-MŌ-nē-ă	
thrush THRŬSH	
vaginal candidiasis VĂJ-ĭn-ăl kăn-dĭ-DĪ-ă-sĭs	

Listen and Learn Online! *will help you master the pronunciation of selected medical words from this medical record activity. Visit* www.davisplus.com/gylys/systems *to find instructions on completing the* Listen and Learn Online! *exercise for this section and to practice pronunciations.*

DISCHARGE SUMMARY: PCP AND HIV

General Hospital

1511 Ninth Avenue ■■ Sun City, USA 12345 ■■ (544) 802-1887

DISCHARGE SUMMARY

March 5, 20xx Age: 31

ADMISSION DATE: March 5, 20xx DISCHARGE DATE: March 6, 20xx

ADMITTING AND DISCHARGE DIAGNOSES:
1. *Pneumocystis* pneumonia.
2. Human immunodeficiency virus infection.
3. Wasting.

SOCIAL HISTORY: Patient's husband is deceased from AIDS 1 year ago with progressive multifocal leukoencephalopathy and Kaposi sarcoma. She denies any history of intravenous drug use, transfusion, and identifies three lifetime sexual partners.

PAST MEDICAL HISTORY: Patient's past medical history is significant for HIV and several episodes of diarrhea, sinusitis, thrush, and vaginal candidiasis. She gave a history of a 10-pound weight loss. The chest x-ray showed diffuse lower lobe infiltrates, and she was diagnosed with presumptive *Pneumocystis* pneumonia and placed on Bactrim. She was admitted for a bronchoscopy with alveolar lavage to confirm the diagnosis.

PROCEDURE: The antiretroviral treatment was reinitiated, and she was counseled as to the need to strictly adhere to her therapeutic regimen.

DISCHARGE INSTRUCTIONS: Complete medication regimen. Patient discharged to the care of Dr. Amid Shaheen.

Michael R. Saadi, MD
Michael R. Saadi, MD

MRS:dp

D: 3-05-20xx
T: 3-06-20xx

Patient: Smart, Joann
Room #: 540

Physician: Michael R. Saadi, MD
Patient ID#: 532850

Analysis

Review the medical record *Discharge Summary: PCP and HIV* to answer the following questions.

1. How do you think the patient acquired the HIV infection?

2. What were the two diagnoses of the husband?

3. What four disorders in the medical history are significant for HIV?

4. What was the x-ray finding?

5. What two procedures are going to be performed to confirm the diagnosis of PCP pneumonia?