

A & P Review of the Hematological and Lymphatic Systems

**NUR 143
OCCC Nursing Program**

Blood

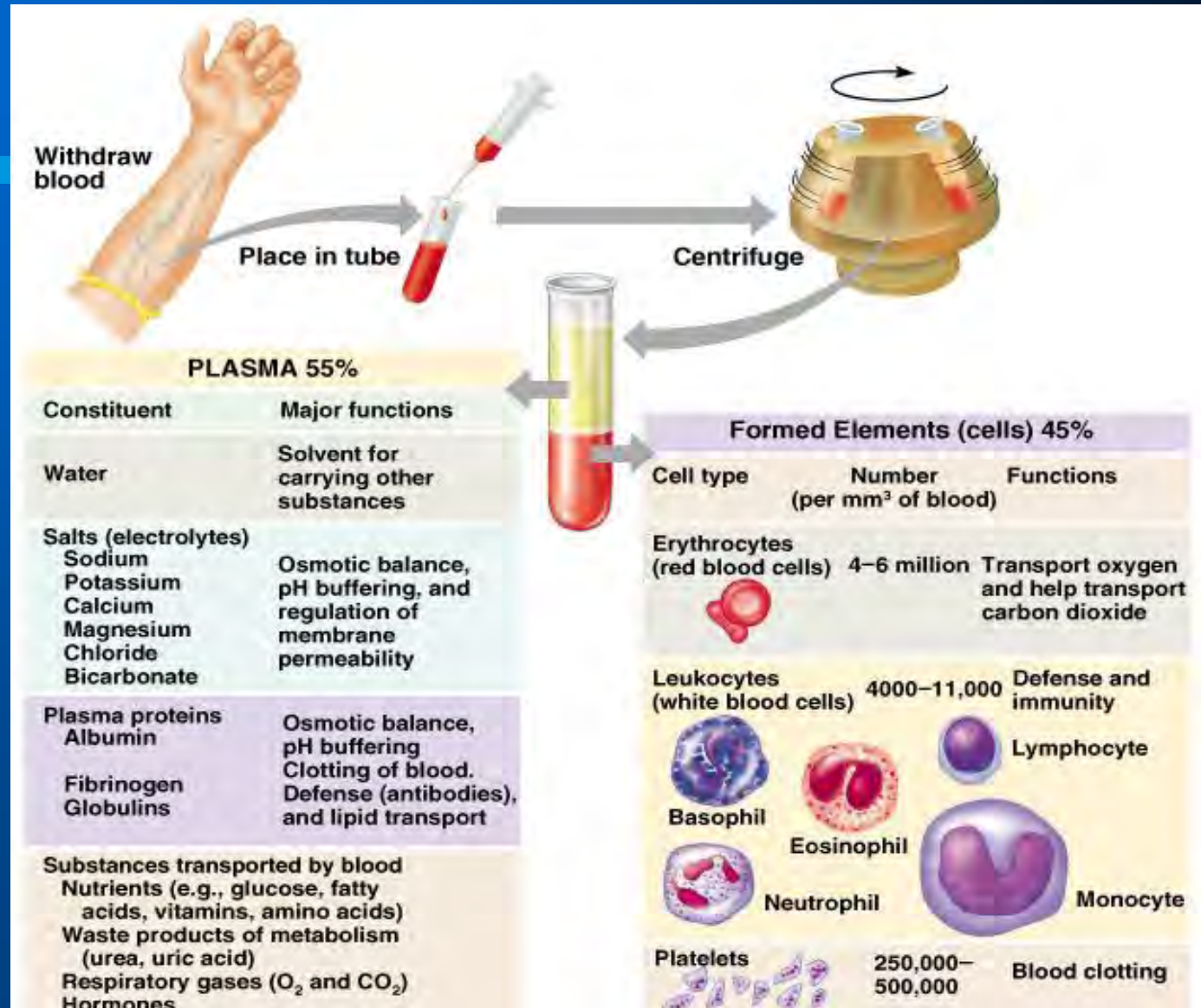


Figure 10.1

Plasma Proteins

- **Albumin – regulates osmotic pressure**
- **Clotting proteins – help to stem blood loss when a blood vessel is injured**
- **Antibodies – help protect the body from antigens**

Slide10.4

Formed Elements

- **Erythrocytes = red blood cells**
- **Leukocytes = white blood cells**
- **Platelets = cell fragments**

Slide
10.5a

Table

10.2

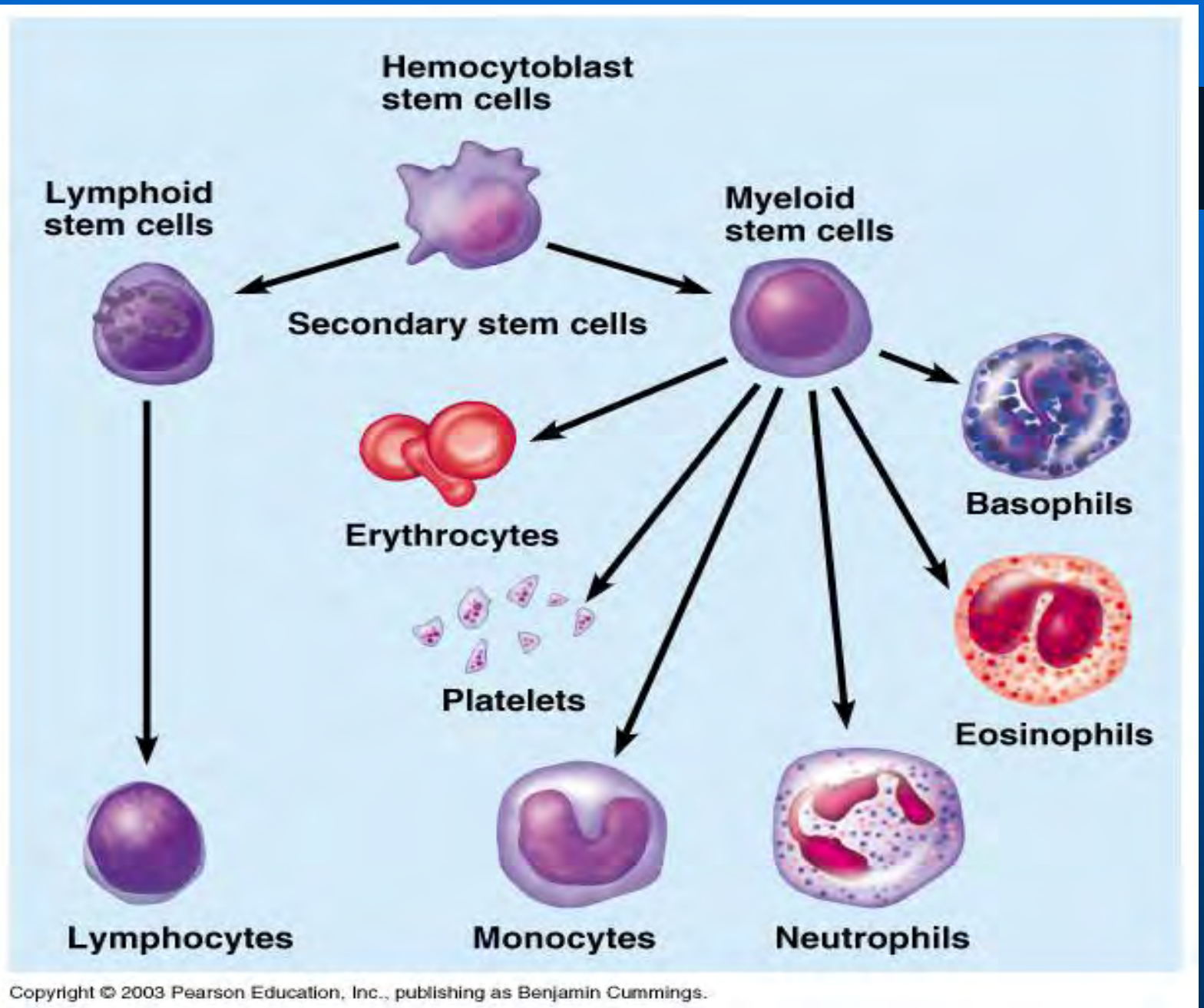
Characteristics of Formed Elements of the Blood

Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
Erythrocytes (red blood cells, or RBCs) 	4–6 million	Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected	Transport oxygen bound to hemoglobin molecules; also transport small amount of carbon dioxide
Leukocytes (white blood cells, or WBCs) <i>Granulocytes</i>	4000–11,000		
• Neutrophils 	3000–7000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; number increases rapidly during short-term or acute infections
• Eosinophils 	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms; increase during allergy attacks; might phagocytize antigen-antibody complexes and inactivate some inflammatory chemicals

*Appearance when stained with Wright

Cell type	Occurrence in blood (per mm ³)	Cell anatomy*	Function
Basophils 	20–50 (0–1% of WBCs)	Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue	Granules contain histamine (vasodilator chemical), which is discharged at sites of inflammation
<i>Agranulocytes</i> lymphocytes 	1500–3000 (20–45% of WBCs)	Cytoplasm pale blue and appears as thin rim around nucleus, spherical (or slightly indented) dark purple-blue nucleus	Part of immune system; one group (B lymphocytes) produces antibodies, other group (T lymphocytes) involved in graft rejection, fighting tumors and viruses, and activating B lymphocytes
Monocytes 	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term "clean-up team"; increase in number during chronic infections such as tuberculosis
Platelets	250,000– 500,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to broken area; help to control blood loss from broken blood vessels

*Appearance when stained with Wright



Erythrocytes (Red Blood Cells)

- The main function is to carry oxygen
- Anatomy of circulating erythrocytes
 - Biconcave disks
 - Essentially bags of hemoglobin
 - Anucleate (no nucleus)
 - Contain very few organelles
- Outnumber white blood cells 1000:1

Hemoglobin

- **Iron-containing protein**
- **Binds strongly, but reversibly, to oxygen**
- **Each hemoglobin molecule has four oxygen binding sites**
- **Each erythrocyte has 250 million hemoglobin molecules**

***Slide
10.7***

Leukocytes (White Blood Cells)

- **Crucial in the body's defense against disease**
- **These are complete cells, with a nucleus and organelles**
- **Able to move into and out of blood vessels**
- **Can move by ameboid motion**
- **Can respond to chemicals released by damaged tissues**

Leukocyte Levels in the Blood

- Normal levels are between 4,000 and 11,000 cells per millimeter
- Abnormal leukocyte levels
 - Leukocytosis
 - Above 11,000 leukocytes/ml
 - Generally indicates an infection
 - Leukopenia
 - Abnormally low leukocyte level
 - Commonly caused by certain drugs

Types of Leukocytes

- **Granulocytes**
 - Granules in their cytoplasm can be stained
 - Include neutrophils, eosinophils, and basophiles

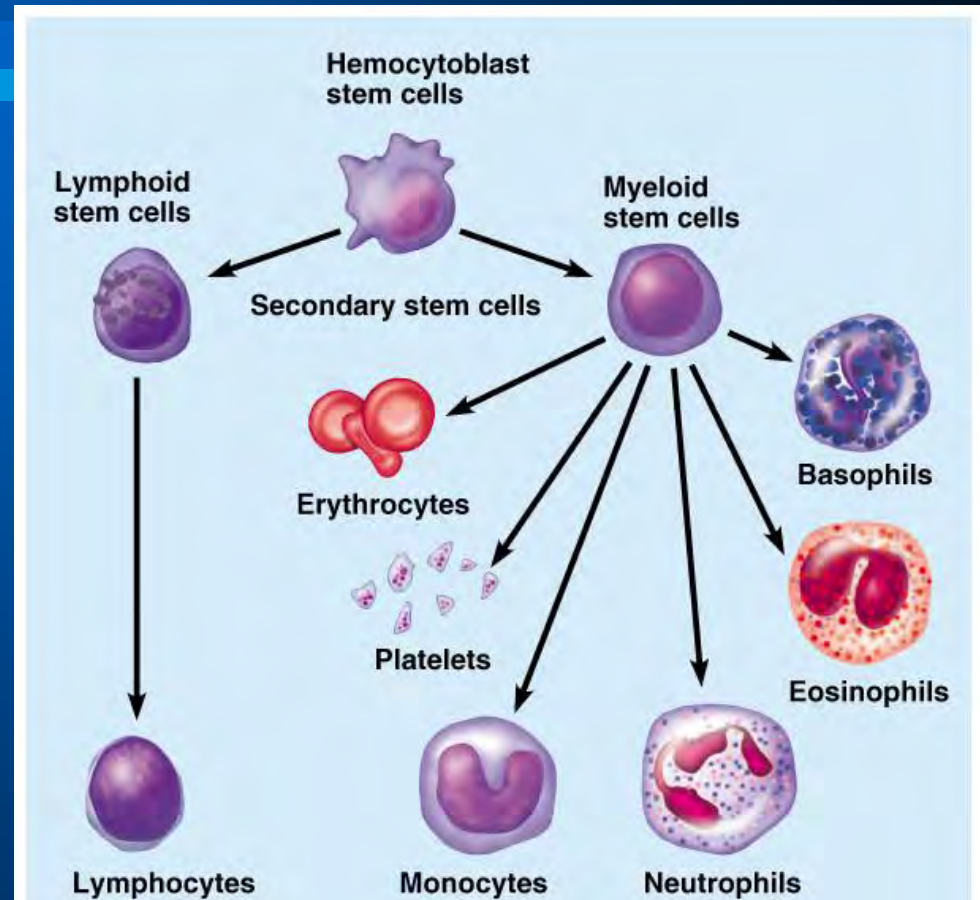


Figure 10.4

Types of Leukocytes

- **Agranulocytes**
 - **Lack visible cytoplasmic granules**
 - **Include lymphocytes and monocytes**

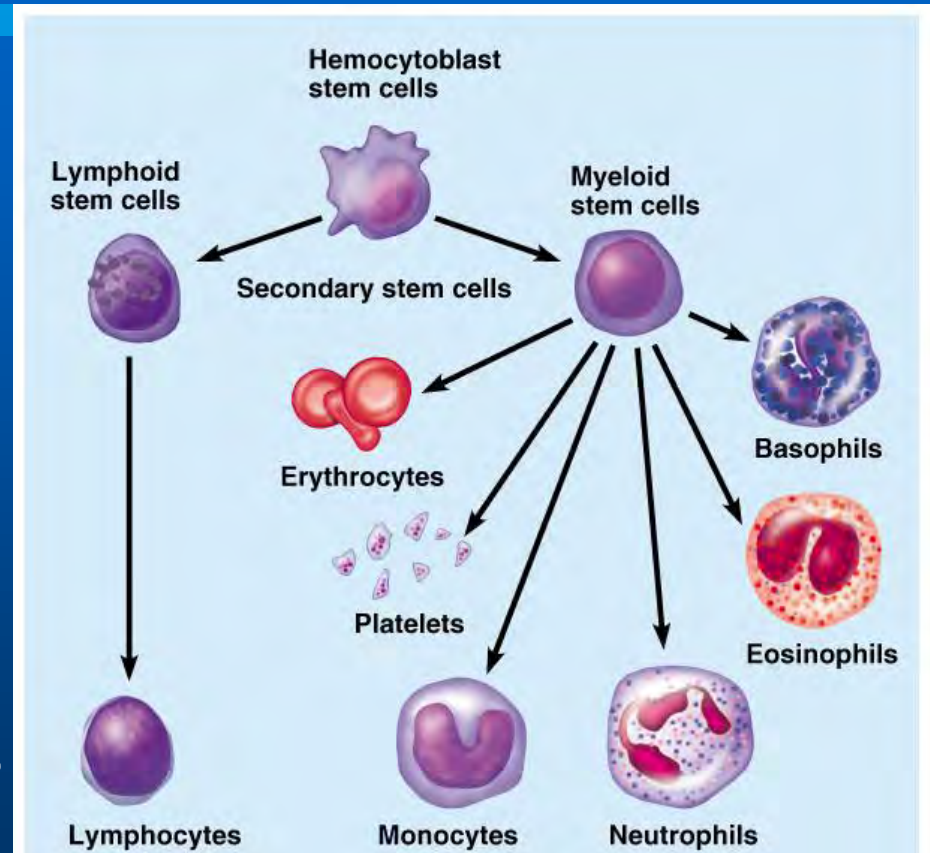


Figure 10.4

Granulocytes

- **Neutrophils**

- **Multilobed nucleus with fine granules**
- **Act as phagocytes at active sites of infection**

- **Eosinophils**

- **Large brick-red cytoplasmic granules**
- **Found in response to allergies and parasitic worms**

Agranulocytes

- **Lymphocytes**
 - Nucleus fills most of the cell
 - Play an important role in the immune response
- **Monocytes**
 - Largest of the white blood cells
 - Function as macrophages
 - Important in fighting chronic infection

Platelets

- Derived from ruptured multinucleate cells (megakaryocytes)
- Needed for the clotting process
- Normal platelet count = $300,000/\text{mm}^3$

Hematopoiesis

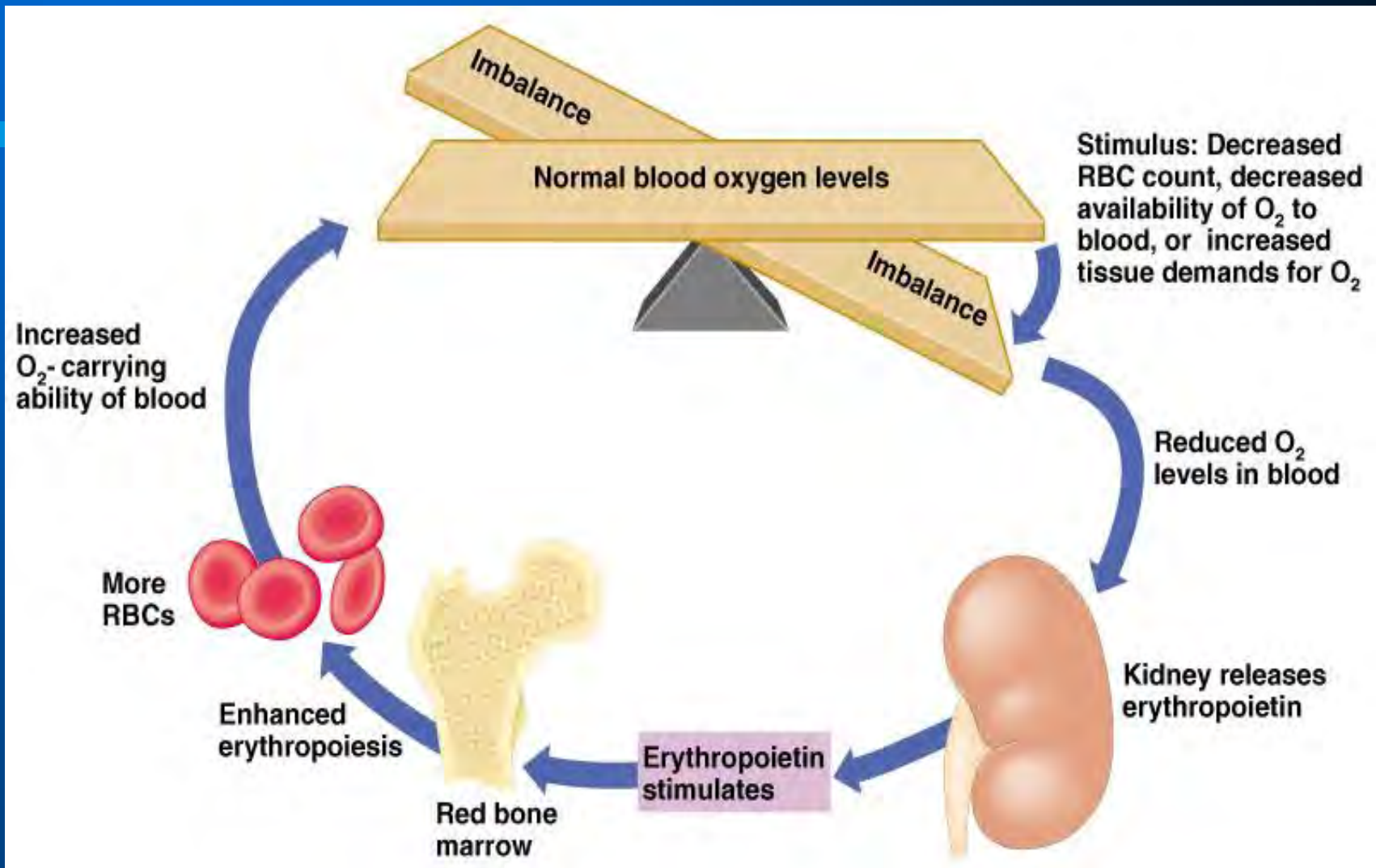
- **Blood cell formation**
- **Occurs in red bone marrow**
- **All blood cells are derived from a common stem cell (hemocytoblast)**
- **Hemocytoblast differentiation**
 - **Lymphoid stem cell produces lymphocytes**
 - **Myeloid stem cell produces other formed elements**

Fate of Erythrocytes

- Unable to divide, grow, or synthesize proteins
- Wear out in 100 to 120 days
- When worn out, are eliminated by phagocytes in the spleen or liver
- Lost cells are replaced by division of hemocytoblasts

Slide
10.15

Control of Erythrocyte Production



Hemostasis

- **Stoppage of blood flow**
- **Result of a break in a blood vessel**
- **Hemostasis involves three phases**
 - **Platelet plug formation**
 - **Vascular spasms**
 - **Coagulation**

Platelet Plug Formation

- Collagen fibers are exposed by a break in a blood vessel
- Platelets become “sticky” and cling to fibers
- Anchored platelets release chemicals to attract more platelets
- Platelets pile up to form a platelet plug

Coagulation

- **Injured tissues release thromboplastin**
- **PF_3 (a phospholipid) interacts with thromboplastin, blood protein clotting factors, and calcium ions to trigger a clotting cascade**
- **Prothrombin activator converts prothrombin to thrombin (an enzyme)**

Blood Clotting

- **Blood usually clots within 3 to 6 minutes**
- **The clot remains as endothelium regenerates**
- **The clot is broken down after tissue repair**

***Slide
10.22***

Undesirable Clotting

- **Thrombus**
 - **A clot in an unbroken blood vessel**
 - **Can be deadly in areas like the heart**
- **Embolus**
 - **A thrombus that breaks away and floats freely in the bloodstream**
 - **Can later clog vessels in critical areas such as the brain**

① Injury to lining of vessel exposes collagen fibers; platelets adhere

Platelet plug forms

Fibrin clot with trapped red blood cells



② Platelets also release serotonin, which causes vessels to constrict; vascular spasms occur. Platelets release chemicals that attract more platelets to the site

③ Coagulation events
(a) Thromboplastin released by damaged cells

(b) PF_3 on + Thromboplastin, calcium, and other clotting factors in blood plasma

Prothrombin activator

(c)

Prothrombin

Thrombin

Fibrinogen (soluble)

(d)

Fibrin (insoluble)

Copyright © 2003 Pearson Education, Inc., publishing as Benjamin Cummings.

Bleeding Disorders

- **Thrombocytopenia**
 - **Platelet deficiency**
 - **Even normal movements can cause bleeding from small blood vessels that require platelets for clotting**
- **Hemophilia/VonWillebrands Disease**
 - **Hereditary bleeding disorder**
 - **Normal clotting factors are missing**

Blood Groups and Transfusions

- Large losses of blood have serious consequences
 - Loss of 15 to 30 percent causes weakness
 - Loss of over 30 percent causes shock, which can be fatal
- Transfusions are the only way to replace blood quickly
- Transfused blood must be of the same blood group

Human Blood Groups

- Blood contains genetically determined proteins
- A foreign protein (antigen) may be attacked by the immune system
- Blood is “typed” by using antibodies that will cause blood with certain proteins to clump (agglutination)

ABO Blood Groups

- **Based on the presence or absence of two antigens**
 - **Type A**
 - **Type B**
- **The lack of these antigens is called type O**

Rh Blood Groups

- **Named because of the presence or absence of one of eight Rh antigens (agglutininogen D)**
- **Most Americans are Rh⁺**
- **Problems can occur in mixing Rh⁺ blood into a body with Rh⁻ blood**

Rh Dangers During Pregnancy

- Danger is only when the mother is Rh⁻ and the father is Rh⁺, and the child inherits the Rh⁺ factor
- The mismatch of an Rh⁻ mother carrying an Rh⁺ baby can cause problems for the unborn child
 - The first pregnancy usually proceeds without problems
 - The immune system is sensitized after the first pregnancy
 - In a second pregnancy, the mother's immune system produces antibodies to attack the Rh⁺ blood (hemolytic disease of the newborn)

Blood Typing

- Blood samples are mixed with anti-A and anti-B serum
- Coagulation or no coagulation leads to determining blood type
- Typing for ABO and Rh factors is done in the same manner
- Cross matching – testing for agglutination of donor RBCs by the recipient's serum, and vice versa

Developmental Aspects of Blood

- **Sites of blood cell formation**
 - **The fetal liver and spleen are early sites of blood cell formation**
 - **Bone marrow takes over hematopoiesis by the seventh month**
- **Fetal hemoglobin differs from hemoglobin produced after birth**

The Lymphatic System

- **Consists of two semi-independent parts**
 - **Lymphatic vessels**
 - **Lymphoid tissues and organs**
- **Lymphatic system functions**
 - **Transport fluids back to the blood**
 - **Play essential roles in body defense and resistance to disease**

Lymphatic Characteristics

- **Lymph – excess tissue fluid carried by lymphatic vessels**
- **Properties of lymphatic vessels**
 - **One way system toward the heart**
 - **No pump**
 - **Lymph moves toward the heart**
 - **Milking action of skeletal muscle**
 - **Rhythmic contraction of smooth muscle in vessel walls**

Lymphatic Vessels

- **Lymph Capillaries**
 - **Walls overlap to form flap-like minivalves**
 - **Fluid leaks into lymph capillaries**
 - **Capillaries are anchored to connective tissue by filaments**
 - **Higher pressure on the inside closes minivalves**

Lymphatic Vessels

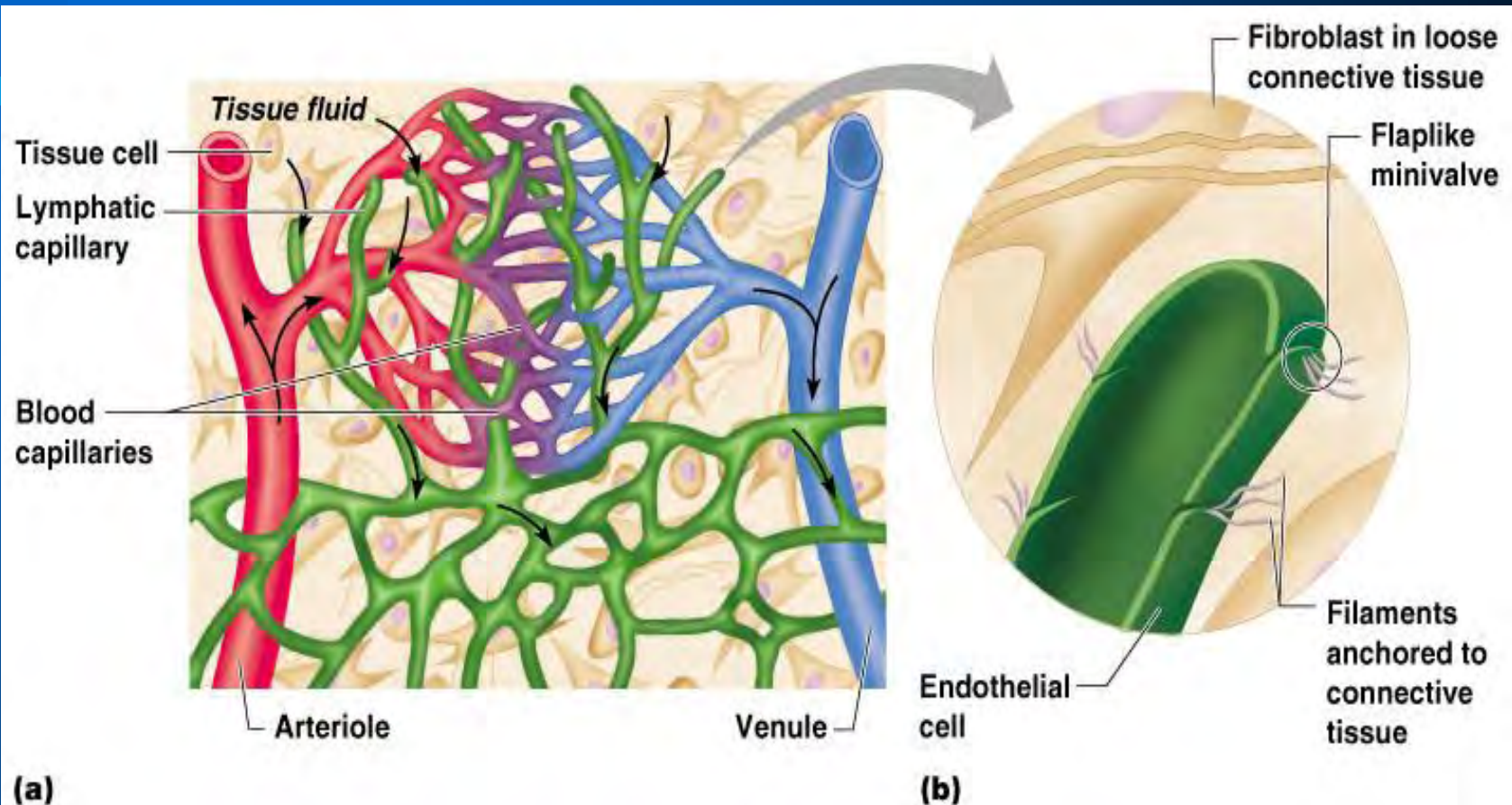
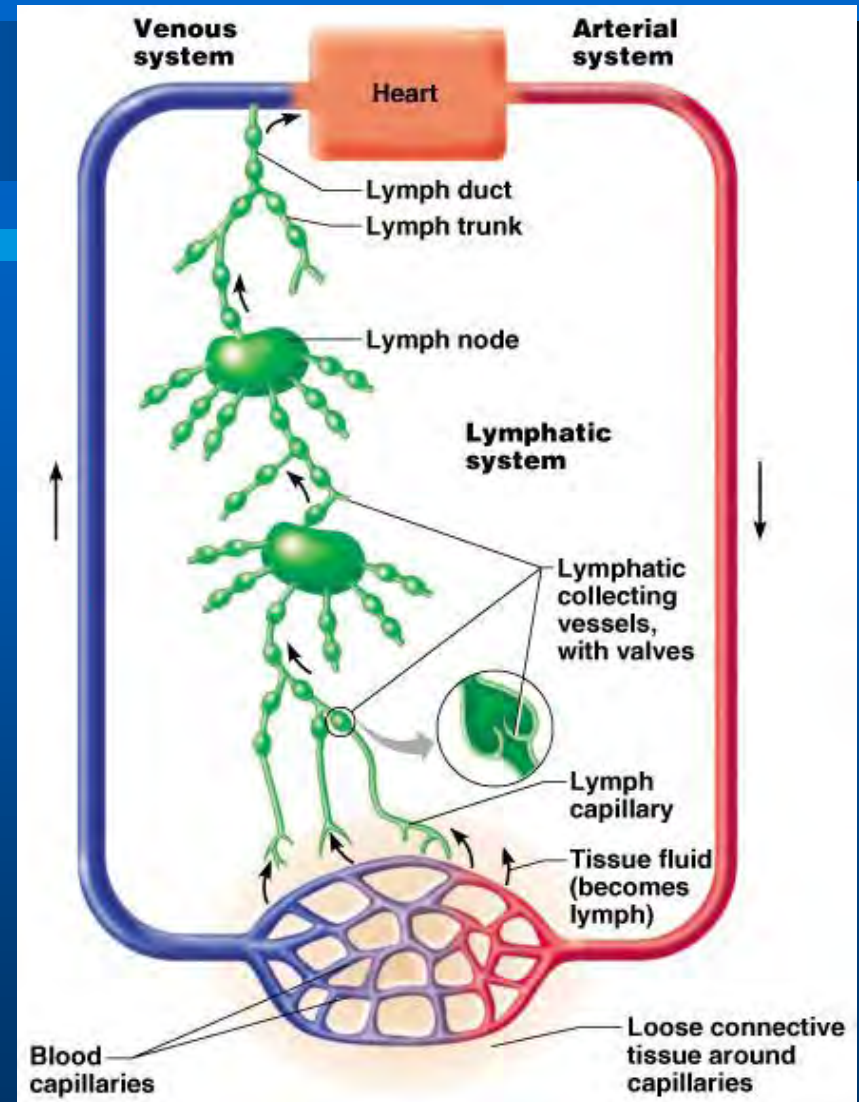


Figure 12.1

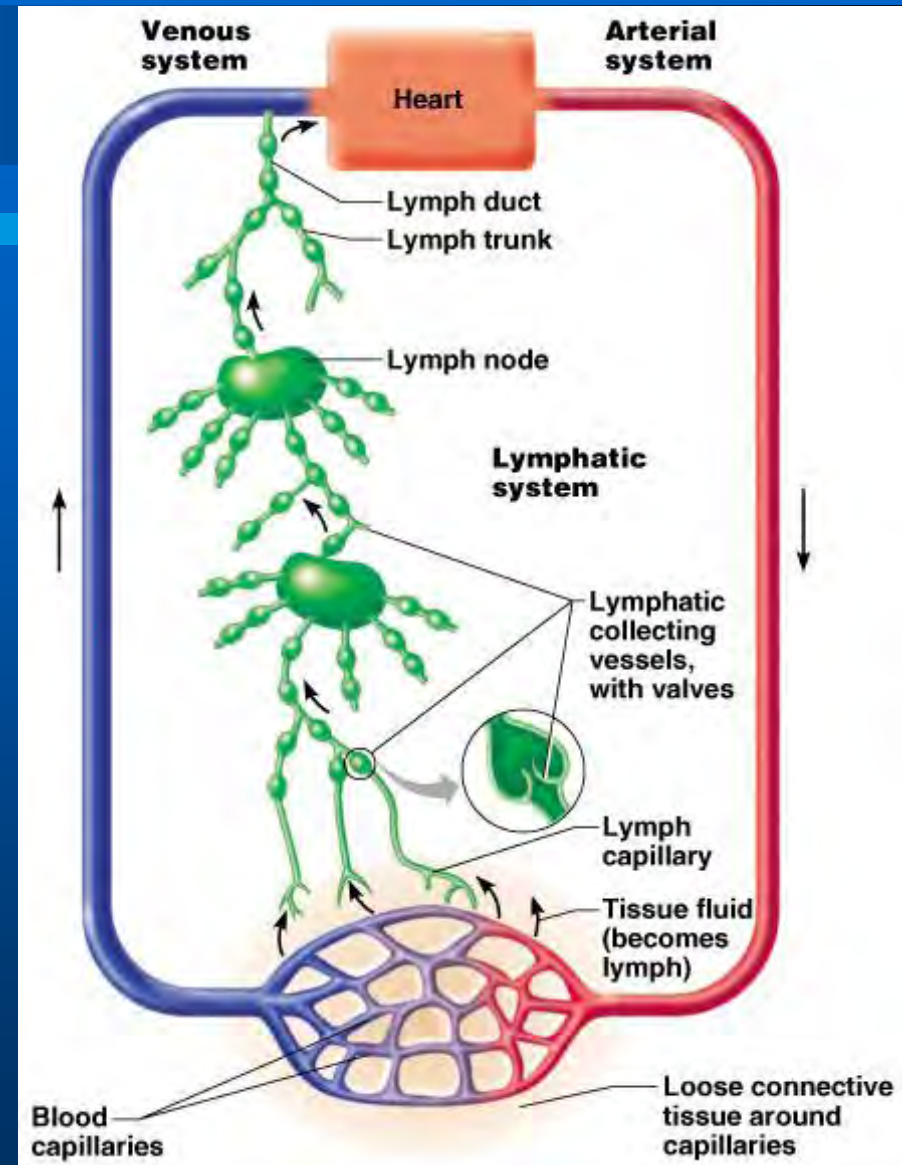
Lymphatic Vessels

- **Lymphatic collecting vessels**
 - Collects lymph from lymph capillaries
 - Carries lymph to and away from lymph nodes



Lymphatic Vessels

- Lymphatic collecting vessels
 - Returns fluid to circulatory veins near the heart
 - Right lymphatic duct
 - Thoracic duct



Lymph

- **Harmful materials that enter lymph vessels**
 - **Bacteria**
 - **Viruses**
 - **Cancer cells**
 - **Cell debris**

Lymph Nodes

- **Filter lymph before it is returned to the blood**
- **Defense cells within lymph nodes**
 - **Macrophages – engulf and destroy foreign substances**
 - **Lymphocytes – provide immune response to antigens**

Lymph Nodes

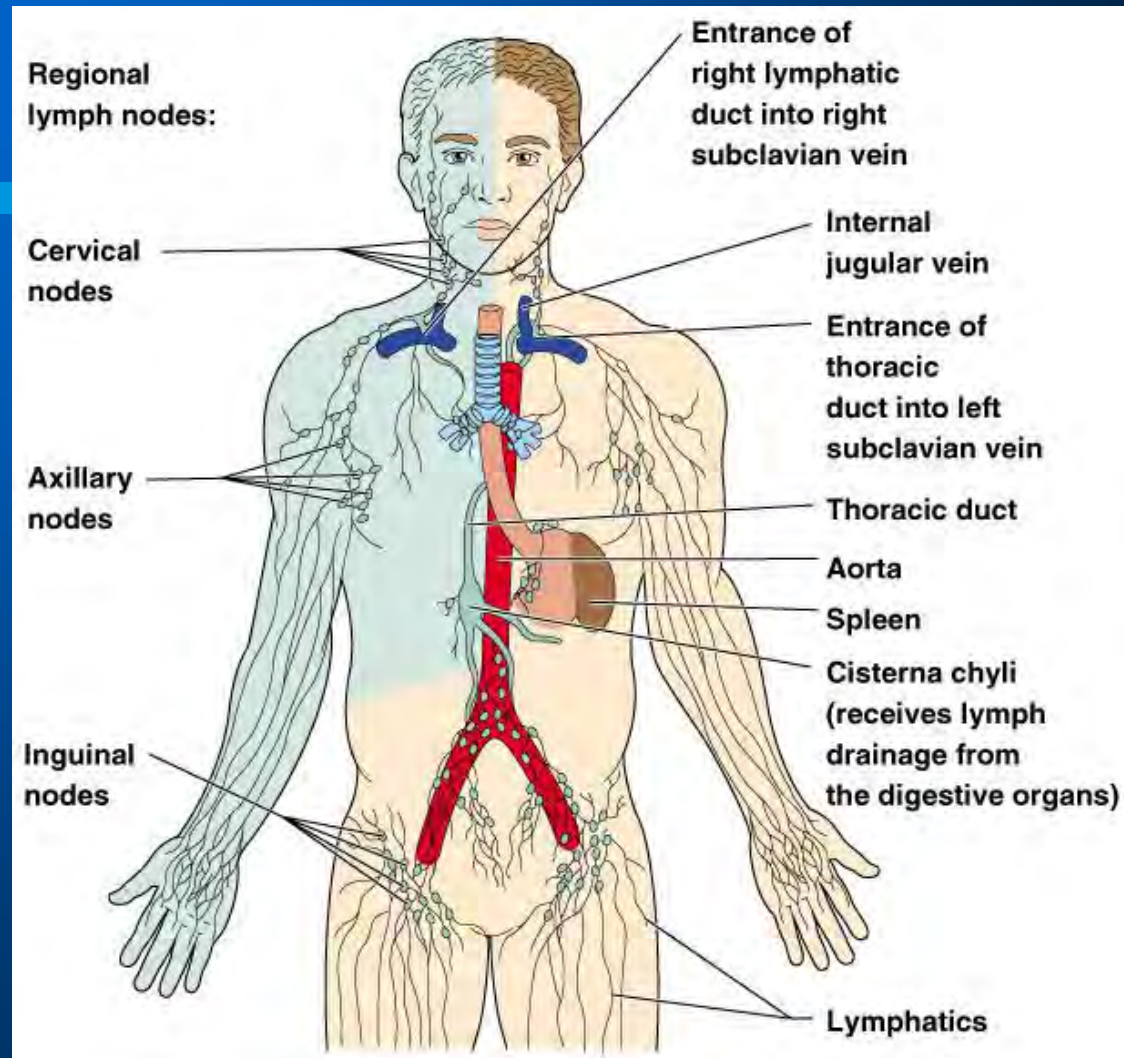


Figure 12.3

Lymph Node Structure

- **Most are kidney-shaped, less than 1 inch long**
- **Cortex**
 - **Outer part**
 - **Contains follicles – collections of lymphocytes**
- **Medulla**
 - **Inner part**
 - **Contains phagocytic macrophages**

Lymph Node Structure

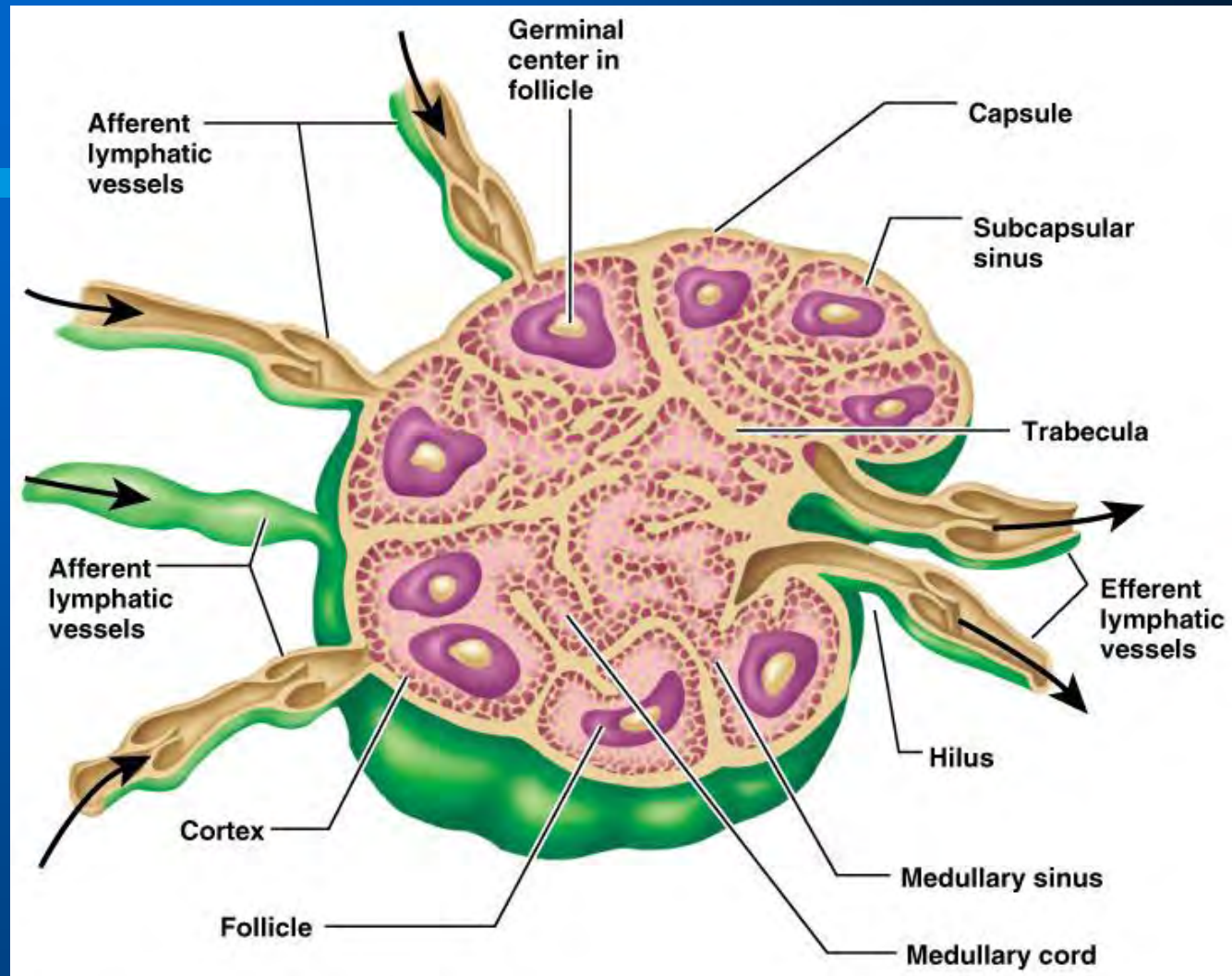


Figure 12.4

Flow of Lymph Through Nodes

- Lymph enters the convex side through afferent lymphatic vessels
- Lymph flows through a number of sinuses inside the node
- Lymph exits through efferent lymphatic vessels
- Fewer efferent than afferent vessels causes flow to be slowed

Other Lymphoid Organs

- Several other organs contribute to lymphatic function
 - Spleen
 - Thymus
 - Tonsils
 - Payer's patches

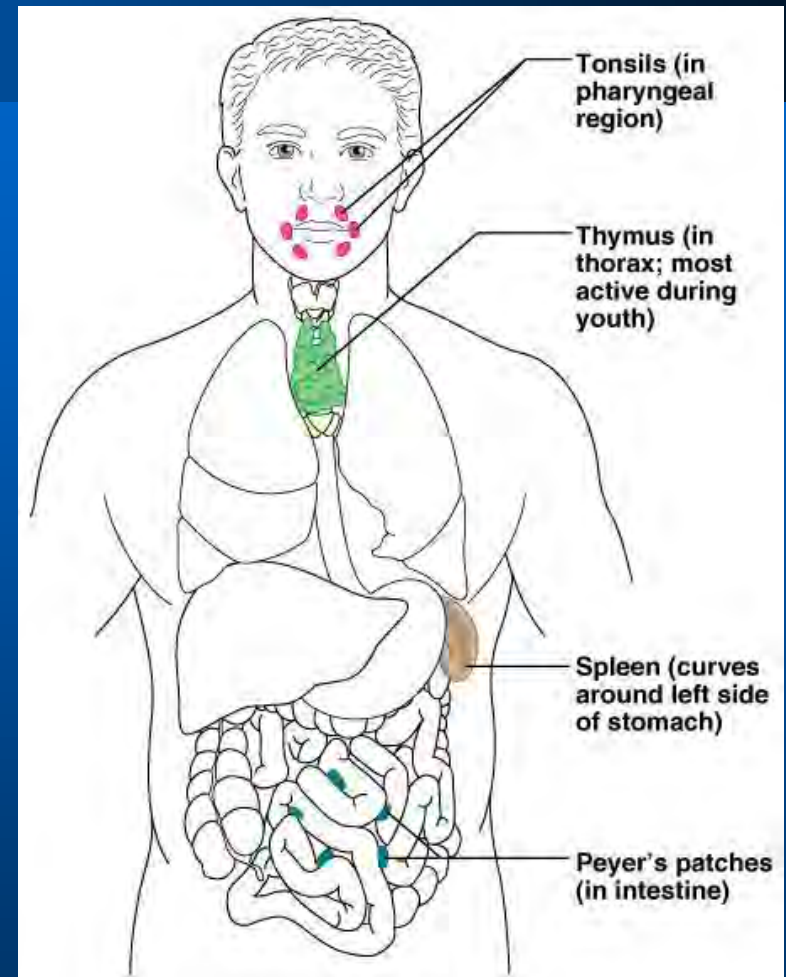


Figure 12.5

The Spleen

- **Located on the left side of the abdomen**
- **Filters blood**
- **Destroys worn out blood cells**
- **Forms blood cells in the fetus**
- **Acts as a blood reservoir**

The Thymus

- **Located low in the throat, overlying the heart**
- **Functions at peak levels only during childhood**
- **Produces hormones (like thymosin) to program lymphocytes**

Tonsils

- Small masses of lymphoid tissue around the pharynx
- Trap and remove bacteria and other foreign materials
- Tonsillitis is caused by congestion with bacteria

Peyer's Patches

- Found in the wall of the small intestine
- Resemble tonsils in structure
- Capture and destroy bacteria in the intestine

Mucosa-Associated Lymphatic Tissue (MALT)

- **Includes:**
 - **Peyer's patches**
 - **Tonsils**
 - **Other small accumulations of lymphoid tissue**
- **Acts as a sentinel to protect respiratory and digestive tracts**