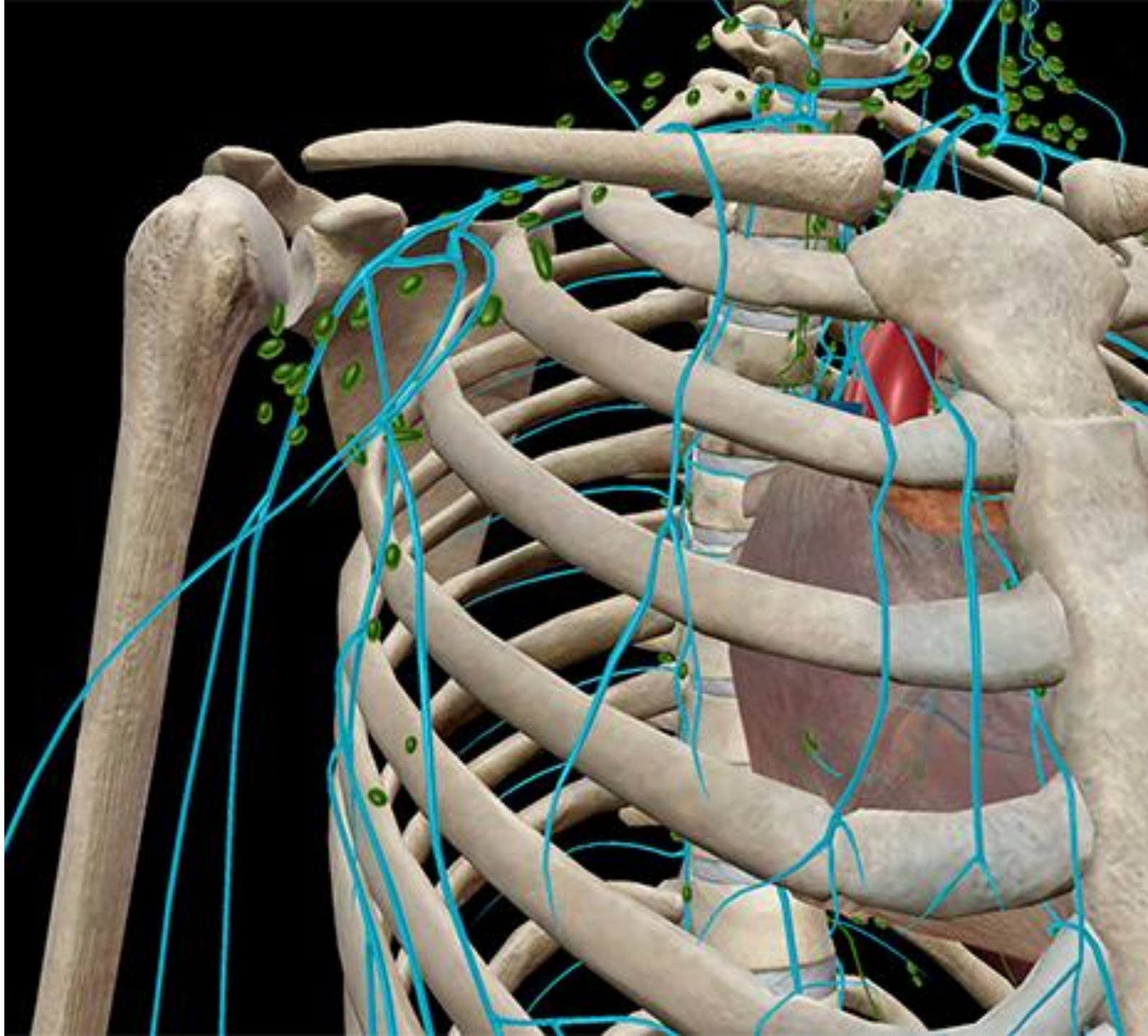
THE LYMPHATIC SYSTEM

HUMAN ANATOMY

College of Pharmacy

Dr. Abeer Abdullah



LEARNING OBJECTIVES

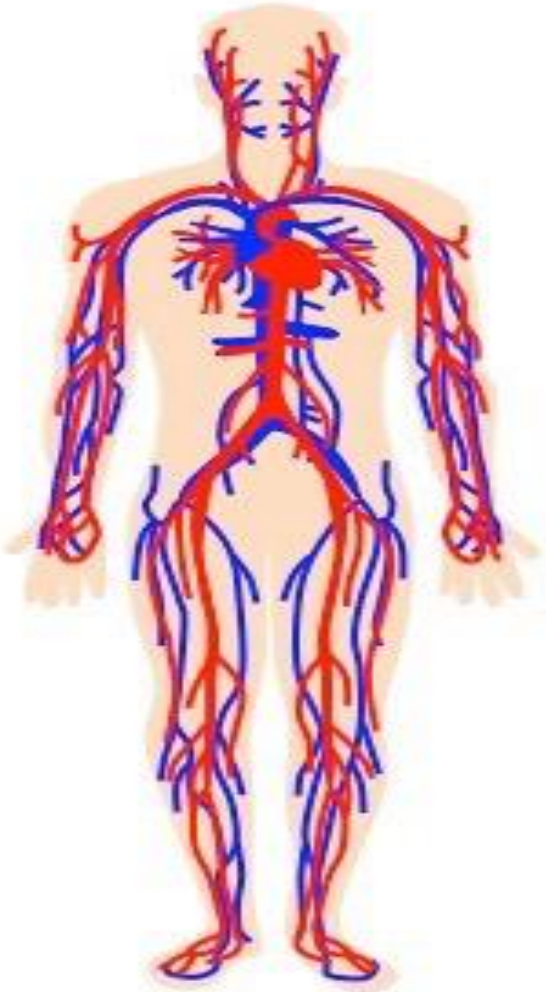
By the end of this lecture, students will be able to:

- Describe the three primary functions of the lymphatic system.
- Describe the **key components** (vessels, nodes, organs) and their roles and structures.

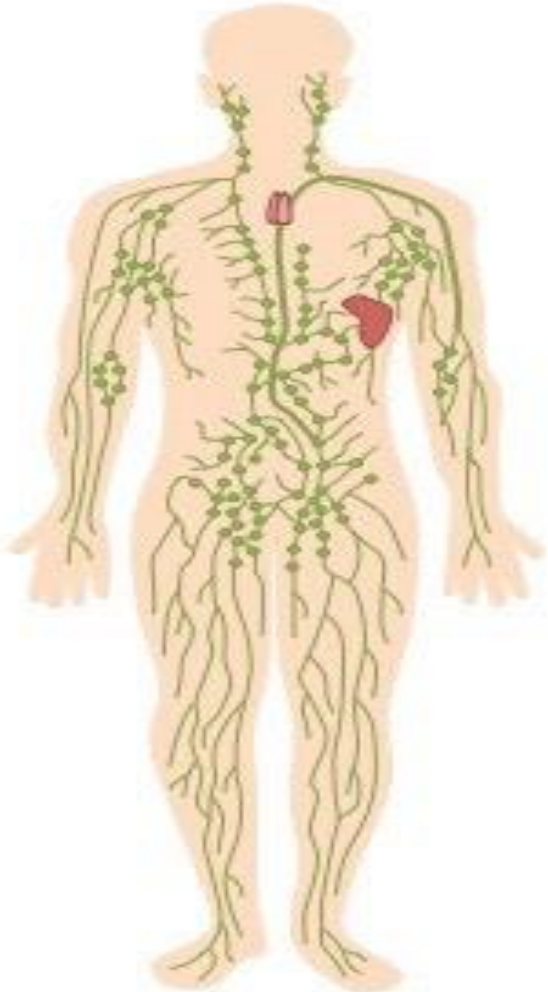
OVERVIEW OF THE LYMPHATIC SYSTEM

- **Definition:** A network of vessels, tissues, and organs maintaining **fluid balance** and **immunity**.
  - Closely associated with the **cardiovascular system**.
  - Transports **lymph** (clear fluid derived from tissue fluid).
  - Critical for **fat absorption** and **immunity**.

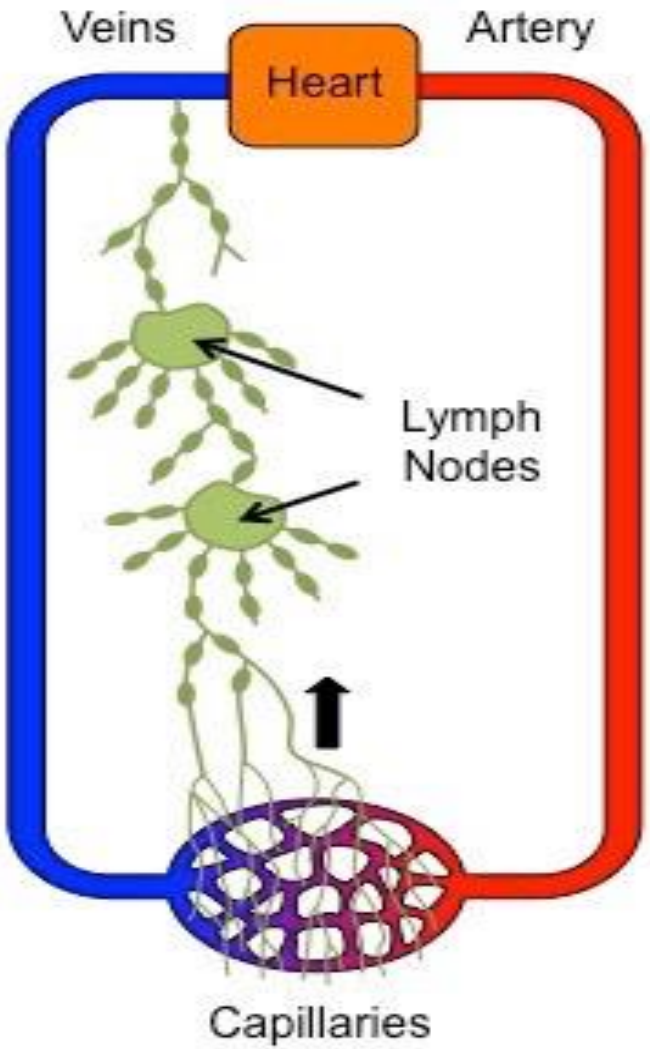
Circulatory System



Lymphatic System

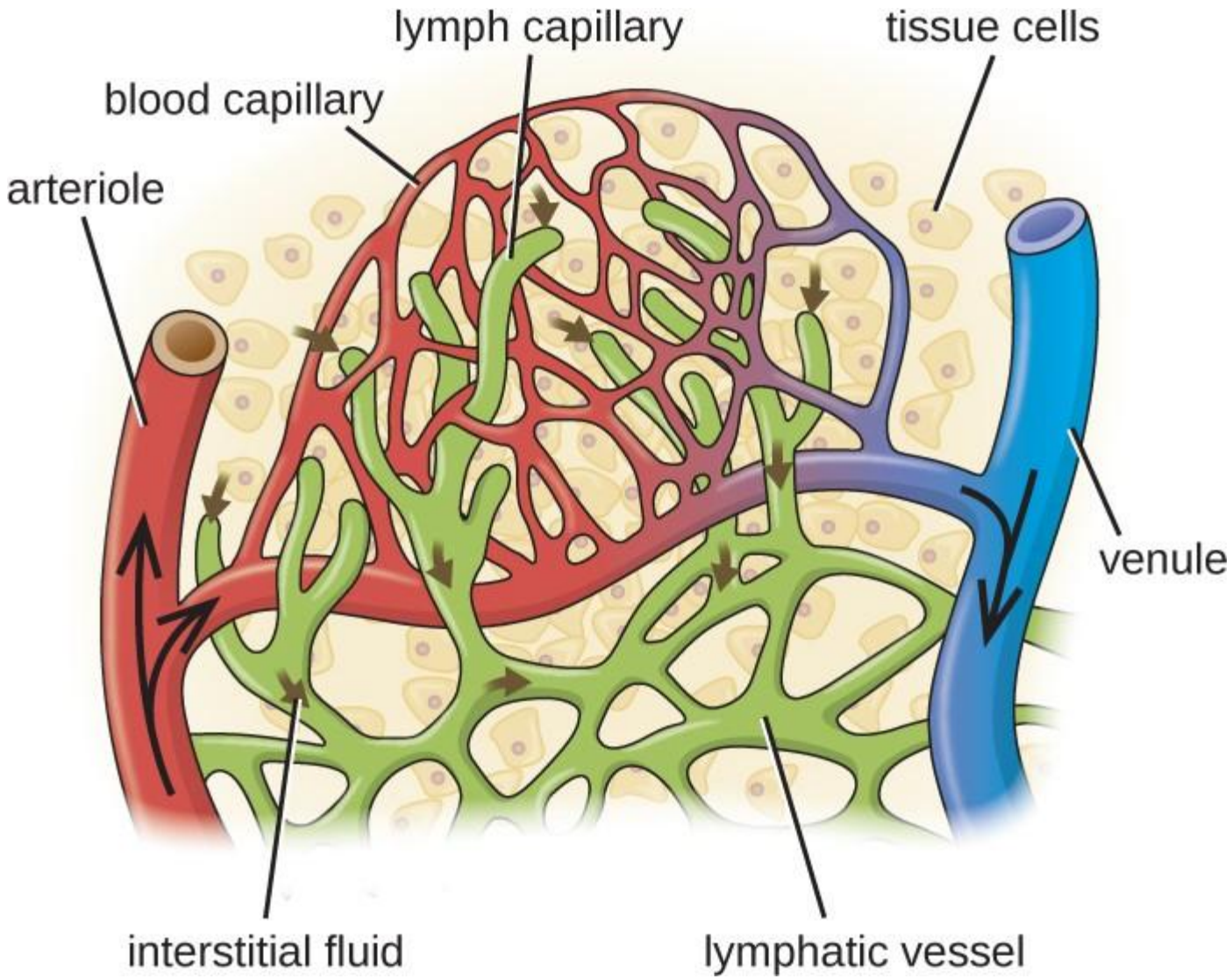


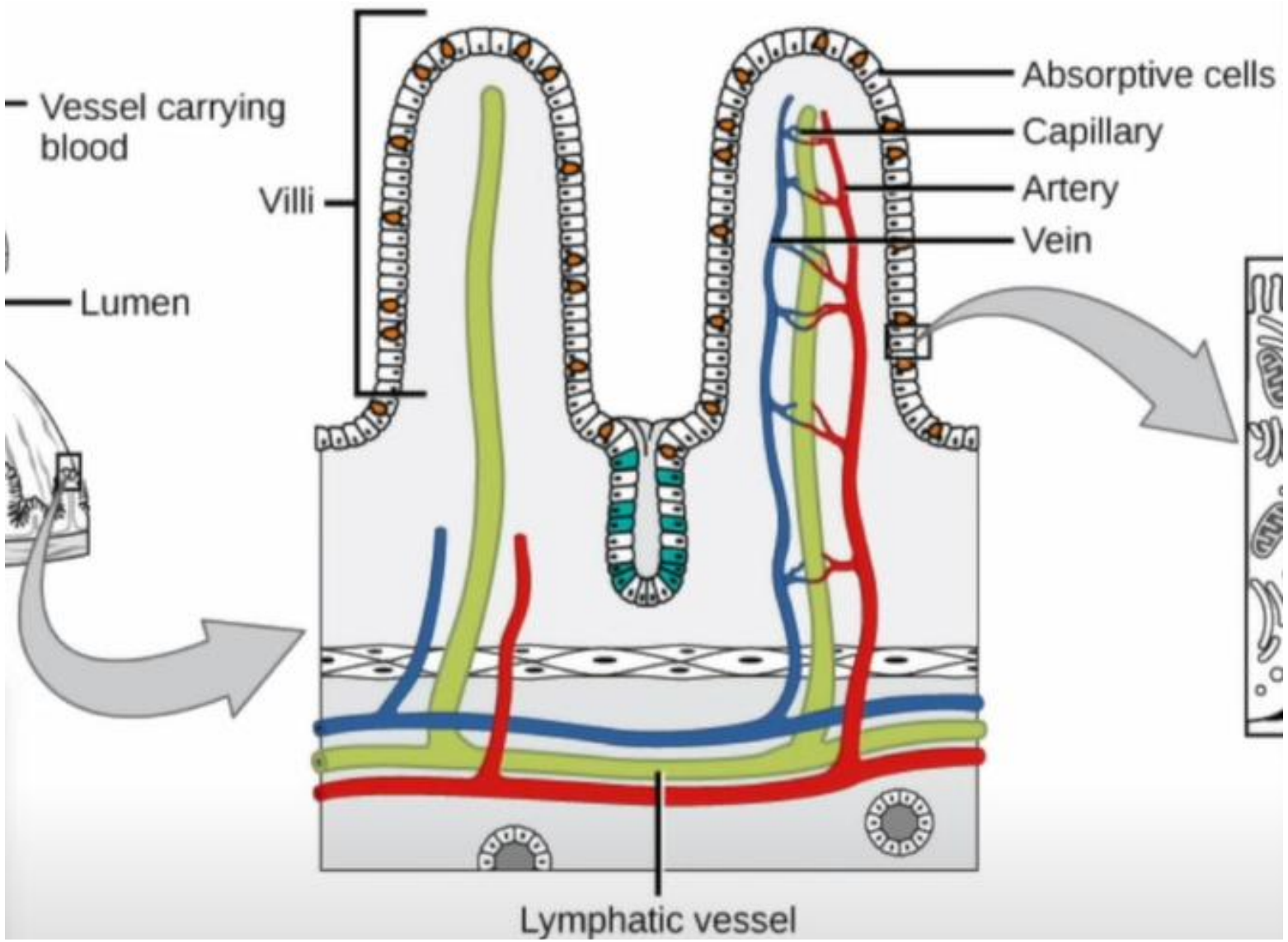
Inter-relationship between systems



FUNCTIONS OF THE LYMPHATIC SYSTEM

- **Fluid Balance:** Returns excess tissue fluid to the bloodstream.
- **Fat Absorption:** Lacteals (special lymphatic capillaries) in intestinal villi absorb dietary fats from the digestive tract and transports them to the bloodstream.
- **Defense:**
  - Lymph is filtered and checked for foreign or pathologic material, such as cancer cells and bacteria.
  - Lymphatic structures contain certain cells (lymphocytes, macrophages) that initiate an immune response to abnormal materials and perform other functions essential to homeostasis and survival.


lymph capillary
tissue cells
blood capillary
arteriole
venule
interstitial fluid
lymphatic vessel


Vessel carrying blood
Villi
Lumen
Absorptive cells
Capillary
Artery
Vein
Lymphatic vessel

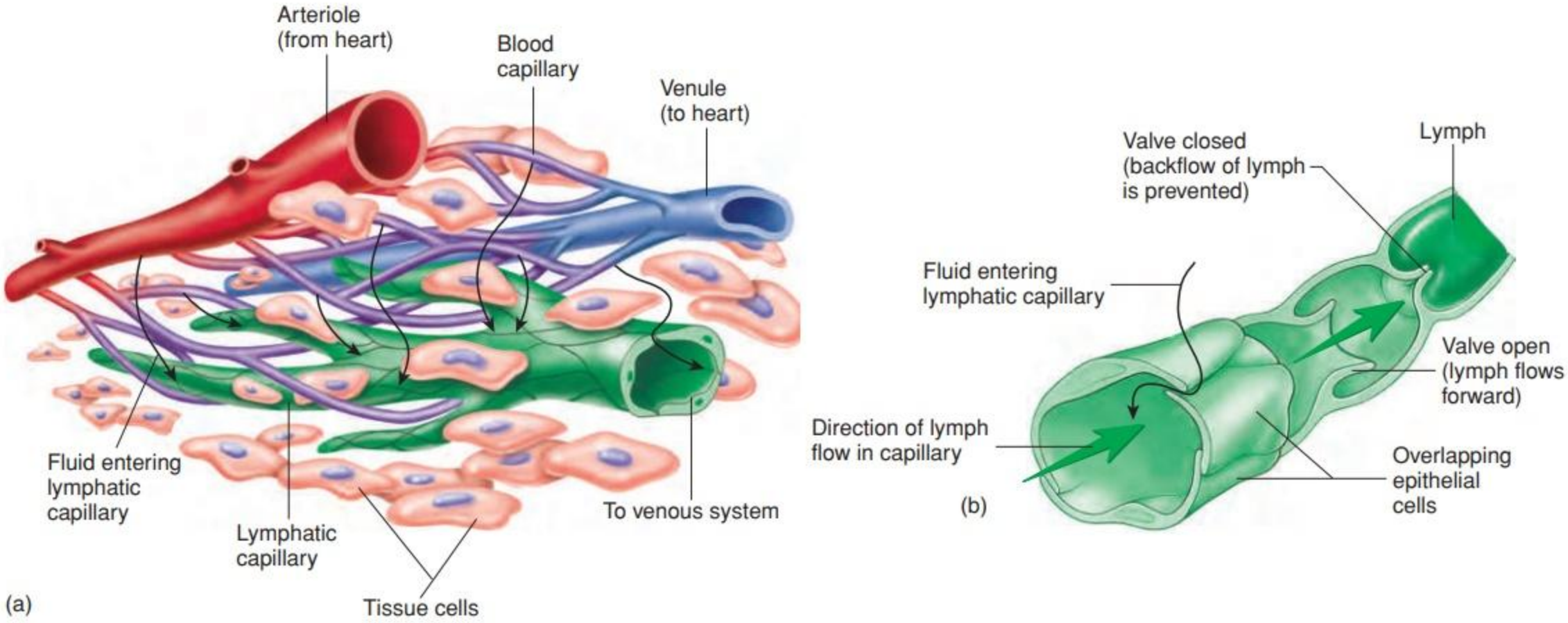
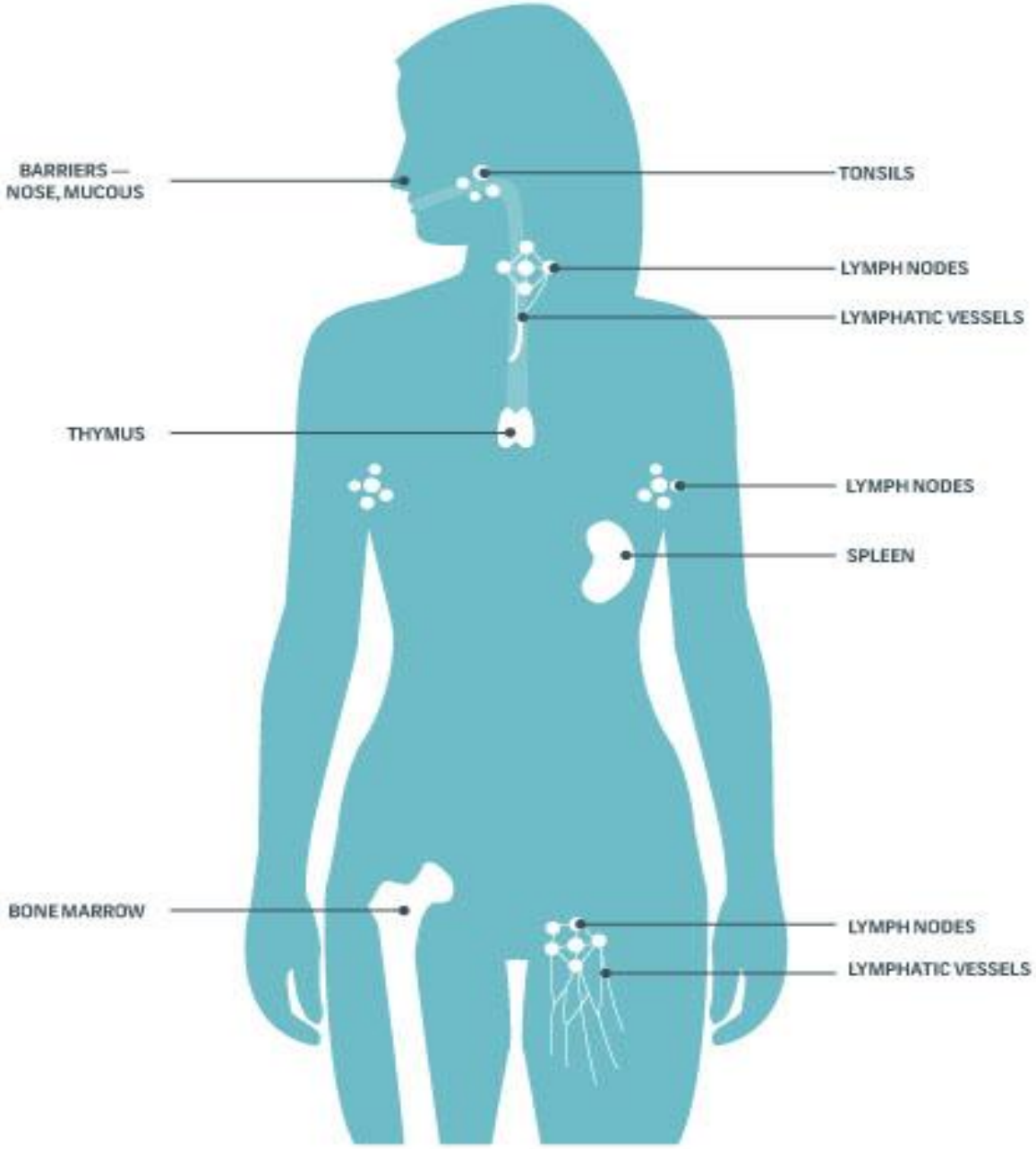


Figure **Lymph Formation and Movement**

(*a*) Fluid moves from blood capillaries into tissues and from tissues into lymphatic capillaries to form lymph. (*b*) The overlap of epithelial cells of the lymphatic capillary allows fluid to enter easily but prevents it from moving back into the tissue. Valves, located farther along in lymphatic vessels, also ensure one-way flow of lymph.



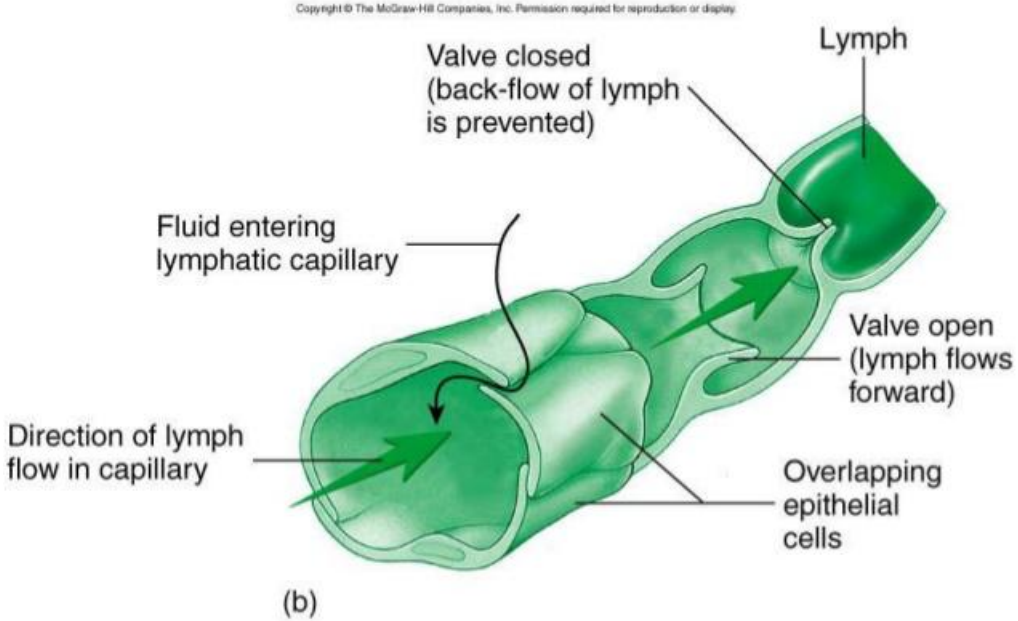
COMPONENTS OF THE LYMPHATIC SYSTEM

- LYMPH
- LYMPHATIC VESSELS
- LYMPH NODES
- LYMPHATIC NODULES
- LYMPHOID TISSUE AND ORGANS

A. LYMPH

Composition & Appearance:	Clear, colorless fluid.
	Similar to blood plasma but **lower in protein.**
Origin & Pathway:	Originates as **tissue fluid** (interstitial fluid).
	Collected by **lymphatic capillaries.**
	Transported through vessels → filtered by lymph nodes → returned to bloodstream.
Contains:	Water , Electrolytes, Immune cells (lymphocytes), Cellular waste, and occasionally fats (after meals).

B. LYMPHATIC VESSELS



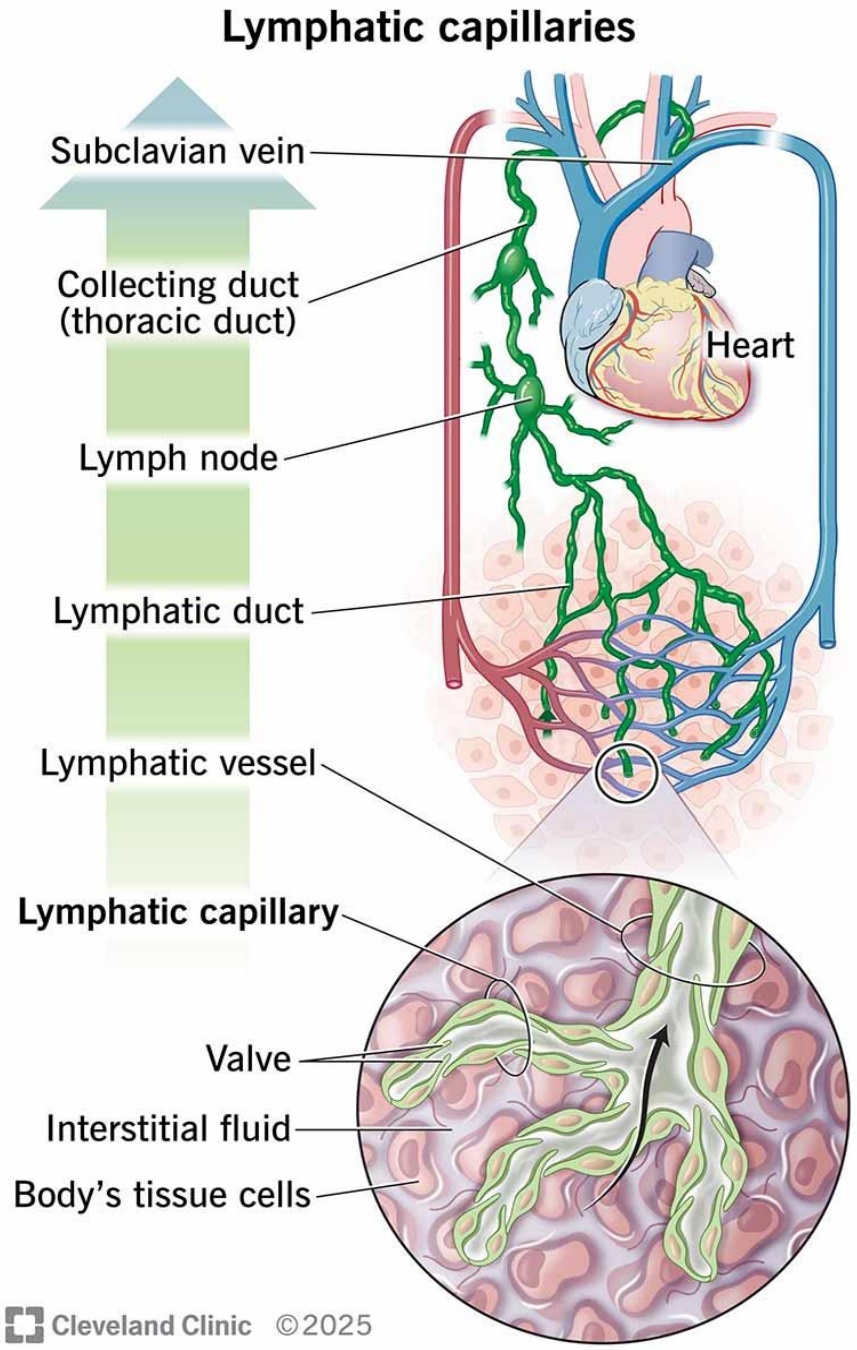
Structure:

- **One-way system** with valves to prevent backflow.
- **Begins as lymphatic capillaries**:
  - Tiny, closed-ended vessels.
  - Permeable (overlapping endothelial cells act as "mini-valves").
  - Found in most body tissues (except and avascular tissues and CNS **)..
  - **Merge to form progressively larger vessels.**

B. LYMPHATIC VESSELS

Functions:

- **Transport Pathway:**
  - Capillaries → Larger collecting vessels → Lymph nodes → Major ducts (**thoracic duct and right lymphatic duct**) → Bloodstream.
- **Fluid Collection**:
  - Collects excess tissue fluid (lymph).
  - Lacteals also absorb dietary fats.



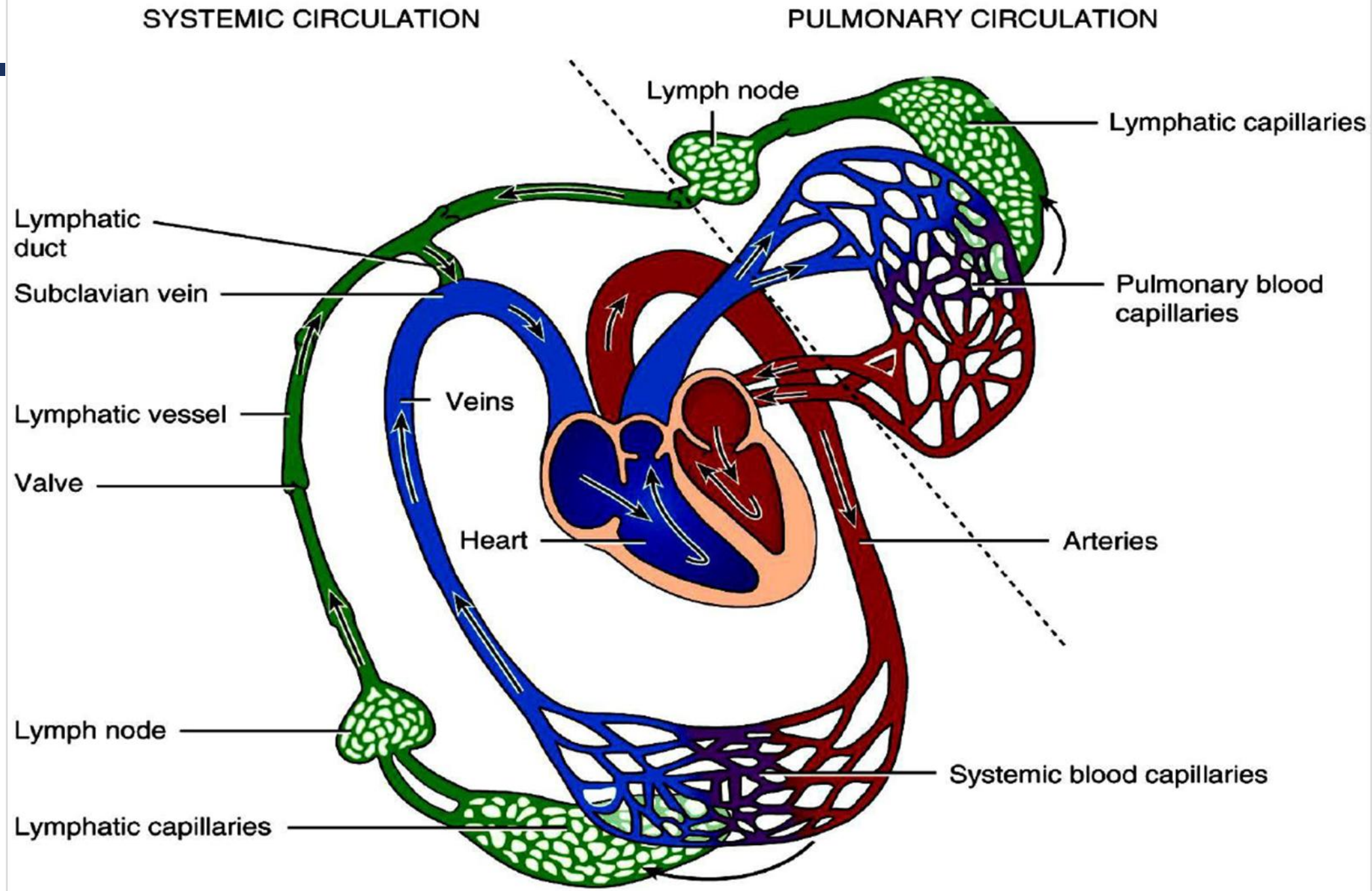
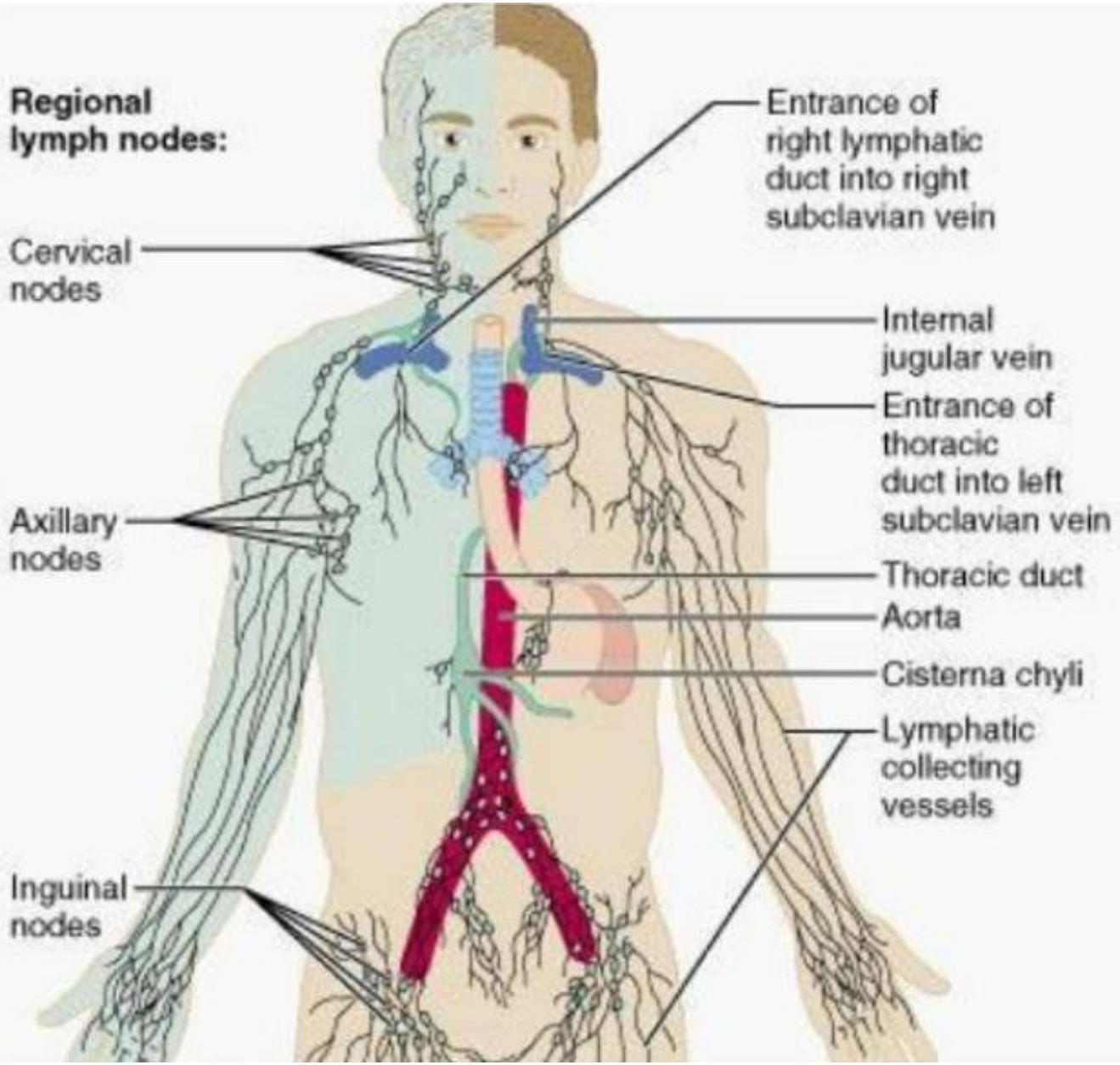
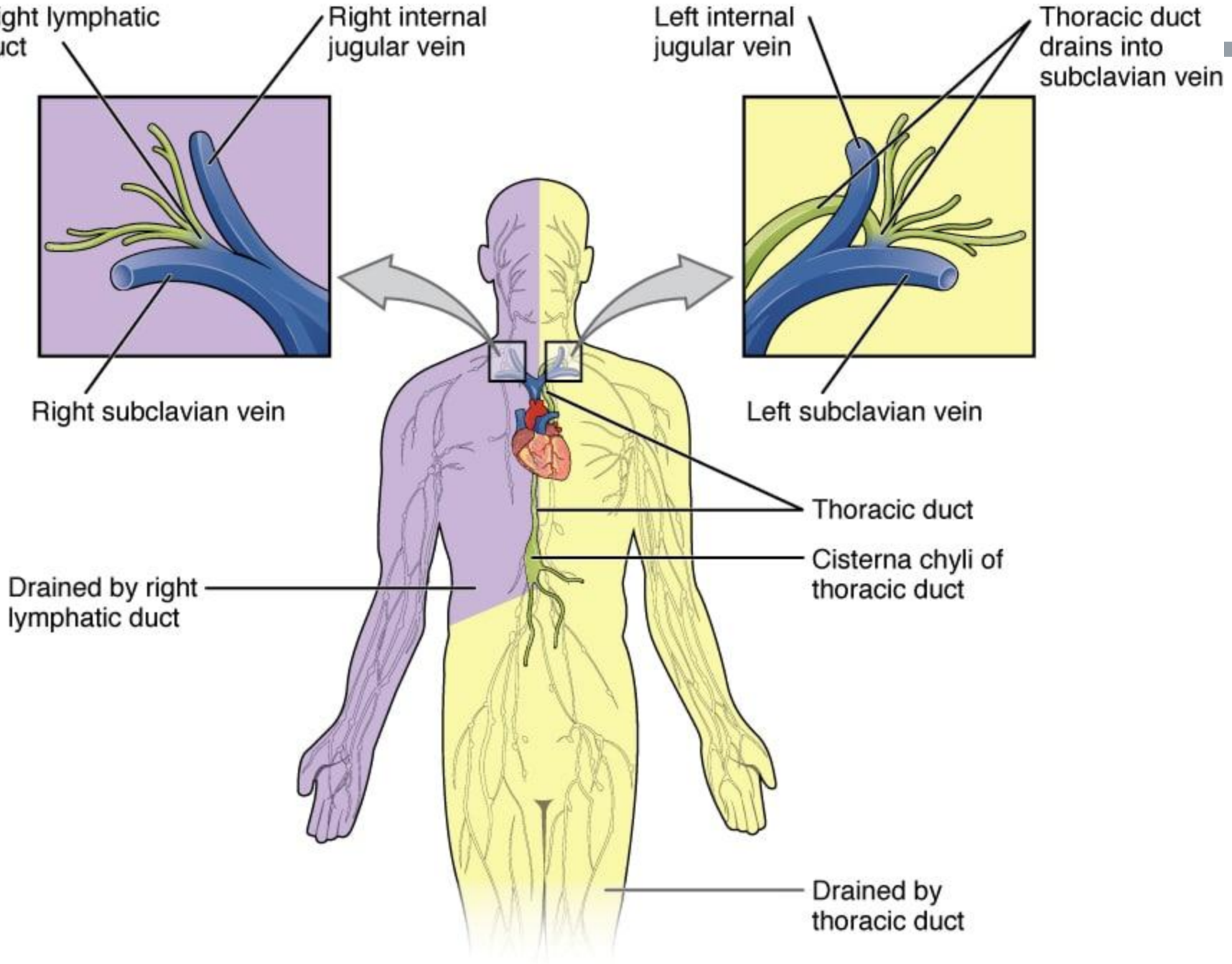


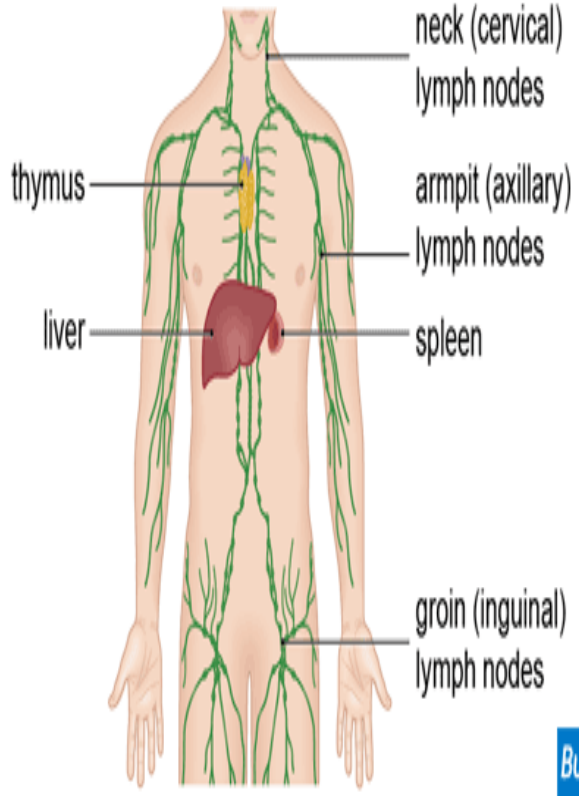
Figure 16.04 Tortora - PHA 11/e


Regional lymph nodes:
Cervical nodes
Axillary nodes
Inguinal nodes
Entrance of right lymphatic duct into right subclavian vein
Internal jugular vein
Entrance of thoracic duct into left subclavian vein
Thoracic duct
Aorta
Cisterna chyli
Lymphatic collecting vessels


Right lymphatic duct
Right internal jugular vein
Left internal jugular vein
Thoracic duct drains into subclavian vein
Right subclavian vein
Left subclavian vein
Thoracic duct
Cisterna chyli of thoracic duct
Drained by right lymphatic duct
Drained by thoracic duct

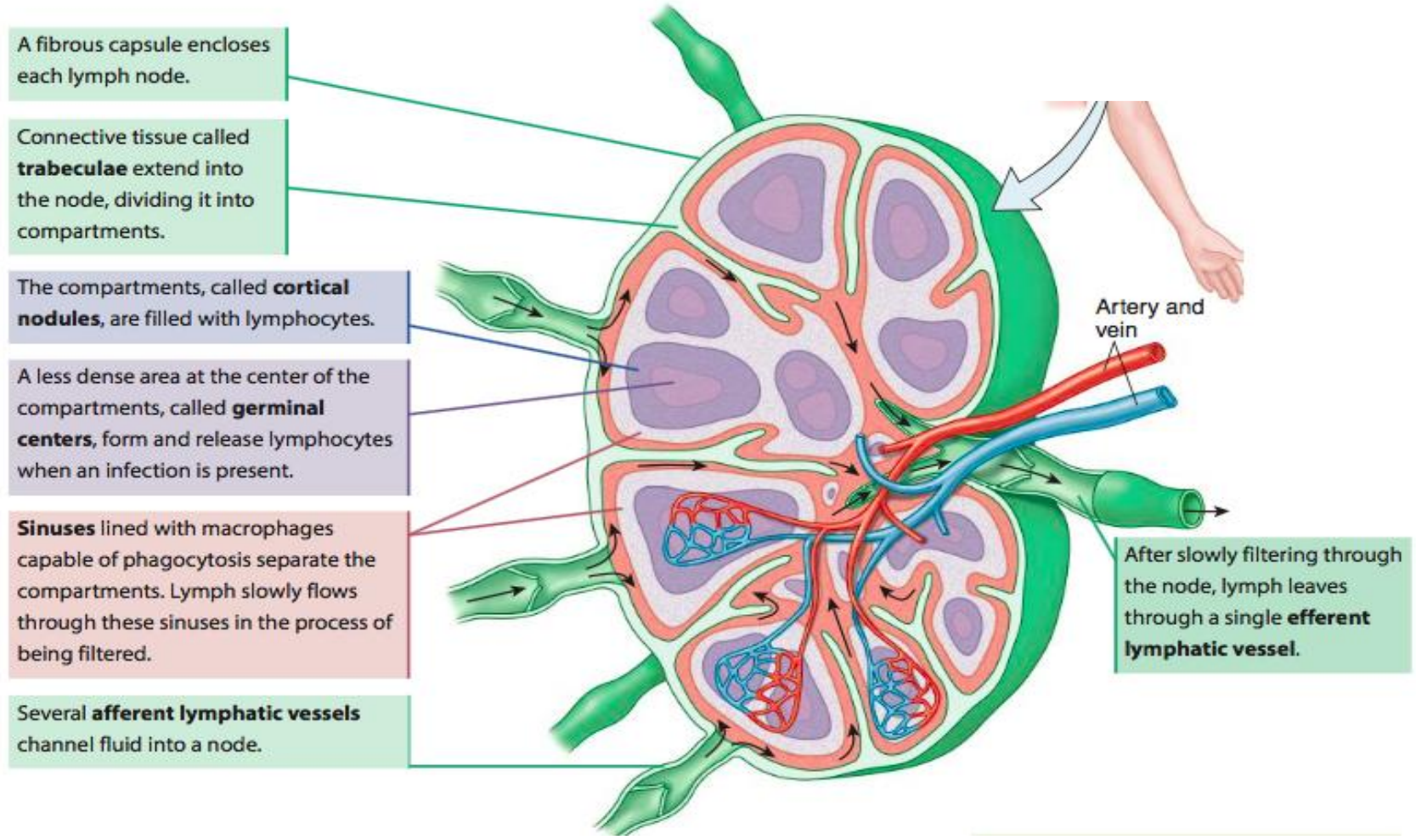
C. LYMPH NODES

- **Structure**:
  - Small, bean-shaped (<2.5 cm).
  - Encased in connective tissue capsule.
  - Contains lymphocytes and macrophages.
  - Divided into lymph nodules (functional compartments).
- **Distribution**:
  - Located along lymphatic pathways throughout body.
- **Key Clusters (three superficial regions):**
  - Cervical nodes (neck), Axillary nodes (armpit), Inguinal nodes (groin).
- **Function:** Filter lymph before it is returned to the blood; contain immune cells.



The lymphatic system

FYI – LYMPH NODES STRUCTURE



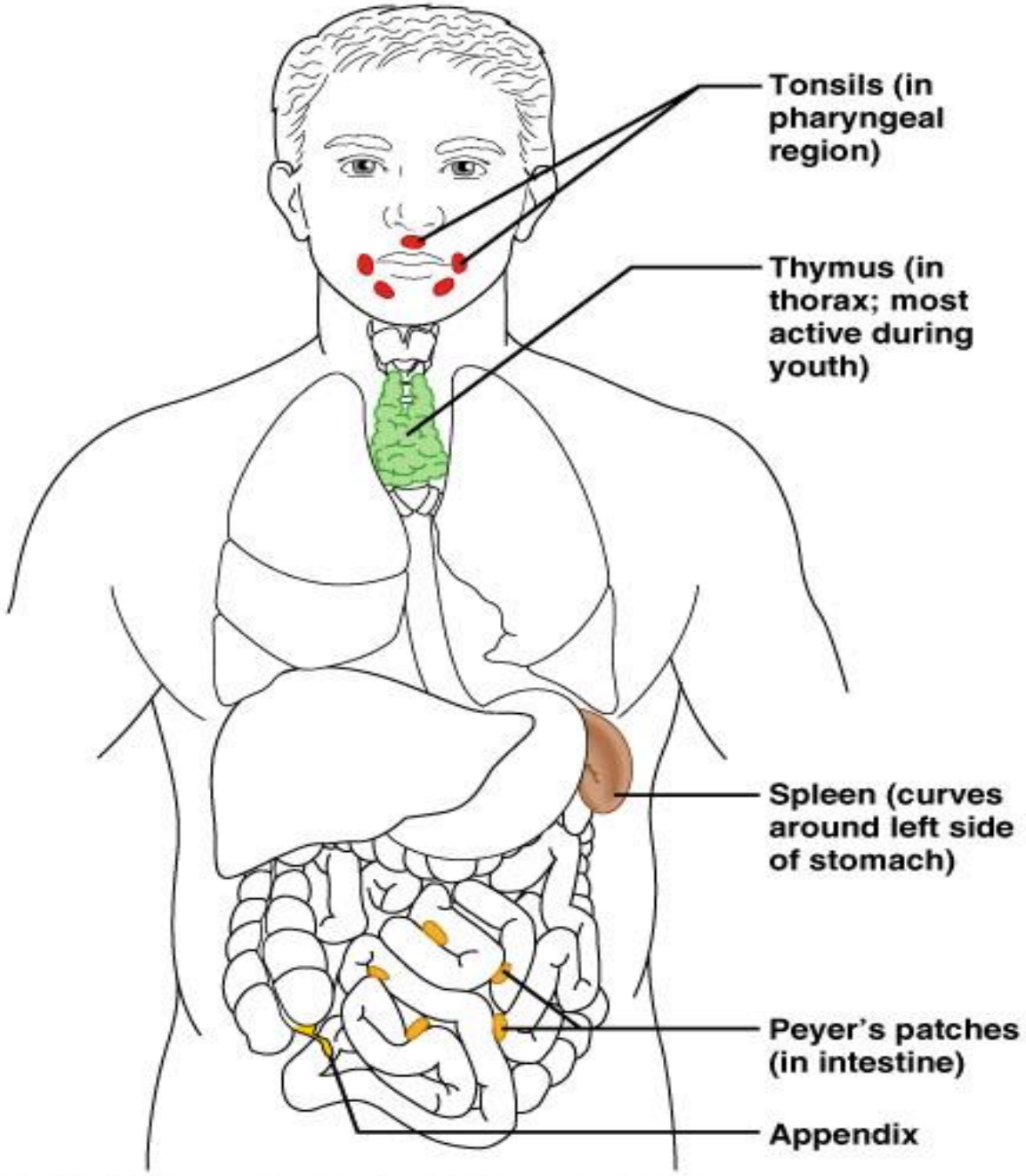
D. LYMPHATIC NODULES

- **Structure:**
  - Egg-shaped masses of lymphatic tissue.
  - No connective tissue capsule.
- **Locations**:
  - Scattered throughout the lamina propria of mucous membranes lining of:
    - GI tract (including intestines).
    - Respiratory airways.
    - Urinary/reproductive tracts.
  - Collectively called **MALT** (Mucosa-Associated Lymphatic Tissue).

D. LYMPHATIC NODULES

- Lymphatic nodules are found individually or in **large aggregations:**

1. **Tonsils** (pharyngeal region).
2. Aggregated lymphatic follicles **Peyer's patches** (ileum of the small intestine).
3. **Appendix.**



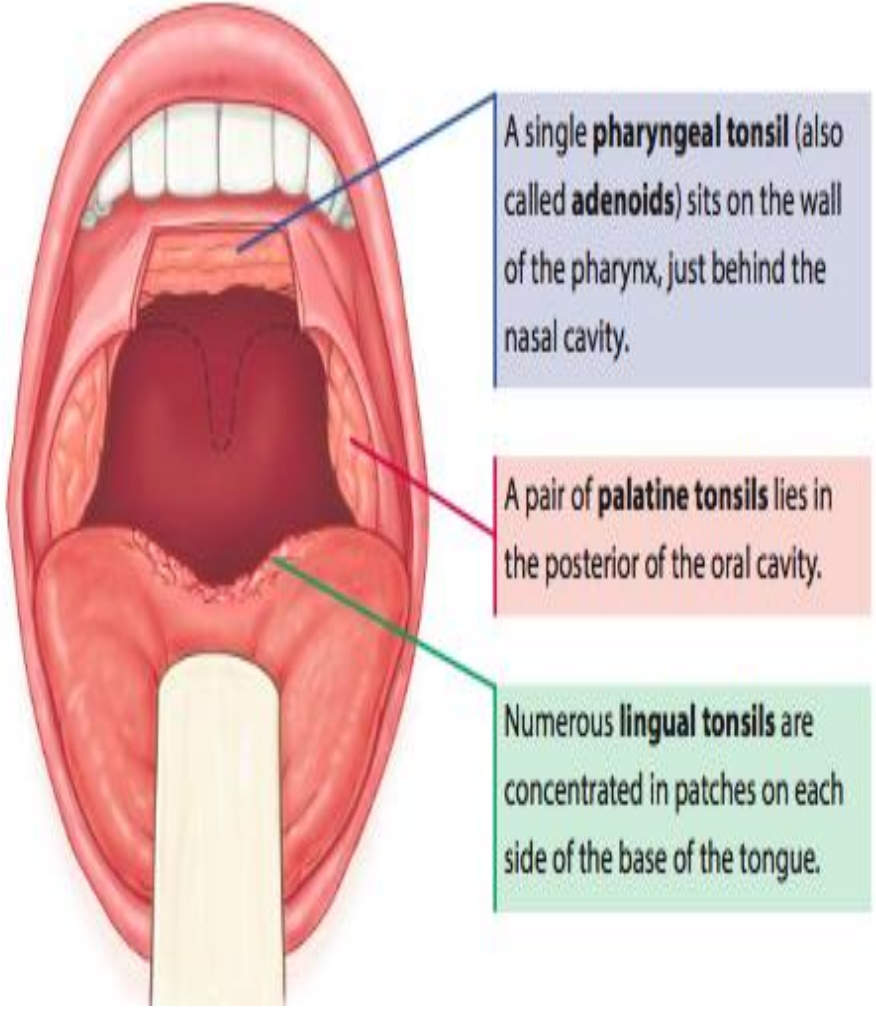
E. TONSILS

Type	Location	Clinical Notes
Pharyngeal tonsil	Nasopharynx (posterior nasal opening)	Enlargement → "Adenoids"; may obstruct breathing
Palatine tonsils	Oropharynx (sides of throat)	Most commonly infected ("tonsillitis")
Lingual tonsils	Base of tongue	Less prone to infection

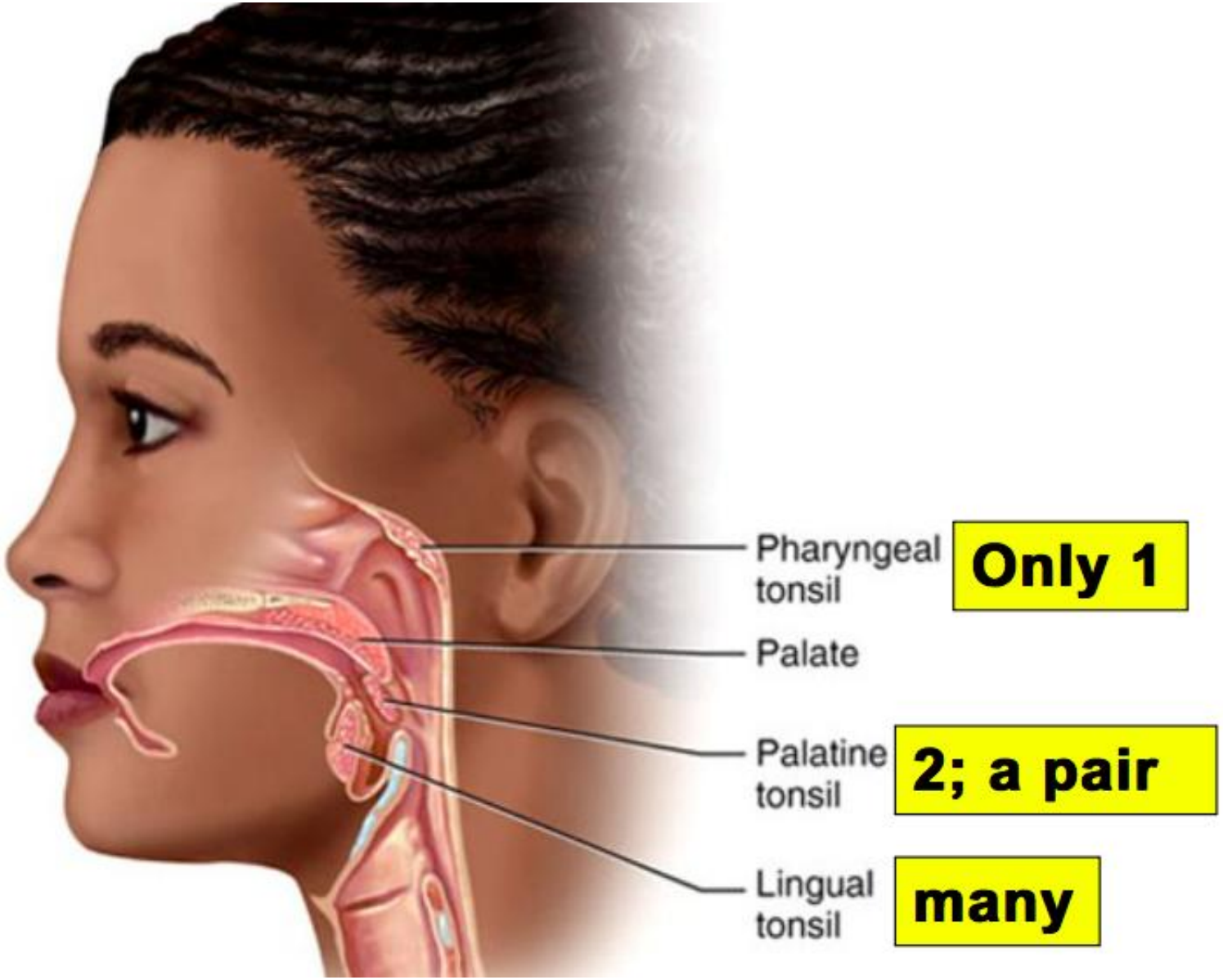
- **Role:** Lymphocytes and macrophages in the tonsils actively protect against pathogens entering through the nose and mouth.

Tonsils

Masses of lymphoid tissue, the tonsils form a protective circle at the back of the throat. They guard against pathogens entering the body through the nose or throat. There are three sets of tonsils:



E. TONSILS


Pharyngeal tonsil
Only 1
Palate
Palatine tonsil
2; a pair
Lingual tonsil
many

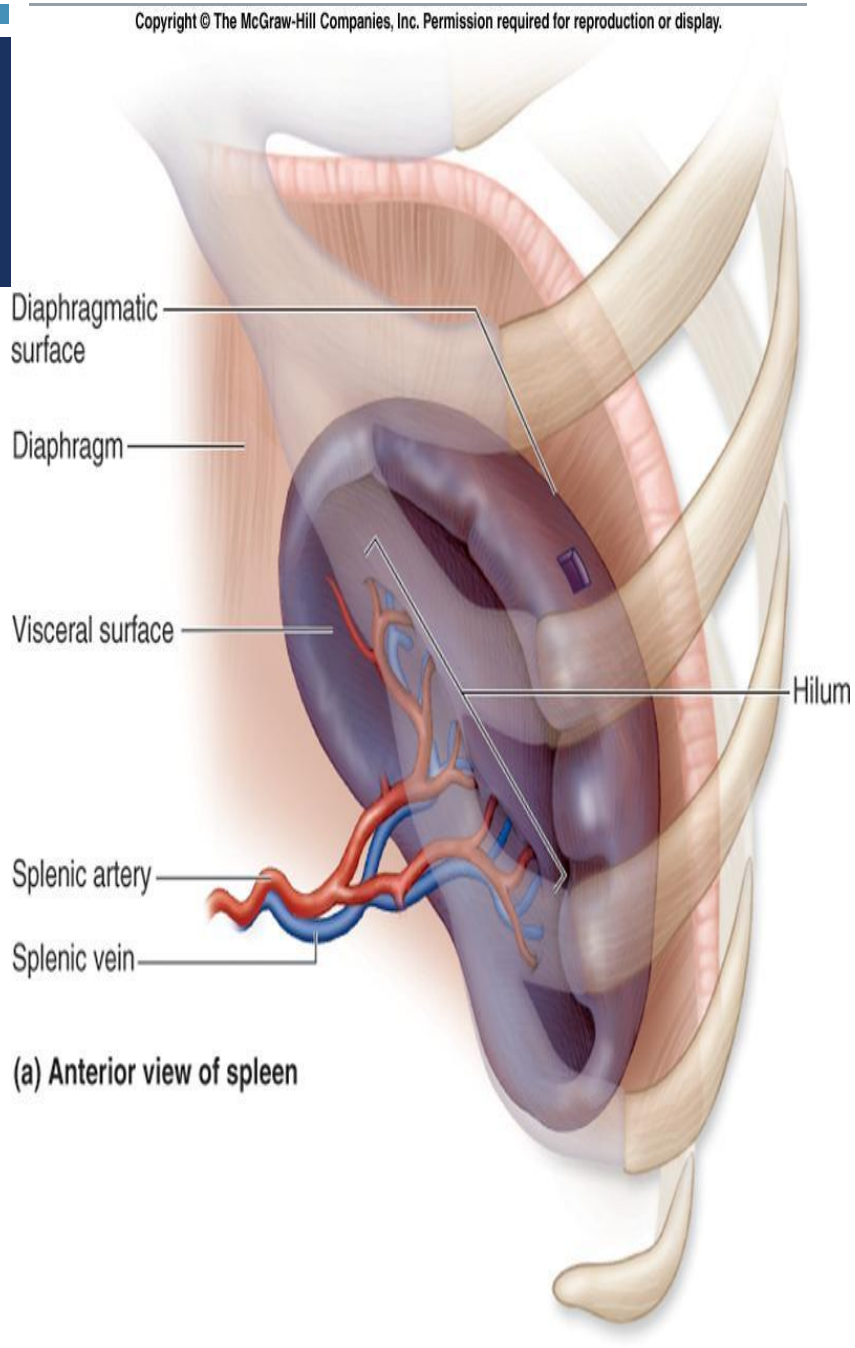
F. SPLEEN

Location:

- Upper left abdominal quadrant (LUQ).
- Inferior to the diaphragm, and posterior to the stomach.
- It is in contact with the stomach, the left kidney and the diaphragm.

Appearance:

- **Largest lymphatic organ**.
- Similar to a lymph node in shape and structure but much larger.
- Approximately12 cm length, 7 cm wide and 2.5 cm thick.
- Weighs about 200 g.
- Surrounded by a connective tissue capsule, which extends inward to divide the organ into lobules.

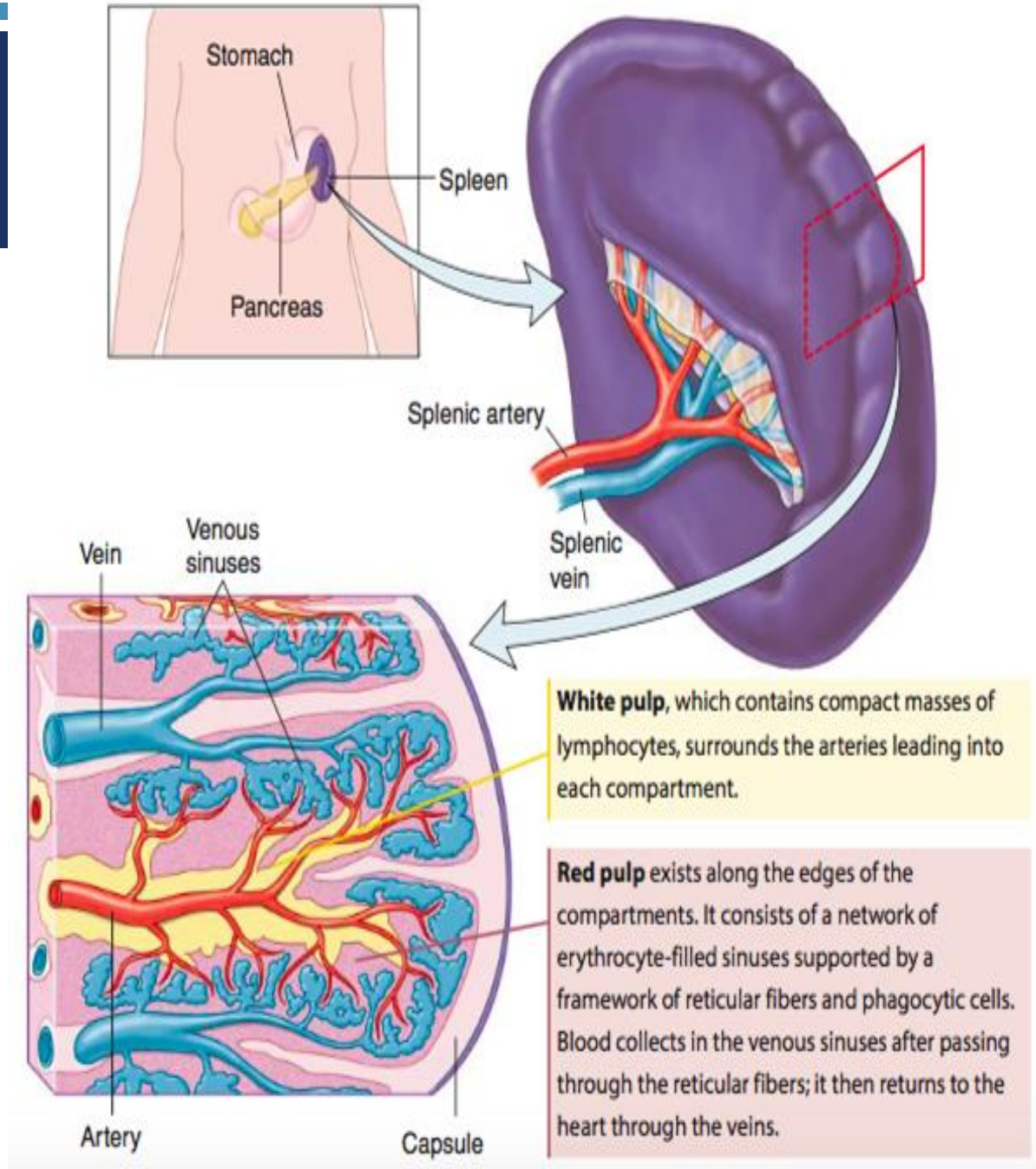


F. SPLEEN

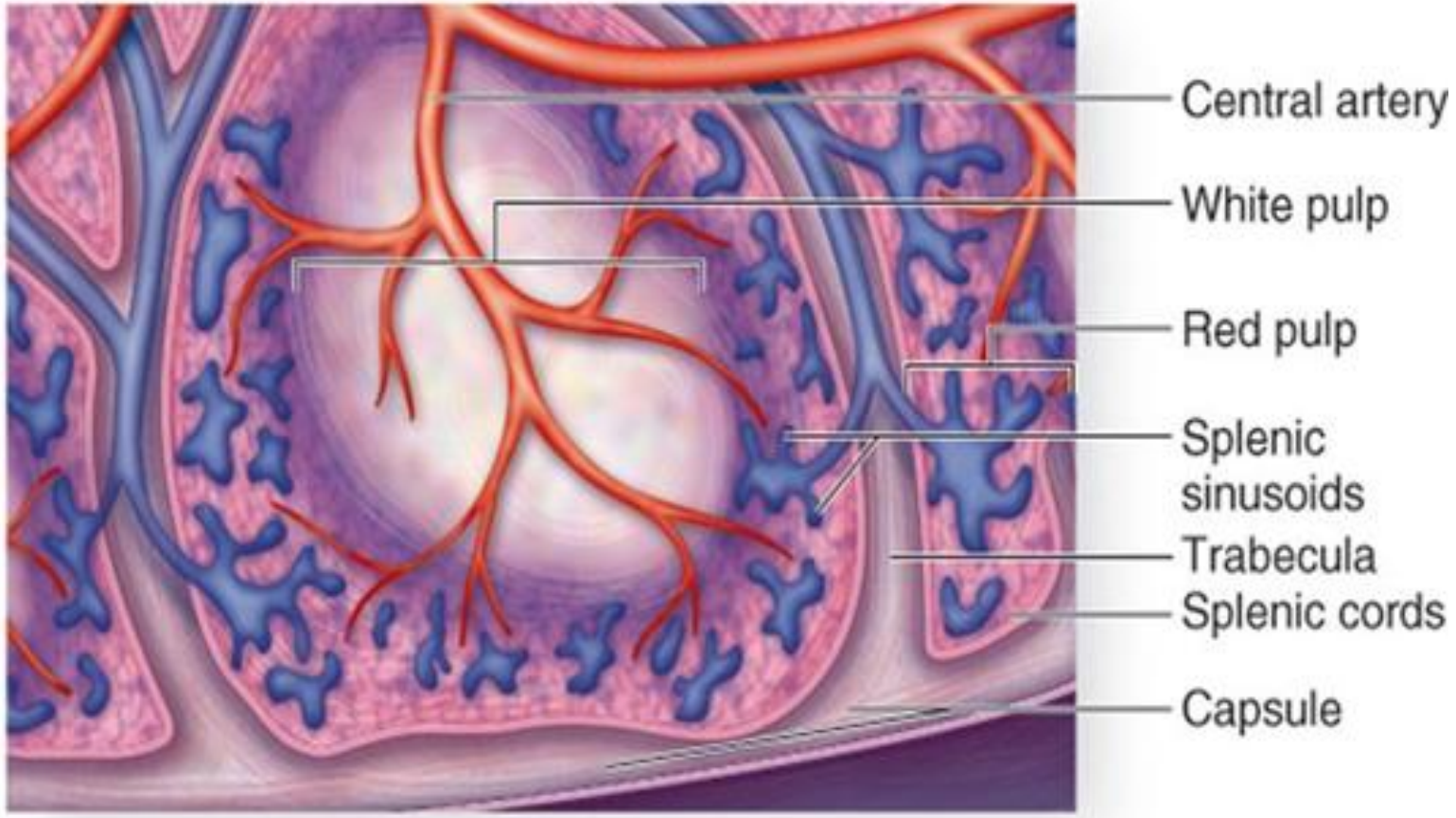
Vascular Supply (enter it at hilum) :

- **Arterial**: Splenic artery (branch of celiac trunk).
- **Venous**: Splenic vein.

Tissue Type	Composition	Function
White pulp	Lymphoid tissue	Immune surveillance
Red pulp	Sinuses & cords	Blood filtration

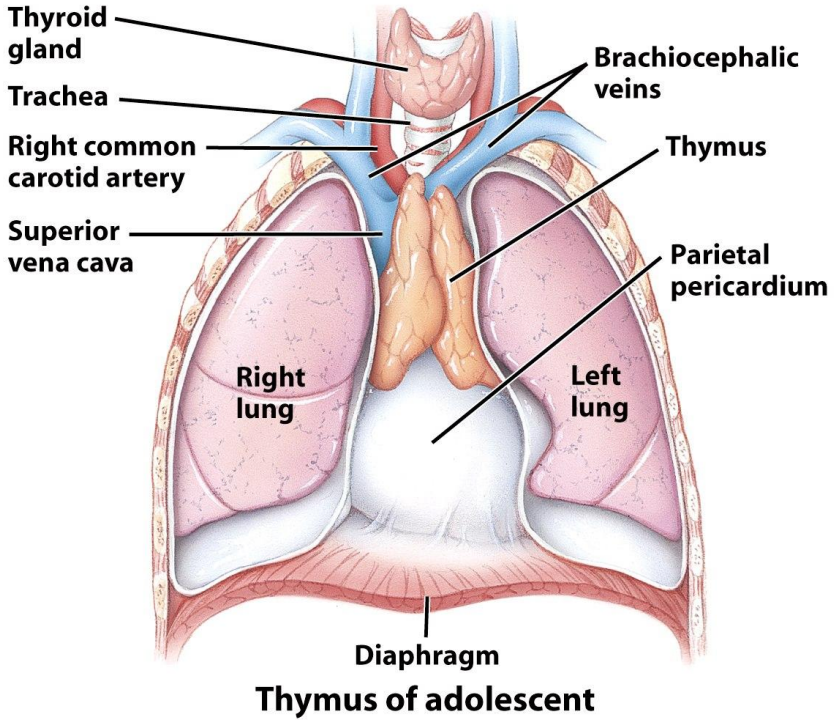


F. SPLEEN



(b)

J.THYMUS



Thymus of adolescent

Figure 22-5a Principles of Anatomy and Physiology, 11/e
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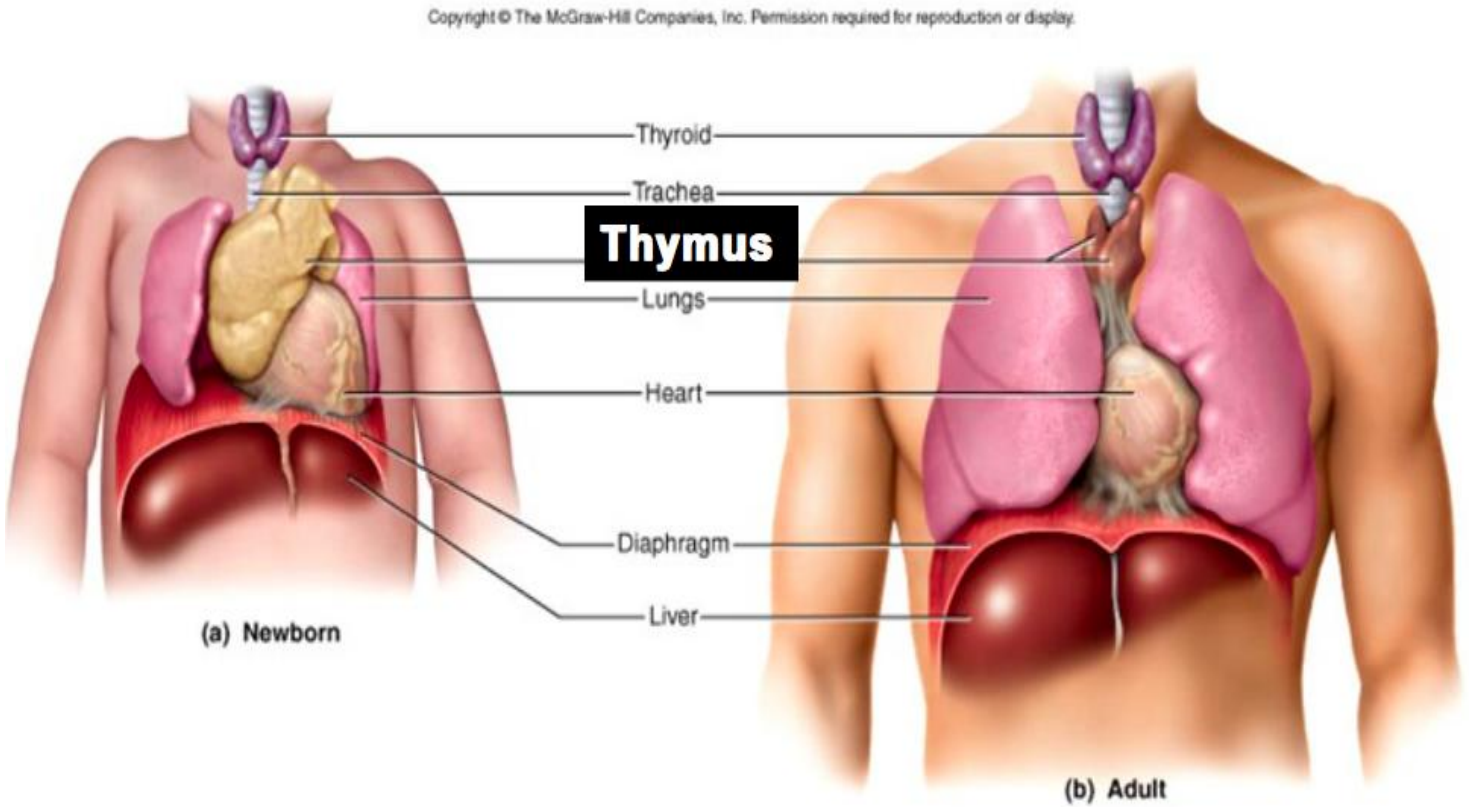
- **Structure**:
  - Soft, bilobed organ.
  - Pinkish-grey lymphoid tissue.
  - No ducts (endocrine function).
- **Location**:
  - Mediastinum (between lungs).
  - Anterior to ascending aorta.
  - Posterior to sternum.

J.THYMUS

- **Age-Related Size Changes**

Infants	Large (relative)
Puberty	Maximum absolute size
Adulthood+	Gradual involution



Atrophies after puberty.

J.THYMUS

Functions:

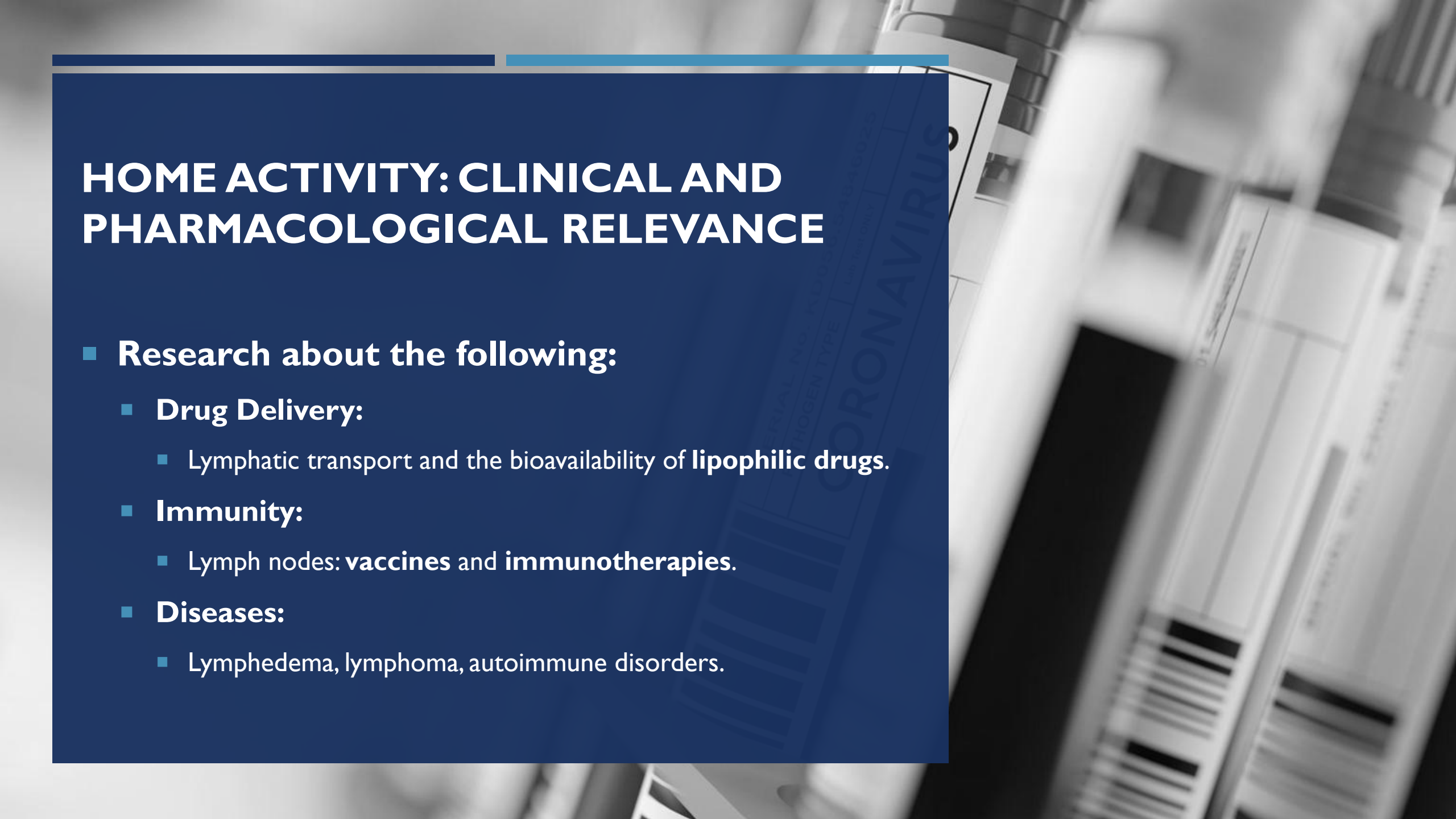
- **T-Cell Education (maturation and selection)**:
  - Matures and selects thymocytes → immunocompetent T-cells.
  - Eliminates self-reactive cells (central tolerance).
- **Hormonal Secretion**:
  - **Thymosin**: Promotes lymphocyte maturation in peripheral organs (promotes T-cell development).
- **Blood-Thymus Barrier**:
  - Isolates developing T-cells from foreign antigens in the blood.
  - Prevents premature activation of immature T cells by external pathogens.

SUMMARY OF KEY TERMS

Component	Role
Lymph	Clear fluid transporting immune cells/fats.
Lymphatic Vessels	Transport lymph; prevent fluid buildup.
Lymph Nodes	Filter lymph; immune cell activation.
Tonsils/MALT	First-line defense in mucous membranes.
Thymus/Spleen	T-cell maturation/blood filtration.

HOME ACTIVITY: CLINICAL AND PHARMACOLOGICAL RELEVANCE

- **Research about the following:**
  - **Drug Delivery:**
    - Lymphatic transport and the bioavailability of **lipophilic drugs**.
  - **Immunity:**
    - Lymph nodes: **vaccines** and **immunotherapies**.
  - **Diseases:**
    - Lymphedema, lymphoma, autoimmune disorders.



Life lesson: Lymph nodes a

Cancer often spreads (*metastasizes*) through the lymphatic system. When cancerous cells break free of the original tumor, they often enter the lymphatic vessels and travel to the nearest lymph node. (The first lymph node reached by metastasizing cancer cells is called the *sentinel lymph node*.) There, the cells multiply, eventually destroying the node. From that point, more cancerous cells may break off and travel to next node.

As an example, more than 85% of the lymph of the breast enters the axillary lymph nodes, making these nodes the most common route for breast cancer metastasis. That's why, during surgery to remove a cancerous breast tumor, the nearby axillary lymph nodes are typically also removed. Closely examining the nodes for cancerous cells following removal signals whether the cancer has spread and helps determine future treatment. Sometimes surgery disrupts normal lymph flow, causing lymph to accumulate in surrounding tissues. This produces swelling called *lymphedema*. Typically, new lymphatic vessels develop to reestablish normal flow.

THANK YOU