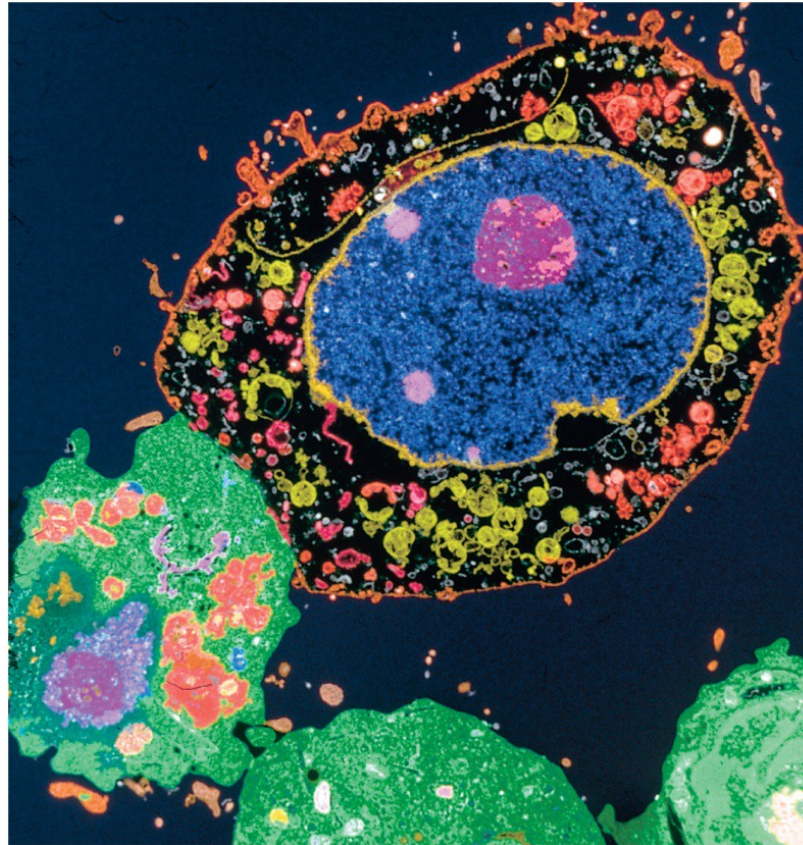


# The Lymphatic System Structure and Lymphatic System's Organs



## SYSTEMIC CIRCULATION

## PULMONARY CIRCULATION

**LYMPHATIC DUCTS** (thoracic duct, right lymphatic duct) empty lymph into the junction of jugular and subclavian veins of the cardiovascular system.

Subclavian vein

**LYMPHATIC VESSELS** pass lymph to lymphatic ducts.

**VALVE** ensures one-way flow of lymph.

**EFFERENT LYMPHATIC VESSELS** carry lymph from lymph nodes.

**LYMPH NODES** filter lymph and remove foreign substances through filtering, phagocytosis, and immune reactions.

**AFFERENT LYMPHATIC VESSELS** carry lymph from lymphatic capillaries to lymph nodes.

**LYMPHATIC CAPILLARIES** absorb interstitial fluid and pass lymph to afferent lymphatic vessels

Lymph node

Lymphatic capillaries

Pulmonary blood capillaries

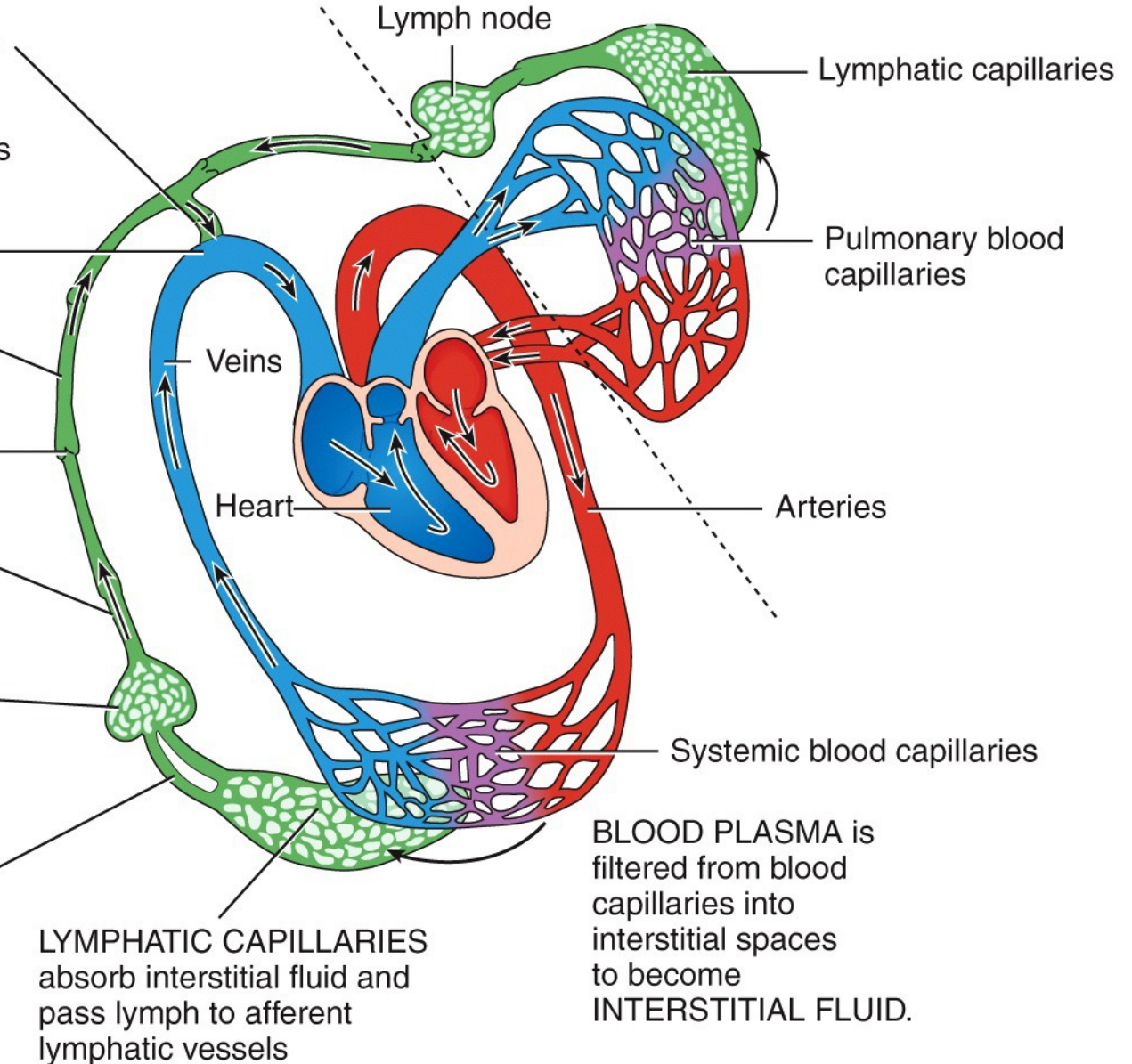
Veins

Heart

Arteries

Systemic blood capillaries

**BLOOD PLASMA** is filtered from blood capillaries into interstitial spaces to become **INTERSTITIAL FLUID**.





# What is the lymphatic system?

*What is the relationship between the lymphatic system and the immune system?*

Lymphatic system functions as a drainage system

Lymphatic system picks up fluid not reabsorbed across capillary beds and returns fluid to systemic circuit

Uses “one way vessels” with bicuspid valves to ensure fluid moves only in one direction.

The lymph passes through lymph nodes (filters to remove cellular debris and pathogens) before returning lymph to the systemic circuit (see next slide)



# What is the lymphatic system?

Lymph nodes play a key role in protecting our body from pathogens // lymph nodes are resting sites for immune cells (T cells, B cells, macrophage)

Pathogens are ingested throughout our body by different types of WBC (the antigen presenting cells) and transported in the lymph fluid to the lymph nodes

As lymph is moved through a lymph node - fluid is inspected for signs of pathogens

Inside the lymph nodes, **antigen presenting cells** will display signs of pathogens to initiate an immune response / APC are required to activate helper T cells, cytotoxic T cells, and B cells



## SYSTEMIC CIRCULATION

## PULMONARY CIRCULATION

**LYMPHATIC DUCTS** (thoracic duct, right lymphatic duct) empty lymph into the junction of jugular and subclavian veins of the cardiovascular system.

Subclavian vein

**LYMPHATIC VESSELS** pass lymph to lymphatic ducts.

**VALVE** ensures one-way flow of lymph.

**EFFERENT LYMPHATIC VESSELS** carry lymph from lymph nodes.

**LYMPH NODES** filter lymph and remove foreign substances through filtering, phagocytosis, and immune reactions.

**AFFERENT LYMPHATIC VESSELS** carry lymph from lymphatic capillaries to lymph nodes.

**LYMPHATIC CAPILLARIES** absorb interstitial fluid and pass lymph to afferent lymphatic vessels

Lymph node

Lymphatic capillaries

Pulmonary blood capillaries

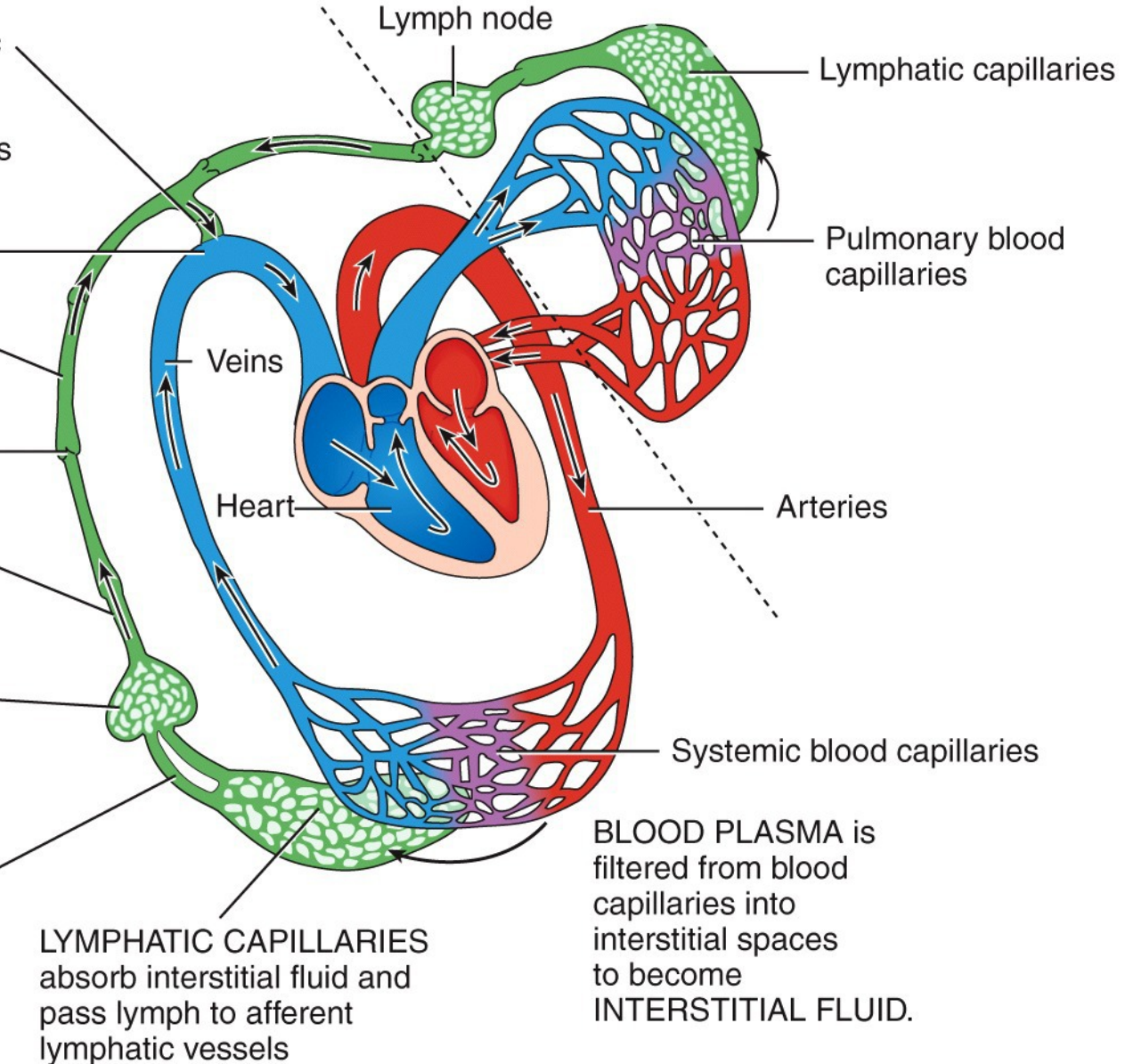
Veins

Heart

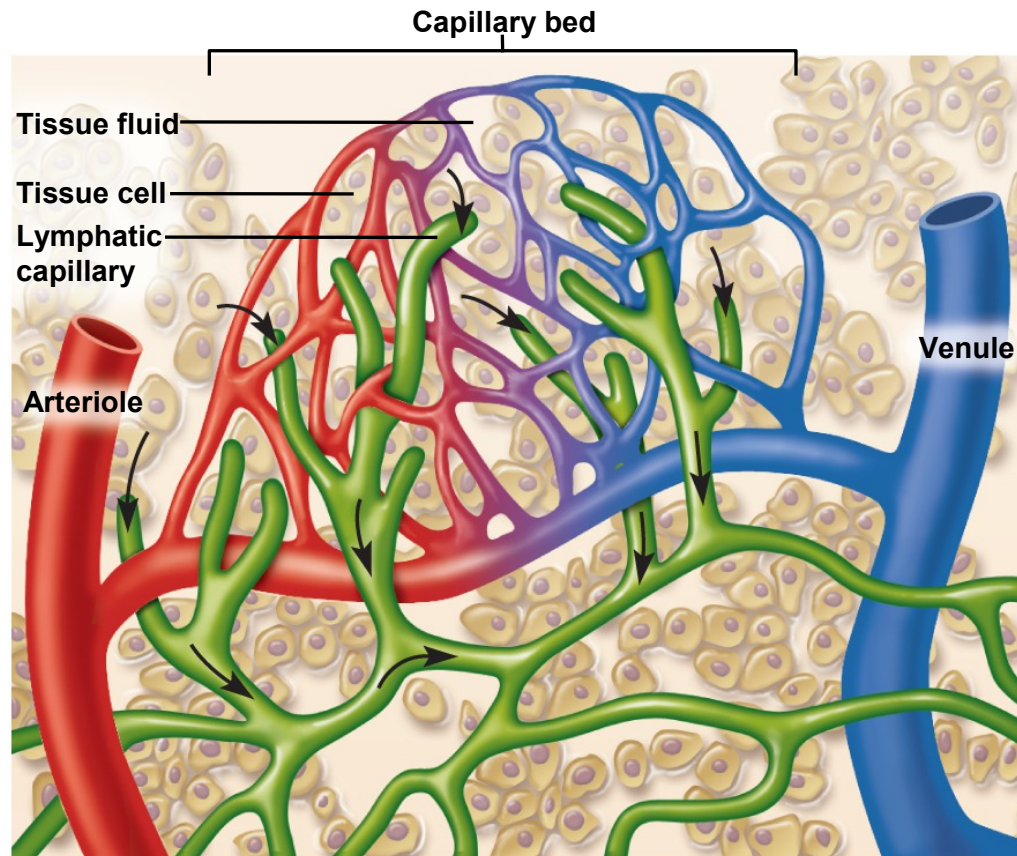
Arteries

Systemic blood capillaries

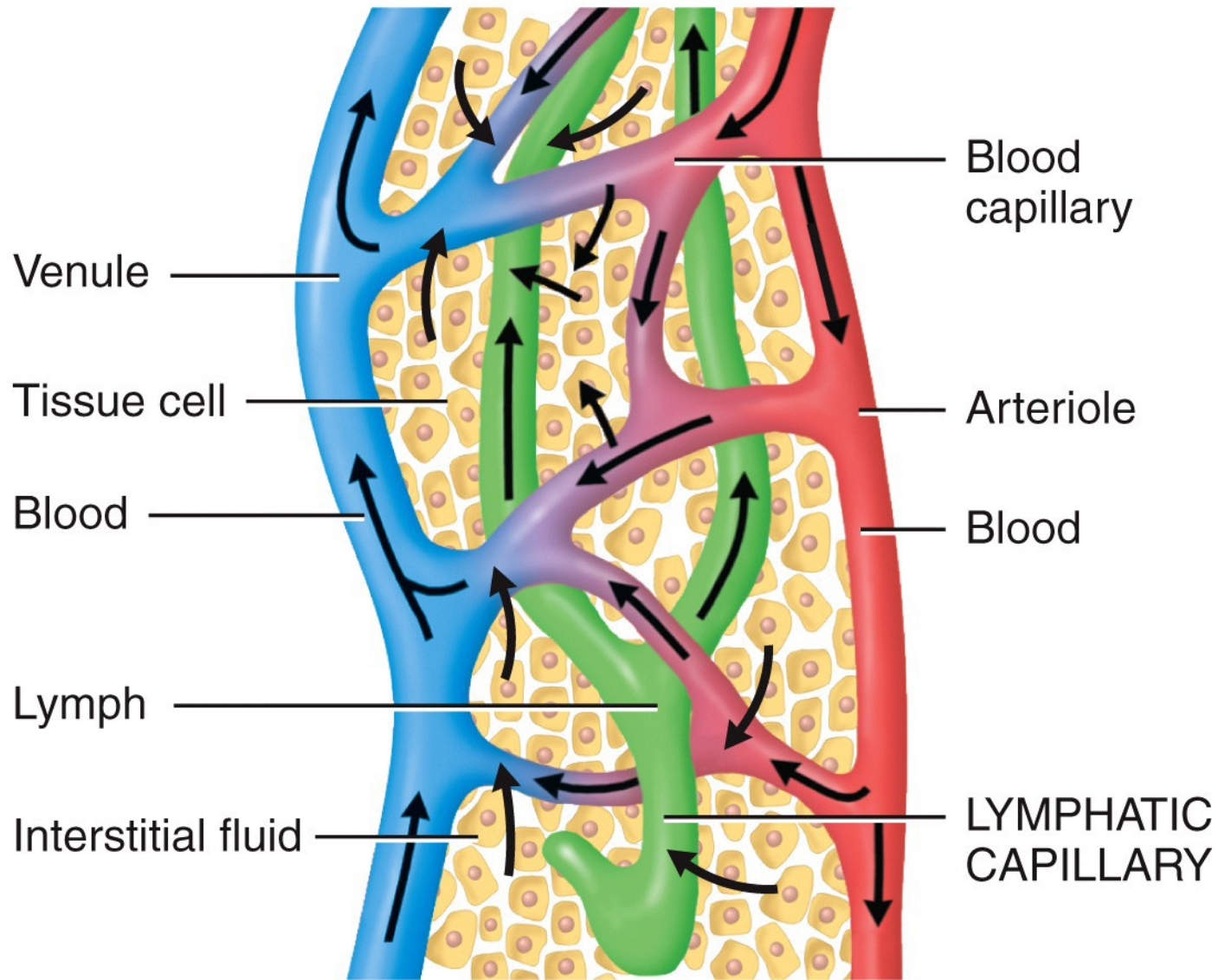
**BLOOD PLASMA** is filtered from blood capillaries into interstitial spaces to become **INTERSTITIAL FLUID**.



# Structure of a Capillary Bed with Lymphatic Capillaries and Their Afferent Vessels



How much fluid is not recovered at the end of the capillary bed? (15%)

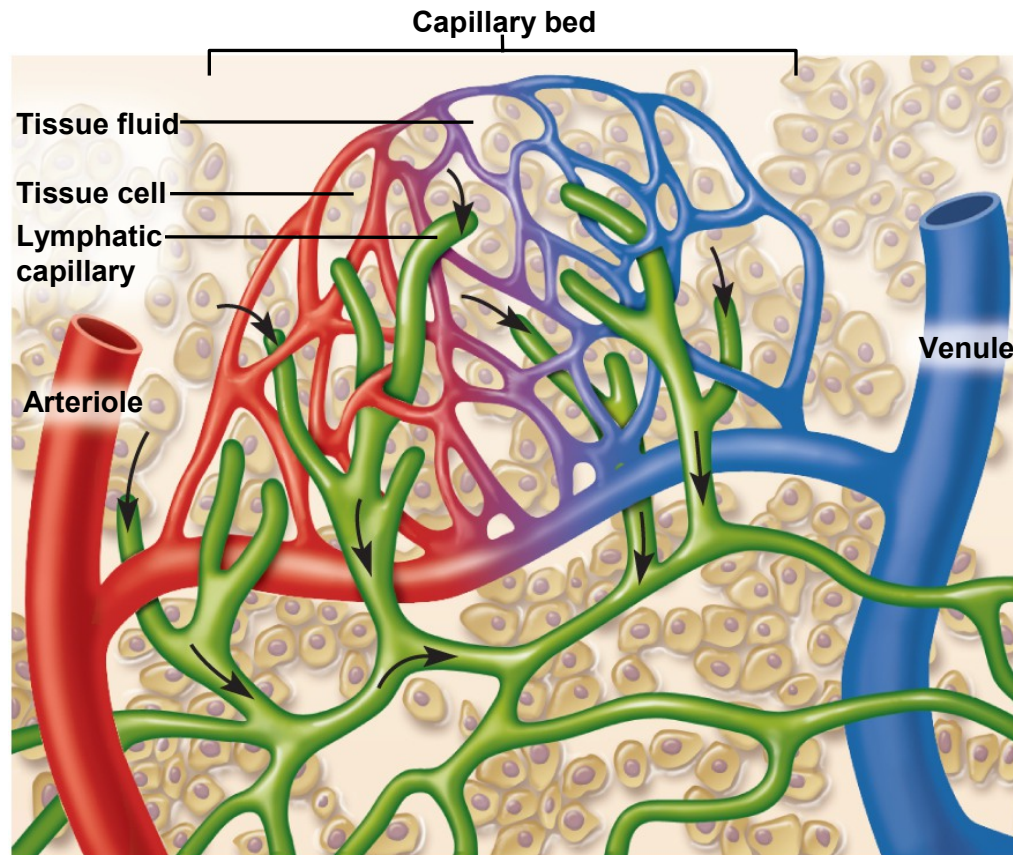


(a) Relationship of lymphatic capillaries to tissue cells and blood capillaries





# Structure of a Capillary Bed with Lymphatic Capillaries and Their Afferent Vessels

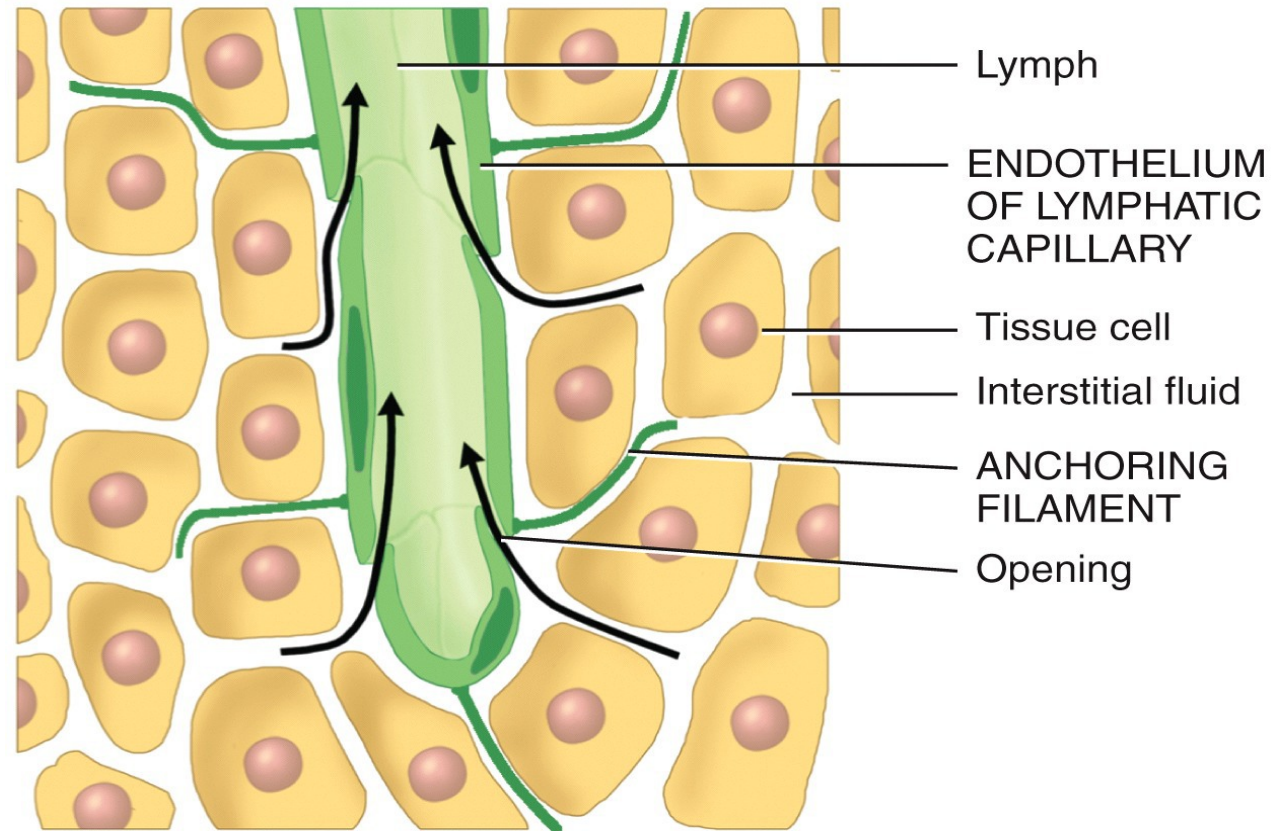


With bacterial infection in tissue space, why is it important to redirect this fluid lost into lymphatic system?





How is fluid directed to flow into lymphatic capillary and not into the veins?



(b) Details of a lymphatic capillary

Edema causes pressure within the tissue space to increase. As this pressure increases: 1) What will happen to the veins? Why? 2) What will happen to the lymphatic capillaries? Why? Where will interstitial fluid flow to?



# What are the three functions of the lymphatic system?

---



- **Fluid recovery** // fluid continually filters from blood capillaries into the interstitial spaces
  - blood capillaries only reabsorb 85% of the fluid crossing capillary bed
  - 15% (2 – 4 L/day) of the water and about half of the plasma proteins enters lymphatic system /// returned to the blood via lymphatic vessels
- **Lipid absorption** // lacteals (i.e. lymphatic capillaries) in small intestine allow lipid to enter lymphatic system /// dietary lipids are unable to enter systemic circuit via continuous capillaries of villus
- **Immunity** // interstitial fluid enter lymphatic capillary to carry antigen presenting cells and pathogens to lymph nodes / T cells and B cells in lymph node initiate immune response
  - immune cells in lymph nodes stand guard against foreign matter
  - naive immunocompetent T and B cells or memory T and memory B cells are able to initiate the immune response
  - T and B cells carry out their function in three steps: **Recognize / React / Remember**
  - there are two forms of immune response: 1. Non-specific resistance and 2. Adaptive Immunity



# Components of the Lymphatic System

---

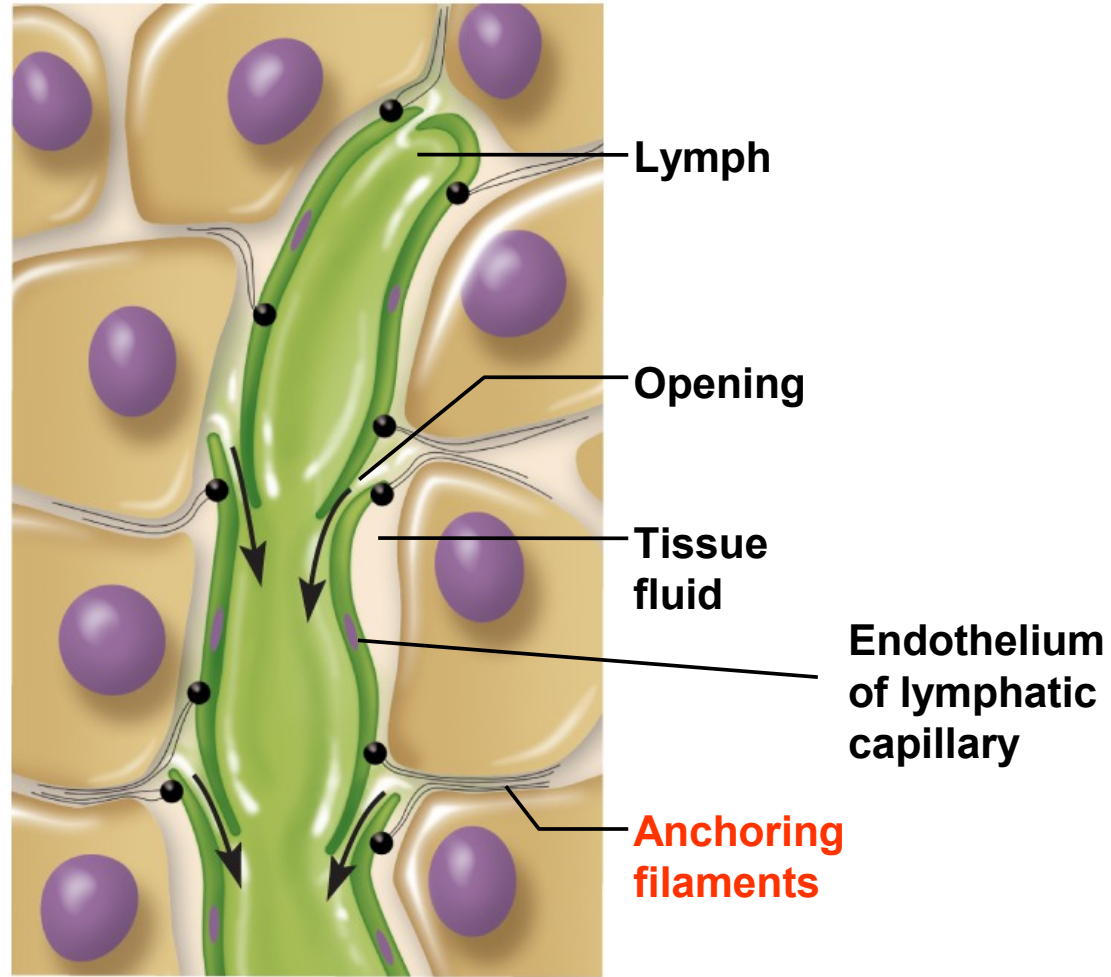
- **Lymph //** the recovered fluid
- **lymphatic vessels //** transport the lymph
- **lymph nodes**
  - Organs inserted in pathway of lymphatic vessels
  - Filters lymph
  - Site of pathogen recognition
- **lymphatic tissues**
  - composed of aggregates of lymphocytes and macrophages that populate many organs in the body
  - “nomadic” cells with the ability to move throughout the tissue and organs of your body
  - these cells patrol for pathogens
- **lymphatic organs**
  - defense cells are especially concentrated in these organs
  - separated from surrounding organs by connective tissue capsules
  - Tonsils, spleen, thymus, lymph nodes

# Lymph and Lymphatic Capillaries

---

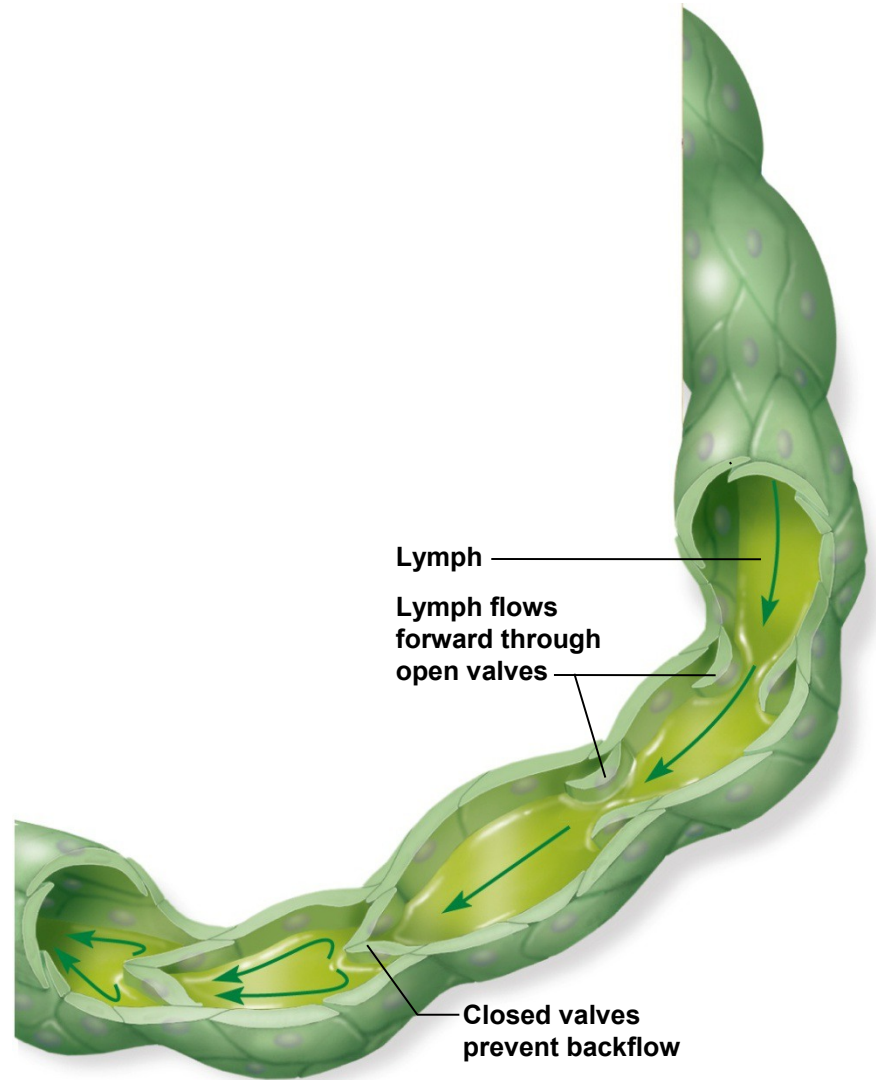
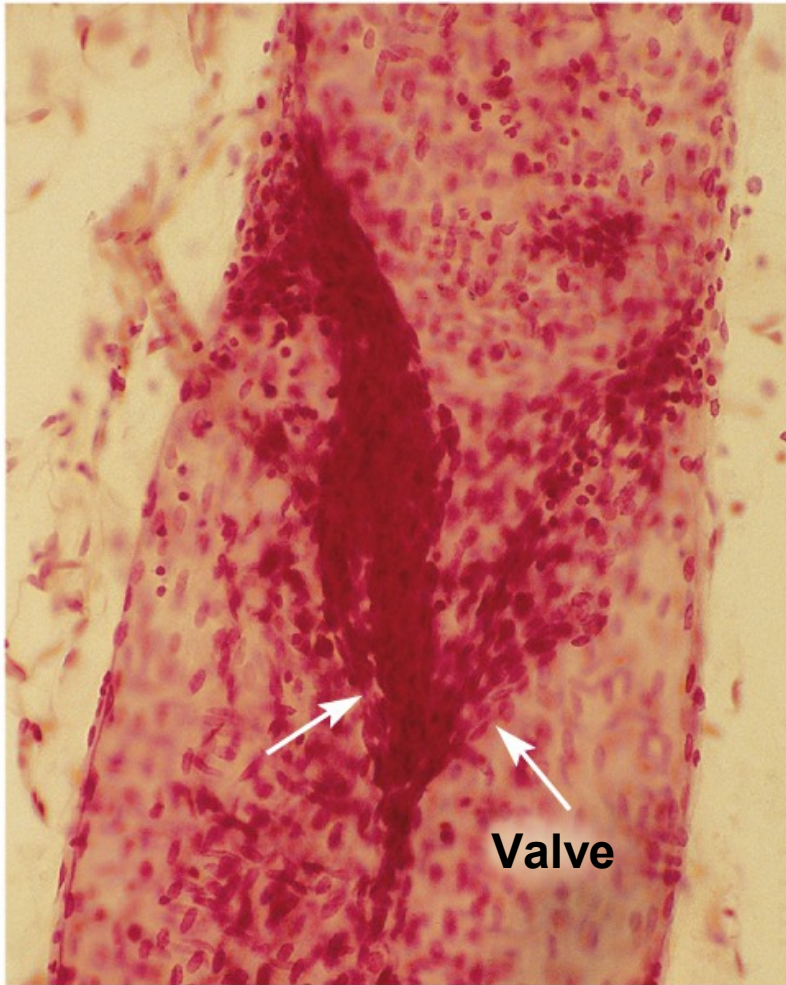
- **Lymph** // clear, colorless fluid, similar to plasma, but much less protein // extracellular fluid drawn into lymphatic capillaries
- **Lymphatic capillaries** (terminal lymphatic)
  - penetrate nearly every tissue of the body // **absent from central nervous system, cartilage, cornea, bone and bone marrow**
  - sacs of thin endothelial cells that loosely overlap each other
  - closed at one end
  - cells **tethered to surrounding tissue by protein filaments** // gaps between cells are large enough to allow bacteria and cells entrance into lymphatic capillary
  - endothelium creates **valve-like flaps** that open when interstitial fluid pressure is high, and close when it is low

# Lymphatic Capillary





# Valves in Lymphatic Vessel



# Route of Lymph Flow

---



- lymphatic capillaries
- collecting vessels // course through many lymph nodes
- six lymphatic trunks // drain major portions of body
- two collecting ducts
  - **right lymphatic duct** – receives lymph from right arm, right side of head and thorax; empties into right subclavian vein
  - **thoracic duct** - larger and longer, begins as a prominent sac in abdomen called the **cisterna chyli**; receives lymph from below diaphragm, left arm, **left side** of head, neck, and thorax; empties into left subclavian vein
- subclavian veins right & left // Receive fluid from respective collecting ducts



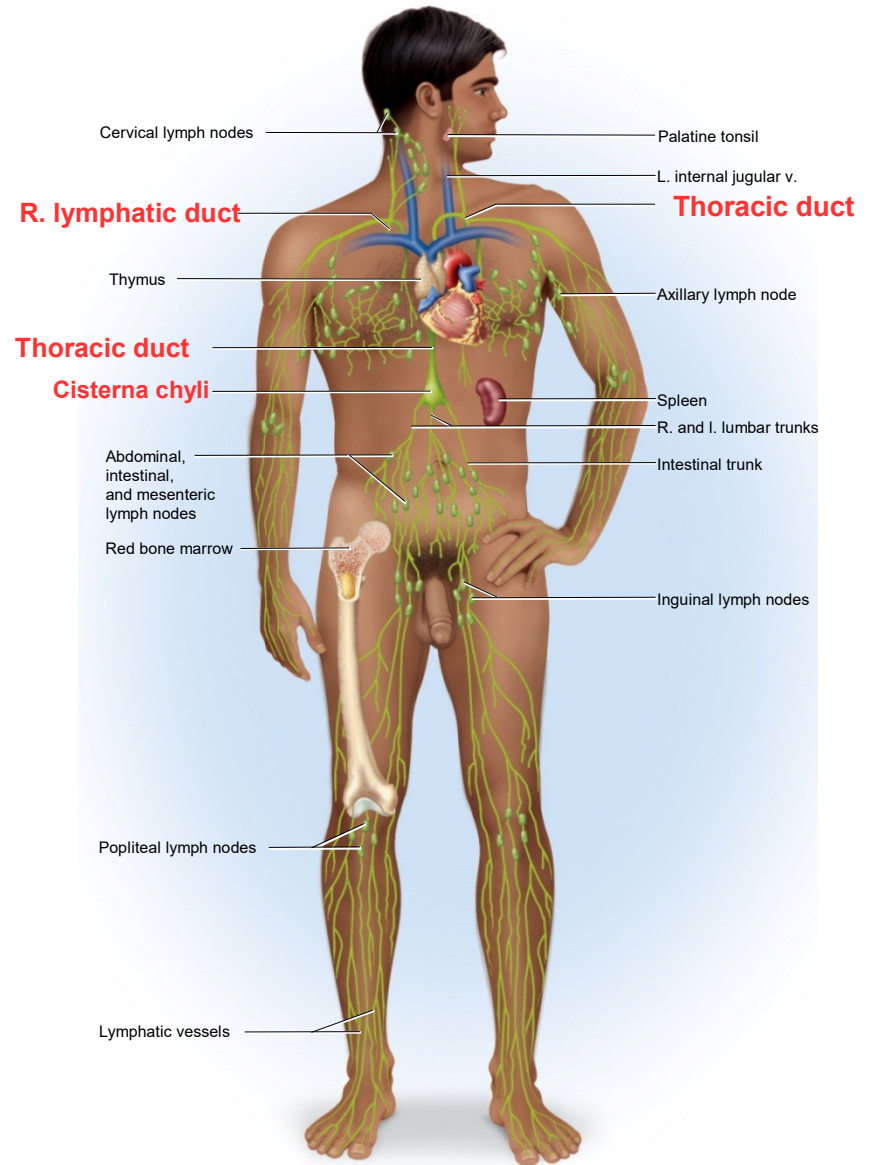
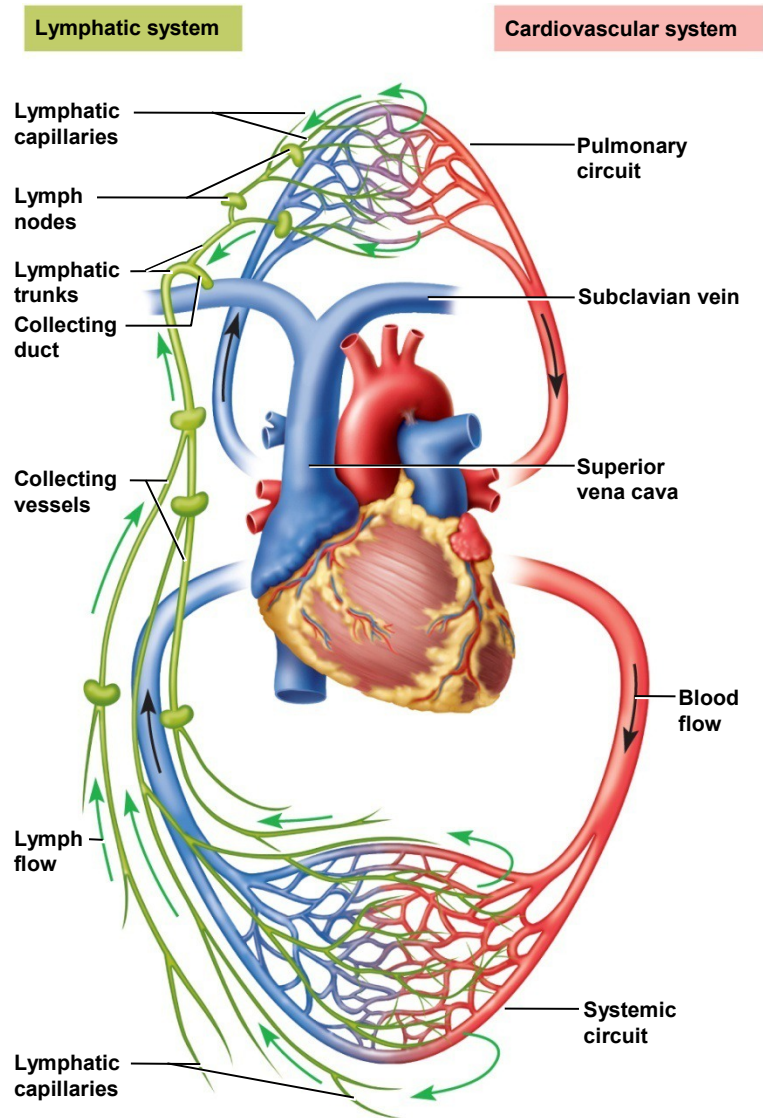
(b) Areas drained by  
right lymphatic and  
thoracic ducts

 Area drained by  
right lymphatic duct

 Area drained by  
thoracic duct



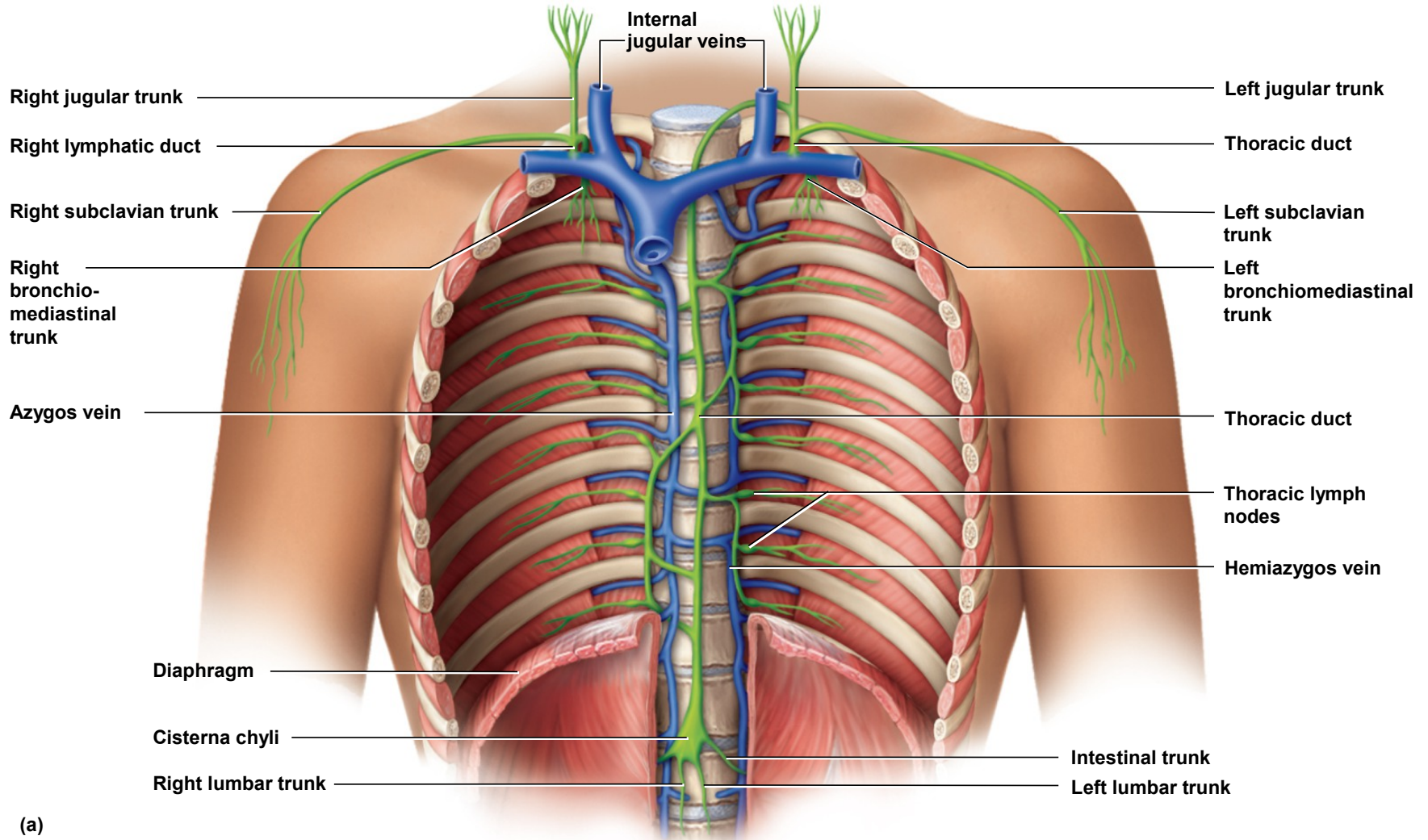
# The Fluid Cycle



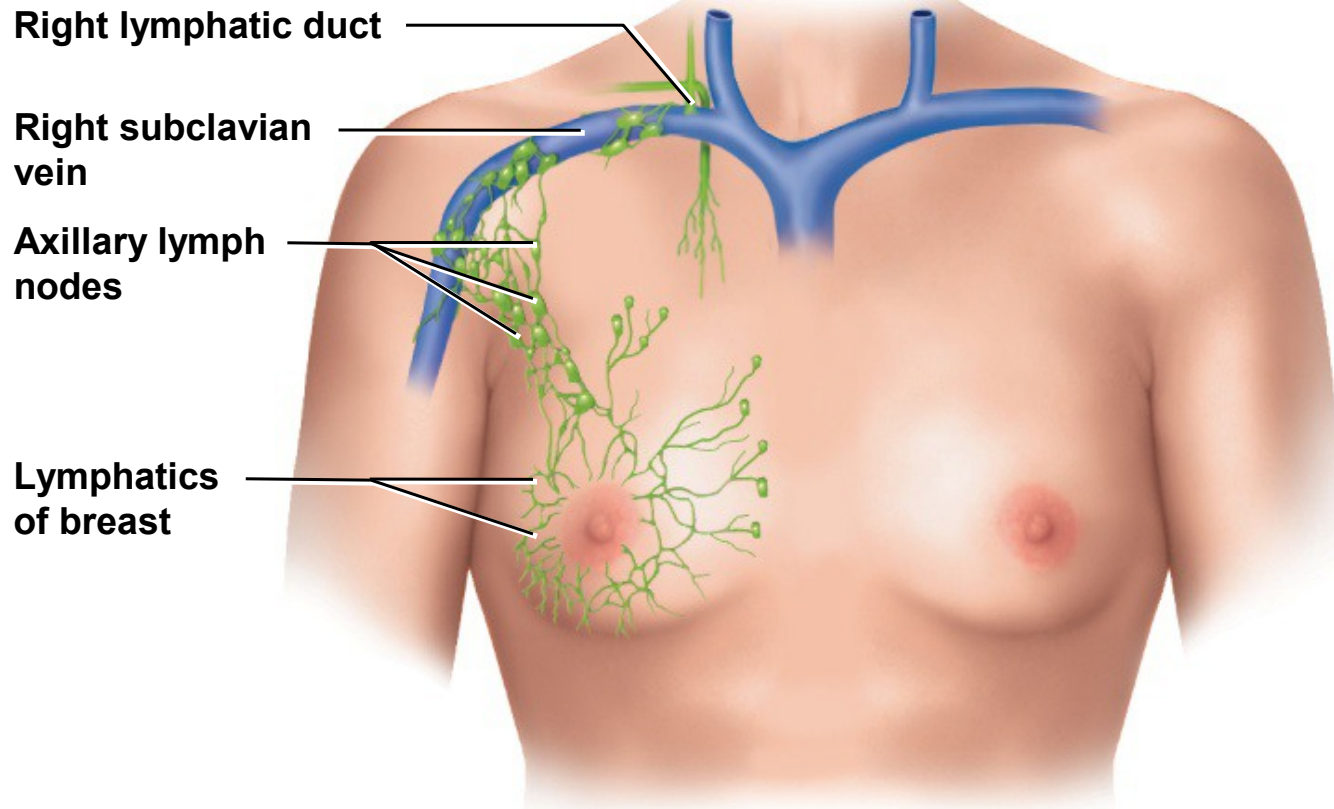
Lab Objectives

# Drainage of Thorax

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



# Lymphatic Drainage of Mammary and Axillary Regions



**lymphadenitis** -  
swollen, **painful** node  
responding to foreign  
antigen (bacteria)

lymph nodes are  
common sites for  
**metastatic cancer** ///  
swollen, firm and but  
usually painless

What is the clinical significance?

# Mechanisms of Lymph Flow

---

- lymph flows under forces similar to those that govern venous return, except **no pump** (heart)
- lymph flows at low pressure and slower speed than venous blood
- **moved along by rhythmic contractions** of lymphatic vessels /// stretching of vessels stimulates contraction
- flow **aided by skeletal muscle pump**
- arterial pulsation rhythmically squeeze lymphatic vessels
- thoracic pump aids flow from abdominal to thoracic cavity
- valves prevent backward flow
- rapidly flowing blood in subclavian veins, draws lymph into it
- exercise significantly increases lymphatic return



# Lymphatic Organs VS Lymphatic Tissue

---



- Lymphatic organs are surrounded by a **connective tissue capsule** and contain a high concentration of WBC.
  - Lymph nodes
  - Tonsils
  - Spleen
  - Thymus
- Lymphatic tissues are clusters of WBC **not surrounded by connective**. These cells come together to defeat a pathogen and then break apart so they may patrol and seek other pathogens.

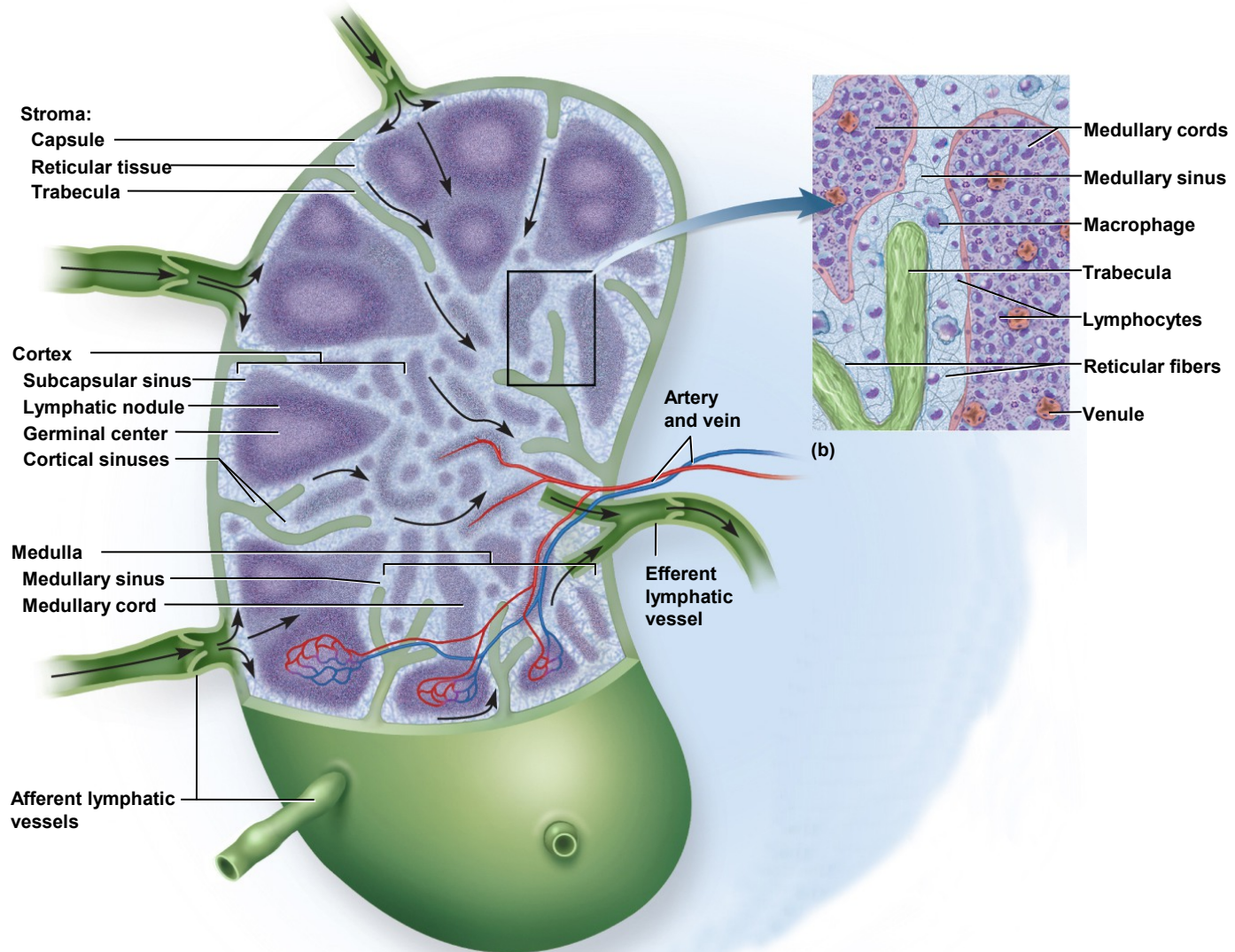
# Lymph Nodes

---

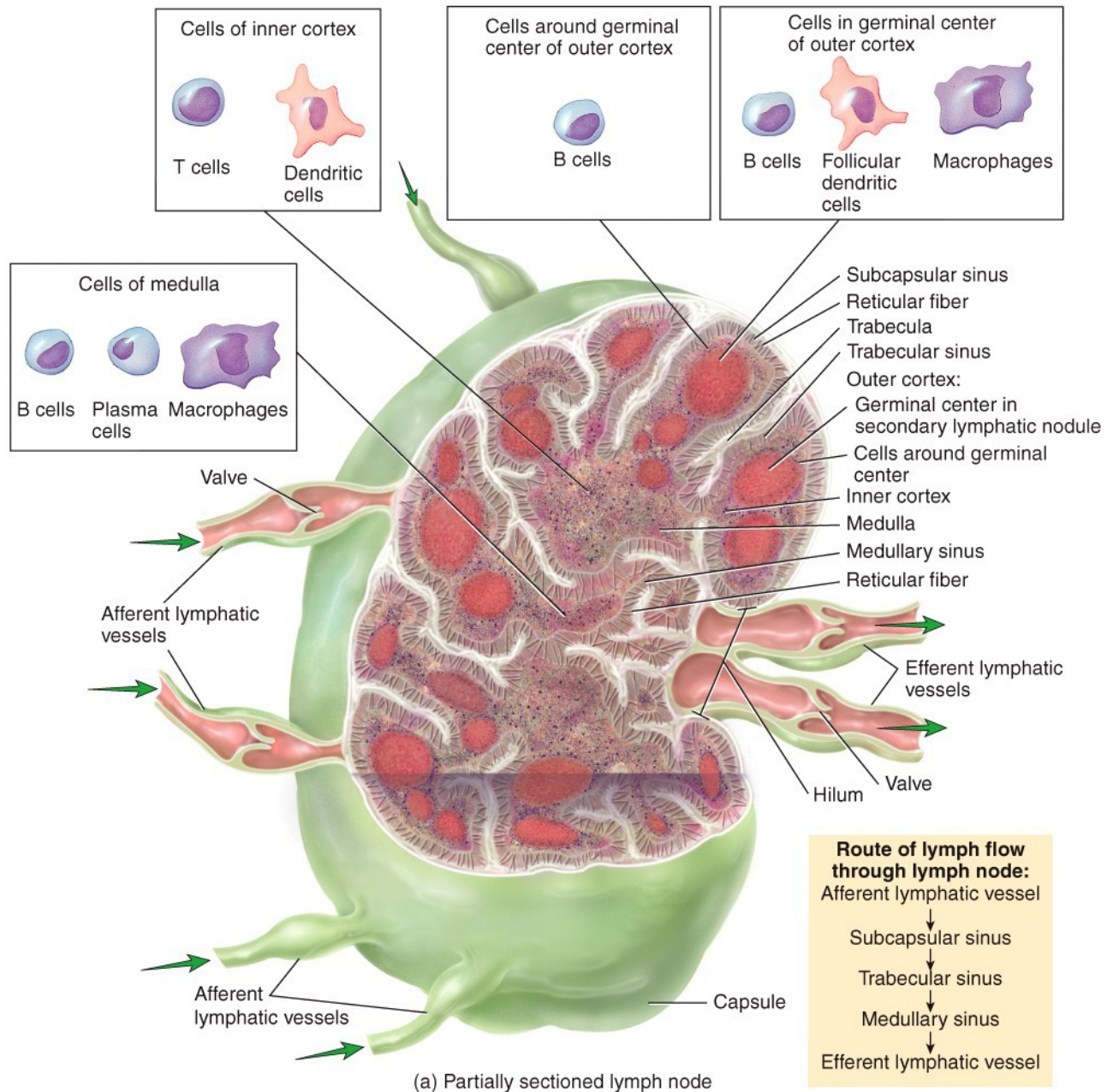


- These are the most numerous lymphatic organs // about 450 in typical young adult
  - they have two functions:
    - cleanse the lymph with macrophage as lymph passes through nodes
    - Initiate an immune response to pathogens // nodes are sites where T and B cell “rest” while they wait to be activated by antigen presenting cells
- Elongated, bean shaped structure with **hilum**
- Enclosed with fibrous capsule // **trabeculae** that divide interior into compartments // stroma of reticular fibers and reticular cells

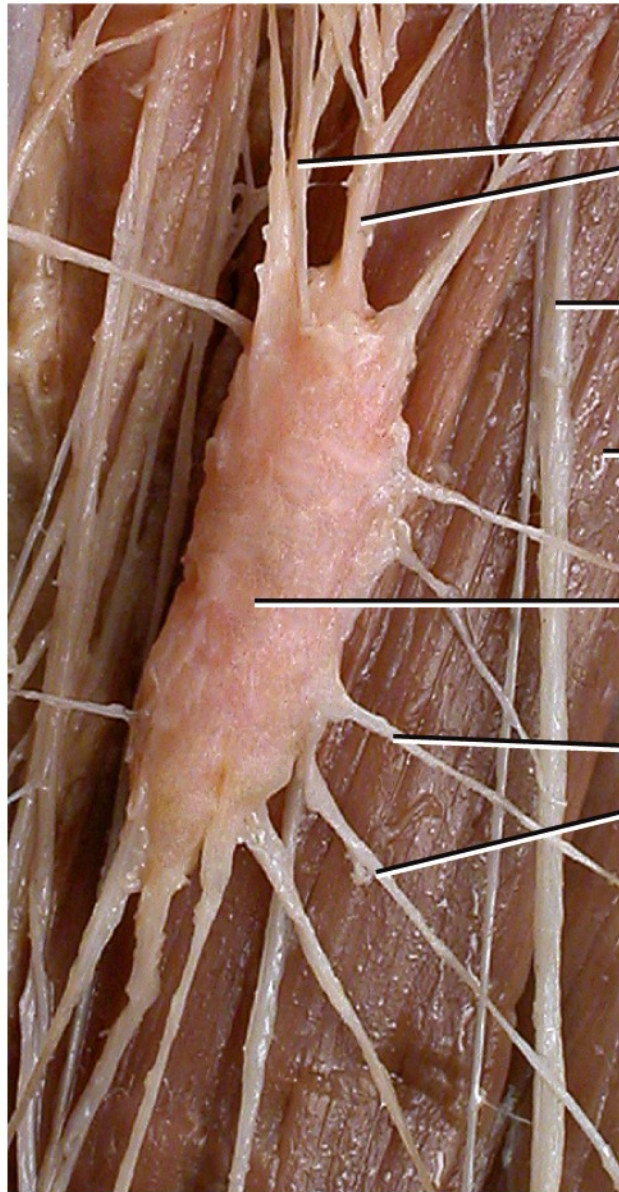
# Lymph Node



Why is this a good example of the important relationship between structure and function?







Efferent lymphatic vessels

Nerve

Skeletal muscle

Lymph node

Afferent lymphatic vessels

(c) Anterior view of inguinal lymph node

# Lymph Node Locations

(Lab Objectives)

---

- **cervical lymph nodes**
  - deep and superficial group in the neck
  - monitor lymph coming from head and neck
- **axillary lymph nodes**
  - concentrated in armpit
  - receive lymph from upper limb and female breast
- **thoracic lymph nodes**
  - in thoracic cavity especially embedded in mediastinum
  - receive lymph from mediastinum, lungs, and airway

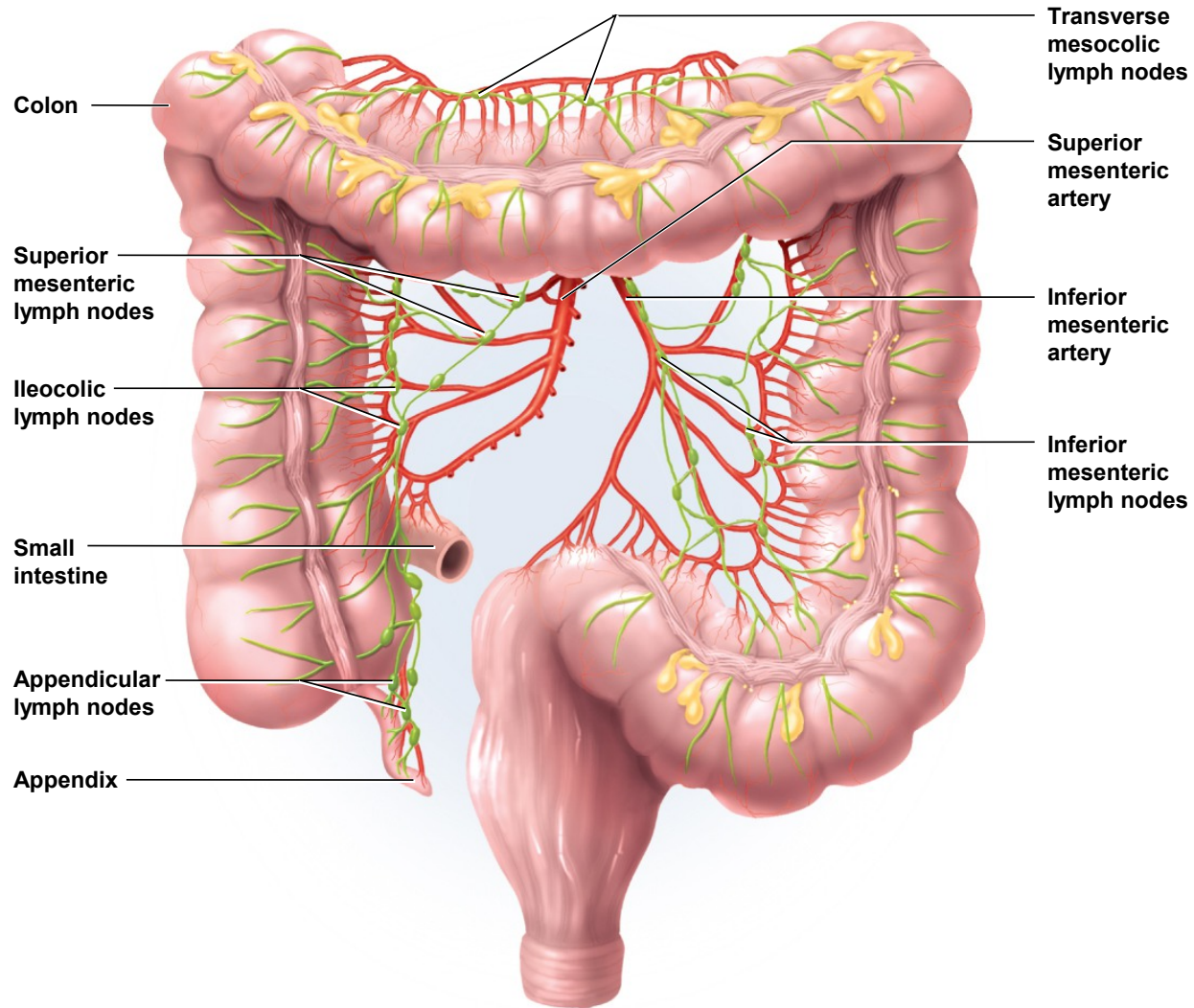
# Lymph Node Locations

(Lab Objectives)

---

- **abdominal lymph nodes**
  - occur in posterior abdominopelvic wall
  - monitor lymph from the urinary and reproductive systems
- **intestinal and mesenteric lymph nodes**
  - found in the mesenteries, adjacent to the appendix and intestines
  - monitor lymph from the digestive tract
- **inguinal lymph nodes**
  - in the groin and receive lymph from the entire lower limb
- **popliteal lymph nodes**
  - occur on the back of the knee
  - receive lymph from the leg proper

# Lymph Node Areas of Concentration





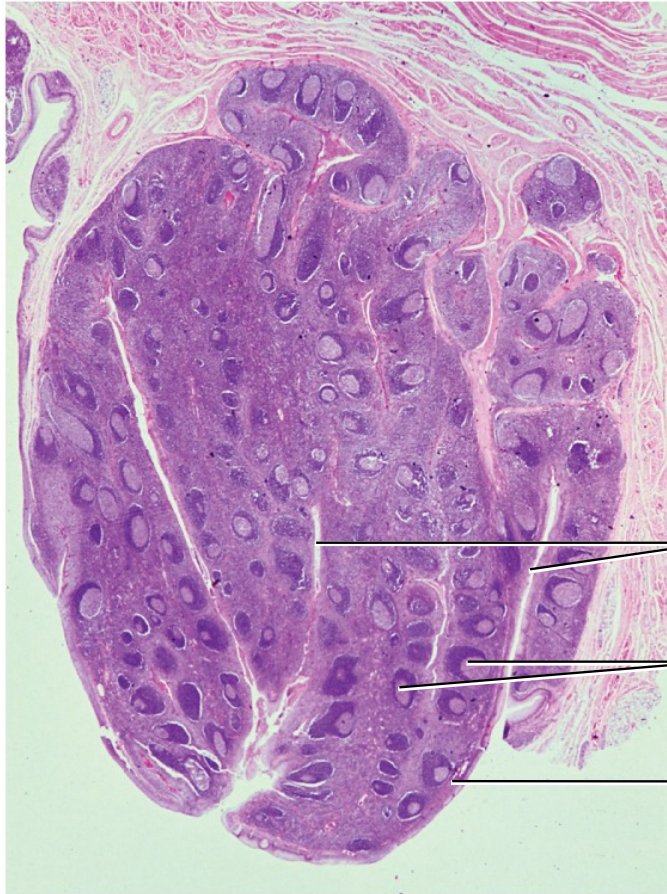
# Tonsils

---



- patches of lymphatic tissue **located at the entrance to the pharynx**
  - guard against ingested or inhaled pathogens
  - covered with epithelium
  - have deep pits – **tonsillar crypts** lined with lymphatic nodules (clusters of macrophages and immune cells)
  - **tonsillitis** and **tonsillectomy**

# Pharyngeal Tonsil



Tonsillar crypts

Lymphatic nodules

Pharyngeal epithelium

- covered by epithelium
- Food with pathogens enter tonsillar crypts and encounter lymphocytes

# Tonsils

(Lab Objectives)

---

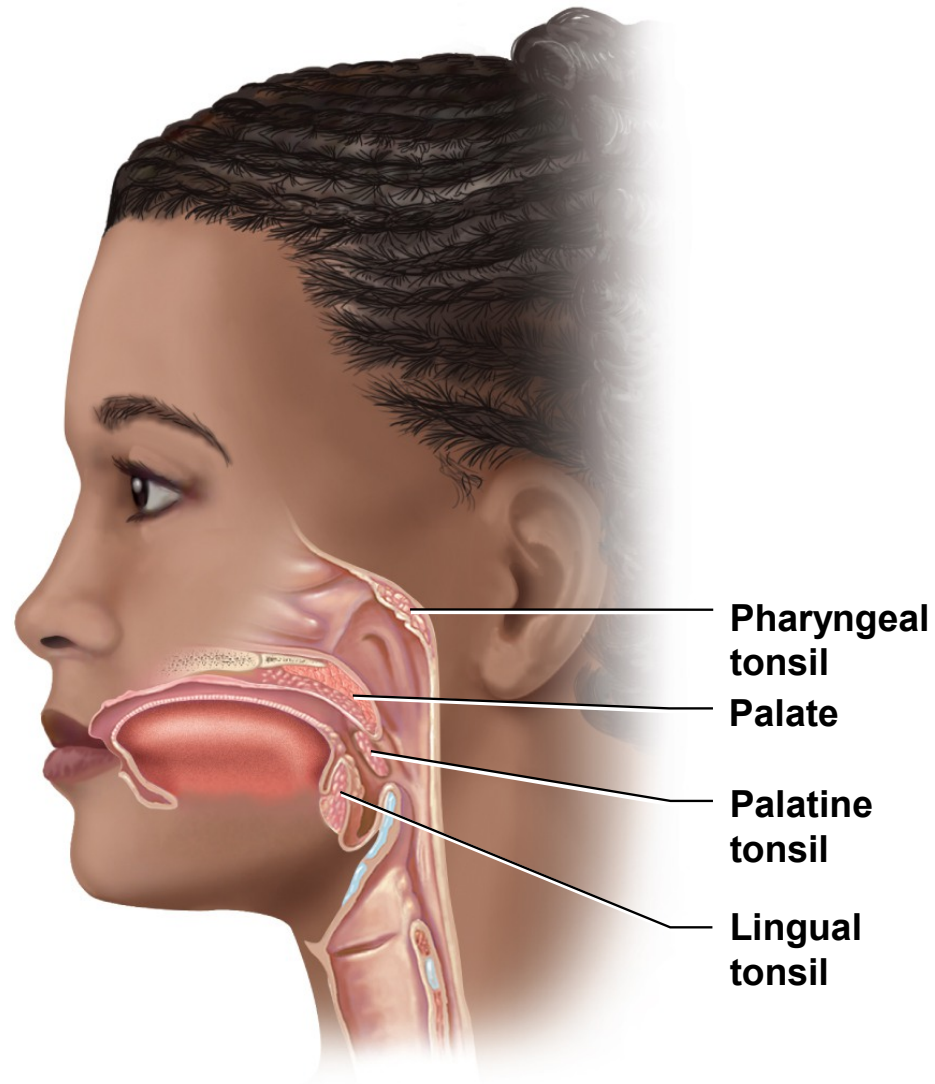
Three main sets of tonsils

palatine tonsils // pair at posterior margin of oral cavity // most often infected

lingual tonsils // pair at root of tongue

pharyngeal tonsil (adenoid) // single tonsil on wall of nasopharynx

# The Tonsils





# Spleen

---



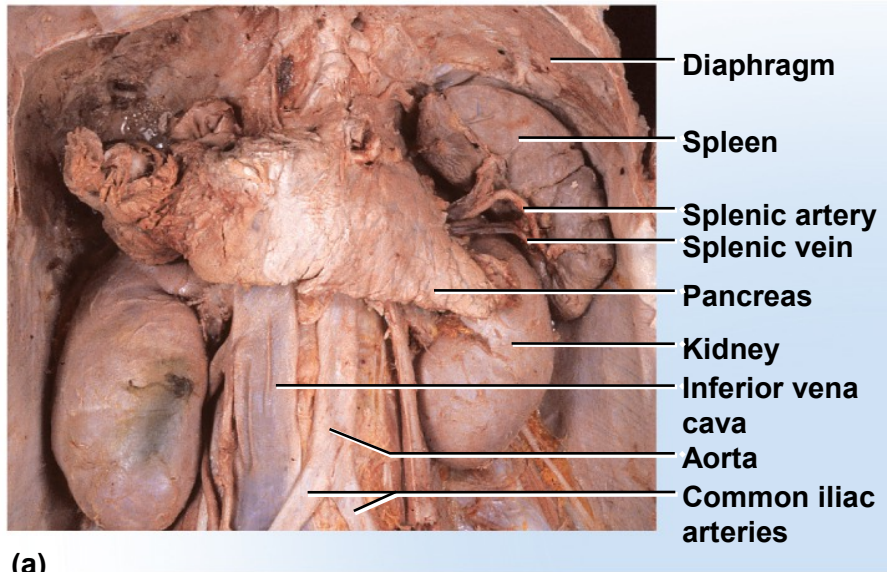
- the body's **largest lymphatic organ**
- **parenchyma** exhibits two types of tissue:
  - **red pulp** - sinuses filled with erythrocytes
  - **white pulp** – lymphocytes & macrophages surrounding small branches of splenic artery

# Spleen Functions

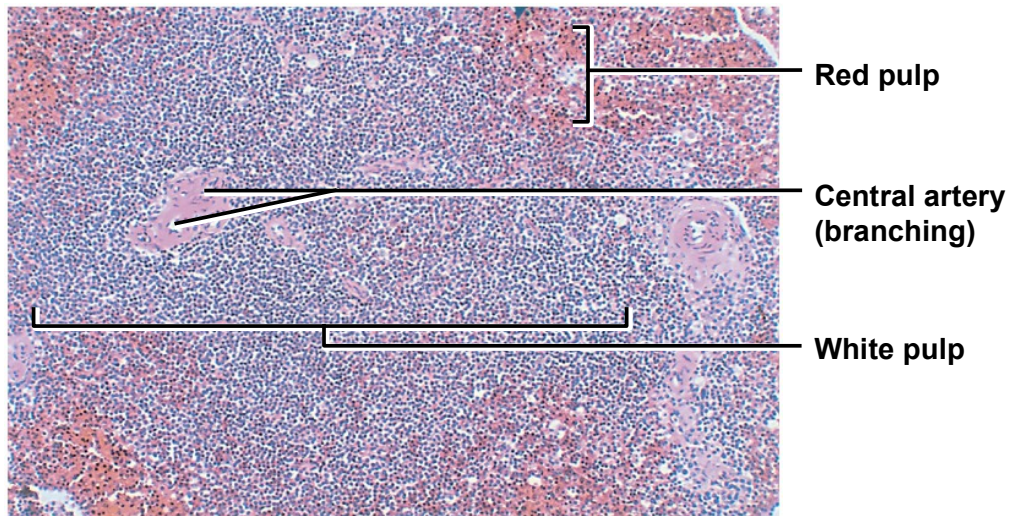
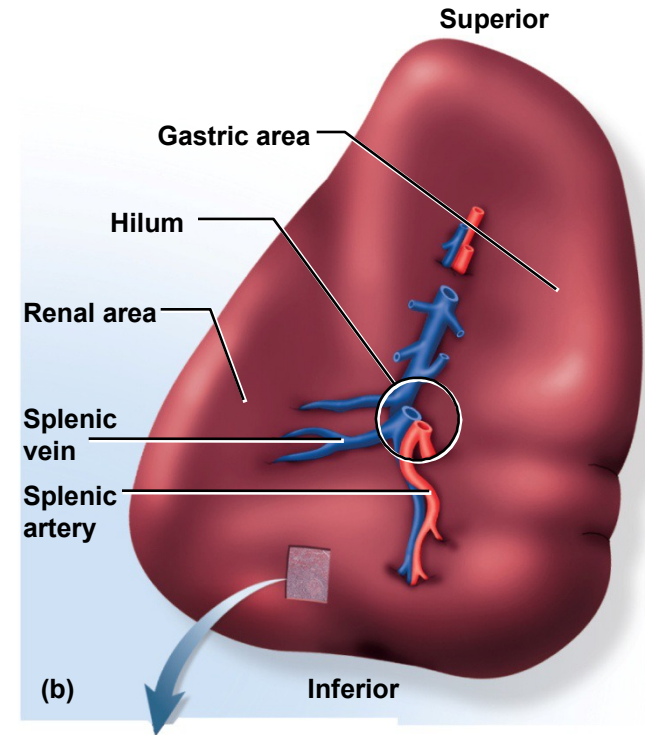
---



- Filters blood – remove bacteria / similar functions as lymph nodes / white pulp = WBC that monitor blood for foreign antigens / site for resting T and B cells in spleen / many macrophage
- blood production in fetus (may resume under certain conditions)
- blood reservoir
- 40% of circulating platelets stored in spleen
- ‘erythrocyte graveyard’ - RBC disposal
- spleen highly vascular and vulnerable to trauma and infection
- ruptured spleen /// often requires the removal of spleen - splenectomy



# Spleen

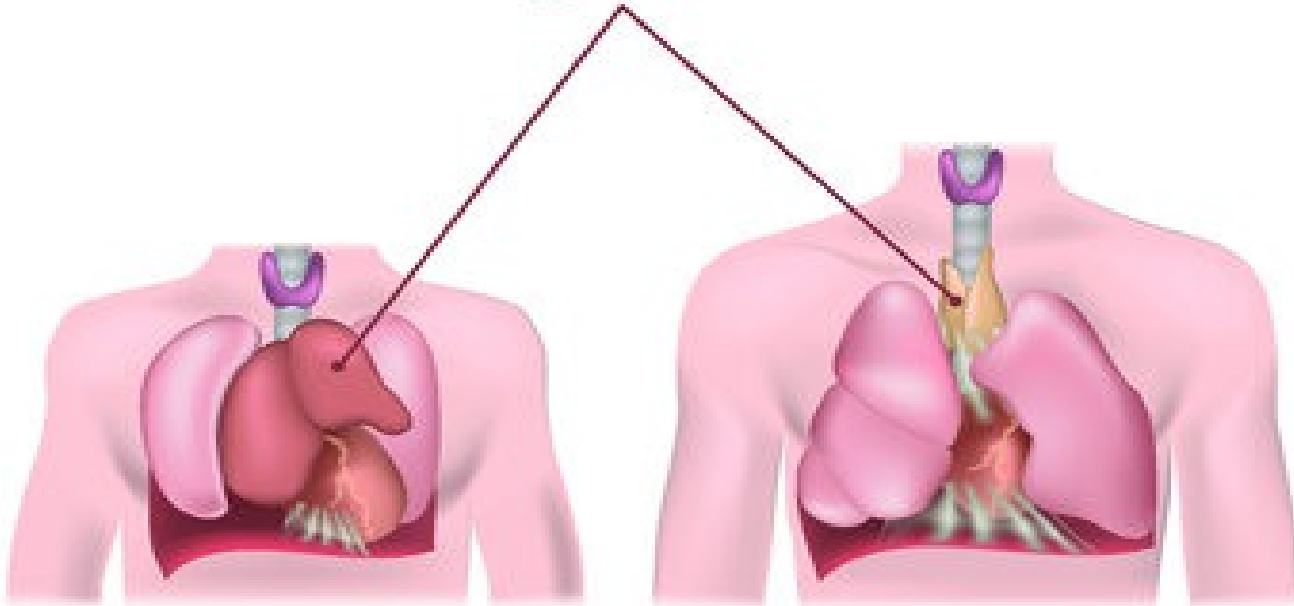


# Thymus



- Contributes functions to the **endocrine, lymphatic, and immune systems**
  - Bi-lobed organ located in superior mediastinum between the sternum and aortic arch // **site where T cells “mature” (born in bone marrow)**
  - secretes hormones regulating their activity
  - degeneration or involution with age
  - fibrous capsule gives off **trabeculae (septa)** that divide the gland into several lobes
    - lobes have cortex and medulla areas populated by T lymphocytes
  - **reticular epithelial cells** seal off cortex from medulla forming a functional **blood-thymus barrier**
    - produce signaling molecules **thymosin, thymopoietin, thymulin, interleukins, and interferon**

**thymus**



**newborn**

**adult**



# Histology of Thymus

