Chapter 21.2

Structure and Organs of the Lymphatic System

Lymphatic System's Functions
Fluid Recovery – Lipid Absorption - Immunity

Fluid recovery // fluid continually moves 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 systemic circuit via lympahatic vessels

Lipid absorption // lacteals (i.e. lymphatic capillaries) in small intestine allow lipid to enter lymphatic system

Dietary lipids (hydrophobic) are unable to enter systemic circuit via continuous capillaries of villus

Hydrophilic molecules enter systemic circuit via fenestrated capillaries in small intestine

More About Lymphatic System's Functions

Immunity // interstitial fluid enter lymphatic capillary and carry pathogens to antigen presenting cells located in 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 are able to initiate the immune response

T and B cells carry out their function in two stages each with three steps: (born, educated, deployed followed by recognize, react, remember)

Three type of immune responses:

- 1. Physical barriers
- 2 Non-specific resistance
- 3. Adaptive Immunity

Components of the Lymphatic System

lymph // the recovered interstitial fluid

lymphatic capillaries and lymphatic vessels // pick up and 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

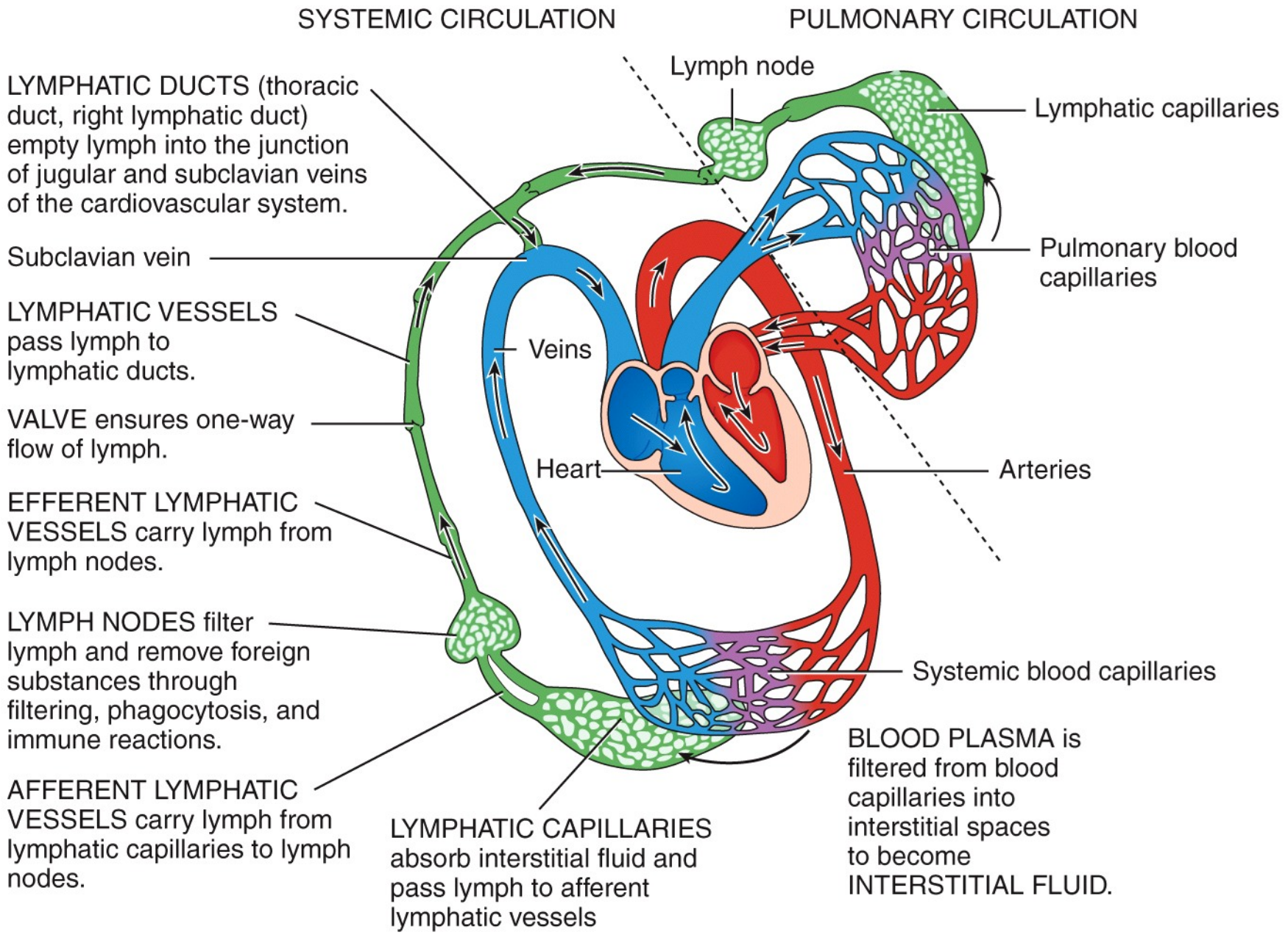
–"nomadic" cells with the ability to move throughout the tissue and organs of your body // these cells patrol for pathogens

lymphatic organs

–defense cells are especially concentrated in these organs

–separated from surrounding organs by connective tissue capsules

–Tonsils, spleen, thymus, lymph nodes


SYSTEMIC CIRCULATION
PULMONARY CIRCULATION
Lymph node
Lymphatic capillaries
LYMPHATIC DUCTS (thoracic duct, right lymphatic duct) empty lymph into the junction of jugular and subclavian veins of the cardiovascular system.
Subclavian vein
Pulmonary blood capillaries
LYMPHATIC VESSELS pass lymph to lymphatic ducts.
Veins
VALVE ensures one-way flow of lymph.
Heart
Arteries
EFFERENT LYMPHATIC VESSELS carry lymph from lymph nodes.
LYMPH NODES filter lymph and remove foreign substances through filtering, phagocytosis, and immune reactions.
Systemic blood capillaries
BLOOD PLASMA is filtered from blood capillaries into interstitial spaces to become INTERSTITIAL FLUID.
AFFERENT LYMPHATIC VESSELS carry lymph from lymphatic capillaries to lymph nodes.
LYMPHATIC CAPILLARIES absorb interstitial fluid and pass lymph to afferent lymphatic vessels

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)

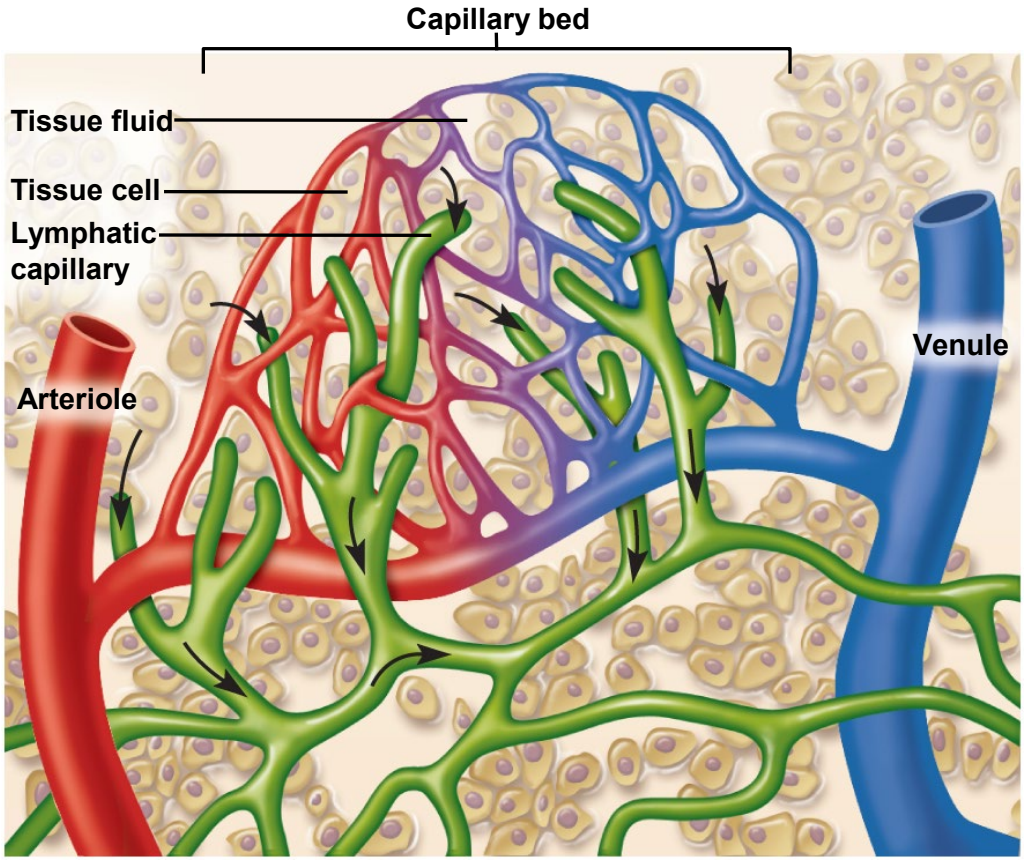
Recent research indicates that lymphatic vessels ***are*** **present within bone,** particularly in the cortical regions and bone marrow, where they play a crucial role in bone regeneration and repairing fractures.

Sacs of thin endothelial cells that loosely overlap each other forming a tube like structure // Closed at one end

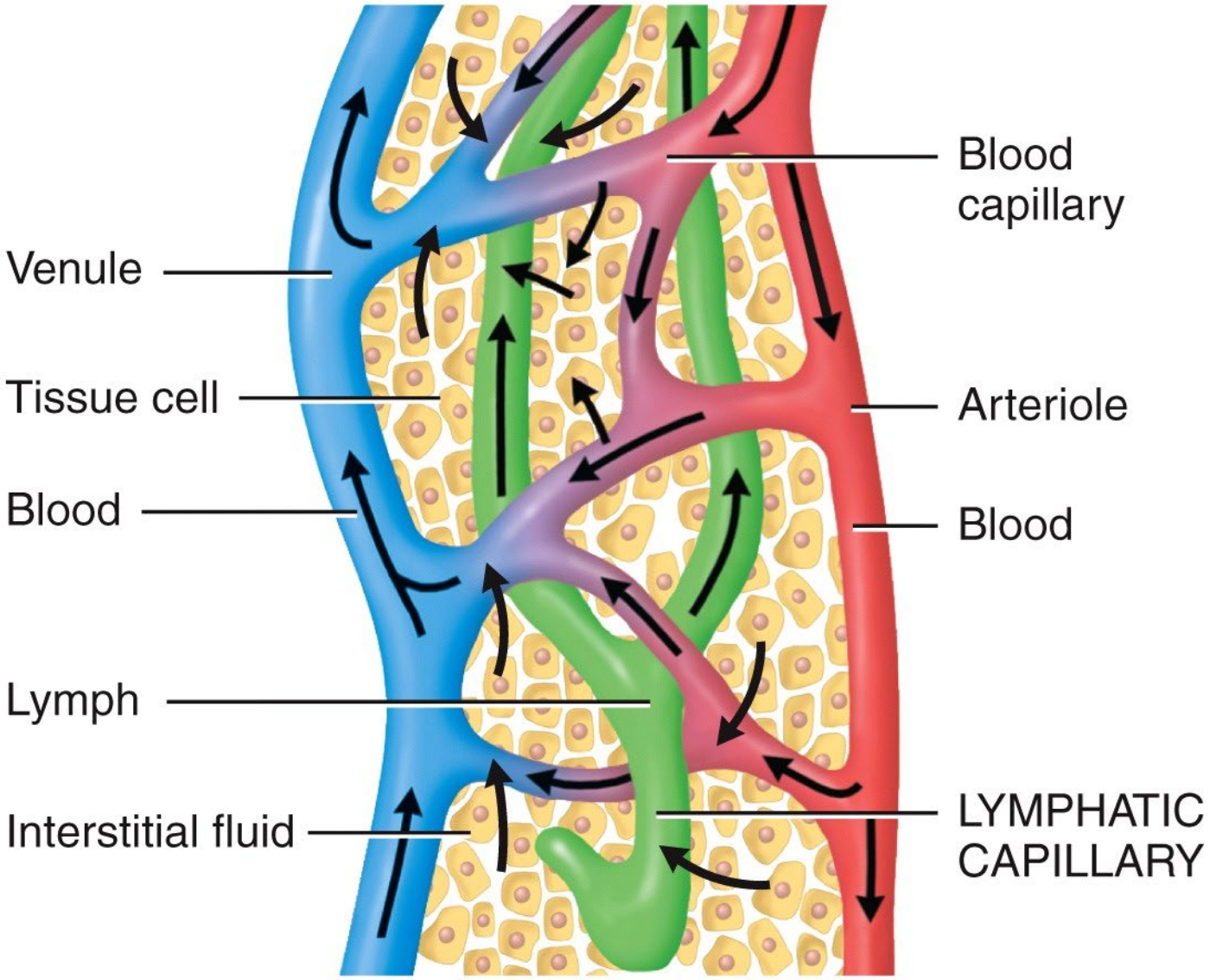
Lymphatic capillaries are tethered to surrounding tissue by protein filaments // gaps between cells are large enough to allow bacteria and cells entrance into lymphatic capillary

Endothelium creates valve-like flaps that open when interstitial fluid pressure is high, and close when it is low

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

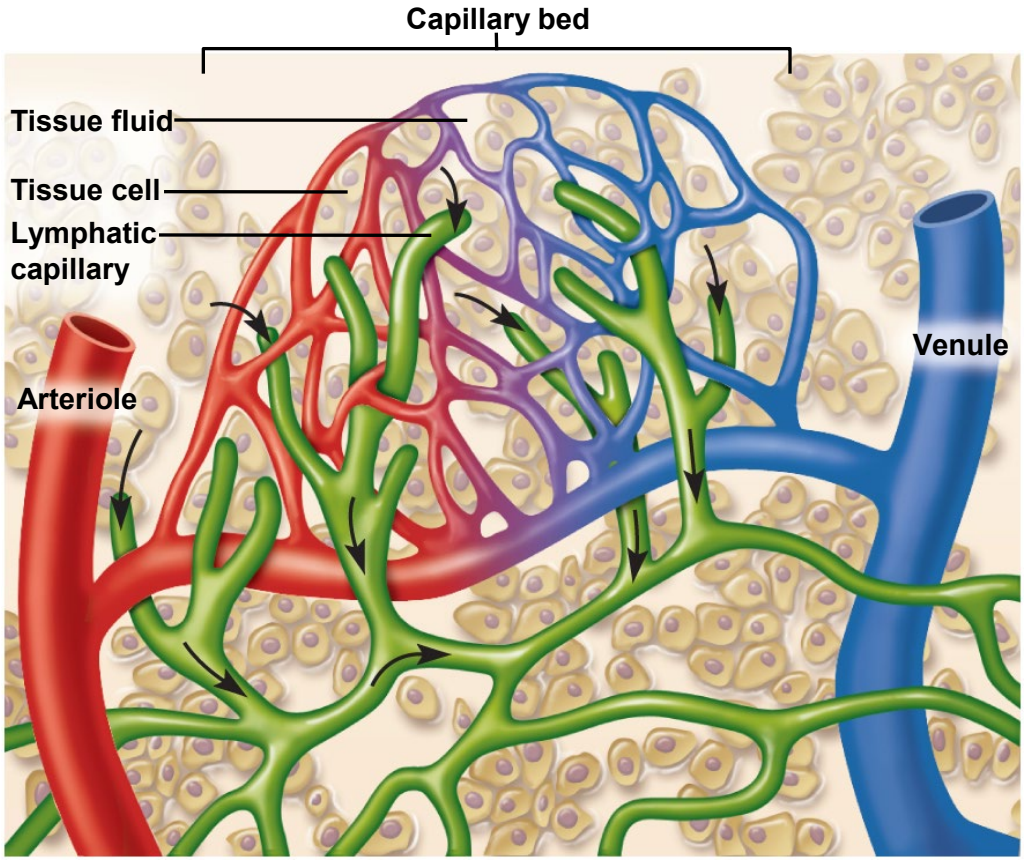


How much fluid is not recovered at the end of the capillary bed? (15%)



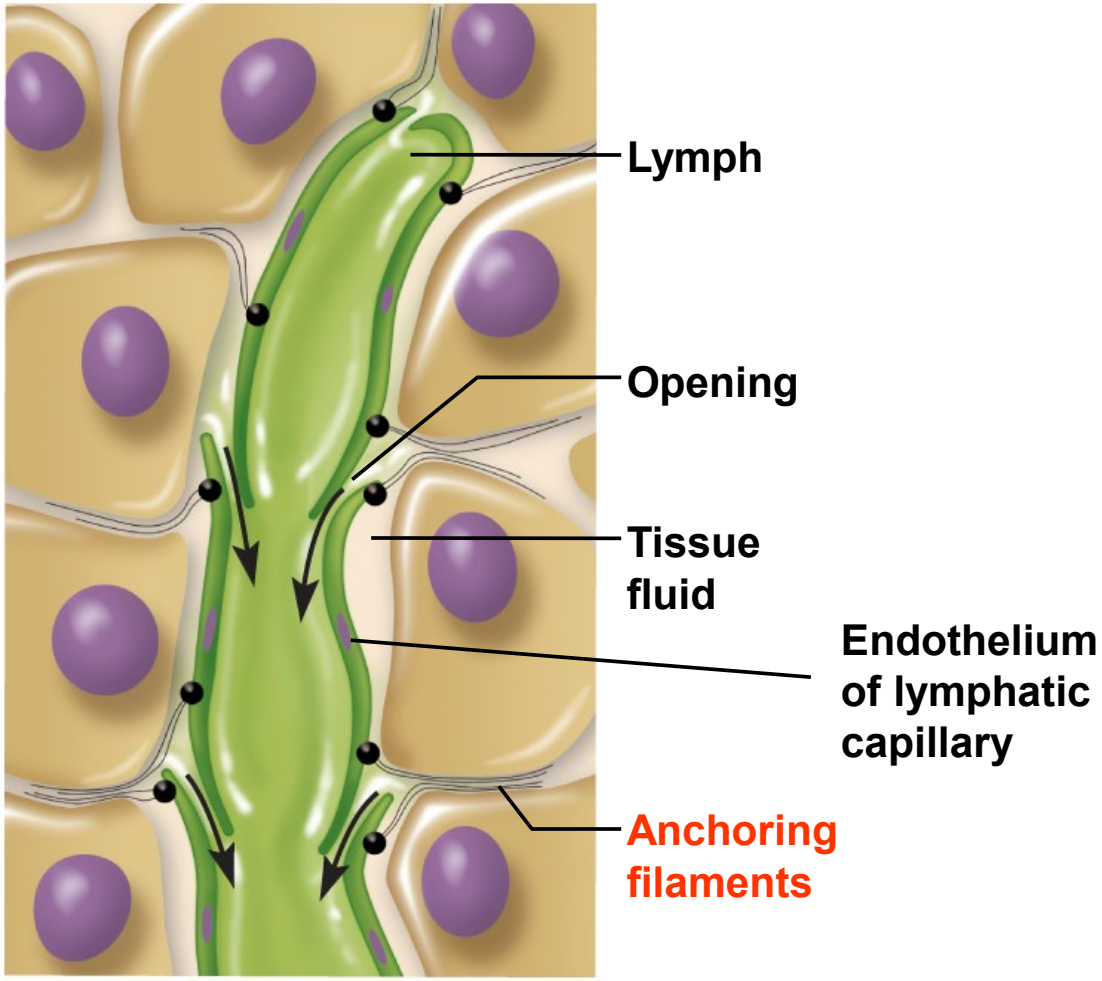
(a) Relationship of lymphatic capillaries to tissue cells and blood capillaries

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

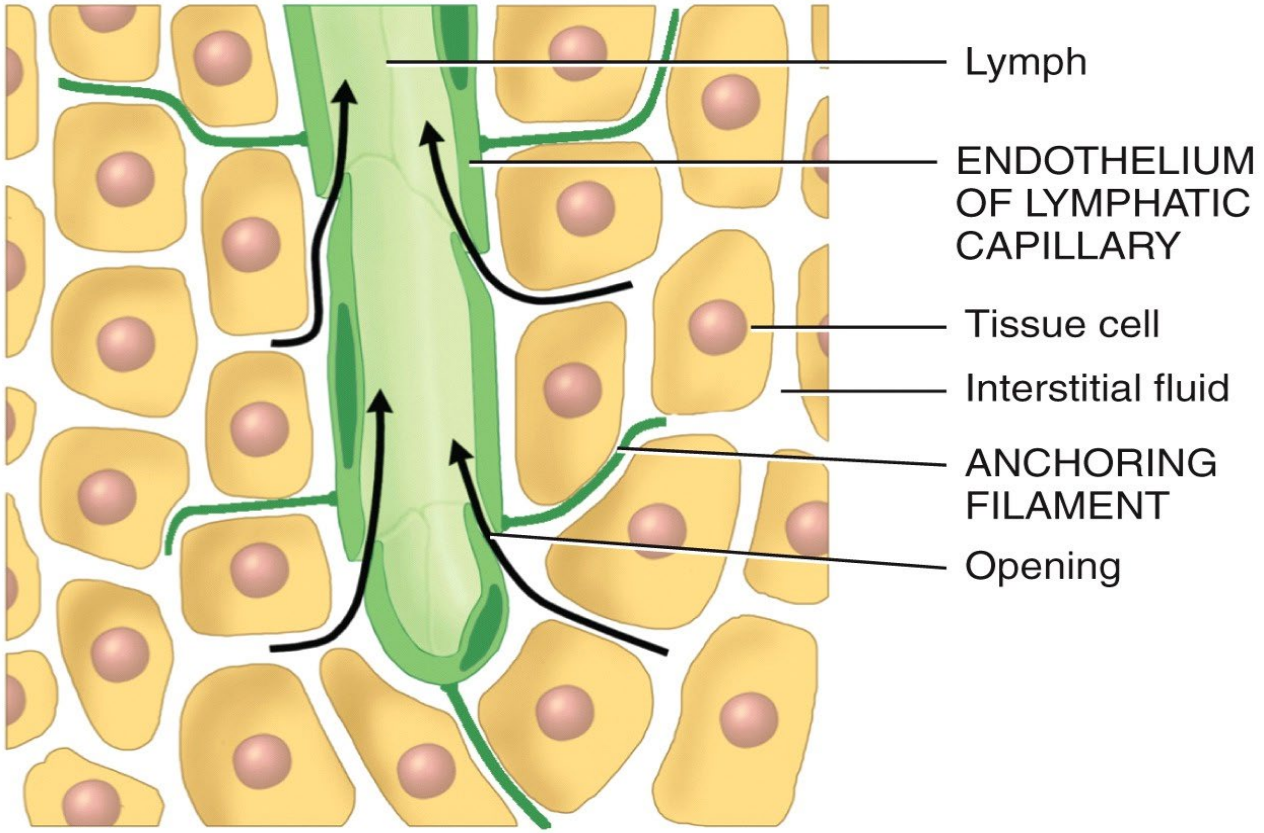


If there is a bacterial infection in a tissue space, why is it important to redirect interstitial fluid into the lymph capillaries?

Lymphatic Capillary



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 increases. 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?

How Lymph Flows Back Into Systemic Circuit

Start with lymphatic capillaries

Collecting vessels // course through many lymph nodes

Six lymphatic trunks // drain major portions of body

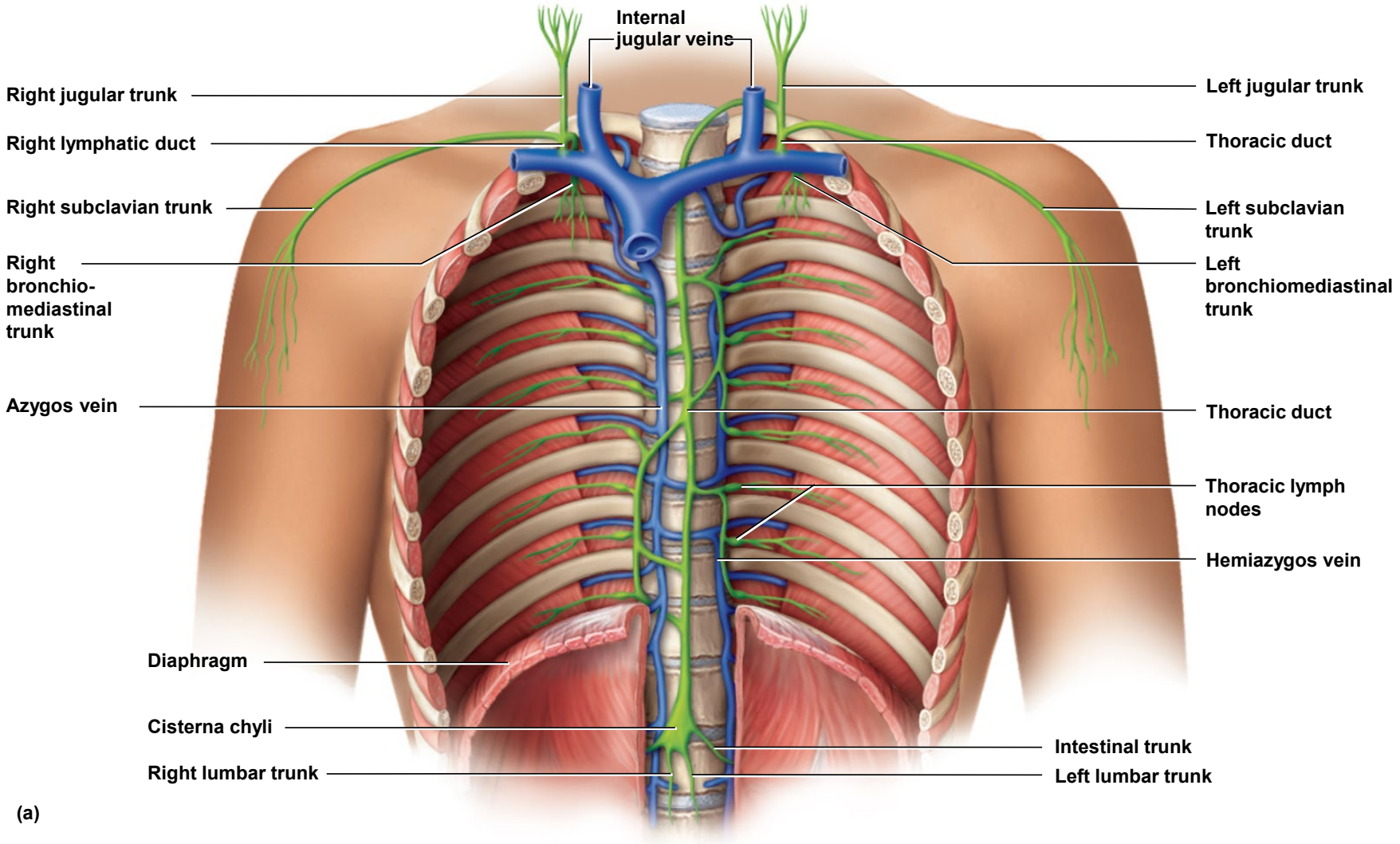
Eventually leads to two collecting ducts

Right lymphatic duct – receives lymph from right arm, right side of head and thorax; empties into right subclavian vein

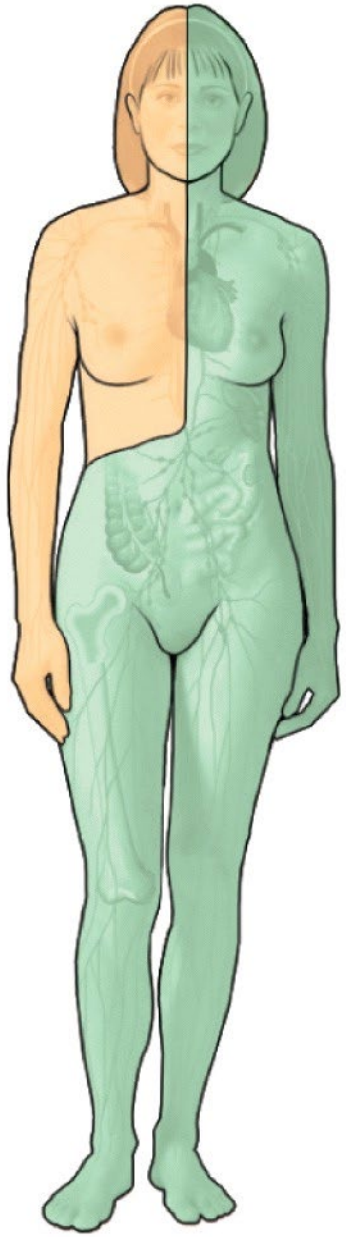
Thoracic duct - larger and longer, begins as a prominent sac in abdomen called the cisterna chyli; receives lymph from below diaphragm, left arm, **left side** of head, neck, and thorax; empties into left subclavian vein

Subclavian veins right & left // Receive fluid from respective collecting ducts

Drainage of Thorax



(a)

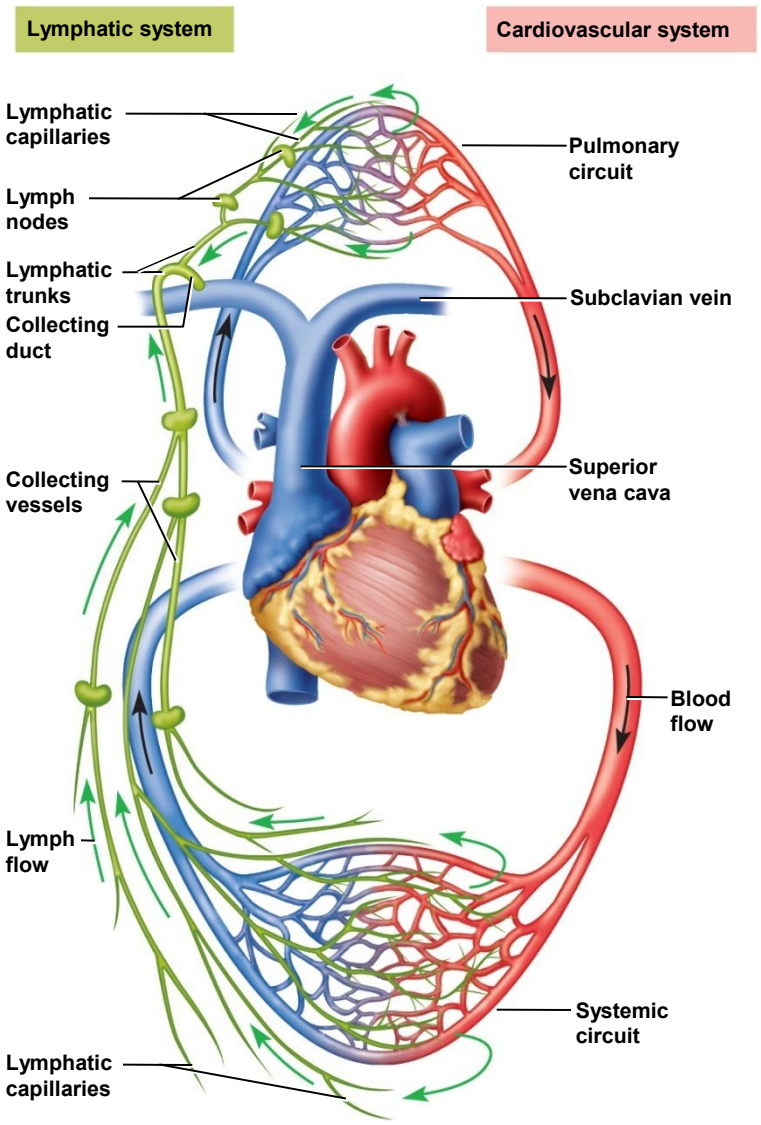


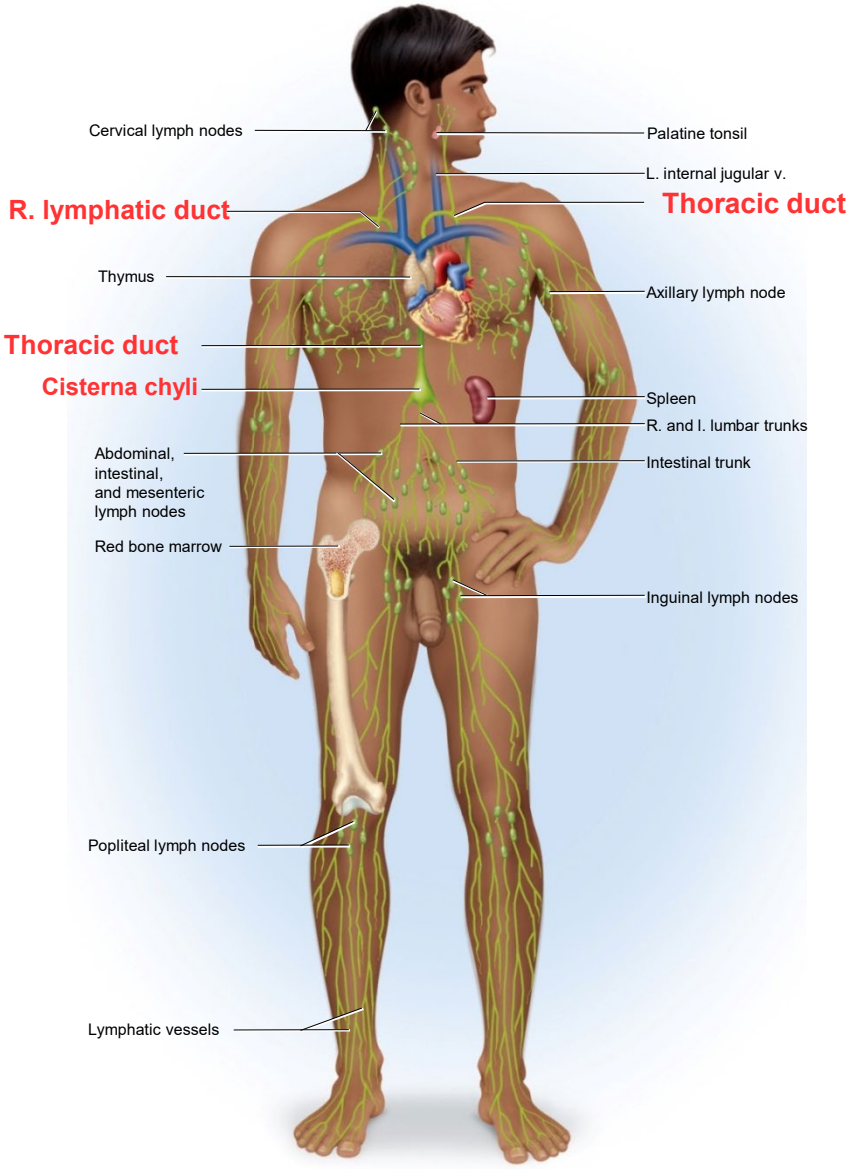
(b) Areas drained by right lymphatic and thoracic ducts

Area drained by right lymphatic duct

Area drained by thoracic duct

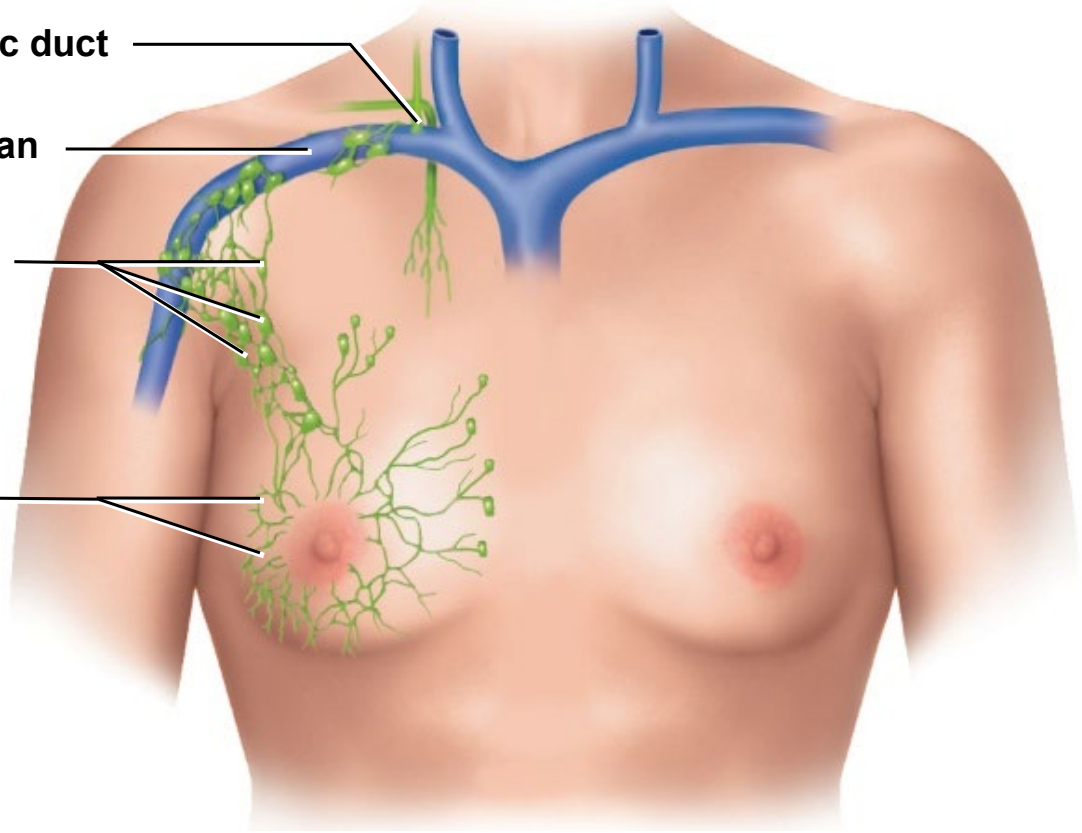
The Fluid Cycle





Lab Objectives

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 like 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

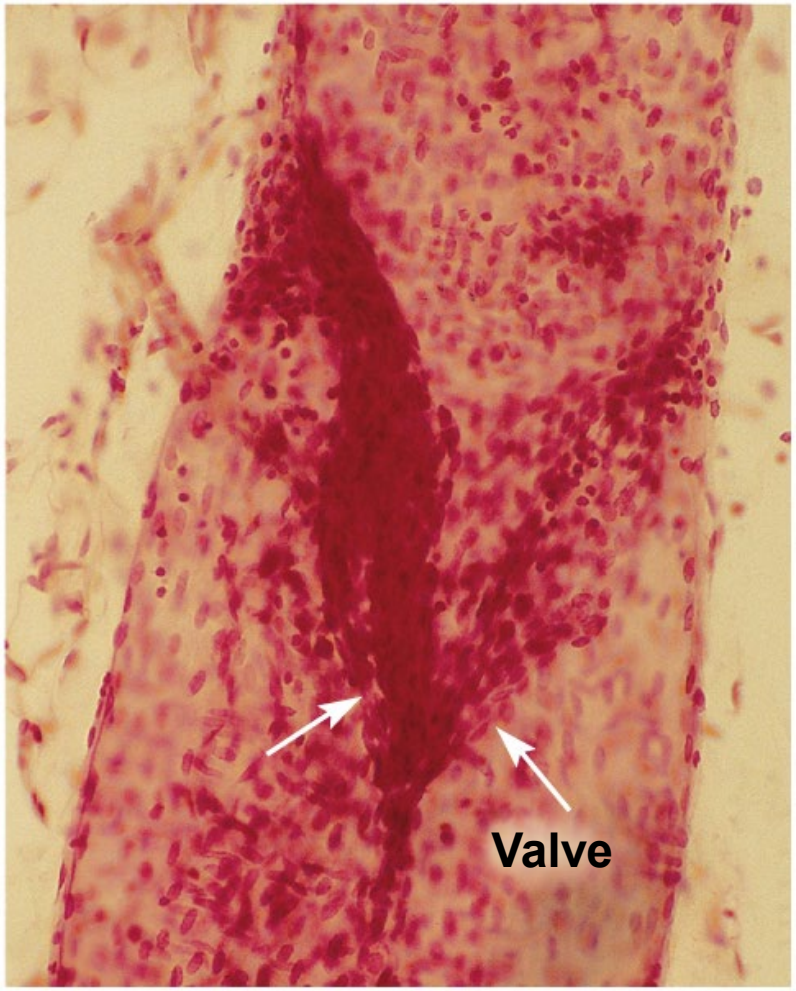
Thoracic pump negative pressure from abdominal to thoracic cavity

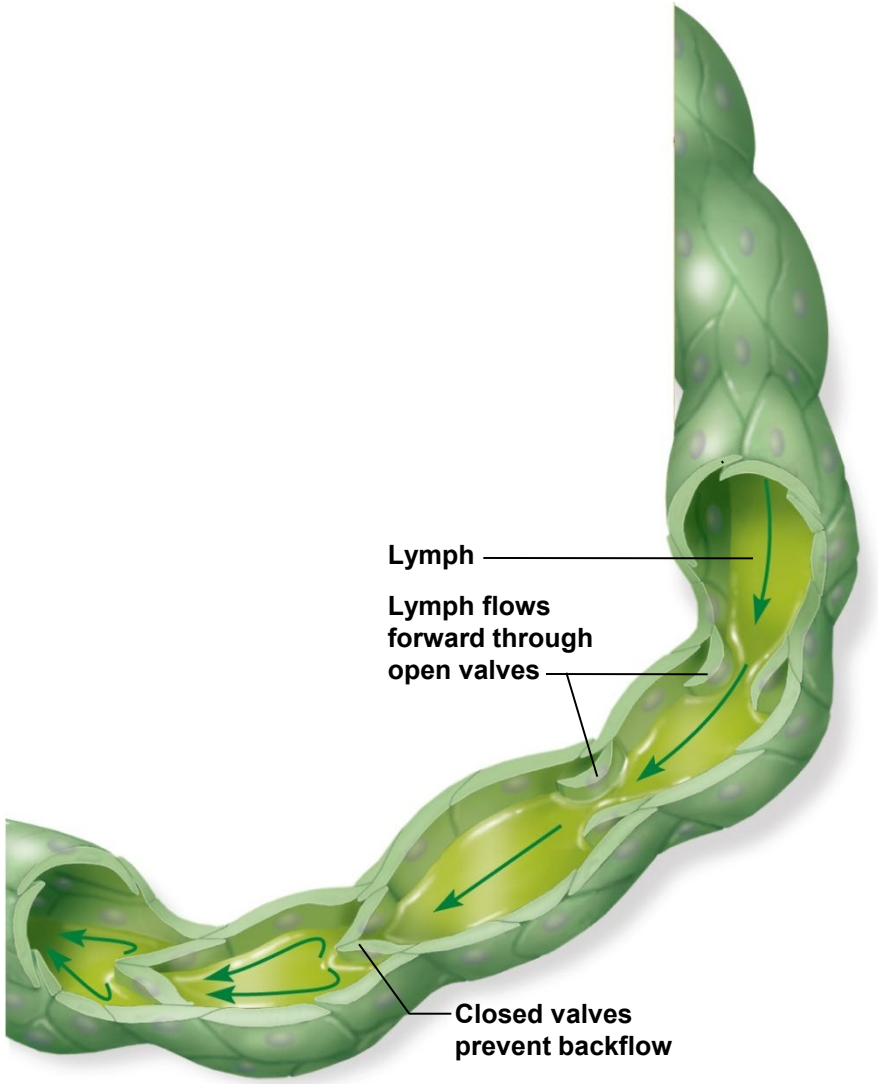
Semi-lunar valves prevent backward flow

Rapidly flowing blood in subclavian veins, draws lymph into it

Exercise significantly increases lymphatic return

Valves in Lymphatic Vessel

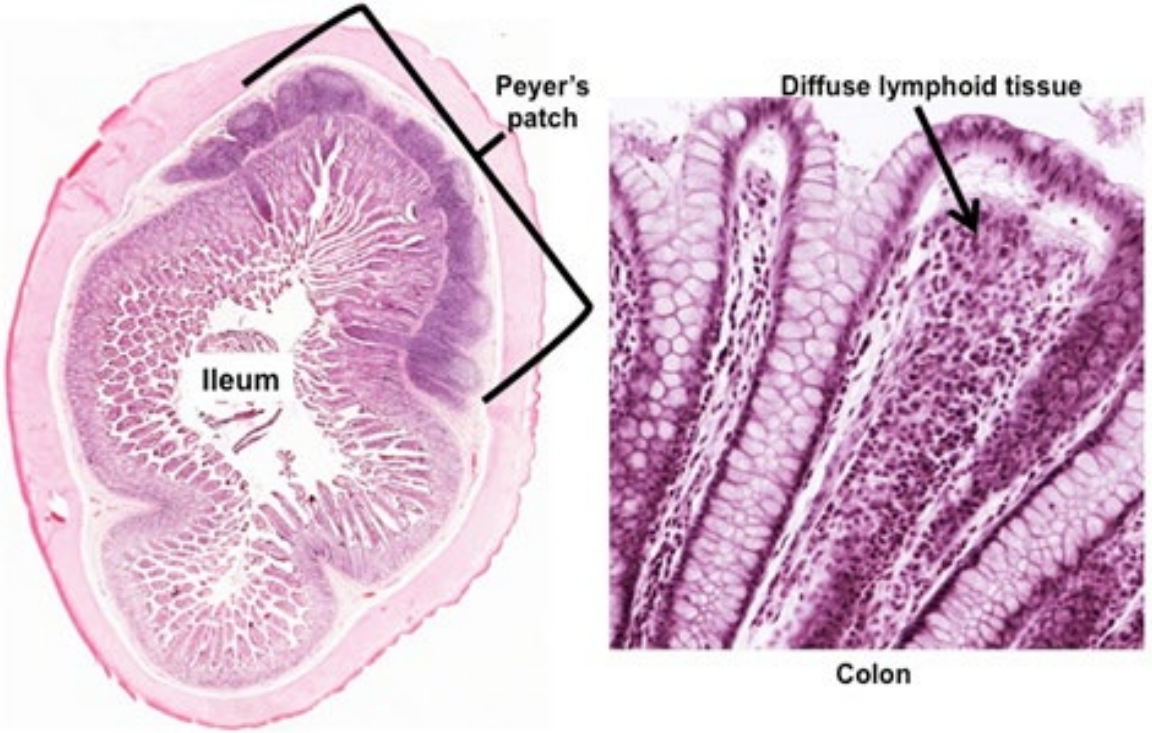




Lymphatic Tissue

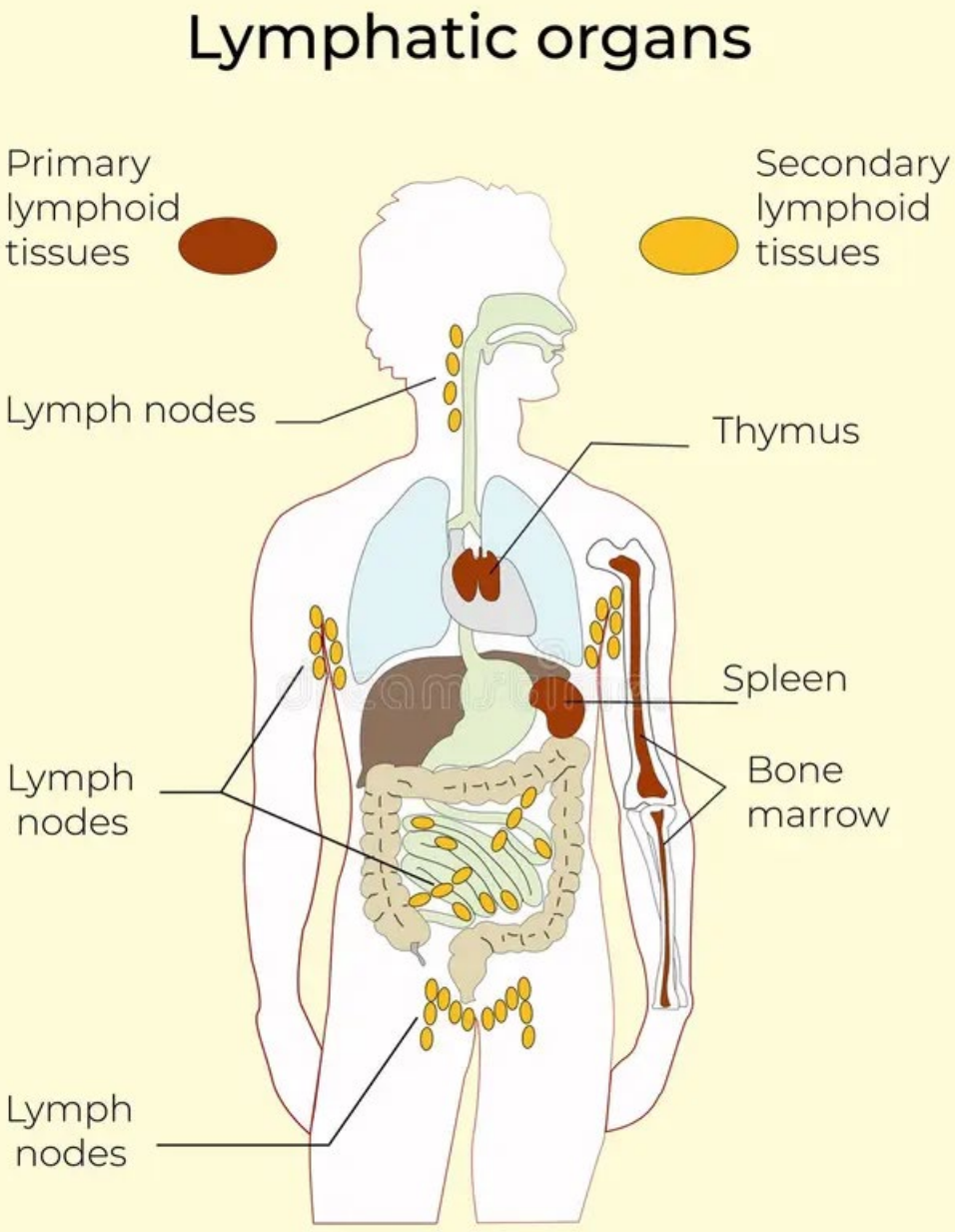
Lymphatic tissues are clusters of WBC not surrounded by connective.

These cells come together to defeat a pathogen and then break apart so they may patrol and seek other pathogens.



Lymphatic organs are surrounded by a connective tissue capsule and contain a high concentration of WBC.

- Lymph nodes
- Tonsils
- Spleen
- Thymus



Lymph Nodes

These are the most numerous lymphatic organs // about 450 in typical young adult /// they have two functions:

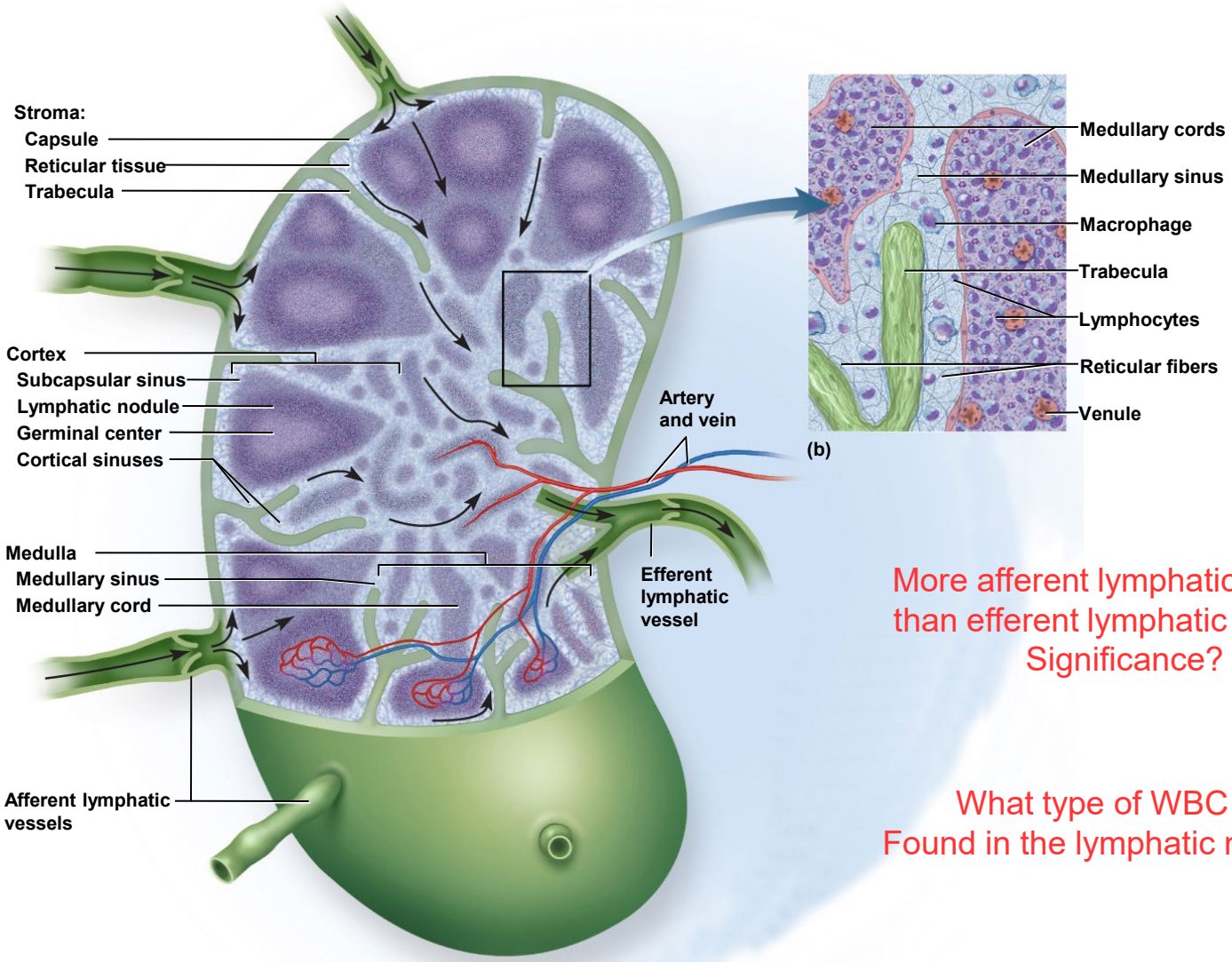
Cleanse the lymph with macrophage as lymph passes through nodes

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

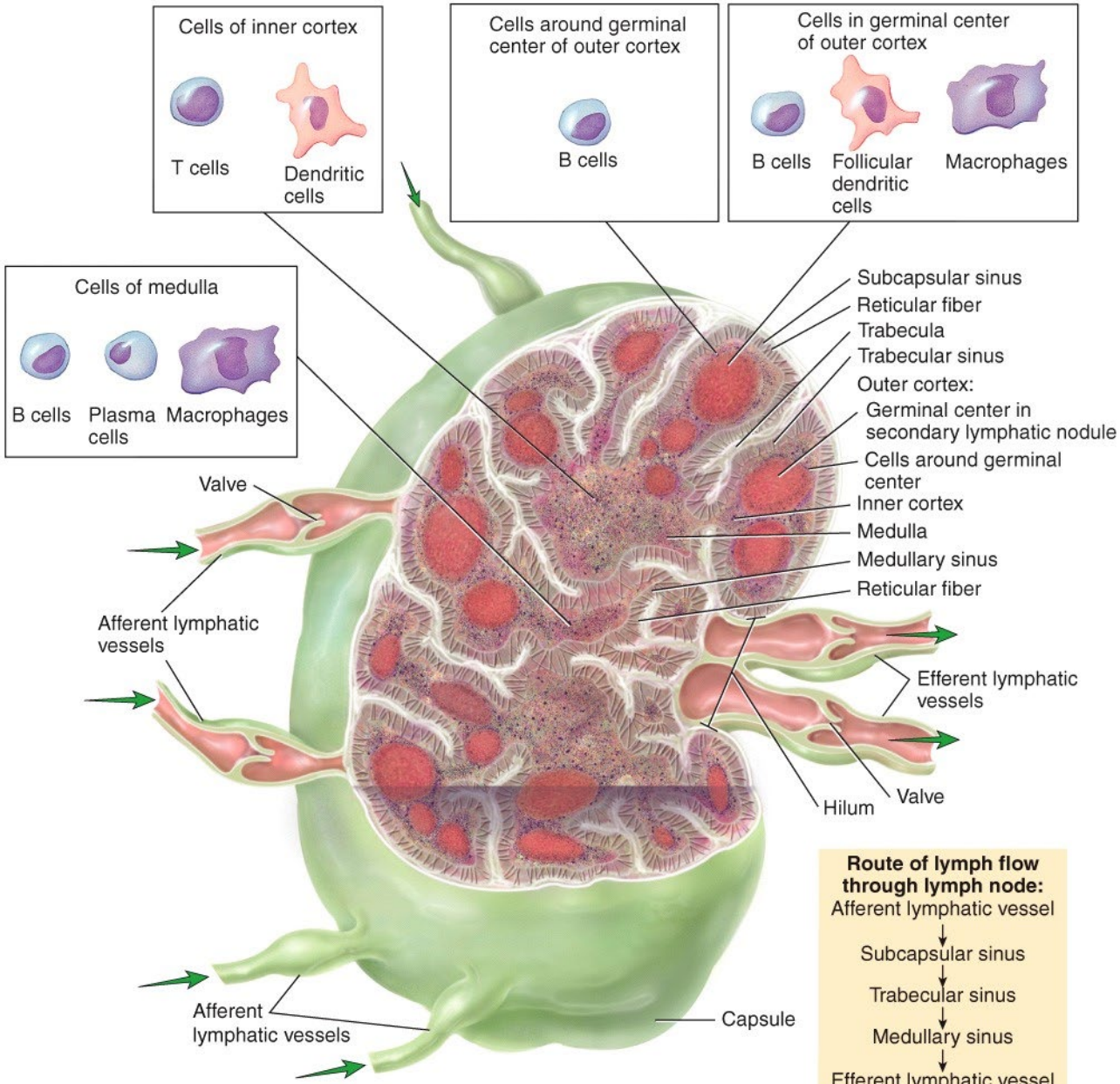
Lymph Node



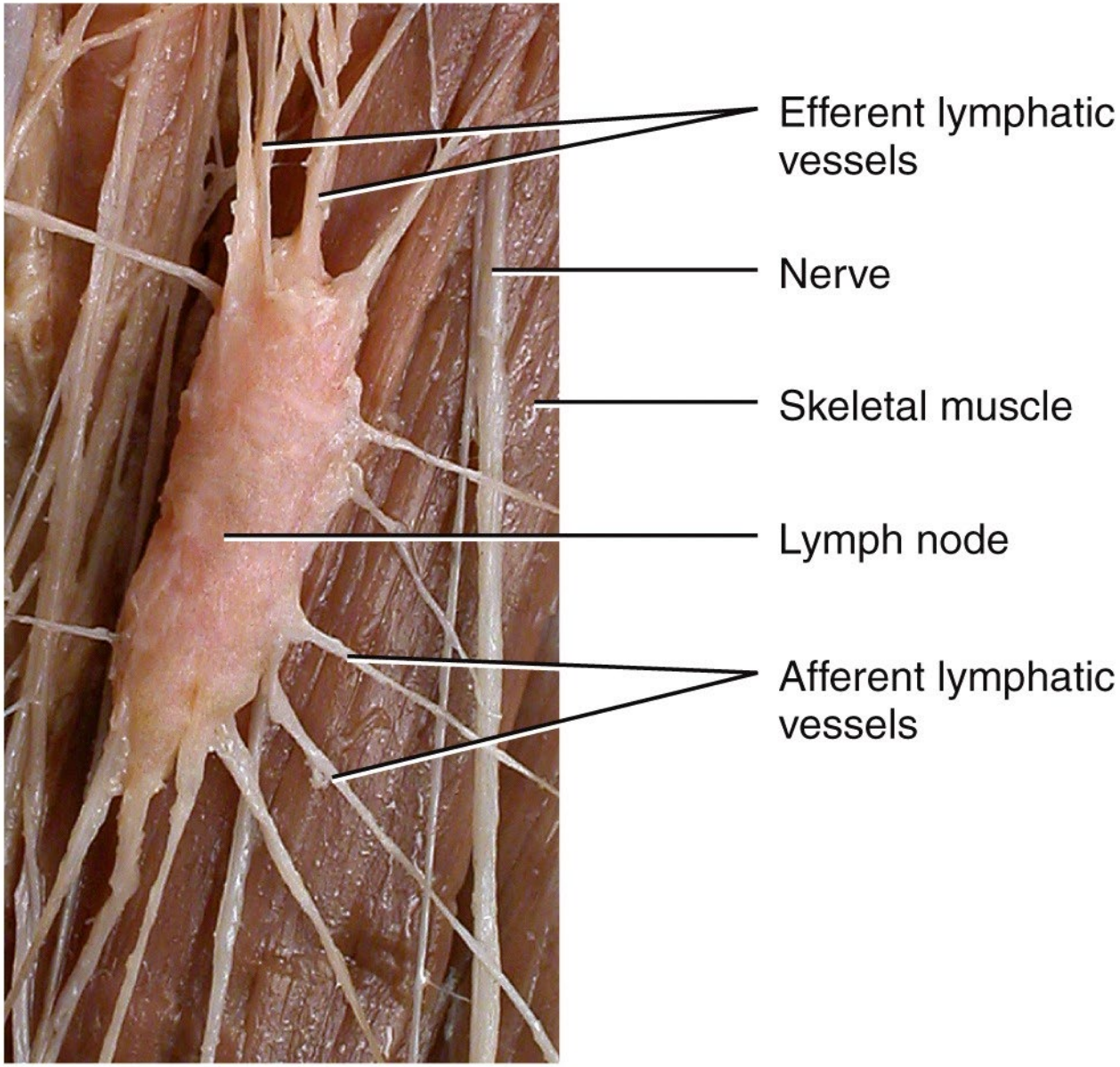
More afferent lymphatic vessels than efferent lymphatic vessels. Significance?

What type of WBC are Found in the lymphatic nodules?

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



(a) Partially sectioned lymph node



(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

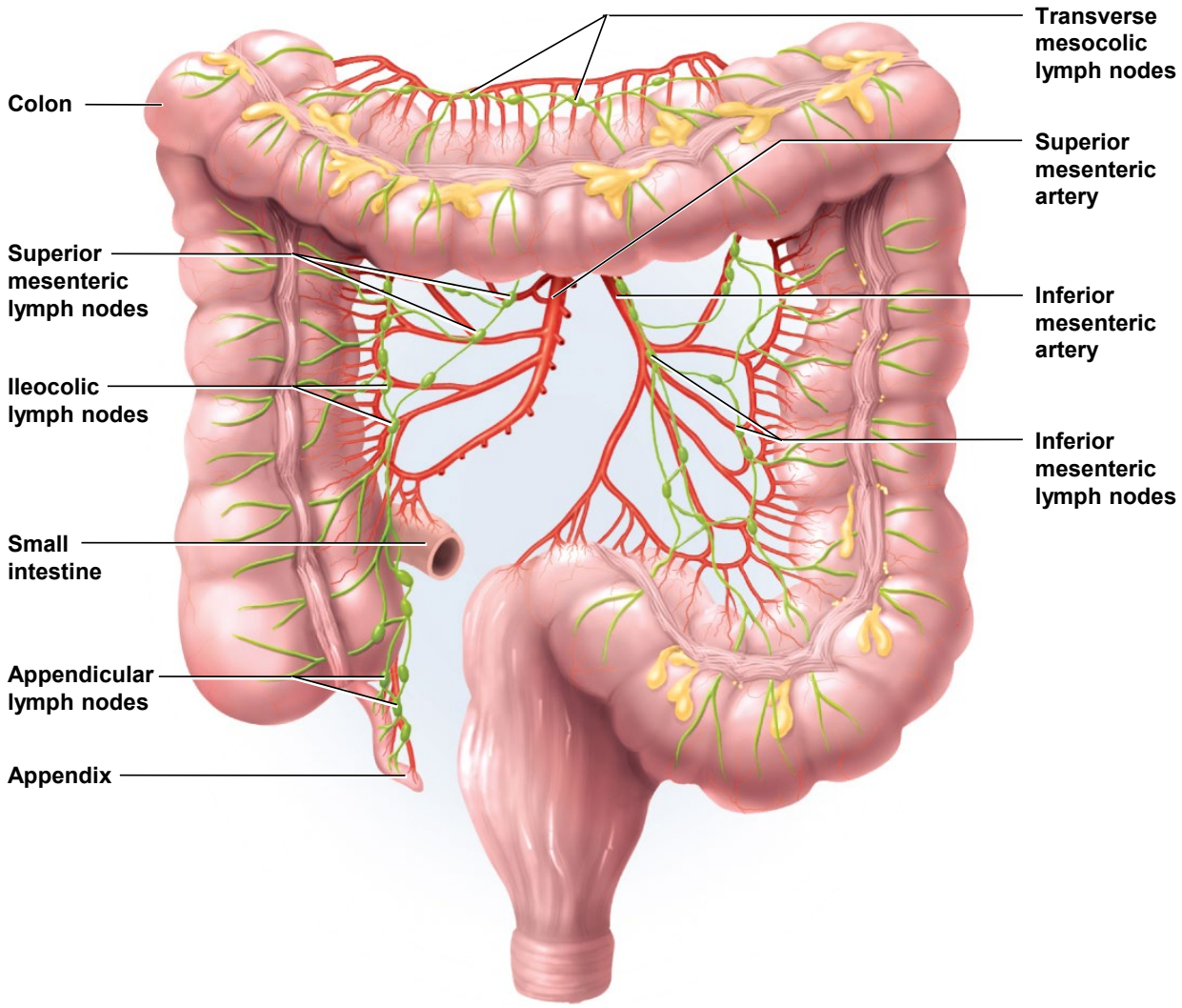
–in the groin and receive lymph from the entire lower limb

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

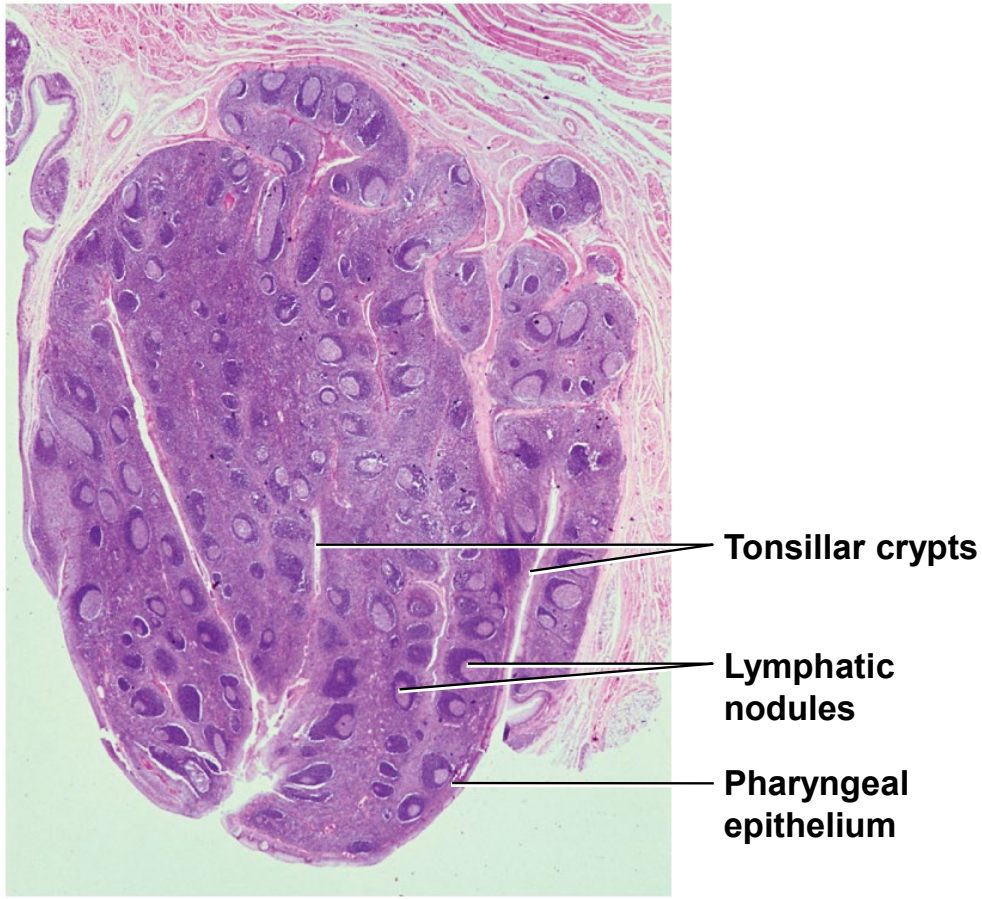
– guard against ingested or inhaled pathogens

– covered with epithelium

– have deep pits – **tonsillar crypts** lined with lymphatic nodules (clusters of macropahage and immune cells)

– **tonsillitis** and **tonsillectomy**

Pharyngeal Tonsil



Covered by epithelium

Food with pathogens enter tonsillar crypts and encounter lymphocytes

Tonsils

(Lab Objectives)

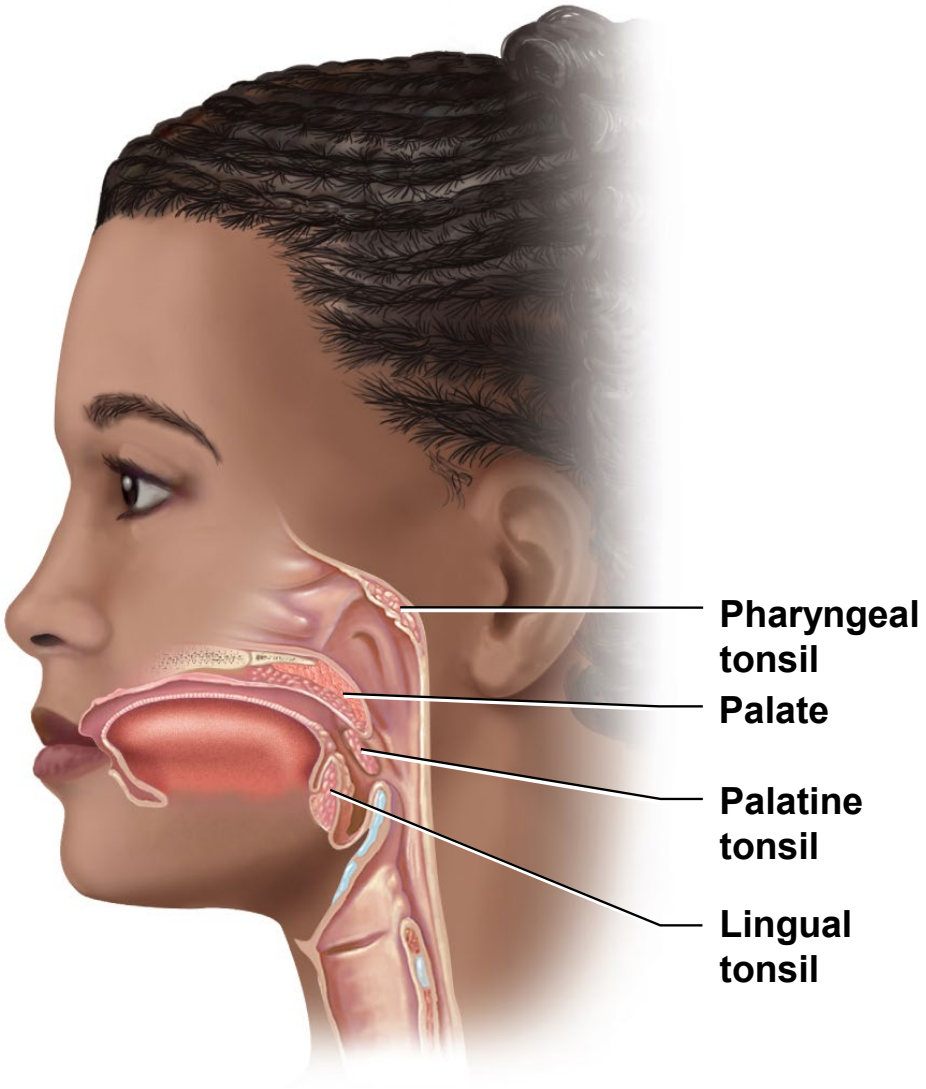
Three main sets of tonsils

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



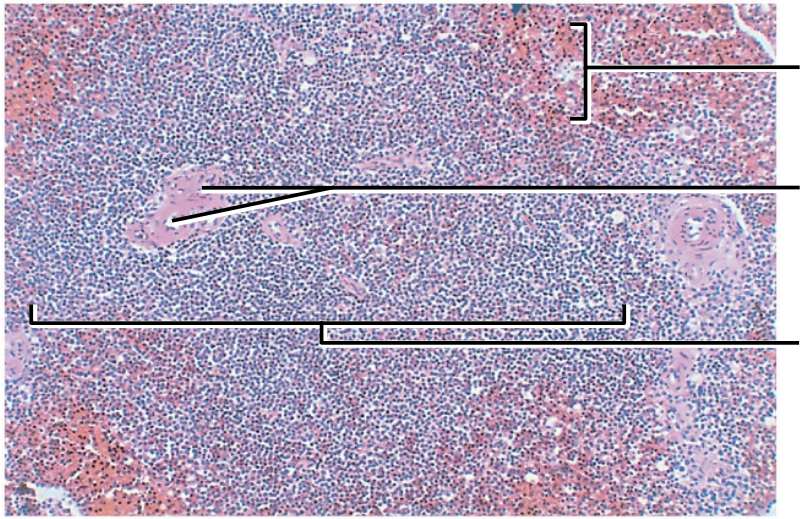
Spleen

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



(c)

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)

Function as a blood reservoir in adults

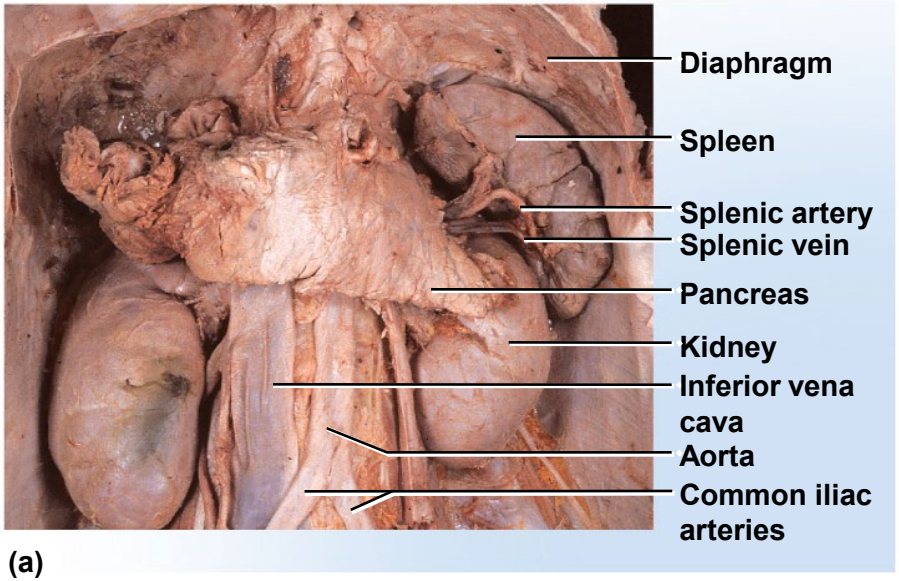
40% of circulating platelets stored in spleen

Erythrocyte graveyard - RBC disposal

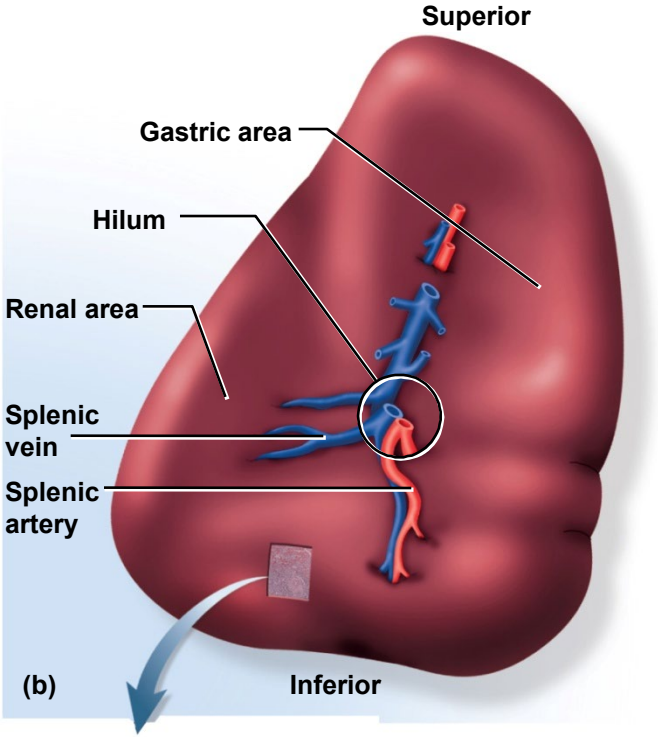
Spleen highly vascular and vulnerable to trauma and infection

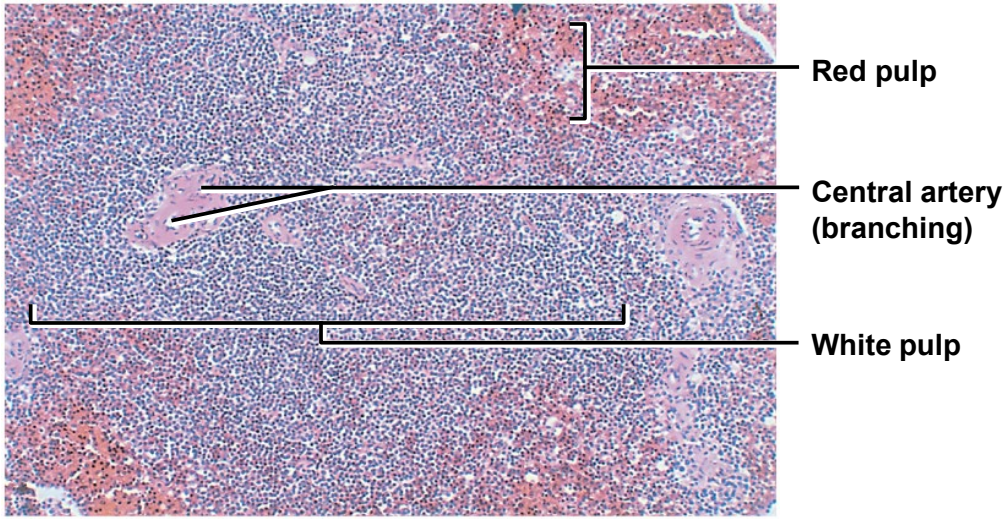
Ruptured spleen /// often requires the removal of spleen - splenectomy

Spleen


Diaphragm
Spleen
Splenic artery
Splenic vein
Pancreas
Kidney
Inferior vena cava
Aorta
Common iliac arteries

(a)


Superior
Gastric area
Hilum
Renal area
Splenic vein
Splenic artery
(b)
Inferior


Red pulp
Central artery (branching)
White pulp

(c)

Thymus

Contributes to the function of 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

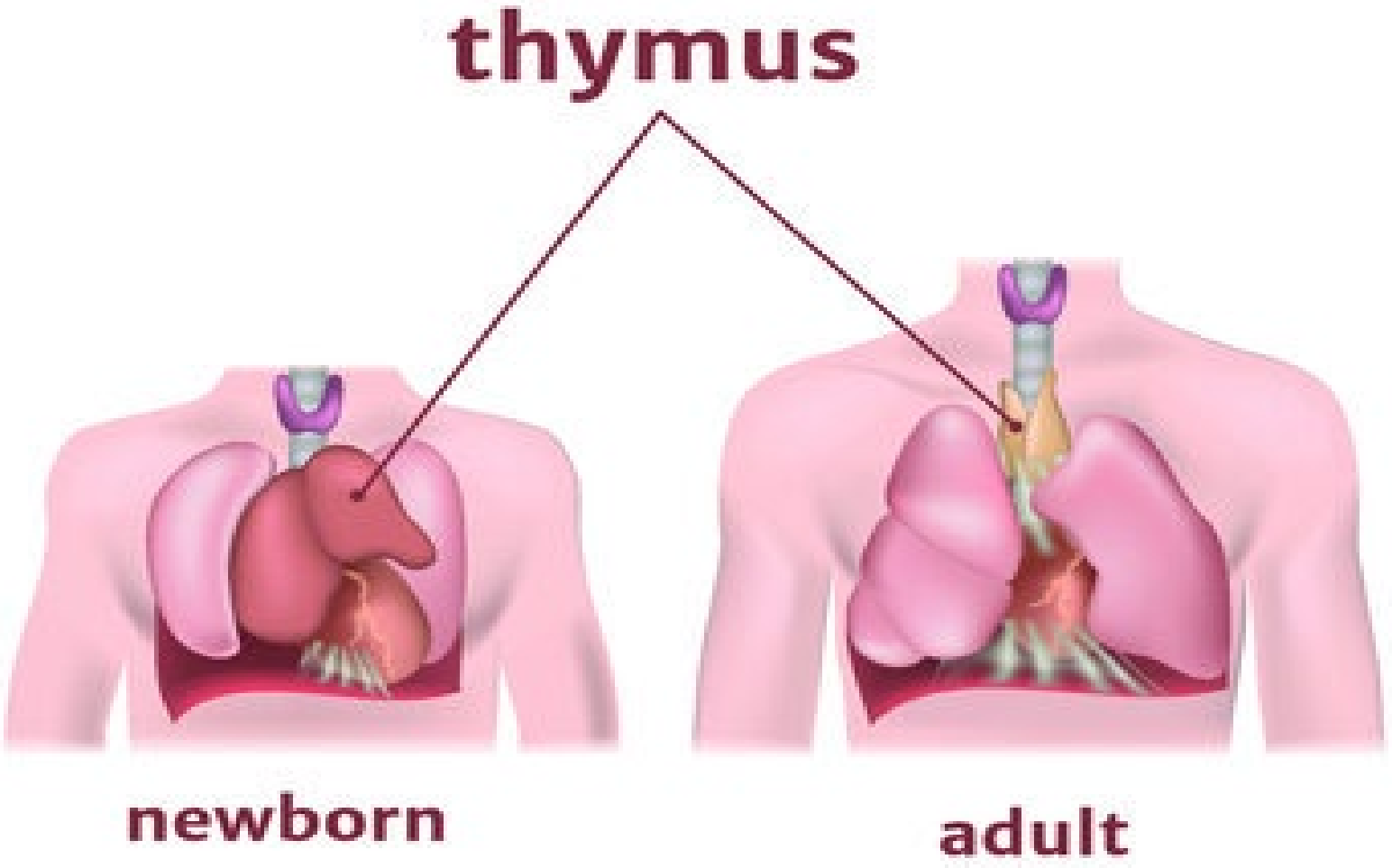
Degeneration or involution with age

Fibrous capsule gives off **trabeculae (septa)** that divide the gland into several lobes

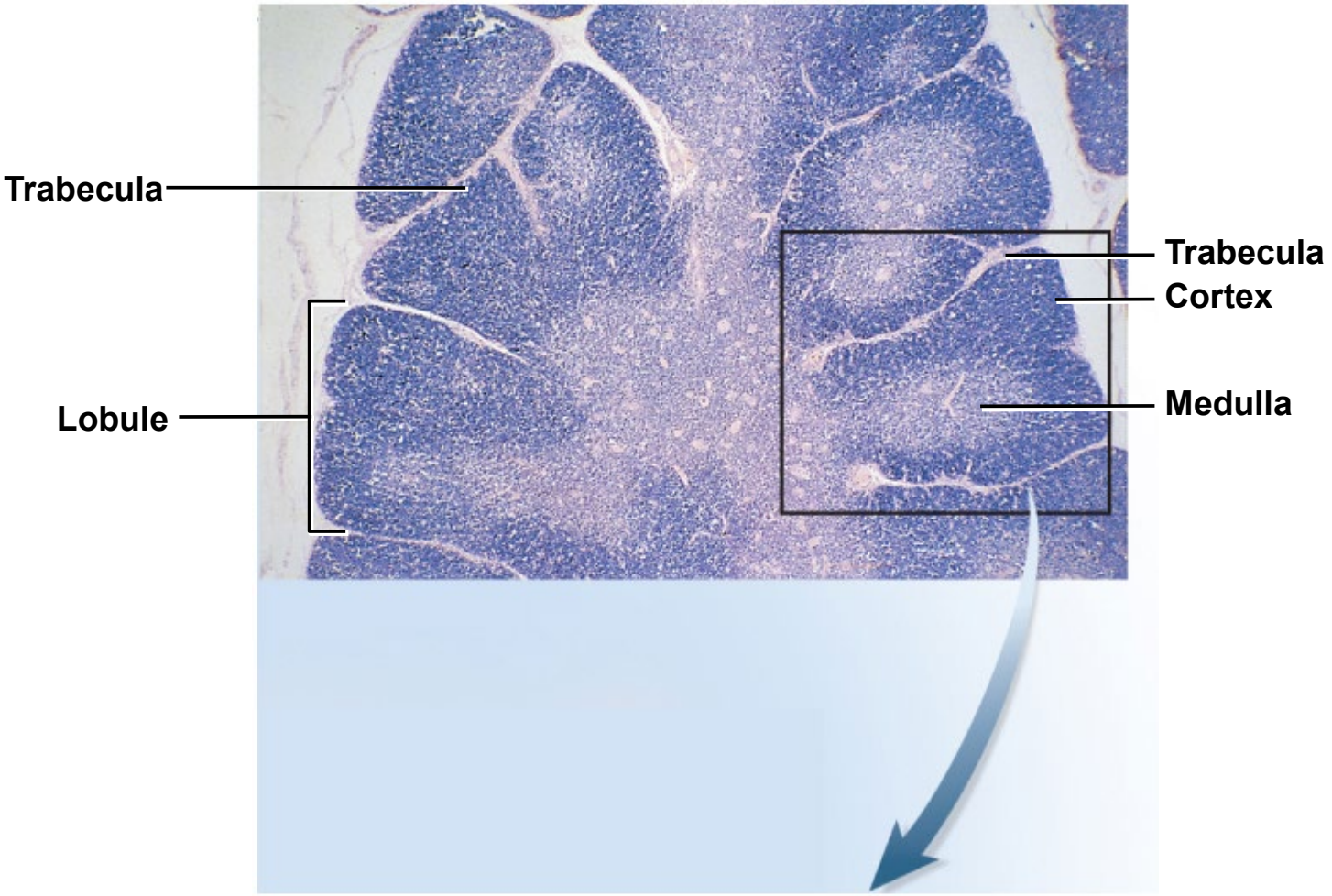
Lobes have cortex and medulla areas populated by T lymphocytes

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



Lymphatic system & Immunity

Lymph nodes plays 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 capture foreign antigen and display signs of pathogens to initiate an immune Responses

APC are required to activate helper T cells, cytotoxic T cells, and B cells