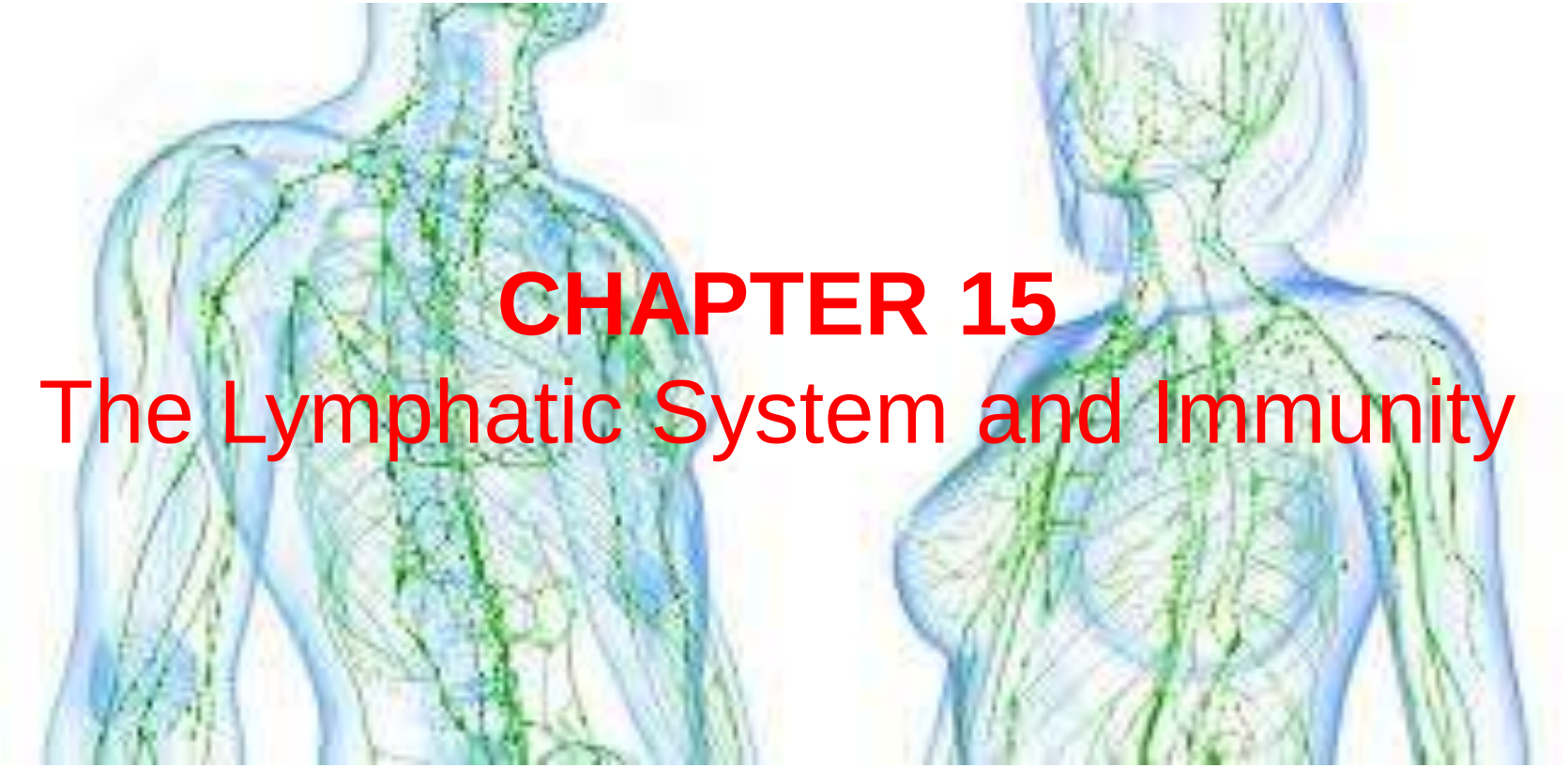

CHAPTER 15
The Lymphatic System and Immunity

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Introduction

- Maintaining physical health requires continuous combat against harmful agents.
- Pathogens
- Immunity or resistance
- Susceptibility
- Two general types of immunity:
  - Innate (nonspecific) immunity
  - Adaptive (specific) immunity

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Disease Resistance

Interactions Animation

- Disease Resistance

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Nonspecific Disease Resistance

Interactions Animation

- Nonspecific Disease Resistance

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Lymphatic System Structure and Functions

- The lymphatic system consists of four elements:
  - Lymph
  - Lymphatic vessels
  - Structures and organs containing lymphocytes
  - Red bone marrow
- Interstitial fluid and lymph are very similar.

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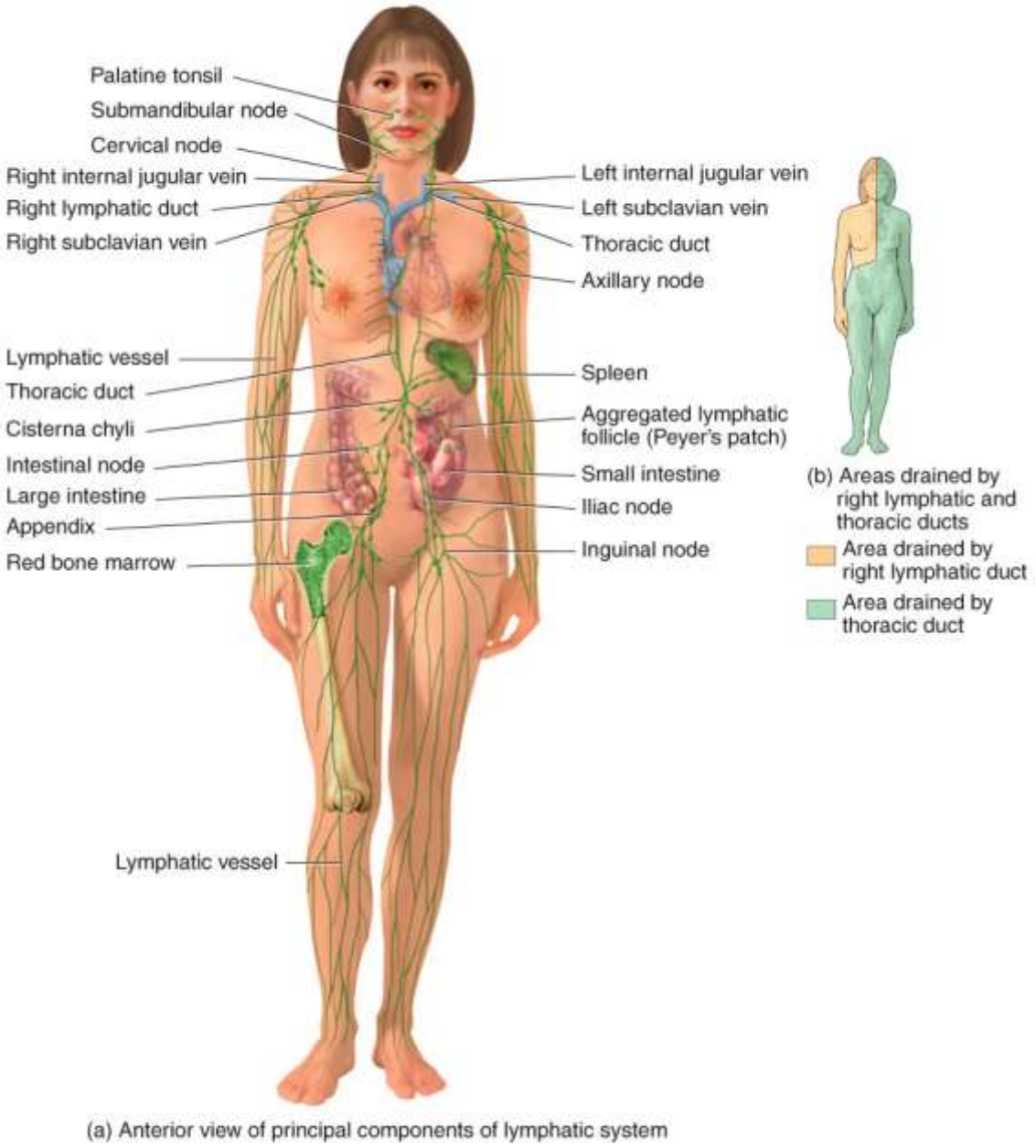
Components of the Lymphatic System



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Functions of the Lymphatic System

- The lymphatic system has three primary functions:
  1. Drains excess interstitial fluid
  2. Transports dietary lipids.
  3. Carries out immune responses
     - antigens
     - B cells
     - antibodies
     - T cells

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Lymph Formation and Flow

Interactions Animation

- Lymph Formation and Flow

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Clinical Connection

- Allergic reactions

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Lymphatic Vessels and Lymph Circulation

- Lymphatic capillaries
- Lymphatic vessels
- Lymph nodes

Tissues that lack lymphatic capillaries include avascular tissues (such as cartilage, the epidermis, and the cornea of the eye), the central nervous system, portions of the spleen, and red bone marrow.

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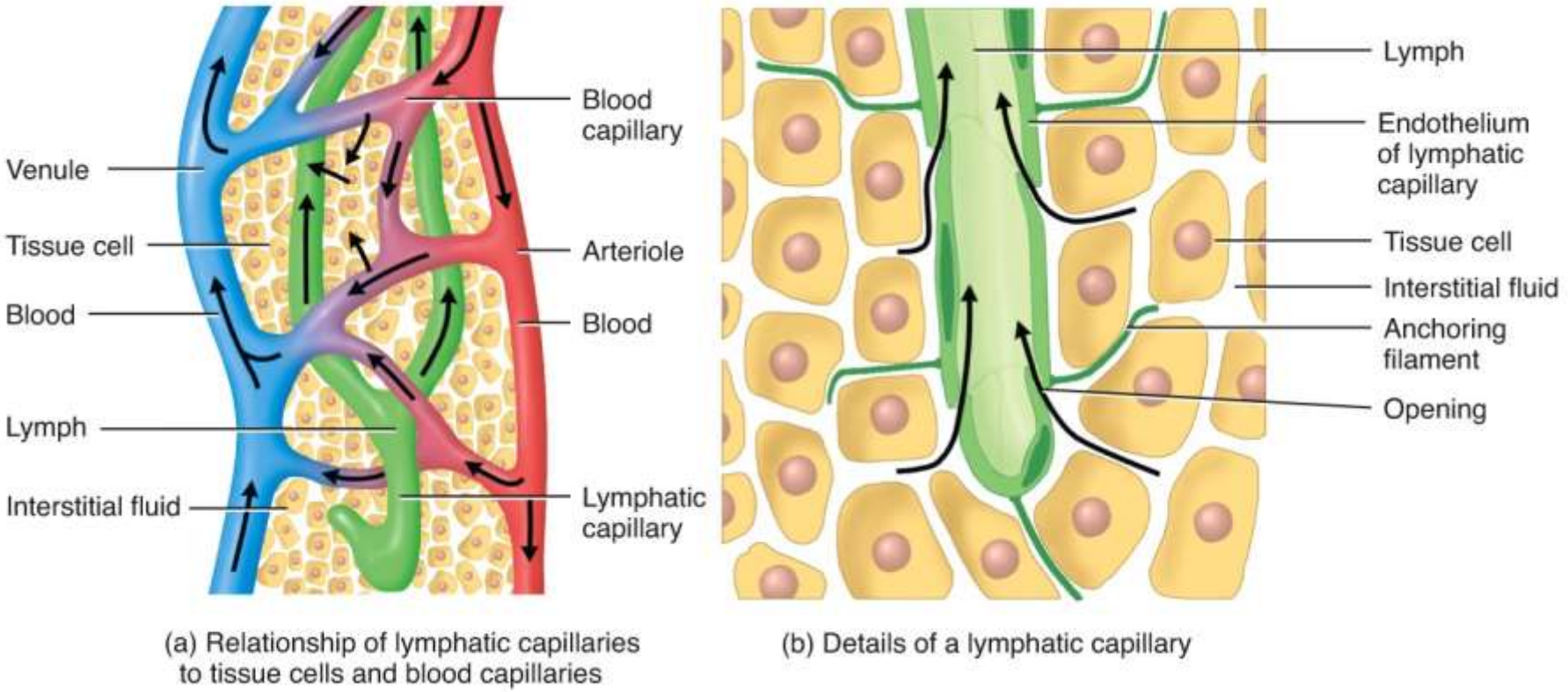
Lymphatic Capillaries



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

(b) Details of a lymphatic capillary

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Lymph Trunks and Ducts

- Principal lymph trunks
  - Lumbar trunks
  - Intestinal trunk
  - Bronchomediastinal trunks
  - Subclavian trunks
  - Jugular trunks
  - Thoracic (or left lymphatic) duct
  - Right lymphatic duct

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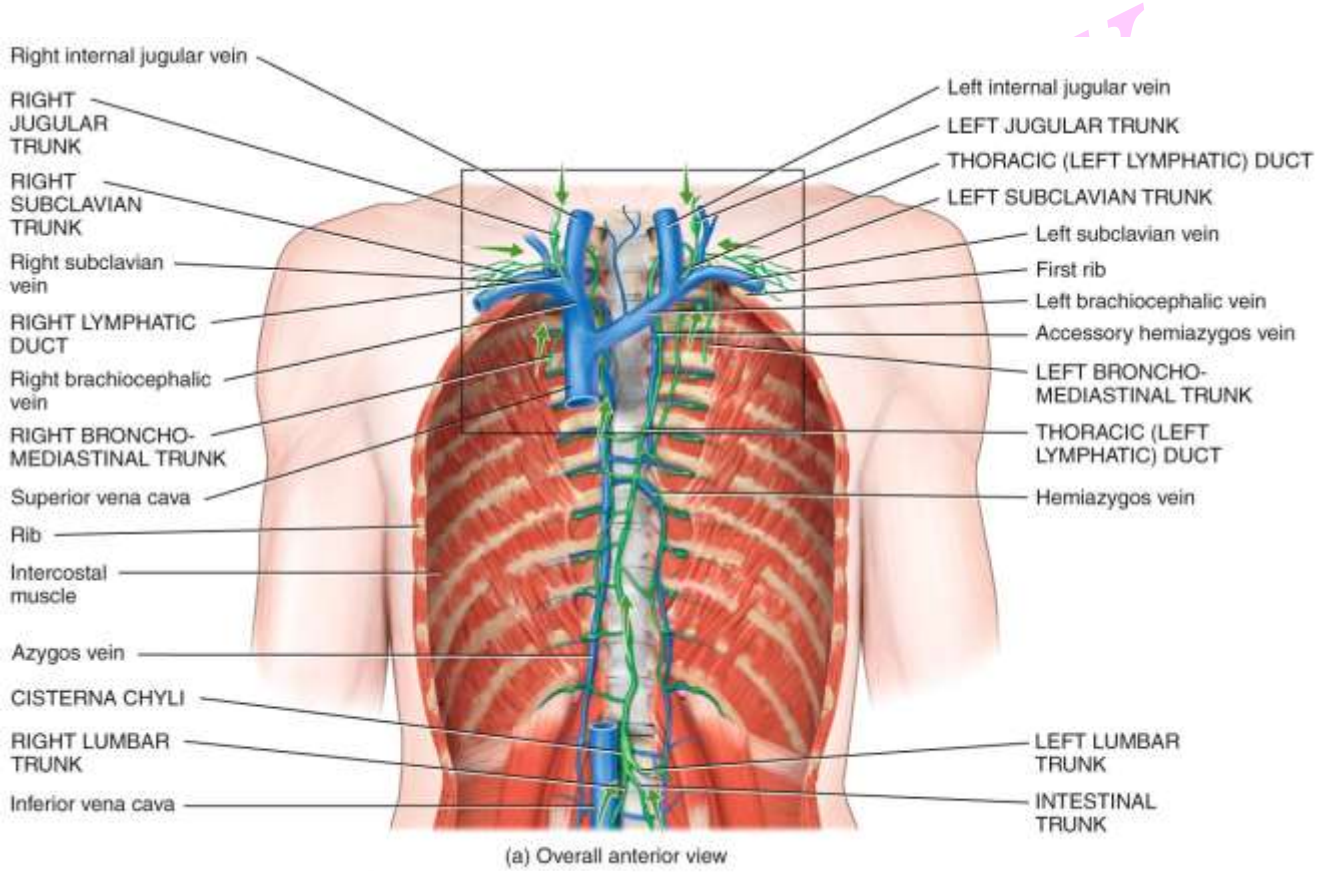
Routes for Drainage of Lymph from Lymph Trunks into the Thoracic and Right Lymphatic Ducts



(a) Overall anterior view

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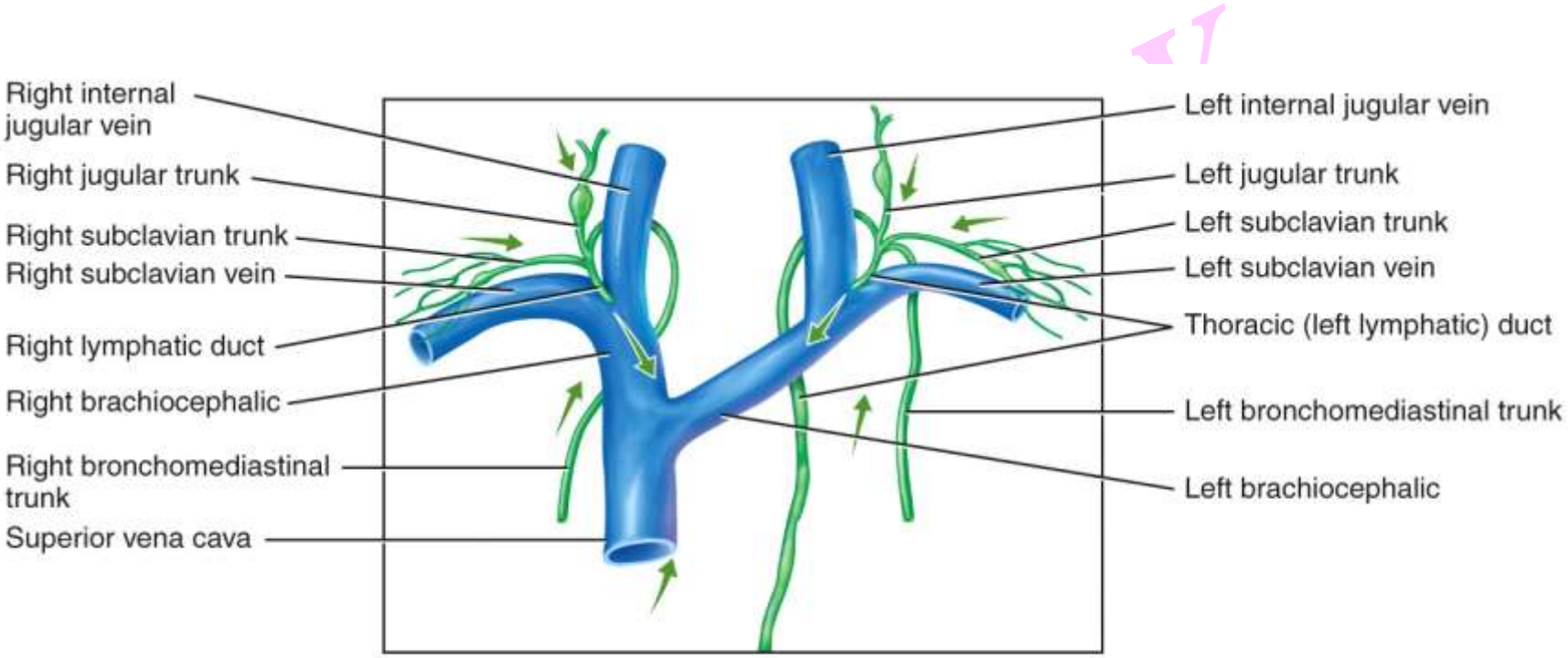
Routes for Drainage of Lymph from Lymph Trunks into the Thoracic and Right Lymphatic Ducts



(b) Detailed anterior view of thoracic and right lymphatic duct

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Formation and Flow of Lymph

- Most components of blood plasma filter freely through the capillary walls to form interstitial fluid.
- More fluid filters out of blood capillaries than returns by reabsorption.
- The excess filtered fluid drains into lymphatic vessels and becomes lymph.
- Most plasma proteins are too large to leave blood vessels.

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Formation and Flow of Lymph

- Proteins that do leave blood plasma cannot return to the blood directly by diffusion.
- The proteins can move readily through the more permeable lymphatic capillaries into lymph.
- An important function of lymphatic vessels is to return lost plasma proteins and plasma to the bloodstream.

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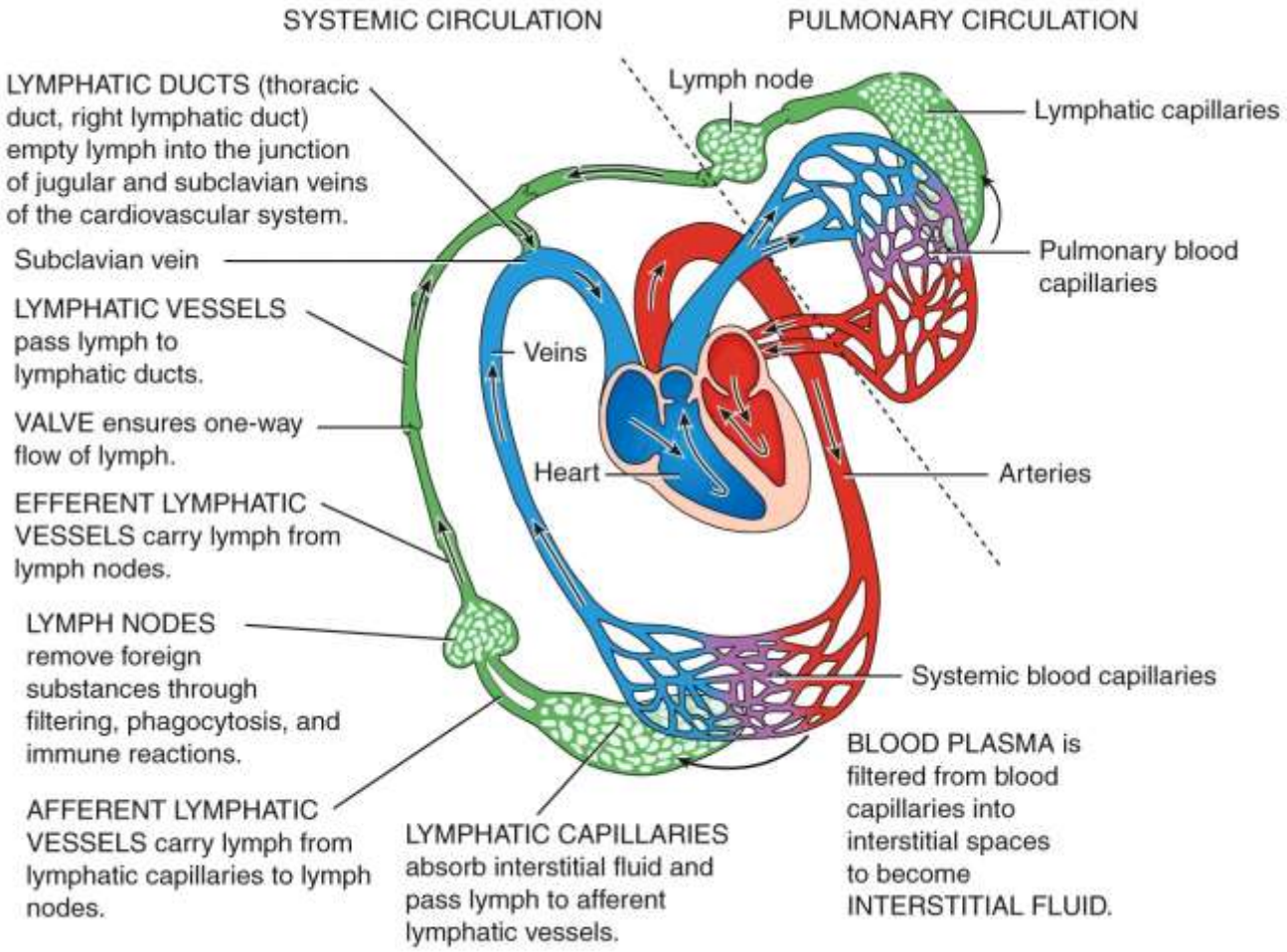
The Relationship of the Lymphatic System to the Cardiovascular System



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Lymphatic Organs and Tissues

- **Primary lymphatic organs:** are where lymphocytes are formed and mature. They provide an environment for stem cells to divide and mature into B- and T- cells: There are two primary lymphatic organs: the *red bone marrow and the thymus gland.*
- **Secondary lymphatic organs:** (SLOs) include lymph nodes, spleen, Peyer's patches *"are small masses of lymphatic tissue found throughout the ileum region of the small intestine",* and mucosal tissues such as the nasal-associated lymphoid tissue, adenoids, and tonsils.

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Thymus

The thymus is a bilobed organ in the mediastinum between the sternum and the aorta.

- Capsule
- Trabeculae
- Lobules
- Cortex
  - Immature T cells migrate from red bone marrow to the cortex of the thymus, where they proliferate and begin to mature.
- Dendritic cells

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Thymus

- Epithelial cells in the cortex have several long processes that surround and serve as a framework for T cells.
- These epithelial cells help pre-T cells mature into T cells.
- Apoptosis (programmed cell death)
- Thymic macrophages help clear out the debris of dead and dying cells.
- The surviving T cells enter the medulla.

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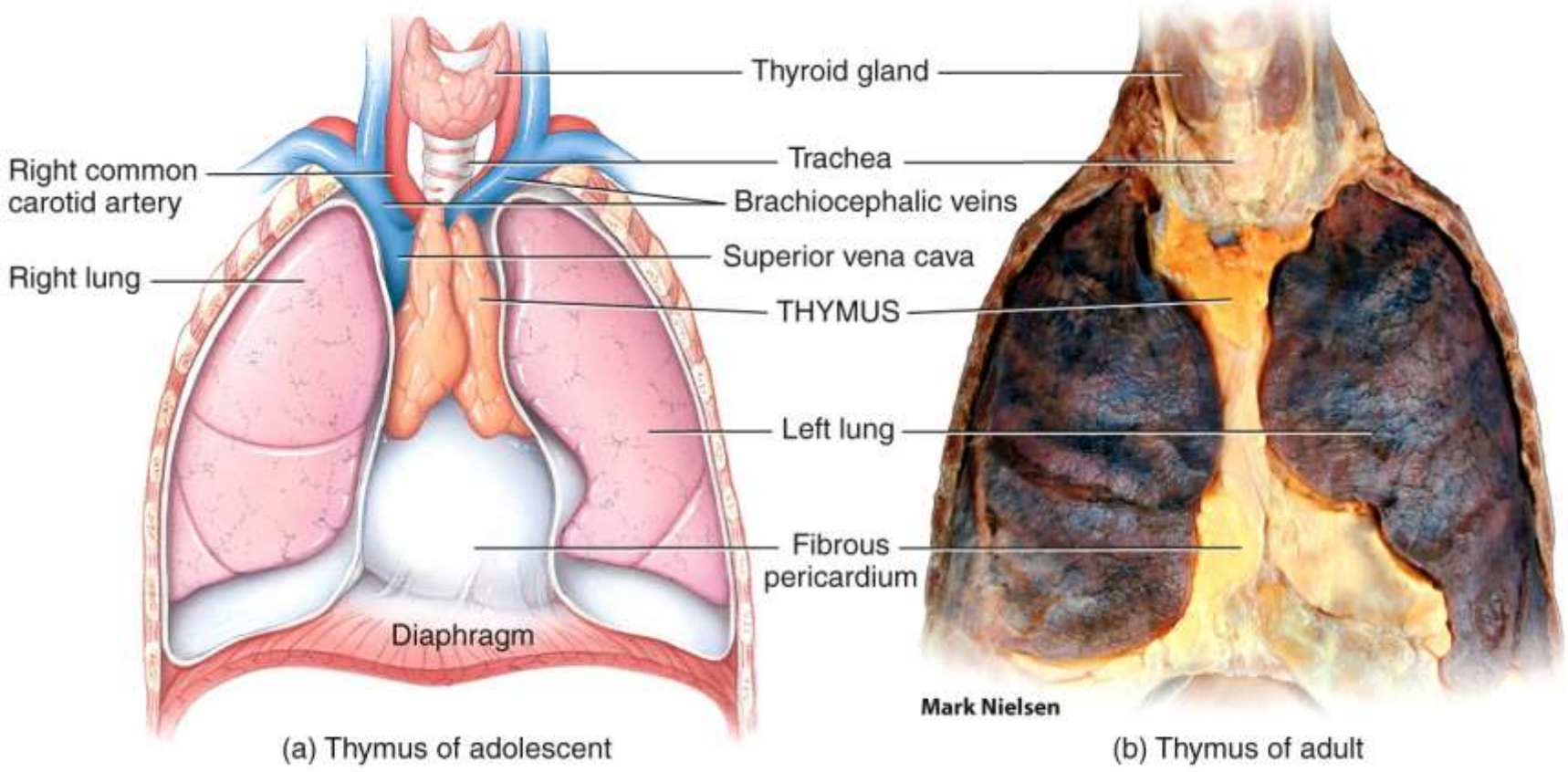
Thymus



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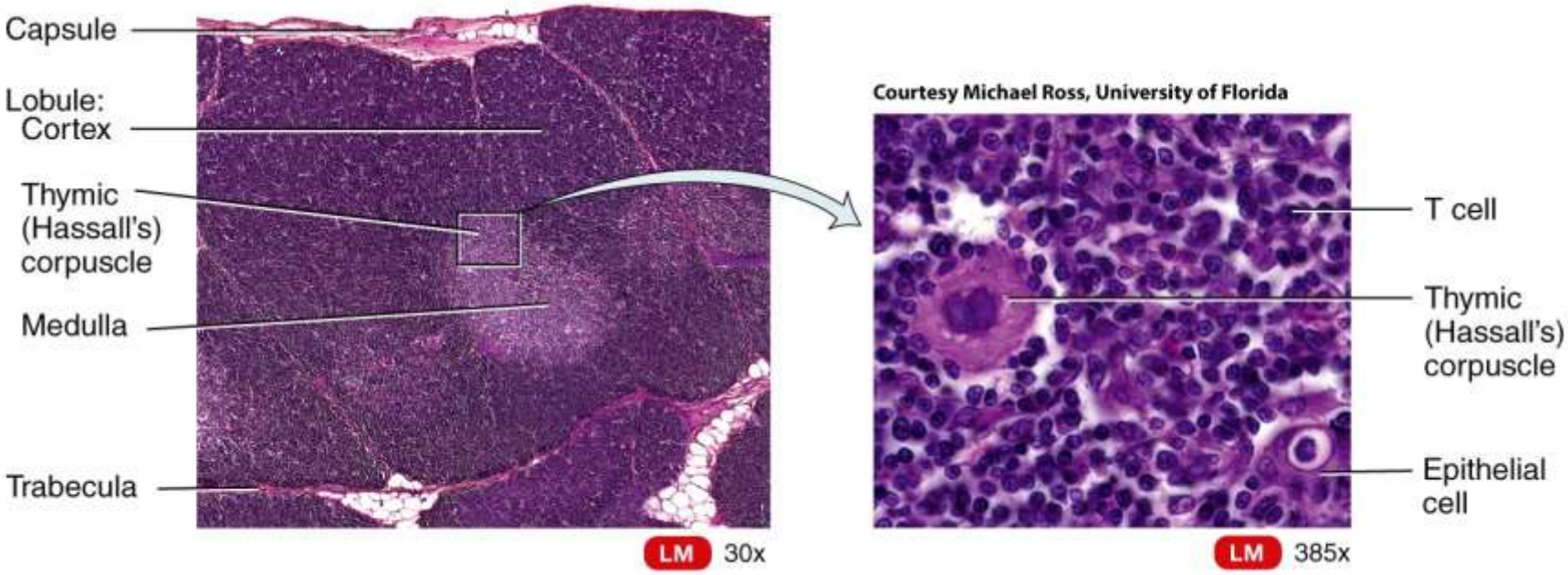
Thymus



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Clinical Connection

- **Edema:** is the medical term for swelling. Body parts swell from injury or inflammation. It can affect a small area or the entire body. Medications, pregnancy, infections, and many other medical problems can cause edema.
- **Edema** happens when your small blood vessels leak fluid into nearby tissues.

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Lymph Nodes

- Along lymphatic vessels, there are about 600 bean-shaped lymph nodes.
- The capsular extensions, called trabeculae, divide a node into compartments.
- Stroma
- The parenchyma of a lymph node is divided into a superficial cortex and a deep medulla.

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Lymph Nodes

- Inner cortex (paracortex)
- Medulla
- Afferent lymphatic vessels
- Sinuses
  - Subscapular sinus
  - Trabecular sinuses
  - Medullary sinuses
- Efferent lymphatic vessels
- Hilum

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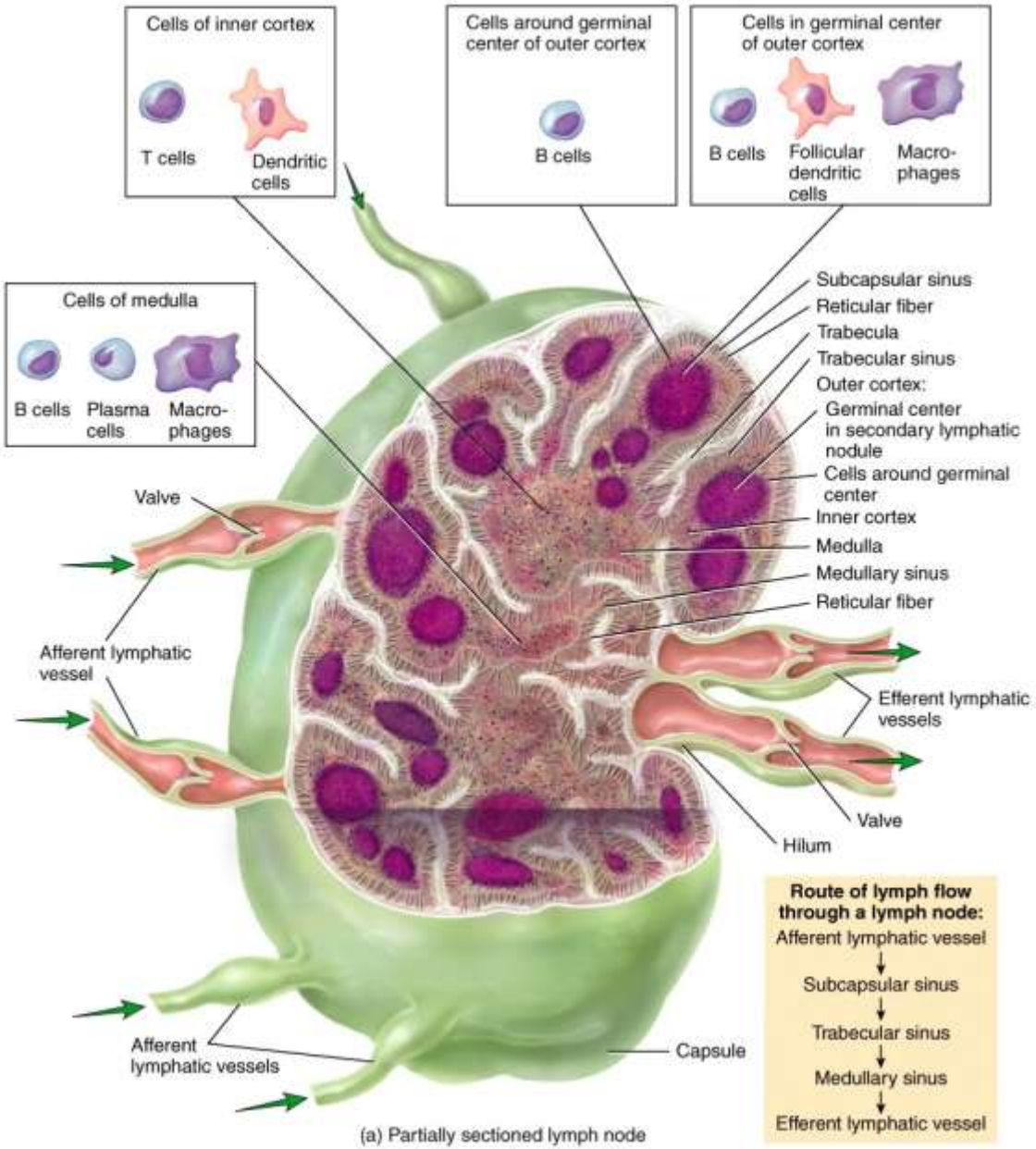
Structure of a Lymph Node



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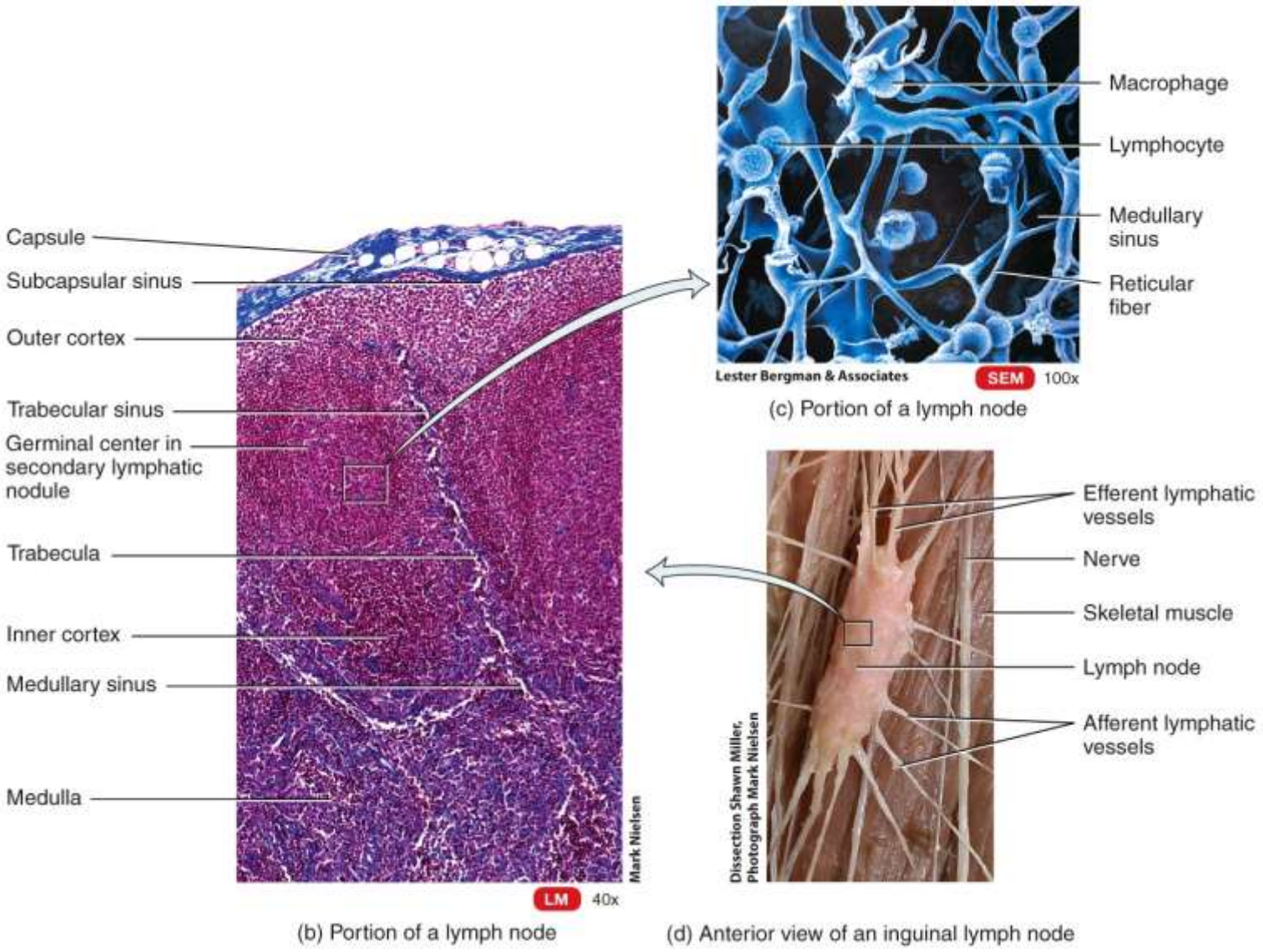
Structure of a Lymph Node



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Spleen

- The largest single mass of lymphatic tissue in the body
- White pulp
- Red pulp
- Splenic (Billroth’s) cords

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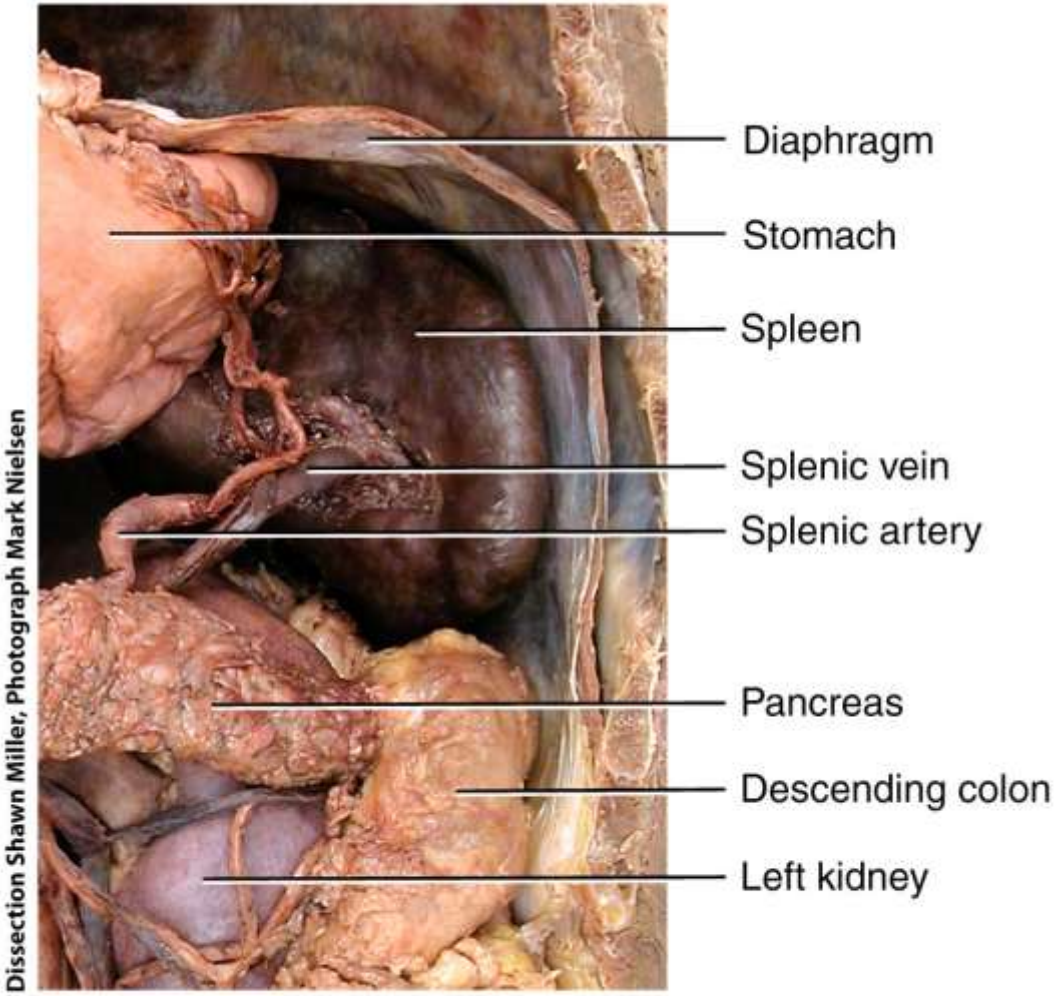
Structure of the Spleen



(a) Anterior view of portion of abdominal cavity

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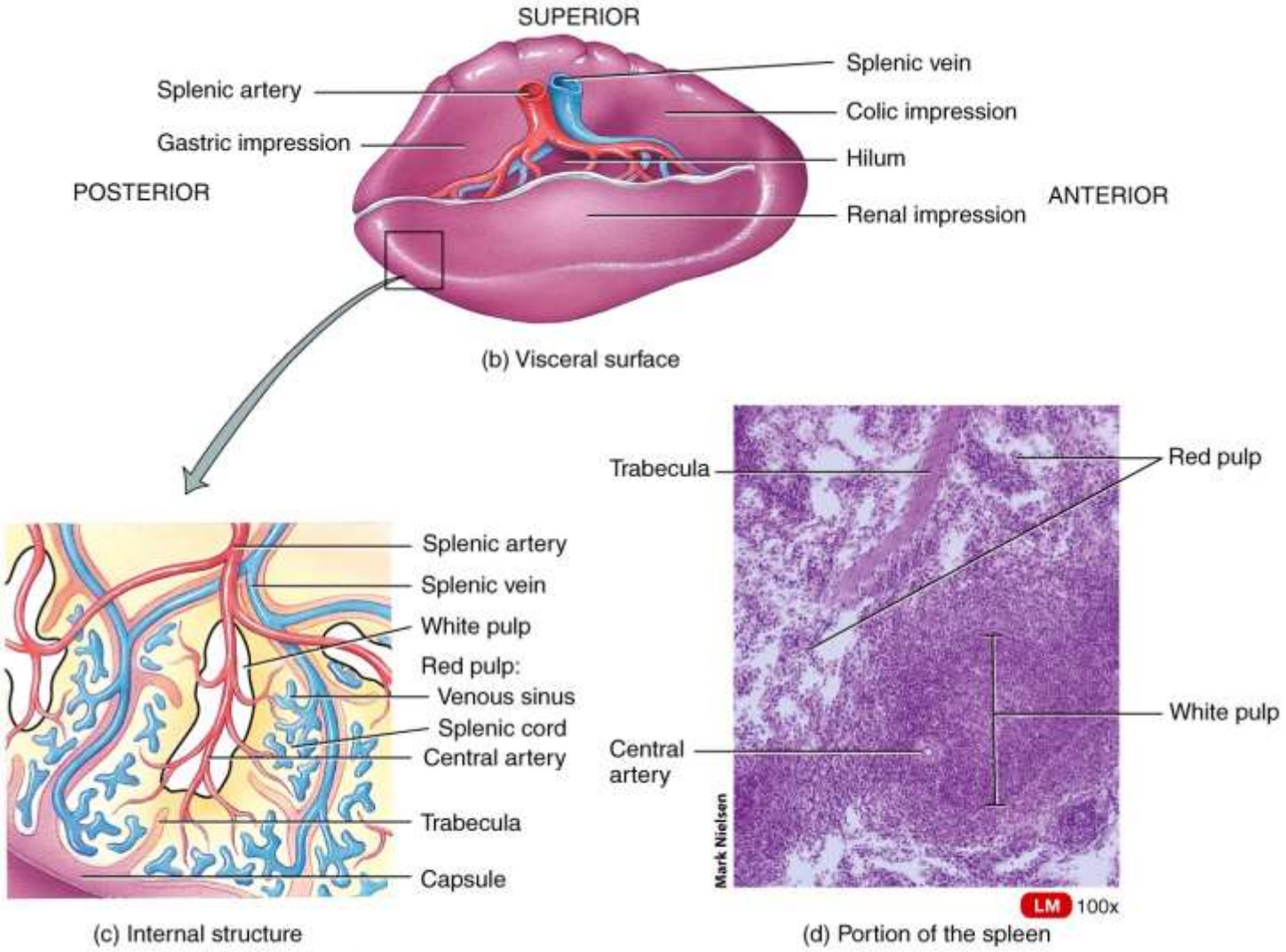
Structure of the Spleen



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Clinical Connection

- **Ruptured spleen:** is an emergency medical condition that occurs when the capsule-like covering of the spleen breaks open, pouring blood into your abdominal area. Depending on the size of the rupture, a large amount of internal bleeding can occur. Your doctor may refer to a ruptured spleen as a "splenic rupture
- **EBV – Epstein Barr Virus (Mononucleosis) :** or EBV, is one of the most common human viruses in the world. It spreads primarily through saliva which is why some people refer to it as the ***kissing disease***.
- EBV can cause infectious mononucleosis, also called mono, and other illnesses. Most people will get infected with EBV in their lifetime and will not have any symptoms.

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Lymphatic Nodules

- Mucosa-associated lymphatic tissue (MALT)
- Aggregated lymphatic follicles (Peyer's patches)
- Tonsils
  - Pharyngeal tonsil (adenoid)
  - Palatine tonsils
  - Tonsilar fossa
  - Lingual tonsils
  - Crypts

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Clinical Connection

- **Tonsillitis :** is inflammation of the tonsils, typically of rapid onset. It is a type of pharyngitis.
- **Symptoms** may include sore throat, fever, enlargement of the tonsils, trouble swallowing, and large lymph nodes around the neck.
- **Complications** include peritonsillar abscess.
- **Diagnostic method:** Based on symptoms, throat swab
- **Causes:** Viral infection, bacterial infection

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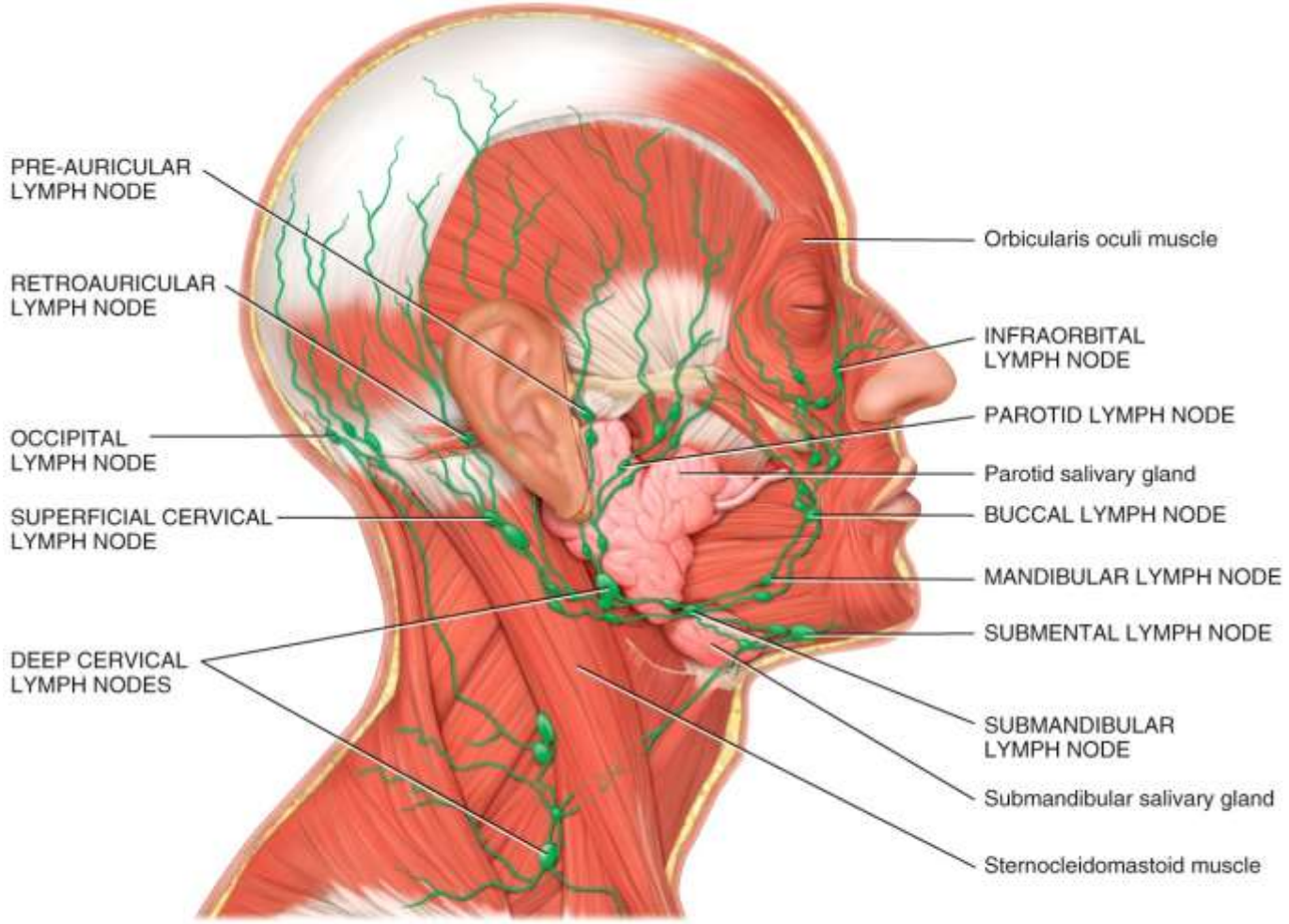
Principal Lymph Nodes of the Head and Neck



Lateral view of lymph nodes of the head and neck

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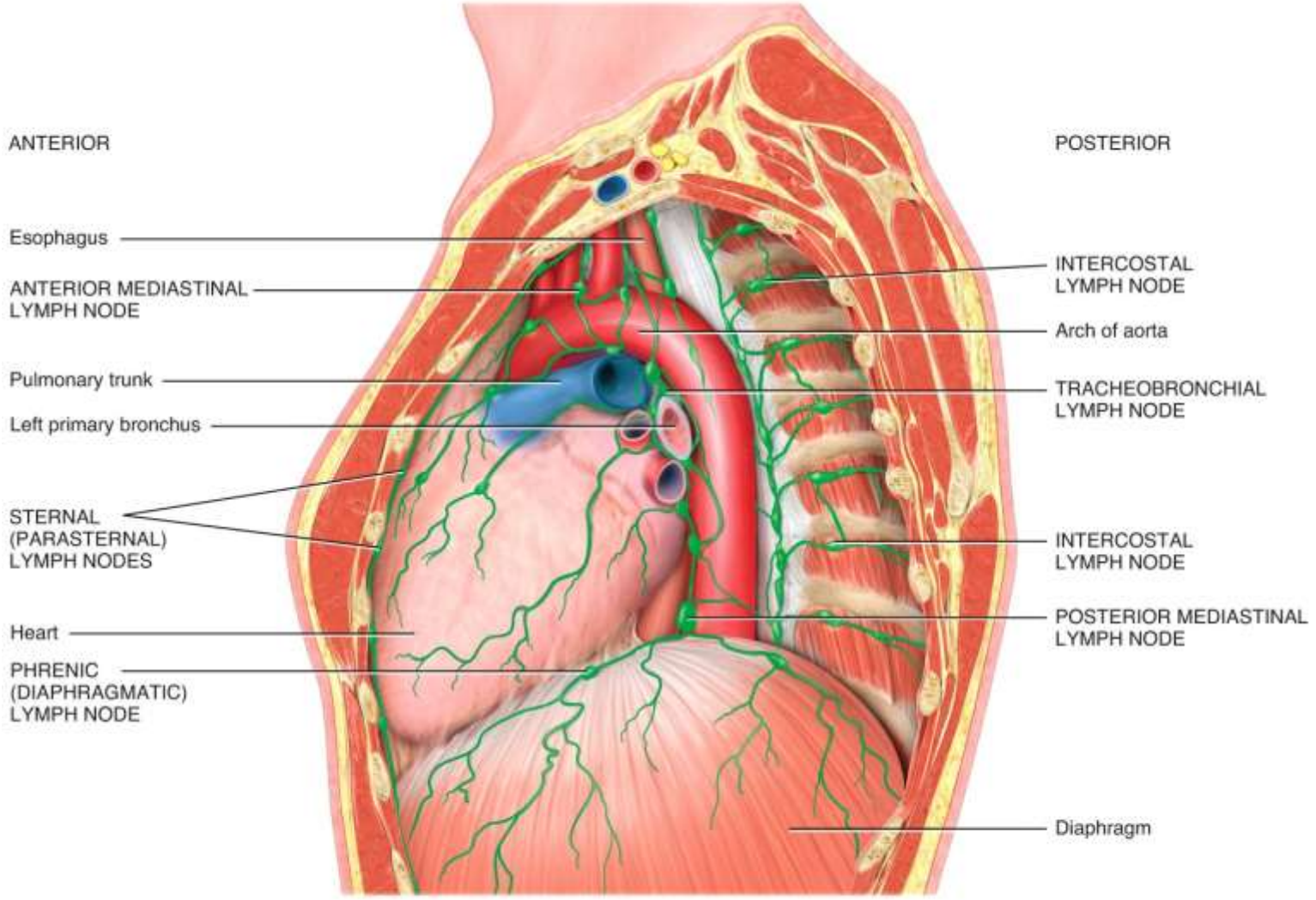
Principal Lymph Nodes of the Thorax



View from left side showing thoracic lymph nodes

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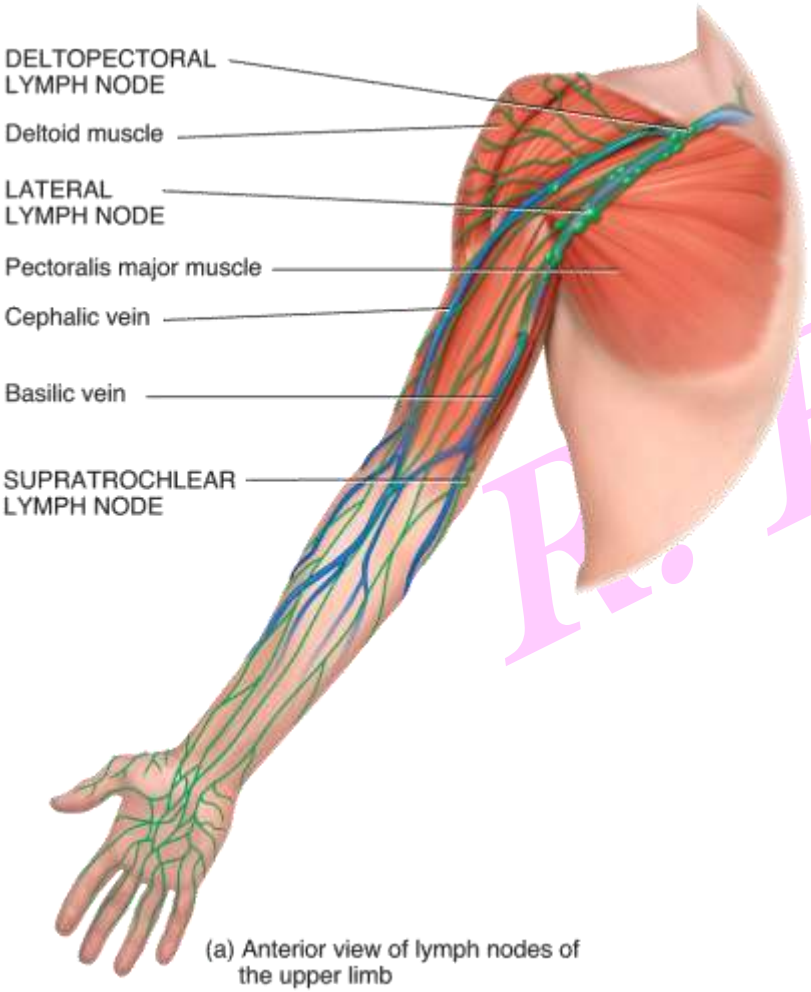
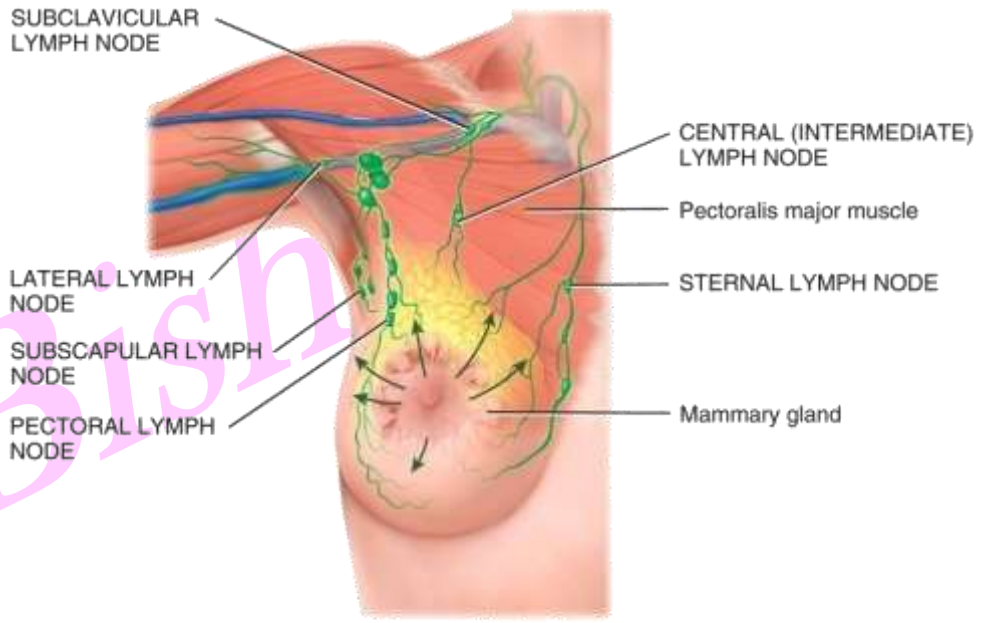
Principal Lymph Nodes of the Upper Limbs



(a) Anterior view of lymph nodes of the upper limb



(b) Anterior view of mostly axillary lymph nodes. Arrows indicate the direction of drainage.

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Clinical Connection

- **Breast cancer and metastasis:** Metastatic breast cancer, also known as advanced, secondary, or Stage IV breast cancer, is the spread of cancerous cell growth to areas of the body other than where the cancer first formed.
- This may happen before or after treatment of the cancer in the breast, or it may occur from a recurrent breast cancer (breast cancer that returns following a period where it could not be detected).
- Though breast cancer cells can spread to almost any part of the body, they most commonly spread to nearby lymph nodes and the bones. Other common sites include the lungs, liver, brain and skin. It is this new cancer that is called a metastasis

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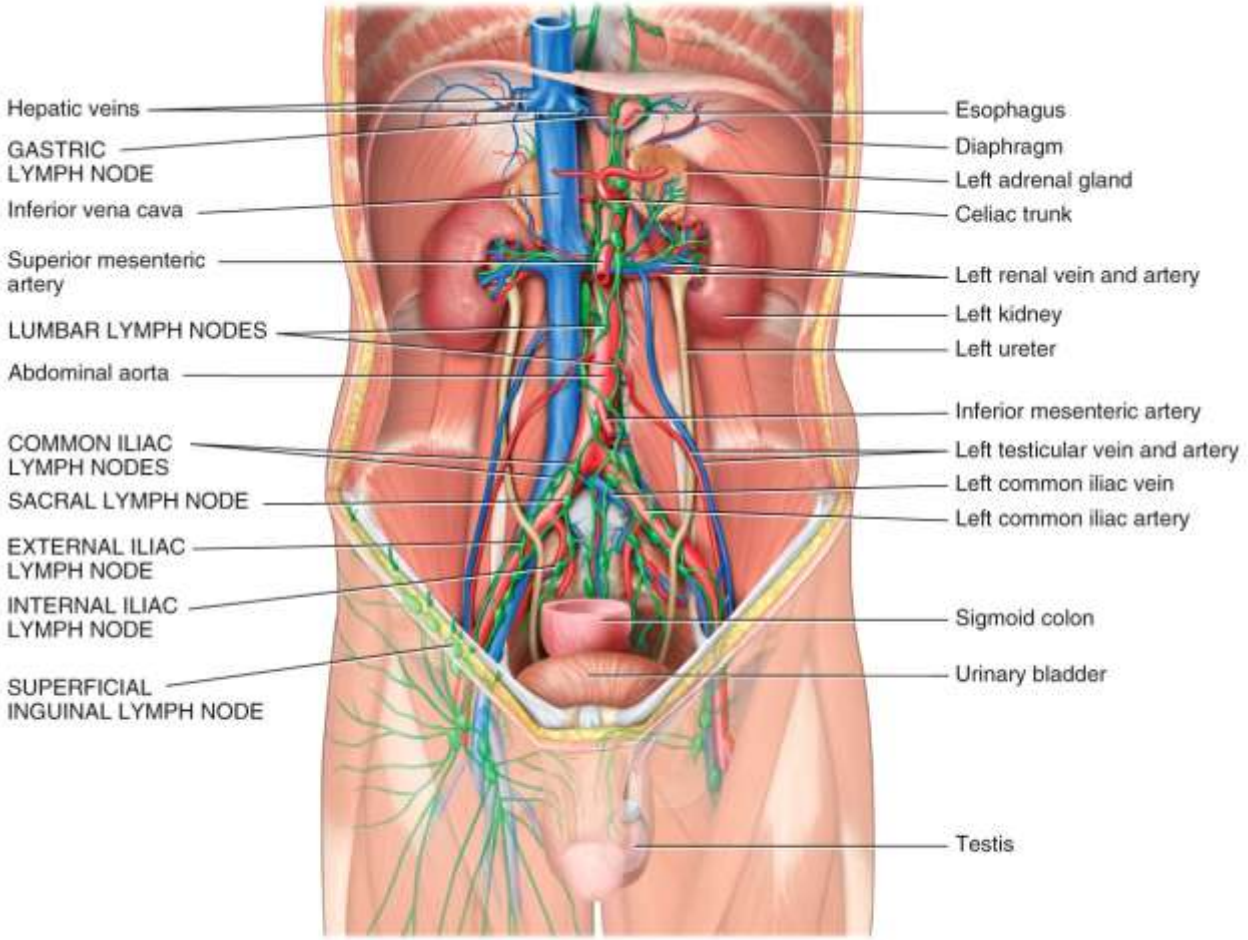
Principal Lymph Nodes of the Abdomen and Pelvis



(a) Anterior view of abdominal and pelvic lymph nodes

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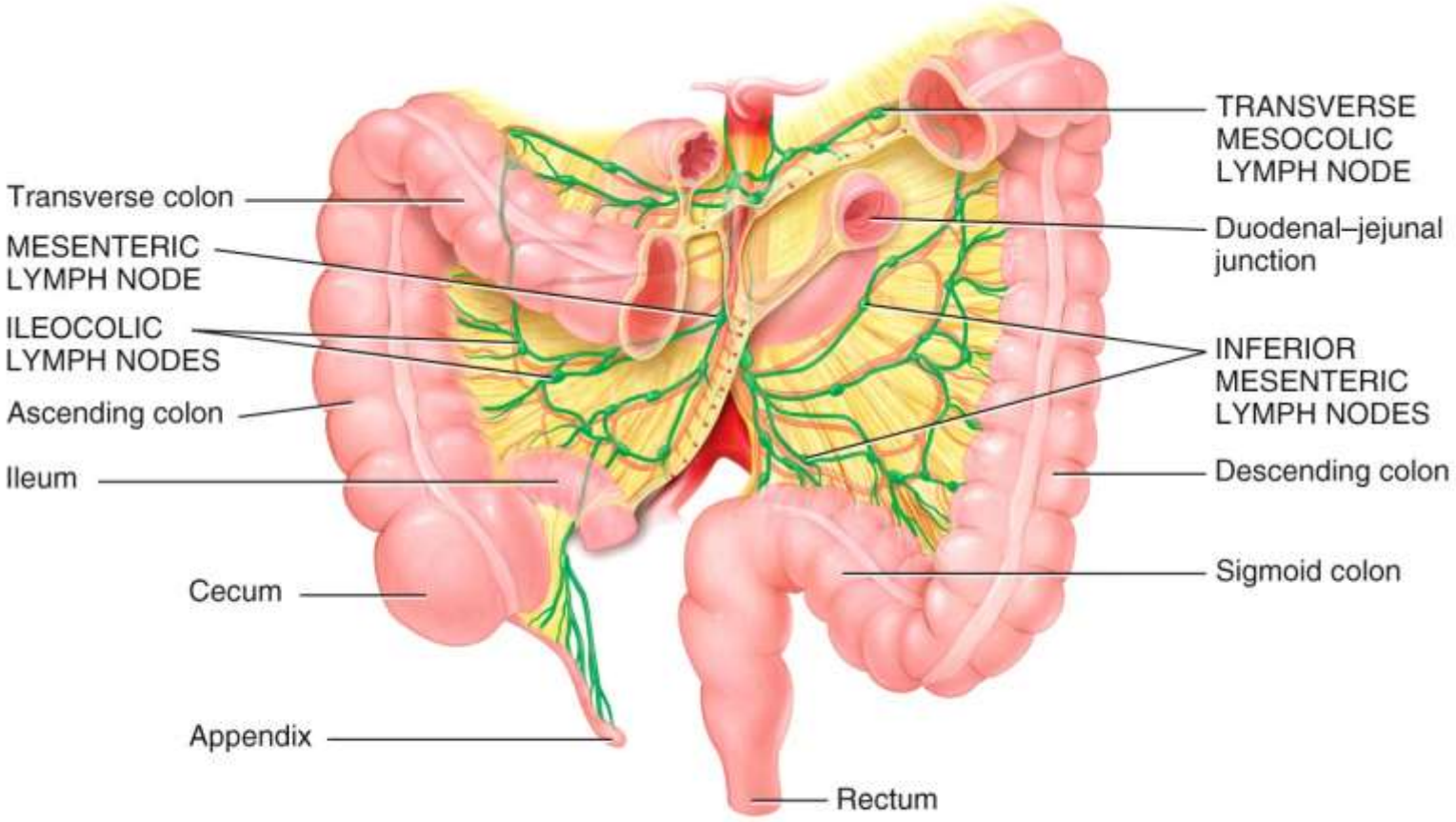
Principal Lymph Nodes of the Abdomen and Pelvis



(b) Anterior view of superior and inferior mesenteric lymph nodes

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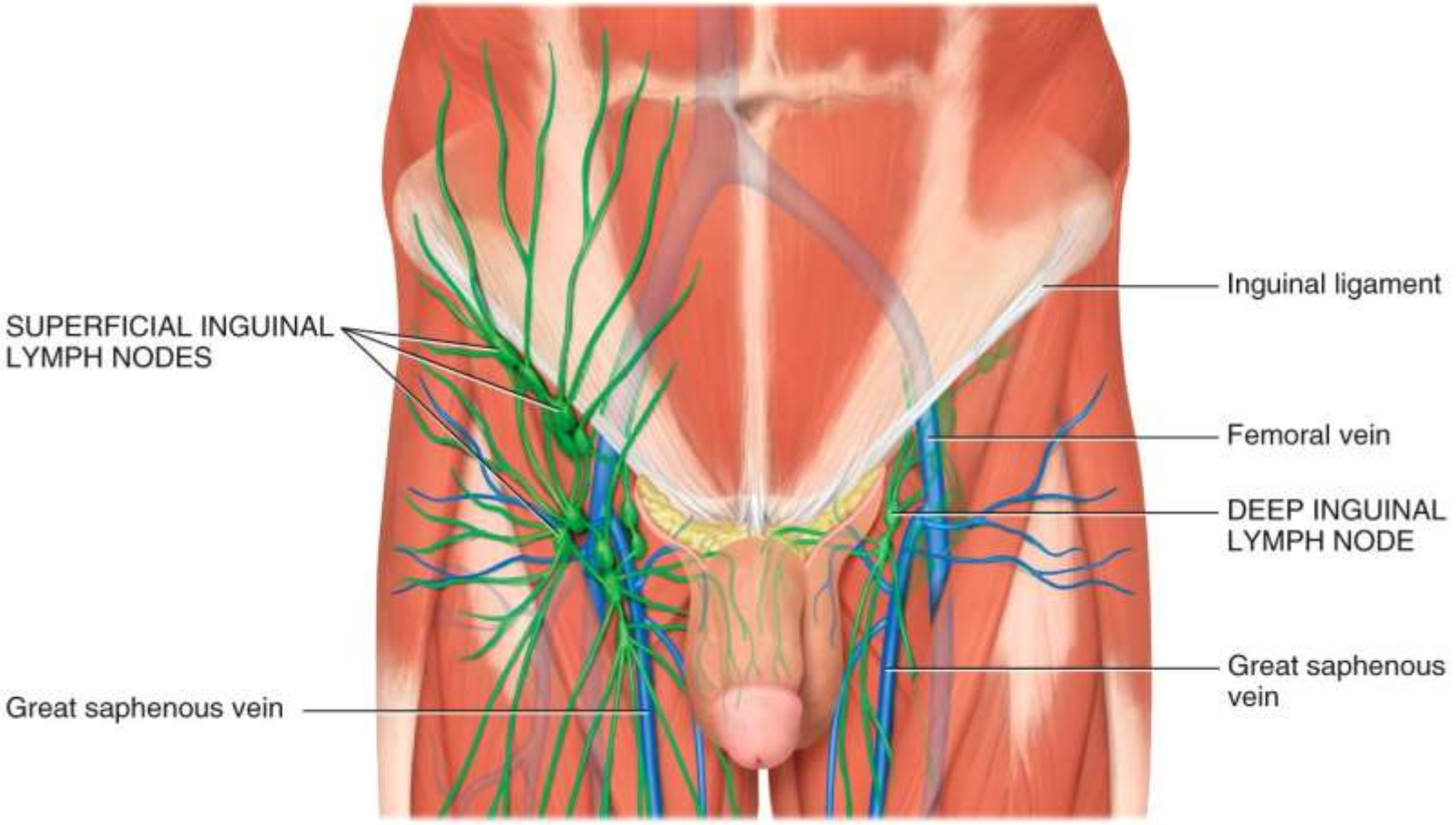
Principal Lymph Nodes of the Lower Limbs



(a) Anterior view of inguinal lymph nodes

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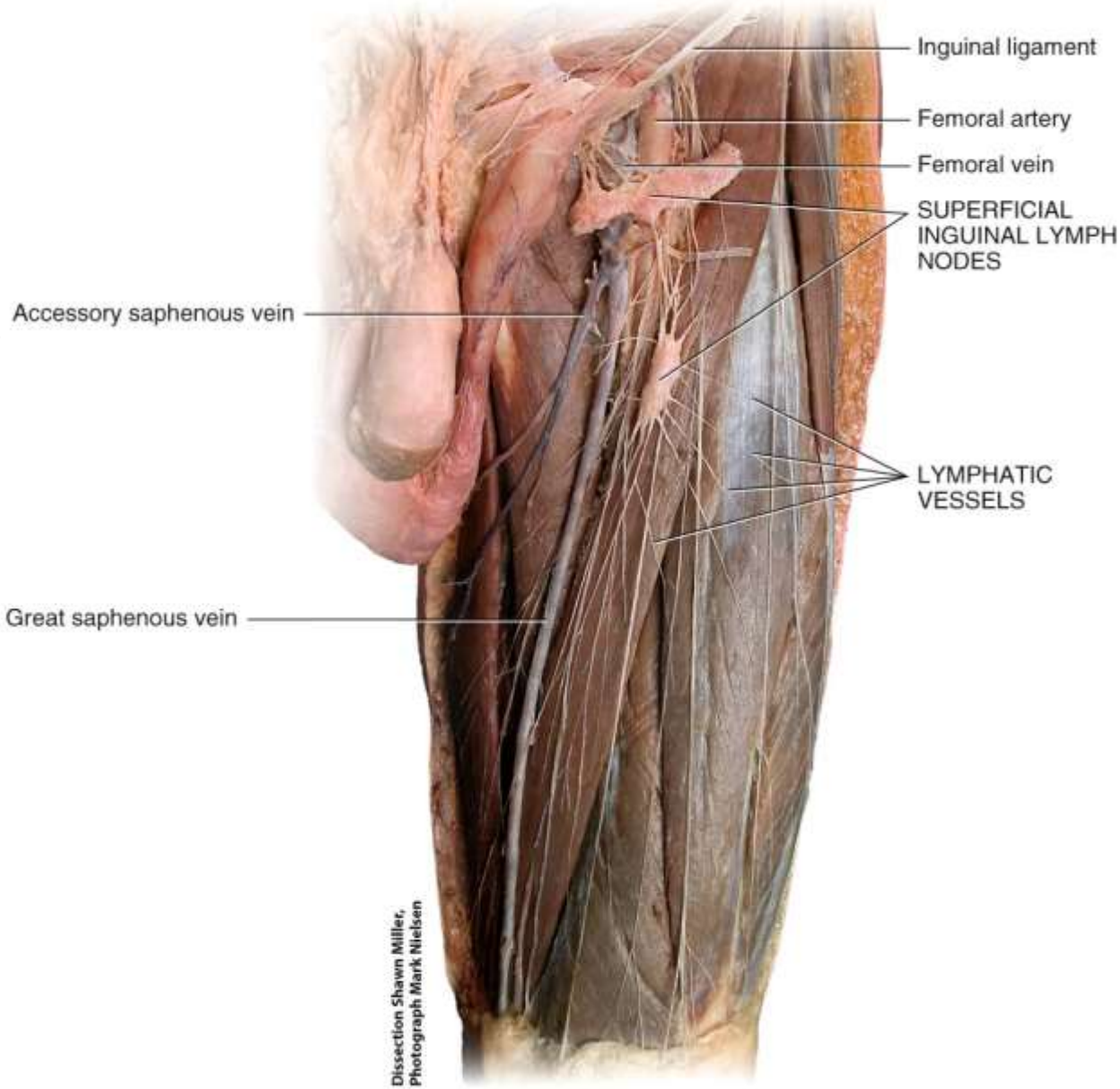
Principal Lymph Nodes of the Lower Limbs



(b) Anterior view of inguinal lymph nodes and lymphatic vessels of the thigh

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Clinical Connections

- **Acquired Immunodeficiency Syndrome:**

  A disease of the immune system due to infection with HIV. HIV destroys the CD4 T lymphocytes (CD4 cells) of the immune system, leaving the body vulnerable to life-threatening infections and cancers.
- **CD4 count (or T-cell count):**
- These are the cells that the HIV virus kills. As HIV infection progresses, the number of these cells declines.
- When the CD4 count drops below 200, a person is diagnosed with AIDS. A normal range for CD4 cells is about 500-1,500.

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