

Lymphatic System

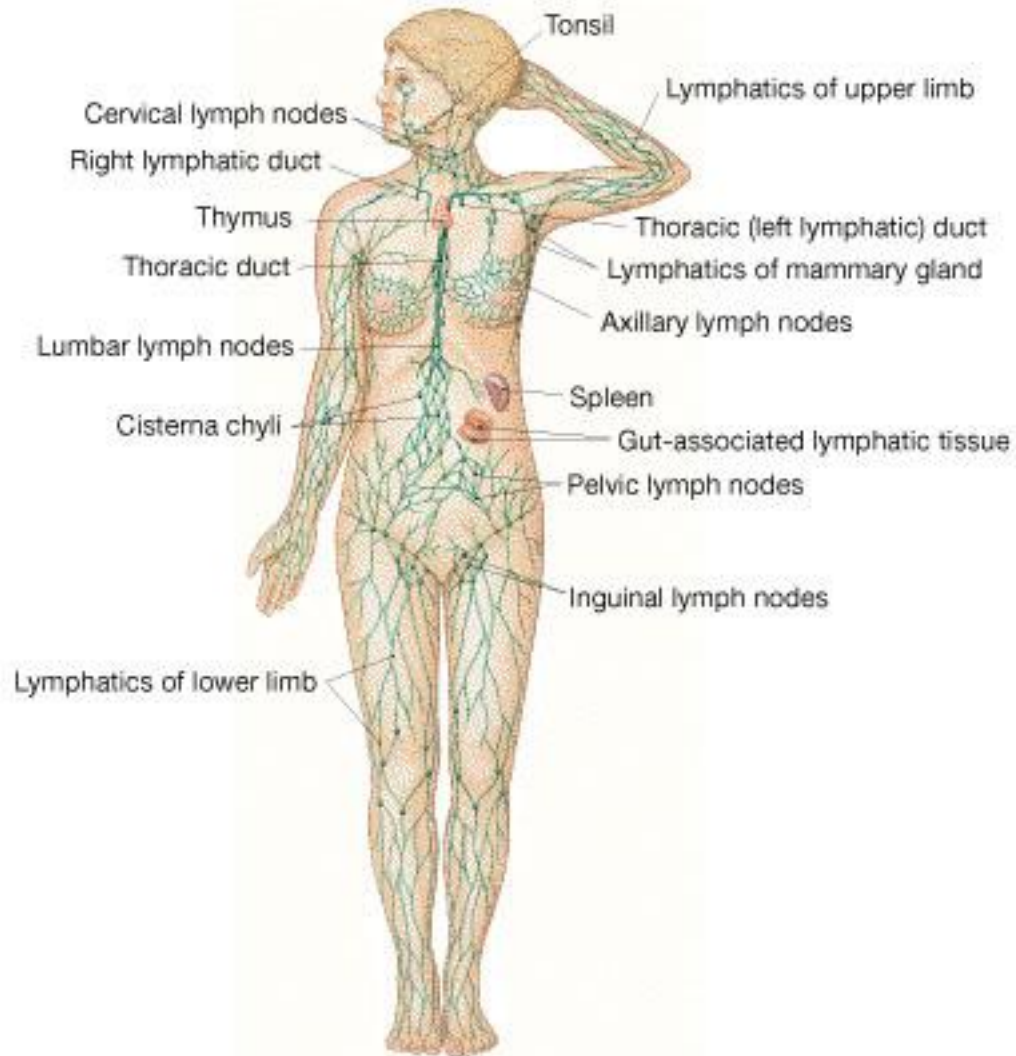
Components

- **Lymph:** a fluid
- Vessels – **lymphatics**
- Structures & organs: nodes, nodules, tonsils, bone marrow, spleen, thymus

Functions

- Return tissue fluid to the blood stream
- Transport fats from the digestive tract to the bloodstream
- Surveillance & defense

The Lymphatic System



Lymphatics

Originate as lymph capillaries

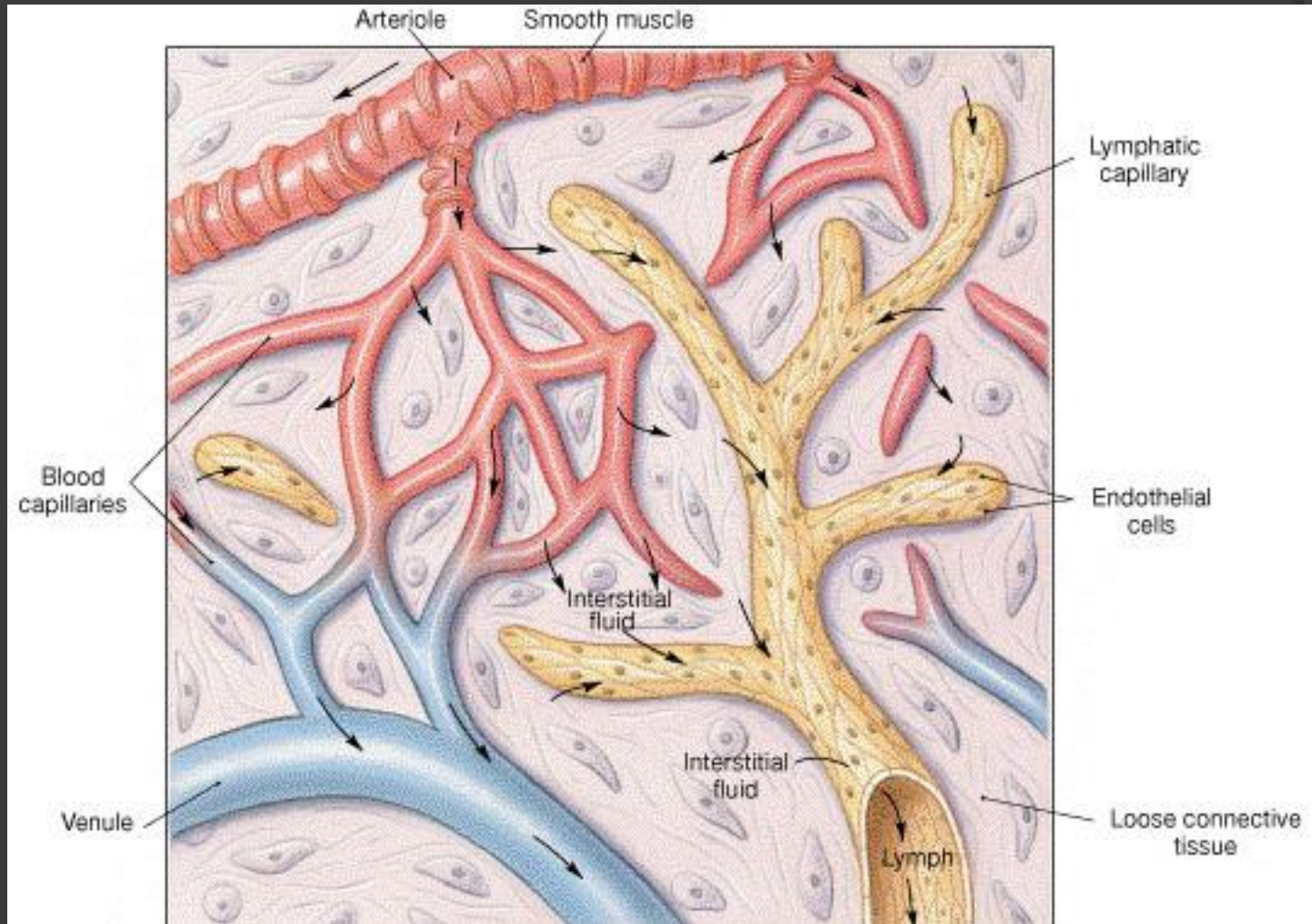
Capillaries unite to form larger vessels

- Resemble veins in structure
- Connect to lymph nodes at various intervals

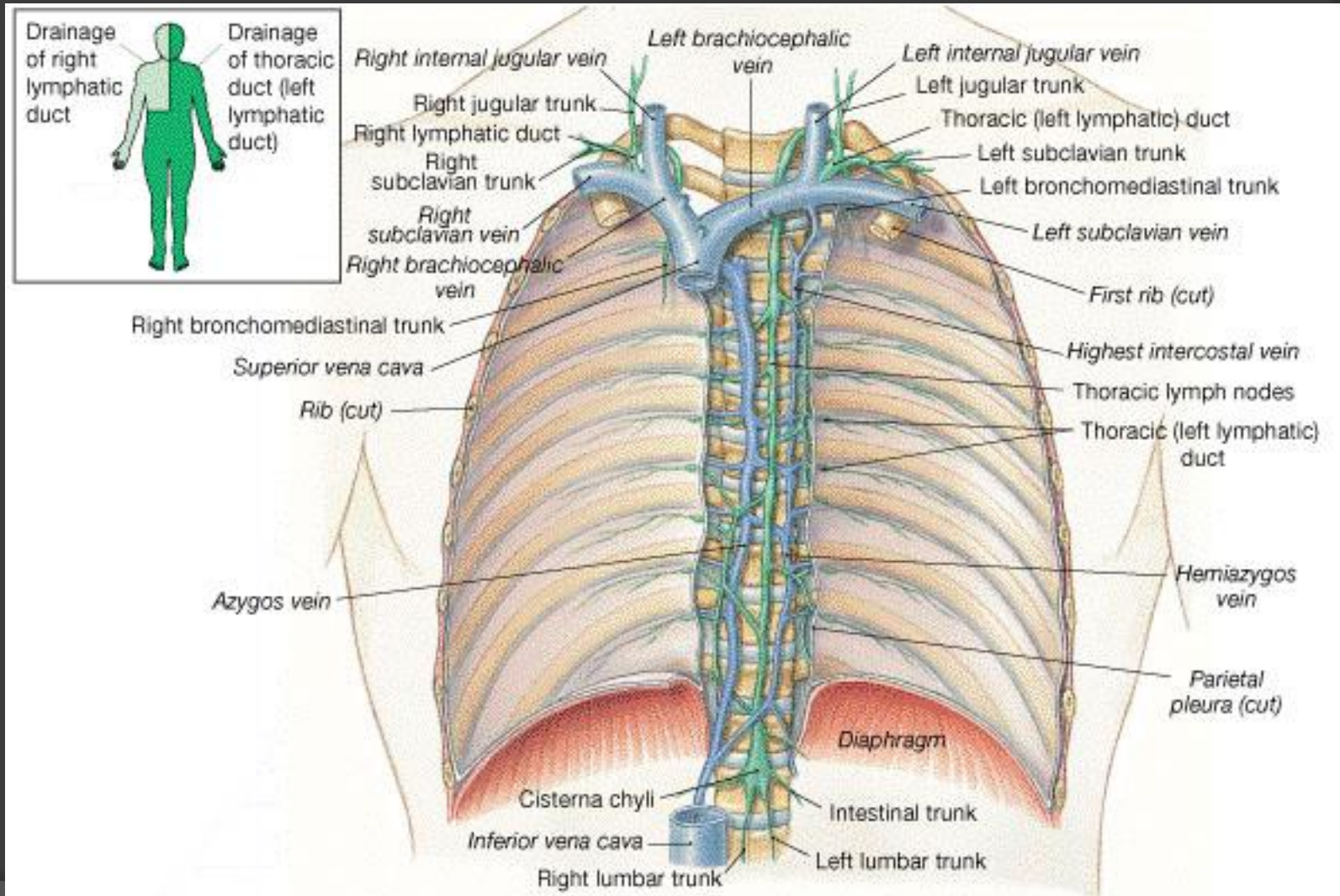
Lymphatics ultimately deliver lymph into 2 main channels

- Right lymphatic duct
 - Drains right side of head & neck, right arm, right thorax
 - Empties into the junction between the right subclavian and internal jugular veins.
- Thoracic duct
 - Drains the rest of the body
 - Empties into the junction between the left subclavian and internal jugular veins.

Lymph Capillaries



Main Channels of Lymphatics

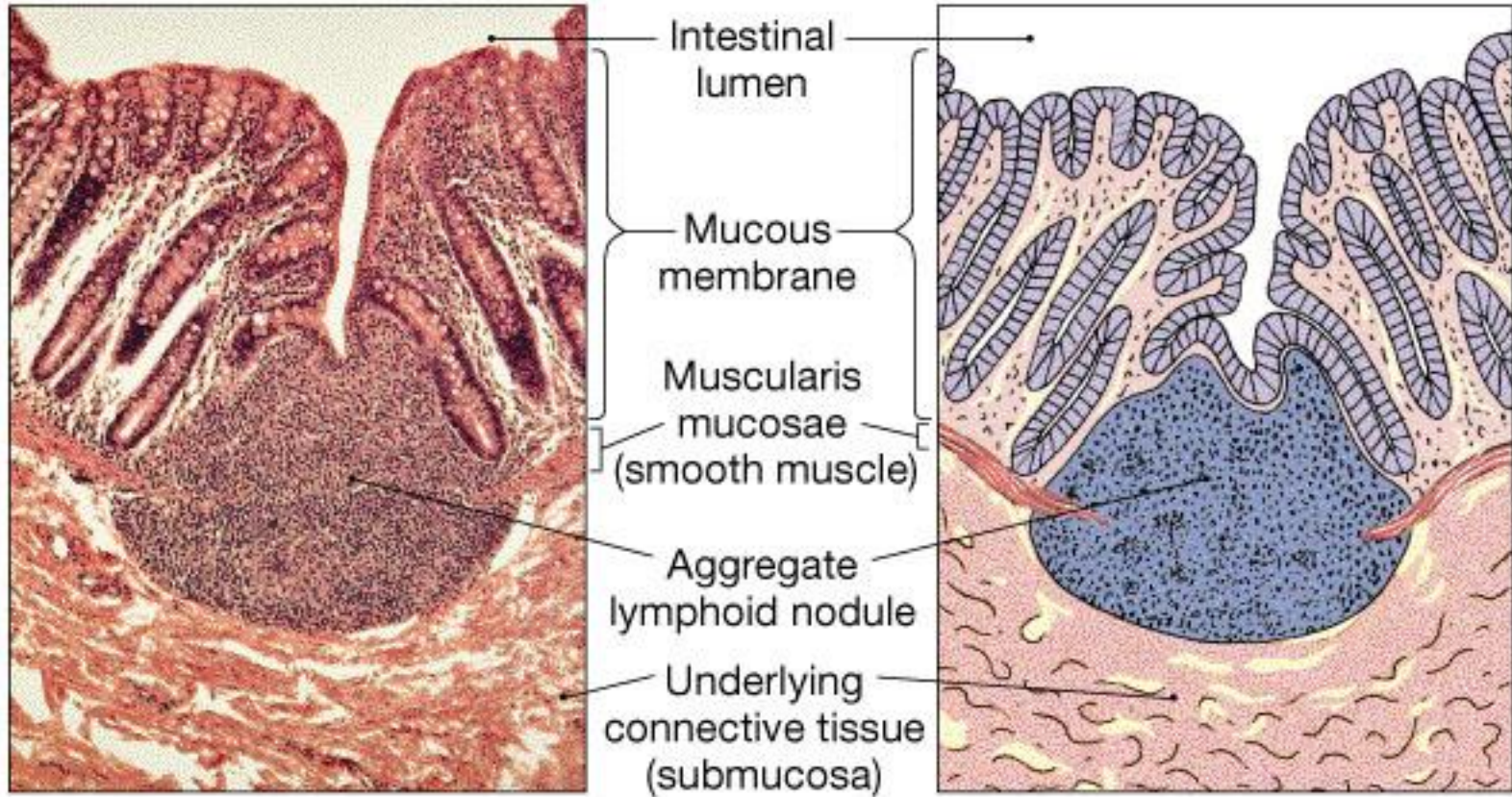


Lymph Tissue

3 types

- Diffuse lymphatic tissue
 - No capsule present
 - Found in connective tissue of almost all organs
- Lymphatic nodules
 - No capsule present
 - Oval-shaped masses
 - Found singly or in clusters
- Lymphatic organs
 - Capsule present
 - Lymph nodes, spleen, thymus gland

Lymph Nodules



(a) Lymphoid nodule

Lymph Node

Lymph nodes are the principal lymphoid organs of the body

Nodes are imbedded in connective tissue and clustered along lymphatic vessels

Aggregations of these nodes occur near the body surface in inguinal, axillary, and cervical regions of the body

The two basic functions of lymph nodes are:

- Filtration – macrophages destroy microorganisms and debris
- Immune system activation – monitor for antigens and mount an attack against them

Structure of Lymph Node ..1

Nodes are bean shaped and surrounded by a fibrous capsule

Trabeculae extended inward from the capsule and divide the node into compartments

Nodes have two histologically distinct regions: a cortex and a medulla

Structure of Lymph Node ..2

The cortex contains follicles with germinal centers, heavy with dividing B cells

Dendritic cells nearly encapsulate the follicles

The deep cortex houses T cells in transit

T cells circulate continuously among the blood, lymph nodes, and lymphatic stream

Structure of Lymph Node ..3

Medullary cords extend from the cortex and contain B cells, T cells, and plasma cells

Throughout the node are lymph sinuses crisscrossed by reticular fibers

Macrophages reside on these fibers and phagocytize foreign matter

Circulation in Lymph Nodes

Lymph enters via a number of afferent lymphatic vessels

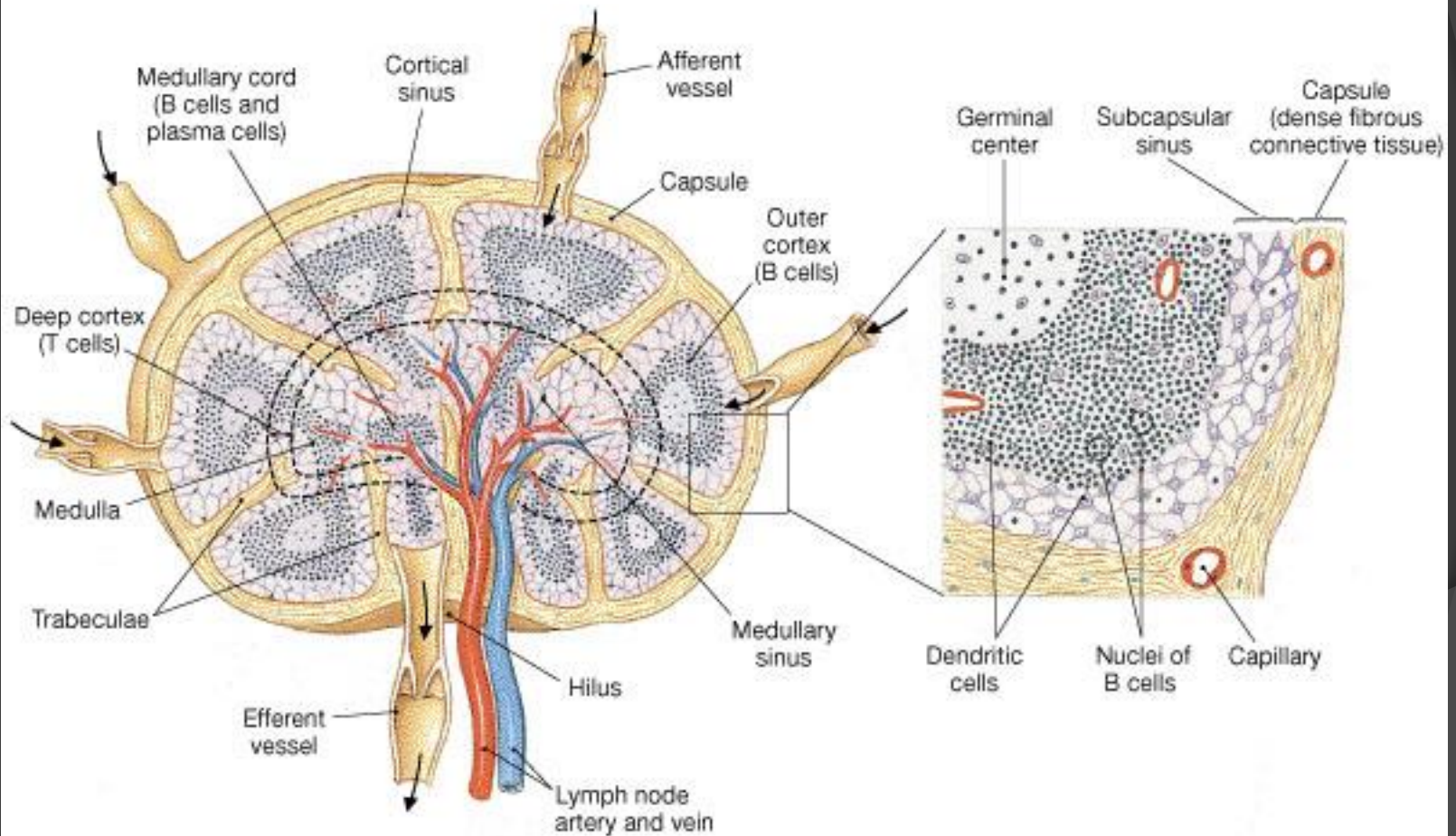
It then enters a large subcapsular sinus and travels into a number of smaller sinuses

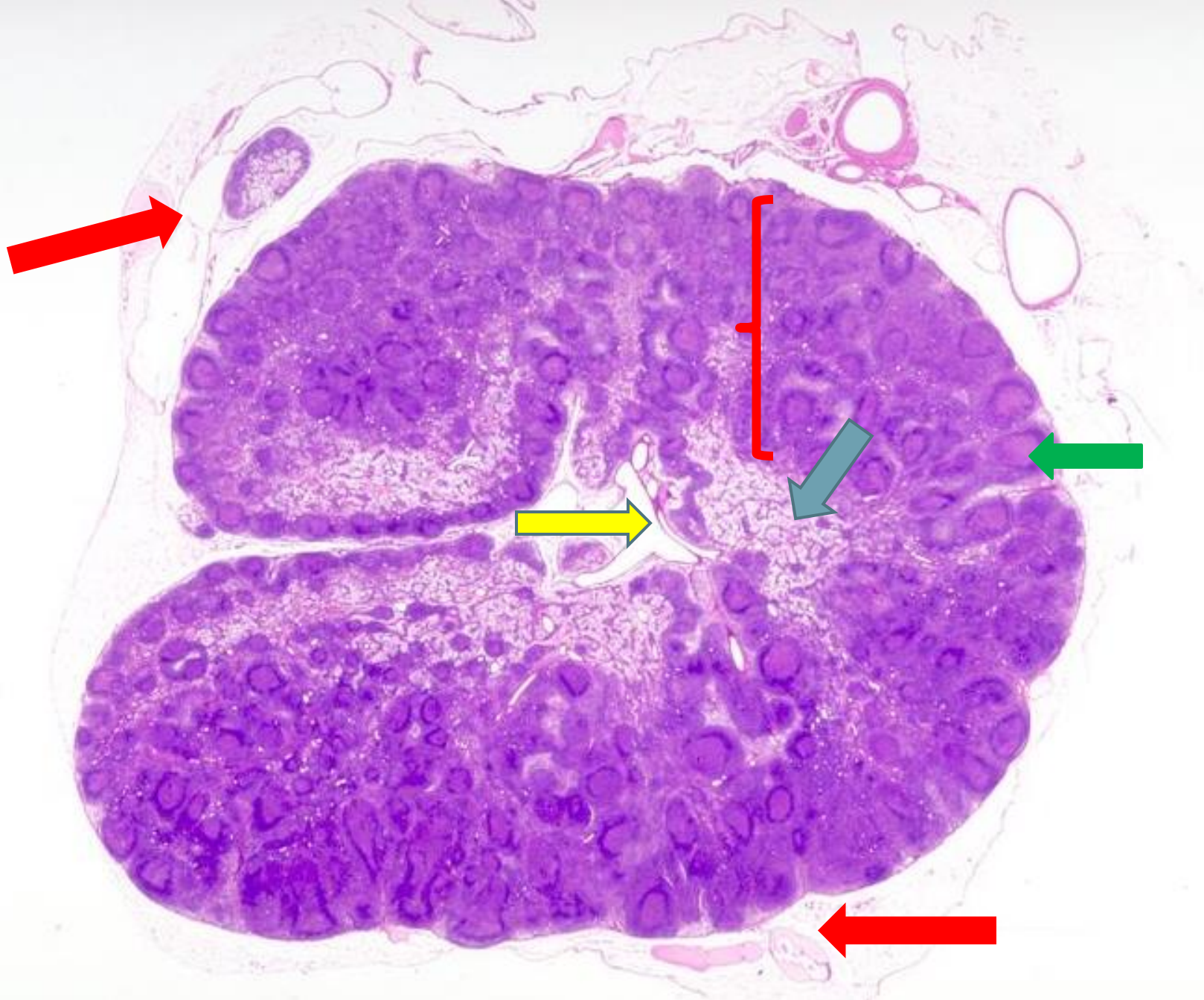
It meanders through these sinuses and exits the node at the hilus via efferent vessels

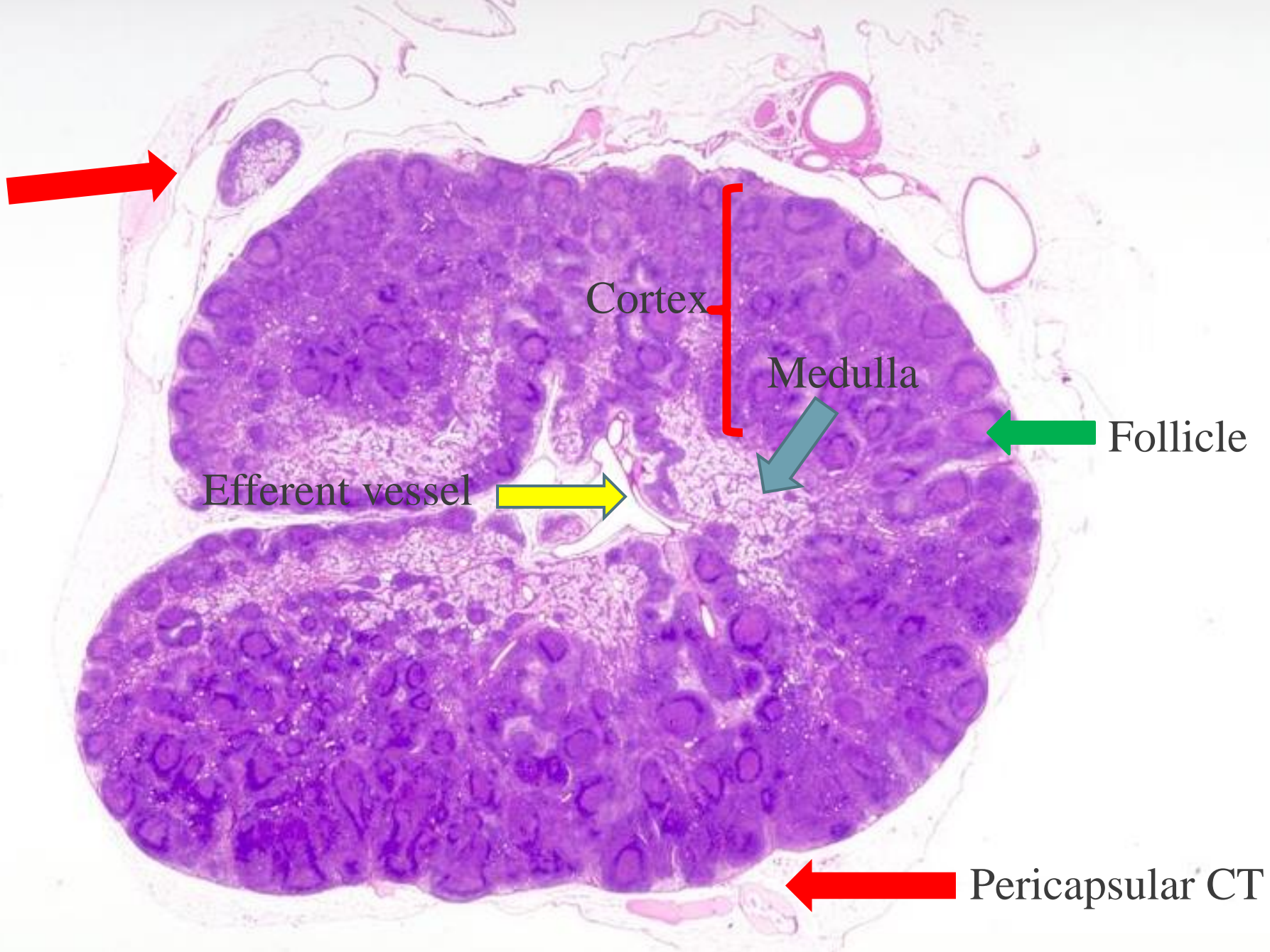
Because there are fewer efferent vessels, lymph stagnates somewhat in the node

This allows lymphocytes and macrophages time to carry out their protective functions

Lymph Node







Cortex

Medulla

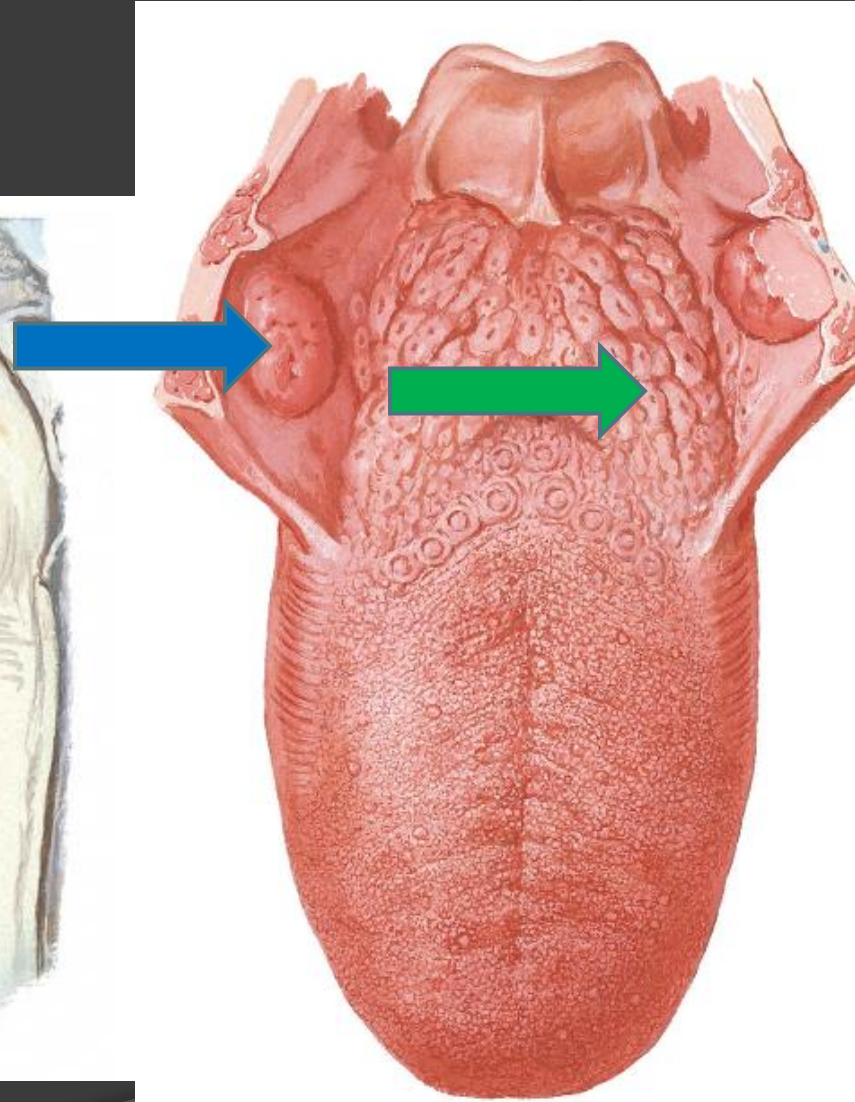
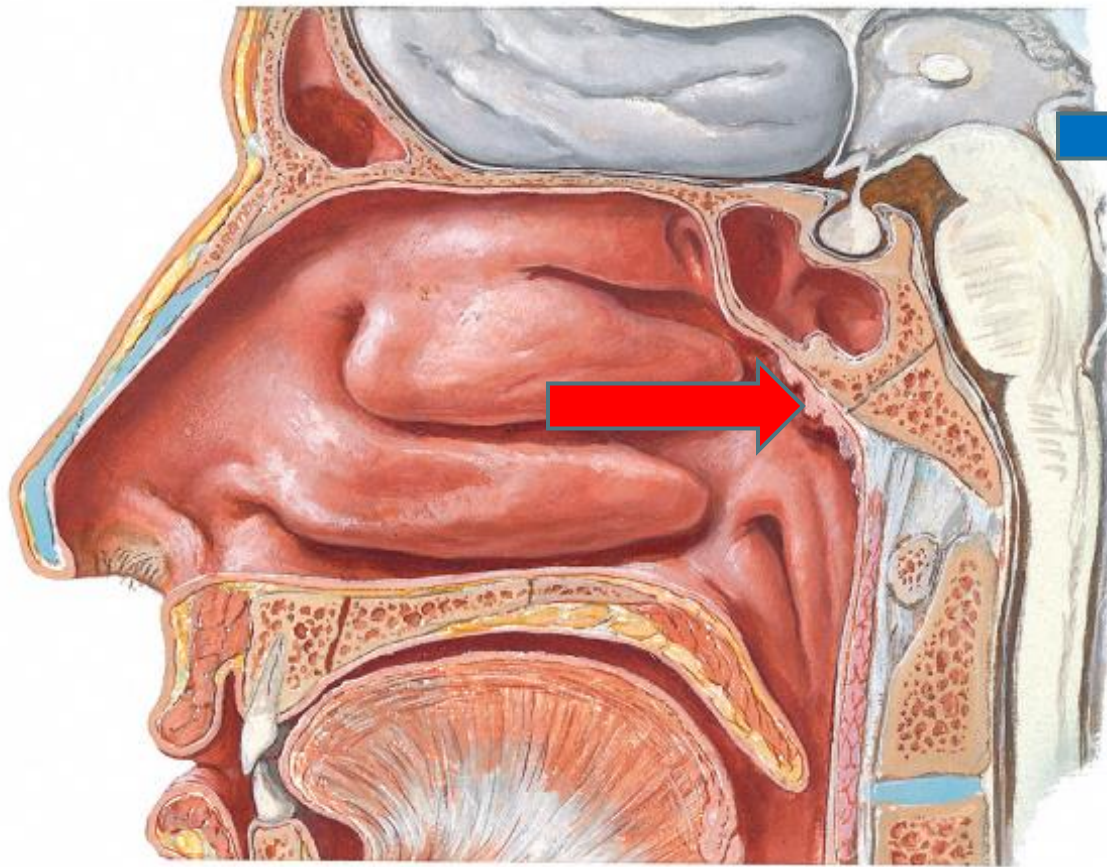
Follicle

Efferent vessel

Pericapsular CT

Tonsils

Tonsils



Simplest lymphoid organs; form a ring of lymphatic tissue around the pharynx

Location of the tonsils

- Palatine tonsils – either side of the posterior end of the oral cavity
- Lingual tonsils – lie at the base of the tongue
- Pharyngeal tonsil – posterior wall of the nasopharynx
- Tubal tonsils – surround the openings of the auditory tubes into the pharynx

Lymphoid tissue of tonsils contains follicles with germinal centers

Tonsil masses are not fully encapsulated

Epithelial tissue overlying tonsil masses invaginates, forming blind-ended crypts

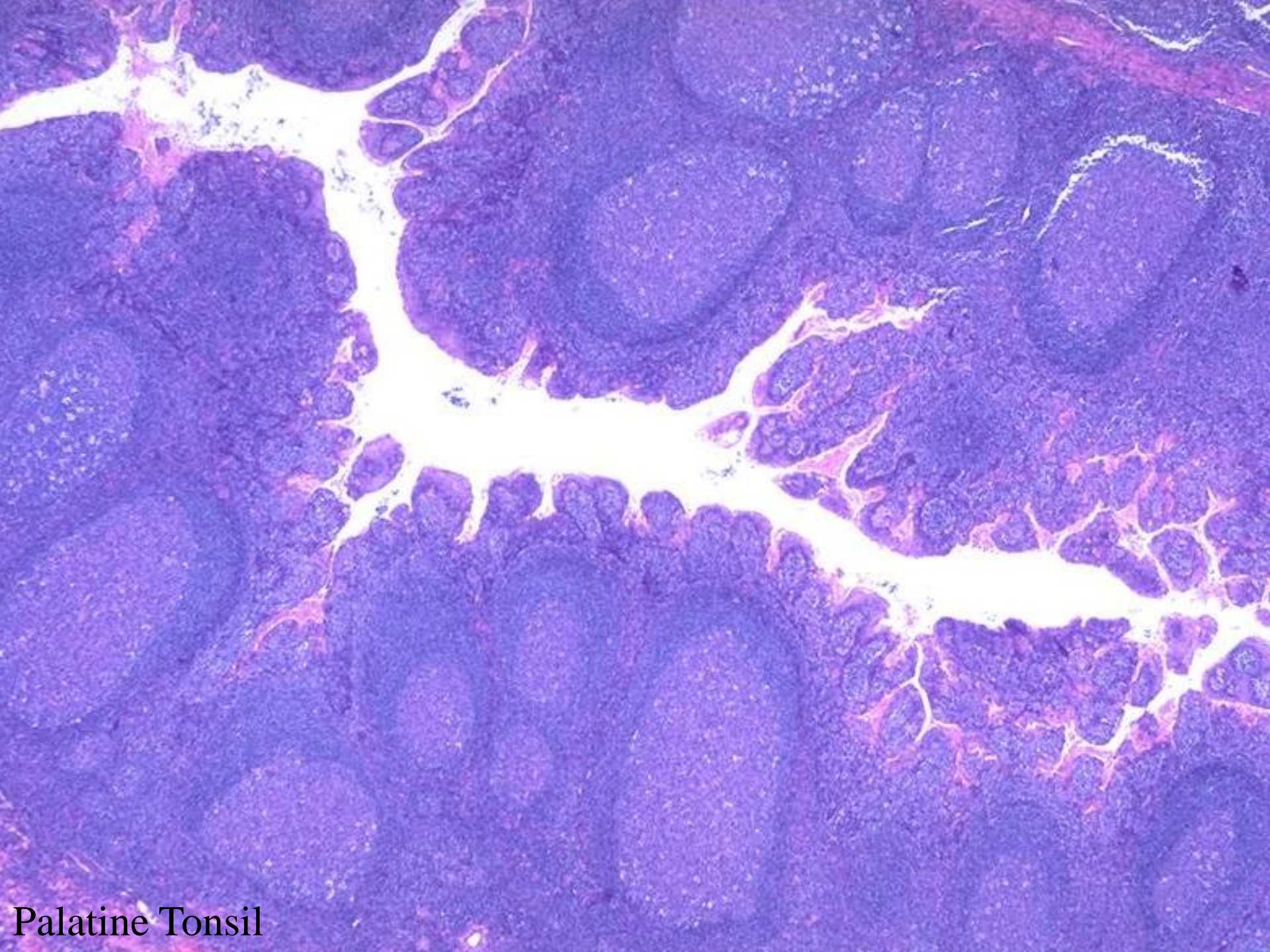
Crypts trap and destroy bacteria and particulate matter

Comparison of Tonsils

	Palatine	Pharyngeal	Lingual	Tubal
Lymph Nodules	Subepithelial in position			
Lymph Vessels	No afferents; blind origins of efferent			
Blood vessels	Arteries enter through the attached surface			
Capsule	Prominent C.T	Less definite	Thin or absent	absent
Cortex and medulla	Absent			
Hilum	Absent			
Epithelium	Stratified squamous	Respiratory	Stratified squamous	Respiratory
Diagnostic features	Deep crypts 10-20	No crypts	Single crypt	Associated with Eustachian tube



Palatine Tonsil



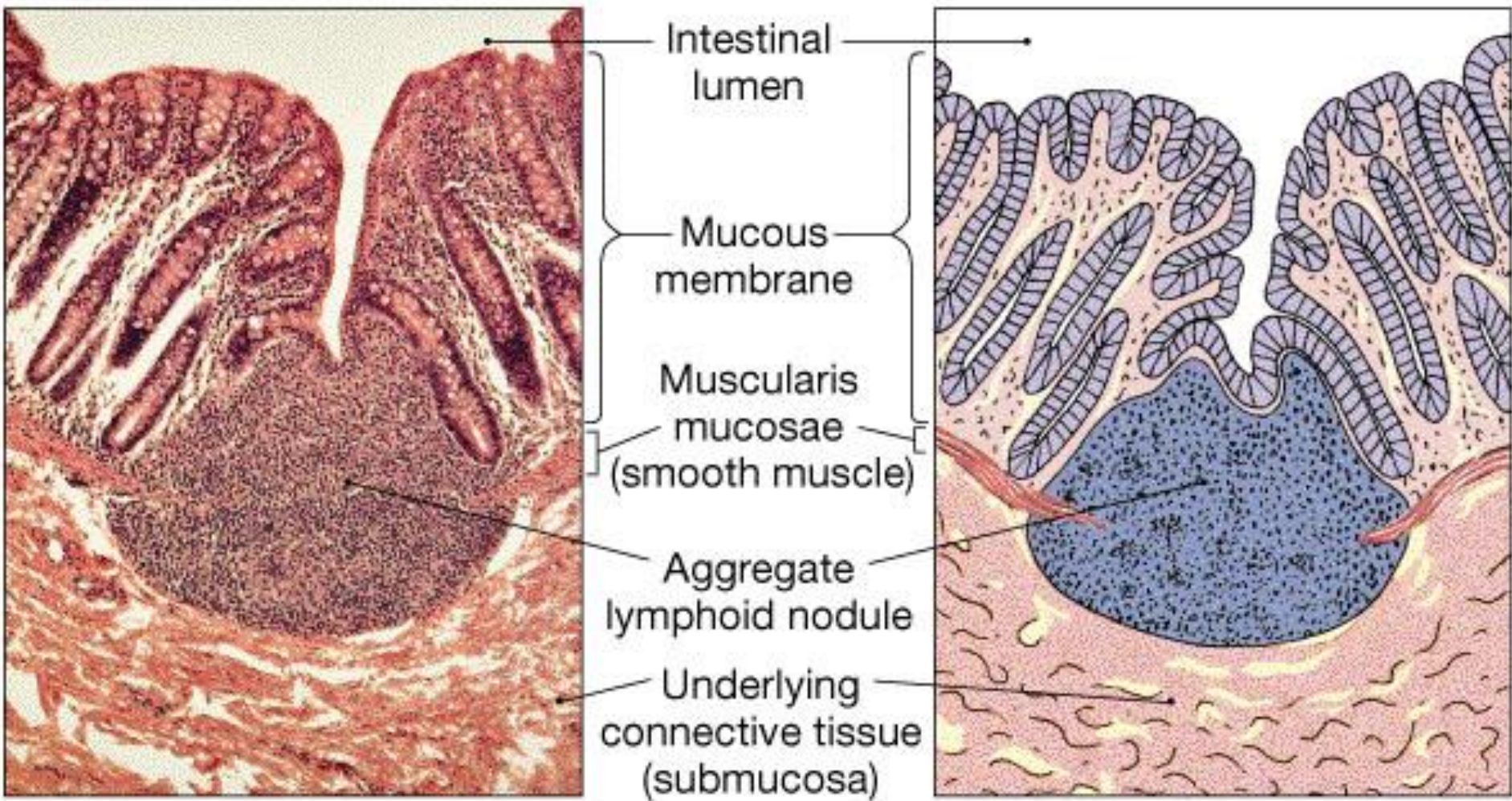
Palatine Tonsil

Aggregates of Lymphoid Follicles

- ⊙ Peyer's patches – isolated clusters of lymphoid tissue, similar to tonsils
 - Found in the wall of the distal portion of the small intestine
 - Similar structures are found in the appendix
- ⊙ Peyer's patches and the appendix:
 - Destroy bacteria, preventing them from breaching the intestinal wall
 - Generate “memory” lymphocytes for long-term immunity

MALT

- ◎ MALT – mucosa-associated lymphatic tissue is composed of:
 - Peyer's patches, tonsils, and the appendix (digestive tract)
 - Lymphoid nodules in the walls of the bronchi (respiratory tract)
 - Lymphoid nodules in the walls of genito-urinary tract
- ◎ MALT protects the digestive, respiratory and genito-urinary systems from foreign matter



(a) Lymphoid nodule



Spleen

Largest lymphatic organ

Located between the stomach & diaphragm

Structure is similar to a node

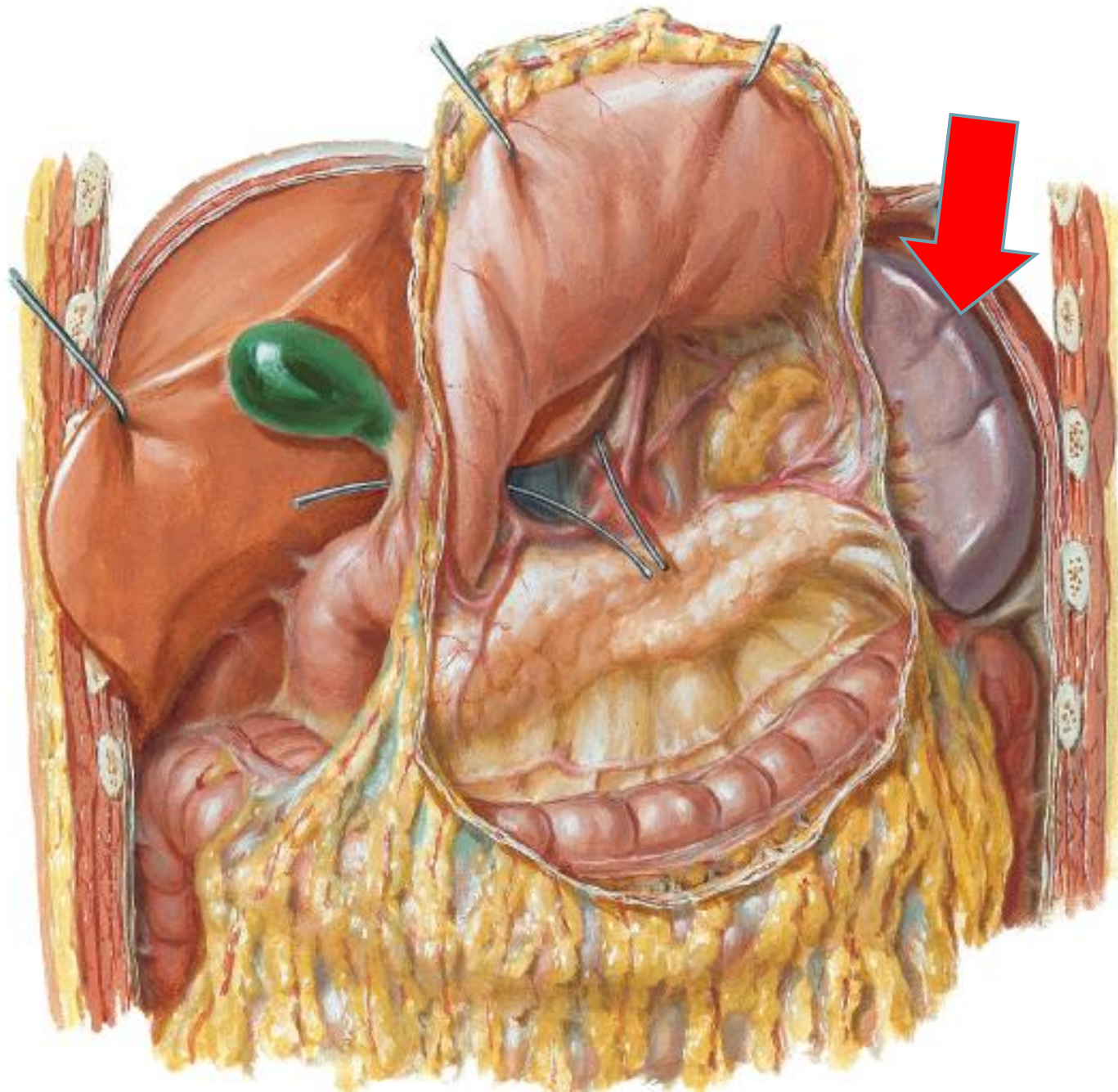
- Surrounded by a capsule of dense connective tissue
- Has efferent but no afferent vessels or sinuses

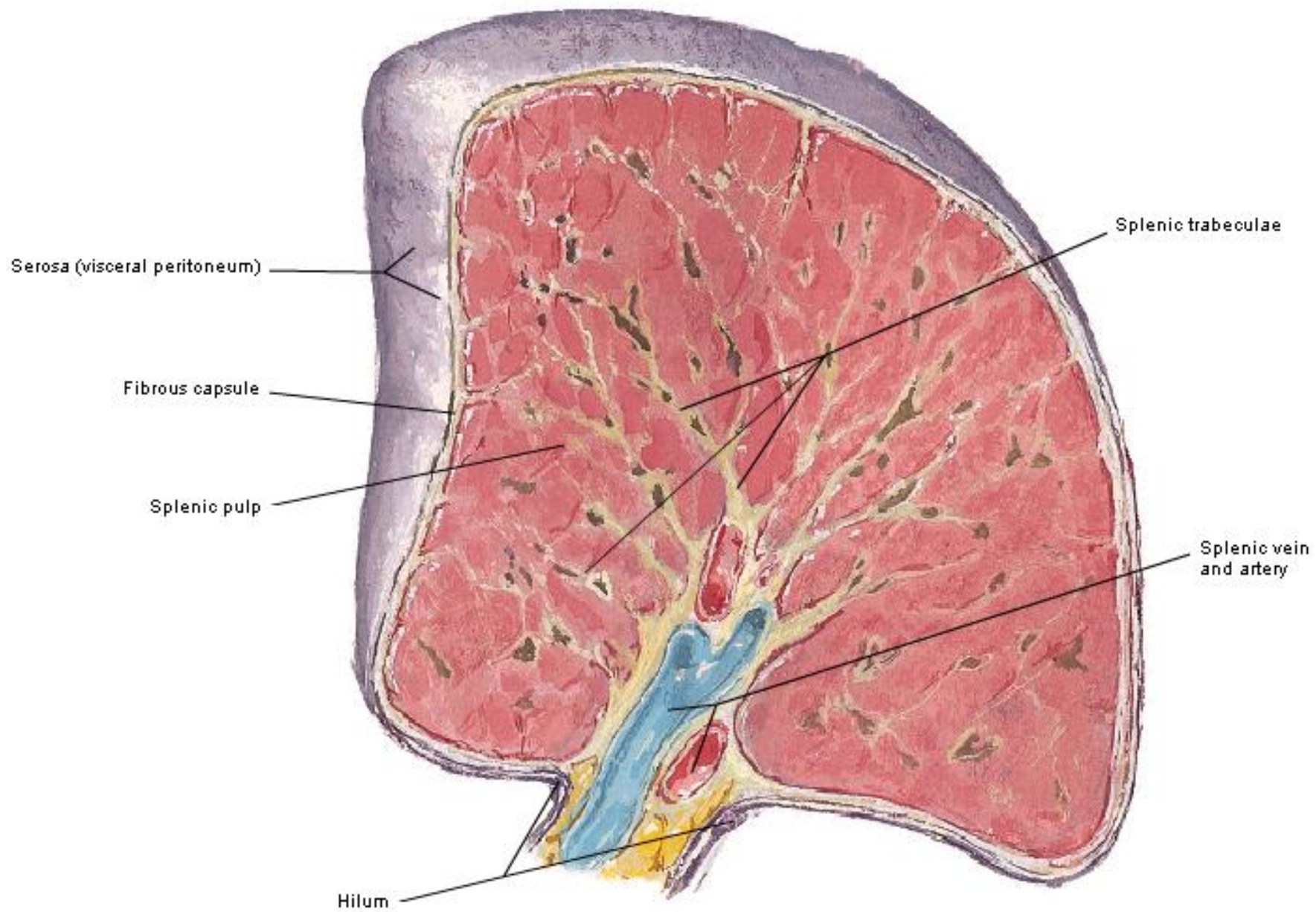
Histology

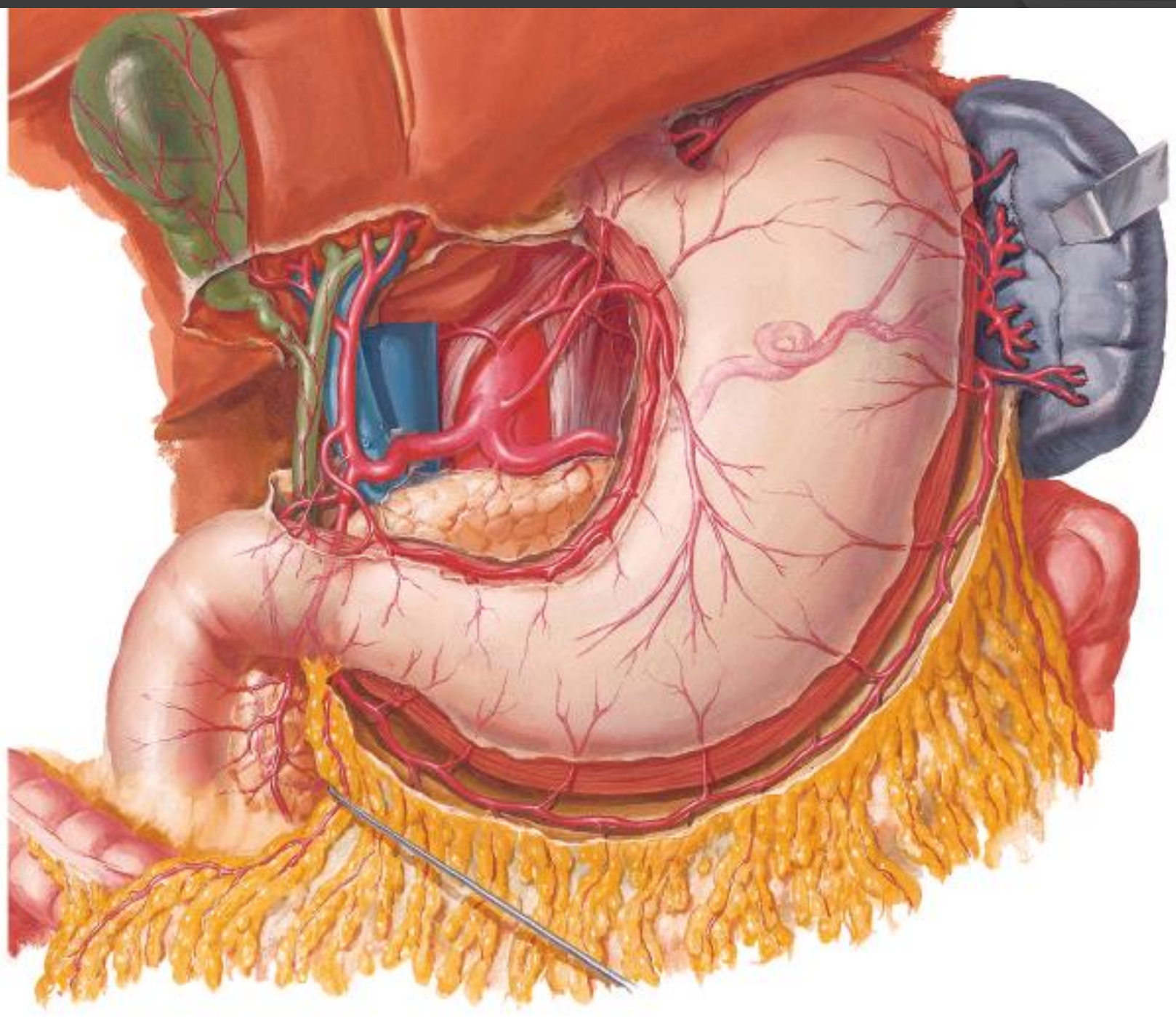
- Red pulp contains all the components of circulating blood
- White pulp is similar to lymphatic nodules

Functions

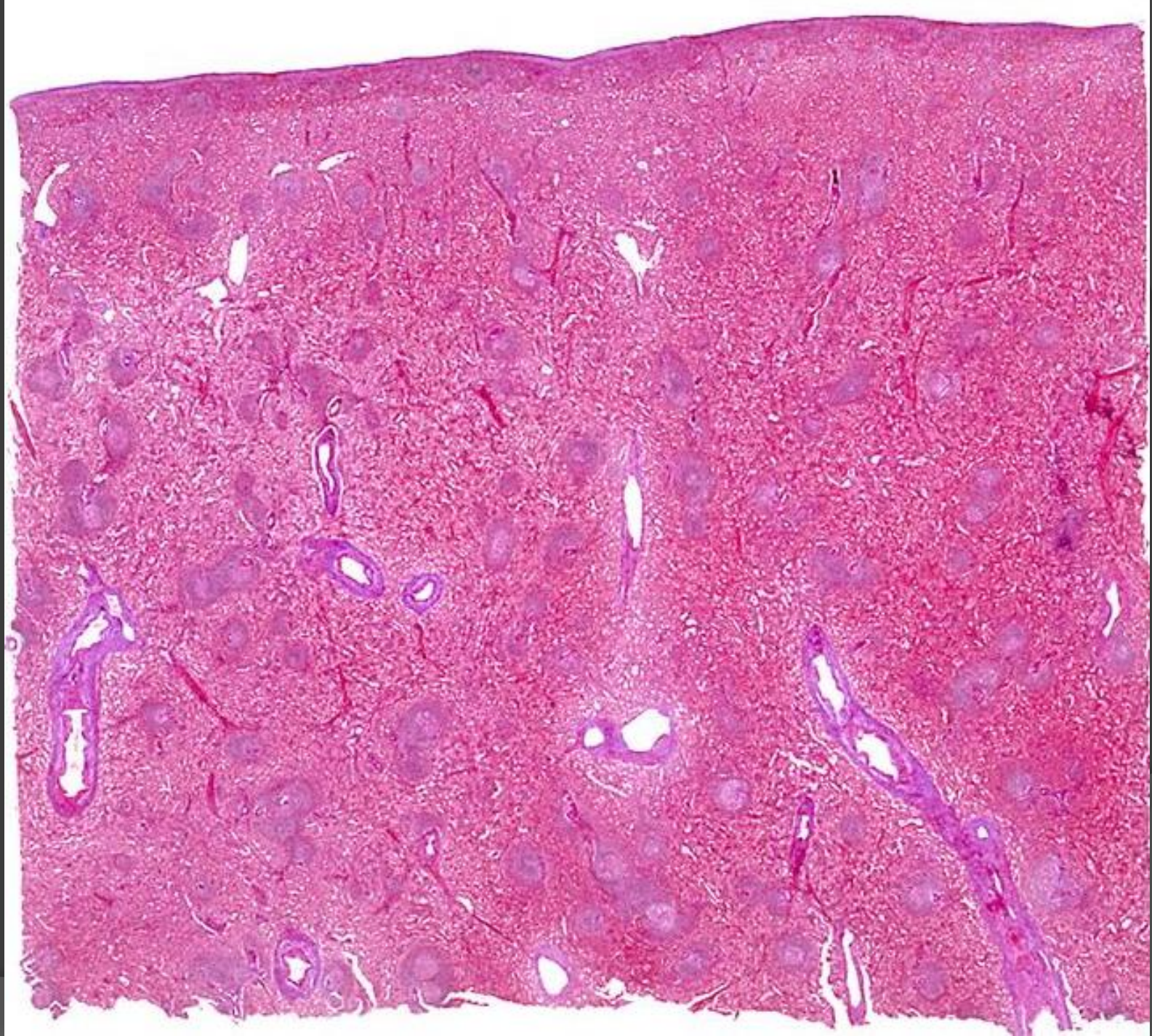
- Filters blood
- Stores blood

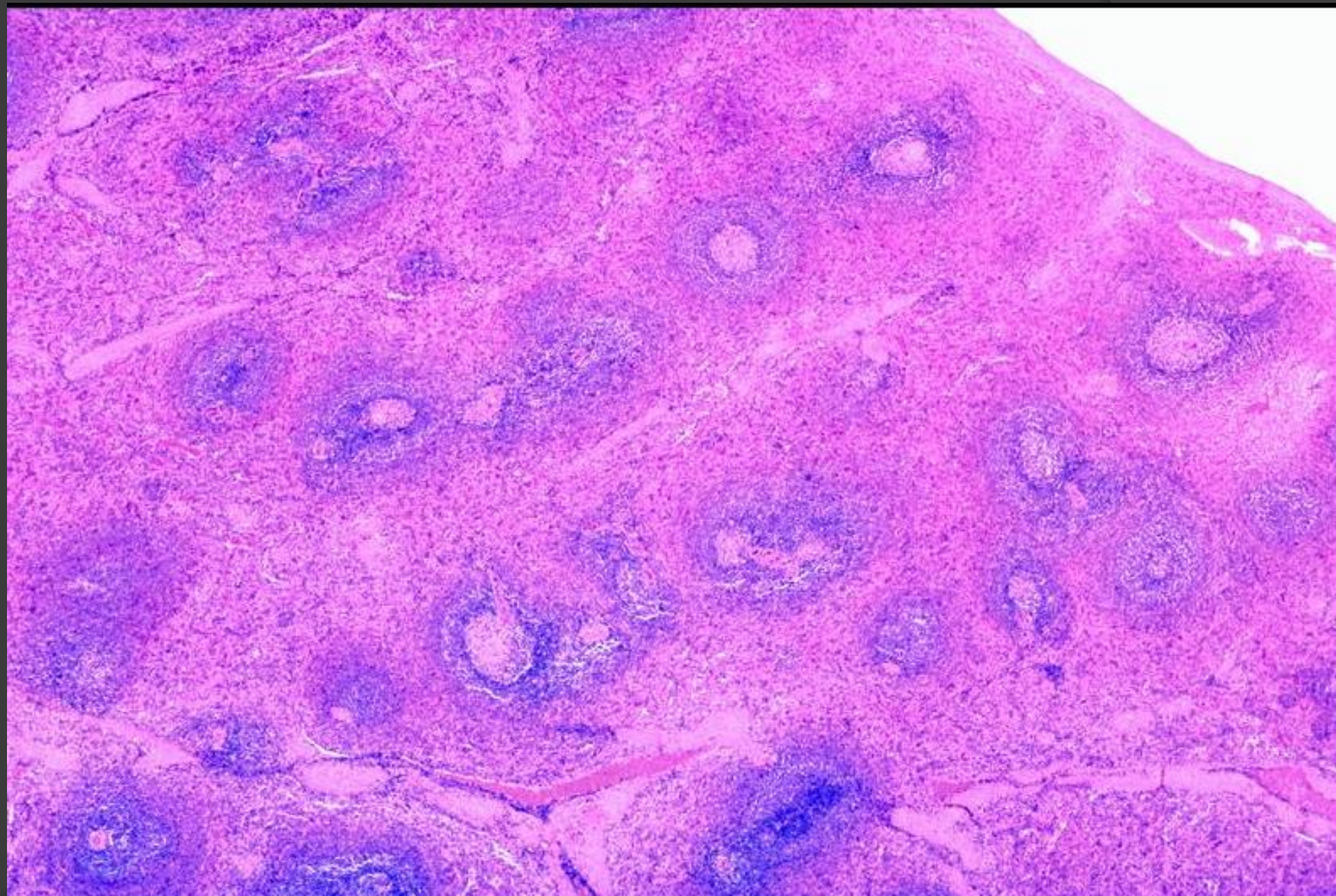


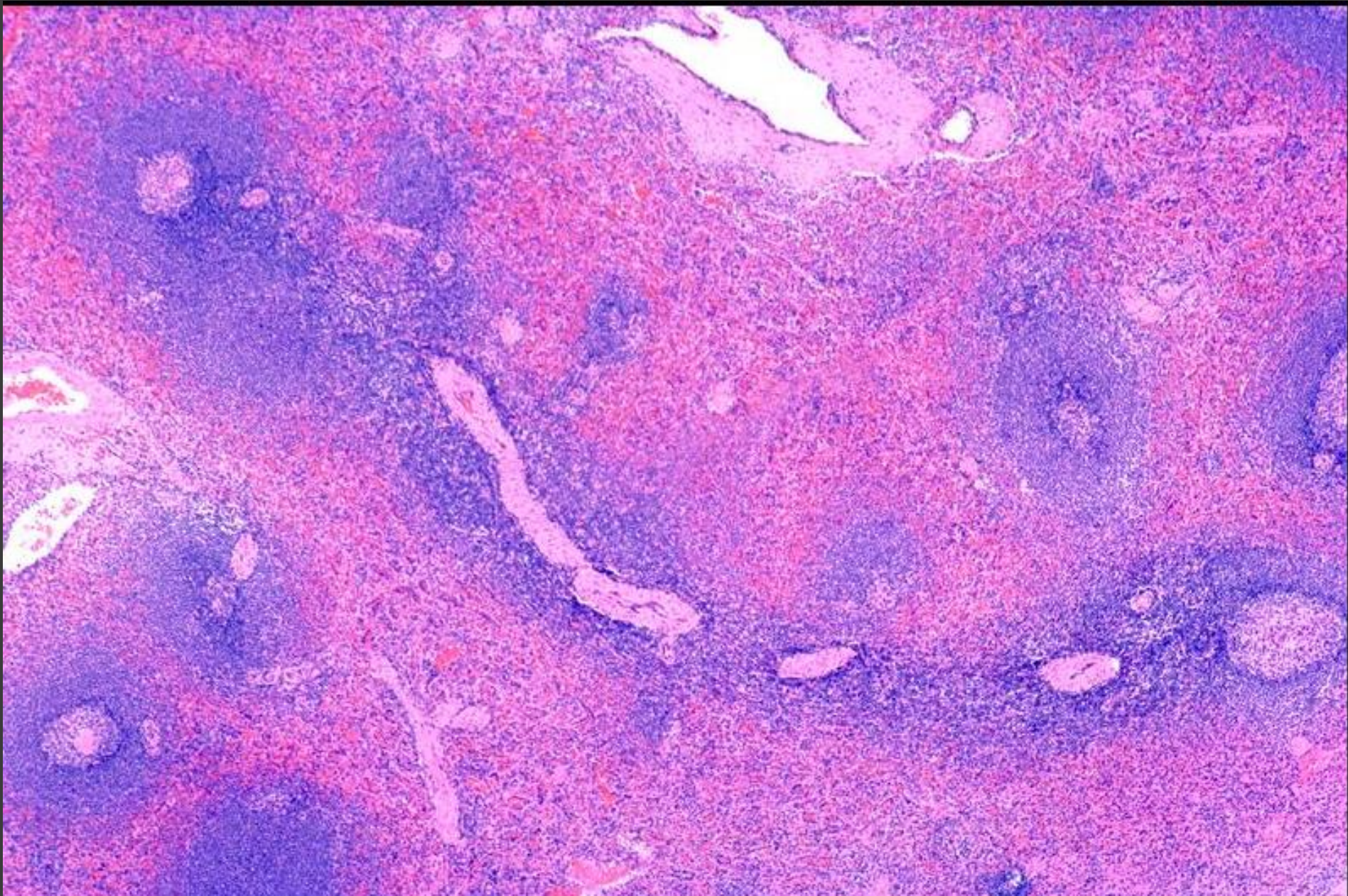


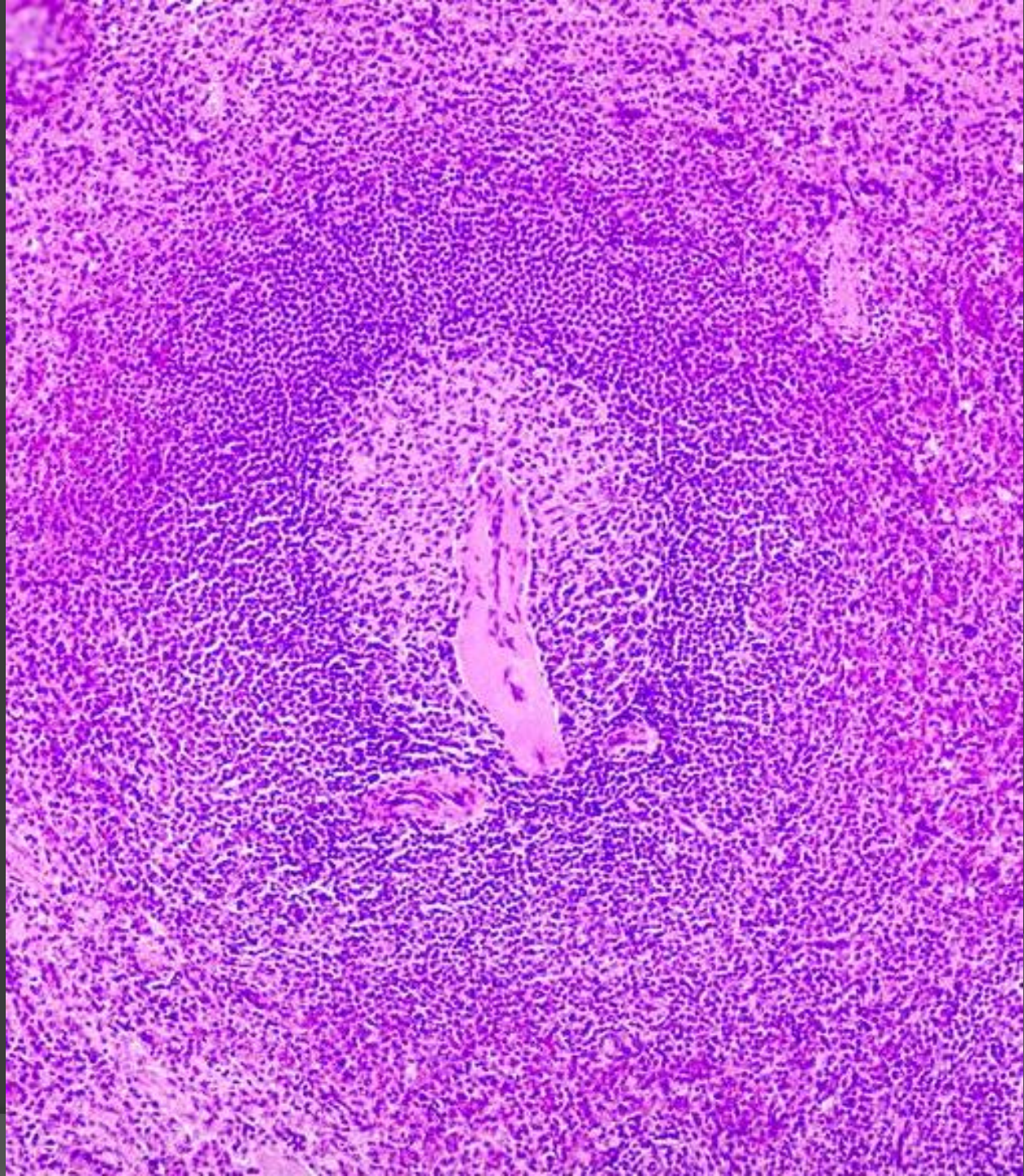


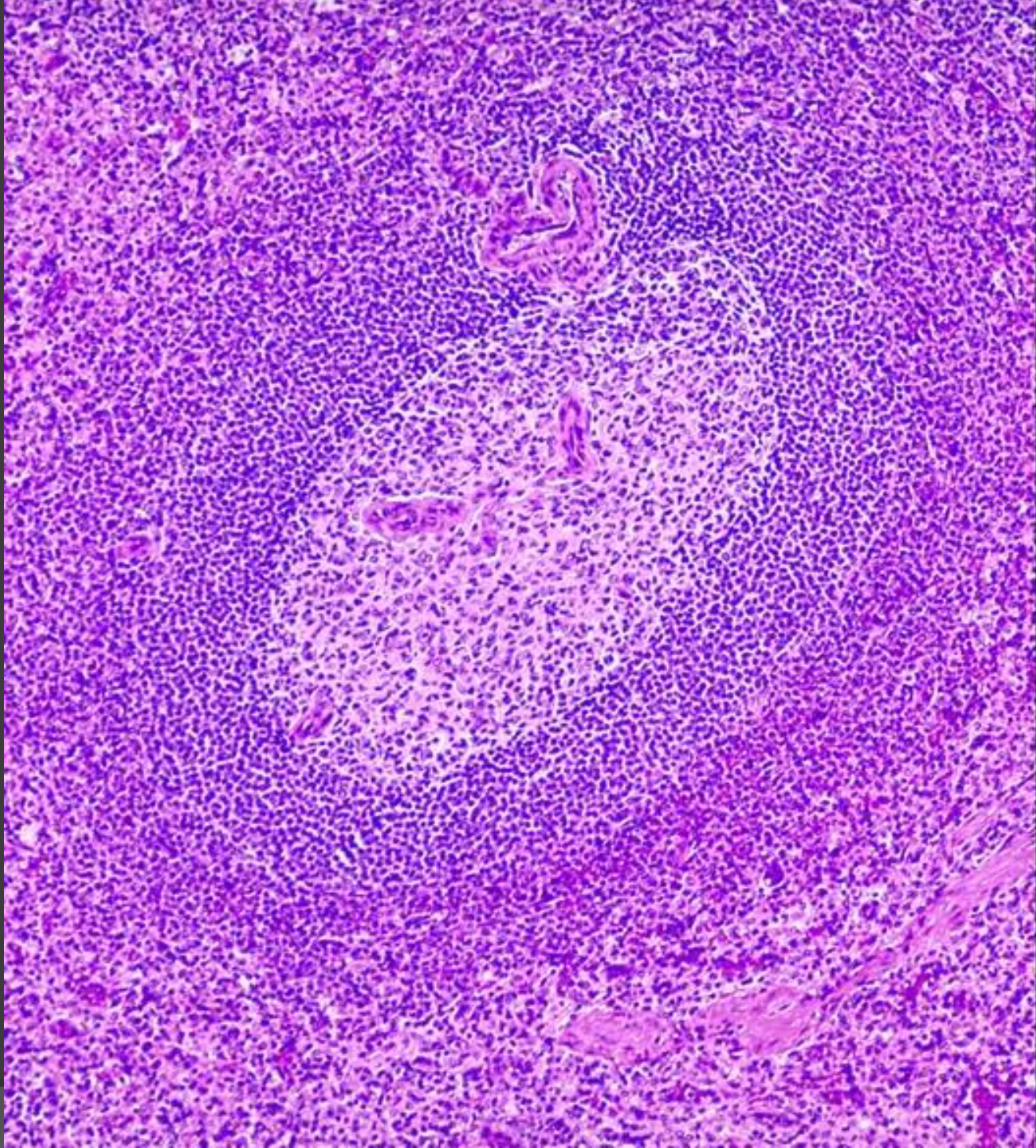




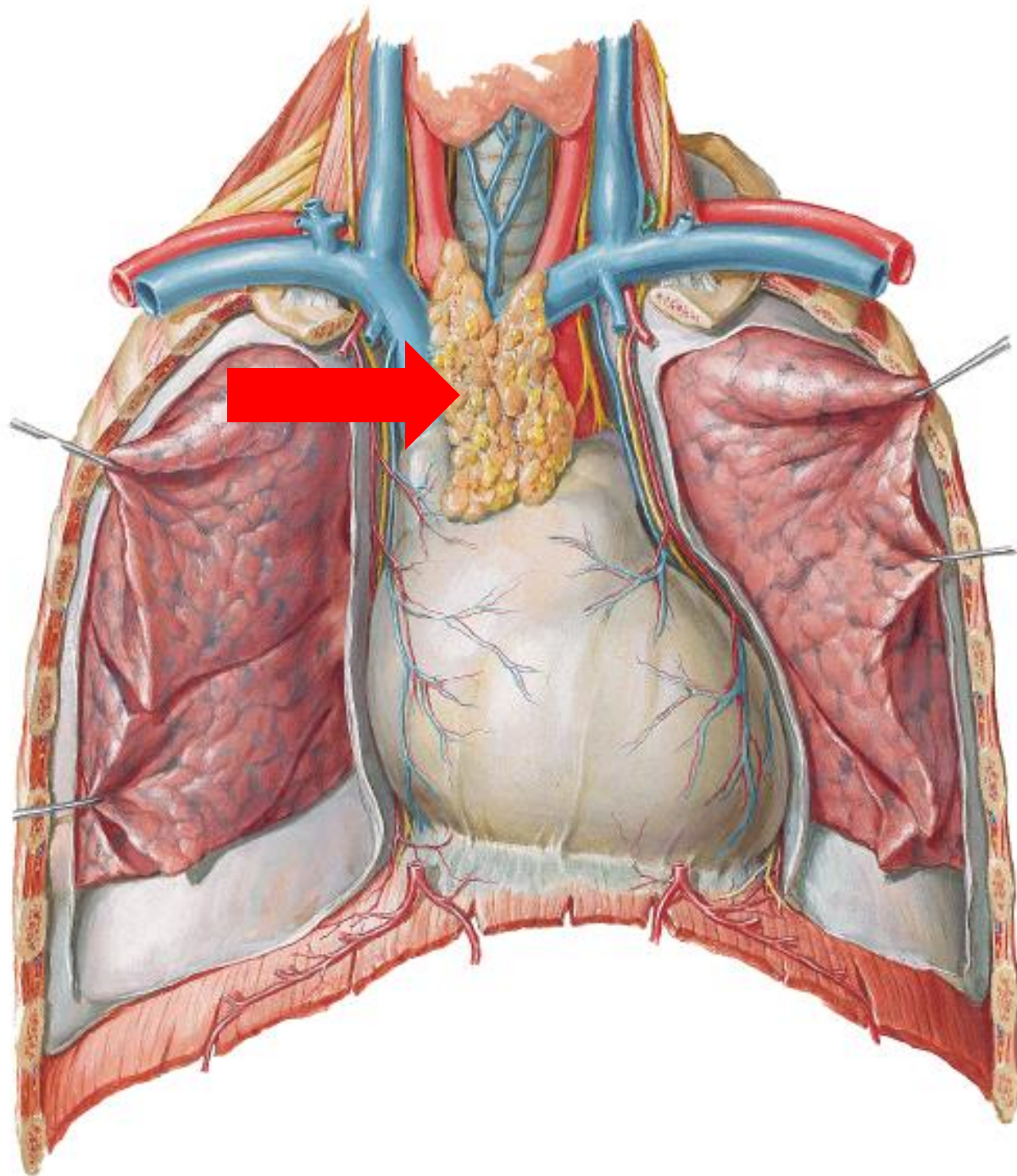








Thymus Gland



It is a bilobed lymphoepithelial organ.

Located in the anterior and superior mediastinum.

Its epithelial component originated from the endoderm of the 2nd and 3rd branchial pouches.

Its lymphocytes are mesodermal in origin.

Reaches its maximum size at ~ 15 years and starts involution.

Its tissue becomes replace by adipose tissue in old age.

Surrounded by connective tissue capsule.

The capsule sends trabecula inside the gland dividing it incompletely into lobules.

Each lobule has its cortex and medulla.

The medulla of adjacent lobules are continuous.

Thymic cortex ..1

Rich in small lymphocytes that make it appear darker than the medulla.

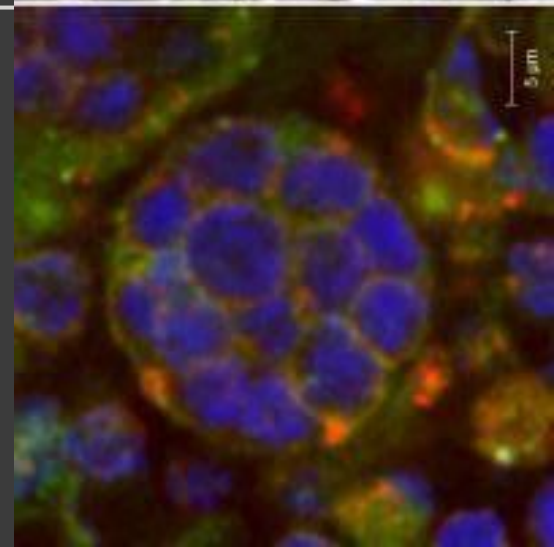
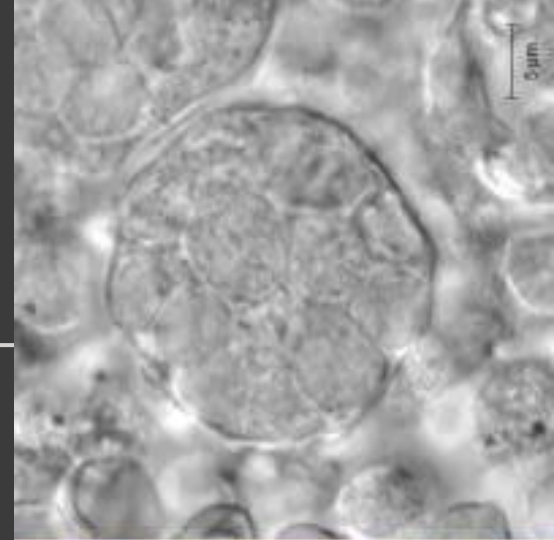
Composed of :

- T cell precursors (thymocytes).
- Epithelial reticular cells
- Macrophages

Thymic cortex ..2

Epithelial reticular cells:

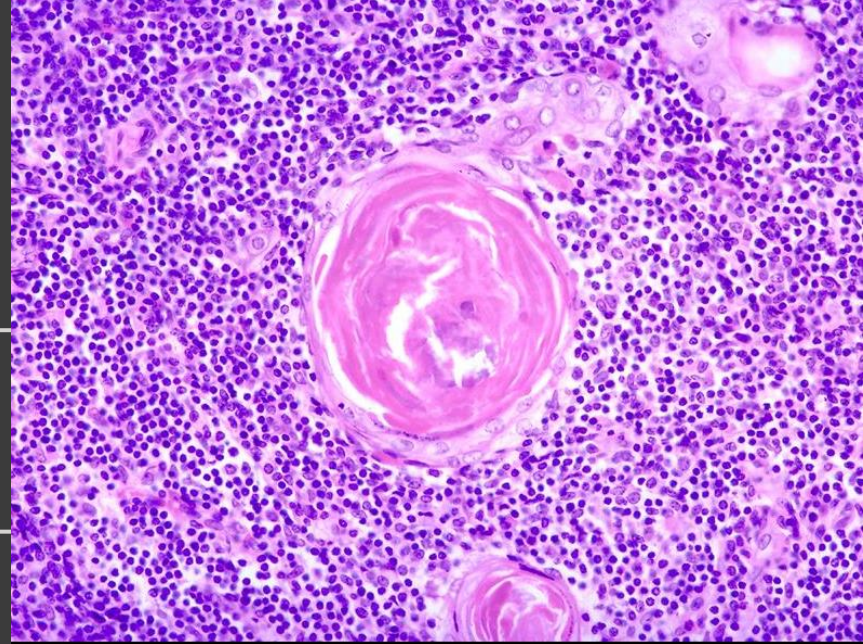
- Stellate cells
- Have light staining oval nuclei
- Joined together by desmosomes
- Cytoplasm contains cytokeratin
- Some of them surround a small population of maturing lymphocytes forming thymic nurse cells.



Thymic medulla

Composed of:

- Epithelial reticular cells.
- Many differentiated T lymphocytes.
- Thymic corpuscles (Hassall corpuscles).
 - Contain flattened epithelial reticular cells filled with keratin.
 - Peculiar to the medulla
 - Unknown function

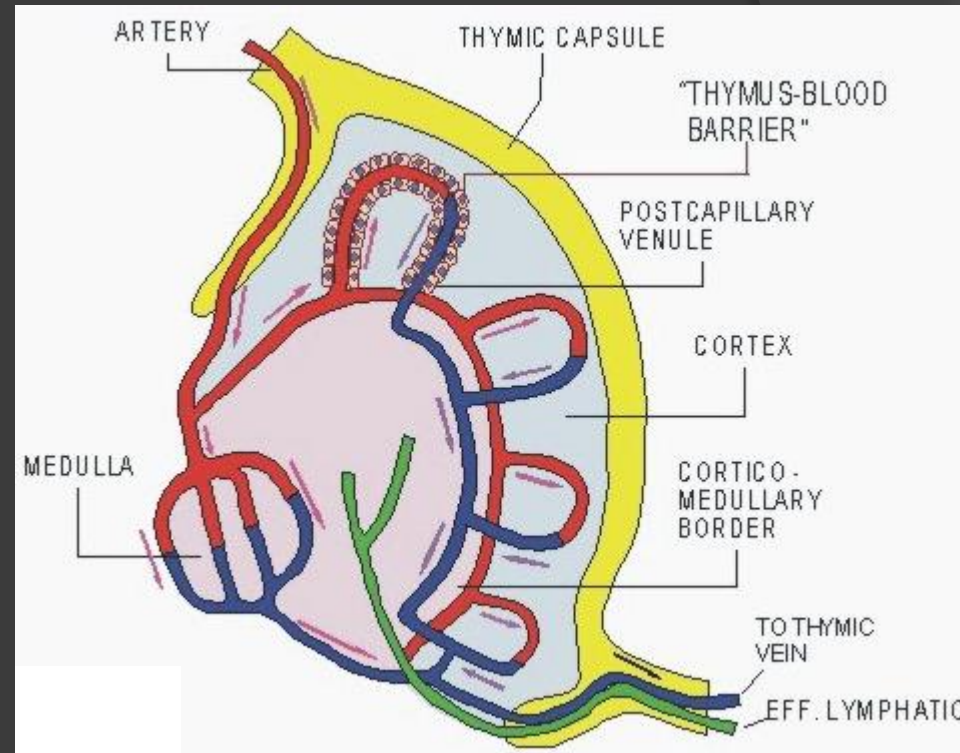


Vascularization of the thymus

Arterioles and capillaries are surrounded by processes of epithelial reticular cells.

Thymus capillaries are non-fenestrated with thick basal lamina.

Blood-thymic barrier in the cortex.



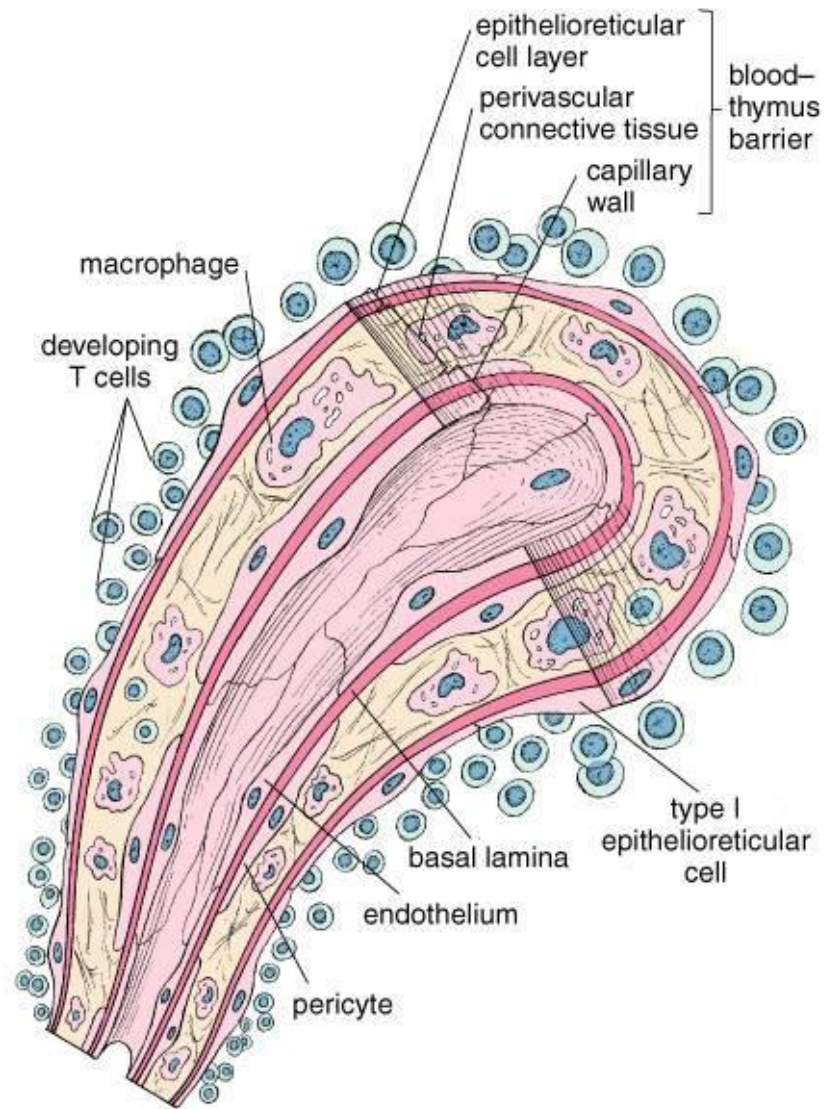


Figure 13.27. Schematic diagram of the blood-thymus barrier.

Thymus

No afferent lymphatic vessels.

Does not form a filter for lymph.

All lymphatic vessels seen are efferent.

Thymus

- ⦿ It is the site of selection and differentiation of T lymphocytes.
- ⦿ It continues to produce lymphocytes until old age.
- ⦿ T cell precursors do not have receptors on their surfaces.
 - Originate from the liver, then migrate to bone marrow and thymus.
 - They divide in the thymic cortex.

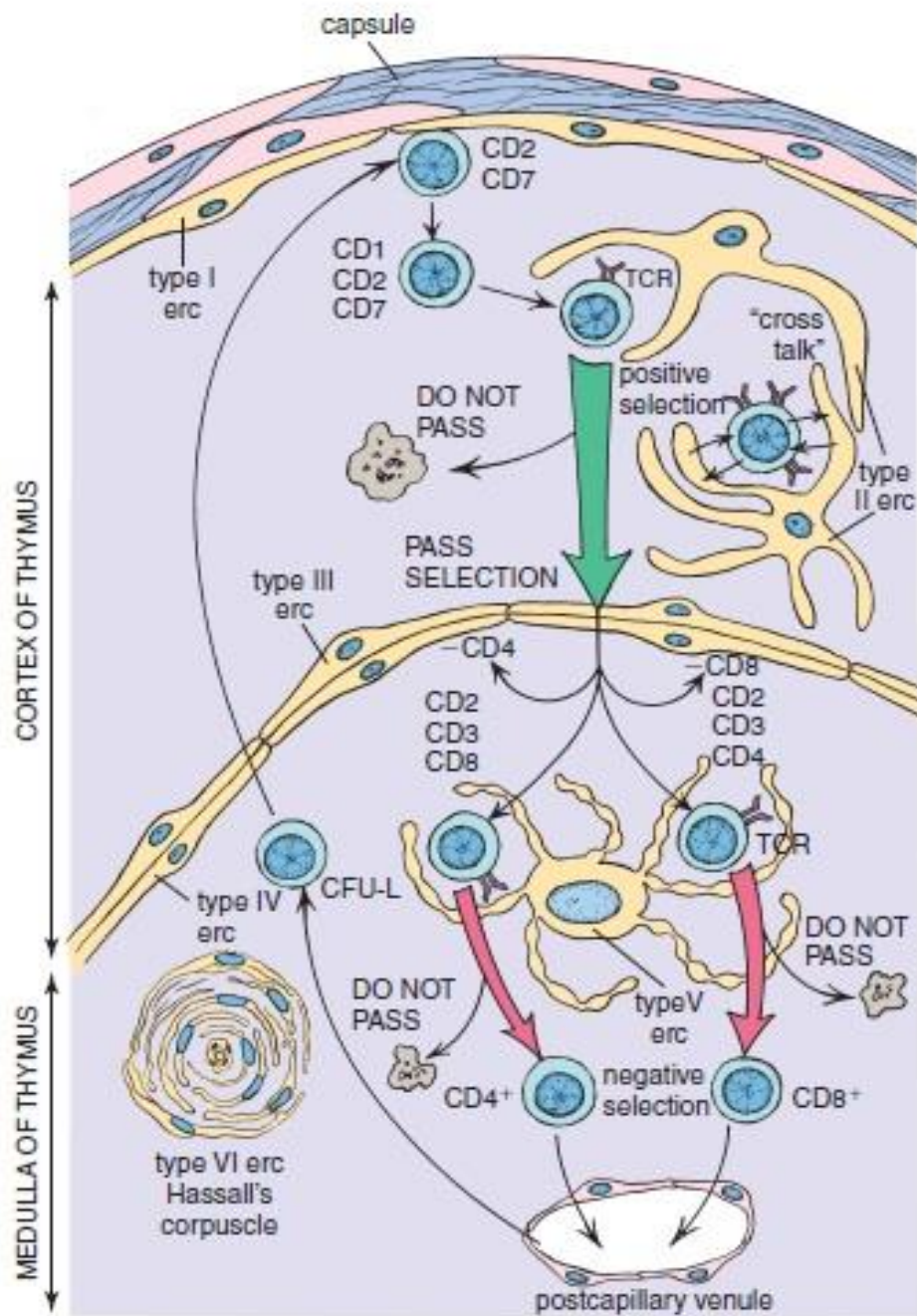


FIGURE 14.28 • Schematic drawing of the major steps in thymic education. The process of multipotential lymphatic stem cell (**CFU-L**) maturation and differentiation into immunocompetent T cells is accomplished by the expression and deletion of specific surface CD antigens. The CFU-L stem cells enter the medulla of the thymus via a postcapillary venule and then migrate to the periphery of the thymic lobule. The presence of CD2 and CD7 molecules on the cell surface indicates an early stage of differentiation. This is followed by expression of the CD1 molecule, indicating the middle stage of T-cell differentiation. As maturation progresses, the cells express TCRs, CD3, CD4, and CD8 molecules. These cells are then presented with self and foreign antigens by type II and III epithelioreticular (**erc**) cells. If the lymphocyte recognizes self MHC and self or foreign antigen, then it will survive the selection (positive selection); if not, death of the cell will occur. Cells that pass the positive selection test leave the cortex and enter the medulla. Here they undergo another selection process in which cells directed to self-antigen displayed by self MHC are eliminated (negative selection). Cells that survive that selection then become either cytotoxic **CD8⁺** T lymphocytes or helper **CD4⁺** T lymphocytes. These cells are now ready for the immune response; they leave the thymus from the medulla and enter the blood circulation. Hormonal substances secreted by type VI epithelioreticular cells within the thymic (Hassall's) corpuscle promote the process of thymic cell education. Note the distribution of all six types of epithelioreticular cells.

Thymic secretion

Several growth factors

Thymosin α

Thymopoietin

Thymulin

Thymus humoral factor

