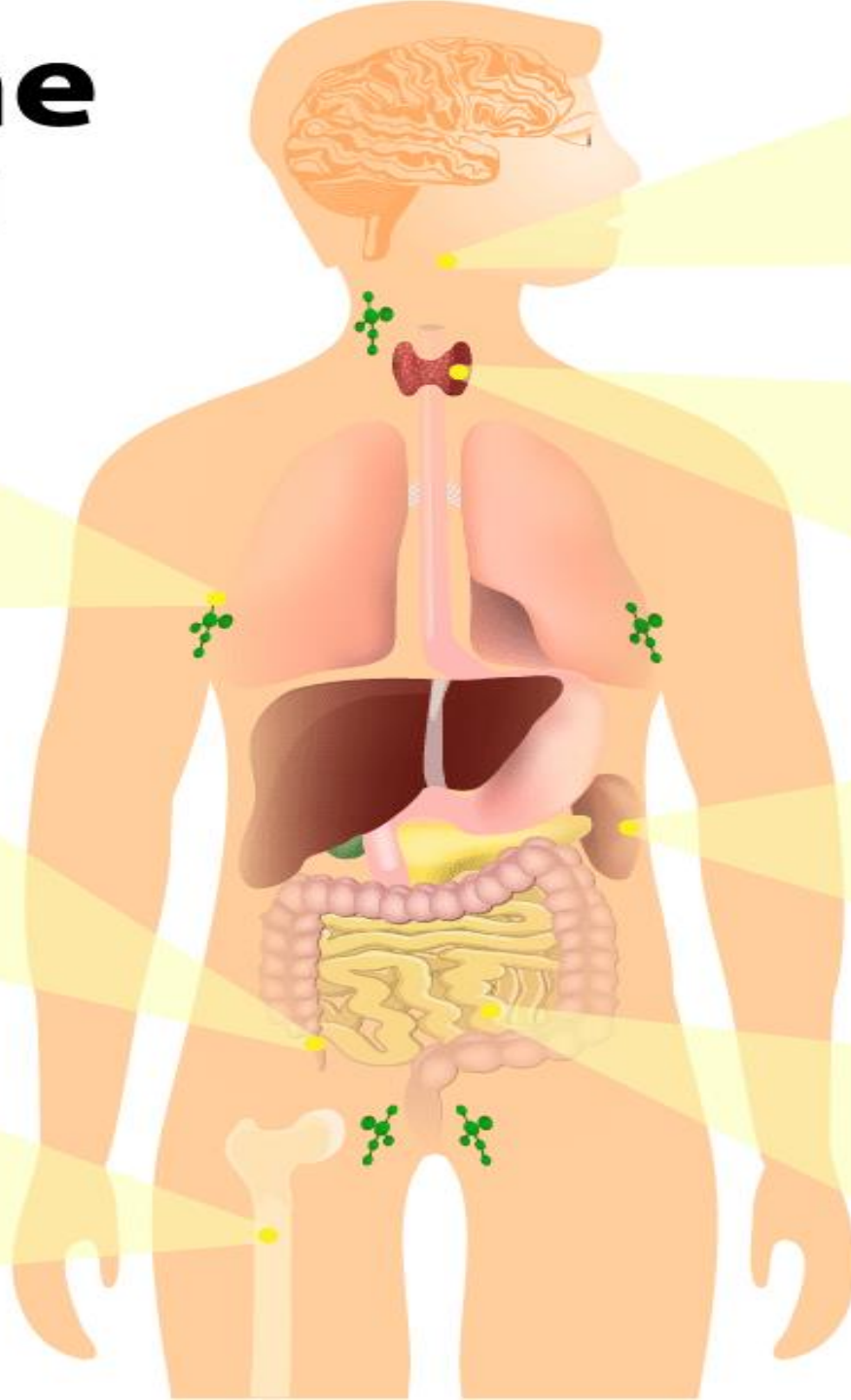
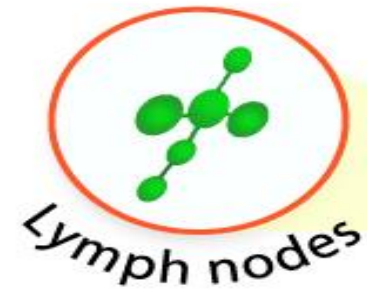


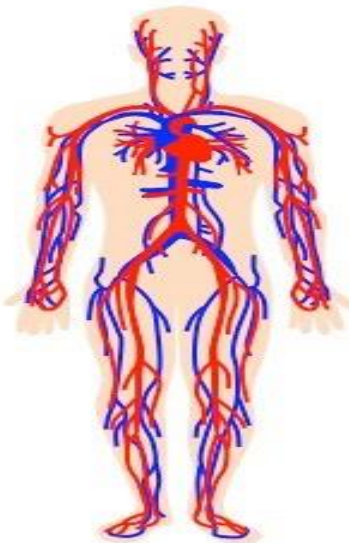
Immune system



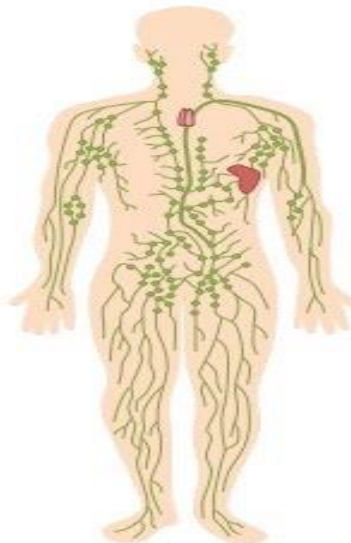
immune system

- All cells and structures distributed throughout the body that Protect the body from invasion of microorganisms or foreign substances.
- Histologically this system consists of a large, diverse population of leukocytes located within every tissue of the body and lymphoid organs interconnected only by the blood and lymphatic circulation.

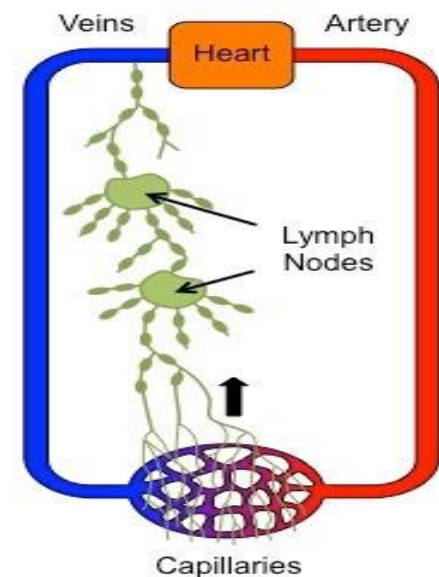
Circulatory System



Lymphatic System



Inter-relationship between systems

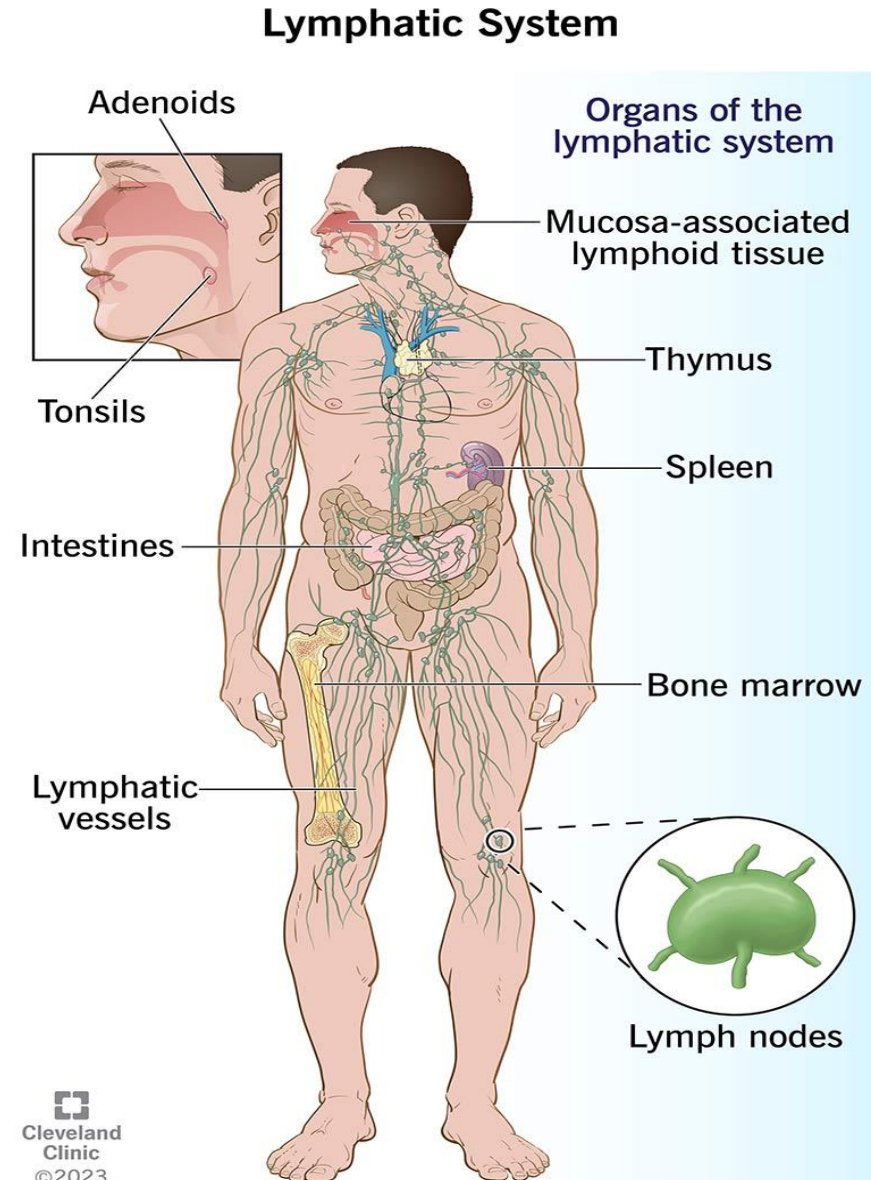


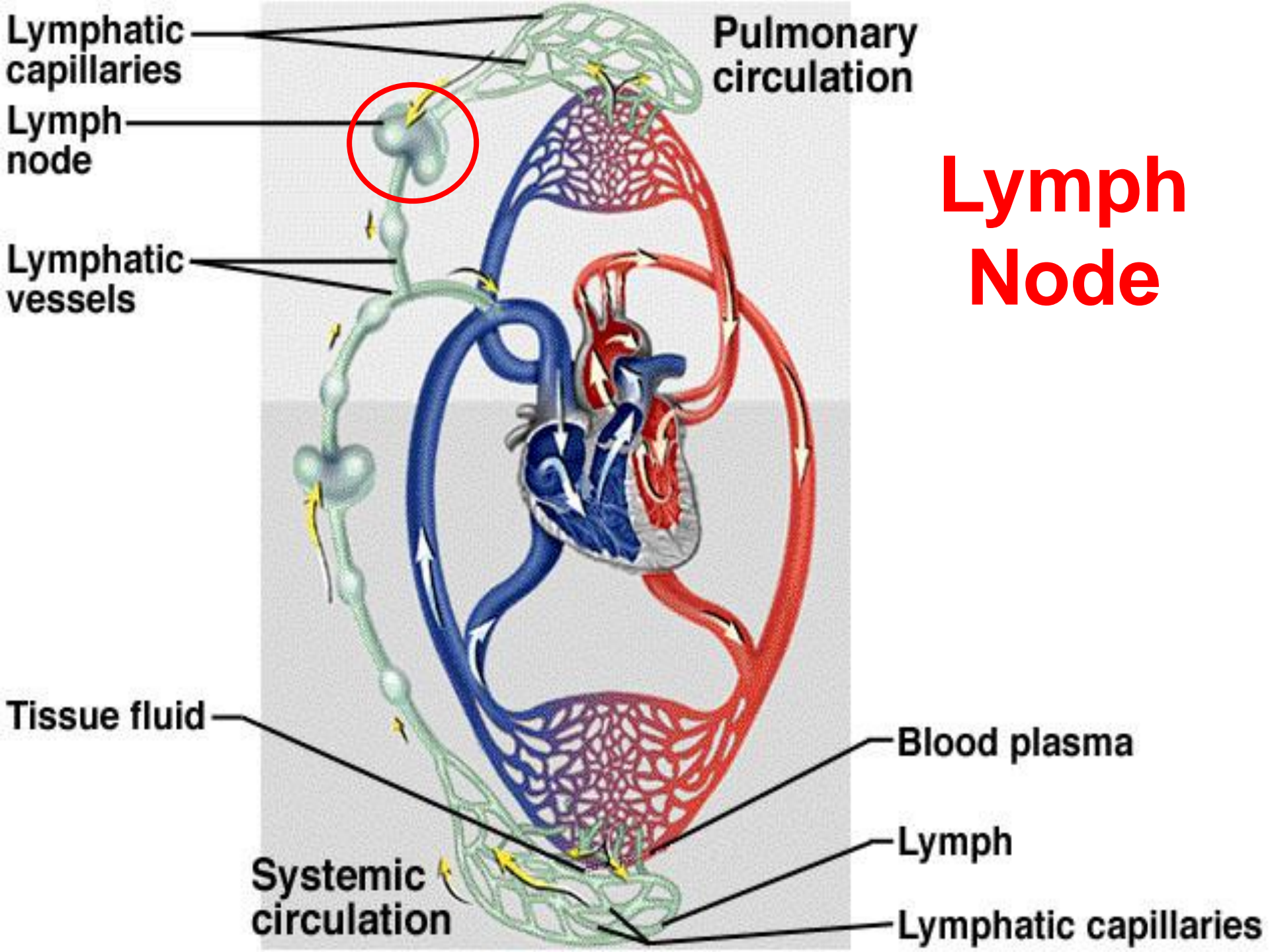
Lymph is protein rich fluid that circulates throughout the lymphatic system.

- It is formed, when the interstitial fluid (the fluid which lies between all body tissues) is collected inside lymphatic capillaries, transported through lymphatic vessels to larger lymph nodes, where it is cleaned by lymphocytes, before emptying finally into the right or the left subclavian vein, where it mixes back with the blood.

Lymphoid organs

- **Encapsulated** (spleen, thymus, lymph nodes).
- **Uncapsulated** (tonsils, Peyer's patches, nodules in tracts).
- **Central** (Thymus, bone marrow)
- **Peripheral** (spleen, lymph nodes).





Lymphatic capillaries

Lymph node

Lymphatic vessels

Tissue fluid

Systemic circulation

Pulmonary circulation

Lymph Node

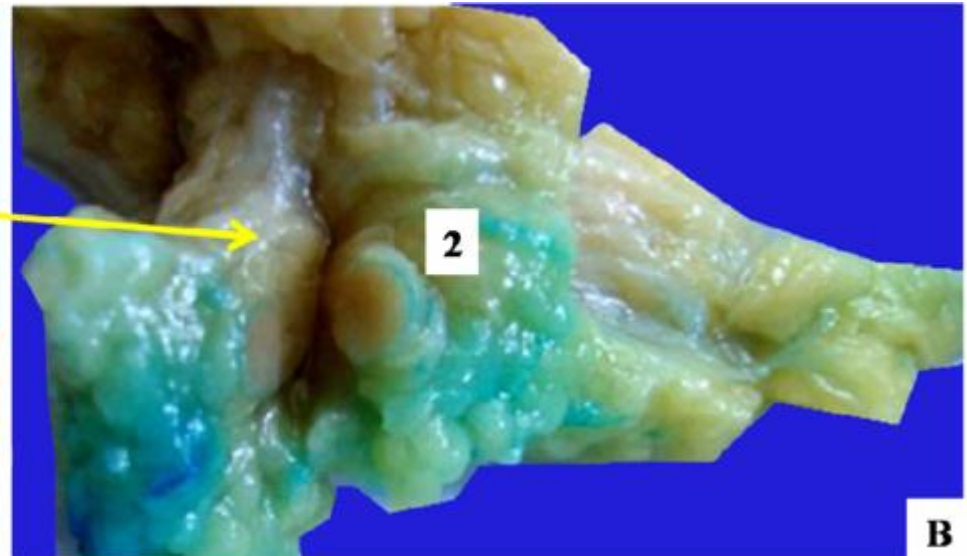
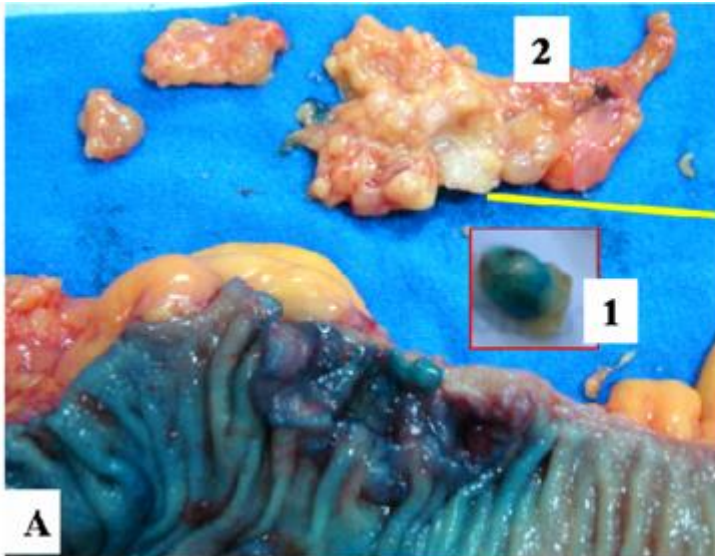
Blood plasma

Lymph

Lymphatic capillaries

Lymph node

- **Shape:**
 - Encapsulated.
 - kidney shaped, convex surface and depression (hilum).
- **Site:**
 - Distributed throughout the body.
 - Along lymphatic vessels 400 to 450 lymph nodes are present, most abundantly in the axillae (armpits) and groin, along the major vessels of the neck, and in the thorax and abdomen, especially in mesenteries



Lymph node

Afferent lymph vessels

Valve in lymph vessel

Outer cortex
B cells

Parenchyma

Blood capillaries

Blood capillaries
around lymph nodule

Capsule and
trabecula

Stroma

Parenchyma

Inner cortex
T cells

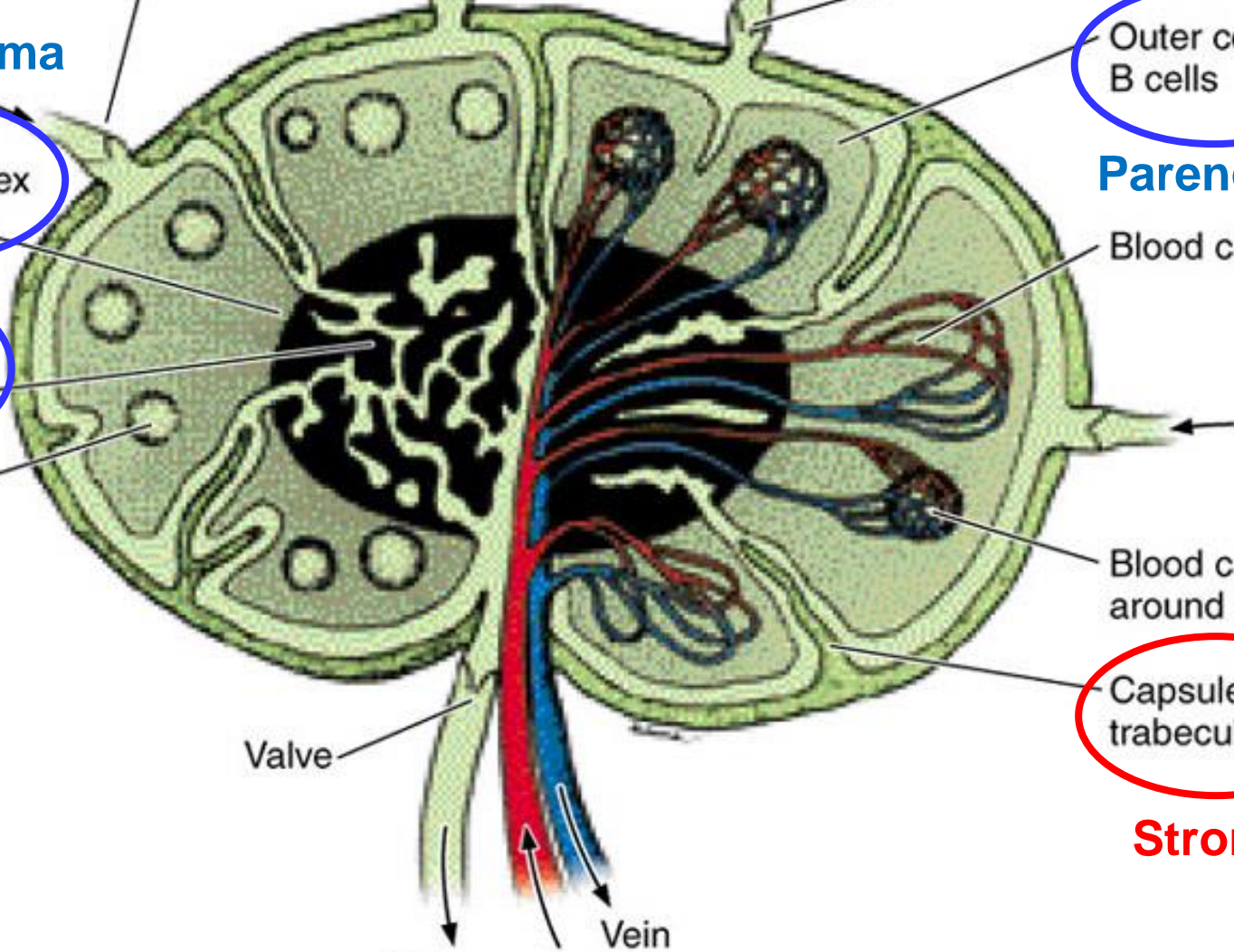
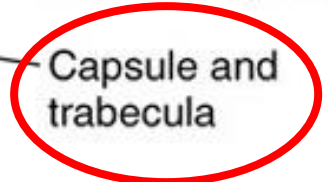
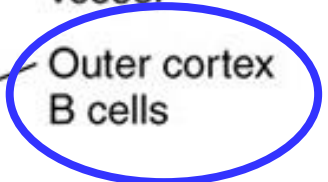
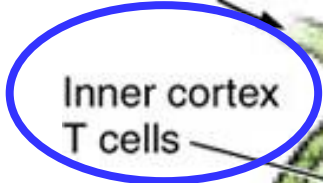
Medulla

Cortical
nodule

Valve

Vein

Efferent lymph vessel
Artery



Structure

1- **Stroma** (supportive CT):

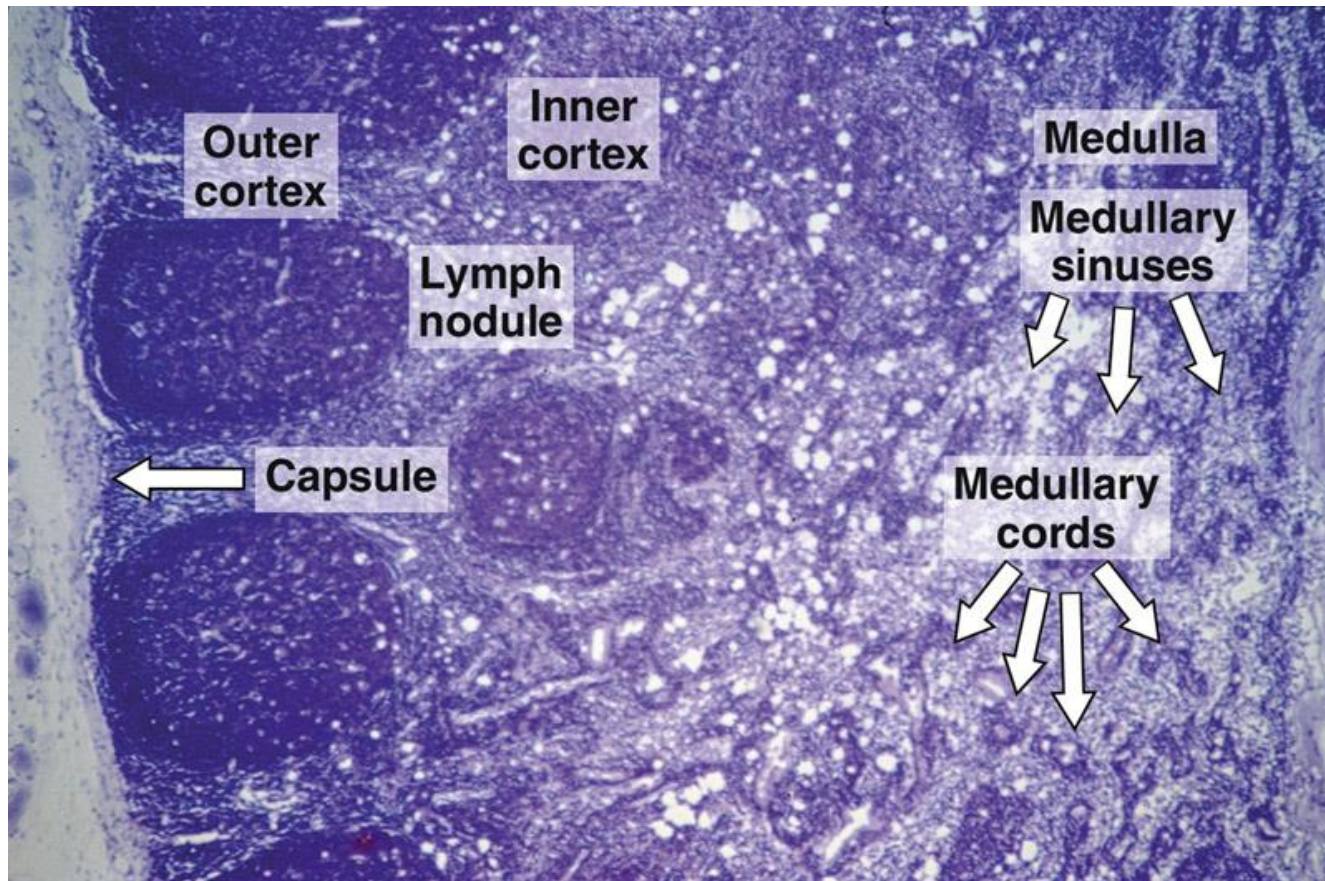
- a) **Capsule**: dense CT thickened at hilum and form sheath around the BV enter the LN.
- b) **Septa**: divide node into incomplete compartments.
- c) **Reticular network**: reticular cells and fibers holding parenchymal cells in its meshes

2- **Parenchyma**:

- Outer and inner cortex.
- medulla

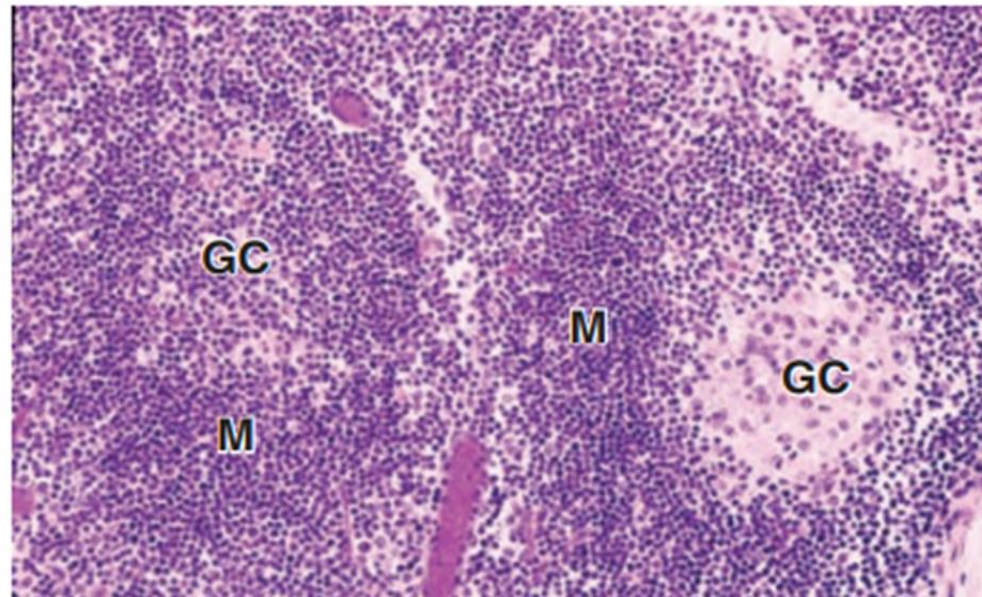
A- Cortex

- *Outer (superficial) cortex*
- *Inner (deep) cortex*



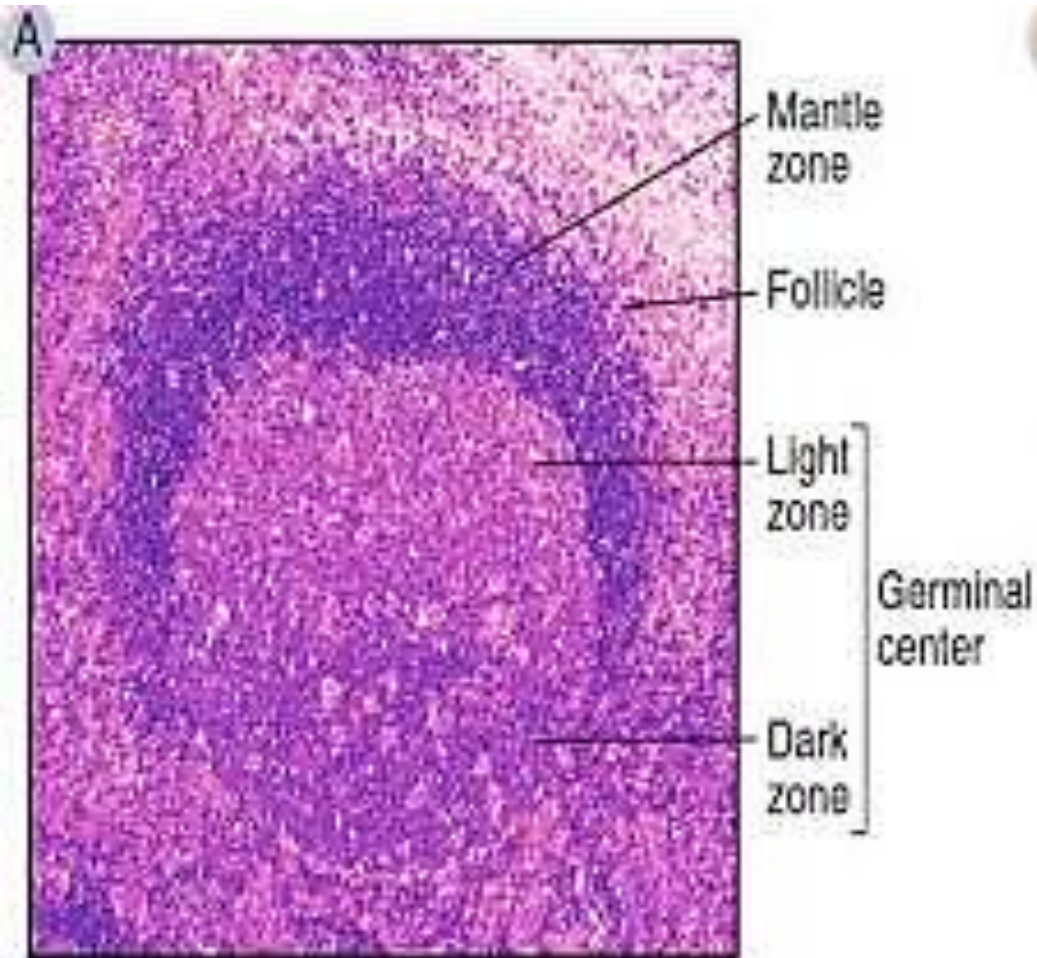
Outer cortex

- Round aggregations of lymphocytes called **lymphatic follicles** with loose lymphocytes inbetween.
- **2 types of lymphatic follicles:**
 - **1ry lymphatic follicles:**
 - **not** exposed to Ag
 - contains **B-cells**, some T-cells, macrophages, reticular cells and Ag presenting cells (follicular dendritic cells).
 - **No** germinal center.
 - **2ry lymphatic follicle:**
 - **exposed** to Ag
 - central pale **germinal center**



Germinal center: Germinal centers (GCs) are specialized microstructures within secondary lymphoid organs (lymph nodes, spleen, tonsils) where B cells proliferate, differentiate, and undergo affinity maturation during T cell-dependent antibody responses. They are organized into two distinct, dynamic zones—the dark zone and light zone—surrounded by a mantle zone.

- **Dark Zone (Basal/Inner):** Populated by rapidly dividing, B cells called centroblasts. This is the site of somatic hypermutation, where antibody genes are mutated.
- **Light Zone (Apical/Outer):** Contains non-proliferating smaller B cells, known as centrocytes undergo selection based on how well they bind antigen. This zone has a high density of Follicular Dendritic Cells (FDCs) that display antigens to centrocytes.
- **Mantle Zone:** The outer ring of small, recirculating, quiescent B cells that surrounds the active GC.
- **T Cell Zone:** T follicular helper cells (Tfh) are found primarily in the light zone, providing critical survival signals to B cells.
- **Macrophages:** Specifically tingible body macrophages in the dark zone, to engulf apoptotic B cells that fail selection

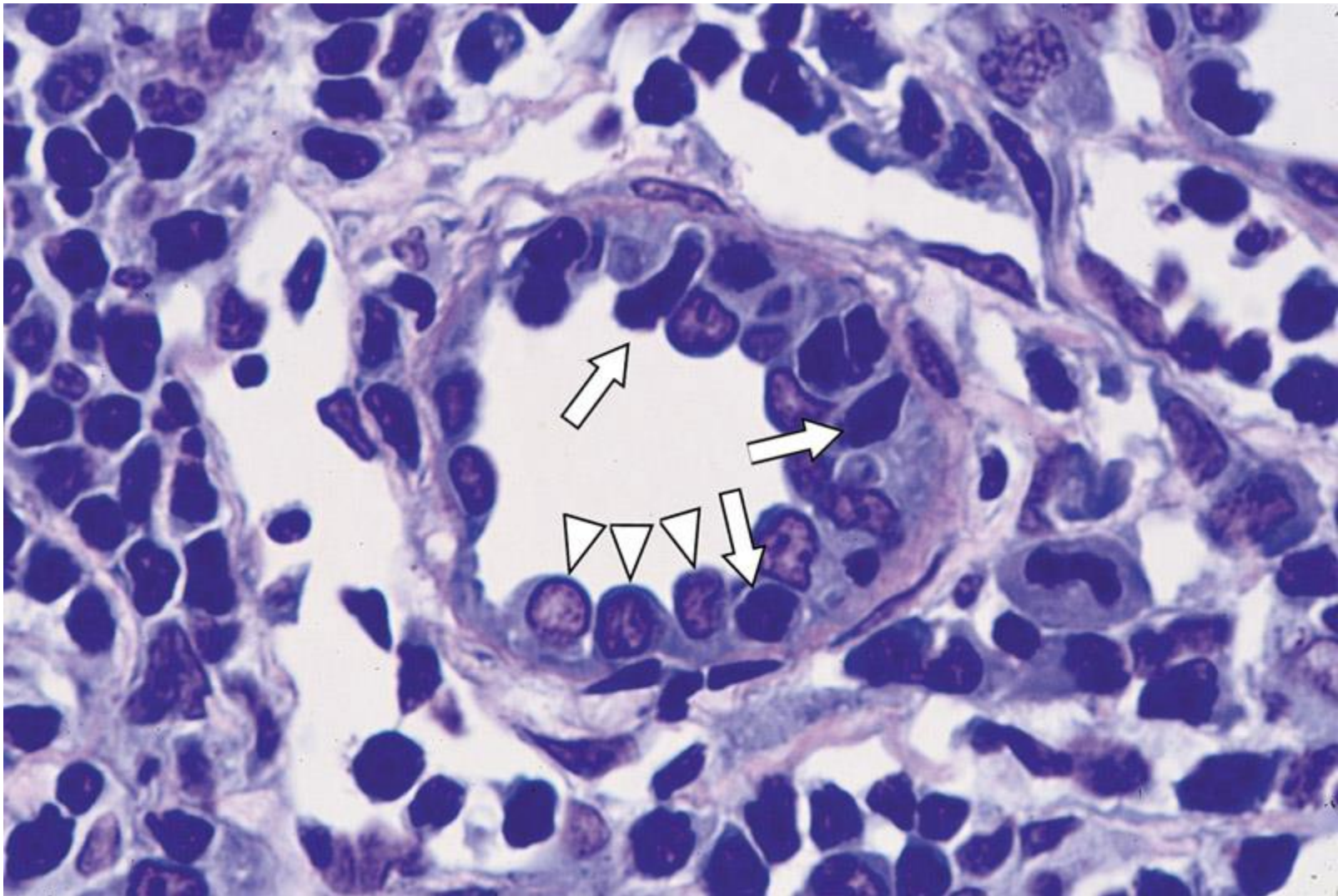


Duration: Germinal centers generally appear 4-5 days after antigen exposure, peaking around 7-10 days, and dissolve after 3-4 weeks if the antigen is cleared.

- This structure ensures that only B cells with high-affinity receptors (positive selection) + survive and differentiate into memory B cells or long-lived plasma cells.

Inner cortex (paracortex)

- **Paracortical zone:** deeper part between outer cortex and medulla.
- **Thymus dependant zone:** contains T cells have migrated from the thymus.
- **High Endothelial Venules:** is the point of entry of T cells from blood to lymph node • its endothelial lining is unusual (cuboidal) and its apical surface has glycoproteins and integrins facilitate rapid diapedesis of lymphocytes out of the blood into the paracortex of the lymph node



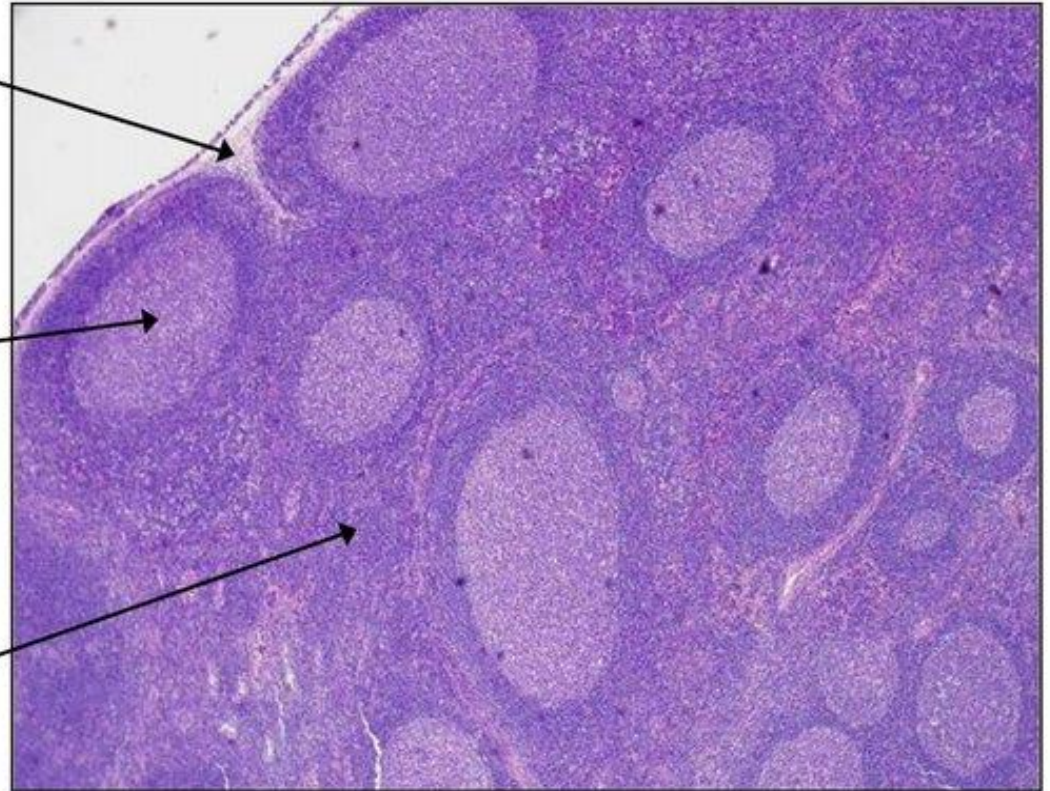
High endothelial venule in a lymph node.
High endothelial cells (arrowheads).
The venule is crossed by lymphocytes (arrows).

Normal Lymph Node Architecture

Sinuses (subcapsular and interfollicular)

Follicles with
mantle zones,
germinal centers
(B cells)

Interfollicular region
(paracortex) (T cells)



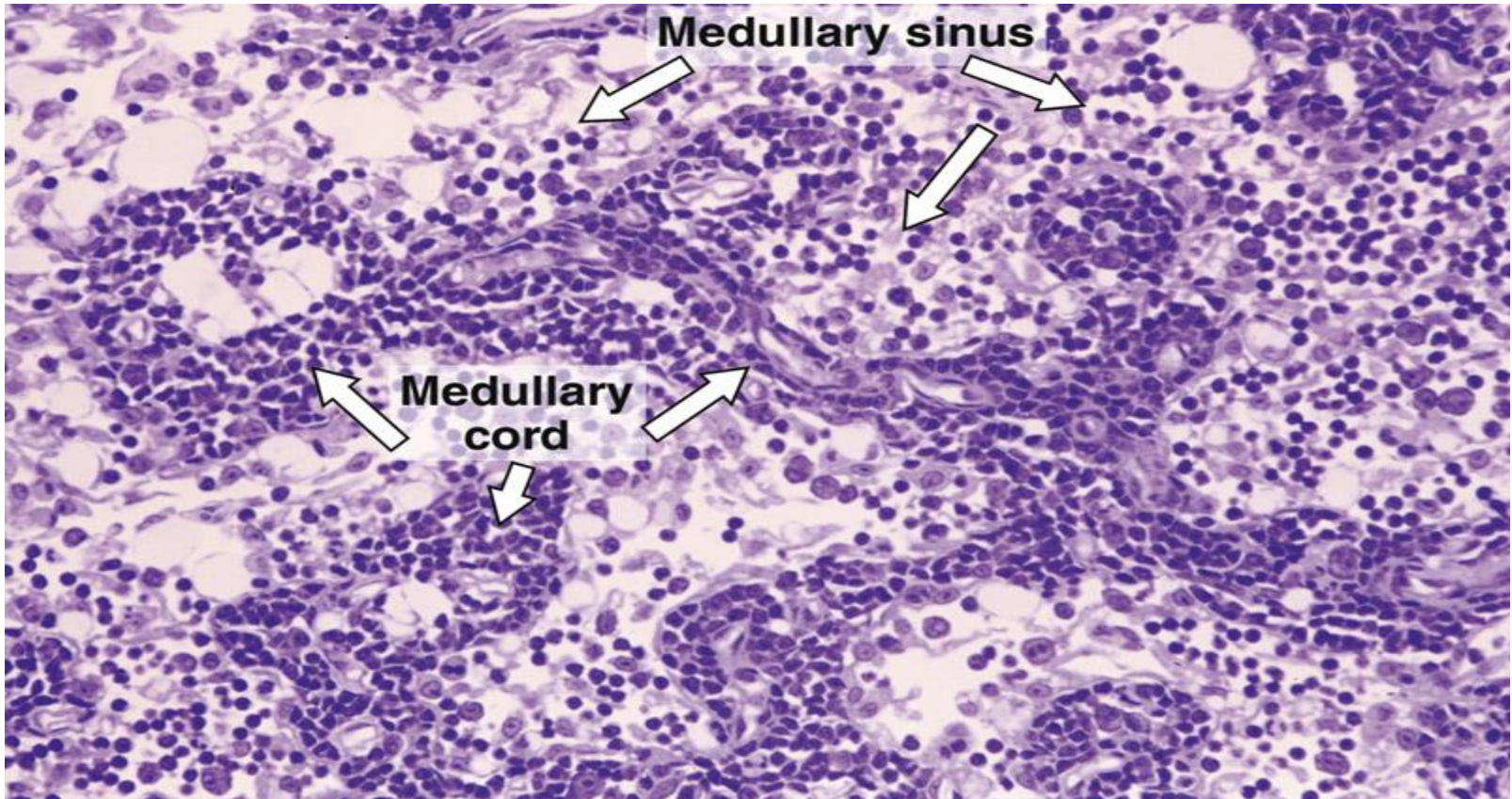
@KyleBradleyMD

Cortical sinuses

- Irregular spaces lined by reticular cells and macrophages filled with lymph.
 - *Subcapsular sinuses* receive lymph from afferents.
 - *Paratrabecular sinuses* connect subcapsular to medullay.
- Lymph passes through sinuses to be filtered.

B- Medulla

- *Medullary cords*
- *Medullary sinuses*



Medullary cords

- Cord like extensions of deep cortical lymphoid tissue.
- Lymphocytes and many plasma cells.

Medullary sinuses

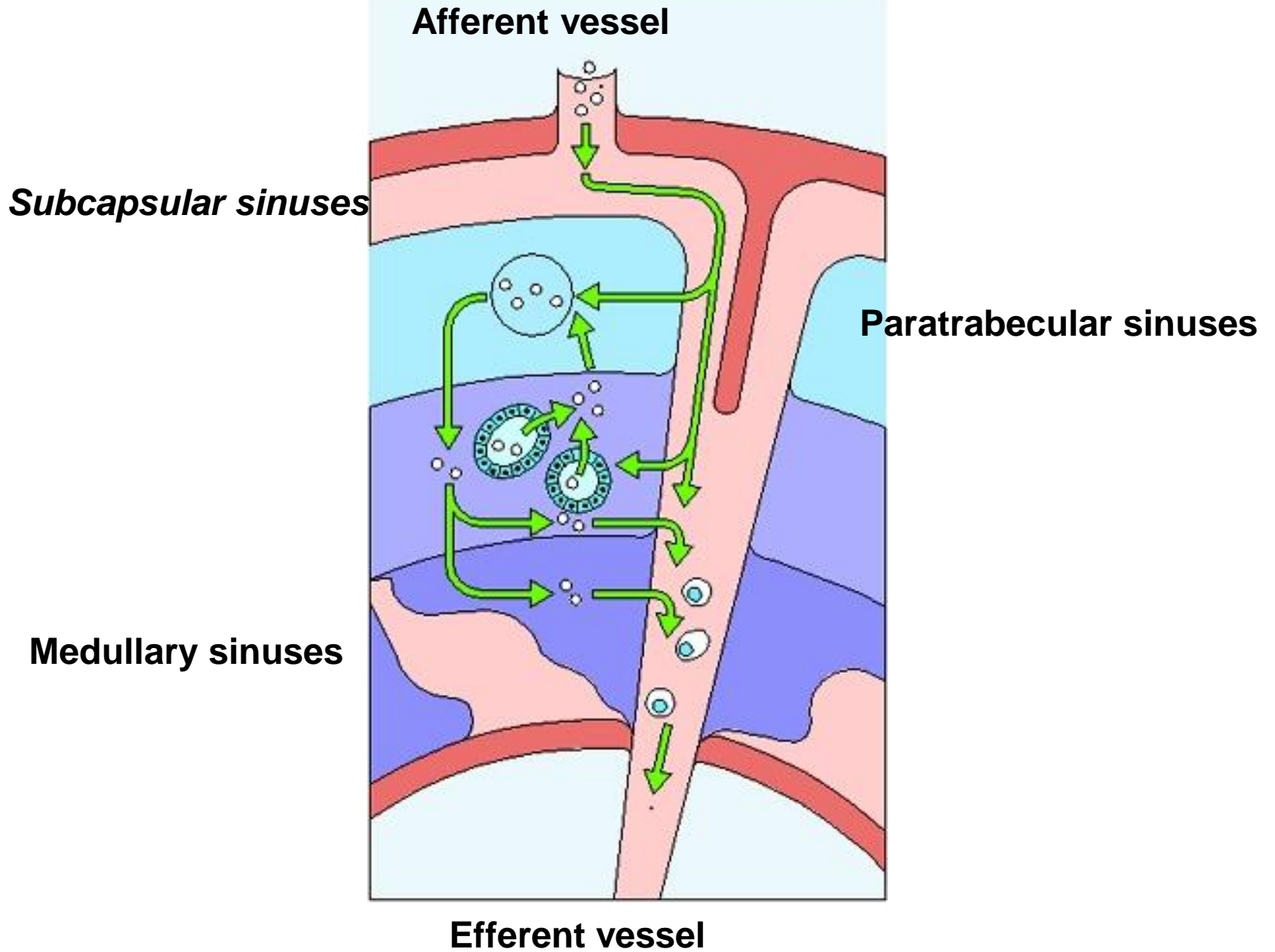
- Receive lymph from cortical sinuses.
- communicate with efferent vessels
- through which lymph leaves the node.
- Movement of lymph is **unidirectional** due to **valves** in afferent and efferent lymphatic vessels.

- **Lymphatic vessels:**

- Afferent enter through convex surface.
- Efferent leaves through hilum with BV & nerves.

- **Lymph circulation:**

- Lymph enters through convex surface and leaves through hilum.
- Lymph expose its contents to defensive cells (macrophages, lymphocytes, APCs).



Functions of lymph nodes

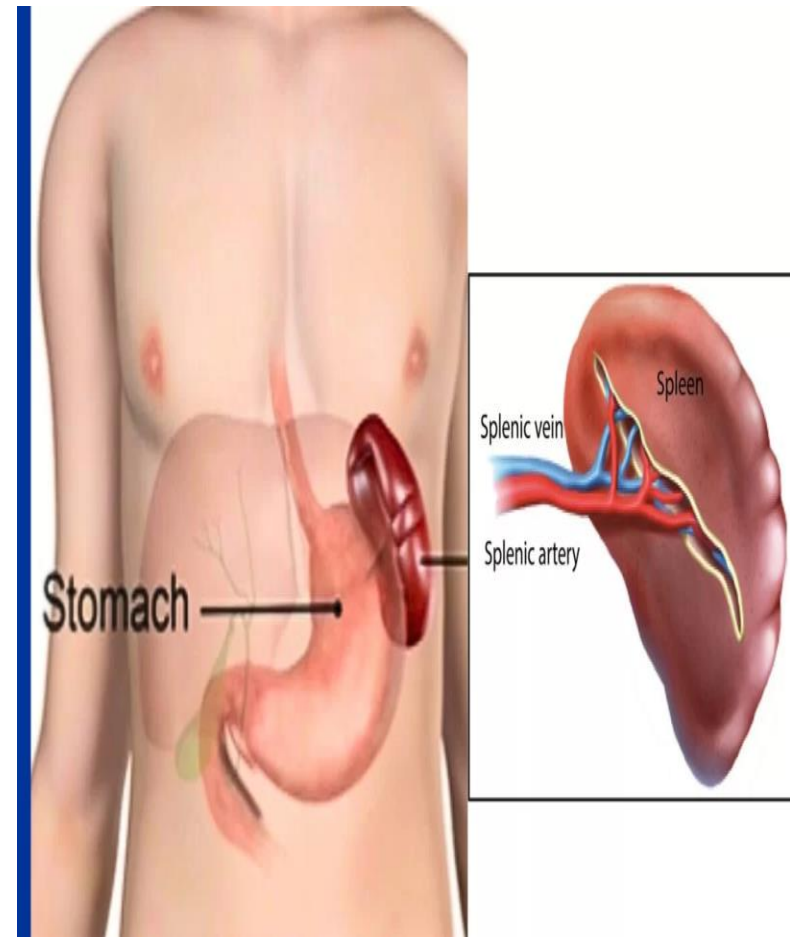
1– **Immunologic reaction**: cellular and humoral.

2– **Filtration of lymph**:

- Each node receives lymph from limited area of the body.
 - 99% of Ag removed by phagocytoses in sinuses.
 - 1% passes through follicles to be presented to lymphocyte by APCs.

Spleen

- **Size:**
 - The largest lymphatic organ in body.
- **Site:**
 - Lying along course of circulatory system.
 - In left side of abdomen beneath diaphragm.
- **Structure:**
 - Stroma
 - Parenchyma



Stroma

1- **Capsule:**

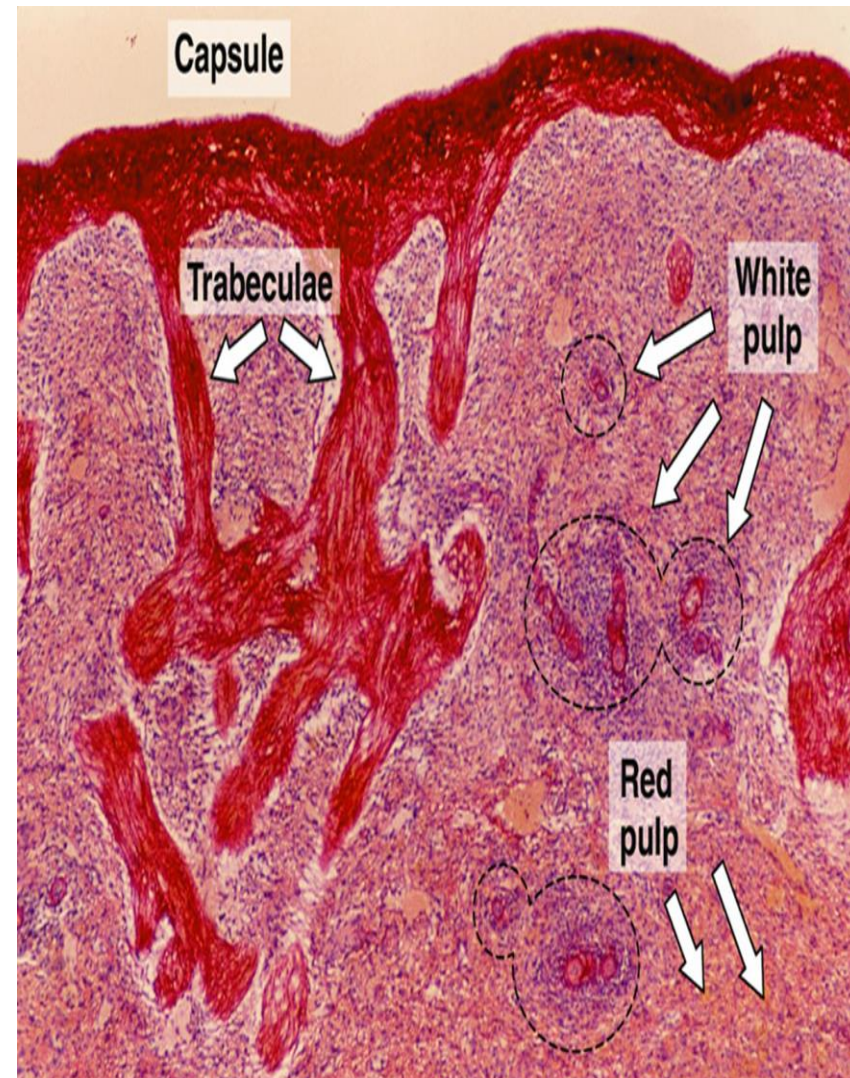
- dense C.T.
- few smooth muscle fibers.
- thickened at hilum
- covered by peritoneum.

2- **Trabeculae:**

- some extend from **capsule**
- others extend from **hilum** like branching tree.
- trabeculae from hilum connect to those of capsule
- convey BV and nerves.

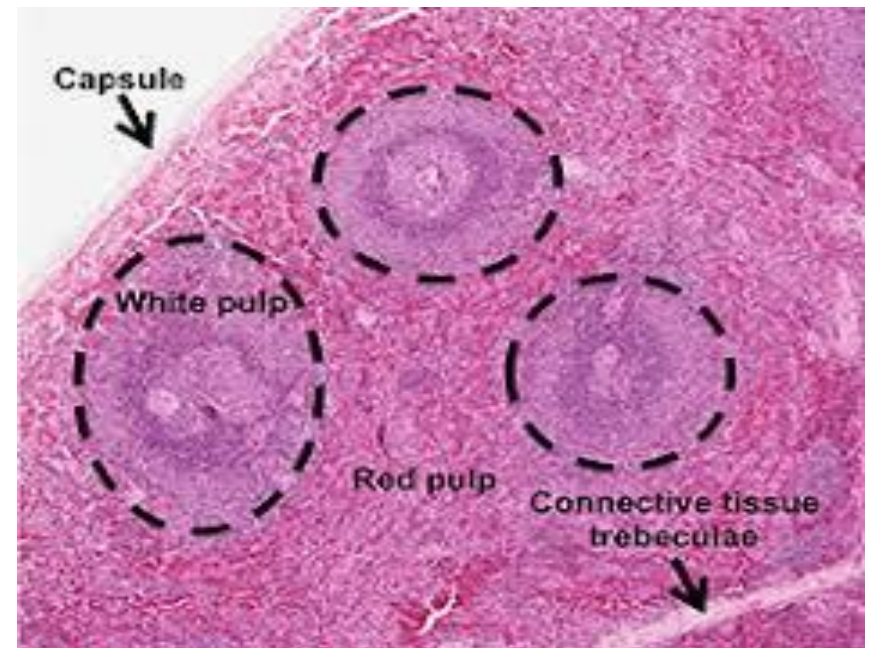
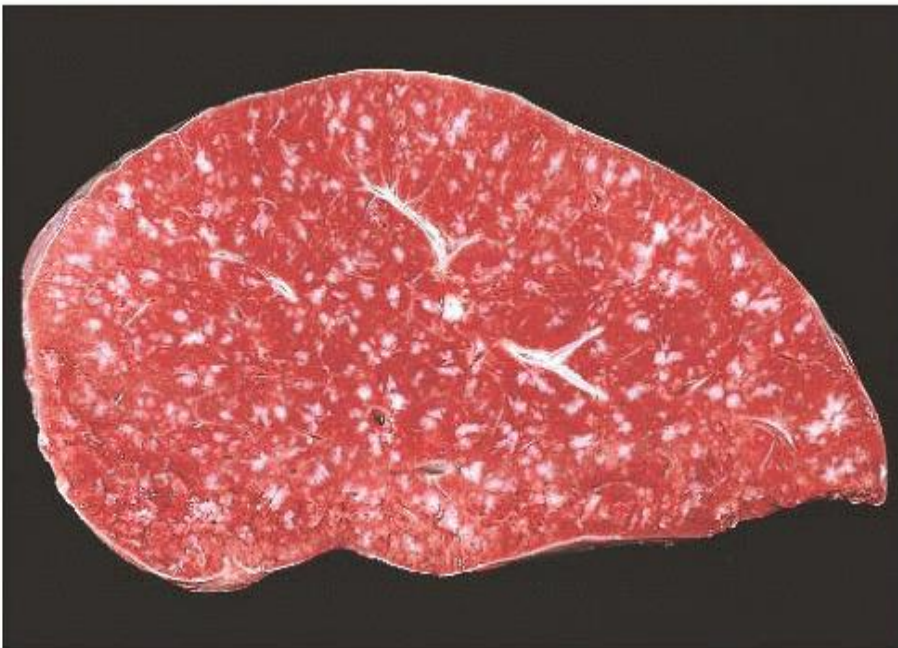
3- **Reticular network:**

- connected to capsule and trabeculae
- contains parenchymal cells in its meshes.



Parenchyma (splenic pulp)

- **Fresh** section of spleen shows
 - dark red tissue (**red pulp**).
 - white spots (**white pulp**).



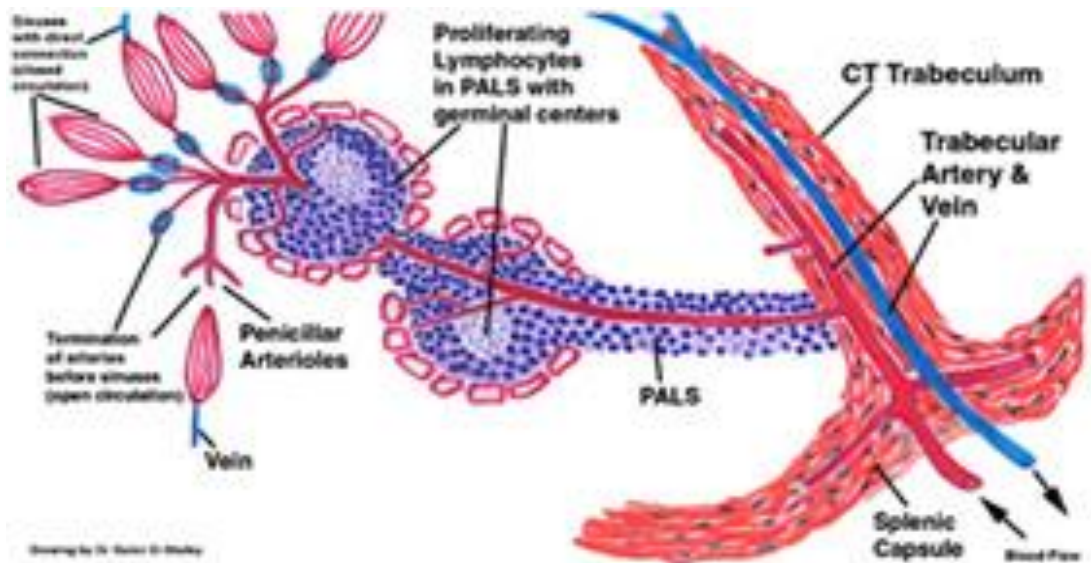
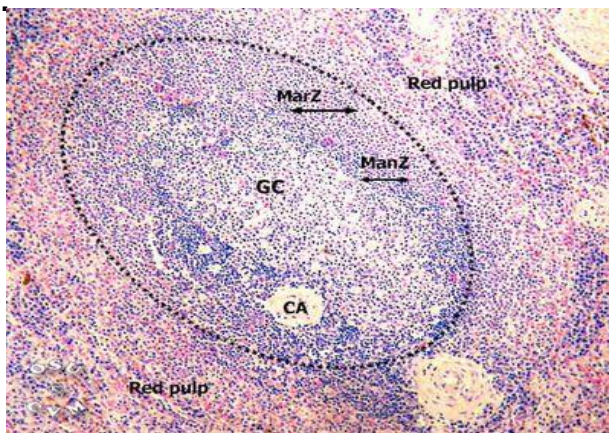
A- WHITE PULP

- Lymphatic tissue forms sheaths around central arteries.
- Then this sheath thickens at intervals to form lymphatic follicles.

1- Periarterial lymphatic sheaths (PALs): (thymus dependant area).

2- Lymphatic follicles:

- B- cells.
- splenic Malpighian corpuscles: with pale germinal centers: contain B cells, activated B cells, plasma cells & macrophages+ mantle zone
- central artery penetrates follicles in eccentric position.

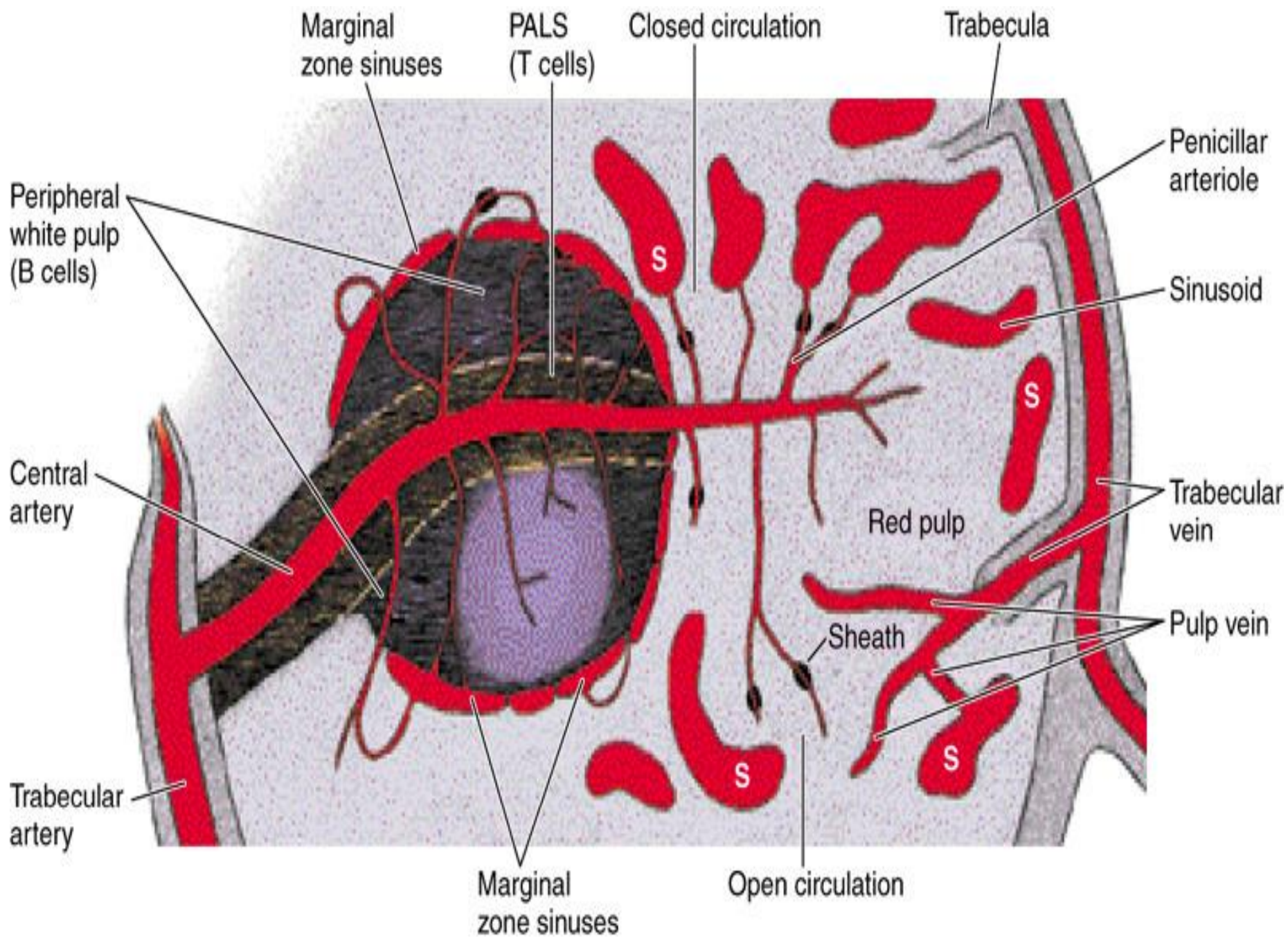


A- WHITE PULP

3- Marginal zone: between white pulp (lymphatic tissue) and red pulp (blood sinuses) .Contains macrophages, dendritic cells, **B-cells** (Specialized for rapid, T-cell independent responses) and some T-cells.

✦ Marginal zone sinuses (Vascular sinuses): Central artery gives branches through the follicle and end in sinuses.

- Sinuses have two roles:
 - **Traps Ag** presented to lymphocytes by APCs.
 - **Route for entry of B- and T- cells** to white pulp from blood.
- **T-cells** migrate to periarterial lymphatic sheaths (PALs).
- **Activated B-cells** migrate to germinal centers to change to plasma cells that migrate to red pulp releasing AB into sinusoids.

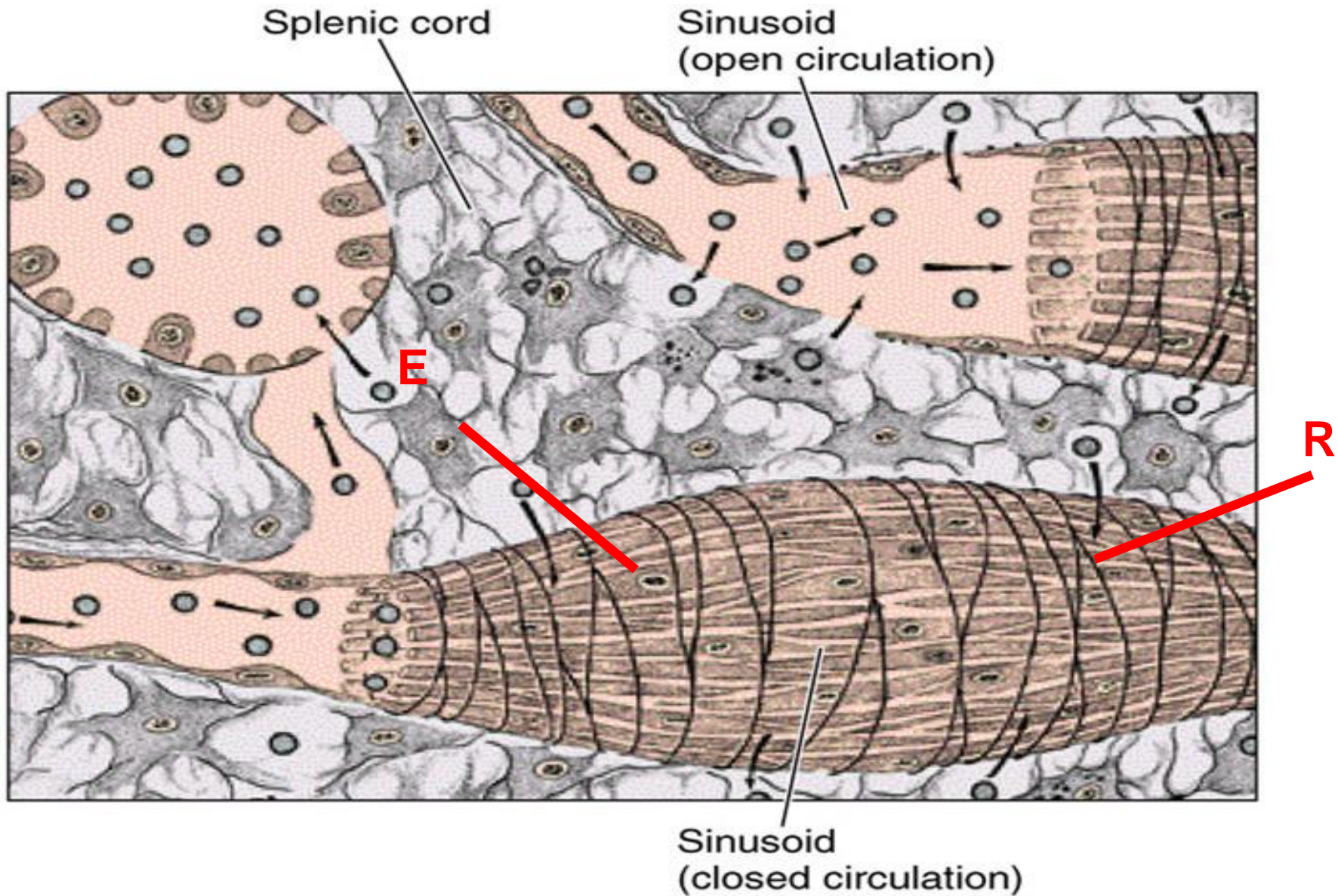


B- RED PULP

- major part of spleen
- red because of large number of erythrocytes.

- composed of:
 - 1– Blood sinusoids**
 - Large thin walled dilated spaces containing blood.
 - Lined by endothelial cells : (stave cells)
 - discontinuous layer.
 - parallel to long axis of sinusoids.
 - with slit-shaped gaps
 - allowing exchange of cells between blood in sinusoids and adjacent tissue.
 - enveloped by reticular fibers perpendicular to long axis of sinusoids.

 - 2– The splenic (Billroth cords)**
 - Cords of cells between blood sinusoids.
 - Contain blood elements, reticular cells, macrophages and plasma cells.



- **Red pulp:** sinusoids and cords with reticular cells and macrophages.
- reticular fibers perpendicular to long axis of sinusoid.

Blood circulation

- **Splenic artery**
 - enters hilum and branches into *trabecular arteries*.
- **Trabecular artery**
 - enters white pulp as *central artery*.
- **Central artery**
 - surrounded by periarterial lymphatic sheath.
 - occupies eccentric position in lymphatic follicles.
 - leaves white pulp to red pulp as *pulp artery*.
- **Pulp artery**
 - subdivides into *penicillar arterioles*.
- **Penicillar arterioles**
 - surrounded near their termination by ellipsoid sheath of macrophages, reticular cells and lymphocytes.
 - continue as *capillaries*.

- **Capillaries** carry blood to red pulp sinusoids in various ways:

1- Closed circulation:

- capillaries open into sinusoids.

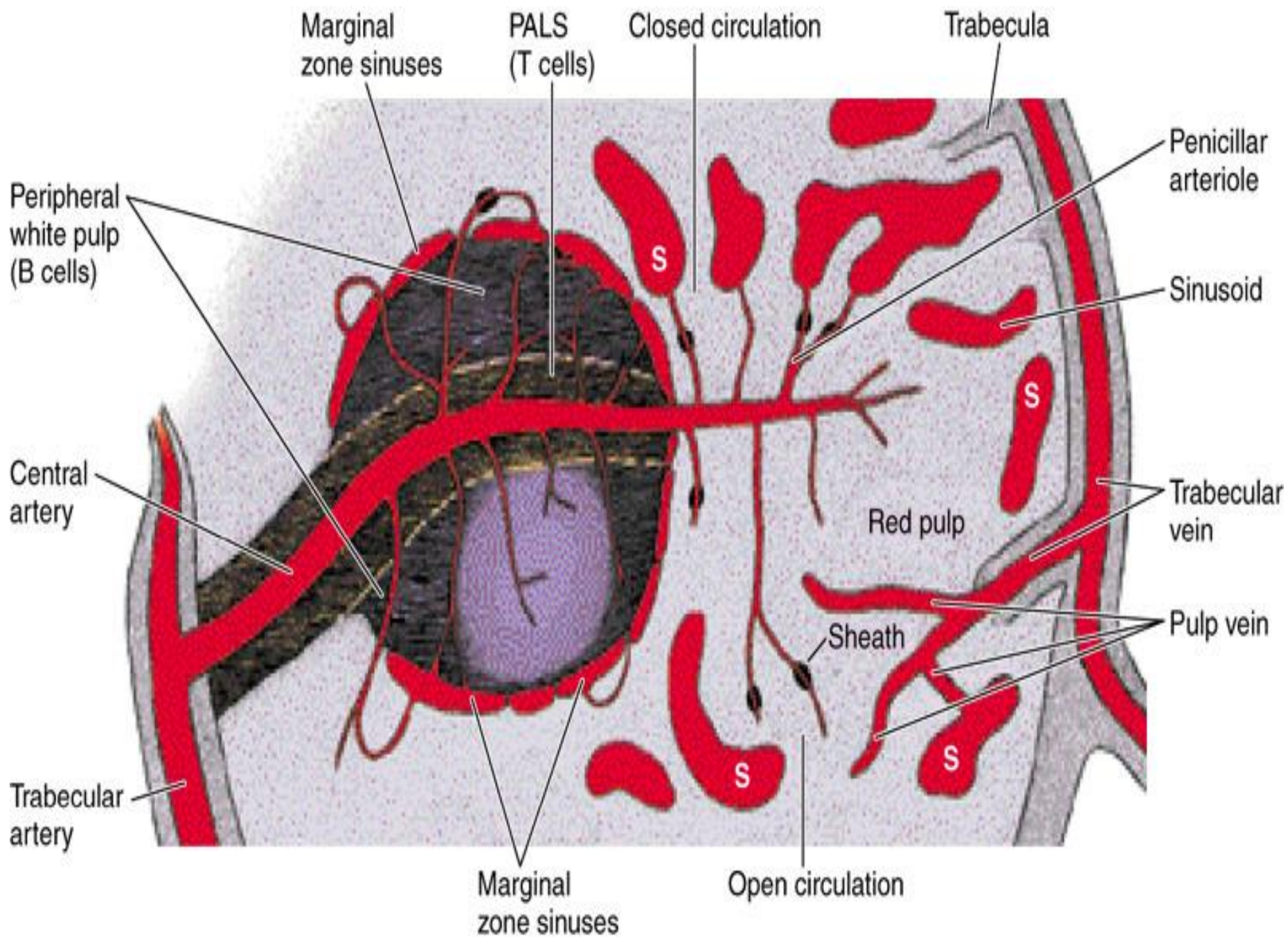
2- Open circulation:

- capillaries open into red pulp.

3- Open – closed circulation:

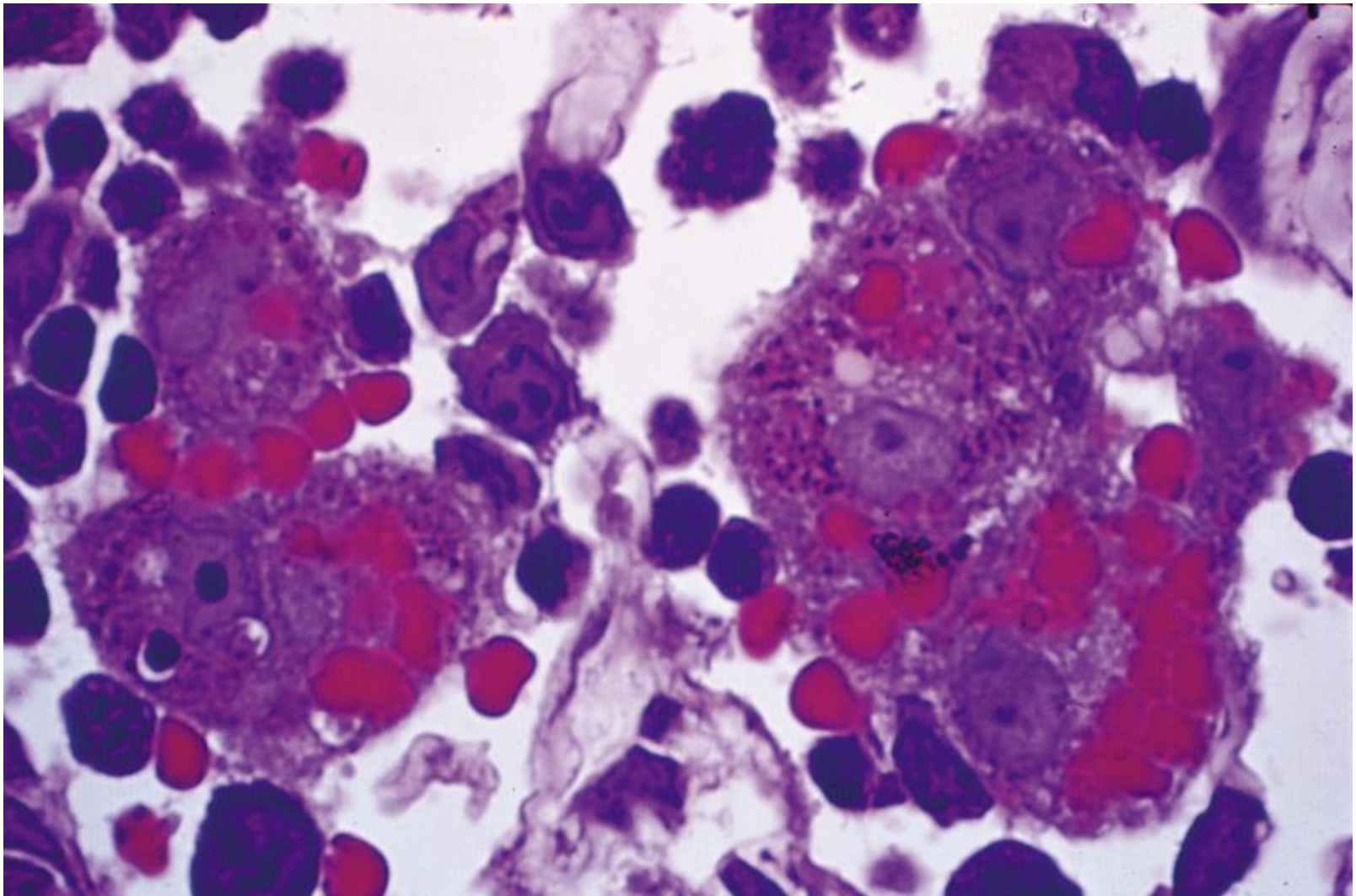
- closed circulation in collapsed spleen.
- open circulation in distended spleen.

- From sinusoids, blood passes to
 - pulp veins
 - trabecular veins
 - splenic vein that merges from hilum.



Functions of spleen

- 1- Immunity (Cellular and humoral).
- 2- Filtration of blood (Immunologic).
- 3- Destruction (old RBCs).
- 4- Haematopoietic function (in fetus).
- 5- Storage of blood (in animals).



5 spleen macrophages in active phagocytosis of erythrocytes
in different stages of degradation.

Thank you

