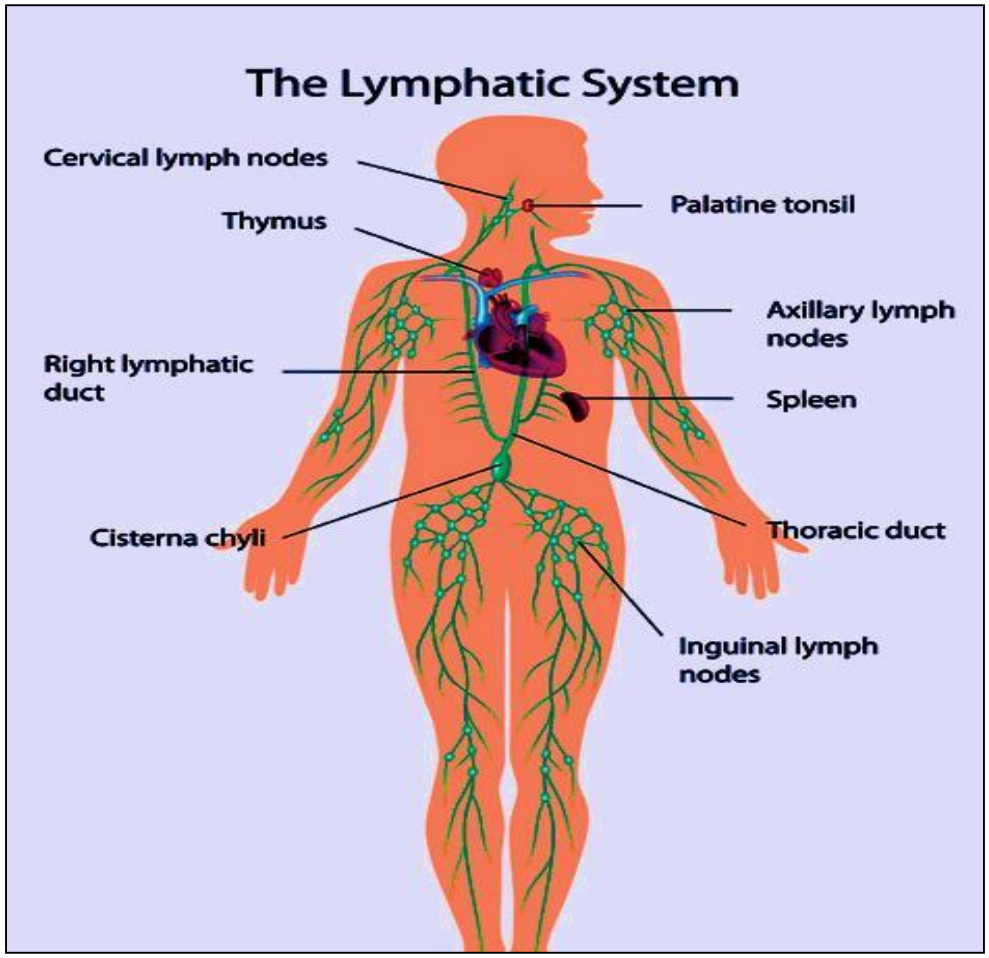
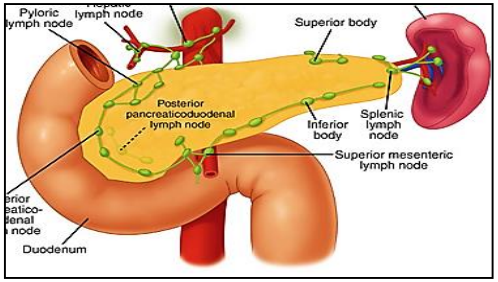
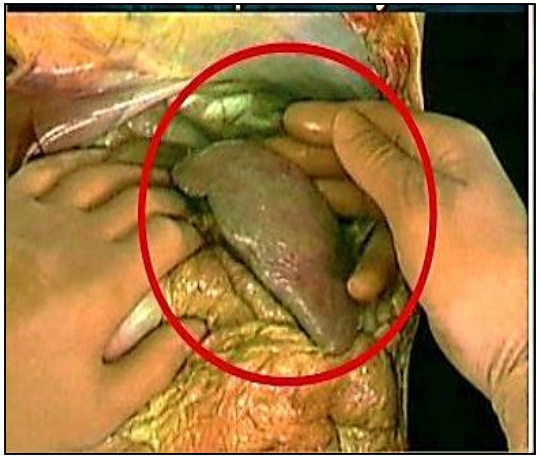
# The lymphatic system (Part II)

## Medical students / First Year





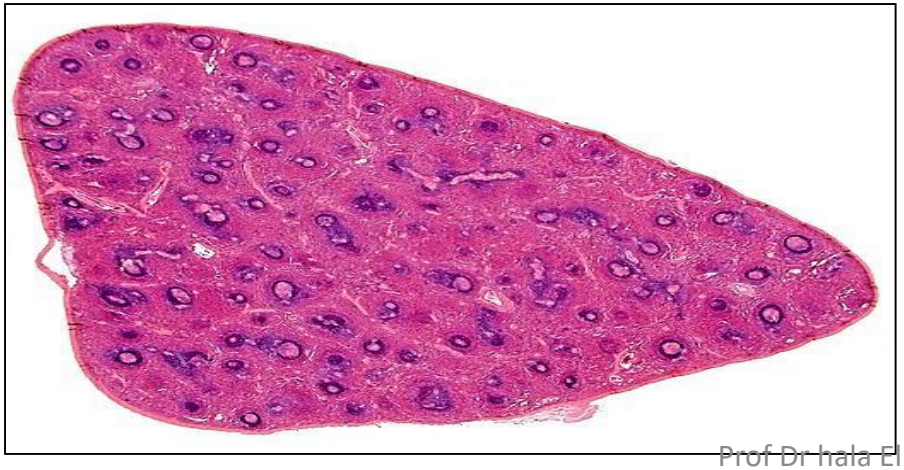

# Spleen



- Largest single hemo-lymphatic organ
- Important blood filter. Is the site of destruction of aged RBCs & recycling of iron
- Immunological function through B & T cells (humoral & cell mediate immunity)
- A site of hematopoiesis in the fetus, and stores RBCs & platelets (blood reservoir in animals ).

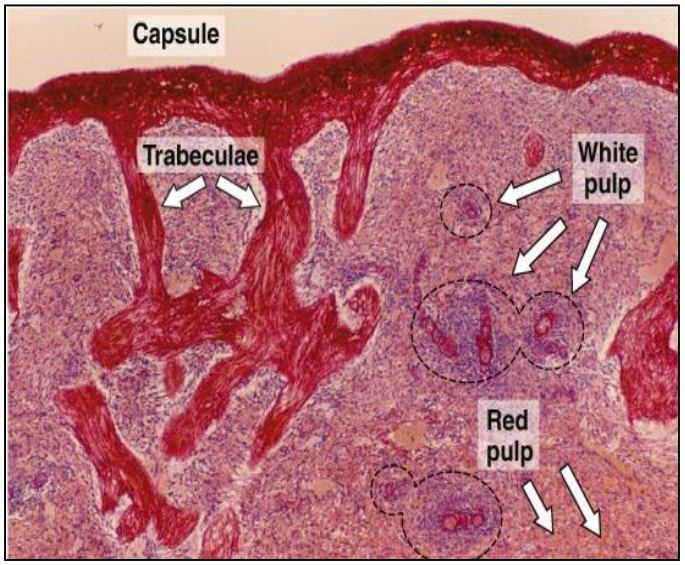
# Spleen

- **A- Stroma**
  - Capsule
  - Trabeculae =septa
  - Reticular CT
- **B- Parenchyma**
  - 1- White pulp
    - Lymphatic nodules
  - 2- Red pulp
    - splenic cords
    - Blood sinusoids



# Structure of spleen

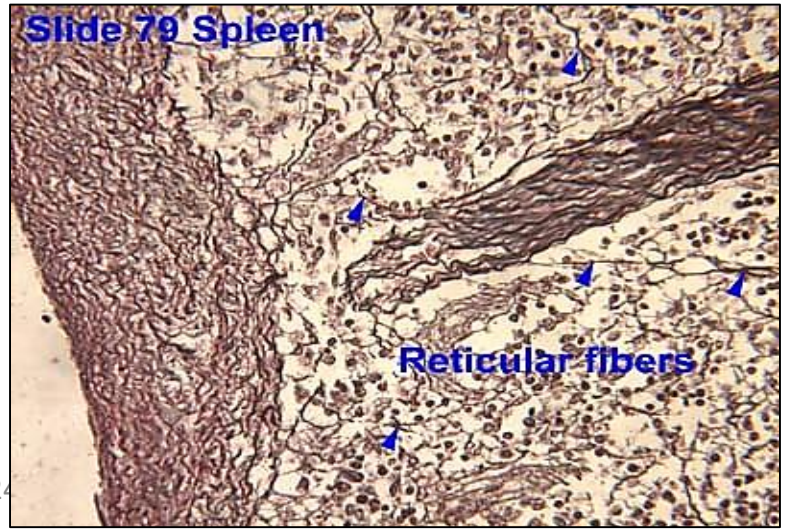
## A-Stroma




**1-Capsule:** thick, rich in collagenous, elastic fibers & **smooth ms cells.**

**2-Trabecula:** are short ones, extend from capsule.

divide the spleen into incomplete compartment, rich in elastic fibers & smooth ms. cells




**3-Reticular CT:**

reticular cells and fibers, form network

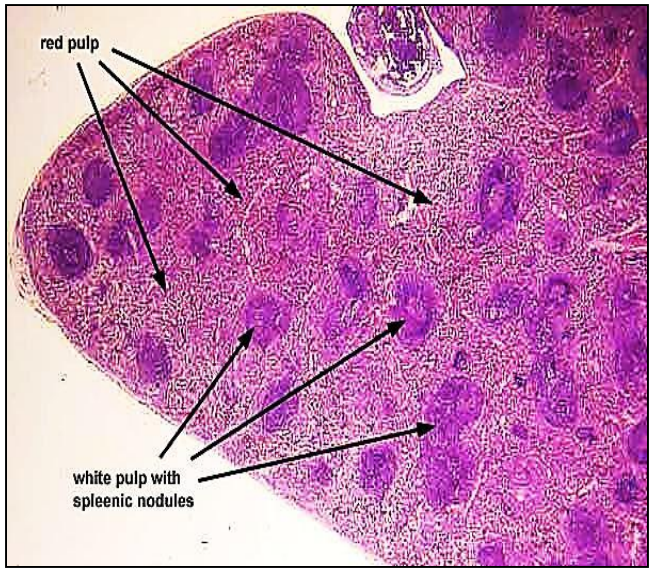
# B-parenchyma

## White pulp

### Lymphoid nodules

#### PALS

Peri-arteriolar lymphatic sheath




## Red pulp

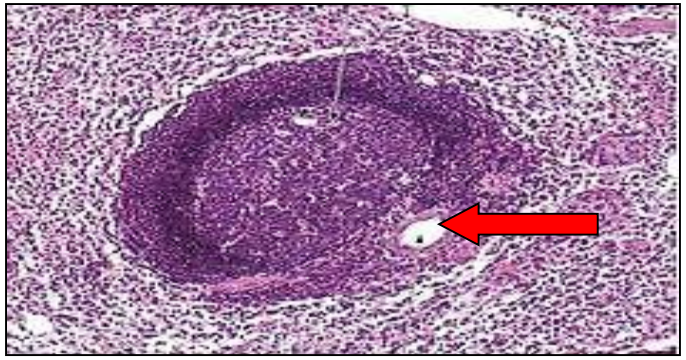
### Blood sinusoids

#### Splenic cords

# I- white pulp

## 1- lymphatic nodules (Splenic Malpighian corpuscles):

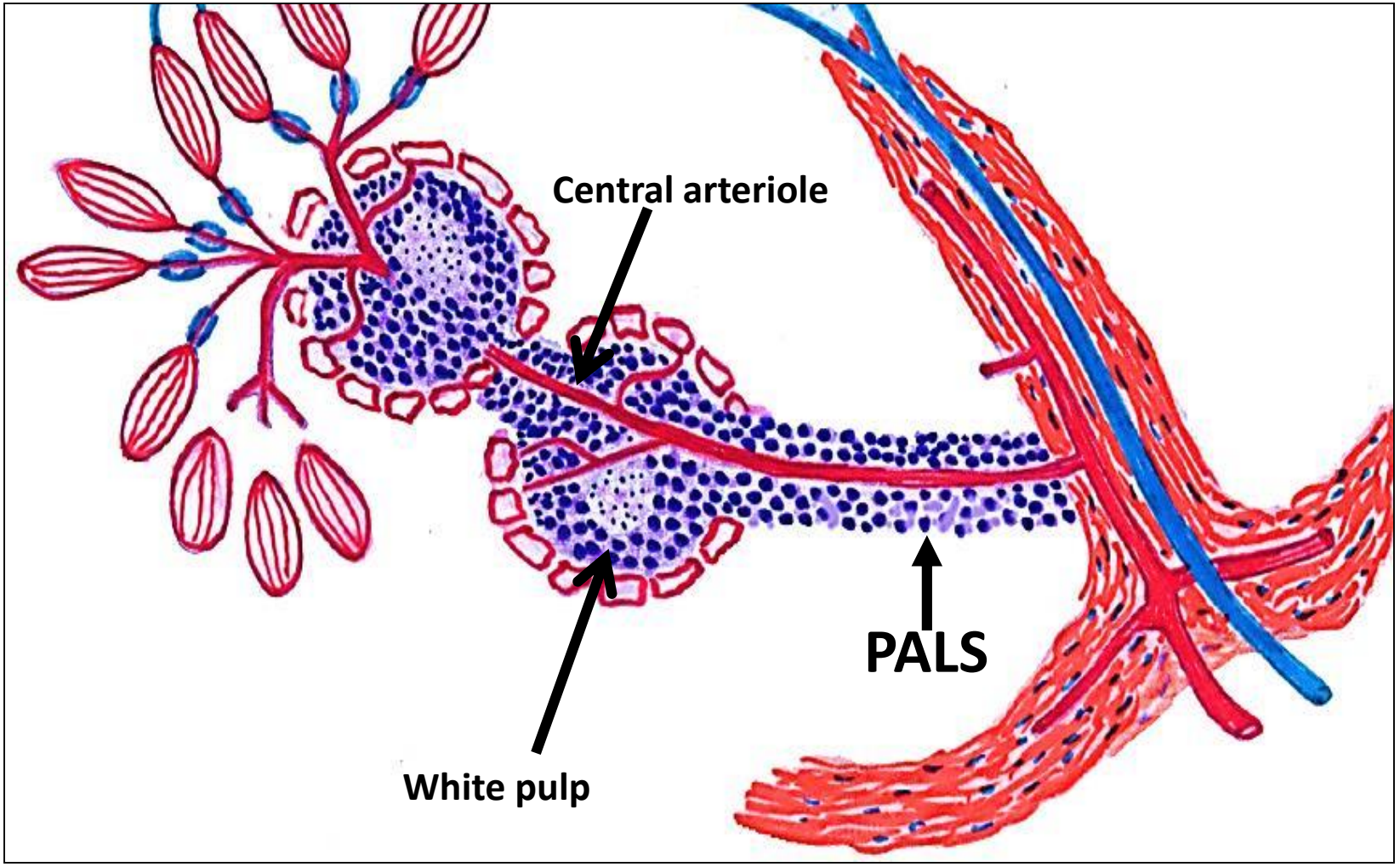
aggregations of lymphocytes forming 1ry or 2ry nodules distributed throughout the parenchyma of the spleen



## 2- Periarteriolar lymphoid sheaths (PALS):

- mainly T lymphocytes encircle the central arteriole and called (Thymus dependent zone of spleen)

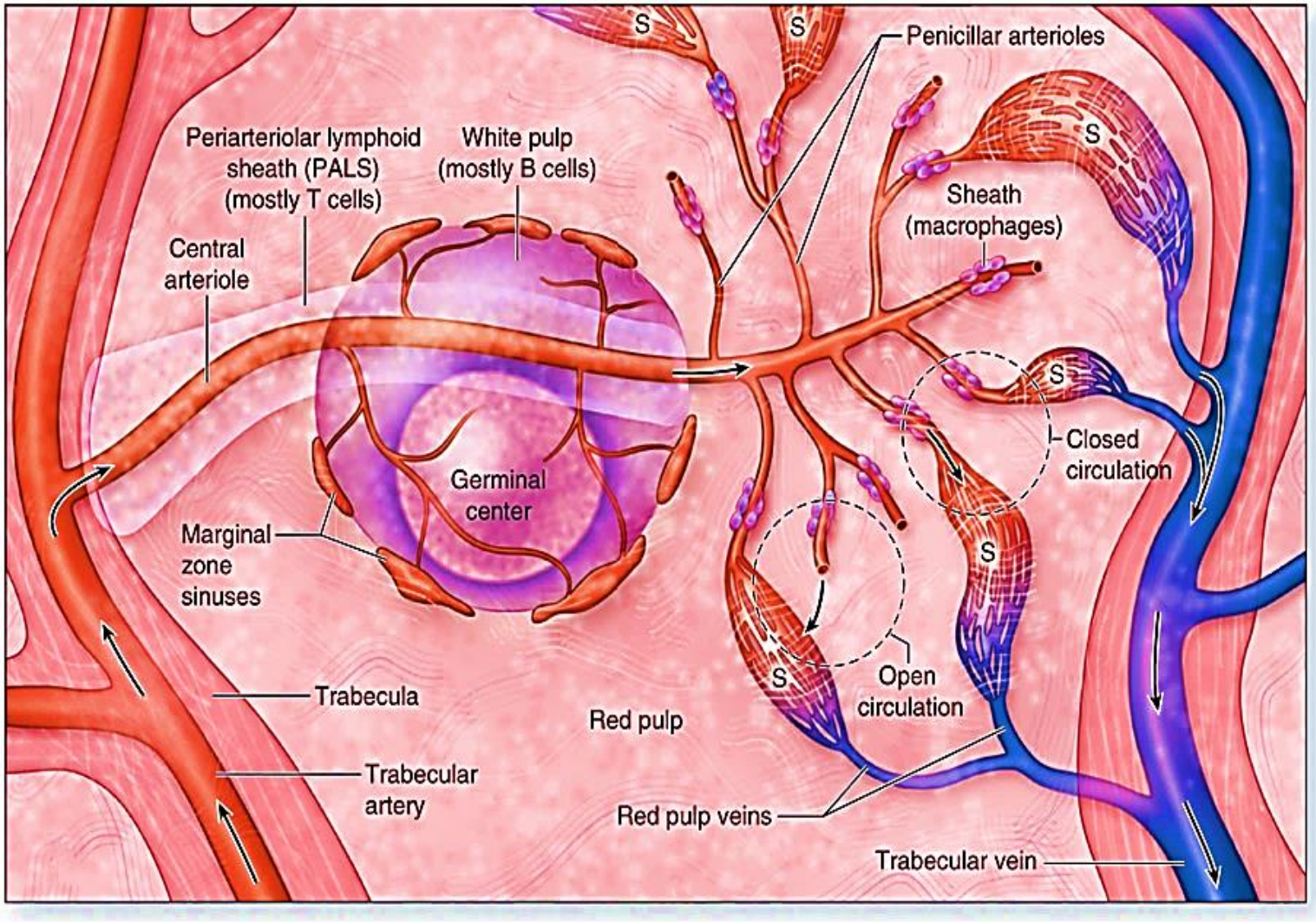
- **Central arteriole** runs at the **periphery** of the nodules (eccentric). They are branches of splenic artery which give numerous branches before leaving the white pulp to enter the red pulp.




**The sketch shows the lay out of the blood supply of the spleen**

- **Germinal center** : lightly stained, contain activated B cells, plasma cells & macrophages

- **Marginal zone** at the periphery of white pulp close to the red pulp has APCs & macrophages.

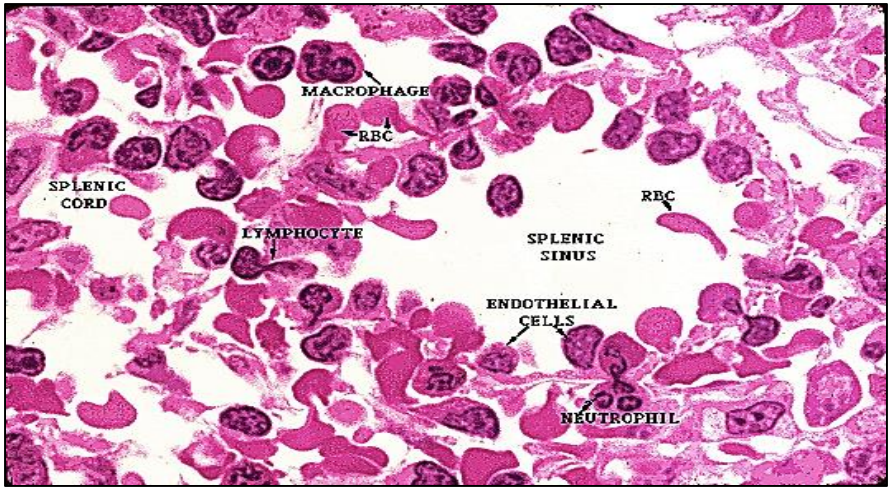


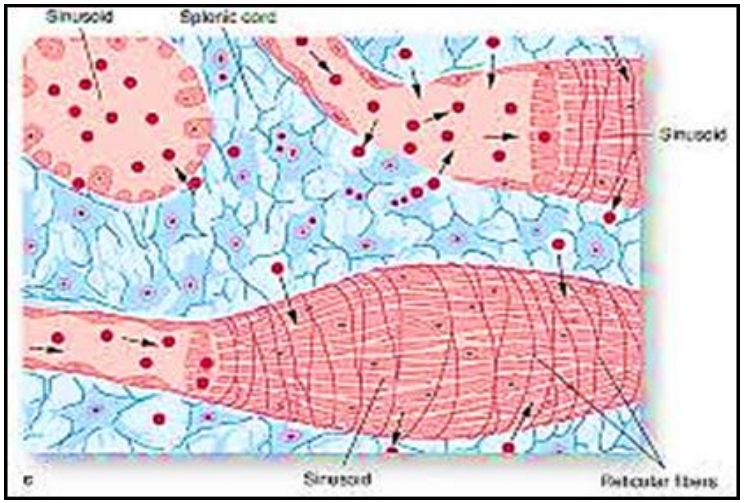

# Organization of Cells in white pulp of spleen

# II- Red pulp (79%)

## 1-Splenic cords (Billroth cords):

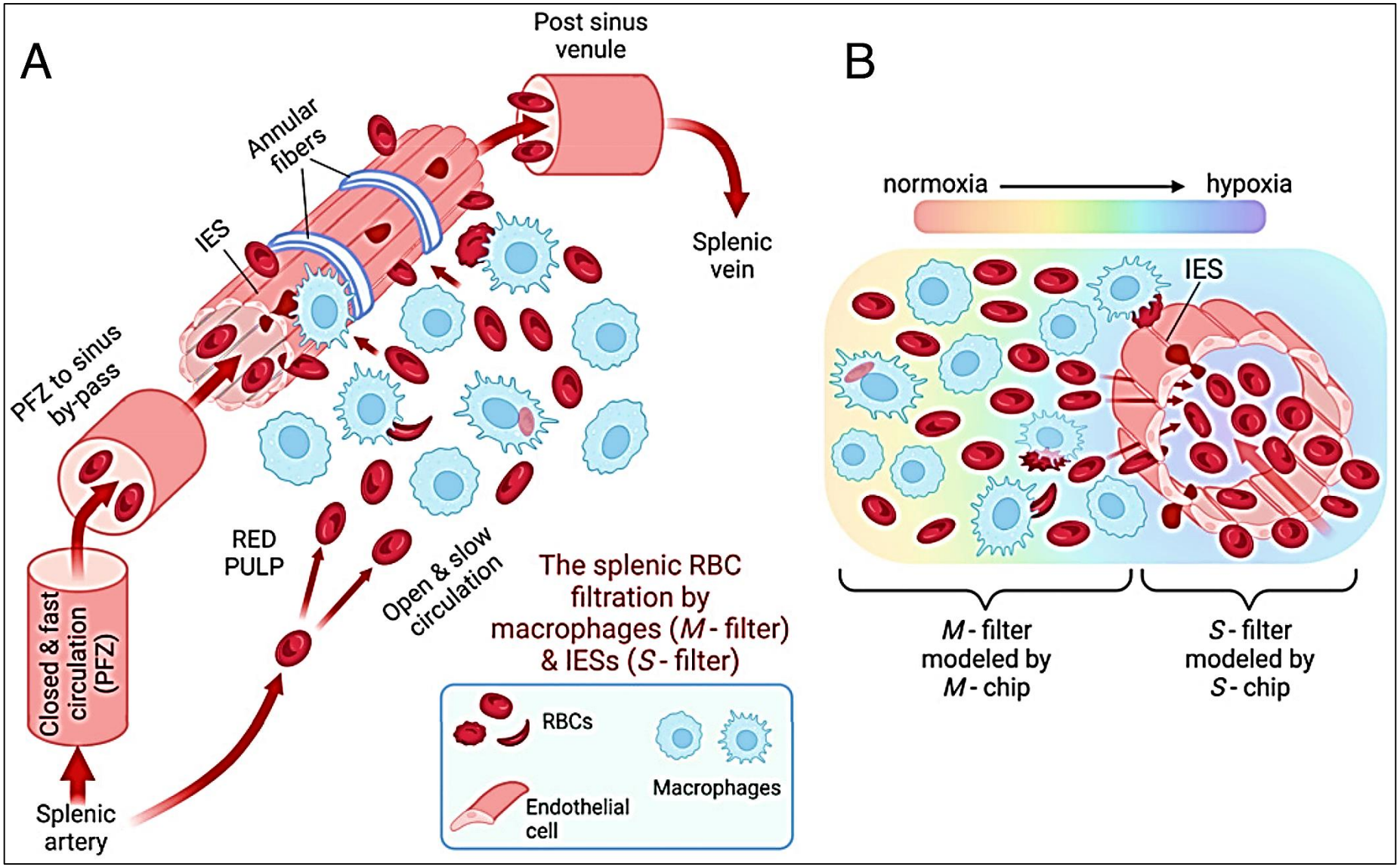
- Network of reticular fibers between blood sinusoids to support the free cells found e.g. blood cells, T & B lymphocytes , plasma cells , macrophages



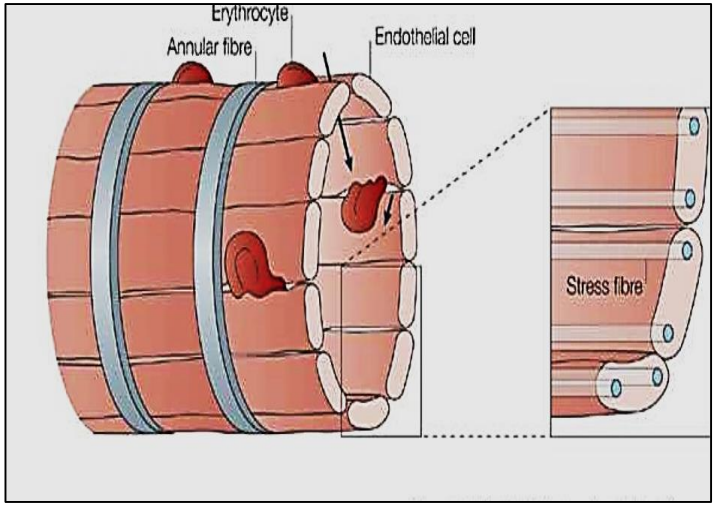

## 2-Blood sinusoids (venous sinuses):

- wide spaces lined with fenestrated endothelium called **stave cells** which filter the blood & surrounded with *Macrophages called* ***Littoral cells***



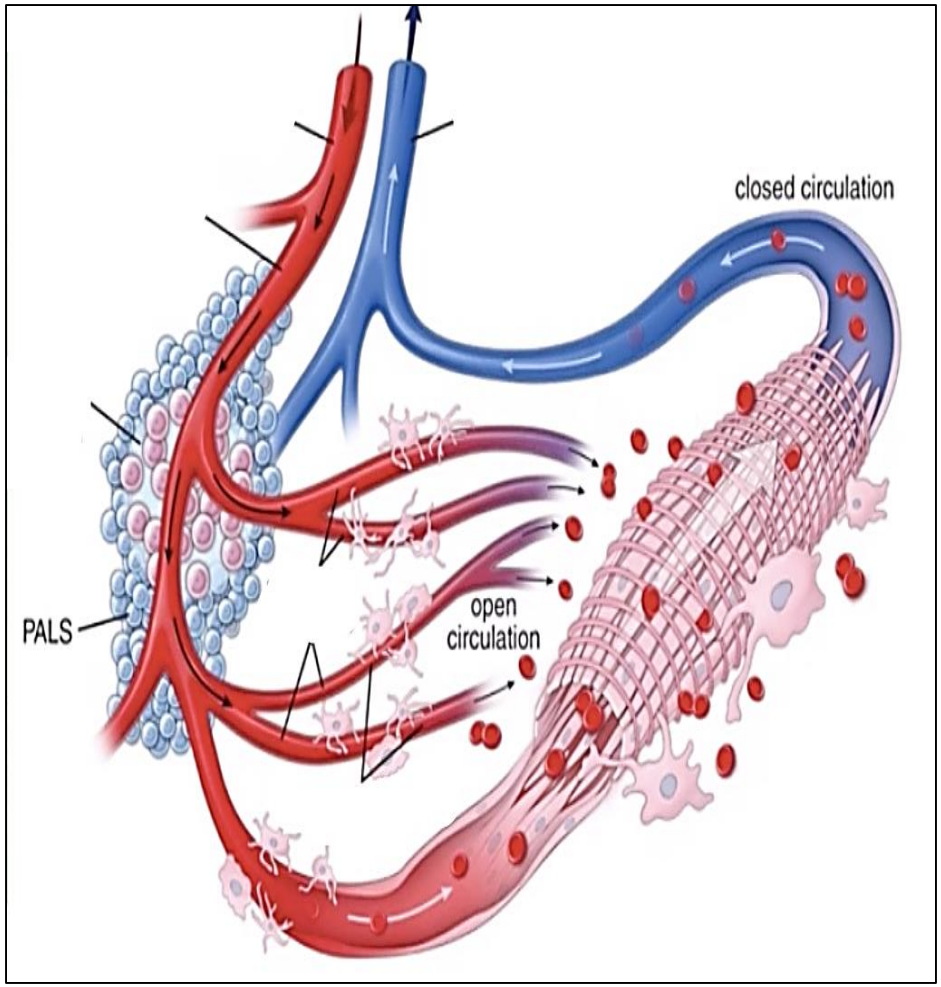

# Destruction of red blood cells in the spleen

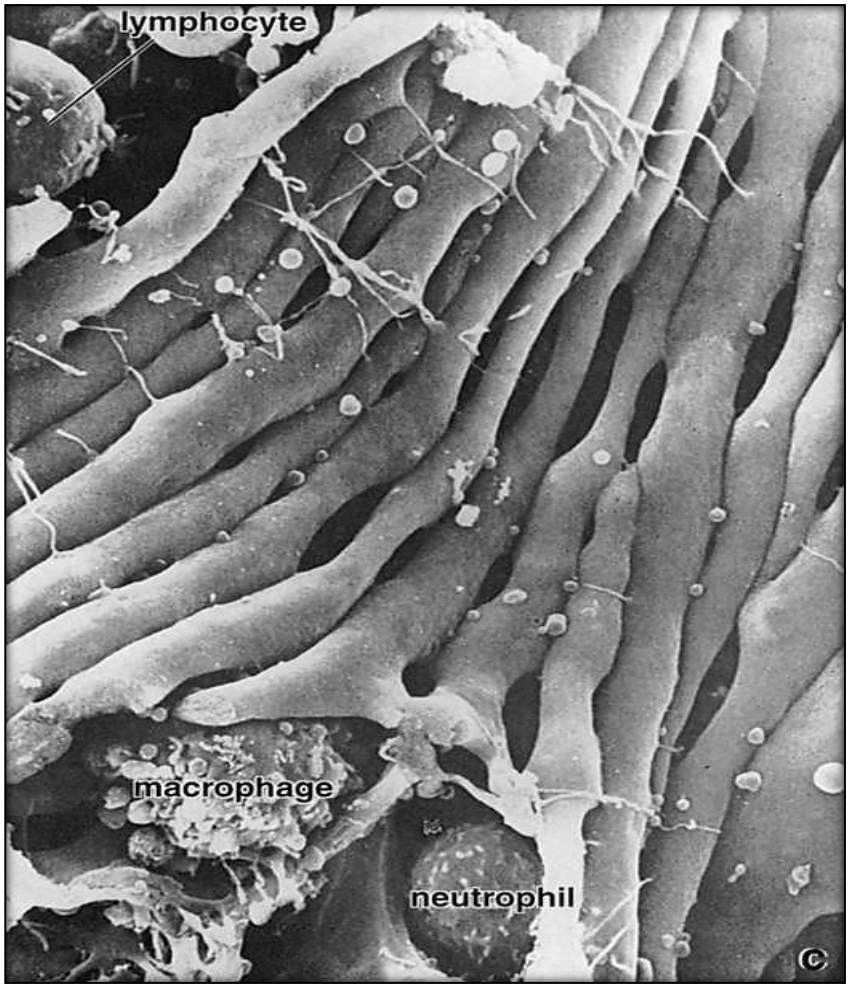
- **Stave cells** , unusual elongated endothelial cells( rod-like) oriented parallel to the sinusoidal blood flow
- These cells have discontinuous basement membrane which wrap the cells cross wise




- The gaps between the endothelial cells mechanically filter the blood cells.. Old or abnormal RBCs attempting to squeeze through the endothelial gaps become badly damaged and subsequently removed by macrophages

**After about 120 days the erythrocytes undergo membrane changes & swell , signals for their engulfment by macrophages in the cords of the reticular between the venous sinuses**

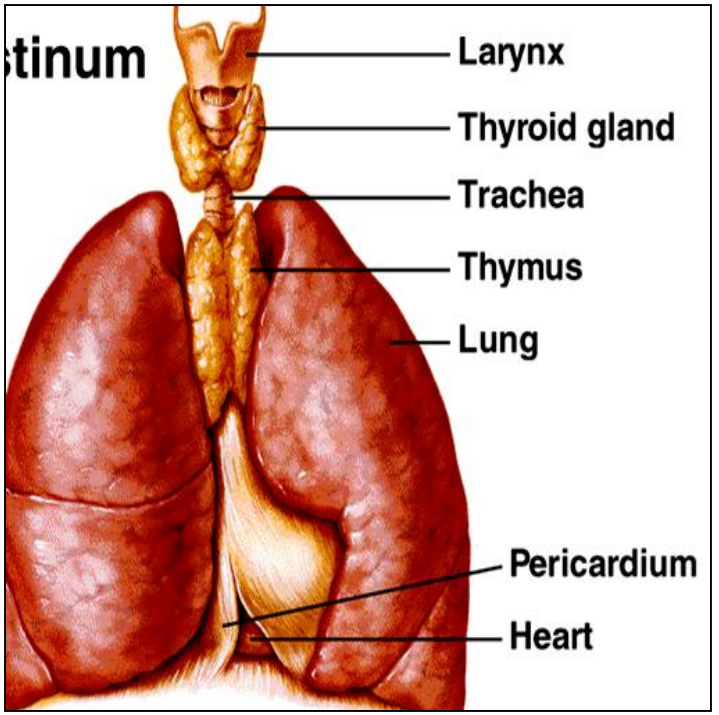



**The lining of splenic sinusoids and the EM of Stave cells**

# Thymus

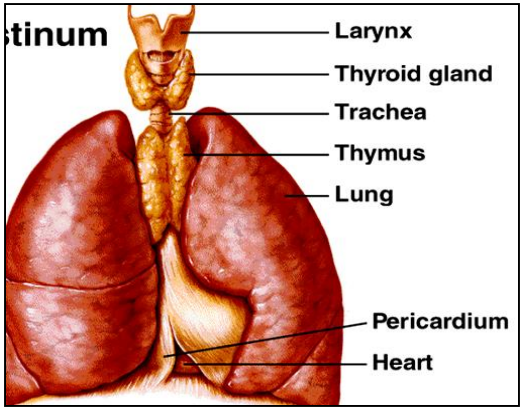
- is a **1ry** lymphatic organ with an endocrine function
- Location: behind the sternum in the mediastinum
- Single bi-lobed structure, highly lobulated organ



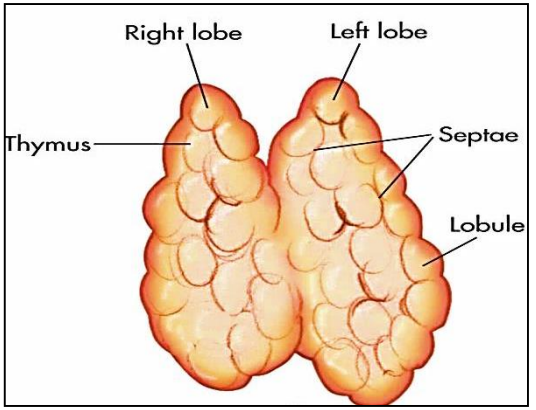

- Development:
  - Infant – ↑ in size
  - Puberty – maximum size
  - Adult – ↓ in size
- **Function**

Differentiation and maturation of T cells

Antigen-independent maturation




# Thymus



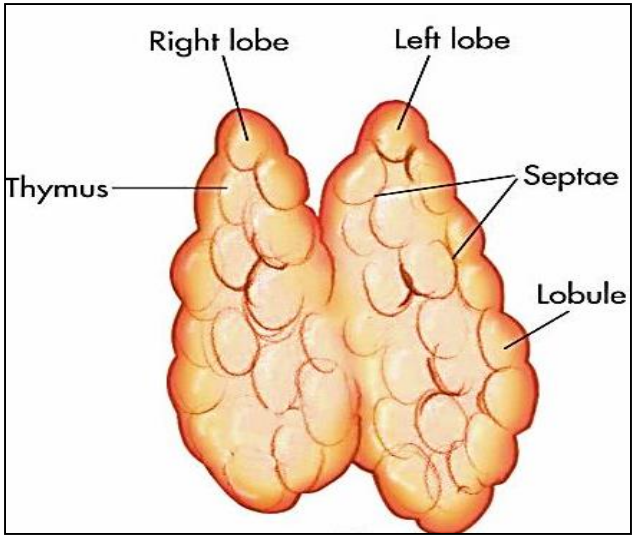

**A-Stroma**
1-Capsule
2-Trabeculae

**B-Parenchyma**
1- Lymphocytes
2- Epithelial R cells

1. Cortex

2. Medulla

## A- Stroma:

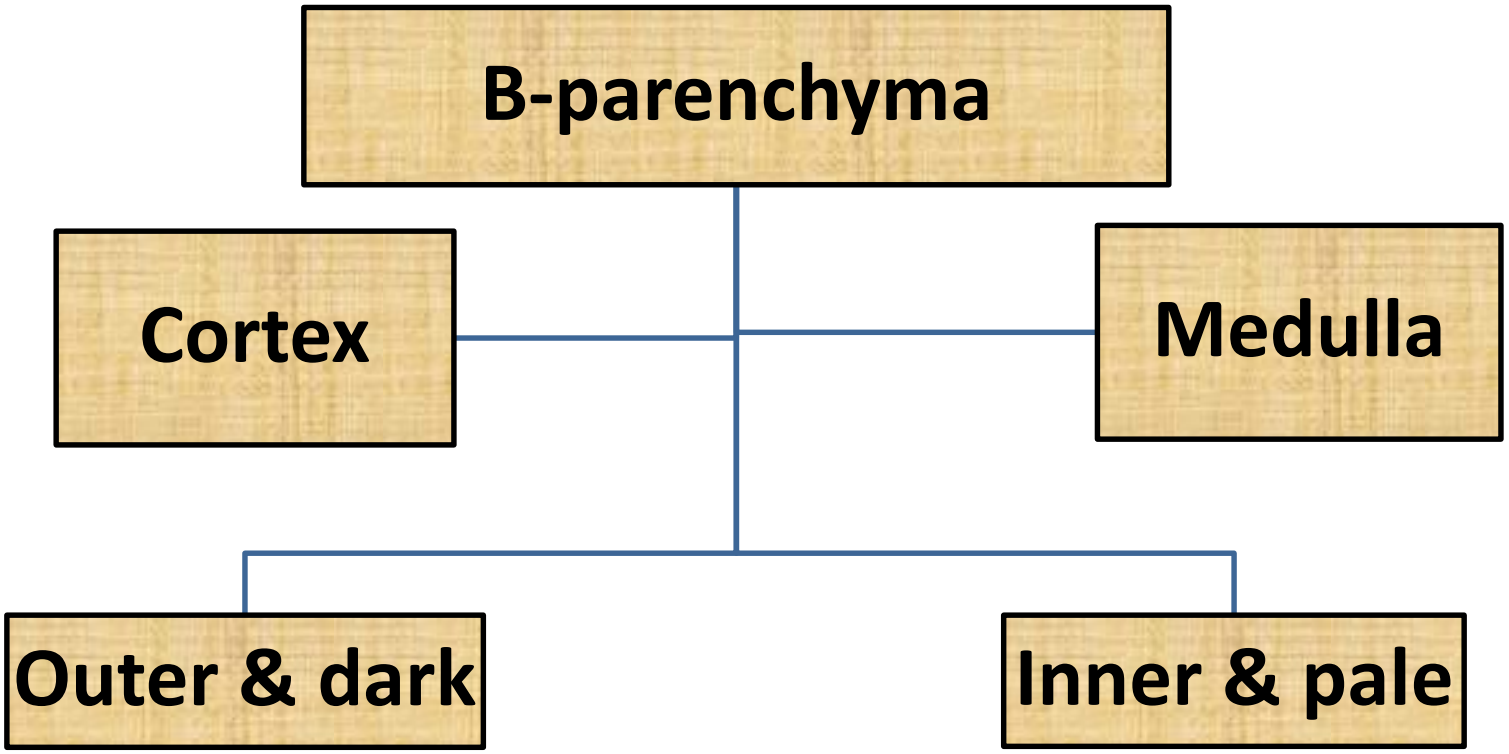



**1- Capsule**: loose CT

**2- Trabeculae (septa):**

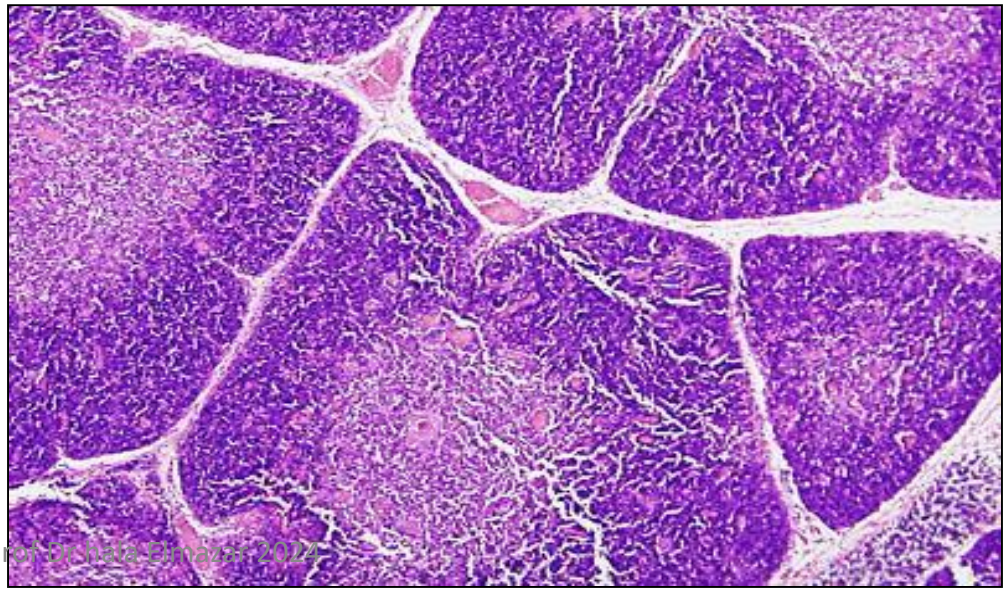
Arise from capsule, penetrate its substance forming lobes, carry blood vessels. Each lobe is divided into incomplete lobules

**3- Thymus** **has no reticular fibers** . Reticulum is formed by the processes of epithelial reticular cells

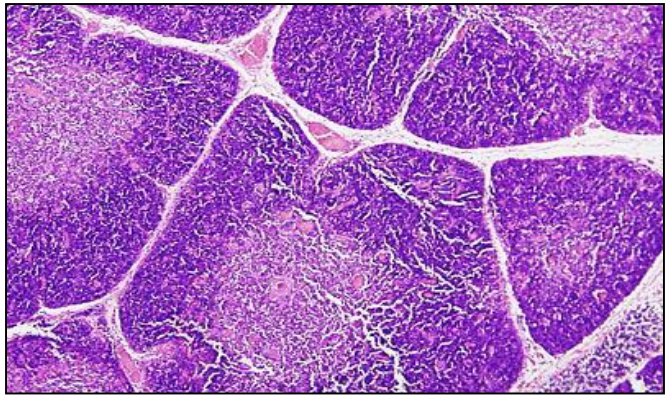



**Both contain:**

1- T. Lymphocytes.
2- Epithelial reticular cells.
3- Few macrophages.
4- Blood capillaries



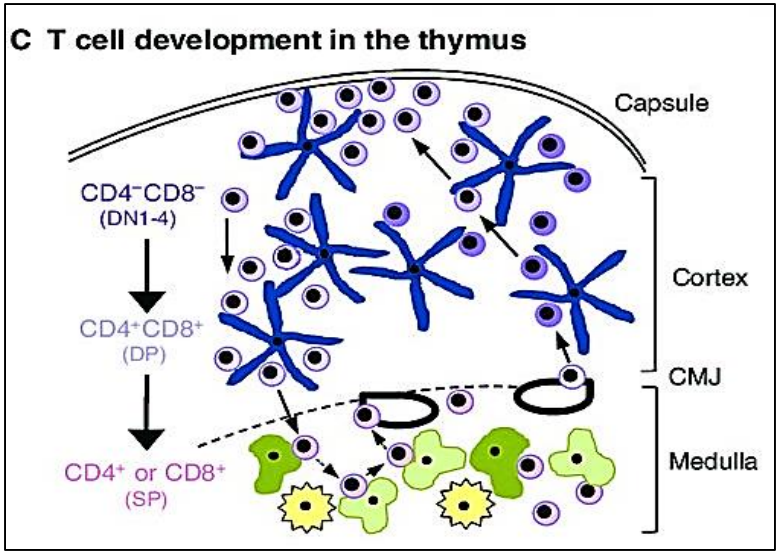
# 1- Cortex:



- Peripheral dark-stained zone,
  **where T cell maturation occur**

- Cortex contains **thymocytes.**

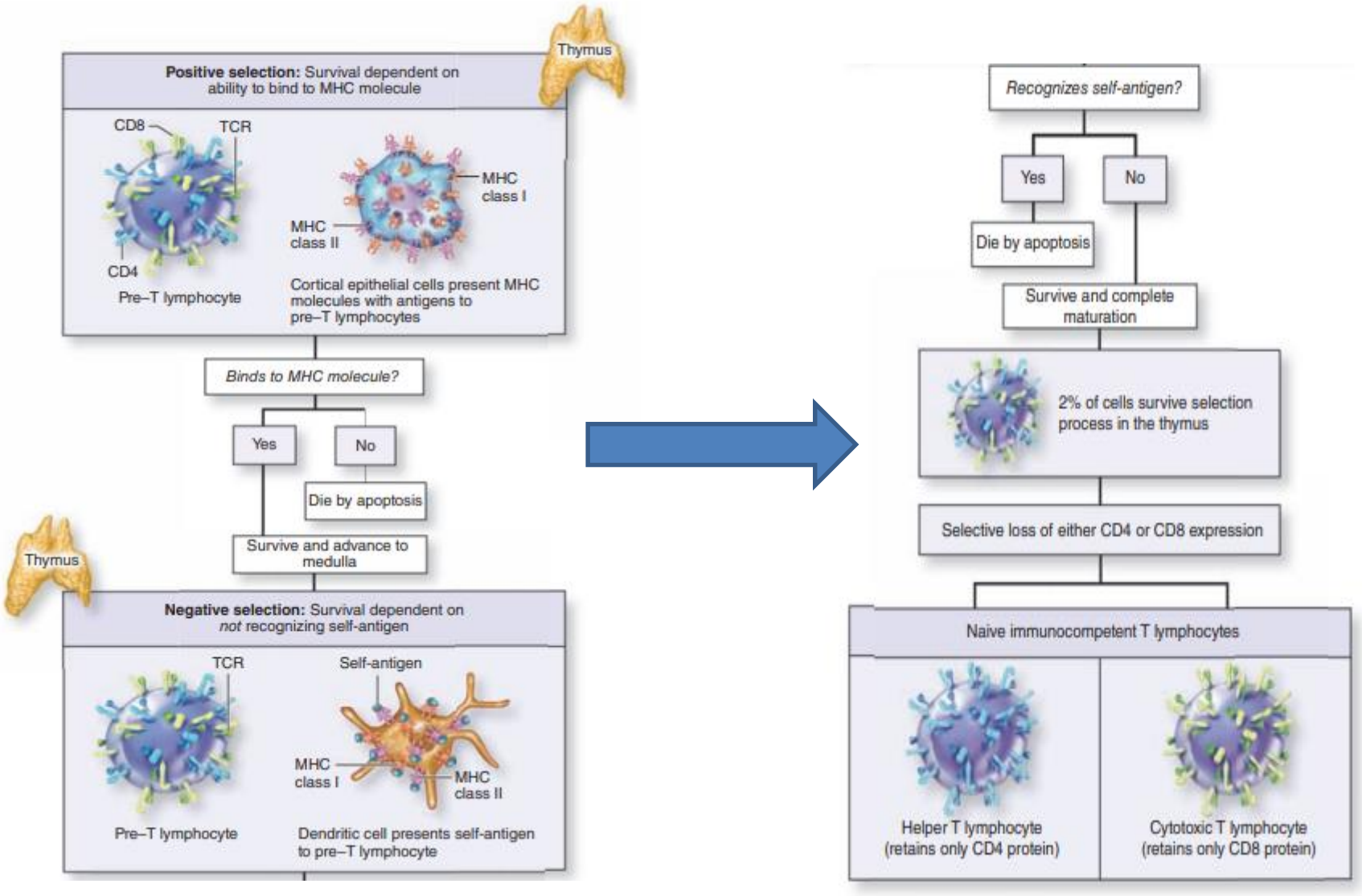
The hematopoietic precursors which migrated from bone marrow → thymus. Thymocytes is supported by a network of finely branched epithelial reticular cells




- Thymocytes **are completely** surrounded epithelial reticular cells

- The cortex is the site of **earliest events in thymocyte development,** where T cell receptor mature & positive selection take place
- **Mature T lymphocytes** leave the **cortex → the medulla.**

**Positive selection** occurs in the cortex and allows survival only of T cells with functional TCRs that recognize MHC class I and class II molecules. **Negative selection** occurs in the medulla and allows survival only of T cells that do not tightly bind self-antigens presented on dendritic cells there



# T- lymphocytes:

- Responsible for cell mediated immunity & also assist B lymphocytes in initiating the humoral response ( T- helper)
- T- cells are several subtypes:

➢ **Naïve ( how they leave the thymus) (HEV) (simple cuboidal epith.)**

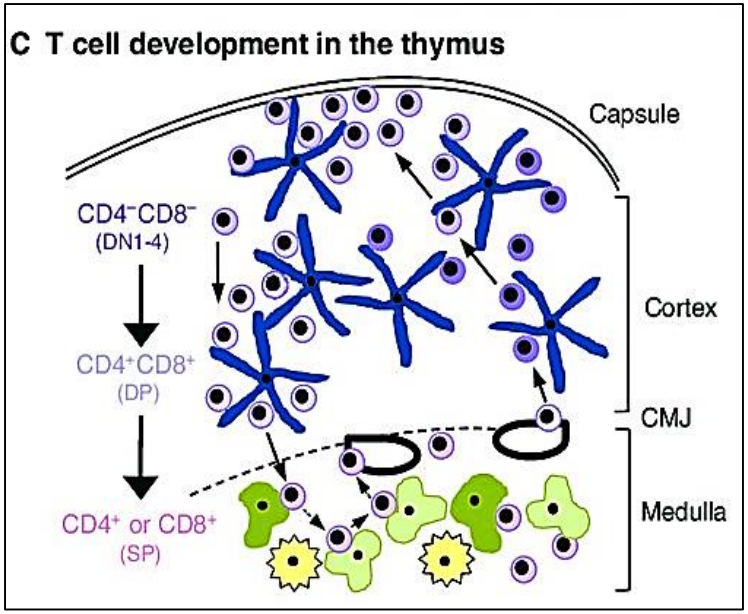
➢ **Effector** (T- helper, T- cytotoxic , T- suppressor (T reg cells) & T- killer cells)

➢ **Memory**

- T cells re-enter blood stream & travel to 2ry lymphatic organs (LN & spleen) where they settle in **thymus dependent zones**

# Epithelial reticular cells (ERCs) :

- Branched, acidophilic cells e oval nuclei, their long processes contain tonofilaments (Keratin filaments)
- Also called thymic **nurse cells**
- They are connected together by desmosomes
- Do not produce reticular fibers.




- Found in both cortex & medulla (Cortical ERCs & medullary ERCs)
- Contain secretory granules which contain the thymic hormones

## Functions of ERCs:

1- nursing cells for T cells during their differentiation

2- Secrete the thymic hormones

- Thymulin
- Thymopoietin
- Thymosins
- Thymic humoral factor

3- Share in the blood-thymus barrier

4- Antigen presenting cells for developing T lymphocytes

5- in medulla form Hassall's corpuscles

# Blood- thymus barrier

Barrier exists in the **cortex only** to separate the developing T-lymphocytes from antigens in blood

The barrier is formed by:

1- Continuous capillary endothelium

2- Pericytes

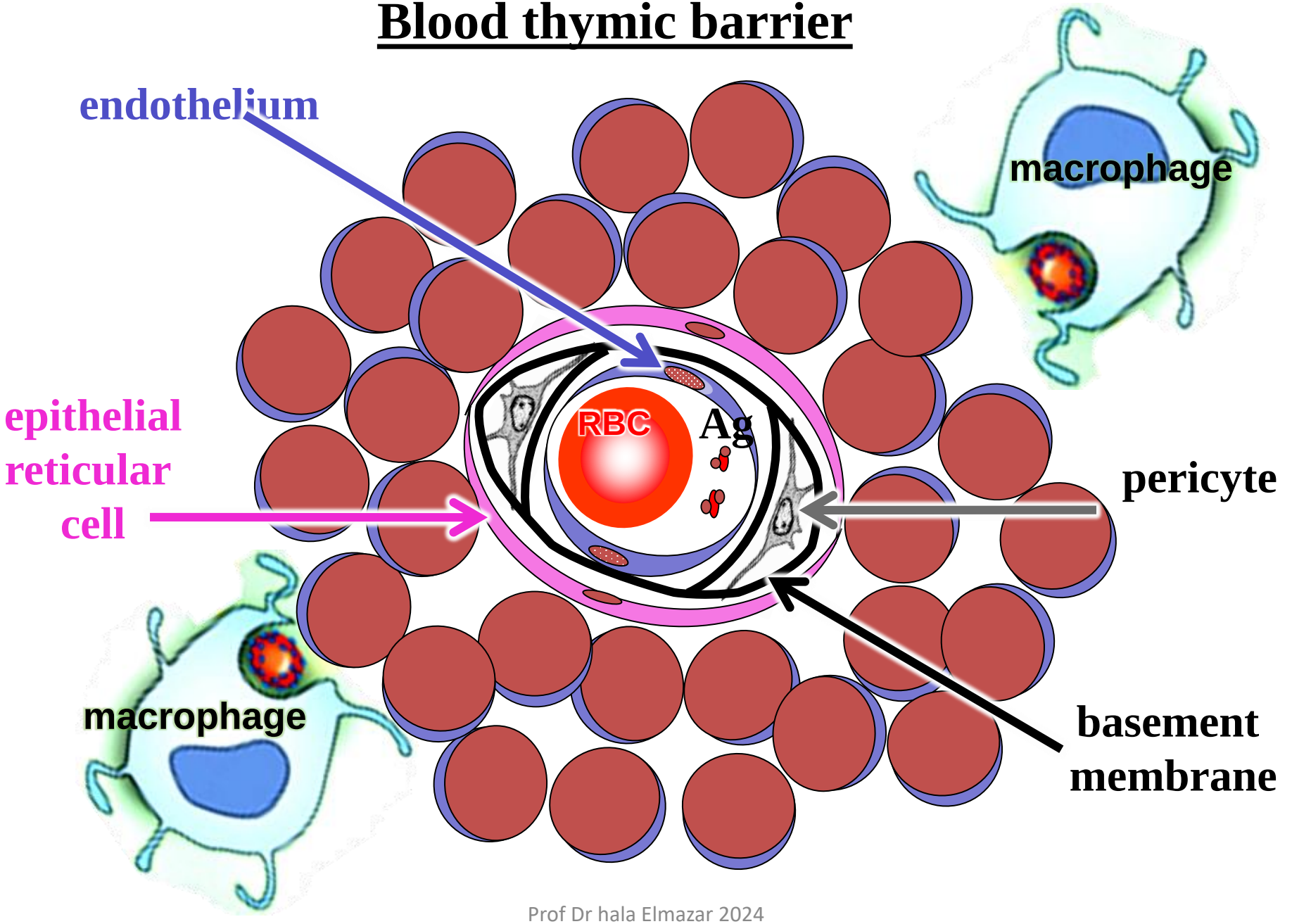
3- Continuous basal lamina around endothelium

4- Perivascular space contains macrophages to deal e any antigen escape

5- Complete layer of epithelial reticular cells around capillaries

*The barrier allow immature T lymphocytes to multiply & differentiate free from foreign Ags before they migrate to medulla & leave thymus to blood*

# Blood thymic barrier



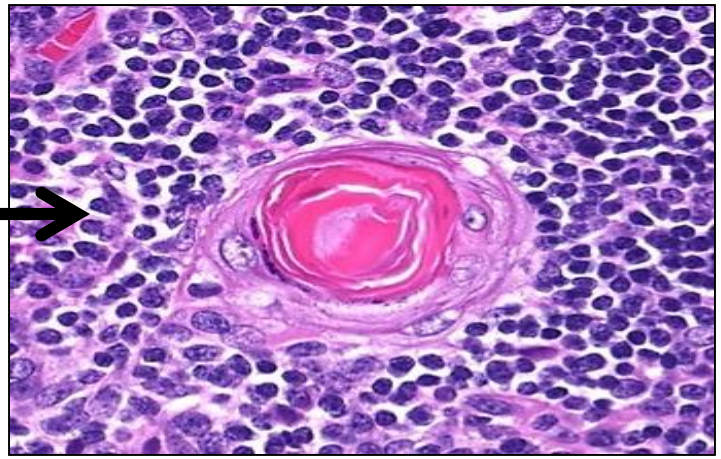
## 2-Medulla:

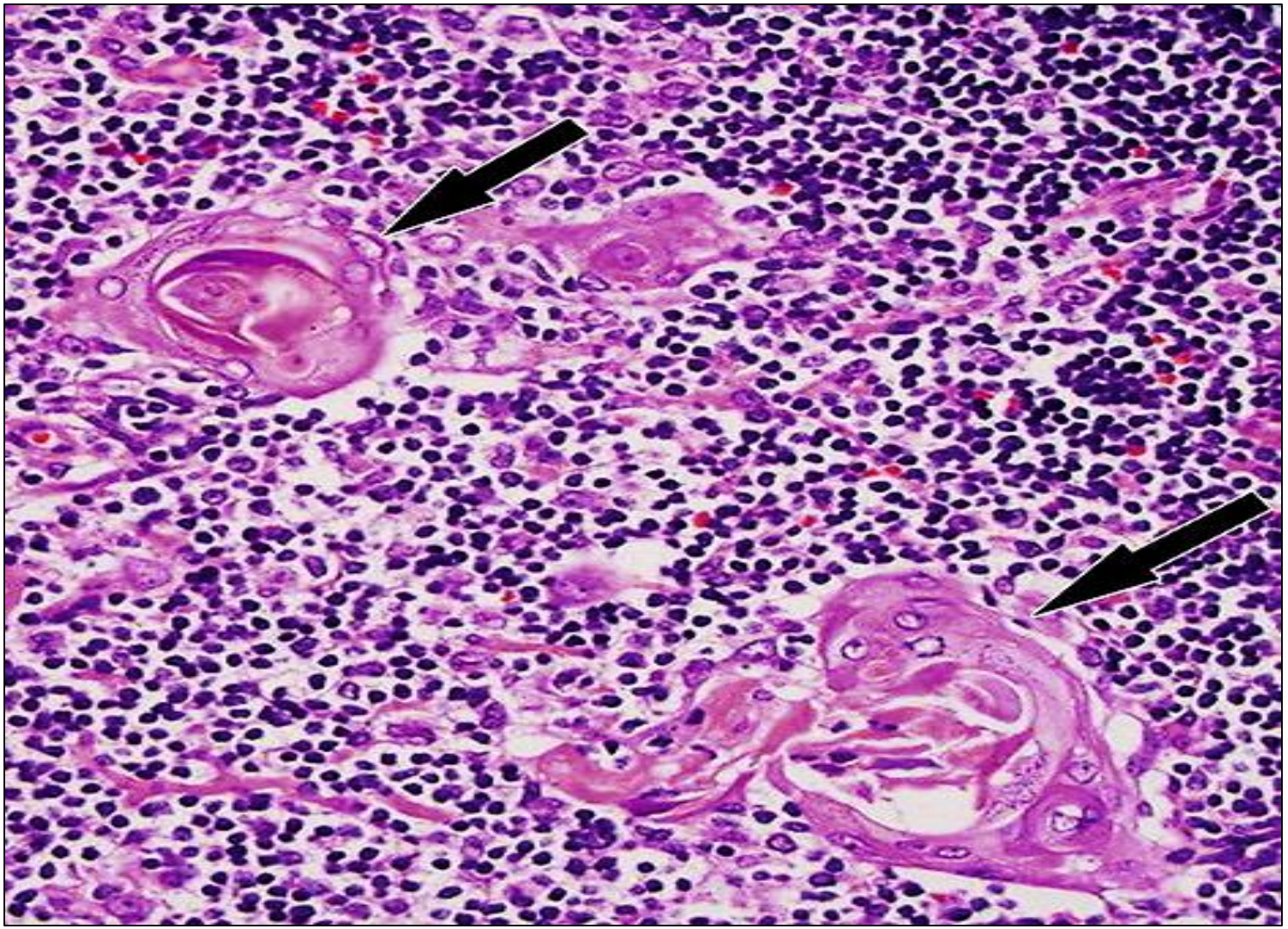
Contains fully differentiated T lymphocytes, which leave medulla through post capillary venules.

T cells will travel to 2ry lymphatic organs (LN & spleen) where they settle in thymus dependent zones

Contains **Hassall's corpuscles** are acidophilic strucureless mass surrounded by concentric layers of epithelial reticular cells responsible for the release of cytokines that regulate dendritic activity.

**Hassall's corpuscle**





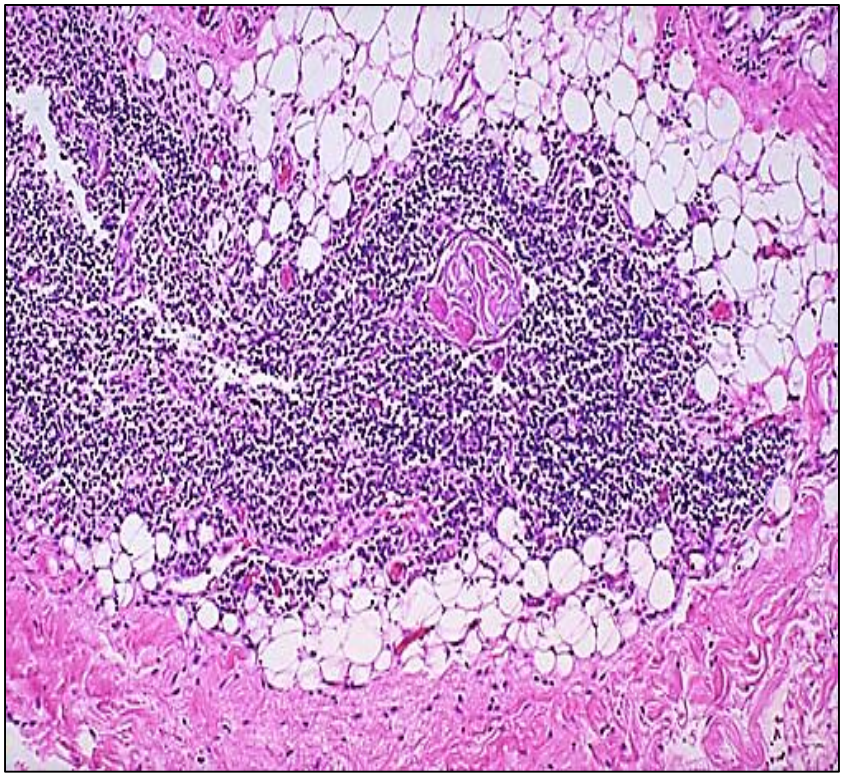
**Thymus gland showing Hassall's corpuscles**

Hassall’s corpuscles provide developing thymocytes with paracrine and juxtacrine signals to ensure their proper functional maturation

## Thymus gland of adult

**Formed by:**

* Fibrous & adipose tissue.
* Few lymphocytes, ↓ ER cells.
* ↑ Hassall's corpuscles



# MALT- mucosa associated lymphoid tissue

- Collective name for the cells of the immune system in the mucosa of respiratory , alimentary , urogenital tracts

- Function : is to augment the mechanical & chemical barriers of surface mucosal epithelium

- Distribution :

✓ Tonsil

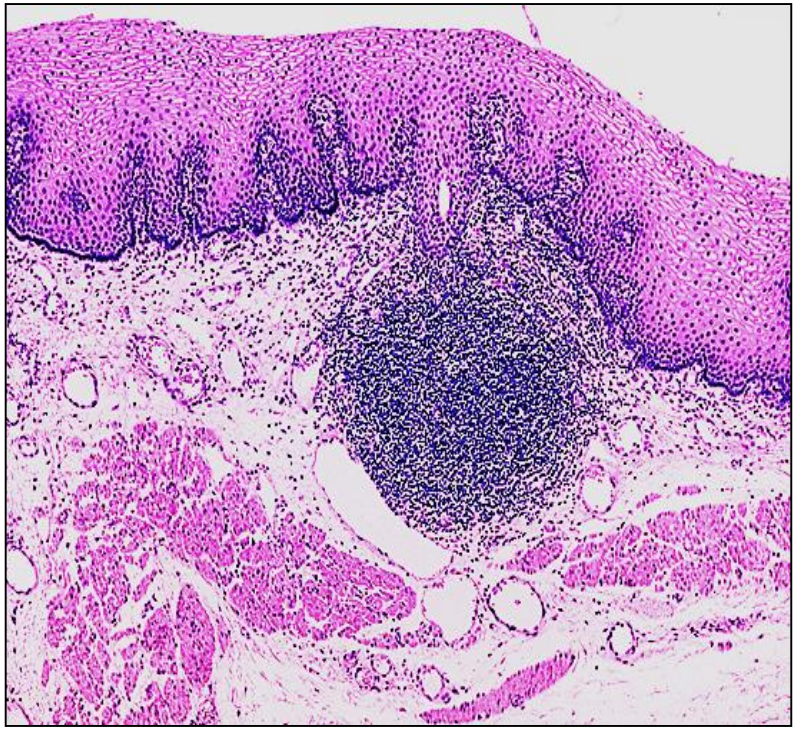
✓ Bronchus : BALT

✓ Gut: GALT

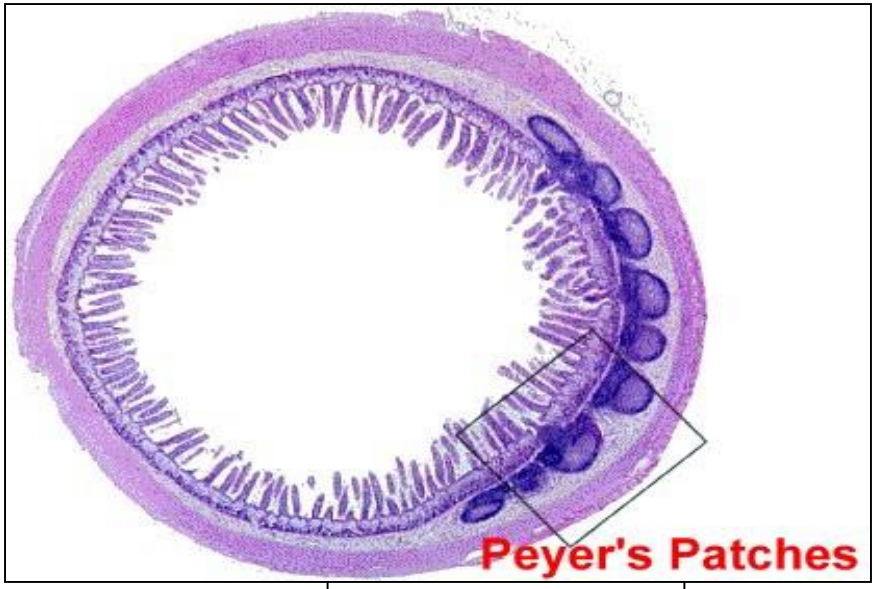
## MALT Examples are:

1 .Payer's patches of ileum .

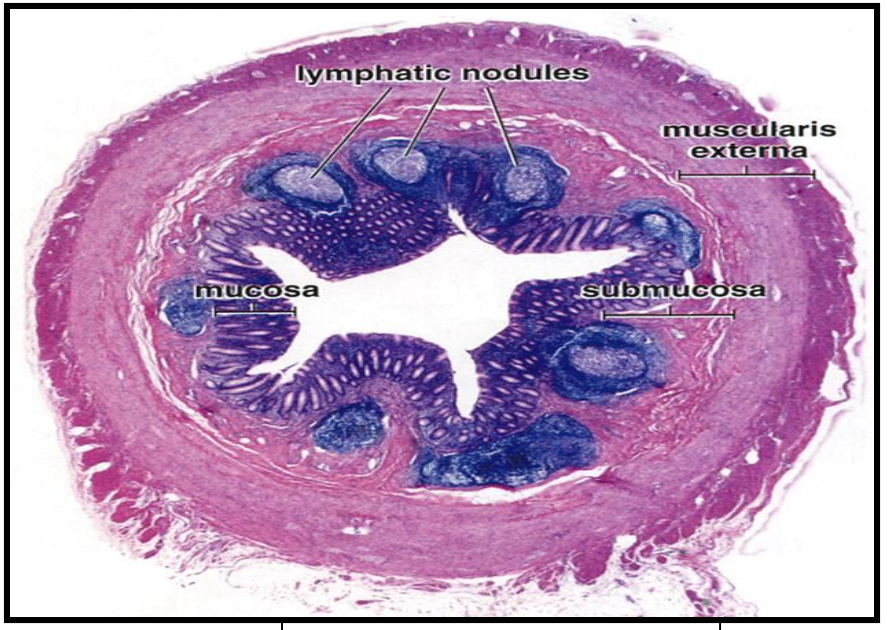
2. MALT of appendix.



**MALT in wall of esophagus**




**MALT in ileum**




**MALT in appendix**

# Thank you