

# Histology lecture 7

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# Spleen

- ✓ The spleen is an oval-shaped **intraperitoneal** organ
- ✓ Approximately **Don't memorise numbers**  
**5** inches in height (12-13 cm)  
**3** inches in width (7-8 cm)  
**1** inch in thickness (2.5 cm)  
Weighs **7** ounces (200gm)  
Lies under ribs **9** to **11**
- ✓ Has a notched anterior border.

## Functions

- ✓ Filtration of blood (defense against blood-borne antigens)
- ✓ The main site of old RBCs destruction.
- ✓ Production site of antibodies and activated lymphocytes (which are delivered directly into the blood)

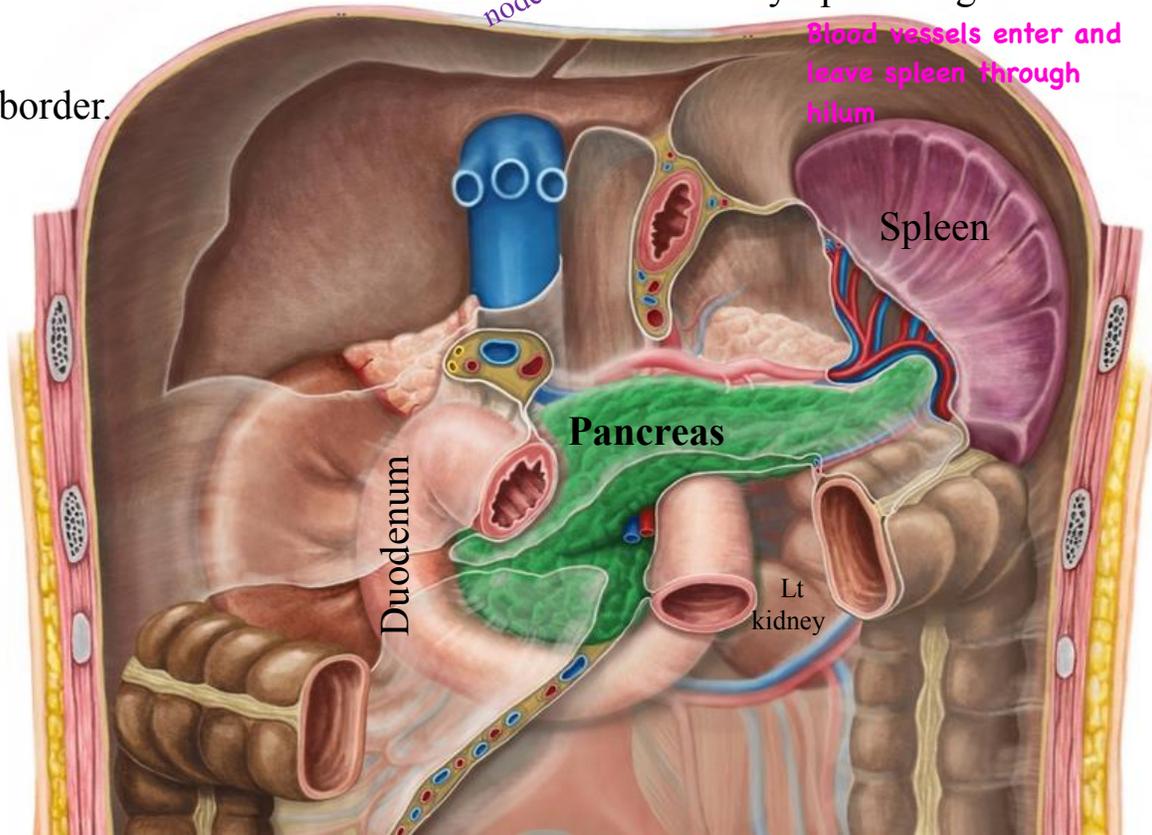
Lymph is formed inside spleen then drained by efferent lymphatic vessels

The spleen is the organ of odds number 1, 3, 5, 7, 9, and 11

The spleen resembles a large lymph node  
↓ ↓  
The spleen filters the blood while lymph nodes filter the lymph

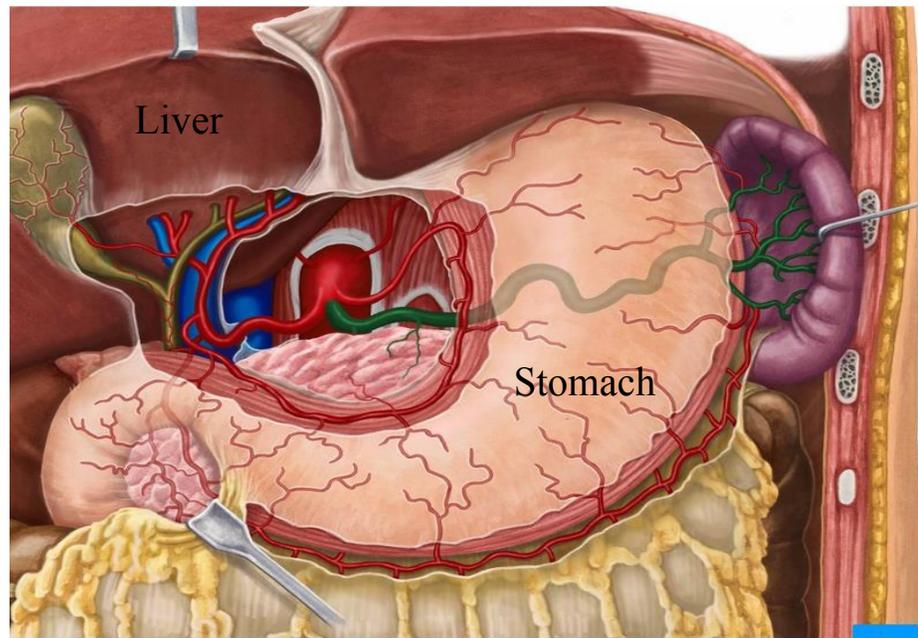
- ✓ It lies high on the upper left portion of the abdomen, just beneath the diaphragm, behind the stomach and above the left kidney.
- ✓ It is the largest of the lymphoid organs

Blood vessels enter and leave spleen through hilum



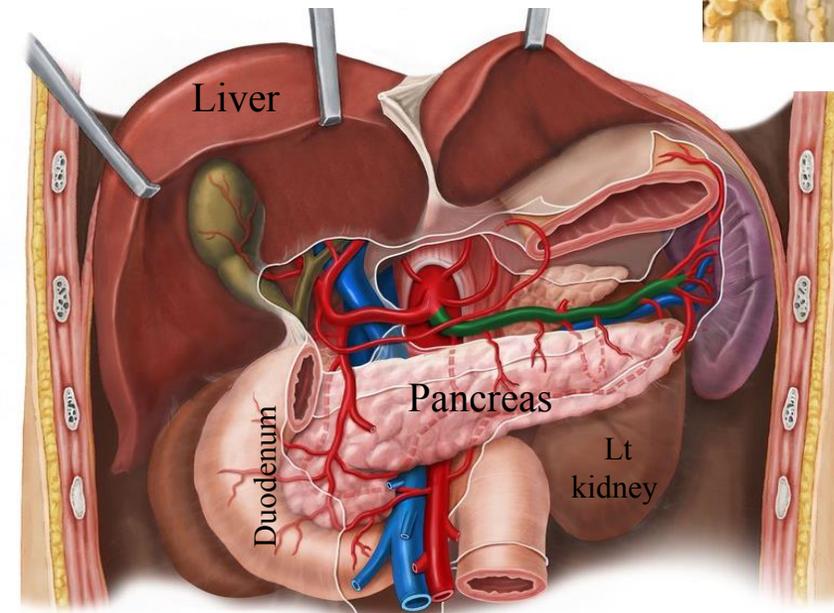
The **splenic artery** is the largest branch of the celiac artery. It has a tortuous course as it runs along the upper border of the pancreas. The splenic artery then divides into about six branches, which enter the spleen at the hilum

The **splenic artery** supplies the spleen as well as large parts of the stomach and pancreas



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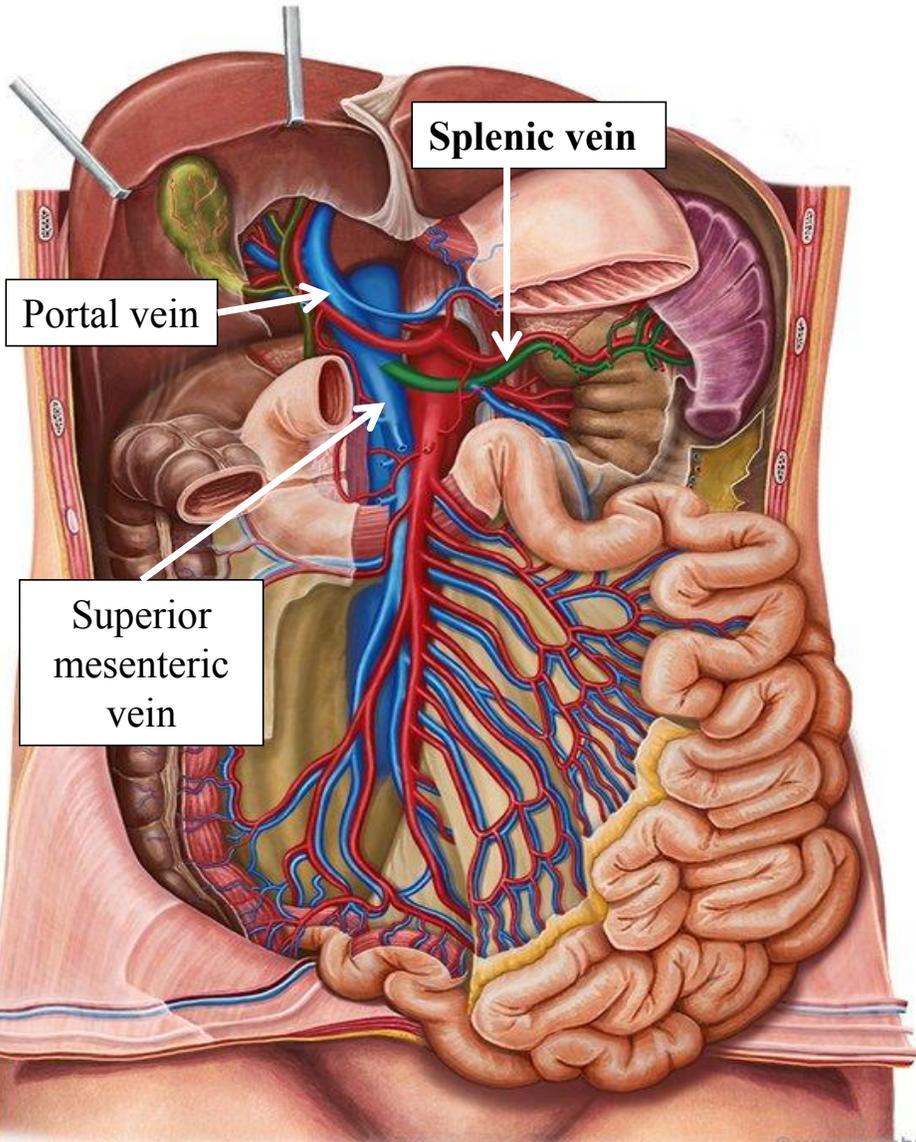
Abdominal Aorta



Celiac Trunk



Splenic artery



The **splenic vein** leaves the hilum and runs behind the tail and the body of the pancreas. Behind the neck of the pancreas, the splenic vein joins the superior mesenteric vein to form the portal vein



Which enters the liver through porta hepatis

In cases of portal hypertension, spleen often enlarges from venous congestion.

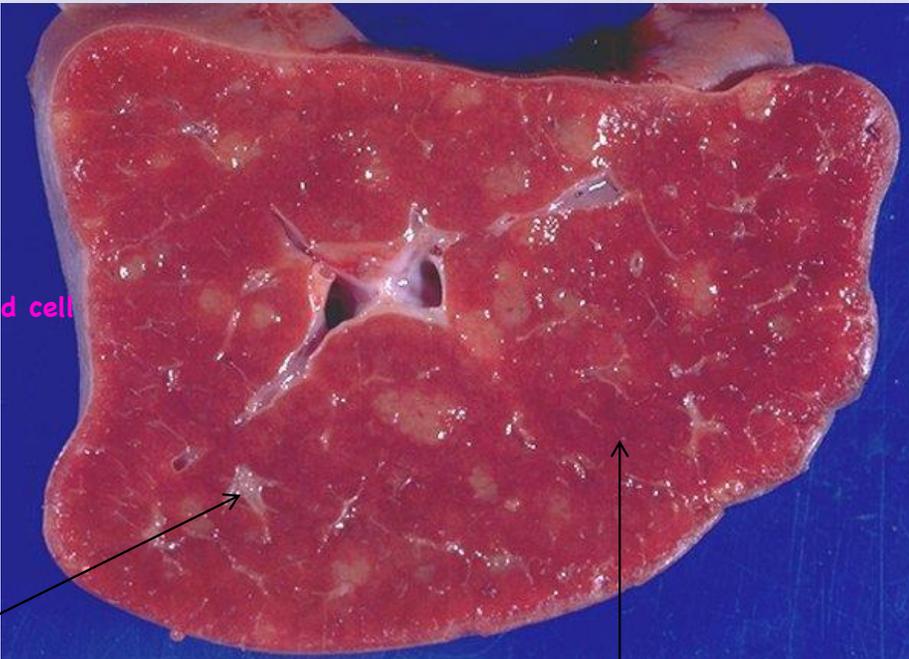
Remember inferior mesenteric vein drains splenic vein



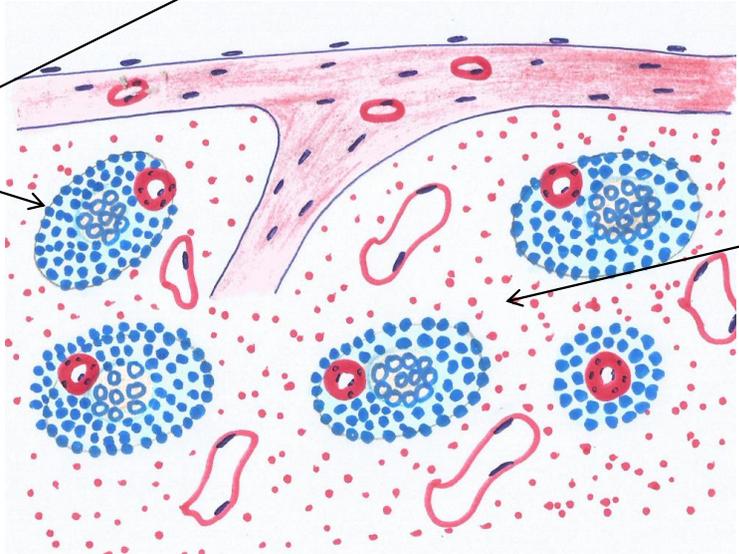
The parenchyma of the spleen appears in fresh specimen as:

**White pulp** which appears white on gross examination (collection of both B and T lymphocytes) *Condensation of white blood cells mainly here lymphocyte*

**Red pulp** which appears red on gross examination (blood filled) *Accumulation of blood*



**White pulp**



*Notice the parenchyma of spleen mainly red in color (red pulp)*

**Red pulp**

H.K

The spleen is covered by a **capsule** of dense connective tissue, and have capsular extensions called the **trabeculae** *To divide spleen into smaller compartment*

Large trabeculae originate at the hilum, on the medial surface of the spleen, and carry branches of the splenic artery, vein, lymphatics, and nerves into the spleen

The spleen is composed of parenchyma and stroma

**Parenchyma:** Splenic pulps

**Stroma:** Reticular tissue (reticular fibers and reticular cells)

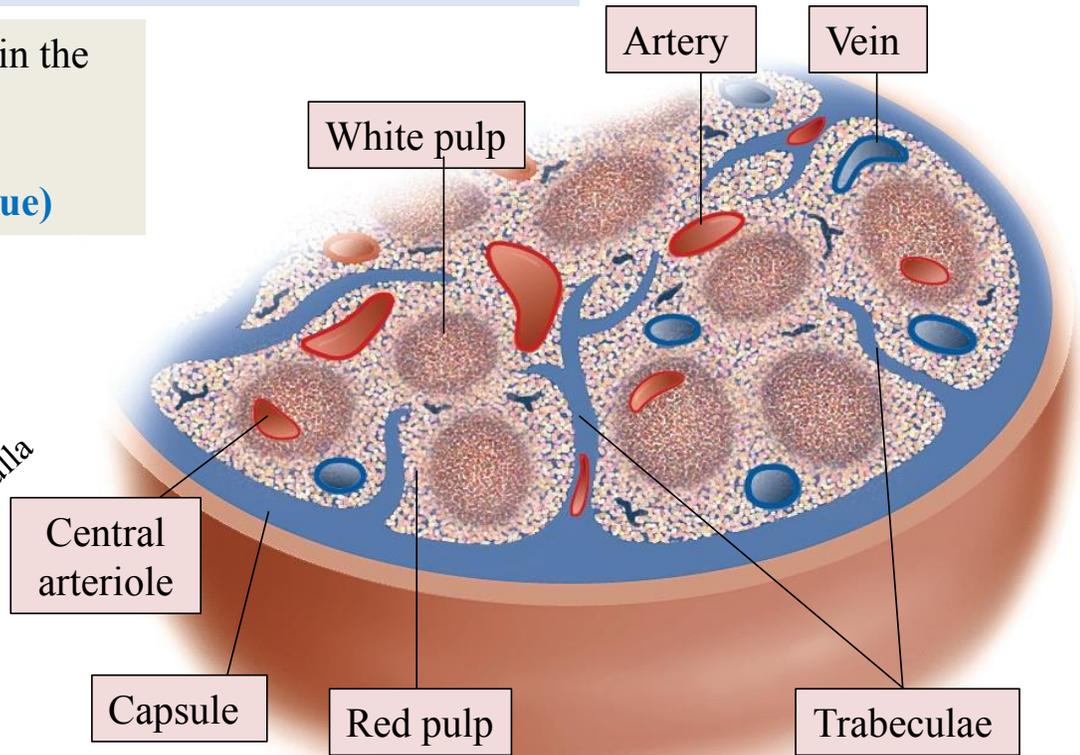
There are two types of pulp in the spleen:

**Red pulp (rich in blood)**

**White pulp (lymphatic tissue)**

Unlike lymph nodes, the spleen:

- 1- Has no afferent lymphatics
- 2- Has no lymphatic sinus system
- 3- Its lymphatic tissue is not arranged into cortex and medulla



Lymphatic follicle (aggregation of B lymphocytes)

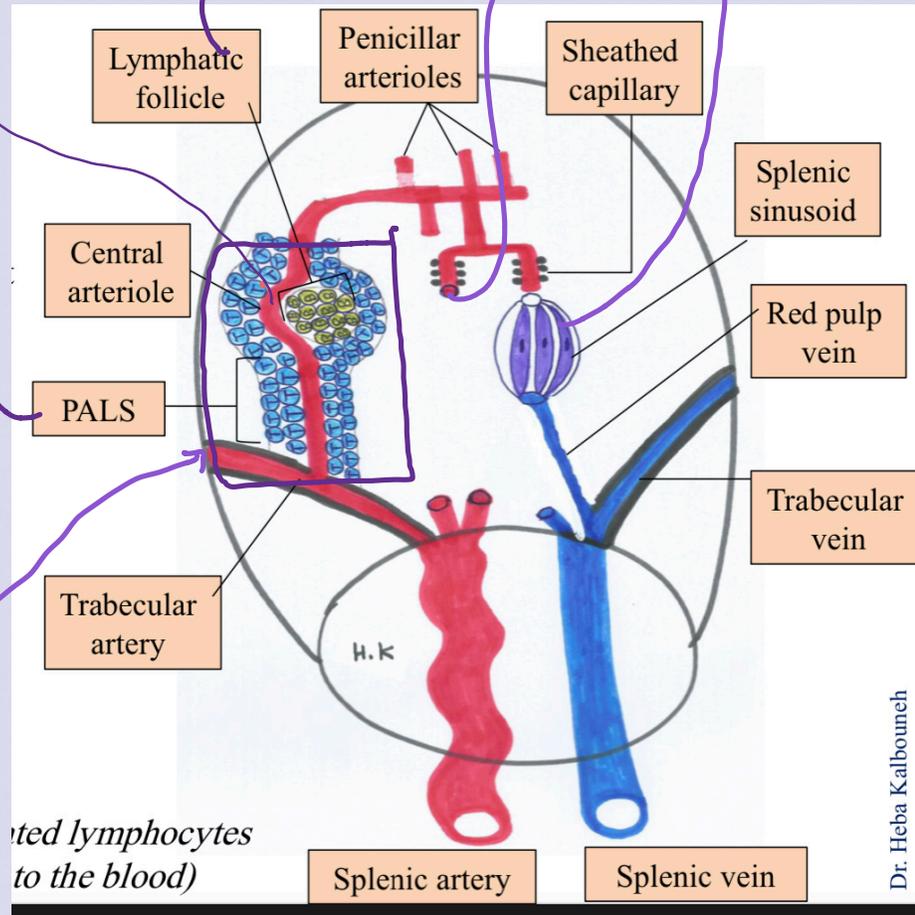
Displacing the Center arteriole into more peripherally location (but still we call it Center arteriole we can also call it Lymphatic arteriole)

Open circulation

Closed circulation

We can call it T dependent zone why? Because mature T cell depend in the normal development of the the thymus

White pulp = ( central arteriole + PALS Lymphatic follicle).



ated lymphocytes to the blood)

Dr. Heba Kalbouneh

Sinusoid: → a special form of capillary... it has large lumen lined with endothelial cells in between endothelial cells we have spaces

**Splenic artery**

Divides into trabecular arteries as it enters the hilum

**Trabecular arteries**

Follow the course of trabeculae

**Central arterioles**

Are branches of trabecular arteries entering the white pulp. They are surrounded by a sheath of lymphocytes.

**Penicillar arterioles** *The morphology is like penicillus*

Each central arteriole eventually leaves the white pulp and enters the red pulp, losing its sheath of lymphocytes and branching as several short straight penicillar arterioles that continue as terminal capillaries.



**Terminal capillaries** (Sheathed capillaries)

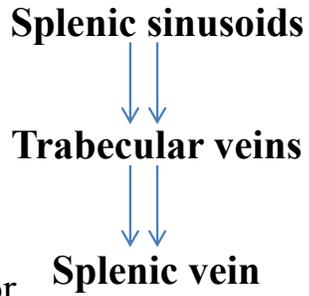
Some of these terminal capillaries are sheathed with APCs for additional immune surveillance of blood

Blood flow through the splenic red pulp can take either of two routes:

**Open circulation:** the capillaries open into the spaces of the red pulp (splenic cords) and then the blood returns to the venous system through the wall of the splenic sinusoids

**Closed circulation:** the capillaries open directly into the splenic sinusoids (blood is enclosed by endothelium)

Because it located exactly in the Center of T lymphocyte sheath



## Red pulp (blood filled)

✓ Constituting 75% of the spleen, the red pulp is responsible for the hematological (circulatory) function of the spleen.

✓ The red pulp contains :

**Splenic cords (Billroth's cords):** consist of all cells between the sinusoids in the red pulp (reticular cells, macrophages, plasma cells, lymphocytes, RBCs, platelets, other leukocytes)

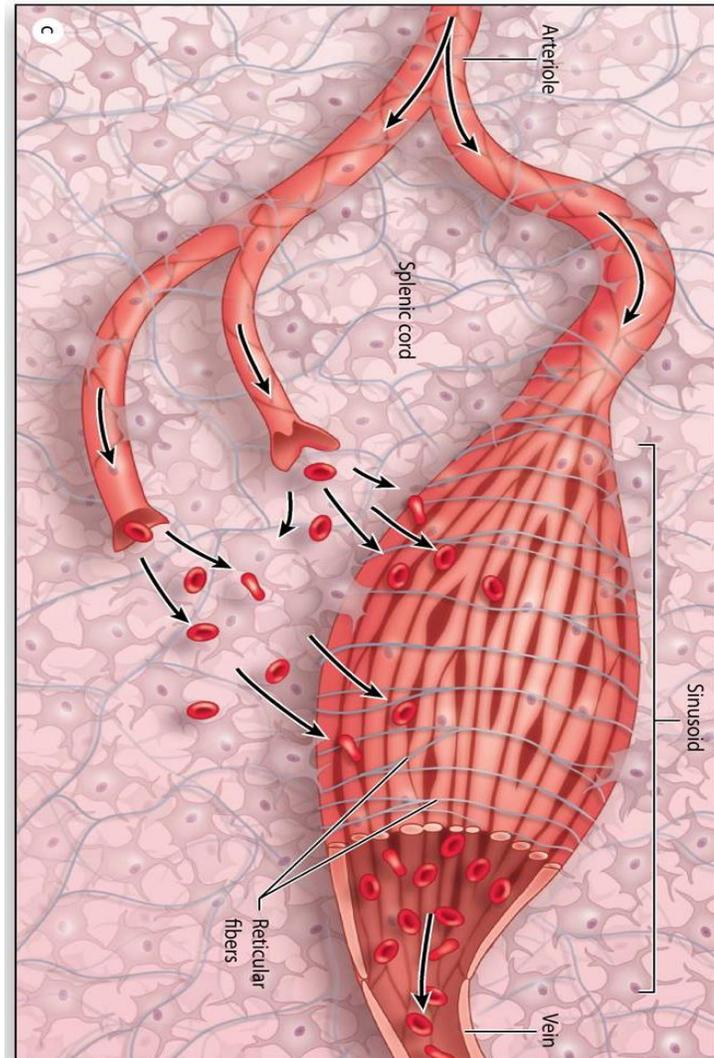
**Splenic sinusoids:** are blood- filled spaces located throughout the red pulp. They have large, dilated, irregular lumens and large pores (spaces between the endothelial cells)

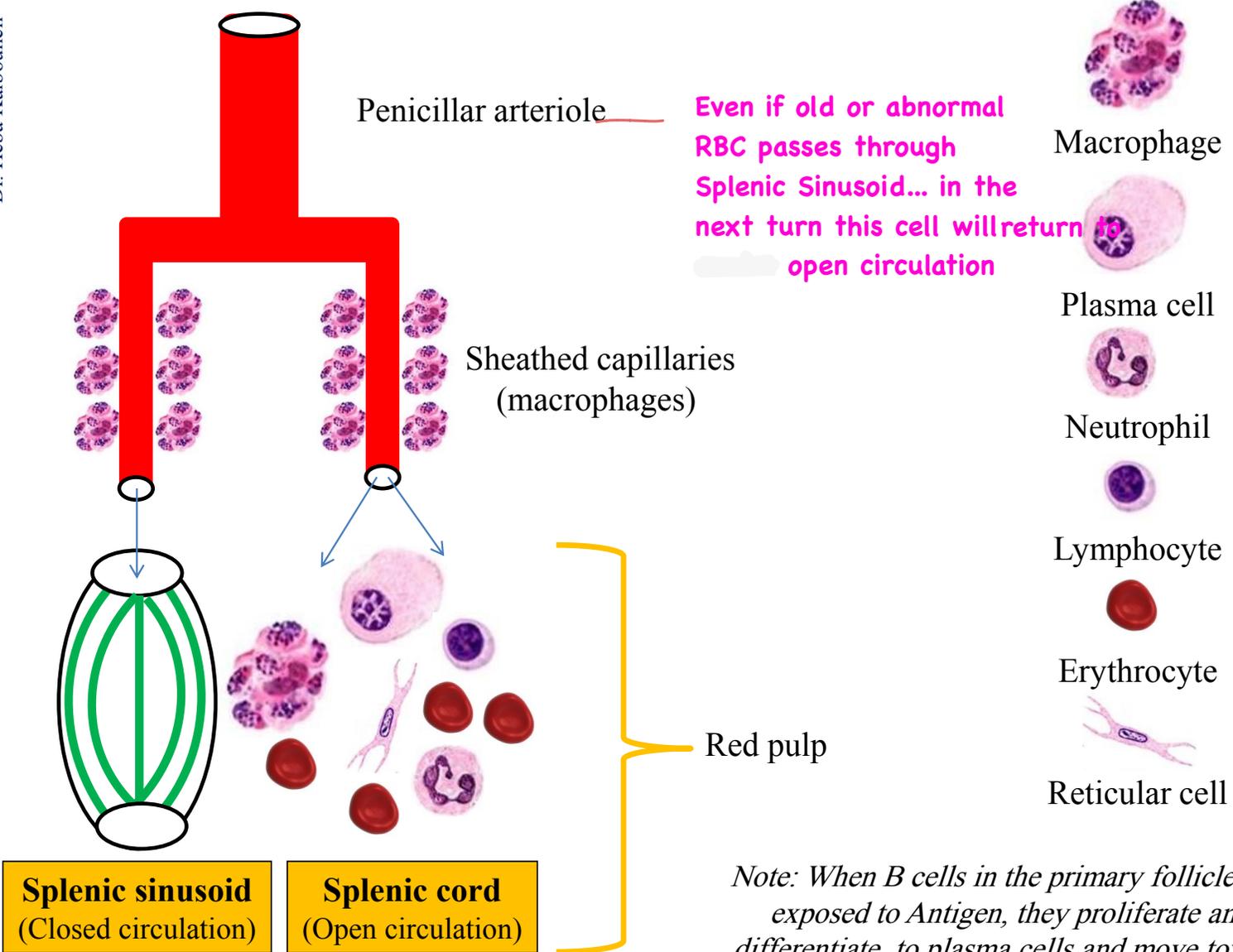


1. The endothelial cells (**stave cells**) are elongated, fusiform cells that lie parallel to the long axis of the vessel
2. The cells lie side by side around the vessel but not joined by any type of intercellular junctions
3. The endothelial cells are supported by highly discontinuous basal lamina (forms bars and encircles the sinusoid)

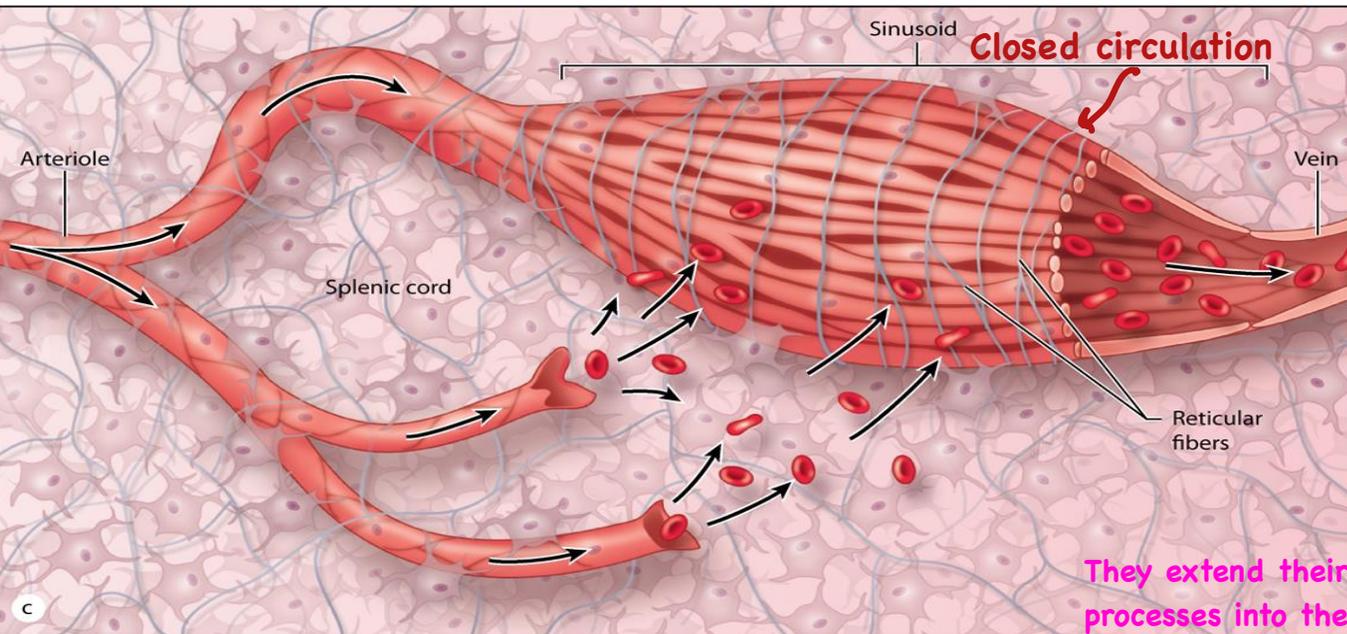
**Function:** Destruction of worn-out RBCs and platelets

## ↓↓ Red pulp



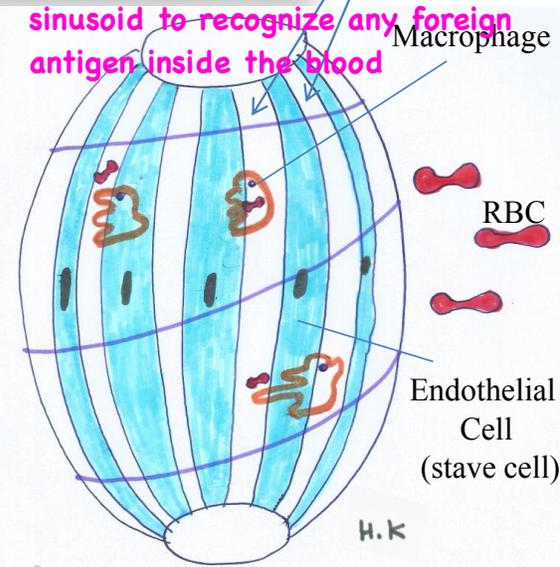


*Note: When B cells in the primary follicles are exposed to Antigen, they proliferate and differentiate to plasma cells and move toward the red pulp.*



Note the wide gaps between endothelial cells which allow for movement of entire cells from cords to sinuses

They extend their cytoplasmic processes into the lumen of this sinusoid to recognize any foreign antigen inside the blood



In this route plasma and all the formed elements of blood must reenter the vasculature by passing through narrow slits between the stave cells into the sinusoids. These small openings present no obstacle to platelets, to the motile leukocytes, or to thin flexible erythrocytes. However stiff or swollen RBCs at their normal life span of 120 days are blocked from passing between the stave cells and undergo selective removal by macrophages



*Deformed or less pliable RBCs cannot squeeze effectively from the cord into the sinus and upon their mechanical fragmentation are removed by resident macrophages (lie just next to the sinusoids)*

Macrophages monitor erythrocytes as they migrate from splenic cords between the endothelial cells into the splenic sinusoids

Old erythrocytes **lose their flexibility**

Due to denaturation of plasma membrane or submembranous proteins



They cannot penetrate the spaces between the endothelial cells and are phagocytosed by macrophages



Old erythrocytes lose sialic acid from their cell membranes



Galactose exposed



Induce phagocytosis of RBCs



Hemoglobin is broken into **Heme** and **Globin**

After surgical removal of the spleen (splenectomy), the number of abnormal erythrocytes in the circulation increases although most such cells are then removed by macrophages in sinusoids of the bone marrow and liver.

● Young red blood cell is a quick cell with high flexibility in between the endothelial cell ...so it enters the venous blood easily

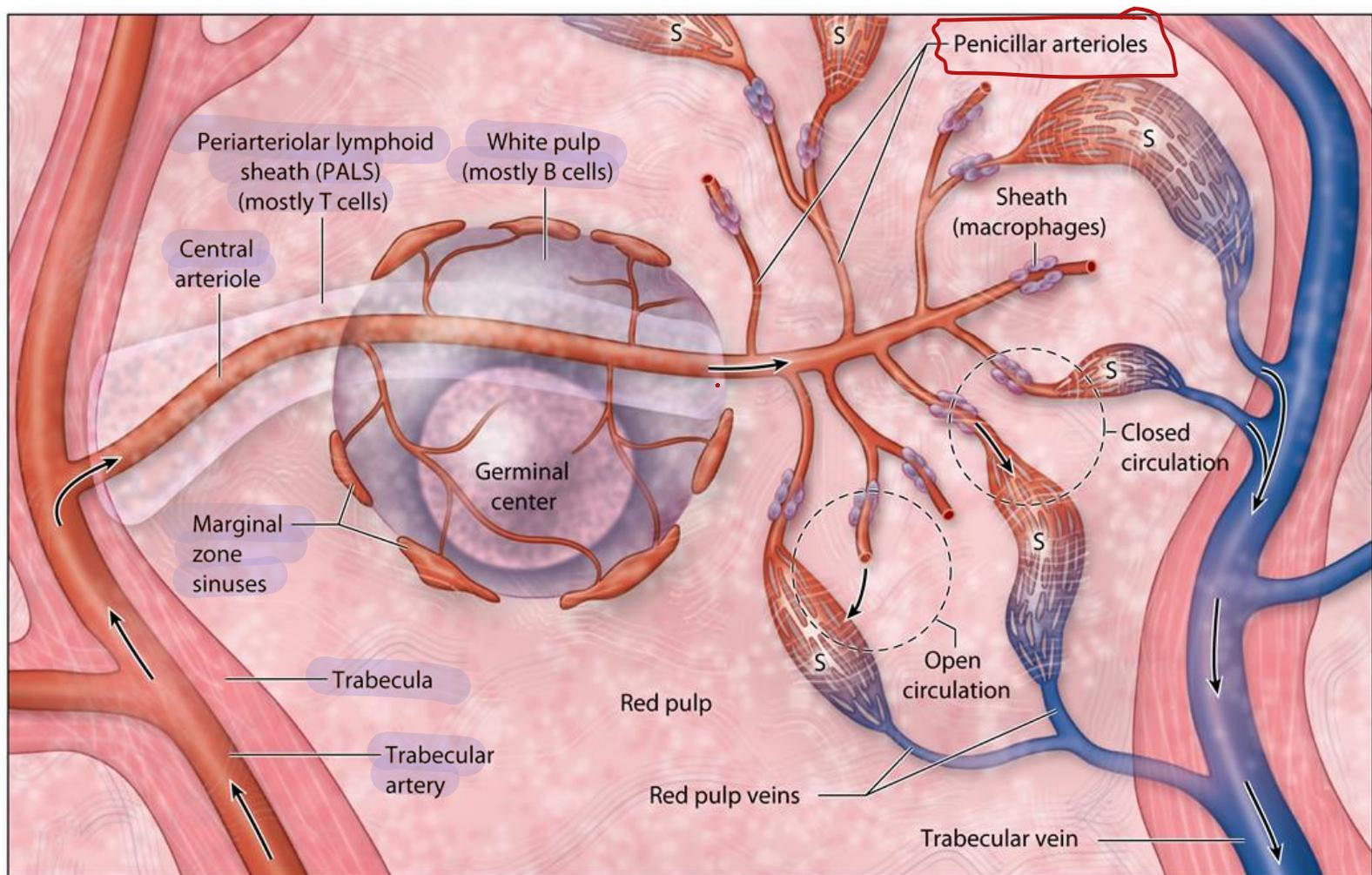
● old or abnormal red blood cell doesn't have the ability to squeeze in between endothelial cell... When it tries it will be slow with fragmented membrane... Then macrophage will identify and phagocytose it.. we call this test twisting or flexibility test

amino acids  
pool of  
blood

**Iron:** carried by transferrin to bone marrow (used again)

**Bilirubin:** excreted by liver bile

Schematic view of the blood circulation and the structure of the spleen, from the trabecular artery to the trabecular vein.



## Marginal zone sinuses

✓ Located between the white and the red pulp

✓ The spaces between these sinuses are wide (2-3µm)



It is here the blood-borne antigens and particulate matter have their first free access to the parenchyma of the spleen

*The following events occur at the marginal zone:*

1- APCs sample the material travelling in blood searching for antigens

*So it's the site for initiation of immune response*

2- Macrophages attack microorganisms present in the blood

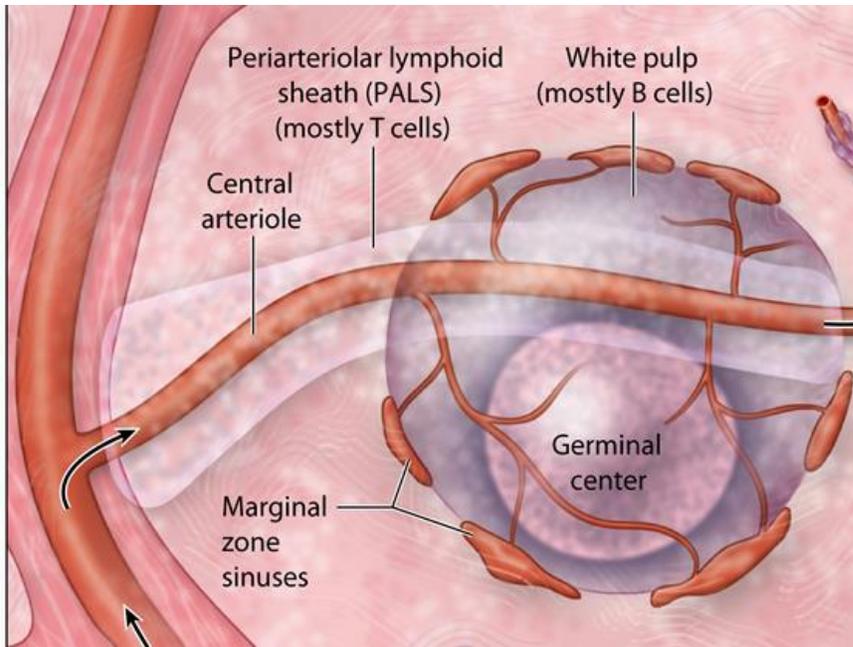
Lymphocytes come into contact with APCs, if they recognize their Ag-MHC complex, the lymphocytes initiate immune response within the white pulp

3- The circulating B and T cells leave the blood stream to enter the preferred location within the white pulp

**T cells: PALS**

**B cells: lymphatic follicles**

**Most of blood passes through open circulation so when spleen contracts it moves the blood from splenic cords into splenic sinusoid and this increases the volume of the blood**



## Functions of the spleen:

It has circulatory as well as lymphatic functions

To summarize

**Blood cell production:** During the fetal life, blood cells are produced in the spleen

**Blood storage:** A small quantity of blood is stored in the sinusoids of the red pulp

**RBC destruction:** Most worn-out or damaged red blood cells are destroyed in the spleen (some in the liver and bone marrow). They are phagocytized by macrophages

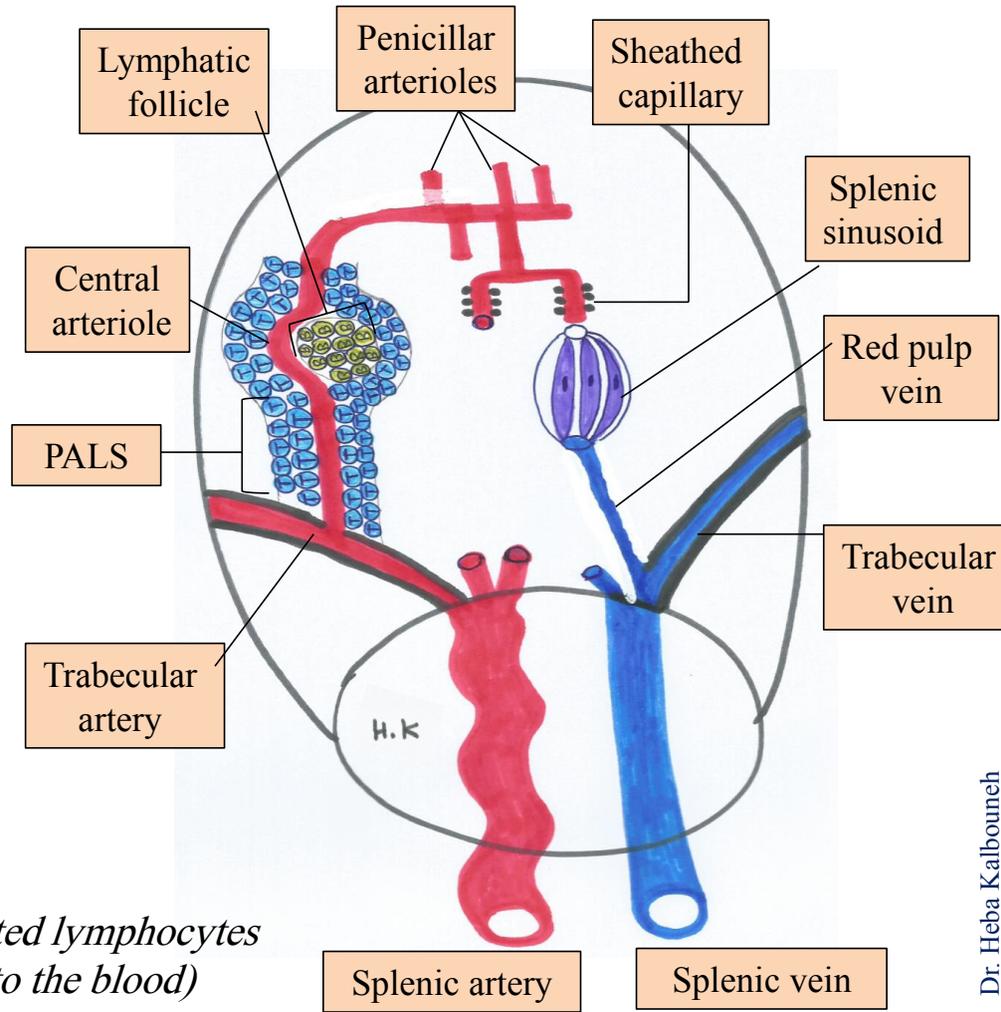
### Defense mechanism:

Macrophages phagocytize microbes that have penetrated the blood. Antigens in the blood activate B and T cells residing in the spleen, triggering immune response



*Production of antibodies and activated lymphocytes  
(which are delivered directly into the blood)*

The blood flow in the spleen goes from splenic artery to trabecular artery to central arteriole, and upon leaving the white pulp, the blood flows through penicillar arterioles and terminal sheathed capillaries to the splenic sinusoids, and back to veins of the pulp, trabecular veins and the splenic vein



## White pulp (lymphoid tissue)

✓ Constituting 25% of the spleen, the white pulp is responsible for the immunological (lymphatic) function of the spleen.

✓ The white pulp contains:

### Periarteriolar lymphatic sheaths (PALS):

tightly packed T cells arranged in cylindrical sheaths around central arterioles

**Lymphoid follicles:** spherical aggregations of B cells scattered throughout the PALS

**Primary (unstimulated) follicles** contain resting (inactive) B cells

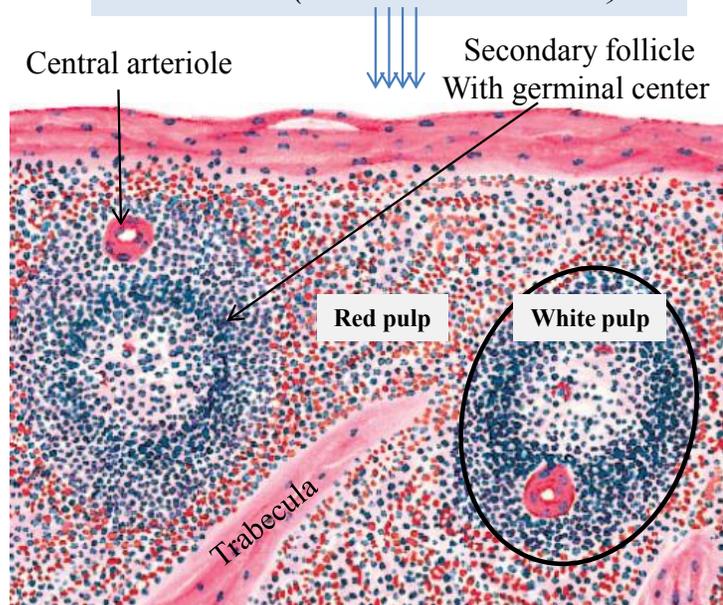
**Secondary (stimulated) follicles** contain activated B cells in a central region (germinal center)

**Splenic nodules (Malpighian corpuscles)**

*Note: These follicles have the same structural organization as those found in lymph nodes*

**Function:** The lymphocytes and APCs monitor the blood for foreign antigens and respond in a similar way to those in the lymph nodes.

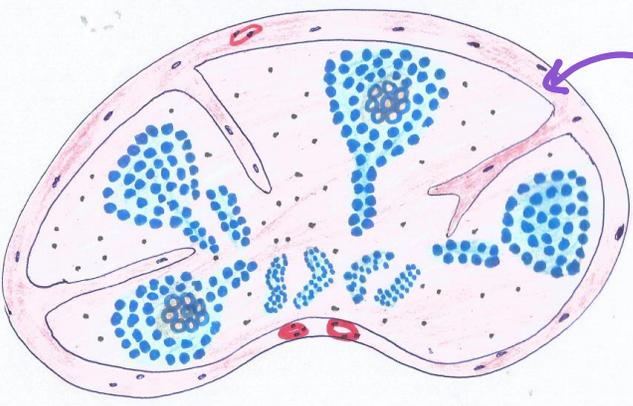
*When the lymphatic sheath expands to incorporate the follicles, the central arteriole is displaced to one side and acquires an eccentric position in the follicle but is still called the central arteriole (Follicular arteriole).*



If all these follicles stimulated → this indicates infection caused by blood born antigen such as capsulated bacteria

*Production of antibodies and activated lymphocytes (which are delivered directly into the blood)*

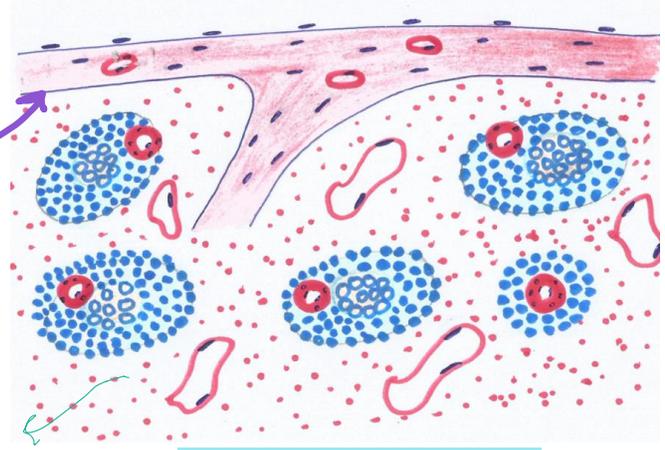




Histology of the lymph

The outermost layer is adventitia

The outermost layer is serosa



Histology of the spleen

Lymph node	Spleen
Multiple, small	Single, large
Along the course of lymphatic vessels	Intra-abdominal
Filters lymph	Filters blood
Covered by fascia	Covered by peritoneum
Has afferent vessels	No afferent vessels
Cortex and medulla	White pulp and red pulp
Contains Lymphatic sinuses	Contains Blood sinuses

The patients WHO do splenectomy they are more bourne to have septicemia

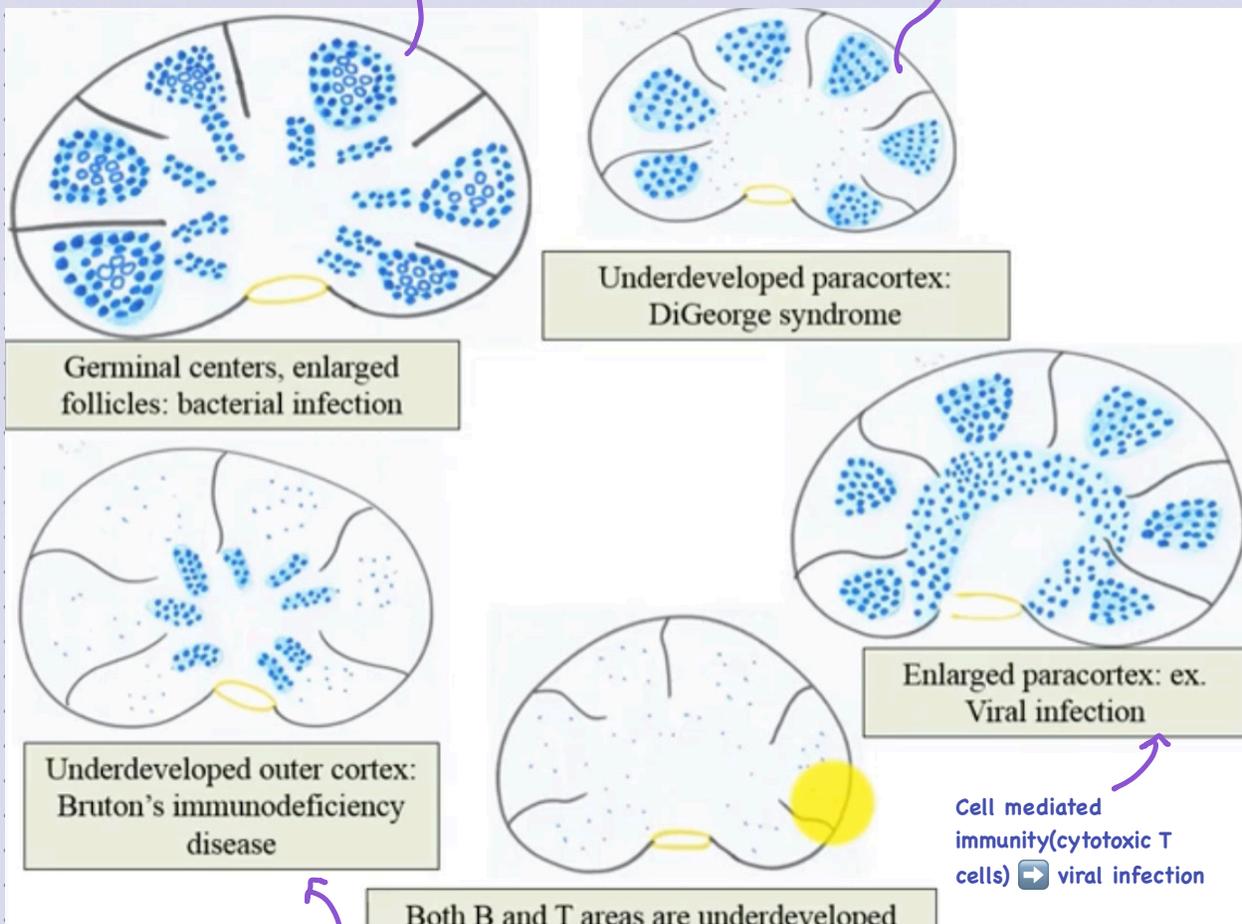
Under the Light microscope → ✓

PLAS → central arteriole is located exactly centrally surrounded by many basophilic nuclei

Lymphatic follicle of white pulp → Aggregation of lymphocyte with an arteriole peripherally located

Absence of the thymus ... Also this patient will suffer from underdeveloped parathyroid glands which lead to hypocalcemia

Enlarged with pale Centers



Underdeveloped lymphoid follicles with normal paracortex problem in B cells this patient have deficiency of antibodies so he cannot handle bacterial infection

This patient can't handle any type of infection

Cell mediated immunity (cytotoxic T cells) → viral infection

