

# Human Anatomy & Embryology

**Lecture:** Lymphatic system

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#19

# Lymphatic system

## Overview

This diagram of the circulation, the heart is in the middle, coming out of the right ventricle is the pulmonary circulation, as well as coming out of the left ventricle is the systemic circulation.

In the periphery, we have what's called the **micro circulation**: the capillaries between cells.

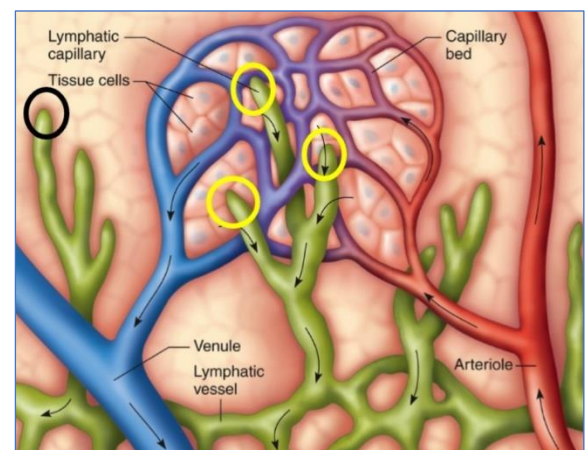
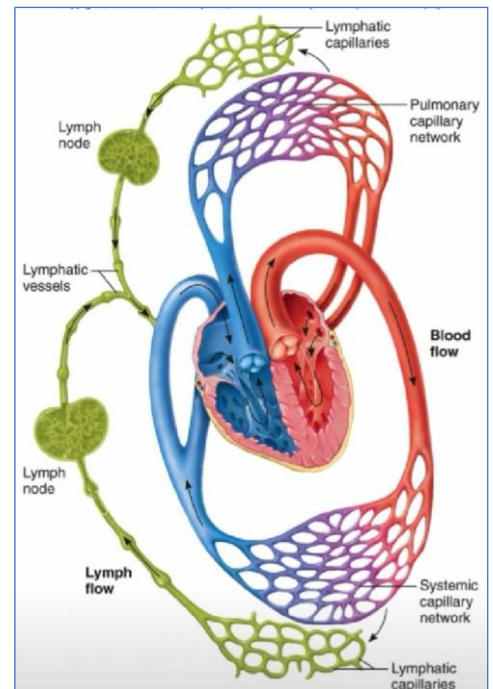
Capillaries start as arterial capillaries, then material exchange between blood and tissue cells will occur, then waste products and excessive interstitial fluid will be taken by venous side of capillaries. this process is very efficient in normal conditions.

But we have a problem, that we can have large molecules produced by the cells or some foreign bodies like bacteria. these structures cannot get into the venous side of the capillaries (because its large size cannot pass through the small pores in the venous capillary walls), so we need capillaries with a special ability to let these large bodies enter them, which are **Lymphatic capillaries**; the beginning of the **Lymphatic system**.

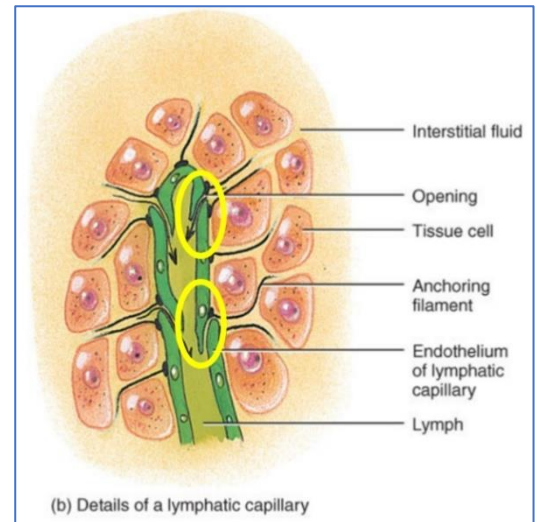
It starts with blind ended capillaries (free random finger like arms lying between cells of the tissue), these capillaries are composed of a single layer of endothelial cells with no basement membrane.

they are special capillaries that can pick up large molecules and then, they need to be filtered out by **Lymph nodes**; which are the filters, that will receive the lymph from the tissue and filter it. lymph can pass through one lymph node and in other circumstances it passes into two or more lymph nodes, then this filtered lymph will go through lymph vessels to finally drain into venous system (as will be discussed later on this sheet).

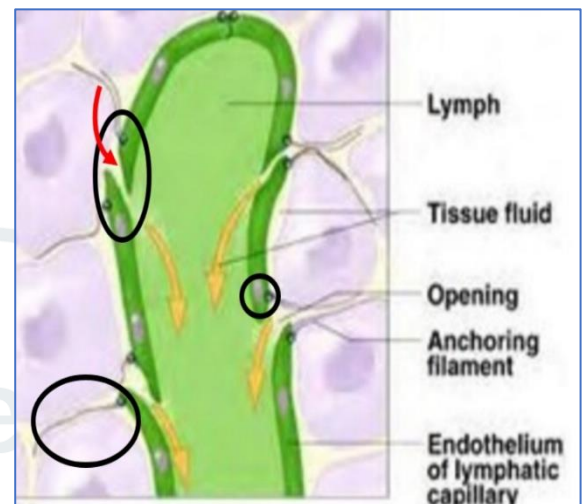
This is a three-dimensional diagram of the area of micro-circulation where we can see that the lymphatic vessels start as blind ended structures between the cells and then they joined together to form large lymphatic vessels and join the lymphatic system.



This is a diagram showing how special lymphatic capillaries are different from blood capillaries, they have the ability to allow large molecules to pass between the **overlapping endothelial cells**, which are not joined by tight junctions or any other type of intercellular junctions, and a large molecule can get into the lymphatic vessels by passing between the overlapping endothelial cells.

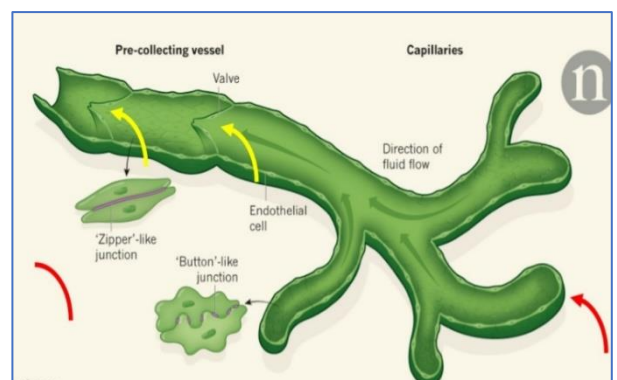


To keep these lymphatics open we have what is called the **anchoring filaments**; which are a kind of connective tissue that attaches to the endothelial cells and to the surrounding tissues. so that when the pressure inside these tissues increases these capillaries will not collapse, they will stay open because of these anchoring filaments.

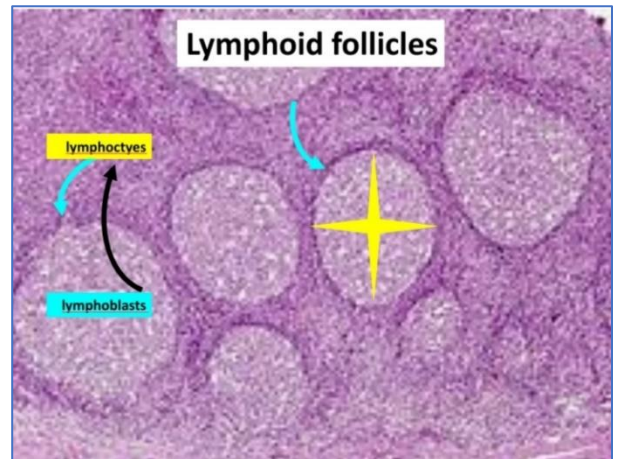


there are many **valves**, which are made of two layers of endothelial cells, so that there will be no back flow of the lymph into the tissue again.

Lymphatic vessels as they get further from the tissue, they grow progressively larger and form 2 lymphatic ducts at the end of lymphatic system just before draining in the venous system.



- After collecting the lymph from the interstitial fluid and passing it through the lymphatic vessels carrying antigens and large molecules, they enter the lymph nodes that contain **lymphoid follicles (lymphatic follicles)**, the basic unit of the lymphatic system, which is a group of **lymphoblasts**, these dividing cells -that come from bone marrow- mature into **lymphocytes**.



- A lymphoid follicle center is called **Germinal center**, it appears **pale** because the lymphoblasts are large cells and contain more cytoplasm.

- lymphoid follicles exist also in the tissues.

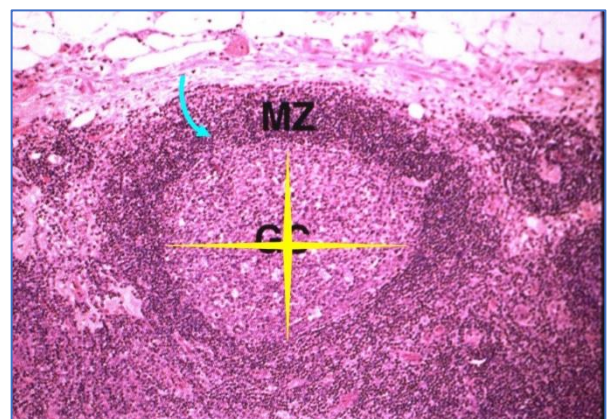
at the circumference of the follicle, there is a dark layer, which is made by **mature lymphocytes**. these lymphocytes they have large dark-stained nucleus with little cytoplasm therefore they appear as dark.

This lymphoid follicle is a **primary lymphoid follicle**, because it has not been stimulated by an antigen or bacteria or any foreign material yet. When it is being stimulated, it will have another look and named as **secondary lymphoid follicle**.

These lymphoid follicles are present in so many tissues, to produce **lymphocytes** that will **produce antibodies** to attack antigens. now these lymphoblasts come from bone marrow and they live inside tissues and they are ready to produce lymphocytes which will produce antibodies.

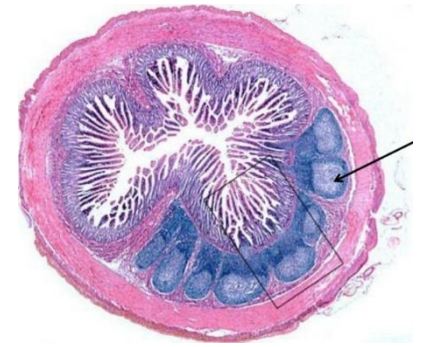
This is a secondary Lymphoid follicle which has been stimulated by an antigen. Therefore, these lymphoblast have differentiated into lymphocytes at the margins of the follicle. it is thicker area than the image before (that belongs to primary lymphoid follicle). and these lymphocytes make thicker layer around germinal center called the **marginal zone**.

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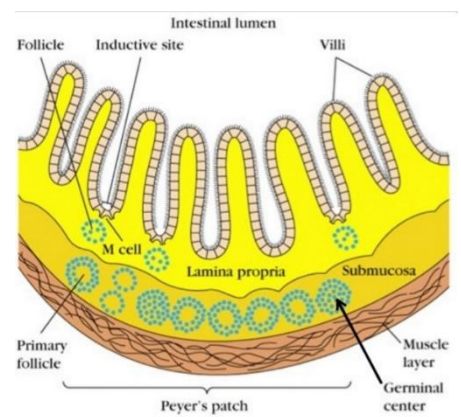


- How to know whether a follicle is a primary or secondary? Answer: by the thickness of the lymphocytes layer. The primary follicle has a thin layer compared to the secondary's one that can be thicker even than the germinal center! (not all circumstances).

It is a famous example of a section of the vermiform appendix which is famous for having lots of lymphoid follicles.



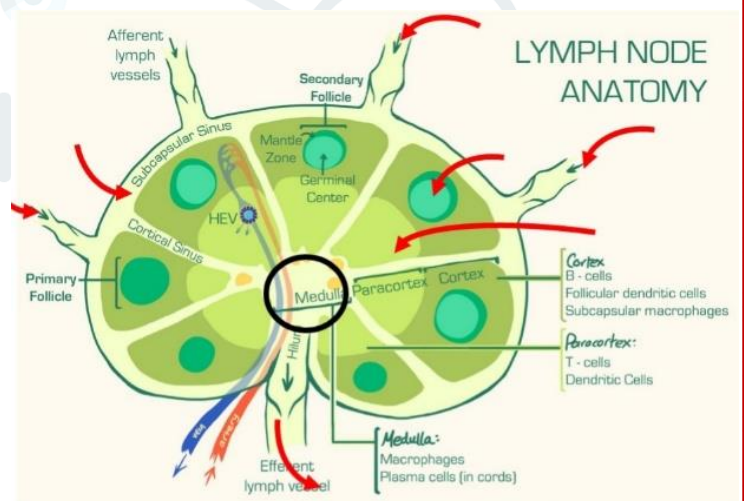
small intestine in the submucosa as well as in the lamina propria have many lymphoid follicles.



- A lymph node receives multiple **afferent Lymphatic vessels** coming from tissues, then the lymph enters the lymph node in a **sinus** surrounding the lymph node (in the image here it is the subcapsular sinus).

- In lymph nodes, the lymphoid follicles are capsulated. while in the tissues, lymphoid follicles are not encapsulated.

- Now after the subcapsular sinus, lymph enters the **outer cortex** of the lymph node which contains lymphoid follicles; some are primary, and some are secondary.



This outer cortex is predominantly filled with B lymphocytes that produce antibodies.

- Then, lymph goes to the inner cortex (the lighter green area) which is predominantly filled with T lymphocytes which are killer cells.

- Then, lymph goes to **medulla** is the place of collection of both T and B lymphocytes.

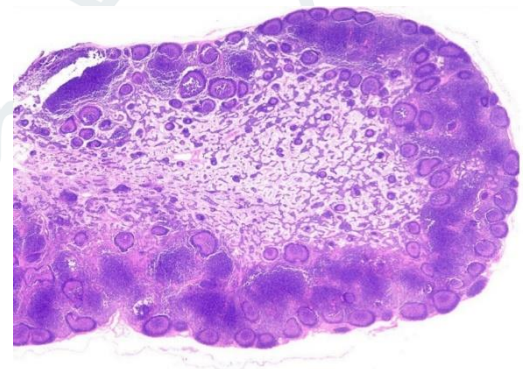
- The filtration process of the interstitial fluid (lymph) results in an interaction between B and T lymphocytes with any bacteria or foreign bodies.

- because of this interaction between lymphocytes and a foreign body (bacterium for instance), the lymph node will be inflamed and become larger (like tonsils inflammation in a next image).
- If the bacterium escaped from being killed in a lymph node, it will be trapped again in the next lymph node to be killed there, and so on.
- after filtration process of lymph, it will exit the node through an **Efferent lymphatic vessel**, usually 1 per lymph node.

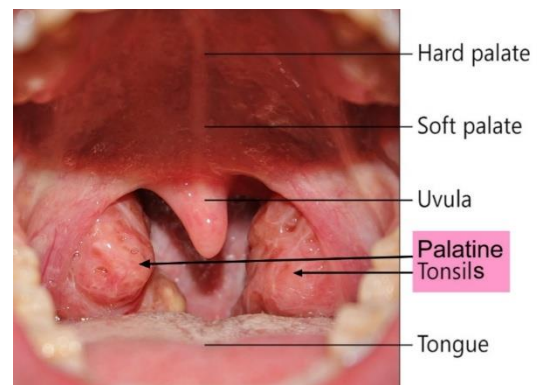
#### Summary of lymph nodes

- Bean-shaped structures.
- Widely distributed throughout the lymphatic pathways.
- Providing a filtration mechanism for the lymph before it rejoins the blood stream.
- Have 2 distinct regions: cortex, medulla.
- The cortex contains follicles are collections of B lymphocytes.
- At the center of the follicles is an area called germinal centers contains B lymphocytes.
- The remaining cells of the cortex are T-lymphocytes.
- Lymphatic vessels entering a lymph node: Afferent lymph vessels, multiple per lymph node.  
Exiting: Efferent lymphatic vessels, 1 per lymph node.

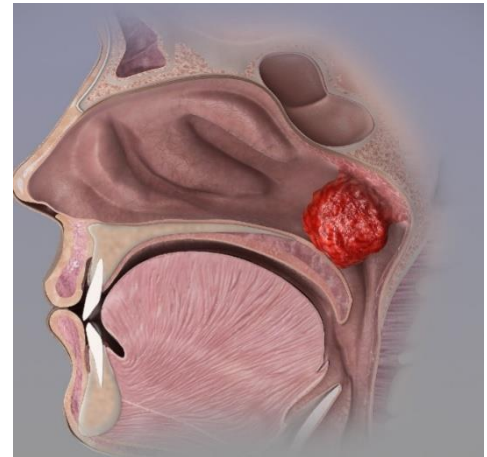
This is a cross section of a lymph node where you can see that the outer cortex it is full of lymphoid follicles in the form of circles and the medulla has no lymphoid follicles and it is collection of connective tissue and lymphocytes leaving this lymph node.



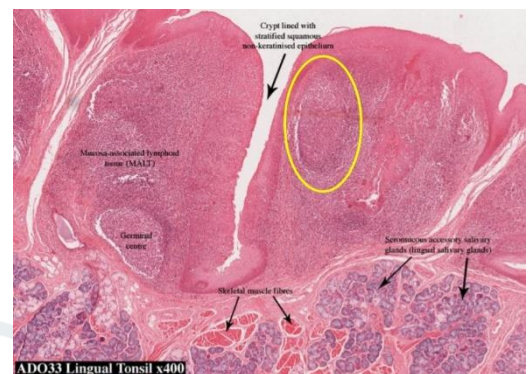
One of the lymphoid tissues that you can see is the Palatine tonsils. these are collections of lymphoid follicles on both sides of the Isthmus of the mouth (point of entry of food from the mouth into the pharynx). if there is any kind of bacteria or viruses, these follicles will get larger (and you see that the tonsils are large). if they are not exposed to any stimulus, they get smaller.



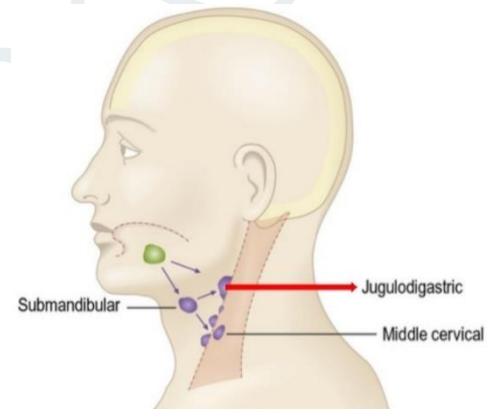
This is collection of lymphoid follicles on the back of the nose in the nasopharynx and this is called the pharyngeal tonsil. when it gets larger because of being stimulated, it blocks the nose. Therefore, the patient will become a mouth breather.



in this section of a tonsil, the lymphoid follicles are not very clear as the germinal center is not that "pale". That is because this tonsil has been stimulated and lots of lymphoblast have changed into Lymphocytes to produce antibodies.



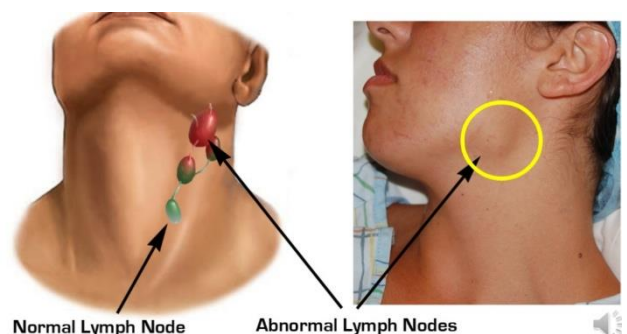
This diagram it is showing a special lymph node which is called The **Jugulodigastric lymph node**. this is the first lymph node to face lymphatic vessels coming from the Palatine tonsils therefore if tonsils are inflamed we should always palpate this jugulodigastric lymph node.



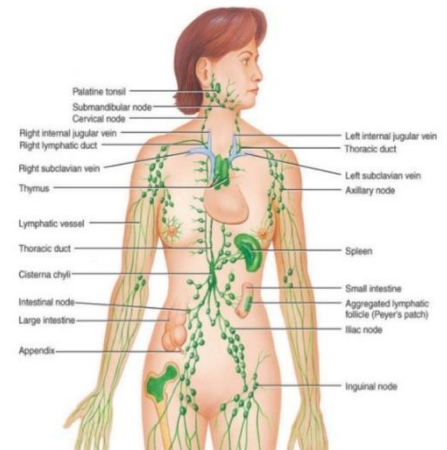
Where is this lymph node? as you can see, it is along the anterior border of sternomastoid muscle near the angle of the mandible.

Here is a patient with a large jugulodigastric lymph node lying anterior to the sternomastoid at the angle of the mandible.

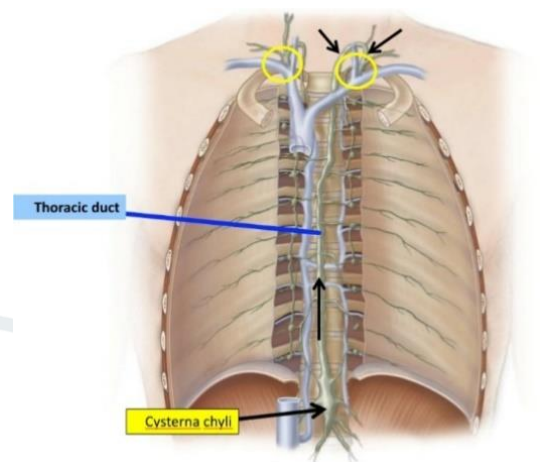
As mentioned before, when this lymph node lose the battle against the bacteria then the afferent lymphatic will take the bacteria to the next group of lymph nodes which are the **superficial** and then to **deep cervical lymph nodes**.



Lymph nodes are present all over the body. for example, lymph from upper limbs is drained to the lymph nodes in the axilla. lymph from the lower limbs is drained to lymph nodes in the inguinal area. Also there are many lymph nodes in the thorax and abdomen. each region has its own group of lymph nodes.



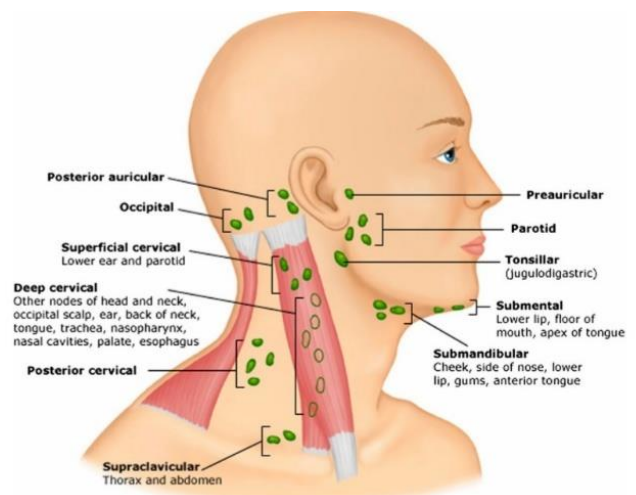
All lymph below the diaphragm (from the lower limbs, from the pelvis, from the abdominal cavity) will collect into a dilated area of lymphatic vessels called **cisterna chyli**. and from this cisterna chyli, the **thoracic duct** goes up in the thorax then turns to the left and joins lymph coming from the head and neck and the left Upper Limb, and the whole lymph is drained into the left subclavian vein here it joins the venous circulation.



That's Lymph coming from below the diaphragm on the right side we also have lymph trunks coming from the head and neck and the right upper limb and these trunks they also drain in the right subclavian vein.

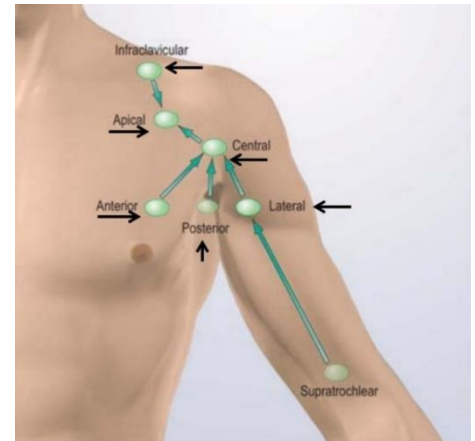
Lymph nodes of the head and neck (important):

- **Preauricular** (also called the **Parotid**).
- **Submental**.
- **Submandibular**.
- **Posterior auricular**.
- **Occipital**.
- **Superficial and the Deep Cervical lymph nodes**.

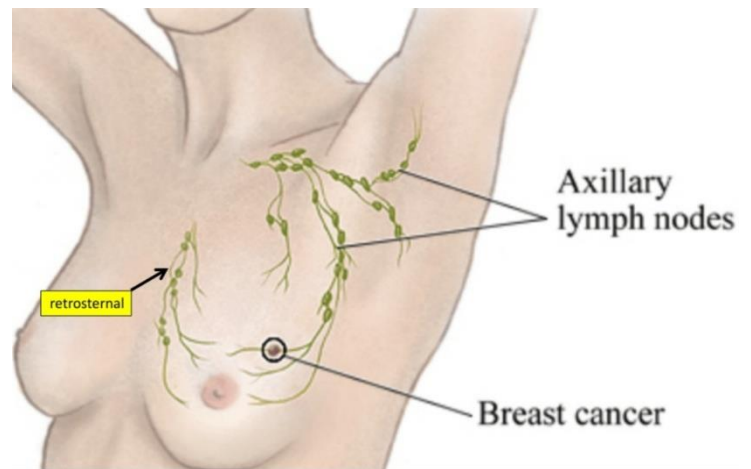




These are the lymph nodes of the axilla draining the upper limb and part of thoracic wall and they are grouped into **lateral group, anterior group, Central group, apical group, posterior group**, and they all drain into the **infraclavicular Group of lymph nodes**.

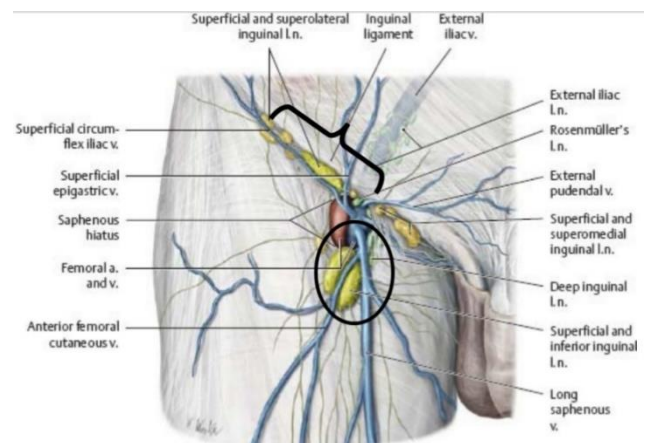


These axillary lymph nodes are very important especially in case of breast cancer; because cancer of the breast is a mass of cancer cells, cancer cells don't produce good intercellular junctions, therefore some cancer cells separate from the mass and they are picked up by lymphatics. so, when we examine the lady with the expectation of breast cancer, we have to examine the axillary lymph nodes and we have to know the groups of axillary lymph nodes.



But there is a problem; that is cancer of the breast can spread to a group of lymph nodes posterior to the sternum (retrosternal) which we can't palpate, so we can't know whether this cancer is metastasizing or not.

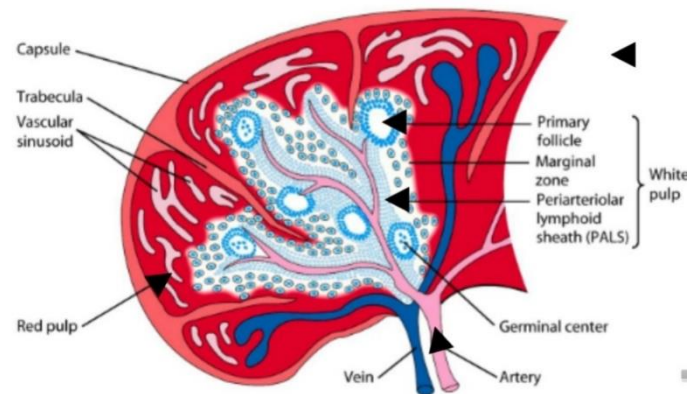
Lymph of lower limbs is drained to lymph nodes along the inguinal area. some of these lymph nodes are superficial along the upper end of the femoral vein and inguinal ligament.



## The process of blood cleaning done by spleen:

The **Spleen** is a lymphoid structure that is encapsulated, and it is a filter for blood, plasma, and blood cells.

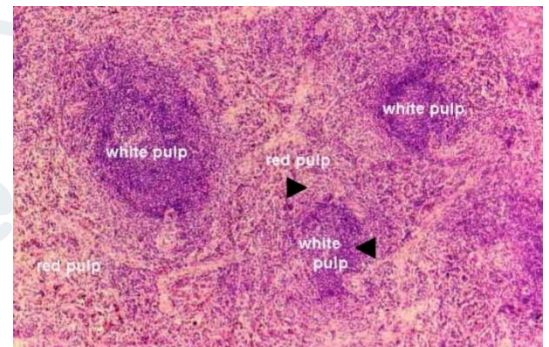
Blood enters the spleen by splenic artery, after entrance it branches and it is surrounded by lymphoid follicles containing B and T lymphocytes, this is a checking process for antigens. this is called **white pulp** because in a cross section of a normal spleen it looks pale.



After this plasma is being checked and cleaned, the arteries will open into an area full of **sinusoids**, where blood cells are being checked (rather RBCs or platelets or WBCs). These sinusoids are surrounded by macrophages; so, any bad blood cells will be picked up.

- red pulp is branching of splenic artery surrounded by sinusoids and macrophages.

This is a histological section showing that the dark area called white pulp because they are the lymphoid follicles and the area between the white pulps called the red pulp because it is full of sinusoids containing blood and surrounding by macrophages.



*Good Luck*