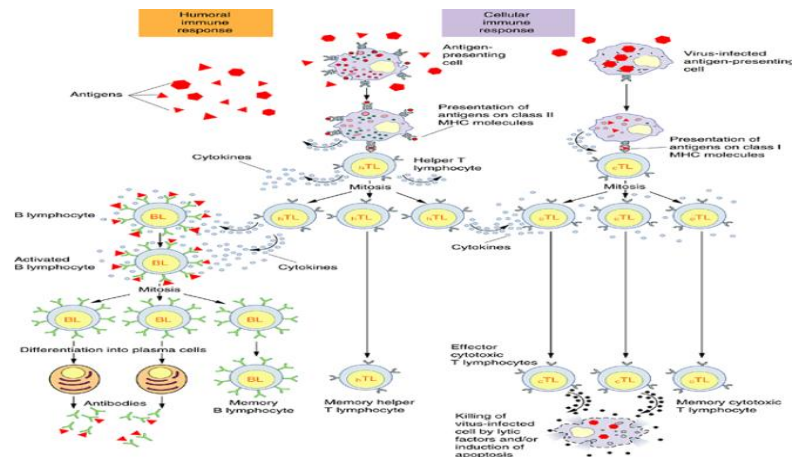


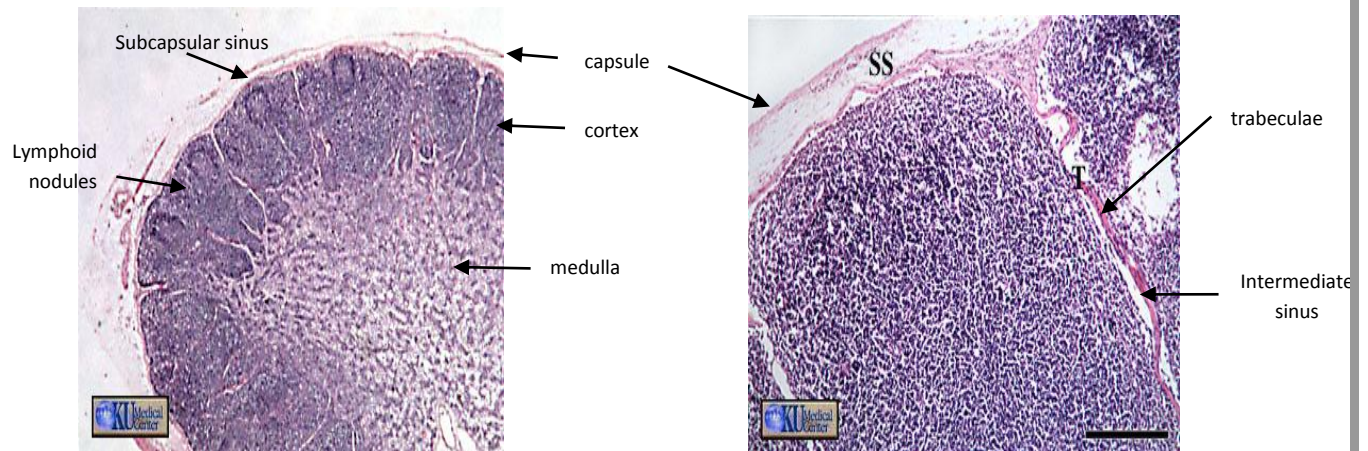
Lecture No – 5



Lymph Nodes

Lymph nodes are distributed throughout the body along the course of the lymphatic vessels . The nodes are found in the axilla and the groin, along the great vessels of the neck, and in large numbers in the thorax and abdomen, especially in mesenteries. Lymph nodes constitute a series of in-line filters that are important in the body's defense against microorganisms and the spread of tumor cells. All this lymph, derived from tissue fluid, is filtered by at least one node before returning to the circulation. **Lymph nodes** are elongated or kidney-shaped organs that have a convex surface that is the entrance site of lymphatic vessels and a concave depression, the **hilum**, through which arteries and nerves enter and veins and lymphatic vessels leave the organ . A connective tissue **capsule** surrounds the lymph node, sending trabeculae into its interior. The most common cells of lymph nodes are lymphocytes, macrophages and other APCs, plasma cells, and reticular cells; follicular dendritic cells are present within the lymphoid nodules. The different arrangement of the cells and of the reticular fibril skeleton that supports the cells creates two regions, a **cortex** and a **medulla** . The cortex can be subdivided into an **outer cortex** and an **inner cortex** or **paracortical region** .





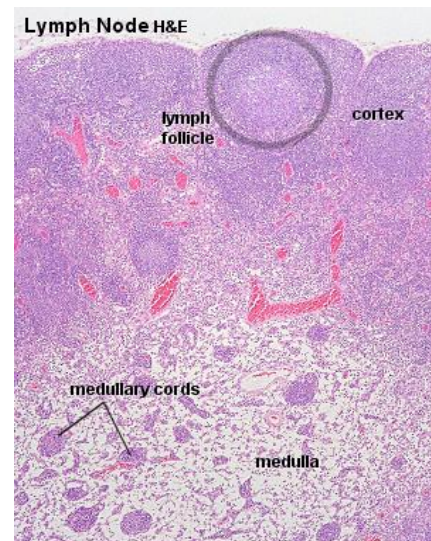
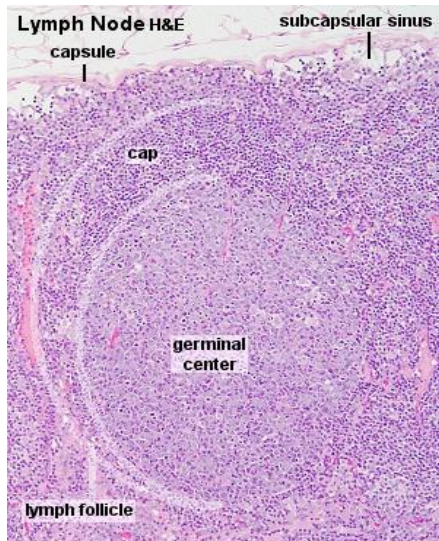
Cortex

The outer cortex, situated under the capsule, consists of the following components:

1. A diffuse population of cells composed mainly of T lymphocytes and reticular cells ; macrophages and APCs are also present in this area.
2. Lymphoid nodules, with or without germative centers, formed mainly by B lymphocytes, embedded in the diffuse population of cortical cells .
3. Areas of loose lymphoid tissue (whose reticular fibril meshes are wide) situated immediately beneath the capsule, called the **subcapsular sinuses** . They are composed of a loose network of reticular cells and fibers. Lymph, containing antigens, lymphocytes, and APCs, circulates around the wide spaces of these sinuses after being delivered into these channels by the afferent lymphatic vessels.
4. **Intermediate** or **radial sinuses** that run between lymphoid nodules. These sinuses arise from and share the same structure with the subcapsular sinuses. They communicate with the subcapsular sinuses through spaces similar to those present in the medulla .

The inner cortex or paracortical region does not have precise boundaries with the outer cortex and contains few, if any, nodules but many T lymphocytes .





Medulla

The medulla has two components:

1. The **medullary cords** are branched cordlike extensions of dense lymphoid tissue that arise in the inner cortex. They contain primarily B lymphocytes and often plasma cells and macrophages .
2. The medullary cords are separated by dilated spaces, frequently bridged by reticular cells and fibers, called the **medullary sinuses** . They contain lymph, lymphocytes, often many macrophages, and sometimes even granulocytes if the lymph node is draining an infected region. These sinuses (which arise from the intermediate sinuses) join at the hilum delivering the lymph to the efferent lymph vessel of the lymph node .

Lymph Circulation

Afferent lymphatic vessels cross the capsule and pour lymph into the subcapsular sinus . From there, lymph passes through the intermediate sinuses and, finally, into the medullary sinuses. During this passage, the lymph infiltrates the cortex and the medullary cords. The lymph is finally collected by efferent lymphatic vessels at the hilum. Valves in both the afferent and efferent vessels aid the unidirectional flow of lymph .

Spleen

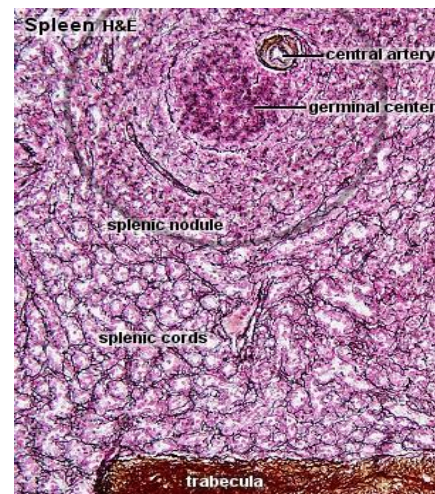
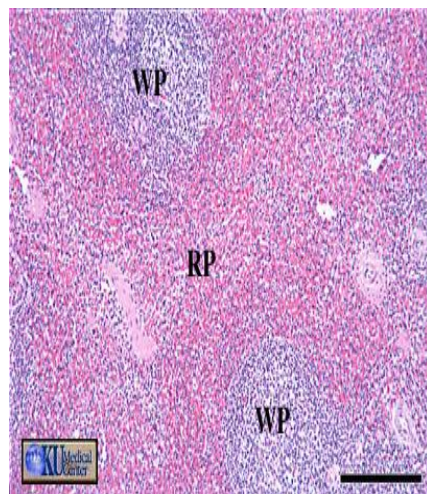
The spleen is the largest accumulation of lymphoid tissue in the body and the only one interposed in the blood circulation. Because of its abundance of phagocytic cells, the spleen is an important defense against antigens



that reach the blood circulation. It is also the site of destruction of aged erythrocytes. As is true of all other lymphoid organs, the spleen is a production site of activated lymphocytes, which are delivered to the blood. The spleen reacts promptly to antigens carried in the blood and is, thus, an important blood filter and antibody-forming organ.

General Structure

The spleen is surrounded by a **capsule** of dense connective tissue from which emerge **trabeculae**, which divide the parenchyma, or **splenic pulp**, into incomplete compartments . Large trabeculae originate at the hilum, on the medial surface of the spleen; these trabeculae carry nerves and arteries into the splenic pulp as well as veins that bring blood back into the circulation. Lymphatic vessels that arise in the splenic pulp also leave through the hilum via the trabeculae.



Splenic Pulp

The spleen is composed of a network of reticular tissue that contains reticular cells, many lymphocytes and other blood cells, macrophages, and APCs. The splenic pulp has two components, the **white pulp** and the **red pulp** . These names derive from the fact that on the surface of a cut through an unfixed spleen, white spots (lymphoid nodules) are observed within a dark red tissue that is rich in blood. The white pulp consists of the **periarterial lymphatic sheath** and the **lymphoid nodules**, whereas the red pulp consists of **splenic cords (Billroth's cords)** and blood **sinusoids**.



White Pulp

The splenic artery divides as it penetrates the hilum, branching into **trabecular arteries** of various sizes that follow the course of the connective tissue trabeculae . When they leave the trabeculae to enter the parenchyma, the arteries are immediately enveloped by a sheath of T lymphocytes, the periarterial lymphatic sheath (**PALS**), which is part of the white pulp . These vessels are known as **central arteries** or **white pulp arteries**. After coursing through the parenchyma for variable stretches, the PALS receive large collections of lymphocytes —mostly B cells—forming lymphoid nodules . In these nodules the artery, which has now turned into an arteriole, occupies an eccentric position but is still called the central artery . During its passage through the white pulp, the artery also divides into numerous radial branches that supply the surrounding lymphoid tissue .

Surrounding the lymphoid nodules is a **marginal zone** consisting of many blood sinuses and loose lymphoid tissue . A few lymphocytes but many active macrophages can be found there. The marginal zone contains an abundance of blood antigens and thus plays a major role in the immunological activities of the spleen. After leaving the white pulp, the sheath of lymphocytes slowly thins and the central artery (arteriole) subdivides to form straight **penicillar arterioles** with an outside diameter of approximately 24 μm . Near their termination, some of the penicillar arterioles are surrounded by a thick sheath of reticular cells, lymphoid cells, and macrophages.

Red Pulp

The red pulp is composed of splenic cords and sinusoids . The splenic cords contain a network of reticular cells supported by reticular fibers. The splenic cords contain T and B lymphocytes, macrophages, plasma cells, and many blood cells (erythrocytes, platelets, and granulocytes). The splenic cords are separated by irregularly shaped wide sinusoids . Elongated endothelial cells line the sinusoids of the spleen with the long axes parallel to the long axes of the sinusoids. These cells are enveloped in reticular fibers set primarily in a transverse direction, much like the hoops on a barrel .

Surrounding the sinusoid is an incomplete basal lamina. Because the spaces between the endothelial cells of the splenic sinusoids are 2–3 μm in diameter or smaller, only flexible cells are able to pass easily from the red pulp cords to the lumen of the sinusoids. Unfortunately, because the



lumen of sinusoids in the red pulp may be very narrow and the splenic cords are infiltrated with red blood cells, microscopic observation of a spleen section is not always easy; observation of PALS may also be difficult.

Closed and Open Blood Circulation in the Spleen

The manner in which blood flows from the arterial capillaries of the red pulp to the interior of the sinusoids has not yet been completely explained. Some investigators suggest that the capillaries open directly into the sinusoids, forming a **closed circulation** in which the blood always remains inside the vessels . Others maintain that the prolongations of the penicillar arteries open into the splenic cords, and the blood passes through the space between the cells to reach the sinusoids (**open circulation**) .

From the sinusoids, blood proceeds to the red pulp veins that join together and enter the trabeculae, forming the **trabecular veins** . The splenic vein originates from these vessels and emerges from the hilum of the spleen. The trabecular veins do not have individual muscle walls. They can be considered channels hollowed out in the trabecular connective tissue and lined by endothelium.

Functions of the Spleen

Phagocytosis and Immunological Defense :

Because of its strategic position in the blood circulation, the spleen is able to filter, phagocytose, and mount immunological responses against blood-borne antigens. The spleen contains all the components (B and T lymphocytes, APCs, and phagocytic cells) necessary for this function.

The white pulp of the spleen is an important production site of lymphocytes, which then migrate to the red pulp and reach the lumen of the sinusoids, where they enter the blood circulation. Inert particles are also intensely phagocytosed by spleen macrophages.

