LYMPHATIC SYSTEM

6.1 LYMPHATIC SYSTEM

- The lymphatic system was first described in the seventeenth century independently by **Olaus Rudbeck and Thomas Bartholin.**
- Lymphatic system is mainly made up of **lymph nodes, lymph capillaries and lymph vessels.**
- Lymph is a tissue fluid which is formed by the passage of substances from **blood capillaries into tissue spaces.**
- Lymphatic system, is a subsystem of the circulatory system in the vertebrate body that consists of a **complex network of vessels, tissues, and organs.**
- It also helps defend the body against infection by supplying disease fighting cells **called lymphocytes.**
- Lymph nodes swell in response to infection due to a build-up of **lymph fluid, bacteria, or other organisms and immune system cells.**
- The lymphatic system is part of the **immune system.**
- It also maintains fluid balance and plays a role in **absorbing fats and fat-soluble nutrients.**

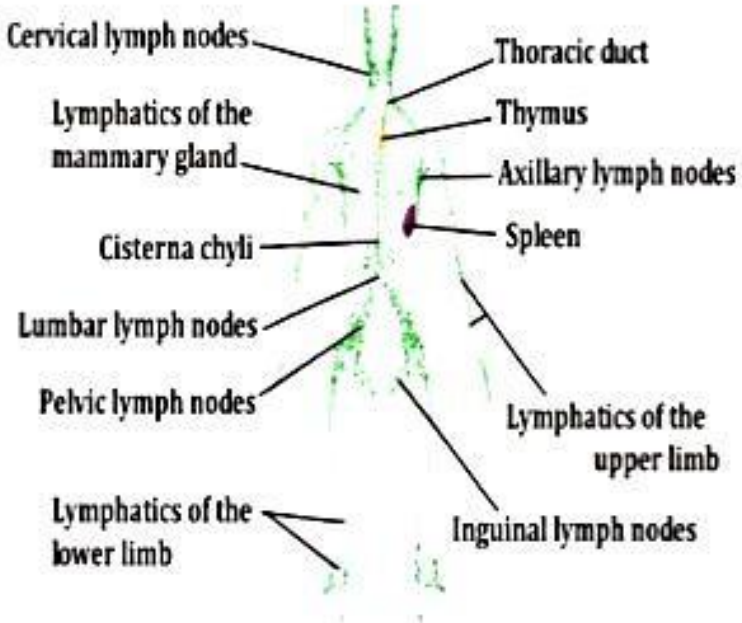

Fig. 6.1: Human Lymphatic System

6.2 LYMPH

- Lymph is a **clear-to-white fluid** made of White blood cells, especially lymphocytes, the cells that attack bacteria in the blood and body tissues.
- Lymph, pale fluid that bathes the tissues of an organism, maintaining fluid balance, and removes bacteria from tissues; it enters the blood system by way of lymphatic channels and ducts. It contains **oxygen, proteins, glucose and white blood cells.**
- Lymph, also called **lymphatic fluid**, is a collection of the extra fluid that drains from cells and tissues in body and isn't reabsorbed into capillaries.

6.2.1 Composition of lymph

- Lymph is a **clear, colourless fluid** that circulates throughout the lymphatic system. Its composition is similar to that of blood plasma but with some differences.

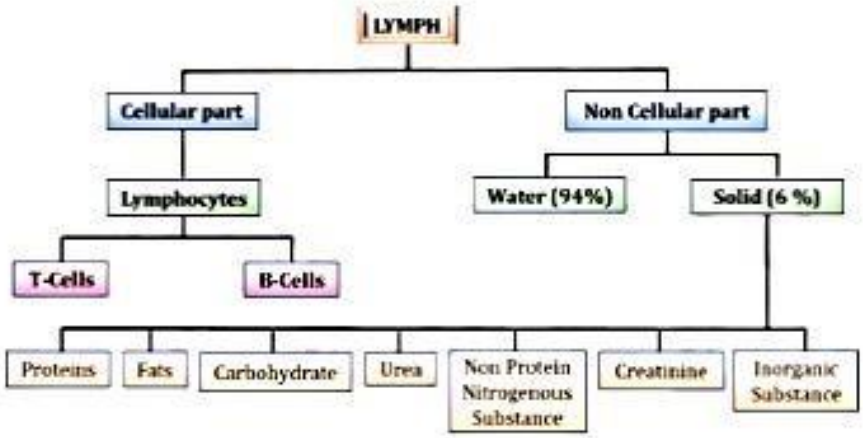

Fig.6.2: Composition of Lymph

➢ Chemical composition

- Proteins (g/100 ml): 2.6
- Chloride (m. eq/lit): 116
- Calcium (m. eq/lit): 4.6
- Urea (mg/100 ml): 23.5

6.2.2 Functions of the lymph

i. Fluid and Protein Balance

- When the blood circulates throughout the body, lot of fluid filtered by the capillaries gets trapped in the tissues of the body, this trapped fluid, also called as interstitial fluid, comprises about 10% (1-2 litres) of the total fluid. The loss of this fluid is substantial as it is rich in several vital

ii. Transportation of Nutrients

- Lymphatic system works in collaboration with the circulatory system to transport various essential nutrients in the body.
- It carries lipids and lipid soluble vitamins (A, D, E & K) absorbed by the gastrointestinal tract to the blood.
- Lymphatic system delivers oxygen, hormones and other essential nutrients through the blood, to the body cells.

iii. Digestion

- Lymphatic system also assists the digestive system in various ways.
- The lymphatic vessels that are located in the gastrointestinal lining help in the absorption of fats from the food that we eat.
- Lymphatic system is required for proper assimilation of fats in the body. Failure on the part of lymphatic system may result in serious malnutrition.
- Lymphatic system prevents obesity which results due to accumulation of 'bad' fat in the body.

iv. Excretion

- Lymphatic system removes dead blood cells, excess fluid, waste, debris, etc. from the body, thereby assisting in excretion of waste materials from the body.
- Lymphatic system also removes pathogens, toxins and cancer cells from the body cells as well as inters cellular spaces.

v. Protections

- Lymphatic system consists **B-Cells and T-Cells.**
- These cells provide us protection against the harmful pathogens like **bacteria, toxins, virus etc.**
- When pathogens enter in to the cells they get **activated and fight against it.**
- First, they identify the pathogen and if it is harmful for us then they kill it by cell mediated **immunity (T-Lymphocyte mediated)** or humeral immunity **(B lymphocyte mediated)** and protect us from harmful diseases.

6.2.3 Formation of lymph

There five Important Steps for the Process of Lymph formation are –

i. Collection of excess fluid
ii. Entry into lymphatic capillaries
iii. Transport through lymphatic vessels
iv. Filtration in lymph nodes
v. Return to bloodstream

i. Collection of Excess Fluid

- The first step in the process of Lymph formation is the collection of excess fluid i.e. interstitial fluid from the body's tissues. interstitial fluid is made up of water, ions and small molecules that leak out of the blood vessels and into the spaces between the cells.
- The collection of interstitial fluid occurs due to a balance of forces between the blood vessels and the surrounding tissues. Blood vessels deliver nutrients and oxygen to the tissues but some of the fluid and small molecules in the blood leak out of the vessels and into the interstitial spaces due to pressure gradients between the vessels and tissues.
- Interstitial fluid then bathes the cells and tissues, delivering nutrients and removing waste products.
- The Interstitial fluid collects in the spaces between the cells and tissues of the body forming a clear colorless fluid that resembles plasma but with lower protein content.

ii. Entry into Lymphatic capillaries

- Lymphatic capillaries are small thin-walled vessels that are found in almost all tissues of the body except for the central nervous system, bone marrow and some other tissues.
- Lymphatic capillaries are similar in structure to blood capillaries but have some important differences.
- The entry of interstitial fluid into lymphatic capillaries is facilitated by several factors like pressure gradients and the presence of anchoring filaments.
- Pressure gradients between the Interstitial fluid and the inside of the lymphatic capillaries help to drive the flow of fluid into the vessels.

- Anchoring filaments are small fibers that connect the lymphatic capillaries to the surrounding tissues allowing the vessels to be pulled open as the tissues move or contract.
- Once interstitial fluid enters the lymphatic capillaries it is called Lymph.

iii. Transport through Lymphatic Vessels

- Once lymph has entered the lymphatic capillaries it flows into larger lymphatic vessels.
- The lymphatic vessels have a similar structure to veins with valves that help to prevent backflow of lymph and smooth muscle that helps to propel the lymph through the vessels.
- These vessels have one-way valves that prevent the backflow of lymph and smooth muscle that helps to propel the lymph through the vessels.
- The movement of lymph through the lymphatic vessels is facilitated by several factors like the pressure gradient created by the movement of muscles and the contractions of smooth muscle in the lymphatic vessel walls.
- The movement of lymph is also aided by the pulsation of nearby arteries and the compression of tissues during normal bodily movements.
- As lymph moves through the lymphatic vessels it passes through a series of Lymph nodes.

iv. Filtration in Lymph nodes

- Lymph nodes are small bean-shaped organs that are distributed throughout the body along the course of the lymphatic vessels.
- Lymph nodes act as filters for the lymph. It removes pathogens, foreign particles and damaged cells before returning the lymph to the bloodstream.
- As lymph flows through the lymphatic vessels, it enters the lymph node through afferent lymphatic vessels and exits through efferent lymphatic vessels.
- As lymph flows through the sinuses these immune cells help to identify and eliminate harmful substances such as bacteria, viruses and cancer cells that may be present in the lymph.
- The lymph also flows through a network of small channels called trabeculae which are lined with lymphatic tissue and contain specialized

immune cells.

v. Return to Bloodstream

- After filtration in the lymph nodes the purified lymph enters larger lymphatic vessels which eventually merge together to form the two main lymphatic ducts the thoracic duct and the right lymphatic duct.
- The thoracic duct is the larger of the two ducts and collects lymph from the lower body, left arm, and left side of the head and neck.
- The right lymphatic duct collects lymph from the right arm, right side of the head and neck and right side of the thorax.
- These ducts then empty the purified lymph back into the bloodstream by emptying it into the subclavian veins which are located near the heart.

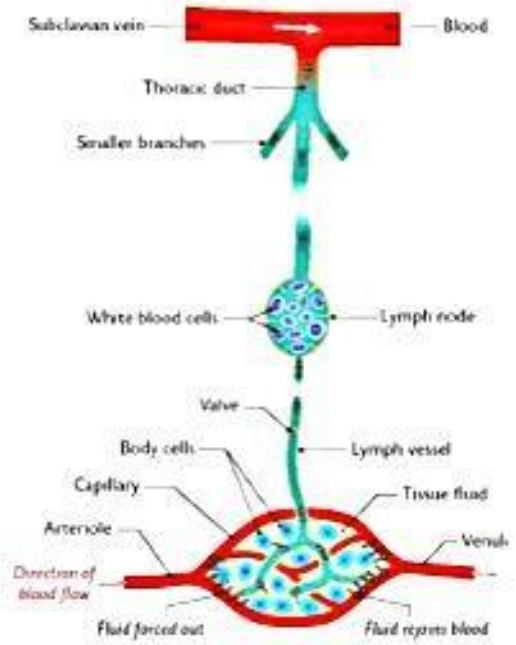

Fig. 6.3: Formation of lymph

6.3 LYMPHATIC CAPILLARIES

- Lymphatic Capillaries are larger in diameter than blood capillaries.
- It is found throughout the body except in:
  - ✓ **Avascular Tissue**
  - ✓ **The Central Nervous System**
  - ✓ **Splenic Pulp**
  - ✓ **Bone Marrow**
- It consists specialized valve which permit the fluid flow in one and unique direction means that permits interstitial fluid to flow into them but not out.

- Lymphatic capillaries are made up by the endothelial cells.
- When the pressure in to the interstitial fluid is greater that time it makes force on lymphatic valve and open it and enter in to the lymphatic capillary after the normalization of pressure again it gets closed in such a direction that lymph may not go back to interstitial space.
- At the right angle to the lymphatic capillaries are structures called anchoring filaments.
- These filaments are made up by the fine collagen fibrils and adhere to the lymphatic endothelial cell to surrounding tissue.

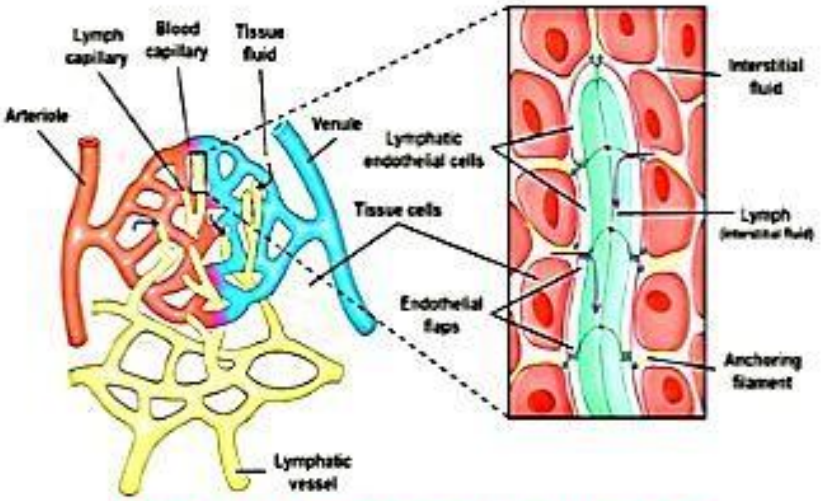

Fig.6.4: Lymphatic Capillaries

6.4 LYMPHATIC VESSELS

- The lymphatic vessels transport lymph fluid around the body.
- There are two main systems of lymph vessels – superficial and deep
- **Superficial vessels –** Arise in the subcutaneous tissue, and tends to accompany venous flow. They eventually drain into deep vessels.
- **Deep vessels –** Drain the deeper structures of the body, such as the internal organs. They tend to accompany deep arteries.
- These are tiny thin-walled vessels.
- These are closed at one end.
- The main purpose is to **drain excess interstitial fluid from around the cell to venous circulation.**
- The wall of lymphatic capillaries is made up of endothelium.
- These are larger in diameter.
- The anchoring filaments hold endothelial cells to the nearby tissues.

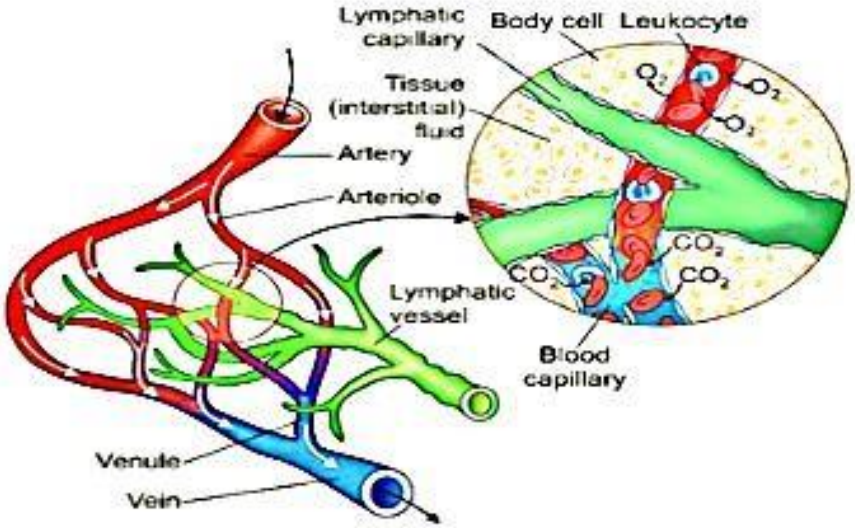

Fig. 6.5- Lymphatic vessels

6.4.1 Lymph Trunks

- Lymph passes from lymphatic capillaries into lymphatic vessels through lymph nodes.
- Then the same group of lymphatic vessels or different of lymphatic vessels unite to form lymph trunks. groups.
- The principal trunks are:

i. **Lumber Trunks:** Drains lymph from lower limbs, pelvis, kidneys, adrenal glands, abdominal walls.

ii. **Intestinal Trunk:** Drain lymph from stomach, intestine, pancreas, spleen and part of lever.

iii. **Broncho mediastinal:** Drain lymph from the thoracic wall, lungs and heart.

iv. **Subclavian trunk:** Drain lymph from upper limbs.

v. **Jugular Trunks:** Drain lymph from head and neck.

6.4.2 Lymph Ducts

Lymph passes from lymphatic trunks to two main lymphatic ducts;

i. **Thoracic duct (Left Lymphatic Duct)**

ii. **Right Lymphatic Duct**

Fig.6.6: Lymphatic Ducts

i. Thoracic duct (Left Lymphatic Duct)

- It is 38-45 cm long and begins as dilation part near the limbic region called cisterna chyli.
- Cisterna chyli receive lymph from:
  - ✓ Left and right lumber trunk.
  - ✓ Intestinal trunk.
- In the neck, thoracic duct also receives lymph from:
  - ✓ Left jugular trunk,
  - ✓ Left subclavin trunk,
  - ✓ Left broncho mediastinal trunk.
- In short thoracic duct receives lymph from left part of body.
- That's why it is also called as left lymphatic duct.
- Finally, it drains the lymph in to left subclavin vein and left jugular vein.

ii. Right Lymphatic Duct

- It is 1.2 cm long and receives lymph from:
  - ✓ Right jugular trunk,
  - ✓ Right subclavin trunk,
  - ✓ Right broncho mediastinal trunk vein.
- It receives lymph from right side of the body part that's why it is known as Right Lymphatic Duct.
- It drains lymph in to right subclavin vein and right jugular vein.

6.5 LYMPHATIC TISSUES AND ORGANS

Lymphatic tissues and organs are classified in to two types

I. Primary lymphatic organs

- The primary lymphatic organs are:
- ✓ Red bone marrow and
- ✓ Thymus gland.
- They are primary lymphatic organs because they produce B and T Cells.
- The B-lymphocyte cells and T-lymphocyte cells are the important cell for immune response.
- The hemopoietic stem cells in red bone marrow produce B-Cells and Pre-T Cells.

- The Pre-T cells than migrate to the thymus gland and become mature T-Cells

6.5.1 Thymus

- The thymus gland contains lymphoid tissue.
- It lies in the thorax behind the sternum but in front of heart and arch of aorta.
- Thymus gland is large in infants and it reaches its maximum size at 10-12 years with 40 gms of weight.
- Thymus gland consist two lobs and each lobe are covered by the connective tissue layer known as capsule.
- The thymus is a small, triangular organ found just posterior to the sternum and anterior to the heart.
- The extended part of the capsule layer inside the lobes is known as trabeculae which divides the lobes in to lobules.
- The lobule consists outer dark and inner light region.
- It is made of glandular epithelium and hematopoietic connective tissues.
- The vast majority of T cells mature, develop, and reproduce in the thymus.
- On maturation, the T cells spread throughout the body to other lymphatic tissues to fight infections.

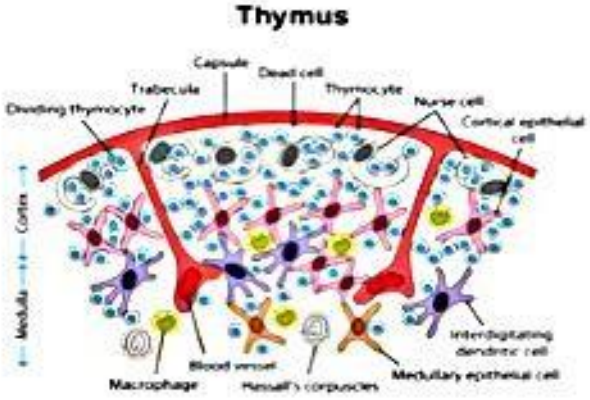

Fig. 6.7- Thymus

II. Secondary Lymphatic organs

- The secondary lymphatic organs are:
  - ✓ Lymph nodes and
  - ✓ Spleen.
- These organs are covered by the capsule layer.

- The lymphatic nodules are not categorized as secondary lymphatic organs because it is not surrounded by the capsule layer and it is a cluster of lymphocytes which guards the all-mucous membrane (Gastrointestinal tract, Respiratory passage, Urinary tract and reproductive tract) against the harmful pathogens.

6.5.2 Lymph Node

- Lymph nodes are small, bean-shaped organs that are the size of a pea.
- It is oval or bean shaped and 1 to 25 mm in length.
- Each node is covered by a capsule of dense connective tissue.
- Lymph nodes throughout body including in armpits, neck and groin.
- Lymph nodes can swell or get bigger, which is a sign that body is fighting an infection or an illness.
- Cells that help fight infections make up lymph nodes along with lymph tissue.
- There are hundreds of lymph nodes throughout the body.

➢ Structure of Lymph node

- Outermost is the covering called capsule composed of fibrous connective tissue.
- Capsule contains the parenchyma or stroma.
- Stroma is differentiated into cortex and medulla.
- Trabeculae extend from cortex to medulla.
- Outer cortex filled with lymph follicles outer edge of follicle contains more T cells.
- Inner germinal center is the site of B- cell proliferation.
- Inner medulla -medullary cords of lymphocytes, macrophages, plasma cells.
- The hilum is a concave region on one side of the lymph node where blood vessels and efferent lymphatic vessels exit and enter.
- Afferent lymphatic vessels bring lymph into the lymph node, allowing it to be filtered. Efferent lymphatic vessels carry filtered lymph away from the lymph node.

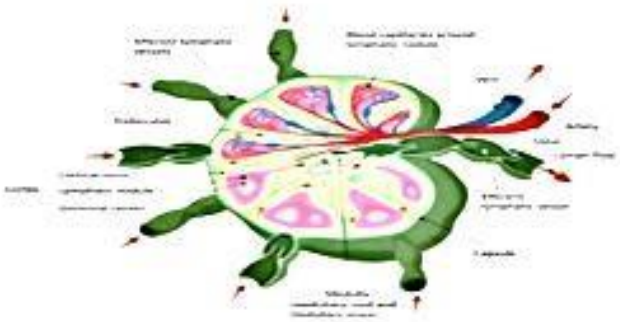

Fig. 6.8- Lymph Node

Functions of Lymph node

- The primary function of lymph nodes is filtering interstitial fluid collected from soft tissues and eventually returning it to the vascular system.
- Filtering this exudative fluid allows for exposure of T-cells and B-cells to a wide range of antigens.
- For antigen-specific B and T cells to activate, they must first suffer exposure to antigens with the aid of antigen-presenting cells, dendritic cells, and follicular dendritic cells.
- These form part of both the innate immune response and play a role in adaptive immunity.
- Lymph nodes filter lymph of harmful pathogens such as bacteria and viruses.
- The nodes also filter out cellular waste, dead cells, and cancerous cells.
- They produce lymphocytes.
- They produce plasma proteins like globulin. This is done by dissolution and disintegration of lymphocytes.

6.5.3 Spleen

- It is a dark purple coloured lymphoid structure.
- It is highly vascular and bean shaped and measures about 12 cm in length.
- The average weights of the spleen are 200gm.
- The spleen is a small organ inside left rib cage, just above the stomach.
- It's part of the lymphatic system (which is part of the immune system).
- The spleen stores and filters blood and makes white blood cells that protect from infection.
- Many diseases and conditions can affect how the spleen works.
- A ruptured (torn) spleen can be fatal.

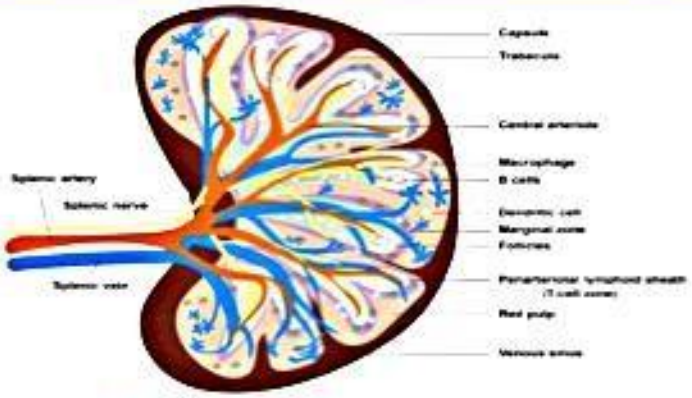

Fig. 6.9- Spleen

Structure of Spleen

- The spleen has diaphragmatic and visceral surfaces. The diaphragmatic surface is in contact with the inner surface of the diaphragm.
- The spleen has an outer coat of peritoneum which is firmly adherent to the internal fibro-elastic coat or splenic capsule that dips into the organ, forming trabeculae.
- The spaces between trabeculae contain the splenic tissue. These tissues contain the lymphoid tissues called as "Malpighian corpuscles".
- Spleen is supplied by splenic artery and drained by splenic vein.
- The spleen has a spongy interior called splenic pulp. The splenic pulps are of two kinds:

i. White Pulp

- It consists of periarteriolar sheaths of lymphatic tissue with enlargements called splenic lymphatic follicles containing rounded masses of lymphocytes.
- These follicles are center of lymphocytes production called primary lymphoid follicles, composed mainly of follicular dendritic cells (FDC) and B cells.
- They are visible to the naked eye in freshly cut surface of the spleen as whitish dots against the dark red background of red pulp.
- The white pulp forms 'islands' within a meshwork of reticular fibers containing red blood cells, macrophages and plasma cells (red pulp).

ii. Red Pulp

- It consists of numerous sinusoids containing blood, separated by a network of perivascular tissue which is referred to as the splenic cords.

- The splenic cords contain numerous macrophages and are the site of intense phagocytic activity.
- They also contain numerous lymphocytes, which are derived from the white pulp.

Function of Spleen

- Spleen produces all types of blood cells during foetal life.
- Filters blood by removing cellular waste and getting rid of old or damaged blood cells.
- Makes white blood cells and antibodies that help infection.
- Histocytes of spleen ingest and destroy foreign particles including bacteria.
- Maintains the levels of fluid in body.
- Spleen serves as a reservoir of blood.
- Produces antibodies that protect against infection.