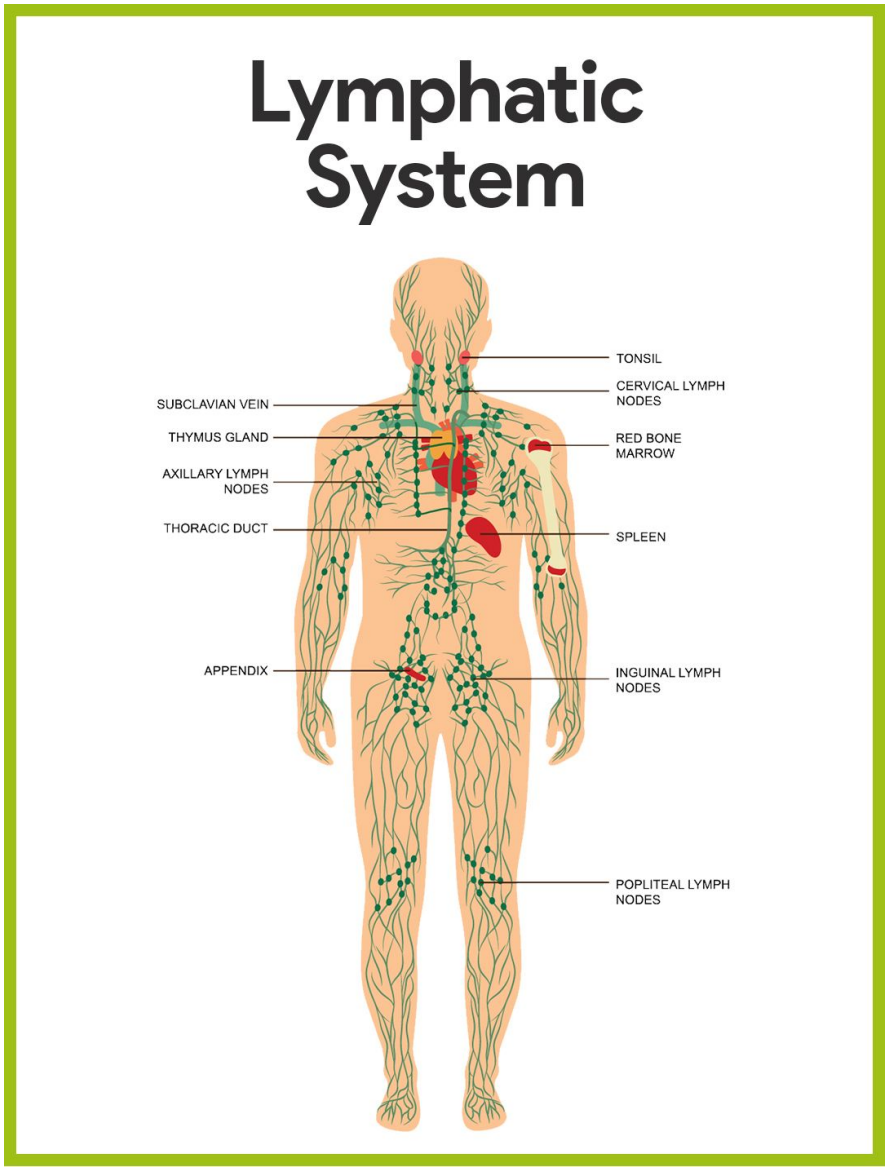
Unit-III (Chapter-II) LYMPHATIC SYSTEM

The lymphatic system is a part of the circulatory system, comprising a network of conducts called lymphatic vessels that carry a clear fluid called lymph, uni-directionally towards the heart.

The cells of the body are bathed in interstitial fluid which leaks constantly out of the blood stream through the permeable walls of blood capillaries.

- It is hence very alike in composition to blood plasma.
- Lymphatic system does not have central pump organ.



COMPONENTS OF LYMPHATIC SYSTEM

The four components of the lymphatic system are:

1. **Lymph**
2. **Lymphatic capillaries / Lymph Vessel**
3. **Lymph node**
4. **Lymphoid Tissue / Lymphoid Organ**
   a) **Tonsil**
   b) **Spleen**
   c) **Thymus gland**
   d) **Aggregated payer patches**

Lymph

- Lymph is a clear colorless watery fluid, similar in composition to plasma, with the important exception of plasma protein.
- Lymph contains less proteins than blood.
- It is identical in composition to interstitial fluid.
- The hydrostatic pressure of blood in the blood vessel force water and small protein into the interstitial space.
- Once carried by the lymphatic capillaries, it is known as lymph.
- Its main function is to nourish and bath tissues.
- It transports the plasma protein that sweeps out of the capillary bed to the blood stream.
- It also carries away larger particles such as bacteria and cell debris from damaged tissues, which can then be filtered out and destroyed by the lymph node.
- Lymph consists of lymphocytes, which circulates in the lymphatic system permitting them to patrol the different regions.
- Lymph is the most common route for cancer cell spread (metastasis). (second common route is via the blood).

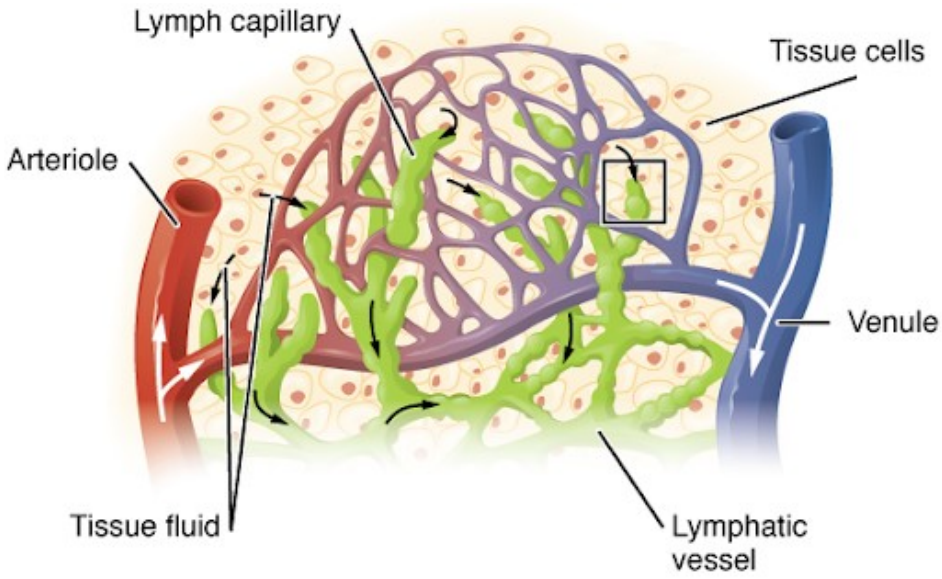
Functions of lymphatic system

1. **Tissue drainage:**
   - It accounts for the removal of interstitial fluid from tissues.
   - Everyday around 21 liters of fluid from plasma protein, escape from the arterial end of the capillaries and into the tissues.
   - Most of this fluid is returned directly to the blood stream via the capillary at its venous end, but the excess, about 3-4 times of fluid, is drained away by the lymphatic vessels.
2. **Absorption and transportation:**
   - It absorbs and transports fats and fat-soluble minerals (fat soluble vitamins) as chyle from the small intestine (central lacteals of the villi).
3. **Immunity:**

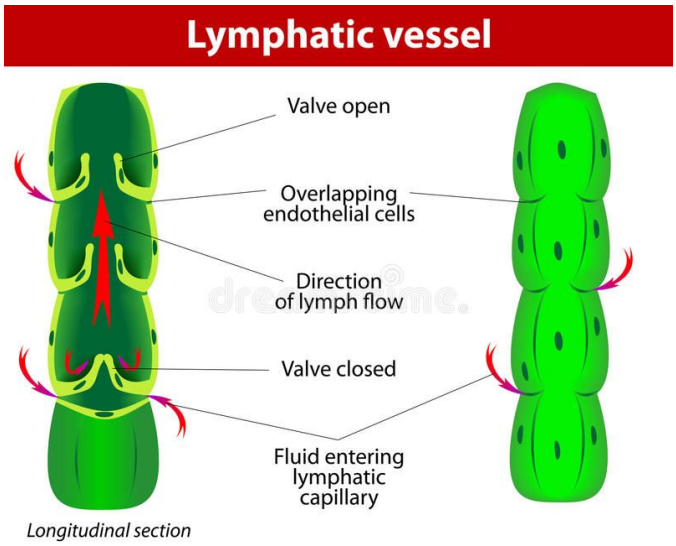
- The lymphatic organs are concerned with the production and maturation of lymphocytes, the WBC responsible for immunity.
- Bone marrow is therefore concerned to be lymphatic tissue since lymphocytes rae produced there.
- The lymph transports antigen presenting cells (APCs) such as dendritic cells, to the lymph node where an immune response is stimulated.

1. Lymphatic capillaries

- These originates as blind end tubes in the interstitial space.
- They have the same structure as blood capillaries i.e. a single layer of endothelial cells, but their walls are more permeable to all interstitial fluid constituents including proteins and cell debris.
- The tiny capillaries join up to form larger lymph vessels.
- Nearly all tissues have a network of lymphatic vessels, important exception being the central nervous system, the cornea of the eyes, the bones and the most superficial layers of the skin.



2. Lymph vessels:



- Lymph vessels are often found running along-side the arteries and veins serving the area.
- These walls are about the same thickness as those of small veins and have the same layers of tissues.
- The layers of tissue consists of fibrous covering, a middle layer of smooth muscle and elastic tissue and an inner lining of endothelium.
- Similar to veins, lymph vessels have large number of cup shaped valves to make sure that lymph flows in a one-way system towards the thorax.
- There is no pump like the heart, involved in the onward movement of lymph, but the muscle layer in the walls of larger lymph vessels has an intrinsic ability to contract rhythmically.
- In addition, lymph vessels are compressed by activity in adjacent structures such as contraction of muscles and the regular pulsation of large arteries.
- This milking action on the lymph vessel walls helps to push lymph along.

Lymph vessels become larger as they join together eventually forming two large ducts, the thoracic duct and right lymphatic duct, which empty lymph into the subclavian veins.

Thoracic duct/Left lymphatic duct

- This duct begins at the cisternae chyli which is a dilated lymph channel situated in front of the bodies of the first two lumbar vertebrae.
- The duct is about 40cm long and opens into the left subclavian vein in the root of the neck.
- It drains lymph from both eyes, the pelvic and abdominal cavities, the left half of the thorax, head and neck and the left arm.

Right lymphatic duct

- This is a dilated lymph vessel of about 1cm long.

- It lies in the root of the neck and opens into right subclavian vein.
- It drains lymph from right half of the thorax, head and neck of the right arm.

3. Lymph node:

- Lymph nodes are oval or bean shaped organs that are found often in groups, along the length of lymph vessels.
- The lymph drains through a number of nodes, usually 8 to 10 before returning to venous circulation.
- These nodes vary considerably in size, some are small as a pin head and the largest about the size of an almond.
- Lymph nodes are the lymphatic tissues covered by the fibrous tissue.
- The outer capsule of fibrous tissue dips down into the node substance forming partitions trabeculae.
- Many lymphocyte and macrophage are found inside lymph node.
- As many as four or five afferent lymph vessels may enter a lymph node while only one efferent vessel carries lymph away from the node.
- Each node has a concave surface called the hilum where an artery enters and a vein and the efferent lymph vessel leave.
- Histologically, it has outer layer cortex and inner layer medulla.
- **Cortex predominantly consists of B-lymphocytes that are responsible for humoral immunity whereas medulla predominantly contains T-lymphocytes responsible for cell mediated immunity**.
- Lymph nodes are particularly numerous in the mediastinum in the chest, neck, pelvis, axilla (armpit), inguinal (groin) region and in association with the blood vessels of the intestine.

Lymph from various regions passes through

I. Head and neck region —> deep and superficial cervical node
II. Upper limbs —-> nodes of elbow region and then to superficial axillary node.
III. Organs and tissue of thoracic cavity ——> Nodes close to mediastinum
IV. Breast —-> axillary nodes
V. Pelvic and abdominal cavity —> lymph nodes —> cisternae chyli
VI. Lower limbs —-> inguinal nodes

Functions of lymph node

Filtering and phagocytosis

- Lymph is filtered by the reticular and lymphoid tissues as it passes through lymph nodes.
- Particulate matters may include bacteria, dead and live phagocytes containing ingested microbes, cells from malignant tumors, worn out and damaged tissue cells and inhaled particles.
- Organic material is destroyed in lymph nodes by macrophages and antibodies.
- Some inorganic inhaled particles cannot be destroyed by phagocytosis.
- These stay inside the macrophages, either causing no damage or killing the cell.

- Material not filtered out and dealt with in one lymph node passes on to successive nodes and by the time lymph enters the blood it has usually been cleared of foreign matter and cell debris.
- In some cases where phagocytosis of bacteria is incomplete, they may stimulate inflammation and enlargement of node (lymphadenopathy).

Proliferation of lymphocytes

- In lymph nodes, activated T and B lymphocytes multiply.
- Antibodies produced by sensitized B-lymphocytes enter lymph and blood draining the node.

4. LYMPHOID ORGANS

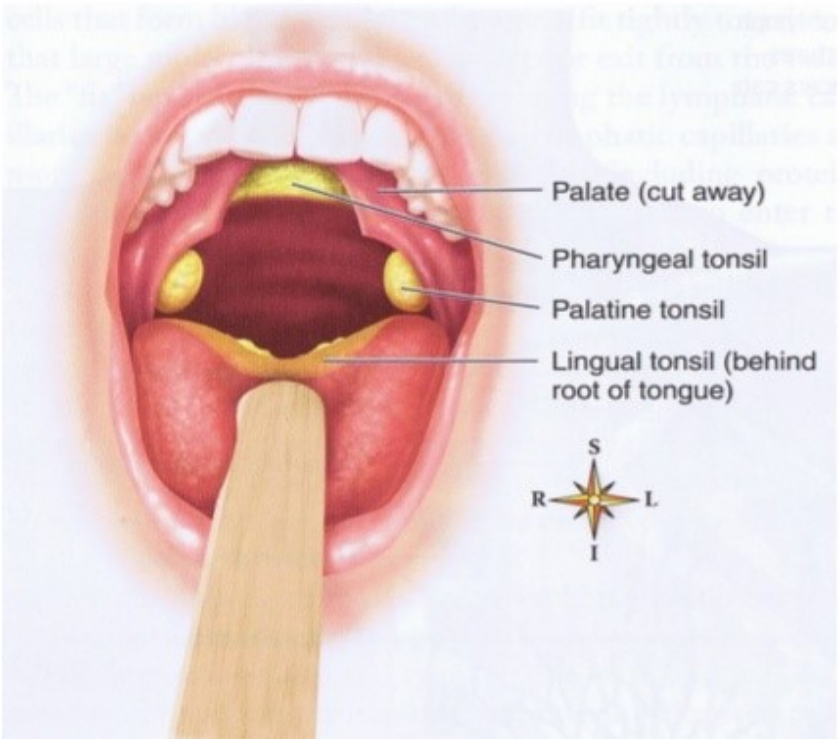
Tonsil

- Tonsil are lymphoid tissue around the pharynx but unlike lymph node they don't have fibrous capsule, cortex and medulla.
- There are three types of tonsils:

  Pharyngeal tonsil —> upper posterior wall of pharynx behind nose

  Palatine tonsil —-> on the side of the soft palate

  Lingual tonsil —-> at the base of the tongue
- Tonsil prevents microorganisms by destroying invading microorganisms.



Lymphoid Organs - Tonsils

- protect against bacteria which may invade tissues in the nasal and oral cavity
- Pharyngeal tonsils are called adenoid when they become swollen.

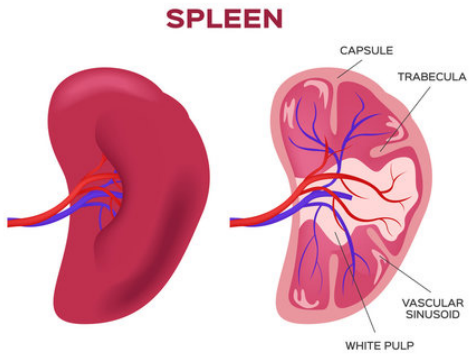
Spleen

1. Spleen is the largest lymphoid organ and contains reticular and lymphatic tissues.
2. The spleen is located in the left hypochondriac region of the abdominal cavity.
3. It lies between the fundus of the stomach and the diaphragm.
4. It is purplish in color and varies in size in different individuals, but it is usually about 12 cm long, 7 cm wide and 2.5 cm thick.
5. It weighs about 200gm.
6. The spleen is more or less oval in shape with the hilum on the lower medial border.
7. The anterior surface is covered with peritoneum.
8. A fibroelastic capsule encloses spleen that dips into the organ, forming trabeculae.
9. Splenic pulp is the term for the cellular material consisting of lymphocytes and macrophages.
10. Red pulp is the part suffused with blood and white pulp consists of areas of lymphatic tissues where there are sleeves of lymphocyte and macrophages around blood vessels.
11. The structures entering and leaving the spleen at hilum are:

    Splenic artery: a branch of coeliac artery

    Splenic vein: a branch of portal vein

    Lymph vessels: (efferent only)



Functions of spleen

Phagocytosis

- In the spleen, old and abnormal erythrocytes are mainly destroyed.
- The breakdown products, bilirubin and iron are transported to the liver via the splenic and portal veins.
- Other cellular materials e.g. leukocytes, platelets and bacteria are phagocytosed in the spleen.

- Unlike lymph nodes, the spleen lacks afferent lymphatics entering it.
- So, it is not exposed to disease spread by lymph.

Storage of blood:

- Spleen contains upto 350ml of blood and in response to symphatetic stimulation can rapidly return most of the volume to the circulation in hemorrhage.

Immune response:

- The spleen contains T and B-lymphocytes, which are activated by the presence of antigens. E.g. in infection.
- Proliferation of lymphocytes during serious infection can result in enlargement of the spleen.

Erythropoiesis:

- The spleen and liver are essential sites of fetal blood cell production.
- The spleen can also fulfil this function in adults in times of much need.

Thymus gland

1. The thymus is pinkish grey ductless gland lies in the upper part of the mediastinum behind the sternum and extends upwards into the root of the neck.
2. It weighs about 10-15gm at birth and grows until puberty when it begins to atrophy.
3. Its maximum weight, at puberty, is between 30 and 40 gm and by the middle age it has returned to approximately its weight at birth.
4. The thymus consists of two lobes joined by areolar tissue.
5. A fibrous capsule encloses the lobes which dip into their substance, dividing them into lobules that consist of an irregular branching framework of epithelial cells and lymphocytes.

Functions of thymus gland

1. Lymphocytes originate from stem cells in red bone marrow.
2. Those that enter the thymus develop into activated T-lymphocytes.
3. Thymic processing produces mature T-lymphocyte that can differentiate self tissue from foreign tissue.
4. These mature T- lymphocytes also provides each T-lymphocyte with the ability to react to only one specific Ag from the millions it will encounter.
5. T-lymphocytes then leave the thymus and enter the blood.
6. Some enter lymphoid tissues and other circulate in the bloodstream.
7. Although T-lymphocyte production is most prolific in youth, it probably continues throughout life from a resident population of thymic stem cells.
8. The maturation of thymus and other lymphoid tissue is stimulated by thymosin, a hormone secreted by the epithelial cell of thymus.
9. Shrinkage of gland begins in adolescence, so the effectiveness of the T-lymphocytes response to Ag declines.