

The Lymphatic System

CHAPTER OUTLINE

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|---|---|
| ■ Introduction | ■ Lymph Nodes |
| ■ Lymph | ■ Organs of the Lymphatic System |
| ■ Lymphatic vessels and Lymph Circulation | ■ Diseases Associated with the Lymphatic System |

STUDY OBJECTIVES

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|--|---|
| ✓ To explain the components and major functions of the lymphatic system. | ✓ To discuss the formation and flow of lymph. |
| ✓ To describe the organization of lymph vessels. | ✓ To describe the lymph nodes and various organs of the lymphatic system. |

INTRODUCTION

The lymphatic system is closely related to the cardiovascular system as both the cardiovascular system and the lymphatic system comprise a network of vessels that transport body fluids throughout the body.

The lymphatic system is a closed system of lymph vessels that transports the lymph and helps defend the body against disease-causing agents.

The study of the lymphatic system is called *lymphatology*.

The lymphatic system consists of a fluid called *lymph*, vessels that transport the lymph called *lymphatic vessels* and lymphatic tissue that includes lymph nodes and nodules and lymph organs (e.g. the spleen and thymus gland) (Fig. 8.1).

FUNCTIONS OF THE LYMPHATIC SYSTEM

1. **Drainage of excess interstitial fluid:** Lymphatic vessels maintain the fluid balance in the body by draining the excess interstitial fluid from tissue spaces and returning the fluid to the blood. The lymphatic vessels serve an important role of returning the lost plasma to the blood without which the body would die within about 24 h.

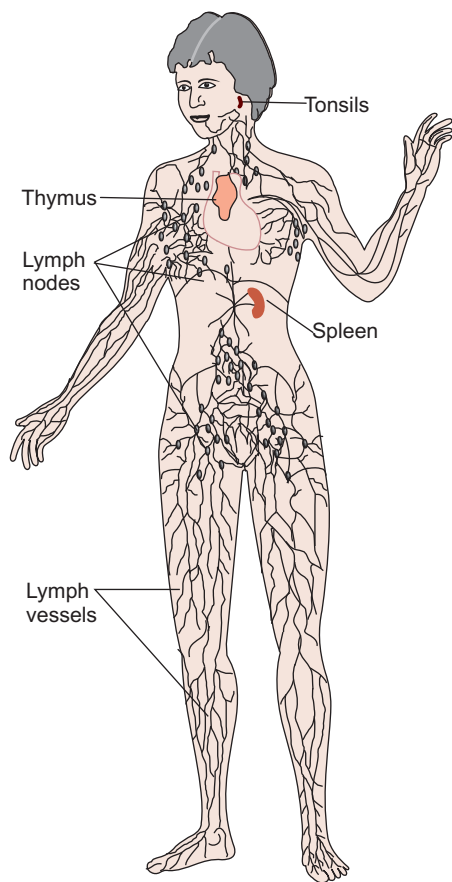


Figure 8.1 Overview of the lymphatic system.



DO YOU KNOW

- ❑ The lymphatic system returns about 3 L of fluid each day from the tissues to the circulatory system.
- ❑ On an average, at any time about 1–2 L of lymph fluid circulates in the lymphatics and body tissues.
- ❑ The lymphatic system is body's sewer, the network of pipes that drains waste from the cells.
- ❑ The lymph nodes in neck, groin or underarm may swell in cold or any other infection as lymphocytes fight germs.
- ❑ Body contains over 600 lymph nodes.
- ❑ When this system is blocked, the human body becomes defenceless against attacks by viruses, bacteria and fungi.

2. **Transport of dietary fats:** The lymphatic vessels transport fats and fat-soluble vitamins (vitamin A, D, E and K) from the gastrointestinal tract to the blood.
3. **Immunity:** The organs of the lymphatic system are involved in the production and maturation of lymphocytes (white blood cells), which help defend the body against microorganisms, foreign substances and abnormal (tumour) cells.

LYMPH

- ❑ Lymph is a fluid connective tissue consisting of plasma and blood corpuscles.
- ❑ Lymph is a clear or slightly opalescent, colourless alkaline fluid as it lacks haemoglobin containing erythrocytes. It contains proteins and fats and white blood corpuscles, especially lymphocytes, fibrinogen, nutrients, hormones, excretory materials and some blood proteins. Red blood corpuscles are absent in lymph.
- ❑ Lymphatic fluid in the intestine (called *chyle*) is milky white in colour as it contains fat.

MEDICAL TERMINOLOGY

- ❑ **Interstitial fluid:** Fluid bathing the intercellular spaces between cells and through which material is exchanged between the blood and the cells.
- ❑ **Lymphatic tissue:** Connective tissue containing lymphocytes.
- ❑ **Osmotic Pressure:** The pressure exerted by the flow of water through a semipermeable membrane separating two solutions with different concentrations.

COMPOSITION OF LYMPH

Lymph consists of 91% water and 9% solid substances. The solid substances present in the lymph have been summarized in the Table 8.1.

Table 8.1 Composition of lymph

Proteins	2–6%	Albumin, globulin, prothrombin, clotting factors, fibrinogen, antibodies and enzymes
Lipids	5–15%	In the form of chylomicrons and lipoproteins
Carbohydrates	120 mg%	Glucose
Amino acids		All amino acids of plasma
Non-protein nitrogenous	34 mg%	Urea, creatinine
Electrolytes		K, Na, Ca, Cl and bicarbonates
Cellular contents		Macrophages, monocytes, lymphocytes

FORMATION OF LYMPH

The blood pressure in the capillaries network forces some of the plasma to move out of the capillaries into the spaces between the tissue cells. When this plasma enters the space between tissue cells, it gets another name and is called *interstitial fluid*. Most of this fluid gets reabsorbed into the capillary due

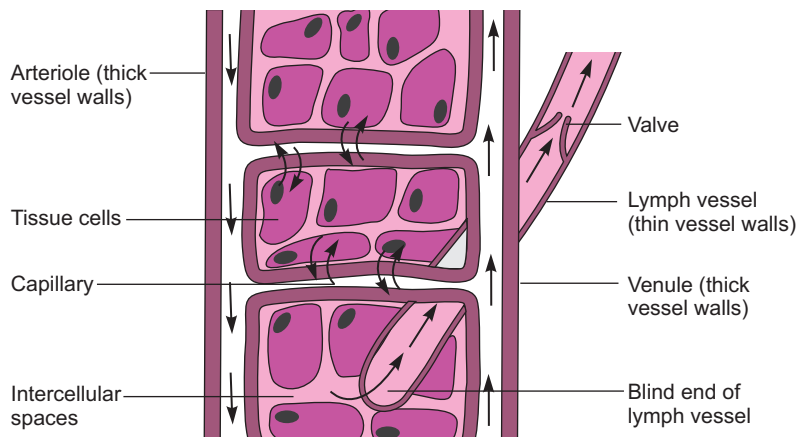


Figure 8.2 Schematic diagram showing lymph formation.

to the difference in osmotic pressure. However, some of the interstitial fluid left in the tissue spaces must be drained to prevent the tissues from swelling or oedema. The lymphatic capillaries drain this interstitial fluid into the lymph capillaries and after which this fluid is called *lymph* (Fig. 8.2).

Some of the proteins that leave blood plasma cannot return to blood by diffusion because of the concentration gradient (there are more proteins inside blood capillaries compared to the lesser level outside). The proteins can, however, move readily through the more permeable lymphatic capillaries into lymph.

In the small intestine, there are special lymphatic vessels called *lacteals* that absorb fats and then transport fats from the gastrointestinal tract to the blood. The presence of these fats gives the lymph a creamy-white appearance and such lymph is referred to as *chyle*.

LYMPHATIC VESSELS AND LYMPH CIRCULATION

LYMPH CAPILLARIES

Lymphatic vessels begin as lymph capillaries in the spaces between cells in most of the body parts except in the central nervous system, bones and most superficial layers of the skin.

These lymph capillaries are tiny, closed-ended tubes and occur singly or in the extensive plexuses. They have the same structure as the capillaries, that is, a single layer of endothelial cells but have thinner walls, which make them more permeable than blood capillaries. The lymph capillaries are interwoven with the blood capillaries and are much larger and also have a large number of valves, which ensure the unidirectional flow of lymph (Fig. 8.3a).

The endothelial cells of lymph capillaries are attached to the surrounding tissues by an *anchoring filament* made of elastic fibres. The ends of these endothelial cells overlap, resulting in a unique one-way structure that permits the interstitial fluid to flow into endothelial cells but not out (Fig. 8.3b).

LYMPHATIC VESSELS

Similar to blood capillaries converging to form venules and then veins, the lymphatic capillaries join to form larger lymphatic vessels called *lymphatics*.

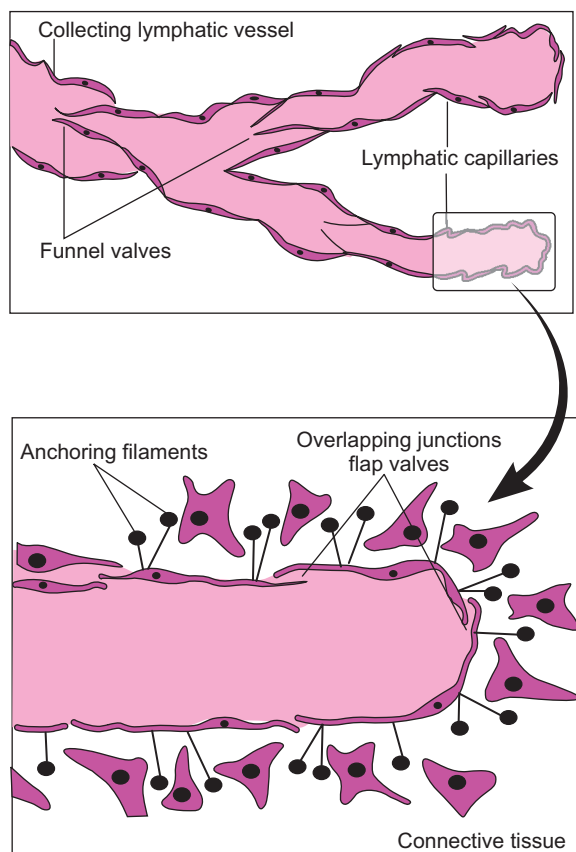


Figure 8.3 (a) Lymph capillaries; (b) Lymph valves.

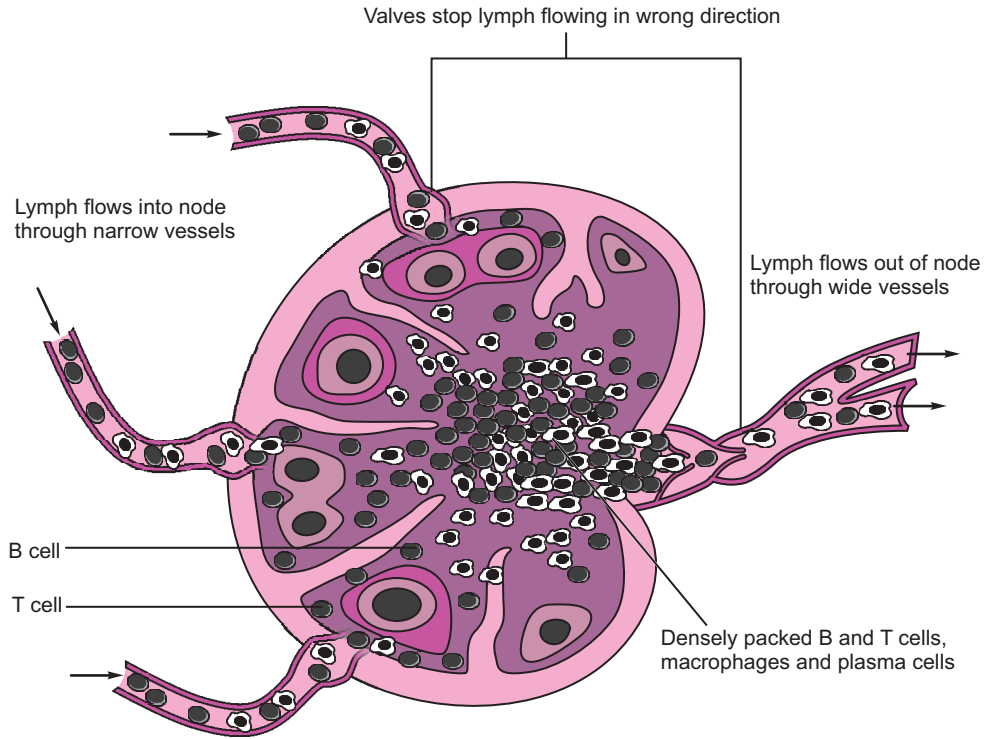


Figure 8.4 Lymph flow through lymph nodes.

The lymphatic vessels resemble veins in structure but have thinner walls and more numerous valves to prevent backflow. At intervals along the length of lymphatic vessels, lymph flows through *lymph nodes*, which are specialized lymphatic tissues consisting of masses of B cells and T cells (Fig. 8.4).

LYMPHATIC TRUNK

As lymphatic vessels leave the lymph node, they unite to form *lymphatic trunks* (Fig. 8.5).

The principal lymphatic trunks of the body are as follows:

1. **Lumbar trunk:** It drains lymph from the lower limbs, viscera of pelvis, kidney, adrenal glands and the abdominal wall.
2. **Intestinal trunk:** It drains lymph from the stomach, intestine, pancreas, spleen and parts of the liver.
3. **Bronchomediastinal trunk:** It drains lymph from the thorax, lungs and heart.
4. **Subclavian trunk:** It drains lymph from the upper limbs.
5. **Jugular trunk:** It drains lymph from the head and neck.
6. **Intercostal trunk:** It drains lymph from portions of the thorax.

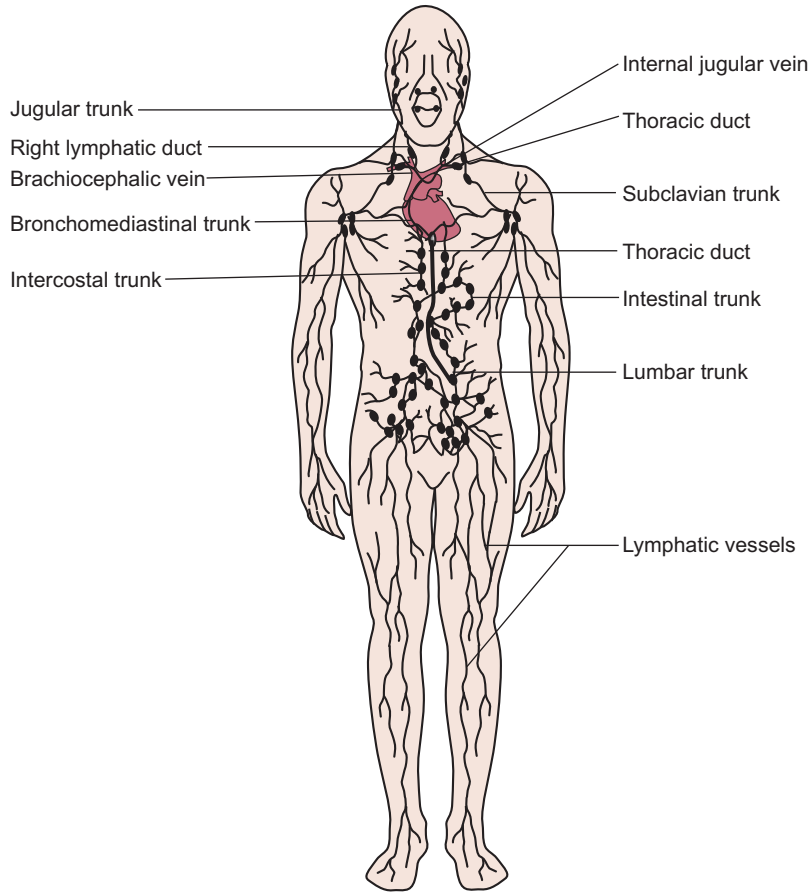


Figure 8.5 Lymphatic trunks.

LYMPHATIC DUCTS

The principal lymphatic trunks then pass their lymph into two main ducts: the *thoracic duct* (also known as the *left lymphatic duct*) and the *right lymphatic duct*.

The thoracic duct is about 40 cm long and begins as a dilation called *cistern chyli* anterior to the second lumbar vertebra. The thoracic duct receives lymph from all parts of the body inferior to the ribs and on the left side of the body (left upper limbs and left side of the head, neck and chest) and empties into the left subclavian vein.

The lymphatic vessels of the intestine (lacteals) appear milky white and empty chyle (absorbed fats) into the thoracic duct.

The right lymphatic duct is about 1 cm long and receives lymph from the upper right side of the body (right head and neck, right area of the thorax) and empties the lymph into the right subclavian veins (Fig. 8.6).

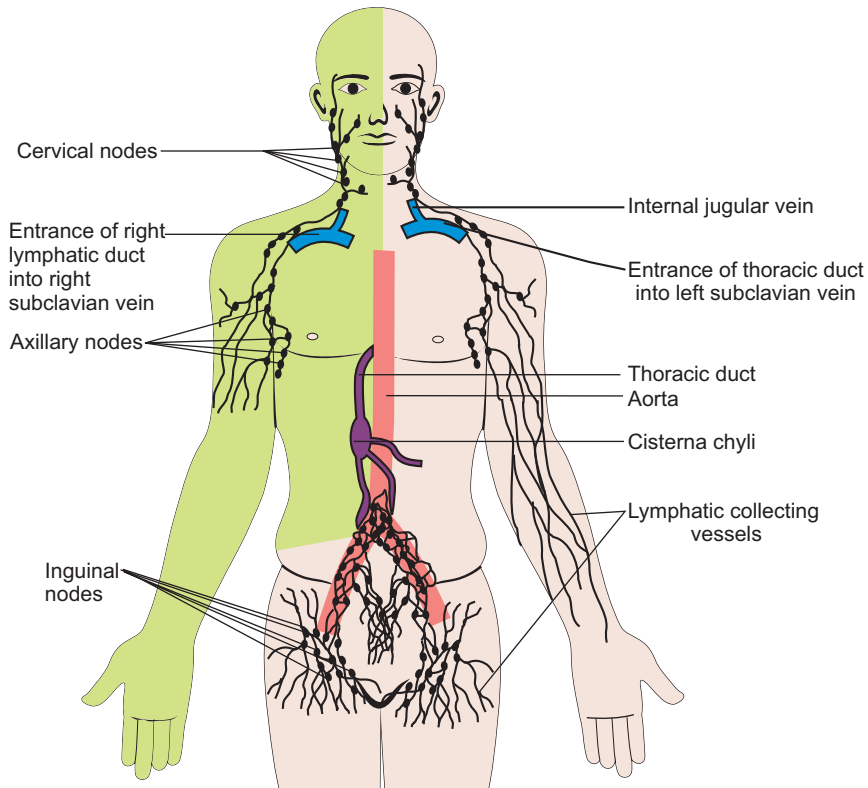
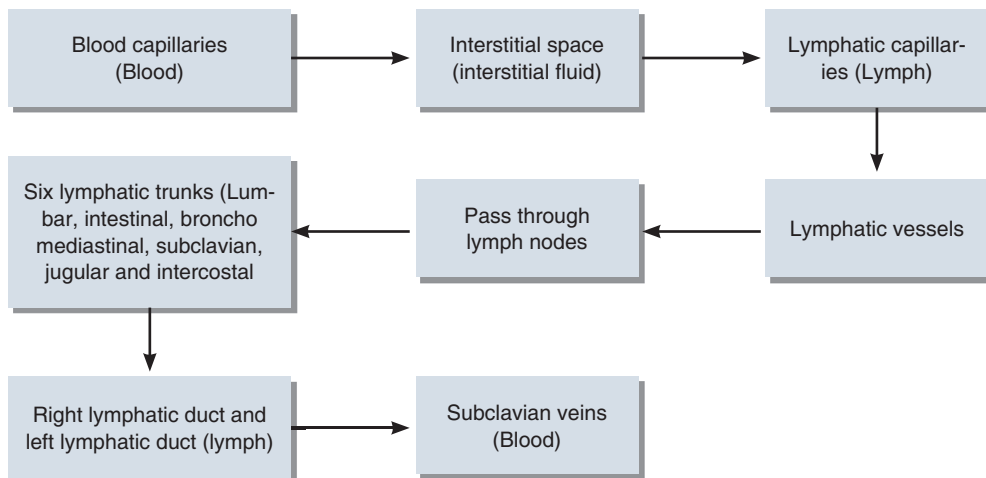


Figure 8.6 Lymphatic ducts.

The lymph circulation can be summarized by the following flowchart:



The lymph is formed from the blood plasma that diffuses out of the blood capillaries; after circulation, the lymph is eventually drained back to the blood stream and the cycle repeats itself. This circulation is continuously repeated and serves an important role to maintain the proper levels of lymph, plasma and the interstitial fluid in the body (Fig. 8.7).

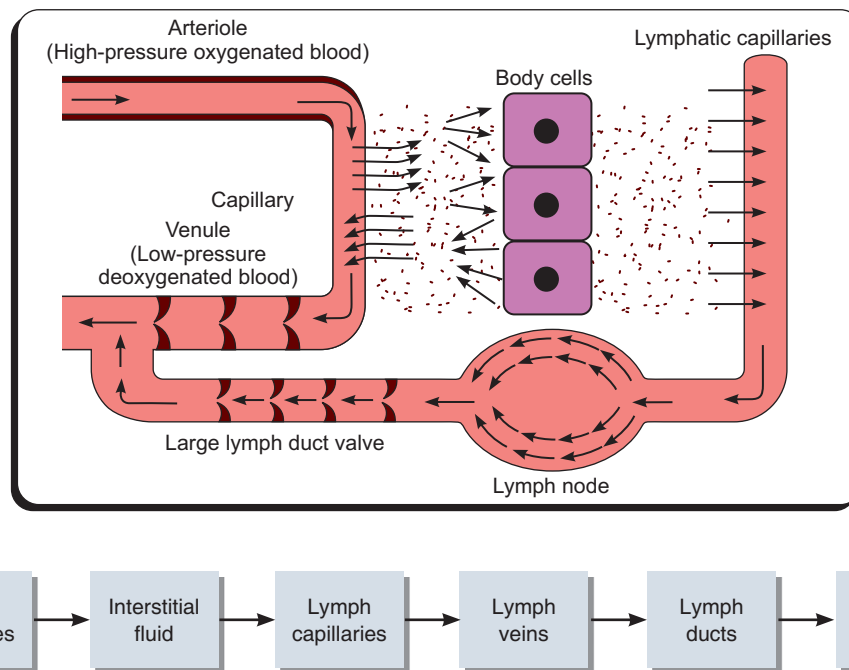


Figure 8.7 Schematic diagram depicting lymph circulation.

FLOW OF LYMPH

The lymph flows in lymphatic vessels very slowly, at the rate of 1–1.5 mL/min. Although there is no pump like the heart involved in the onward movement of lymph, the circulation of lymph is maintained by the following factors:

1. **Contraction of skeletal muscles:** Skeletal muscle contraction compresses the lymphatic vessels, which pushes the lymph in only one direction, that is, towards the subclavian veins due to the presence of valves that prevent backflow.
2. **Respiration or breathing movements:** Inhalation and exhalation causes pressure changes in the thorax, facilitating lymph movement.
3. **Contraction of smooth muscles in lymphatic vessels:** The contraction of smooth muscles pushes the lymph forward.
4. **Gravity:** It helps in moving the lymph down the lymphatic vessels of the head and the neck.

If the lymphatic vessels get blocked due to any obstruction, excessive amount of interstitial fluid develops in the tissue spaces, which might cause oedema or swelling.

LYMPH NODES

Lymph nodes are 1–25 mm long, oval- to bean-shaped structures found along the length of lymphatic vessels. They are also known as *lymph glands* or *lymphatic nodes*. They are scattered throughout the body, whereas large groups of lymph nodes are aggregated in the groin, armpits and neck (Fig. 8.8).

STRUCTURE OF THE LYMPH NODE

Each lymph node comprises of masses of lymphatic tissue covered by a capsule of fibrous connective tissue. The capsular extensions, called *trabeculae*, divide the lymph node internally into various compartments.

Lymph enters the lymph node through four or five afferent lymphatic vessels, whereas only one efferent vessel carries lymph away from the node. Each node has a slight depression on one side, called the *hilum*, where an artery enters and a vein and the efferent lymphatic vessel leaves.

The parenchyma (functional part) of the lymph node is divided into three regions: the cortex, paracortex and medulla (Fig. 8.9).

1. Cortex

- (a) The cortex of the lymph node consists of primary and secondary lymphatic nodules (follicles) that contain aggregates of B lymphocytes and macrophages.
- (b) The primary lymphatic nodule develops first and when some antigens enter the body and reach the lymph node, the B cells recognize them and begins to proliferate. The active proliferation of the cells occurs in a particular area of the nodule called the *germinal centre*. After the proliferation of cells, the primary nodule develops into the secondary lymphatic nodule.

2. Paracortex (or inner cortex)

- (a) The paracortex is present between the cortex and the medulla and does not contain lymphatic nodule.
- (b) It mainly consists of T lymphocytes.

3. Medulla: The medulla contains B lymphocytes, T lymphocytes and macrophages.

The lymph enters the lymph node through four or five afferent lymphatic vessels and flows in only one direction as it circulates through the cortex, paracortex and medulla. From the medulla, lymph leaves the node through one efferent lymphatic vessel. Thus, the lymph node serves as a tank where lymph stagnates for some time due to fewer outgoing and more incoming lymphatic vessels. This stagnancy gives enough time for the proliferation of lymphocytes and macrophages. The macrophages destroy some foreign substances by phagocytosis, whereas lymphocytes destroy by immune responses.

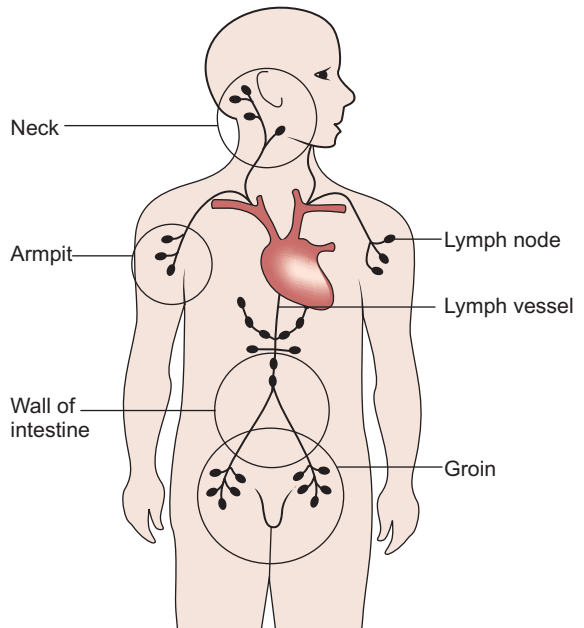


Figure 8.8 Location of aggregated lymph nodes.

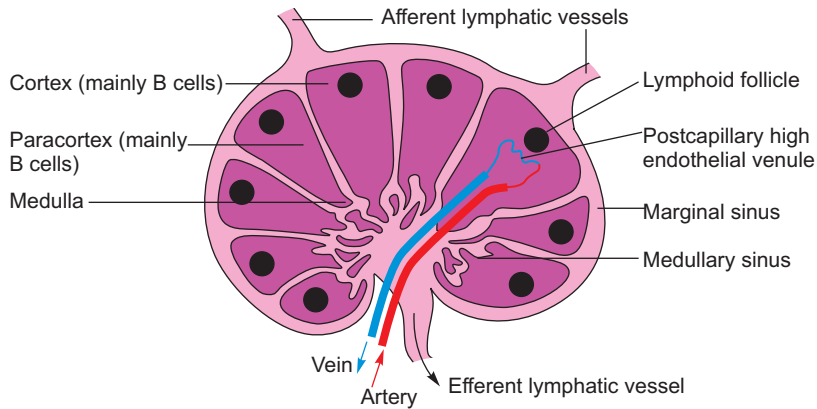


Figure 8.9 Structure of the lymph node.

FUNCTIONS OF THE LYMPH NODES

The lymph nodes perform various functions, which include the following:

1. **Filtration:** Lymph nodes filter the lymph before it is returned to the circulatory system. Macrophages and antibodies in the lymph node destroy the microbes, worn out or damaged tissue cells and cells from malignant tumours (Fig. 8.10). Thus, when the lymph enters blood after passing through successive lymph nodes, it is usually cleared of the foreign matter and cell debris.
2. **Phagocytosis:** The macrophages of the lymph nodes destroy and engulf the microorganisms, cellular debris and other toxic substances present in the lymph.

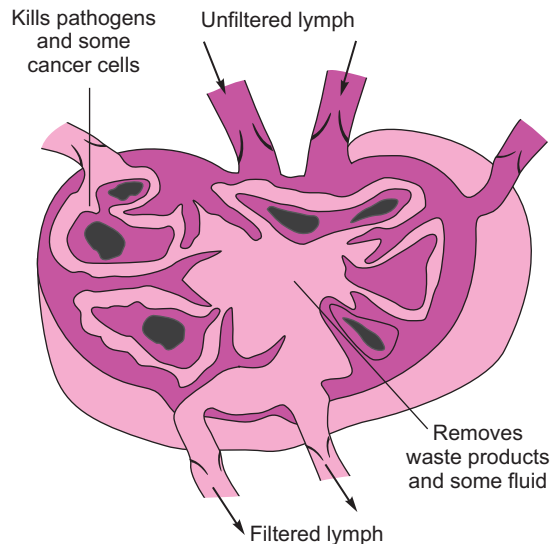


Figure 8.10 Filtration by lymph node.

3. **Destruction of cancer cells:** Lymph nodes can detect and destroy cancer cells. They can also trap cancer cells and slow the spread of cancer until they are overwhelmed of it.

ORGANS OF THE LYMPHATIC SYSTEM

SPLEEN

The spleen is the largest lymphatic organ in the body weighing about 200 g in adults. It is located in the left hypochondrial region of the abdominal cavity between the stomach and the diaphragm. It is purplish in colour and varies in size in different individuals, but is usually about 10 cm long in adults.

Structure of the Spleen

The spleen is slightly oval in shape with the hilum on one side similar to the lymph nodes, through which the splenic artery, splenic vein and efferent lymphatic vessels pass. It is enclosed by a capsule of fibrous connective tissue and the capsular extensions called *trabeculae* extend inward and form a network.

The parenchyma (functional part) of the spleen is composed of two different kinds of tissue called *white pulp* and *red pulp*. The red pulp has small patches of white pulp scattered in it (Fig. 8.11).

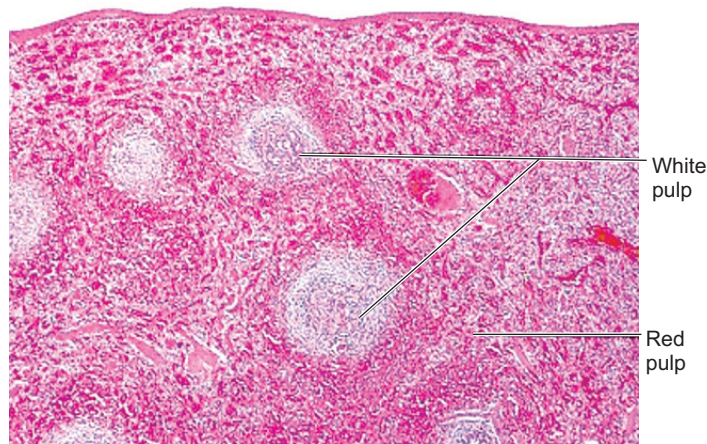


Figure 8.11 White pulp and red pulp in spleen.

The white pulp is lymphatic tissue and consists of splenic corpuscles (or Malpighian corpuscles) present around the branches of the splenic artery called *central arteries*. The splenic corpuscles contain lymphocytes and macrophages. The red pulp is closely associated with the veins and consists of blood-filled venous sinuses and cords of splenic tissue called *splenic cords*. The splenic cords consist of a large quantity of concentrated red blood cells (RBCs), macrophages and lymphocytes (Fig. 8.12).

Note: Unlike the lymph nodes, the spleen does not have afferent lymphatics entering it; hence, it is not exposed to diseases spread by the lymph.

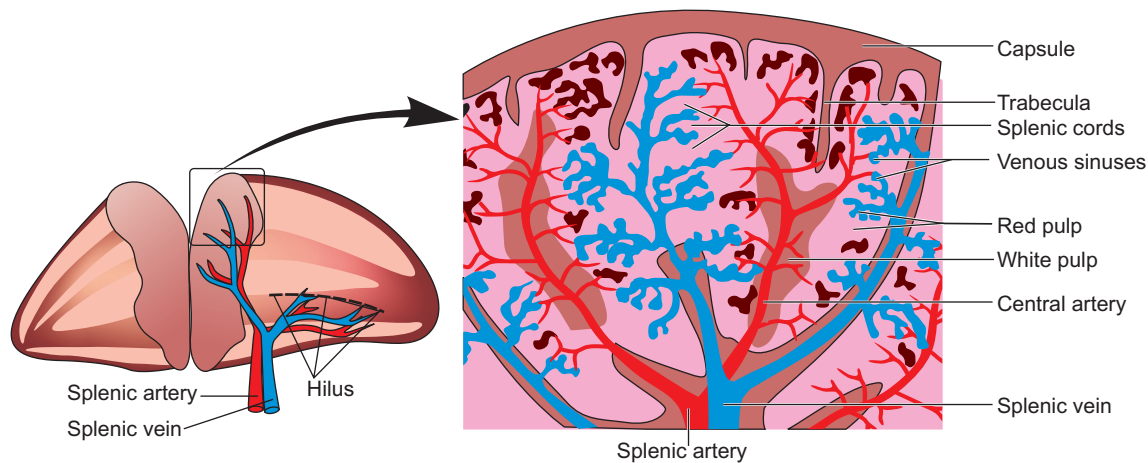


Figure 8.12 Structure of spleen.

Functions of spleen

The various functions of spleen are as follows:

1. **Destruction of worn-out blood cells:** The old and abnormal red blood corpuscles, lymphocytes and thrombocytes are phagocytized by the macrophages present in spleen. When the RBCs become old (120 days), their cell wall becomes fragile and gets damaged while squeezing through capillaries. It mostly occurs in spleen as splenic capillaries have a thin lumen. On this account, spleen is often referred to as the *graveyard of red blood cells*.
2. **Reservoir for RBCs:** In animals, the spleen stores RBCs when the animal is at rest and needs less oxygen. The RBCs are released into the blood stream during times of emergency like hypoxia and haemorrhage. However, this function is not significant in humans.
3. **Storage of iron:** Spleen stores the iron released from the haemoglobin of worn-out RBCs and sends it to the liver for reutilization.
4. **Immune response and defence of body:** The spleen contains T and B lymphocytes, which are activated by the presence of antigens, for example, in infection. The macrophages present in the spleen phagocytize the microorganisms and other foreign bodies.
5. **Erythropoiesis:** The spleen and liver are important sites of fetal blood cells production, and the spleen can perform this function when required.

THYMUS GLAND

The thymus gland is a bilobed organ located in the mediastinum between the sternum and the aorta (Fig. 8.13a). It weighs about 10–15 g at birth and grows until puberty. After puberty, adipose and areolar connective tissues begins to replace the thymic tissue and it begins to atrophy. In older individuals, it becomes very small and may weigh only 3 g.

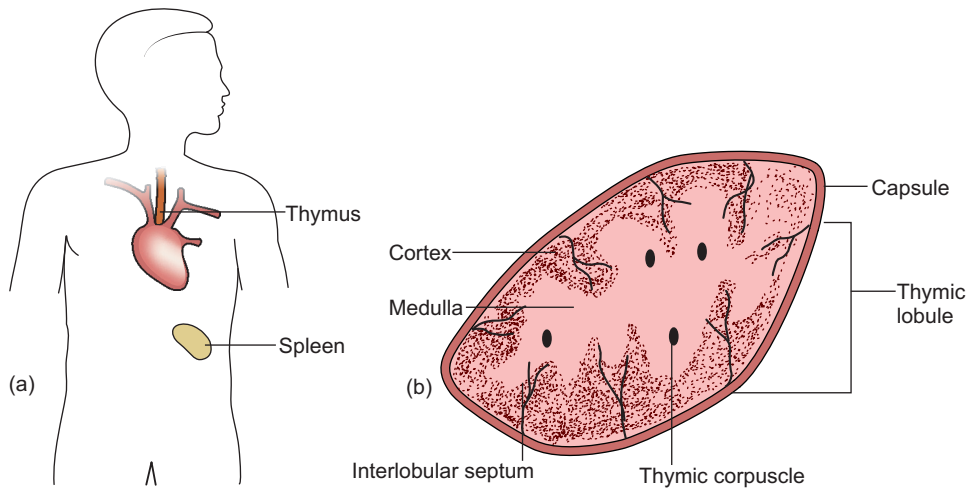


Figure 8.13 (a) Location of thymus; (b) Structure of thymus.

Structure of the thymus gland

The thymus consists of two lobes joined by areolar connective tissue. The lobes are enclosed by a capsule of fibrous connective tissue, and the capsular extensions called *trabeculae* extend inward and divide each lobe into lobules.

Each lobule of the thymus consists of the outer cortex and the inner medulla (Fig. 8.13b). The cortex consists of a large number of T lymphocytes, dendritic cells, epithelial cells and macrophages.

Immature T lymphocytes from the bone marrow migrate to the cortex of thymus where they proliferate and begin to mature. Dendritic cells assist in the maturation of T lymphocytes, and epithelial cells produce the hormones thymopoietin and thymosin, which stimulate their maturation. The macrophages clear out the debris of dead and dying cells. Most of the maturing T cells die in the cortex, whereas the surviving T cells leave the cortex and enter the medulla.

The medulla consists of mature T cells, epithelial cells, dendritic cells and macrophages. The mature T lymphocytes leave the thymus to enter the lymph nodes, spleen or other lymphatic tissues where they colonize parts of these organs and tissues.

Functions of the thymus gland

The various functions of spleen are as follows:

1. **Production of T lymphocytes:** The thymus is the site of production of T lymphocytes in the fetus and in infants for a few months after birth.
2. **Maturation of T lymphocytes:** The thymus gland is responsible for the maturation of T lymphocytes, which protect the body against foreign substances and harmful microorganisms.

3. **Specification of T lymphocytes:** Thymus educates the T lymphocytes in the fetus to distinguish body cells from foreign cells and also provides each T lymphocyte the ability to react to only one specific antigen.

LYMPHATIC NODULE

Lymphatic nodules (follicles) are egg-shaped small masses of lymphoid tissue that are not enclosed by a capsule. They are present throughout the mucous membrane that lines the gastrointestinal, respiratory, urinary and reproductive tract and thus are also referred to as *mucosa-associated lymphatic tissue (MALT)*.

The lymphatic nodules present in large aggregation in specific body parts include the tonsils and Peyer's patches.

Tonsils

Tonsils are the masses of lymphoid tissue present in the pharyngeal region. There are three groups of tonsils (Fig. 8.14):

1. **Pharyngeal or adenoid tonsils:** They are located in the posterior wall of the nasopharynx.
2. **Palatine tonsils:** They are located at the posterior region of the oral cavity, one on either side. These are the ones commonly removed in tonsillectomy (removal of tonsils).
3. **Lingual tonsils:** They are located on the back surface of the base of the tongue.

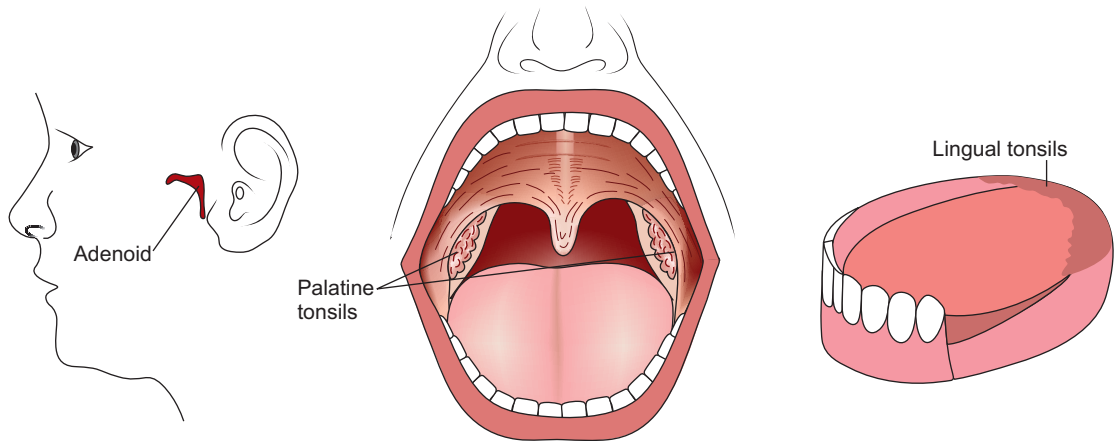


Figure 8.14 Three groups of tonsils: (a) Adenoid; (b) Palatine; (c) Lingual.

Note: These tonsils protect the body against harmful microorganisms that might enter the nose or the oral cavity.

Peyer's patches

Peyer's patches are the aggregated lymphoid tissues located in the wall of the small intestine. They mostly contain macrophages that protect the intestine from bacterial infection.

The lymph nodes and various organs of the lymphatic system can be summarized in Figure 8.15:

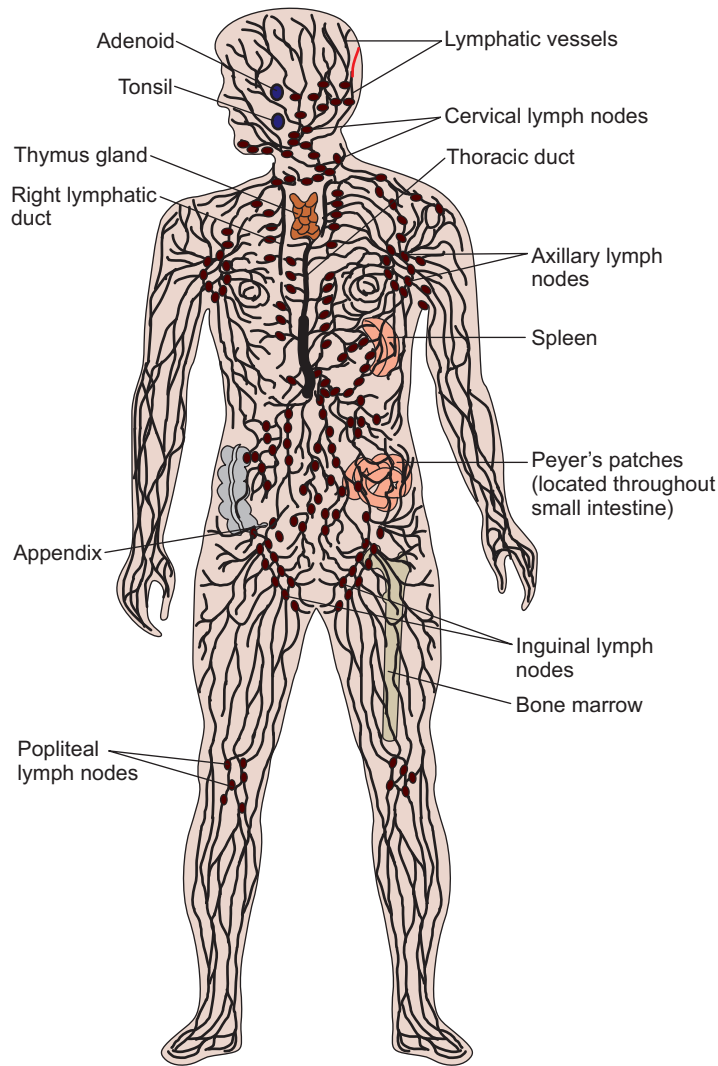


Figure 8.15 Summary of the lymphatic system.

DISORDERS ASSOCIATED WITH THE LYMPHATIC SYSTEM

LYMPHOID LEUKAEMIA

It is a form of cancer characterized by the uncontrolled production of lymphocytes that remain immature. These leukaemic cells eventually appear in such great numbers that they crowd out the normal, functioning cells.

Chemotherapeutic drugs are fairly effective in treating lymphoid leukaemia.

HODGKIN'S LYMPHOMA

It is a malignant disorder of the lymph nodes; there is progressive enlargement of the lymph nodes but the actual cause is unknown. The enlarged lymph nodes may compress the adjacent tissues and organs.

The first symptom is usually a swollen but painless lymph node, often in the neck region. The disease leads to reduced immunity due to depressed lymphocyte function.

This disease is often curable if diagnosed early and treated properly.

LYMPHOEDEMA

It is a kind of oedema developed due to lymphatic obstruction in diseases such as filariasis. The parasitic worm lives in lymphatic vessels and obstructs the drainage of lymph, causing prominent swellings of the legs and scrotum. Severe form of such obstruction may lead to elephantiasis.

ACUTE LYMPHADENITIS

It is the acute infection of lymph nodes caused by microbes reaching via lymph, draining the infected areas of the body. The infection within the lymph nodes attracts a large number of phagocytes, making them inflamed and enlarged.

NON-HODGKIN'S LYMPHOMA

It is more common than Hodgkin's lymphoma. It includes all cancers of lymphoid tissues except Hodgkin's disease.

It is characterized by the presence of uncontrolled multiplication and metastasis of undifferentiated lymphocytes, with swelling of the lymph nodes and spleen. A low-grade type, which affects the elderly, is resistant to chemotherapy and so is often fatal.

SPLENOMEGALY (MEGA: LARGE)

It is characterized by the enlargement of the spleen due to certain pathological conditions. Conditions like inflammatory disorders, liver and blood diseases lead to the accumulation of infectious microorganisms, often causing increased activity of the spleen, which in turn causes spleen enlargement.

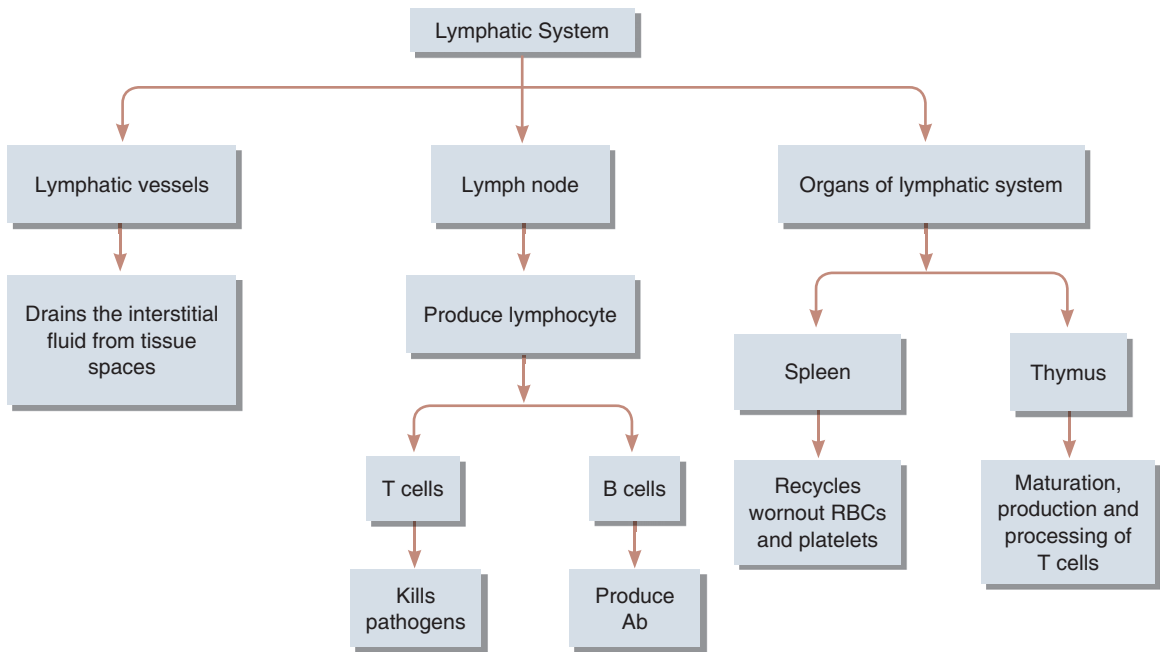
TONSILLITIS

It is characterized by the inflammation of the tonsils, typically due to bacterial infection; they become red, swollen and sore.

BUBONIC PLAGUE

It is also called *black plague* and is a serious disease caused by a bacterium and spreads by fleas from rats or rodents to people. It got its 'black' name from 'buboes,' which are dark swellings found in the groin or armpit of people with plague.

OVERVIEW OF THE LYMPHATIC SYSTEM



Embryonic Development of the Lymphatic System

- ❑ End of 5th week: Marks the beginning of the development of the lymphatic system.
 - Mesoderm forms developing veins → gives rise to lymph sacs → forms lymphatic vessels
 - I Lymph sac: *Jugular lymph sac* → gives rise to lymph capillaries in the thorax, upper limbs, neck and head.
 - II Lymph sac: *Retroperitoneal lymph sac* → forms lymph capillaries in abdominal viscera.
 - III Lymph sac: *Cisterna chyli* → forms thoracic duct and cisterna chyli of thoracic duct.
 - IV Lymph sac: *Posterior lymph sac* → forms lymph vessels in abdominal wall, pelvic region and lower limbs.
- ❑ The mesenchymal cells invade all the lymph sacs except the cistern chyli and convert into groups of lymph nodes.
- ❑ Mesenchymal cells between layers of stomach form spleen.
- ❑ Outgrowth of the 3rd pharyngeal pouch forms the thymus gland.

Ageing and Lymphatic System

- ❑ With age, the thymus gland decreases in size and gets replaced by adipose tissue. The secretion of thymic hormones also decreases, resulting in fewer T cells for responding to infections.
- ❑ As the T cells decrease with age, the B cells also become less responsive. Thus, the elderly are more susceptible to various infections.

Review Questions

Long Answer Questions

1. Explain the relationships among plasma, tissue fluid and lymph. Compare and contrast blood, interstitial fluid and lymph in terms of the movement of water throughout the body.
2. Describe the system of lymph vessels. Explain how lymph is kept moving in these vessels. Into which vein is lymph emptied?
3. State the locations of the major groups of lymph nodes and explain their functions.
4. Describe the location of the spleen and explain its functions.
5. Explain the function of the thymus.
6. Compare the structure and functions of a lymph node with those of the spleen.

Multiple Choice Questions

1. Lymphatic vessels
 - (a) Serve as sites for immune surveillance
 - (b) Filter lymph
 - (c) Transport leaked plasma proteins and fluids to the cardiovascular system
 - (d) Are represented by vessels that resemble arteries, capillaries and veins
2. The saclike initial portion of the thoracic duct is the
 - (a) Lacteal
 - (b) Right lymphatic duct
 - (c) Cisterna chyli
 - (d) Lymph sac
3. Entry of lymph into the lymphatic capillaries is promoted by which of the following?
 - (a) One-way mini valves formed by overlapping endothelial cells
 - (b) The respiratory pump, (c) the skeletal muscle pump
 - (d) Greater fluid pressure in the interstitial space
4. The structural framework of lymphoid organs is
 - (a) Areolar connective tissue
 - (b) Hematopoietic tissue
 - (c) Reticular tissue
 - (d) Adipose tissue
5. Lymph nodes are densely clustered in all of the following body areas except
 - (a) The brain
 - (b) The axillae
 - (c) The groin
 - (d) The cervical region
6. The germinal centres in lymph nodes are largely sites of
 - (a) Macrophages
 - (b) Proliferating B lymphocytes
 - (c) T lymphocytes
 - (d) All of these
7. The red pulp areas of the spleen are sites of
 - (a) Venous sinuses, macrophages and red blood cells
 - (b) Clustered lymphocytes
 - (c) Connective tissue septa
8. The lymphoid organ that functions primarily during youth and then begins to atrophy is the
 - (a) Spleen
 - (b) Thymus
 - (c) Palatine tonsils
 - (d) Bone marrow
9. Which of the following is *not* a major organ of the lymphatic system?
 - (a) Lymph nodes
 - (b) Thymus
 - (c) Kidney
 - (d) Spleen

10. A dilation of the lymphatic duct in the lumbar region that marks the beginning of the thoracic duct is
 - (a) The cisterna chyli
 - (b) The right lymphatic duct
 - (c) The hilum
 - (d) The mesenteric lymph node
11. The spleen does *not*
 - (a) House lymphocytes
 - (b) Filter foreign particles, damaged red blood cells and cellular debris from the blood
 - (c) Contain phagocytes
 - (d) Change undifferentiated lymphocytes into T lymphocytes

Fill in the Blanks

1. Specialized bands of connective tissue, called _____, divide the lymph nodes.
2. Clusters of _____ (Peyer's patches) are associated with the small intestine.
3. The _____ is located in the anterior thorax, near the manubrium of the sternum.
4. _____ is an enzyme in tears, saliva and blood plasma that breaks down bacterial cell walls.

Careers in Lymphatic System

- ✓ Lymphoedema therapists are trained professionals who relieve the swellings caused by blockage of lymph vessels. They use massage therapy, exercises and bandaging to relieve such swellings.
- ✓ Immunologists are physicians who specialize in the body's immune system to counteract any pathological condition.