Q. 4. What is Lymph Gland or Lymph Node ? Describe the structure and functions of Lymph gland.

The lymph node is small, oval or bean-shaped body. It is a collection of lymphoid elements scattered in the submucous tissue of the respiratory passage, intestine and genitourinary tracts. They are particularly well developed in the tonsils which stand as a guard at the entrance of the gastrointestinal tract. These are not well developed in the foetus or in the

germ free animals but take their full form following exposure to antigen. Therefore, these are of great immunological significance.

Gross Structure of Lymph gland : A lymph gland consists of a capsule made up of fibro-fatty tissue, the outer cortical portion and the inner medullary portion.

(a) **Capsule :** It is made of fibrofatty tissue and from the capsular region, the *trabeculae*, a connective tissue extensions protrude centrally. It provides support and a channel along which blood vessels run. Some web-like

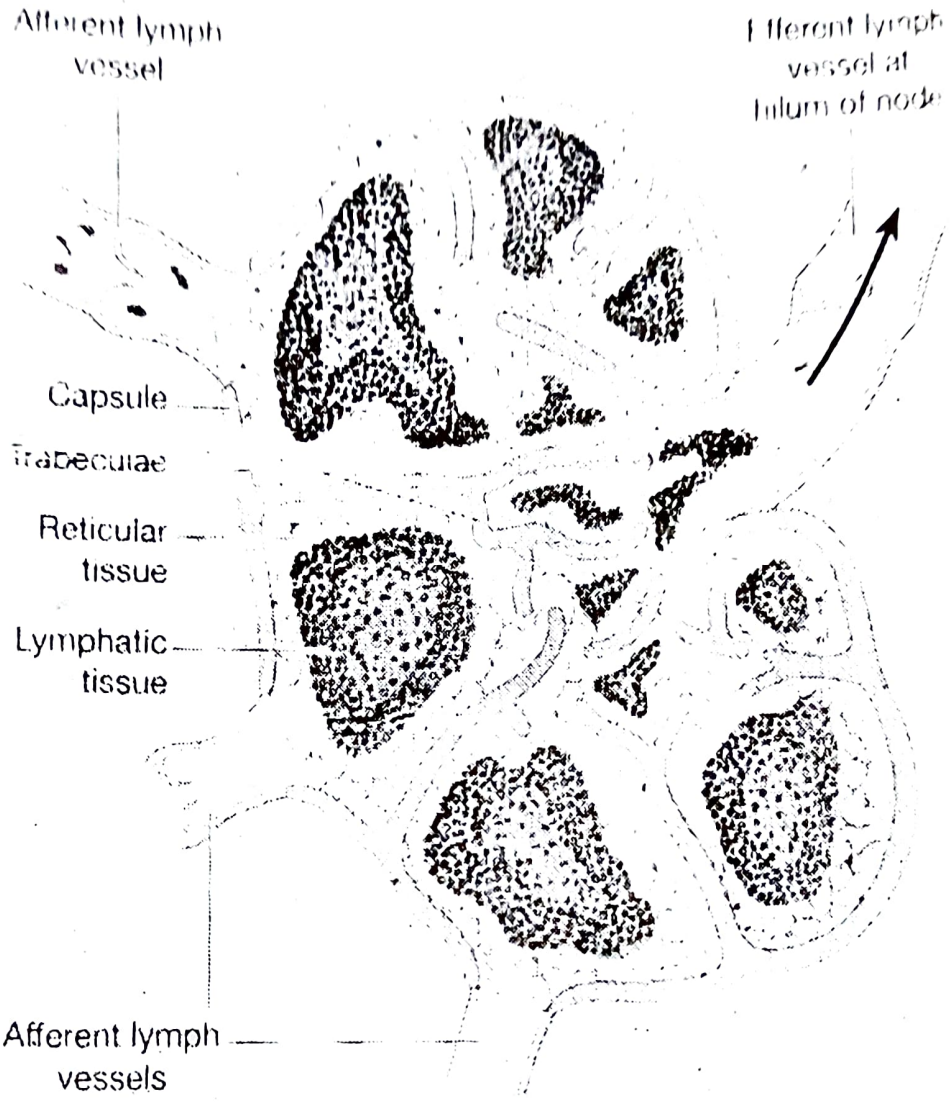

Fig. 47. Disgrammatic Representation of the Structure of a Lymph Node.

structures of reticular fibres containing the phagocytic elements of the macrophage system extend from the trabecular element into the substance of the lymph node. The lymph node has a cortex and a medulla.

(b) Cortex : The lymphoid tissues remain scattered throughout the node but in the cortex they are found in specially collected islands known as *lymphoid nodules* or *follicles* which vary from 0·35 to 1·0 mm. in diameter. These nodules remain arranged parallel to the surface and sometimes consist of two or three layers deep. (1) The periphery of the cortical region of a lymph node contains an organised pattern of lymphoid follicles at the centre of which there is a central arteriole which is surrounded by collections of

actively dividing cells known as *Primary follicle* or *Germinal centre*. Each germinal centre consists of lymphocytes at the centre, lymphocytes at the periphery and the supporting reticulum. This centre is regarded as the area in which new lymphocytes are being formed by active cell division. Numerous macrophages are formed in the germinal centre under certain pathological conditions and for this reason this central zone is known as *reaction centre*. (2) The subcortical or paracortical region contains the postcapillary nodules lined by the characterstic cuboidal types of endothelial cells through which the lymphocytes pass from blood into lymph. This is the mechanism by which the lymphocytes enter the lymph node through both the blood vascular and lymph vascular systems.

(c) Medulla : It is a much less dense than the cortex and is devoid of lymphatic nodules. It consists of scattered lymph cells, different varieties of reticulo-endothelial cells and sometimes a few multinucleated giant cells. The lymph sinuses of the medulla separate the trabeculae and lymph cords. In this region, plasma are believed to be engaged in antibody synthesis. In the central part of medulla, there are medullary cords which are composed of adult lymphocytes and reticulum cells encircled by delicate argyrophilic structure known as *reticulin*.

(d) Hilum : It is a depression situated at one side of the node where the capsule is thickened. Here the cortical part becomes very much thin and the medulla comes to the surface. At the hilum, the node is pierced by three vessels which are an artery, a vein and the efferent lymph channel. The afferent lymph vessels enter the capsule in a scattered distribution and pen-etrate the subcapular sinuses. The efferent vessels leave the node through the hilum.

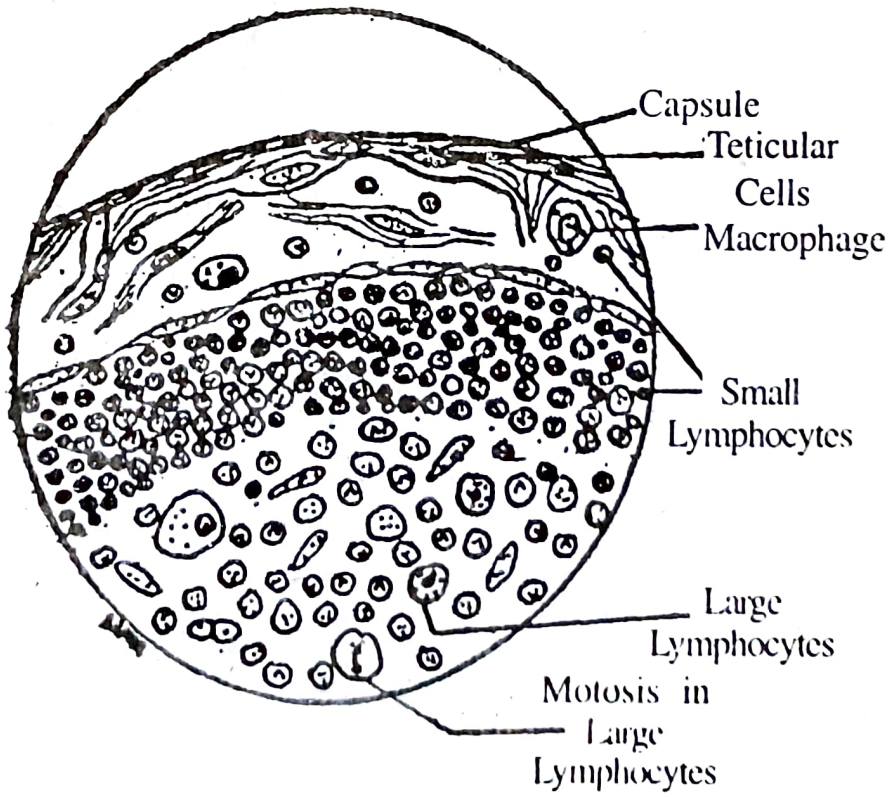

Fig. 48. Histological Structure of Lymph gland.

Histological Structure of Lymph gland :

The histological structure of the lymph gland are : (1) Presence of outer thin fibro elastic connective tissue capsule with trabe-culae extending in- wards through cortex and anastomosing with one another in medulla. (2) Presence of dense lymphoid tissue both in cortical lymph nodules and rounded cords at medulla. (3) Presence of channels of

lymph sinus between fibrous tissue and lymphoid tissue. (4) Presence of radially arranged incomplete septa from capsule with trabeculae.

Functions of Lymph gland : The lymph gland is a manufacturing concern with guards of that concern at the gate. The most important functions are :

(1) *Production of Lymphocytes :* The mature or old lymphocyte cells from the peripheral portion of the lymphoid follicles are added to the blood during recirculation of lymphocytes which is concerned with the development of specific immunologic events involving differentiation of cells as immunocytes, plasma cells, etc. The trabeculae carry blood vessels which supply the lymph node.

(2) *Mechanical Filtration :* The lymph nodes act as mechanical filters to resist the entrance of poisonous substances into circulation. The lymph percolates the filtration of foreign material through the multichannelled structure which removes the particulate matter. The endothelial or littoral cells are particularly involved in the filtering mechanism.

(3) *Screening Mechanism :* They make screening of the lymph by means of phagocytic activity.

(4) *Defensive Mechanism* : They serve as a great defensive role against bacterial infections.

(5) *Barrier of Cancer cells :* They temporarily stop the spread of cancer cells because they penetrate through the lymph vessels to the lymph nodes from where they spread in the body.

(6) *Related to Immunity :* They help in elaboration of antibodies and in the development of immunity.

(7) *Formation of* γ-globulin : Lymph nodes help in the production of γ-globulin.

Q. 6. What is Lymph ? What are the anatomical considerations of Lymphatic System ? Describe the formation, composition, circulation and functions of lymph.

Lymph is the modified tissue fluid, secreted by the lymph glands, carried through lymphatic channels performing nutritive to the extreme part of the extremities of the body where blood connot reach.

Anatomical Considerations of Lymphatic System : The lymphatic channels begin as a closed system to delicate vessels as *lymph capillaries* in the tissue spaces. They unite to form large channels which finally join together to form two

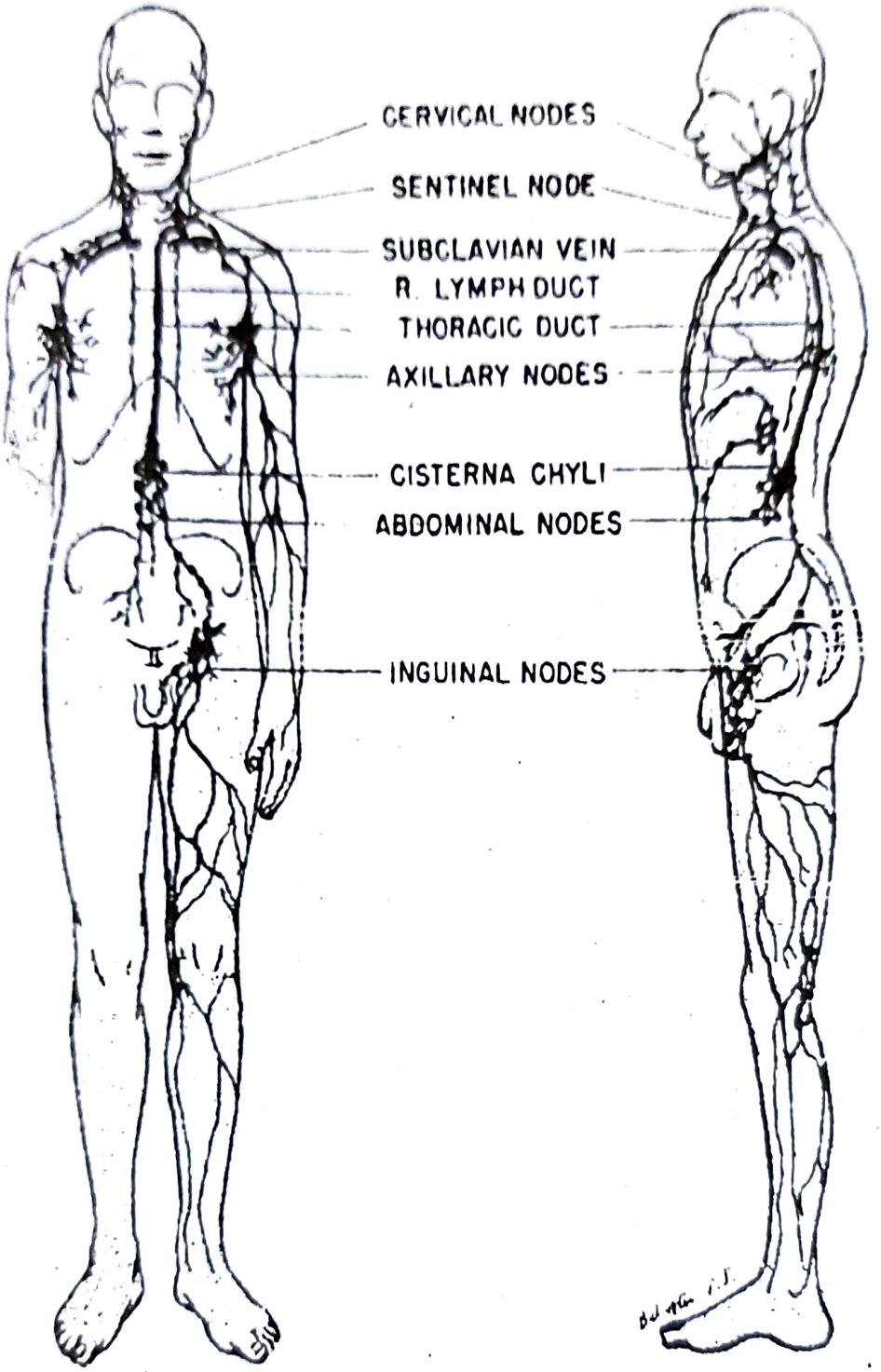

Fig. 52. The lymphatic system

large tributaries -the right lymphatic duct which open respectively at the right and left subclavian veins. Lymph from the right side of the neck and head, right arm, right side of the thorax enters into the junction of right internal jugular vein and right subclavian vien. All the lymph from the lower part of the body passes through the thoracic duct draining at the junction of subclavian and left internal jugular veins. Some of the lymph from the lower extremity can enter the veins in

the inguinal region and also at various portions of the abdomen. Lymph from the left side of the head, left arm and left chest region also enters the thoracic duct before it opens into the veins. The thoracic duct, being about 38 to 45 cm. long and about 4 to 6 m.m. in diameter emerges from the *cisterra chyli* or *recepatculum chyli*. The lymphatics of the gastrointestinal tract passing through the mesentry enters a common reservoir known as cisterna chyli. There are presence of lymph channels practically every part of the body excepting superficial portions of the skin, in the central nervous system, deeper portions of the peripheral nerves, the endomysium of the muscles and the bones. The function of lymphatics is to carry tissue fluid from tissues to veins and the return of water and protein from the interstitial fluids to blood from which they come.

Formation of Lymph : The process of lymph formation is connected with the metabolic interchanges between the blood and the tissues. The lymph is derived from the tissue fluid which exudes from the blood plasma through the capillary wall.

Factors Necessary for Lymph Formation : The factors are :

(a) Increased Capillary Pressure : *Landis* and *Gibbon* found that in man, filtration from the capillaries showed a definite increase when the venous pressure raise above 12 or 15 cm. of water. The filtration from the capillaries was directly proportional to the increase in venous pressure. Increased pressure in the veins of the portal area as may be produced by filtration into the tissues of the abdominal viscera and a great increase in the volume of lymph flowing along the thoracic duct.

(b) Increased Permeability of the Capillary Wall : These are :

(1) Rise in Temperature : It increases capillary permeability, raises the filtration rate and the flow of lymph has been increased.

(2) Capillary Poisons : (i) *Peptone* increases the flow of lymph from the thoracic duct probably as a result of its injurious effect upon the abdominal capillaries. (ii) *Lymphagogues of the first class of Heidenhain* are the extracts of straw berries, crayfish, muscles, leeches, histamins and foreign protein stimulate the quick formation of lymph. (iii) *Reduced oxygen supply* to the tissues act probably through damage to the capillary endothelium.

(c) Lymphagogues of the Second Class : (I) *Hypertonic Solutions :* The intravenous injection of a concentrated solution of glucose, sodium sulphate or sodium chloride causes an increased flow of lymph from the thoracic duct. The hypertonic solution causes an outward flow of lymph and tissue fluid which results in the mechanical removal of the bacteria and their toxins from the tissues bordering the wound. (2) *Isotonic Normal Saline solution :* This injection will also increase the lymph flow since the plasma colloids are diluted and thereby the filtration through the capillary is increased.

(d) Increased Functional Activity : (1) Formation of metabolites which increase the osmotic pressure of the tissue fluids and so attract more fluid from the vessels. (2) Vasodilatation and increased capillary pressure. (3) The

contracting muscles exert a pumping effect upon the lymph, during it along the vessels.

(e) Massage and Passive Movement : It acts to a certain extent like muscular activity. They augment the blood flow and capillary pressure and so increase lymph formation. The manipulations and movements of the muscles serve to propel the lymph along the lymphaticchannels.

Composition of Lymph : The major difference in composition of plasma, interstitial fluid and lymph is in the protein concentration. The protein concentration of plasma is about 7%. In interstitial fluid, it varies from about 0·3% on upto 3%. The concentration of protein in lymph reflects than in the interstitial fluid. Lymph collected from the thoracic duct usually contains about 3% protein.

I. Physical Properties : These are as follows :

(a) Amount : The amount of lymph returning to the blood through the lymphatic in the course of a day is about 1200 to 1600 millilitres. (b) **Colour :** (1) *During fasting :* It is transparent and yellowish in Colour. (2) *After fatty food intake :* It is milky white due to minute droplet of emulsified fat absorbed from alimentary canal. **(c) Colloidal Osmotic Pressure :** It is lower than that of plasma and higher than that of tissue fluid. **(d) Reaction :** It is alkaline is reaction. **(e) Specific gravity :** It is about 1015. **(f) Viscosity :** The viscosity is less because lymph contains less amount of protein than blood plasma.

II. Chemical Composition : It consists of :

A. Water : 94%. **B. Solids :** 6%.

(a) Cellular Part : It includes : (1) Leucocytes—2,000 to 20,000 per cu. mm. of blood. (2) Erythrocytes—3,000 to 13,000 per cu. mm. of blood.

(b) Non-Cellular Part : (1) Proteins—3.32%. Mainly three types of proteins are found in lymph such as albumin, globulin, fibrinogen and traces of prothrombin. (2) Fat—5 to 15% after a meal rich in fatty foods. (3) Carbohydrate—Glucose 132·2 mg% (4) Other Constituents :

(i) Urea—23.5 mg. (ii) Non-protien Nitrogen—34.8 mg. (iii) Crea-tinine—1.4 mg. (iv) Chlorides—718 mg. (v) Total Phosphorous —11.8 mg. (vi) Inorgnic Phosphorous—5.9 mg. (vii) Calcium—9.84 mg.

Circulation of Lymph : The lymph from right forelimb, right head, neck and chest region is drained into the superior vena cava via right lymphatic duct and right subcavian vein. The lymph from hind limbs of right and left side, alimentary canal, abdominal and pelvic region is drained into the thoracic duct via receptaculum chyli. The thoracic duct also receives lymph from left forelimb and left head, neck and chest region. The lymph of the thoracic duct drains into the left subclavian vein then into superior vena cava. All the lymph materials of the superior vena cava are finally drained into the right artrium of the heart.

The circulation of lymph has been maintained by the following factors :

(a) Rate of Flow : The rate of flow along the human thoracic duct is from 1

to 1·5 ml. per minute. *Cain* and his *associates* found an average flow 3·46 ml. per minute in the thoracic duct, of which more than half, about 0·26 ml. was contributed by the lymph vessels of liver. **(b) Pressure Gradient :** Under ordinary conditions the pressure of the thoracic duct content is about 15 cm. of water. The pressure in the peripheral lymph vessels during rest, run from 0 to 6 cm. of water. **(c) Presence of Valves :** The presence of valves in the lymphatic channels help to maintain the flow of lymph in one direction. **(d) Muscular Action :** It may be active or passive which compresses the lymphatic vessels and help to flow the lymph from cisterna chyli to the thoracic duct. **(e) Respiratory Movement :** During inspiration, intra-thoracic pressure falls but intra-abdominal pressure rises which compresses the cisterna chyli and flow the lymph in the thoracic duct has been increased.

Functions of Lymph : Lymph performs a number of vital functions to maintain the constancy of the internal environment of the body such as transport of nutrition, return of excess tissue fluid, drainage of waste products, transport of protein, absorption of fat and remove of certain microbes and foreign elements. The important functions of lymph are as follows :

(1) **Nutritive :** It supplies as a form of oxygen via blood to those part where blood cannot reach. **(2) Drainage :** It drains many excess tissue fluids and the metabolites and thereby constant volume and composition of tissue fluid is maintained. **(3) Absorption of Fat :** Fats from the intestine are absorbed mainly through the lymphatic channel via lacteals. **(4) Defensive Function :** The lymphocytes and monocytes of lymph acts as a defensive cells of the body. Foreign substances, such as bacteria, are engulfed by the polymophonuclear leucocytes and macrophages. These cells are then removed from the lymph by the nodes. In addition, the nodes seem to be responsible for the formation of gamma-globulin and specific antibodies to assist in combating infection. **(5) Transport of Nutrition :** It is an additional route for the transport of tissue fluid. Lymph returns to the blood from the tissue spaces. The tissue fluid participates, in the exchange of nutrients, metabolic products, respiratory gases, inorganic ions, water, secretory products and hormones between the plasma and tissue cells to those parts of tissue cells where blood cannot reach directly. **(6) Removal of Tissue fluid :** One tenth of the tissue fluid is removed through lymph. If there is an obstruction in the lymphatics as in lymphangitis, accumulation of tissue fluid takes place in the tissue space. **(7) Redistribution of body fluids :** The body fluid is transferred from one part of the circulatory system to another through lymph and prevents its stagnation in a particular tissue or organ.

Q. 5. What is Tissue fluid or Interstitial fluid ? Describe its formation, composition, drainage and functions.

Tissue fluid occupies the intercellular spaces of the tissue cells and forms the connecting link in the transport of nutrition, gases and the metabolic end products between blood capillaries, the tissue cells and the lymph. It constitutes the internal environment of the body which surrounds the tissue cells.

Formation of Tissue Fluid : Tissue fluid is formed by exchange of fluid between plasma and tissue spaces. They are produced from two sources like Blood capillaries and Tissue activities.

(a) From Blood Capillaries : Tissue fluid is derived from blood capillaries which depends upon : (i) Capillary permeability. (ii) Difference of pressure between the capillary and tissue fluid. (ii) Difference of colloidal osmotic pressure and tissue fluid.

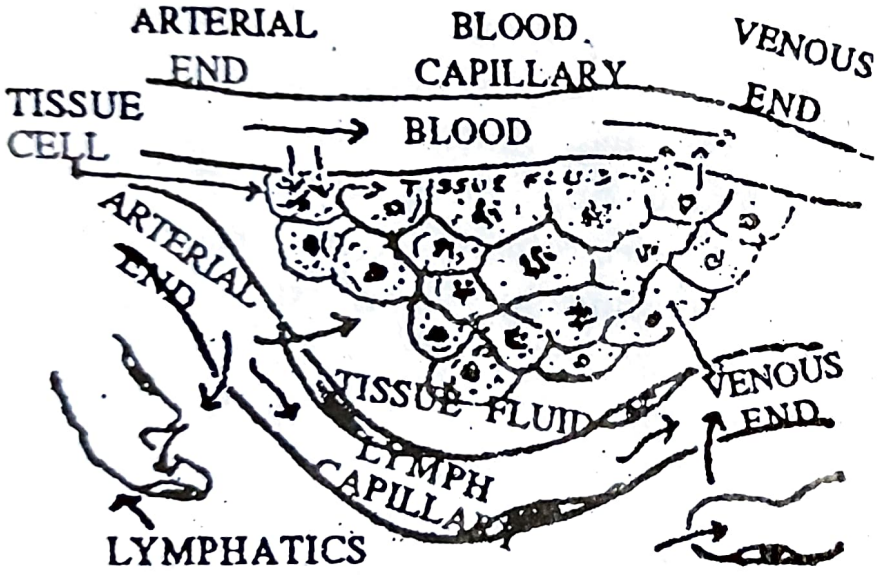

Fig. 51. Schematic Representation of the formation of Tissue fluid between blood and tissue space.

(b) Tissue Activities : (i) During activity, large non-osmotic molecules of the resting organ break down into numerous smaller molecules, which pass into the tissue spaces. These metabolites diffuse slowly into the blood and remain in considerable concentration in the tissue spaces for a long period. Such metabolites as are osmotically active, attract fluid from the blood and retain

it. (ii) The blood-flow through the active organ is very great and so fresh supplies of fluid are constantly available to make up for the fluid lost to the tissues.

Composition of Tissue Fluid : The composition of tissue fluid is same as that of lymph except the protein content is negligible and thereby its colloidal osmotic pressure is very low. The blood and lymph remain on two sides of tissue fluid and try to keep it constant in volume and composition by continuous interchange. The concentration of protein in a tissue fluid is difficult to assess and doubtless from tissue to tissue.

Drainage of Tissue Fluid : The removal of tissue fluid are done by the following means : (1) It is retained in the tissue spaces. (2) It escapes into the lymphatics. This may be the purpose of the lymphatics in the normal body in the absence of infection. (3) In the case of glands, it is mainly poured out in the external secretion. When the tissue comes finally to rest the metabolities either diffuse into the blood or are oxidized, and thus the osmotic pressure of the tissue spaces falls.

Functions of Tissue Fluid : The functions of the tissue fluid are : (1) It constitutes the internal medium in which the tissue cells are bathed and supplies nourishment for them and excretes their metabolites. (2) It acts as a great reservior of water, salts, nutrition for supply to cells and replenishes the depletion of the plasma constituents in times of emergency. (3) It maintains the turgescence of the connective tissue and the skin. (4) Tissue fluid in some places like pericardial fluid, intraocular fluid, cerebrospinal fluid, intrapleural fluid, etc. affords protection and maintains the shape of the structures concerned.

Applied Physiology :

(1) Oedema : The term oedema is applied to an abnormal excessive accumulation of fluid in the intercellular tissue spaces due to a disturbance in the mechanisms of fluid interchange in the body.

(2) Elephantiasis : It is a condition of swelling of the extremities of the body due to the blockage of the lymphatic duct from a limb. There will be high concentration of protein i.e. 2 to 3·5% in the extra-cellular fluid.

(3) Blisters : These are localised swelling over the skin surfaces of the body caused by mustard gas and other vesicants, the protein concentration is very high due to increase permeability of the capillaries to proteins.