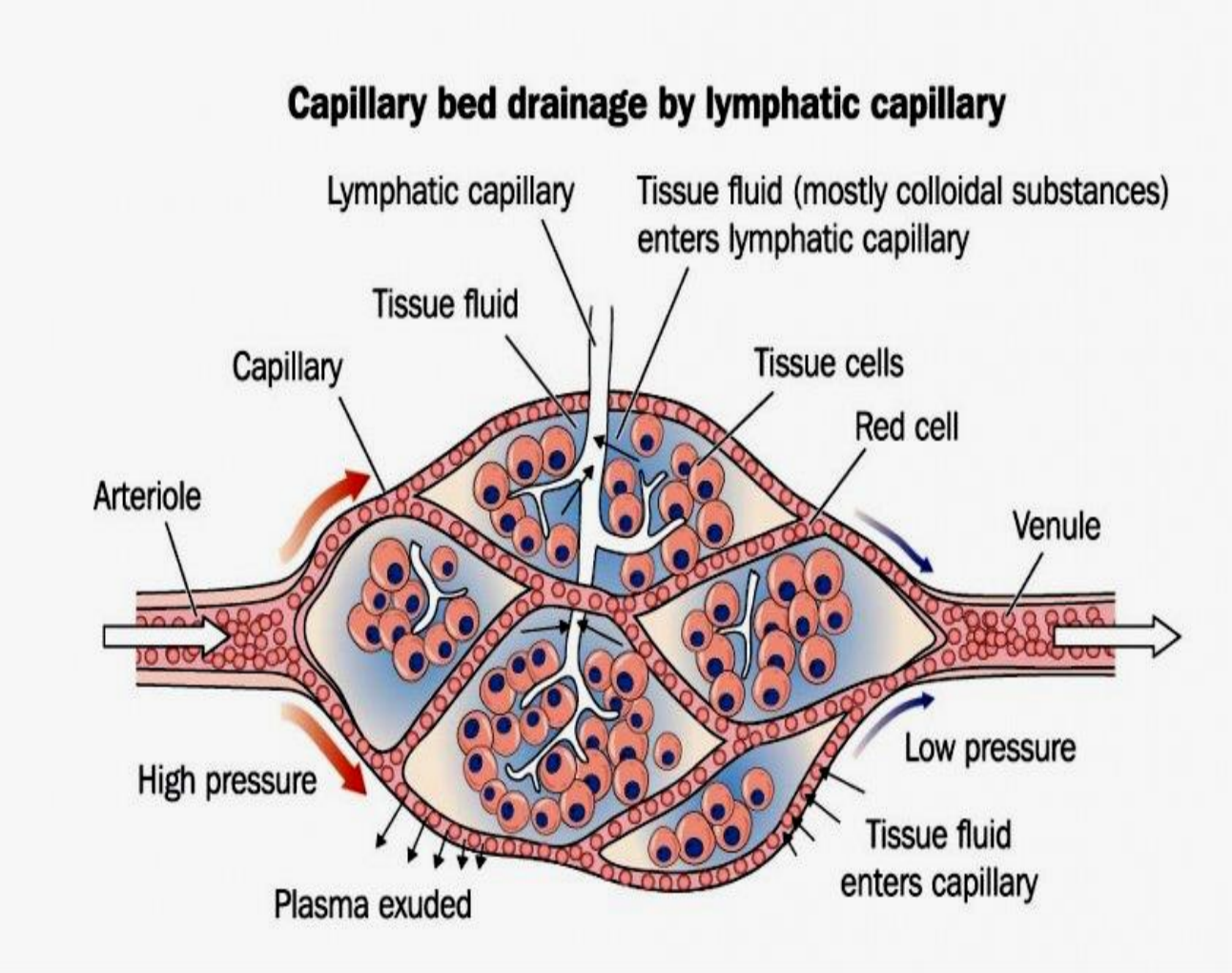
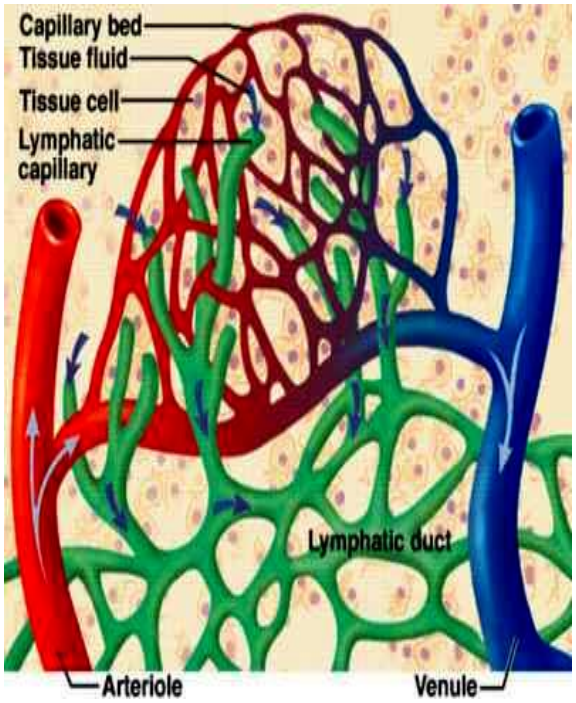
Lymphatic System and Immunity

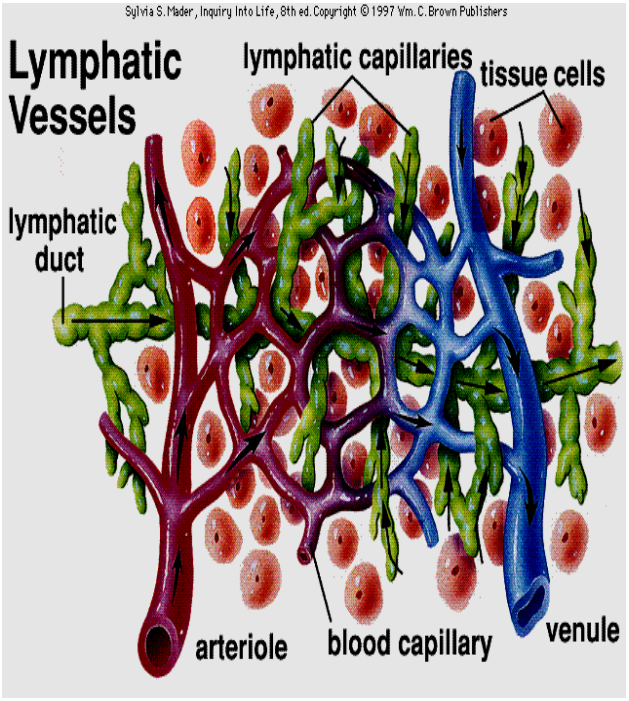
Lymphatic System

Lymphatic System

- High hydrostatic pressure in the arterioles and capillaries at the arterial part of the circulation leads to move plasma fluid from the capillaries to the interstitial tissue. Some of this fluid returns to the bloodstream at the venous site while the remainder returns to the circulation through vessels of a separate system that is called the lymphatic system.
- The fluid that enters the lymphatic vessels is called lymph.
- The lymphatic system is a part of circulatory system. The main function of it is to return fluids escaped from capillaries to the circulation and also play an important role in defense and immunity.







Functions of the Lymphatic System

1. Tissue drainage: every day around 21 liters of fluid of plasma, carrying dissolved substances and some plasma protein escape from the arterial end of the capillaries and into the tissues. Most of this fluid is returned directly to the bloodstream via the capillary at its venous end, but the excess, about 3-4 liters of fluid is drained away by the lymphatic vessels.
2. Returns the excess protein to the circulation.
3. Remove waste products and toxins.
4. Fat absorption: fat and fat soluble materials (e.g. fat soluble vitamin) are absorbed into the central lacteals.
5. Essential to the immune system.

Components of Lymphatic System

I. Lymph

II. Lymph vessels

III. Lymph nodes

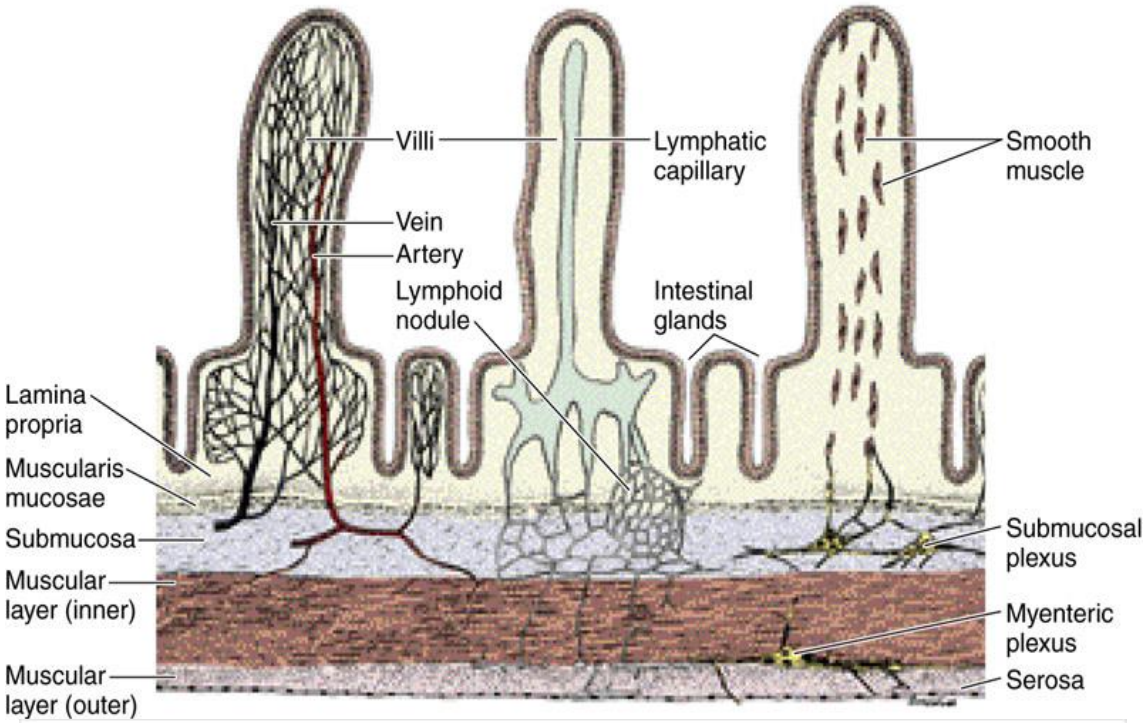
IV. Lymph organs

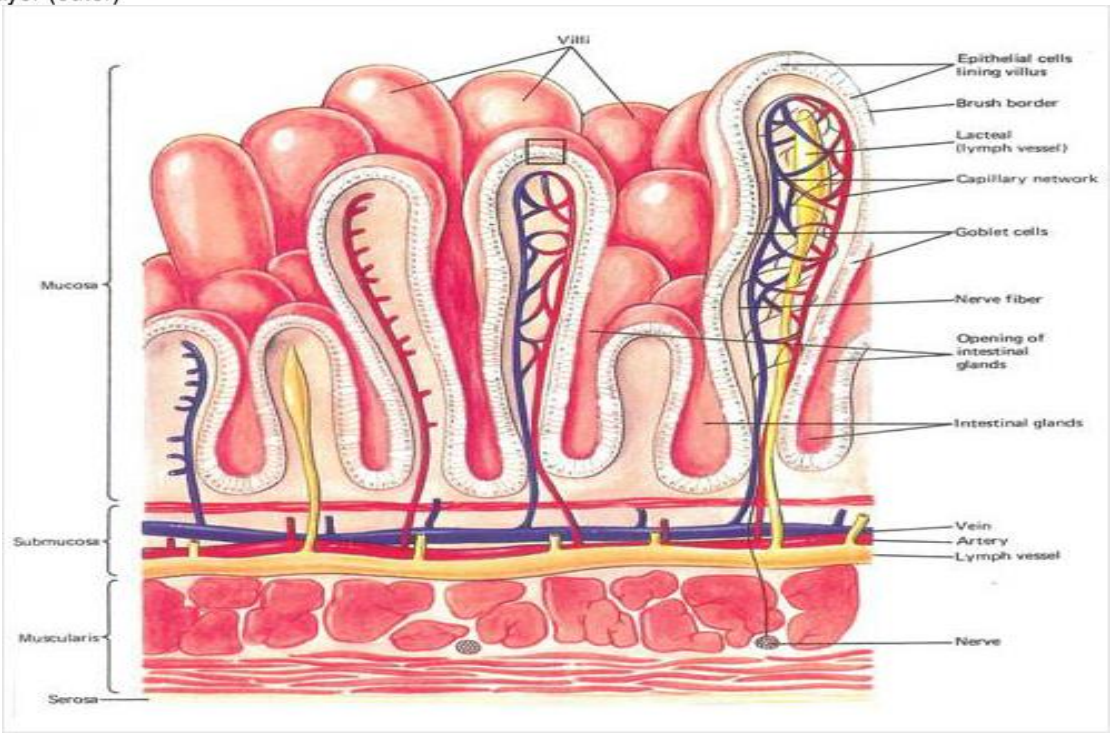
V. Diffuse lymphoid tissue

I. The Lymph

- Lymph is a clear watery fluid, similar in composition to plasma, with exception of plasma proteins (lymph contains small amounts of proteins).
- Lymph contains cells mainly lymphocytes, large molecules of fat (chylomicrons) that are absorbed from the intestines enter lymph vessels.

Blood circulation, lymphatic circulation, and innervation of the small intestine. The smooth muscle system for contracting the villi is illustrated in the villus on the right.





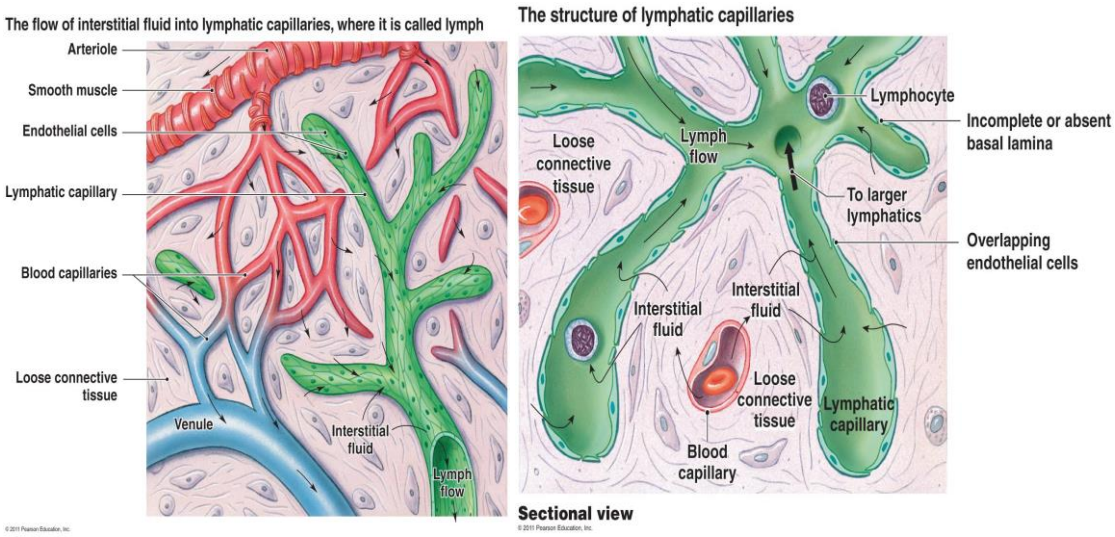
II. Lymph Vessels = Lymphatic Vessels

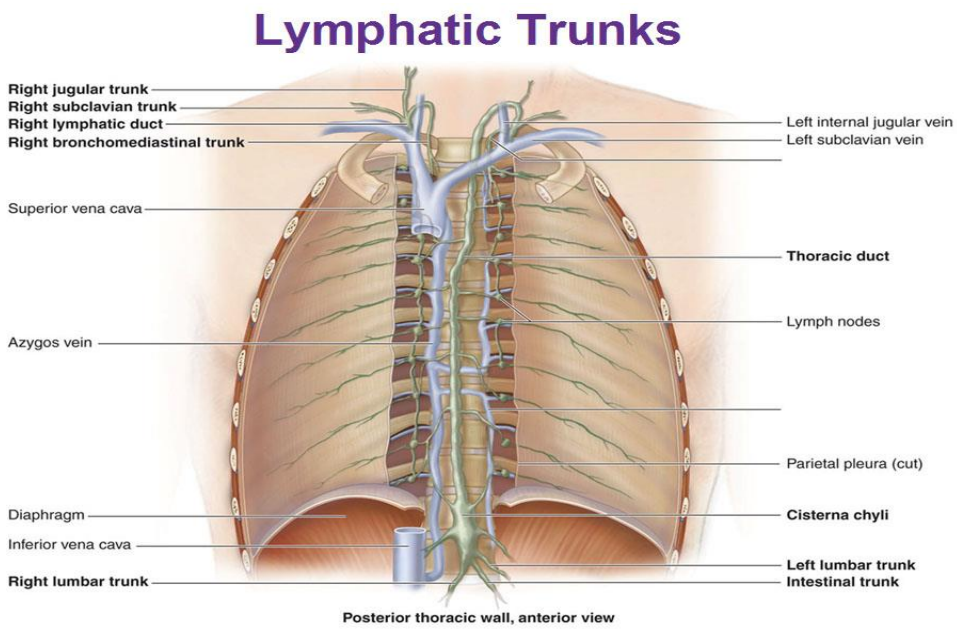
- **Lymph capillaries:** these originate as blind-end tubes. They have the same structure as blood capillaries (single layer, but their walls are more permeable to proteins, cell debris and others).
- The tiny capillaries join up to form **larger lymph vessels.**
- The wall of lymph vessels have three layers like blood vessels.

- Lymph vessels have valves (like veins) to ensure that lymph flows in a one way system toward the thorax.
- Lymph vessels become larger as they join together, eventually forming two large ducts:

    1. **the thoracic duct**
    2. **the right lymphatic duct**.

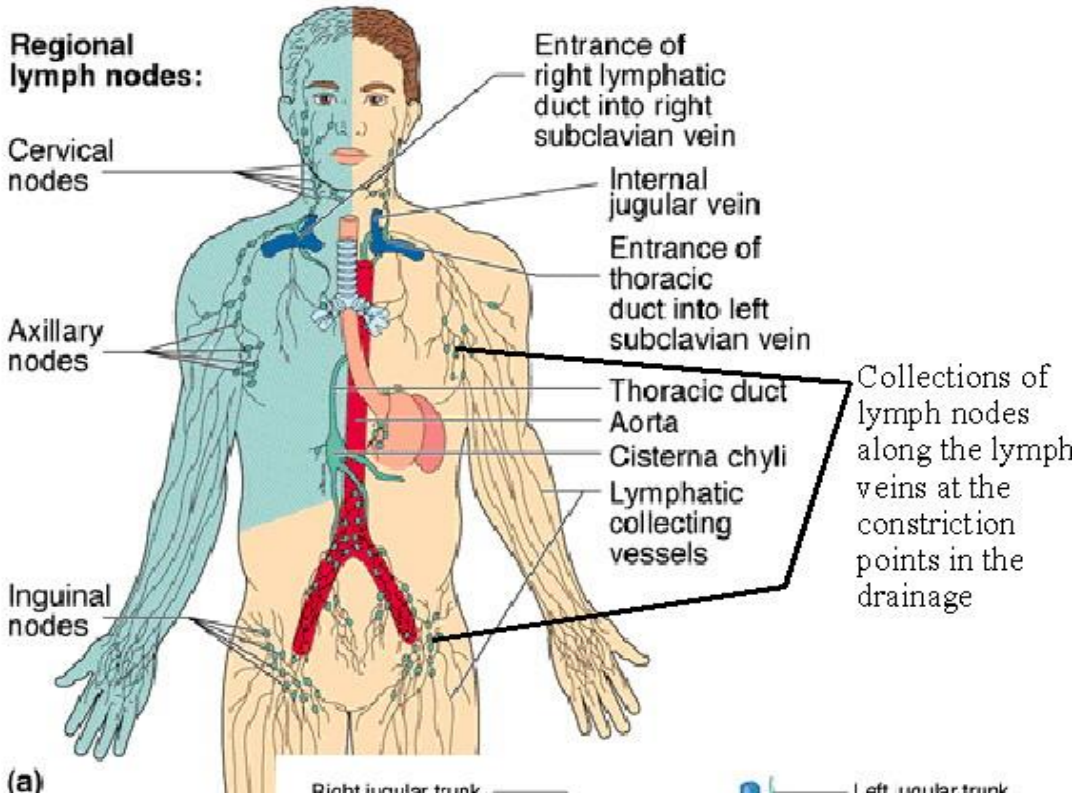
- These two ducts empty lymph to subclavian veins.

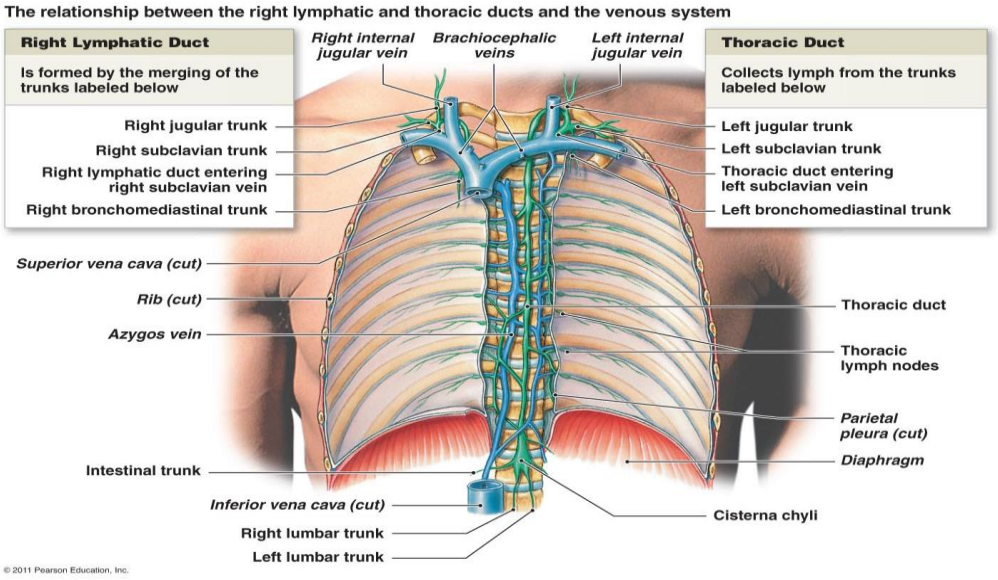




1). Thoracic Duct

- It is a largest duct and it begins at the *cisterna chyli.*
- The cisterna chyli is a dilated lymph channel situated in front of the bodies of the first two lumber vertebrae. It extends from abdomen through diaphragm and runs next to the aorta.
- The duct is about 40 cm long and opens into the left subclavian vein in the root of the neck.
- It drains lymph from both legs, the pelvic and abdominal cavities, the left thorax, head and neck, and the left arm.





2). Right lymphatic duct

- This is a dilated lymph vessel a bout 1 cm long.
- It lies in the root of the neck and opens into the right subclavian vein.
- It drains lymph from the right half of the thorax , head and neck and the right arm.

How Can Lymph Flow in the lymph Vessels?

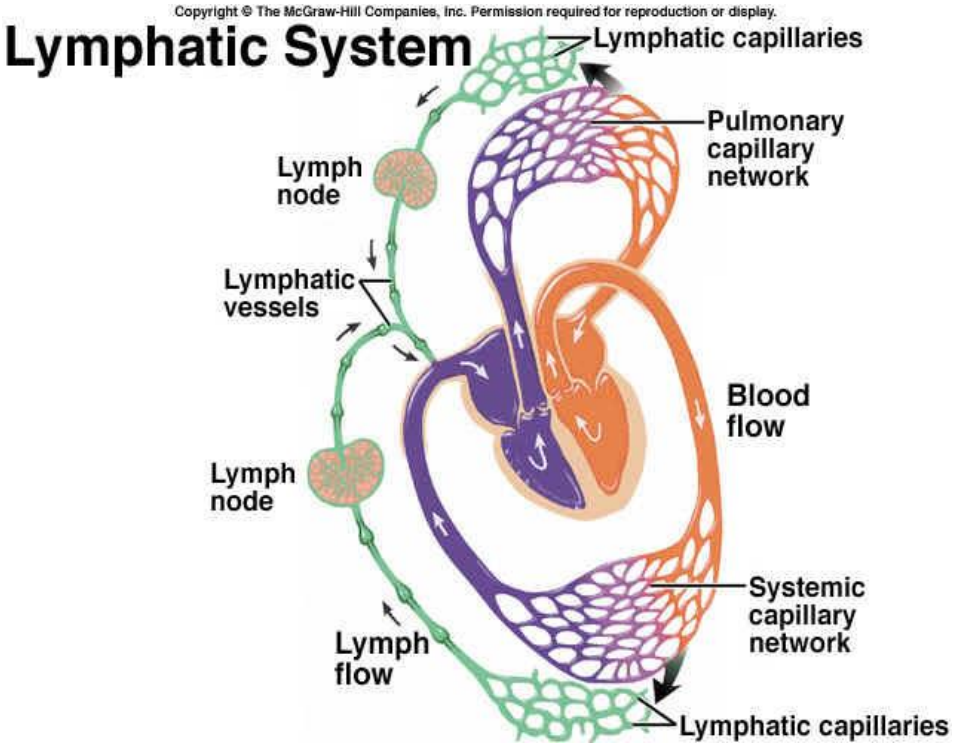
1. Large lymph vessels has an intrinsic to contract rhythmically (lymphatic pump).
2. Compression on the lymph vessels due to activity of structures adjacent to these vessels helps to push the lymph along.

Structures activity such as: skeletal muscle contraction, thoracic pump (during respiration), exercises accelerate lymph flow.

3. Valves

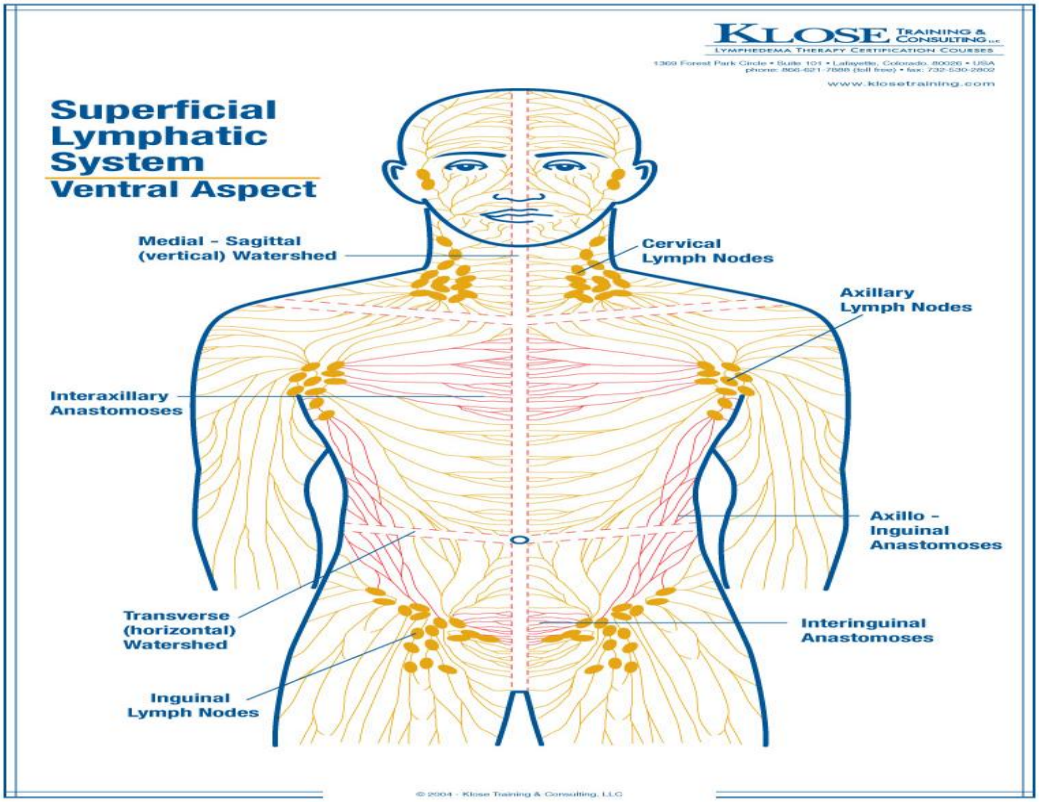
III. Lymph Nodes

- Lymph nodes are encapsulated spherical or kidney- shaped organ composed of lymphoid tissue that are distributed throughout the body along the course of the lymphatic vessels.
- Lymph nodes present everywhere in the body except brain.
- The lymph drain through a number of nodes usually 8-10 before returning to the venous circulation.
- Four or five lymphatic vessels enter a lymph node these vessels are called Afferent lymph vessels and only one lymph vessel leave it which is called Efferent lymph vessel.
- The lymph nodes have a convex side and concave depression side is called Hilum
- The hilum, where artery, and nerve enter and vein and lymph vessel leave the lymph node.

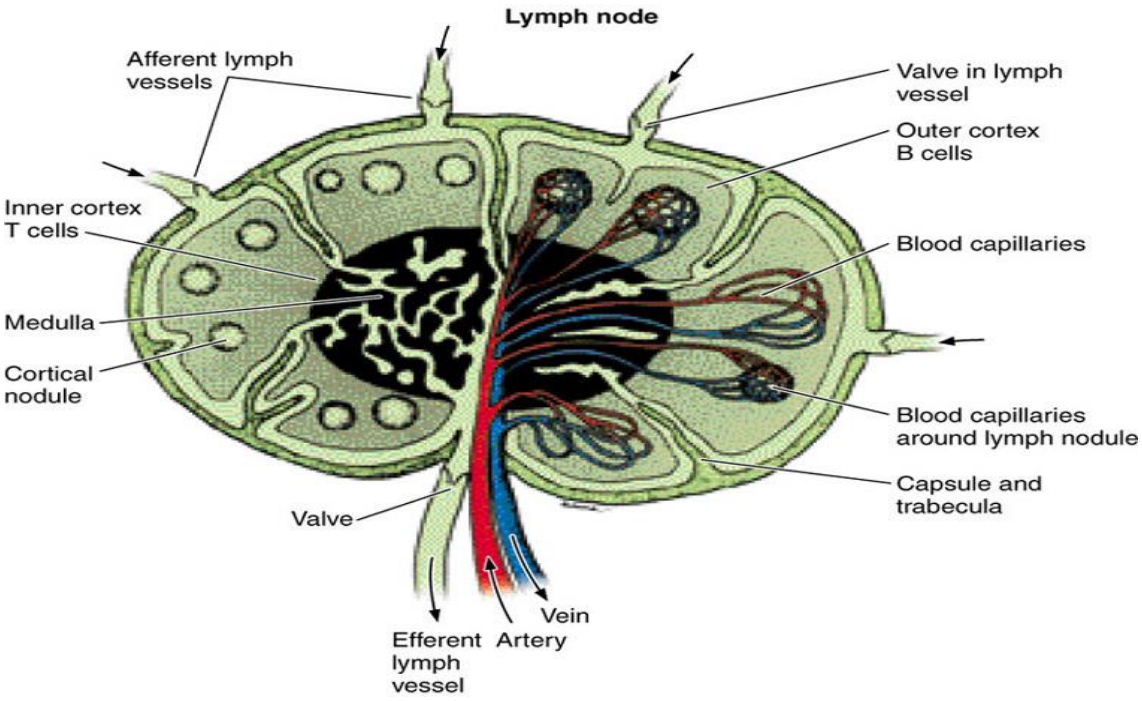


Main groups of lymph Nodes

1. In the neck there are superficial and deep Cervical lymph nodes.
2. In each axilla there are Axillary lymph nodes.
3. In the thorax there are Mediastinal lymph nodes.
4. In the abdomen there are Mesenteric lymph nodes.
5. In the grion there are Inguinal lymph nodes.



Schematic representation of the structure of a lymph node. Note the outer and inner cortex, the medulla, and the blood and lymph circulation. Also note that the lymph enters through the convex side of the node and leaves through the hilum. The lymph percolates through the node, exposing its contents to the action of defensive cells (macrophages, lymphocytes, APCs).



Structure of lymph Node

- Each lymph node is covered by a capsule. A number of septa (trabeculae) extend into the node from the capsule.
- Each lymph node contains two parts outer part cortex and inner part medulla.
- The area between capsule and cortex is called subcapsular sinus which contains a network of macrophages, reticular cells and fibers.
- Within the cortex there are several rounded areas that are called lymphatic follicles or lymphatic nodules.
- Each lymphatic follicles has a paler centre (germinal centre) surrounded by a zone of densely packed lymphocytes.
- Within the medulla the cells are arranged in the form of branching and anastomosing cords (medullary cords). Also in the medulla there are capillary like structures called medullary
- lymphoid sinuses
- the medullary lymphoid sinuses are communicated with subcapsular sinus by intermediate sinuses.

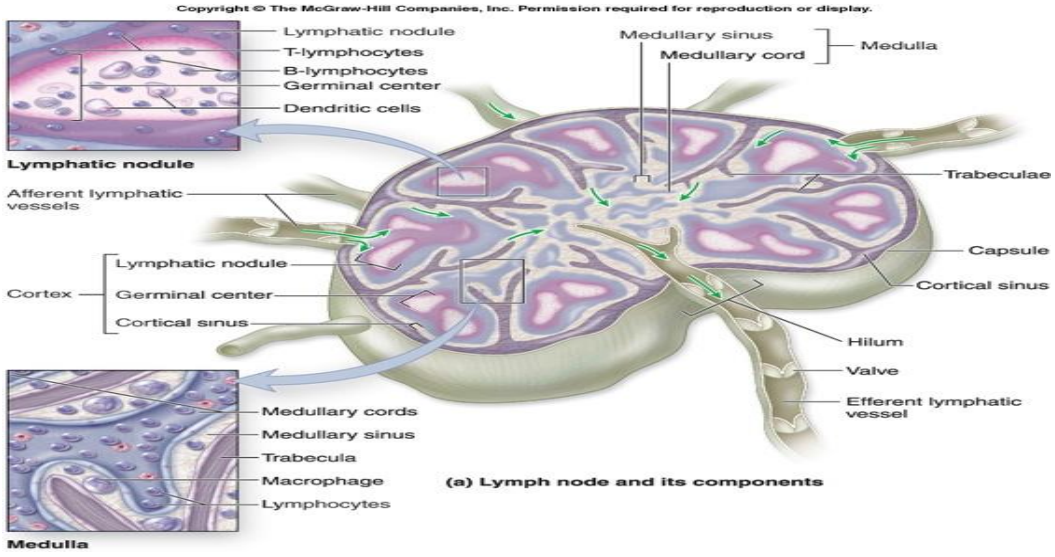
Cells of Lymph Nodes

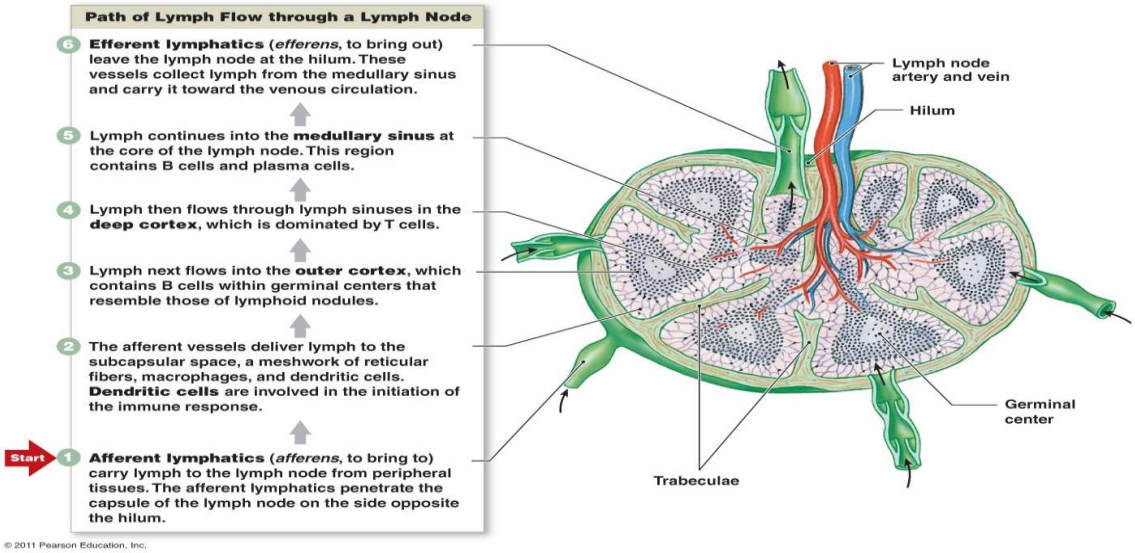
- Both B- lymphocytes and T- lymphocytes are present in the lymph node.
- The lymphatic follicles are composed of B- lymphocytes.
- The diffuse lymphoid tissue intervening between nodules is made up mainly of T-lymphocytes.
- T lymphocytes are also present in the medullary cords.
- Plasma cells (derived from B- lymphocytes), Macrophages, Fibroblast, also present.

Lymph flow in the lymph Node

Afferent lymphatic vessels pour the lymph into the subcapsular sinus. Then lymph passes through intermediate sinuses to reach medullary sinuses and is collected by efferent lymphatic vessel at the hilum.

Lymph Flow in the lymph node





Functions of Lymph Nodes

Lymph nodes perform the following major functions:

1. Filtering and phagocytosis: Lymph is filtered by the reticular and lymphoid tissues as it pass through lymph nodes.
2. They are centers of lymphocytes production.
3. Plasma cells (representing fully mature B- lymphocytes) produce antibodies against foreign body. While T- lymphocytes attack cells that are foreign to the body.

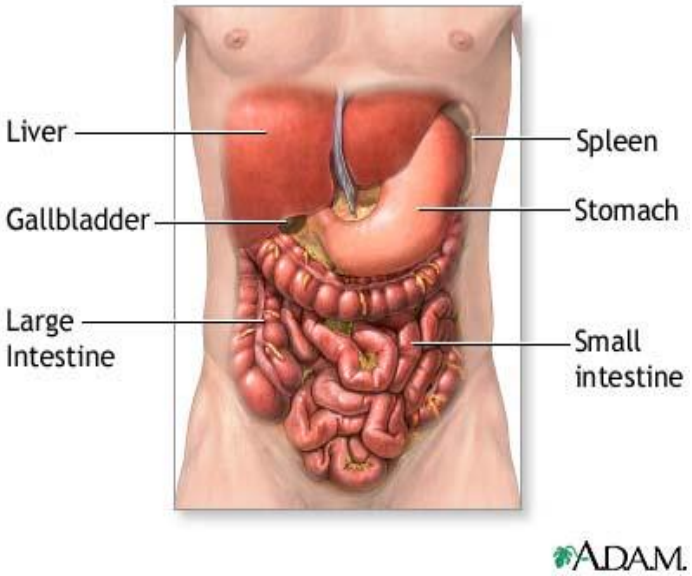
Lymphatic Organs

IV. Lymphatic organs include:

1. Spleen
2. Thymus

1. The Spleen

- The spleen is the largest lymphoid tissue in the body. It is slightly oval in shape with hilum . It is located on the left side of the upper part of the abdomen. And its surface is covered with peritoneum.
- The spleen is contact with diaphragm, stomach and the left kidney.
  Blood reaches to the spleen through Splenic artery

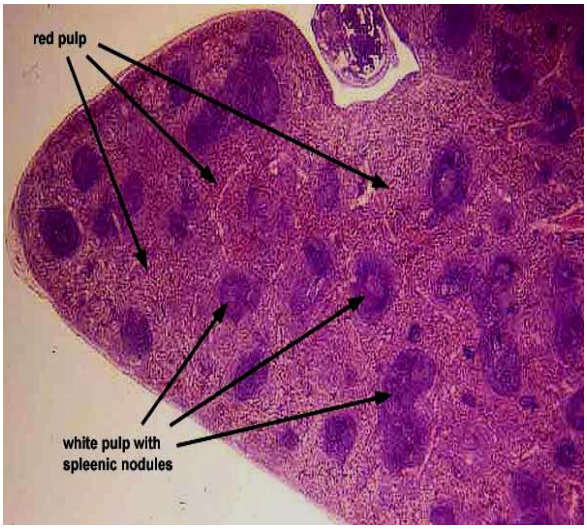


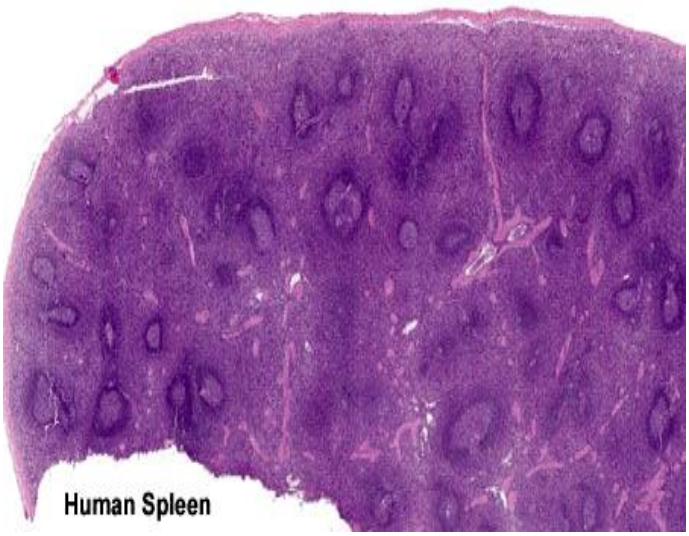
General structure of the spleen

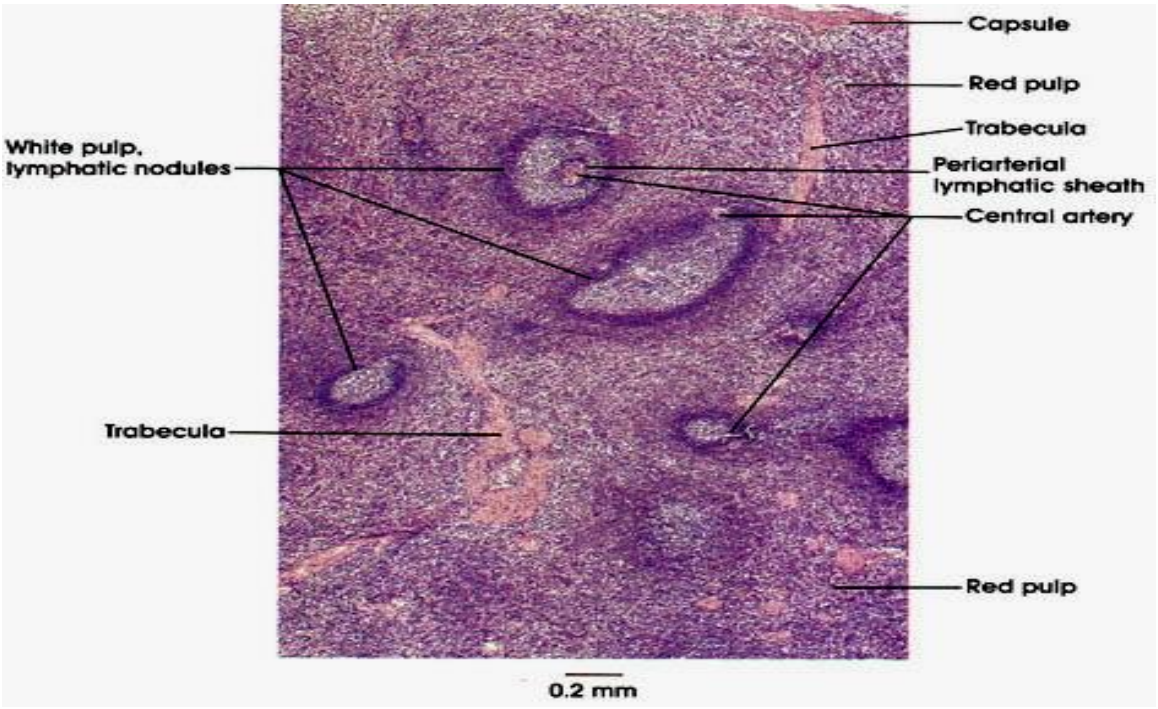
1. Capsule it covers spleen and sends trabeculae into the body of spleen. These trabeculae carry arteries and veins.
2. White pulp: a white area of lymphoid nodules. It is composed of many central arteries, each central artery surrounded by lymphatic nodule

3. Red pulp: a dark red tissue that is rich in blood. It contains Splenic sinuses, arterioles and the Splenic cords (Billroth).

- Splenic Cords are thin aggregation of lymphatic tissue containing mainly lymphocytes
- also the red pulp is rich in macrophages.
- The red pulp is the site of blood filtration.





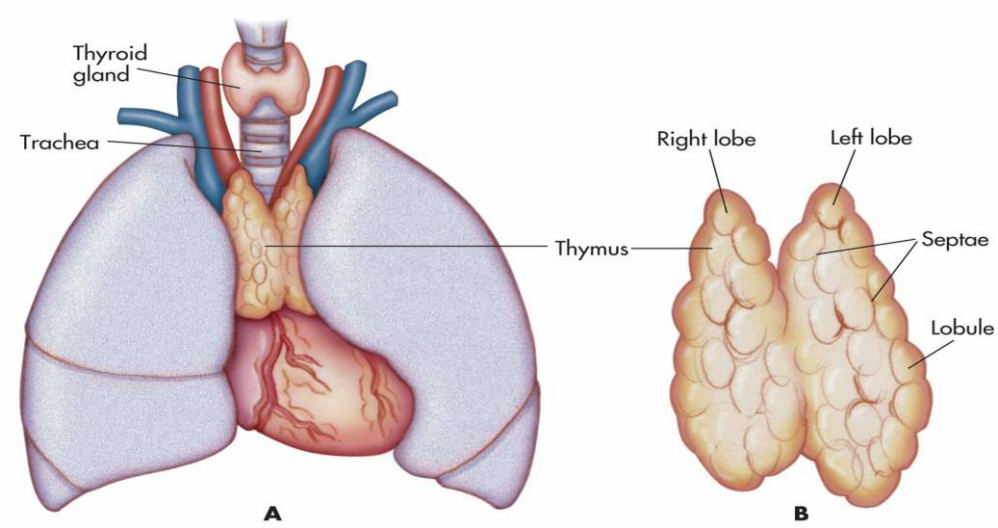


Functions of the spleen

- Production of lymphocytes.
- Destruction of aged erythrocytes.
- Act as defense organ against invaders that enter the bloodstream.
- Immunologically it acts as blood filter and antibodies forming organs.
- The storage of the blood.

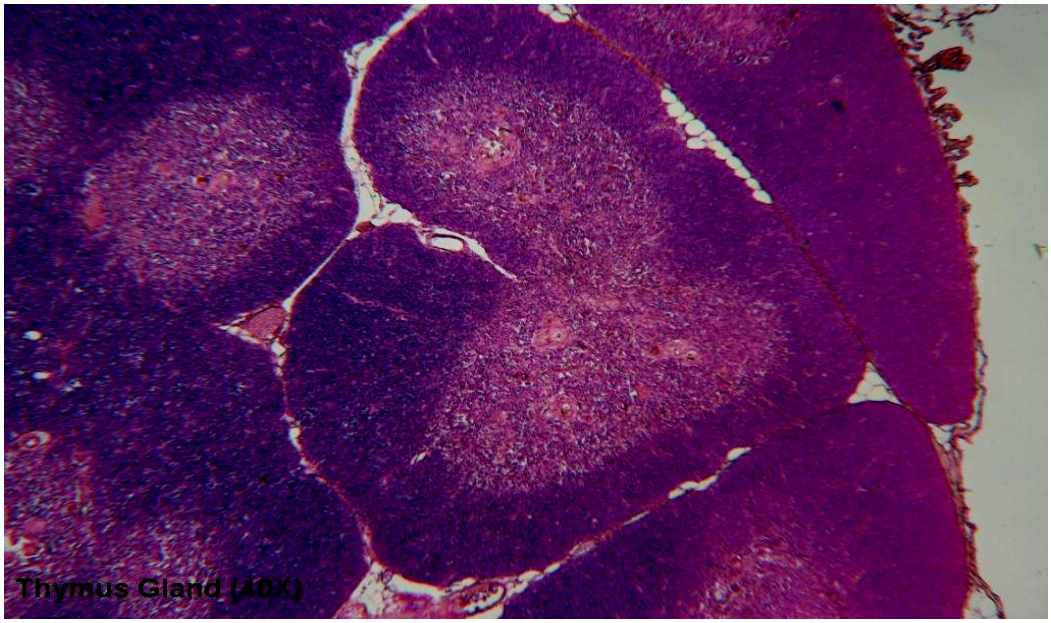
2. The thymus gland

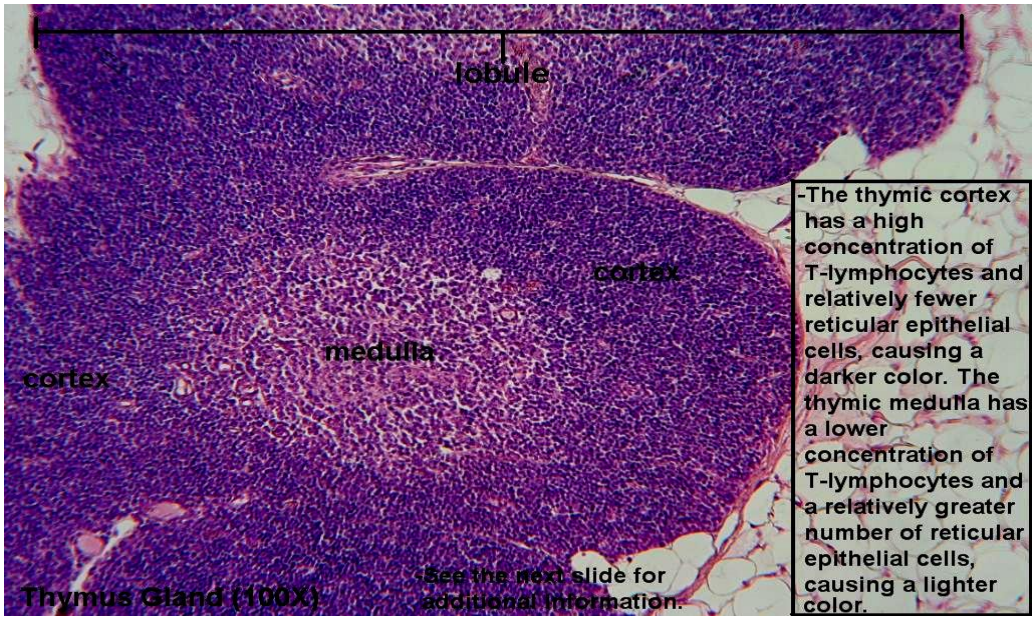
- It is a lymphoepithelial tissue, located in the upper part of the mediastinum behind the sternum and extend upwards into the root of the neck. It divides into two lobes.
- It weighs about 10-15g at birth and grows until puberty to reach 30-40g in weight.
- After puberty i.e. by middle age it becomes atrophied.

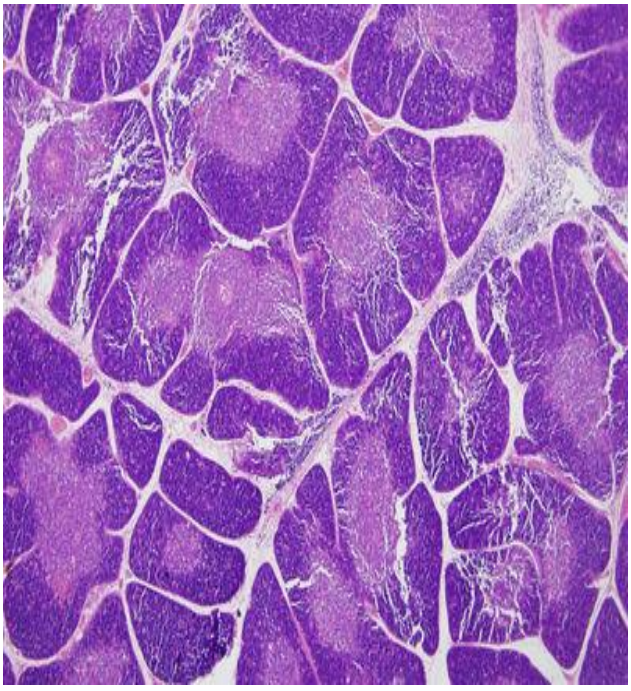


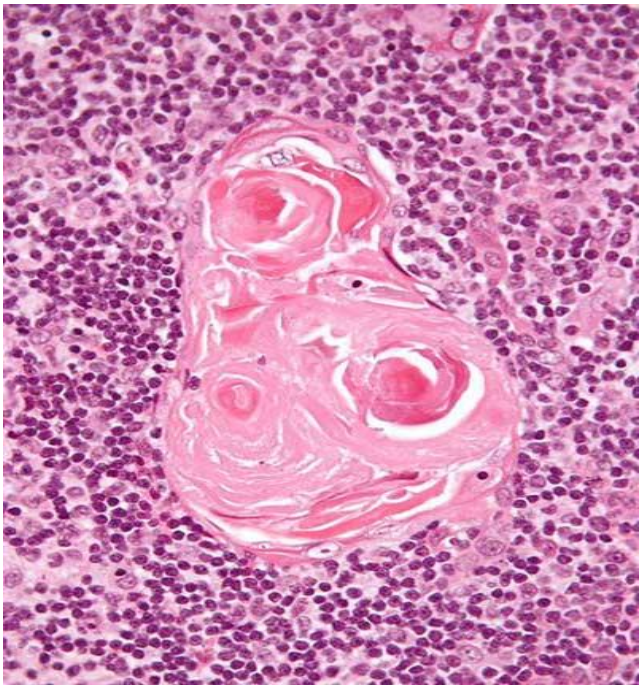
Structure of the Thymus

- Thymus has a connective tissue capsule.
- The capsule penetrates the parenchyma of thymus and divides it into lobules.
- Each lobules has a peripheral dark zone known as the cortex and a central light zone called the medulla.
- The cortex is composed of an extensive population of T lymphocytes, and also epithelial reticular cells with few macrophages.
- In the medulla there are small rounded structures called Hassall's corpuscles.
- The thymus has only efferent lymphatic vessels.
- The thymus produces several protein growth factors that stimulate proliferation and differentiation of T lymphocytes.
- These growth factors are: Thymosin-α1, thymopoietin, thymolin and thymus humeral factor.
- Shrinkage of the thymus gland begins in adolescence and with increasing age therefore the effectiveness of T lymphocyte response to foreign body decline.


Thymus Gland (40X)


lobule
cortex
medulla
cortex
Thymus Gland (100X)
-See the next slide for additional information.
-The thymic cortex has a high concentration of T-lymphocytes and relatively fewer reticular epithelial cells, causing a darker color. The thymic medulla has a lower concentration of T-lymphocytes and a relatively greater number of reticular epithelial cells, causing a lighter color.





The main function of the thymus is activation of the T lymphocytes.

Diffuse lymphatic Tissue = Mucosa Associated lymphoid tissue (MALT)

- Aggregation of lymphoid tissue in the mucosa of respiratory system, alimentary system and urogenital system is called Mucosa associated lymphoid tissue.
- In the respiratory system the aggregations are relatively small and are present in the walls of the trachea and large bronchi.
- In the alimentary system occurs in

a) near the junction of the oral cavity with the pharynx there are a number of collections of lymphoid tissue that are referred to as Tonsils

1. Palatine tonsils
2. Pharyngeal tonsils (present in the posterior wall of the pharynx). Hypertrophy of this tonsils in children is called adenoids.
3. Lingual tonsils

b). Peyer;s Patches (Gut associated lymphoid tissue)

Defense Mechanisms and Immunity

The Defense Mechanisms and Immunity:

The body has ability to protect itself from any invader (e.g. bacteria, virus, parasites, fungus, and others) by two types of defense mechanisms.

Defense Mechanisms

1. Non Specific Defense Mechanisms (Innate Immunity =Native Immunity).
2. Specific Defense Mechanisms (Acquired Immunity).

Non Specific Defense Mechanisms

This type is divided into two lines:

- First line

Natural Barriers : which includes

1. **Skin:** intact skin prevents microorganism to get in.
2. **Mucous membranes** that cover respiratory tract, digestive tract, urogenital system, conjunctiva.
3. **Secretions and body fluids** like *mucus secretions* that cover mucous membrane of respiratory and other tracts which trap bacteria and other other foreign substances, *saliva* which contains antibodies, lysozymes and antibacterial substances, *tears* contains lysozymes, *gastric juice*

contains hydrochloric acid (low pH) and digestive enzymes that kill microorganisms swallowed into the stomach, and *low pH in the urine*, and low pH in the vagina, Sebaceous *glands*

4. **Hair** in the nastrils, **eyelashes**, **wax** in the ears trap the particular matters

2. Second line:

1. Antimicrobial substances: e.g. Interferons and compelement system

Interferons are proteins produced by lymphocytes macrophages and fibroblast mainly in response to viral infection.

Functions of interferons:

a). They act as antiviral

b). They activate immune cells such as natural killer cells and macrophages.

c). Increase recognition of infection and tumor cells to T lymphocytes.

d). Increase the ability of uninfected cells to resist new infection by virus.

Complement system :

is a group of about 20 proteins in the blood plasma and on the cell membrane. Normally these proteins are inactive but when activated they enhance certain immune, allergic and inflammatory reactions.

Phagocytosis : means ingestion of the foreign substances by cells called phagocytes.

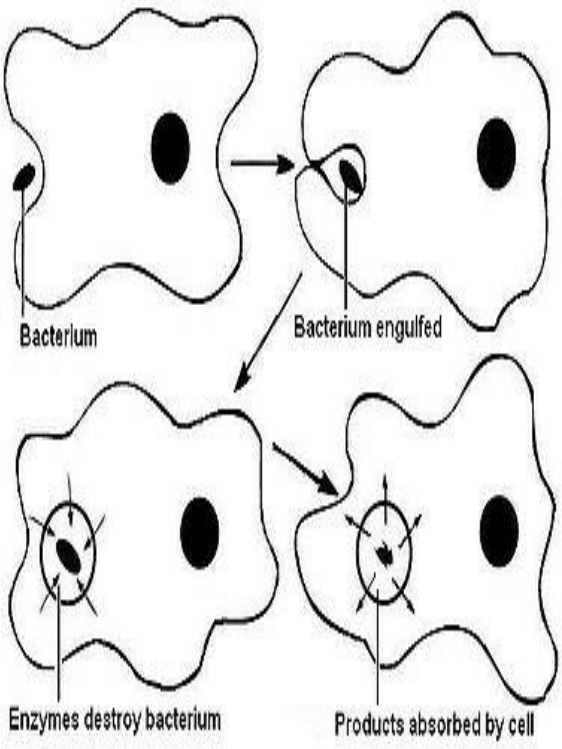
- Phagocytes include neutrophils and macrophages.
- Three phases of phagocytosis include chemotaxis, adherence, and ingestion.

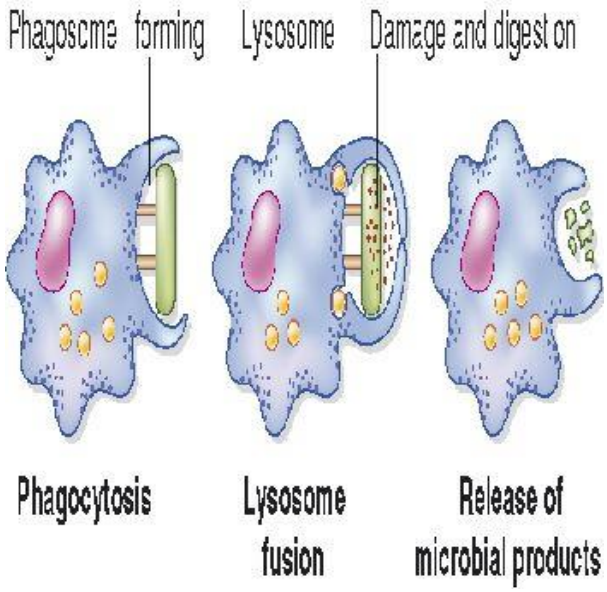
i). Chemotaxis: means movement of phagocytic cells toward certain substances (such as microbial products and activated complement proteins).

ii). Adherance: the cell membrane of phagocyte attaches to the surface of foreign body.

iii). Ingestion: the cell membrane of phagocyte extends projections (psuedopodias) that engulf the organism; pseudopods fuse together and surrounded the organism in a phagocytic vesicle.

- After ingestion the phagocytes release chemicals that kill the organism.





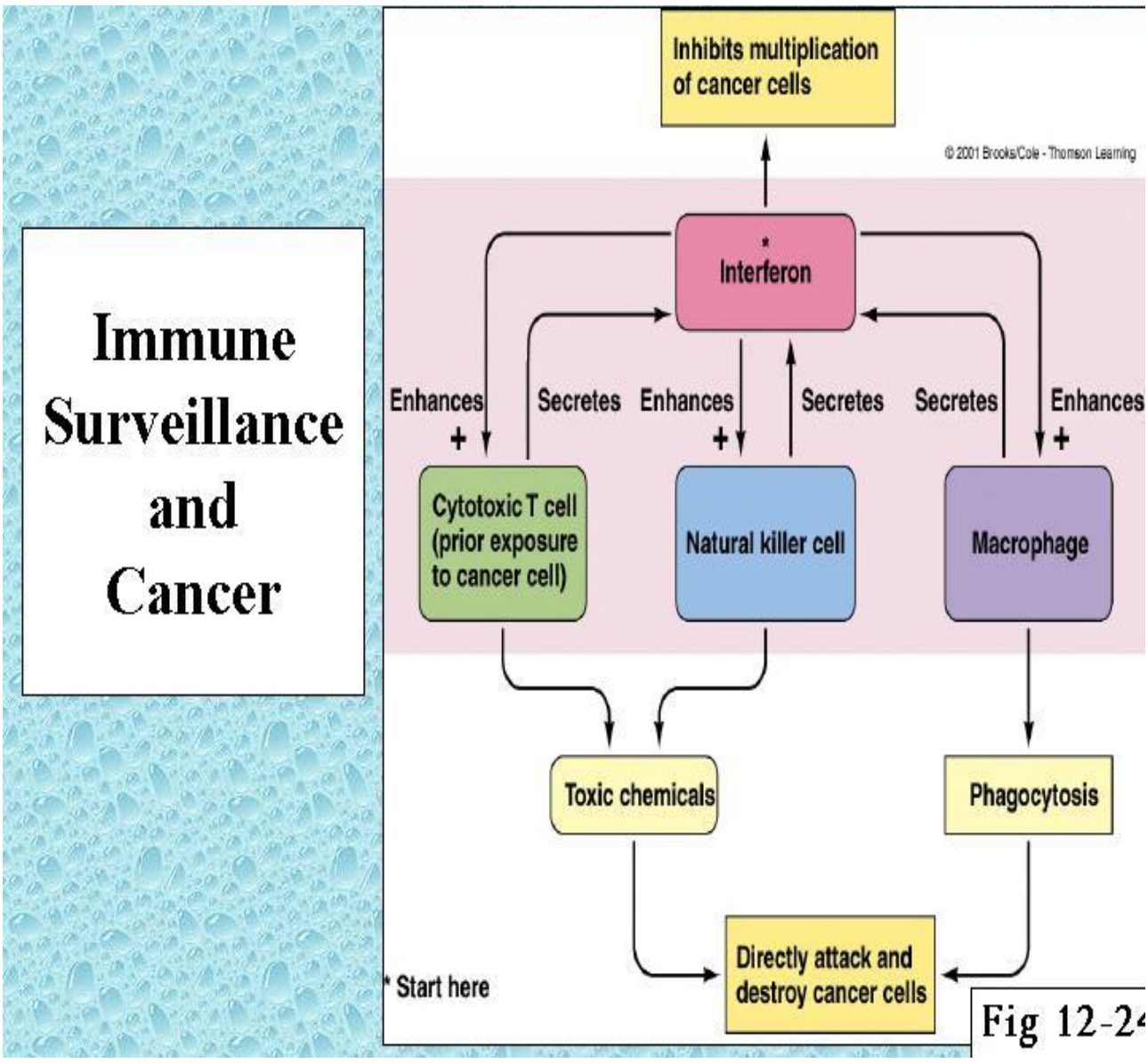
Inflammation: it is very important biological process by which the microorganisms and other foreign bodies are destroyed.

- In inflammation the WBC migrate from circulation to the inflamed area and engulfed the microorganism or foreign body.
- Inflammation usually causes redness, pain, heat, swelling and loss of function.
- Inflammation helps **remove** organisms, toxins, and foreign substances from affected site, **inhibiting** their spread and **preparing** the site for tissue repair.

. Fever

- It means increase in body temperature.
- Fever occurs when microorganisms invade body that leads to release certain substances which is called Interleukin 1 (IL1).
- Interleukin1(IL1) act on the hypothalamus which leads to increase body temperature.
- Fever prevent the growth of some microorganisms and also it may enhance activity of immune system.
- Immunological Surveillance:

- Natural killer cells are kind of lymphocytes which have ability to detect and kill any transformed cells (abnormal cells) in the body. So NK acts to remove abnormal cells and prevent tumor formation.



Lymphatic System and Immunity

Immune System

Specific Defense Mechanisms (Acquired immunity = Adaptive immunity)

The system responsible for this kind of body defense mechanisms is called **Immune System**. And the science that deals with this device (immune system) is called **immunology. and Memory.**

Specificity: An immune response is directed against one antigen and no more. i.e. immune response against antigen1 is different than immune response against antigen2.

Antigen (Ag): any molecule has ability to provoke immune response is called an antigen.

Memory: means when immune response occurs against one antigen (particular antigen) will usually generate immunological memory of that antigen. That means the immune response on subsequent exposures to the **same antigen** is **faster** and **more powerful.**

Organs of Immune System

Primary Organs:

-Bone Marrow

-Thymus

Secondary Organs:

-Lymph Nodes

-Spleen

-Mucosa Associated Lymphoid tissues

Cells of Immune System

The main cells or primary cells of immune system are **Lymphocytes** but **macrophages** play an important role in many immune responses.

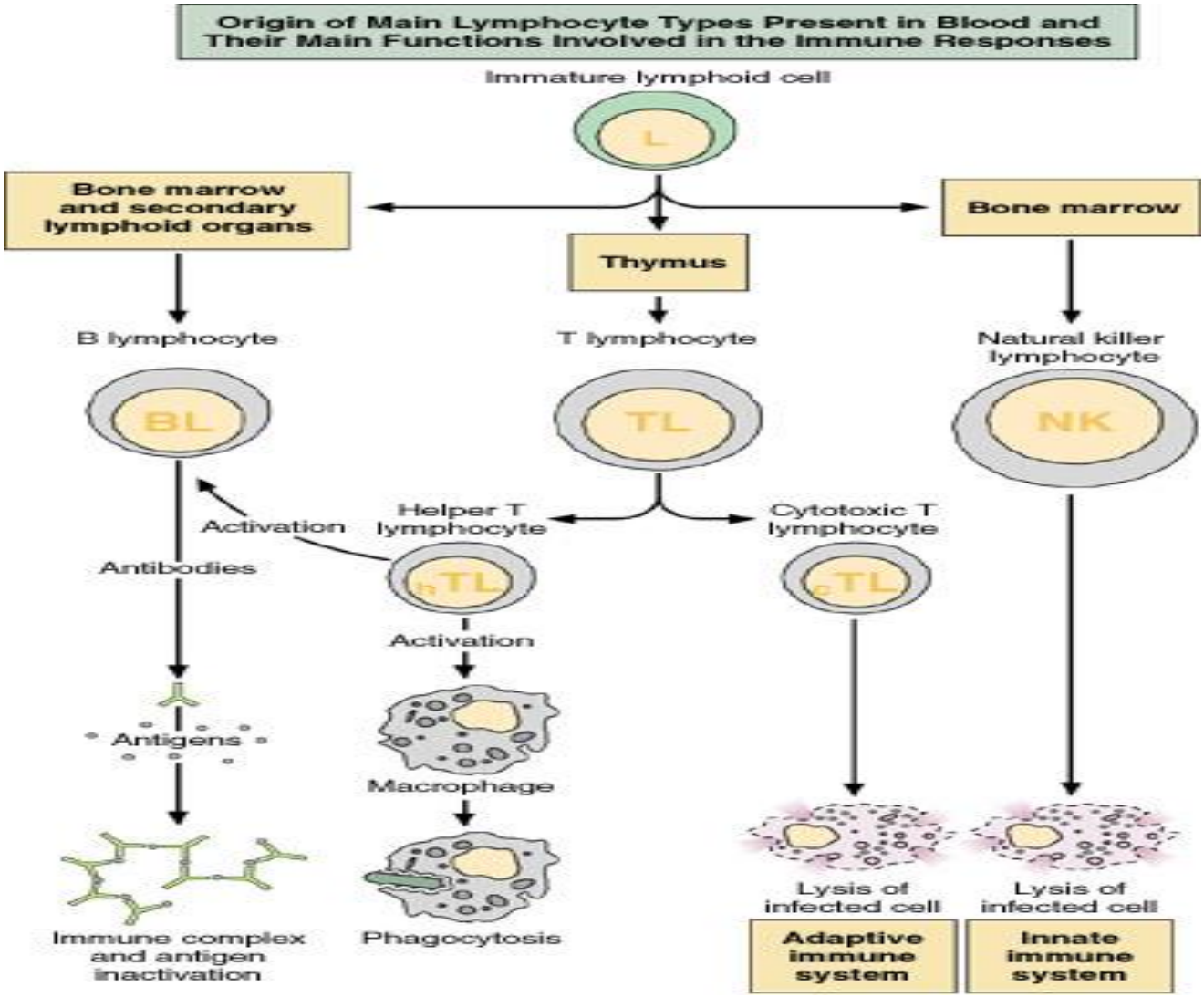
Types of Immune responses

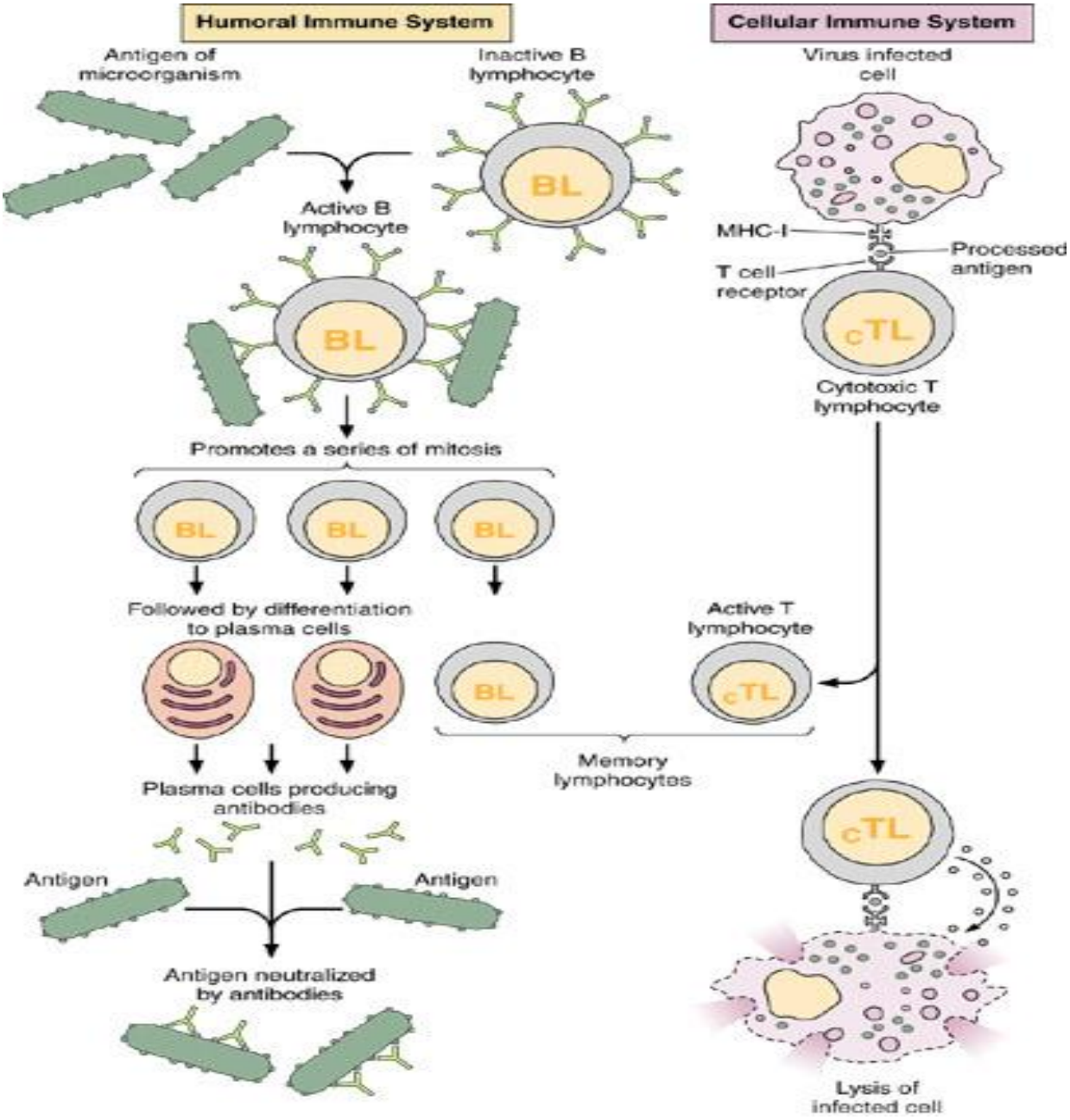
There are 2 types of immune responses:

1. Cell Mediated Immunity (Cellular Immunity)
2. Humeral Immunity (Antibody- Mediated immunity)

Cell-Mediated Immunity (Cellular Immunity)

- The responder cells in this type of immunity are **T lymphocytes.**
- T lymphocytes are processed by thymus which leads to the formation of specialized, mature and functional T lymphocytes.
- T lymphocyte has been programmed to recognise only one type of antigen. i.e. T lymphocyte which can recognise Ag1 cannot react with Ag2 and that react with Ag2 cannot react with Ag1 or Ag3 and so on.
- Thus the T lymphocyte which has ability to recognise Influenza virus has no ability to recognize measles virus or cancer cell or tuberculosis bacterium (T.B).
- Some antigens need macrophages or neutophils to presented them to the T lymphocytes.
- When Ag activates T lymphocyte, that leads to divide and proliferation of the activated T cell. Four main types of specialised T lymphocytes are produced, each of which is still directed against the original Ag.





Types of T- Lymphocytes

1. Memory T- Cells: these are long lived cells. They are very important in providing cell-mediated immunity by responding rapidly when the body exposes to the same antigen (Ag) at the second time.

2. Cytotoxic T Cells (CD8 = T8). These type of cells have ability to attach to the target cell and kill it by releasing powerfull toxins.

3. Helper T Cells (CD4 = T4): these cells are essential for both cell mediated immunity and humeral immunity.

Functions:

1. Production of special chemicals
called Cytokines, like interferon, interleukins which support and promot cytotoxic T lymphocytes.

Cytokines are protein substances
produced either by lymphocytes or macrophages. They act to enhance and regulate immune Responses.

2. stimulate B cells to produce
antibodies.

4. Suppressor T Cells: these cells act as brakes turning
off activated T and B lymphocytes

Humeral Immunity (Antibody Mediated Immunity)

- The responder cells for this type of immunity are B lymphocytes.
- Stimulation of B lymphocytes by antigen leads these cells begins to divide and produce two types of cells, Plasma Cells and Memory B- Cells.
- Plasma Cells these cells have ability to produce (manufacture) and secret a large number of antibodies into the blood.
- Antibodies are proteins in nature also called immunoglobins. These immunoglobins have ability to bind with specific antigen that stimulate their production. There are five types of immunoglobins (IgA, IgM, IgD, IgG, and IgE).
- Antibodies bind to specific antigen one of three step may occurs:

1- Neutralising the antigen.

2- Activate Cytotoxic T lymphocytes or macrophages.

3- Activate complement.

- Memory B- Cells: these cells remain in the body for long time after the foreign body (Ag) has been remove and rapidly respond to another exposure to the same Ag by stimulating the production of antibody secreting plasma cells.

Acquired Immunity= Adaptive Immunity

- **Primary immune response (primary immunity):** occurs when exposure to the antigen at first time.
- **Secondary Immune response (Secondary immunity)** occurs when subsequent exposures to the same antigen (i.e. at the second time, third time, fourth time and so on). Secondary immunity characterized by the immune response is *much faster* and *more powerful*.
- Immunity may be acquired **naturally** or **artificially** and both forms may be **active** or **passive.**
- **Active naturally acquired immunity:** in this type the immunity occurs due to exposure the body to the antigen by disease or subclinical infection.
- **Active naturally acquired immunity:** means the immunity develops in response to the administration of dead or live artificially weakened pathogens **(vaccine).**
- **Passive naturally acquired immunity:** occurs before birth by the passage of maternal antibodies to the fetus. And after birth to the baby in breast milk.
- **Passive artificial acquired immunity:** in this type the antibodies prepared in the human or animal and then inject to other person (recipient).