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LYMPHATIC ORGANS

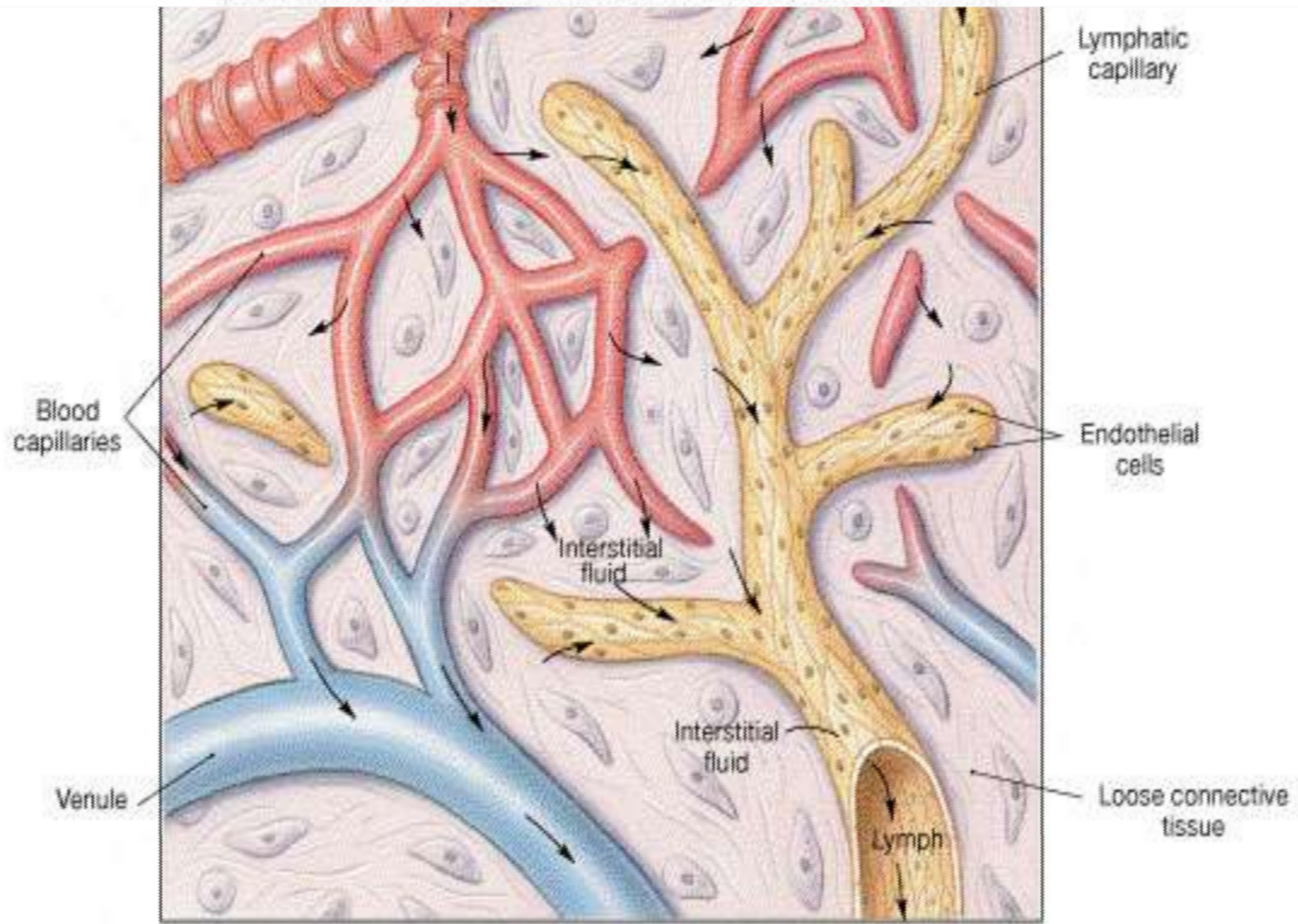
Suman Kumar Meikap

Asst. Professor (Pharmacology)

CUTM, Bhubaneswar



(a) Association of blood capillaries, tissue, and lymphatic capillaries



(a) Association of blood capillaries, tissue, and lymphatic capillaries



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The lymphatic system represents an accessory route through which fluid can flow from the interstitial spaces into the blood. Most important, the lymphatics can carry proteins and large particulate matter away from the tissue spaces, neither of which can be removed by absorption directly into the blood capillaries.

The **lymphatic system (lim-FAT-ik)** consists of a **fluid called lymph**, **vessels called lymphatic vessels** that transport the lymph, a number of **structures and organs containing lymphatic tissue** (lymphocytes within a filtering tissue), and red bone marrow.

The lymphatic system assists in circulating body fluids and helps defend the body against disease-causing agents.



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Most components of **blood plasma filter** through **blood capillary walls**

to form interstitial fluid. After interstitial fluid passes into lymphatic

vessels, it is called **lymph** (LIMF clear fluid).

Lymphatic tissue is a specialized form of reticular connective tissue that contains large numbers of lymphocytes, These lymphocytes are **Agranular** white blood cells participate in immune responses: **B cells and T cells.**

The major difference between interstitial fluid and lymph is **location:** Interstitial fluid is found between cells, and lymph is located within lymphatic vessels and lymphatic tissue.

This return of proteins to the blood from the interstitial spaces is an

essential function **without** which we would die within about 24 hours.



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FUNCTIONS OF THE LYMPHATIC SYSTEM

The lymphatic system has three primary functions:

Drains excess interstitial fluid. Lymphatic vessels drain excess interstitial fluid from tissue spaces and return it to the blood.

Without this function, the maintenance of circulating blood volume would not be possible.

Transports dietary lipids. Lymphatic vessels transport lipids absorbed by the

soluble vitamins (A, D, E, and K) absorbed by the Gastrointestinal tract.

Carries out immune responses. Lymphatic tissue initiates highly specific

responses directed against particular microbes or abnormal cells.

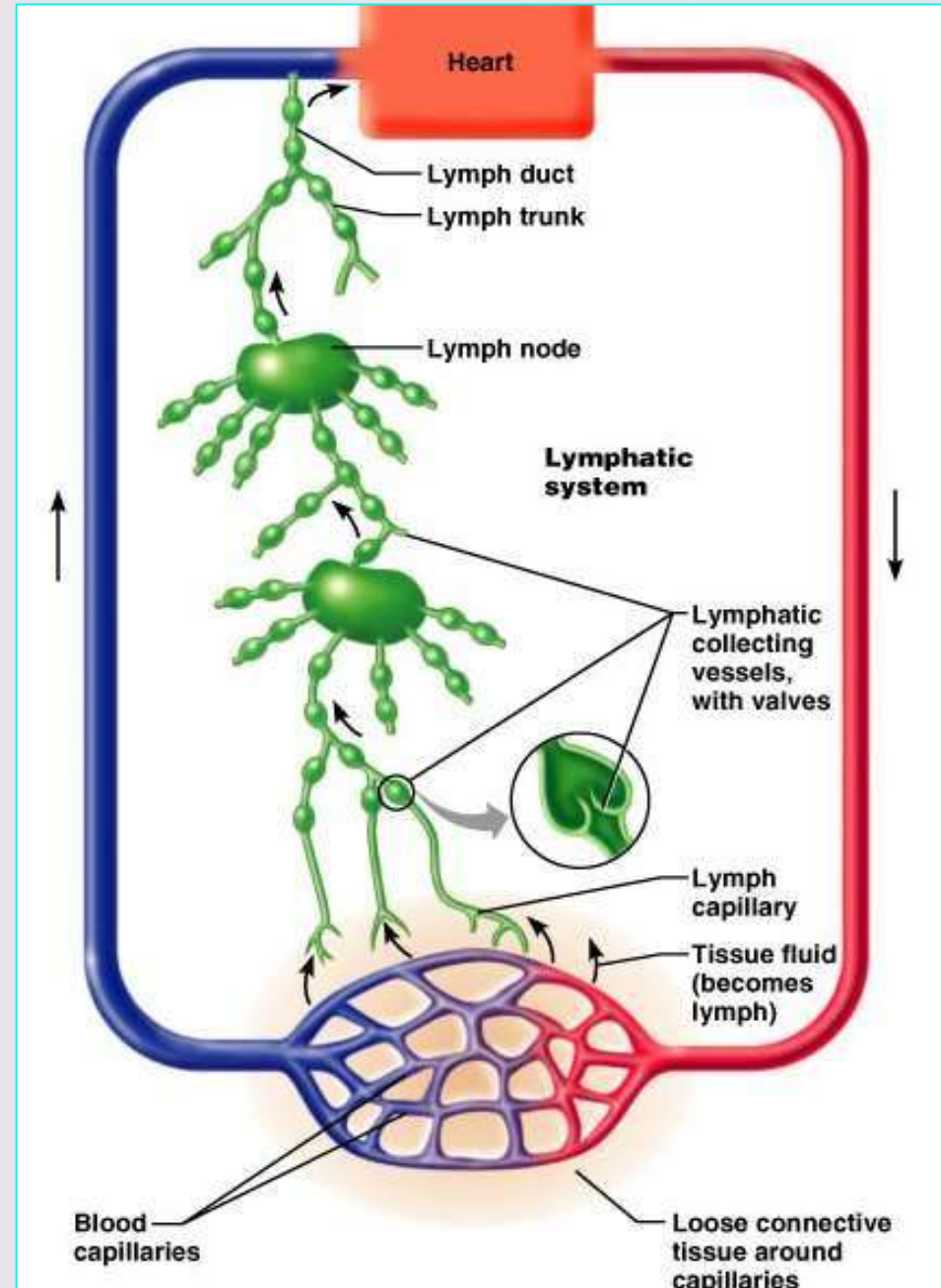


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Lymphatic system contains

1. Lymph
2. Lymph capillaries
3. Lymph vessels
4. Lymph trunks and ducts
5. Lymph nodes
6. Lymph tissues or organs





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FORMATION OF LYMPH.

Lymph is a clear , watery appearing fluid found in the lymphatic vessels.

Plasma gets filtered into the interstitial space across the capillary wall.

This will be re absorbed , leaving a small amount of fluid behind.

In glands, various substances like proteins ,fats, are also enters into the interstitial space.

Various organic substances from degenerating cells are also enters in the inetrstitial space.

The left out fluid and other substances enter the lymph vessels and constitute lymph.

Small pressure favours the formation of more fluid than they absorbed.this fluid enters the lymphatic vessels.



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Composition of lymph



Hydrogen Peroxide----**94%** and Solids---**6%**.



Lymphocytes---various from 1000 to 2000 /mm³



Plasma cells are present as small numbers.



Electrolytes –same as that plasma .



Urea, amino acids and Creatinine same as that plasma



Proteins, calcium, Phosphorous are lower than plasma



Chloride and glucose are more than plasma



Clotting factors , plasma enzymes and antibodies are present.



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Factors which influence formation of lymph



Increase in hydrostatic pressure increases the lymph formation.



Increase in capillary surface.



Increase in capillary in capillary permeability... hypoxia, ADP, hydrogen ions, Bradykinin, histamine.



Increased functional activity.



Lymph flow is aided by



Presence of valves in the lymphatic vessels



Movement of muscles



Pressure gradient , respiratory pump during inspiration



An increase in lymph formation.



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Functions of lymph



Returns of protein, electrolytes and water to blood from the tissue spaces.



Helps in the redistribution of body water.



Removes the particulate matter and bacteria.



Maintain the interstitial fluid levels



Body defense by lymphocytes and antibodies.



Fat absorption from intestine by the lacteals.



Transport antibodies and other drugs injected by intramuscularly.



Lymph flow is responsible for structural and functional integrity of tissues.



Lymph flow in kidney helps in formation of concentrated urine by supplying nutrients and oxygen to those parts where blood maintaining osmotic pressure gradient



Any factor which increases lymph formation is called lymphatogogue.

Ex: sunlight, Histamine....



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- Blood capillaries

- Interstitial spaces

- Lymphatic capillaries

- Lymph vessels

- Lymph ducts

- Junction of the internal jugular and subclavian veins



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The two “pumps” that aid the return of venous blood to

Skeletal muscle pump. The “milking action” of skeletal muscle

➤ Contractions compresses lymphatic vessels (as well as veins) and forces lymph toward the junction of the internal jugular and subclavian veins.

Respiratory pump. Lymph flow is also maintained by pressure

➤ Changes that occur during inhalation (breathing in). Lymph flows from

the abdominal region, where the pressure is higher, toward the thoracic region, where it is lower.

➤ When the pressures reverse during exhalation (breathing out), the valves in lymphatic vessels Prevent backflow of lymph. In addition, when a lymphatic vessel distends, the smooth muscle in its wall contracts, which helps move lymph from one segment of the vessel to the next.



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LYMPHATIC CAPILLARIES

Lymphatic capillaries have greater permeability than blood capillaries and thus can absorb large molecules such as proteins and lipids.



Lymphatic capillaries are also slightly larger in diameter than blood capillaries and have a unique one-way structure that permits interstitial fluid to flow into them but not out.



The ends of endothelial cells that make up the wall of a lymphatic capillary overlap.



When pressure is greater in the interstitial fluid than in lymph, the cells separate slightly, like the opening of a one-way swinging door, and interstitial fluid enters the lymphatic capillary.



When pressure is greater inside the lymphatic capillary, the cells adhere more closely, and lymph cannot escape back into interstitial fluid.



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The pressure is relieved as lymph moves further down the lymphatic capillary.

Attached to the lymphatic capillaries are *anchoring filaments*, which contain *elastic fibers*.

They extend out from the lymphatic capillary, attaching to surrounding lymphatic endothelial cells to surrounding tissues.

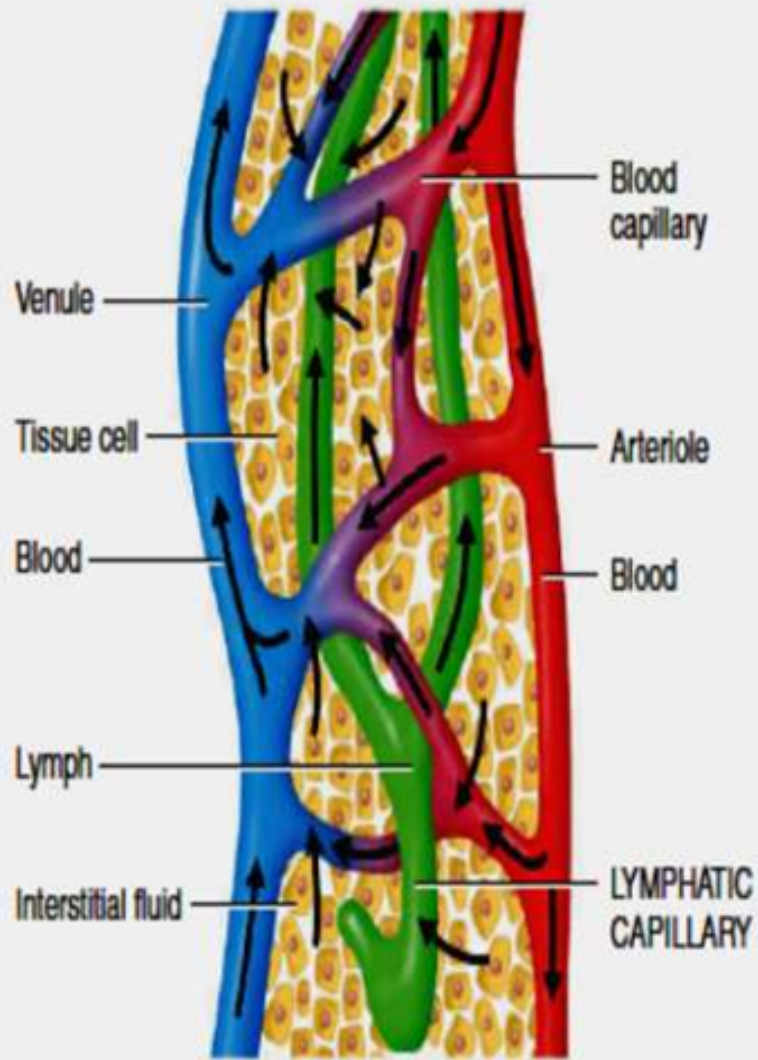
When excess interstitial fluid accumulates and causes tissue swelling, the anchoring filaments are pulled, making the openings between cells even larger so that more fluid can flow into the lymphatic capillary.

In the small intestine, specialized lymphatic capillaries called **lacteals** carry

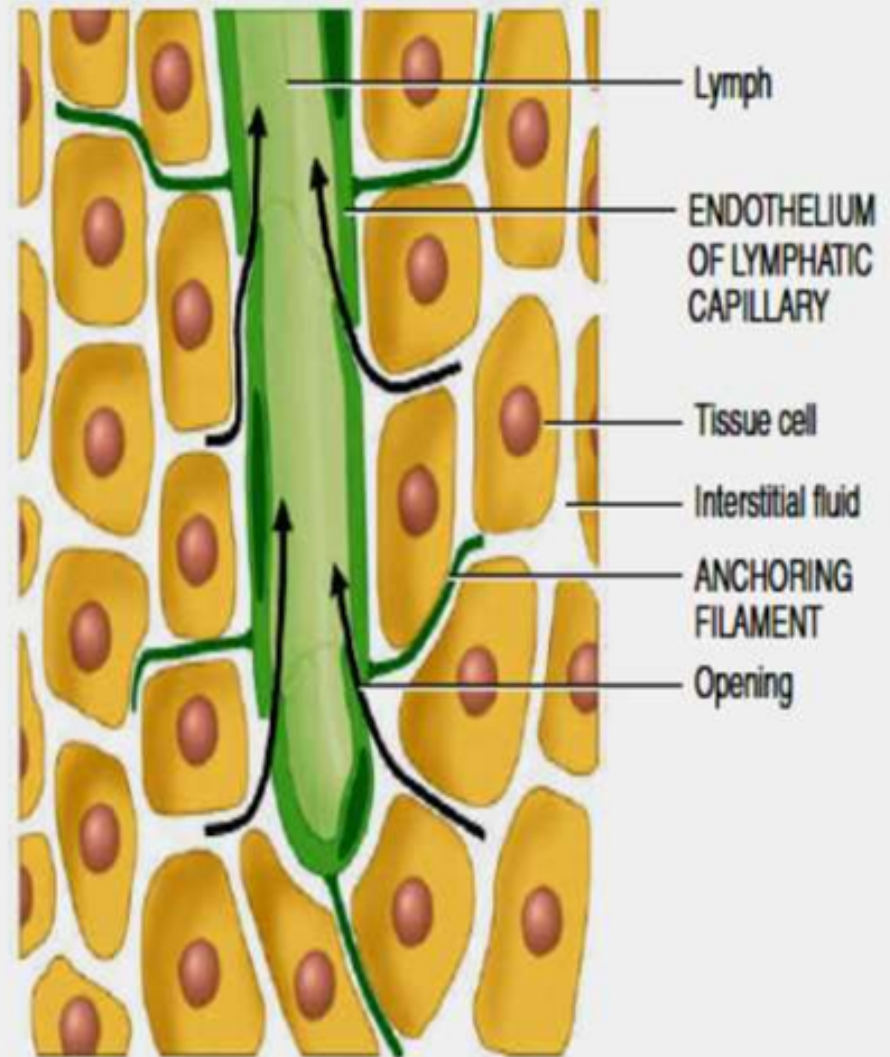
dietary lipids into lymphatic vessels and ultimately into the blood .

The presence of these lipids causes the lymph draining from the small intestine to appear creamy white; such lymph is referred to as **CHYLE** , Elsewhere, lymph is a clear, pale-yellow fluid.

🔑 Lymphatic capillaries are found throughout the body except in avascular tissues, the central nervous system, portions of the spleen, and bone marrow.



(a) Relationship of lymphatic capillaries to tissue cells and blood capillaries



(b) Details of a lymphatic capillary



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Lymphatic Vessels and Lymph Circulation

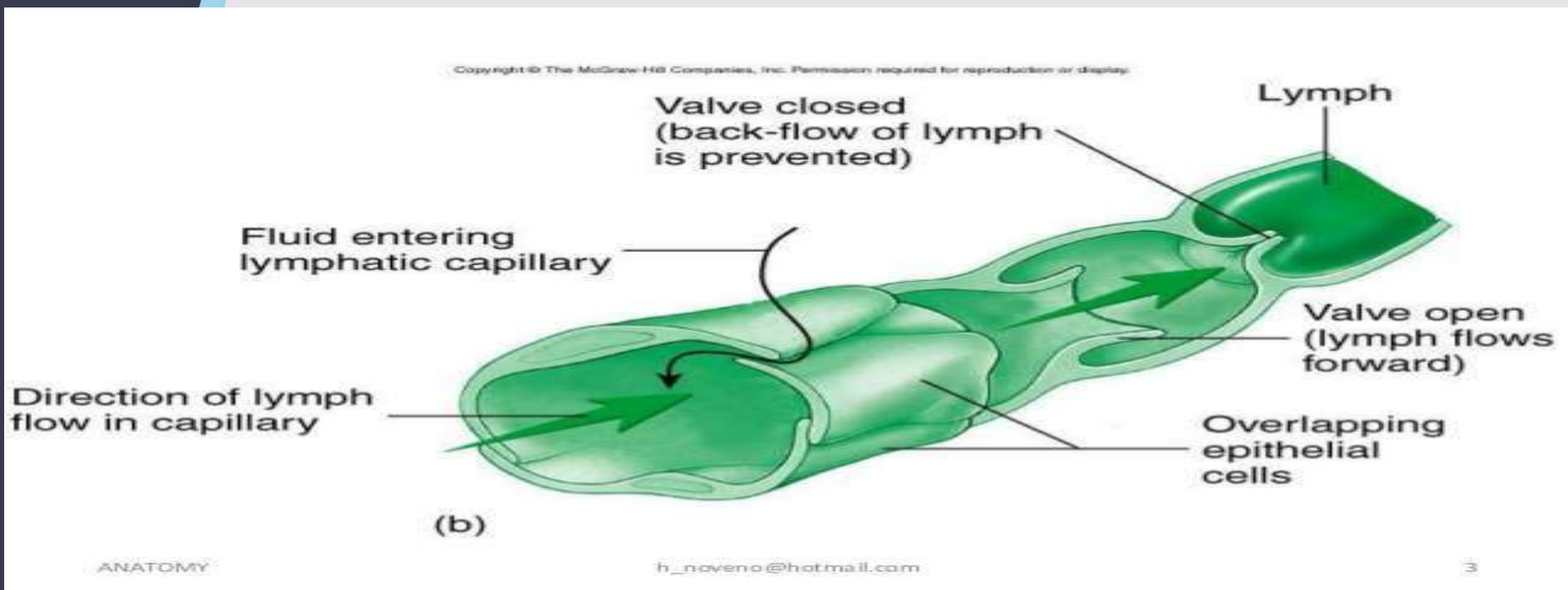
1. Most of the fluid filtering from the *arterial ends of blood capillaries flows among the cells and finally is reabsorbed back into the venous ends of the blood capillaries.*
2. *But on the average, about one tenth of the fluid instead enters the lymphatic capillaries and returns to the blood through the lymphatic system rather than through the venous capillaries.*
3. The total quantity of all this lymph is normally only 2 to 3 liters each day
4. Lymphatic vessels begin as **lymphatic capillaries**. These **capillaries**, which are located in the spaces between cells, are closed at one end.
5. Just as blood capillaries converge to form venules and then veins, lymphatic capillaries unite to form larger **lymphatic vessels, which resemble small veins** in structure but have thinner walls and more valves.



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5. At intervals along the lymphatic vessels, lymph flows through lymph nodes, encapsulated bean-shaped organs consisting of masses of B cells and T cells.
6. In the skin, lymphatic vessels lie in the subcutaneous tissue and generally follow the same route as veins;
7. Tissues that lack lymphatic capillaries include a vascular tissues (such as cartilage, the epidermis, and the cornea of the eye), the central nervous system, portions of the spleen, and red bone marrow.





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Lymph Trunks and Ducts

As you have already learned, lymph passes from lymphatic capillaries into lymphatic vessels and then through lymph nodes.

As lymphatic vessels exit lymph nodes in a particular region of the body, they unite to form **lymph trunks**. The **principal trunks** are the **lumbaintestinal**, **bronchomediastinal**, **subclavian**, and **jugular** trunks.

The **lumbar trunks drain lymph** from the lower limbs, the wall and viscera of the pelvis, the kidneys, the adrenal glands, and the abdominal wall.

The **Intestinal trunk drains lymph** from the stomach, intestines, pancreas, Spleen, and part of the liver.

lymph from the thoracic

The **Bronchomediastinal trunks** drain



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The Subclavian trunks drain the upper limbs. The jugular trunks drain the head and neck.

Lymph passes from lymph trunks into two main channels, the thoracic

duct and the right lymphatic duct, and then drains into venous blood.

The **thoracic (left lymphatic) duct is about 38– 45 cm (15–18 in.)** long and begins as a dilation called the **Cisterna chyli (cisterna cavity or reservoir) anterior** to the second lumbar vertebra.

The thoracic duct is the main duct for the return of lymph to blood.

The **cistern chyli** receives lymph from the right and left lumbar trunks

and from the intestinal trunk.

In the neck, the thoracic duct also receives lymph from the left jugular, left subclavian, and left bronchomediastinal trunks.



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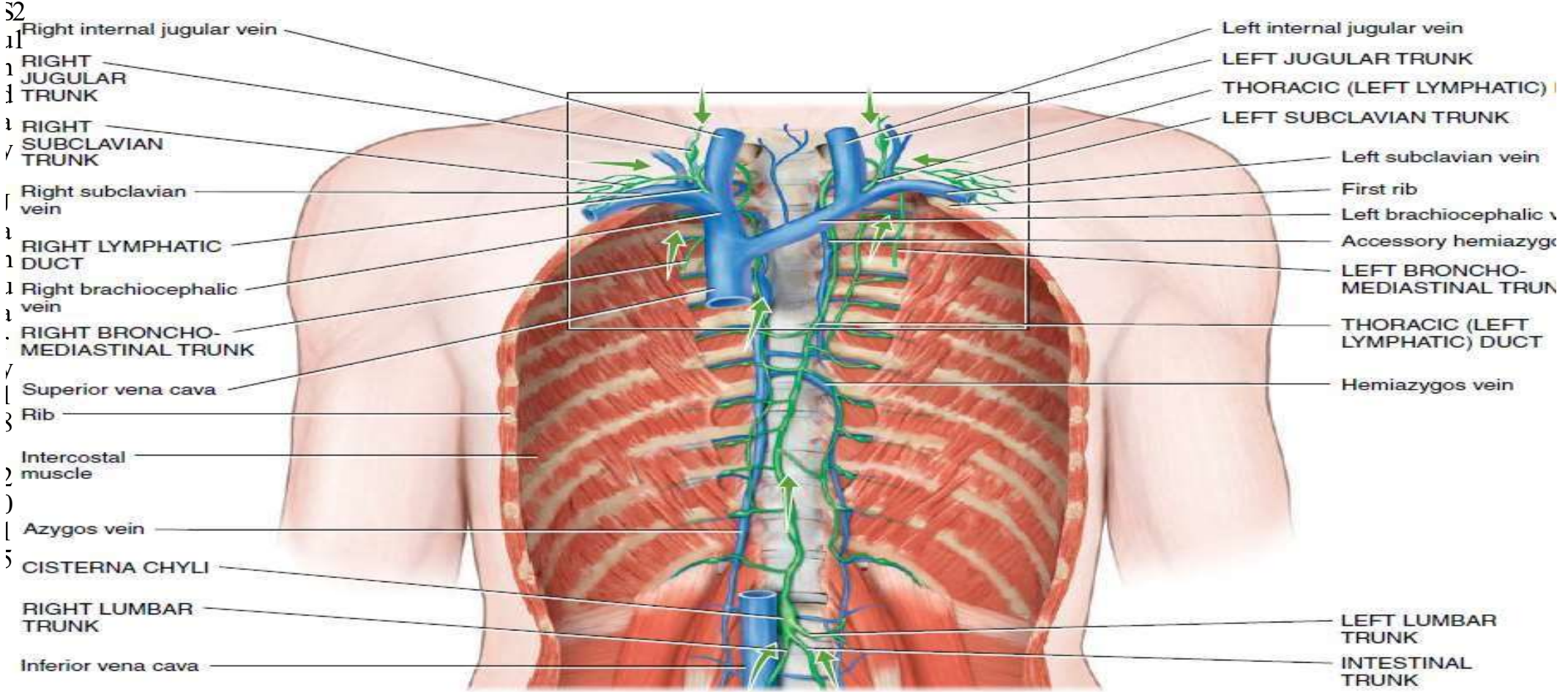
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The thoracic duct receives lymph from the left side of the head, neck, and chest, the left upper limb, and the entire body inferior to the ribs .

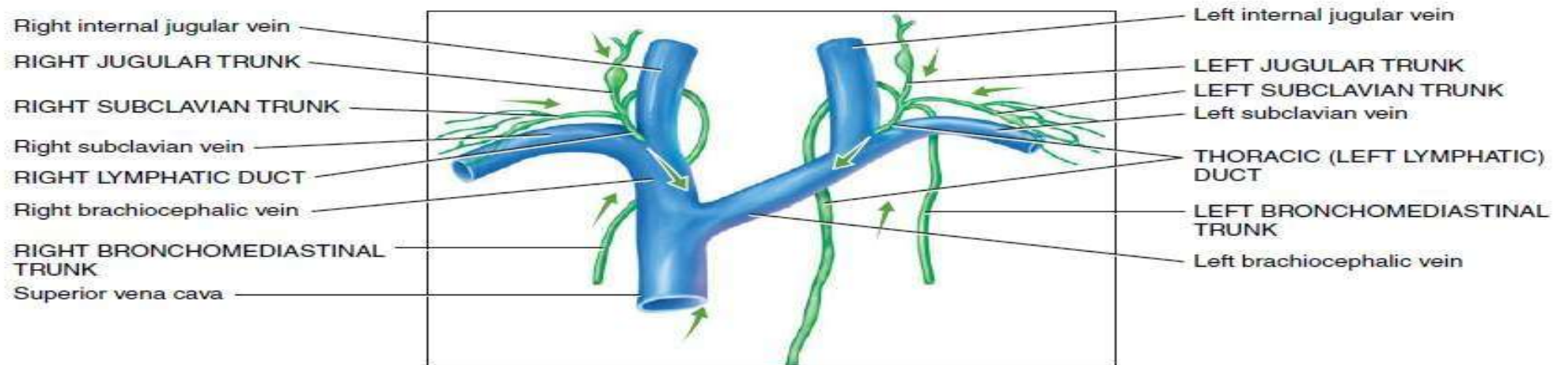
The thoracic duct in turn drains lymph into venous blood at the junction of the left internal jugular and left subclavian veins.

The **right lymphatic duct is about 1.2 cm (0.5 in.)** long and receives lymph from the right jugular, right subclavian, and right bronchomediastinal trunks.

The right lymphatic duct receives lymph from the upper right side of the body. From the right lymphatic duct, lymph drains into venous blood at the junction of the right internal jugular and right Subclavian veins.



(a) Overall anterior view



(b) Detailed anterior view of thoracic and right lymphatic duct



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Lymphatic Organs and Tissues

The tissue responsible for immunity is aggregated separately into

Primary and *Secondary lymphoid* organs.

Primary organs are **BONE MARROW & THYMUS**.

Secondary Organs Are **SPLEEN, LYMPH NODES, PAYER'S PATCHES OF GUT, & WALDEYER'S RING** (Tonsils and Adenoids).

WALDEYER'S ring of lymph consists of five tonsils.

Pharyngeal tonsil or adenoid is embedded in the posterior wall of the Nasopharynx

The two palatine tonsils lie at the posterior region of the oral cavity, one on either side, these can be removed by tonsillectomy.

The paired lingual tonsils are located at the base of the tongue.



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The primary lymphoid organs develop firstly and provide proper microenvironment for differentiation of immature precursors into functionally matured lymphocytes.

The secondary lymphoid organs provide an optional microenvironment for

attacking **Ag specific** lymphocytes directing their final maturation and

effecting the distribution of effectors into all parts of the body.

THYMUS

The **thymus** is a **Bilobed organ located in the mediastinum between the sternum and the aorta.**

An enveloping layer of connective tissue holds the two lobes closely together, but connective tissue **capsule** **separates the two.**

Extensions of



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Each thymic lobule consists of a deeply staining outer cortex and a lighter- staining central medulla.



The **cortex** is composed of large numbers of T cells and scattered

dendritic cells, epithelial cells, and macrophages.



Immature T cells (pre-T cells) migrate from red bone marrow to the cortex of the thymus, where they proliferate and begin to mature.



Dendritic cells (**den-DRIT-ik**; *dendr-* a tree), which are derived from

monocytes assist the maturation process.



Dendritic cells in other parts of the body, such as lymph nodes, play another key role in immune responses. Each of the specialized epithelial cells in the cortex has several long processes that surround and serve as a frame work for as many as 50 T cells.



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These epithelial cells help “educate” the pre-T cells in a process known as positive selection.

Additionally, they produce Thymic hormones that are thought to aid in the maturation of T cells. Only about 2% of developing T cells survive in the cortex. The remaining cells die via apoptosis.

Thymic **macrophages help clear out the debris** of dead and dying cells. The surviving T cells enter the medulla.

The ***MEDULLA*** consists of **widely scattered, more mature T**

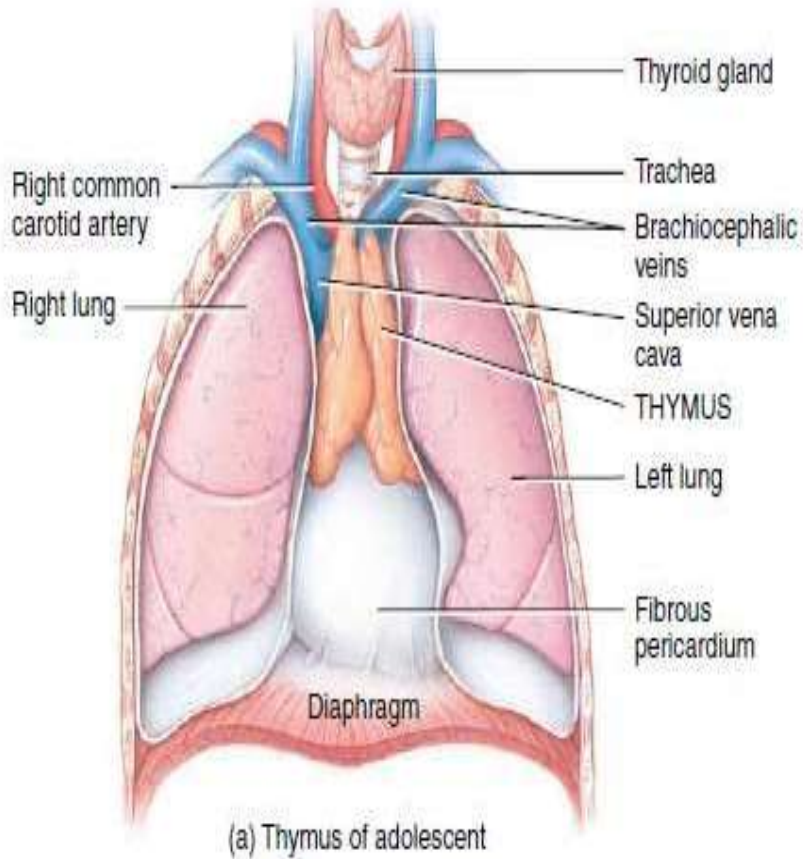
cells, epithelial cells, dendritic cells, and macrophages

Some of the epithelial cells become arranged into concentric layers of flat cells that degenerate and become filled with keratohyalin granules and keratin.

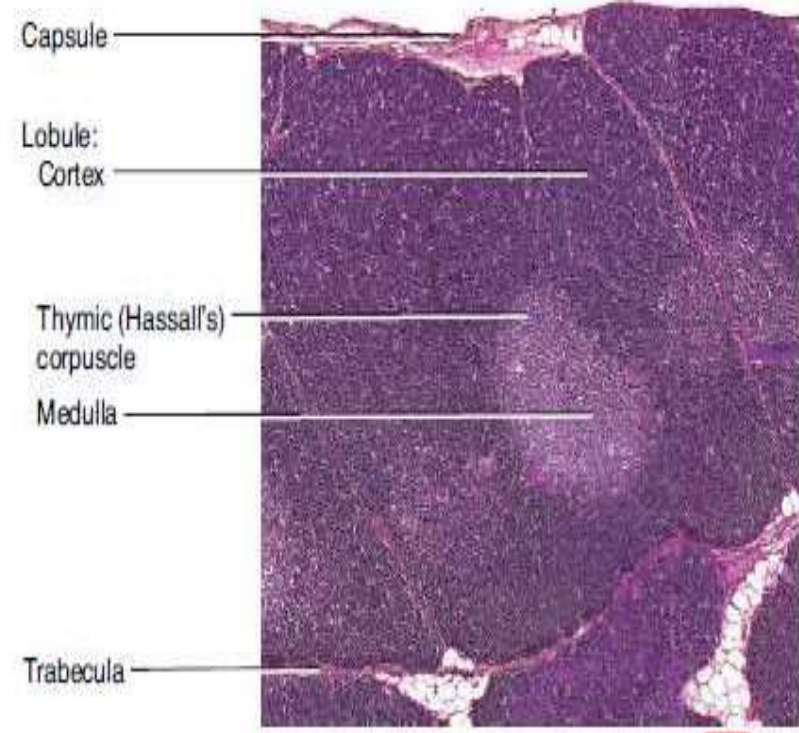
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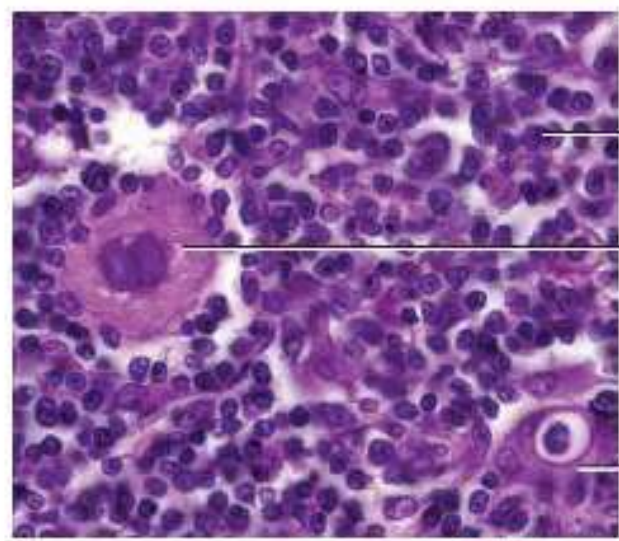


(a) Thymus of adolescent



LM 30x

(b) Thymic lobules



LM 385x

(c) Details of thymic medulla



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These clusters are called **thymic corpuscles** or *Hassall's corpuscles*. *their role is uncertain, they may serve as sites of T cell death in the medulla.*

T cells that leave the thymus via the blood migrate to lymph nodes, the spleen, and other lymphatic tissues, where they colonize parts of these organs and tissues.

Because of its high content of lymphoid tissue and a rich blood supply, the thymus has a reddish appearance in a living body. With age, fatty infiltrations replace the lymphoid tissue and the thymus takes on more of the yellowish color of the invading fat, giving the false impression of reduced size.



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The actual **size** of the thymus, defined by its connective tissue capsule, does not change. In **infants**, the thymus has a mass of about **70 g**.

It is after puberty that adipose and areolar connective tissue begin to replace the thymic tissue. By the time a person reaches maturity, the functional portion of the gland is reduced considerably, and **in old age** the functional portion may weigh only **3 g**.

Before the thymus atrophies, it populates the secondary lymphatic organs and tissues with T cells. Some T cells continue to proliferate in the thymus throughout an individual's lifetime, but this number decreases with age.



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Lymph Nodes

Located along lymphatic vessels are about 600 bean-shaped **lymph nodes**. They are scattered throughout the body, **both superficially** and deep, and usually occur in groups .

Large groups of lymph nodes are present near the mammary glands and in the axillae and groin.

Lymph nodes are 1–25 mm long and, like the thymus, are covered by a

capsule of dense connective tissue that extends into the node. The capsular extensions, called **trabeculae**, **divide the node into compartments**, provide support, and provide a route for blood vessels into the interior of a node.

Internal to the capsule is a supporting network of reticular fibers and fibroblasts. The capsule, trabeculae, reticular fibers, and fibroblasts constitute the *stroma* (supporting framework of connective tissue) of a lymph node.



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The **parenchyma (functioning part)** of a lymph node *is divided* into a superficial cortex and a deep medulla. The cortex consists of an outer cortex and an inner cortex.

Within the **outer cortex** are **egg-shaped aggregates of B cells** called

lymphatic nodules (*follicles*).

A lymphatic nodule consisting chiefly of B cells is called a *primary*

lymphatic nodule.

After B cells in a primary lymphatic nodule recognize an antigen, the primary lymphatic nodule develops into a secondary lymphatic nodule.

Most lymphatic nodules in the outer cortex are *secondary lymphatic nodules* which form in response to an antigen and are sites of plasma cell and memory B cell formation



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The center of a secondary lymphatic nodule contains a region of light-staining cells called a *germinal center*. In the *germinal center* are *B cells*, follicular dendritic cells, and macrophages.



When follicular dendritic cells “present” an antigen, *B cells* proliferate and develop into antibody-producing plasma cells or develop into memory *B cells*.



Memory *B cells* persist after an initial immune response and “remember” having encountered a specific antigen. *B cells* that do not develop properly undergo apoptosis and are destroyed by macrophages.



The region of a secondary lymphatic nodule surrounding the germinal center is composed of accumulations of *B cells* that have migrated away from their site of origin within the nodule.



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The **inner cortex does not contain lymphatic nodules**. It consists mainly of T cells and dendritic cells that enter a lymph node from other tissues.

The dendritic cells present antigens to T cells, causing their proliferation.

The newly formed T cells then migrate from the lymph node to areas of the body where there is antigenic activity.

The **medulla of a lymph node contains B cells, antibody producing** plasma cells that have migrated out of the cortex into the medulla, and macrophages.

lymph flows through several **afferent lymphatic vessels** which penetrate the convex surface of the node at several points.



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The afferent vessels contain valves that open toward the center of the node, directing the lymph *inward*. *Within the node*, enters **sinuses**, a **series of irregular channels that contain** branching reticular fibers, lymphocytes, and macrophages.

From the afferent lymphatic vessels, lymph flows into the **subcapsular Sinus**, from here the lymph flows through **trabecular sinuses**, into **medullary sinuses**. The medullary sinuses drain into one or two **efferent lymphatic vessels**

Efferent lymphatic vessels. which are wider and fewer in number than afferent vessels. They contain valves that open away from the center of the lymph node to convey lymph, antibodies secreted by plasma cells, and activated T cells *out of the node*. *Efferent lymphatic vessels emerge* from one side of the lymph node at a slight depression called a **hilum** **Blood vessels also enter and leave the node at the hilum**



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Lymph nodes function as a type of filter. As lymph enters one end of a lymph node, foreign substances are trapped by the reticular fibers within the sinuses of the node. Then macrophages destroy some foreign substances by phagocytosis, while lymphocytes destroy others by immune responses.

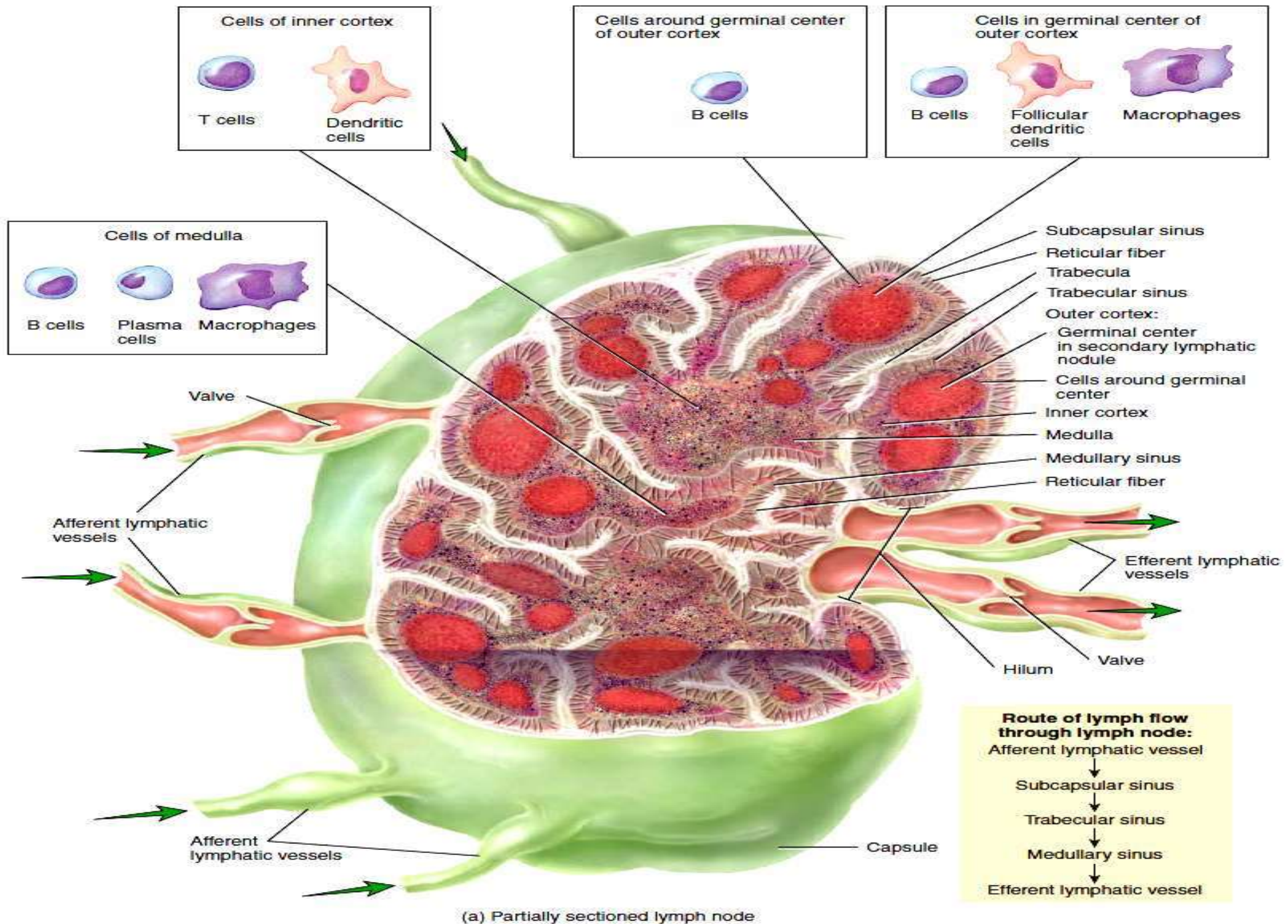
The filtered lymph then leaves the other end of the lymph node. There are many afferent lymphatic vessels that bring lymph into a lymph node and only one or two efferent lymphatic vessels that transport lymph out of a lymph node, the **slow flow** of lymph within the lymph nodes allows **additional** time for lymph to be filtered. Additionally,

All lymph flows through multiple lymph nodes on its path through the lymph vessels. This exposes the lymph to multiple **filtering events before** returning to the blood.

Figure 22.6 Structure of a lymph node. Arrows indicate the direction of lymph flow through a lymph node.



Lymph nodes are present throughout the body, usually clustered in groups.



(a) Partially sectioned lymph node



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SPLEEN

The oval spleen is the largest single mass of lymphatic tissue in the

body, measuring about 12 cm (5 in.) in length.

It is located in the left hypochondriac region between the stomach and diaphragm. The superior surface of the spleen is smooth and convex and conforms to the concave surface of the diaphragm.

Neighbouring organs make indentations in the visceral surface of the spleen—the *gastric impression* (stomach), the *renal impression* (left kidney), and the *colic impression* (left colic flexure of large intestine).

Like lymph nodes, the spleen has a hilum. Through it pass the splenic

artery, splenic vein, and efferent lymphatic vessels.

A capsule of dense connective tissue surrounds the spleen



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The parenchyma of the spleen consists of two different kinds of tissue called white pulp and red pulp



White pulp is lymphatic tissue & The red pulp consists of blood- filled venous sinuses

Within the red pulp, the spleen performs three functions related to

blood cells:

- a) Removal by ruptured, worn out, or defective blood cells and platelets
- b) Storage of platelets, up to one-third of the body's supply
- c) **Production of blood cells** during fetal life.

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🔑 The spleen is the largest single mass of lymphatic tissue in the body.

