

Lymphatic System

Lymph: Definition And Composition

Definition:

- **Lymph** is a **clear to slightly yellowish fluid** that is derived from **interstitial fluid** (the fluid that surrounds tissue cells).
- It enters **lymphatic vessels** and eventually returns to the **blood circulation**.
 - It is similar to plasma but **contains less protein**.
 - It plays a vital role in **immune defense** and in **maintaining fluid balance**.

Composition of Lymph

The composition of lymph varies depending on the location in the body, but generally includes:

Component	Description
Water	Major component (~95%)
Proteins	Lower concentration than plasma, includes albumin, globulins
Electrolytes	Sodium, potassium, calcium, etc.
Lymphocytes	Especially T and B cells for immune defense
Macrophages	Engulf pathogens and debris
Lipids (chyle)	Present especially in intestinal lymph (from lacteals)
Waste products	From cellular metabolism
Occasional pathogens	Bacteria, viruses (filtered in lymph nodes)

Formation of Lymph

- Lymph is formed through a carefully regulated process that begins with filtration of plasma from blood capillaries and ends with its entry into lymphatic vessels.
- This process ensures the return of interstitial fluid to the bloodstream and plays a crucial role in fluid balance, immunity, and waste removal.

Step-by-Step Process

A. Capillary Filtration

- At the **arterial end of blood capillaries**, **hydrostatic pressure** forces plasma out of the capillaries into the surrounding tissue spaces.
- This filtered plasma becomes **interstitial fluid**.
- Approximately **20 liters per day** of fluid is filtered into the tissues.

B. Interstitial Fluid Exchange

- The interstitial fluid bathes tissue cells, providing oxygen, nutrients, and hormones, while also collecting metabolic waste products and carbon dioxide.
- Of this fluid, about 17 liters per day are reabsorbed into the capillaries at the venous end, driven by osmotic (oncotic) pressure.

C. Lymph Formation

- The remaining 3 liters per day of interstitial fluid that are not reabsorbed enter the lymphatic system, becoming lymph.
- This fluid contains proteins, cell debris, pathogens, and sometimes immune cells.

D. Entry into Lymphatic Capillaries

- **Lymphatic capillaries** are:
 - Blind-ended, meaning they are closed at one end.
 - Lined with endothelial cells that form flap-like one-way valves.
- Fluid enters when interstitial fluid pressure exceeds lymphatic pressure, pushing the flaps open.
- Once inside, the fluid is officially termed **lymph**.

Lymphatic System

- The lymphatic system is a **crucial part** of the circulatory and immune systems.
- It is a network of vessels, tissues, and organs that help maintain **fluid balance**, remove **waste products**, and defend the body against **infections and diseases**.

Main Components of the Lymphatic System

1. Lymphatic Vessels:

- A network of thin-walled vessels that transport lymph, a clear fluid containing excess interstitial fluid, proteins, waste, and immune cells.
- Present throughout the body (except CNS, avascular tissues, and bone marrow), they help maintain fluid balance by returning excess fluid to the bloodstream.

2. Lymph Nodes:

- Small, bean-shaped structures along lymphatic vessels, rich in lymphocytes (B and T cells) and macrophages.
- Filter lymph, detect and eliminate pathogens, and serve as sites for immune cell activation and proliferation.

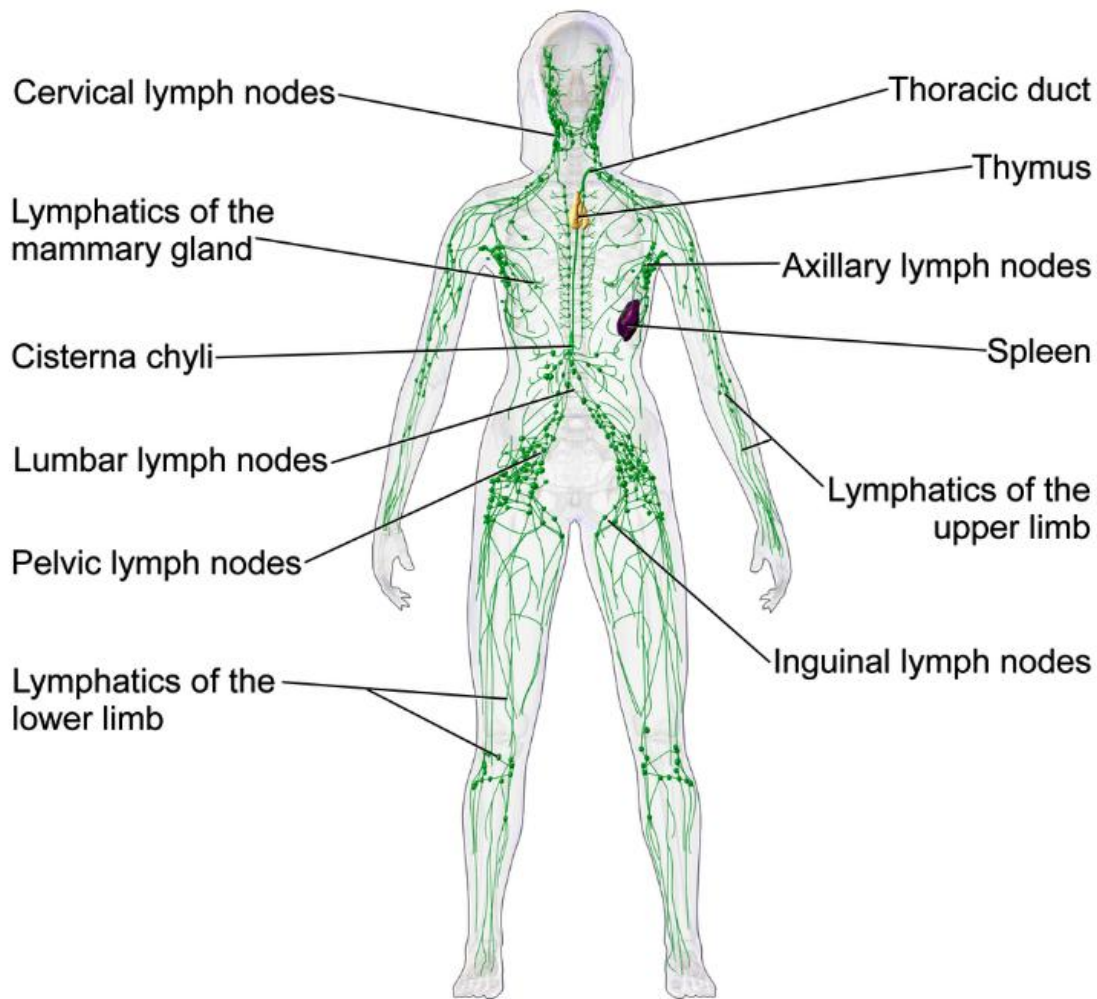
3. Lymphoid Organs:

- Specialized organs involved in immune function.

- **Primary:** Bone marrow and thymus (where lymphocytes are generated and mature).
- **Secondary:** Spleen, tonsils, adenoids, Peyer's patches (where immune cells interact with antigens and initiate immune responses).

4. **Lymphocytes:**

- White blood cells crucial for adaptive immunity.
- **B cells:** Produce antibodies.
- **T cells:** Regulate immune responses and attack infected or abnormal cells.



Lymphatic System

The lymphatic system essential functions

1. Fluid balance:

- It helps maintain fluid balance by collecting excess interstitial fluid from tissues and returning it to the bloodstream.

2. Waste removal:

- The lymphatic system transports waste products, cellular debris, and foreign particles away from tissues for elimination.

3. Immune defence:

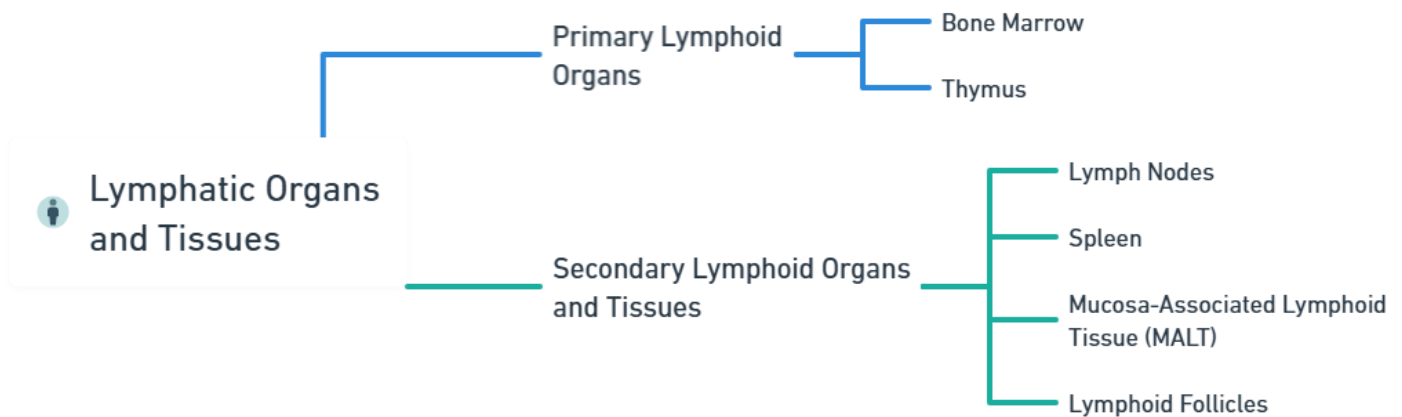
- The lymphatic system is involved in both innate and adaptive immune responses.
- Lymph nodes and other lymphoid organs filter pathogens and abnormal cells from lymph, and immune cells in these tissues help detect and eliminate threats.

4. **Fat absorption:**

- Lymphatic vessels in the intestines, known as lacteals, absorb dietary fats and fat-soluble vitamins from the digestive system and transport them to the bloodstream.

Lymphatic Organs and Tissues

- Vital for the immune system, providing environments for immune cells to develop, mature, and interact with antigens.
- Classified into **primary lymphoid organs** (where lymphocytes are generated and mature) and **secondary lymphoid organs** (where immune responses are initiated).



Primary Lymphoid Organs:

1. **Bone Marrow:**

- Soft tissue in bone cavities, site of hematopoiesis (blood cell production).
- B cells are generated and mature here, expressing unique antigen receptors.

2. **Thymus:**

- Bi-lobed organ in the upper chest, where T cells mature and differentiate.
- Immature T cells from the bone marrow undergo selection to ensure proper immune response.

Secondary Lymphoid Organs and Tissues:

1. **Lymph Nodes:**

- Bean-shaped structures along lymphatic vessels containing B cells, T cells, macrophages, and dendritic cells.
- Filter lymph, trap pathogens, and facilitate immune cell-antigen interactions to initiate adaptive immune responses.

2. Spleen:

- Organ in the upper left abdomen that filters blood, removes old red blood cells, recycles iron, and hosts immune responses to bloodborne pathogens.

3. Mucosa-Associated Lymphoid Tissue (MALT):

- Lymphoid tissues in mucous membranes (e.g., gastrointestinal, respiratory tracts).
- Includes Peyer's patches, tonsils, and adenoids, protecting against pathogens entering through mucosal surfaces.

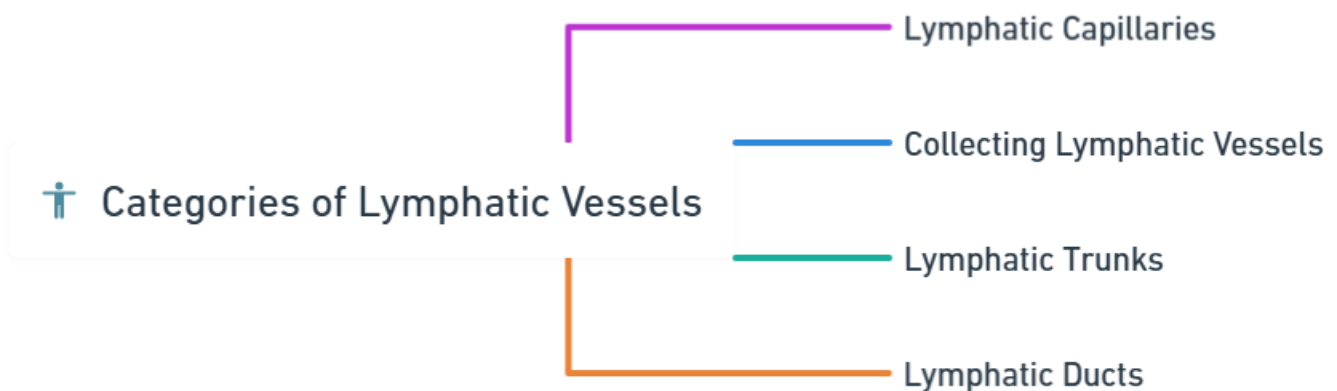
4. Lymphoid Follicles:

- Clusters of immune cells, mainly B cells, in secondary lymphoid organs like lymph nodes, spleen, and MALT.
- Crucial for B cell activation and antibody production.

Lymphatic Vessel

- Lymphatic vessels are crucial components of the lymphatic system, forming a network of thin-walled, branching tubes that transport lymph—a clear fluid containing excess interstitial fluid, proteins, waste, and immune cells.
- They maintain fluid balance by returning excess fluid from tissues to the bloodstream.

Categories of Lymphatic Vessels



1. Lymphatic Capillaries:

- Smallest lymphatic vessels, composed of a single layer of endothelial cells.
- Specialized structure allows absorption of excess interstitial fluid and large molecules.
- Found in nearly all body tissues except the CNS, avascular tissues, and bone marrow.

2. Collecting Lymphatic Vessels:

- Larger vessels that gather lymph from lymphatic capillaries.
- Contain smooth muscle cells and valves to prevent backflow.



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