# Lymphatic system

## Lymph

- Lymph is a clear, colorless fluid that circulates through the lymphatic system.
- It originates from interstitial fluid.
- The fluid that surrounds the body’s cells plays a crucial role in maintaining fluid balance, immunity, and waste removal.

## Composition of Lymph

Lymph is made up of several key components:

1. **Water** – The main component, making up over 90% of lymph.
2. **Proteins** – Mainly small plasma proteins that have escaped from the bloodstream.
3. **Electrolytes** – Such as sodium, potassium, and calcium.
4. **Waste Products** – Including cellular debris and metabolic by-products.
5. **Lipids** – Especially after absorption from the intestines (chyle, a lipid-rich lymph, is milky in appearance).
6. **Immune Cells** – Especially **lymphocytes** (B and T cells) and **macrophages**.
7. **Pathogens** – Such as bacteria, viruses, or abnormal cells (e.g., cancer cells) picked up from tissues.

## Function of Lymph

Lymph serves several vital functions in the body:

### 1. Fluid Balance:

- Returns excess interstitial fluid to the bloodstream, preventing tissue swelling (**edema**).

### 2. Immune Surveillance:

- Transports immune cells and foreign substances (like pathogens) to **lymph nodes** where immune responses are initiated.

### 3. Fat Absorption:

- Specialized lymphatic capillaries in the small intestine (**lacteals**) absorb fats and fat-soluble vitamins from the digestive tract and transport them via lymph.

### 4. Waste Removal:

- Clears waste products and cellular debris from tissues.

## Formation of Lymph

The formation of lymph is a dynamic process involving several steps:

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1. **Capillary Filtration:**
   - Blood pressure forces plasma out of capillaries into the **interstitial space**, forming **interstitial fluid**.
2. **Interstitial Fluid Uptake:**
   - Most interstitial fluid is reabsorbed into blood capillaries, but about **10%** enters **lymphatic capillaries**.
3. **Lymph Formation:**
   - Once inside lymphatic vessels, interstitial fluid is called **lymph**.
   - Lymphatic capillaries have **flap-like valves** that open when tissue pressure increases, allowing fluid to enter.
4. **Transport and Filtration:**
   - Lymph is carried through progressively larger lymphatic vessels, passing through **lymph nodes**, where it is filtered.
   - Eventually, lymph drains into the **venous circulation** via the **thoracic duct** or **right lymphatic duct**.

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# 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

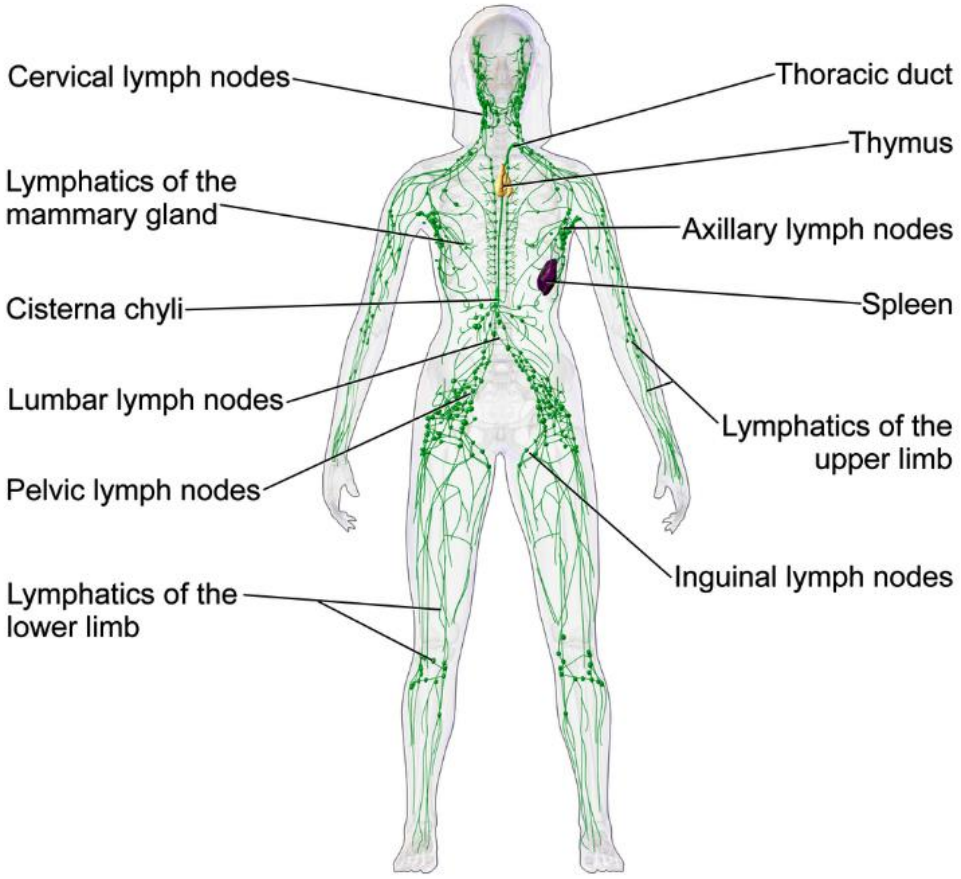
1. **Lymphatic Vessels:**
   - A network of thin-walled vessels that transport lymph, a clear fluid containing excess interstitial fluid, proteins, waste, and immune cells.
   - Present throughout the body (except CNS, avascular tissues, and bone marrow), they help maintain fluid balance by returning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

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- **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.




## The lymphatic system performs several essential functions, including:

### A. Fluid balance:

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

### B. Waste removal:

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

### C. 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.

### D. Fat absorption:

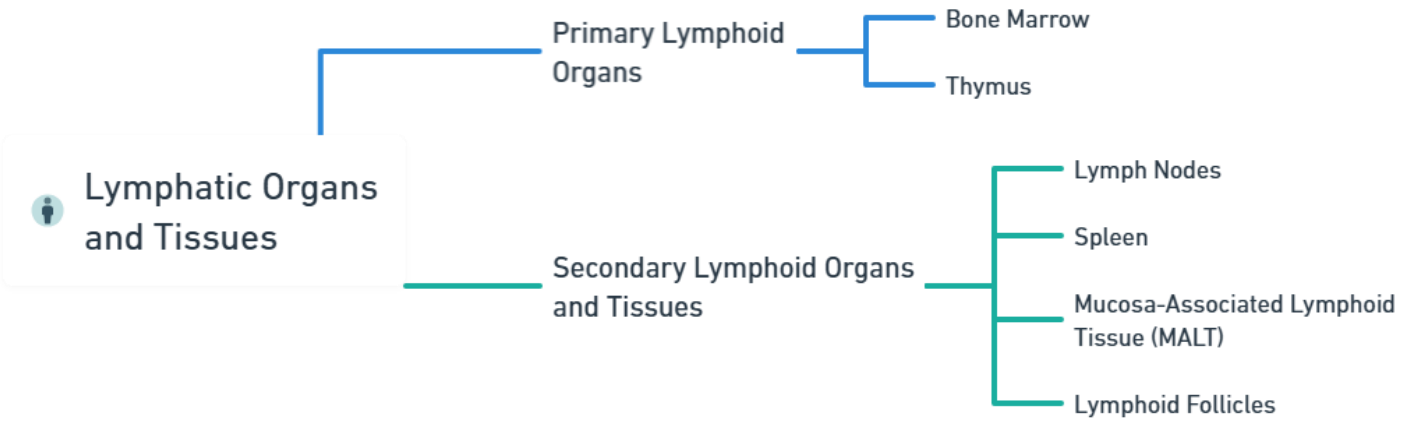
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- Lymphatic vessels in the intestines, known as lacteals, absorb dietary fats and fat-soluble vitamins from the digestive system and transport them to the bloodstream.

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# 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:

### A. 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.

### B. Spleen:

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

### C. Mucosa-Associated Lymphoid Tissue (MALT):

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

### D. Lymphoid Follicles:

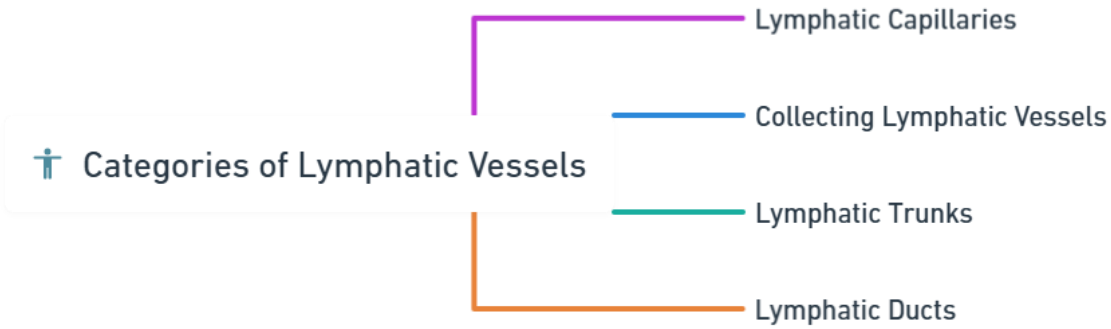
- Clusters of immune cells, mainly B cells, in secondary lymphoid organs like lymph nodes, spleen, and MALT.
- Crucial for B cell activation and antibody production.

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# 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.
- Transport lymph through lymph nodes, where it is filtered, and immune cells detect and eliminate pathogens.

### 3. Lymphatic Trunks:

- Formed by the convergence of collecting lymphatic vessels after they pass through lymph nodes.
- Drain lymph from specific body regions, such as the jugular trunk (head and neck) and lumbar trunk (lower limbs and pelvis).

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