NOVA

Charting New Horizons in Education

Cells and Organs of the Immune System

03

Immunology

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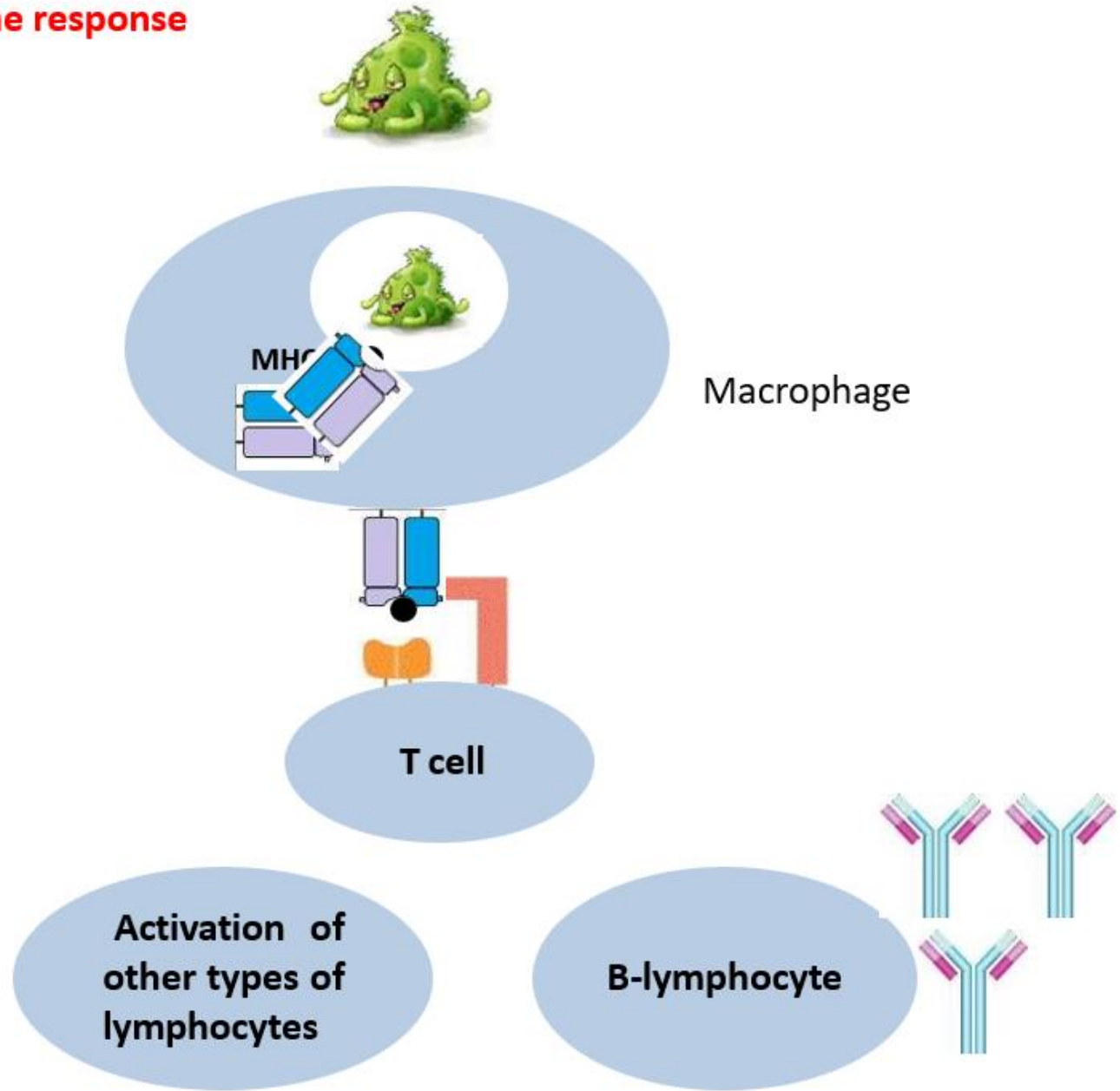
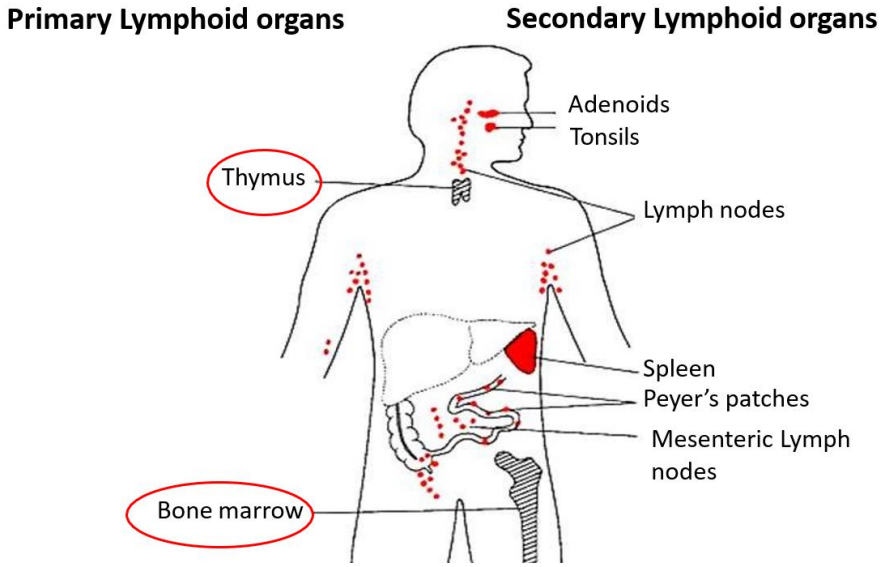
Principle of immune response



Lymphoid organs

Lymphoid Organs

- Lymphoid organs are distributed throughout the body.
- These organs and tissues are interconnected by blood vessels and lymphatic vessels, through which lymphocytes circulate.
- Lymphoid organs are classified into:
  - **Primary (central) lymphoid organs**
  - **Secondary (peripheral) lymphoid organs**

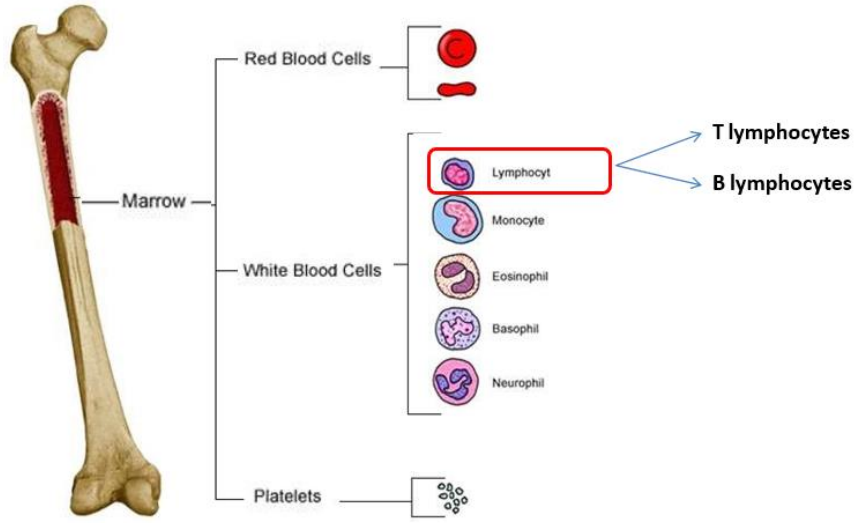


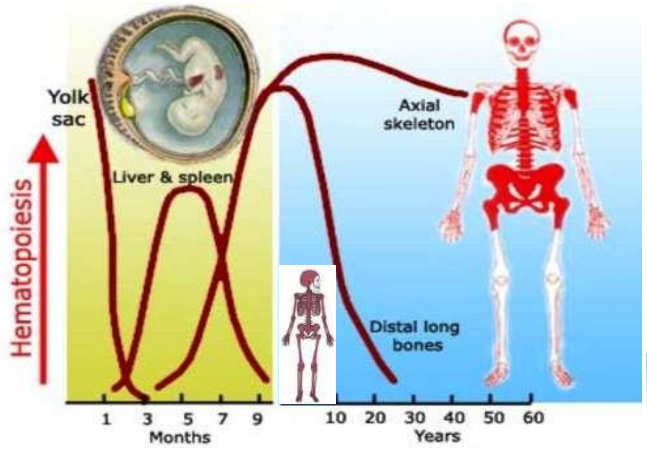
Primary Lymphoid Organs;

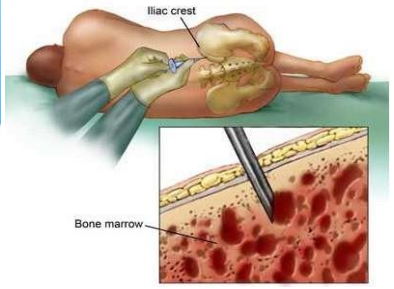
- The **thymus** and **bone marrow** are known as central lymphoid organs.
- They are responsible for the synthesis and maturation of lymphoid cells

Bone Marrow

- All the cells of the immune system are initially derived from the bone marrow through a process called **hematopoiesis**.
- In the fetus, hematopoiesis occurs initially in the **yolk sac** and later in the **liver** and **spleen**. After birth, this function is taken over by the bone marrow.
- During hematopoiesis:
  - **B-cells** mature in the bone marrow itself.
  - **T-cells** migrate out of the bone marrow to continue their maturation in the thymus.

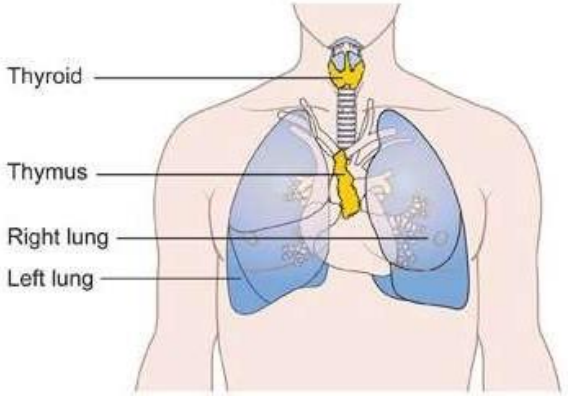


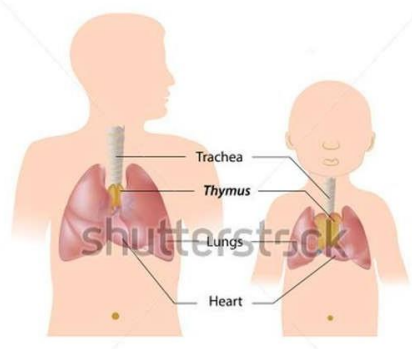


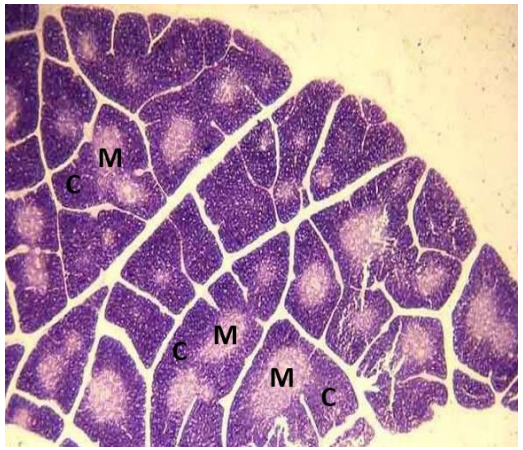


Thymus

- The **thymus** is a gland located in the anterior mediastinum, just above the heart. It reaches its greatest size just before birth, then atrophies with age, and the production of new T cells in adults declines.
- Immature lymphocytes begin to accumulate in the thymus of human embryos around **90-100 days after fertilization**.
- The thymus is divided into:
  - **Cortex** – contains mostly immature T cells, some of which mature and migrate to the medulla.
  - **Medulla** – where mature T cells gather before leaving the thymus.
- **T cells** leave the medulla, enter the peripheral blood circulation, and are transported to secondary lymphoid organs.

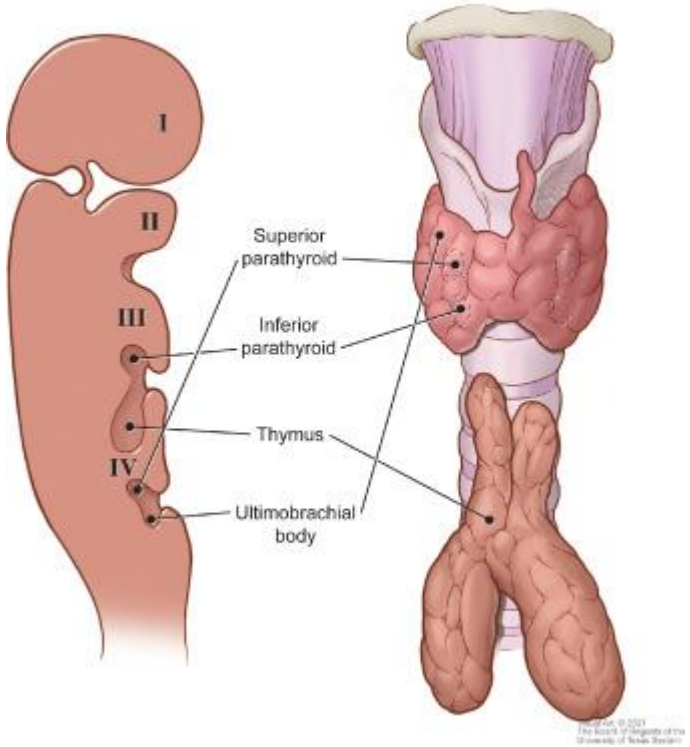






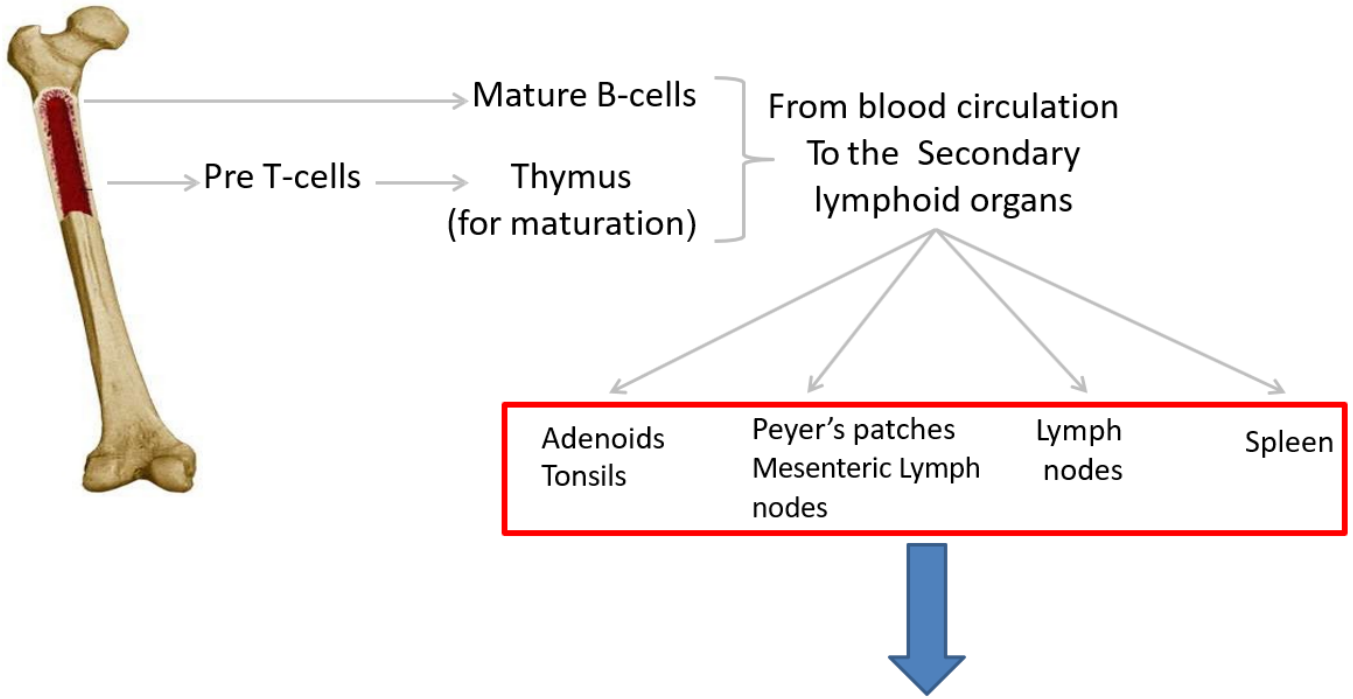
Thymus

- **DiGeorge syndrome** (thymic aplasia or thymic hypoplasia); occurs in children with abnormal thymus development. It is characterized by a deficiency in T cell development, though B cells remain normal, leading to immune disorders due to reduced T cell numbers.



Secondary (Peripheral) Lymphoid Organs

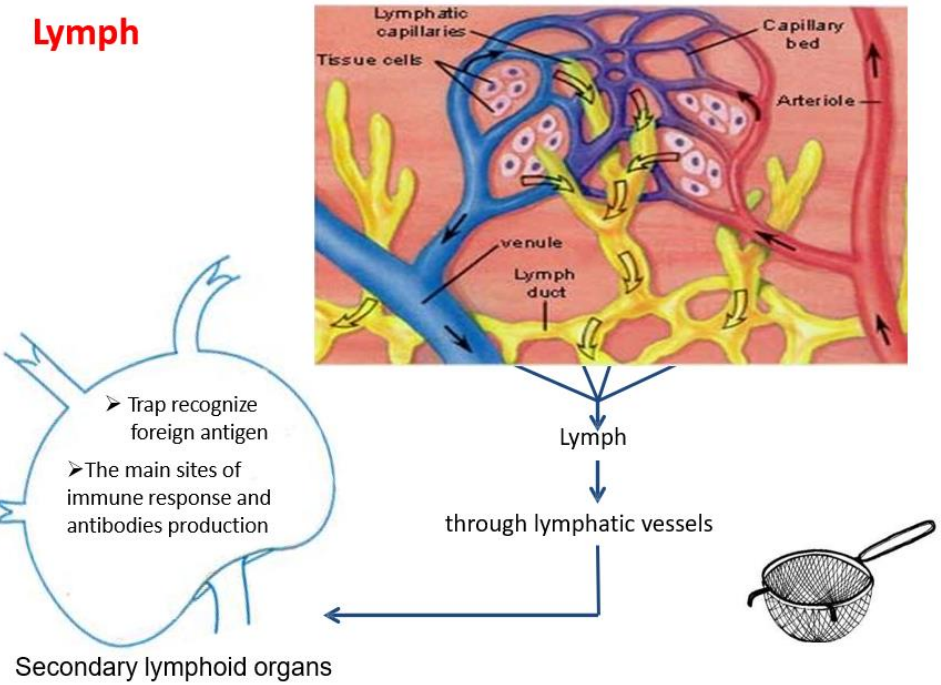
- **B cells** leave the bone marrow completely mature and begin homing in secondary lymphoid tissues.
- **T cells** complete their maturation in the thymus gland before settling in secondary lymphoid tissue

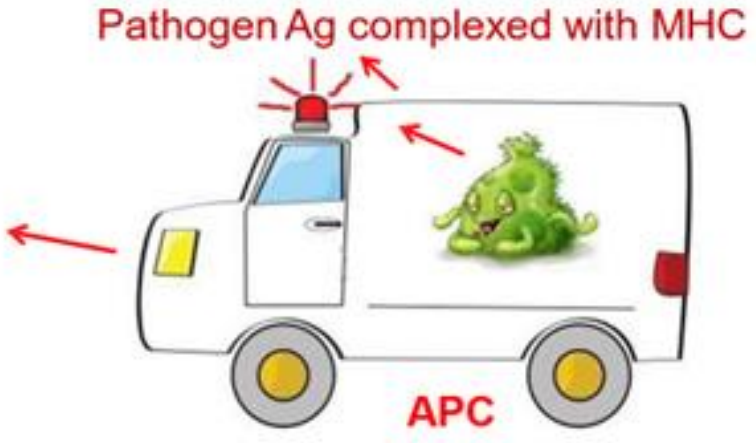


•Some lymphoid organs are **capsulated** (e.g., lymph nodes and spleen), while others are **non-capsulated**, such as **mucosa-associated lymphoid tissue (MALT)**.

Lymph Node

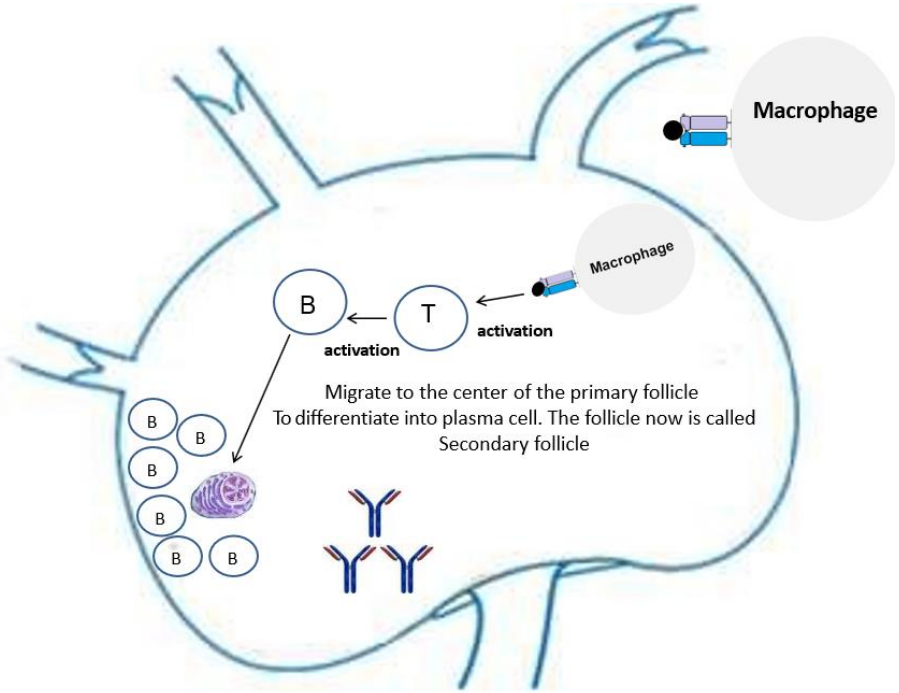
- **Lymph** is formed when interstitial fluid is collected through lymph capillaries. It is then transported through lymph vessels to **lymph nodes**, before emptying into the right or left subclavian vein, where it mixes back with blood. Lymph may pick up bacteria and bring them to lymph nodes, where they are destroyed.
- These organs are the sites where lymphocytes:
  - Localize, trap, and recognize foreign antigens.
  - Are the main sites for antibody production.



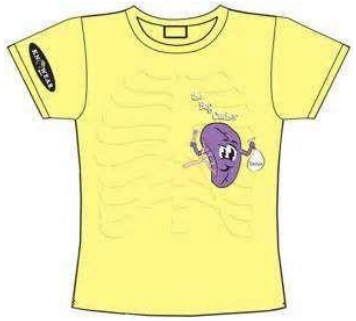


Lymph Node

- **Lymph nodes** are located in the neck, axillae, groin, mediastinum, and abdominal cavity.
- Each lymph node is divided into three regions:
  - **Outer cortex** – also referred to as the **B cell area**, primarily consisting of B cells.
  - **Inner medulla** – contains plasma cells.
  - **Paracortical region** – also known as the **T cell area**, where T cells reside.
- Aggregates of B cells are called **follicles**:
  - **Primary follicles** contain mature but resting B cells.
  - **Secondary follicles** are activated and have central areas called **germinal centers**, which contain reactive B cells and plasma cells.
- **Germinal centers** develop in response to antigenic stimulation and consist of reactive B cells.



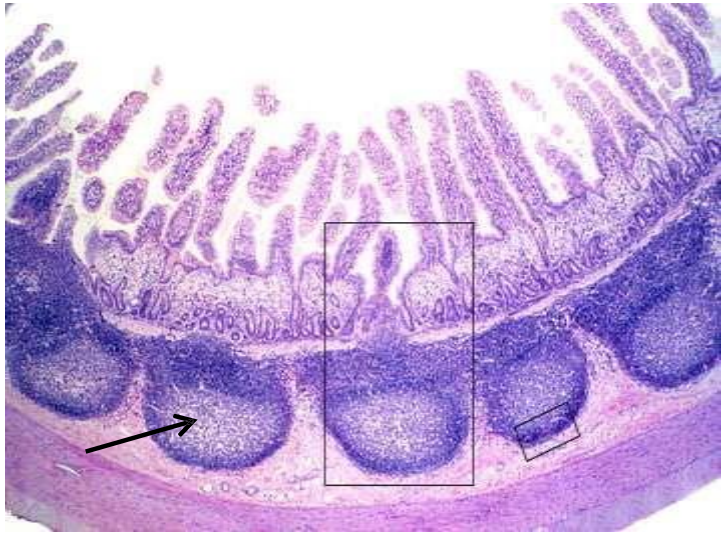
Spleen



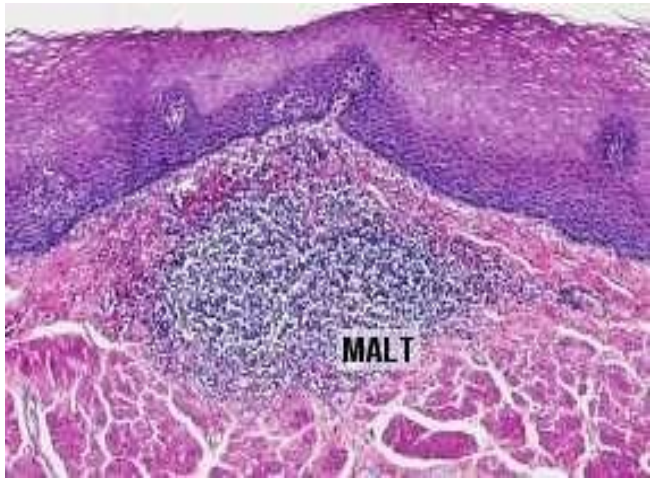
- The **spleen** is the largest single lymphoid organ in the body.
- Location: left upper quadrant of the abdomen and weighing about 150 grams
- It filters blood and is a major site for the synthesis and release of antibodies into circulation.
- The spleen plays a critical role in the phagocytosis of antibody-coated bacteria. As a result, individuals without a spleen (e.g., after splenectomy) are highly susceptible to infections by capsulated bacteria such as **pneumococci** and **meningococci**.
- The spleen consists of two types of tissue:
  - **Red pulp** – the site where aged platelets and erythrocytes are destroyed.
  - **White pulp** – contains **T lymphocytes** clustered around small arterioles, known as the **periarteriolar lymphoid sheath (PALS)**.
- **Lymphoid follicles**, predominantly composed of B cells, are attached to the PALS.
  - Activation of **B cells** occurs at the junction between the follicle and PALS.
  - Activated B cells migrate to the **germinal centers** to differentiate into plasma cells and begin antibody production.

Mucosa-Associated Lymphoid Tissue (MALT)

- Over **50% of lymphoid tissue** in the body is associated with the mucosal system.
- **MALT** is composed of:
  - **Gut-associated lymphoid tissue (GALT)**, lining the intestinal tract.
  - **Bronchus-associated lymphoid tissue (BALT)**, lining the respiratory tract.
  - Lymphoid tissue lining the **genitourinary tract**.
- The primary function of MALT is to provide local immunity through the production of **IgA** and **IgE immunoglobulins**.
- The **intestinal epithelium** overlying Peyer's patches is specialized to transport antigens into lymphoid tissue.
  - This function is carried out by specialized epithelial cells known as **microfold (M) cells**.
  - **M cells** endocytose, transport, and present antigens to subepithelial lymphoid cells, initiating a response to foreign antigens.

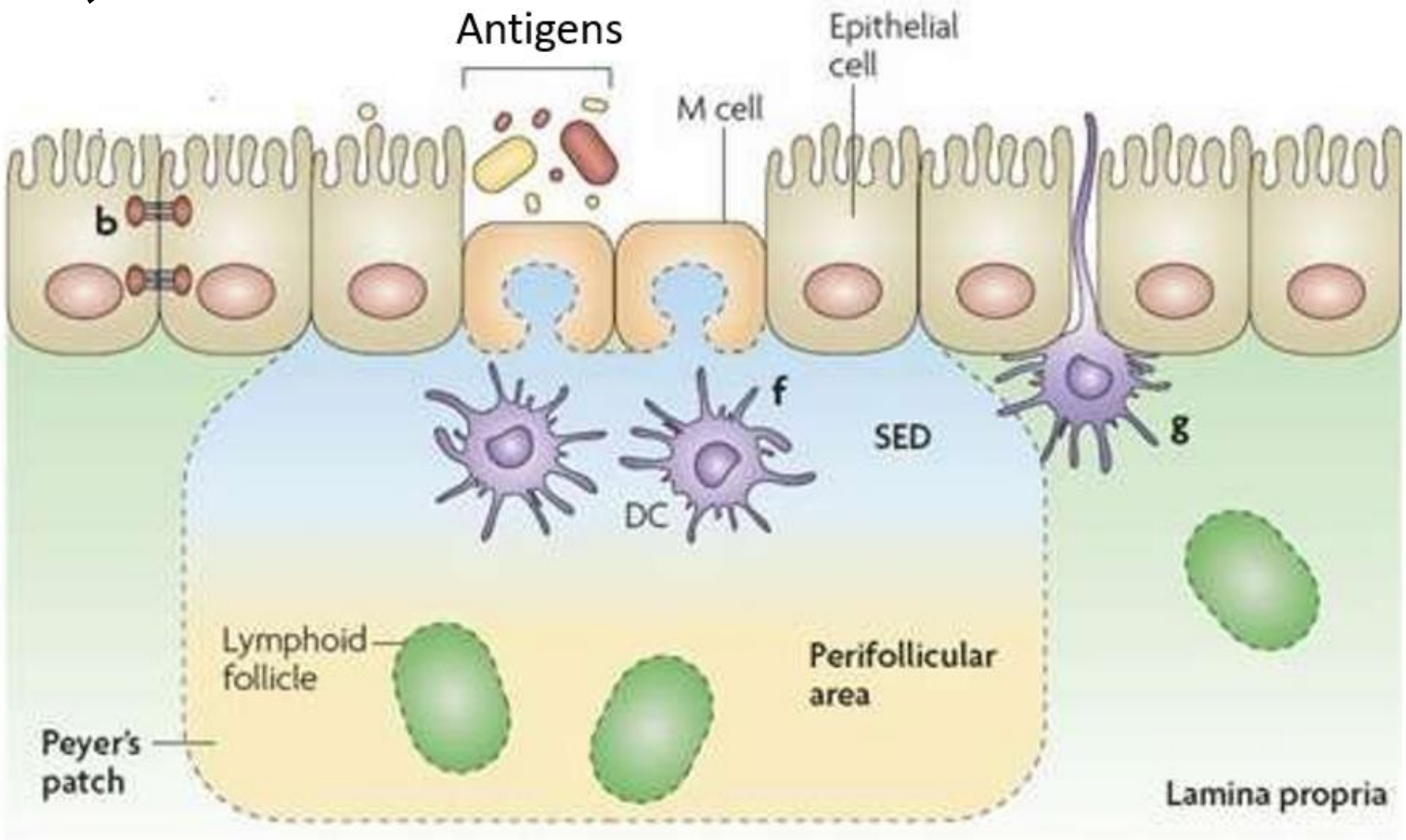


ileum, Peyer's patches



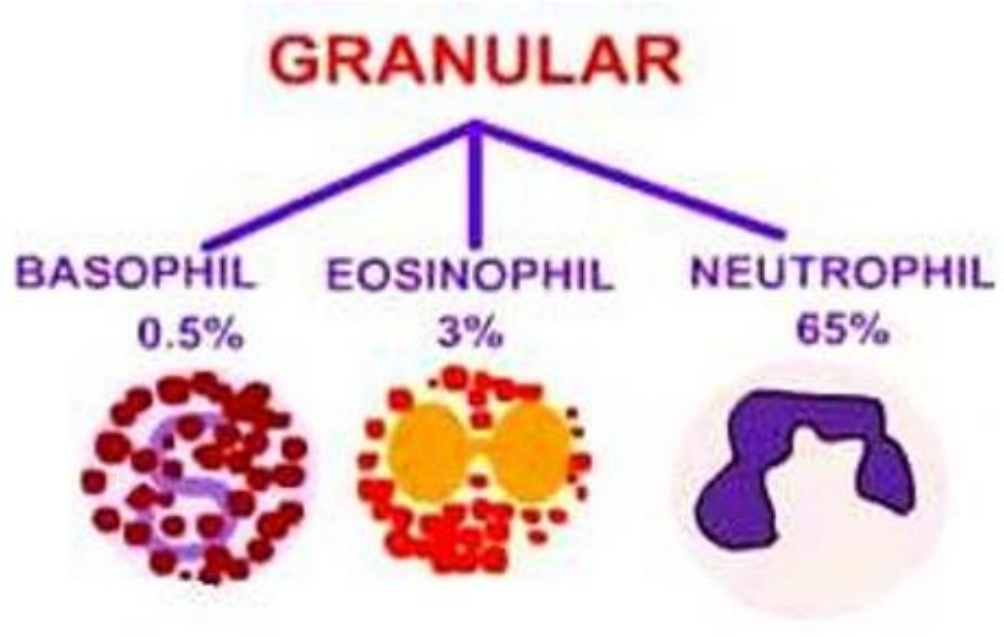
Esophagus MALT

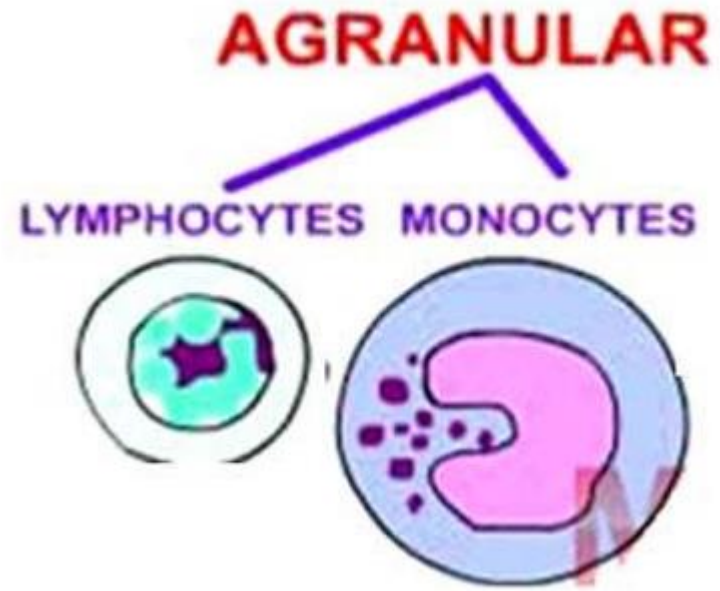
Mucosa-Associated Lymphoid Tissue (MALT)



Cells of the Immune System

Cells of the Immune System



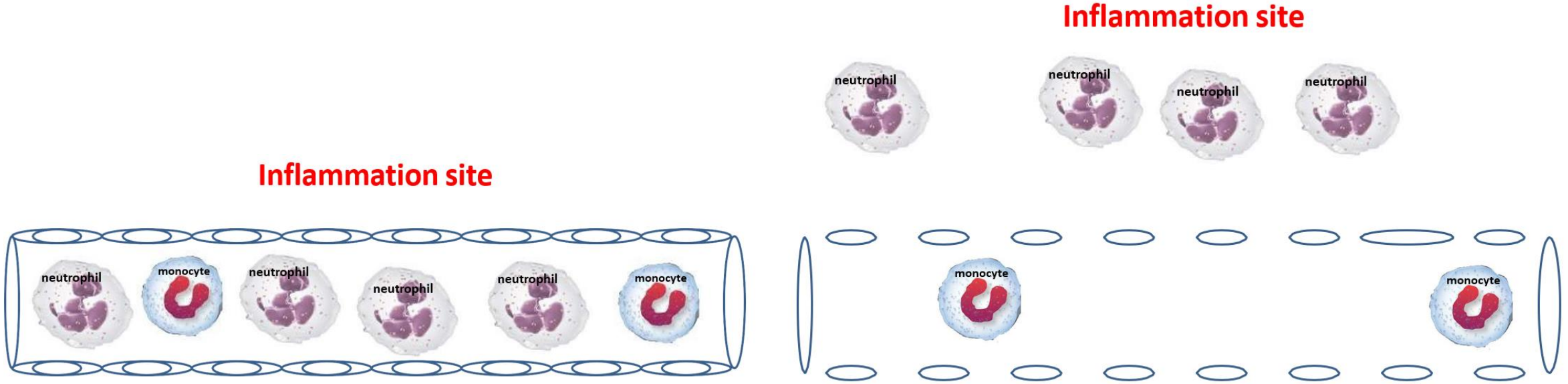


Neutrophils

- **Neutrophils** have a short lifespan; they circulate in the blood for **6-7 hours** before migrating into tissues, where they live for only a few days and do not multiply.
- They are called neutrophils because their granules stain poorly with the dyes used in staining leukocytes
- They are the first responders at the site of infection due to being the most abundant leukocytes, comprising **54-75%** of the WBCs. Their high motility and the presence of neutrophil chemoattractants contribute to their swift arrival.
- The nucleus of neutrophils has **3-5 connected lobes**, which is why they are also referred to as **polymorphonuclear leukocytes**.
- They are named **neutrophils** because their granules stain poorly with the mixture of dyes used for staining leukocytes.
- Neutrophils contain various types of **proteolytic enzymes**, including:

Lysozyme // Collagenase // Elastase

Neutrophils

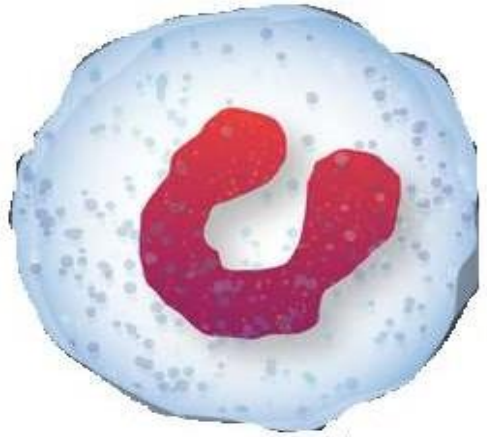


Most abundant

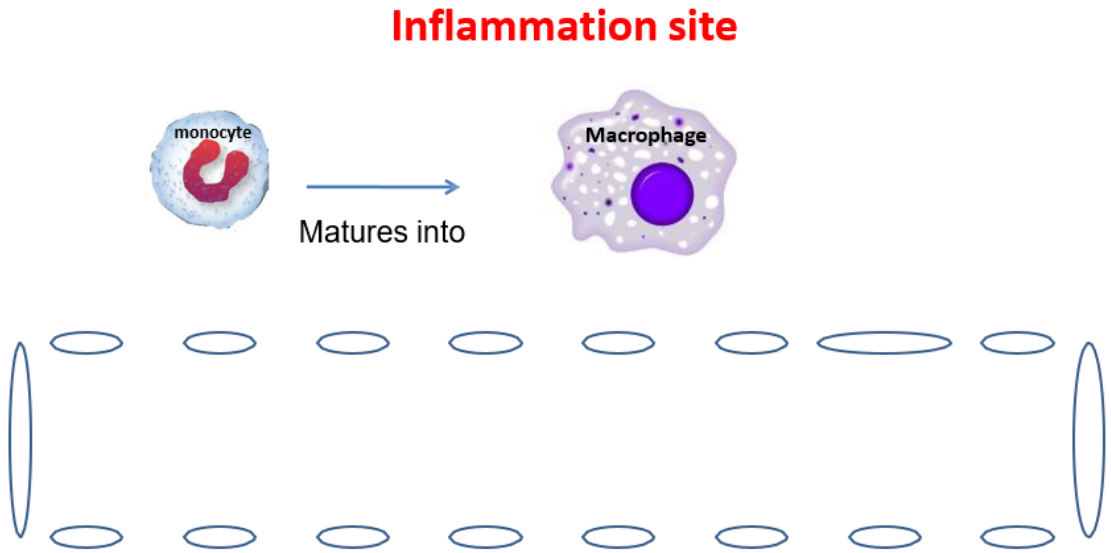
Highly motile

Neutrophils chemoattractants are produced at first

Monocytes

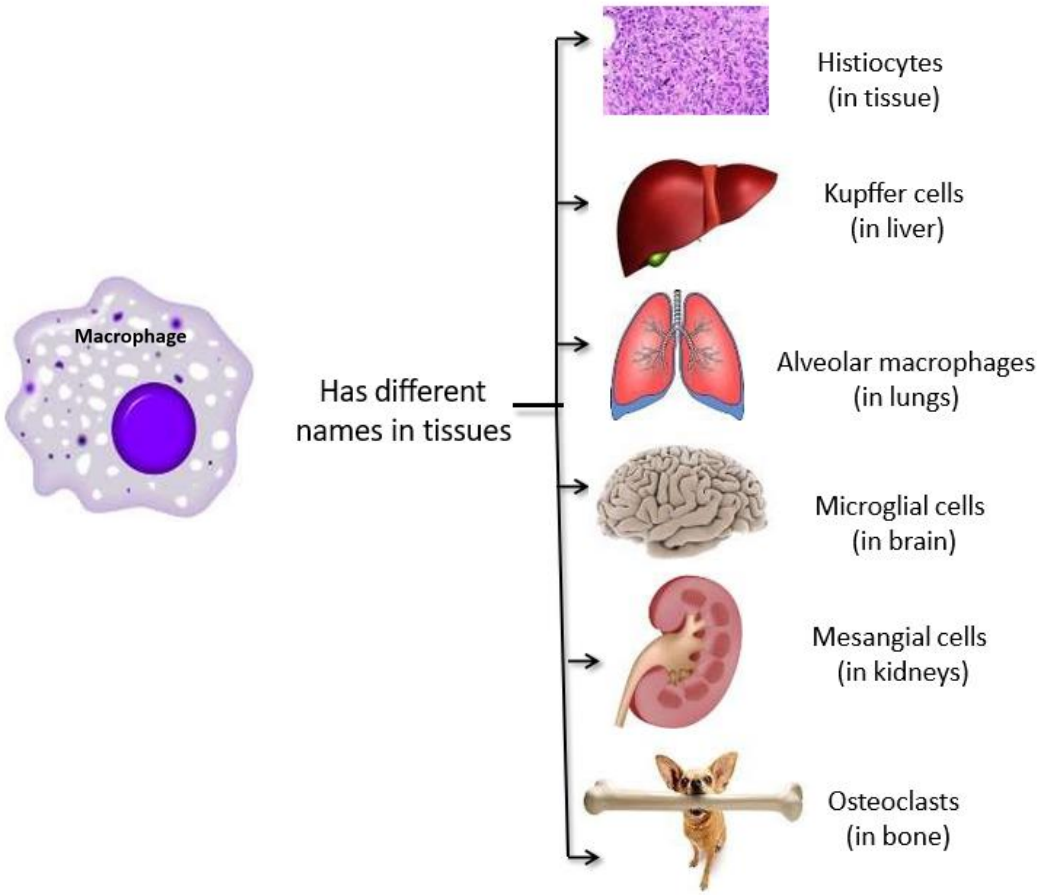


- **Monocytes** have a half-life of **3 days** in circulation.
- They make up **2-8%** of the WBCs.
- Monocytes have rounded or **kidney-shaped nuclei** and measure **12-15 µm** in diameter.
- When monocytes leave circulation and enter tissues, they are referred to as **macrophages**.



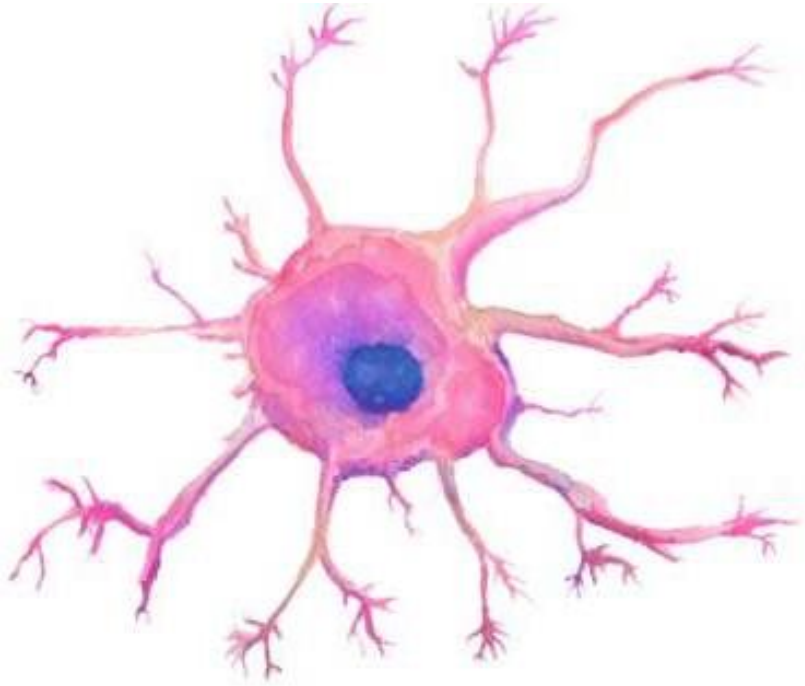
Macrophages

- **Tissue macrophages** can survive for months and have the ability to multiply.
- Macrophages present in different organs are given specific names:
  - **Histiocytes** (in tissue)
  - **Kupffer cells** (in the liver)
  - **Alveolar macrophages** (in the lungs)
  - **Peritoneal macrophages** (in the peritoneum)
  - **Microglial cells** (in the brain)
  - **Mesangial cells** (in the kidneys)
  - **Osteoclasts** (in bone)
- Functions of macrophages include:
  - Killing microbes, infected cells, and tumor cells.
  - Secretion of immunomodulatory **cytokines**.
  - Antigen processing and presentation to **T cells**



Dendritic Cells

- **Dendritic cells** are morphologically identified by **spiny membranous projections** on their surfaces.
- Their main function is to capture and transport protein antigens to the draining lymph node, acting as **antigen-presenting cells (APCs)**.



Thank you

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