

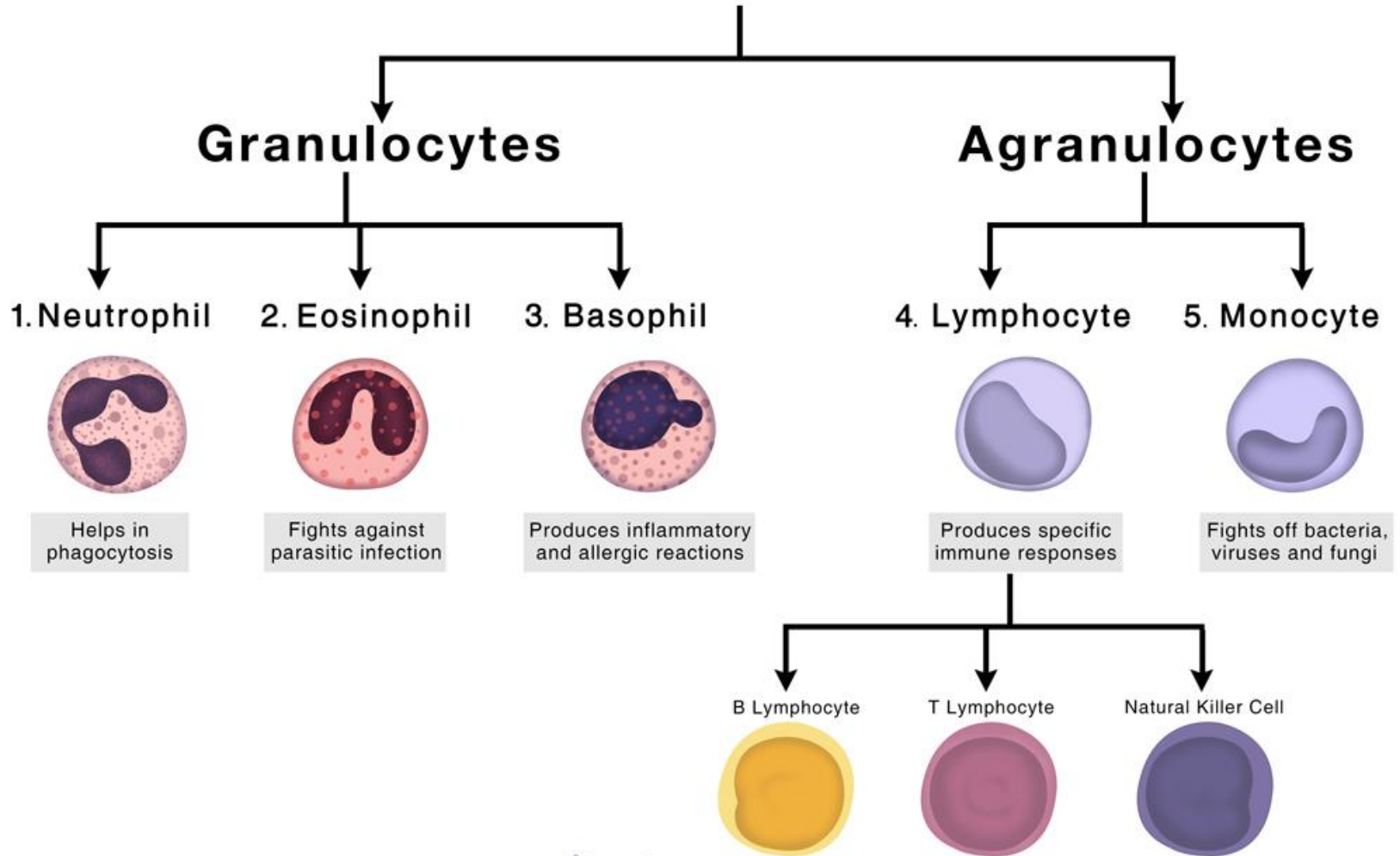
Cells of the Immune system

Microbiology V

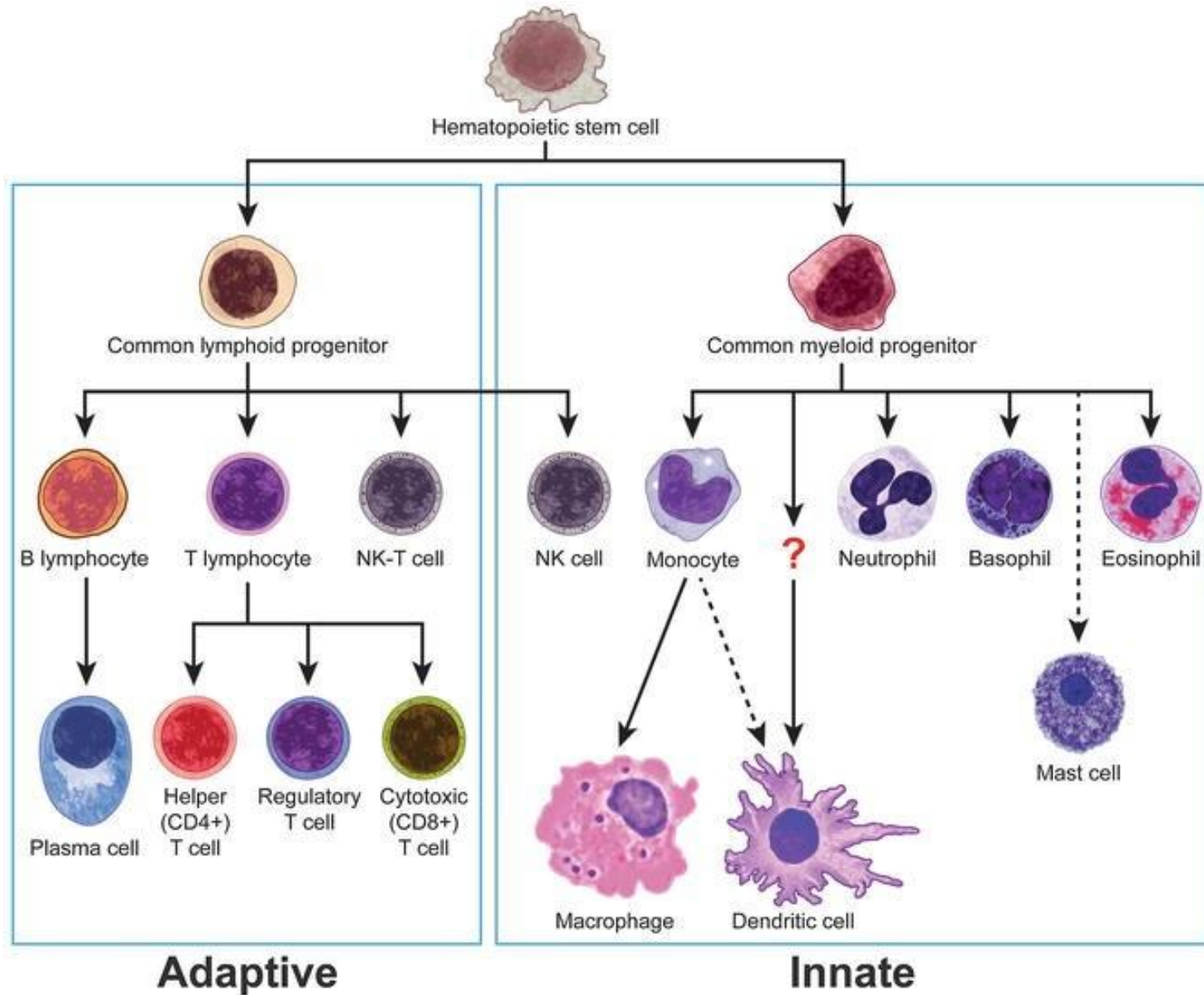
WHITE BLOOD CELL (WBC)

- White blood cells (WBCs) are also known as **leukocytes**. They can be divided into:
 - Granulocytes and
 - Agranulocytes.
- **Granulocytes** have cytoplasm that contains organelles that appear as coloured granules through light microscopy, hence their name.
- Granulocytes consist of **neutrophils, eosinophils and basophils**.
- **Agranulocytes** do not contain granules.
- They consist of **lymphocytes and monocytes**.

TYPES OF WHITE BLOOD CELLS

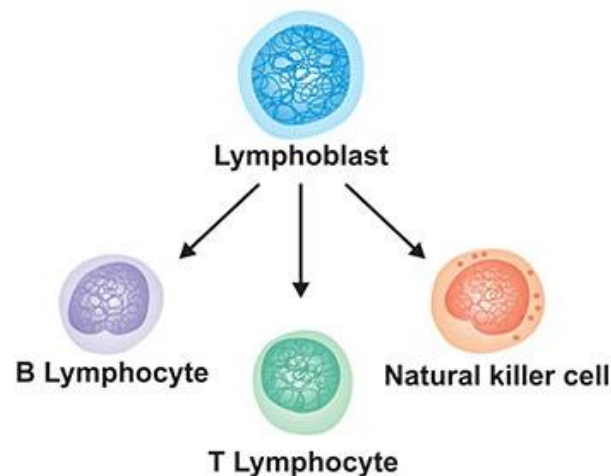


Blood Cell types



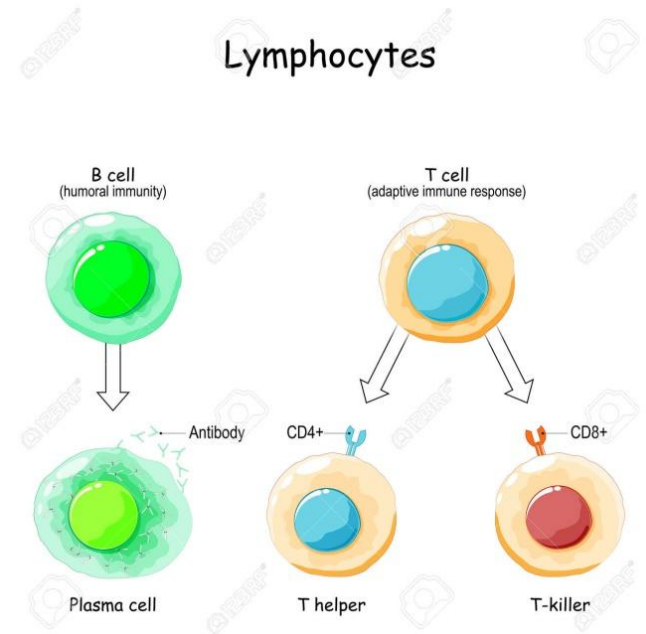
Lymphocytes

- Small white blood cells which are responsible for much of the work of the Immune System.
- Lymphocytes are derived from lymphoblast & can be divided into three classes:
 - B cells
 - T cells and
 - Natural Killer (NK) cells
- Mature lymphocytes all have a similar appearance.
- They are small cells with a deeply basophilic nucleus and scanty cytoplasm.



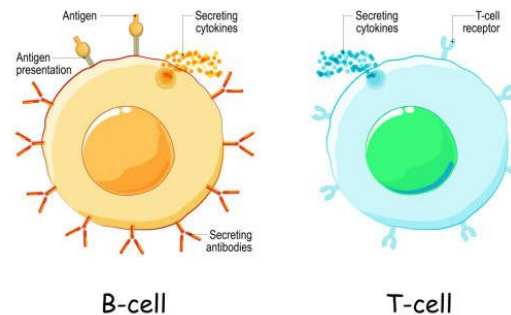
B Cells and T Cells

- Also known as B lymphocytes and T lymphocytes.
- **T cells** or T lymphocytes belong to a group of white blood cells and play a central role in **Cell-mediated Immunity**.
- T cells, leave the bone marrow at an early age and travel to the thymus, where they mature.
- **B cells** are lymphocytes that play a large role in the **Humoral Immunity** (antibody mediated immunity).
- B cells is an essential component of the Adaptive Immune System.
- B cells spend their entire early life in the bone marrow.



Functions of B and T cells:

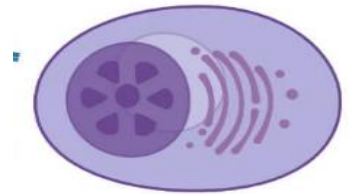
- B cells: The principal functions of **B cells** is to make **antibodies** against antigens, perform the role of antigen-presenting cells (APCs) and eventually develop into **memory B cells** after activation by antigen interaction.
- T cells: **T cells** constitutes 65-75% of blood lymphocytes. They can be distinguished from other lymphocytes by the presence of a *T cell receptor (TCR)* on the cell surface.
- Another key feature of B cells and T cells, includes the **receptors** it has in its surface.
- T cells recognize a linear sequence of **amino acids**
- B cells the spatial arrangement of proteins, nucleic acids, polysaccharides or lipids.



- **Helper T-Cell:** assist other white blood cells in immunologic processes, including maturation of B cells into plasma cells and memory B cells, and activation of cytotoxic T cells and macrophages.
- **Cytotoxic T-Cell:** destroy virally infected cells and tumor cells, and are also implicated in transplant rejection.
- **Regulatory T-Cell:** formerly known as suppressor T cells, are crucial for the maintenance of immunological tolerance.
- **Memory T-Cell:** are a subset of antigen-specific T cells that persist long-term after an infection has resolved.

Plasma B-Cells:

- Plasma cells, also called plasma B cells, plasmocytes, and effector B cells.
- They're large **B cells** that have been exposed to antigen and produce and secrete large amounts of antibodies.
- They are transported by the blood plasma and the lymphatic system.
- They have basophilic cytoplasm and an eccentric nucleus with heterochromatin in a characteristic cartwheel or clock face arrangement.
- Most of these die after 4-5 days. Few survive to become memory cells.
- Antibodies assist in the destruction of microbes by binding to them and making them easier targets for phagocytes and activation of the complement system.

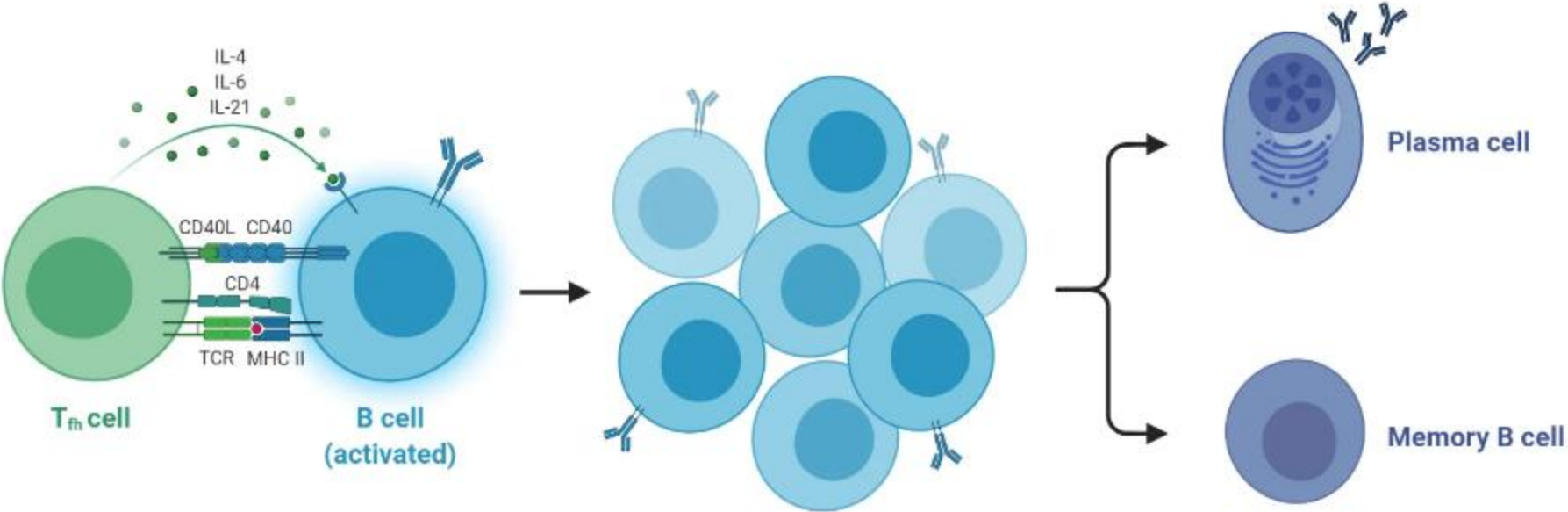
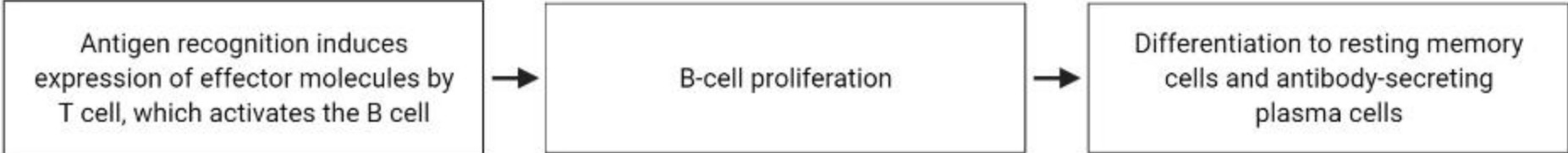


Plasma B cell

Memory B-Cells:

- are formed from activated B cells that are specific to the antigen encountered during the primary immune response.

Steps in B-cell Differentiation

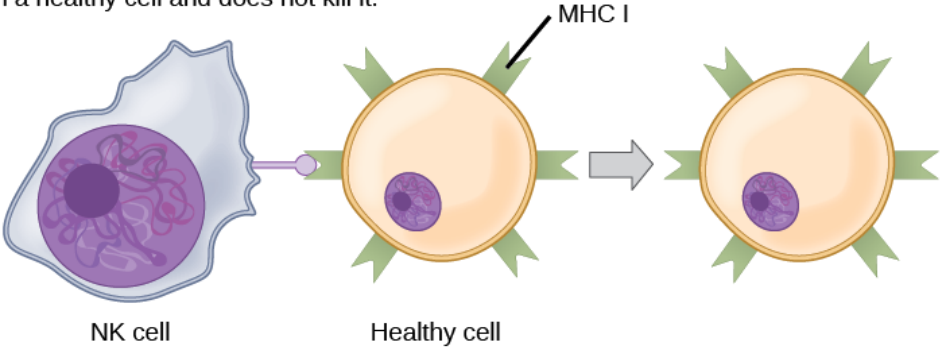


Natural Killer (NK) Cells

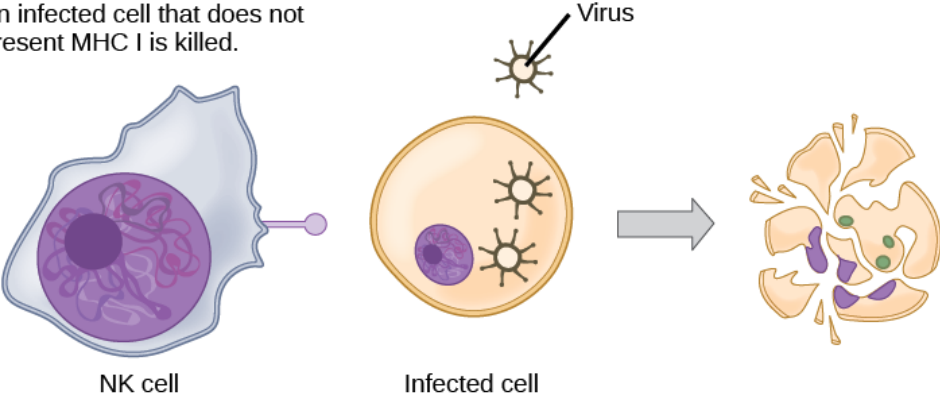
- These cells lack the marker molecules characteristic of B and T cells.
- They comprise about 10-15% of the lymphocytes of circulating blood.
- The role NK cells play is similar to that of cytotoxic T cells in the vertebrate adaptive immune response.
- NK cells provide rapid responses to **virally infected cells** and respond to tumor formation, acting at around 3 days after infection.
- NK cells are unique, however, as they have the ability to recognize stressed cells in the absence of antibodies and MHC, allowing for a much faster immune reaction.
- They were named “natural killers” because of the initial notion that they do not require activation in order to kill cells that are missing “self” markers of major histocompatibility complex (MHC).

Natural killer cells function

A natural killer (NK) cell recognizes MHC I on a healthy cell and does not kill it.



An infected cell that does not present MHC I is killed.



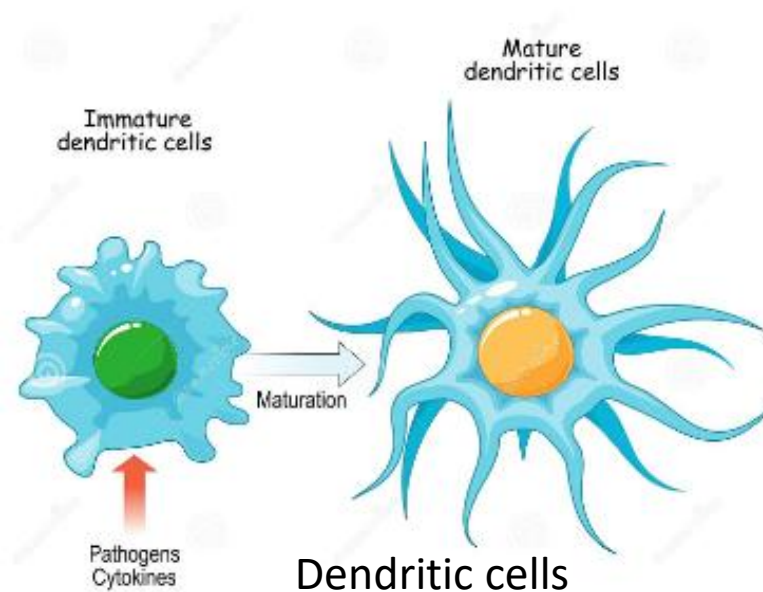
ANTIGEN-PRESENTING CELLS (APC)

- These are group of diverse cell types that assists other cells in the Immune Response.
- Cells which do not have antigen-specific receptors.
- Instead, they capture and process antigens, present them to T cell receptors.
- These cells include:
 - Macrophages
 - B Cells
 - Dentrtric cells.

DENDRITIC CELL

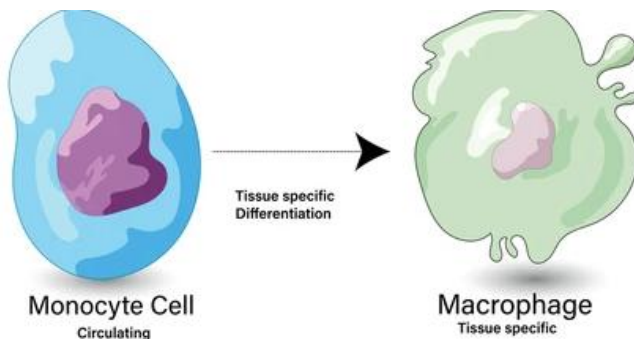
- These cells are immune cells forming part of the Mammalian Immune System.
- Their main function is to **process antigen** material and present it on the surface to other cells of the immune system.
- They act as messengers between the innate and adaptive immunity.
- At certain development stages they grow branched projections, the dendrites.
- While similar in appearance, these are distinct structures from the dendrites of neurons.
- Immature dendritic cells are also called **veiled cells**, as they possess large cytoplasmic “veils” rather than dendrites.

- Dendritic cells are present in tissues in contact with the external environment, such as the skin and the inner lining of the nose, lungs, stomach and intestines.
- They can also be found in an immature state in the blood.
- Once activated, they migrate to the lymph nodes where they interact with T cells and B cells to initiate and shape the adaptive immune response.



MACROPHAGES

- Macrophages are cells produced by the differentiation of monocytes in tissues.
- It function in both non-specific defense, Innate Immunity, as well as help initiate specific defense mechanisms, Adaptive Immunity, of vertebrate animals.
- Their role is to “phagocytose” (engulf and then digest) cellular debris and pathogens, either as stationary or as mobile cells.
- They also stimulate lymphocytes and other immune cells to respond to pathogens.
- They are specialized **phagocytic cells** that attack foreign substances, infectious microbes and cancer cells through destruction and ingestion.



Marophage showing phagostosis

MONOCYTE

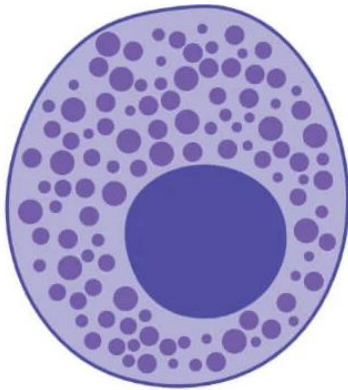
- Monocytes are type of white blood cell and are part of the Innate Immune System of vertebrates including all mammals.
- Monocytes play multiple roles in immune function.
- Such roles include:
 - replenish resident macrophages and dendritic cells under normal states.
 - in response to inflammation signals, monocytes can move quickly (approx. 8-12 hours) to sites of infection in the tissues and divide into macrophages and dendritic cells to elicit an immune response.



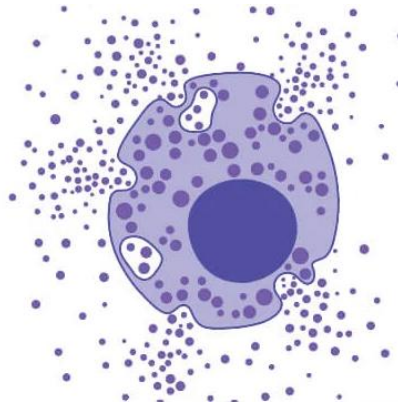
Monocyte

MAST CELLS

- These are cells concentrated within the respiratory and gastrointestinal tracts, and within the deep layers of the skin.
- These cells release histamine upon encountering certain antigens, thereby triggering an allergic reaction.
- The mast cell is very similar in both appearance and function to the Basophil, a type of white blood cell.



Mast cell



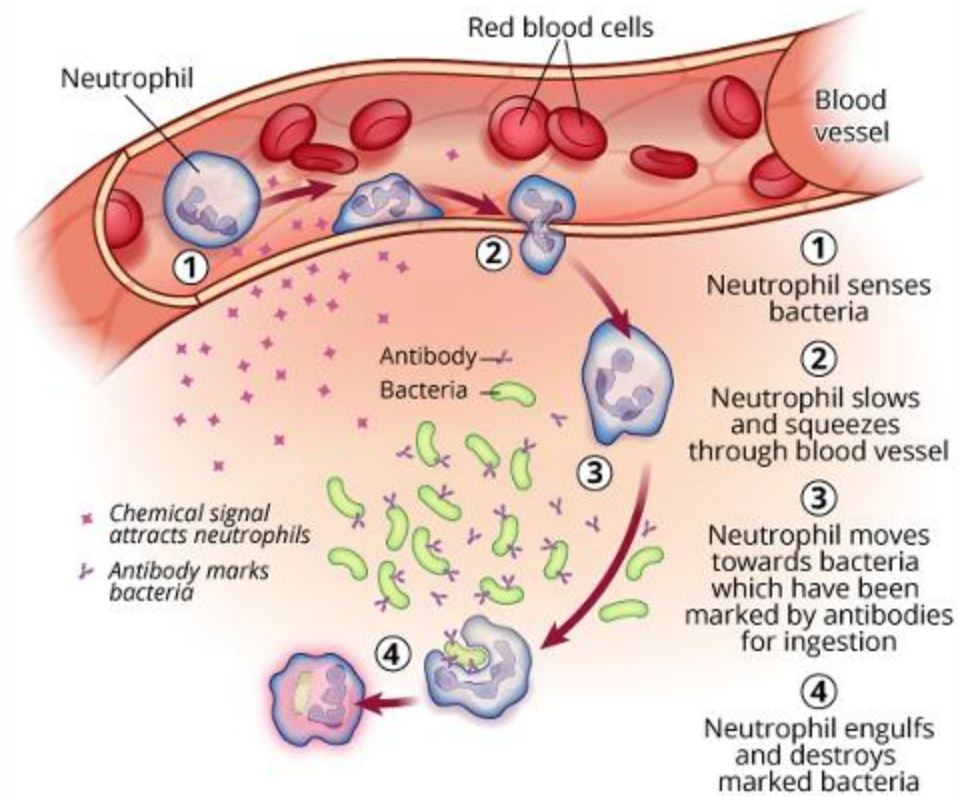
Activated mast cell

NEUTROPHILS

- These cells are the most abundant type of white blood cells in mammals and form an essential part of the innate immune system.
- In general, they are referred to as either neutrophils or **polymorphonuclear neutrophils**.
- They are subdivided into segmented neutrophils and banded neutrophils.
- Neutrophils are normally found in the blood stream.
- During the beginning (acute) phase of inflammation, particularly as a result of bacterial infection, environmental exposure, and some cancers.
- They are the predominant cells in pus, accounting for its whitish/yellowish appearance.
- Neutrophils are recruited to the site of injury within minutes following trauma and are the hallmark of acute inflammation.



Neutrophils in the Immune System



EOSINOPHILS

- These cells are white blood cells that are one of the immune system components responsible for combating **multicellular parasites** and certain infections in vertebrates.
- Along with mast cells, they also control mechanisms associated with **allergy** and asthma.
- They are granulocytes that develop during hematopoiesis in the bone marrow before migrating into blood.



Eosinophils

BASOPHIL

- The name comes from the fact that these leukocytes are basophilic; they are susceptible to staining by basic dyes.
- Basophils contain large cytoplasmic granules which obscure the cell nucleus under the microscope.
- However, when unstained, the nucleus is visible and it usually has 2 lobes.



Basophils

MEGAKARYOCYTE

- It is a bone marrow cell responsible for the production of blood thrombocytes (**platelets**), which are necessary for normal blood clotting.
- Megakaryocytes are 10 to 15 times larger than a typical red blood cell, averaging 50-100 μm in diameter.

RED BLOOD CELL

- It is also called “Erythrocytes” and has two functions:
- To pick up oxygen from the lungs and deliver it to tissues elsewhere.
- To pick up carbon dioxide from other tissues and unload it in the lungs.
- An erythrocyte is a disc-shaped cell with a thick rim and a thin sunken centre.
- RBCs are incapable of aerobic respiration, preventing them from consuming the oxygen they transport because they lose nearly all their inner cellular components during maturation



Erythrocyte



Platelets







PLATELET

- Platelets are small fragments of bone marrow cells and are therefore not really classified as cells themselves.

Platelets have the following functions:

- Secrete vasoconstrictors which constrict blood vessels, causing vascular spasms in broken blood vessels.
- Form temporary platelet plugs to stop bleeding.
- Secrete procoagulants (clotting factors) to promote blood clotting.
- Dissolve blood clots when they are no longer needed.
- Digest and destroy bacteria.
- Secrete chemicals that attract neutrophils and monocytes to sites of inflammation.
- Secrete growth factors to maintain the linings of blood vessels.

Types & functions of blood cells in immunity

Features of Erythrocytes and Platelets in Wright-Stained Blood Smears						
Cells	Diameter (µm)	Life span (days)	No. of cells/ L of blood	Shape and nucleus type	Cytoplasm	Functions
Erythrocyte (red blood cell) 	7–10	120	5×10^{12} in males; 4.5×10^{12} in females	Biconcave disc, anucleate	Pink because of acidophilia of hemoglobin; halo in center	Transports hemoglobin that binds O ₂ and CO ₂
Platelet (thrombocyte)  <i>C. Machado - M.D.</i>	2–4	10	150 to 400 × 10 ⁹	Oval biconvex disc, anucleate	Pale blue; central dark granulomere, peripheral less dense hyalomere	In hemostasis, promotes blood clotting; plugs endothelial damage
Features of Leukocytes in Wright-Stained Blood Smears (Total Number: 5–10 × 10 ⁹ /L Blood)						
Cells	Diameter (µm)	Differential count (%)*	Nucleus	Cytoplasm	Functions	
Granulocytes						
 Neutrophil	9–12	60–70	Segmented, 3–5 lobes, densely stained	Pale, finely granular, evenly dispersed specific granules	Phagocytoses bacteria; increases in number in acute bacterial infections	
 Eosinophil	12–15	1–4	Bilobed, clumped chromatin pattern, densely stained	Large homogeneous red granules that are coarse and highly refractile	Phagocytoses antigen-antibody complexes and parasites	
 Basophil	10–14	0–1	Bilobed or segmented	Large blue specific granules that stain with basic dyes and often obscure nucleus	Involved in anticoagulation, increases vascular permeability	
Agranulocytes						
 Monocytes	12–20	3–10	Indented, kidney shaped, lightly stained	Agranular, pale blue cytoplasm, with lysosomes	Is motile; gives rise to macrophages	
Lymphocyte • Small • Medium to large	6–10 11–16	20–40	Small, round or slightly indented, darkly stained	Agranular, faintly basophilic, blue to gray	Acts in humoral (B cell) and cellular (T cell) immunity	

*Note: Differential count (%) is based on adult values.