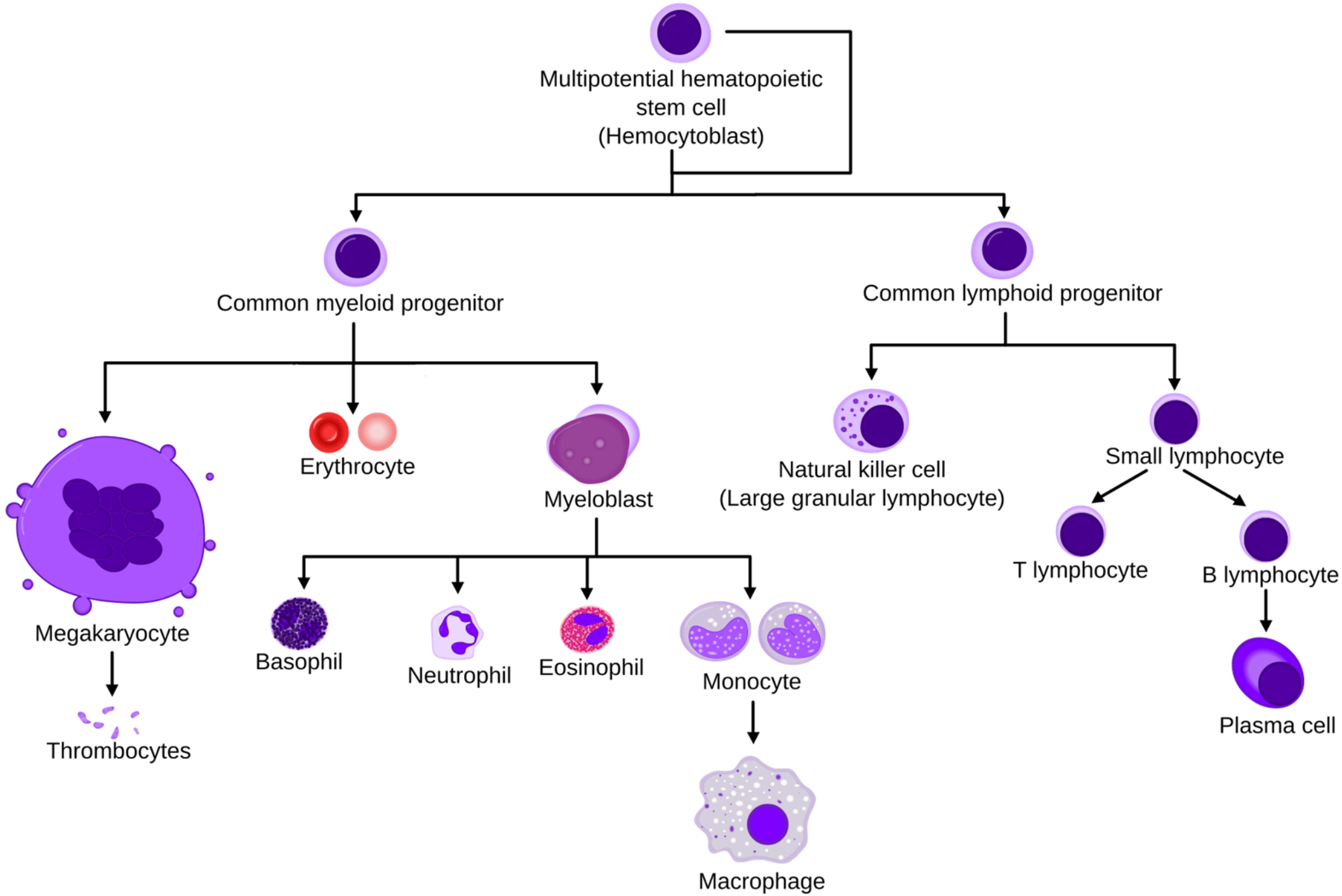
Leukocytes And White Cell Count

MEDEMIA ACADEMY

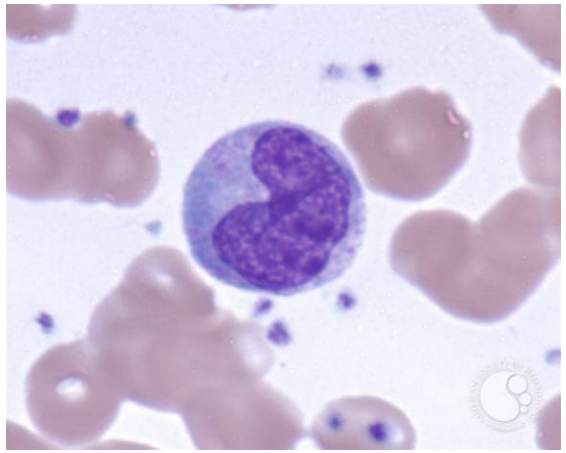

Multipotential hematopoietic stem cell (Hemocytoblast)
Common myeloid progenitor
Common lymphoid progenitor
Megakaryocyte
Thrombocytes
Erythrocyte
Myeloblast
Basophil
Neutrophil
Eosinophil
Monocyte
Macrophage
Natural killer cell (Large granular lymphocyte)
Small lymphocyte
T lymphocyte
B lymphocyte
Plasma cell

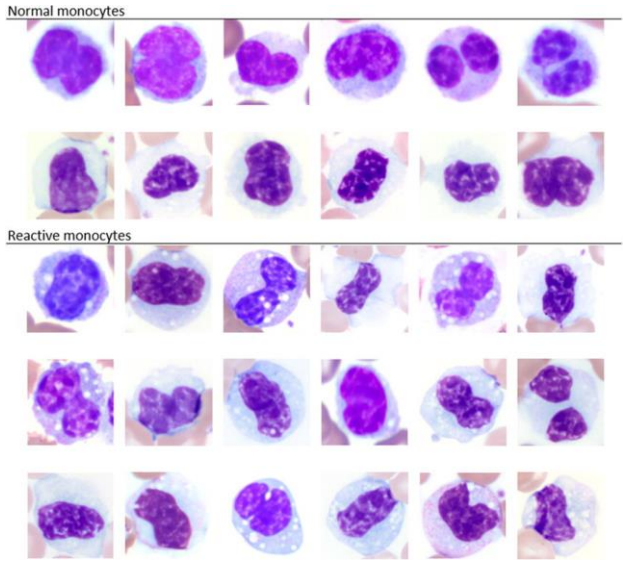
1. Mononuclear phagocyte system (Monocytes)

❖**Shape**
- Large, spherical cells with a diameter of 15-20 µm.
- **Nucleus**: kidney-shaped or oval and takes up a significant portion of the cell. (12-15 µm)
- **Cytoplasm**: abundant, finely granular and typically appears light blue or gray

❖**Functions**
- **Monocytes** have a half-life of 3 days in circulation
- **Macrophages** survive for months and can multiply
- **The primary function** is **phagocytosis**
  - Killing of microbes, infected cells, tumor cells
- **Other functions include** antigen presenting and cytokine production

❖**Origin**: bone marrow; and first to leave





1. Mononuclear phagocyte system (Monocytes)

❖Monocytes subtypes

- **Macrophages**: Monocytes that migrate from the bloodstream and settle in tissues, where they differentiate and function as phagocytic cells involved in immune defense.
- **Dendritic Cells**: A subset of mononuclear cells that differentiate into antigen-presenting cells responsible for activating T-cells in the immune response.
- **Multinucleated Giant Cells**: Formed when multiple mononuclear cells, such as macrophages, fuse together, often in response to chronic inflammation or foreign body reactions.

❖**Macrophages** naming according to the tissue they reside in

Blood	Monocytes	**Connective tissue**	Histiocytes
Bone marrow	Macrophages	**Bone**	Osteoclasts
Spleen	Macrophages	**Liver**	Kupffer cells
Lymph nodes	Macrophages	**Kidney**	Mesangial cells
Skin	Langerhan's cells	**Brain/CNS**	Microglial cells

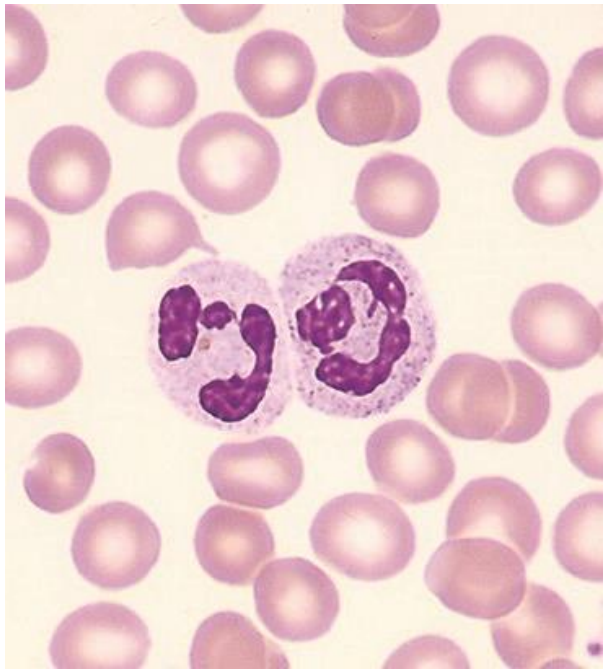
2. Neutrophils (95% of granulocytes)

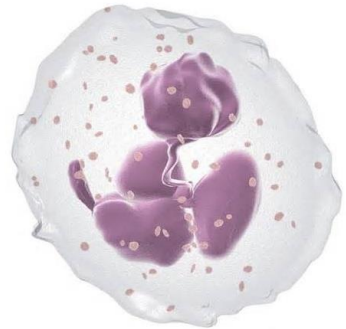
❖**Shape**

- Spherical cells with a multilobed nucleus (typically 3-5 lobes), giving them the appearance of being segmented hence the name polymorphonuclear leukocyte
- The cytoplasm contains fine granules that are not strongly stained with standard dyes.

❖**Functions**

- First responders; respond within 24 hours of stimulus
  - Most abundant (60% of leukocytes)
  - Highly motile
  - Neutrophil chemoattractants are produced first

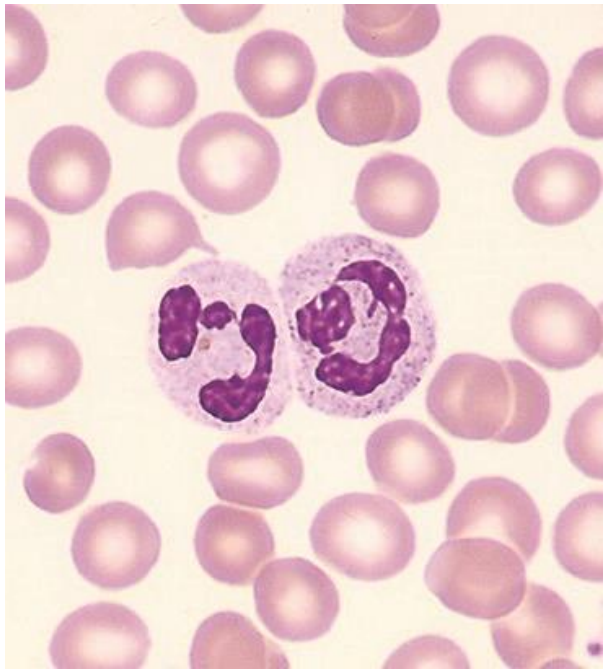


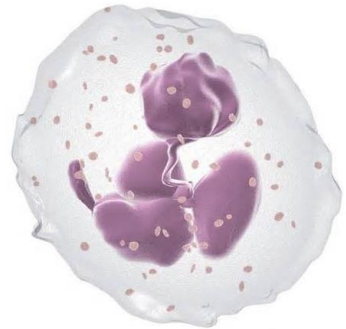


2. Neutrophils (95% of granulocytes)

❖ **Functions**

- **Have short life span**
  - 6-7 hours in blood and few days in tissue spaces and do not multiply
- **Primary functions**: phagocytosis and the release of enzymes to kill bacteria
  - Have 20 times as many receptors as macrophages
    - Fc receptor to IgG and IgA antibodies
    - Complement receptors
  - Intracellular killing by azurophil lysosomal granules and specific granules
  - Containing different types of proteolytic enzymes such as lysozyme, collagenase and elastase





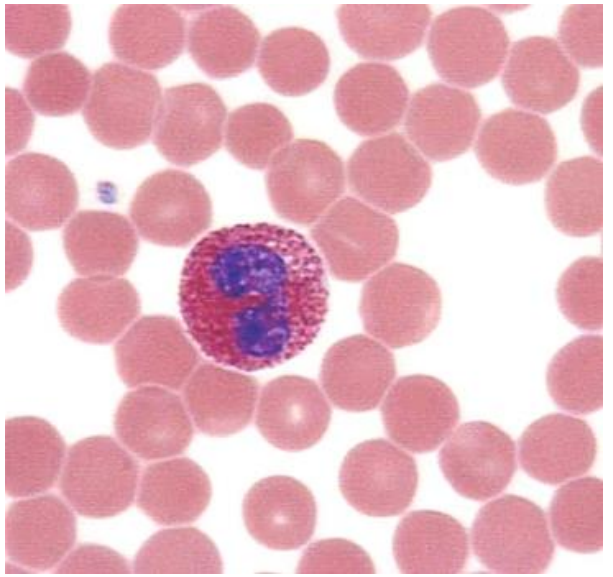
3. Eosinophils

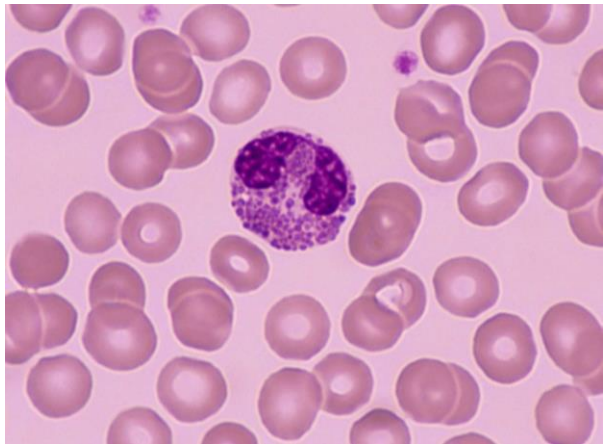
❖**Shape**

- Spherical cells with a bilobed nucleus (two lobes), and the cytoplasm is filled with large, red or pink-staining granules (eosinophilic granules).
- They are "acid-loving" as shown by their affinity to coal tar dye

❖**Functions**

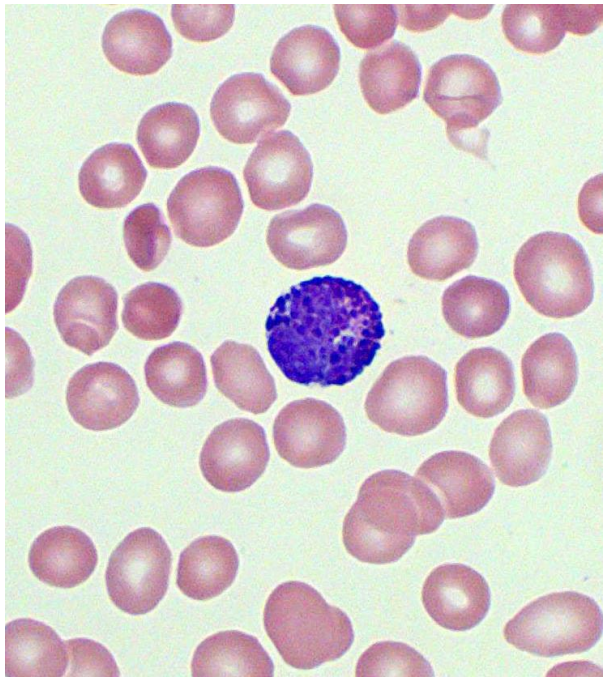
1. **Anti-helminthic activity**
   - Contain **Major Basic Protein (MBP)**, a highly toxic substance to worms
2. Play a role in **allergic reactions**





4. Basophils

- The least common granulocyte
- Basophils are the circulating form.
- Mast cells are the sessile form
- **Shape**
  - Spherical cells with a bilobed or S-shaped nucleus, often obscured by large, dark purple or blue-staining granules (basophilic granules) in the cytoplasm, which stain with methylene blue.
- **Function**
  - Involved in **allergic and inflammatory responses**
  - Contains **acidic proteoglycans** which are crucial for **storing histamine** and other immune mediators

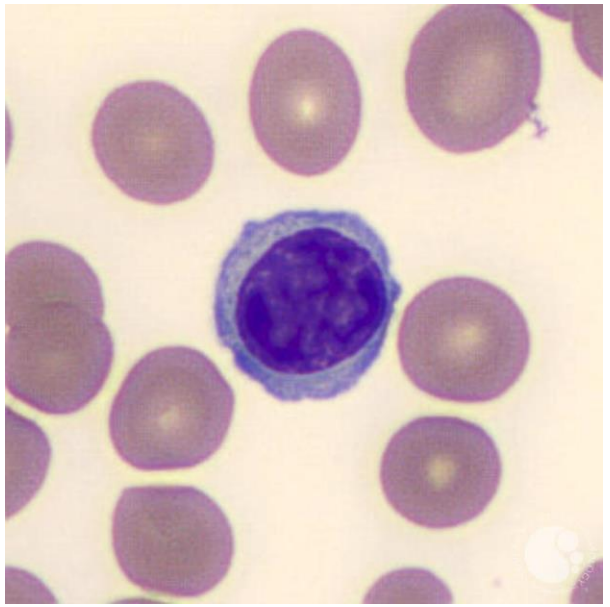


5. Lymphocytes

❖**Shape**
- Small, round cells with a large, dense nucleus that occupies most of the cell's volume.
- The nucleus is usually round or slightly indented, and the cytoplasm forms a thin rim around it, appearing light blue under the microscope

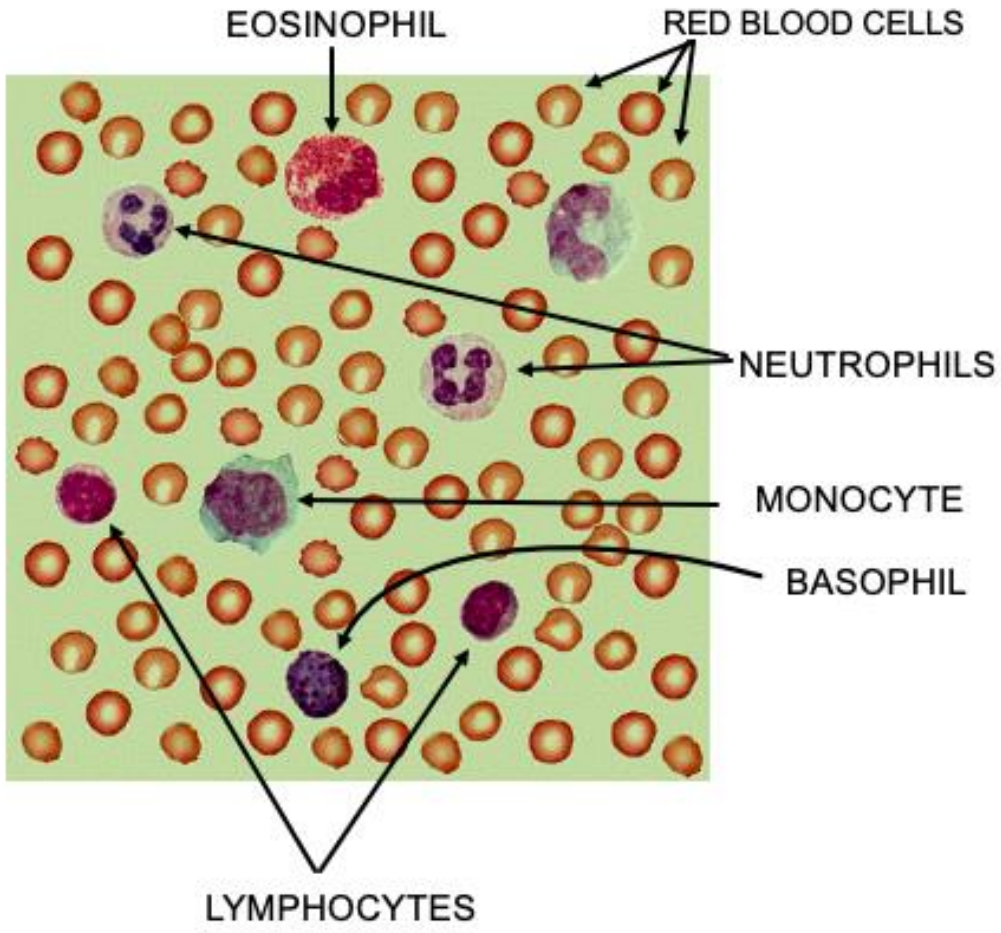
❖**Types**
- **T cells**: Involved in cell-mediated immunity.
- **B cells**: Responsible for producing antibodies in humoral immunity.
- **Natural Killer (NK) cells**: Involved in the destruction of infected or cancerous cells without the need for prior sensitization.

❖**Origin**
- Lymphocytes originate from **hematopoietic stem cells** in the bone marrow
- **B cells** and **NK cells** mature in the bone marrow
- **T cells** migrate to the **thymus**, where they mature



Percentages of each type of leukocyte in the blood

- **Neutrophils**: 50-70% (60%)
- **Lymphocytes**: 20-40% (30%)
  - T-cells (60%), B-cells (30%), NK (10%)
- **Monocytes**: 2-8% (6%)
- **Eosinophils**: 1-4% (3%)
- **Basophils**: <1% (1%)
- **Never Let Monkeys Eat Banna**

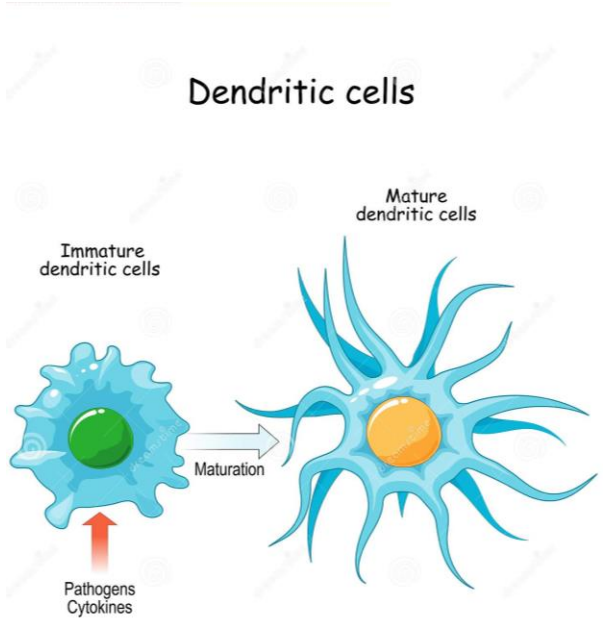


Dendritic cells (DCs)

❖**Shape**
- Dendritic cells have a branched structure with dendrites, which facilitate interaction with other immune cells for antigen presentation.

❖**Location**
- Present in tissues exposed to the external environment, such as the skin (including specialized Langerhans cells), respiratory tract, gastrointestinal tract, and genitourinary tract. They also circulate in the blood in an immature form, ready to respond to infection or injury.

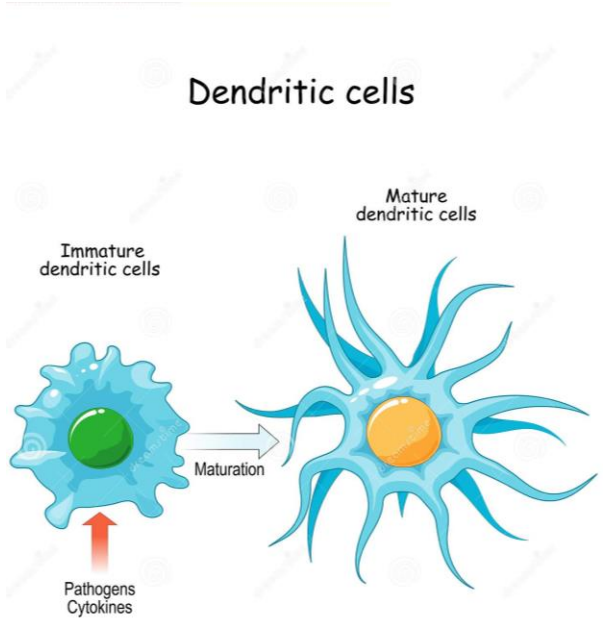
❖**Function**
- Phagocytose (engulf) antigens.
- Process and present antigens on their surface to T cells and B cells, initiating the adaptive immune response.
- After activation, they migrate to lymphoid tissues (like lymph nodes), where they interact with lymphocytes to shape immune responses.



Dendritic cells (DCs)

❖**Origin**: 4 types

- **Myeloid Dendritic Cells**: From macrophage lineage, widely distributed, they perform phagocytosis and T cell activation.
- **Lymphoid Dendritic Cells**: From lymphocyte lineage, they help recruit immune cells to infection sites.
- **Follicular Dendritic Cells**: From mesenchymal origin, located in peripheral lymph nodes, they are specialized in B cell activation.
- **Plasmacytoid Dendritic Cells**: Found in blood and tissues, they are early responders to viral infections and have potent antiviral capabilities.



White Cell Count

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White Cell Count

- **Definition**: the number of the white cells in 1.0 cubic millimeter of blood (no distinction is made among the six normal types: neutrophils, bands, lymphocytes, monocytes, eosinophils, basophils).
- **Normal values**:
  - In health the WBC count varies between 4,500 and 11,000 cells per cubic millimeter (4.5 – 11.0 x 10^9/ L). These variations are caused by some activities done by the person such as bath, exercise, digestion and others.
  - WBC reference range (N.B. these are guideline figures which should be checked locally)
    - **Children at one y/o**: 6.0-18.0 x 10^9/L
    - **Children at 4-7 y/o**: 5.0-15.0 x 10^9/ L
    - **Adults**: 4.0-10.0 x 10^9/ L
    - **Pregnant women**: up to 15.0 x 10^9/L

White Cell Count Cont.

The change in WBC count (rise or fall) indicates the cause and progression of a disease/infection

Leukocytosis	Leukopenia
The WBC count rises above the normal values in some diseases (may rise to 20,000 cells per cubic millimeter)	The WBC count drops below normal values in other diseases (may drop to 3000 cell per cubic millimeter)
It is due to a stimulation of the WBC factories in the bone marrow	This is due to a depression of the WBC factories in the bone marrow.
○ **Physiological causes**: Stress, Exercise, Menstruation, Pregnancy ○ **Pathological causes**: • Acute infections: e.g., pneumonia, meningitis, abscess, cholera, tonsilitis, septicemia, etc… • Inflammation and tissue necrosis e.g. burns, trauma, arthritis, tumors • Leukemia • Acute hemorrhage	○ Hypersplenism ○ Bone marrow infiltration ○ Ionizing radiation ○ **Overwhelming bacterial infections** such as miliary TB, relapsing fever, typhoid fever, brucellosis ○ **Some viral infections** e.g. HIV, viral hepatitis, measles, rubella, influenza, rickettsial infections ○ **Some parasitic infections** including leishmaniasis and malaria

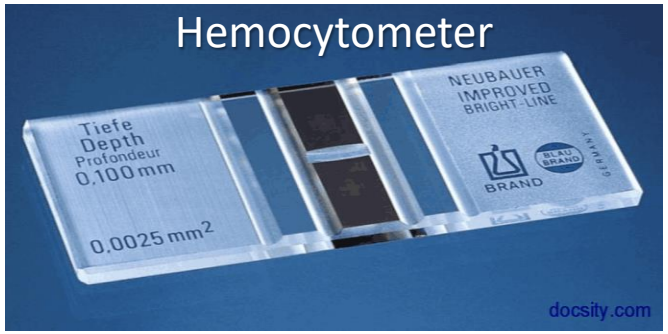
Differential White Cell Count

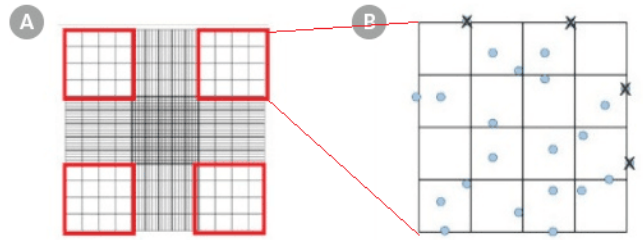
Cell Type	Normal Value	Elevated Levels May Indicate
Neutrophil	54-62%	Bacterial infections, stress
Lymphocyte	25-33%	Mononucleosis, whooping cough, viral infections
Monocyte	3-9%	Malaria, tuberculosis, fungal infections
Eosinophil	1-3%	Allergic reactions, autoimmune diseases, parasitic worms
Basophil	<1%	Leukemia, chicken pox, hypothyroidism

- **Never Let Monkeys Eat Banna**
- **60 – 30 – 6 – 3 – 1**

Methods used for the white cell count

- **Methods used for the white cell count**
  - Automatic method
  - Microscopic method (Hemocytometer)
- **Microscopic method (Hemocytometer)**
  - The simplest, most convenient and cheapest mean of accurately determining the number of cells in a sample.
  - **A hemocytometer** is a specialised slide that has a counting chamber with a known volume of liquid.
  - **Principle of the test**:
    - Blood is diluted (1 in 20) in an acid reagent which causes haemolysis to the red cells, leaving the white cells to be counted by using a haemocytometer.
    - Number of WBC are counted in a 16 corner square (i.e. 0.1 cmm)





Hemocytometer diagram indicating the 16 corner squares which should be used for counting

WBC Count by Hemocytometer

- The WBC count is the number of white cells in 1.0 cubic millimeter of undiluted blood.
- **So we have 2 correction factors**: dilution factor and volume factor.
  - **Dilution factor**: the blood has been diluted 1 in 20.
  - **Volume factor**: the chamber (16 corner square) has an area of 1 square millimeter and depth of 0.1 so the volume of the chamber is = area x depth = 1 x 0.1 = 0.1 cmm.
- Number of cells/cmm = number of cells in chamber (16 corner square) x dilution factor x volume factor = N x 20 x 10