BLOOD

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Blood composition

- Blood is specialized connective tissue
- Human adult blood amount is about 5 to 6 liters
- Consists of blood cells 45% and Plasma 55%
- Functions:

1. Transportation
2. Immune system
3. Regulation of body temperature
4. Acid-base balance

Plasma (55% of whole blood)

Water	Proteins	Other solutes
92% by weight	7% by weight	1% by weight
	Albumins 58% Globulins 37% Fibrinogen 4% Regulatory proteins <1%	Electrolytes Nutrients Respiratory gases Waste products

Erythrocytes (44% of whole blood)

Erythrocytes
4.2-6.2 million per cubic mm





Buffy coat (<1% of whole blood)

Platelets
150-400 thousand per cubic mm



Leukocytes
4.5-11 thousand per cubic mm



Neutrophils
50-70%



Lymphocytes
20-40%



Monocytes
2-8%



Eosinophils
1-4%



Basophils
0.5-1%

Plasma

- It’s the aqueous solution that contain all the blood constituents
- Plasma components:

➢ 92% is water

➢ 7% of plasma is dissolved proteins (mainly Albumin)

➢ 1% is electrolytes

Other plasma proteins are: transferrin, fibronectin, lipoprotein, coagulation proteins, fibrinogen, immunoglobulin and complement proteins.

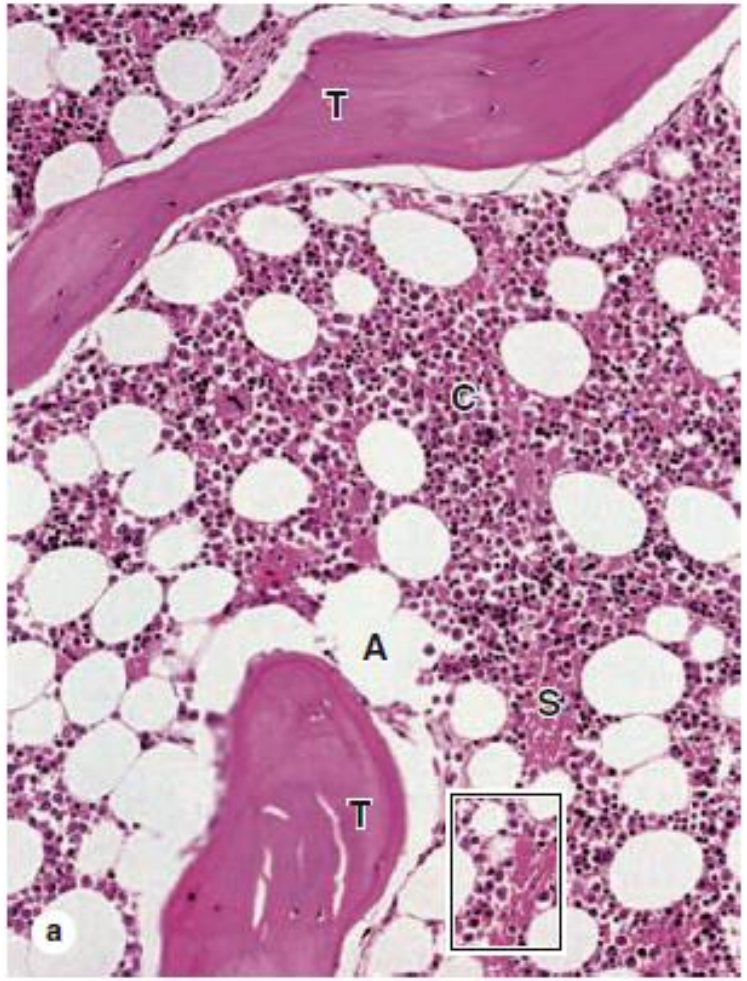
Blood cells

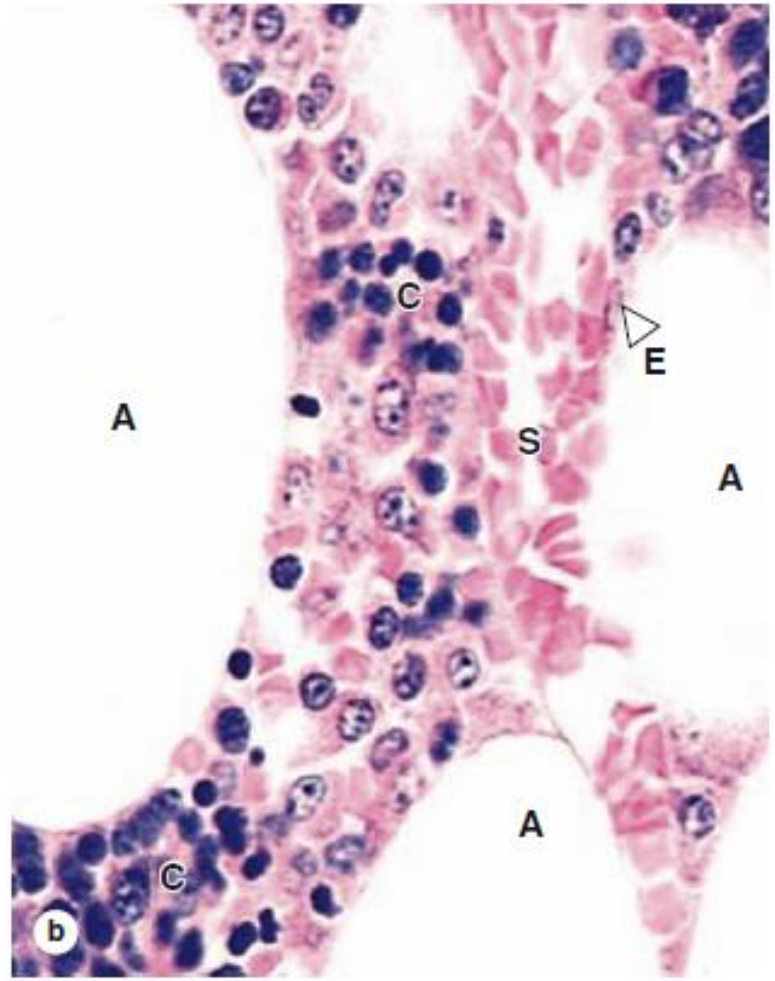
1. Erythrocytes (Red blood cells RBCs)
2. Thrombocytes (platelets)
3. Leukocytes (White blood cells WBCs):
   - Neutrophils
   - Eosinophil
   - Basophil
   - Lymphocytes(T, B & Natural Killer cells NKCs)
   - Monocytes/Macrophage
   - Mast cells

Hemopoiesis

- Blood is produced by a process called hempoiesis
- Site varies with age:

1. Yolk sac during first trimester of intrauterine life
2. Liver mainly and spleen partially during 2nd trimester
3. Bone marrow in the 3rd trimester and after birth

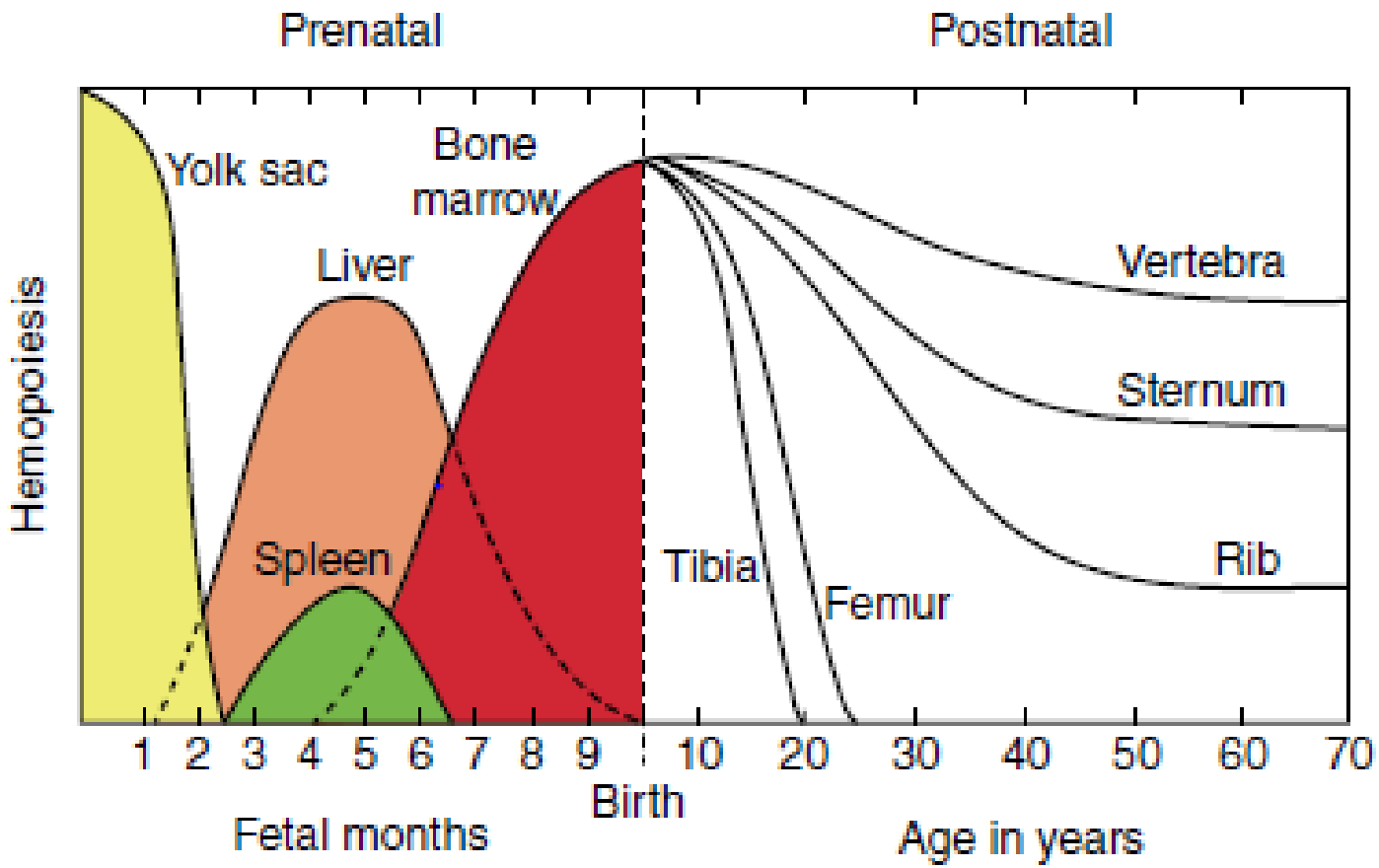




Red bone marrow contains adipocytes but is primarily active in hemopoiesis, with several cell lineages usually present. It can be examined histologically in sections of bones or in biopsies, but its cells can also be studied in smears. Marrow consists of capillary sinusoids running through a stroma of specialized, fibroblastic stromal cells and an ECM meshwork with reticular fibers. Stromal cells produce the ECM; both stromal and bone cells secrete various CSFs, creating the microenvironment for hemopoietic stem cell maintenance, proliferation, and differentiation.

(a) Sections of red bone marrow include trabeculae (**T**) of cancellous bone, adipocytes (**A**), and blood-filled sinusoids (**S**) between hemopoietic cords (**C**) or islands of developing blood cells. (X140; H&E)

(b) At higher magnification the flattened nuclei of sinusoidal endothelial cells (**E**) can be distinguished, as well as the variety of densely packed hemopoietic cells in the cords (**C**) between the sinusoids (**S**) and adipocytes (**A**). Most stromal cells and specific cells of the hemopoietic lineages are difficult to identify with certainty in routinely stained sections of marrow. (X400; H&E)



Hemopoiesis, or blood cell formation, first occurs in a mesodermal cell population of the embryonic yolk sac, and shifts during the second trimester mainly to the developing liver, before becoming concentrated in newly formed bones during the last 2 months of gestation. Hemopoietic bone marrow occurs in many locations through puberty, but then becomes increasingly restricted to components of the axial skeleton.

Hemopoiesis

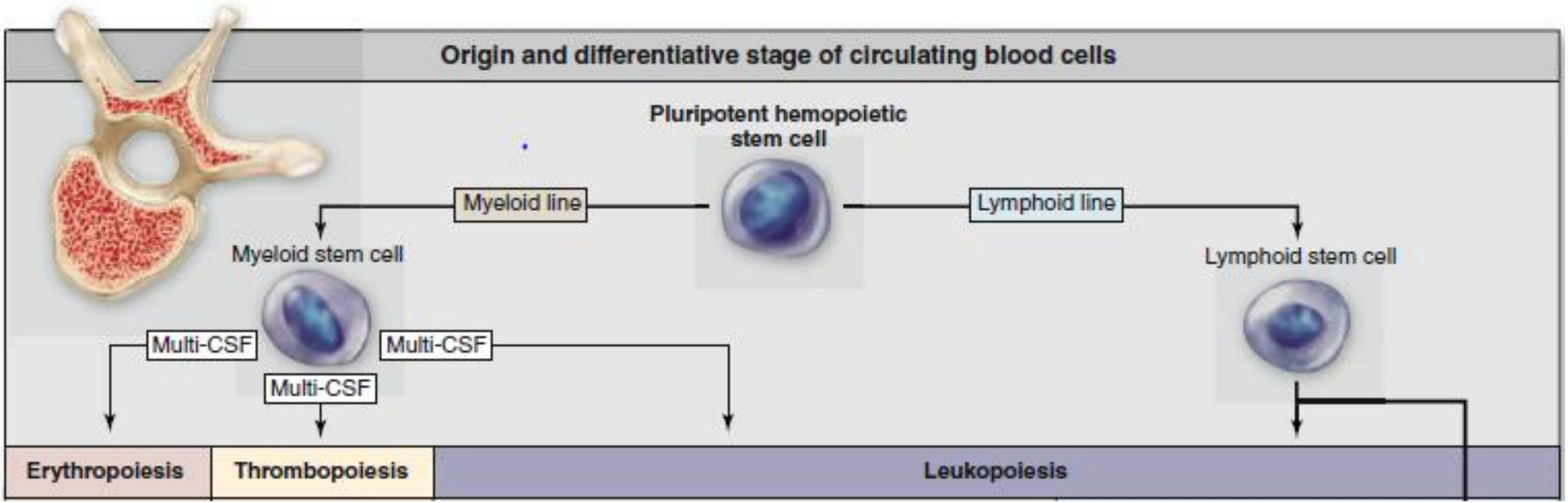
- All blood cells originate from pluripotent stem cells
- Stem cells are capable of asymmetric division.
- It gives 2 major cell lineage, **lymphoid** and **myeloid** stem cells
- Myeloid stem cells give type of progenitor cells called CFU (Colony Forming Unit):

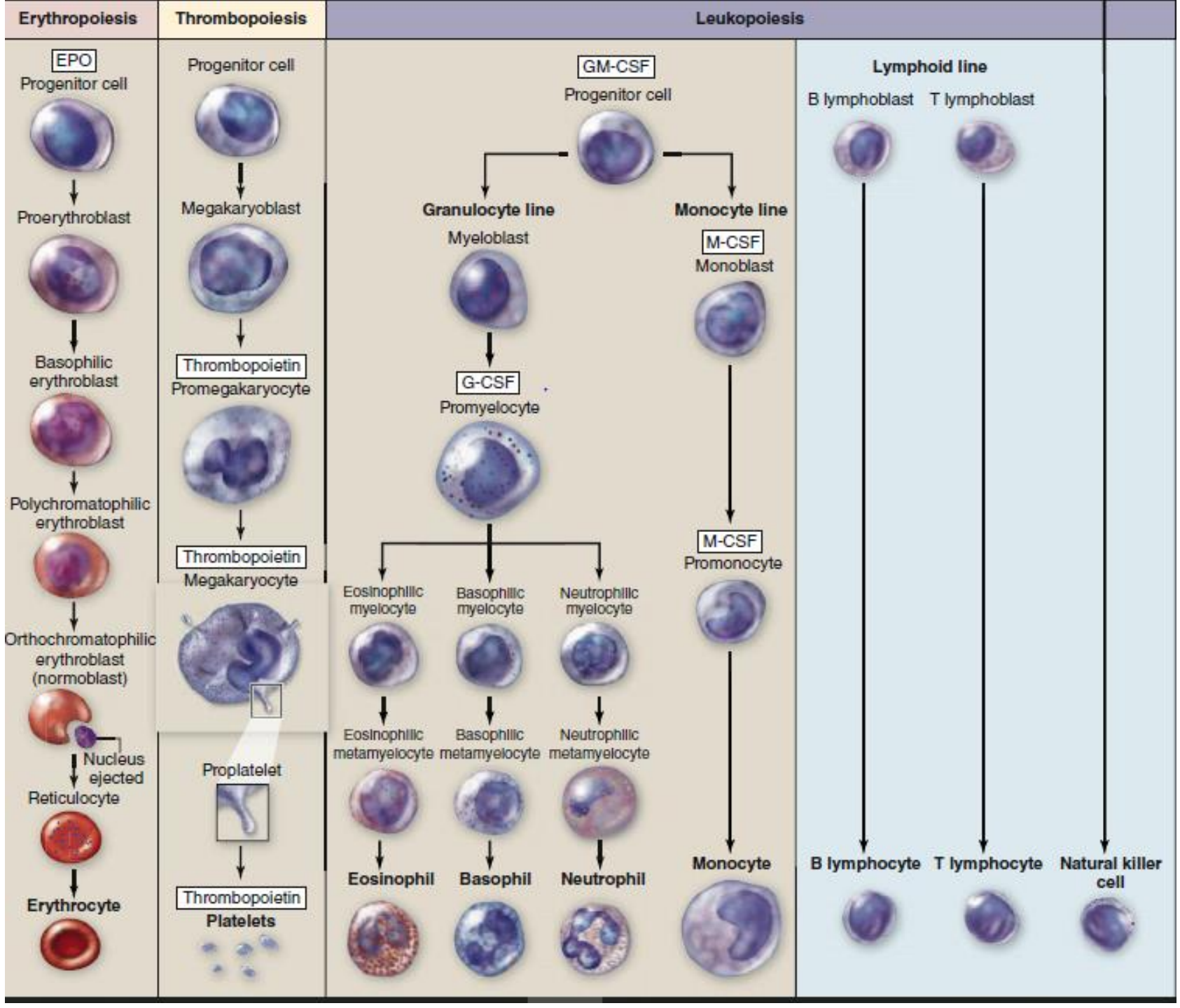
1. Erythrocyte CFU
2. Thrombocytes CFU
3. Granulocyte-monocyte CFU

- Progenitor cells give blast cells
- Blast cells undergo multiple cell division to give mature blood cells
- The process is controlled by hempoietic cytokines (SCF, EPO, THP, CSF, IL 1-7)

A. Myeloid progenitor gives: erythrocytes, thrombocytes, granulocytes (neutrophils, basophils and eosinophils) and monocytes.

B. Lymphoid progenitors give: T lymphocytes, B lymphocytes and NKCs.

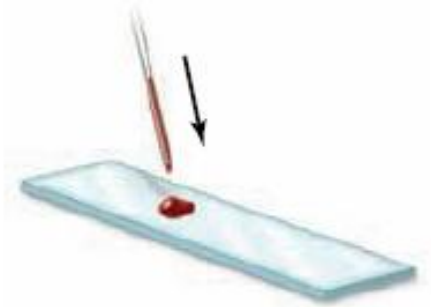

Origin and differentiative stage of circulating blood cells
Pluripotent hemopoietic stem cell
Myeloid line
Lymphoid line
Myeloid stem cell
Lymphoid stem cell
Multi-CSF
Multi-CSF
Multi-CSF
Erythropoiesis
Thrombopoiesis
Leukopoiesis


Erythropoiesis
Thrombopoiesis
Leukopoiesis
EPO
Progenitor cell
Proerythroblast
Basophilic erythroblast
Polychromatophilic erythroblast
Orthochromatophilic erythroblast (normoblast)
Nucleus ejected
Reticulocyte
Erythrocyte
Progenitor cell
Megakaryoblast
Thrombopoietin
Promegakaryocyte
Thrombopoietin
Megakaryocyte
Proplatelet
Thrombopoietin
Platelets
GM-CSF
Progenitor cell
Granulocyte line
Myeloblast
G-CSF
Promyelocyte
Eosinophilic myelocyte
Basophilic myelocyte
Neutrophilic myelocyte
Eosinophilic metamyelocyte
Basophilic metamyelocyte
Neutrophilic metamyelocyte
Eosinophil
Basophil
Neutrophil
Monocyte line
M-CSF
Monoblast
M-CSF
Promonocyte
Monocyte
Lymphoid line
B lymphoblast
T lymphoblast
B lymphocyte
T lymphocyte
Natural killer cell

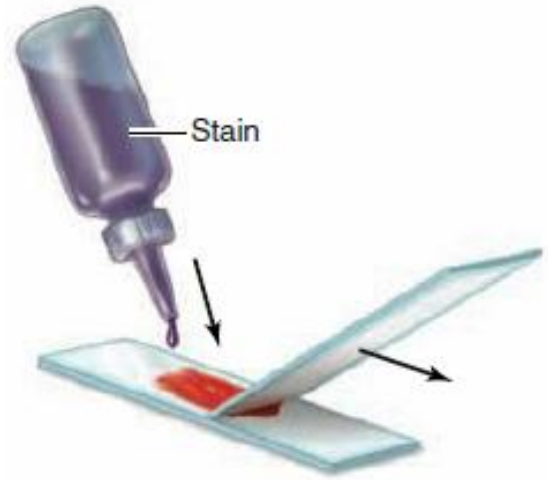
Smear preparation



(1) Prick finger and collect a small amount of blood using a micropipette.

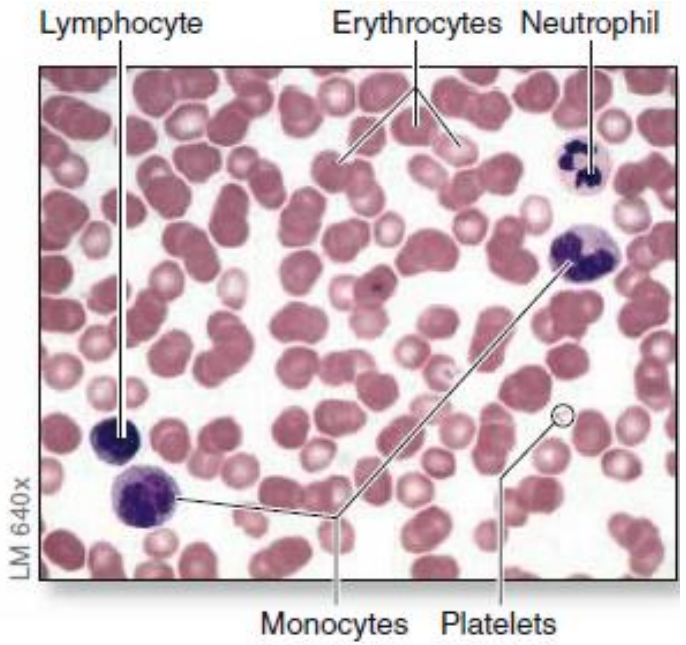


(2) Place a drop of blood on a slide.



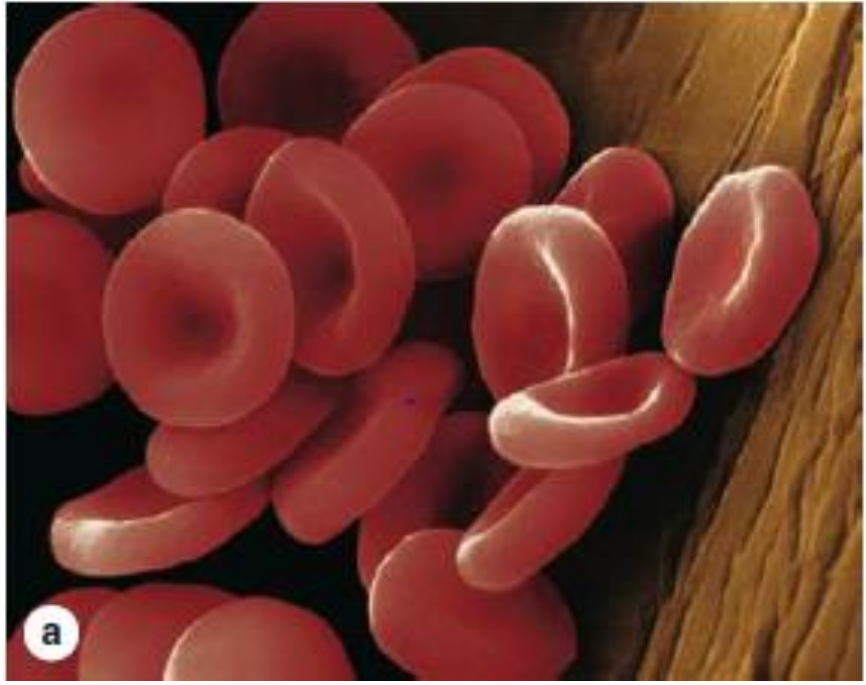
(3a) Using a second slide, pull the drop of blood across the first slide's surface, leaving a thin layer of blood on the slide.

(3b) After the blood dries, apply a stain briefly and rinse. Place a coverslip on top.



(4) When viewed under the microscope, blood smear reveals the components of the formed elements.

Erythrocytes RBCs



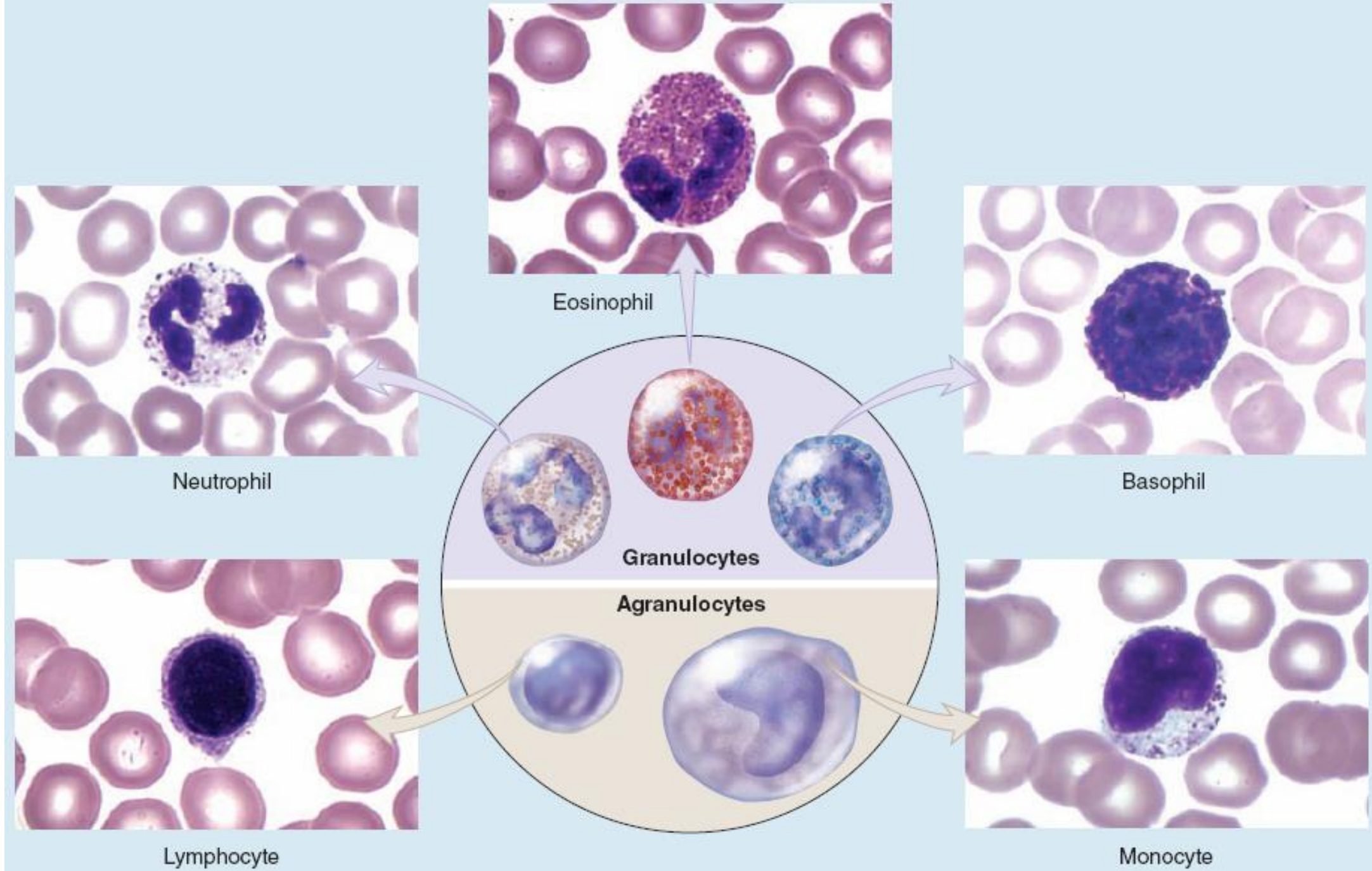
- Represent about 44% of blood.
- Biconcave disc, 7.5 micrometer in diameter.
- Large surface-volume ratio.
- Flexible, can adapt their shape.
- Plasma membrane includes glycoprotein that define the antigenicity and ABO blood type system.
- Sub membranous meshwork of actin, spectrin, ankrin and glycophorin.
- The cytoplasm is filled with hemoglobin (carries oxygen and Co2) but lack organelles and depends on anaerobic glycolysis to get energy.
- Life span is 120 days then removed by macrophages of liver, spleen and bone marrow.

- Packed cell volume or hematocrit is the % of RBCs in the blood.
- It indicates the state of RBCs production, state of hydration and various other diseases
- Low hematocrit or hemoglobin is a clinical condition know as Anemia
- High hematocrit is Polycythemia

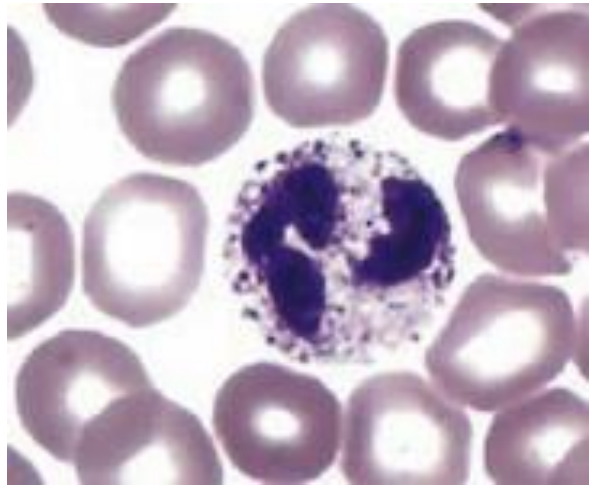
Leukocytes WBCs

- Based on the density of their cytoplasmic granules leukocytes are divided into, granulocytes and agranulocytes.

1. **Granulocytes** (Neutrophil, Eosinophil and Basophil) posses abundant cytoplasmic granules, lysosomes and specific granules seen under light microscope. Has polymorphic nuclei with 2 or more lobes, poorly developed Golgi apparatus & ER. Undergo apoptosis in C.T and removed by macrophage
2. **Agranulocytes** (Lymphocytes and monocytes) contains lysosomes but lack specific granules.


Eosinophil
Neutrophil
Basophil
Granulocytes
Agranulocytes
Lymphocyte
Monocyte

Neutrophils

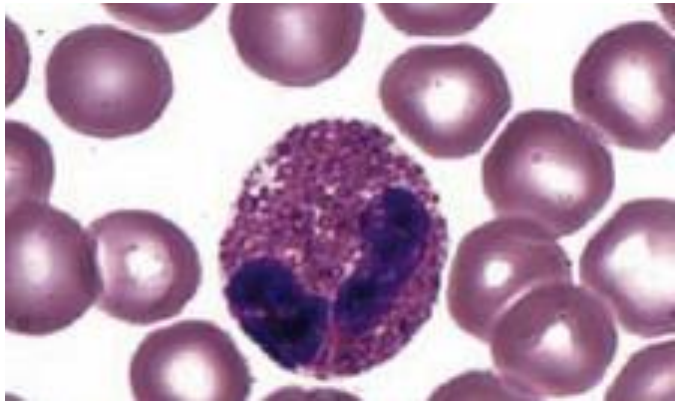


- 50 to 70 %of circulating leukocytes
- 12 to 15 micrometer in diameter, **nuclei with 2-5 lobes**
- Inactive neutrophils are spherical in shape and found in blood vessels
- Active neutrophils are amoeboid and found in tissue after migration through a process know as diapedesis
- The cytoplasm contain **azurphilic** granules:

1. Primary granules contain myeloperoxidase, lysozymes & defensin
2. Specific granules contain collagenase and other bactericidal proteins

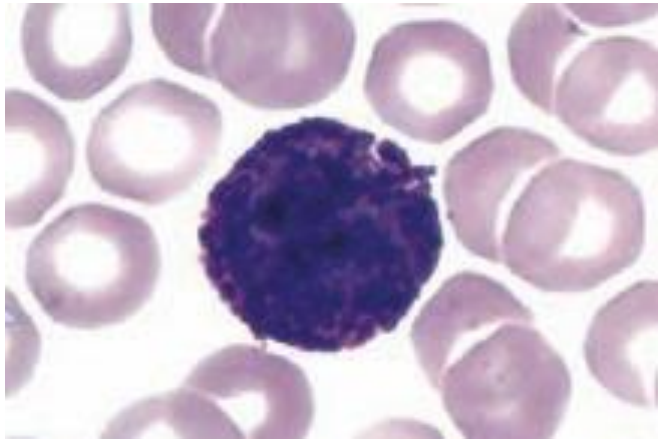
- Life span is 6 to 8 hours in blood and one to 4 days in C.T
- Neutrophils are phagocytic cells that ingest and kills **bacteria** by lysosomes and other enzymes
- Neutrophilia is higher neutrophil count and neutropenia is the opposite.

Eosinophil



- 1 to 4 % of circulating leukocytes
- 12 – 15 micrometer in diameter, **bilobed nucleus** and abundant large **acidophilic** specific granules that stain red or pink
- Specific granules contain major basic protein(MBP), peroxidase and other enzymes that kills parasites
- Play important role in **allergy** and found abundantly in C.T of intestinal lining and sites of **chronic inflammation**
- Eosinophilia is higher eosinophil count

Basophils



- Form less than 1% of leukocytes
- The nucleus is divided into 2 lobes and obscured by the overlying large specific granules
- **Basophilic** granules stain purple with basic dye and contain- heparin, histamine, phospholipase A, platelet activating factor, and eosinophil activating factor
- Has surface antigen for IgE, function as initiator of the inflammatory process and supplement mast cells
- Basophilia is higher basophil count

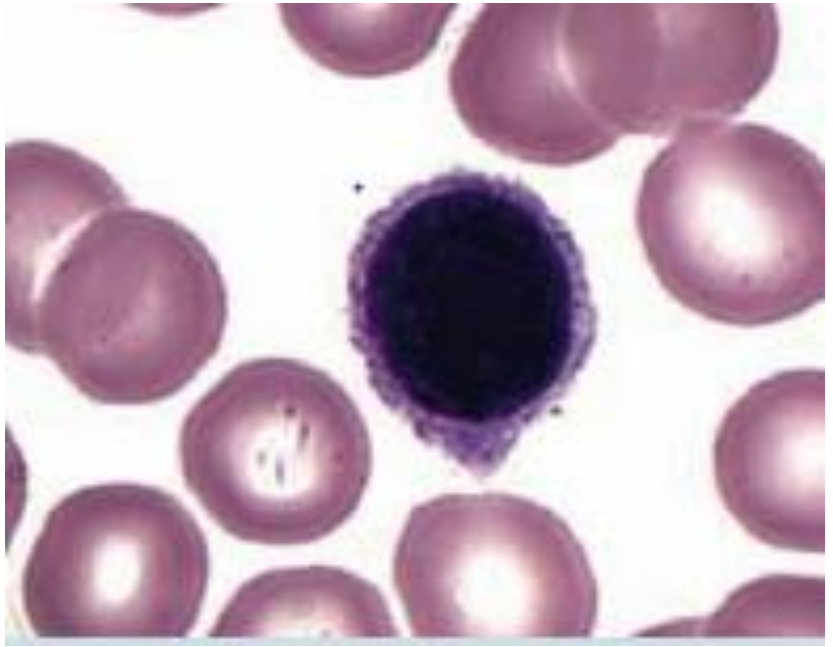
Lymphocytes

- The smallest and most numerous of the WBCs.
- Constitute about 30%.
- Morphologically similar but grouped by their antigen that called Cluster of Differentiation or CD marker.
- Major classes are:

1. B lymphocytes
2. T lymphocytes (helper T cells and cytotoxic T cells)
3. Natural killer cells (Non T Non B lymphocytes).

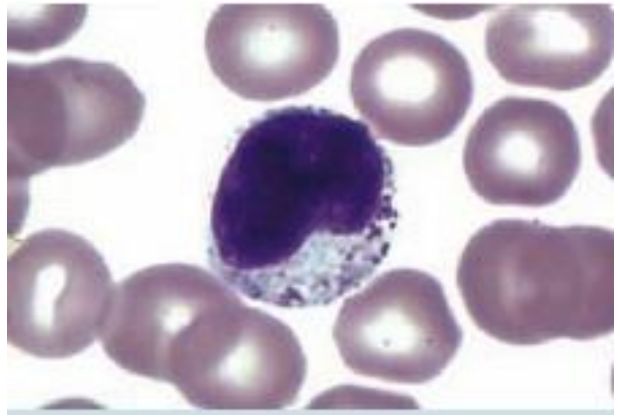
Lymphocytes

- Small newly released lymphocytes has diameter similar to RBCs but active ones has diameter of 9-18 micrometer.
- Characterized by spherical nuclei, dense chromatin and surrounding scant cytoplasm.
- Large lymphocytes has indented nuclei, more cytoplasm that stain **basophilic with few azurophilic** granules and some lysosomes.
- Life span is days to years.



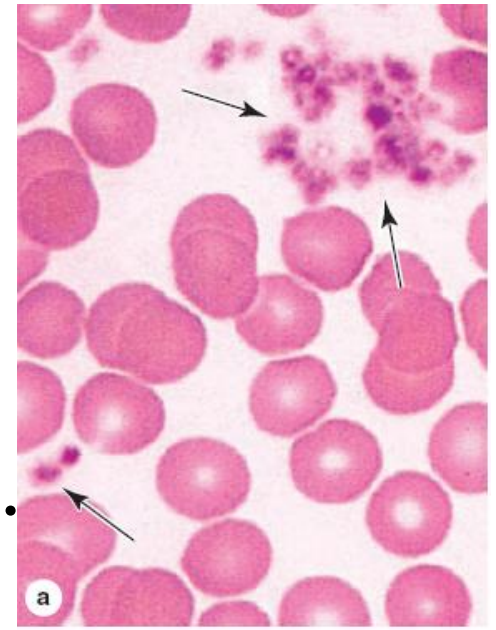
- After stimulation T and B lymphocytes become, **effector** and **memory cells.**
- B lymphocytes become plasma cells and function in **humeral immunity** via immunoglobulin (Ig)
- T lymphocytes function in **cell mediated immunity**, these are : T helper & cytotoxic T cells that release cytokines.
- NKs kill **foreign and viral infected cells**.
- Lymphocytosis is higher lymphocytes count and lymphopenia is lower count.

Monocytes



- They are the precursors of: macrophages, osteoclast, and microglia
- Diameter is 12 – 15 micrometer, C -shaped nucleus that stain lighter and basophilic cytoplasm contains azurophilic granules stain bluish- gray
- Life span is 12 to 100 hours and they do not re-enter into circulation
- In **chronic inflammation** there is continuous recruitment of monocytes

Thrombocytes (platelets)



- Very small, only 2- 4 micrometers.
- Comes from cytoplasmic process of megakaryocytes.
- In slide under light microscope appear in clumps.
- Single one is discoid in shape with light stain on peripheral zone called hyalomere and dark central zone called granulomere.
- The ultrastructure of thrombocytes has marginal bundle which is a system of microtubules and actin filaments that help maintain the shape.

- Thrombocyte also has:

1. Large alpha granules that contain PDGF, platelet factor 4, and other specific proteins.
2. Small Delta granules contain Calcium, ADP, ATP and serotonin.

- Platelets function in thrombus formation (clotting).
- Thrombocytosis is high platelet count and thrombocytopenia is low count (associated with increased bleeding tendency).

Thank You