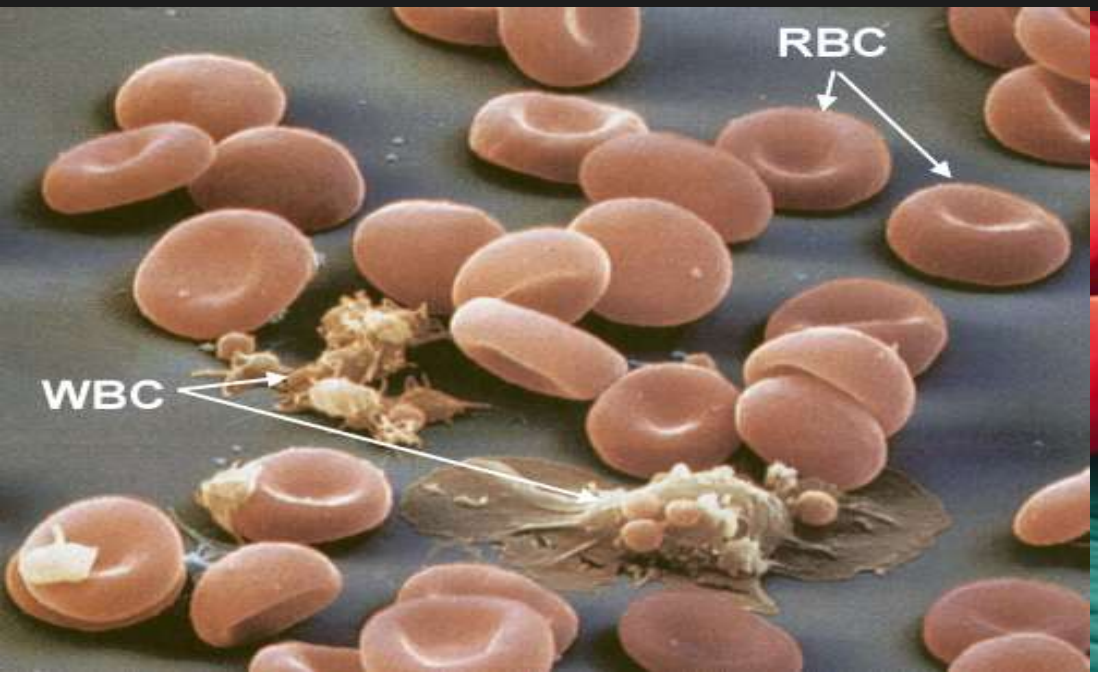
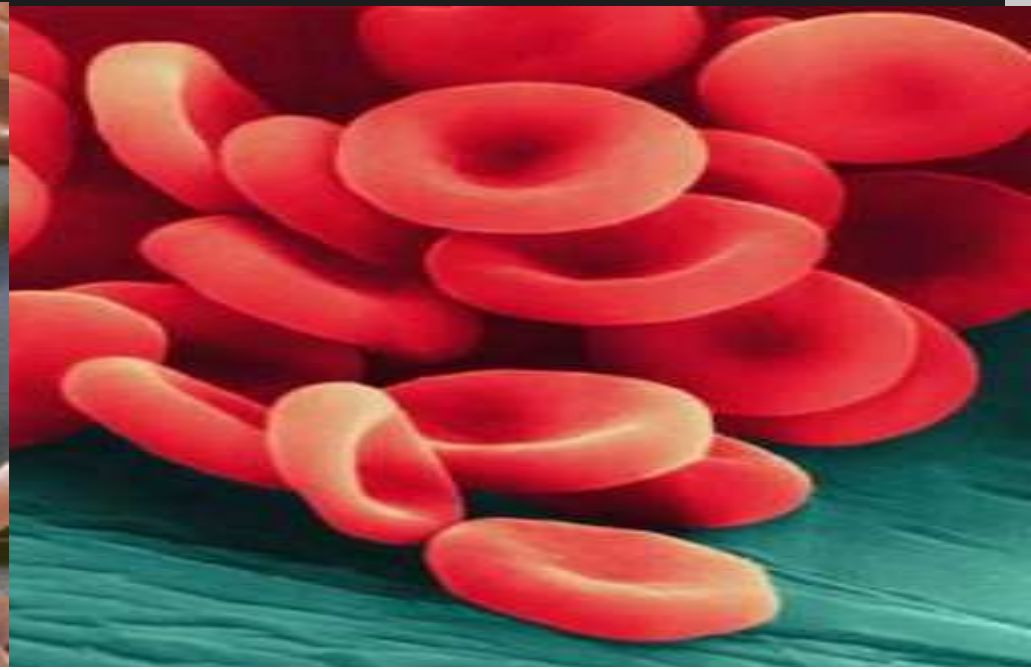
MICROSCOPY ANALYSIS OF BLOOD

Danil Hammoudi. MD





Steps in Blood Microscopy Analysis

1.Sample Collection

1. Blood is typically collected in an EDTA tube (to prevent clotting).
2. A drop of blood is placed on a glass slide.

2.Smear Preparation

1. A second slide is used to spread the drop across the first slide, creating a "feathered edge."
2. The smear is air-dried.

3.Staining

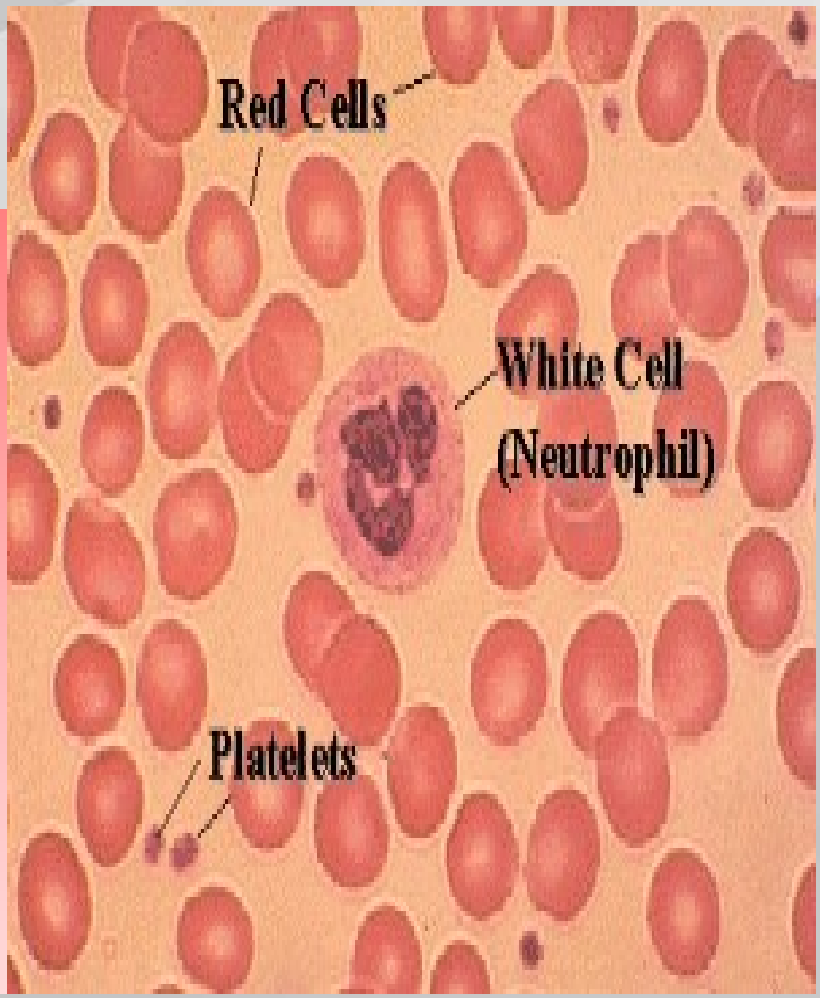
1. Common stains include **Wright**, **Giemsa**, or **Leishman** stain.
2. These help differentiate cellular components by color.

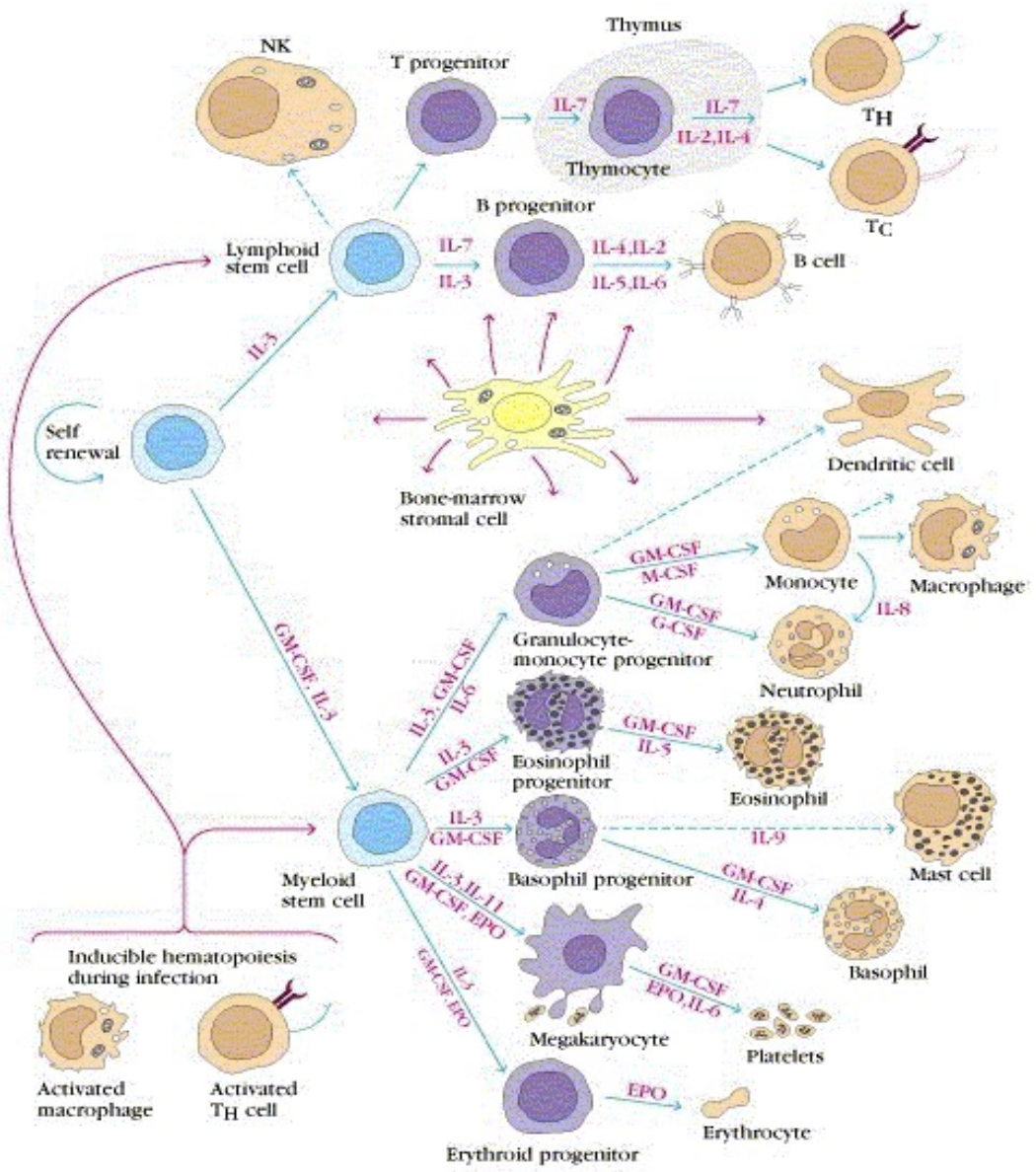
4.Microscopic Examination

1. Using **low power (10x)**: to locate the optimal area for examination.
2. **High power (40x, 100x oil immersion)**: to examine individual cells in detail.

Components of Blood

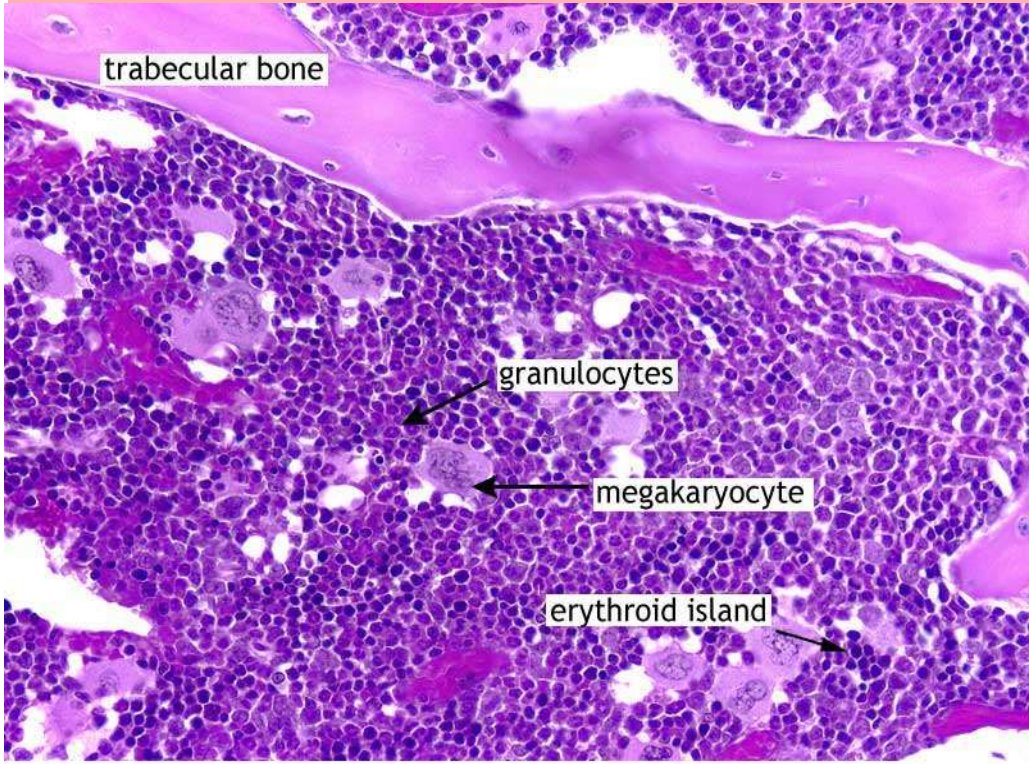
- - average adult has about 5 liters (about 5 qts):
- 1 - Formed elements:
  - Red blood cells (or erythrocytes)
  - White blood cells (or leucocytes)
  - Platelets (or thrombocytes)
- 2 - Plasma = water + dissolved solutes

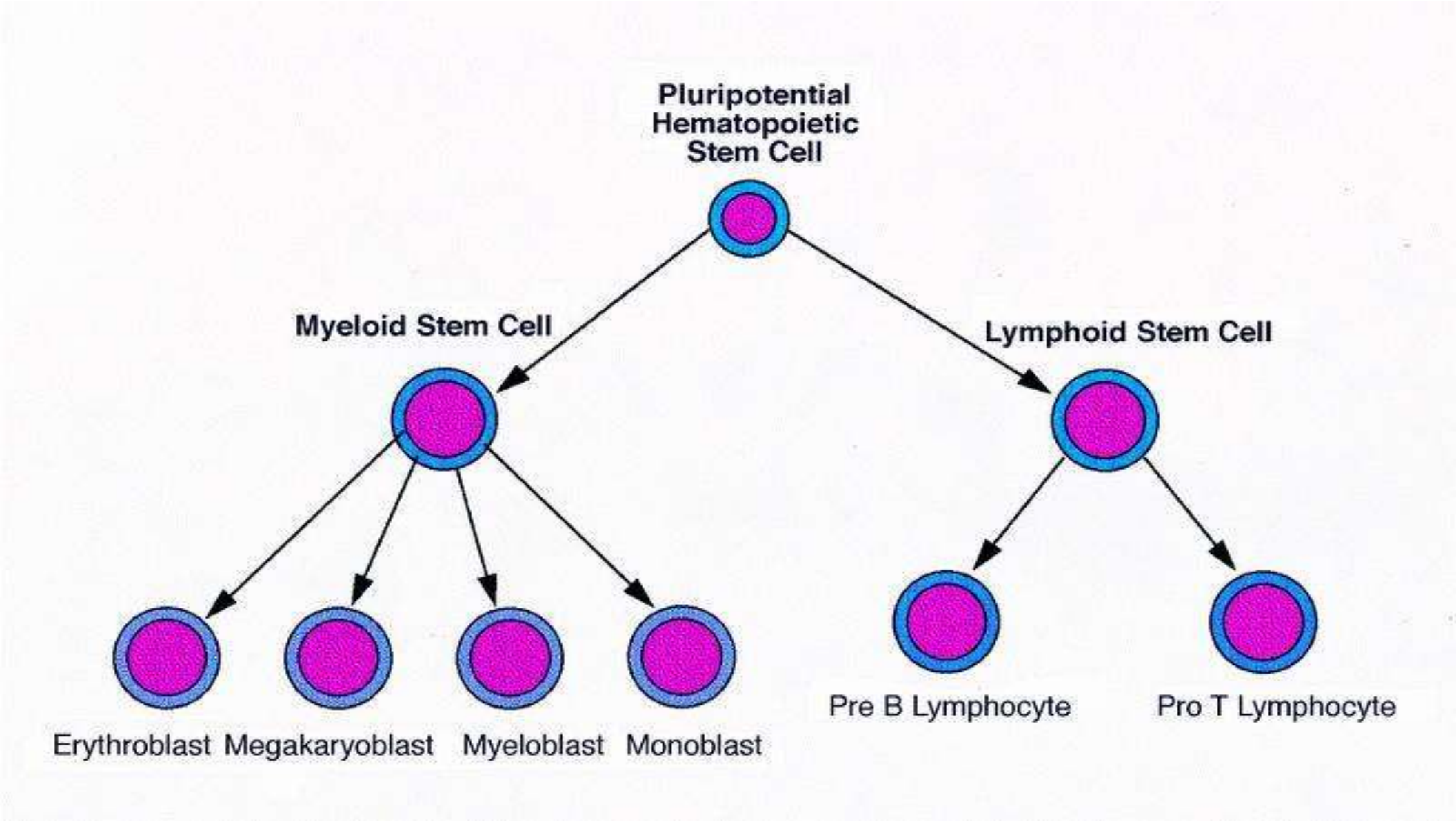




Formed elements: ORIGIN

- RED Bone MARROW : **HEMATOPOIESIS**




Pluripotential
Hematopoietic
Stem Cell
Myeloid Stem Cell
Lymphoid Stem Cell
Erythroblast
Megakaryoblast
Myeloblast
Monoblast
Pre B Lymphocyte
Pro T Lymphocyte

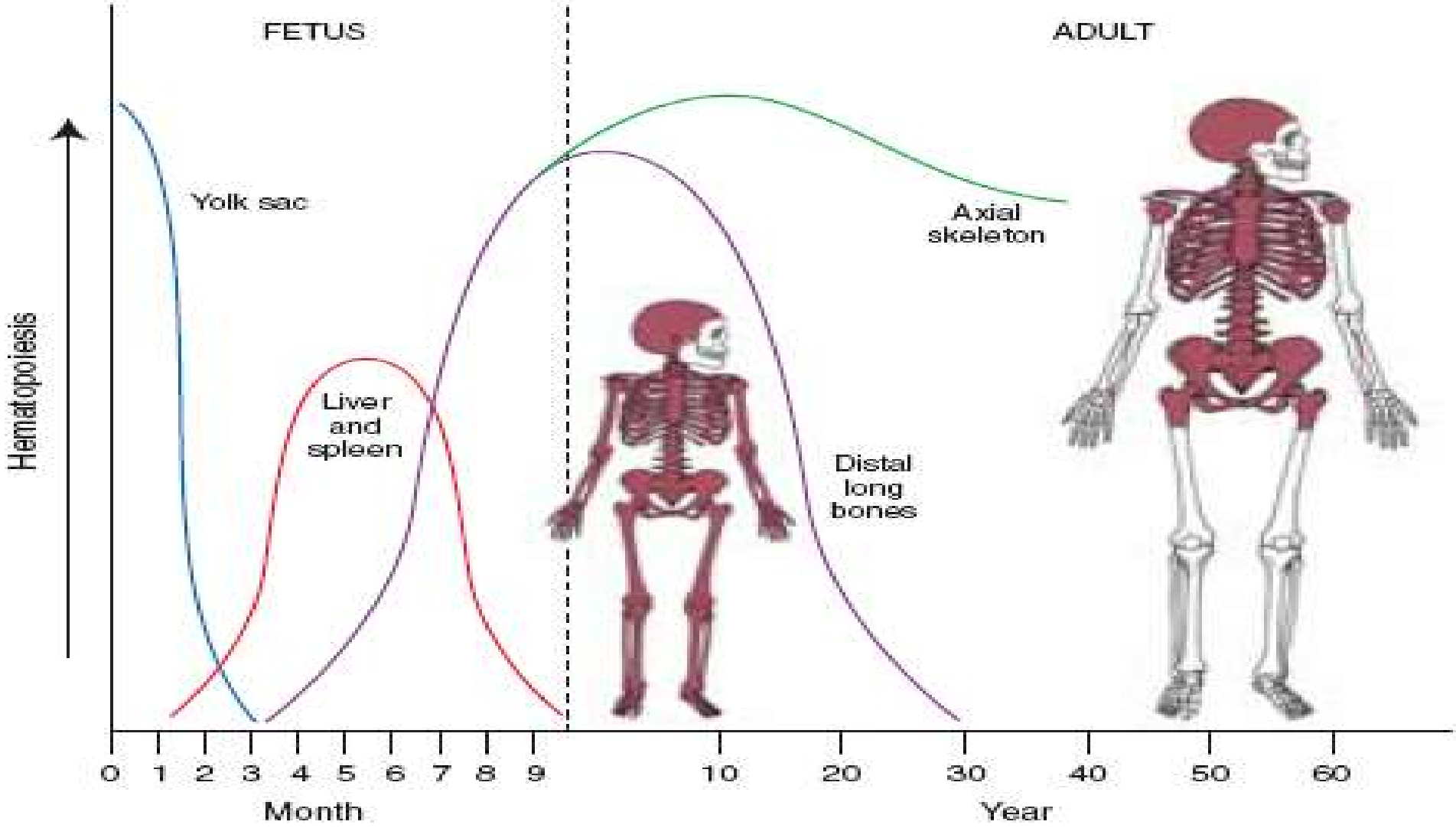
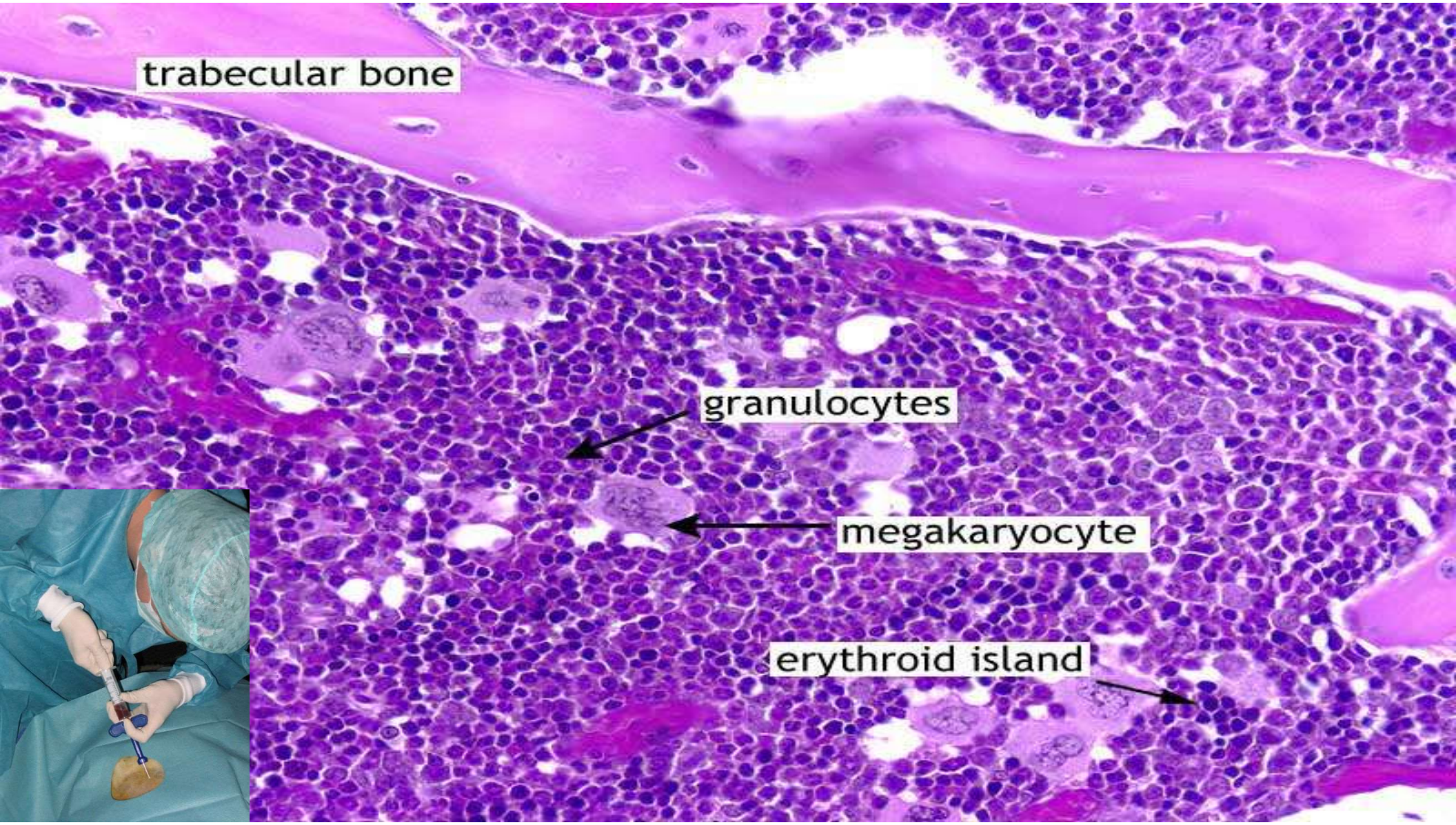
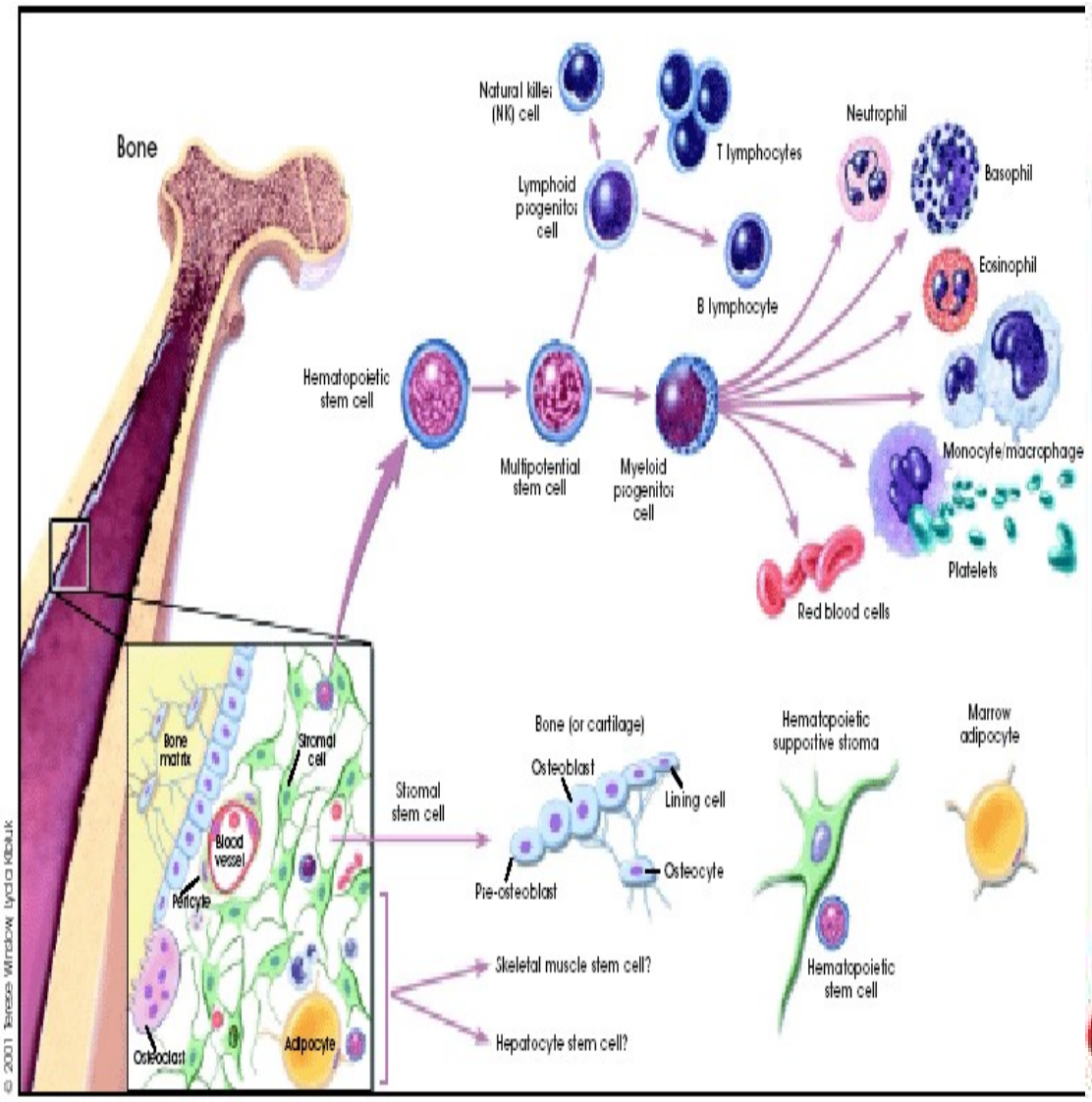


Figure 2.1 Marrow formation in fetus *(left)* versus the adult *(right)*


trabecular bone
granulocytes
megakaryocyte
erythroid island



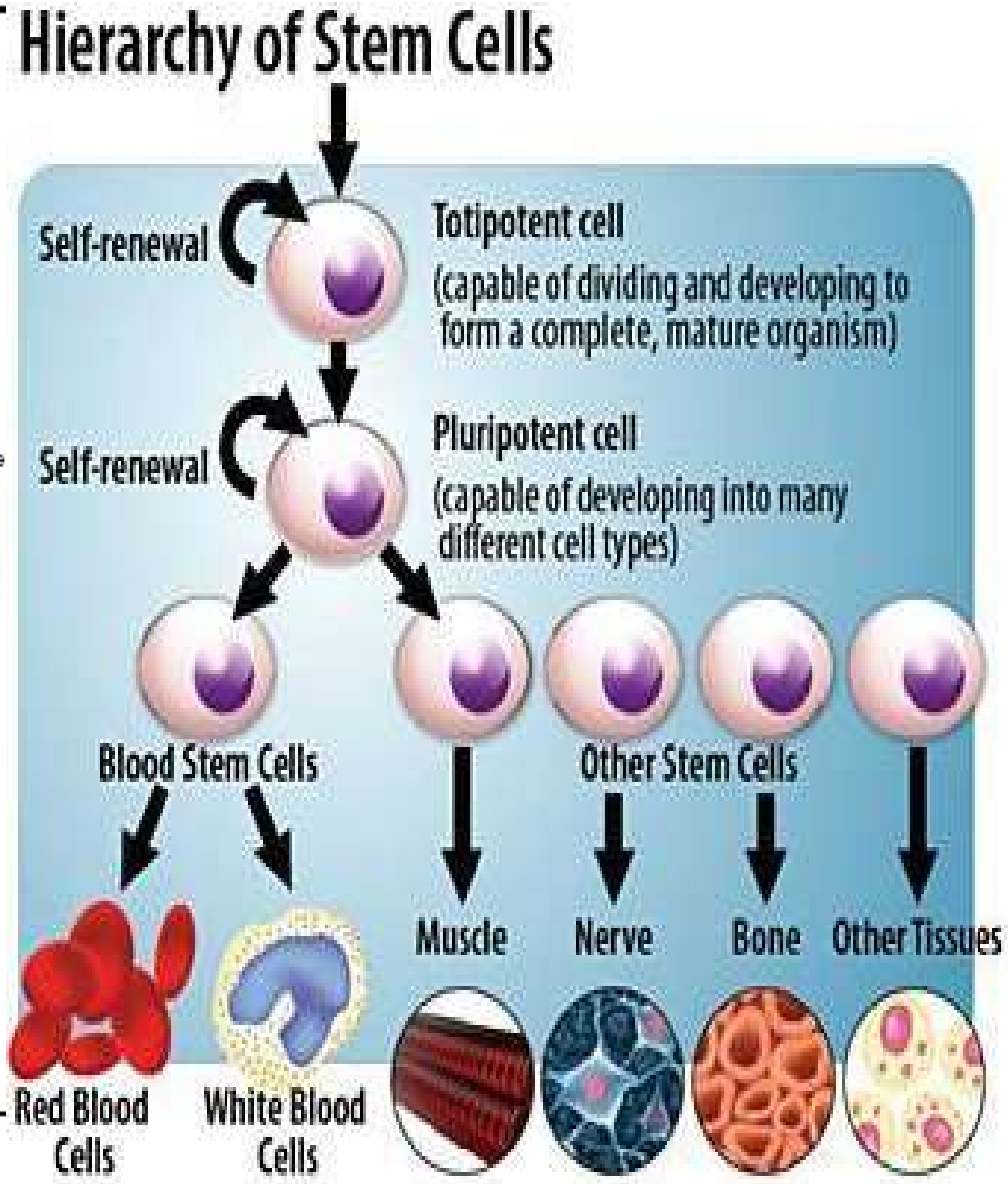
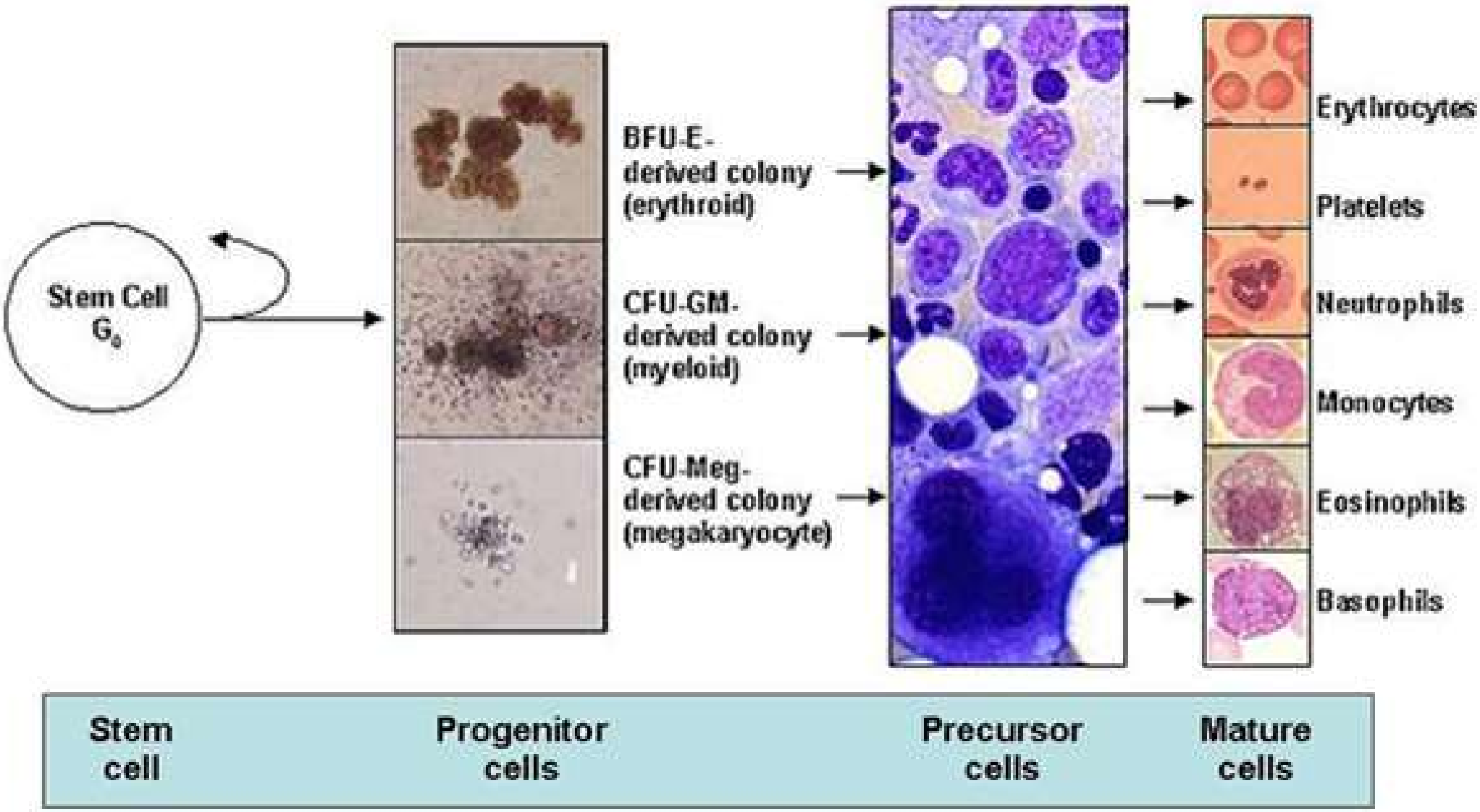


Figure 4.3. Hematopoietic and Stromal Stem Cell Differentiation.


Stem Cell
G_0
BFU-E-derived colony (erythroid)
CFU-GM-derived colony (myeloid)
CFU-Meg-derived colony (megakaryocyte)
Erythrocytes
Platelets
Neutrophils
Monocytes
Eosinophils
Basophils
Stem cell
Progenitor cells
Precursor cells
Mature cells

Functions of Blood:

- 1 - **Transportation:**

•**Oxygen** from lungs to tissues
•**Carbon dioxide** from tissues to lungs
•**Nutrients** from the digestive tract to cells
•**Hormones** from endocrine glands to target organs
•**Waste products** (e.g., urea, creatinine) to kidneys/liver for excretion

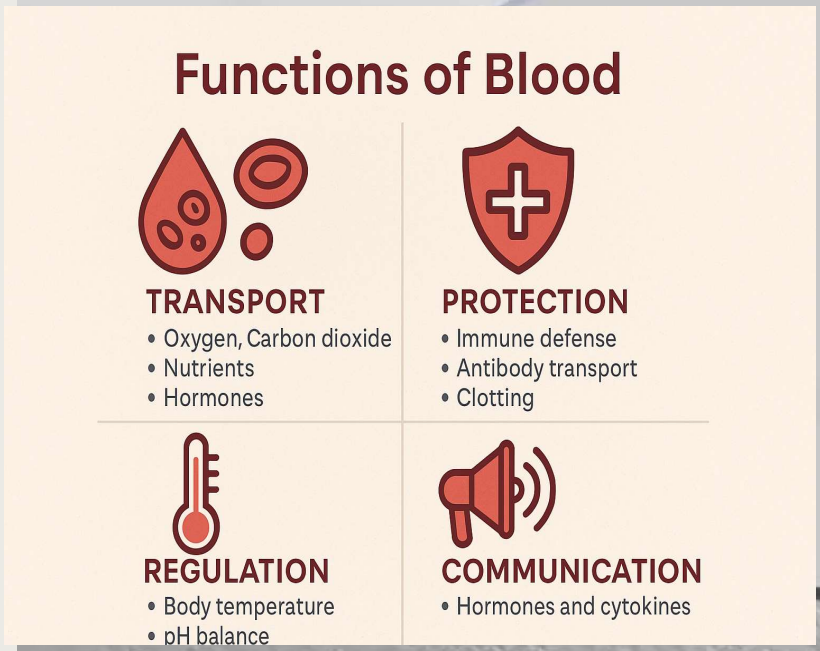
- 2 - **Regulation** –

•**Body temperature**: Distributes heat throughout the body
•**pH balance**: Buffers like bicarbonate help maintain stable pH
•**Fluid balance**: Plasma proteins (like albumin) maintain osmotic pressure and prevent fluid loss

- 3 - **Protection** -

•**Immune defense**: White blood cells (WBCs) identify and destroy pathogens
•**Antibody transport**: Plasma carries antibodies and immune proteins
•**Clotting**: Platelets and clotting factors stop bleeding and seal injuries

4. Communication
•**Hormones and cytokines** travel in the bloodstream to coordinate body responses (e.g., stress, growth, inflammation)



- In human **adults about 5 liter of blood contribute 7-8 % to the body weight of the individual**.

- The contribution of red blood cells (erythrocytes) to the total volume of the blood **(hematocrit) is about 43%.**

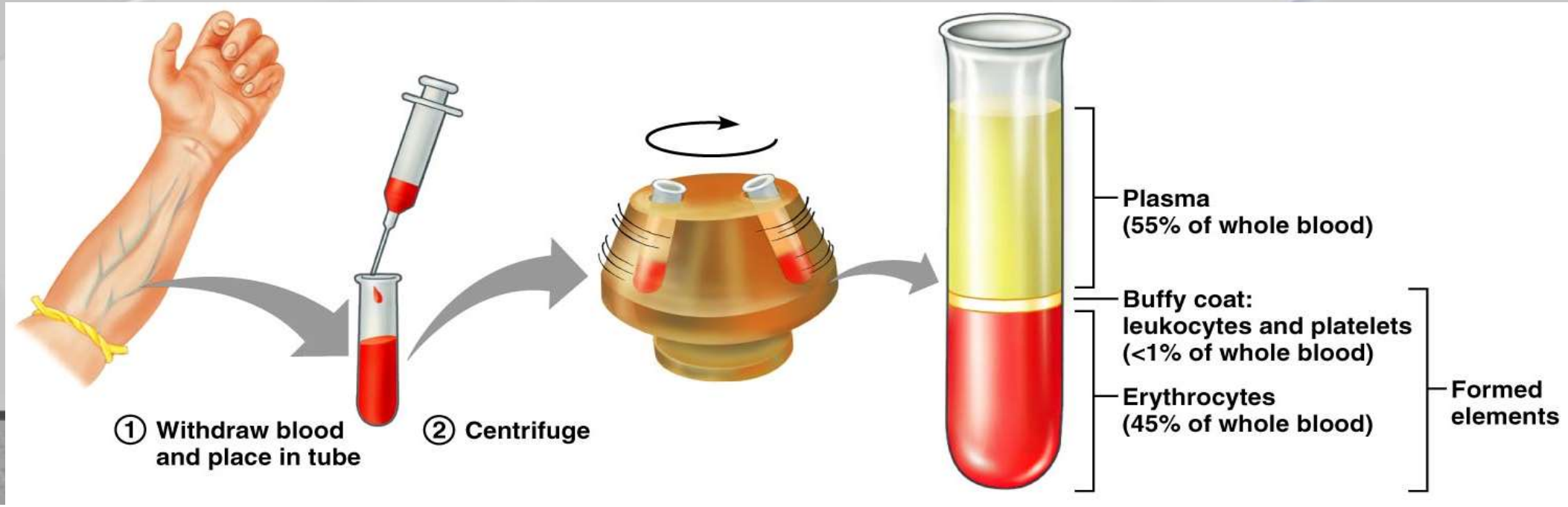
- Erythrocytes are the dominant (99%) but not the only type of cells in the blood.
- . Erythrocytes, leukocytes and blood platelets are also being referred to as the **formed elements of the blood**.

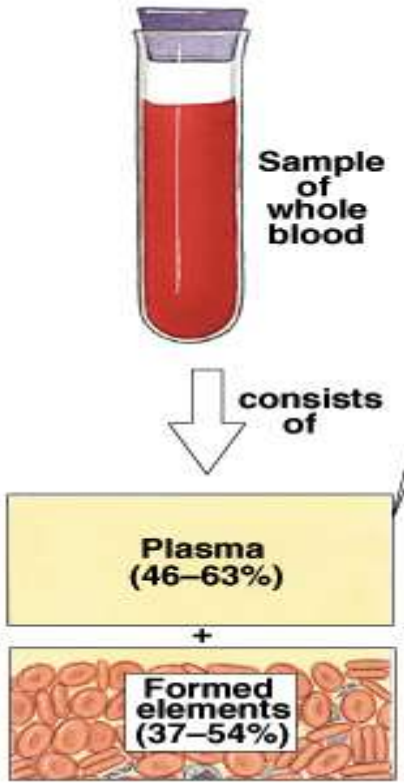
- Erythrocytes and blood platelets perform their functions exclusively in the blood stream.
- In contrast, **leukocytes reside only temporarily in the blood.**
- Leukocytes can leave the blood stream through the walls of capillaries and venules and enter either connective or lymphoid tissues.

Components of Whole Blood

Whole blood is a living tissue that circulates through the heart, arteries, veins, and capillaries carrying nourishment, electrolytes, hormones, vitamins, antibodies, heat, and oxygen to the body's tissues.

Whole blood contains red blood cells, white blood cells, and platelets suspended in a fluid called plasma.

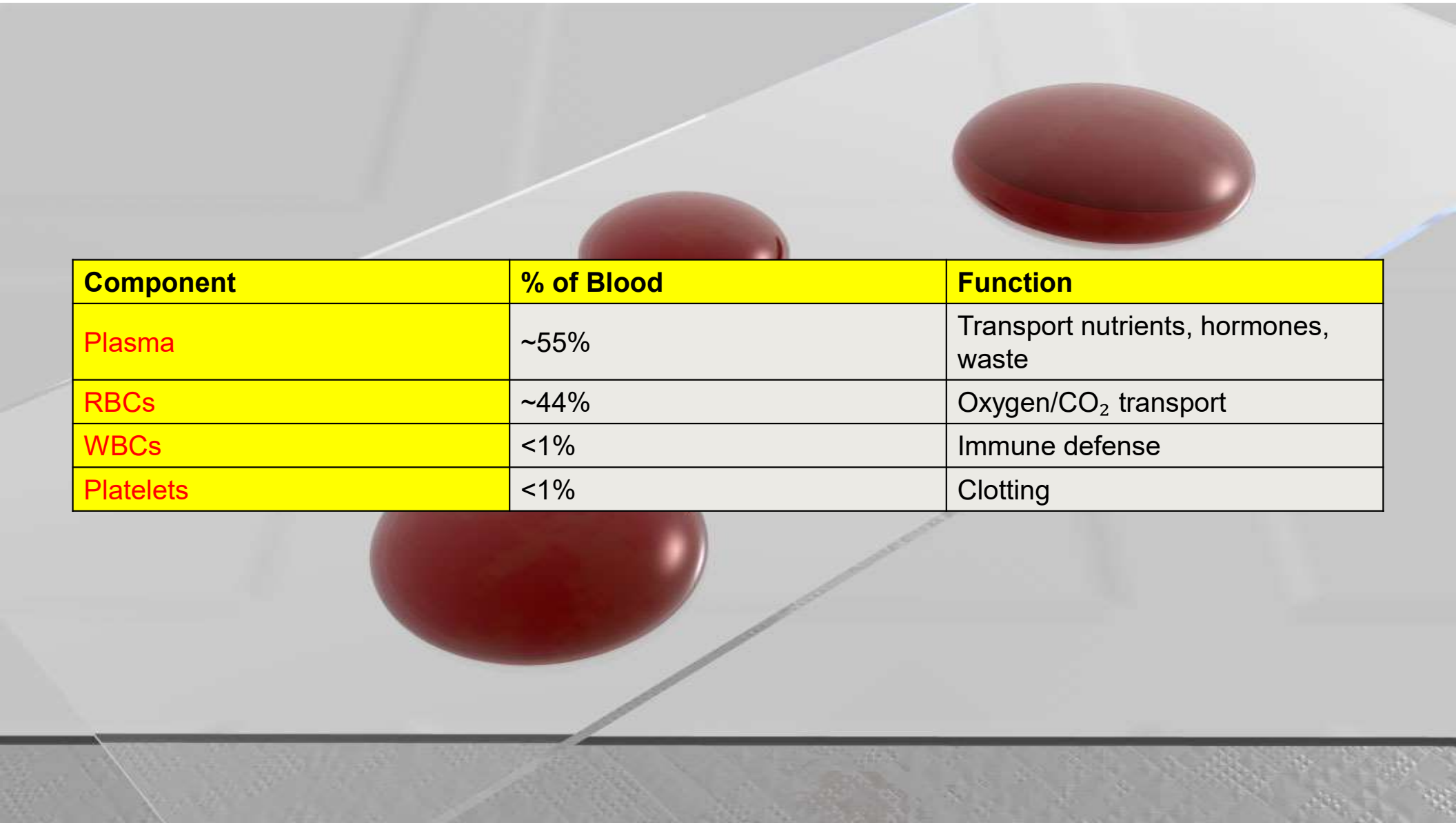




PLASMA COMPOSITION	
Plasma proteins	7%
Other solutes	1%
Water	92%
Transports organic and inorganic molecules, formed elements, and heat	

PLASMA PROTEINS	
Albumins (60%)	Major contributors to osmotic pressure of plasma; transport lipids, steroid hormones
Globulins (35%)	Transport ions, hormones, lipids; immune function
Fibrinogen (4%)	Essential component of clotting system; can be converted to insoluble fibrin
Regulatory proteins (<1%)	Enzymes, proenzymes, hormones

OTHER SOLUTES	
Electrolytes	Normal extracellular fluid ion composition for essential vital cellular activities. Ions contribute to osmotic pressure of body fluids. Major plasma electrolytes are Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, HPO_4^{2-}, SO_4^{2-}
Organic nutrients	Used for ATP production, growth, and maintenance of cells; include lipids (fatty acids, cholesterol, glycerides), carbohydrates (primarily glucose), and amino acids
Organic wastes	Carried to sites of breakdown or excretion; include urea, uric acid, creatinine, bilirubin, ammonium ions

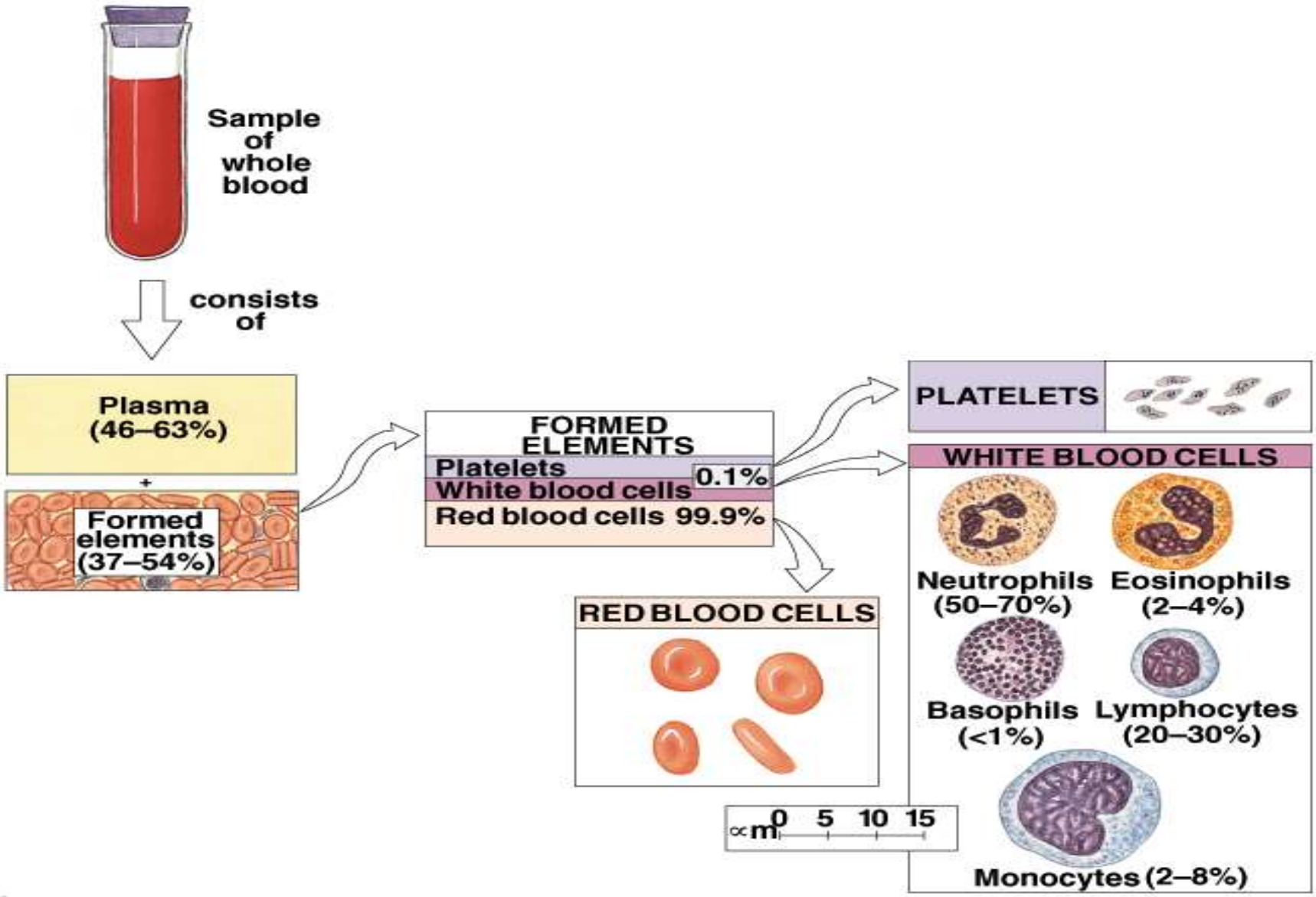


Component	% of Blood	Function
Plasma	~55%	Transport nutrients, hormones, waste
RBCs	~44%	Oxygen/CO_2 transport
WBCs	<1%	Immune defense
Platelets	<1%	Clotting

Plasma (≈ 55% of total blood volume)

•**Definition**: The liquid portion of blood.
•**Composition**:

- **Water (≈ 90–92%):** Acts as a solvent and medium for transport.
- **Plasma proteins** (≈ 7%):
  - **Albumin** – maintains oncotic pressure.
  - **Globulins** – immune function (e.g., antibodies).
  - **Fibrinogen** – key role in blood clotting.
- **Solutes** (≈ 1%): Electrolytes (Na^+, K^+, Ca^{2+}), nutrients (glucose, amino acids), gases (O_2, CO_2), hormones, metabolic waste (urea, creatinine).


Sample of whole blood
consists of
Plasma (46–63%)
+
Formed elements (37–54%)
FORMED ELEMENTS
Platelets
White blood cells
0.1%
Red blood cells 99.9%
PLATELETS
WHITE BLOOD CELLS
Neutrophils (50–70%)
Eosinophils (2–4%)
Basophils (<1%)
Lymphocytes (20–30%)
Monocytes (2–8%)
RED BLOOD CELLS
0 5 10 15
μm

2. Formed Elements (≈ 45% of total blood volume)
These are the **cellular components** of blood:

A. Erythrocytes (Red Blood Cells / RBCs)
•**Function**: Transport oxygen (via hemoglobin) and a small amount of CO_2.
•**Features**: No nucleus, biconcave shape, lifespan ~120 days.
•**Count**: ~5 million per microliter.

B. Leukocytes (White Blood Cells / WBCs)
•**Function**: Defense against infections and immune responses.
•**Types**:

- **Granulocytes**:
  - **Neutrophils** – phagocytosis of bacteria (most abundant).
  - **Eosinophils** – combat parasites and modulate allergies.
  - **Basophils** – release histamine during allergic reactions.
- **Agranulocytes**:
  - **Lymphocytes** – B cells (antibodies), T cells (cell-mediated immunity), NK cells (kill virus-infected cells).
  - **Monocytes** – differentiate into macrophages; phagocytic.

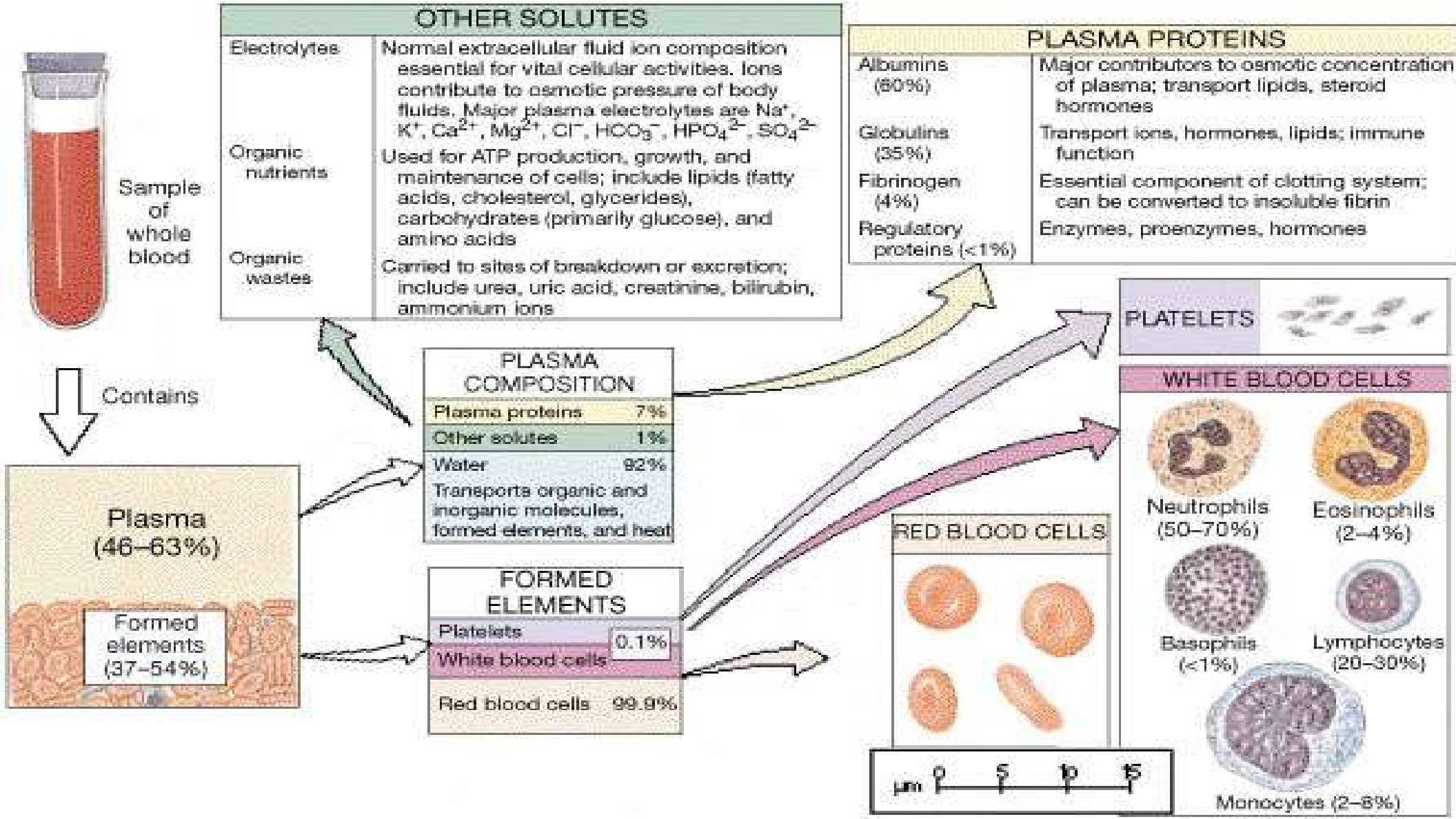
C. Thrombocytes (Platelets)
•**Function**: Essential for blood clotting (hemostasis).
•**Origin**: Fragments of megakaryocytes from bone marrow.
•**Lifespan**: ~7–10 days.

Blood Plasma

- **Blood plasma contains over 100 solutes, including:**
  - **Proteins** – albumin, globulins, clotting proteins, and others
  - **Lactic acid, urea, creatinine**
  - **Organic nutrients** – glucose, carbohydrates, amino acids
  - **Electrolytes** – sodium, potassium, calcium, chloride, bicarbonate
  - **Respiratory gases** – oxygen and carbon dioxide

Plasma

- it's a straw-colored, clear liquid that is 90 percent water, and it is an essential ingredient for human survival.
- It might seem like plasma is less important than the blood cells it carries. But that would be like saying that the stream is less important than the fish that swims in it. You can't have one without the other.
- Besides water, plasma also contains dissolved salts and minerals like calcium, sodium, magnesium, and potassium. Microbe-fighting antibodies travel to the battlefields of disease by hitching a ride in the plasma.
- Without plasma, the life-giving blood cells would be left floundering without transportation. Never underestimate the importance of plasma.


Sample of whole blood
Contains
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Water 92%
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FORMED ELEMENTS
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PLATELETS
WHITE BLOOD CELLS
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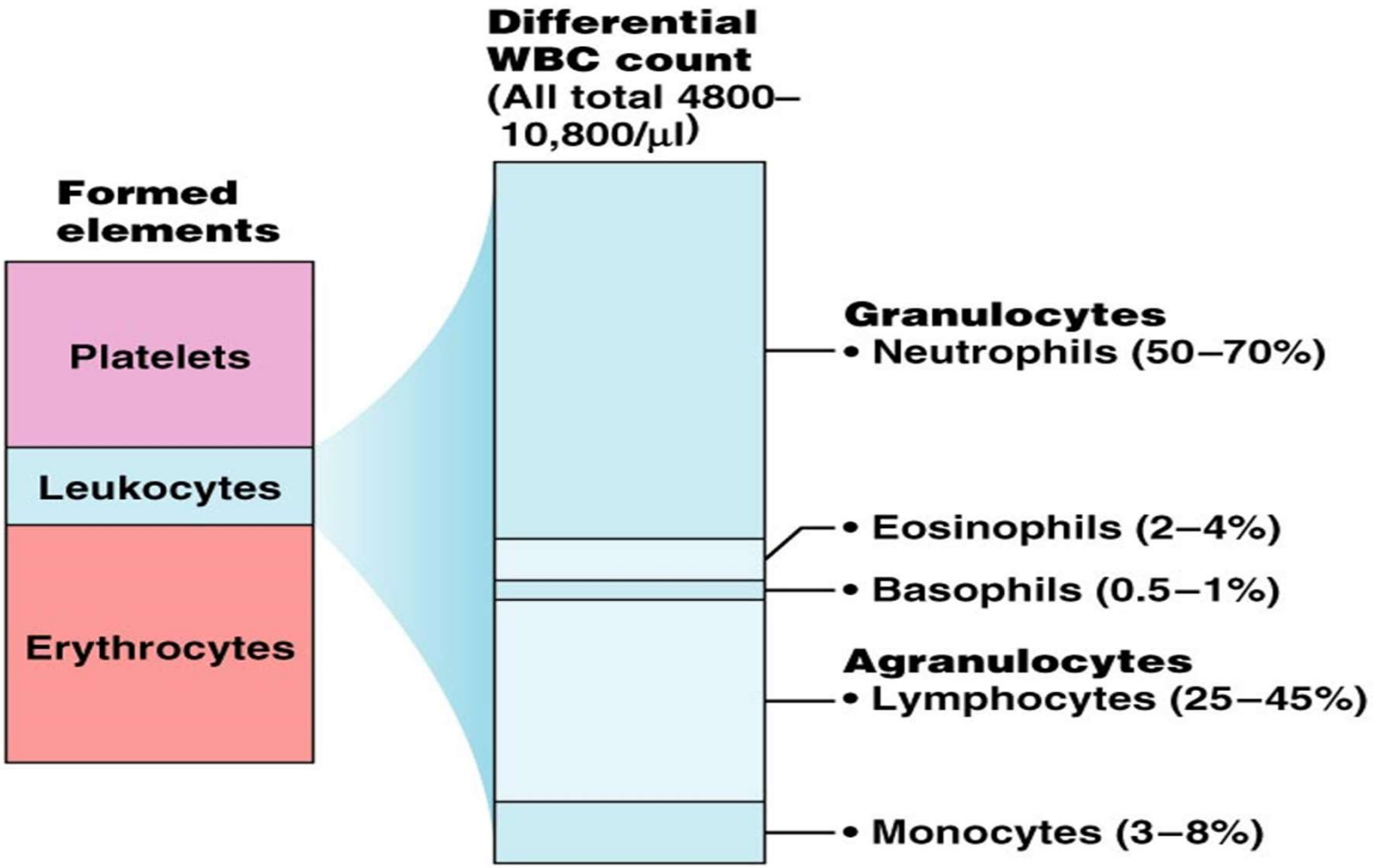
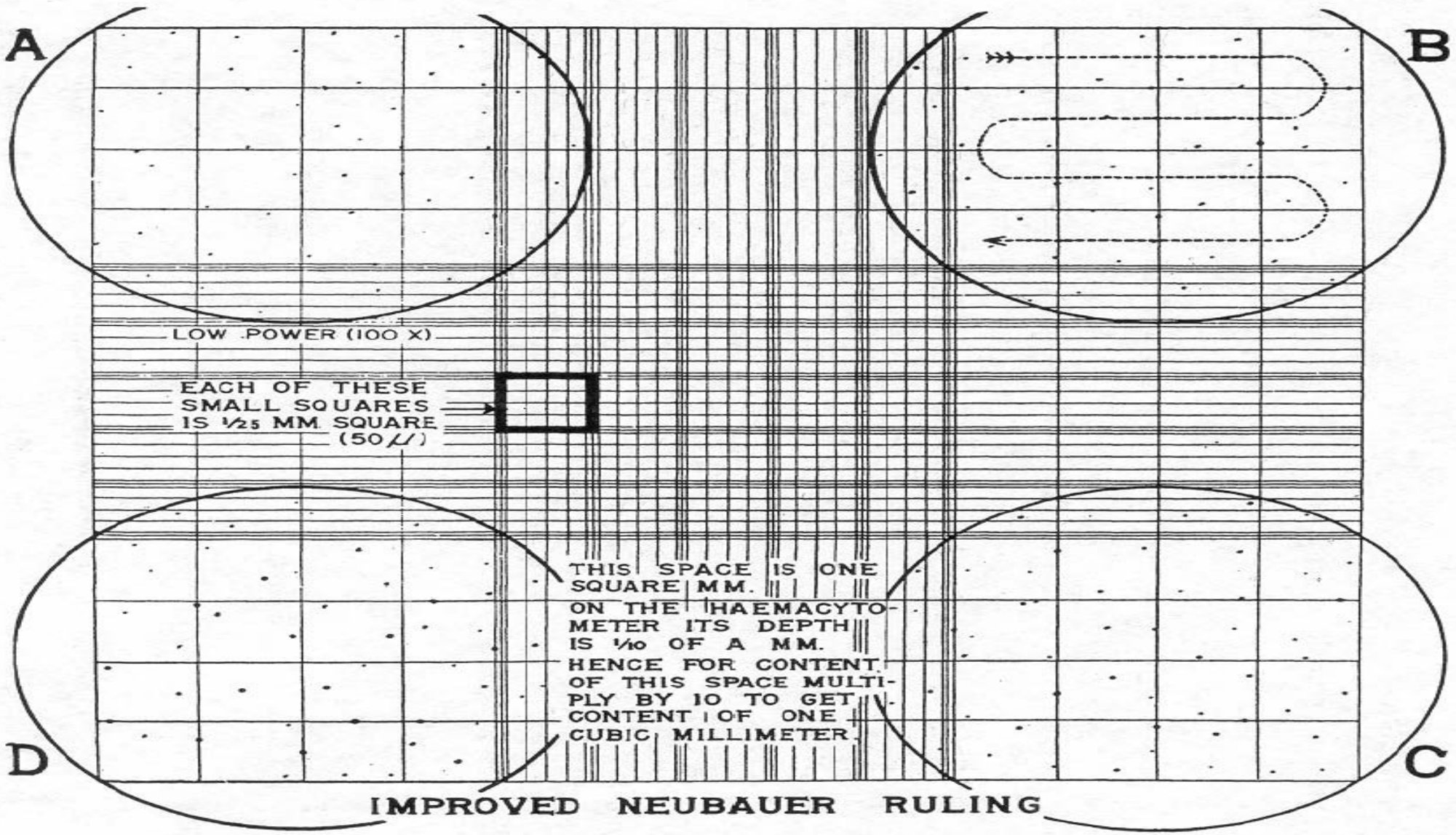
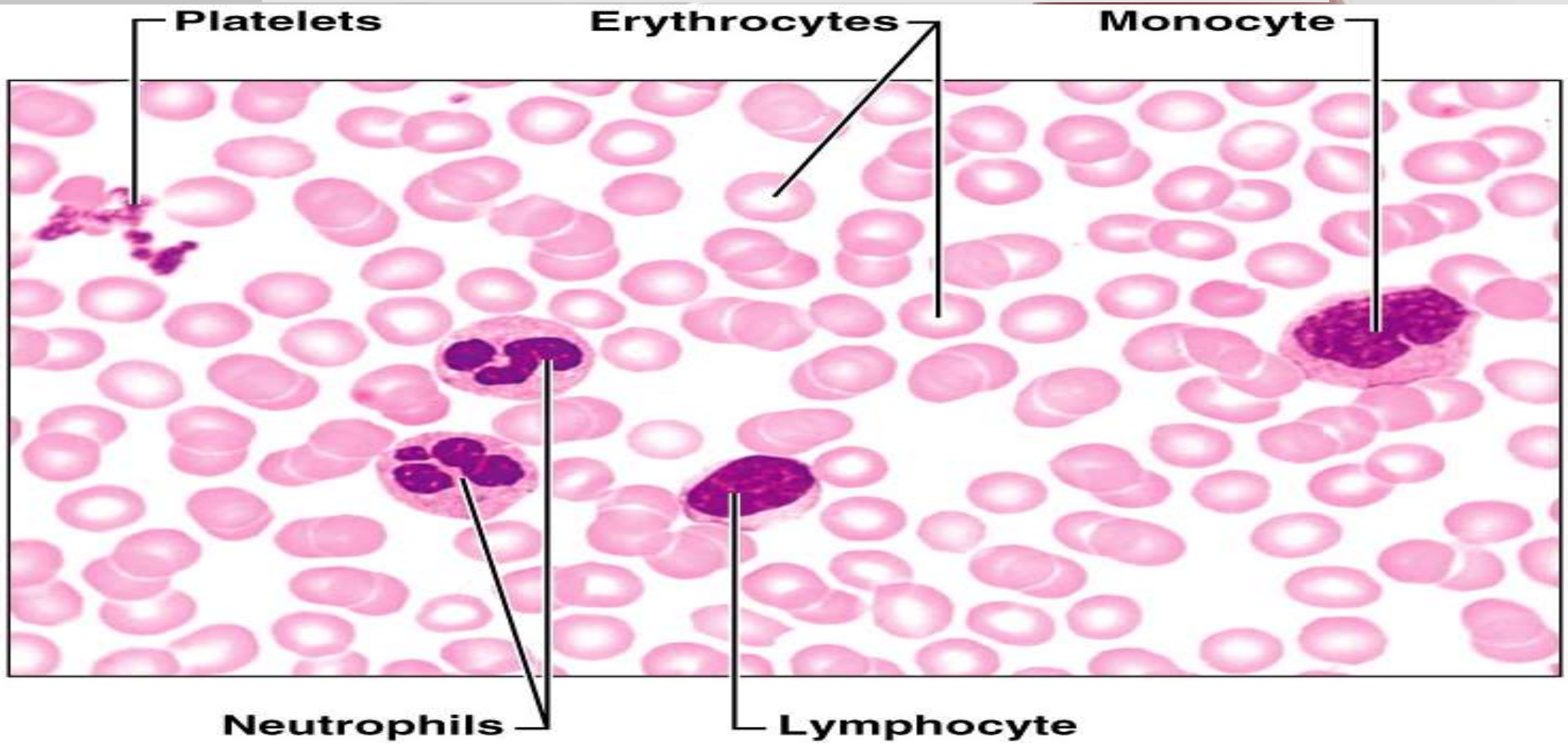
RED BLOOD CELLS
μm 0 5 10 15


Differential
WBC count
(All total 4800–
10,800/μl)
Formed
elements
Platelets
Leukocytes
Erythrocytes
Granulocytes
• Neutrophils (50–70%)
• Eosinophils (2–4%)
• Basophils (0.5–1%)
Agranulocytes
• Lymphocytes (25–45%)
• Monocytes (3–8%)

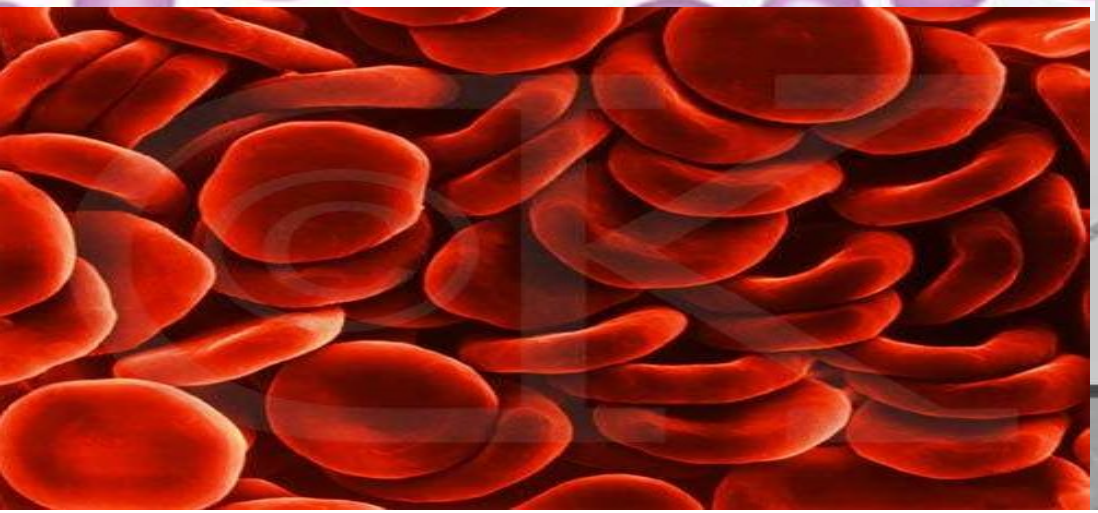


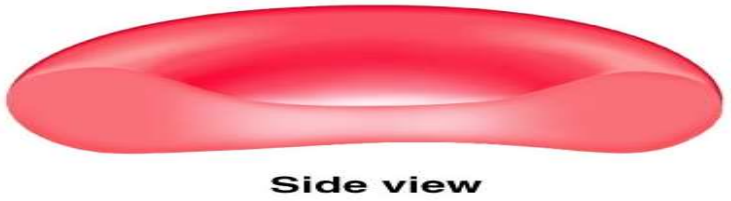
IMPROVED NEUBAUER RULING

Components of Whole Blood

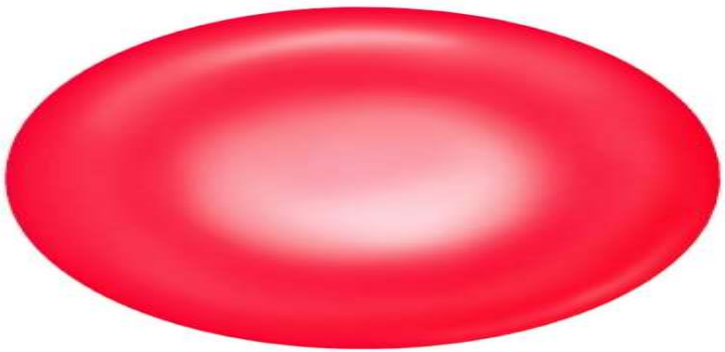


Erythrocytes (RBCs)

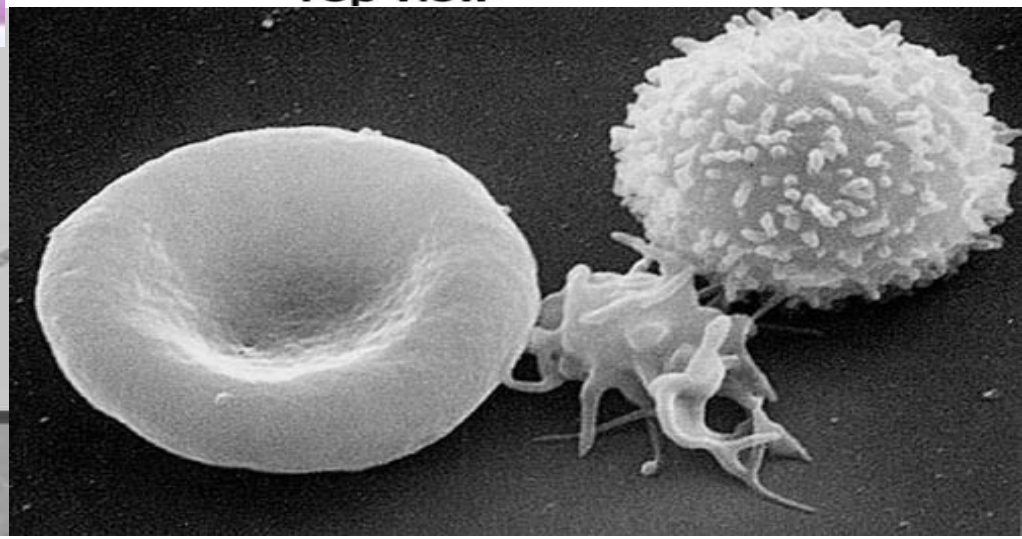


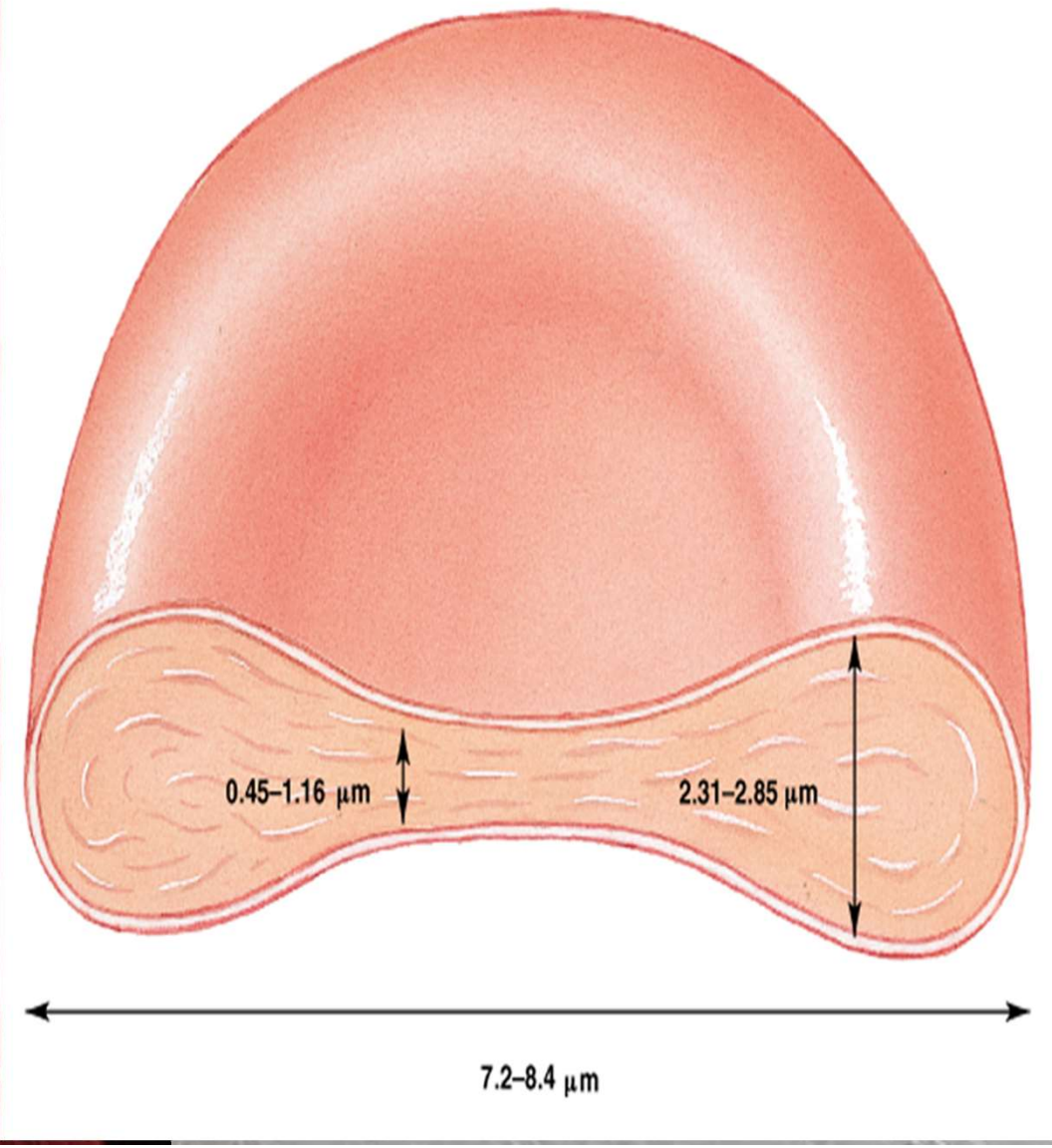


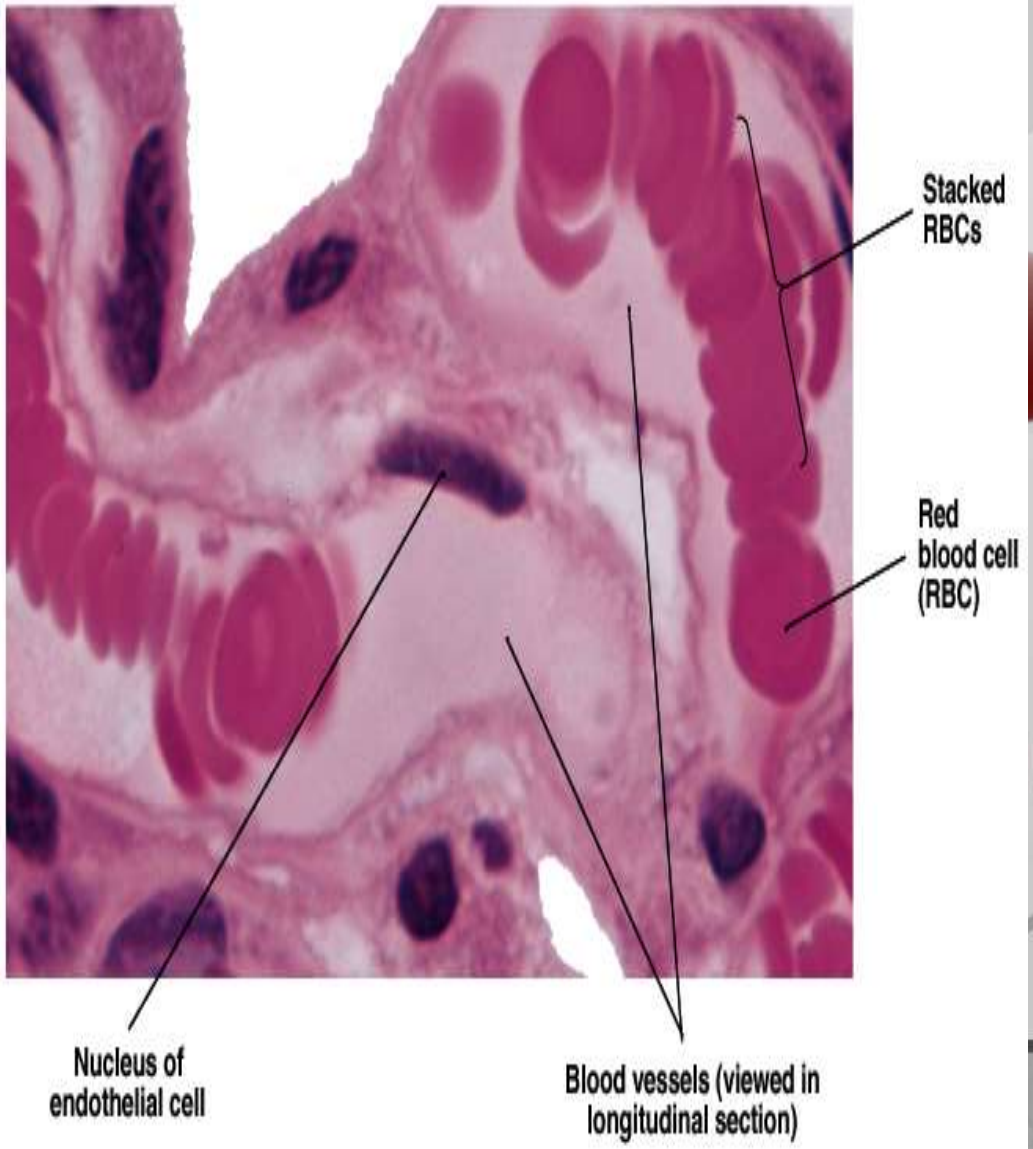
Side view



Top view




0.45–1.16 μm
2.31–2.85 μm
7.2–8.4 μm



1. Erythrocytes (Red Blood Cells – RBCs)

◆ **Origin:**

•Derived from **myeloid lineage** via **erythropoiesis**

•Regulated by **erythropoietin (EPO)** (produced by kidneys in response to hypoxia)

◆ **Structure:**

•Biconcave disc, anucleate

•Contains **~270–300 million hemoglobin molecules** per cell

•Diameter: ~7–8 μm

•Lifespan: ~120 days

•Removed by macrophages in spleen, liver, and bone marrow

◆ **Function:**

•Oxygen transport via hemoglobin (HbA)

•CO_2 transport (as carbaminohemoglobin and bicarbonate)

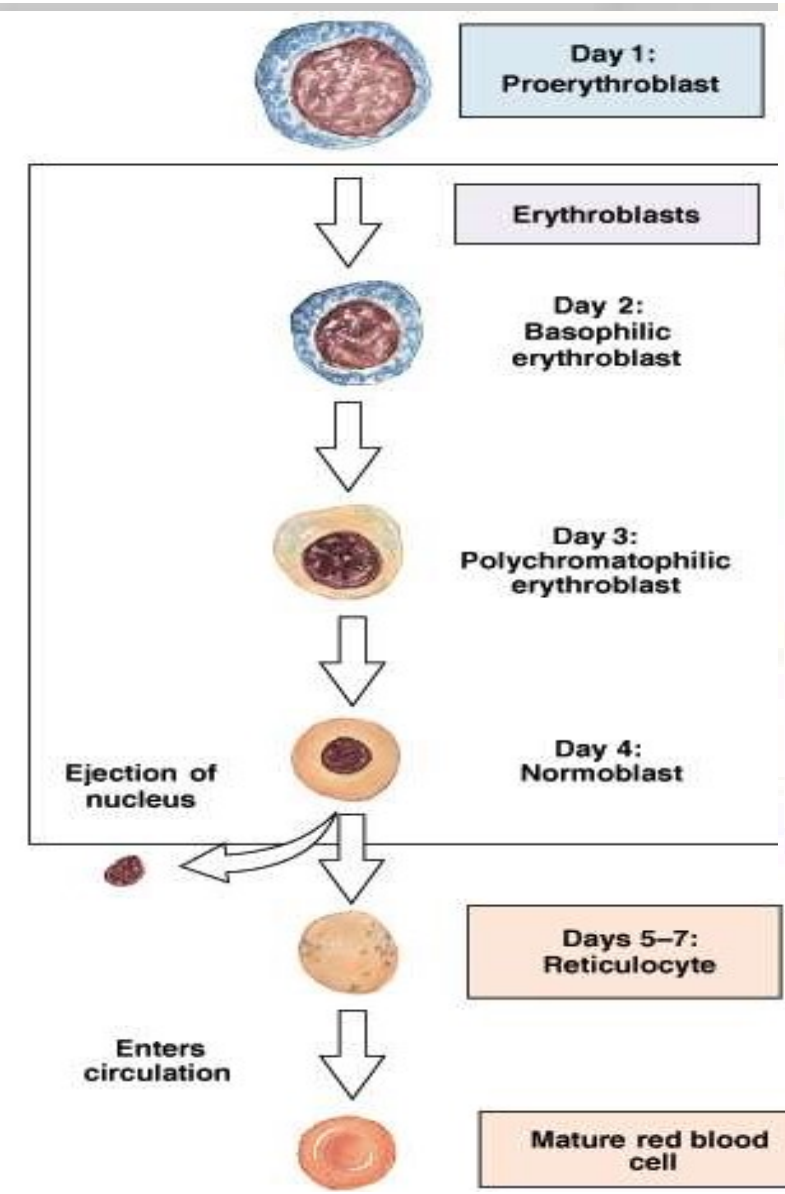
•Acid-base buffering via carbonic anhydrase

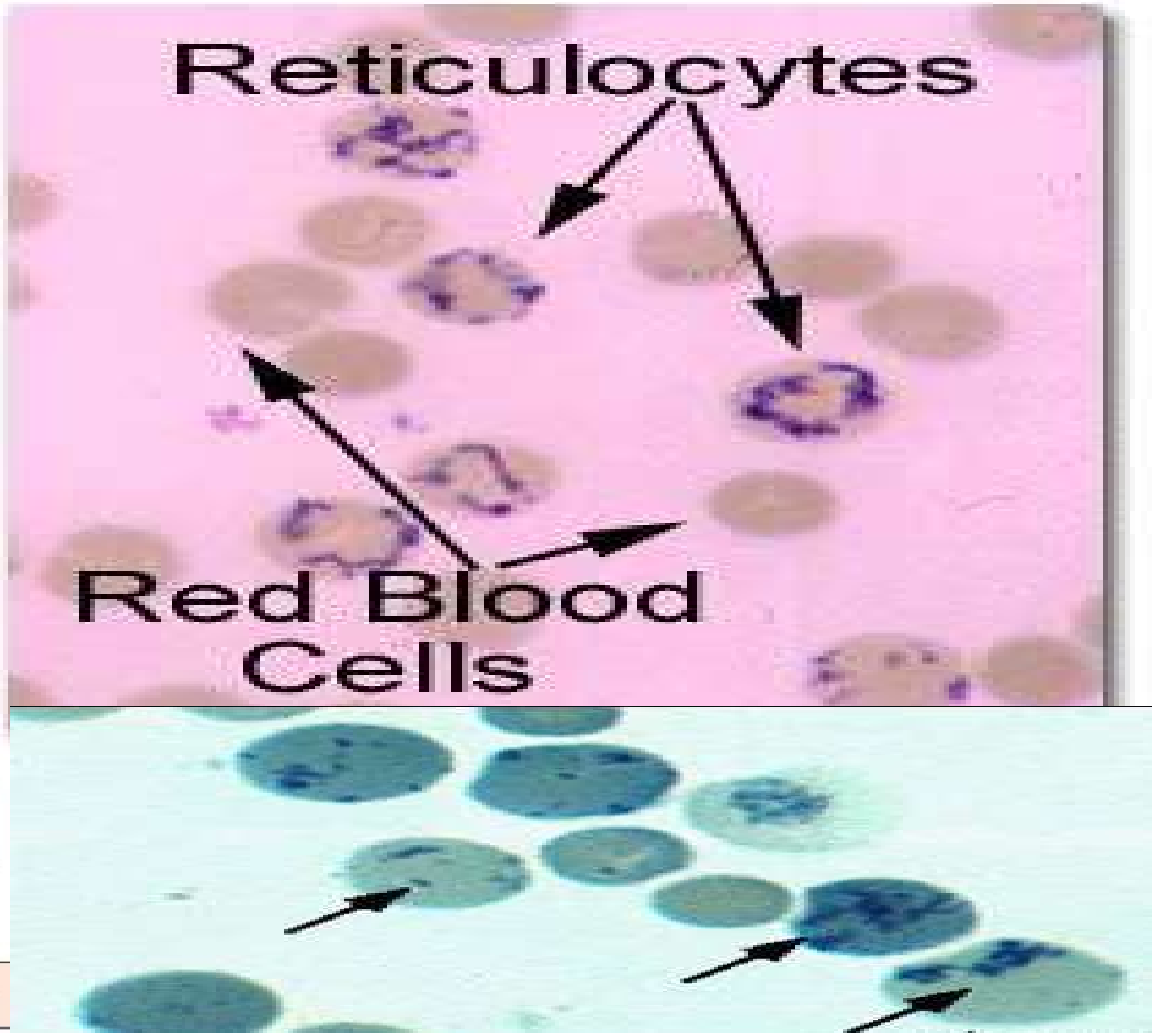
◆ **Key Pathologies:**

•Anemia (microcytic, normocytic, macrocytic)

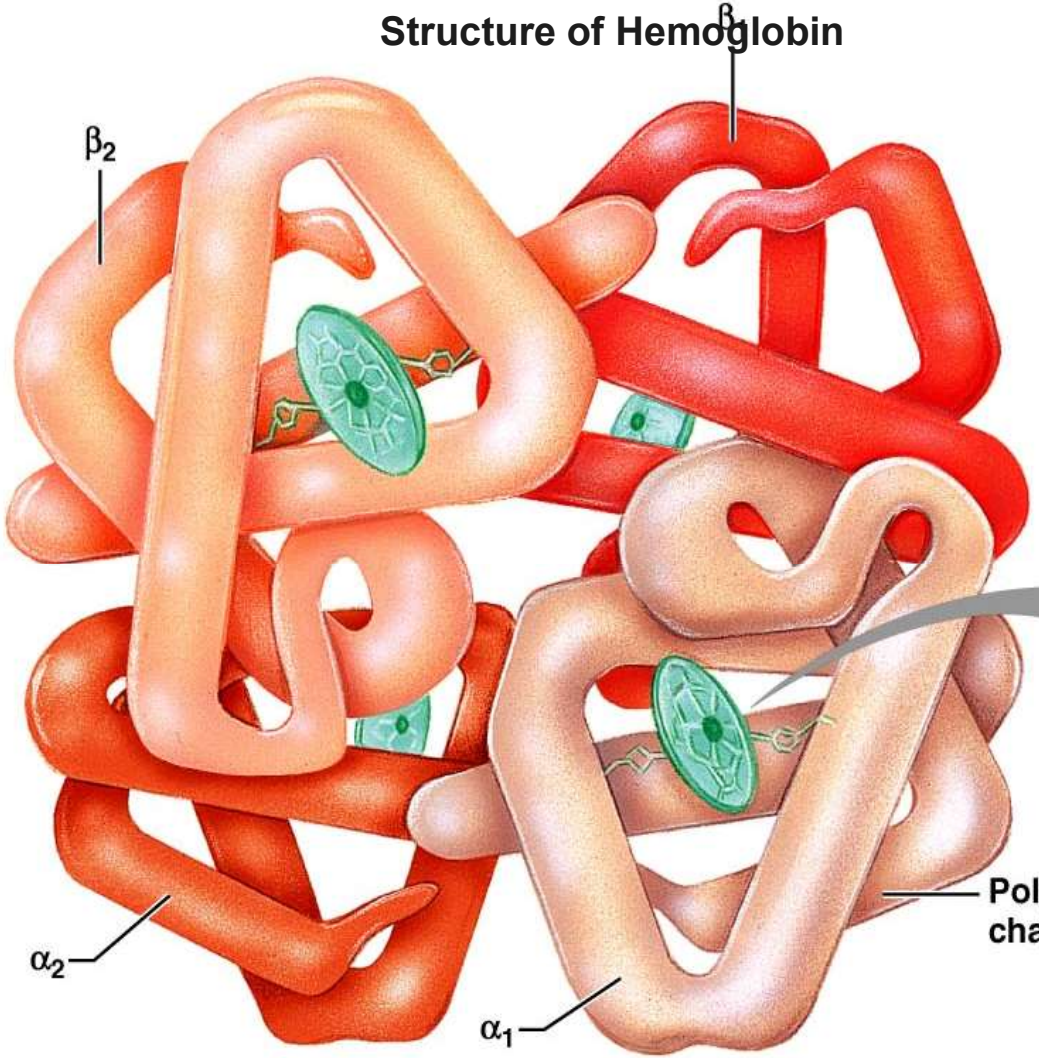
•Polycythemia vera

•Sickle cell disease, thalassemia

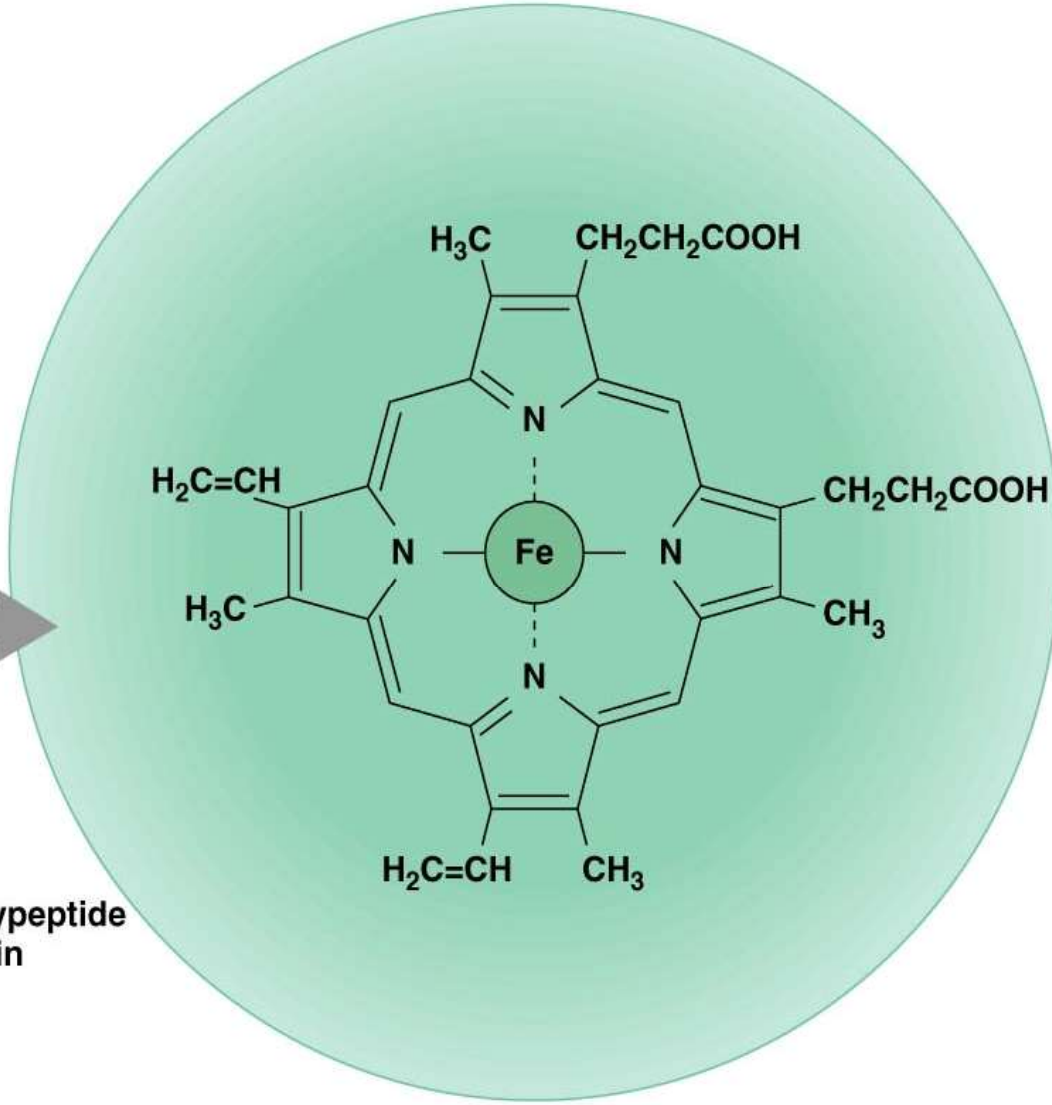

Day 1:
Proerythroblast
Erythroblasts
Day 2:
Basophilic
erythroblast
Day 3:
Polychromatophilic
erythroblast
Day 4:
Normoblast
Ejection of
nucleus
Days 5–7:
Reticulocyte
Enters
circulation
Mature red blood
cell


Reticulocytes
Red Blood
Cells

Structure of Hemoglobin

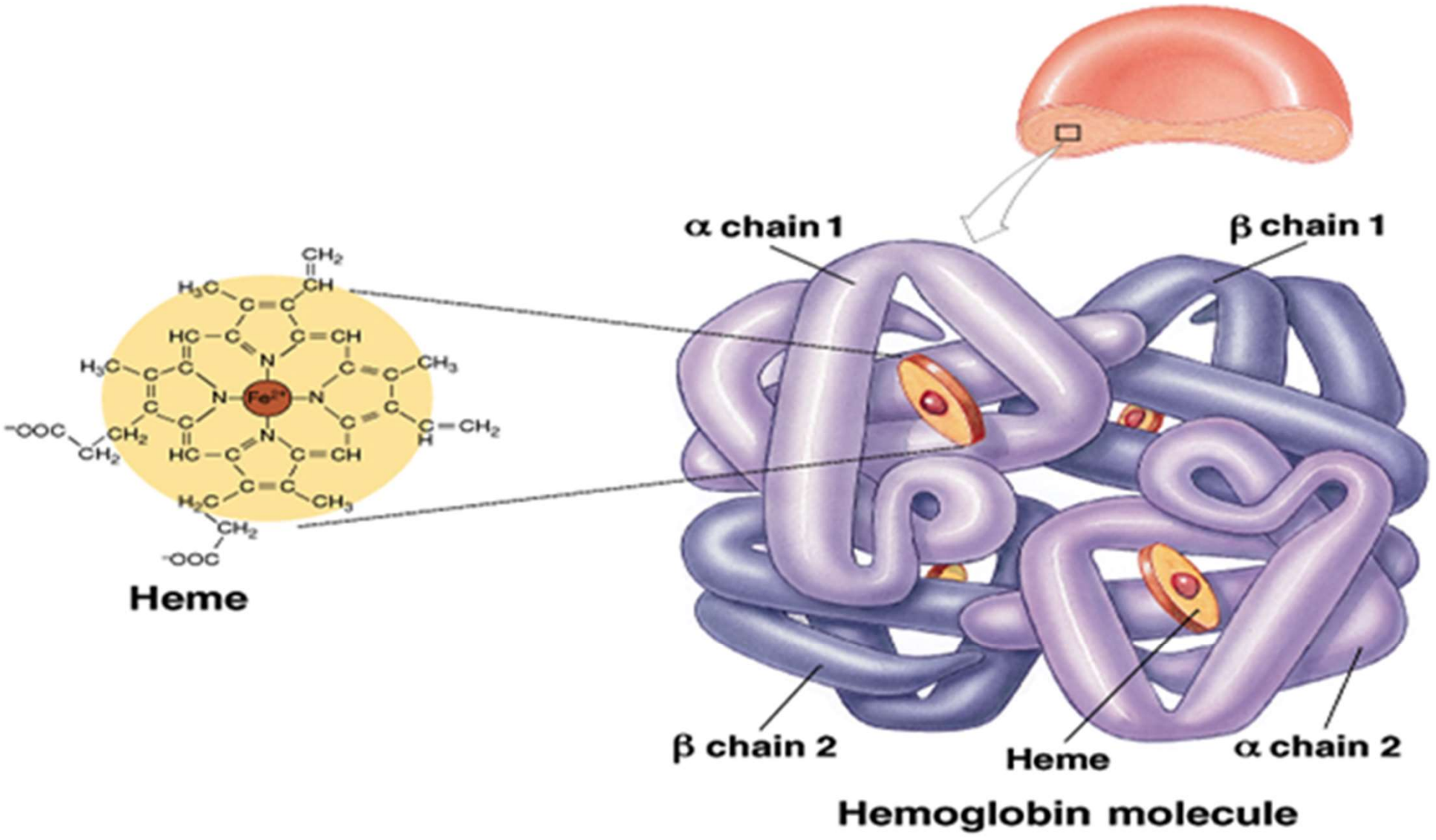


(a) Hemoglobin



(b) Iron-containing heme group

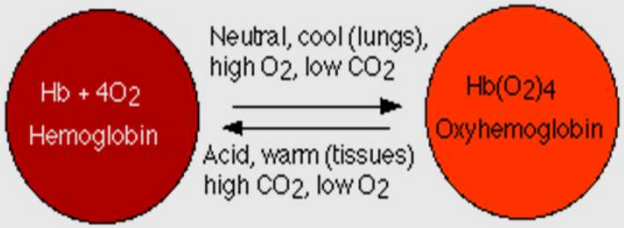
Figure 17.4


α chain 1
β chain 1
β chain 2
Heme
α chain 2
Heme
Hemoglobin molecule

Hemoglobin (Hb)

- **Oxyhemoglobin** – Hb bound to oxygen
  - Oxygen loading takes place in the lungs

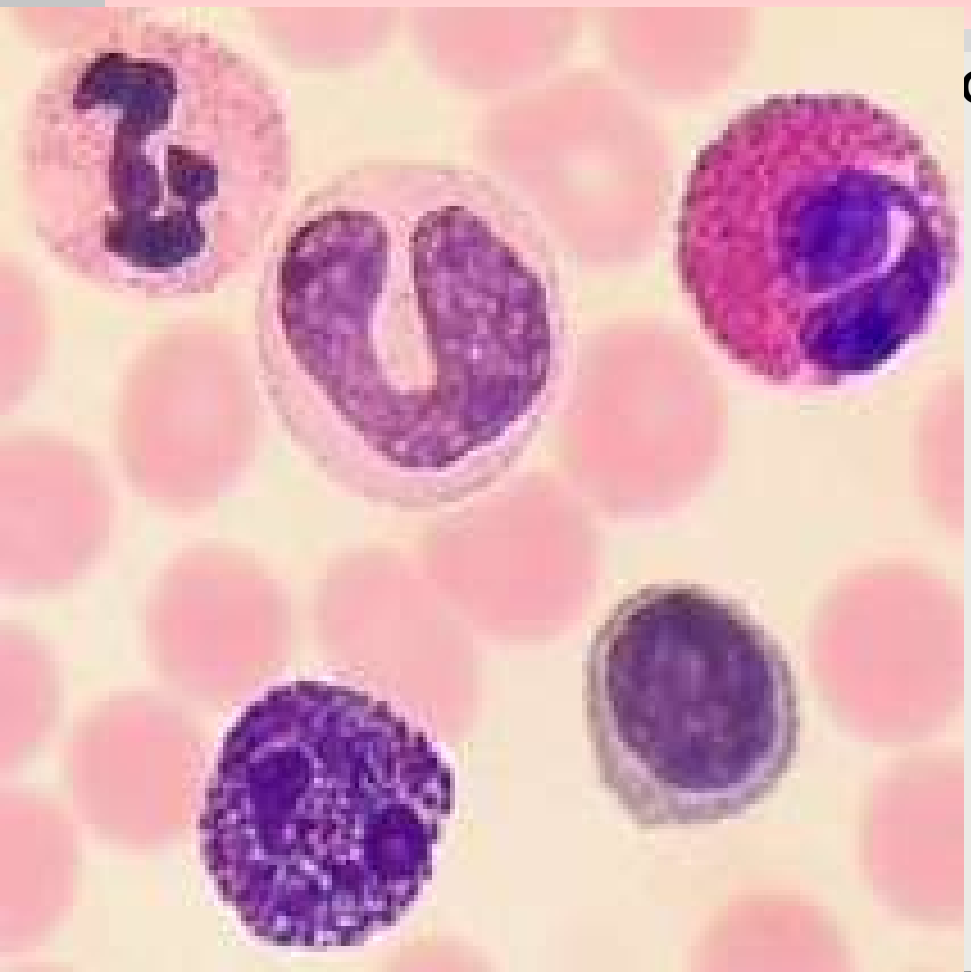
- **Deoxyhemoglobin** – Hb after oxygen diffuses into tissues (reduced Hb)
- **Carbaminohemoglobin** – Hb bound to carbon dioxide
  - Carbon dioxide loading takes place in the tissues



- Men: 13.5 to 16.5 g/dl
- Women: 12.1 to 15.1 g/dl
- Children: 11 to 16 g/dl
- Pregnant women: 11 to 12 g/dl

Name of Hemoglobin	Subunit Structure	Time of Expression
Hemoglobin Portland	$\zeta_2\gamma_2$	Embryonic
Hemoglobin Gower I	$\zeta_2\varepsilon_2$	Embryonic
Hemoglobin Gower II	$\alpha_2\varepsilon_2$	Embryonic
Hemoglobin F	$\alpha_2\gamma_2$	Fetal
Hemoglobin Barts	γ_4	Fetal (pathologic Hb secondary to absence of all 4 α globulin genes; fatal in utero)
Hemoglobin A_2	$\alpha_2\delta_2$	Minor adult hemoglobin
Hemoglobin A	$\alpha_2\beta_2$	Major adult hemoglobin

Granulocytes



Granulocytes –

- **neutrophils,**
- **eosinophils,**
- **and basophils**

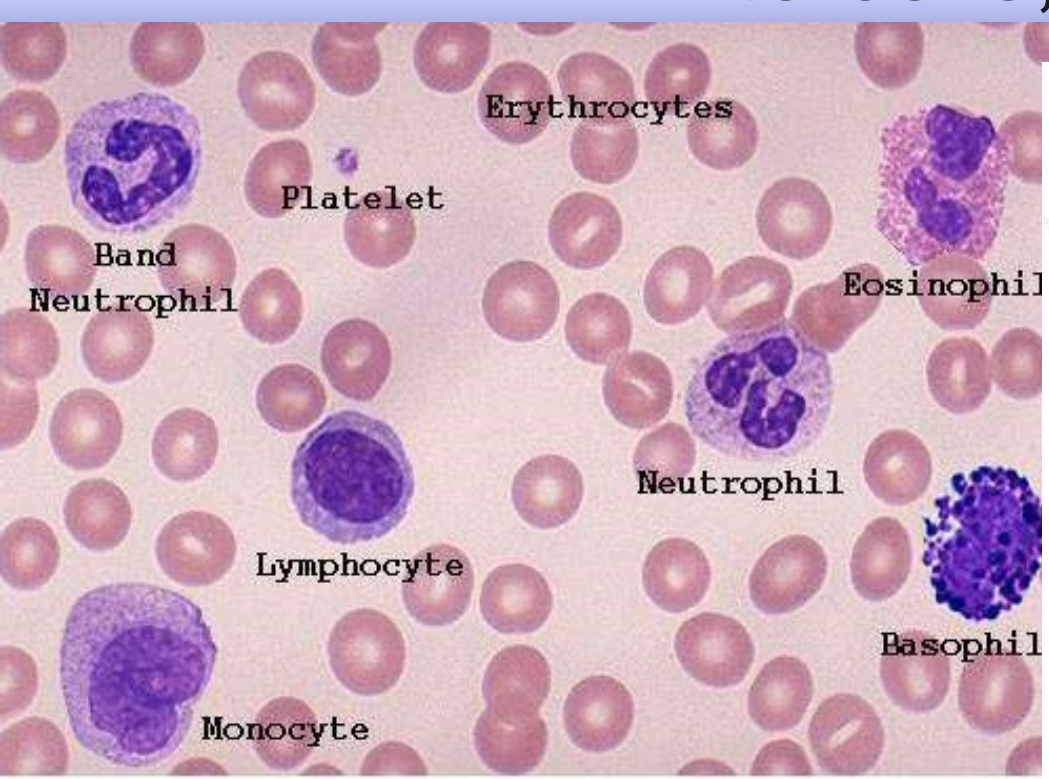
» Contain cytoplasmic granules that stain specifically (acidic, basic, or both) with Wright's stain

» Are larger and usually shorter-lived than RBCs

» Have lobed nuclei

» Are all phagocytic cells

White cells, leukocytes



Wright-stained smear of normal blood (x1000)
The RBC's are biconcave discs stained buff-pink, and the WBC's nucleus and cytoplasmic granules and platelet stain varying degrees of blue and pink.

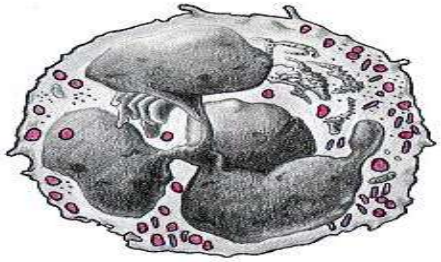


Fig. 8 - Neutrophil

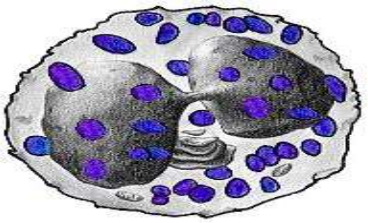
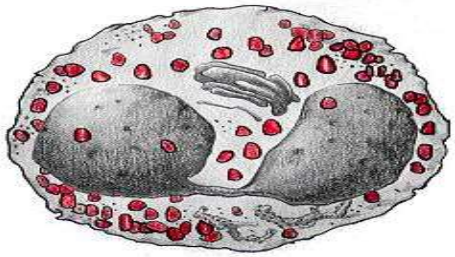


fig. 10 - Basophil



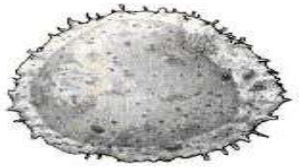


Fig. 11 - Lymphocyte

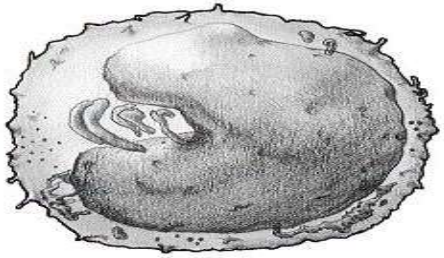
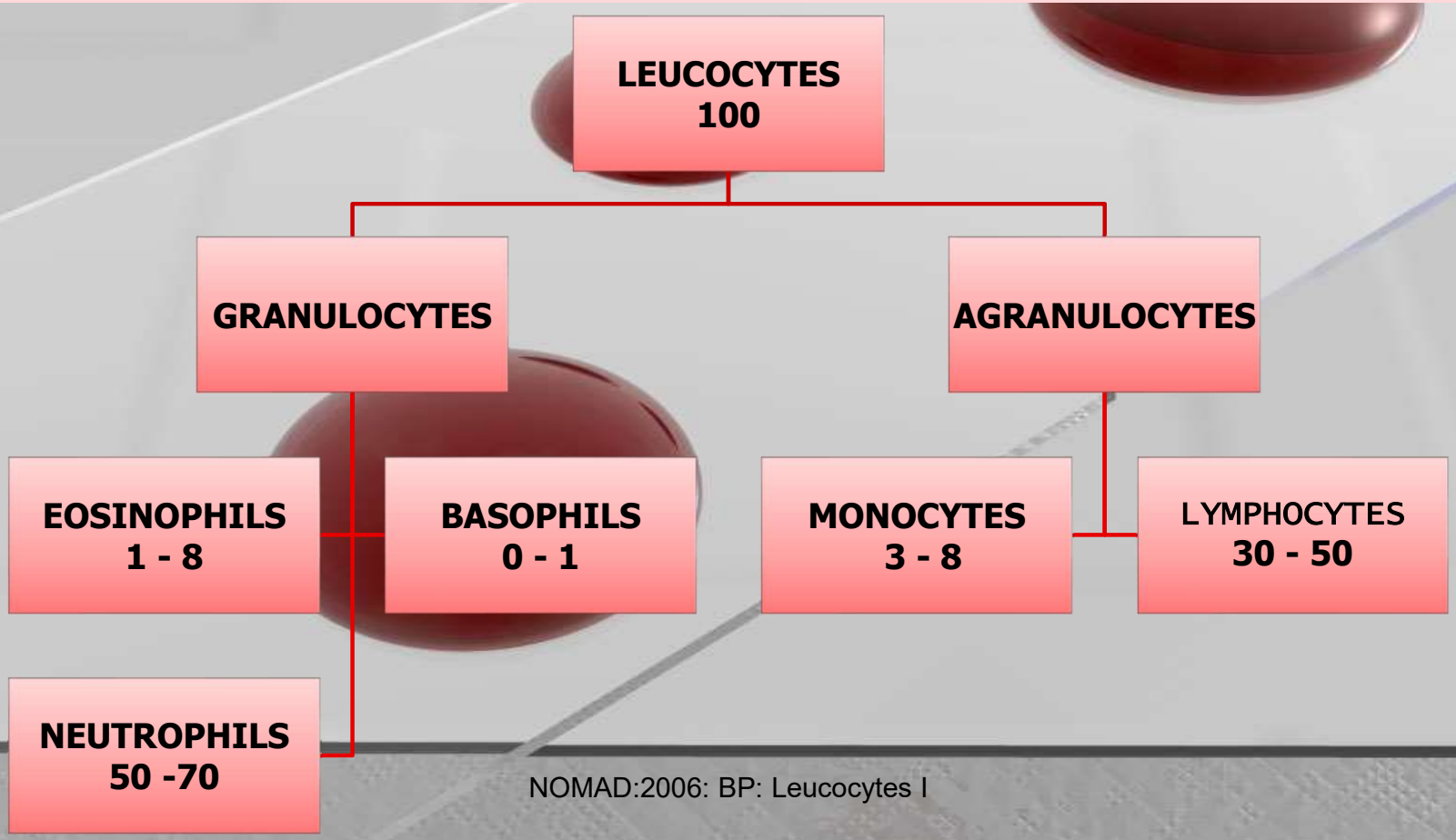


Fig. 12 - Monocyte

Classification of Leucocytes



WBC count: 4,500-11,000/µL

Polymorphonuclear neutrophils: 1800-7800/µL; (50-70%)

Band neutrophils : 0-700/µL; (0-10%)

Lymphocytes : 1000-4800/µL; (15-45%)

Monocytes : 0-800/µL; (0-10%)

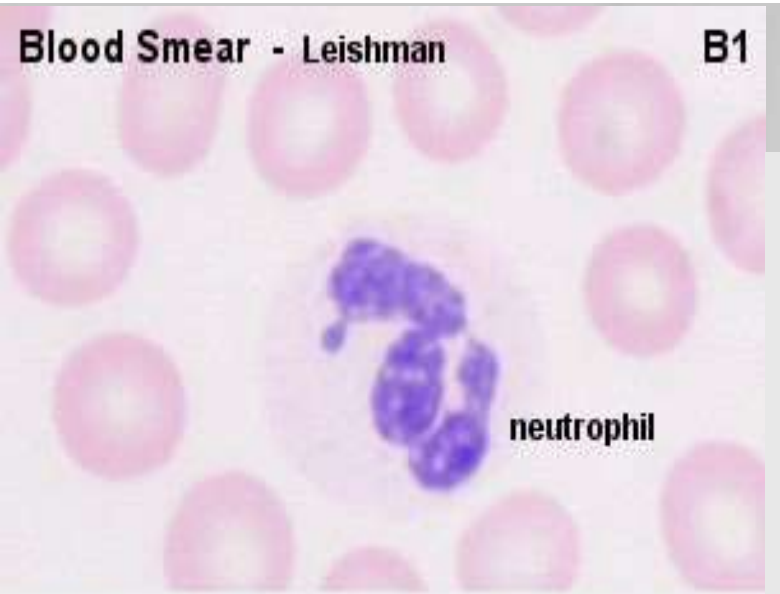
Eosinophils : 0-450/µL; (0-6%)

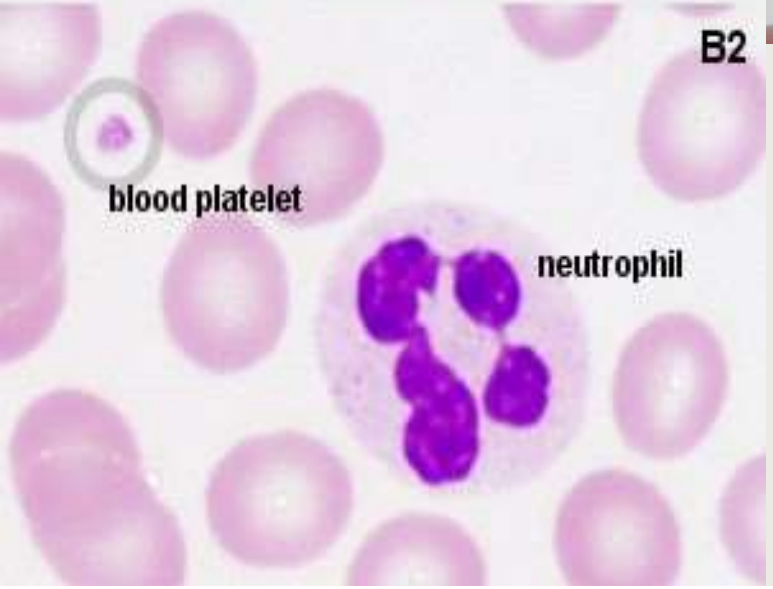
Basophils : 0-200/µL; (0-2%)

WBC Type	Normal %	Absolute Count (/μL)	Function
Neutrophils	55–70%	2,500–7,000	Acute bacterial infection, inflammation
Lymphocytes	20–40%	1,000–4,000	Viral infection, adaptive immunity
Monocytes	2–8%	200–800	Chronic inflammation, antigen presentation
Eosinophils	1–4%	50–500	Parasites, allergies, asthma
Basophils	<1%	15–100	Allergic reactions, histamine release

To find the **absolute number** of each WBC type:
Absolute count = (% cell type) × (Total WBC count) ÷ 100

Example:
If WBC = 12,000/μL and neutrophils = 65%
→ Absolute neutrophil count (ANC) = 0.65 × 12,000 = **7,800/μL**





Neutrophils

Neutrophils (50–70%)

•**Polymorphonuclear** (segmented nucleus)

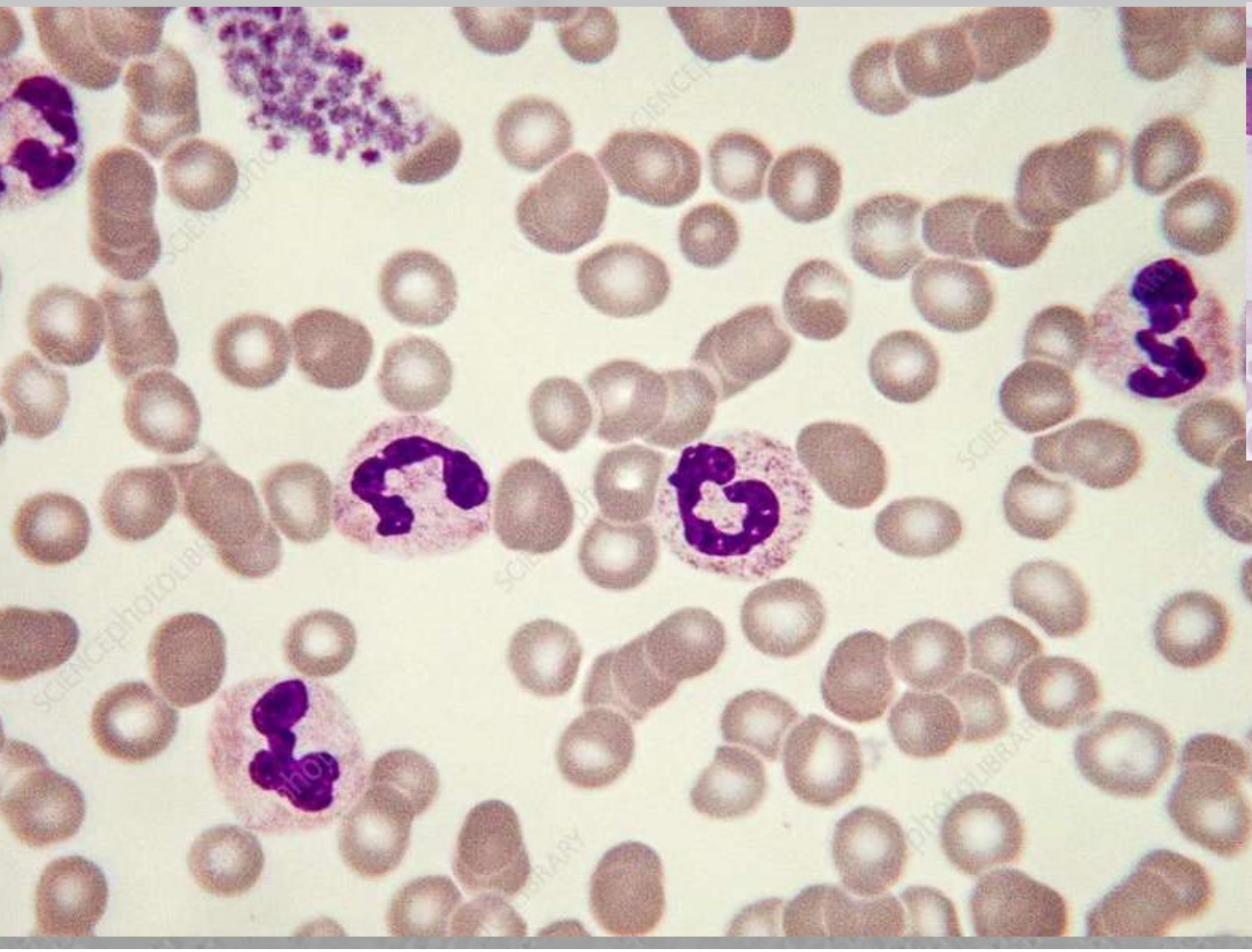
•**Primary function**: Phagocytosis of bacteria and debris, acute inflammation , are on site within 4h

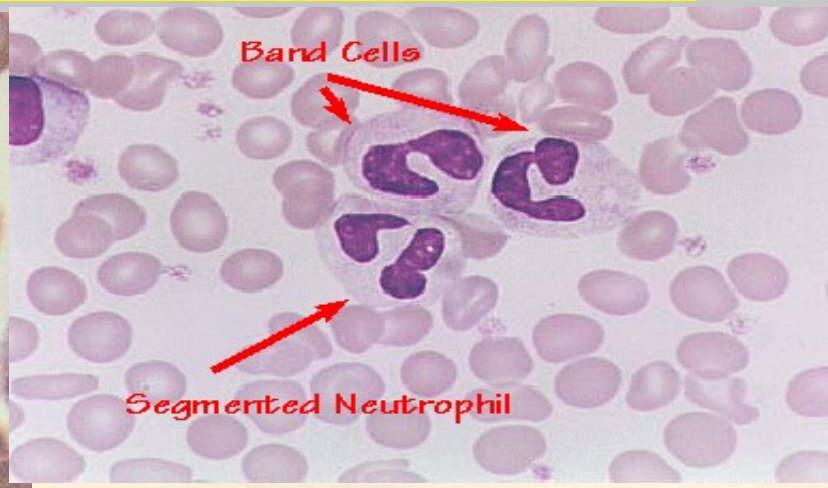
•Contain **azurophilic (primary)** and **specific (secondary)** granules
•Rapid responders to acute bacterial infection (↑ in bacterial infections)
•Lifespan: Hours to days

- Neutrophils have two types of granules that:
  - Take up both acidic and basic dyes
  - Give the cytoplasm a lilac color
  - Contain peroxidases, hydrolytic enzymes, and defensins (antibiotic-like proteins)
- Neutrophils are our body's bacteria slayers
- The most abundant wbcs
- Differential neutrophil count = $\frac{\#\text{neutro}}{\text{total \# wbc}} \times 100$

What Are Band Cells?

Band cells are **immature neutrophils** released from the bone marrow during **acute infection or inflammation**. They are the **precursors to mature segmented neutrophils**.





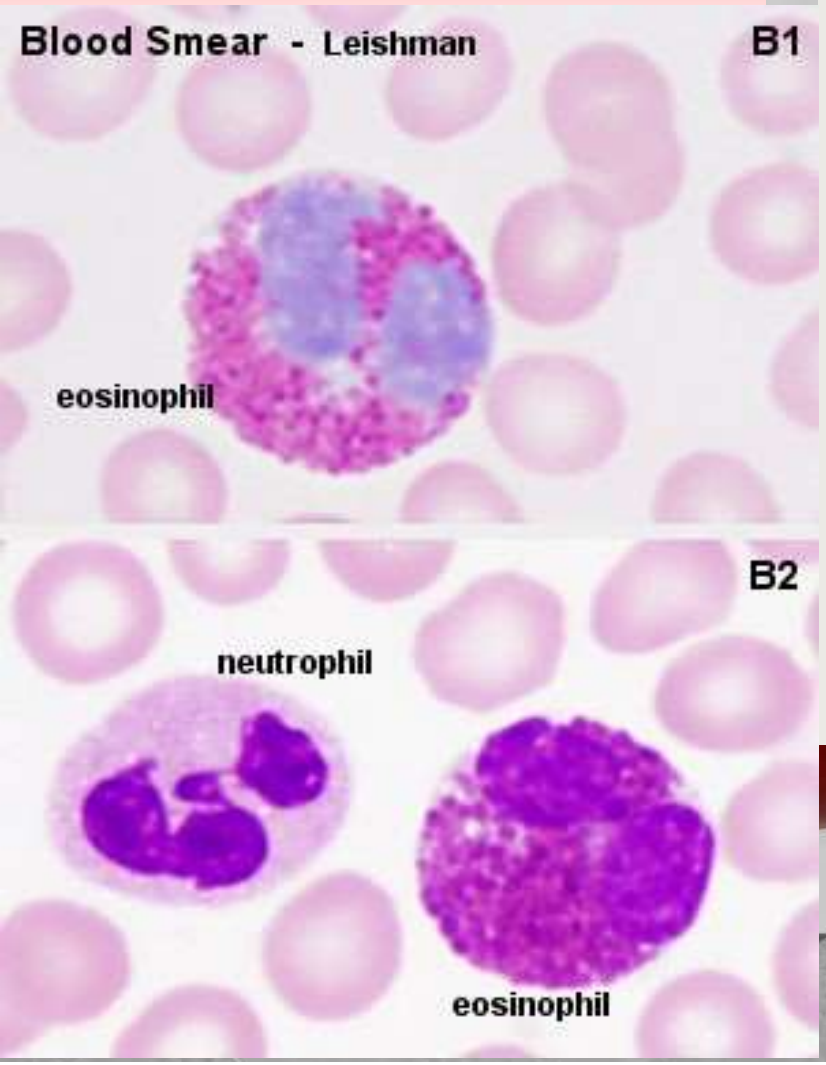
↑ Neutrophilia

- Bacterial infections
- Inflammation, trauma, stress
- Myeloproliferative disorders
- Steroid use (demargination)

↓ Neutropenia

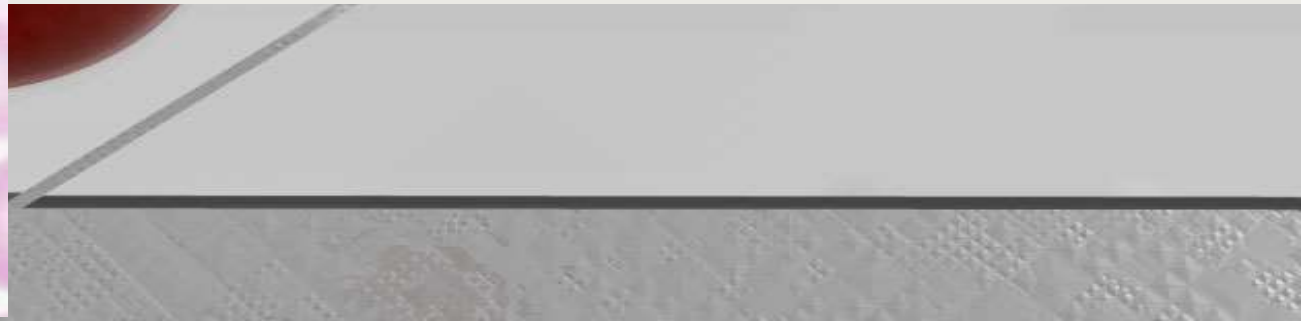
- Viral infections
- Bone marrow suppression
- Chemotherapy
- Aplastic anemia

Eosinophils

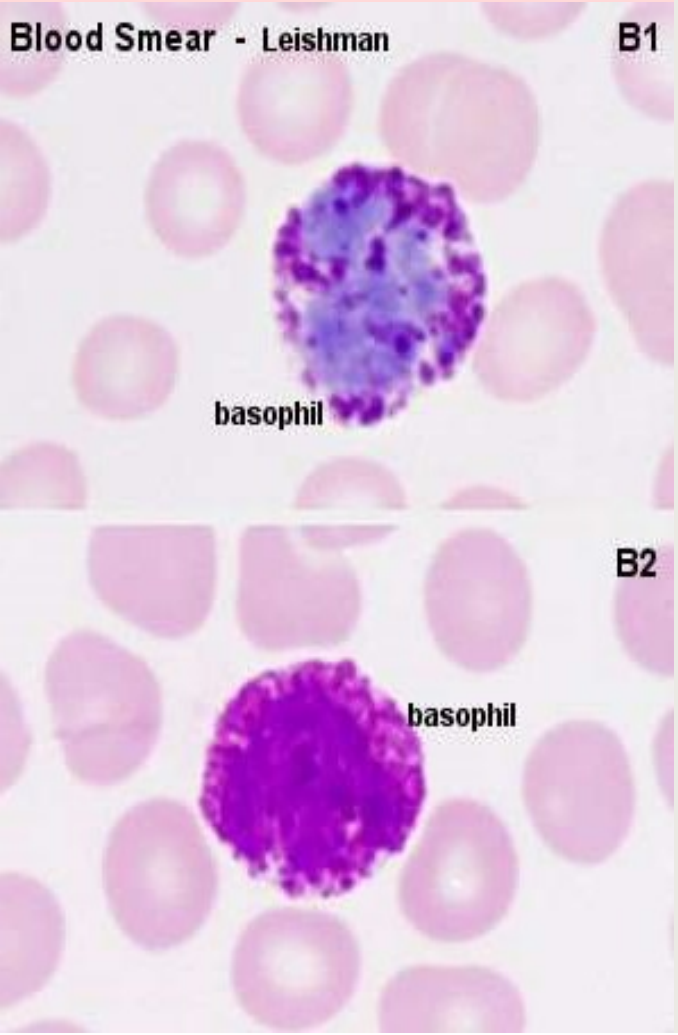


- Eosinophils account for 1–4% of WBCs
  - Have red-staining, bilobed nuclei connected via a broad band of nuclear material
  - Have red to crimson (acidophilic) large, coarse, lysosome-like granules
  - Lead the body's counterattack against parasitic worms
  - Lessen the severity of allergies by phagocytizing immune complexes

•Defense against **parasites** and involved in **allergic reactions**
•↑ in parasitic infections, asthma, eosinophilic esophagitis



Basophils



- Have U- or S-shaped nuclei with two or three conspicuous constrictions
- Are functionally similar to mast cells
- Have large, purplish-black (basophilic) granules that contain histamine
  - **Histamine** – inflammatory chemical that acts as a vasodilator and attracts other WBCs (antihist amines counter this effect)
  - **Heparin**
  - **Leukotrienes (ipid-based inflammatory mediators derived from arachidonic acid via the lipoxygenase pathway. They play key roles in inflammation, bronchoconstriction, chemotaxis, and vascular permeability.**

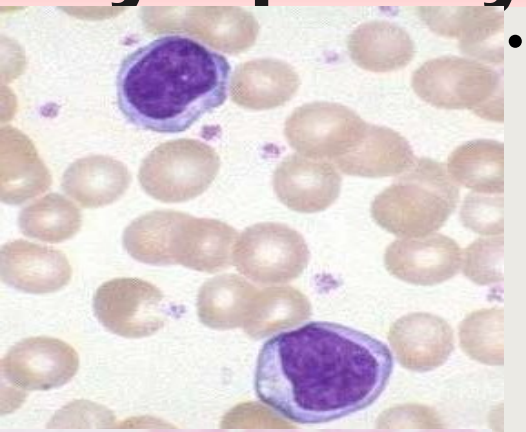
Basophils (<1%)
- Bilobed nucleus obscured by large basophilic granules
- Contain **histamine**, **heparin**, **leukotrienes**
- Involved in **hypersensitivity reactions** (Type I)
- Functionally similar to mast cells

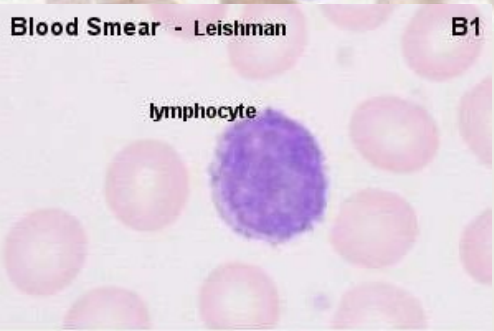
Agranulocytes

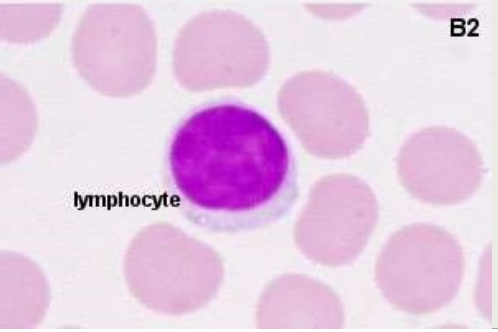
- Agranulocytes :

- **lymphocytes and monocytes**:
  - Lack visible cytoplasmic granules
  - Are similar structurally, but are functionally distinct and unrelated cell types
  - Have spherical (lymphocytes) or kidney-shaped (monocytes) nuclei

Lymphocytes







- Account for 25% -30% or more of WBCs and:
  - Have large, dark-purple, circular nuclei with a thin rim of blue cytoplasm
  - Are found mostly enmeshed in lymphoid tissue (some circulate in the blood)

- **B cells**: Humoral immunity (differentiate into plasma cells → secrete antibodies)
- **T cells**:
  - $CD4^+$ T-helper: Orchestrate immune response
  - $CD8^+$ Cytotoxic T cells: Kill infected/tumor cells
- **Natural Killer (NK) cells**: Innate immune cytotoxicity
- **↑ in viral infections and chronic inflammation**
- Long-lived, memory-capable

↑ Lymphocytosis

- Viral infections (EBV, CMV)
- CLL (chronic lymphocytic leukemia)
- TB, pertussis

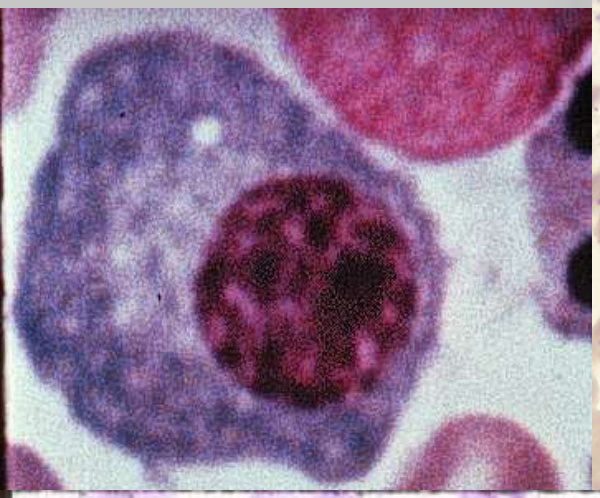
↓ Lymphopenia

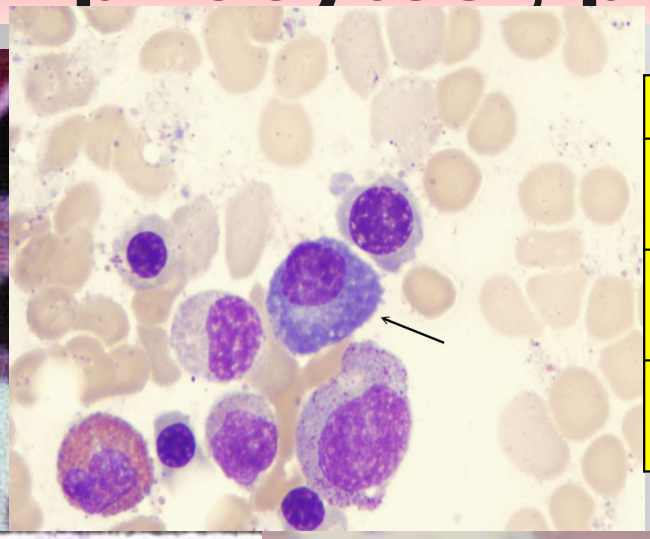
- HIV/AIDS
- Steroids
- Immunodeficiency
- SLE

LYMPHOCYTES: IMMUNOCYTES

- **Physiological Classification:T and B**
  - **'T' LYMPHOCYTES :**
    - **Thymus trained or schooled cells**
    - **Responsible for Cell mediated immunity.**
    - **Provide protection against intracellular pathogens**

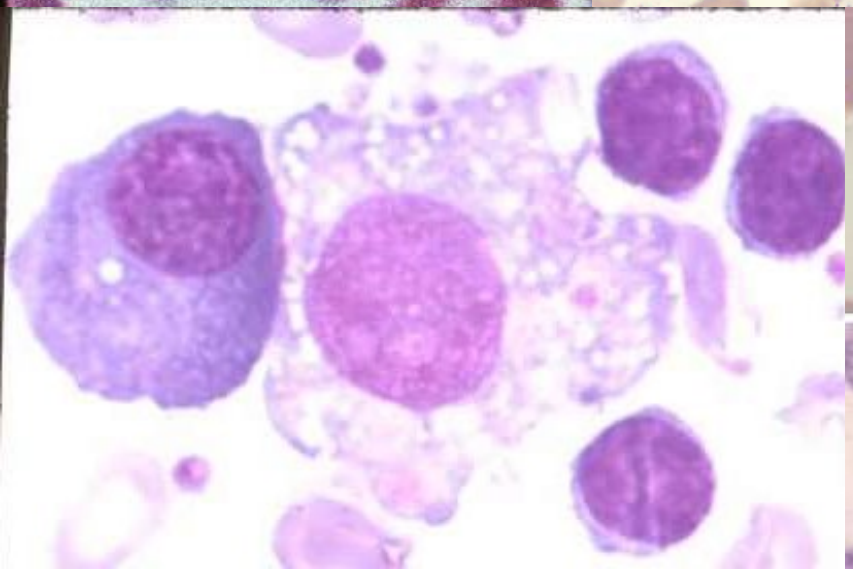
B lymphocytes , plasma cells

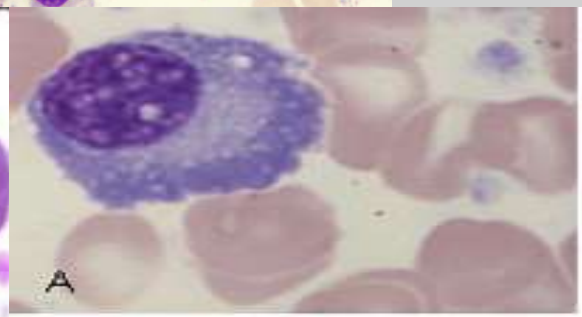


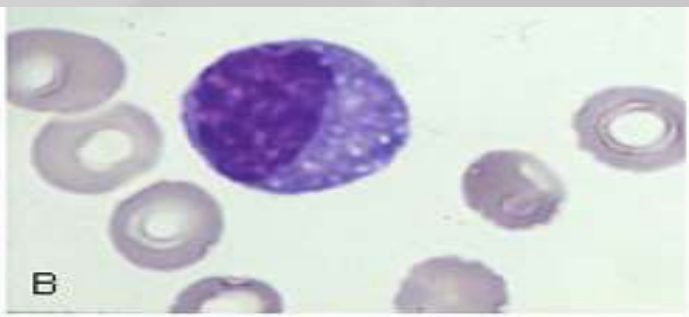


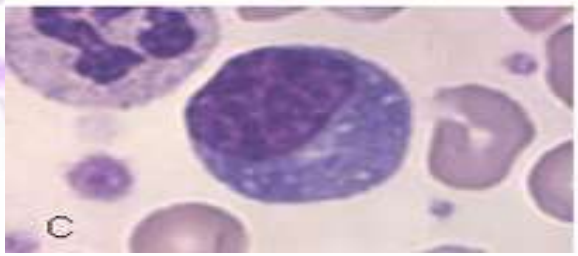
Origin & Maturation

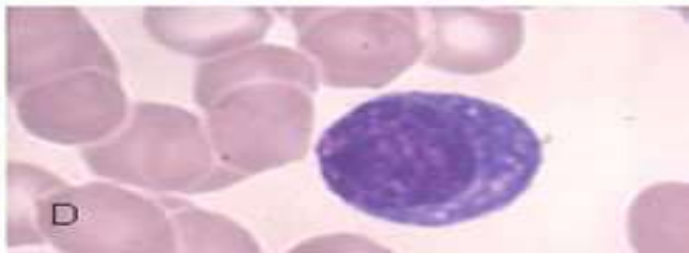
Stage	Location
Origin	Bone marrow (hematopoietic stem cell)
Maturation	Bone marrow (unlike T cells which mature in thymus)
Activation	Peripheral lymphoid tissues (lymph nodes, spleen, MALT)



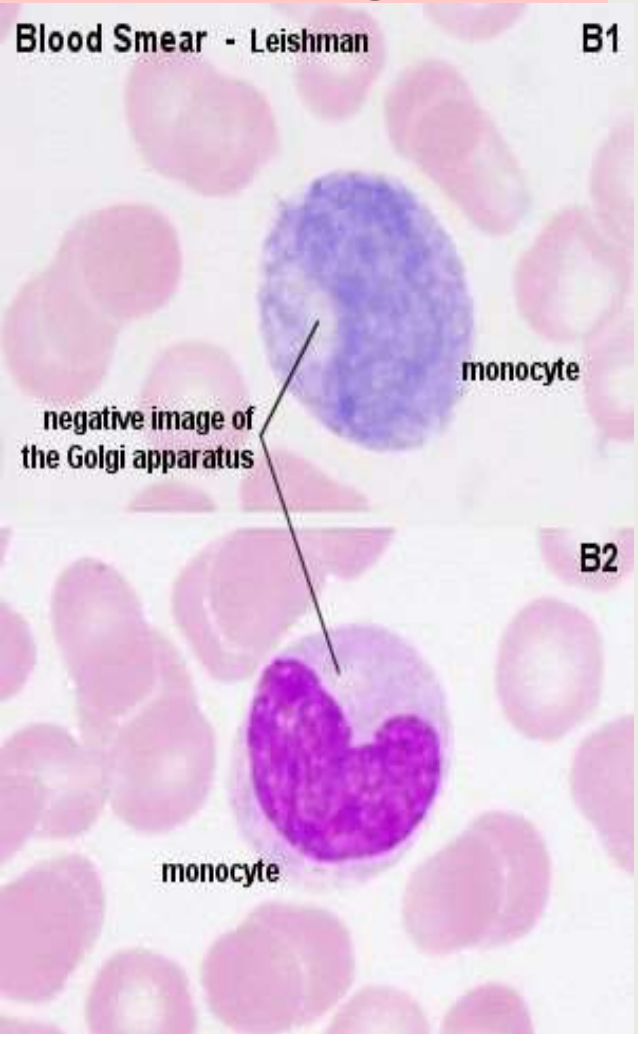








Monocytes



- Monocytes account for 4–8% of leukocytes
  - They are the largest leukocytes
  - They have abundant pale-blue cytoplasms
  - They have purple-staining, **U- or kidney-shaped nuclei**
  - **They leave the circulation, enter tissue, and differentiate into macrophages and dendritic cells**

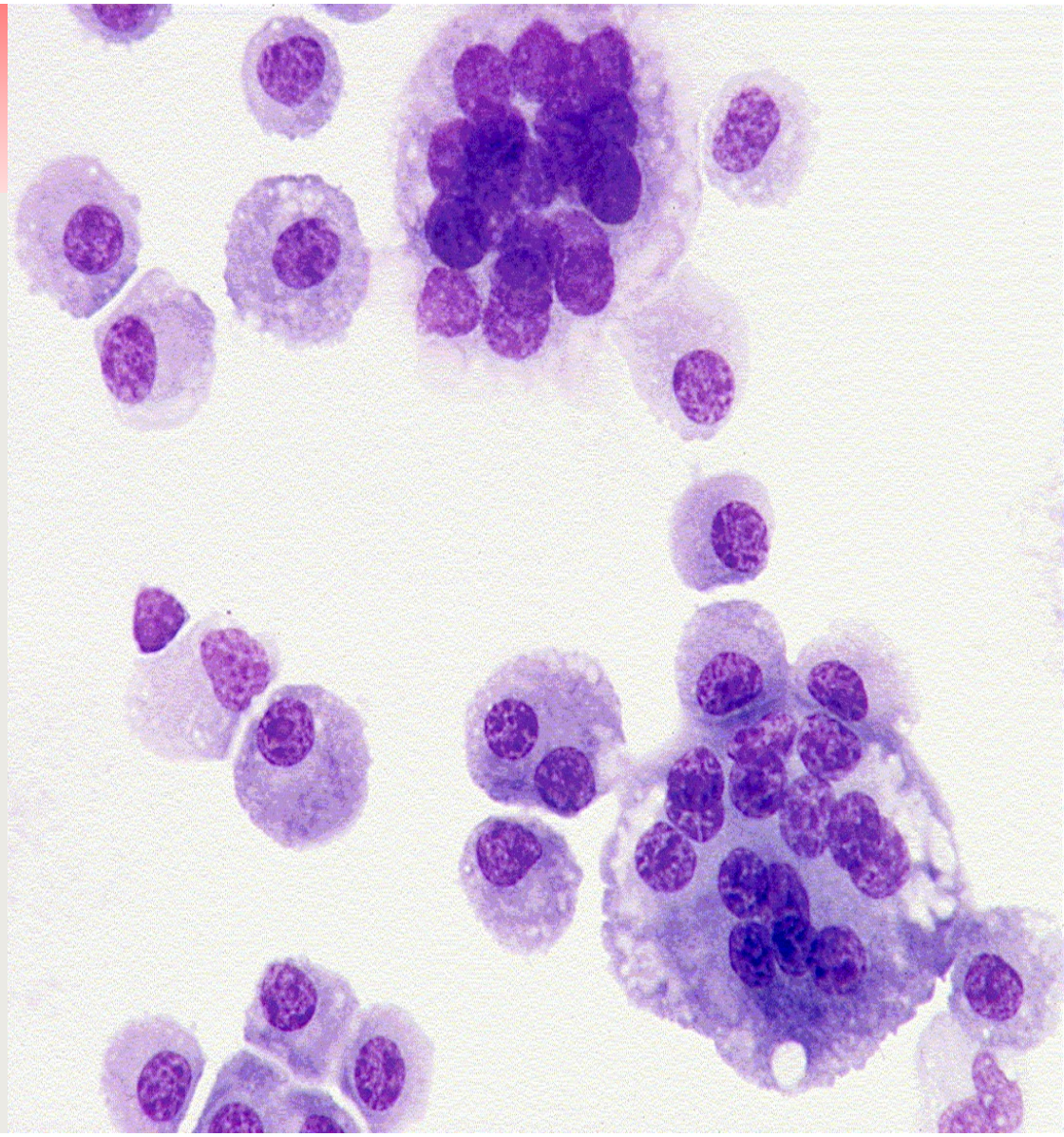
•Circulate in blood, then differentiate into **macrophages** or **dendritic cells** in tissues

•Phagocytose pathogens, present antigens (APCs)

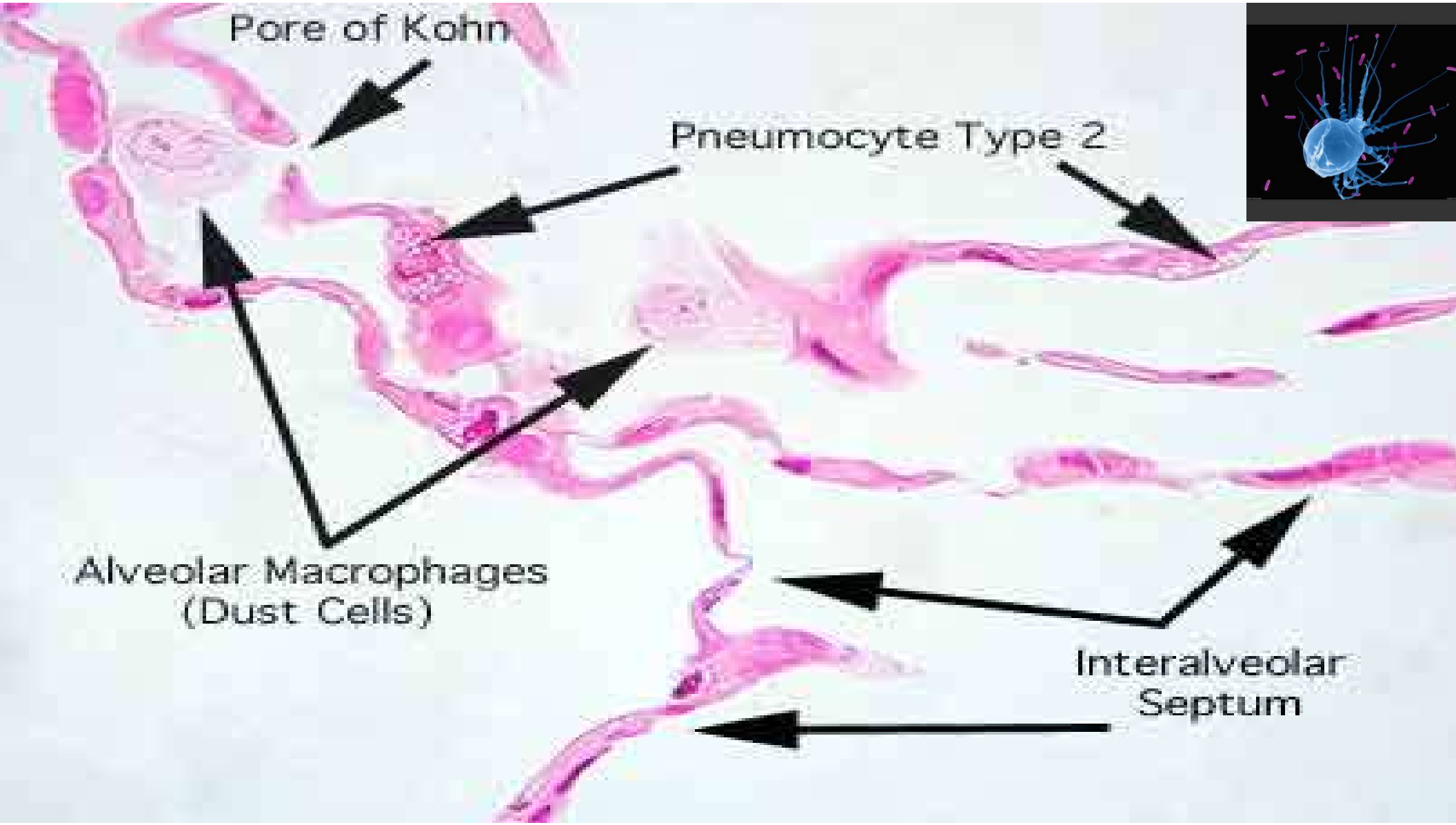
•↑ in chronic infections (e.g., TB), certain leukemias
•Macrophage can become giant cells in chronic inflammation

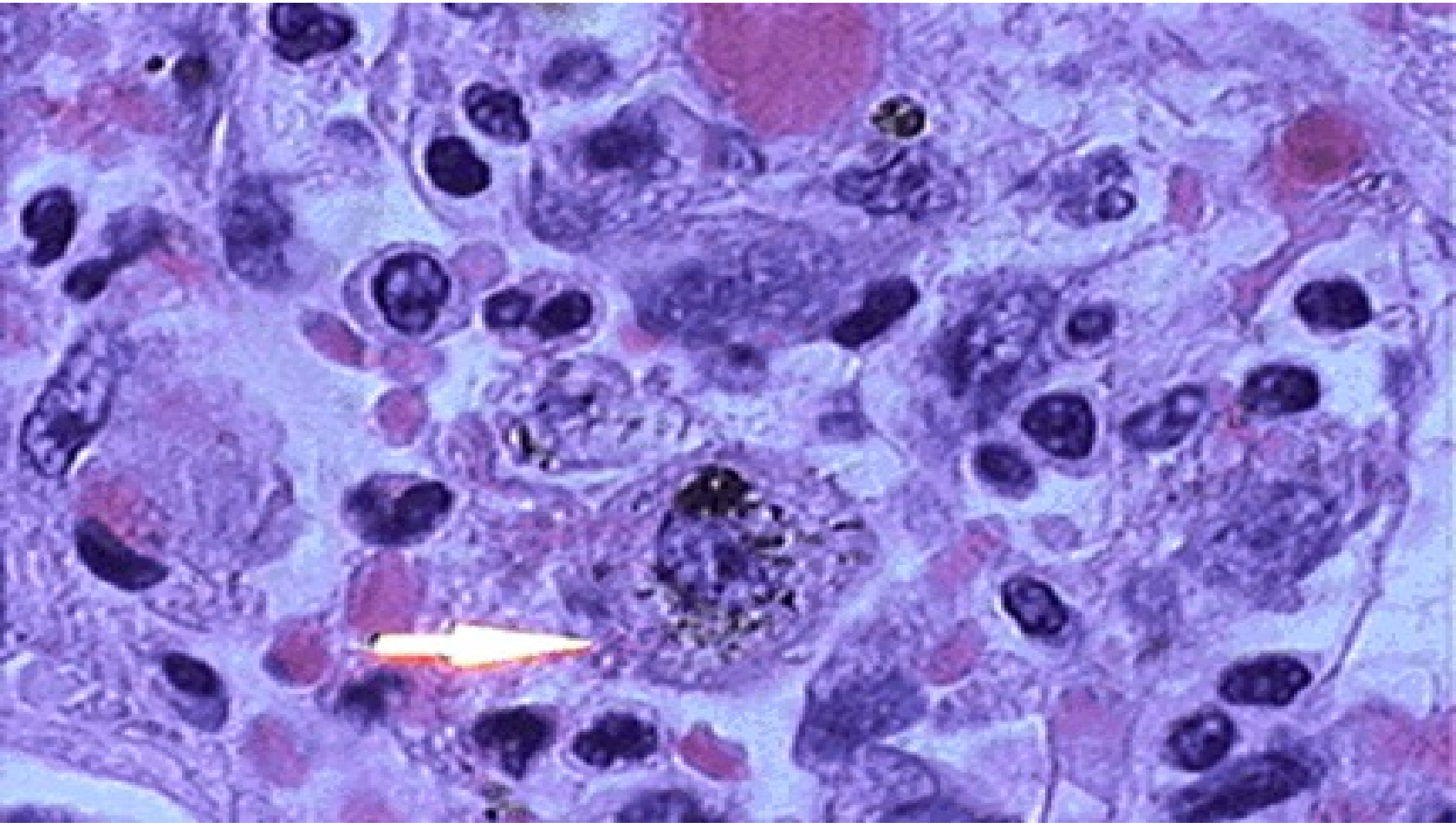
Macrophages

- Macrophages:**mononuclear phagocyte system** or **reticuloendothelial system**
  - Are highly mobile and actively phagocytic
  - Activate lymphocytes to mount an immune response
  - Will have different names depending on the location



Tissue / Organ	Macrophage Type	Key Functions
Liver	**Kupffer cells**	Phagocytose bacteria, debris, and old RBCs from portal blood
Lung (alveoli)	**Alveolar macrophages**	Clear inhaled particles and pathogens, regulate inflammation
Brain & CNS	**Microglia**	Immune surveillance, synaptic pruning, neuroinflammation
Skin	**Langerhans cells**	Antigen presentation to T cells (also considered dendritic cells)
Spleen	**Red pulp macrophages**	Remove old RBCs and blood-borne pathogens
Bone	**Osteoclasts**	Resorb bone matrix, involved in calcium homeostasis
Lymph nodes	**Subcapsular sinus macrophages**	Trap and present antigens from afferent lymph
Peritoneum	**Peritoneal macrophages**	Immune defense in peritoneal cavity, produce cytokines
Placenta	**Hofbauer cells**	Fetal macrophages, involved in development and immune tolerance
Intestines (lamina propria)	**Intestinal macrophages**	Tolerate gut flora but respond to pathogens
Thymus	**Thymic macrophages**	Clear apoptotic thymocytes during T cell development
Heart	**Cardiac macrophages**	Tissue repair and regulation of electrical conduction


Pore of Kohn
Pneumocyte Type 2
Alveolar Macrophages
(Dust Cells)
Interalveolar
Septum



↑ Monocytosis
- Chronic infections (TB, endocarditis)
- Recovery phase of neutropenia
- Leukemias (AML-M5)

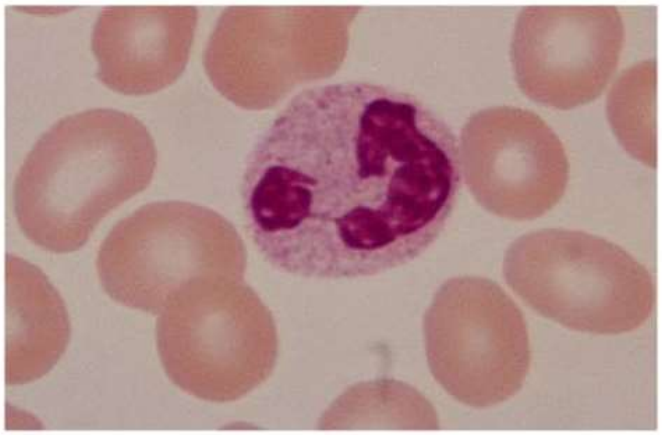
↑ Eosinophilia
- Parasitic infections (especially helminths)
- Allergies, asthma
- Eosinophilic leukemia
- Autoimmune diseases (e.g., Churg-Strauss)

↑ Basophilia
- Rare; seen in:
  - Myeloproliferative disorders (esp. **CML**)
  - Allergic responses
  - Hypothyroidism (occasionally)

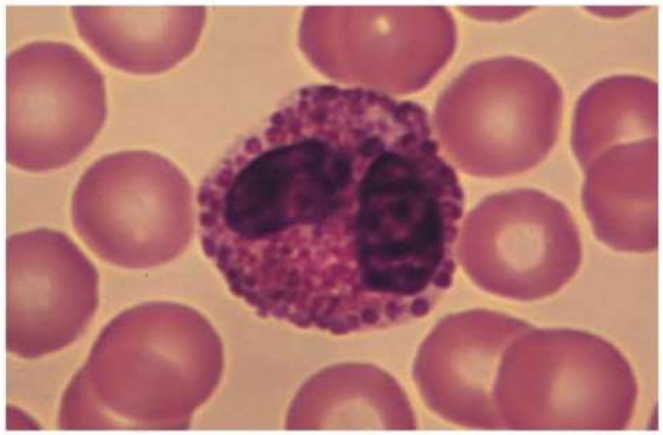
Neutrophils & Macrophages

- **Diapedesis:** They squeeze through the pores of the blood vessels.
- **Amoeboid movement:** They move at rates several times their own length!
- **Chemotaxis**: Directed movement – cells move to wards infected areas.

Leukocytes



(a)



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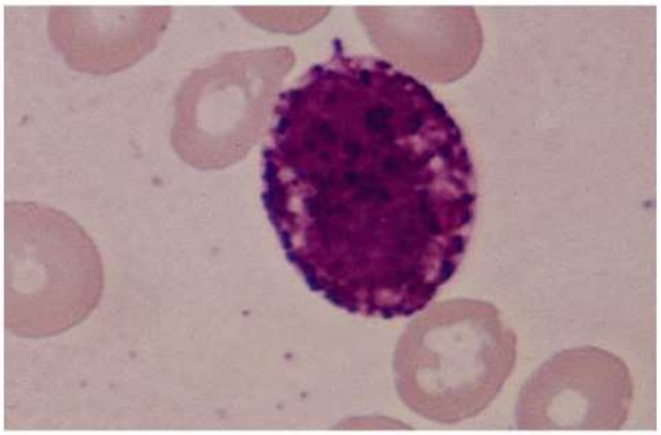

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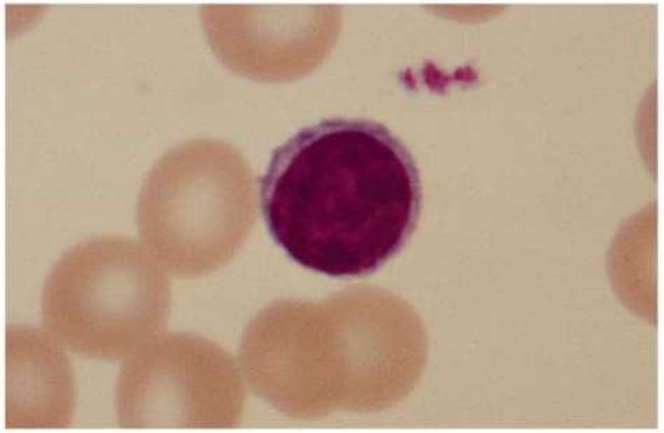

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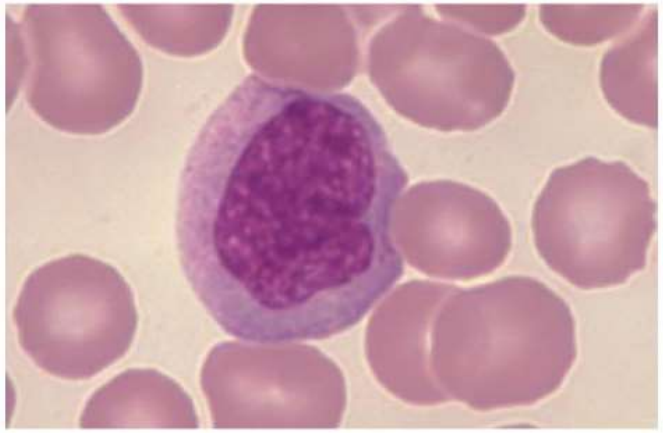


(e)

Clinical Red Flags

•**Left shift**: ↑ bands (immature neutrophils) → acute infection or leukemia

•**Right shift**: ↑ hypersegmented neutrophils → megaloblastic anemia

•**Leukemoid reaction**: Marked neutrophilia with left shift, toxic granules, but **no blasts**

•**Blast cells**: Always suspicious for **leukemia**

Left Shift
•↑ Band cells in blood = **"left shift"** (a term from hematopoiesis charts: immature cells to the left)
•Seen in:

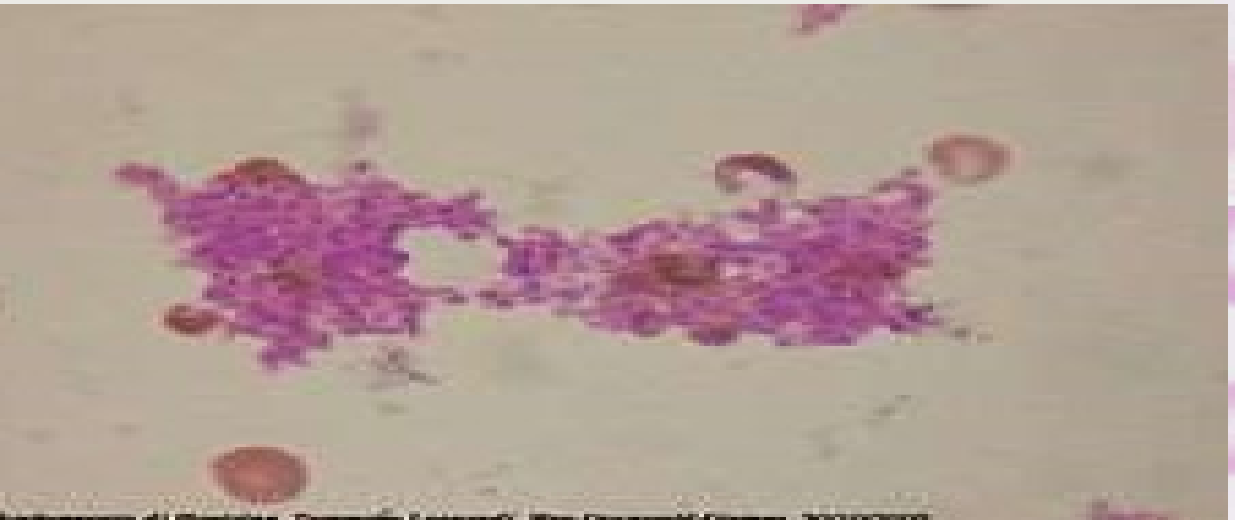
- **Acute bacterial infections**
- **Sepsis**
- **Hemorrhage**
- **Tissue necrosis** (e.g., MI, burns)
- **Inflammation**
- Myeloproliferative diseases (if persistent)

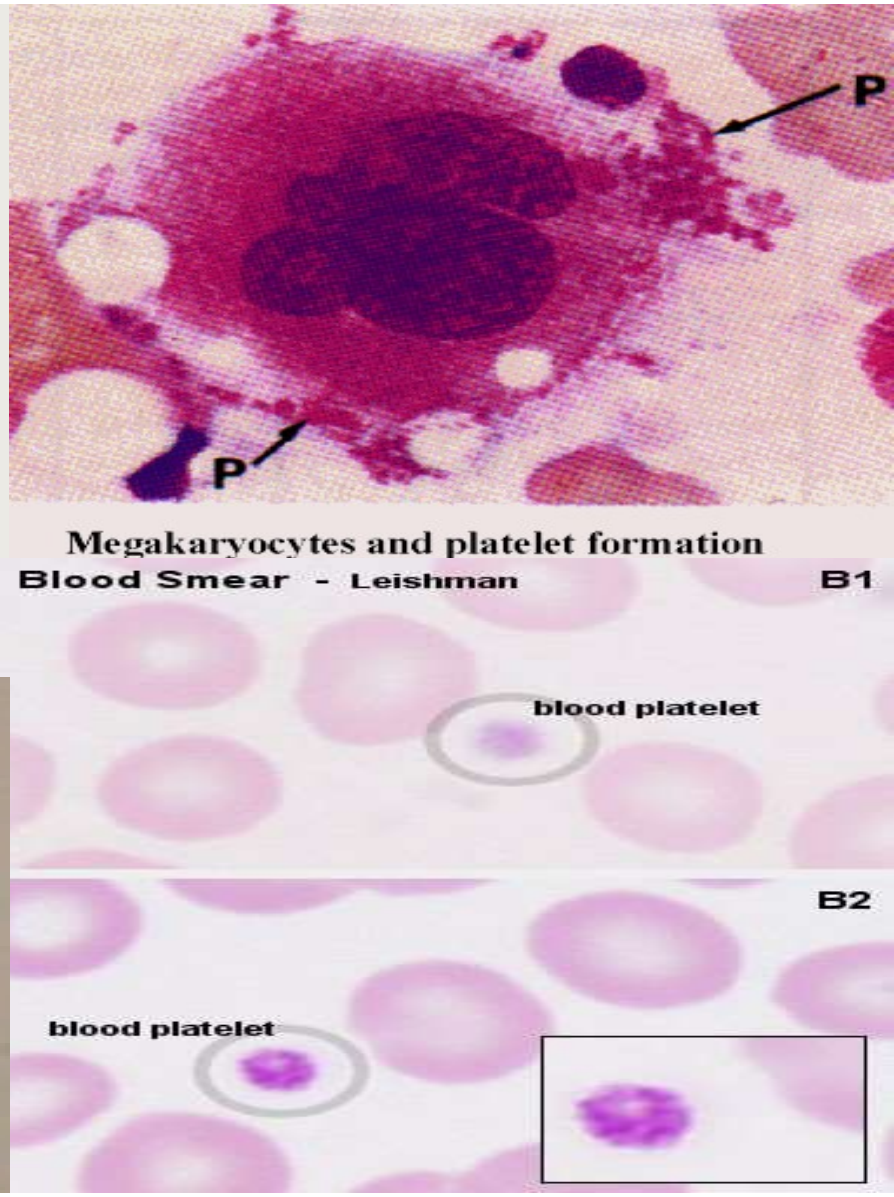
Toxic Granulation (often coexists with bandemia)
•Seen in severe infection or sepsis
•Granules are darker and coarser

Bandemia = >10% band cells or absolute band count >1,000/μL
→ Suggests the bone marrow is under stress and releasing immature neutrophils early.

Platelets = Thrombocytes

- Platelets are fragments of **megakaryocytes** with a blue-staining outer region and a purple granular center
- Their granules contain
  - **serotonin, Ca^{2+},**
  - **enzymes, ADP,**
  - **and platelet-derived growth factor (PDGF)**
- Platelets function in the clotting mechanism by forming a temporary plug that helps seal breaks in blood vessels
- **Platelets not involved in clotting are kept inactive by NO and prostacyclin**





Thrombocytes (Platelets)

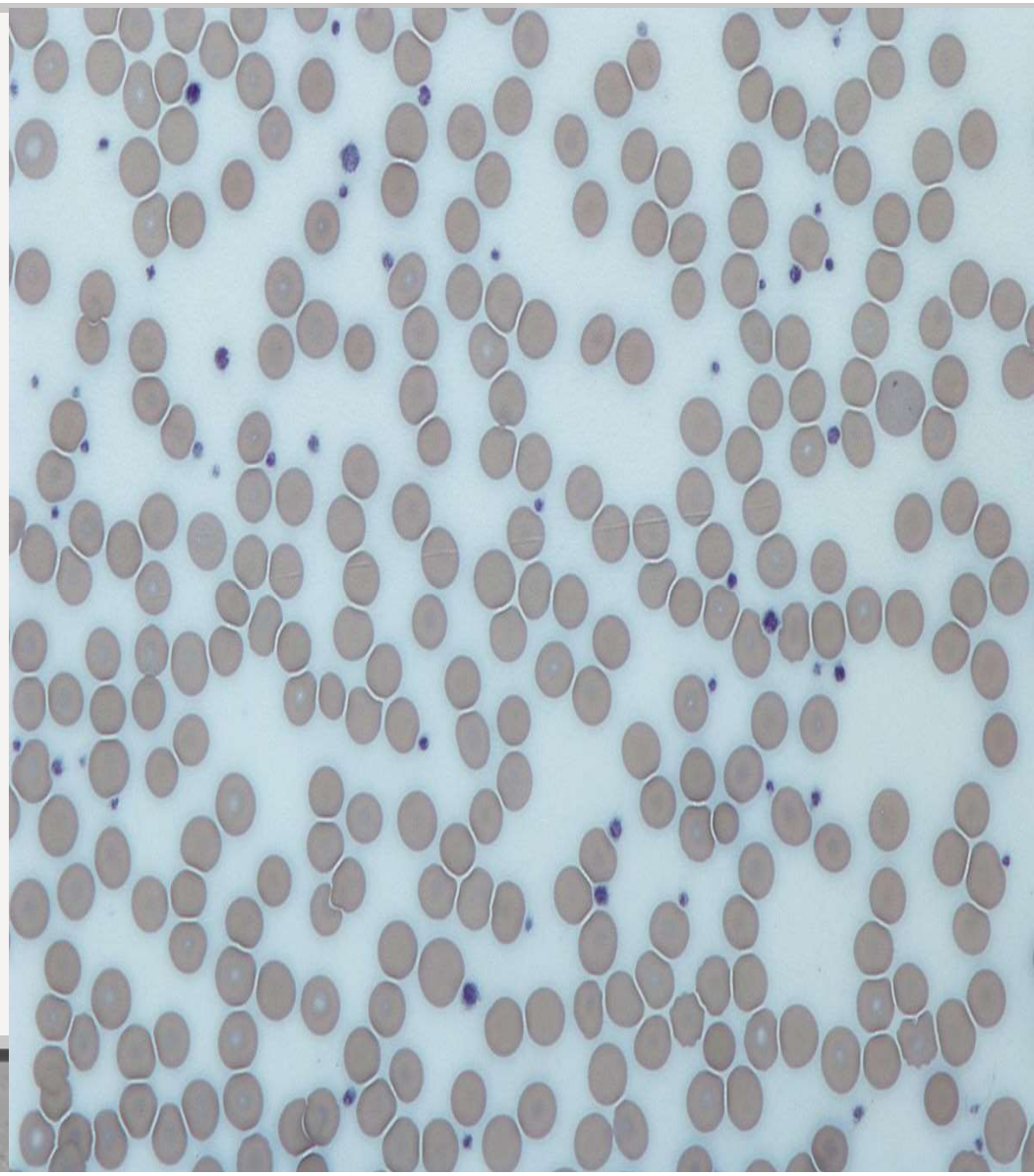
◆ Origin:
•Derived from **megakaryocytes** via fragmentation in bone marrow
•Stimulated by **thrombopoietin (TPO)**

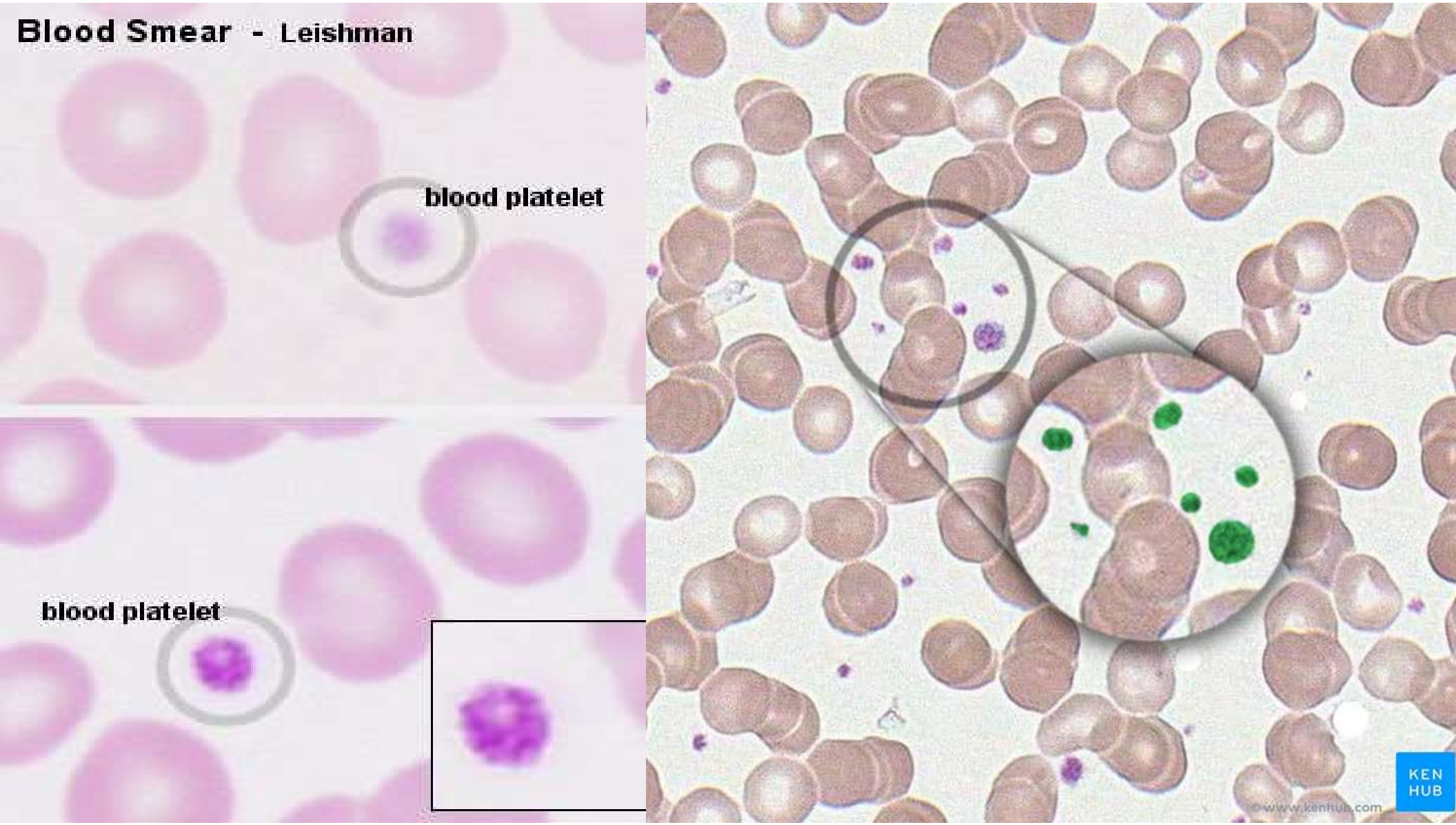
◆ Structure:
•Small, anucleate cell fragments (~2–3 μm)
•Contain α-granules (fibrinogen, PDGF) and dense granules (ADP, Ca^{2+}, serotonin)

◆ Function:
•**Hemostasis**: adhere to damaged endothelium (via vWF), activate, and aggregate to form platelet plug
•Provide surface for **coagulation cascade** activation
•Release factors that stabilize clot and promote repair

◆ Lifespan:
•~7–10 days

◆ Key Disorders:
•Thrombocytopenia (low count)
•Thrombocytosis (essential thrombocythemia)
•Platelet function disorders (e.g., Glanzmann thrombasthenia)




Blood Smear - Leishman
blood platelet
blood platelet
KEN HUB

Functions of the Spleen

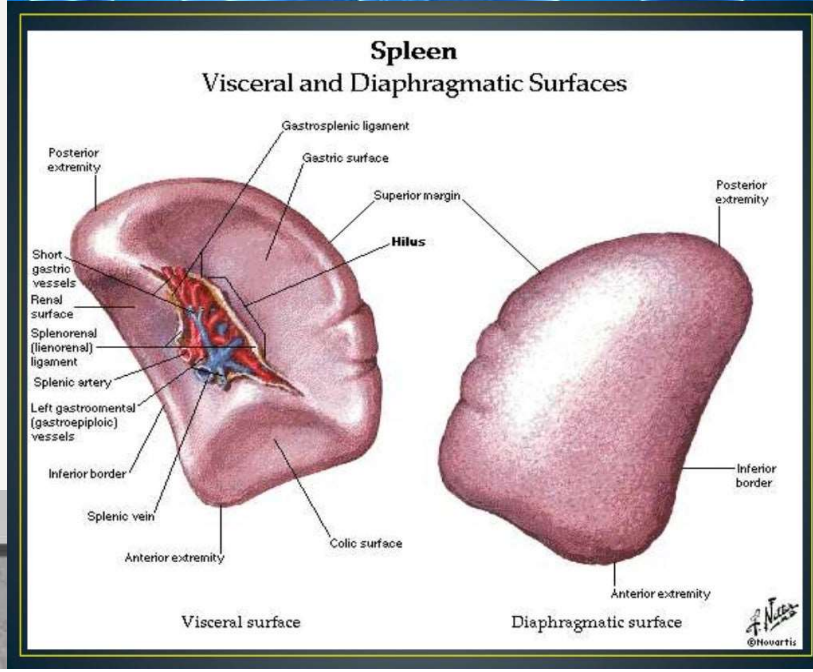
largest secondary lymphoid organ, located in the LUQ (left upper quadrant), protected by ribs 9–11.

•**Hematopoietic function Can produce white cell, red** cells, and platelets if necessary

•**Reservoir function One third of platelets and granulocytes** are stored in the spleen

•**Filtration function Aging red cells are destroyed,** spleen removes inclusion from red cells, if red cell membrane is less deformable or antibody-coated spleen presents a hostile environment leading to production of spherocytes

•**Immunologic function Opsonizing antibodies produced,** trapping and processing antigens from encapsulated organs



Spleen: Functions Overview

1. Blood Filtration

•Red Pulp (80%)

- Removes **senescent or damaged RBCs** (especially those with membrane defects like in spherocytosis)
- **Splenic macrophages** phagocytose opsonized bacteria and parasites
- Filters particles like **inclusion bodies** (e.g., Howell-Jolly bodies)

2. Immune Surveillance

•White Pulp

- Contains **lymphoid follicles (B cells)** and **periarteriolar lymphoid sheaths (PALS – T cells)**
- Functions similarly to a **lymph node for the blood** (rather than lymph)
- Initiates **adaptive immune responses** to blood-borne antigens

3. Reservoir Function

•Stores:

- **Platelets** (~30% of total)
- **Monocytes** (rapidly mobilized after injury to form tissue macrophages)

4. Defense Against Encapsulated Organisms

•Particularly vulnerable in **asplenic or hyposplenic** patients

•Important in clearing encapsulated bacteria:

- **S. pneumoniae**
- **H. influenzae type B**
- **Neisseria meningitidis**
- **Salmonella spp.**

Clinical Tip: These patients require **vaccination** and **prophylactic antibiotics**.

5. Hematopoiesis (Fetal Life)

•During the **1st–2nd trimesters**, the spleen contributes to **fetal erythropoiesis**

•In adults: can resume hematopoiesis in diseases like **myelofibrosis** (extramedullary hematopoiesis → splenomegaly)

Cell Type	Lineage	Nucleus	Key Markers / Features	Function	Clinical Note
RBC	Myeloid	None	Hemoglobin, biconcave	O_2/CO_2 transport	Anemia, polycythemia
Neutrophils	Myeloid	Multilobed	$CD15^+$, $CD16^+$	Phagocytosis	Acute infection
Eosinophils	Myeloid	Bilobed	Major basic protein	Parasite defense, allergies	Asthma, parasitosis
Basophils	Myeloid	Obscured	Histamine, heparin	Hypersensitivity	Anaphylaxis
Lymphocytes	Lymphoid	Round	$CD3^+$ (T), $CD19^+$ (B), $CD56^+$ (NK)	Adaptive immunity	HIV, leukemia
Monocytes	Myeloid	Kidney-shaped	$CD14^+$	APC, phagocytosis	TB, chronic infection
Platelets	Myeloid	None	GPIIb/IIIa, α and dense granules	Clot formation	ITP, TTP, thrombosis