Blood Cells خلية كلوحات لدب الدسيوكم الرابع

٩ محاضرات

2 Labs ⇒ 4 hours (2 Theoretical lectures + 2 hours Lab).

2 recorded lectures

the rest is face to face

Dr. Heba Kalbouneh
DDS, MSc, DMD/PhD
Professor of Anatomy, Histology and Embryology

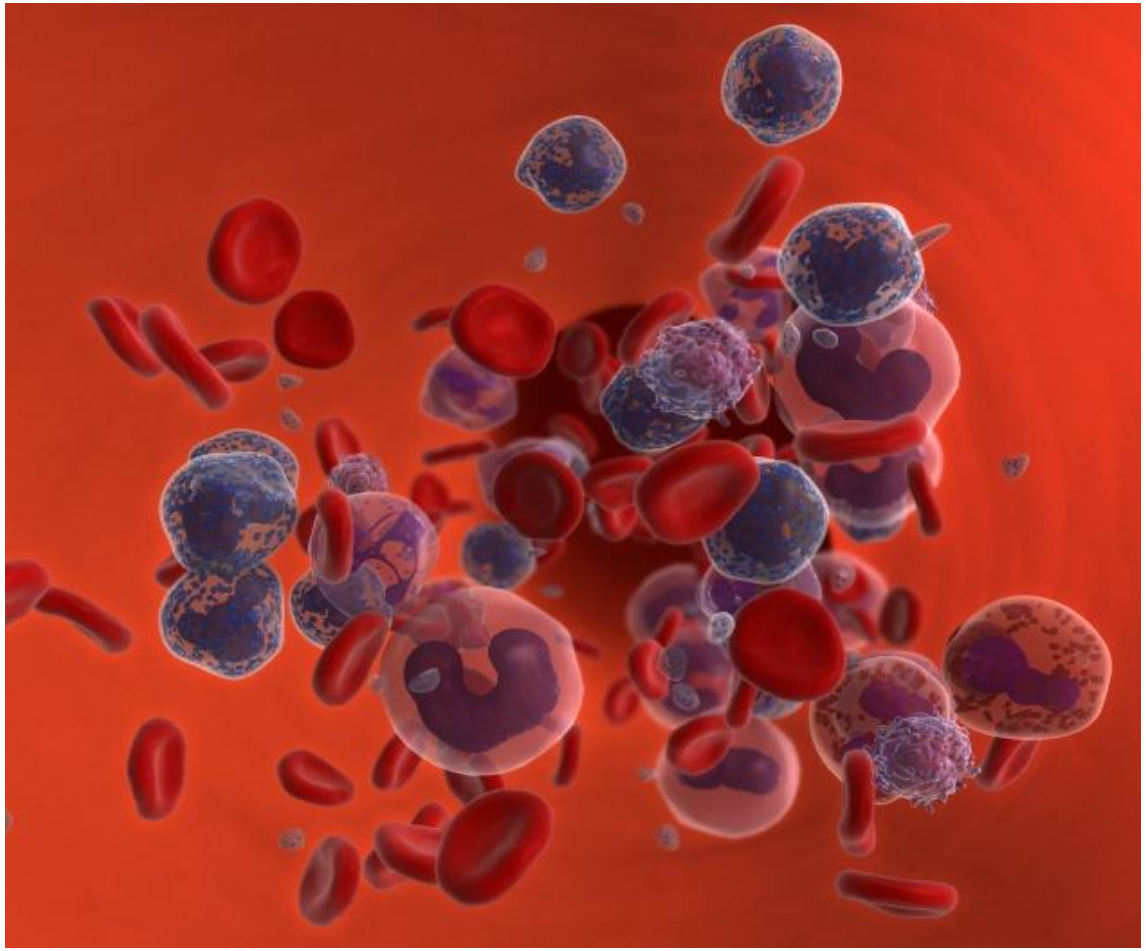
Prepared and adapted for teaching by Prof. Dr. Heba Kalbouneh.
Illustrations adapted from multiple educational resources for educational purposes.
These slides are intended for students enrolled in this course and should not be distributed without permission.

Blood

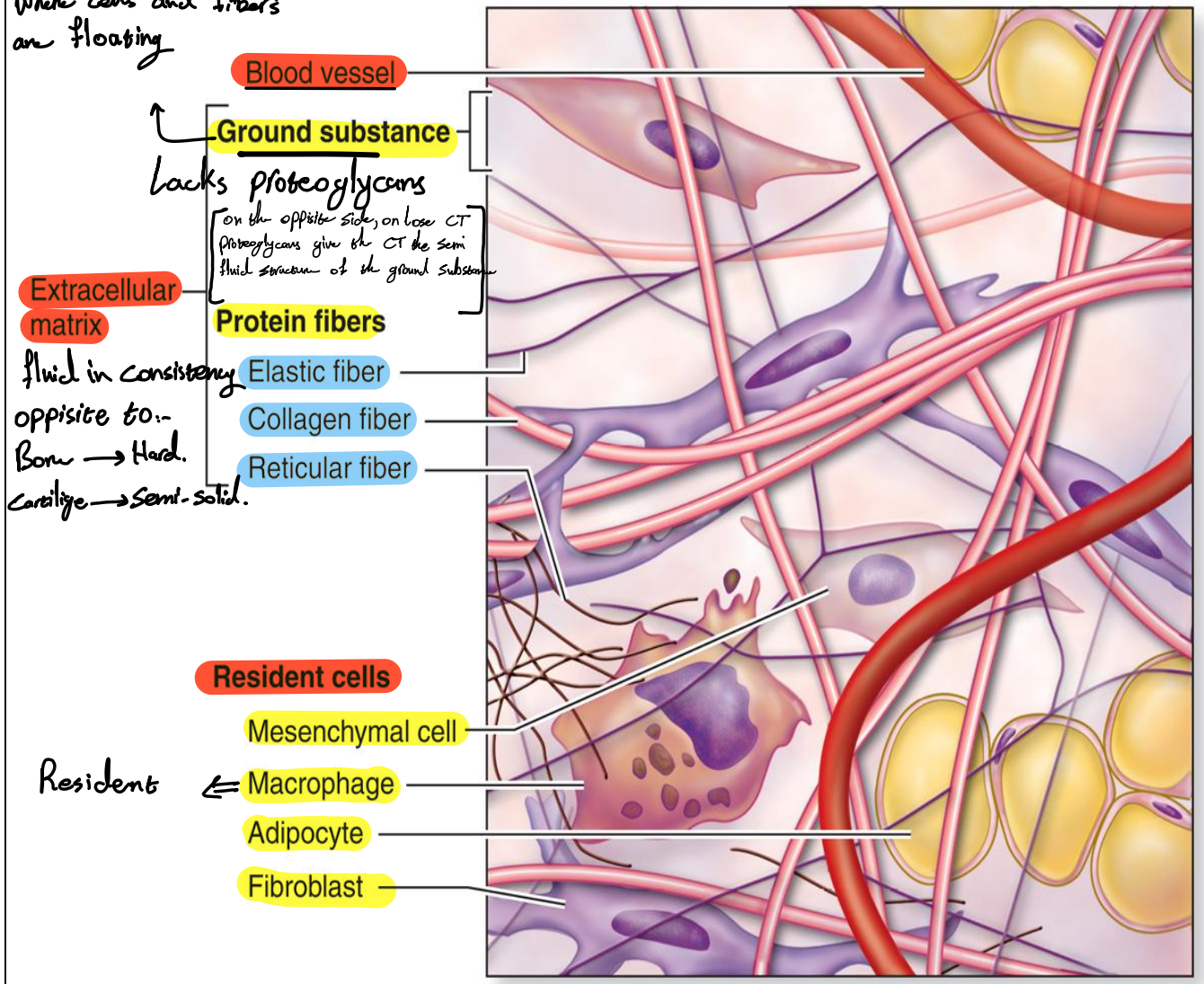
All types of connective tissue originates from mesenchyme (from Mesoderm).

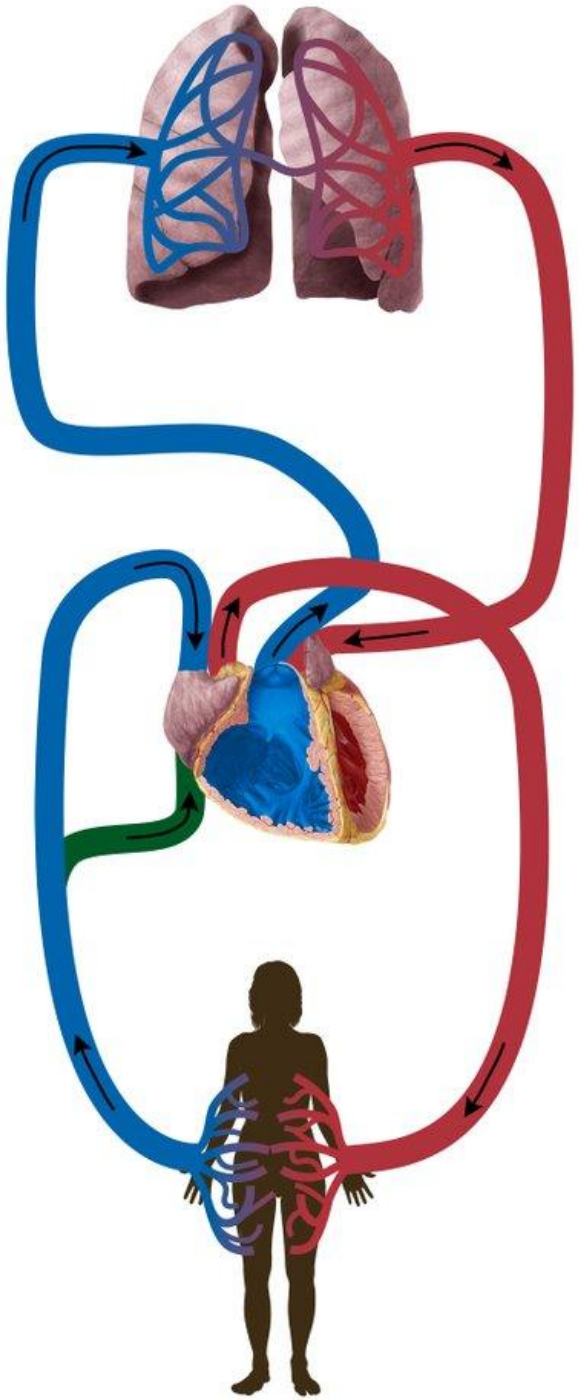
Prof. Dr. Heba Kalbouneh

- Specialized form of **connective tissue**
- Components: → RBC, WBC
  - Blood cells (several types)
  - Plasma (extracellular matrix) fluid



where cells and fibers are floating





Functions of Blood

- Transports nutrients and respiratory gases. & Hormones
- Transports waste products to organs and tissues where they can be recycled or eliminated.
- Transports hormones.
- Transports immune cells throughout the body. towards site of infections.
- Helps regulate body temperature. ⟹ through Vasodilation & Vasoconstriction.
- Maintains acid–base and osmotic balance. ⇒ pH of blood is slightly alkaline.

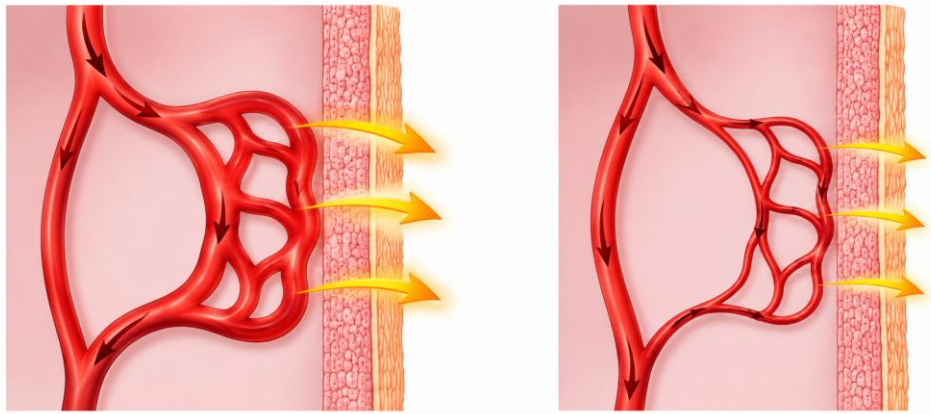
Prof. Dr. Heba Kalbouneh

Characteristics of Blood

pH: Approximately 7.4

Color: Depends on the amount of oxygen:

- More oxygen → brighter red
- Less oxygen → darker/duller red



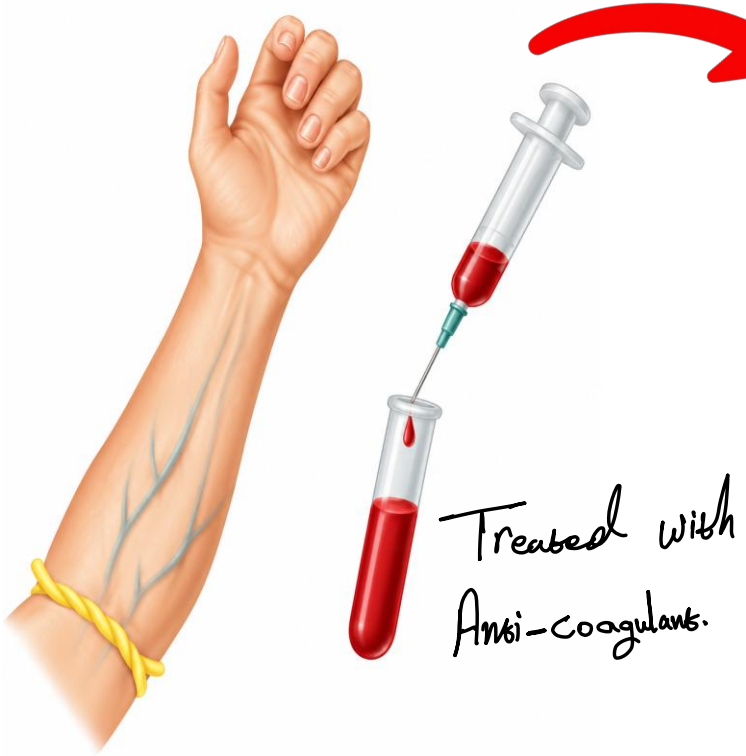
Blood Circulation

- ✓ Blood is propelled mainly by the rhythmic contractions of the heart.
- ✓ An average adult has approximately 5–6 liters of blood.
- ✓ Blood moves unidirectionally within the closed circulatory system.

Prof. Dr. Heba Kalbouneh

1

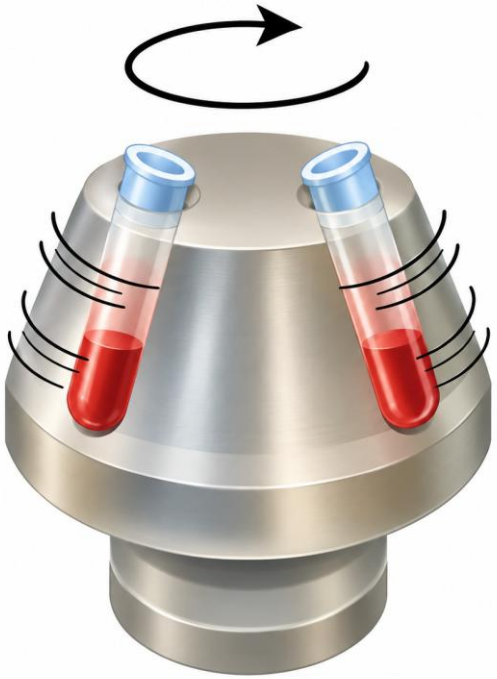
Withdraw blood and place in tube



Treated with Anti-coagulants.

2

Centrifuge





Plasma
(55% of whole blood)

Buffy coat:
Leukocytes and platelets
(<1% of whole blood)

whitish in color (that's why WBCs are named so.)

Erythrocytes
(44% of whole blood)

Formed elements

Names aren't required.

Blood collected with an anticoagulant (e.g., heparin, citrate, or EDTA) can be separated by centrifugation into distinct layers that reflect its heterogeneous composition.

Composition of Blood

formed in Red Bone Marrow. (Hematopoiesis).

Formed Elements ~45%

- **Erythrocytes (RBCs):** transport oxygen
- **Leukocytes (WBCs):** immune defense
- **Platelets (thrombocytes):** involved in blood clotting

Plasma ~55%

- Pale-yellow fluid component of blood
- ~90% water
- ~10% dissolved substances, including:
  - Plasma proteins (e.g., albumin)
  - Electrolytes
  - Nutrients
  - Metabolic waste products
  - Dissolved gases
  - Hormones

Lacks proteoglycans.

Serum = Plasma − Clotting Factors



Top layer
Plasma 55 ml
90 % water
10 % Nutrients, waste,

Middle layer
Buffy coat (1 ml)

Bottom layer
RBCs (44 ml)
(Packed Cell Volume)

Hematocrit (Hct) clinical correlation

Hematocrit: The percentage of the total blood volume occupied by red blood cells (RBCs).

Example:

A hematocrit of 40% means that 40 mL of every 100 mL of whole blood consists of RBCs.

Normal hematocrit values:

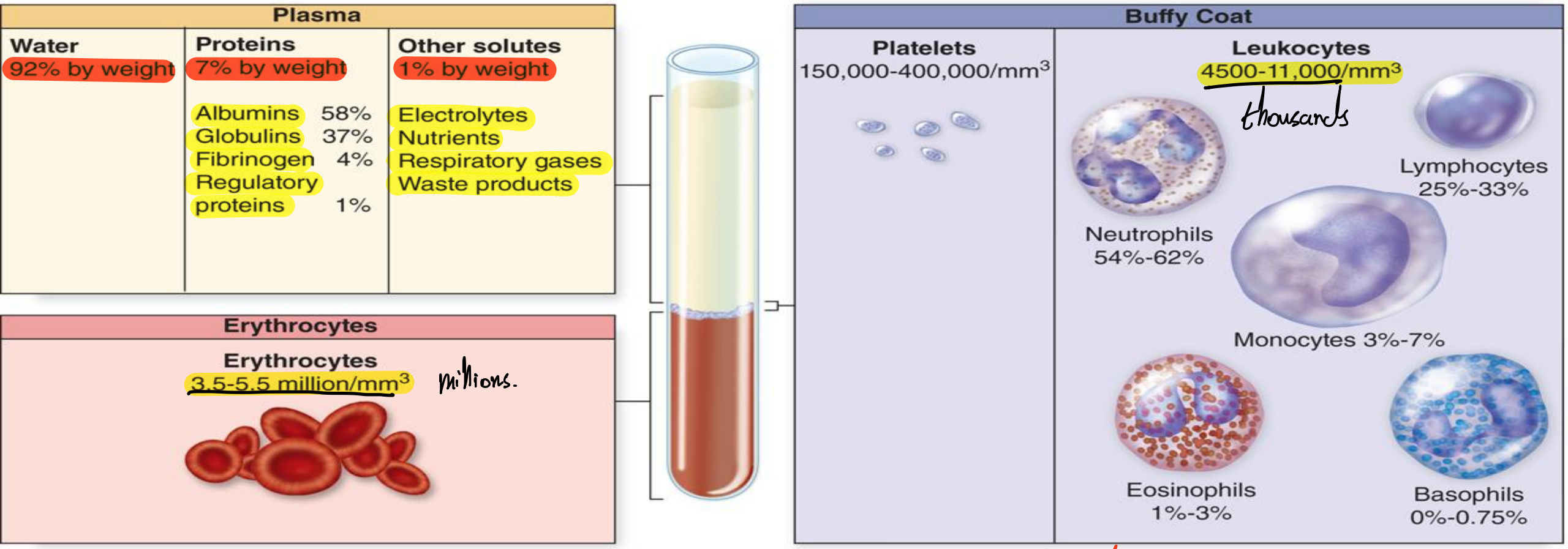
- **Males: 40–53%**
- **Females: 36–48%**

Testosterone activates bone marrow (Activates Hematopoiesis).
(Blood loss through menstruation).

Prof. Dr. Heba Kalbouneh

NOTE: A cubic millimeter of blood is equivalent to a microliter (μL)

Values are those used by the US National Board of Medical Examiners



Total leukocyte count (TLC): Total number of leukocytes per μL of blood. ↑ ⇒ indicate infection

Differential Leukocyte Count (DLC): Percentage of each leukocyte type among 100 leukocytes counted.

Copyright © McGraw-Hill Companies

Albumin

- ✓ The most abundant plasma protein.
- ✓ Synthesized mainly by the liver.
- ✓ Helps maintain colloid osmotic (oncotic) pressure of the blood.
- ✓ Acts as a carrier protein, transporting substances such as: Steroid hormones and Fatty acids

Fibrinogen

- ✓ The largest major plasma protein.
- ✓ Synthesized by the liver.
- ✓ Plays an essential role in blood clotting.
- ✓ During clot formation, fibrinogen is converted into fibrin, which forms a mesh that helps stabilize the blood clot.

net ?!

Fresh plasma



Prof. Dr. Heba Kalbouneh

Importance of Plasma Proteins

Plasma proteins help maintain the colloid osmotic (oncotic) pressure of blood, preventing excessive fluid loss from the blood vessels into the tissues.

→ help keep fluid within the blood vessels.

pressure to keep blood inside vascular system.

immunoglobulins

Maged ← Mnemonic

- IgM
- IgE
- IgA
- IgD
- IgG

Globulins (α, β and or γ globulins):

Synthesized by Plasma cells

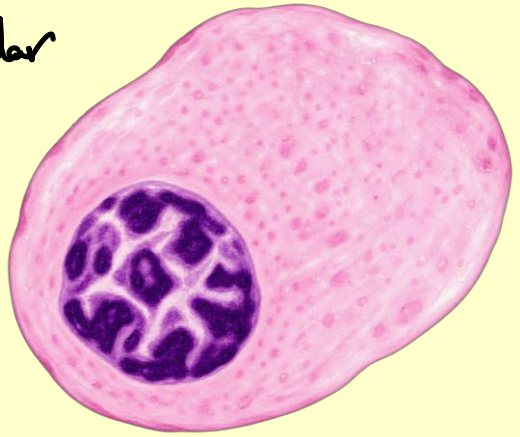
α- and β-Globulins

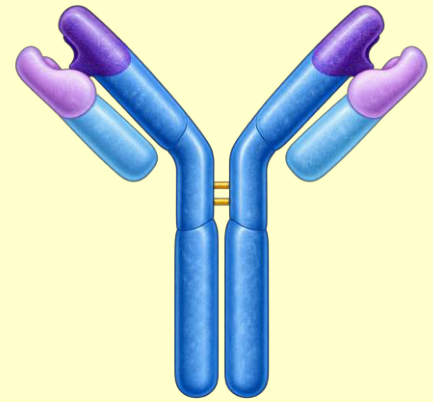
- ✓ Synthesized mainly by the liver.
- ✓ Function primarily as transport proteins.
- ✓ Transport substances such as: Lipids, Fat-soluble vitamins, and Iron → *Iron is transported mainly by transferrin, a β-globulin.*

γ-Globulins (Immunoglobulins/Antibodies)

- ✓ Produced and secreted by plasma cells.
- ✓ Function as antibodies.
- ✓ Play an essential role in humoral immune defense.

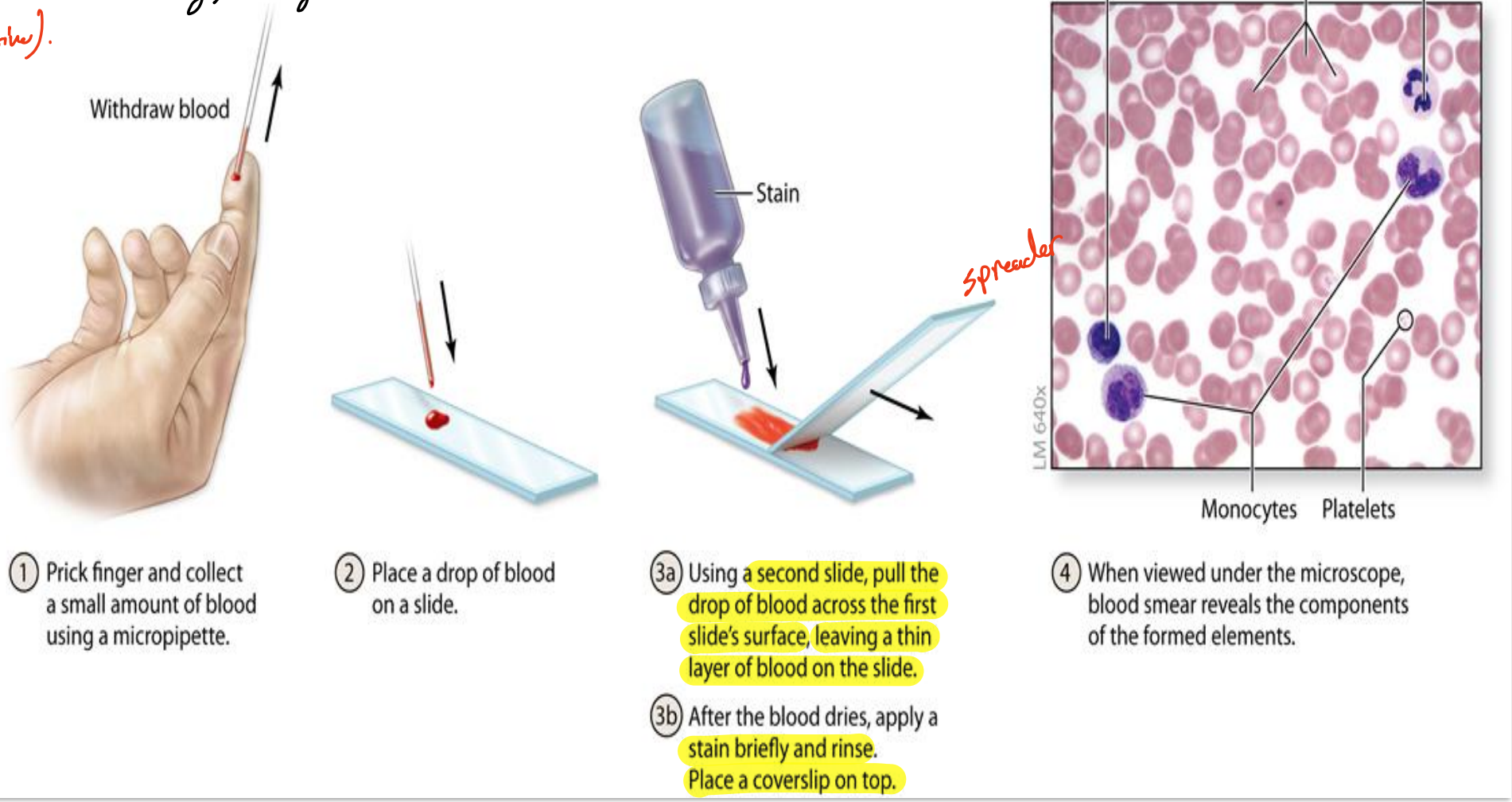
Plasma cell





We don't use Formaldehyde, we use Methylalcohol (Lighter form of fixative).
→ to strong, destroy cells

Preparing a blood smear



(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.

Polychromatic stains:
Giemsa
Wright
Leishman

memorise

examples of blood stain

Blood cells can be studied histologically in smears prepared by spreading a drop of blood in a thin layer on a microscope slide

Figure 12-3

Copyright © McGraw-Hill Companies

The Staining of Blood Cells

Blood film/ smear: A drop of blood is spread into a thin layer on a glass slide and allowed to air-dry.

Staining: with polychromatic stain e.g **Leishman's stain**

Leishman's stain: formed of a mixture of:

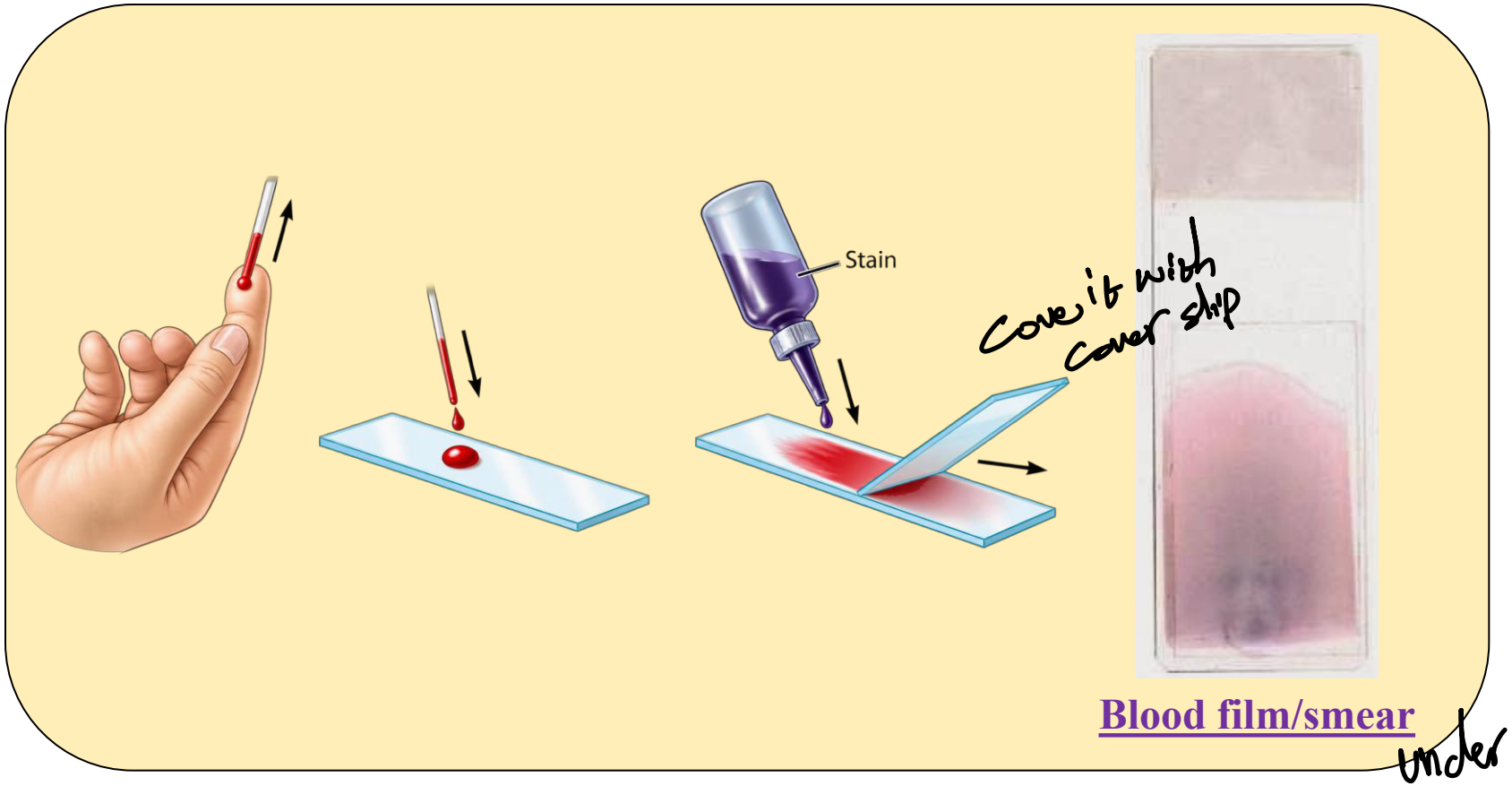
- Eosin, an acidic dye that stains pink to red
- Methylene blue, a basic dye that stains blue to purple

Dissolved in methyl alcohol (fixative)

Azure dye!!

when eosin & methylin blue are mixed together they for by product such as Azure dye.
↳ oxidation reaction that results in the formation

Prof. Dr. Heba Kalbouneh



Blood film/smear

Polychromatic Stains

Commonly used for staining peripheral blood smears:

- Giemsa stain
- Wright stain
- Leishman stain

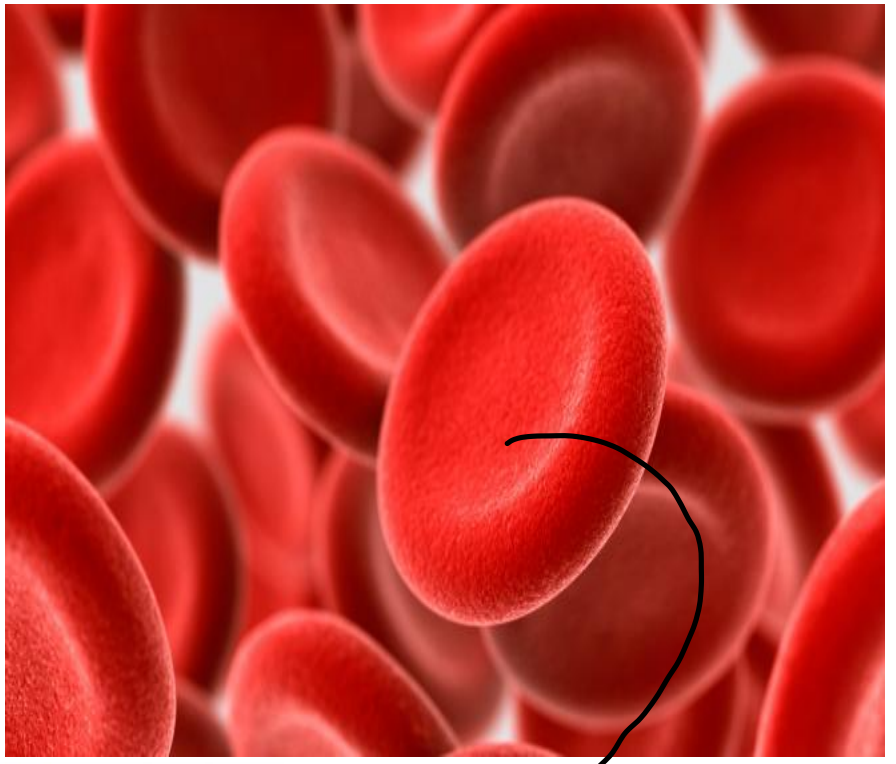
These are Romanowsky-type stains that use combinations of acidic and basic dyes to differentiate blood cells and their components.

under light microscope.

Erythrocytes (RBCs) Red blood cells

- Small, biconcave discs.
- Specialized for the transport of O_2 and CO_2.
- Cytoplasm is packed with hemoglobin.
- Mature RBCs have no nucleus or organelles.
- Pick up O_2 in the pulmonary capillaries and release it in tissue capillaries.
- Carry part of the CO_2 from tissues back to the lungs.

Male: 4.5-5.5 million/mm3
Female:4-5 million/mm3

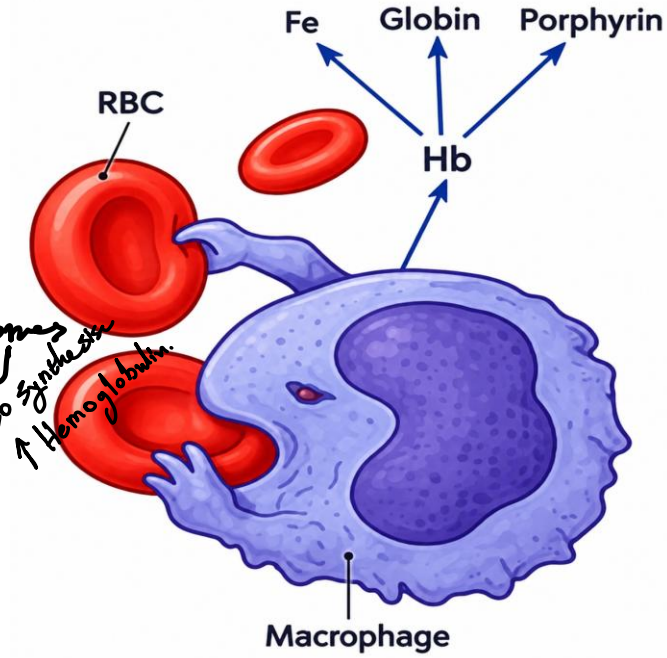


not real cells (No organells)

Life Span and Fate

relatively short lived (no nucleus or organells for compensating their needs).

- Circulate for approximately 120 days.
- Aged or damaged RBCs are removed by macrophages, mainly in the spleen (1), and also in the liver (2) and bone marrow (3).
- Their components, particularly iron, are recycled.



the RBC's precursor contains high amounts of ribosomes to synthesize ↑ Hemoglobin.

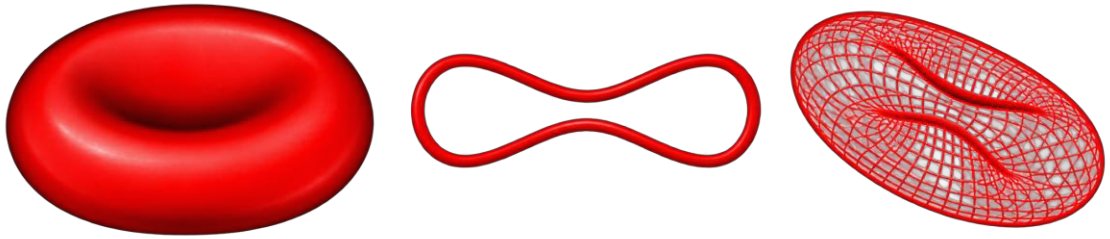
high amount of hemoglobin

Note: During maturation, erythrocytes extrude their nuclei, progressively lose their cytoplasmic organelles and enter the bloodstream as anucleate cells.

Prof. Dr. Heba Kalbouneh

Immediately beneath the plasma membrane is a **meshwork of proteins** (Spectrin and Ankyrin) forming a cytoskeleton

This sub-membranous meshwork stabilizes the membrane, maintains the cell shape, and provides the cell elasticity required for passage through capillaries



Top view

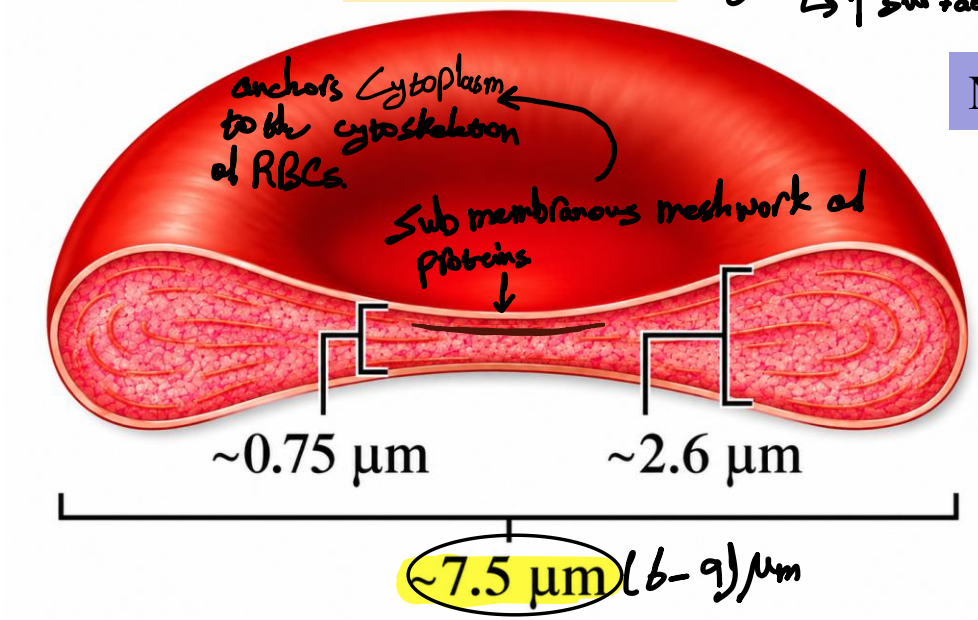
Rounded edges (outline)

Prof. Dr. Heba Kalbouneh



Sectional view

By concave in shape
↳ ↑ surface area for gas exchange.



Normocytic RBCs

Some Blood vessels 4 µm so RBCs should be flexible.

Size

6-9 um in diameter (7.5 um)

Thickness

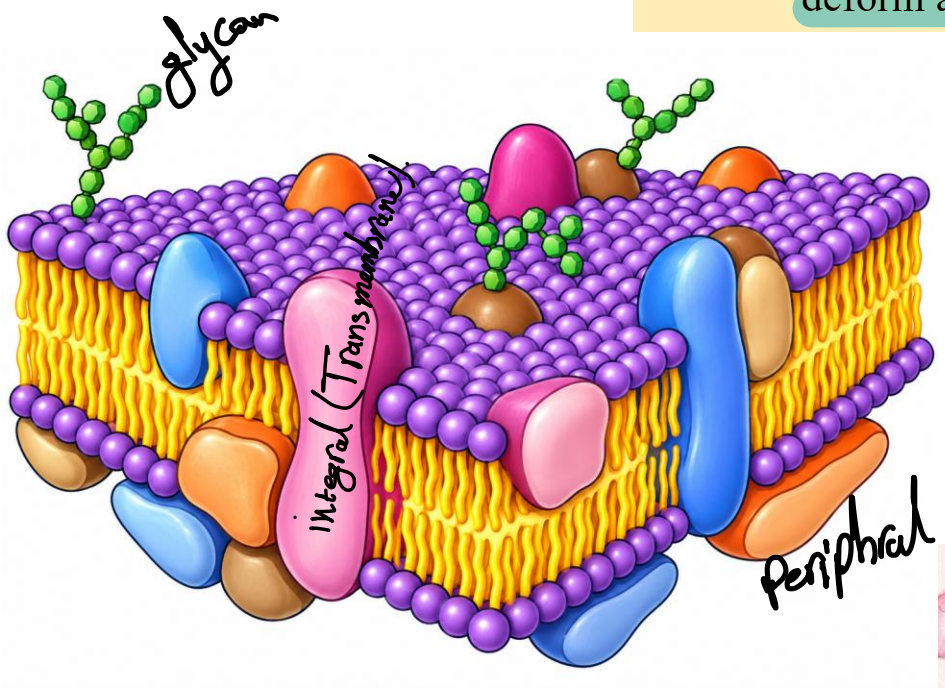
2.6-µm thick at the rim, but only 0.75-µm thick in the center

!!!!! Erythrocytes can be used as a size reference for other cell types

Biconcave shape provides 20-30% greater surface area than a sphere relative to cell volume, facilitating gas exchange

increase surface area for gas exchange.

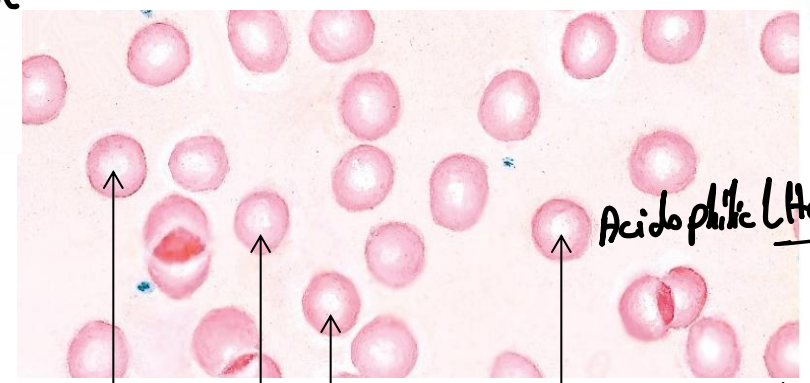
The biconcave shape, together with the flexibility of the plasma membrane and its underlying cytoskeleton, allows erythrocytes to deform and pass through narrow, tortuous capillaries.

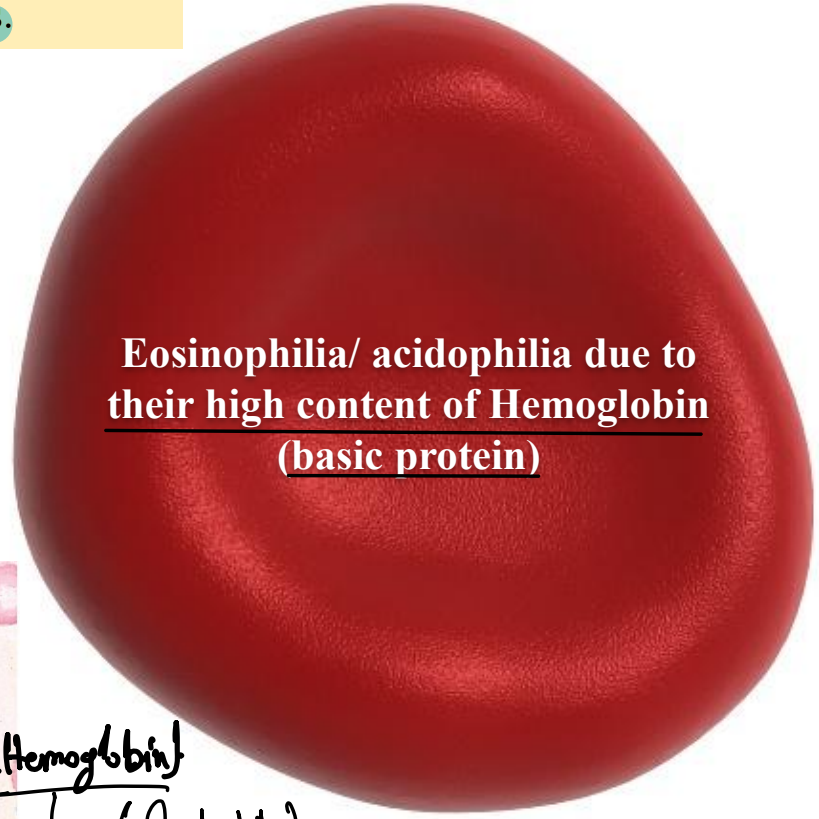


RBC membrane: approximately 50% protein, 40% lipid, and 10% carbohydrate by weight.

Lipid bilayer → provides fluidity

Erythrocyte consists of an **outer plasma membrane** enclosing hemoglobin and a **limited number of enzymes** necessary for maintenance of plasma membrane integrity and gas transport functions





Eosinophilia/ acidophilia due to their high content of Hemoglobin (basic protein)

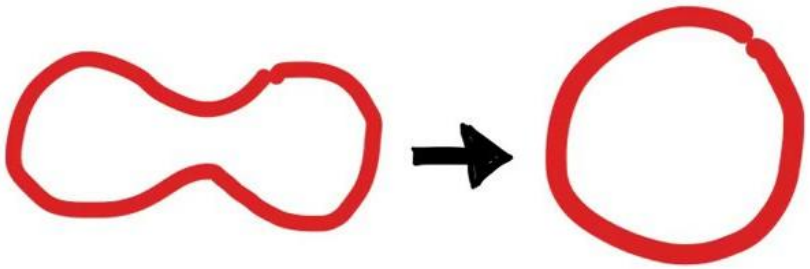
The pale staining of the central region is a result of its biconcave disc shape → less hemoglobin at the center.

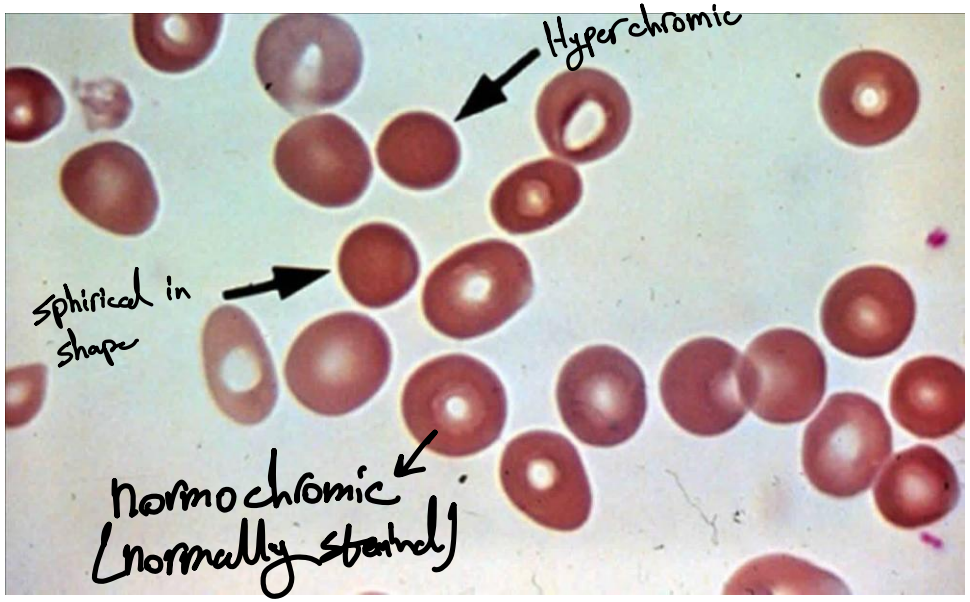
→ **Normochromic RBCs**

Prof. Dr. Heba Kalbouneh

Hereditary Spherocytosis

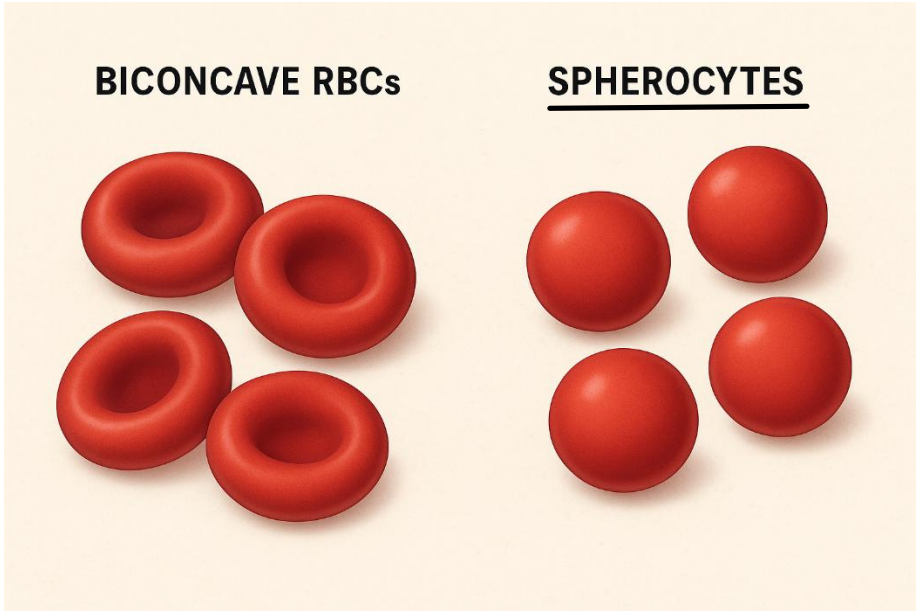
Normocytic
Normal shape ?!!





Hereditary spherocytosis: Caused by defects in RBC membrane cytoskeletal proteins (especially spectrin and ankyrin), resulting in loss of the normal biconcave shape and formation of spherical, less deformable RBCs.

anchors plasma to cyto-skeleton which stabilizes the shape



In spherocytosis, membrane loss decreases the surface-area-to-volume ratio. The RBC becomes a sphere, with no central pallor

Spherocytosis → membrane loss → spherical RBC + loss of central pallor + increased splenic destruction.

LM:

Blood film stained with Leishman:

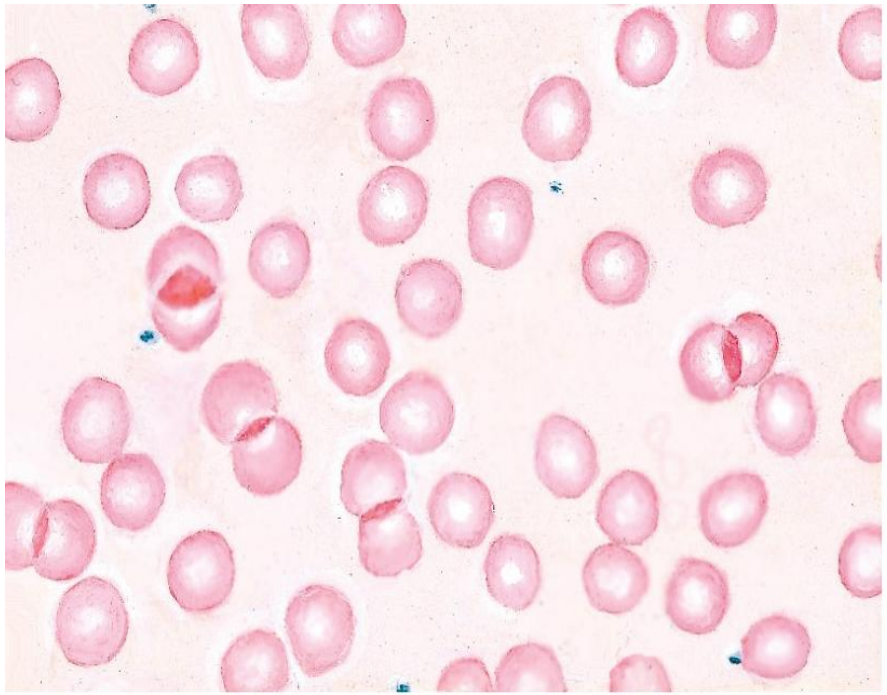
Rounded

Non nucleated

Acidophilic (with pale central area)

A zone of **central pallor** is about 1/3 the size of the RBC

LM



EM:

✓Have no nucleus or organelles

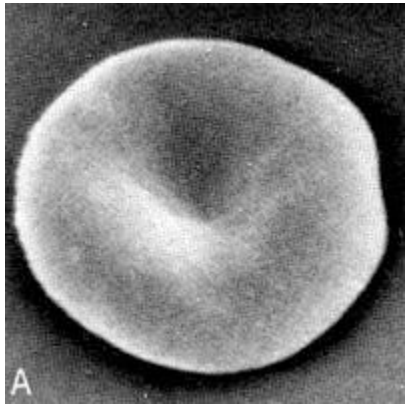
✓Filled with hemoglobin

Electron dense and homogenous

TEM



SEM



TEM Of Erythrocytes Passing Through Capillary Wall



Single Erythrocyte squeezing through capillary



Prof. Dr. Heba Kalbouneh

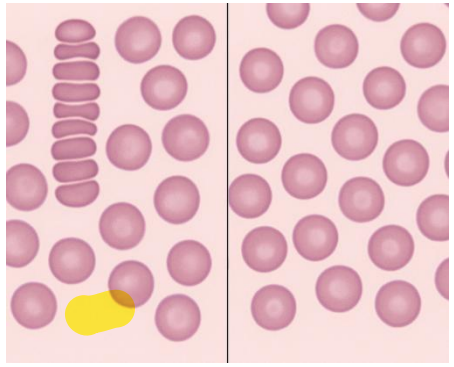
this is not an indication of pathological condition (since it is an artefact because of preparation).

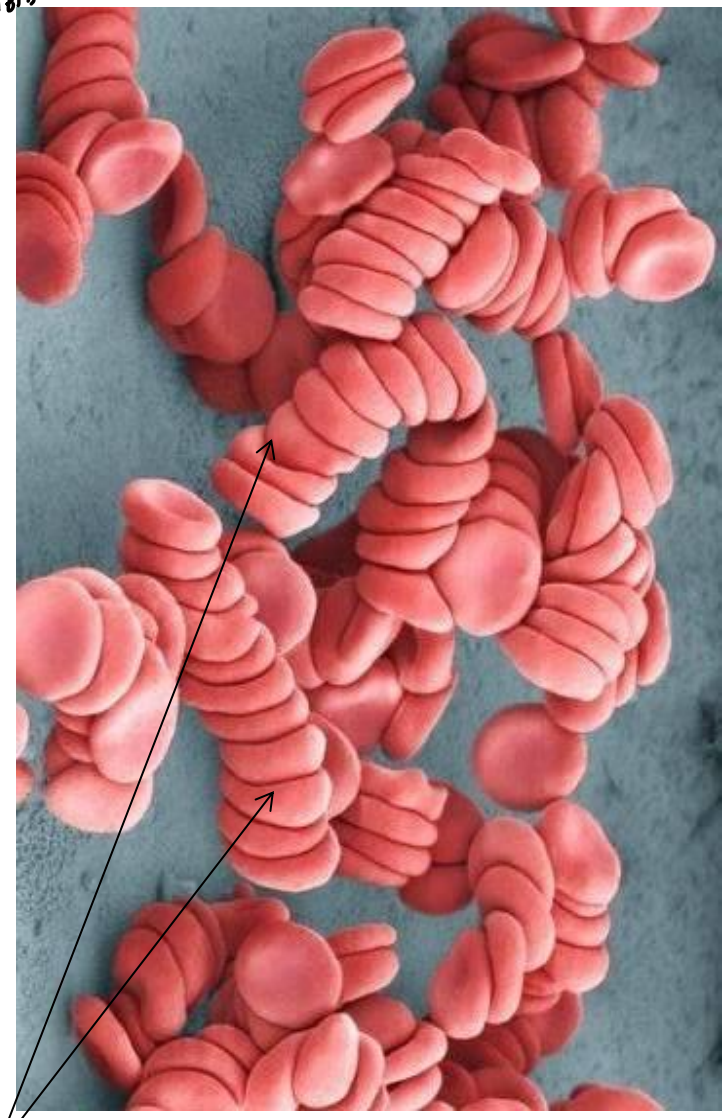


Anything that increases plasma proteins concentration will cause Rouleax formation.

Prof. Dr. Heba Kalbouneh

Rouleaux appearance occurs to some extent in all films







Normally, RBCs tend to repel each other because their surfaces carry a negative charge (zeta potential).

Slow circulation

When plasma proteins increase, they reduce this repulsive force, allowing RBCs to come together and form rouleaux.

slimt

Rouleaux formation: is the arrangement of red blood cells in stacks resembling a stack of coins.

✓In slow (not in normal) circulation

Due to reduced repulsive forces (zeta potential) between erythrocytes, especially in the presence of increased plasma proteins such as fibrinogen and globulins (reversible)

Abnormalities of Erythrocytes

Change from the normal **size**, **shape** or **staining properties** of erythrocytes are **important indicator of disease**. However, some of these abnormalities may be found in healthy individuals

Abnormal sizes:

Microcytes (<6um)

Macrocytes (>9um)

Anisocytosis (different sizes)

Abnormal shapes: either due to defects in hemoglobin or in submembranous meshwork.

Due to changes either in the cell membrane or Hb content

Poikilocytosis: variation in RBC shape

Abnormal staining:

Hypochromia: Decreased staining intensity of RBCs due to reduced hemoglobin, resulting in increased central pallor.

Hyperchromia: Increased staining intensity of RBCs with reduced or absent central pallor, typically due to altered RBC shape, as seen in spherocytes.

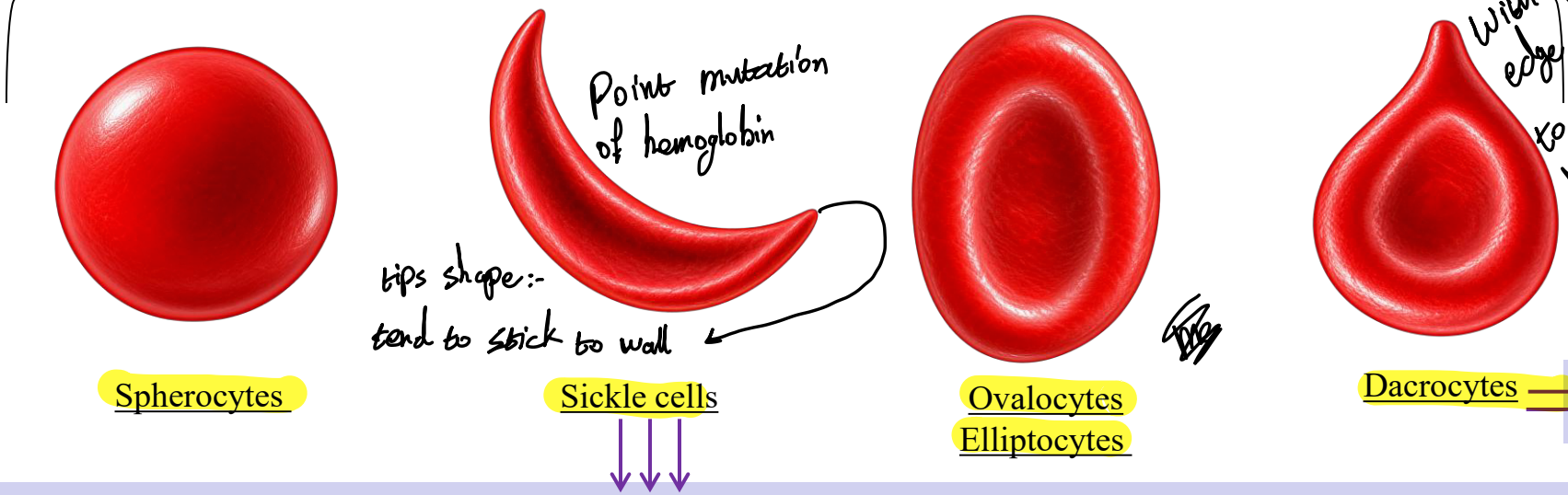
Poikilocytosis = *abnormal RBC* ***shape***

Anisocytosis = *abnormal RBC* ***size***

abnormal shape

Poikilocytes

(Poikilocytosis)

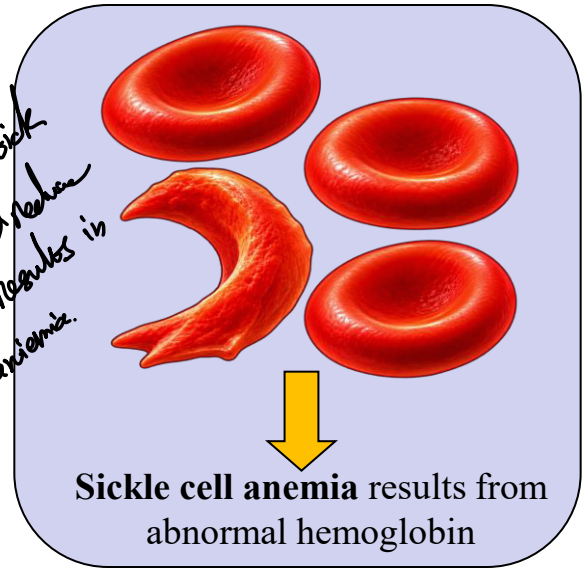


Spherocytes

Sickle cells

Ovalocytes
Elliptocytes

Dacrocytes → Teardrop shaped cells



Sickle cell anemia results from abnormal hemoglobin

One of the most sever changes in shape occurs during SICKLING of RBCs in sickle cell anemia where erythrocytes take on the form of crescents

Prof. Dr. Heba Kalbouneh

Based on Hemoglobin Content (color /chromasia):

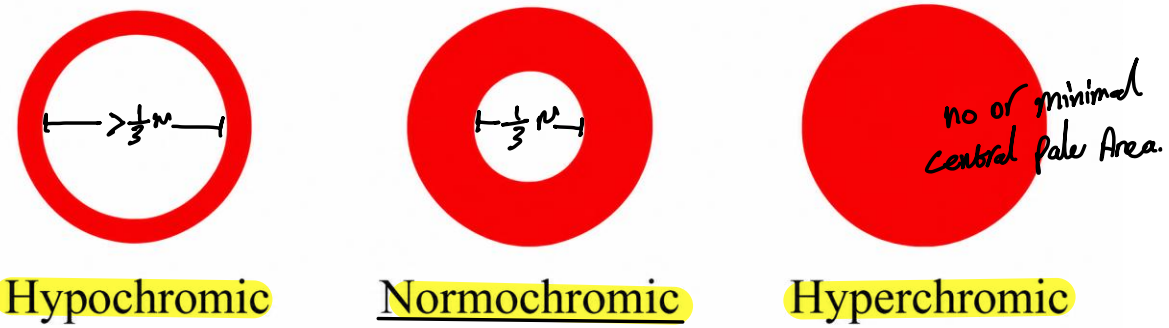
Basis of naming different types of aniemia.

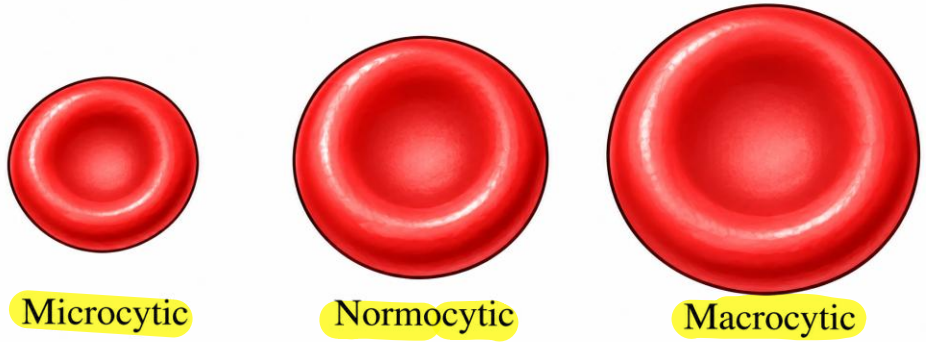
Normochromic: RBCs have a normal hemoglobin concentration → exhibit normal pink staining with central pallor occupying approximately one-third of the cell diameter.

Hypochromic: RBCs have reduced hemoglobin concentration → appear paler with increased central pallor (commonly seen in iron deficiency anemia).

Hyperchromic: RBCs exhibit increased staining intensity with reduced or absent central pallor, often associated with increased hemoglobin concentration, as seen in hereditary spherocytosis**.**

Note: Hypochromia frequently accompanies microcytosis, resulting in hypochromic microcytic anemia, as commonly seen in iron deficiency anemia.





Together, these terms are used to describe and classify anemias (e.g., microcytic hypochromic anemia in iron deficiency, or macrocytic normochromic anemia in B12 deficiency).

?!?! Search on ChatGPT

Based on Cell Size (cytometry):

Normocytic: RBCs are of normal size.
Microcytic: RBCs are smaller than normal (seen in iron deficiency anemia).
Macrocytic: RBCs are larger than normal (seen in vitamin B12 or folate deficiency anemia).

Prof. Dr. Heba Kalbouneh

When RBC count or blood oxygen-carrying capacity decreases, such as during blood loss, tissue hypoxia develops.

↓

Hypoxia is detected by the kidneys. by special type of cells surrounding the vessels of kidney. (Simply Endothelial cells).

↓

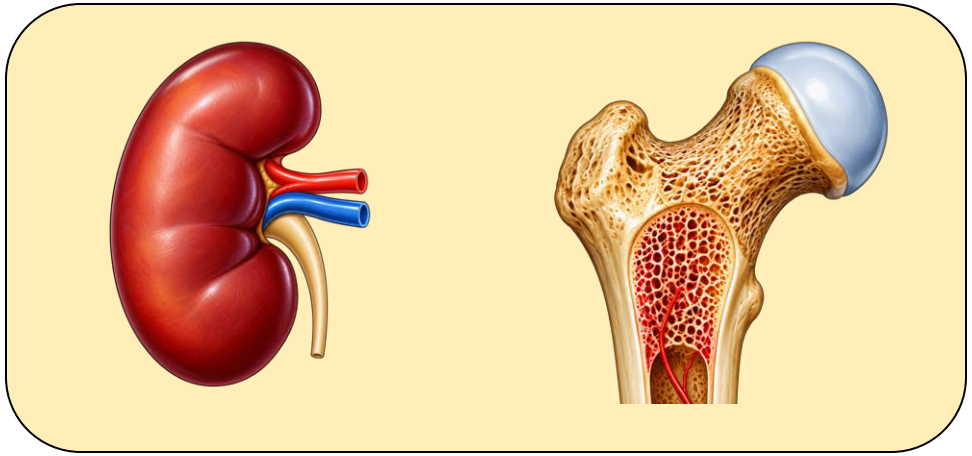
The kidneys respond by increasing the production and secretion of erythropoietin (EPO). (A hormone that is needed for the Erythropoiesis process).

↓

Erythropoietin stimulates erythropoiesis in the red bone marrow.

↓

RBC production increases, improving the oxygen-carrying capacity of the blood.



At high altitudes, lower oxygen levels stimulate erythropoietin production, leading to an increased RBC count.

Since its more difficult for our lungs to take oxygen.



⇓

Take at least 7 days to cope (since RBCs production take 7 days)

Endurance athletes may have an increased red blood cell production to support greater oxygen demands.

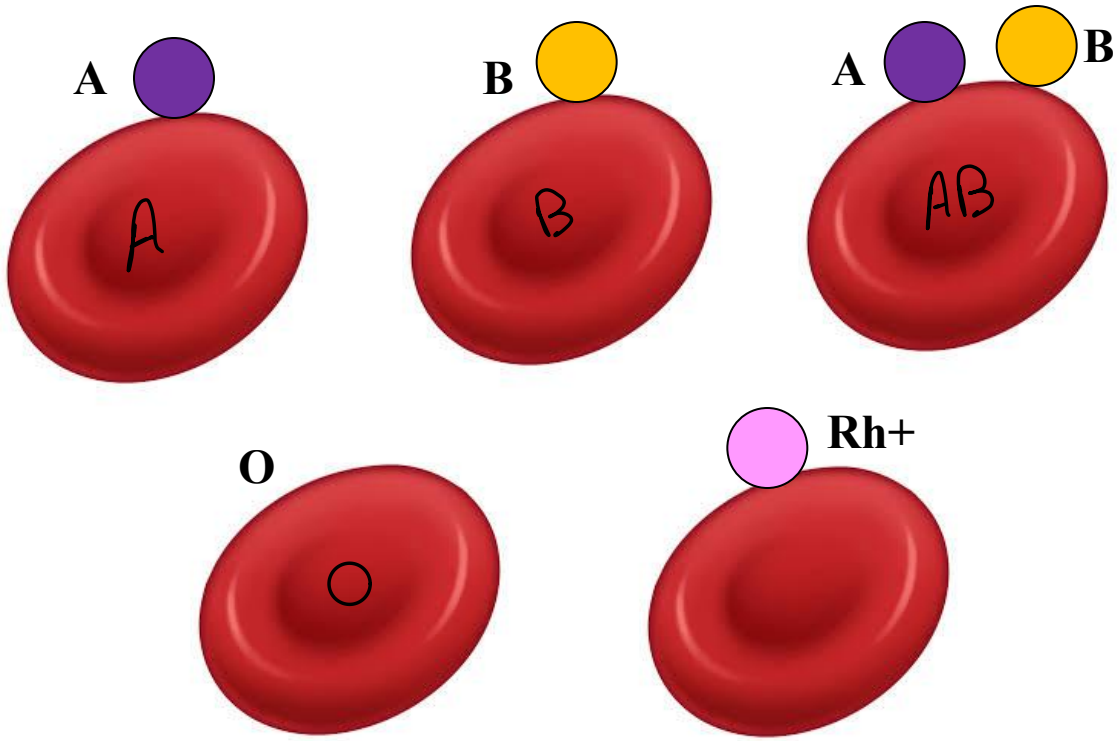
increase in the number of RBCs can be physiological or pathological



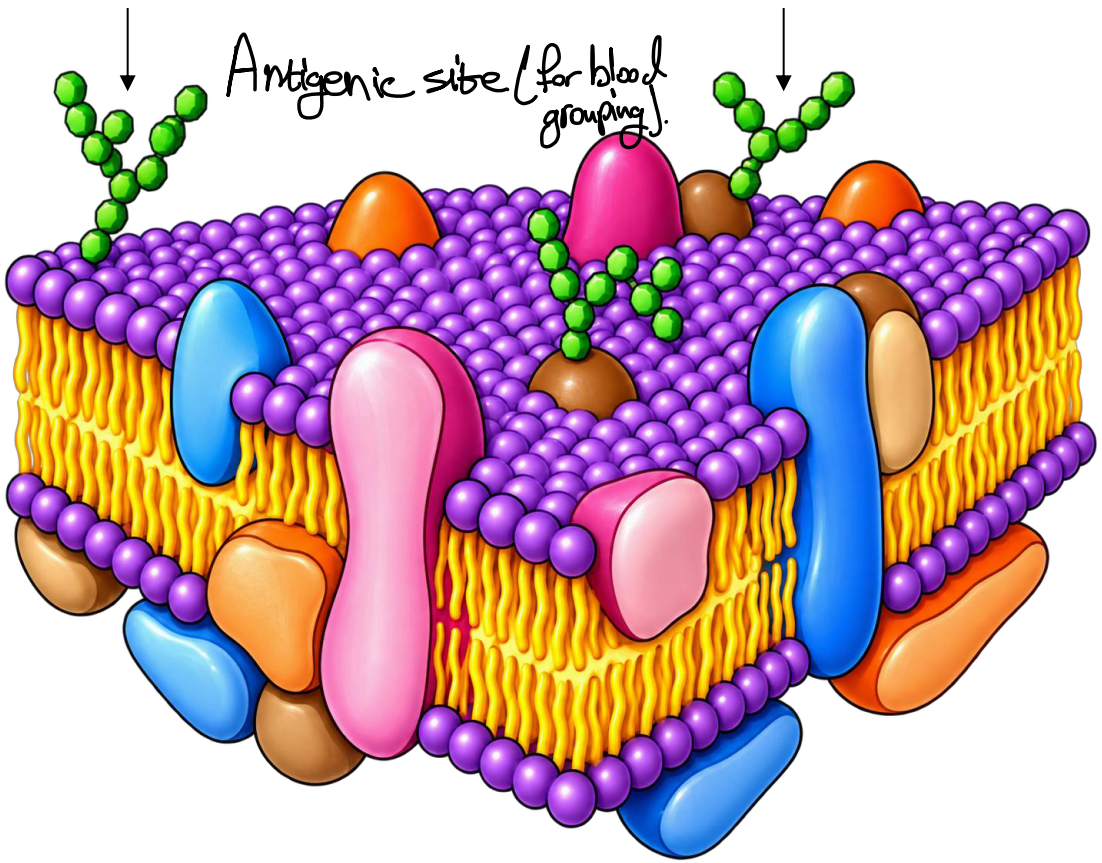
Prof. Dr.
Heba Kalbouneh

RBC plasma membranes carry carbohydrate antigens (A and/or B antigens) on their external surface.

These carbohydrate antigens are attached to glycoproteins and glycolipids in the RBC membrane.



Prof. Dr. Heba Kalbouneh



The ABO blood group system consists of four main blood groups: A, B, AB, and O. These groups are determined by the presence or absence of specific carbohydrate antigens (A and B antigens) on the surface of RBCs.

Mast cells
- Heparin
- Histamin.

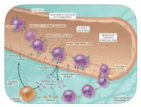
	RBCs (Erythrocytes)	WBCs (Leukocytes)
Types	1 type	5 types — Eosinophils, Basophils, Neutrophils, Lymphocytes, Monocytes
Nucleus	Anucleate	Nucleated
Number	Male: ~4.5–5.5 million/mm³; Female: ~4.0–5.0 million/mm³ (millions)	~4,500–11,000/mm³ (Thousands)
Diameter	~6–9 µm (flexible); average ~7.5 µm	~7–20 µm, depending on type (wide range)
Life span	~120 days	Hours/days to years, depending on type
Origin and maturation	Red bone marrow	Red bone marrow and lymphoid tissue
Shape	Biconcave discs	Variable; generally spherical in blood (irregular in shape ⟹ at the infection site)
Function	Transport of O_2 and CO_2	Defense and immunity
Motility	Non-motile	Motile
Location/ function	Function exclusively within vascular system	Function mainly OUTSIDE blood vessels in the tissues

Don't memorise numbers

Comparison

* When their is an infection, The white blood cells moves closser to the vascular wall [Margination] then start rolling on the vascular wall using lose adhesion, then attach using strong adhesion & diapedesis occur [sequezing through the blood vessels

The process has **6 main steps**:



1. **Margination**

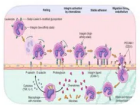
Due to slowed blood flow (*stasis*), leukocytes move toward the vessel wall instead of remaining in the center of the blood.



2. Rolling — Selectins

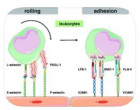
Leukocytes attach weakly to the endothelium, detach, and attach again, causing them to roll along the vessel wall.

Mediators: E-selectin and P-selectin.



3. Integrin activation — Chemokines

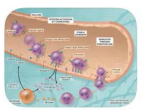
Chemokines activate leukocyte integrins, changing them from a **low-affinity** to a **high-affinity** state.



4. Firm adhesion — Integrins

Activated integrins bind strongly to endothelial ligands, especially **ICAM-1**, stopping the leukocyte in place.

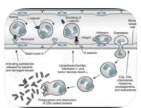
TNF and IL-1 stimulate endothelial cells to increase adhesion molecule expression.



5. Transmigration (Diapedesis)

The leukocyte squeezes between endothelial cells to leave the blood vessel.

Key molecule: PECAM-1 (CD31). The leukocyte also crosses the basement membrane.



6. Chemotaxis

The leukocyte moves through the tissue toward the infection by following a chemical gradient of chemoattractants.

Examples: **bacterial peptides, IL-8 (a chemokine), C5a, and leukotriene B4 (LTB4).**

The whole process at a glance

* At the site of infection, the endothelium become active by mediators released by residents macrophages. and attracts the white blood cells for weak attachments, then strong attachments.

Margination
Leukocyte moves toward the vessel wall

↓

Rolling — Selectins
Weak attachment

↓

Integrin activation — Chemokines
Weak binding becomes strong binding

↓

Firm adhesion — Integrins + ICAM-1
Leukocyte stops

↓

Diapedesis — PECAM-1 (CD31)
Leukocyte crosses the vessel wall

↓

Chemotaxis
Leukocyte follows chemical signals to the infection

Leukocytes (White Blood Cells)

- Originate in the bone marrow and released into the blood
- Travel in bloodstream but function mainly outside blood vessels (in loose CT)
- Form a mobile defense system that protects the body against bacteria, viruses, parasites, toxins, and tumor cells.

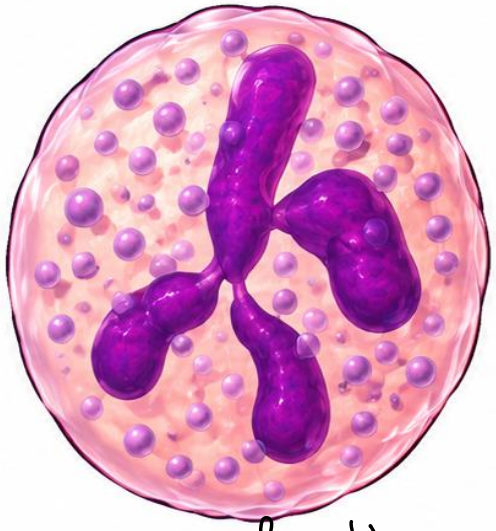
Note: Agranulocytes are not literally devoid of all granules. They lack the prominent specific granules characteristic of granulocytes, although lymphocytes and monocytes can contain azurophilic granules (lysosomes).

Prof. Dr. Heba Kalbouneh

Leukocytes, or WBCs, are nucleated and subdivided into granulocytes and agranulocytes, depending on the presence or absence of specific granules in their cytoplasm.

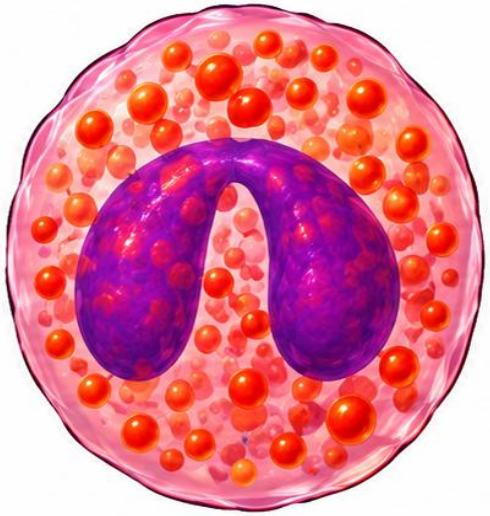
All contains Azurephilic granules.

Granulocytes



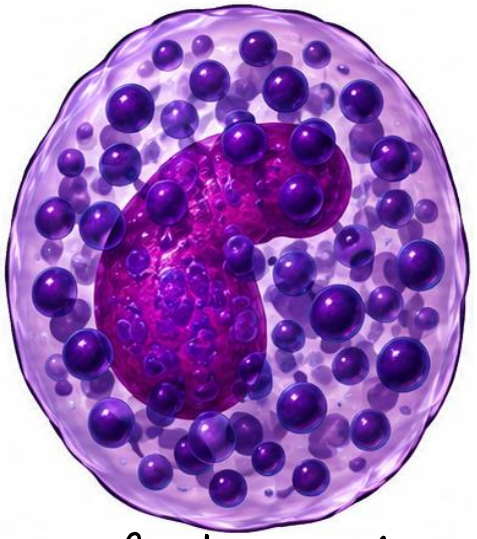
non-specific staining to either stains. (equally stained by both).

Neutrophil



Acidic staining of granules

Eosinophil



Basophils staining of granules.

Basophil

Agranulocytes

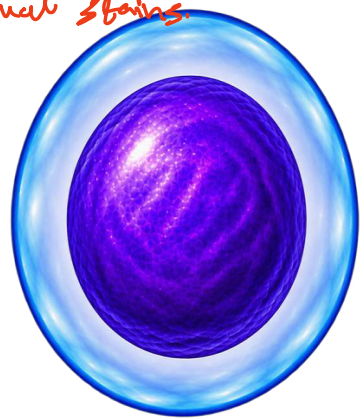
Non-specific granules are not usually seen using usual stains.



Largest WBC

Monocyte

↳ Differentiate into Macrophages.



Lymphocyte

Cytoplasmic granules

Specific granules
Secondary granules

Non-specific granules (primary granules).
Azurophilic granules
Lysosomes not lysosomes
Primary granules — present in all WBCs.

Granulocytes

- Cytoplasmic granules (containing enzymes or chemicals) → makes cytoplasm look grainy
- Have a single, segmented (multilobed) nucleus. ~~All~~ WBCs
- All are phagocytic; Phagocytic ability varies: prominent in neutrophils, limited in eosinophils, and very limited in basophils.

Large granules, Red



~~Neutrophil~~ Eosinophilis.

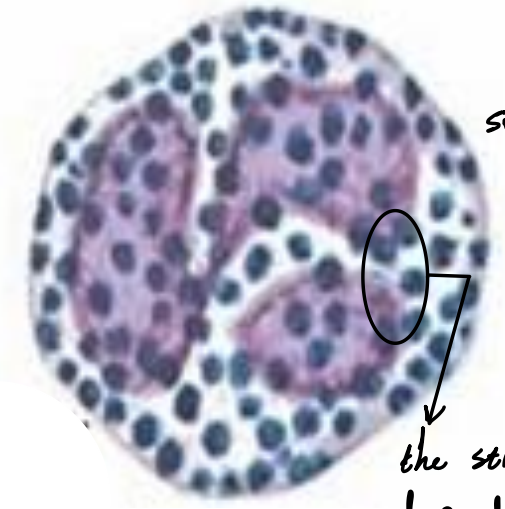
Small granules, pale pink/ salmon pink/ pale lilac



~~Eosinophil~~ Neutrophils.

Large granules, blue

usually (S) shaped



single nucleus

the stik is absents depending on the type of infection.

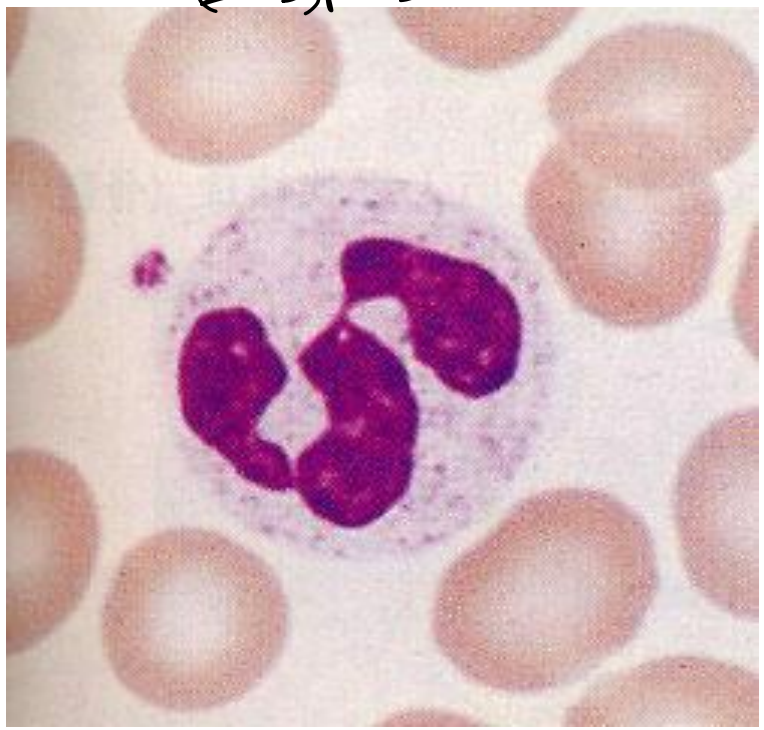
Basophil

Prof. Dr. Heba Kalbouneh

Differential Leukocyte count (The percentage of one type to all number of WBCs, ex:- Neutrophilis is 60 %)

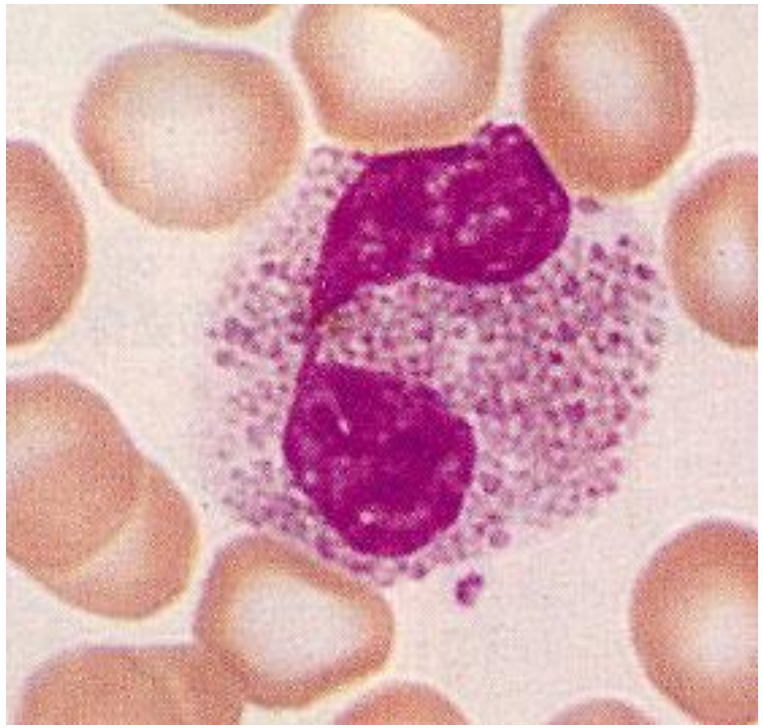
Neutrophil

(2-5) poles



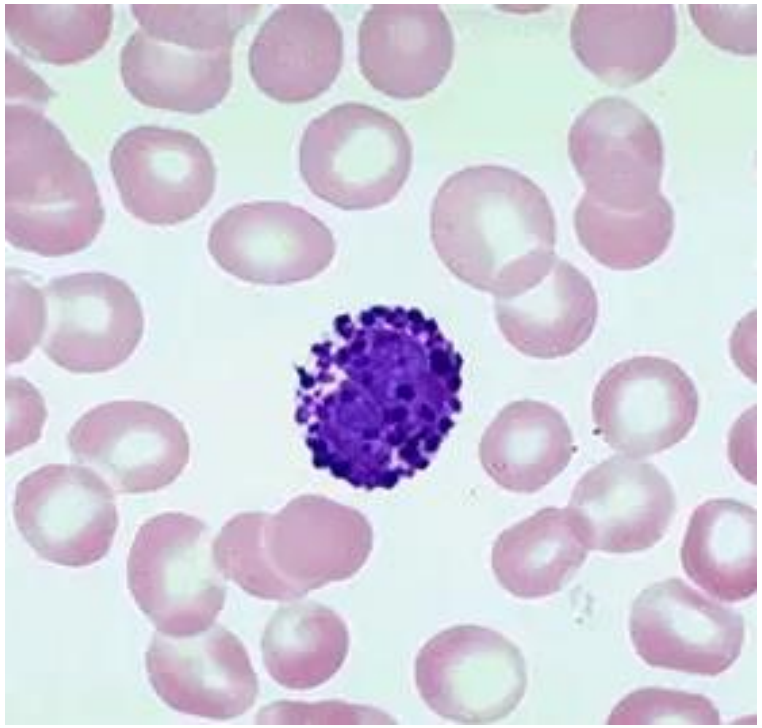
These granules are neutrophilic, meaning they show no special affinity for either acidic or basic stains but are stained mildly by both

Eosinophil



These specific granules stain red with acidic stains

Basophil



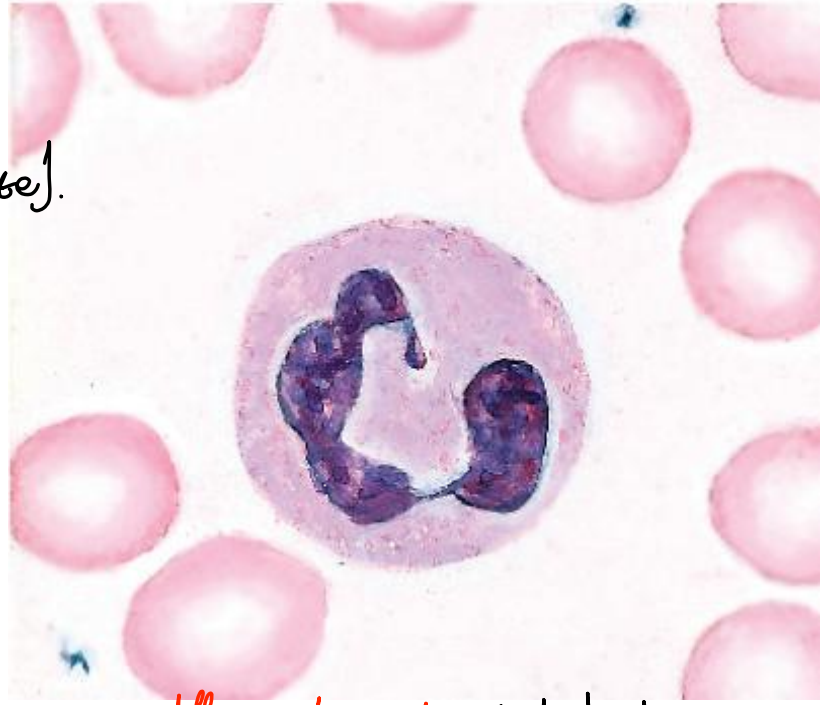
These specific granules stain with basic stains

Prof. Dr.
Heba Kalbouneh

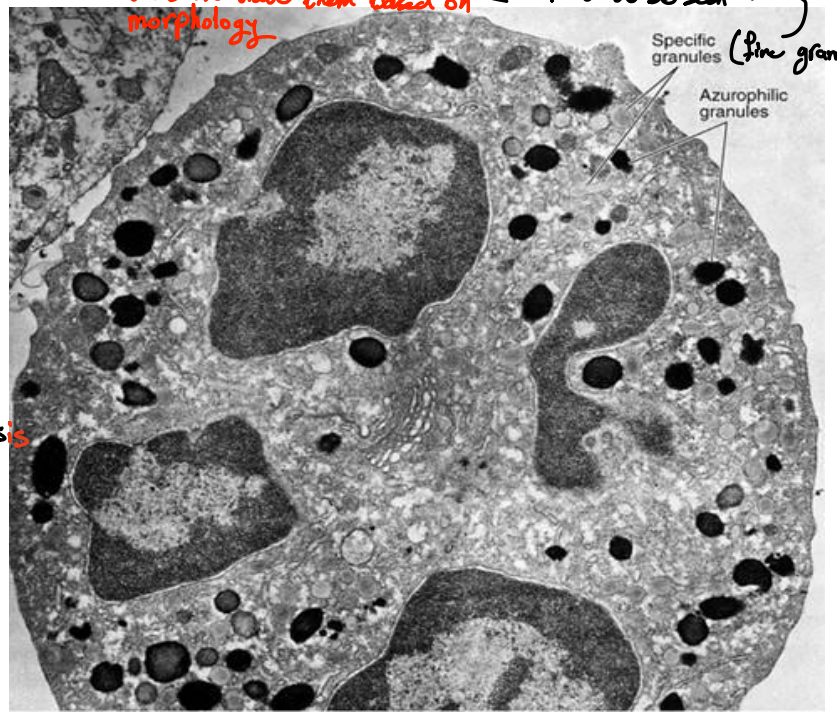
Neutrophils

- The most common leukocyte
- **Nucleus:** Typically consists of 2–5 lobes (most commonly 3), connected by thin strands of chromatin. Therefore, neutrophils are also called polymorphonuclear leukocytes **(PMNs or polymorphs)**.
- **Cytoplasm:** Pale pink or pale lilac, containing numerous fine, specific granules that are often difficult to distinguish individually under the light microscope.
- Called neutrophils because cytoplasm takes up red (acidic) and blue (basic) stains equally
- **Function:** Specialized for rapid defense against bacterial infections, particularly acute pyogenic (pus-forming) bacterial infections, through phagocytosis and microbial killing.
- **Lifespan:** Neutrophils are relatively short-lived cells. Traditionally, their circulating half-life is estimated at approximately 6–8 hours, and they may survive for about 1–2 days in tissues. They are generally eliminated through apoptosis followed by phagocytosis by macrophages.

indicates the age of leukocyte (maturity stage).



we differentiate them based on morphology ⇐ hard to be seen → (fine granules)



* They can enter the CT and stays for some hours and then die by apoptosis
* Number of lobes indicates its maturity stage.
* in the bone marrow ⇒ 1 lobe
  → circulating through blood for a several hours ⇒ 3 lobes
  → in the connective tissue ⇒ 4 lobes
  → at the end of its life before its apoptosis.

Prof. Dr. Heba Kalbouneh

Specific granules (secondary)

Smaller, more numerous, formed later in development.

Lysozyme not Lysozome

(destroys bacterial cell walls)

Lactoferrin

essential for bacterial proliferation

(sequesters iron and inhibits bacterial growth → bacteriostatic)

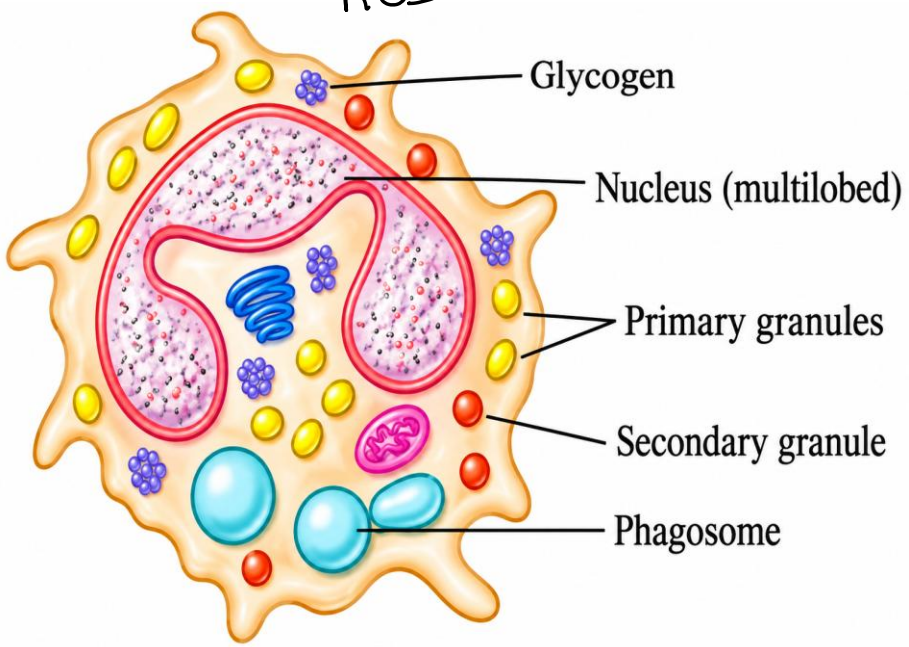
Collagenase

(degrades collagen in the ECM)

NADPH oxidase

(produces superoxide anions (O_2^-))

ROS



Azurophilic granules (primary)

Larger, formed early in neutrophil development.

Myeloperoxidase

(generates hypochlorous acid (HOCl) from hydrogen peroxide (H_2O_2) and chloride ions (Cl^-) → a powerful antimicrobial substance)

Acid hydrolase

(digests microbial components and cellular debris following phagocytosis)

Defensins

(disrupts microbial membranes)

Protease (eg. Elastase)

(degrades microbial proteins, degrades ECM proteins, including elastin)

Different names for neutrophils:

Polymorphs
Polymorphonuclear leukocytes (PMNs)
Pus cells
Microphages not Macrophages.
Cells of acute inflammation

Prof. Dr. Heba Kalbouneh

Oxygen-dependent killing:

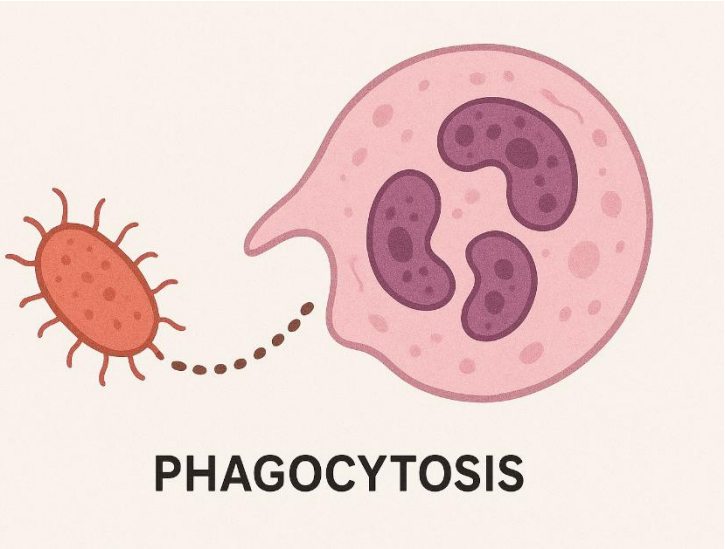
The neutrophil undergoes a 'respiratory burst'—activating NADPH oxidase to produce reactive oxygen species. Hydrogen peroxide is formed, and with the help of myeloperoxidase, it generates hypochlorous acid.

This is extremely toxic to microbes.

oxygen gas $O_2 \xrightarrow{\text{NADPH oxidase}} O_2^{\cdot-}$ Superoxide

$O_2 \rightarrow O_2^- \rightarrow H_2O_2$ Hydrogen Peroxide

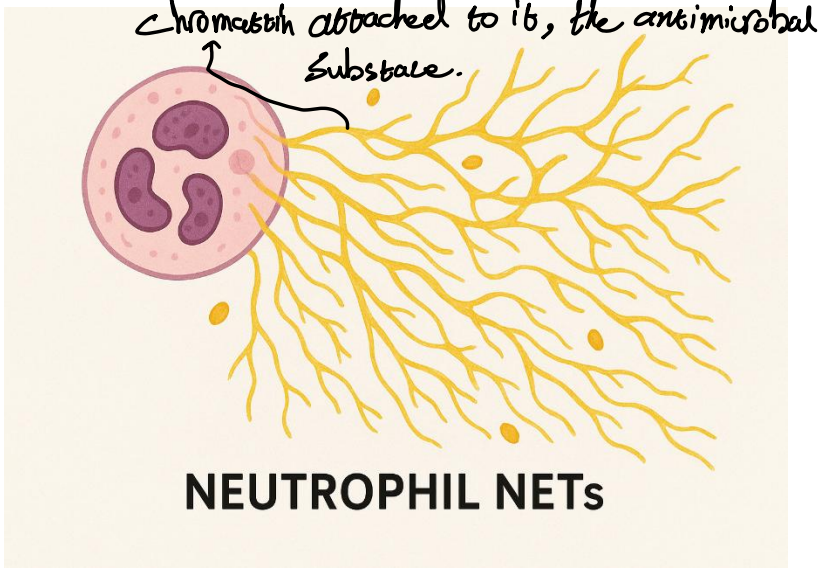
$H_2O_2 + Cl^- \rightarrow$ hypochlorous acid (HOCl)



Prof. Dr. Heba Kalbouneh

Oxygen-independent killing:

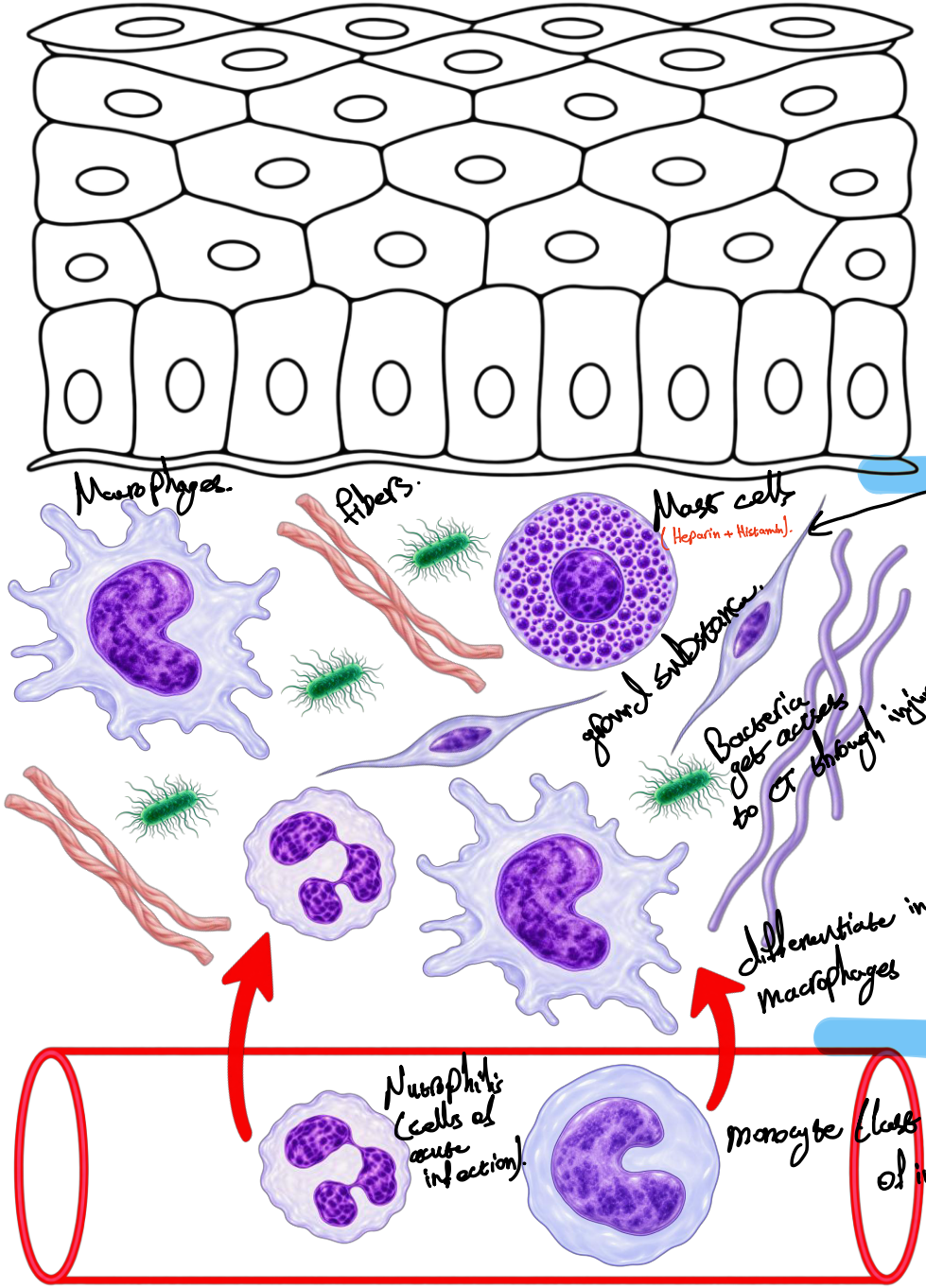
Neutrophil granules fuse with the phagosome and release antimicrobial substances that kill and degrade engulfed microorganisms without requiring reactive oxygen species.



high number of microbes

the **Neutrophil Extracellular Trap**, or **NET**. When overwhelmed, a neutrophil can undergo NETosis—a unique cell death where it releases its DNA coated with antimicrobial proteins.

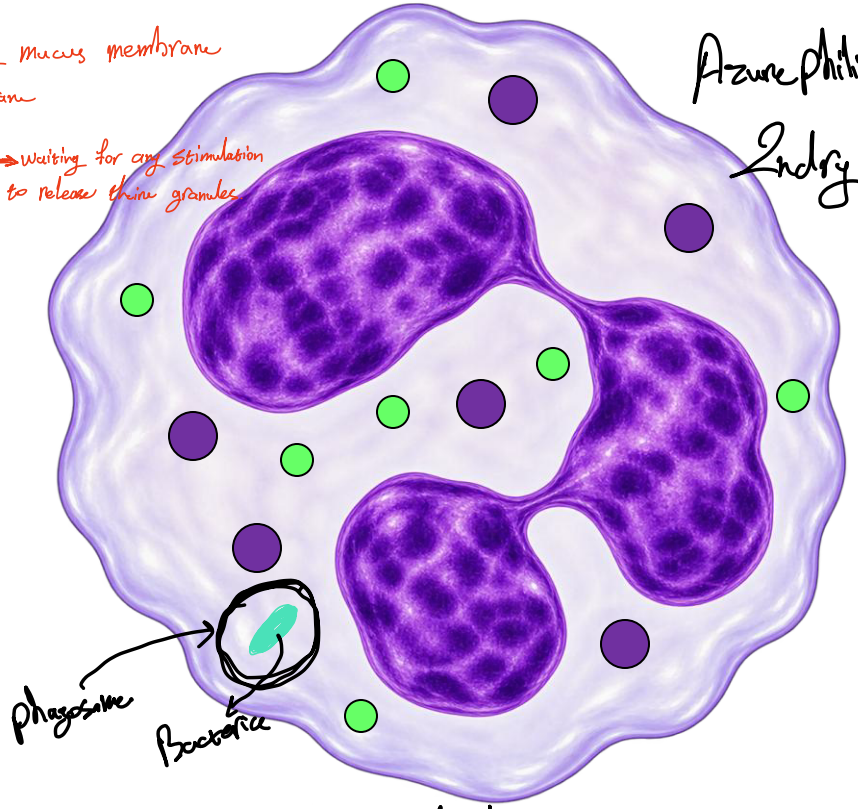
This sticky web traps and kills microbes outside the cell, preventing them from spreading.



Mast cells ⇒ Scattered along mucus membrane + Cutaneous membrane

⇒ Called alarm cells → waiting for any stimulation to release their granules

there is more types of microphages.



* it can engulf the microbe into intracellular phagosome.

* it can release its granules components in cases of ↑ number of microbes.

Prof. Dr. Heba Kalbouneh

Scenario: Acute Inflammation in Connective Tissue

1. Break in the epithelium

Bacteria gain access to the underlying connective tissue, which contains collagen fibers, elastic fibers, and reticular fibers embedded in the ground substance. This tissue is highly vascularized and contains blood capillaries.

2. Bacterial proliferation

The bacteria begin to multiply and release toxins, which damage the host cells.

3. Release of inflammatory mediators

The damaged host cells secrete inflammatory mediators. In addition, bacterial products stimulate immune cells, particularly macrophages and mast cells.

4. Mast cell degranulation

Mast cells undergo exocytosis (degranulation), releasing histamine and heparin. Histamine causes vasodilation and increases vascular permeability.

5. Increased blood flow and vascular permeability

Vasodilation increases blood flow to the infected area, while increased vascular permeability allows fluid and plasma proteins to move from the blood into the interstitial tissue. This facilitates the recruitment of white blood cells to the site of infection.

6. Macrophage activation

Macrophages interact with bacteria and their products, then secrete cytokines and other chemotactic factors that attract white blood cells to the infection site.

7. Neutrophil recruitment

Neutrophils are the first major white blood cells recruited to the site during acute inflammation. Chemotactic factors guide them toward the infection. thats why its called cells of acute infection.

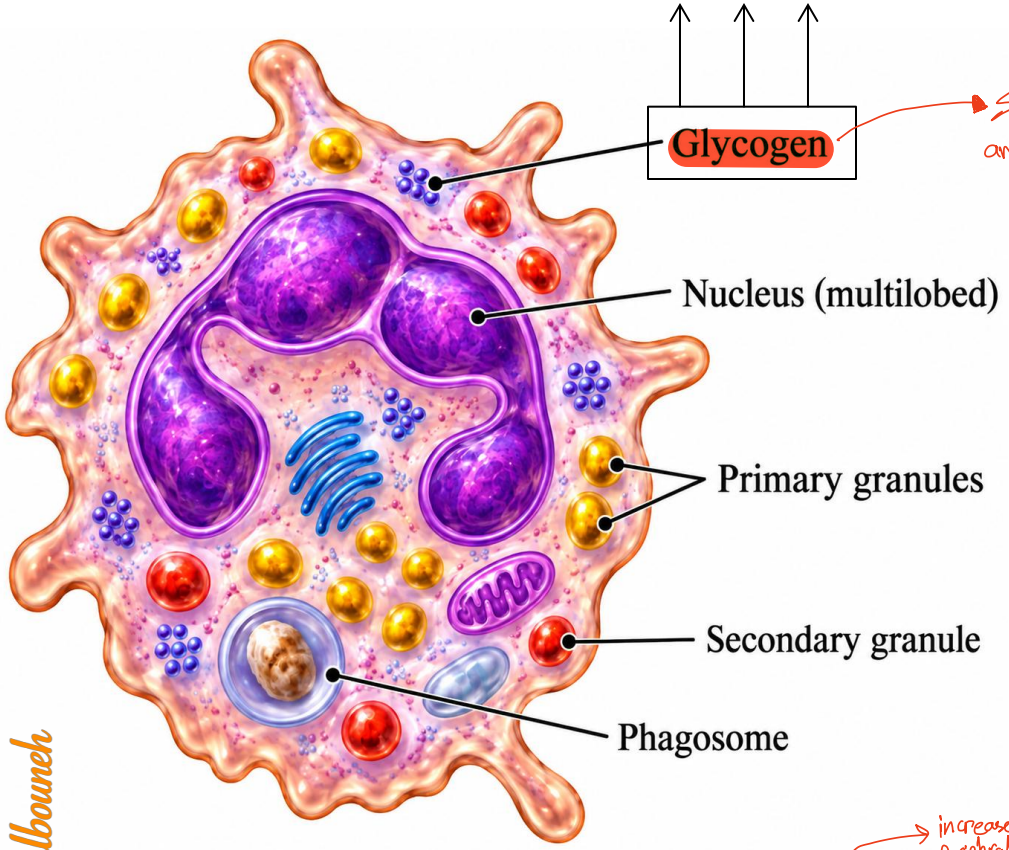
8. Endothelial activation and neutrophil migration

Inflammatory mediators activate the endothelial cells lining the blood vessels, making them more adhesive to neutrophils. The neutrophils adhere to the endothelium, migrate through the vessel wall by **diapedesis (transmigration)**, and move toward the infection site by **chemotaxis**.

The ability of neutrophils to survive in an anaerobic environment is highly advantageous, because they can kill bacteria and help clean up debris in poorly oxygenated regions, for example, damaged or necrotic tissue lacking normal microvasculature.

from plasma

Dead neutrophils, bacteria, lysed ECM, and tissue-fluid form a viscous, usually yellow collection of fluid called **pus**.



Few organelles



Pyogenic: Refers to infections, usually bacterial, that produce pus.

Pyrogenic: Refers to substances or processes that produce fever.

increase in Neutrophils in peripheral Blood.

Neutrophilia ↑ neutrophils (Acute infections).

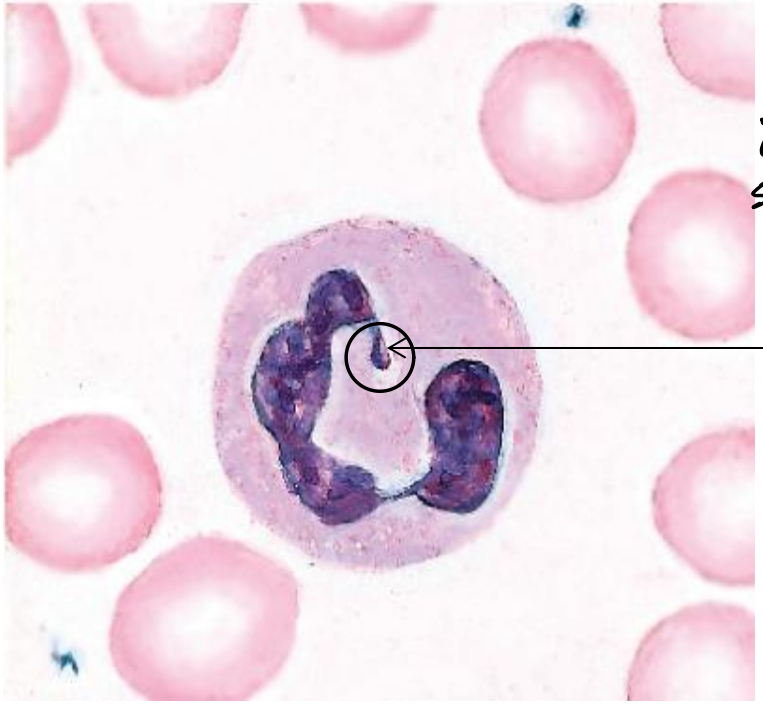
Neutropenia ↓ neutrophils (problem in bone marrow).

Pyo- → pus

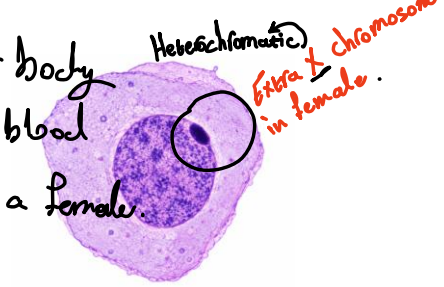
Pyro- → fever/heat (fever inducing)

Prof. Dr. Heba Kalbouneh

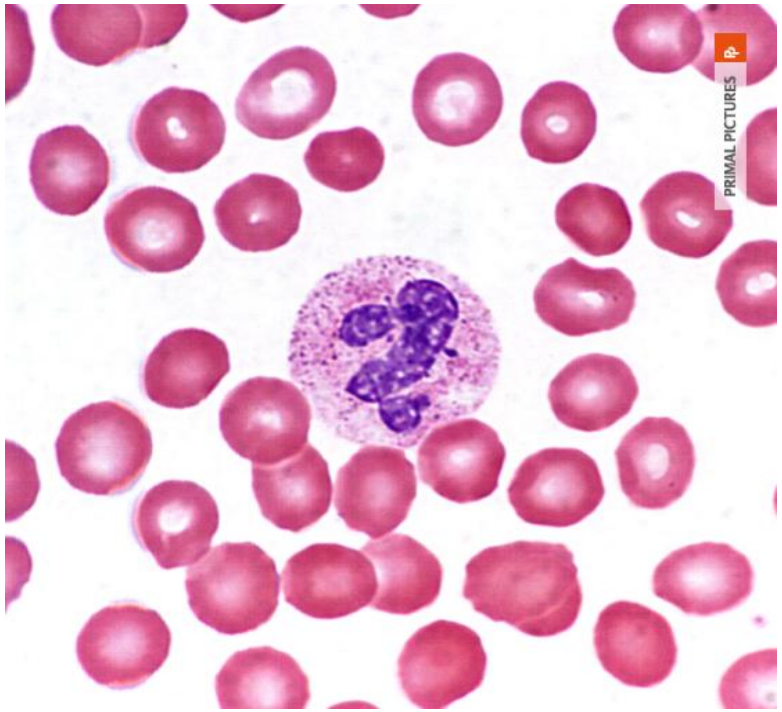
Prof. Dr.
Heba Kalbouneh



if you see a barr body you know it is a blood smear taken from a female.



In females, the inactive X chromosome (**Barr body**) may appear as a drumstick-like appendage on one of the lobes of the nucleus *(about 3% of neutrophils in peripheral blood)*

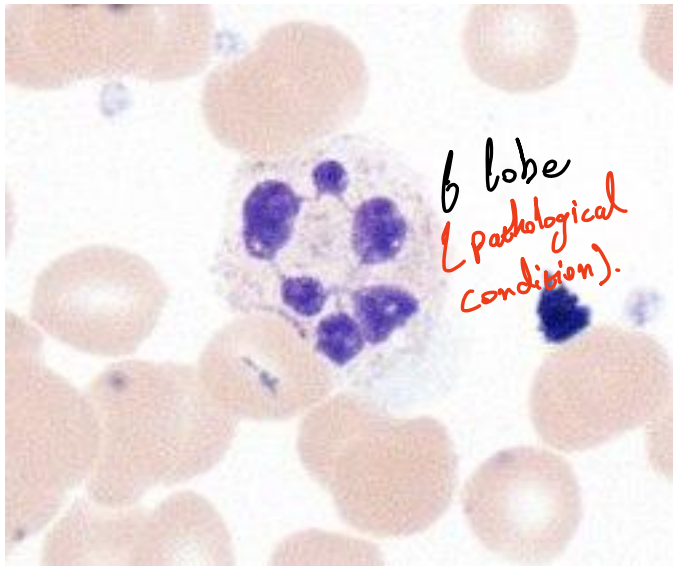


Neutrophils are the first WBCs that leave the blood in large numbers to reach the site of inflammation

Cells of acute inflammation

Why???

1- The most abundant
2-The most motile (migrate rapidly)
3- Highly responsiveness to chemotactic factors

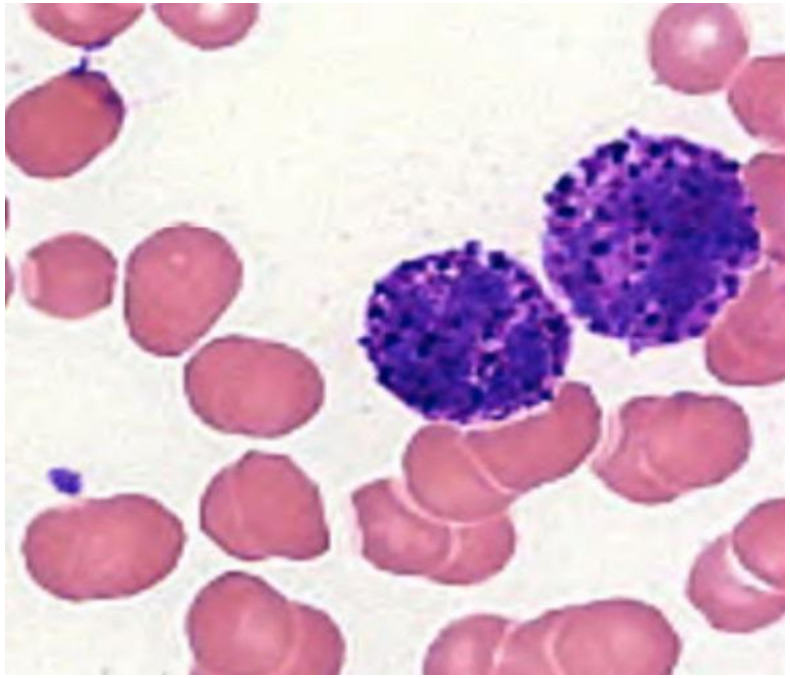


As neutrophils mature, their nuclei become increasingly segmented. A mature neutrophil typically has 3–5 nuclear lobes. Hypersegmentation (usually ≥6 lobes) is abnormal and and may be seen in certain pathological conditions.

* The last cells to leaves the infection site.

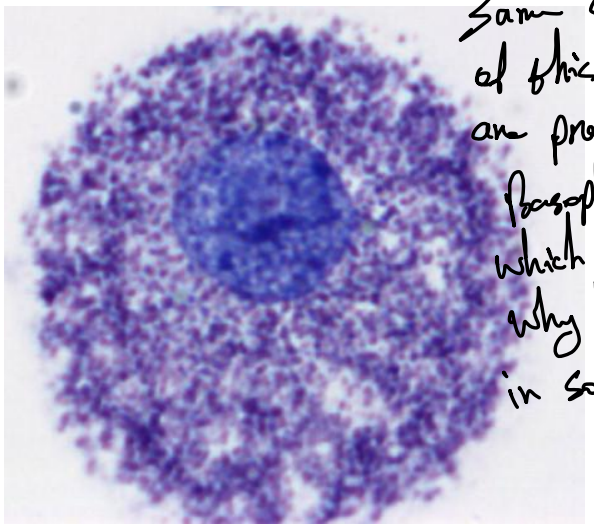
Basophils (Unique features :- nucleus is difficult to be seen)

- Rarest circulating leukocytes, accounting for approximately 0–1% of white blood cells; therefore, they may be difficult to find in routine blood smears.
- Usually have a bilobed or S-shaped nucleus, which is frequently obscured by large cytoplasmic granules.
- Contain numerous large, coarse, basophilic granules that stain dark blue to purple with basic dyes.
- Granules contain histamine, heparin, and other inflammatory mediators. Basophils can also release eosinophil-attracting chemokines and cytokines.
- Express high-affinity receptors for IgE and participate in immediate hypersensitivity reactions and immune responses to parasitic infections.



Remember: Mast cells are large immune cells found mainly in connective tissues, particularly near blood vessels and beneath epithelial surfaces.

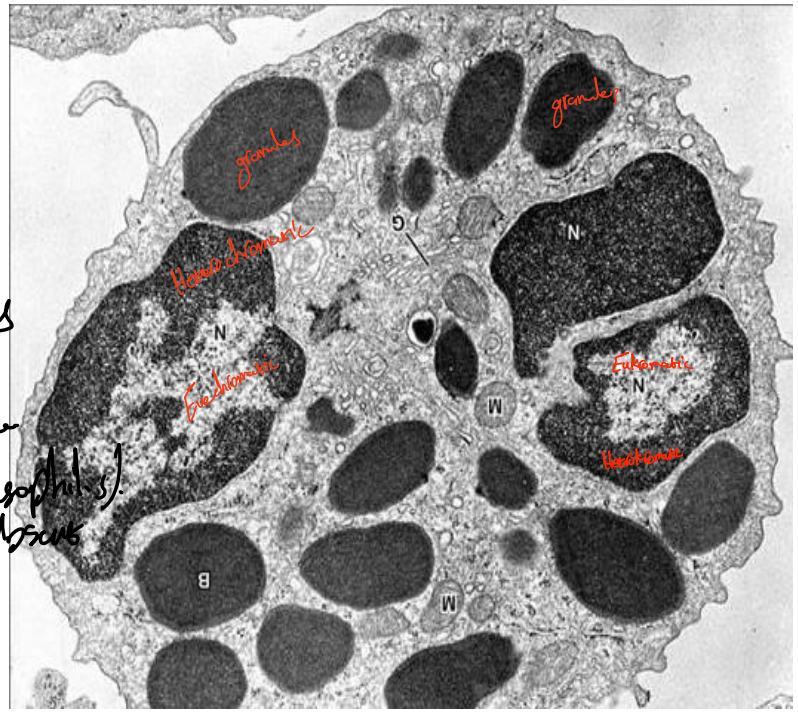
Note: Although functionally similar to basophils, mast cells are distinct tissue-resident cells.



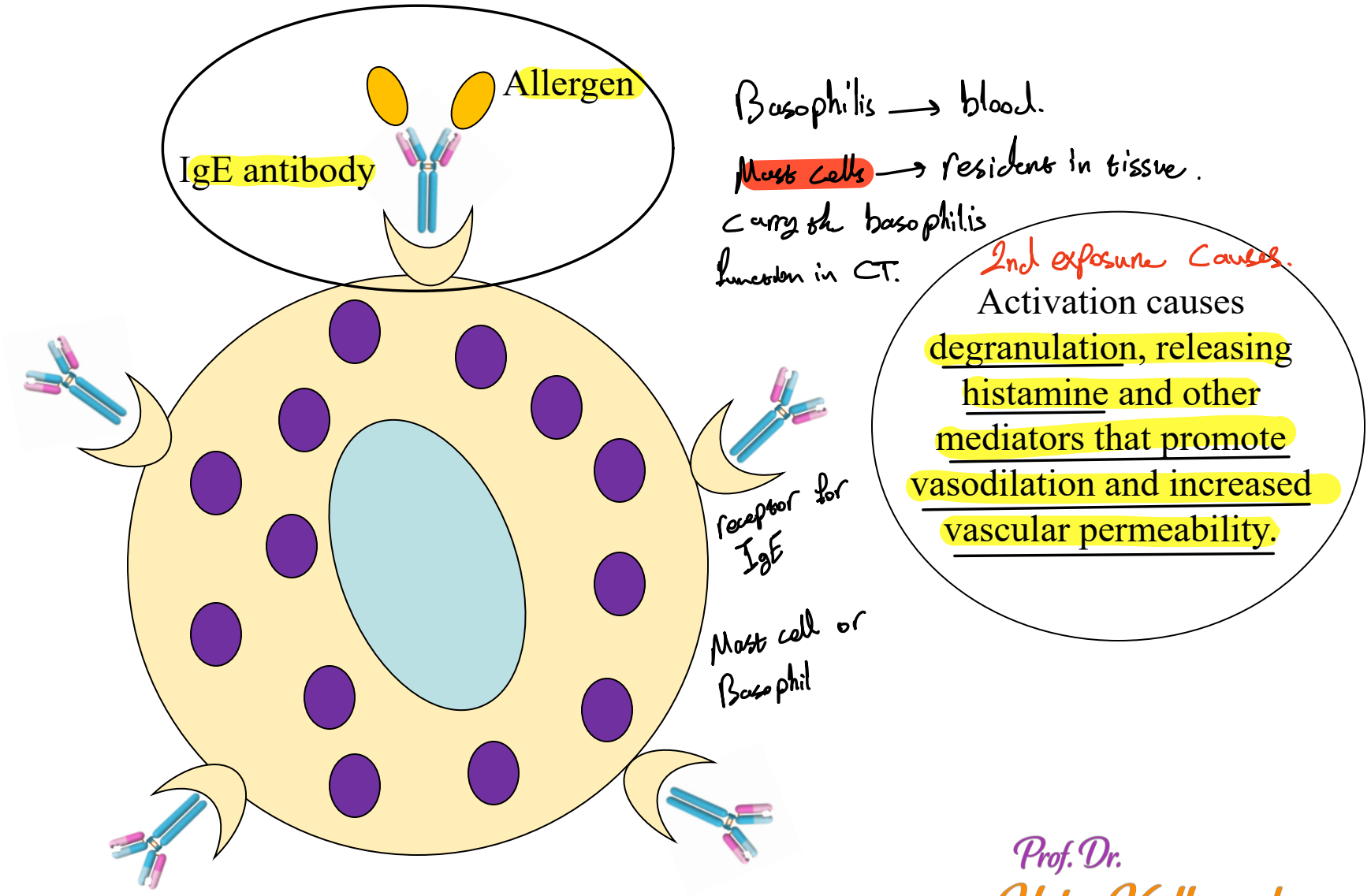
Mast cell

Same contents of this granules are present in Basophil's granules which explains why it is absence in some ppl (Basophils) also

Prof. Dr. Heba Kalbouh



Both basophils and mast cells have surface receptors for immunoglobulin E (IgE), and secrete their granular components in response to certain antigens and allergens.



Basophilis → blood.

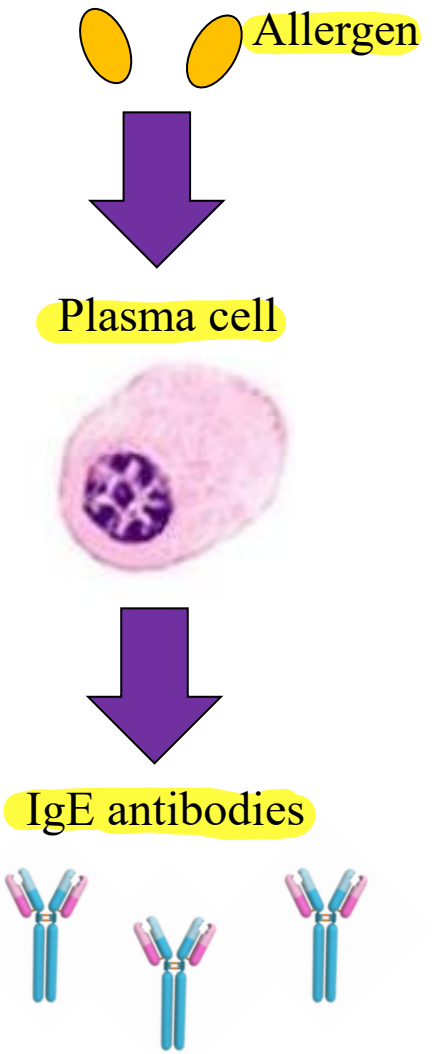
Mast cells → residents in tissue.

carry the basophilis

function in CT.

2nd exposure causes.

Activation causes degranulation, releasing histamine and other mediators that promote vasodilation and increased vascular permeability.



Prof. Dr.
Heba Kalbouneh



Contact dermatitis.

Basophils may constitute up to 15% of infiltrating inflammatory cells in allergic dermatitis and skin allograft rejection.



Exposure may be by ingestion, inhalation, injection, or direct contact

First exposure

In some individuals substances such as certain pollen proteins or specific proteins in food are allergenic, that is, elicit production of specific IgE antibodies, which then bind to receptors on mast cells and immigrating basophils.

Second exposure

Upon subsequent exposure, the allergen combines with the receptor-bound IgE molecules, triggering rapid degranulation of the cytoplasmic granules.

Release of the inflammatory mediators in this manner can result in bronchial asthma, cutaneous hives, rhinitis, conjunctivitis, or gastrointestinal allergic reactions



Immediate or type 1 hypersensitivity

Think of it as a degranulation of all basophils.

In some individuals a second exposure to a strong allergen, such as that delivered in a bee sting, may produce an intense, adverse systemic response. Basophils and mast cells may rapidly degranulate, producing vasodilation in many organs, a sudden drop in blood pressure, and other effects comprising a potentially lethal condition called **Anaphylaxis or anaphylactic shock**.

Prof. Dr. Heba Kalbouneh