Blood Cells

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Blood

- blood has same origin of C.T → mesenchyme.

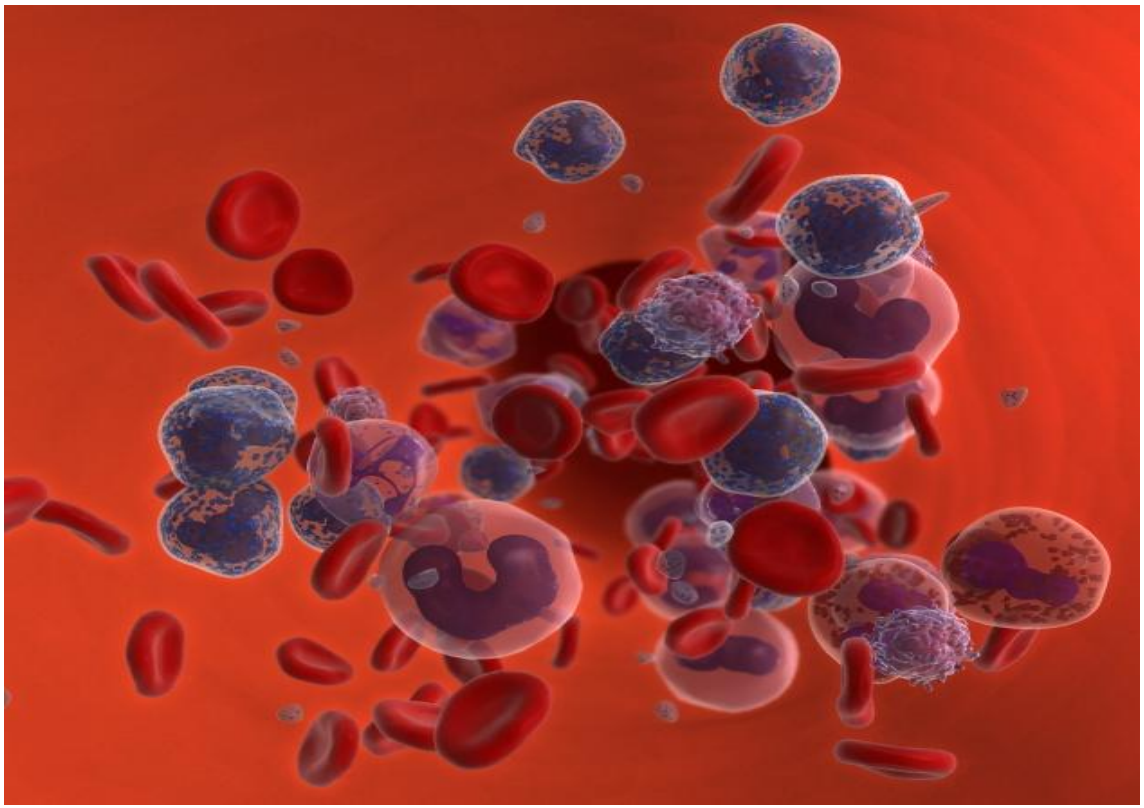
- Specialized form of **connective tissue**
  ↳ cells + ECM (fibers + ground substance)
- Components:
  - Blood cells (several types)
  - Plasma (extracellular matrix)

Fibroblast
ECM لل هصنّعة

المكان الي بتسبح فيه الاشياء (السائل او الماء)
[Water + macromolecules] = Viscus.
(بودرة الجلي)

[proteoglycan] [glycoprotein] Adhesive molecules: connect cells with component of ECM (fiber...)

we consider blood as a special type of connective tissue:
1) same composition as connective T < cell, ECM
called plasma



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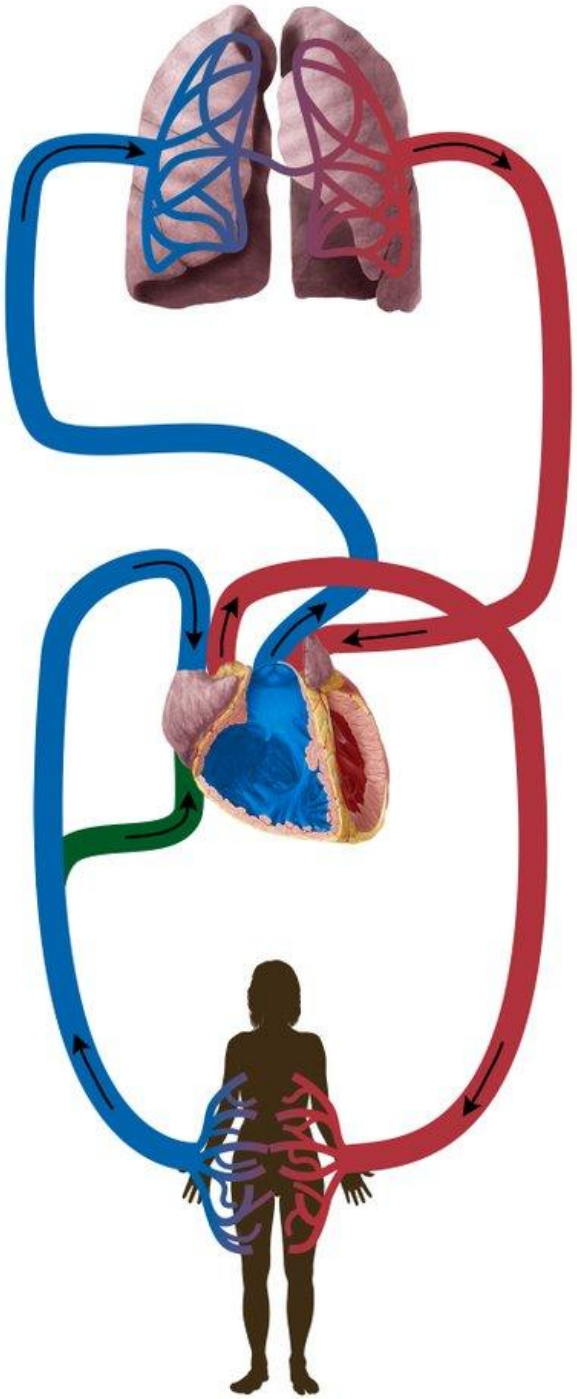

Functions of Blood

- Transports nutrients and respiratory gases
- Transports waste products to organs and tissues where they can be recycled or released
- Transports hormones
- Transports immune cells throughout the body to reach the site of infection.
- Helps regulate body temperature - vasodilation → ↑ heat loss. -
- Maintains of acid-base and osmotic balance

PH

✓ pH of 7.4 (7.35-7.45)
✓ Color is dependent on amount of Oxygen
More oxygen = brighter the red
Less oxygen = duller the red

Blood is propelled mainly by rhythmic contractions of the heart

About **5-6 Liters** of blood in an average adult moves unidirectionally within the closed circulatory system

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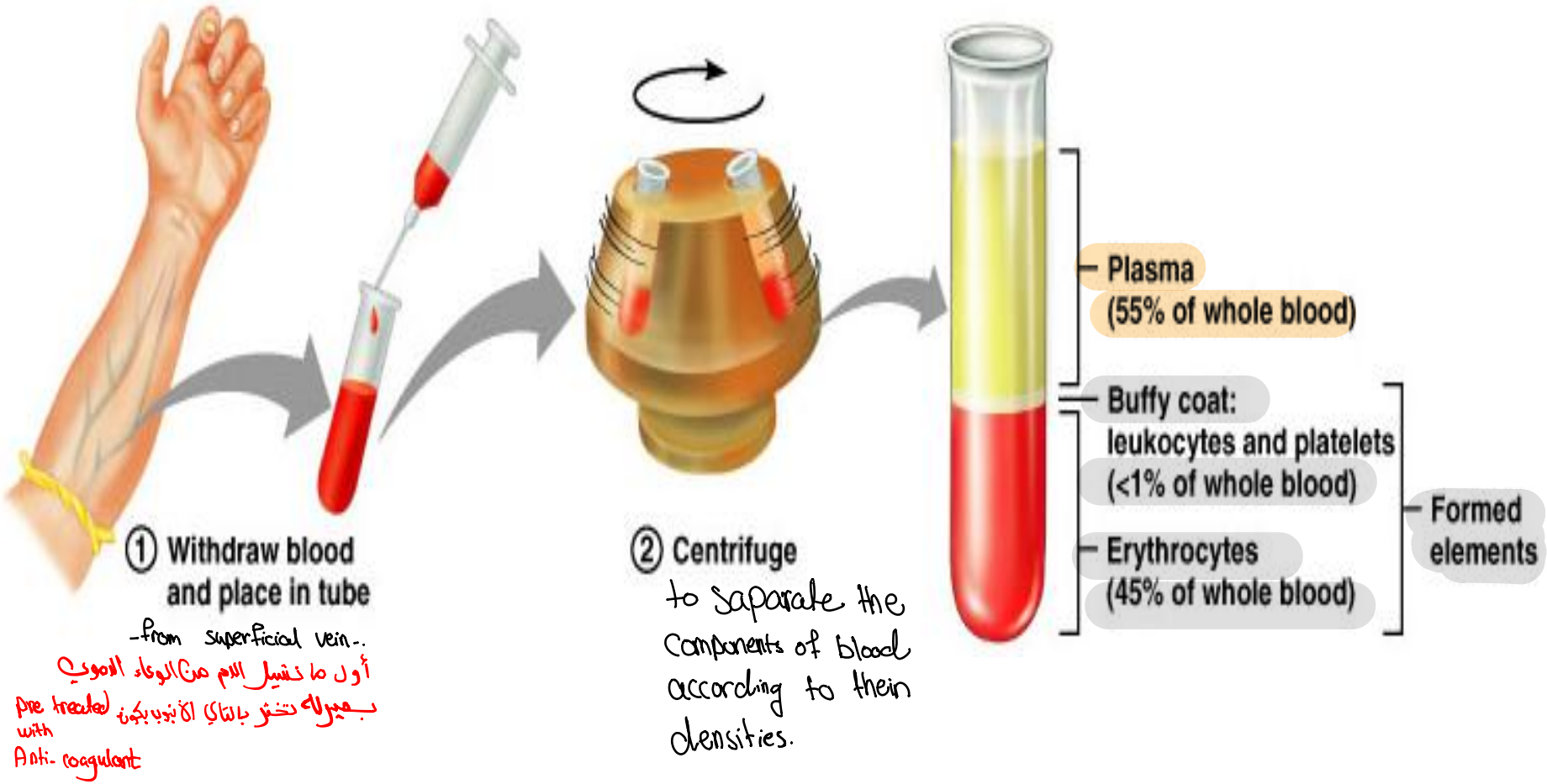


Collected blood in which clotting is prevented by the addition of anticoagulants (eg, heparin , citrate or EDTA) can be separated by centrifugation into layers that reflect its heterogeneity

Physical Characteristics

HEMATOCRIT: Ratio of the volume of RBCs to the volume of whole blood

Example: a hematocrit value of 40% means that there are 40 ml of RBCs in 100 ml of whole blood

Normal hematocrit:

Males=40-53%

Females= 36-48% lower (concentration)

100 mL of blood → 45 ml cells → 44 ml RBC, 1 ml WBC + platelets.
→ 55 ml plasma.

Fluid

- **Living 45%**

  Cells (**formed elements**) since cells are formed inside bone marrow by Hemato poiesis ou-si

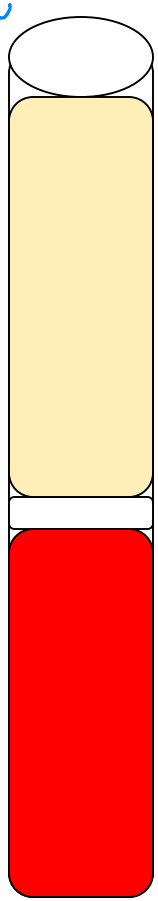
  - RBC **Erythrocytes** (carry oxygen)
  - WBC **Leukocytes** (immune)
  - Platelets **Thrombocytes** (clotting)

  BUFFY COAT

- **Non living (Matrix) 55%**

  Plasma (pale yellow fluid)

  - 90% water
  - 10 % (electrolytes, nutrients, proteins (albumin), waste (CO_2, ammonia, urea), gases, hormones)



Top layer= plasma

Middle layer= buffy coat (بفوة)

→ appear whitish in color

the condensation of these cells look white so we call cells WBC.

Bottom layer=RBCs

(Packed Cell Volume)

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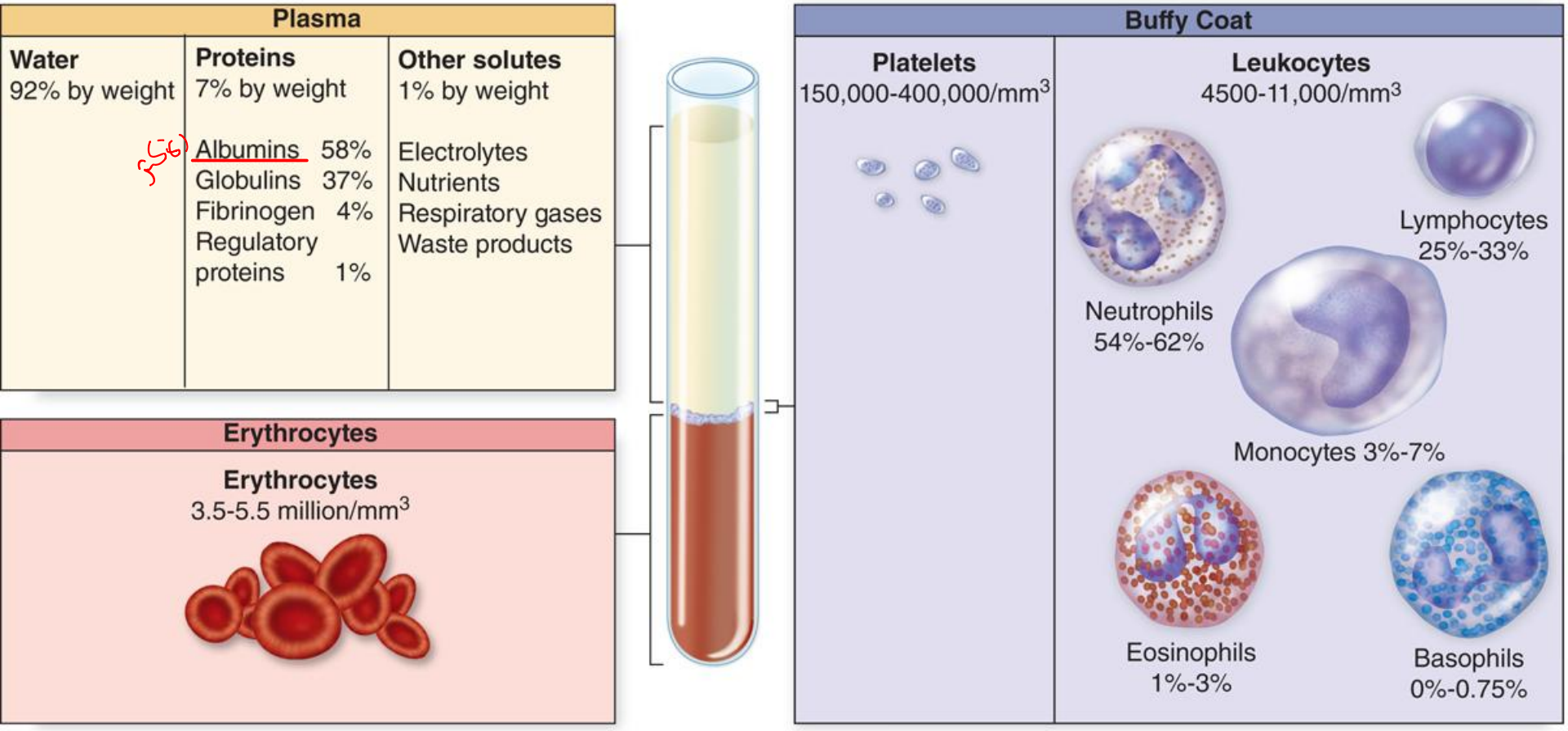
*In each 1 microliter of blood → 5 millions of RBC.
→ thousands of WBC.

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



Serum = everything in plasma, minus the clotting factors

Albumin:

- ✓ The most abundant plasma protein
- ✓Is made in the liver
- ✓Helps maintain the osmotic pressure in capillaries
- ✓Transports steroid hormones and fatty acids

Plasma Proteins

stay inside blood vessels necessary to keep blood inside vessels.

-Contraction of heart and smooth muscle in Bv Produce ⟶ Hydrostatic Pressure

-Plasma protein produce ⟶ Osmotic Pressure

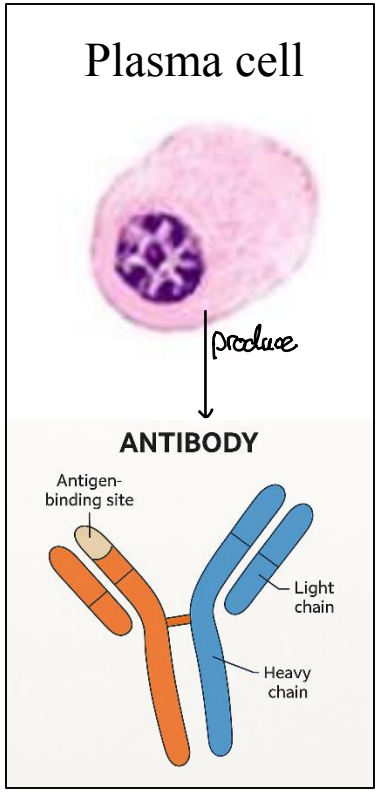
Fibrinogen:

- ✓ The largest plasma protein
- ✓ Is made in the liver
- ✓Important for clot formation

Fresh plasma

The importance of proteins inside the plasma is to prevent fluid loss and to create osmotic pressure (to keep the blood inside the blood vessels)

Plasma cell



Globulins (α, β and or γ globulins):

α and β globulins

- ✓Are made mainly by liver
- ✓Transport fat soluble vitamins, lipids and iron

γ-globulins (Immunoglobulins (antibodies):

secreted by plasma cells

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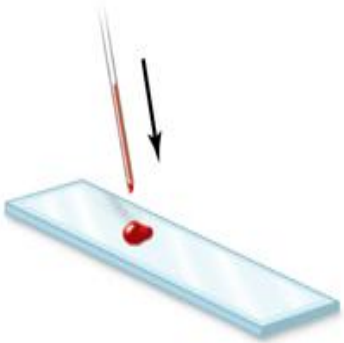
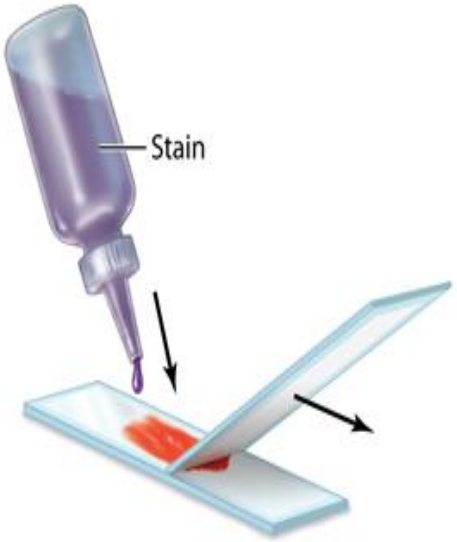
Preparing a blood smear

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

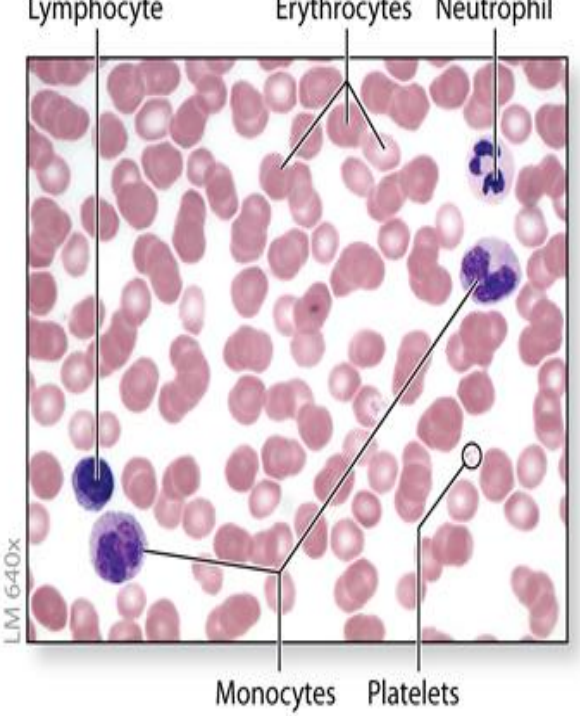


(2) Place a drop of blood on a slide.



(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

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

The Staining of Blood Cells

Blood film/ smear: a drop of blood is spread on a glass slide and left dry in air

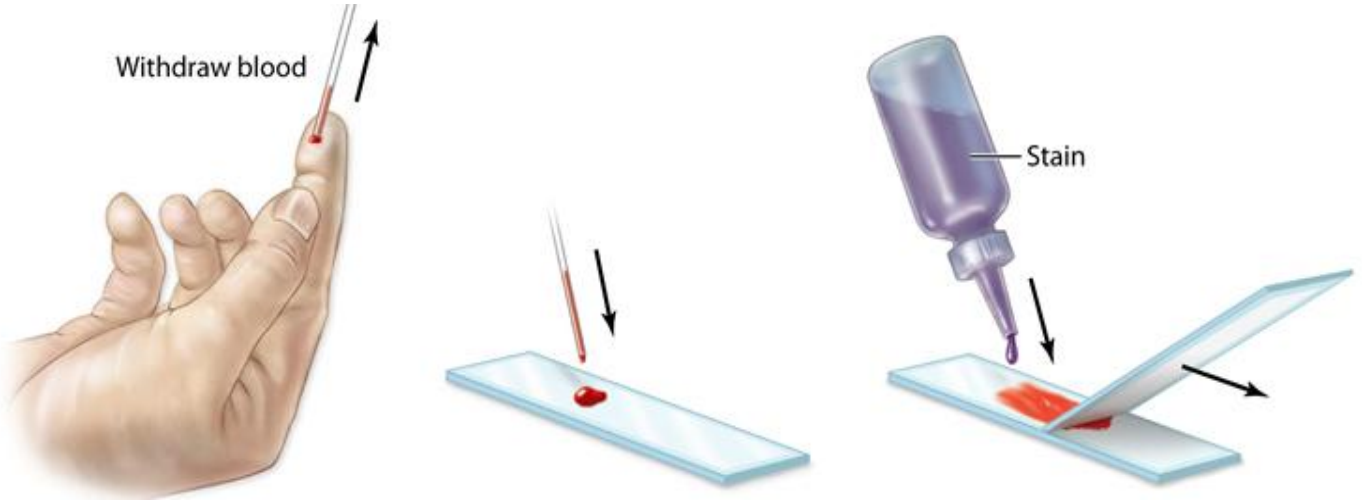
Staining: with neutral stain e.g **Leishman's stain**

Leishman's stain: formed of a mixture of: fixation and stain in the same step!

- **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!!



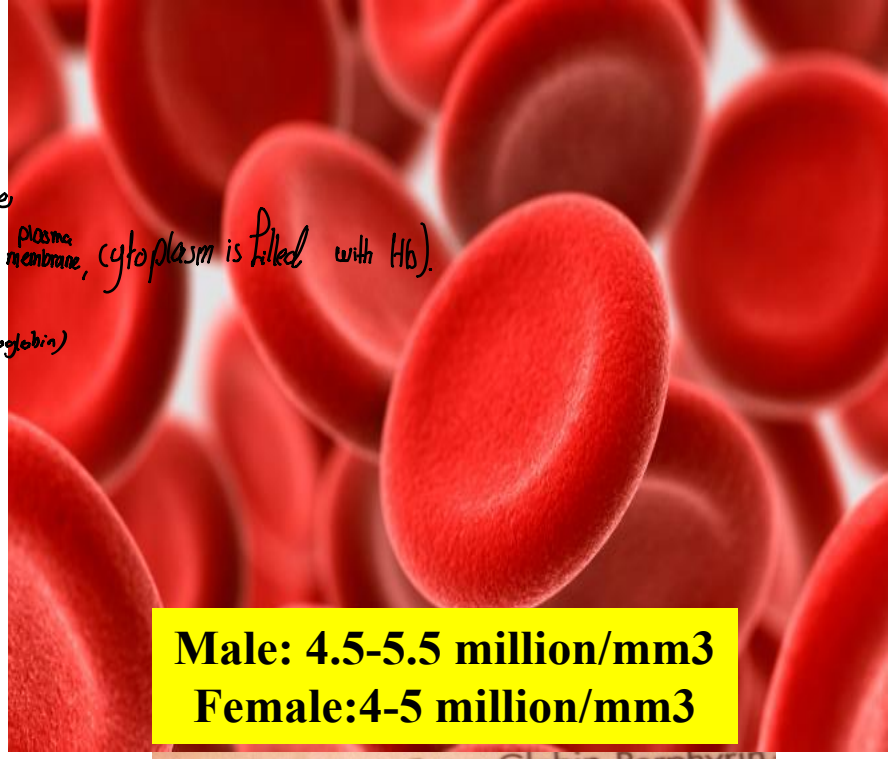
Blood film/smear

Erythrocytes (RBCs)

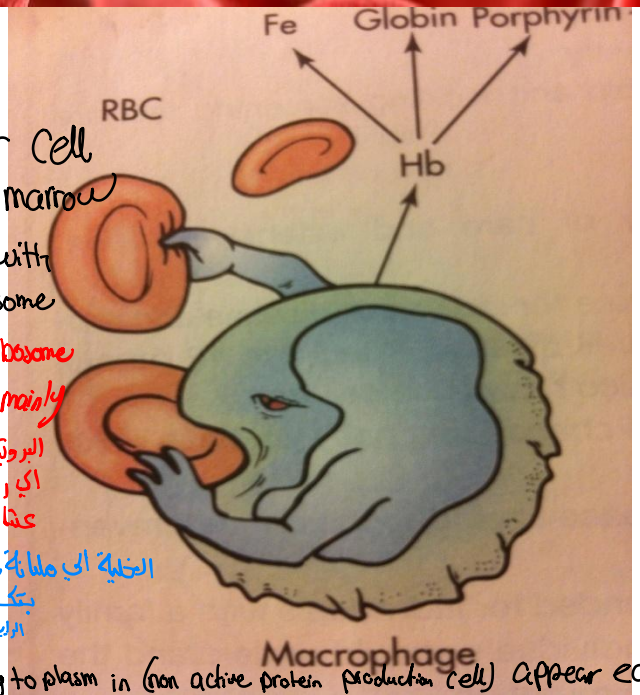
- Small, biconcave discs
- Transport oxygen and CO_2, cytoplasm is full of hemoglobin molecules
- Have no nuclei or organelles
- Pick up O_2 at lung capillaries and release it at body tissue capillaries

During their maturation process, the erythrocytes extrude their nuclei, and the mature RBCs enter the bloodstream, without their nuclei

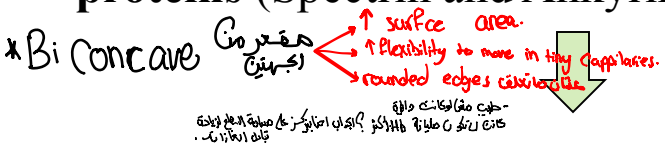
- **Fate:** Survive for ~100-120 days in the circulation. Worn out RBCs are removed by macrophages of the spleen, bone marrow and liver.



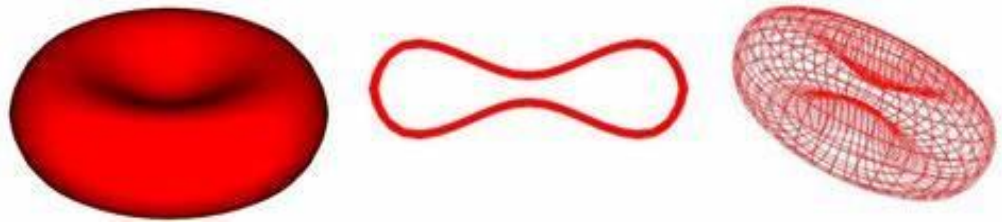
Male: 4.5-5.5 million/mm3
Female:4-5 million/mm3



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

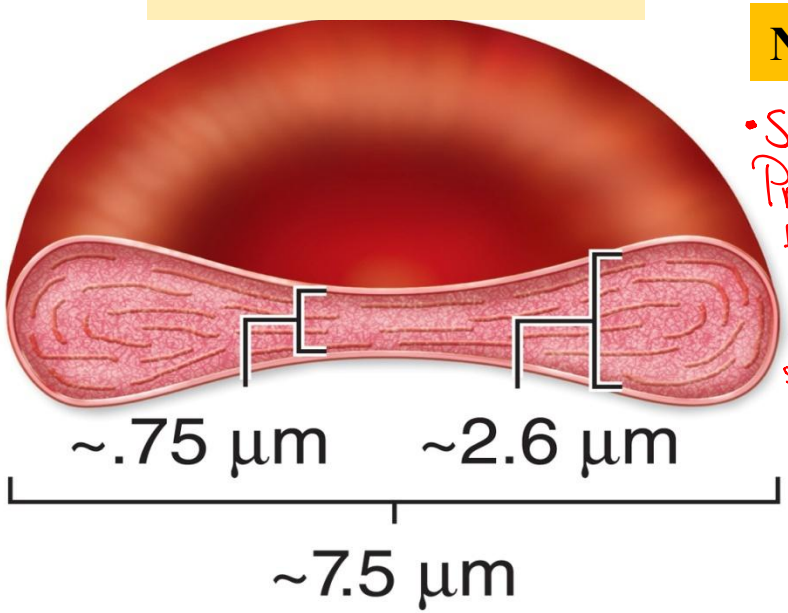


This submembranous meshwork stabilizes the membrane, maintains the cell shape, and provides the cell elasticity required for passage through capillaries



Top view

Sectional view



Normocytic RBCs

- Submembranous cytoskeleton Protein keep the shape and anchore membrane with substances of RBC.

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

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

The biconcave shape along with the fluidity of the plasma membrane (50% proteins) permits erythrocytes to bend and adapt to the small diameters and irregular turns of capillaries

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

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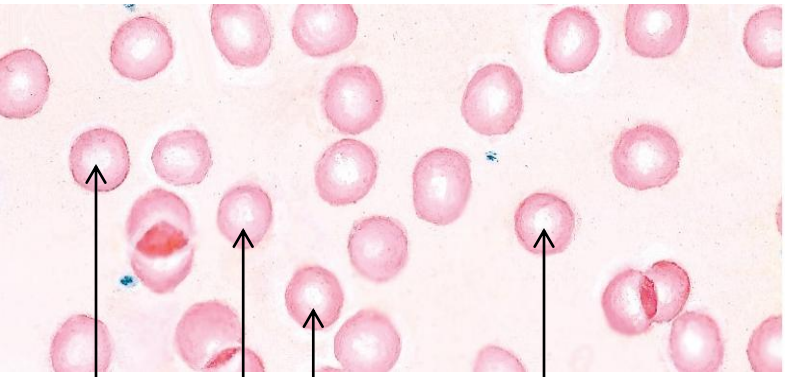
Acidophilic → because of Hb



بسبب شكلها كمية Hb بالمركز قليلة (زي بعبة الدونتس)

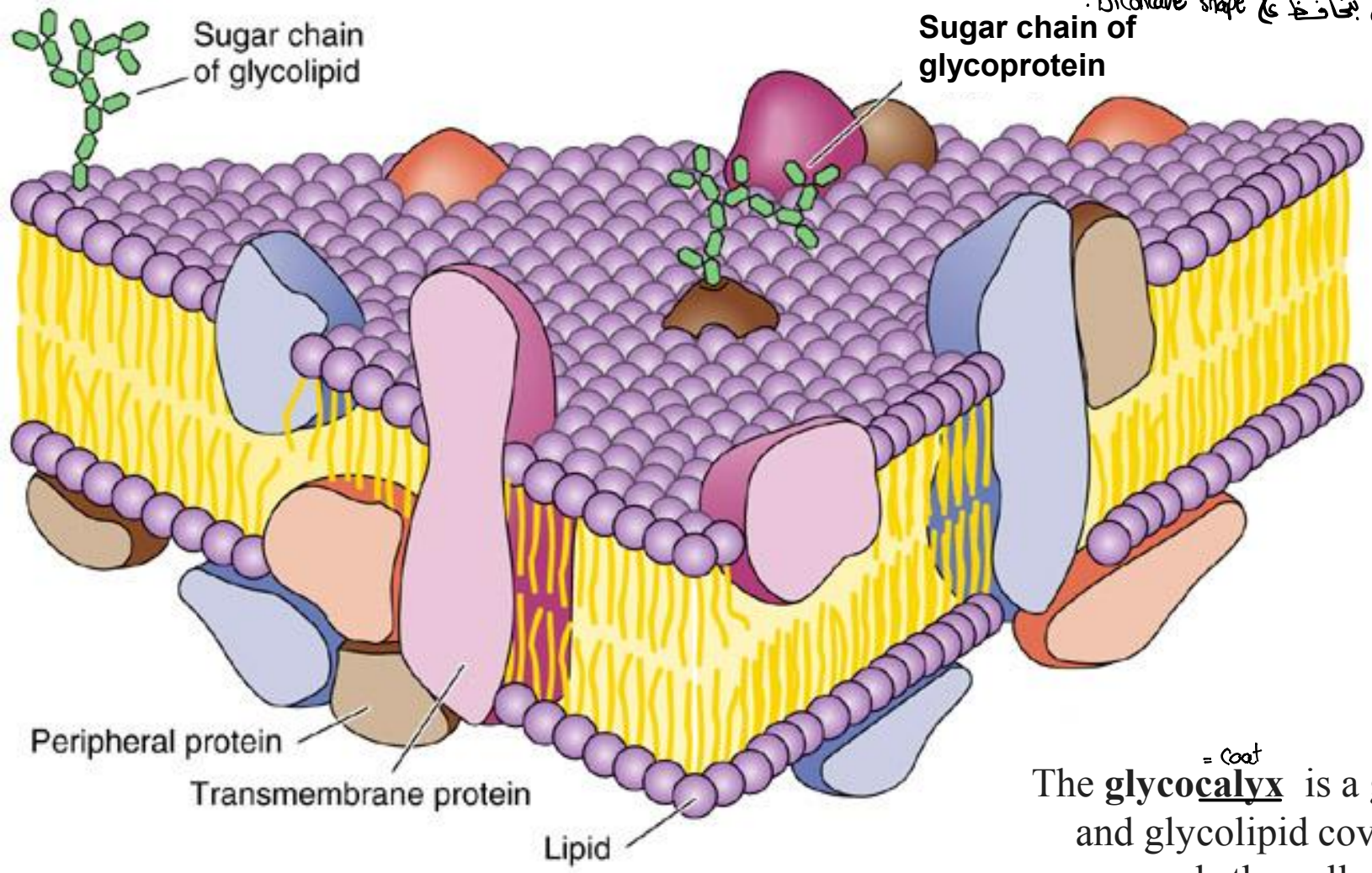
The pale staining of the central region is a result of its biconcave disc shape ⟹ **Normochromic RBCs**

Normocytic = كريات دم حمراء بحجم طبيعي.
Normochromic = كريات دم حمراء بلون طبيعي (هيموغلوبين طبيعي).

Cell Membrane ---------> Contribute in flexability..

Since it's composed of
- 10% sugar / 40% lipids / 50% proteins
- biconcave shape

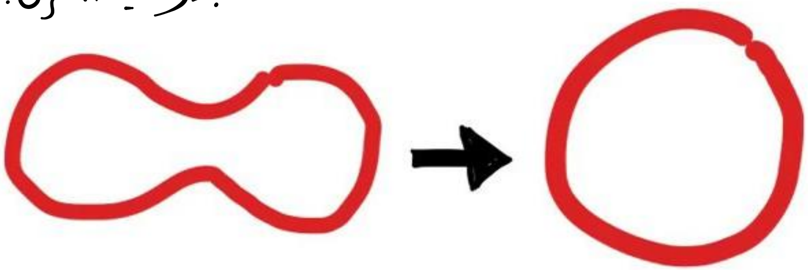
- Sub membranous Cyto skeleton Protein

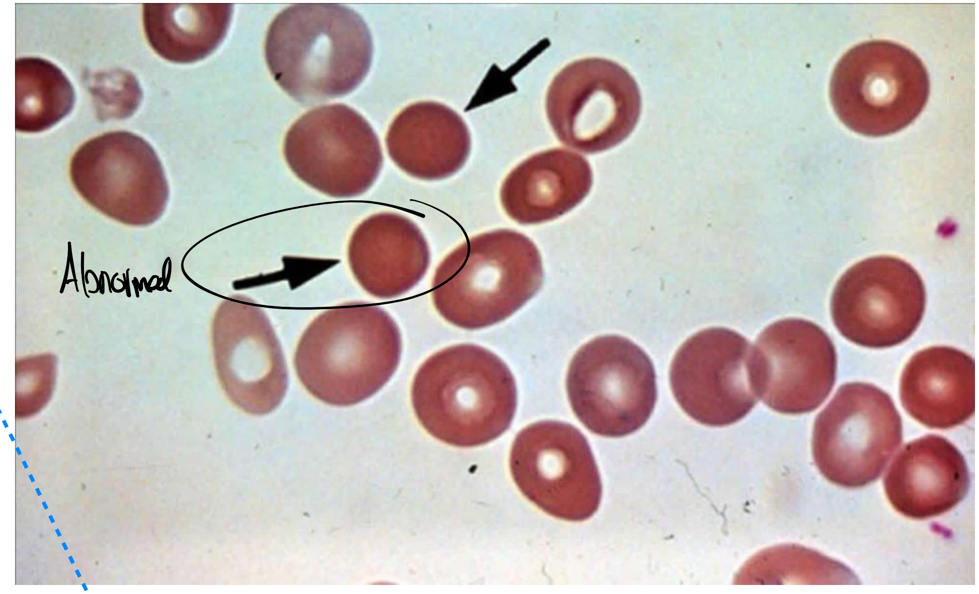


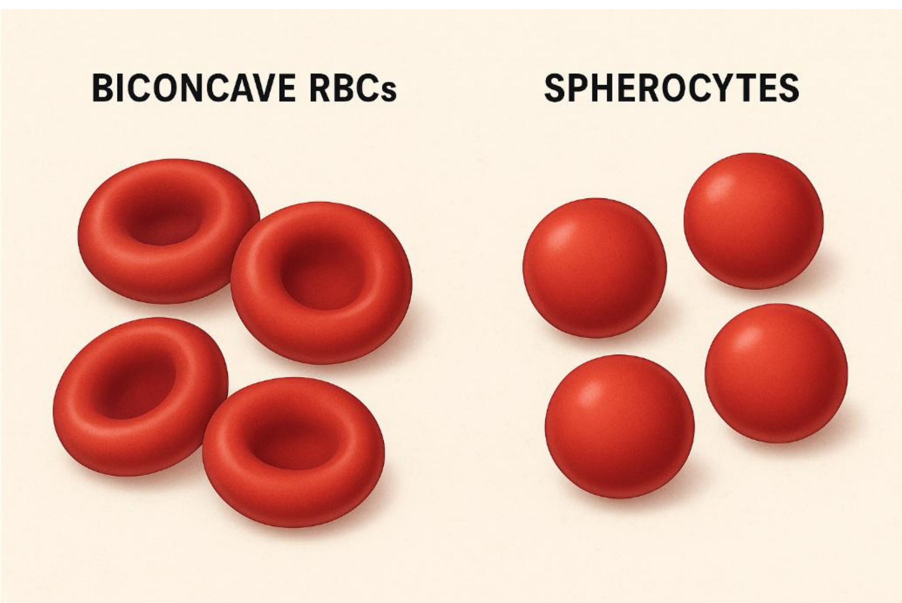
The **glycocalyx** (= coat) is a glycoprotein and glycolipid covering that surrounds the cell membranes

Hereditary Spherocytosis

بيمزع الغشاء مع الحركة بالشعيرات لانه مافي اشي يثبت الشكل فبتصير زي الكرة.







Caused by mutations in genes relating to membrane proteins (mostly Spectrin and Ankyrin) that allow for the erythrocytes to maintain their biconcave shape

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LM:

Blood film stained with Leishman:

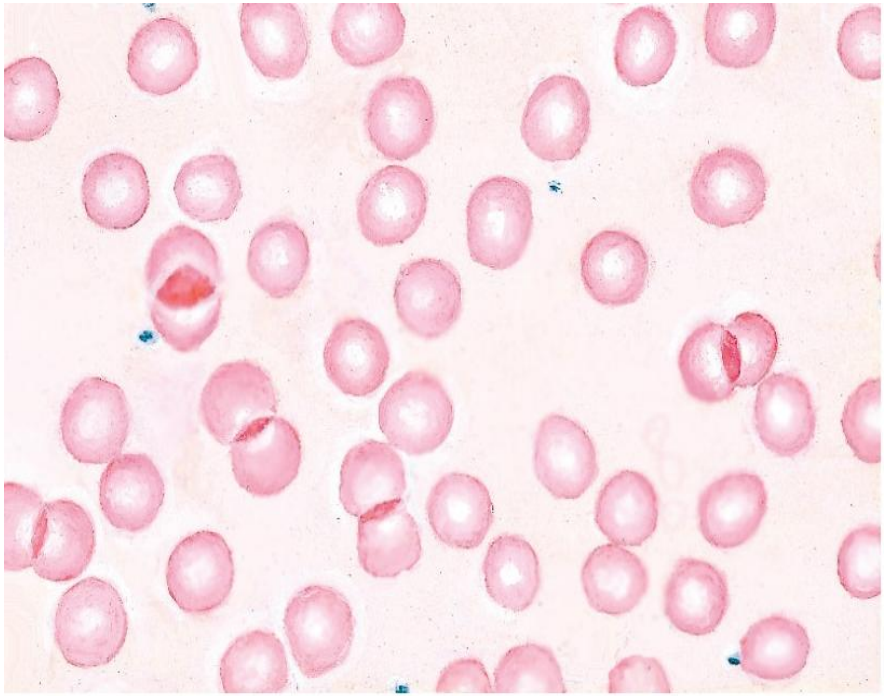
Rounded

Non nucleated

Acidophilic (with pale central area)

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

LM



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EM:

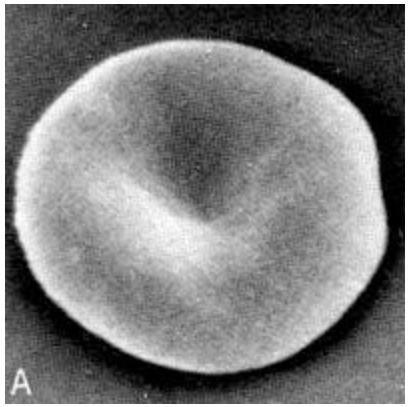
✓Have no nucleus or organelles

✓Filled with hemoglobin

Electron dense and homogenous

TEM

SEM



Rouleaux appearance occurs to some extent in all films

مع التحفيز بلا فيم لزقوا بس عادي normal
إذا كانوا كل الكريات ملزقين بوضعها في منكلة

-normally → RBC don't stick to each other.
بعض التفاعلات الطبيعية (من البروتينات) بعض تتفاعل بين الكريات

إذا زاد تركيز البلازما بروتين بعمل neutralizing for (-) charge → cells stick!! يعني عمود من coins

Rouleaux formation means that red blood cells (RBCs) adhere to each other, forming stacks that look like a pile of coins 💰.
It's called "Rouleaux" (a French word meaning "rolls" or "stacks").

🔷 ***Where it occurs:***
To some extent in all blood films → يعني ممكن تلاحظها بشكل بسيط في أي شريحة دم.
But it becomes more prominent:
In slow circulation (where blood flow is sluggish)
In conditions with high plasma proteins (like fibrinogen or globulins) → e.g. chronic inflammation, infections, multiple myeloma.

🔷 ***Mechanism:***
RBCs have a biconcave shape, which creates surface tension that allows them to stick together loosely.
This adhesion is reversible — they can separate again when blood flow speeds up.

Rouleaux formation:

- ✓RBCs may adhere to one another loosely in stacks called Rouleaux (pile of coins)
- ✓In slow (not in normal) circulation

Due to surface tension caused by their biconcave surface (reversible)

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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

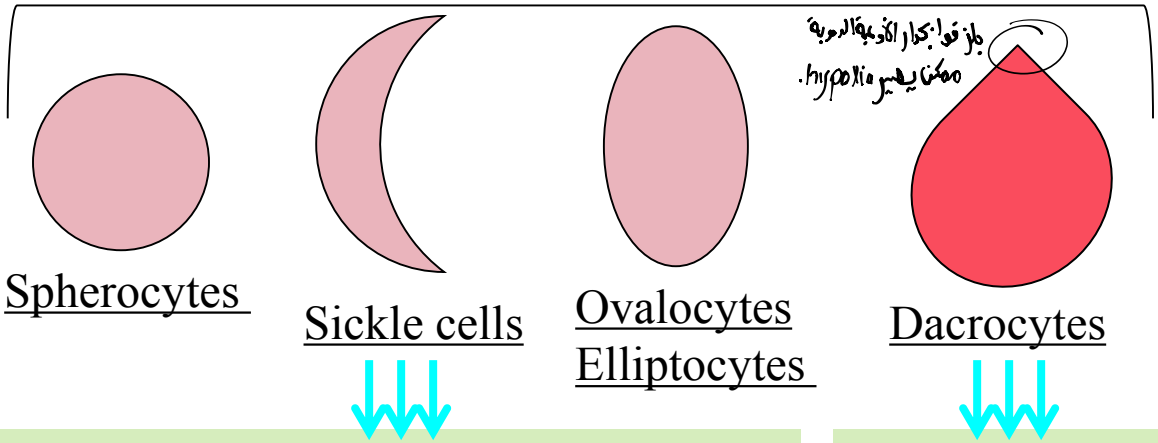
Abnormal sizes:
Microcytes (<6um)
Macrocytes (>9um)
Anisocytosis (different sizes)

Abnormal shapes:
Due to changes either in the cell membrane or Hb content

Abnormal staining:
Hypochromia: Denotes a decrease in the intensity of staining
Indicates a decreased amount of hemoglobin
Frequently accompanies microcytosis

Hypochromic microcytic anemia

Poikilocytes any abnormal cell
(Poikilocytosis)



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

Teardrop shaped cells

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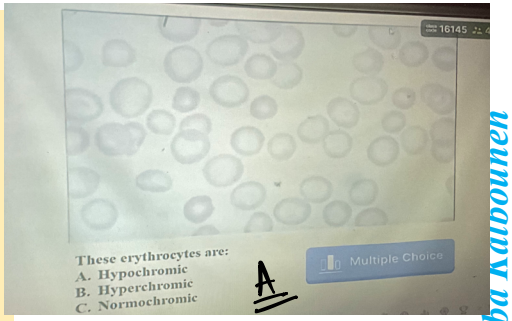
Sickle cell anaemia results from abnormal hemoglobin

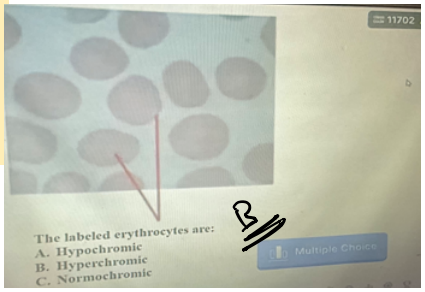
Based on Hemoglobin Content (color /chromasia):

Normochromic: RBCs have a normal hemoglobin concentration → normal color, normal central pallor (about one-third of the cell).

Hypochromic: RBCs have less hemoglobin than normal → appear paler with an abnormally large central pallor (Common in iron deficiency anemia).

Hyperchromic: RBCs have more hemoglobin concentration than normal → cells look denser and darker with absent central pallor (seen in spherocytosis).





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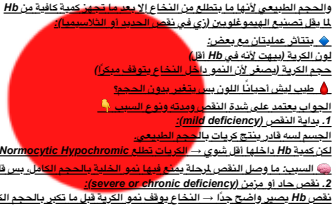
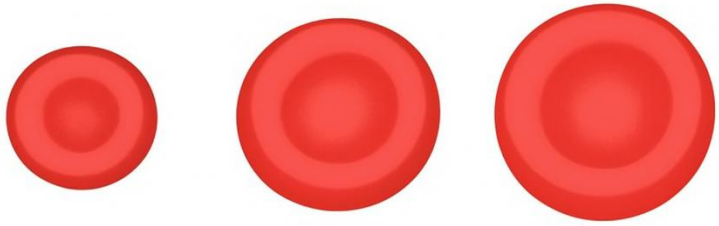


الهيموغلوبين هو اللي بيعطي:
اللون الأحمر الغامق لل RBC
والحجم الطبيعي لأنها ما بتطلع من النخاع إلا بعد ما تجهز كمية كافية من Hb
لما بقل تصنيع الهيموغلوبين لازي في نقص الحديد او الثالاسيميا):
بتتأثر عمليتان مع بعض:
لون الكرية (بيهت لإنه في Hb اقل)
حجم الكرية (بصغر لأن النمو داخل النخاع بتوقف مبكرا)
طب ليش أحيانًا اللون بس متغير بدون الحجم؟
الجواب يعتمد على شدة النقص وسببه ونوع السبب :
1. بداية النقص (mild deficiency):
الجسم لسه قادر ينتج كريات بالحجم الطبيعي.
لكن كمية Hb داخلها اقل شوي → الكريات تطلع Normocytic Hypochromic (لون فاتح، حجم طبيعي).
السبب: ما وصل النقص لمرحلة يمنع فيها نمو الخلية بالحجم الكامل، بس قلل تعبئة Hb.
2. نقص حاد او مزمن (severe or chronic deficiency):
نقص Hb يصير واضح جدًا → النخاع يوقف نمو الكرية قبل ما تكبر بالحجم الكامل.
النتيجة: Microcytic Hypochromic (صغيرة وفاتحة).

[Hypochromia] less amount of Hb. [Normochromia] 1/3 pale area. [Hyperchromia] more amount of Hb.

MICROCYTIC NORMOCYTIC MACROCYTIC



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).

ملخص سريع بالجدول:

Mechanism (Why)	Main Diseases	Type	Feature
Hb synthesis ↓	Iron deficiency, Thalassemia	Hypochromic	↓ Color
Surface area → appears darker ↓	Hereditary spherocytosis	Hyperchromic	↑ Color
Hb → delayed growth, smaller ↓ cells	Iron deficiency, Thalassemia	Microcytic	↓ Size
Impaired DNA synthesis → large cells	B12/Folate deficiency	Macrocytic	↑ Size

Based on Cell Size (cytometry):

Normocytic: RBCs are of normal size, about 7–8 µm in diameter.

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).