MED437
KING SAUD UNIVERSITY

تمت المراجعة
غيداء آل مصمم
&
عبدالرحمن الحيسوني

PHYSIOLOGY

- Females & Males Slides
- Only Found in Males' slides
- Only Found in Females' slides
- Vary Important Notes
- Notes
- Extra Information

Blood physiology (1,2)
-female-

Erythropoiesis

Composition and Functions of the Blood

-male-

Objectives"female":

Blood physiology (1)

-Describe Cellular and non-cellular components of blood.

-Recognize functions of blood.

-Define Erythropoiesis; leucopoiesis, thrombopoiesis.

-Recognize sites of RBC formation at different developmental age.

-Describe different stages of RBC differenation.

-Describe features of RBC maturation.

-Describe regulation of RBC production and erythropoietin hormone secretion in response to hypoxia.

-Recognize clinical conditions associated with high level of erythropoitein in the blood.

Objectives”male”: Erythropoiesis

–Define erythropoiesis, leucopoiesis, and thrombopoiesis

-List the sites (areas) of the body that produce red blood cells

-Describe the steps involved in erythropoiesis from differentiation of stem cell to progenitor cell to final RBC

-Outline the features of RBC maturation

-Summarize the synthesis of Hemoglobin

-Recognize hemoglobin structure and its functions

-Describe the life cycle of normal RBCs

Objectives"female":

Blood physiology (2)

- Describe essential elements needed for RBC formation.
- Describe the process of Vit B12 absorption and its malabsorption.
- Recognize haemaglobin structure and its functions.
- Discuss iron metabolism (absorption , storage , transport).
- Describe the fate of old RBC.
- Describe anemia and its causes.
- Recognize causes of polycythemia.

Objectives”male”:

Composition and Functions of the Blood

- List the functions of the blood
- Describe the physical characteristics of blood
- Discuss the composition of the blood
- Differentiate between the terms formed elements, Packed Cell Volume, plasma and serum
- Outline the functions of the plasma proteins
- Describe the shape of mature red blood cells and explain the advantages of this shape
- Explain what maintains the shape of the normal red blood cell and outline the pathogenesis of hereditary spherocytosis
- Summarize the functions of red blood cells
- Describe the different hematological indices and indicate their physiological significance

Physical Characteristics of Blood

volume	- Blood makes up 7-9% of body weight - Blood volume is 5 to 6 liters in adult males , 4 to 5 liters in adult females 45% is packed cells volume (PCV). 55% is plasma volume.
Viscosity (thickness and stickiness of blood)	- Blood is thicker (more viscous) than water and flows more slowly than water - Plasma at 37°C is about 1.8-times more viscous than water; therefore, the relative viscosity of plasma (compared to water) is about 1.8 - Whole blood viscosity (relative to water) = 4.5-5.5
PH	- Slightly alkaline: 7.4 - Ranges from 7.35 to 7.45
color	- Bright red = O_2 rich - Dull red = O_2 poor
Osmolarity	- Plasma osmolarity is about 300 mOsmol/L - Plasma osmolarity is equal to the osmolarity of Normal Saline = 0.9% NaCl Solution. Hence, Normal Saline is an Isotonic solution

Male slide

Physical Characteristics of Blood

Osmotic Pressure: is the pressure necessary to prevent net movement of water (in osmosis)

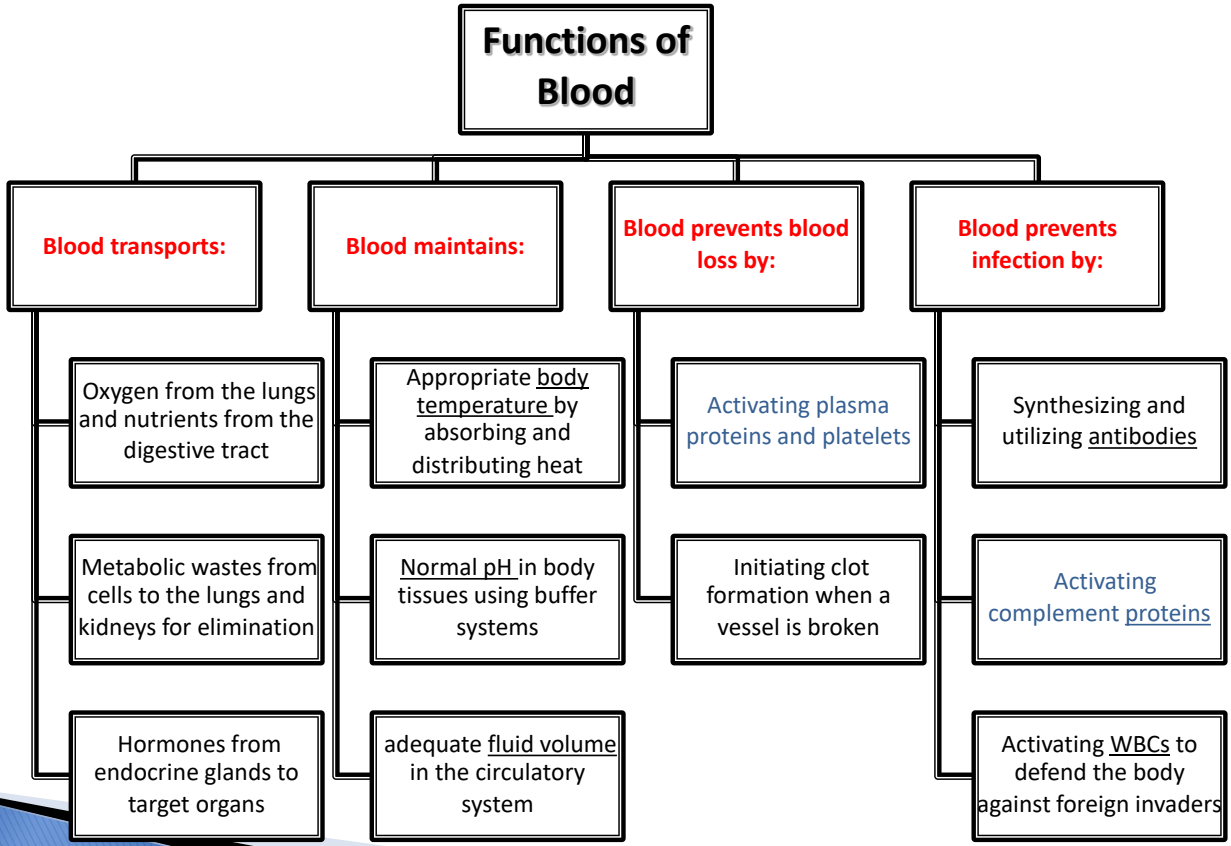
In other words, osmotic pressure is the pressure developed by solutes dissolved in water working across a selectively permeable membrane.

- **At normal plasma osmolarity of about 300 mOsmol/L,**
- **plasma osmotic pressure is about 5540 mmHg.**

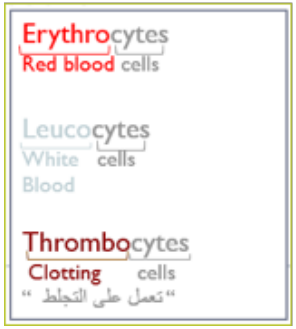
Plasma Osmotic Pressure :

Crystalloid osmotic pressure:	Colloid osmotic pressure:
is the pressure generated by all crystal substances, particularly electrolytes (mainly NaCl).	is the pressure generated by plasma proteins, particularly albumin.
This pressure modulates water distribution between inside and outside of cells	This pressure modulates water distribution between inside and outside of blood capillaries.
it is important in maintaining fluid balance across cell membranes.	it is important in fluid transfer across capillaries. It is normally about 25 mmHg, which represents about 0.5% of the total plasma osmotic pressure.

Male slide


Functions of Blood
Blood transports:
Blood maintains:
Blood prevents blood loss by:
Blood prevents infection by:
Oxygen from the lungs and nutrients from the digestive tract
Metabolic wastes from cells to the lungs and kidneys for elimination
Hormones from endocrine glands to target organs
Appropriate body temperature by absorbing and distributing heat
Normal pH in body tissues using buffer systems
adequate fluid volume in the circulatory system
Activating plasma proteins and platelets
Initiating clot formation when a vessel is broken
Synthesizing and utilizing antibodies
Activating complement proteins
Activating WBCs to defend the body against foreign invaders

Blood Composition



1. **Cellular components 45% :**

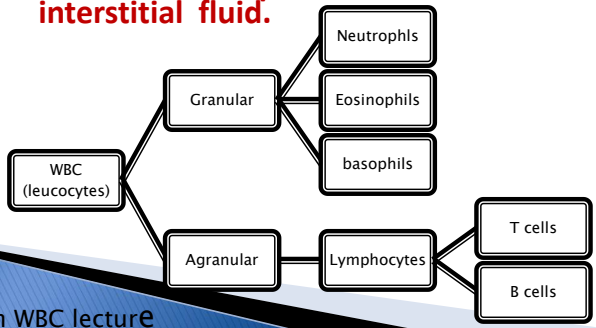
- **Red Blood Cells 99%** (Erythrocytes)
- **White Blood Cells < 1%** (Leucocytes)
- **Platelets** (Thrombocytes)

2. **Plasma makes up 55% of blood volume :**

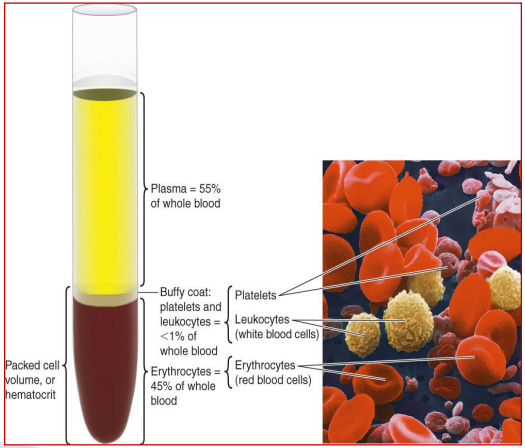
- **98% water + ions + plasma proteins e.g.**

(Albumin, globulin, Fibrinogen)

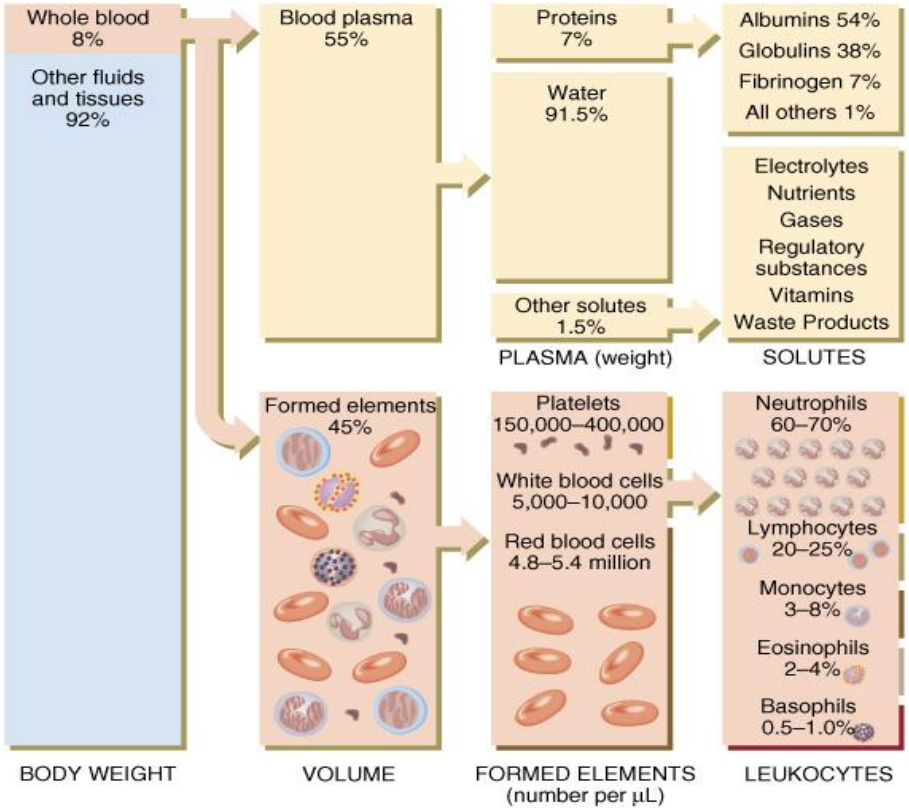
❖ **Same ionic composition as interstitial fluid.**



NOTE: **red blood cells** are in **millions**
- **Platelets** are **hundred thousands**
- **white blood cells** are in **thousands.**

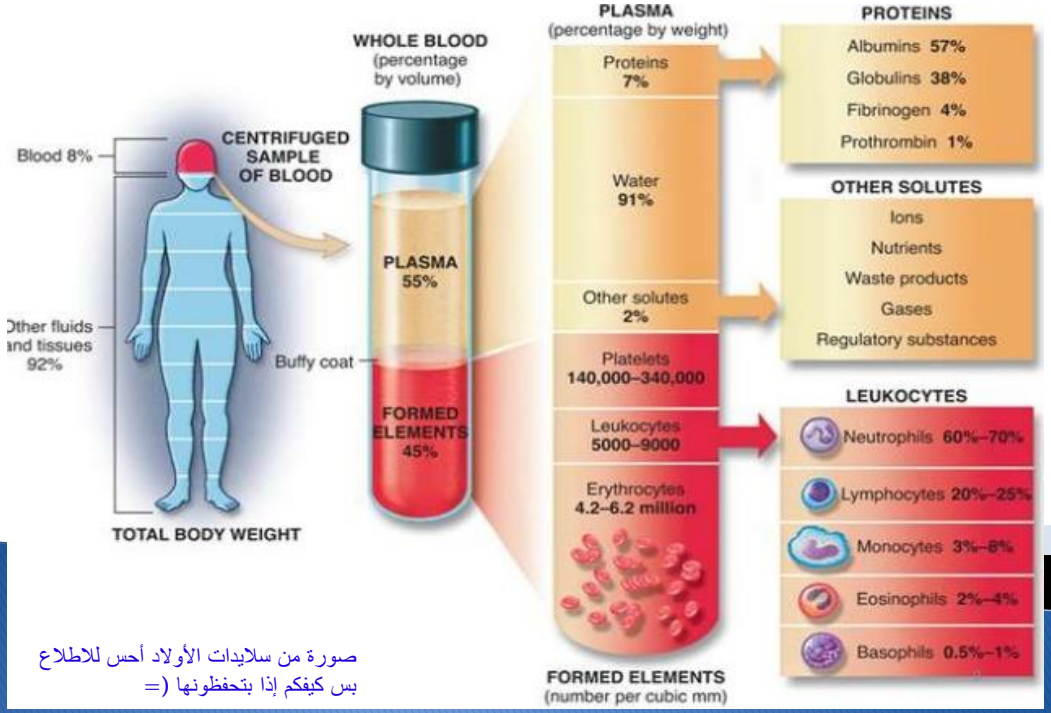


Will be in detail in WBC lecture

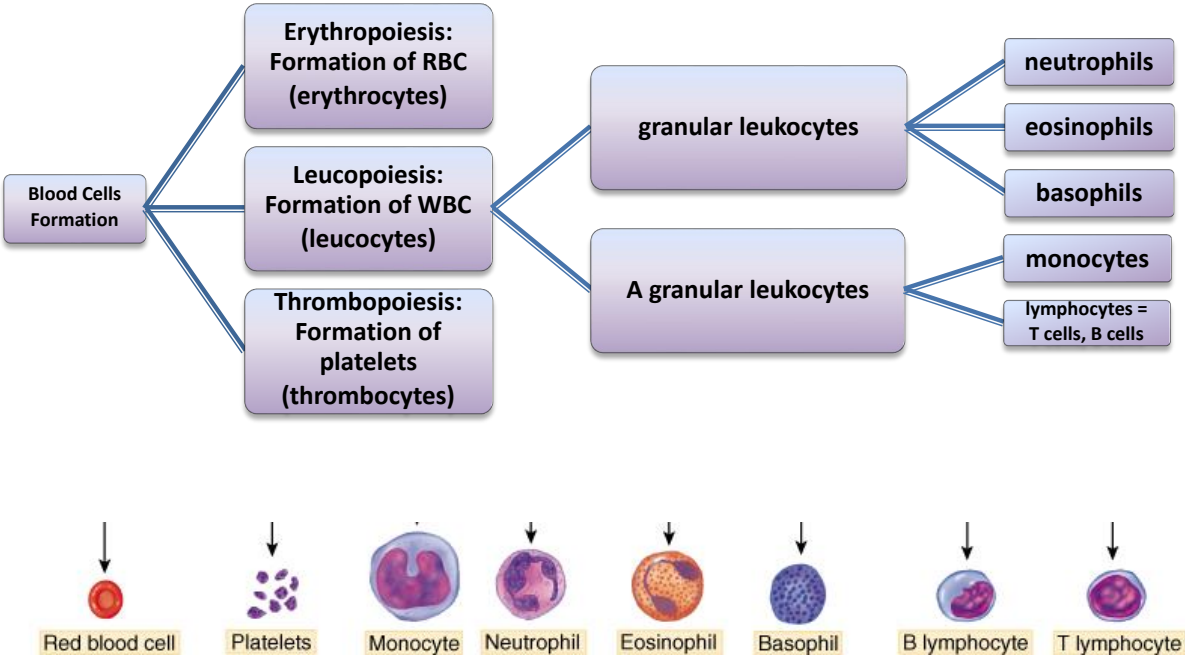


صورة من سلايدات الأولاد أحس للاطلاع
بس كيفكم إذا بتحفظونها (=

Composition of Blood



صورة من سلايدات الأولاد أحس للاطلاع
بس كيفكم إذا بتحفظونها (=


Blood Cells Formation
Erythropoiesis: Formation of RBC (erythrocytes)
Leucopoiesis: Formation of WBC (leucocytes)
Thrombopoiesis: Formation of platelets (thrombocytes)
granular leukocytes
A granular leukocytes
neutrophils
eosinophils
basophils
monocytes
lymphocytes = T cells, B cells
Red blood cell
Platelets
Monocyte
Neutrophil
Eosinophil
Basophil
B lymphocyte
T lymphocyte

Formation of Blood Cells

Erythropoiesis

- Formation of erythrocytes (RBC)

Leucopoiesis

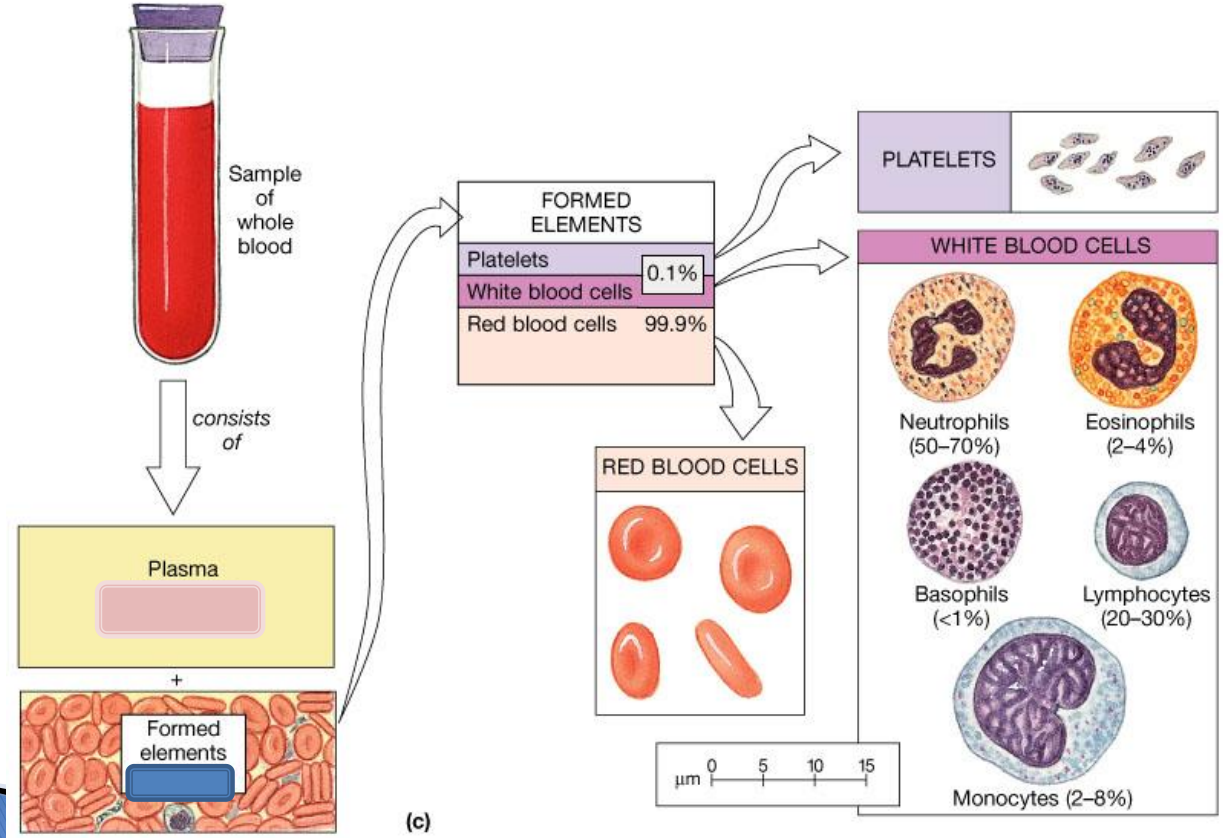
- Formation of leucocytes (WBC)

Thrombopiesis

- Formation of thrombocytes (platelets)

Haematopoiesis

- Formation of blood



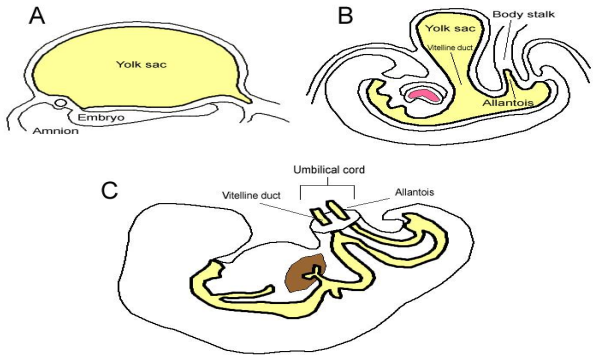
Production of Red Blood Cells

- **In-utero**
  - The nucleated RBCs are formed in the Yolk Sac during early few weeks of embryo — 1st 8 weeks
  - RBC are formed in the liver, spleen, & lymph nodes during the middle trimester (week 13-28) — 2nd to 5th months
  - RBC are formed in the bone marrow of all the bones during the last month — 5th month and on
- **After Birth**
  - The bone marrow of the flat bone will continue producing RBC into adult life
  - Shaft of long bone stio to produce RBC at puberty while epiphysis continued

Female slide

هذي السلايد نفسها موجوده عند الأولاد بس بصيغه ثانيه وتحت مسمى

"location of erythropoiesis"



Male slide

Location of Erythropoiesis

embryonic development:

During the 1st 8 weeks of, RBCs are formed in yolk sac

During the 2nd to 5th months, RBCs are formed in liver (main supplier) and spleen

From the 5th month on, RBCs formed in bone marrow

After birth

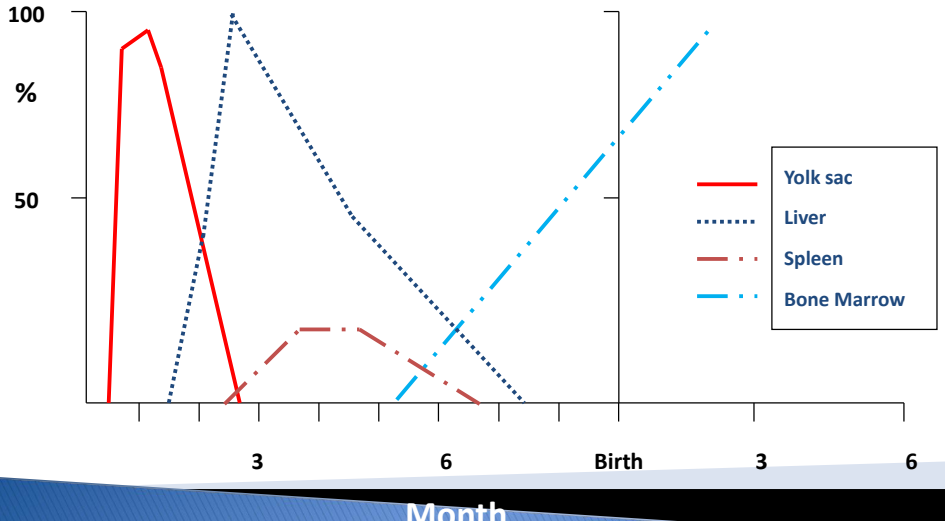
and in adults, RBCs are formed in red bone marrow

- Bone marrow of **all bones** produces red blood cells until a person is **5 years old**.
- Bone marrow of **long bones**, except for the proximal portions of the humeri and tibiae, **becomes quite fatty** and produces no more red blood cells after about **age 20 years**.
- **Beyond this age**, most red cells continue to be produced in the marrow of the vertebrae, sternum and ribs.

Portions of: vertebrae, ribs, scapulae, skull, pelvis, proximal heads of femur and humerus

Yellow marrow of medullary cavities can be converted back into red marrow, if needed

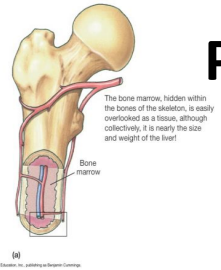
Locations of Erythropoiesis

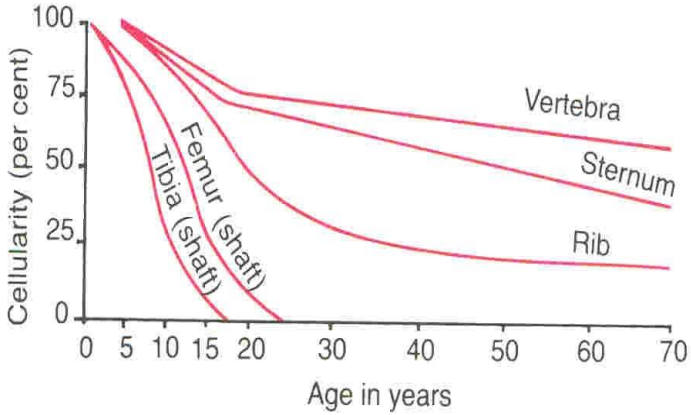


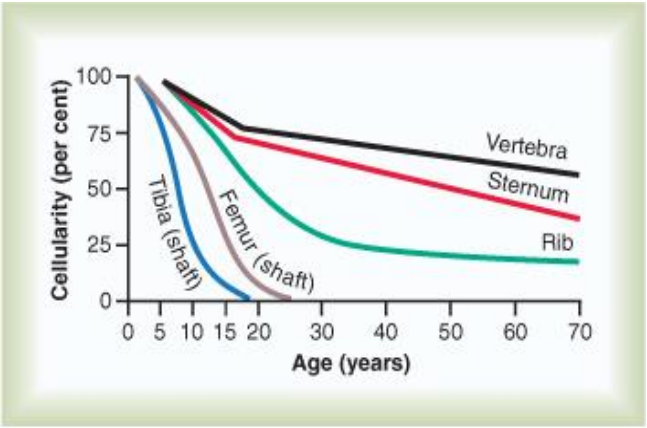
Locations of Erythropoiesis

Normal bone marrow conversion

Production of RBC

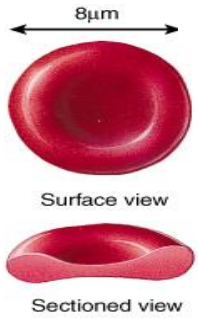






"Children need **RBC** more than adults for their growth"

Red Blood Cells Shape & size



- Flat biconcave disc
- Non-nucleated
- Flexible
- Number = 4.7 – 5 x10^6
- Dimensions are about (7.5X2X1 µm)
- Average volume is about 90-95 μm^3
- Hb - 14-16 g/dl in the blood

- it doesn't have nucleus, mitochondria, ribosomes, endoplasmic reticulum or golgi apparatus.

- What does the cytoplasm contains?
  - Hemoglobin (protein that functions in gas transport)
  - Carbonic Anhydrase (enzyme)
  - Other enzymes responsible for glucose metabolism and 2,3 DPG synthesis
    - Glucose enters RBC by facilitated (carrier-mediated) diffusion.
    - Glycolysis accounts for 90% and HMP Shunt for 10% of glucose metabolism.

RBC : able of storage

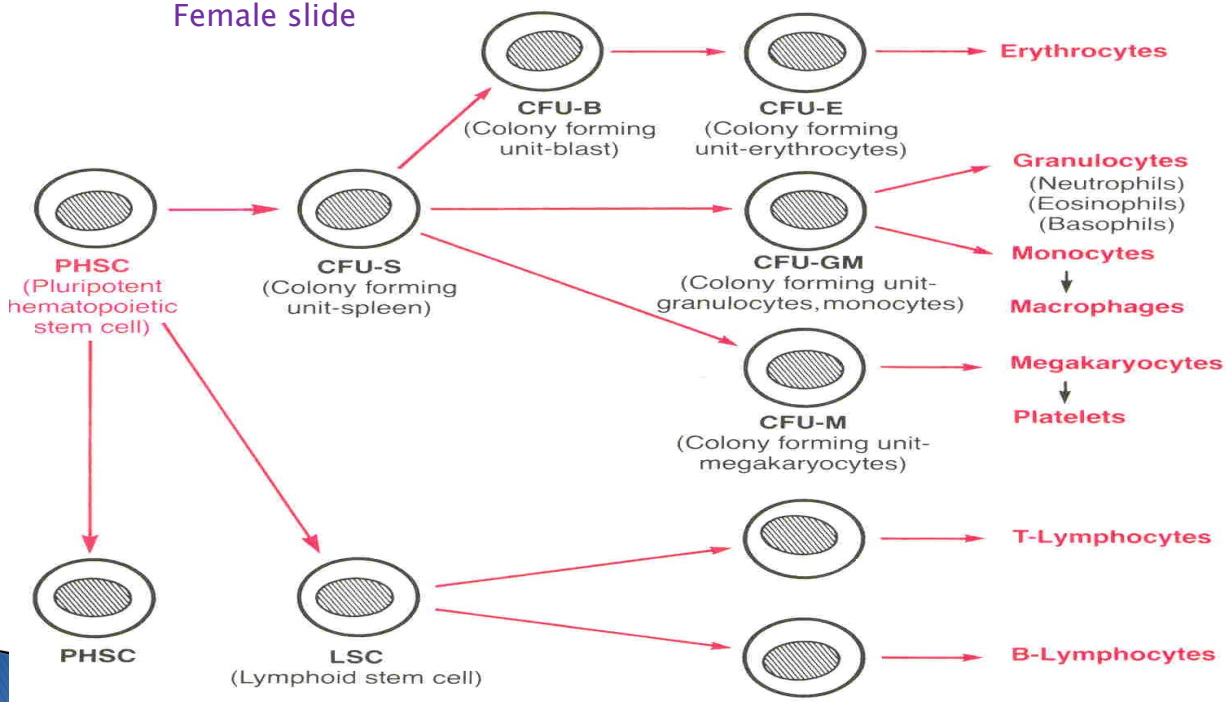
Genesis (Production) of RBC

- The Pluripotent hematopoietic stem cells (PHSC); hemocytoblast from which all the cells of the circulating blood are eventually derived.
- (Committed Cells) is where all blood cells are formed from.
- These PHSC are least differentiated and can develop into any blood cell.
- They give rise to uncommitted stem cells that in turn give rise to committed stem cells; committed progenitor cells; progenitor cells (colony-forming units).
- A committed stem cell that produces erythrocytes is called a *colony-forming unit-erythrocyte (CFU-E).*
- CFUs form differentiation lines leading to RBCs, megakaryocytes and most WBCs.
- Thus, the CFUs are specialized to form specific cell types.
- For example: CFU-E develops eventually into only red blood cells
- There are two separate committed cells for both RBC and WBC.
- Growth factors are what controls the growth of the different stem cells.

* الكلام اللي بالأزرق مموجود بسلايدز البنات بس موجود بصوره حاطتها د. نيرفانا (السلايد الجاية).

Genesis (production) of RBC

Female slide



Growth and reproduction of stem cells

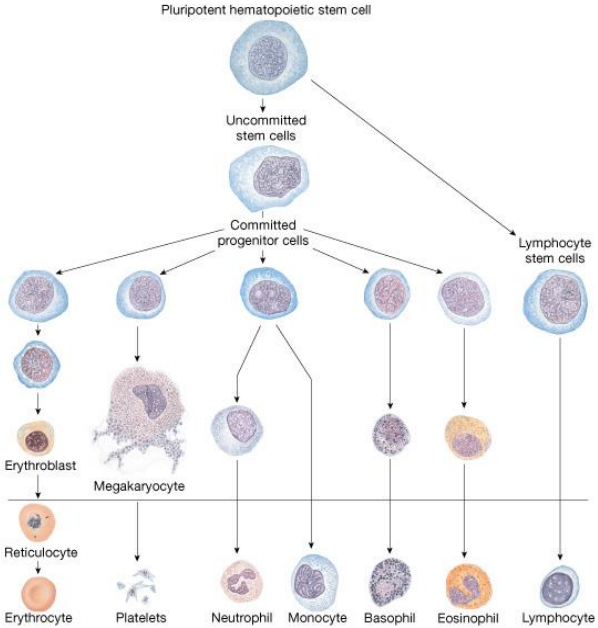
- Growth and reproduction of the different stem cells are controlled by multiple proteins called **growth inducers**. One of these**, interleukin-3**, promotes growth and reproduction of virtually all the different types of committed stem cells, whereas the others induce growth of only specific types of cells.

- Differentiation of the cells is the function of another set of proteins called differentiation inducers. Each of these causes one type of committed stem cell to differentiate one or more steps toward a final adult blood cell.

- Formation of the growth inducers and differentiation inducers is itself controlled by factors outside the bone marrow. For instance, in the case of erythrocytes (red blood cells), exposure of the blood to low oxygen for a long time results in growth induction, differentiation, and production of greatly increased numbers of erythrocytes.

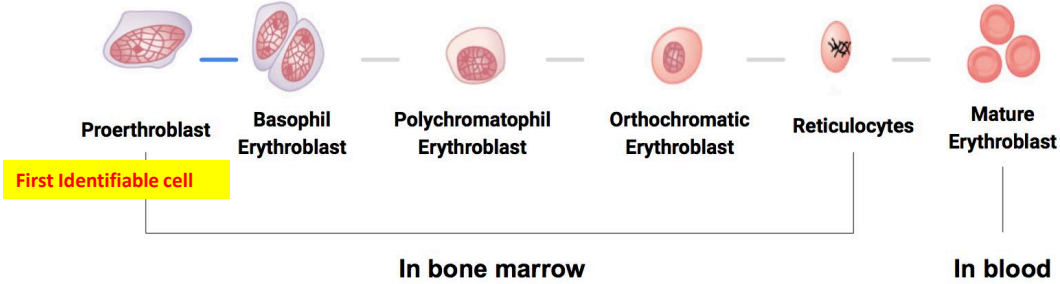
Required Growth factors:(growth inducers)

- ❑ Erythropoietin
- ❑ Colony stimulating factors
- ❑ Interleukins
- ❑ Thrombopoietin



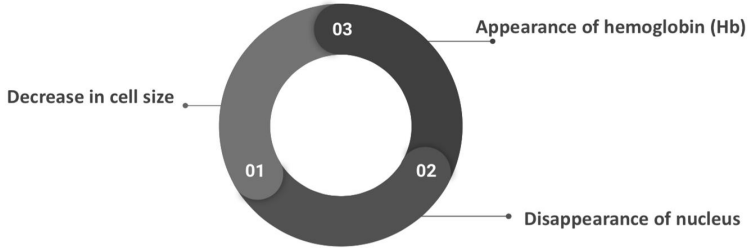
Stages of differentiation od RBC:

You have to know the stages
د نيرفانا أكدت عليها.



- In cases of rapid RBC production
  → ↑ reticulocytes in the circulation.

RBC development is characterized by:



Stages of differentiation of RBC:

- RBCs are formed from **PHSC** (hemocytoblasts).
- These give rise to **uncommitted stem cells**, which in turn give rise to **committed stem** (progenitor) cells (CFU-E), which give rise to **proerythroblasts**.
- The **proerythroblasts** are considered as differentiated RBC precursors.
- They are the first cells that can be identified as belonging to the red blood cell series.
- The proerythroblasts give rise to ***basophil erythroblasts***

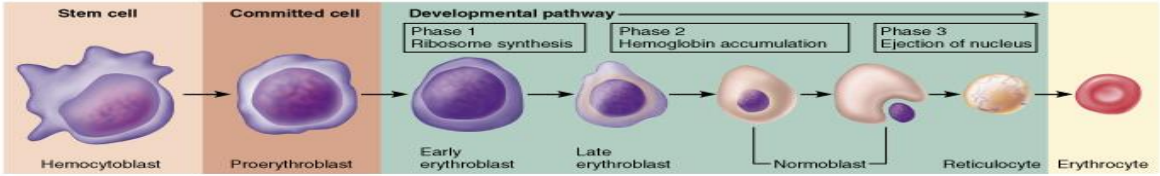
→ **erythroblasts**: synthesize Hb

→ **normoblasts**: lose nucleus , some mitochondria

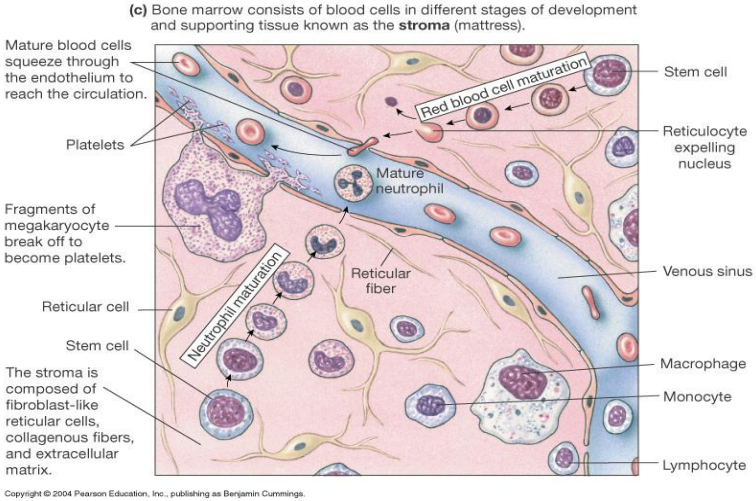
→ **Reticulocytes** contain ribosomes and mitochondria (but no nucleus)

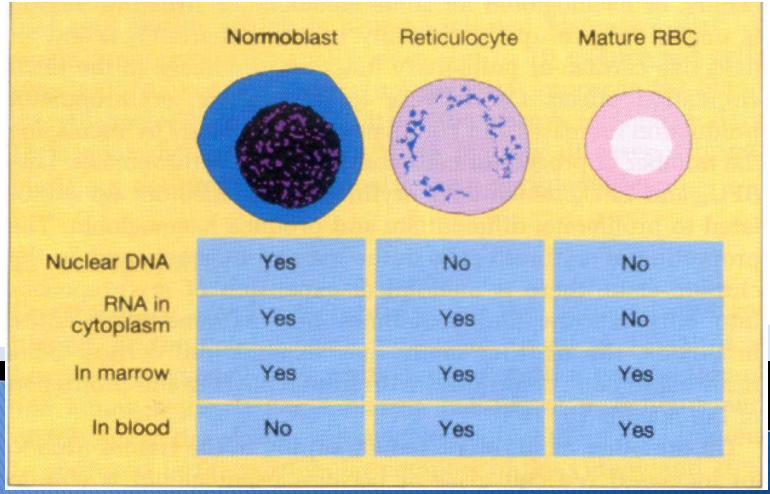
reticulocyte count: normally 0.8-2.0% of RBC population

In 1-2 days, reticulocytes eject the remaining organelles to become a **mature RBC**



Stages of Erythropoiesis

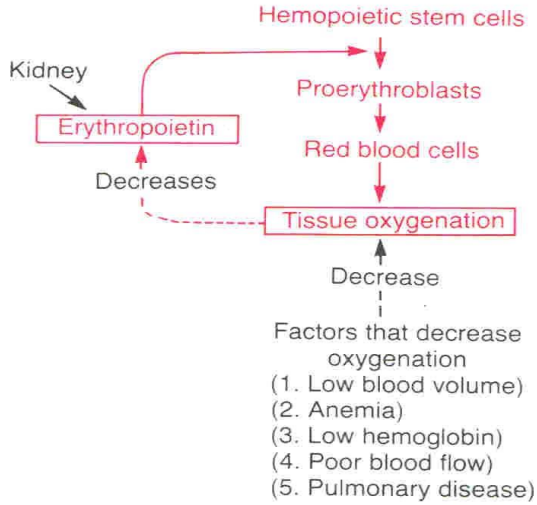




Regulation of RBC Production:

- When hypoxia (low oxygen in the blood) occurs the kidney response by producing a hormone called Erythropoietin which stimulate Erythropoiesis.

- **Causes of hypoxia (⇩O2):**
  - Low RBC count (anaemia)
  - Hemorrhage
  - High altitude
  - Prolong heart failure
  - Lung disease

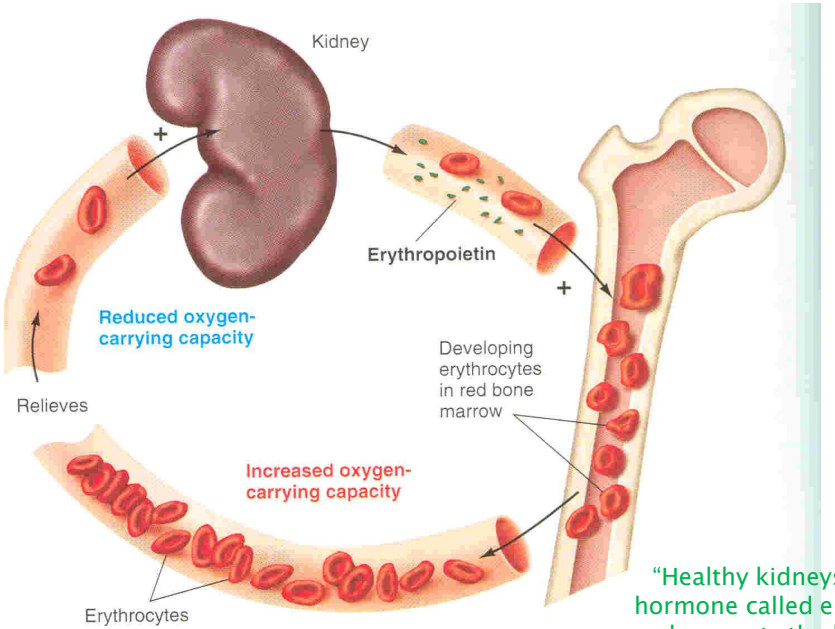


Erythropoietin

- **Characteristics of erythropoietin:**
  - Glycoprotein.
  - 90% comes from renal cortex (kidney) while 10% liver.
  - Stimulate the growth of early stem cells.
  - Does not affect maturation process.
  - Measured in plasma & urine.

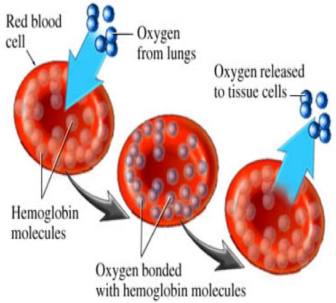
- Conditions like **(anemia, high altitude, heart failure, & lung disease)** result in high erythropoietin levels and polycythemia.

Role of the kidneys in RBC formation



"Healthy kidneys produce a hormone called erythropoietin and prompts the bone marrow to make red blood cells, which then carry oxygen throughout the body"

Functions of Red Blood Cells:

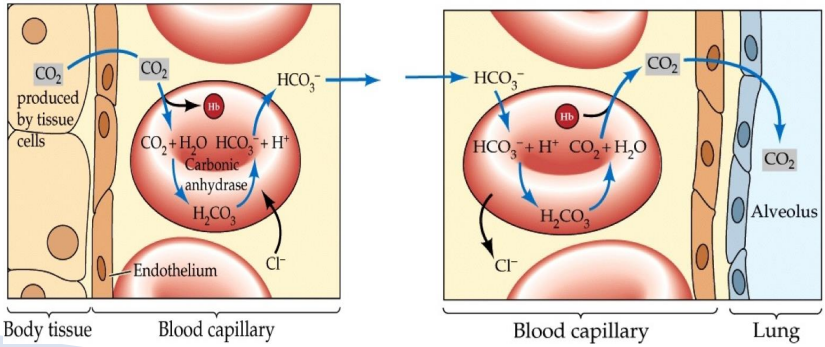


- **Transportation of O_{2*} and CO_2 from the lungs to the tissues:**
  - -Hemoglobin combines reversibly with oxygen as blood passes through pulmonary capillaries in the lungs where oxygen is high.
  - -Hemoglobin releases oxygen as blood passes through systemic capillaries in the tissues where oxygen is low.

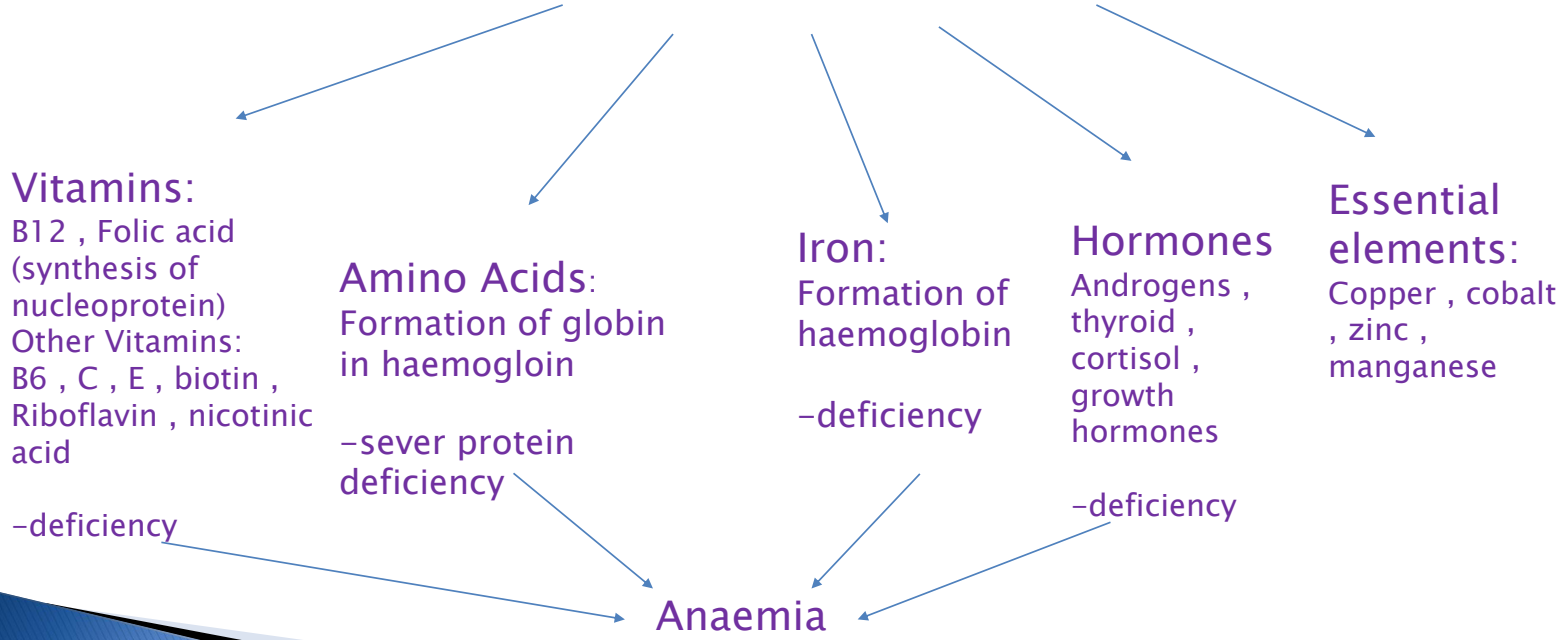
- RBCs contain the enzyme **carbonic anhydrase**. This enzyme that catalyzes the reversible reaction between carbon dioxide **(CO_2)** and **H_2O** to form **carbonic acid (H_2CO_3)**, increasing the rate of this reaction several thousand fold.

- The rapidity of this reaction makes it possible for the water of the blood to transport enormous quantities of CO_2 in the form of bicarbonate ion ($HCO3^-$) from the tissues to the lungs, where it is reconverted to CO_2 and expelled into the atmosphere as a body waste product.

- **Buffer**



Essential elements for RBCs formation and maturation

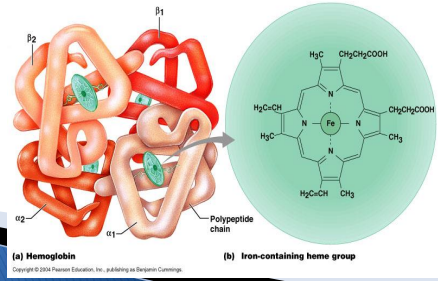


Hemoglobin

- **Hemoglobin is a Globular protein**
- **Accounts for more than 95% of protein in RBC.**
- **Concentration of Hb in the Blood Measured as g/dl** (grams per deciliter, or per 100 ml)

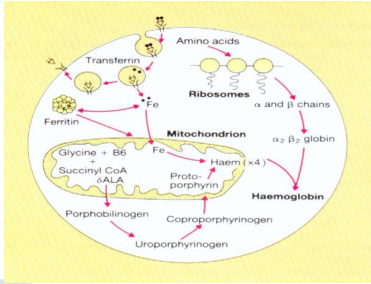
- **Main function:**
  - **Carriage of O2** It carries ~ 98.5% of all O2
    HP reversibly bind O2 (oxyhemoglobin) , affected by PH , temperature , h+
  - **Carriage of CO2**
    HP bind CO2 (carboxyhemoglobin)
  - **Buffer** → Because Protein
  - **Main component of blood**

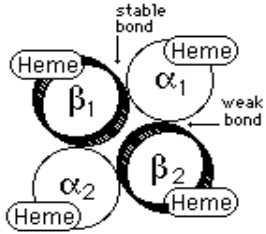
Carbon Monoxide
CO
Attaches
IRREVERSIBLY
(يمسك و ما بيسيبهوش)
يسبب اختناق ويشب نار
زي الدفاية وقت الشتاء



Hemoglobin (Hb) Synthesis

- **Hemoglobin** synthesis occurs in the mitochondria of the developing RBC in bone marrow
- **Transferrin** attaches to surface receptor
- **Iron**(F^{2+}) is released and transported to mitochondria where it combines with **protoporphyrin ring** to form **heme**
- **Heme** combines with **α and β protein chains** formed on the ribosomes to make **haemoglobin**
- **Hemoglobin** molecules consist of 4 chains each formed of (Heme) and polypeptide chain (Globin).





Types of Hemoglobin (Hb)

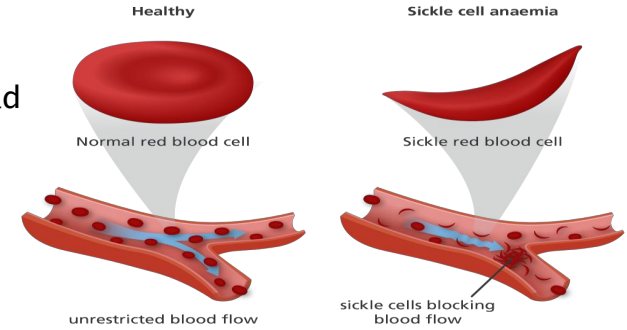
HB F = Fetal Life
-higher affinity to oxygen
(يسحب الاكسجين بكمية اكبر)
-Baby انماني
GROWS THEN TO HB A

HB A :
(Adult HP)
2α and 2β chains
98%
tetrameric protein
alpha 141 aa residues
beta 146 aa residues

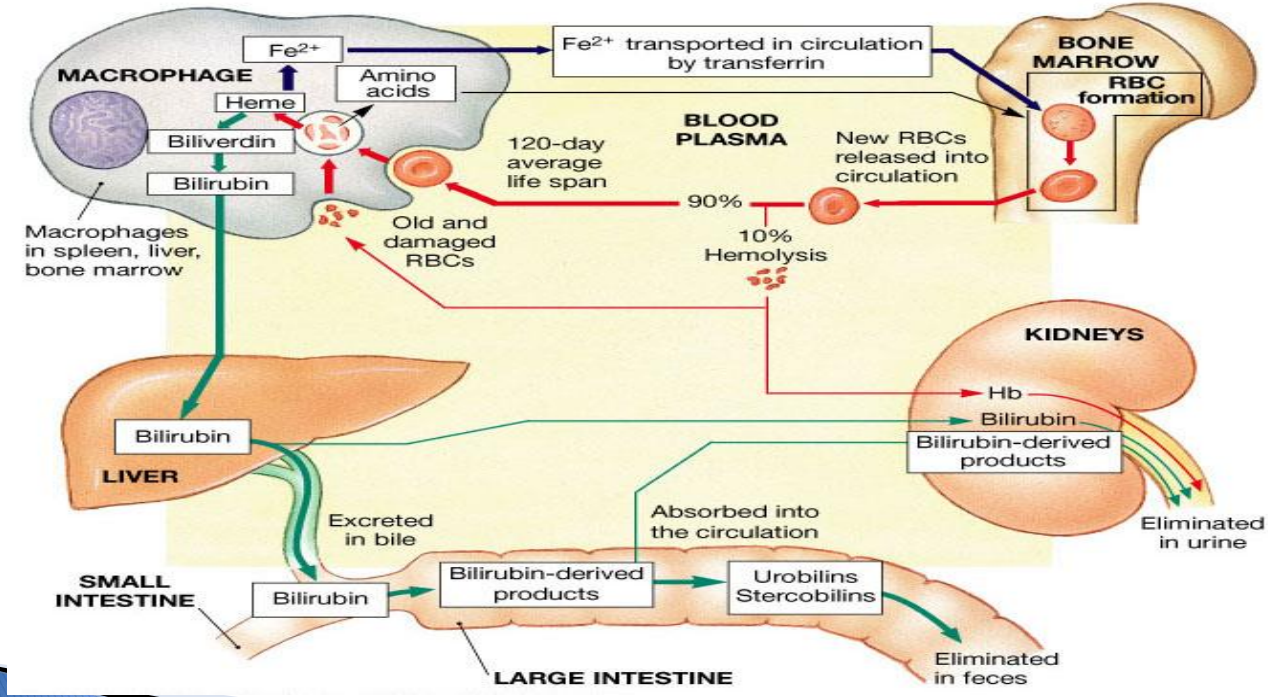
HB A2 :
(Minor Adult Form)
2α and 2 *delta* ($\alpha_2\delta_2$) chains
2%-2.5%

HB F :
(Fetal Hemoglobin)
intrauterine life
2α and 2γ chains
80-90% of fetal Hb at birth
Gamma

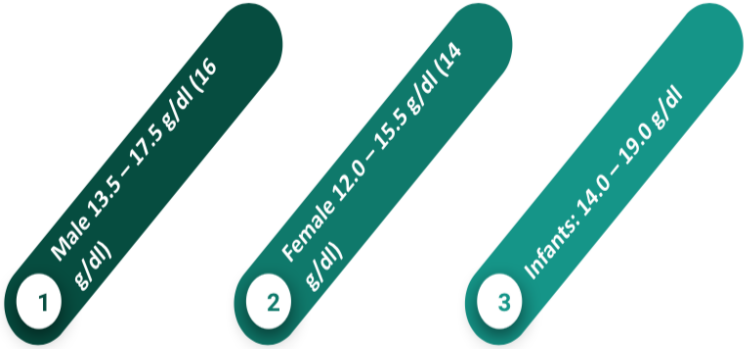
-Abnormality in the polypeptide chain will lead to an abnormal HP (hemoglobinopathies)
e.g thalassemias ,sickle cell anemia (HbS).



Fate of Components of Heme



Average Volume of Hemoglobin

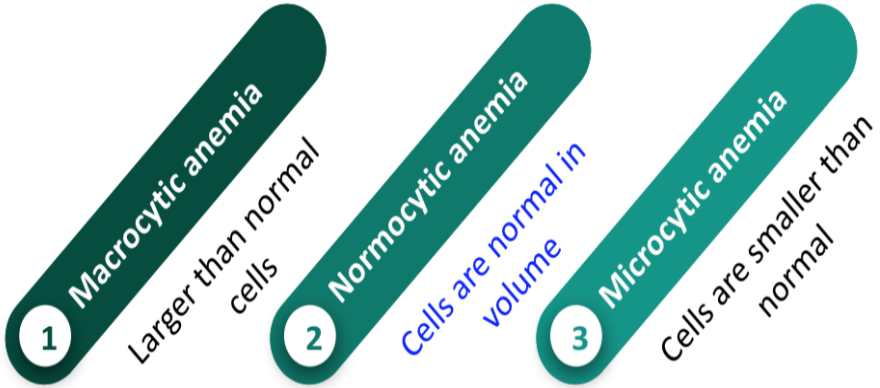


- Each gram of pure hemoglobin is capable of combining with 1.34 ml of oxygen.
- Therefore, in a normal man a maximum of about 20 milliliters of oxygen can be carried in combination with hemoglobin in each 100 milliliters of blood, and in a normal woman 19 milliliters of oxygen can be carried.

Haematological indices

- **Mean corpuscular volume (MCV): The average volume of the red blood cells expressed in femtoliters (fl) or cubic micrometers.**
  - **Normal value: 90-95 femtoliters (10^{-15} liters) abbreviated fl.**

$$= \frac{\text{Hct} \times 10}{\text{RBC}\ (10^6/\mu\text{L})}$$



Haematological indices

- Mean corpuscular Hb (MCH):
- The average amount of hemoglobin inside a RBC is expressed in picograms (pg).
- Normal value: 27-33 pg (10^{-12} gram)

$$= \frac{Hb \times 10}{RBC\ (10^6/\mu L)}$$

Haematological indices

Mean corpuscular Hb concentration (MCHC):

The average concentration of hemoglobin in the RBCs expressed as (gm/dl).

- Normal value: 32- 35 g/dl of RBCs

$$= \frac{Hb \times 100}{Hct}$$

Indices		Males	Females
Hematocrit (Hct) (%)		47	42
Red blood cells (RBC) (10^6/L)		5.4	4.8
Hemoglobin (Hb) (g/dL); dL = 100 milliliters		16	14
Mean corpuscular volume (MCV) (fL) [a]	$= \frac{Hct \times 10}{RBC\ (10^6/\mu L)}$	90 - 95	90 - 95
Mean corpuscular hemoglobin (MCH) (pg)	$= \frac{Hb \times 10}{RBC\ (10^6/\mu L)}$	29	29
Mean corpuscular hemoglobin concentration (MCHC) (g/dL of cells) [b]	$= \frac{Hb \times 100}{Hct}$	34	34
Mean cell diameter (MCD) (µm)	= Mean diameter of 500 cells in smear	7.5	7.5

[a] Cells with MCVs > 95 fL are called macrocytic; cells with MCVs < 80 fL are called microcytic.

[b] Cells with MCHs < 25 g/dL are called hypochromic.

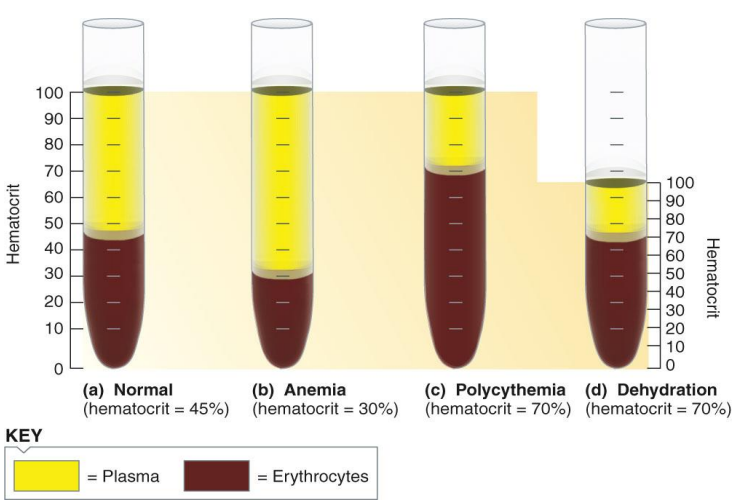
Hematocrit; Hct (PCV)

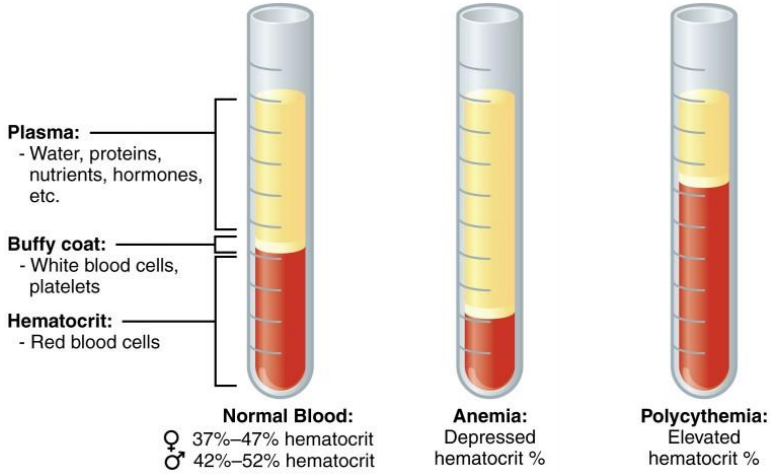
Male slide

- **Hct** is the ratio of formed elements to whole blood
- It is the proportion of blood made up of cells (mainly RBCs)
- It is expressed as **percentage**
- Percentage of blood made up of cells
  - Males: average 47% (range: 42-52%)
  - Females: average 42% (range 37-47%)
  - Minimum hematocrit to donate blood = 38%

- **Hct** is measured by centrifuging a tiny sample of blood
- Centrifugation separates formed elements from plasma
- After centrifugation the heavier red blood cells settle to the bottom of the tube. The plasma remains at the top.
- The two layers are separated by a '**buffy coat**' of white cells and platelets.

Hct under various conditions





Anaemia

Anemia is decrease in RBC mass as determined by Hct or Hb values below reference level for age and gender.

Symptoms: tired , fatigue , short of breath , heart failure

VERY IMP.
You compare for the same AGE and the same SEX (women Hb count to normal women Hb count. NOT MEN)

Macrocytic anemia:

-The RBC are almost as large as the lymphocyte.
-Fewer RBCs.

Microcytic anemia:

-The RBCs are smaller than normal and **have an increased zone of central pollar**.
-This is indicative of a microcytic (smaller size)and hypochromic (less hemoglobin) anemia. (باهتة)
-There is also increased **anisocytosis** (variation in size) and **poikilocytosis** (variation in shape).

Causes of anemia:

again: the Causes and the shape of Anemia it gives

Blood loss:

-acute ⟶ accident (RBC return to normal 3-6 weeks).

-chronic ⟶ microcytic hypochromic anaemia (ulcer , worms).

Chronic: كمية بسيطة (Menstrual)
Acute: حاد (نقل دم ، حوادث)

Decrease RBC production:

-Nutritional causes:

Iron ⟶ microcytic hypochromic anaemia.

Vit B12 and Folic Acid ⟶ megaloblastic anaemia.

-Non-nutritional causes:

Bone marrow failure, destruction by cancer , radiation , drugs , Aplastic anaemia.

Heamolytic ⟶ excessive destruction:

تصنيع مع عيوب

-Abnormal cells or HB ⟶ (Sepherocytosis , sickle cells)

-Incompatible blood transfusion.

-Erythroblastosis fetalis.

Polycythemia

Polycythaemia is increase in RBC mass as determined by Hct or Hb values above reference level for age and gender

Normal: 5 million
Polycythemia: 15 million

types are:

CAUSE

Primary (polycythemia rubra vera – PRV):
Uncontrolled RBC production.

سبب غير معلوم.
Type of autoimmune disease

Secondary to hypoxia:
High altitude (physiological) , chronic respiratory or cardiac disease.

يعوض الجسم عن نقص
Oxygen
(Type of Adaption)

- **Relative**

  Hemoconcentration:

  » loss of body fluid in vomiting, diarrhea, sweating

Complications of polycythemia: hyperviscosity of the blood

مافي intrinsic

↓

يصير pernicious Anemia

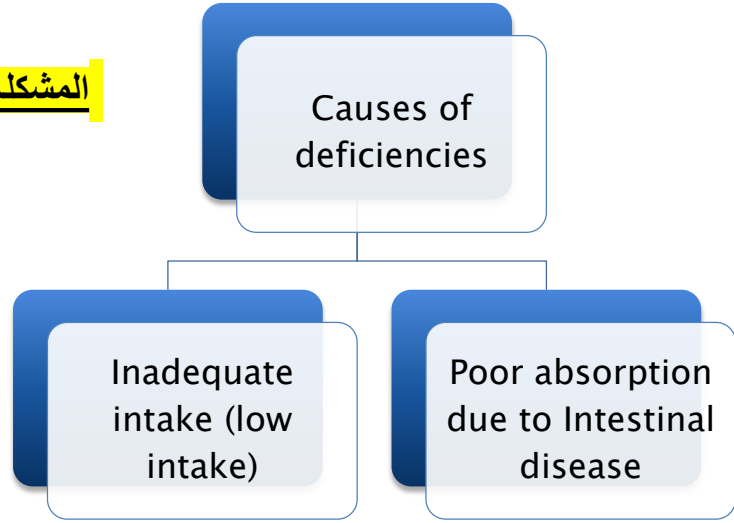
Malabsorption of Vitamin B12

Megaloblastic (macrocytic)

- Pernicious Anemia: lack of vitamin B12
- Vit. B12 needs an intrinsic factor to get absorbed, therefore it gets released by parietal cells of stomach.
- Then the Vit. B12 binds to the intrinsic factor which get absorbed in the *terminal ileum*

المشكلة هنا

(رخيص و بكل مكان فيكون في تحت) VB12



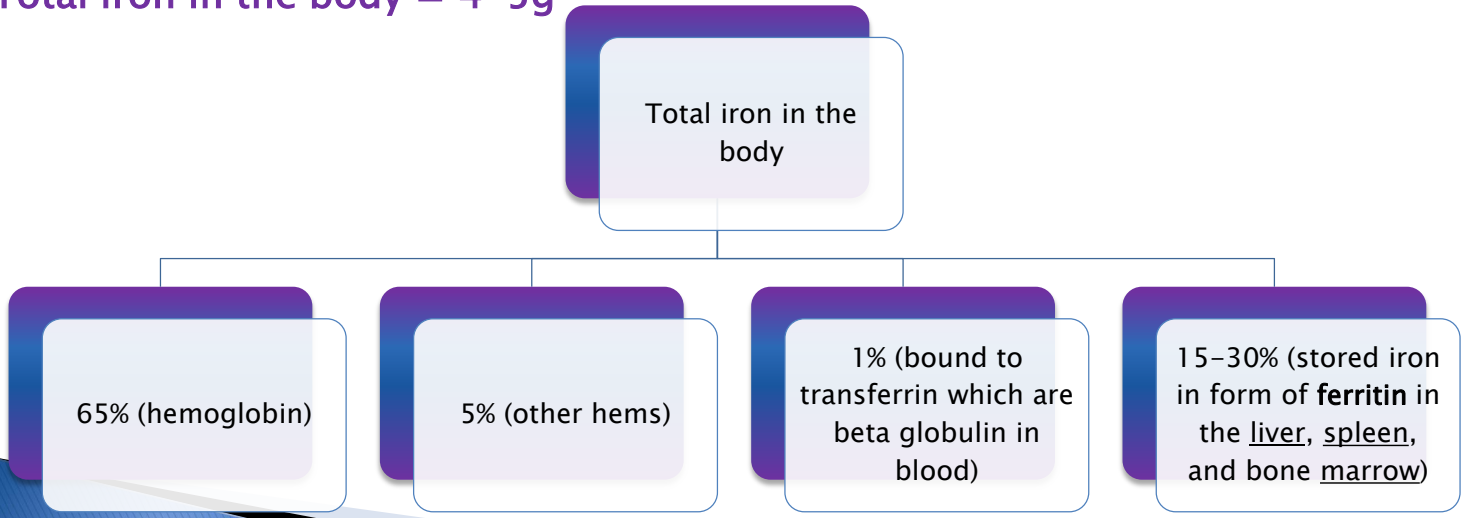
V B12 + Intrinsic = absorbed in the terminal ileum

↓

released in the stomach

Iron metabolism (Fe)

- Iron is needed for the synthesis of hemoglobin, myoglobin cytochrome oxidase, peroxidase, and catalase.
- Total iron in the body = 4-5g



Iron absorption

Iron in food mostly in oxidized form

- Ferric F^{+3}

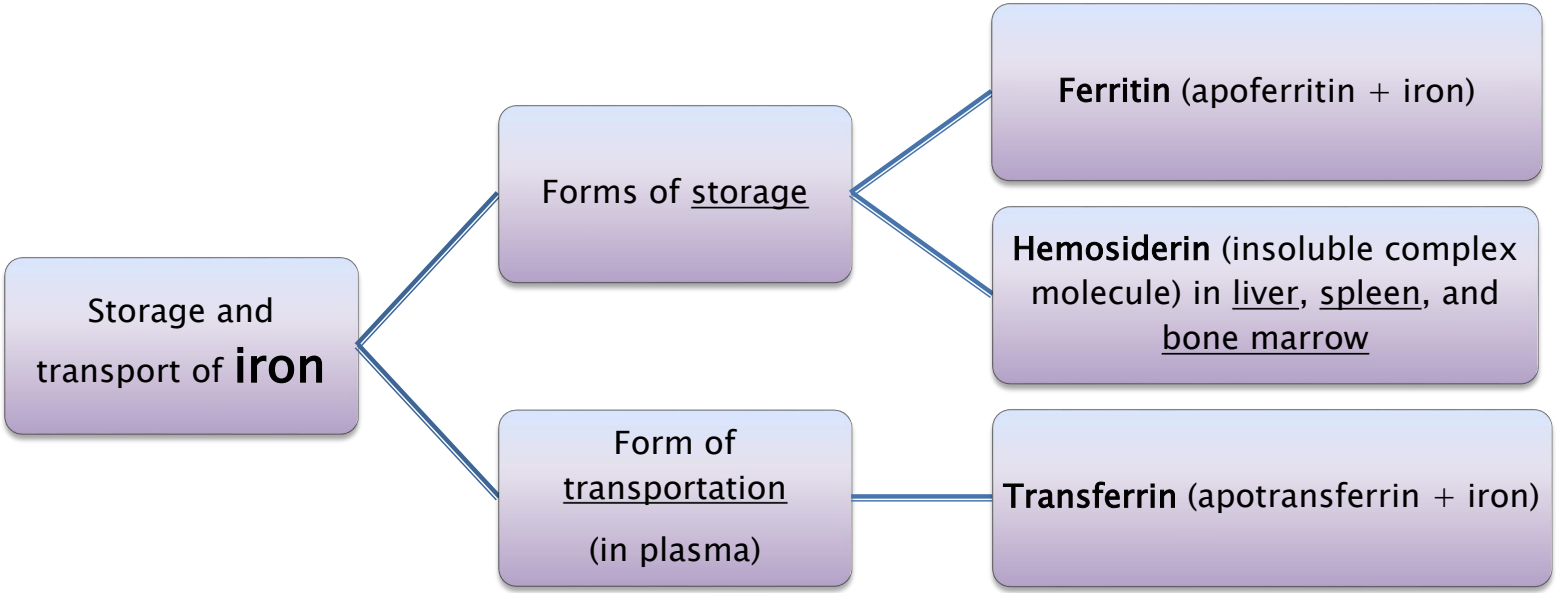
Better absorbed in reduced form

- Ferrous F^{+2}

Iron in stomach is reduced by

gastric acid + vit. C

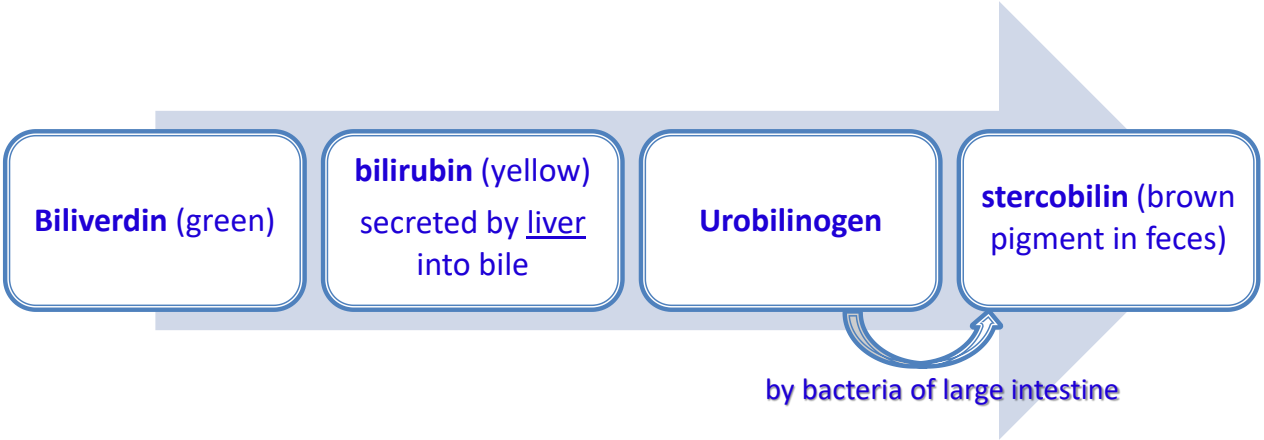
* Rate of absorption depends on the amount of iron stored.



* Daily loss of iron is 0.6 mg in male & 1.3mg/day in females.

Male slide

Fate of Components of Heme



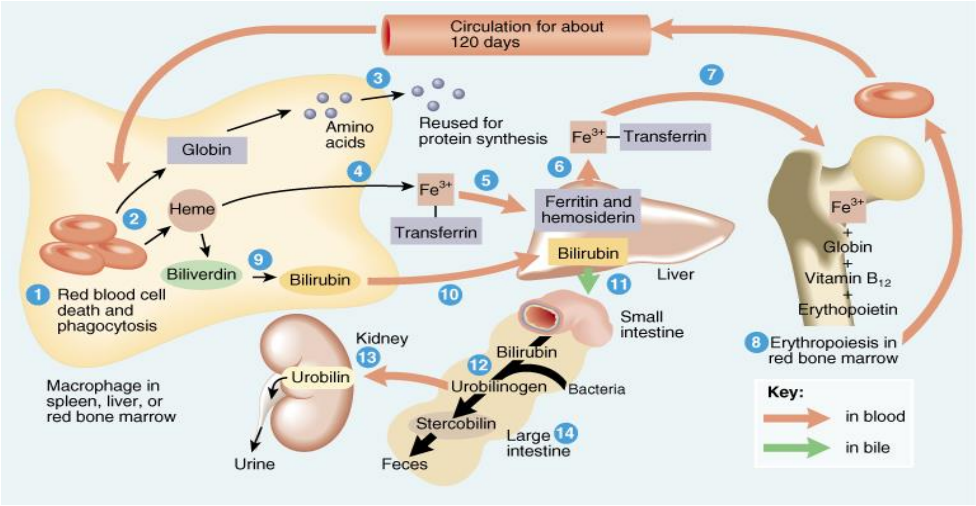
- if **urobilinogen** is reabsorbed from intestines into blood, it will be converted to a yellow pigment, **urobilin** and excreted in urine.

Destruction of RBC

- **RBC life span in circulation = 120 days.**
- **Metabolic active cells.**
- **Old cell has a fragile cell membrane, cell will rupture as it passes in narrow capillaries of the spleen.**
- **Released Hemoglobin is taken up by macrophages in liver, spleen & bone marrow:**
  - **Hemoglobin is broken into its component:**
  - **Globin:**
    - Polypeptide ➡ amino acids (protein pool = storage)
  - **Heme:**
    - Iron (get away from the heme) ➡ ferritin (iron without heme)
    - Porphyrin ➡ biliverdin (bilirubin) ➡ secreted by the liver into bile. (excess destruction of RBC causes Jaundice)

RBC life cycle

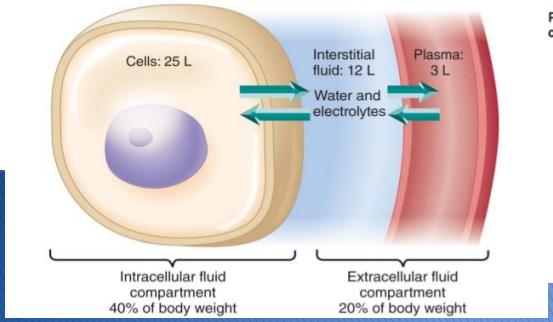
- Cells wear out from bending to fit through capillaries
- Repair is not possible due to lack of organelles
- Breakdown products are recycled

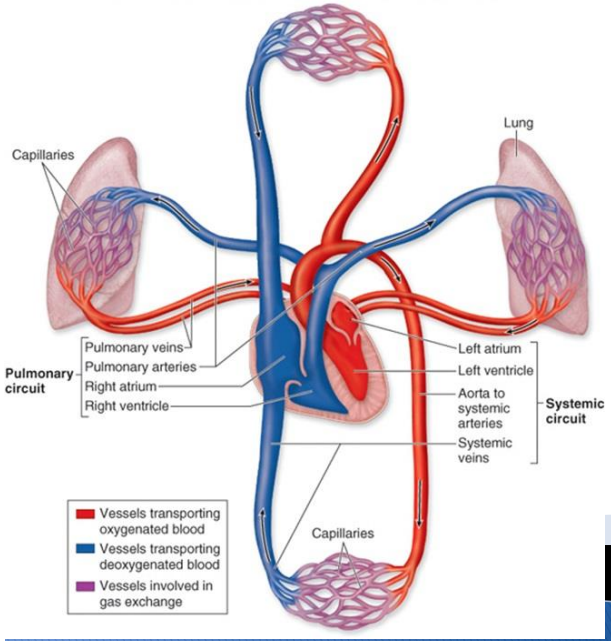


Major Components of the Circulatory System

- Heart
- Blood vessels
- Blood

Major fluid compartments in the body





Plasma: Definition and Composition

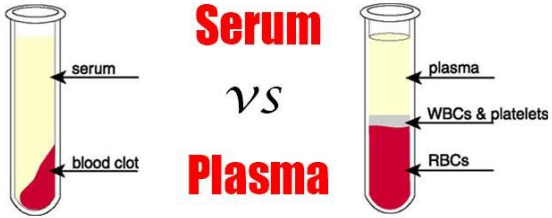
Plasma = whole blood minus cells

Serum = plasma minus clotting proteins

- If whole blood is allowed to clot
- Then, clot is removed, the remaining fluid is SERUM
- Thus, serum doesn't contain coagulation factors

- Constituents of plasma

- 91.5% water (In female 98% so its 90~99)
- 7% plasma proteins
- 1.5% other solutes including:
  - -Electrolytes
  - -Organic nutrients and wastes
  - -Respiratory gases
  - -Vitamins

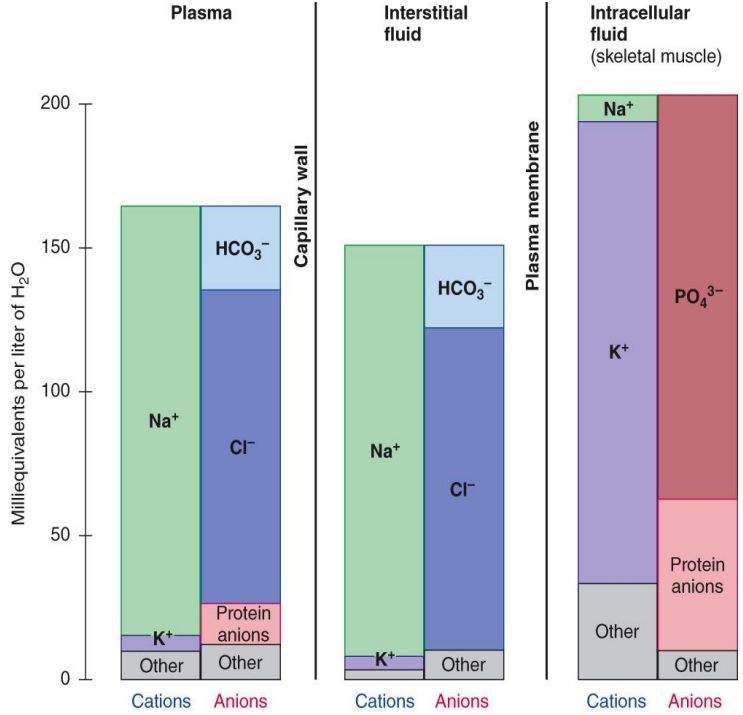


Serum = Plasma – Clotting Factors

Male slide

Ionic Composition of the Plasma

Ionic composition of the plasma is very similar to that of the interstitial fluid



Functions of Plasma Proteins

- Generation of plasma **colloid osmotic pressure** (oncotic pressure): most capillary walls are relatively impermeable to the proteins in plasma, and the proteins therefore exert an osmotic force of about 25 mm Hg across the capillary wall (oncotic pressure that pulls water into the blood.) **Albumin** is the most abundant protein in plasma: about half of all plasma protein. It provides about 80% of plasma oncotic pressure.

- **Buffering** function of plasma proteins: the plasma proteins are also responsible for 15% of the buffering capacity of the blood.

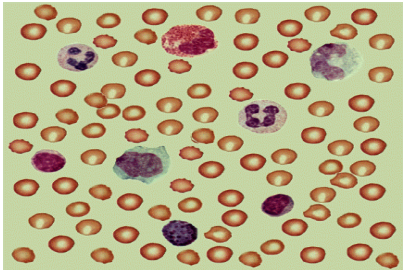
- Plasma proteins function as **nonspecific carriers** : for various hormones (e.g., cortisol, thyroxin), other solutes (e.g., iron, cupper), and drugs.

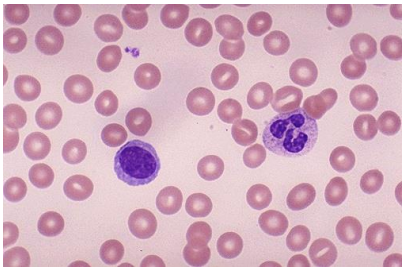
- **Defense**: Gamma globulins are antibodies

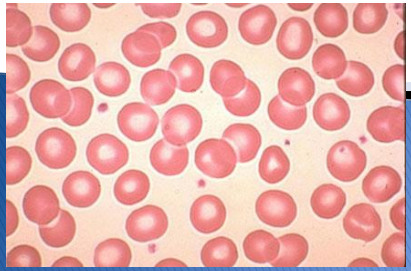
- Plasma proteins include proteins concerned with **blood clotting**.

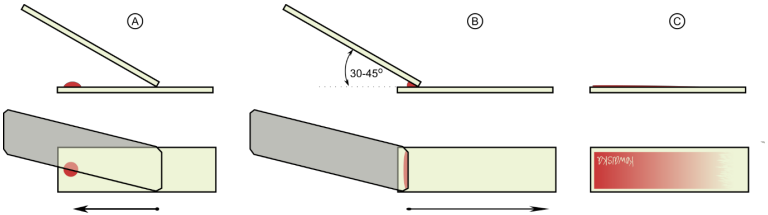
Male slide

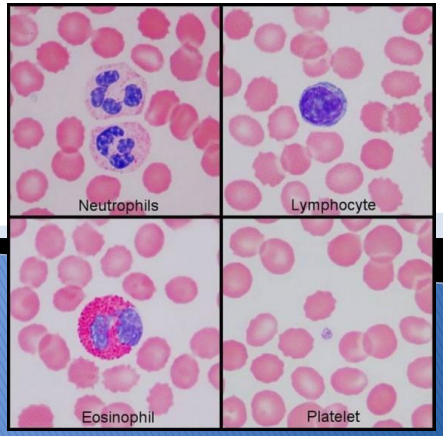
Blood Film (Blood Smear) Technique







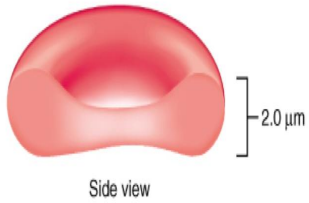


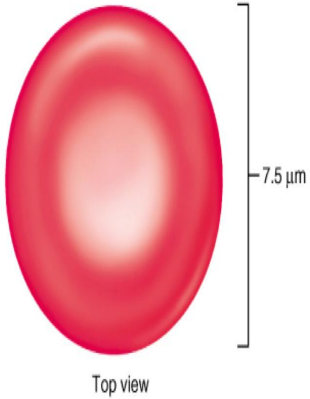


Male slide

Characteristics of a Mature Erythrocytes (RBC)

- What does the plasma membrane contains?
  - Protein spectrin which responsible for:
    - Giving RBCs their **flexibility**.
    - **Change shapes** as necessary with significantly smaller forces.
- An example of the complementarities of structure and function are **Erythrocytes**
- What are the structural characteristics that contribute to gas transport function?
  - **Biconcave** shape that has a huge surface area to volume ratio which is is essential for gas exchange.
  - **Discounting water content**, erythrocytes are 97% hemoglobin
  - ATP is generated **anaerobically** so RBCs don't consume the oxygen they transport.



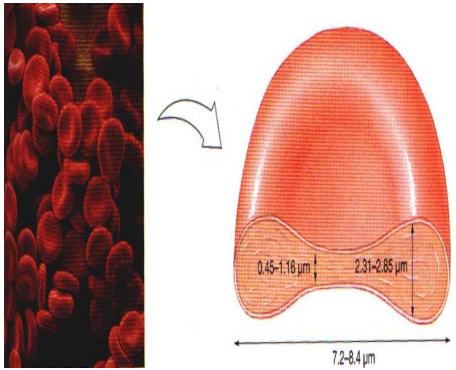


- Normally, RBCs account for >99% of all formed elements
- Red blood cell count:

	Males	Females
Average number of RBCs per cubic millimeter	5,200,000 (±300,000)	4,700,000 (±300,000)

- Persons living at high altitudes have greater numbers of red blood cells.

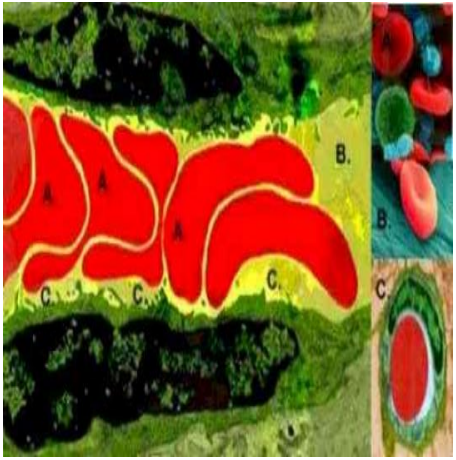
لأنه الأوكسجين أقل وبالتالي رح تزيد RBCs (وممكن يسوي polycythemia)



Red Blood Cells in Blood Capillaries

Male slide

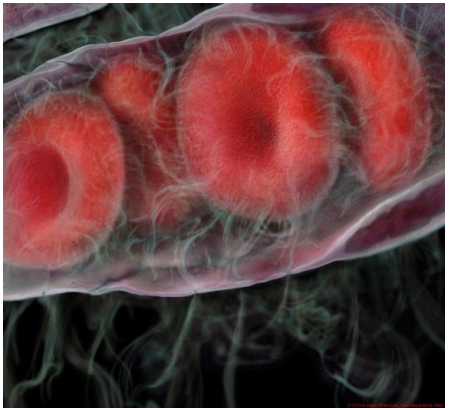
- Blood capillaries are very narrow blood vessels.
- The shapes of RBCs can change as the cells pass through blood capillaries since they squeeze through capillaries.
- RBC is a bag of hemoglobin that can be deformed into almost any shape.
- This keeps them in very close contact with the capillary walls, which reduce the diffusion distance for gas exchange with the surrounding tissues.
- Because RBC has a great excess of cell membrane for the quantity of material inside, deformation does not stretch the membrane greatly and it consequently does rupture the cell just like any other cell.



Male slide

Characteristics of RBCs in Blood Capillaries:

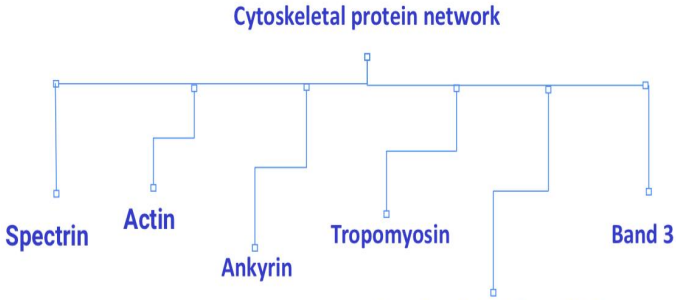
- RBCs in **single file**
- RBCs are **flexible** and **elastic**
- They are subject to high amounts of shear stress as they traverse the narrow capillaries of the microvasculature since they **squeeze through the narrow capillaries**.

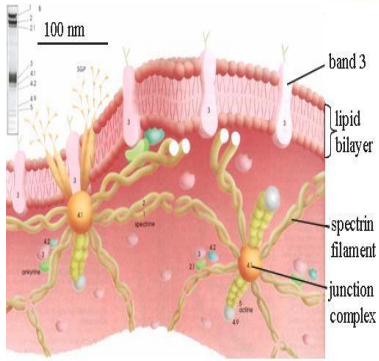


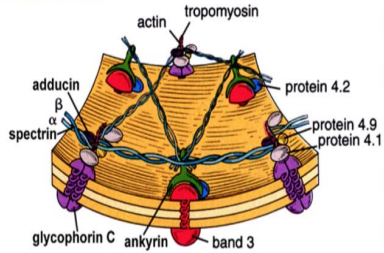
Red Blood Cell Cytoskeleton

Male slide

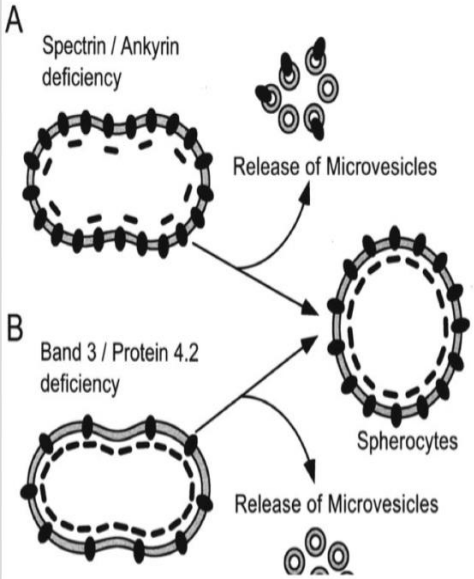
- The RBC, as it continuously circulates the narrow capillaries of the microvasculature, must be able to undergo extensive passive deformation and to resist fragmentation.
- This requires a highly deformable yet remarkably stable membrane.
- The **cytoskeletal proteins** are responsible for these important characteristics of the plasma membrane and give the red blood cell the unique biconcave shape.

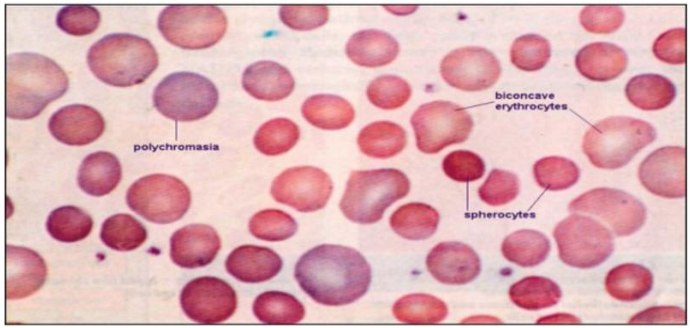


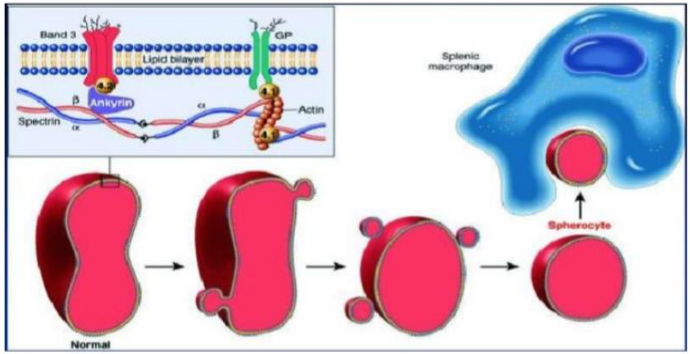




Hereditary Spherocytosis







Quiz:

1-Have an increase zone of central pallor?

A- microcytic hypochromic anemia B-macrocytic anemia C-aplastic anemia D-pernicious anemia

2-Heme (in hemoglobin) consist of?

A-folic acid and Vit B12 B-iron and Vit B6 C-protoporphyrin ring and iron D-apotransferrin and iron

3-Intrinsic factors are secreted by?

A-metabolic active cell B-parietal cell in stomach C-sickle cell D-terminal Ileum

4-Irone in stomach is reduced by?

A-gastric acid and Vit C B-folic acid and Vit B12 C-iron and Vit B6 D-riboflavin

5-Haemoglobin (Hb) of intrauterine life is?

A-Hb A B-Hb A2 C-Hb F

6- The RBCs are flat biconcave disc and nucleated

a - T b - F

1-A
2-C
3-B
4-A
5-C
6- b

Thank you & good luck

Girls team members:

- مها العمري
- هديل عورتاني
- ريما العنزي
- روتانا خطيب
- لجين عزيز الرحمن
- العنود المفرج
- ريم القرني
- عهد القرين
- العنود المنصور
- مها النهدي
- بلقيس الراجحي
- ميعاد النفيعي
- نورة البسام
- عبير العبدالجبار
- وجدان الشامري
- الجوهرة الشنيفي

Boys team members:

- هشام الشايع
- محمد الحسن
- محمد الصويغ
- محمد المنجومي
- معاذ الحمود
- خالد العقيلي
- عبدالجبار اليماني
- عمر الفوزان
- فهد الحسين
- سعد الهداب
- نواف اللويمي
- انس السيف
- سيف المشاري
- سعود العطوي
- نايف المطيري
- عبدالرحمن العقيلي

together everyone
TEAM
achieves more

Team Leaders:

-مها بركة -طارق العميم