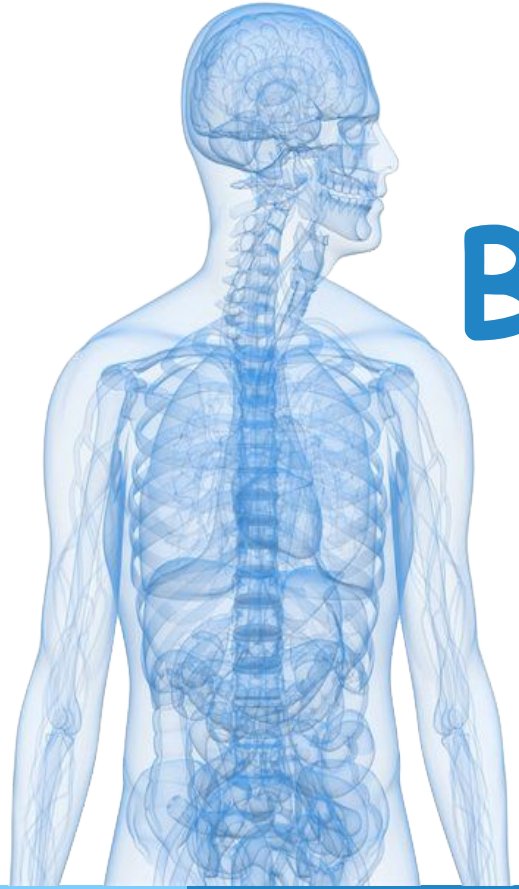
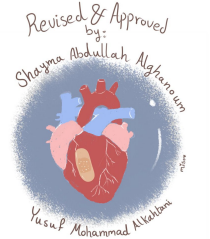


Blood Physiology

Team Leaders:
Haya Alenazi
Abdulrahman Alswat



Red: Important
Black: In Male & Female slides
Blue: In male slides
Pink: In female slides
Green: Notes & extra information

Objectives

-Summarize the synthesis of Hemoglobin and Its structure, functions, types of HB.

-Plasma: Definition, Composition, Ionic Composition of the Plasma, functions of the plasma proteins.

- Discuss the importance of Vitamin B12 & Folic Acid as maturation factors for the RBCs.

-Describe the process of Vit B12 & folic acid absorption and Vit B12 malabsorption.

-Discuss iron metabolism (absorption, storage and transport) .

-Outline the pathogenesis of hereditary spherocytosis

-Anemia: Definition, Symptoms, Causes.

-Recognize causes of polycythemia.

Hemoglobin

Synthesis:

It occurs in the mitochondria of the developing RBC in bone marrow

1- Transferrin attaches to surface receptor.

2-Iron (F2+) is released and transported to mitochondria where it combines with protoporphyrin ring to form heme.

3- Heme combines with α and β protein chains formed on the ribosomes to make hemoglobin

Hemoglobin structure

- Concentration of Hb in the Blood Measured as g/dl (grams per deciliter, or per 100 ml)
- Accounts for more than 95% of protein in RBC.
- It is a Globular protein
- Each Hemoglobin molecule can have 4 Oxygen molecules(O_2)
- consist of 4 chains each formed of
  - Heme
    - iron (F2+)
      - Iron in the heme is ferrous (fe $^{2+}$), combines reversibly with oxygen.
    - protoporphyrin ring
  - polypeptide chain (Globin).

functions:

- Buffer
- Transportation of respiratory gases.
  - - Carriage of O2: Hb reversibly bind O2 to form oxyhemoglobin, affect by pH, temperature,H+
  - - Carriage of CO2: Hb bind CO2 = carboxyhemoglobin

Average values:

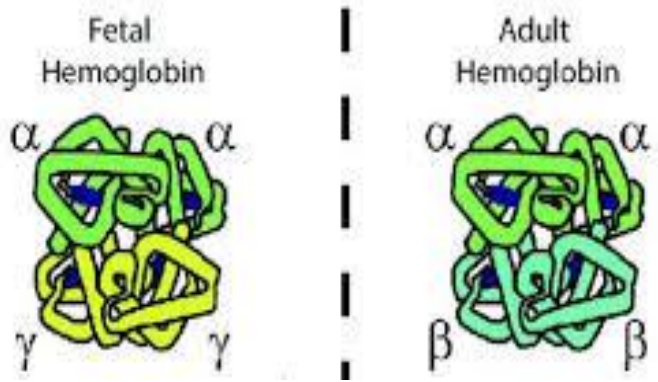
Male:13.5-17.5 g/dl (16 g/dl)

Female: 12.0-15.5 g/dl (14 g/dl)

Infants: 14.0-19.0 g/dl

القيم اللي باللون الأحمر مهمة جدًا

Types of HB



Breakdown :

Globin → protein pool.

Haem → iron (reused).

→ porphyrin is converted to bilirubin.

Jaundice is caused by a buildup of bilirubin, which is a waste material in the blood results from the breaking down of Hb.

Types of Hb

Normal types

Hb-A: Adult hemoglobin (98%) 2 alpha + 2 beta chains

Hb-F: fetal hemoglobin (Hemoglobin of intrauterine life) 2 alpha + 2 gamma chains Has higher affinity for Oxygen than Hb-A

Hb-A2: Hb-A2 (2%) 2 alpha + 2 delta chains

Abnormal types

Thalassemia: Decreased synthesis of globin polypeptide chains. (Hb-A)

Sickle cell anemia: Abnormal sequence of the amino acids in the polypeptide chains.(There is no decrease in synthesis of globin)

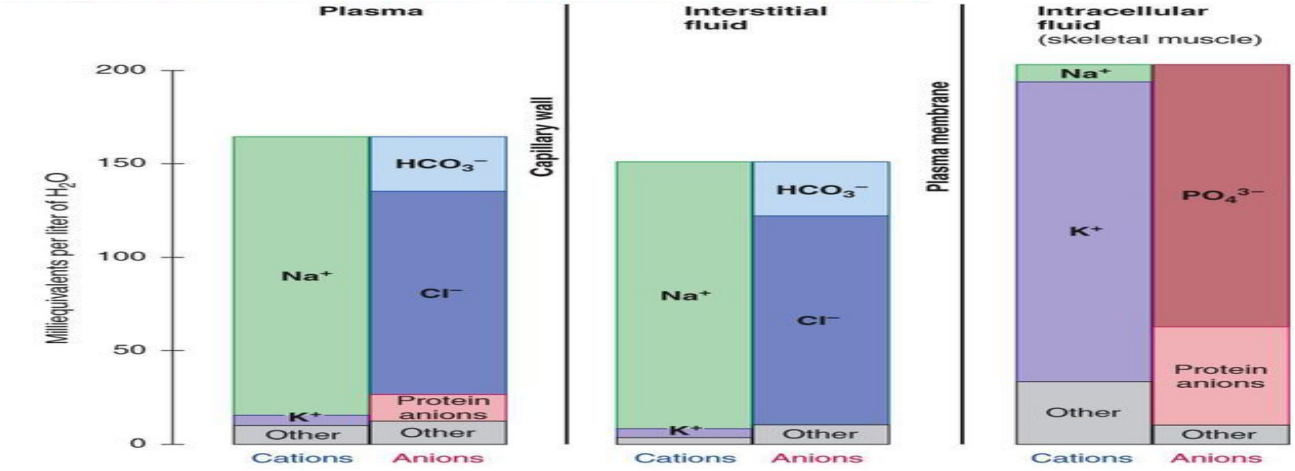
Abnormality in the polypeptide chain leads to an abnormal Hb (hemoglobinopathies).

Plasma

plasma Composition

- **plasma proteins** — 7% — e.g. (Albumin, globulin, Fibrinogen)
- **Water** — 91.5% in male, 98% in female
- other solutes — 1.5%
  - 1- Electrolytes(ions)
  - 2-Organic nutrients and wastes
  - 3-Respiratory gases
  - 4-Vitamins

Serum: plasma minus clotting proteins



Same ionic composition as interstitial fluid.

This slide was found only in male slides

Plasma

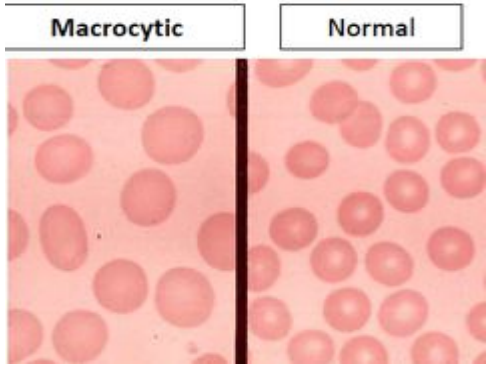
Function	details	Type of the plasma Protein
Generation of plasma colloid osmotic pressure (oncotic pressure)	most capillary walls are relatively impermeable to the proteins in plasma, and the proteins therefore exert an osmotic force of about 25 mm Hg across the capillary wall (oncotic pressure that pulls water into the blood.) Albumin is the most abundant protein in plasma	Albumin
Buffering function of plasma proteins	the plasma proteins are also responsible for 15% of the buffering capacity of the blood.(Hemoglobin had 85% of the buffering power of the blood)	All types of plasma proteins
Plasma proteins function as nonspecific carriers	for various hormones (e.g.,cortisol, thyroxin), other solutes (e.g., iron, cupper), and drugs	Albumin + α Globulins
Defense	Gamma globulins are antibodies	Y Globulins
Blood clotting	-	β Globulins, Fibrinogen Prothrombin

α Globulins	γ Globulins	β Globulins
Transport Protein	-Defensive Protein -Immunoglobulins -Antibodies	Coagulation factor

Vitamin B12 and Folic acid

Importance:
- Final Maturation factors for the RBCs.
-Essential for DNA synthesis.

Manifestations of Deficiency:
-Macrocytic (megaloblastic anemia)
- Abnormal large
- Fragile cells & oval shape.
-Failure of nuclear maturation & division.
-short life span.
-reduced RBC count & Hb.



	Vitamin B12	Folic acid
Origin - source -	Animal sources only (meat, liver,milk,...etc)	Animal and plant sources (meat, liver, fruits, vegetables). Easily destroyed by cooking.
Storge	In the liver in large amounts, enough for around 3 -4 years	In the liver in very small amounts.
Causes of Deficiency	1 – Defective absorption (pernicious anemia). 2 – Defective storage (liver diseases). 3 – Dietary deficiency (very rare).	1 – Dietary deficiency (Important cause). 2 – Defective absorption. 3 – Defective storage (liver diseases).
Absorption	Intrinsic factor is secreted by parietal cells of the stomach to bind vitamin B12 and helps its absorption. Absorption occurs in the terminal ileum, So macrocytic anemia occurs in: 1 – Distal small intestinal diseases. 2 – deficiency of intrinsic factor lead to **malabsorption** of vitamin B12 (Pernicious anemia).	Mainly in the jejunum.

Iron

Total amount in the body =3-5 gm, distributed as follows:

1- Hb (65-75%)

2- storage iron (20-30%) in the liver, spleen & bone marrow (ferritin)(available).

3- intracellular oxidative enzymes(1%)(non-available).

4- transport or plasma iron.Myoglobin (4%)

Sources:

Animal and plant (liver-meat-fruits-vegetables)

Forms:

1-Organic 2-Inorganic

Daily intake:

10-20 mg/day

Iron absorption:

-Absorption mainly in the duodenum.
-Iron must be absorbed in the Ferrous form (Fe^{2+}).

Steps of iron absorption:

1- Iron in food is in the oxidized form (ferric)(Fe^{3+}), to be absorbed it is reduced to the ferrous state (Fe^{2+}).

2-When Ferric reaches the stomach: Ferric $\xrightarrow[\text{Vitamin C}]{\text{HCl}}$ Ferrous

(The function of gastric **HCl** & Ascorbic acid (**vitamin C**) is to convert the Ferric to Ferrous (the absorption form))

3-*Duodenum & upper part of small intestine*:

- Active transport of ferrous ions at the luminal border.

- once in the intestinal mucosal cell iron is attached to a non-ferritin protein carrier & either ;

transported across the serosal border to be picked up by transferrin.

OR

stored as ferritin by combining with apoferritin.

Iron

Rate of ***absorption*** is determined by:

- - the rate of iron loss from the body
- - Size of iron stores
- - Rate of erythropoiesis.

it is regulated by the protein (Hepcidin),

normally 10-15% will be absorbed

Then Iron is ***transported*** in the bloodstream (Plasma) carried on the carrier protein: (Transferrin) " transferrin= apotransferrin+iron "

Factors ***decreasing*** iron ***absorption***:

- Phosphates, phytates & oxalates in diet.

- Achlorhydria (decrease Hcl),gastrectomy.

-Malabsorption syndromes or chronic diarrhea.

Iron ***deficiency***:

Causes:

1 – **Blood loss** (the most important cause).
2 – Dietary deficiency.
3 – Defective absorption.
4 – Defective storage (liver diseases).

Results in blood film:

Microcytic anemia

Iron ***excretion***:

0.5-1.0 mg (faces, skin, urine)
Daily loss of iron is 0.6 mg in male & 1.3mg/day in females

Iron ***storage (1 gm)*** :

Iron is stored in two forms:

1-Ferritin (apoferritin + iron)
1-Hemosiderin (insoluble complex molecule, in liver, spleen, bone marrow)

This slide was found only in female slides

Anemia

Definition:

- Decrease the number of RBC
- Decrease HB
- Oxygen supply to tissues

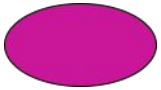
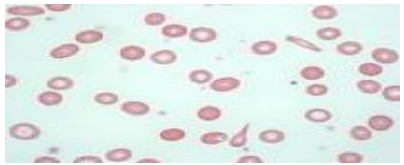
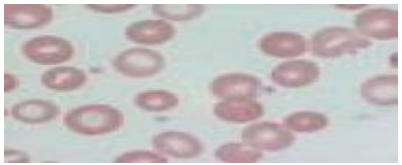
Below the normal level of the same age & Gender

Symptoms - depending on the severity - :

- Pale skin
- Fatigue + Weakness + Tiring easily
- Breathlessness + Racing heart or palpitations
- Postural (orthostatic) hypotension: Drop in blood pressure when standing from a sitting or lying position – this may happen after acute blood loss, like a heavy period
- Frequent headaches
- Becoming irritated easily + Concentration difficulties
- Loss of appetite or Strange food cravings.

This slide was found only in female slides

Types of anemia

Microcytic hypochromic	Normocytic normochromic	Megaloblastic or macrocytic
		
		
- microcytic = smaller size - hypochromic = less hemoglobin - increased zone of central pallor - anisocytosis = variation in size -poikilocytosis= variation in shape	- Normal HB - normal RBCs' size. - Decreased number Of RBCs	- The hypersegmented neutrophil and also that the RBC are almost as large as the lymphocyte. - There are fewer RBCs.

This slide was found only in female slides

Full Blood Count (FBC)

- MCV (Mean Corpuscular Volume)
  - The MCV shows the size of the red blood cells.

$$MCV = \frac{Hct}{RBC}$$

- MCH (Mean Corpuscular Hemoglobin)
  - The MCH value is the amount of hemoglobin in an average red blood cell.

$$MCH = \frac{Hgb}{RBC}$$

This slide was found only in female slides

Anemia

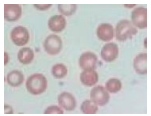
Blood loss " bleeding "

Acute

Accident

RBCs return to normal 3-6 W

normocytic normochromic

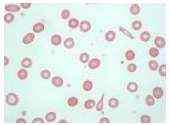


chronic

Iron deficiency anemia

- Menstruation
- GIT bleeding (peptic ulcer- Bilharziasis- piles-hookworms).

Microcytic hypochromic

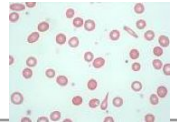


Decreased RBCs production

Nutritional deficiency

Iron deficiency

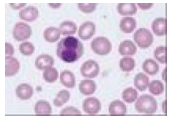
Microcytic hypochromic



Vit. B12 & folic acid deficiency

Pernicious anemia:

is a special type of megaloblastic anemia due to intrinsic factor deficiency causing vit B12 deficiency.



Increased demands

(childhood & pregnancy)

Bone marrow failure

Aplastic anemia

- irradiation or excessive X-ray usage.
- invasion of bone marrow by (secondary cancer cells or fibrosis).
- drugs e.g. chloramphenicol

Destruction of RBCs

Haemolytic anaemia

Abnormal Cells (membrane defect)

spherocytosis

Abnormal Hb

(Hb-S) = Sickle cell anaemia

Incompatible blood transfusion

Erythroblastosis fetalis

Enzymatic defect

glucose 6 phosphate dehydrogenase deficiency (G6PD)

- It's inherited condition
- The body doesn't have enough of the enzyme G6PD, which helps (RBCs) function normally.

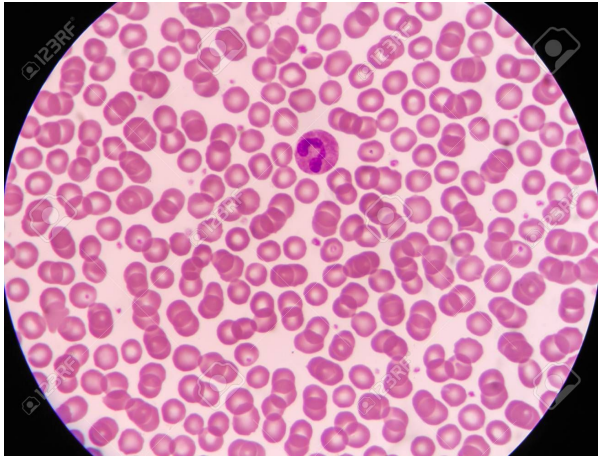
Clinical correlation

Hereditary Spherocytosis

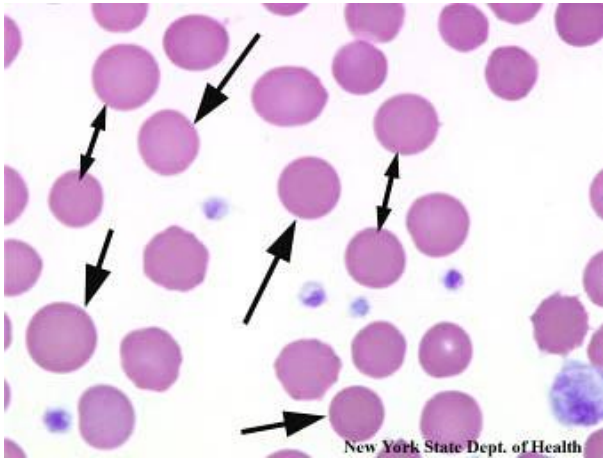
Cause	Manifestation	On blood film
Congenital deficiency of the protein spectrin.	Anemia + spherical RBCs instead of the normal biconcave shape.	Loss of central pallor. Maybe polychromasia.

This slide was found only in male slides

Normal RBC



Spherical RBCs



Polycythaemia

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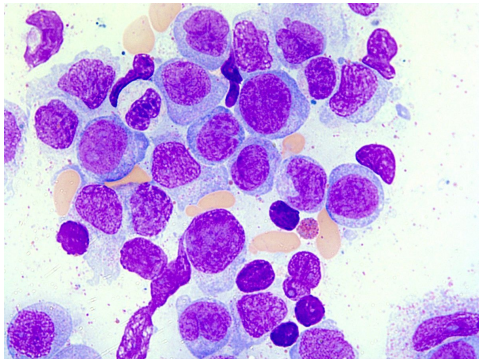


Definition:

Increase in the number of RBCs per unit volume of blood

Classification & Causes

- **Relative**
  In cases of dehydration
  (haemoconcentration)
  - decrease in the volume of plasma
- True or absolute
  - Primary (polycythaemia Rubra vera - PRV)
    يسمى برايمري لأن ما فيه سبب أدى للزيادة
    - More in female
  - Secondary due to hypoxia
    يسمى سكندري لأن بالبداية تحدث الهايبوكسيا وبعدها يحدث زيادة في إنتاج RBCs

Hypoxia: deficiency in the amount of oxygen reaching the tissues

QUIZ!

MCQs

Q1: The average amount of hemoglobin in **Male** :			
A) 5	B) 13	C) 16	D) 19
Q2: **Hb-F** found in :			
A) Male	B) Female	C) Adult	D) Fetal
Q3: The type of plasma protein that generate **osmotic pressure :**			
A) albumin	B) α Globulins	C) γ Globulins	D) β Globulins
Q4 : Congenital deficiency of the protein **spectrin** will cause:			
A) Hypoxia	B) Hereditary Spherocytosis	C) Pernicious anemia	D) megaloblastic anemia

SAQ

Q1: what are the main causes of deficiency Vitamin B12?

Q2: **Hemoglobin** molecules consist of:

MCQs key answer :
1) C
2) D
3) A
4) B

SAQ answer key :
1)A-Defective absorption
B-Defective storage

2)4 chains each formed of (Heme) and polypeptide chain (Globin).

QUIZ!

MCQs

Q5: which type of Anemia has RBC's are **smaller** than normal?			
A) MACROCYTIC ANEMIA	B) MICROCYTIC HYPOCHROMIC ANEMIA	C) Megaloblastic Anemia	D) Macrocytic Anemia
Q6: The **haem** is breakdown into :			
A) Iron	B) Globin	C) Vitamin B12	D) folic acid
Q7: **Increased demands** of RBCs - like during childhood & pregnancy - will lead to :			
A) Increased RBCs production	B) Destruction of RBCs	C) Blood less	D) Decreased RBCs production
Q8 : Daily loss of iron In **Female** is :			
A) 1.3	B) 0.6	C) 0.3	D) 1.6

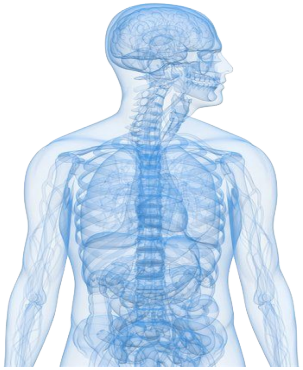
SAQ

Q3: what are the **symptoms** of Anemia? - Only 2 -

Q4: What Are the Classification of **Polycythaemia**?

MCQs key answer :
5) B
6) A
7) D
8) A

SAQ answer key :
3) Pale skin
- Fatigue + Weakness + Tiring easily
- Breathlessness + Racing heart or palpitations
4) 1- Relative. 2- True.



Thank You

Team members:

- ماجد العسكر
- مشعل الثنيان
- عبدالعزيز الربيعة
- باسل فقيها
- محمد بياري
- محمد السلمان
- عبدالرحمن الدويش
- مرشد الحربي
- منيب الخطيب
- نايف الشهري
- فيصل العمري
- عبدالعزيز الغليقة
- عبدالعزيز السحيم
- حصة العليان
- شذى الظهير
- سمو الزير
- نورة الشثري
- سارة القحطاني
- ريناد الحميدي
- ياسمين القرني
- يارا الزهراني
- لمى الأحمدي
- آلاء السلمي
- سارة العيدروس
- بدور المبارك
- فرح البكر
- سارة العبيد

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- Made by

Contact info:physiology439@gmail.com

Editing file

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