BLOOD PHYSIOLOGY (1+2) Control of Erythropoiesis, Iron Metabolism and Hemoglobin (3)

Red: very important.
Green: only found in males' slides.
Purple: only found in females' slides.
Gray: notes.

Physiology Team 436 – Foundation block lectures 8+9+10

Lecture: If work is intended for initial studying.
Review: If work is intended for revision.

Objectives

- Describe : physical and chemical characteristics of blood
- Describe: Cellular and non-cellular blood components
- Describe: different stages of RBC differentiation.
- Describe: features of RBC maturation
- Describe: regulation of RBC production and erythro-poietin hormone secretion in response to hypoxia.
- Describe: essential elements needed for RBC formation
- Describe: the process of Vitamin B12 absorption and its malabsorption.
- Describe: the fate of old RBC.
- Describe: anemia and its causes
- Recognize: blood functions.
- Recognize: clinical conditions associated with high level of erythropoietin in the blood.
- Recognize: sites of RBC formation at different developmental age.
- Recognize: the causes of polycythemia.
- Define: Erythro-poiesis; leuco-poiesis, thrombo-poiesis.
- Recognize: hemoglobin structure and its functions.
- Discuss: Iron metabolism (absorption, storage and transport).
- Describe essential elements needed for RBC formation.
- Describe the process of Vitamin B12 absorption and its malabsorption .
- Recognize hemoglobin structure and its functions .
- Discuss iron metabolism (absorption,storage and transport) .
- Describe the fate of old RBC .
- Describe anemia and its causes .
- Recognize causes of polycythemia .
- Understand steps of erythropoiesis & its regulation .

Blood Composition

1.Cellular components:

- Red Blood Cells(Erythrocytes)
- White BloodCells(Leucocytes)
- Platelets (Thrombocytes)

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

Erythrocytes
Red blood cells

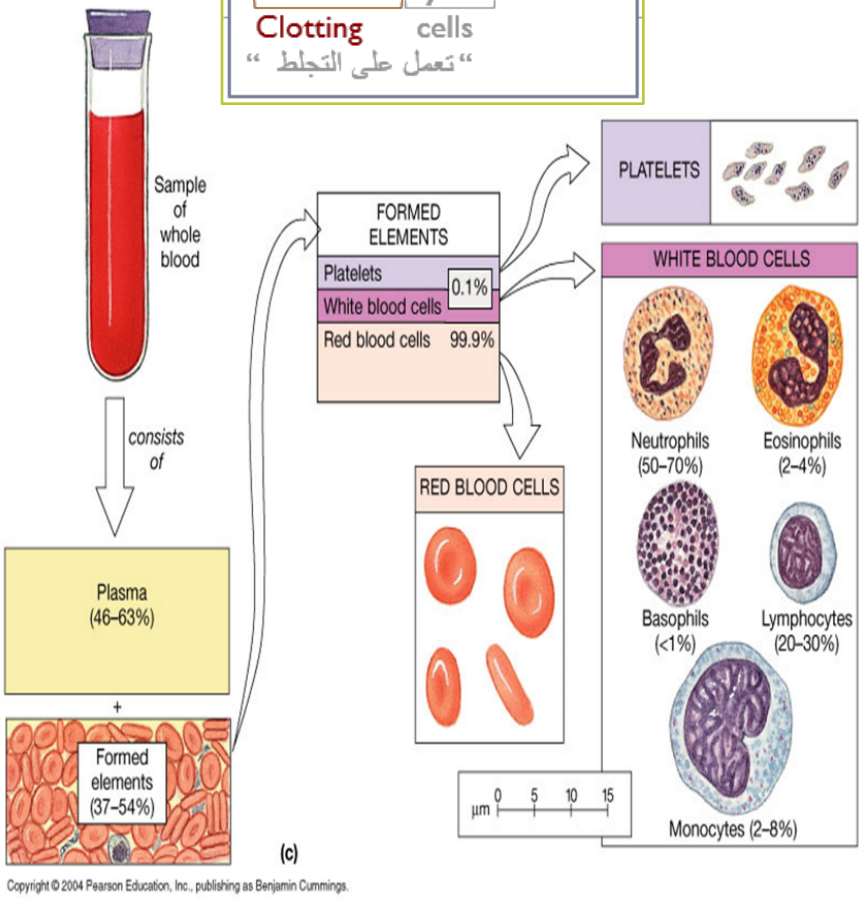
Leucocytes
White cells
Blood

Thrombocytes
Clotting cells
" تعمل على التجلط "

2. Plasma (ECF):

- **98% water + ions** + plasma proteins e.g. (Albumin, globulin, Fibrinogen)

- #notice: it's the same ionic composition as interstitial fluid. (Na, K, PO4, etc)



Note: in males' slides water is 92%, ions are 7%, and proteins are 1%

Characteristics of Blood

Viscosity	• 3-4 times than Water. • Blood relative viscosity: (4-5) mainly depends on the numbers of RBC. • Plasma relative viscosity: (1.6-2.4) is mainly involved in plasma protein.
pH	• Slightly alkaline, with a pH of 7.35-7.45. • It has a salty metallic taste and is Sticky. • Hb acts as blood buffer.
Temperature	• about 37C (slightly higher than normal body temp).
Color	• Bright red = O2 rich; • Dull red = O2 poor
Osmolarity	• Plasma osmolality is about 300 mmol/L (Equal to 0.9% NaCl Solution=Isotonic).
Regeneration	• Tremendous regenerative capacity.

Characteristics of Blood

Plasma osmotic pressure:

- Is 300 mmol/L or 770kPa
- **Crystal osmotic pressure**: results from NaCl and modulates water distribution between inside and outside cells.
- **Colloid osmotic pressure**: results from albumin and regulates water distribution between inside and outside of capillaries.

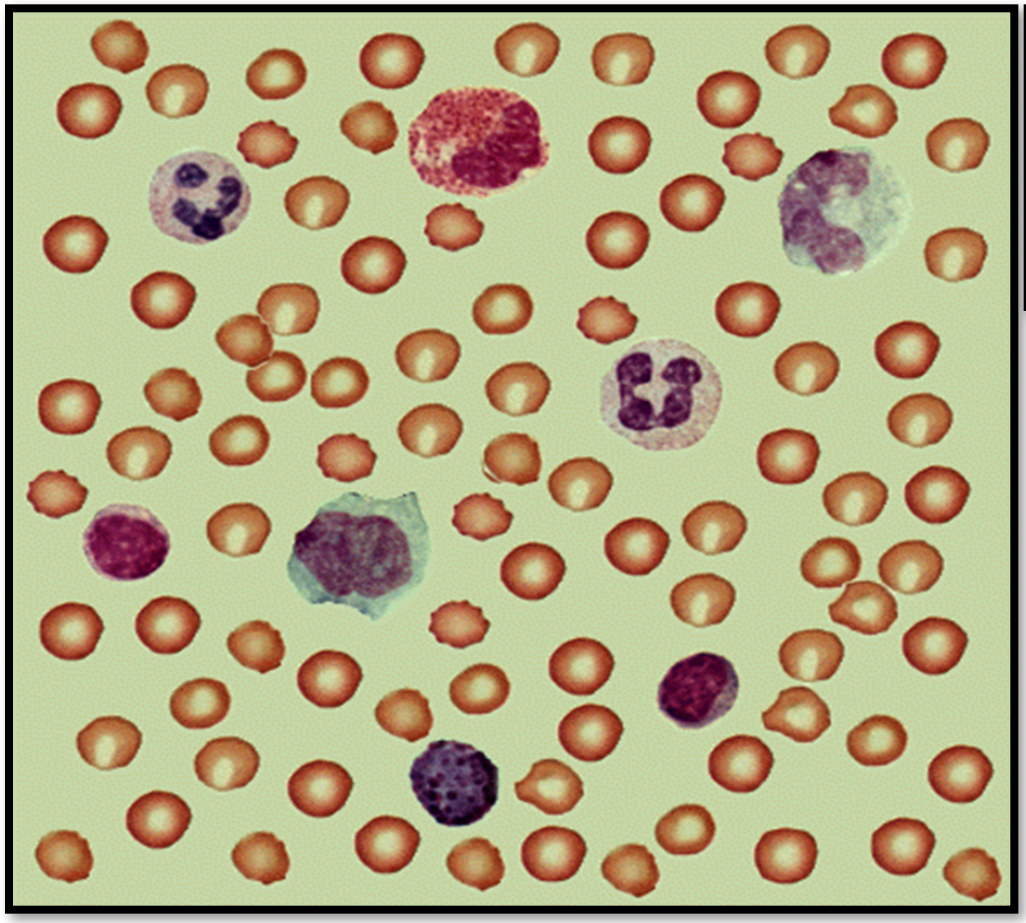
Specific gravity:

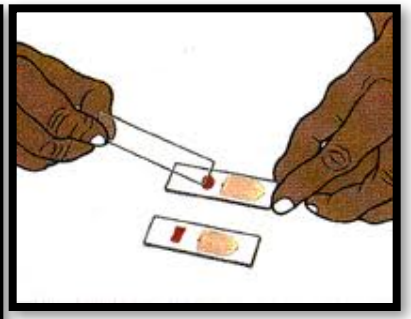
- Total blood: (1.050-1.060) more influenced by RBC.
- Plasma: (1.025-1.030) more influenced by plasma protein.
- RBC: (1.090-1.092) more influenced by hemoglobin.

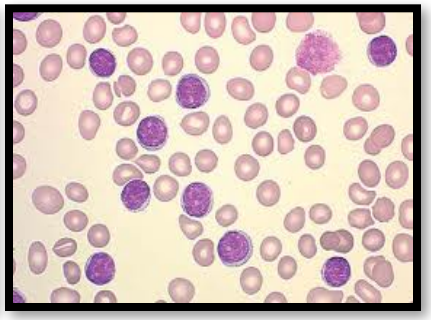
Erythrocyte sedimentation rate (ESR)

- It the red blood cell descending distance per hour.
- Normal male 0¬15mm/h.
- Normal Female 0¬20mm/h.

Blood Film







نقطه دم نضعها على الشريحه الأولى ثم نحضر شريحه أخرى ونسحب الدم قليلا (مثل المناكير لما تسحبينه بالفرشه).

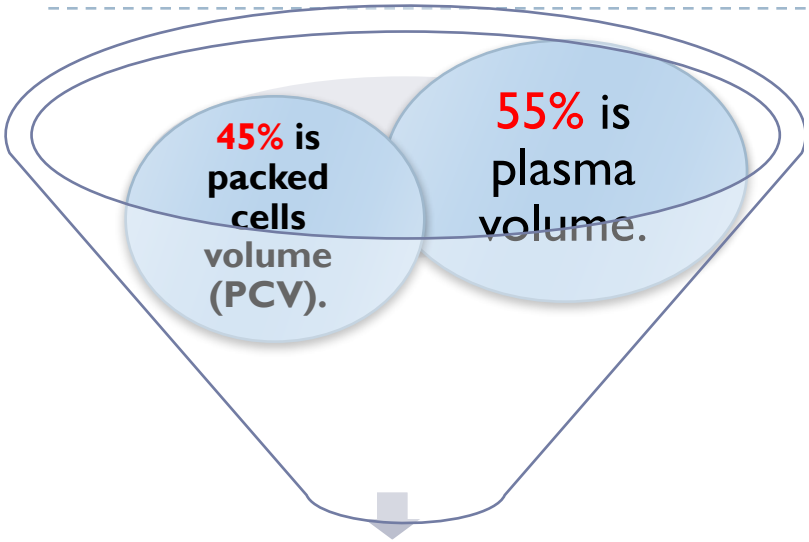
نستفيد من الـ Blood Film:

القدرة على معرفة لو كان هناك انيميا او لا وشكل الـ Cells

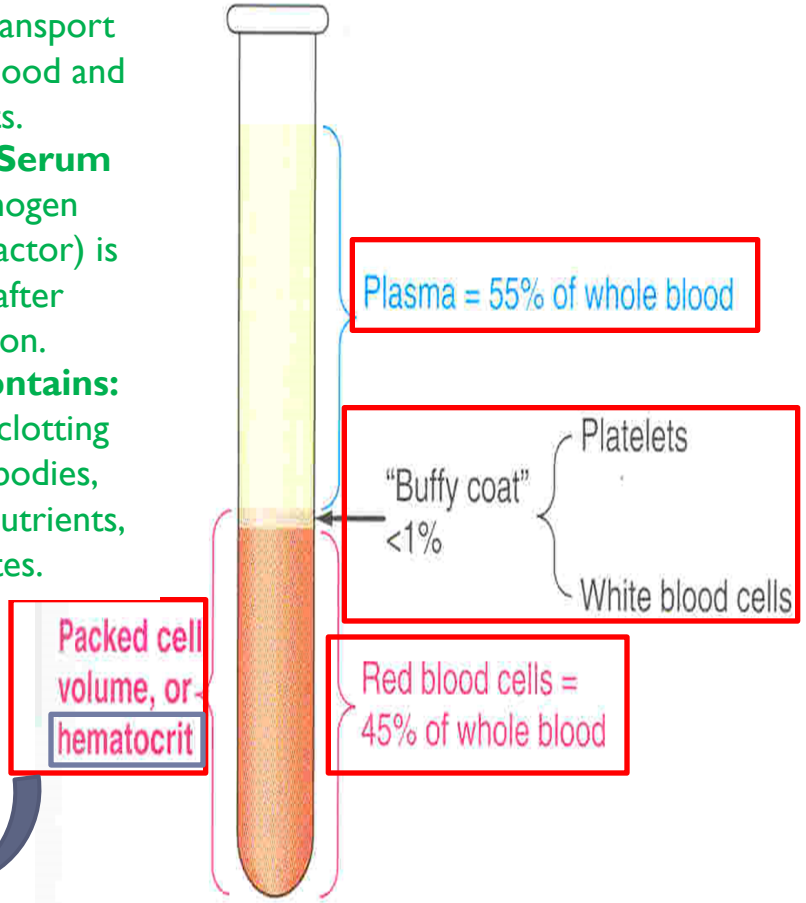
ونستطيع أيضا أن نرى الـ White blood cells وكم عددها.

Blood Volume

The volume of blood cells in a sample of blood after it has been *centrifuged (separation of contents).*



Plasma: Straw colored liquid that serves as a transport medium for blood and platelets.
It is called **Serum** when fibrinogen (coagulating factor) is removed after coagulation.
Plasma contains: Electrolytes, clotting factors, antibodies, blood gases, nutrients, and wastes.



- Males => 5 to 5.5 L
- Females => 4 to 4.5

Because females lose every month half a liter of blood due to menstruation

Ratio of the volume of red blood cells to the total volume of blood.
يساعدنا في التشخيص أشياء كثير زي الانيميا.

Functions of the Blood

1. **Transport**
   - **Respiration:** O2, CO2
   - **Trophic:** nutrients to the tissue
   - **Excretive:** waste products (metabolites) from tissues to excretory organs
   - **Regulative:** hormones
2. **Homoeostasis**
   - **Regulation of:**
     1) Body temperature **by redistributing blood between skin and internally**
     2) ECF pH
3. **Protecting against Infections:** White Blood Cells, Antibodies
4. **Blood clotting: to prevent blood loss**

- Waste product ex) Urea (creatinine) + product for any metabolism process .
- Homoeostasis => Keeping the internal environment constant [او راح تموت الخليه]
- Blood stop
- Hemostasis => Stopping of the flow of blood [stop bleeding]

Formation of Blood Cells: Haemopoiesis

Erythro-poiesis:

Formation of RBC (erythrocytes)

Erythropoiesis
RBC formation " تصنيع "

Leuco-poiesis:

Formation of WBC (leucocytes)

Thrombo-poiesis:

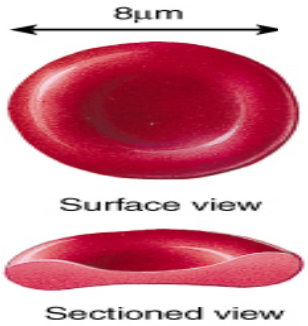
Formation of platelets (thrombocytes)

* Note: Active cellular marrow is called red marrow; inactive marrow that is infiltrated with fat is called yellow marrow.

Thrombopoiesis
Clotting formation
cells

Cyte: Mature cell
Blast: Still not mature cell

Red Blood Cells (RBCs)



الوحدات غير مهمه .مو مهم نعرفها لما تجي بالاختبار يجيبون كل الخيارات نفس الوحده.
لكن الارقام حفظ.

Functions

- Transport of: O2 and CO2
- Buffer (keeps pH level at 7.4)

لان الدم فيه هيموجلوبين فهو يحاول يوازن الـ pH

Shape & Size

- **Flat Biconcave Disc** لزيادة مساحة السطح.
- **Non-nucleated**
- **No mitochondri**

وجود النواة في ال RBCتلزم في حالة تصنيع البروتين (الهيموجلوبين), و"بعد النضج التام "تختفي النواة لتنقل أكبر كمية **من الاكسجين** – على **الهيموجلوبين**- وبكفاءة اعلى.

- **Flexible**
- **Diameter 7-8µmx2.5µmx1 µm.**
- **Average volume 90-95 µm3**
- **Number = 4.7 - 5 x106**
- **Hb = 14-16 g/dl in the blood**
- **It is negatively charged**

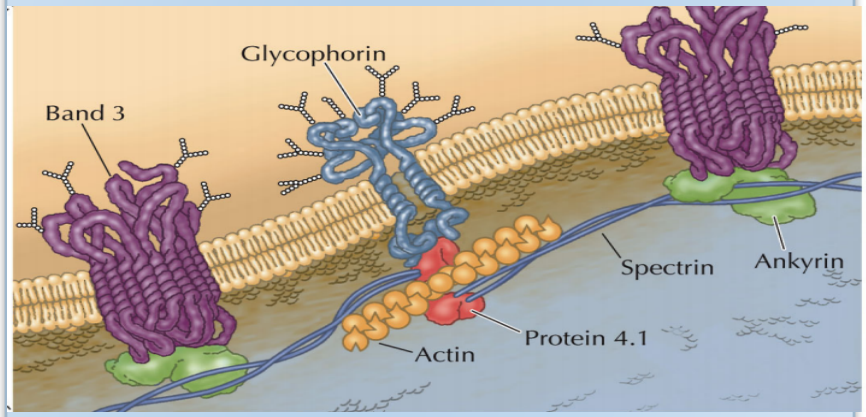
هذا عند الـMales
عند الـ Females أقل بسبب الدورة الشهرية.

ثلاث مزايا بشكل الـRBCs مهمه جداً :

1. **Flexible** so it can go through the capillaries.
2. **Flat biconcave** is the best shape to let the gases exchange easily.
3. **Storage**: the shape of the RBCs can store big amounts of RBCs so it allows more gas exchange.
زي اثاث ايكيا

Red Blood Cells Cytoskeleton

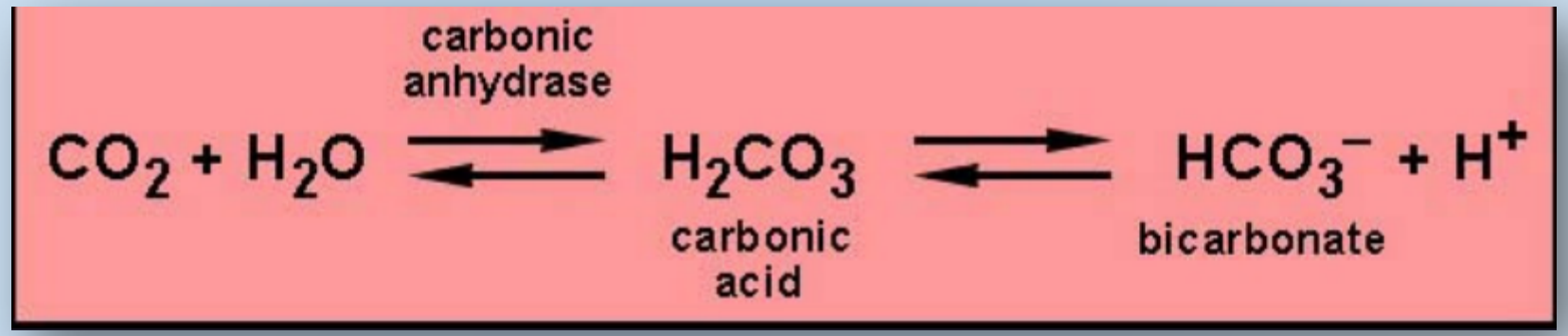
- **Skeletal protein network**
- • Spectrin
- • Actin
- • Ankyrin
- • Tropomyosin
- • Proteins 4.1 and 4.9



- The red cell, as it continuously circulates, must be able to undergo extensive passive deformation and to resist fragmentation. These two essential qualities require a highly deformable yet remarkably stable membrane. Blood cells that lyse(breakdown) without difficulty at low ionic strength are a sign of **Hereditary Spherocytosis.**

RBCs Enzyme- Carbonic Anhydrase

- Carbonic anhydrase is an enzyme that catalyzes the reversible reaction between carbon dioxide (CO2) and water to form carbonic acid (H2CO3), increasing the rate of this reaction several thousand fold. It plays **a major role in CO2 transport.**

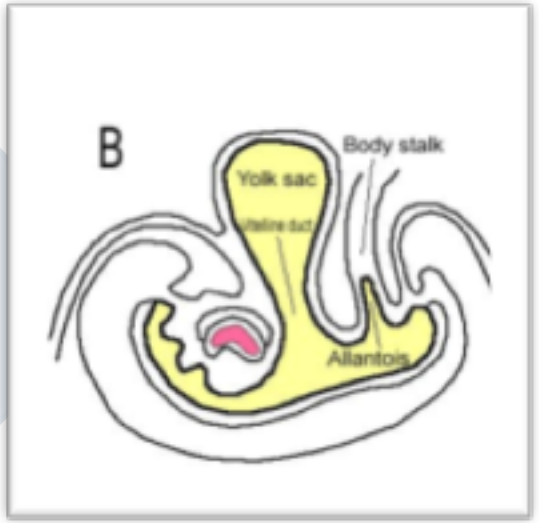


Production of RBCs

RBCs are only nucleated in fetus

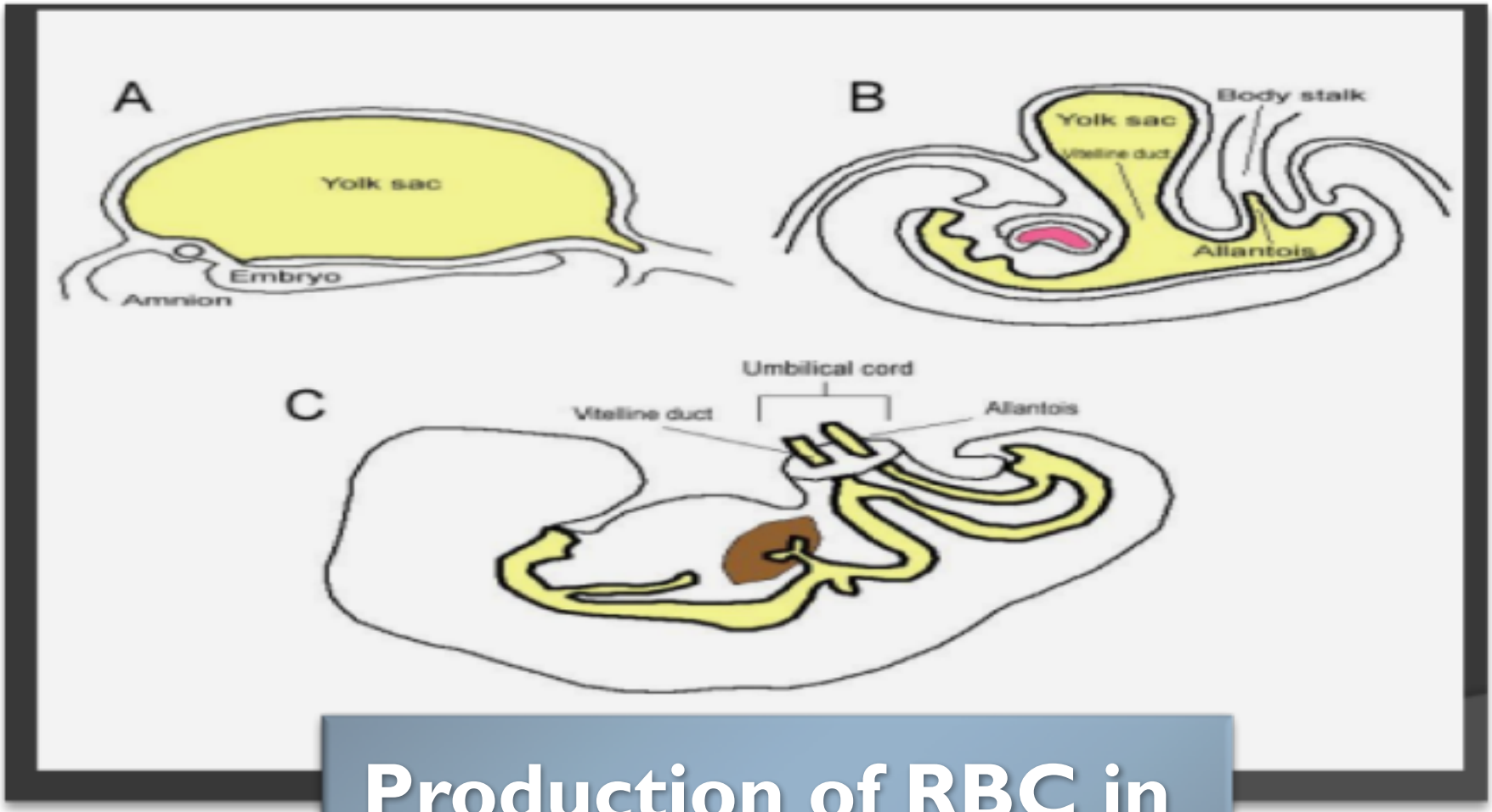
In-utero:

- **Early few weeks (1st 4 months) : embryo nucleated RBCs are formed in yolk sac. (nucleus is needed for division)**
- **Middle trimester: mainly in liver & spleen & lymph nodes.**
- **Last months: RBCs are formed in bone marrow of all bones**



After Birth:

- **Bone marrow of flat bones (e.g. scapula, skull,..) continue to produce RBC into adult life.**
  In children: all bones produce RBCs until 5 years old.
  Shaft of long bones stop producing RBC at puberty while epiphysis continues.
- In adults: after 20, membranous bones such as vertebrae, sternum, ribs, and ilia produce RBCs



Production of RBC in utero

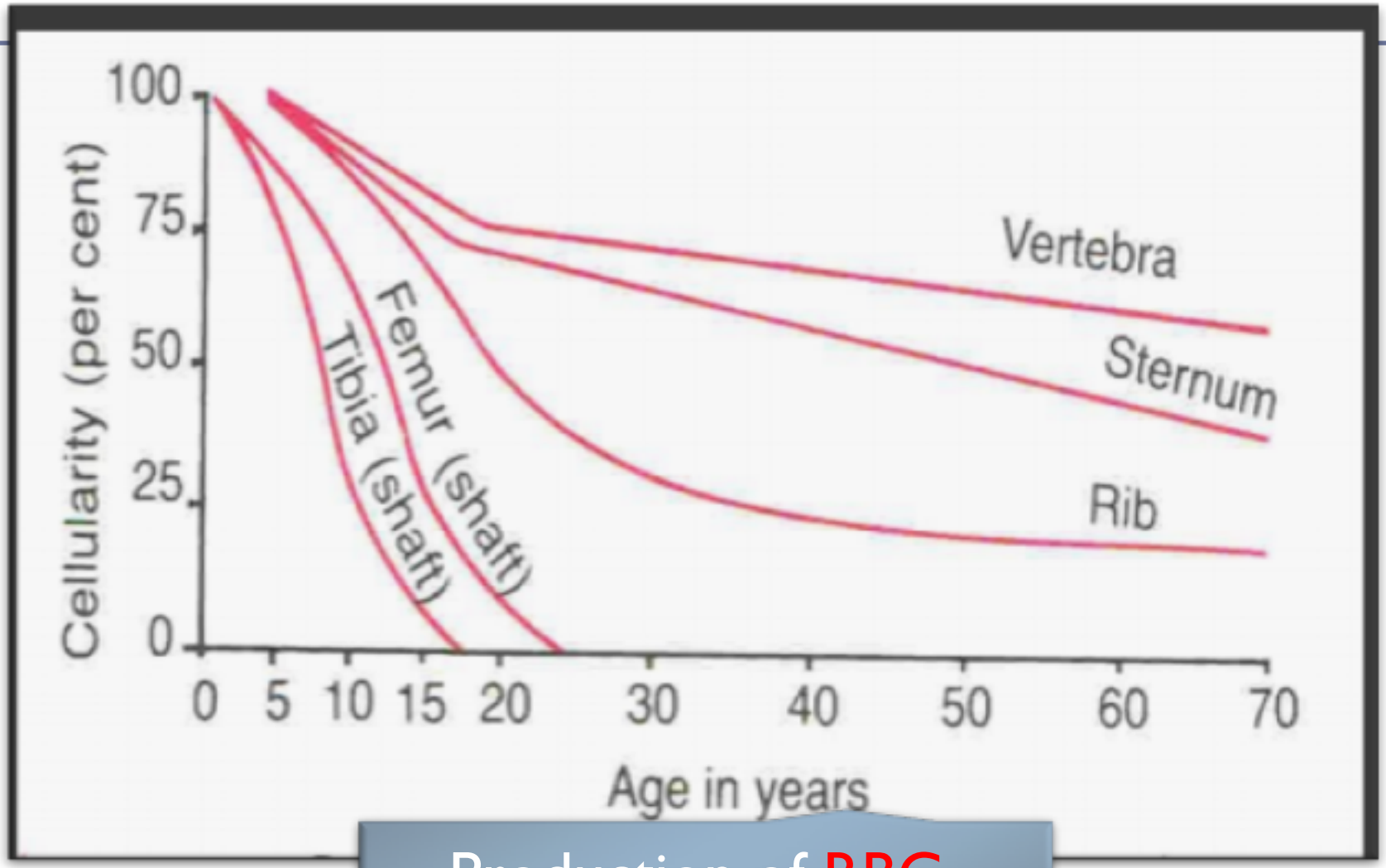
Normal bone marrow conversion

Note: Children need **RBC** more than adults for their growth.

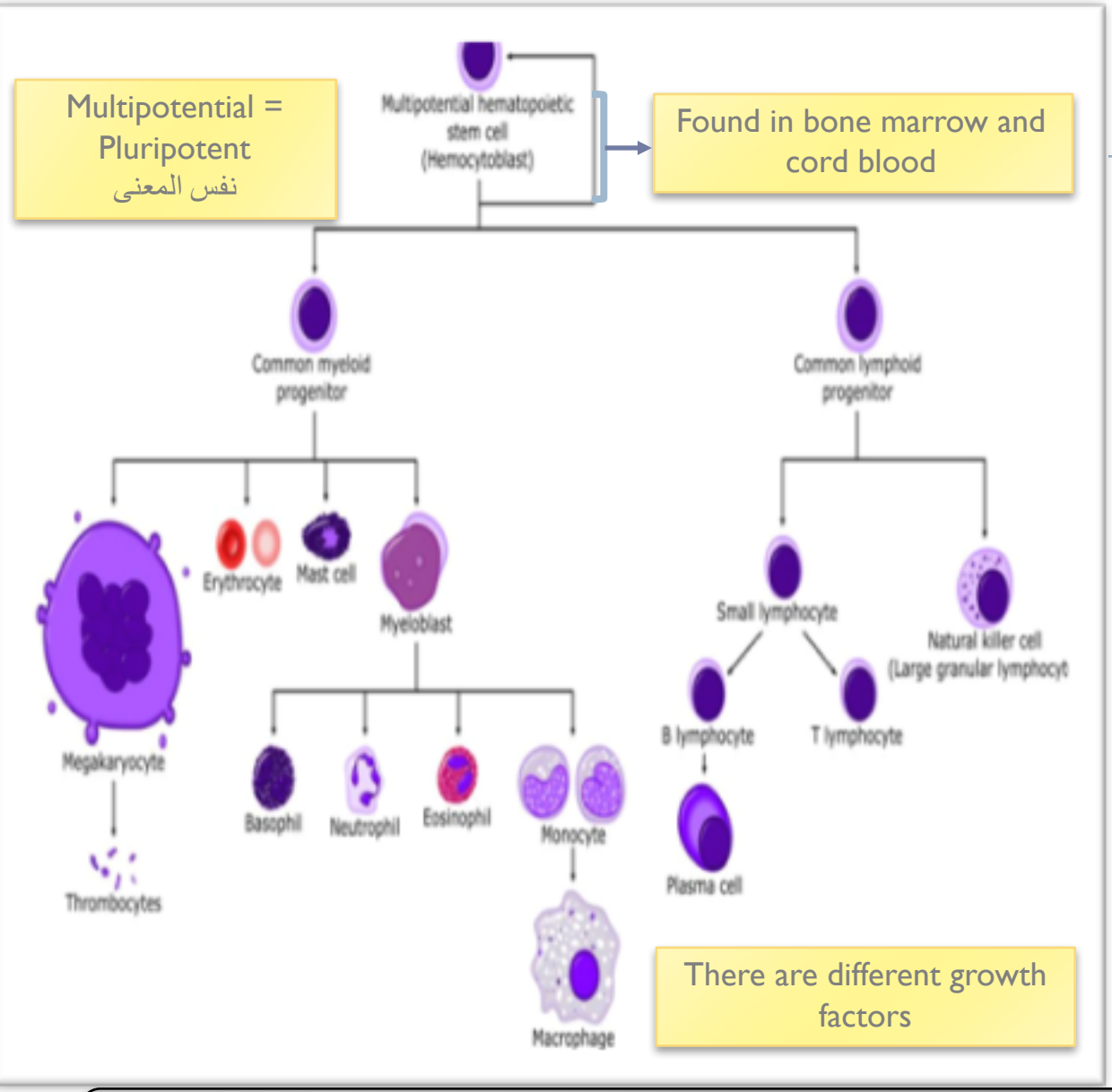
As mentioned in the previous slide: (After birth)

-Flat bones (Sternum, Ribs) and the Vertebras (Irregular bones) **continue** to produce RBCs.

-Shafts of long bones (Femur, Tibia) **stop producing** RBCs after puberty.



Production of RBC



شرح محتوى الصورة:

All blood cells are formed from **(stem cells)**

stem cells have two paths:

1- First Path:

" myeloid" ➡ that forms RBCs + some types of WBCs +

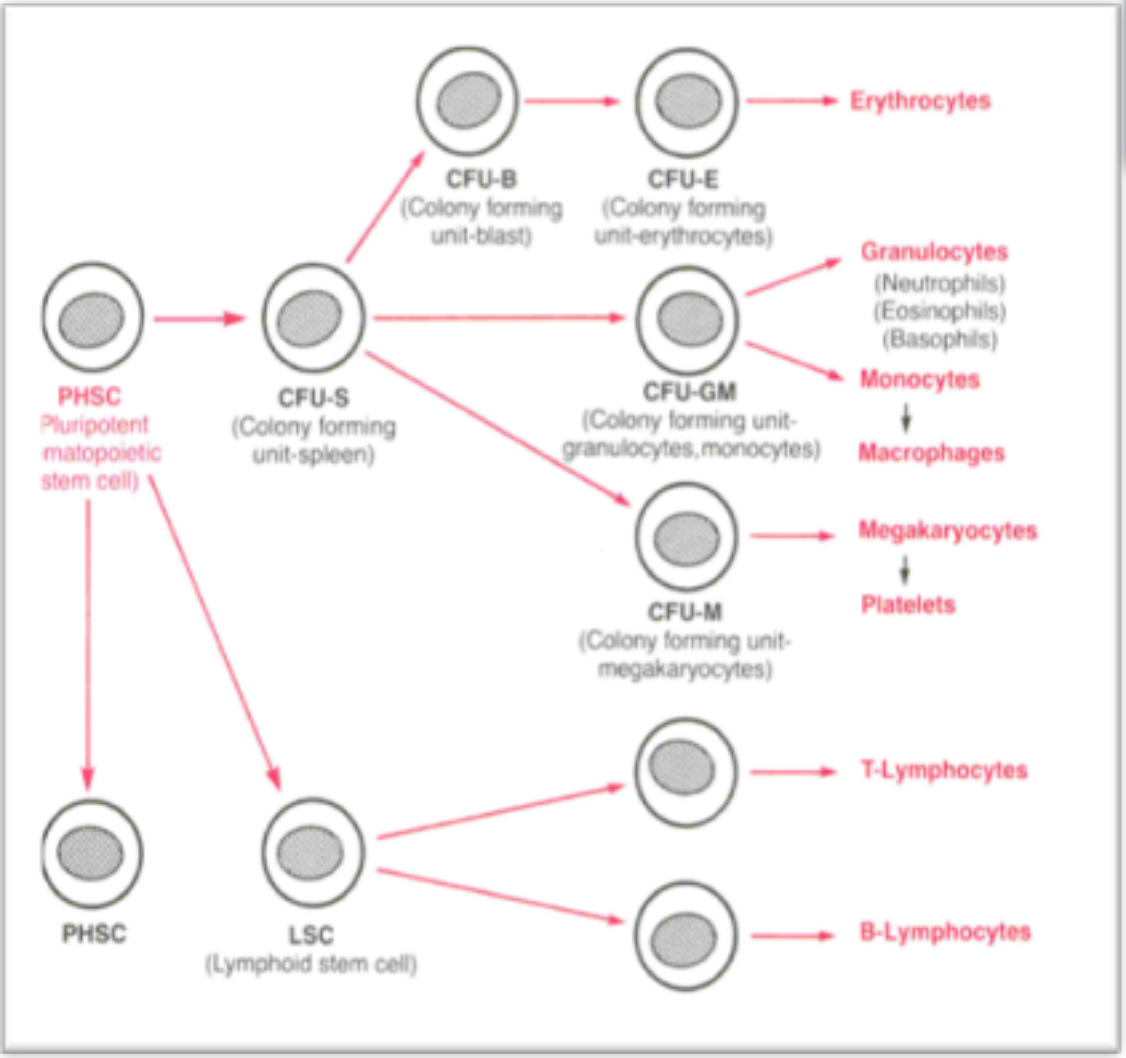
2-Second Path:

" lymphoid" ➡ that forms lymphocytes (another type of WBC)

Lymphocytes are always special ;)

Note: Stem cells can differentiate into a lot of different cells. Myeloblast gives white blood cells.

Genesis (Production) of RBCs



Pluri-potential hemato-poietic stem cells: give rise to (create) all the other blood cells

committed cells

- **Committed stem cells for RBC**
- **Committed stem cells for WBC**

Growth of different stem cells are controlled by different growth factors

Note

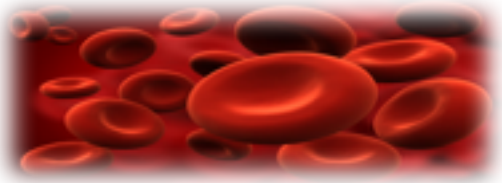
Colony-Forming Unit CFU:

cells produce colonies of their own type

Stages of RBCs Differentiation (development): 7 Days

- Committed stem cell:
- **Proerythro-blast** (first identifiable cell)
- **Basophil erythro-blast**
- **Poly-chromatophil erythro-blast**
- **Ortho-chromatic erythro-blast**
- **Reticulocytes (loses nucleus)**
- **Mature erythrocytes**

In cases of rapid *fast* RBC production → ↑ reticlocytes in the circulation



Reticulocytes: First cell to appear in Circulation Matures in 24-48 Hours.
Contain remnants of the Golgi apparatus & mitochondria.

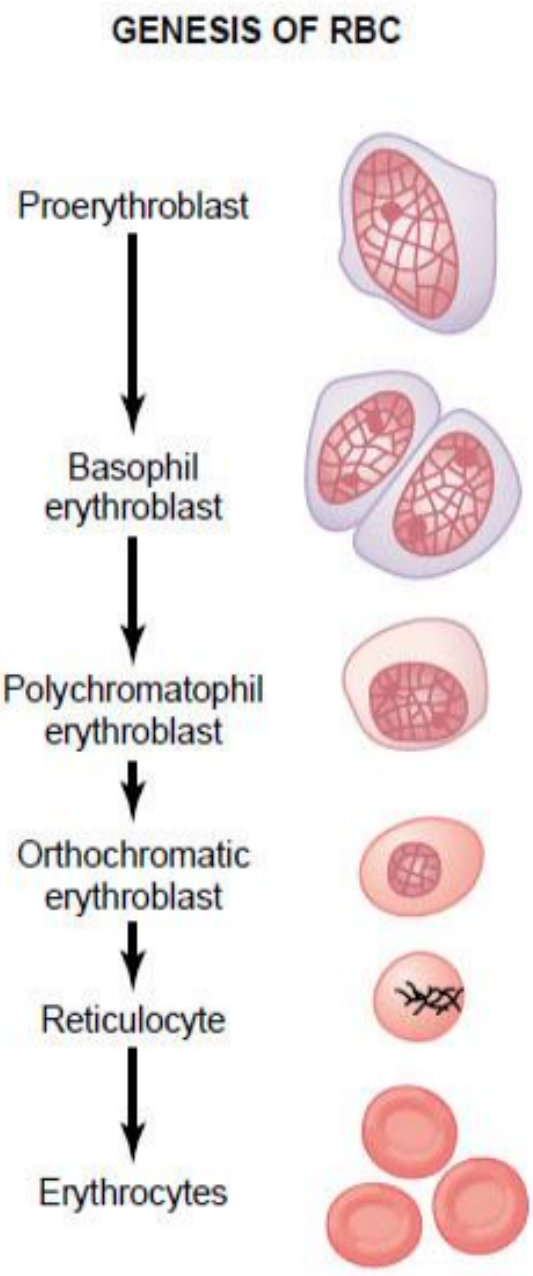
Note: RBC goes into stages to get its concave structure, **Reticulo-cyte** is the stage where the cell loses its nucleus and is covered by a net.

Erythro-poiesis

RBC development is characterized by

- **Decrease (Reduction)** in cell size.
- **Disappearance** of nucleus.
- **Appearance (Aquisiton)** of hemoglobin (Hb)

تختفي النواه عشان الهيموجلوبين
حل محل النواة



Memorize steps and shapes in the figure.

Regulation of RBC Production

- **Erythro-poiesis**
- **stimulated by: erythro-poietin hormone**

(which is produced by: the kidney in response to hypoxia (low oxygen in the blood)

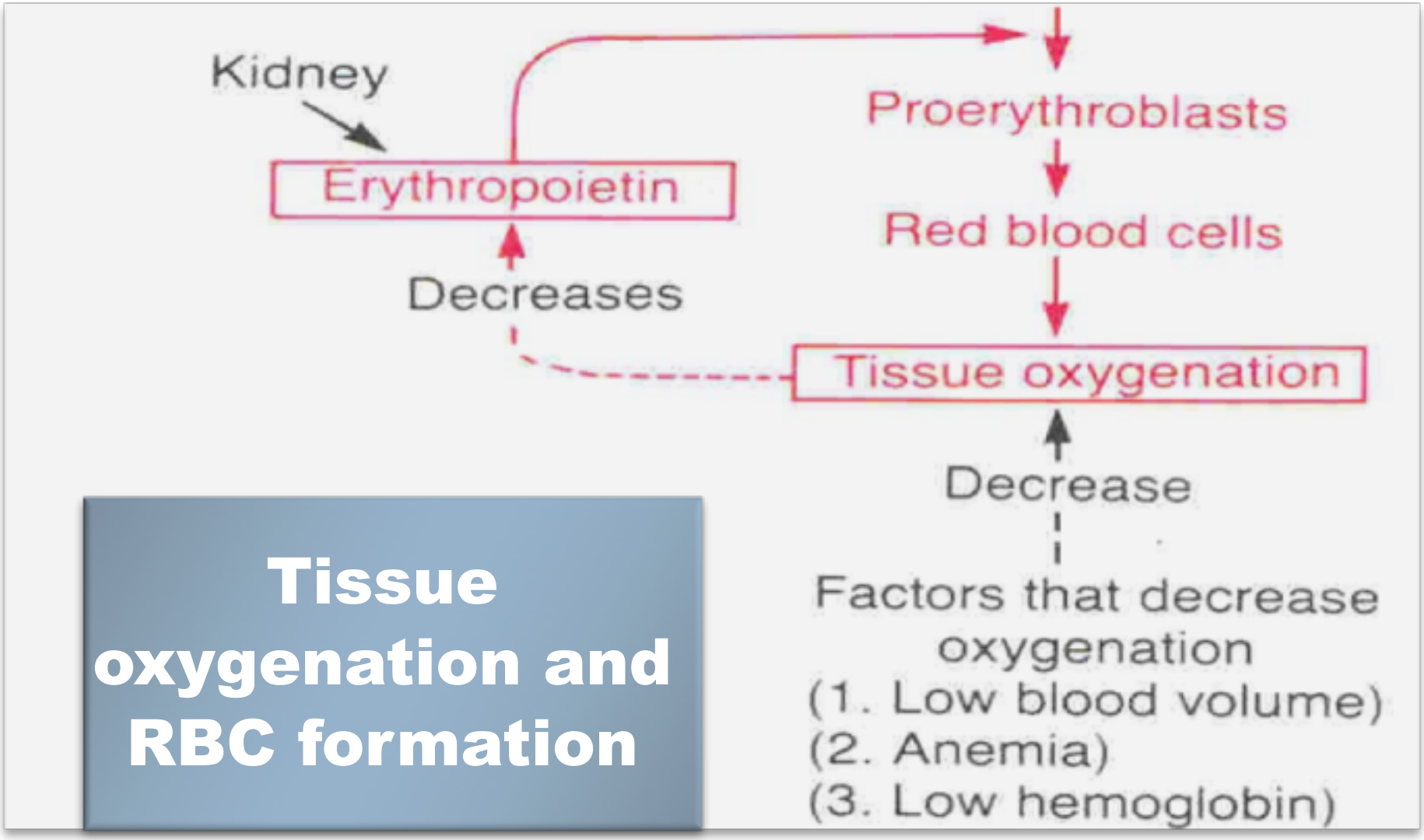
لما يكون مستوى الاوكسجين في الدم قليل (وهذا يسمى hypoxia) تروح الـ kidney تفرز هرمون اسمه Erythropoietin عشان توازن الـ Erythropoiesis

Causes of Hypoxia

الجو مافيه اوكسجين كثير زي فوق الجبال

القلب مايقدر يوزع الدم

- Low RBC count (Anaemia)
- Hemorrhage (نزيف)
- High altitude
- Prolong heart failure
- Lung disease



Tissue oxygenation and RBC formation

Erythro-poietin (Hormone)

- **Glycoprotein**
- 90% from renal cortex (kidney)
- 10% from the liver.
- **Stimulate**: the growth of early stem cells.
- **Does not affect**: maturation process of RBCs.
- **Can be measured** in plasma & urine.

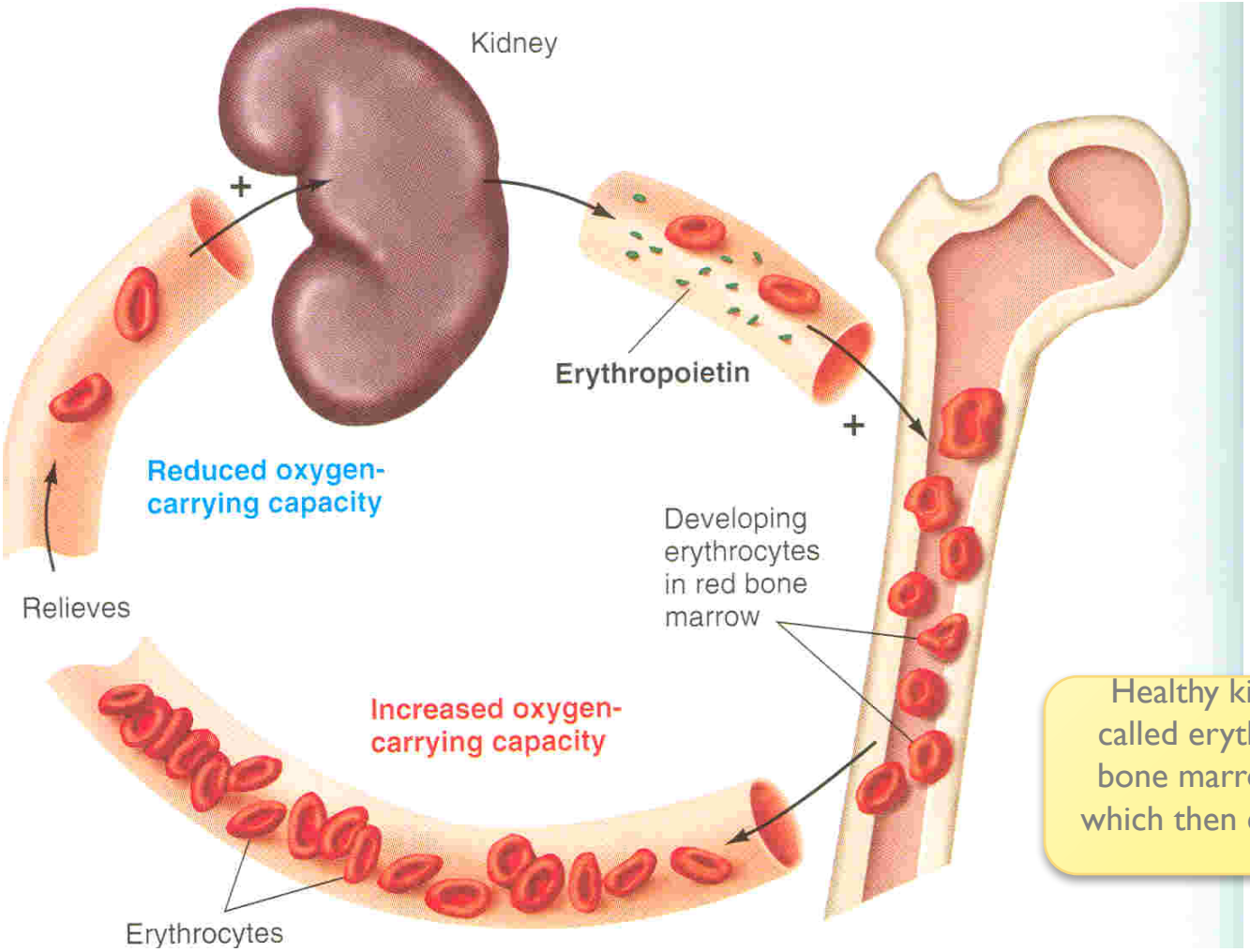
- Conditions like: **anemia, High altitude, Heart failure, Lung Disease** result in:
- **High erythropoietin levels**
  polycythemia

Polycythemia = RBCs level is up
Erythropoietin => works when RBCs level is down

أي كلمه تنتهي بمقطع mia
معناها زياده

The hormone controls the early stages of RBC formation (production of proerythroblasts from stem cells), not the middle or last stages, so erythropoietin makes the cells pass more rapidly through the erythroblastic stages and can increase it to 10 or more times than normal.

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.

Kidney stimulate the production of Erythropoietin

Essential Elements for Formation and Maturation of RBCs

ملاحظة للفهم:

Hemo-globin: Heme: iron. Globin: protein

Other :Vit B6, Riboflavin, nicotinic acid, biotin, Vit C, Vit E

Amino acids (Proteins)

- Formation of globin in hemoglobin

Iron

- Formation of Hemoglobin.
- Heme Synthesis.

Vitamins: B12 and Folic Acid

- Synthesis of nucleoprotein.
- Synthesis of DNA
- Cell division
- RBC Final maturation

Vit C

- Iron absorption
- deficiency lead to: Iron Deficiency

Vit B6

- RBC Synthesis
- Deficiency lead to: normochromic normocytic Anaemia

Deficiency leads to

- **Anemia and Hemoglobino-pathy**
- **Micro-cytic and hypochromic Anemia**
- **Megaloblastic (macrocytic) Anemia**

Hormones:

- Androgens, Thyroid, cortisol & growth hormones.
- Deficiency lead to Anemia.

Essential elements:

- Copper, Cobalt, zinc, manganese.

Most of this slide is found only in females' slides.

Vitamin B12 & Folic acid

- **Important for DNA synthesis and final maturation of RBC.**
- (Important for all stages of maturation of RBCs)

- **Dietary source: meat, milk, liver, fat, green vegetables.**

Deficiency Leads to

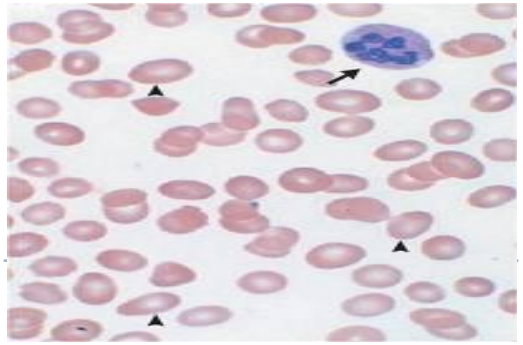
(in erythropoiesis)
Failure of:
-nuclear maturation
-division

In shape:
Abnormally large & oval shape RBC

Short life span

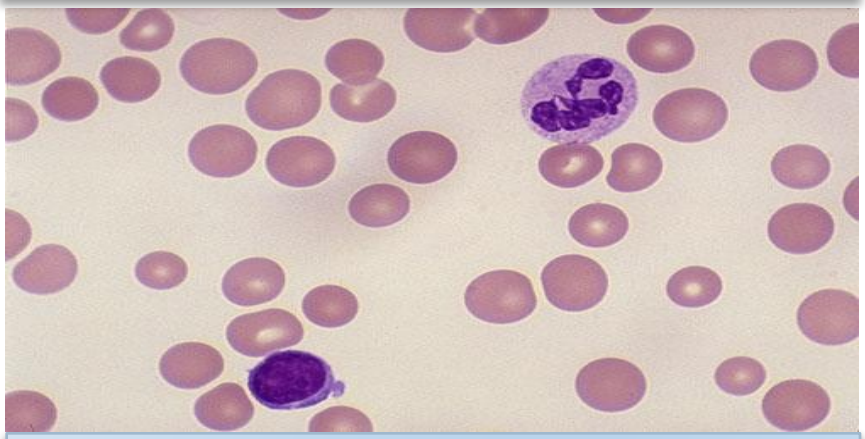
In count:
Reduced RBC count & Hb

Type of Anemia:
Macrocytic (megaloblastic) anemia



MACROcytic (Megaloblastic) Anemia

It is caused by the deficiency of vit B12 and Folic Acid



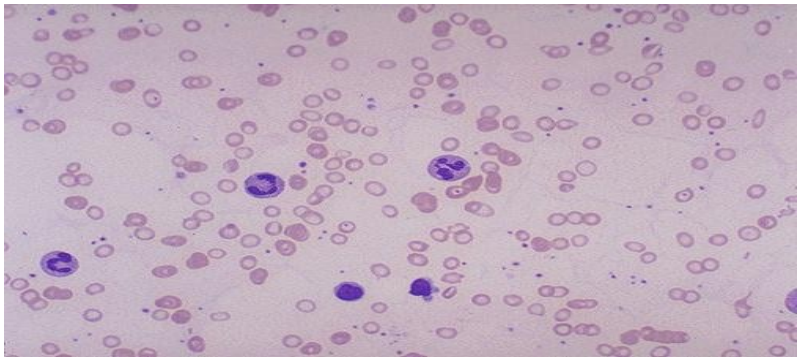
Note

1- The hyper-segmented Neutrophil (WBC)

2- The RBC are almost as large as the lymphocyte (WBC).

3-There are fewer RBCs.

MICROcytic hypochromic Anemia



- ★ **The RBC's are smaller than normal**
- ★ **Have an increased zone of central pallor.**
- ★ **Increased anisocytosis (variation in size)**
- ★ **Increased poikilocytosis (variation in shape)**
- ★ Causes: Iron deficiency and Thalassemia.

Most of this slide is found only in females' slides.

Microcytic hypochromic anemia

smaller size of each RBC

less hemoglobin in each RBC

(MCV<80 fl)

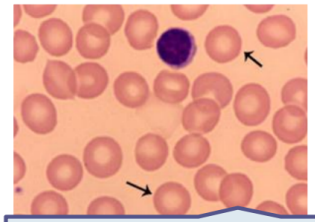
(MCH<27pg)

MCV: the average volume of RBCs.

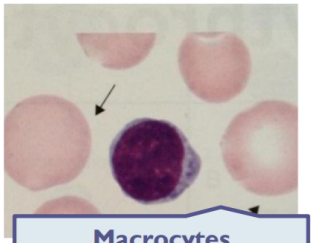
MCH: the average mass of hemoglobin per RBC.

According to size :

Microcytes
(small sized RBCs)

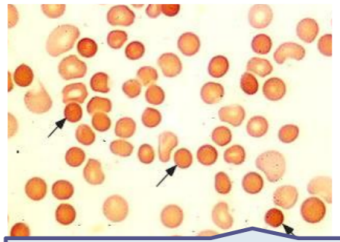


Normocytes
(Normal sized RBCs)

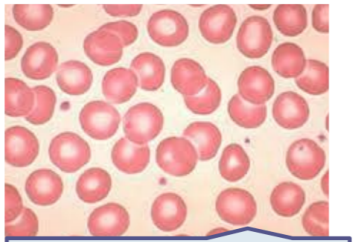


Macrocytes
(Large sized RBCs)

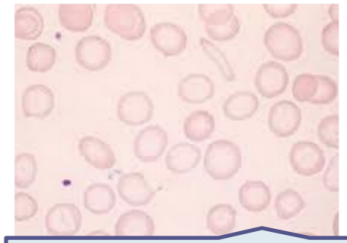
According to color :



Hyperchromia
(Darker due increased Hb)



Normochromia
(Normal colored RBCs)



Hypochromia
(paler due decreased Hb)

شاحب = paler / Hb = hemoglobin /الصور خارجية وللإيضاح فقط

This slide is found only in females' slides.

Mal-absorption of vit.B12

Pernicious Anemia

parietal cells الـ Stomach فيه الـ
Intrinsic factor وهي اللي تطلع لي الـ

- ★ **VB12 absorption needs <u>intrinsic factor</u> secreted by parietal cells of stomach**
  خلايا جدار المعدة
- ★ **VB12 + intrinsic factor is absorbed in the <u>terminal lleum</u>.**

- لازم الـ VB12 يكون ماسك بالـ Intrinsic factor عشان تمتصه .
- Terminal ileum = اخر حته في الـ Small intestine

Causes of deficiency

- **Inadequate intake**
- **Poor absorption due to Intestinal disease**

Poor absorption = decrease in intrinsic factors

Iron Metabolism (Fe):

Iron is needed for the synthesis of **hemoglobin, myoglobin cytochrome oxidase, peroxidase & catalase.**

Total Iron in the body = 3-5 / 4-5g

Note: Females' Slides

- 65% - 75%.. Haemoglobin (3g)
- 5% …….. other hems
- 1% ……. bound to transferrin (betaglobulin) in blood
- 15-30% …… stored iron in the form of ferritin in the liver, spleen and bone marrow.

Note: Males' Slides

- 4% …….. Muscle Hb (myoglobin)
- 1% ……. Enzymes (cytochrome)
- 0.1% …… Plasma iron: (transferrin)

Iron Absorption:

عشان كذا لما ناخذ iron ينصحون نشرب معه عصير برتقال (فيتامين سي) ليه؟ لانه يساعد بالامتصاص

اللي عندهم Stomach diseases عندهم Decrease in vitC ما يقدرون يمتصون الـ iron كويس.

- Iron in food is mostly in oxidized form (Ferric, F^{+3})
- Better absorbed in reduced form (Ferrous, F^{+2})
- Iron in stomach is reduced by gastric acid, Vitamin C.

Vitamin C يساعد في الامتصاص

- What does rate of iron absorption depend on?
- -The amount of iron stored.
- When does rate of iron absorption decrease?
- - when iron stores are saturated (When all the apoferritin is saturated).

-Ferritin: *intracellular iron-storage protein*
-Ferritin that is not combined with iron is called apoferritin.

Transport and Storage of Iron

- **Iron transportation:**

in plasma in the form of Transferrin (apotransferrin + iron).

- **Normally 30-40 saturated with Fe: (plasma iron 100-130ug/100ml)**
- **When transferrin is 100% saturated with Fe:(plasma iron 300ug/100ml)**

Haemosiderin: Iron storage complex only found in cells (not in circulating blood) appears to be
1. a complex of ferritin. 2. denatured ferritin. 3. other material.
(not a good supplier of iron when needed)

- **Iron storage:**
  - ★ **Ferritin : (apoferritin + iron) (Loose bond)**
  - ★ **Haemosiderin : insoluble complex molec**
    (Firm bond)
  - ★ **Sites : liver, spleen & bone marrow**
- **Daily loss of iron is 0.6 mg in male & 1.3mg/day in females.**
- **Diet provides 10-20 mg iron per day.**

نفقد الـ Iron عن طريق جرح بالجلد أو قص الأظافر والشعر

Iron excretion

Iron losses
feces: unabsorbed, dead epithelial cells
bile and saliva.
Skin: cell, hair, nail, in sweat.
Urine
Menstruation, pregnancy and child birth

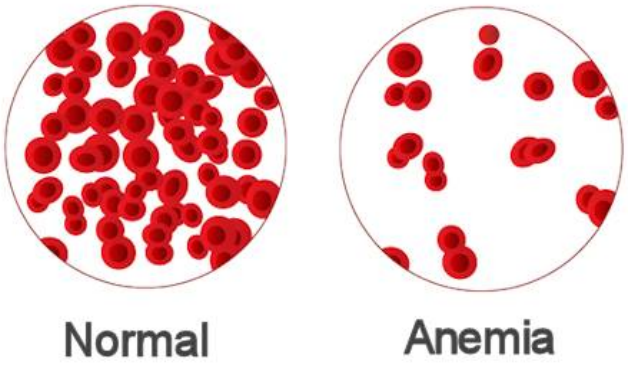
Destruction of RBCs

- RBC life span in circulation **= 120 days**.
- Metabolic active cells.
- Old cells have a fragile cell membrane, the cell will rupture as it passes in narrow sinusoidal capillaries of the spleen, **bone marrow & liver**.
- **Released Hb is taken up by macrophages in liver, spleen & bone marrow:**
  - Hb is broken into its component:
    - **Polypeptide** → amino acids → amino acid pool (protein pool = storage).
    - **Haem**:
    - **Iron** → **recycled (reused)** → **iron storage** (ferritin form).
    - prophyrin → **biliverdin** → bilirubin (secreted by the liver into bile) **(excess destruction of RBC can cause Jaundice)**

Anemia:

★ Definition

- Decrease number of RBC
- Decrease Hb



★ **Normal ranges of Hb:**

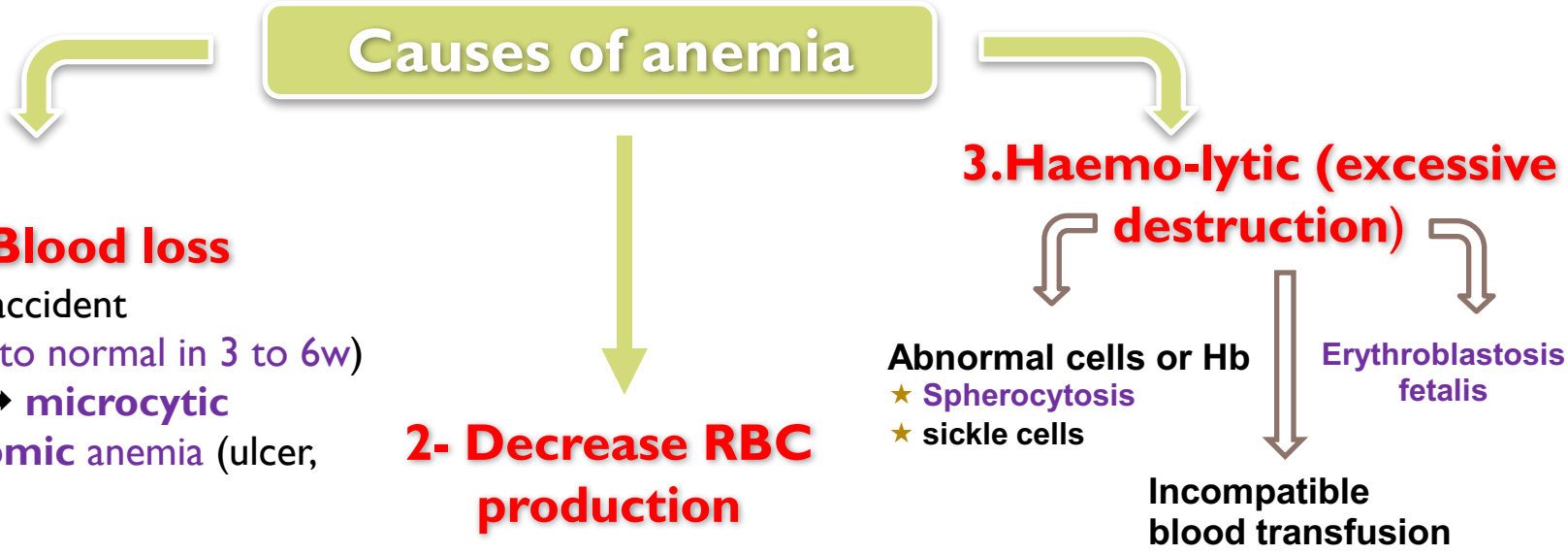
- Men: Hb 13.5 to 17.5 g/dL
- Women: Hb 12.0 to 15.5 g/dL
- Infants : Hb 14 – 19 g/dL

★Symptoms:

Fatigue
Tired
Dyspnea
(shortness of breathing)
Pallor
Tachycardia
heart failure.

Greek word (an-haîma) meaning "without blood"

Causes of Anemia



Acute = حاد
Chronic = يفقد الدم على فترات زي الدوره الشهريه مثلاً + اللي عنده قرحه بالمعده , بواسير , ديدان بالامعاء

1- Nutritional causes

★ Iron ➡ microcytic Hypochromic anemia
★ Vit B12 & Folic acid ➡ megaloblastic anemia

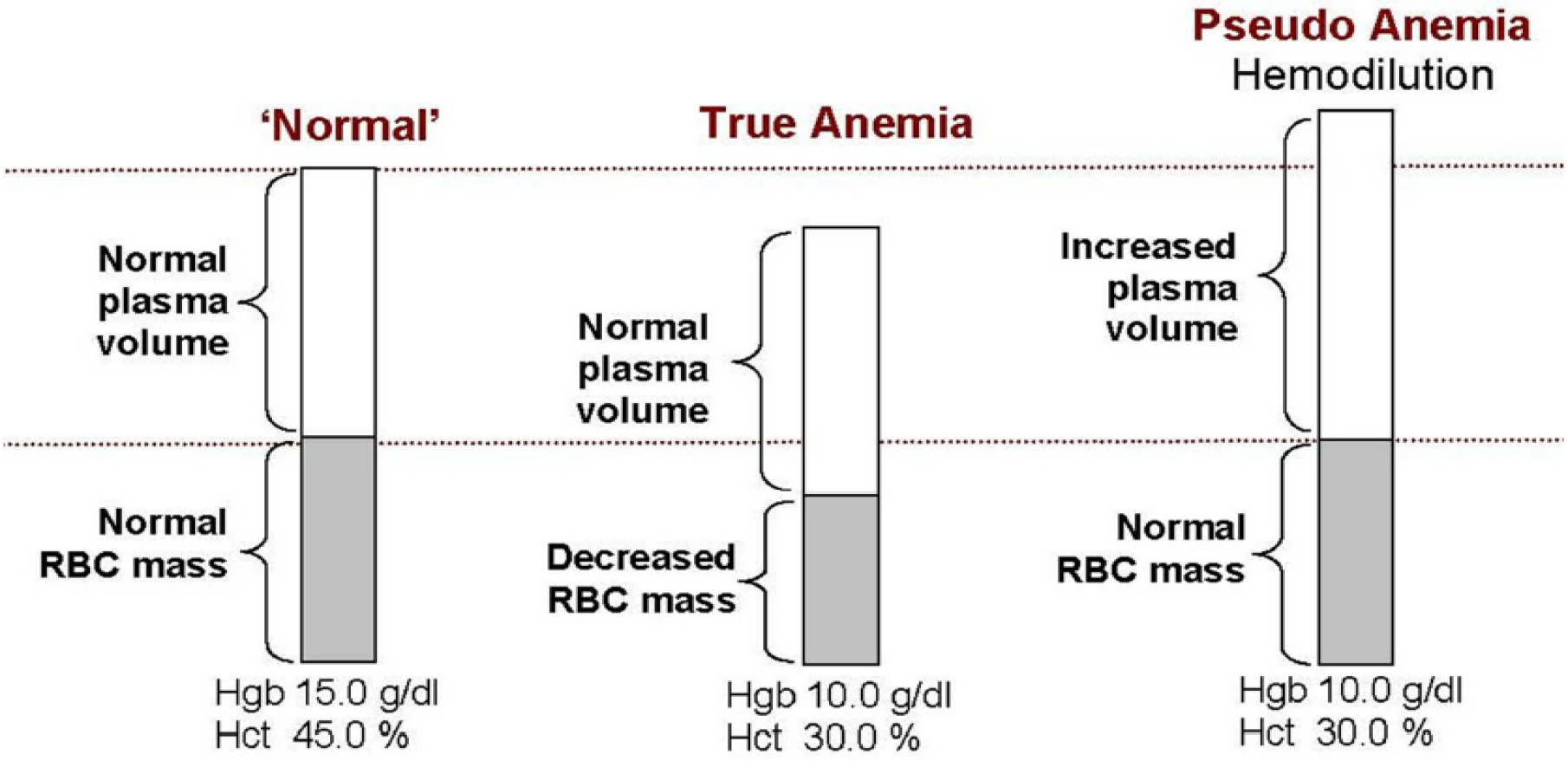
2- Bone marrow failure:
Destruction by cancer, radiation, drugs ➡ Aplastic anaemia.

Spherocytosis = مشكله بالـ cell membrane تتكسر الـ RBCs بسرعه.

Sickle cells = تغير في شفره وحده فحدثت طفره , وراثي.

Incompatible blood transfusion = لما يُنقل للشخص دم غير مناسب

RBC Mass and Plasma Volume Relationship



Hct (Hematocrit): is the volume or percentage of RBC in the blood.
Hgb : Hemoglobin

حجم ال RBCs طبيعي ولكن زيادة حجم البلازما أدت الى تقليل Hct .

Polycythemia

Polycythemia

"Increased number of RBC or high concentration of Hb (hemoglobin) in the RBCs"

Types :

- True
- Absolute

Primary (Polycythemia Rubra Vera - PRV):

uncontrolled RBC production."

- Hypoxia = نقص الاوكسجين

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

- Primary = (بالمناعه
- عند النساء اكثر) يصير الجلد محمر.
- Secondary =

يعني لما يصير hypoxia يحدث polycythemia بمعنى يحدث نتيجة لسبب اخر , زي هنا يقل الاوكسجين فيحدث Polycythemia

Polycythemia Cont.

Polycythemia is either caused by:

1- Increase in RBC, therefore, increase in hemoglobin.

2- Increase in hemoglobin content of RBC **WITHOUT** increase in RBC count.

3- Decrease in plasma therefore hemoglobin is more dominant and apparent.

End result always: an increase in hemoglobin.

Relative:

Haemoconcentration
» loss of body fluid in vomiting, diarrhea and sweating.

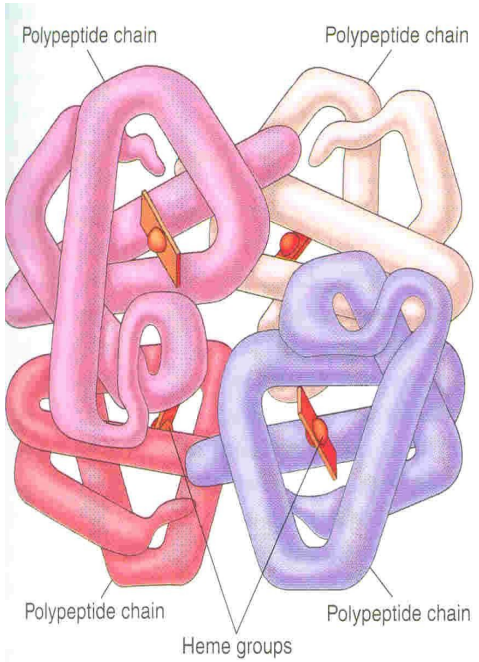
Note: Polycythemia is always due to an ABNORMAL increase or decrease.

Most of this slide is found only in females' slides.

Structure of Hemoglobin (Hb)

مهم معرفه الـStructure

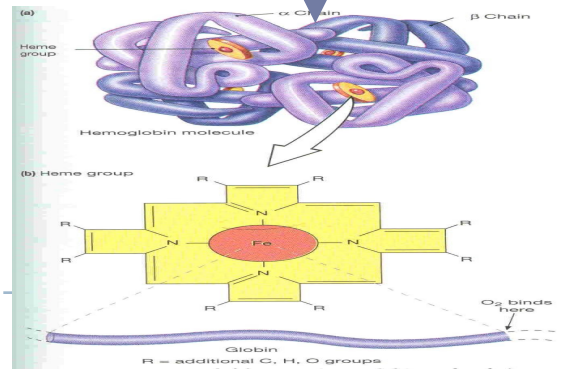
- **Hb molecules is made of 4 chains, each formed of heme & polypeptide chain (globin)**



heme + Polypeptide chain (globin) = Hemoglobin chain

Protoporphyrin ring + iron (F2+)

Hemoglobin structure:



Hemoglobin holds/contains:
(4 MOLECULES of hydrogen) OR (8 ATOMS of hydrogen)

Types of Hb

normal

- Hb A ($\alpha_2\beta_2$) 2 alpha, 2 beta chains.
  (adult Hb)
  Most common (98%)
- Hb A2 ($\alpha_2\delta_2$) (2%)
  - delta
  - gamma
- Hb F ($\alpha_2\gamma_2$)
  (Hb of intrauterine life).
  (80-90%)

abnormal

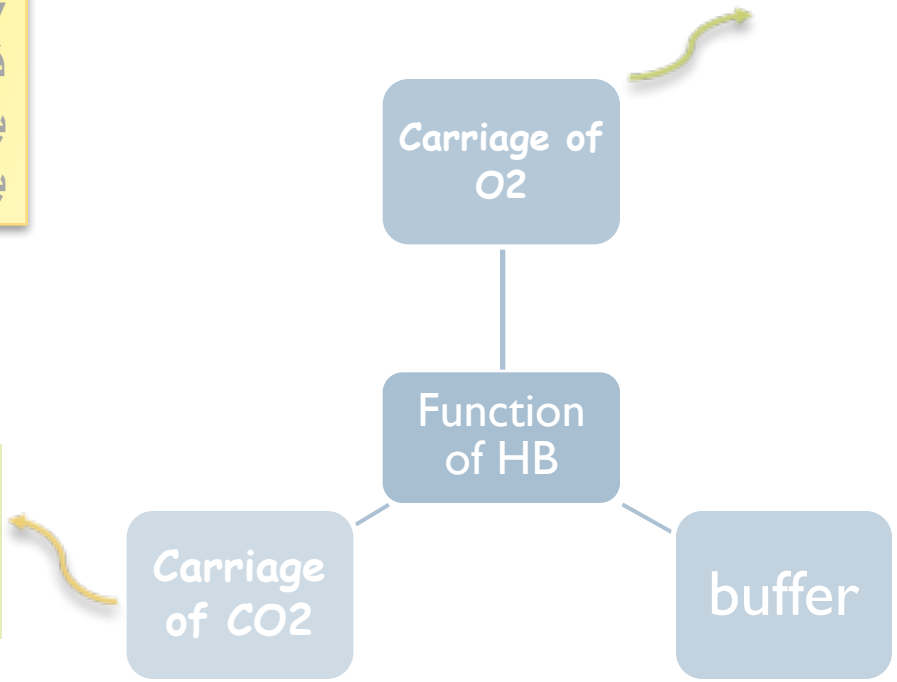
- Abnormality in the polypeptide chain
- abnormal Hb (hemoglobin-pathy) e.g thalassemias, sickle cell (HbS).

Hb F = high nifty of O2
يكون بالبيبي , ولما يكبر يتحول الى Hb A +

Function of Hemoglobin

Carbon monoxide :
اول اكسيد الكربون يمسك بالهيموجلوبين ولا يخليه يوّصل الـO2 لانه binds irreversibly
فيصير اختناق زي شب النار بالخيام او الدفايات بغرف مغلقه بدون تهويه .

Hb <u>reversibly</u> binds to O_2 to form <u>oxyhemoglobin</u>, affected by pH, temperature, H+



In smokers:

Hb binds to CO_2= carboxyhemaglobin

This slide is found only in males' slides.

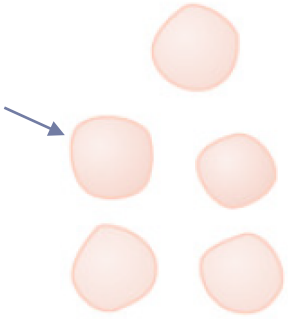
Quantity of Hemoglobin in Blood

- **RBCs have the maximum ability to concentrate hemoglobin in the cell fluid up to about 34 grams in each 100 milliliters of cells.**
- **• Each gram of hemoglobin can combine with 1.34 ml of oxygen if Hb is 100% saturated with O2.**

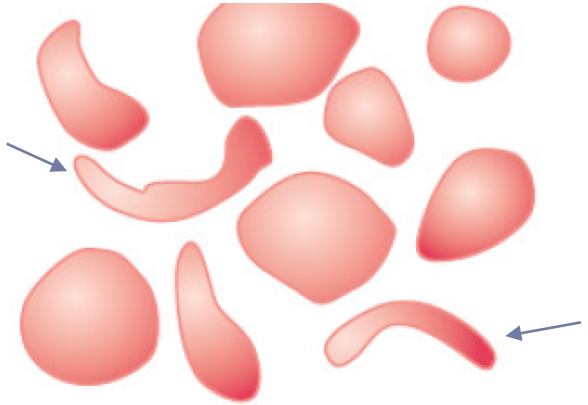
O_2 Carrying Capacity of Blood:

- It is the amount of O2 carried by 100 ml of blood.
- **Calculated by:** Hb conc x 1.34.
- **Example:** 16 x 1.34 = 21.4 ml

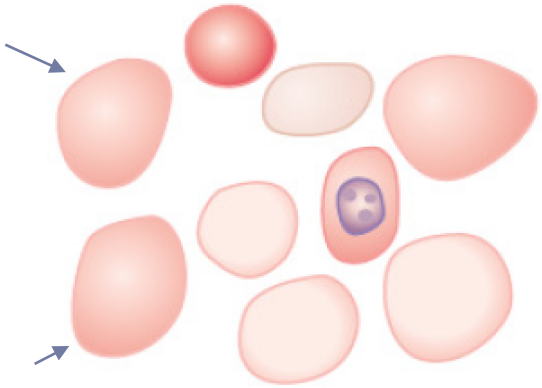
Different Cell Morphology



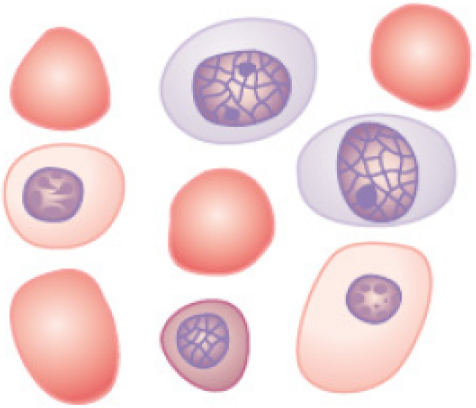
Microcytic,
hypochromic anemia



Sickle cell anemia



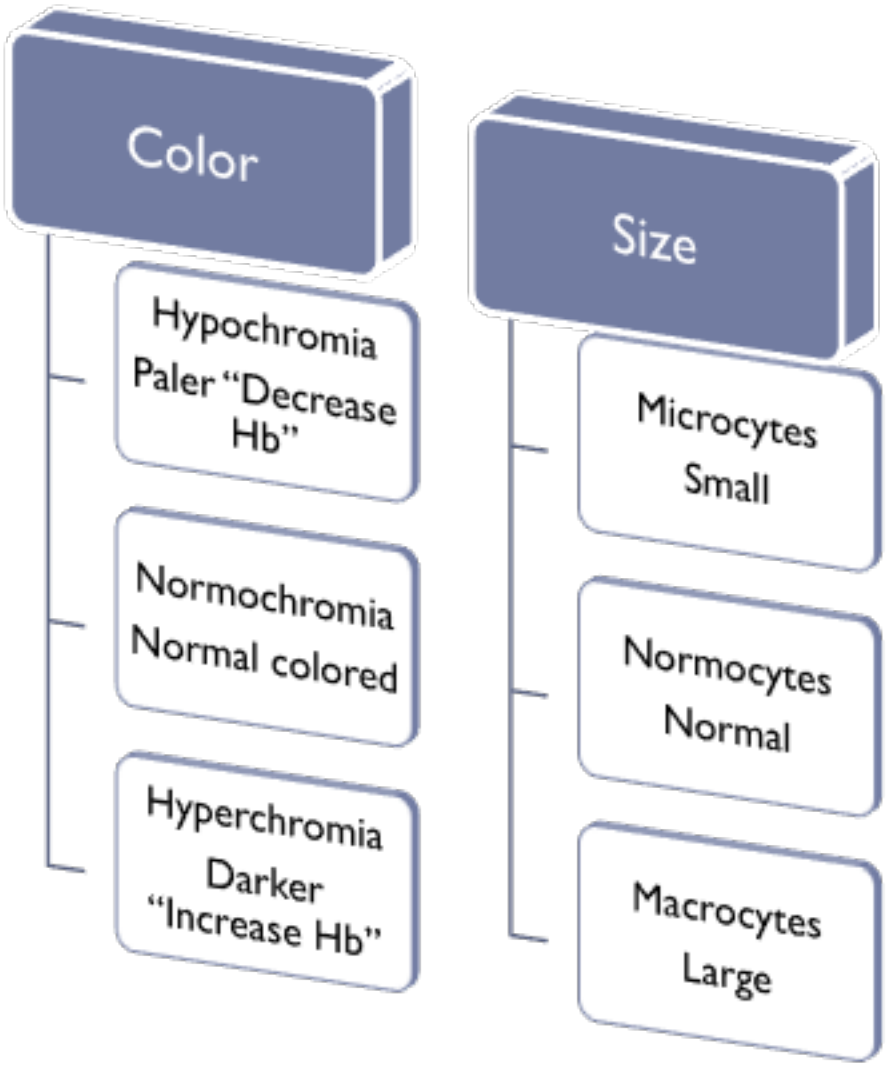
Megaloblastic anemia



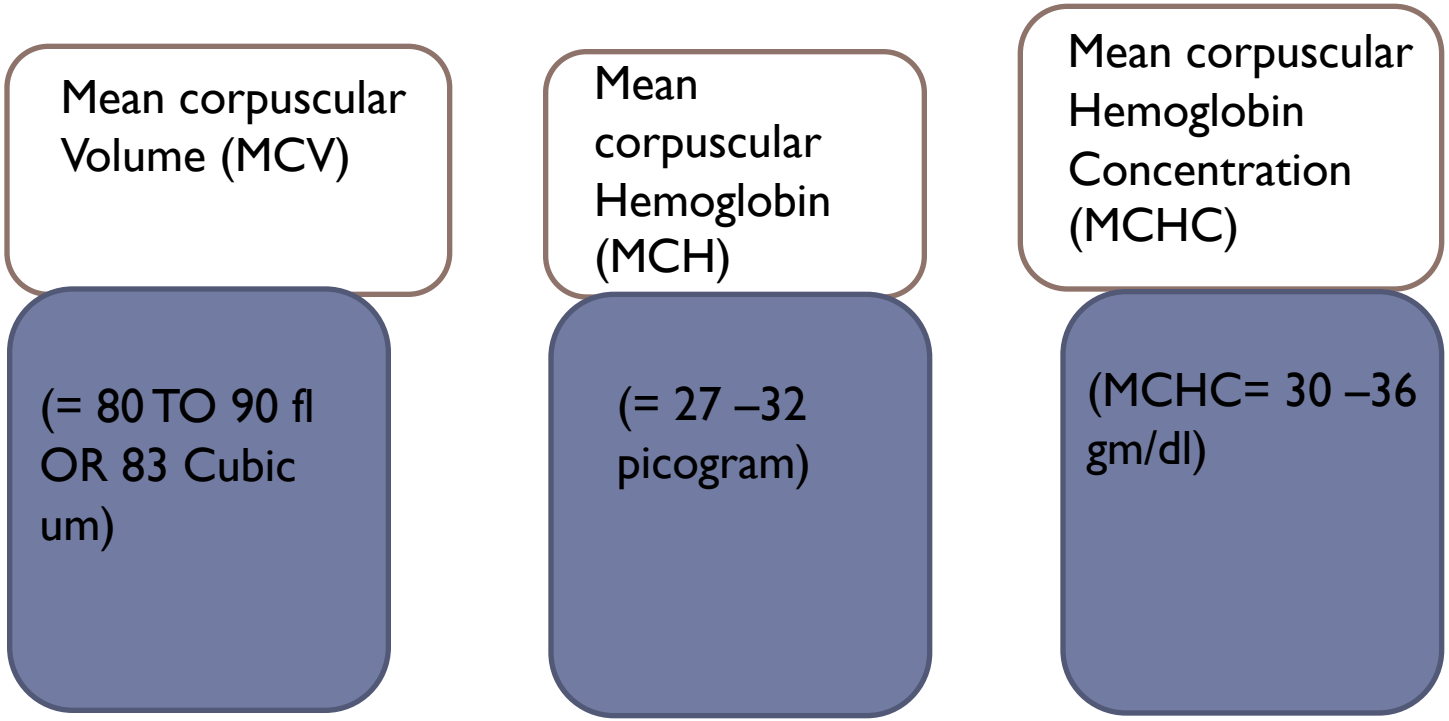
Erythroblastosis fetalis

Megaloblastic anemia = Macrocytic anemia

Classification of RBCs by Size & Color



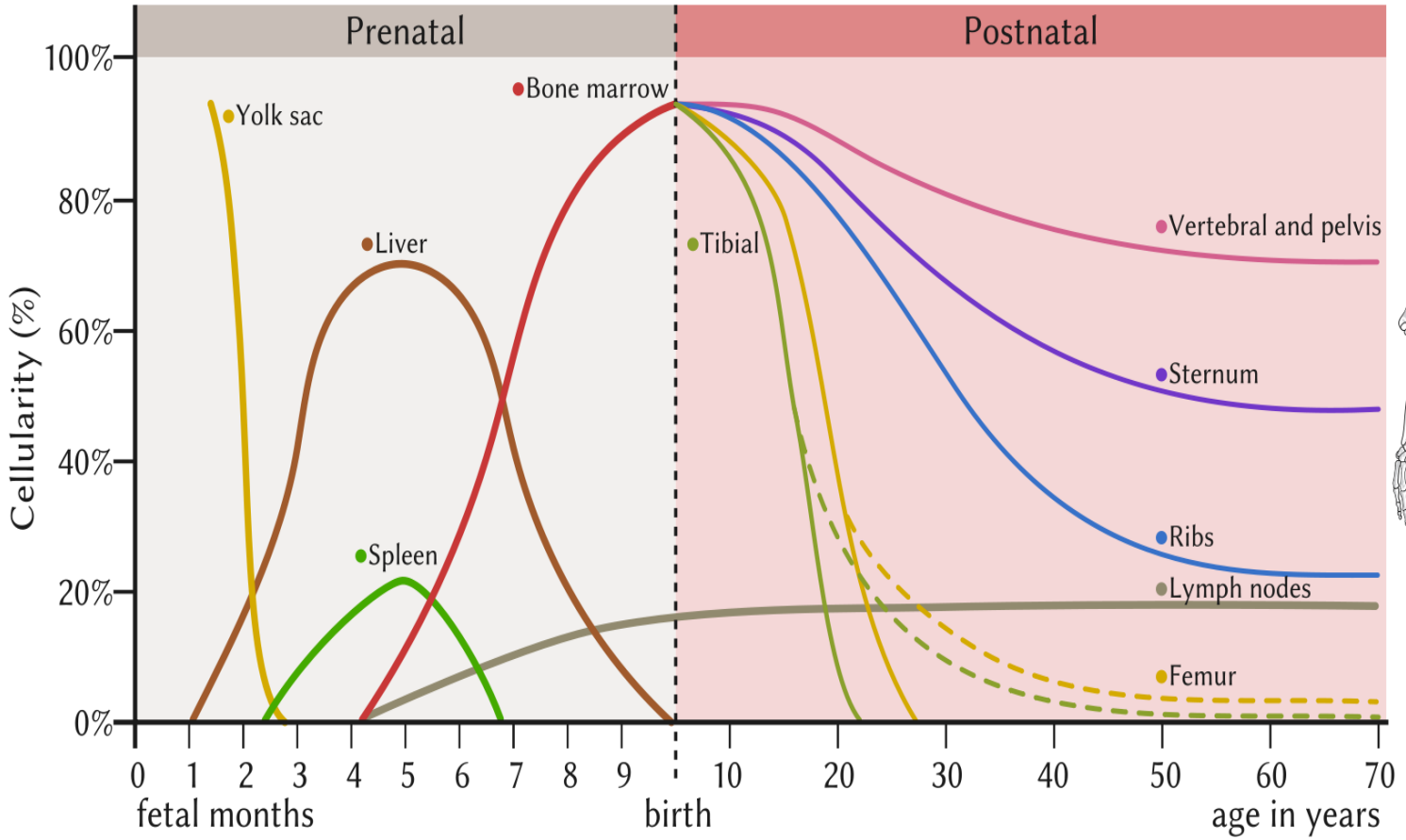
RBC Indices

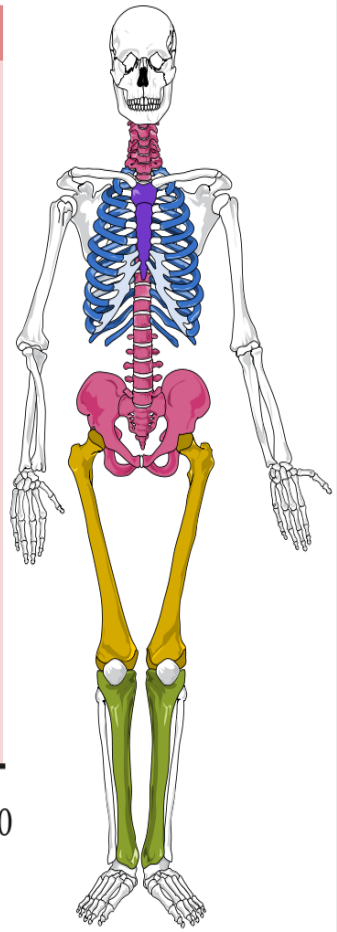


* Fl : fimto liter

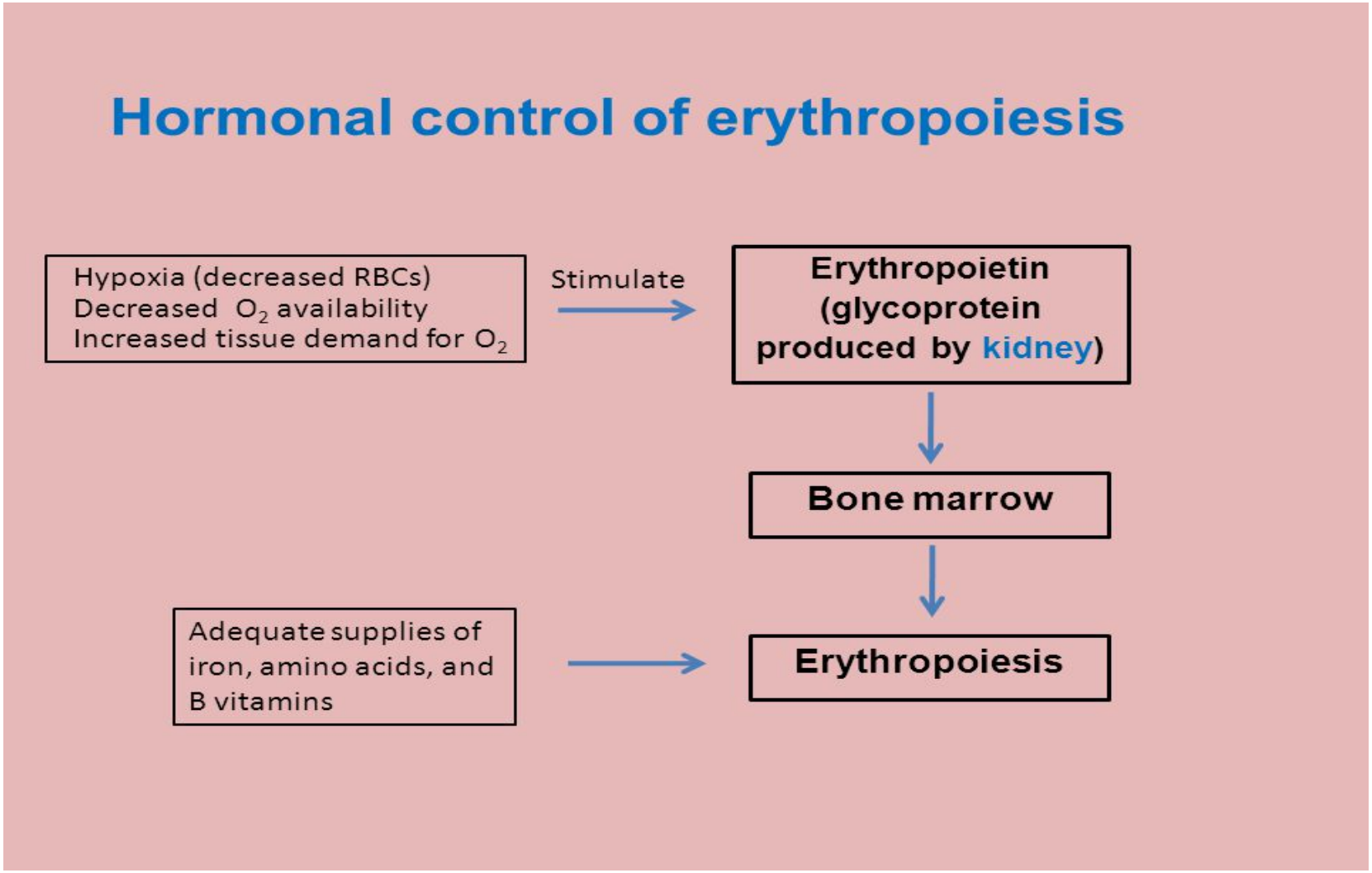
*gm/dl : gram per Deci liter

HEMATOPOIESIS





Control of Erythropoiesis



Percentages & Numbers

Blood volume : 5 liter in adult
55%plasma
45% is packed cells volume (PCV)
1% buffy coat
Plasma (ECF): 98% water

Diameter 7-8µmx2.5µmx1 µm.
Average volume 90-95 µm3
Number 4.7 - 5 x106
Hb 14-16 g/dl in the blood

Total Iron in the body 3-4-5 g
Normally: 30-40% saturated with Fe: plasma iron 100-130ug/100ml
When transferrin is 100% saturated with Fe: plasma iron 300ug / 100ml
Daily loss of iron is 0.6 mg in male & 1.3 mg/day in females.

Normal ranges of Hb:
Men: 13.5 to 17.5 g/dL
Women: 12.0 to 15.5 g/dL
Infants : 14 – 19 g/dL

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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