LECTURE 6

# (F) Blood Physiology (I) + (M) Blood Composition

Note: a part or the Erythropoiesis lecture for boys is included here

Physiology

Team 438

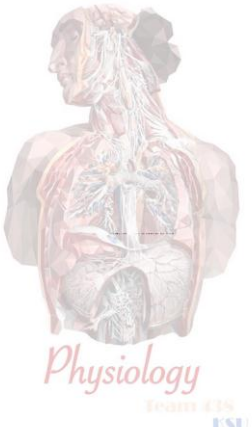
KSU

- Red : important
- Black : in male / female slides
- Pink : in girls slides only
- Blue : in male slides only
- Green : notes, Extra

Reviewed by Razan AlRabah & Khalid Alkhani

# Objectives

1. Describe Cellular and non-cellular components of blood.
2. Recognize functions of blood.
3. Define Erythropoiesis; leucopoiesis, thrombopoiesis.
4. Recognize sites of RBC formation at different developmental age.
5. Describe different stages of RBC differenation.
6. Describe features of RBC maturation.
7. Describe regulation of RBC production and erythropoietin hormone secretion in response to hypoxia.
8. Recognize clinical conditions associated with high level of erythropoitein in the blood.



# Blood

- **Transport** : O2, CO2, nutrient, hormones, waste product
- **Homoeostasis**: regulation of body temperature, ECF, PH
- **Protecting** against infections : white blood cells, antibodies
- **Blood clotting** prevents blood loss

Function of blood

Blood volume

5 liters in adult.

- Female has less volume than male by 0.5 liter

4.5 liters for female

- 7 – 9% of body weight

composition

Plasms volume ( ECF ) 55%

- 98% water + ions + plasma proteins (Albumin, globulin, Fibrinogen)
- Same ionic composition as interstitial fluid.

Cellular components (packed cell volume) 45%

red blood cells (erythrocytes)

White blood cells (leucocytes)

Platelets (thrombocytes)

RBC shape & size:

1\ flat Biconcave disc. 2\ non-nucleated 3\ dimeter 7-8 µmx2.5µmx1µm.
4\ flexible. 5\ average volume 90-95 µm3 6\ number= 4.7 -5x10^6
7\ Hb (haemoglobin)= 14-16 g/dl in the blood
for male= 14-16g/dl … for female= 12-14g/dl

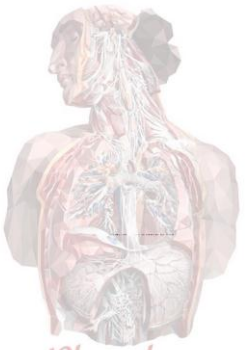
Functions of RBC:

- $O_2$ transport
- $CO_2$ transport
- Buffer (regulation of PH)

| Complete blood count | Result | Reference values |
|---|---|---|
| WBC | 7.36 × 10.e9/L | (4-11) |
| RBC | 5.12 ×10.e12 | (4.2-5.5) |
| HGB | 15.4 g/dl | (12-16) |
| HCT | 45% | (37-47) |
| MCV | 87.9 fl | (80-94) |
| MCH | 30 pg | (27-32) |
| MCHC | 34 g/dl | (32-36) |
| RDW | 11.4 % | (11.5-14.5) |
| Platelet count | 183 × 10.e9/L | (140-450) |
| MPV | 9.43 fl | (7.2-11.1) |

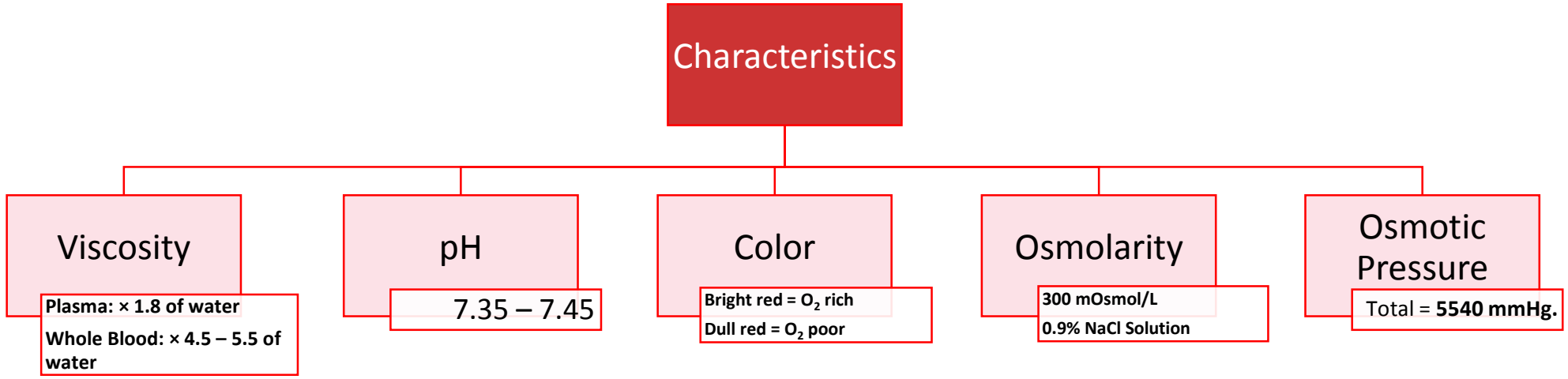
WBC: White blood cells, RBC: Red blood cells, HGB: Hemoglobin, HCT: Hematocrit, MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RDW: Red cell distribution width, MPV: Mean plasma volume.

شرحتها الدكتورة بشكل مبسط لكن غير مطالبين فيها بهذه المحاضرة وبتكون مطلوبة في المحاضرات القادمة



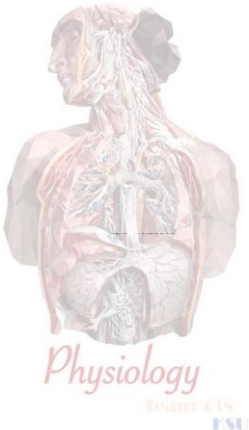
From male slides

# Physical Characteristics Of Blood




**Plasma Osmotic Pressure:**

- **Crystalloid osmotic pressure: is the pressure generated by all crystal substances, particularly electrolytes (mainly NaCl).**
- **Colloid osmotic pressure: is the pressure generated by plasma proteins, particularly albumin.**

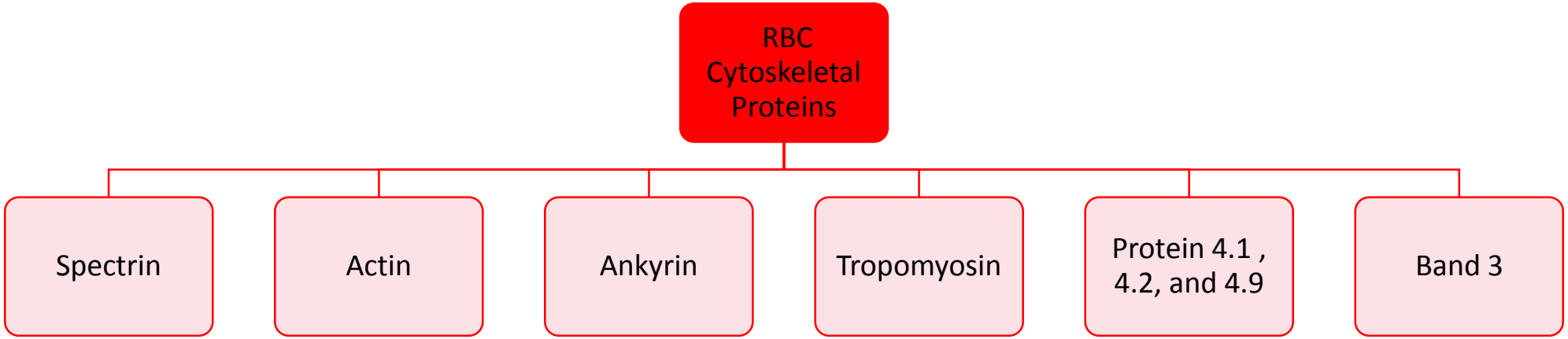


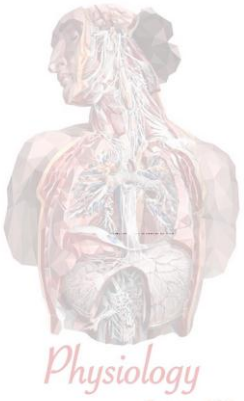
From male slides

# Plasma Proteins

| Functions of **Plasma Proteins** | |
|---|---|
| | 1. Oncotic Pressure |
| | 2. Buffering: 15% of buffering capacity of blood |
| | 3. Nonspecific carriers |
| | 4. Defense and Blood clotting |

- RBCs need to be Highly deformable yet remarkably stable.
- Cytoskeletal proteins are responsible for these characteristics.



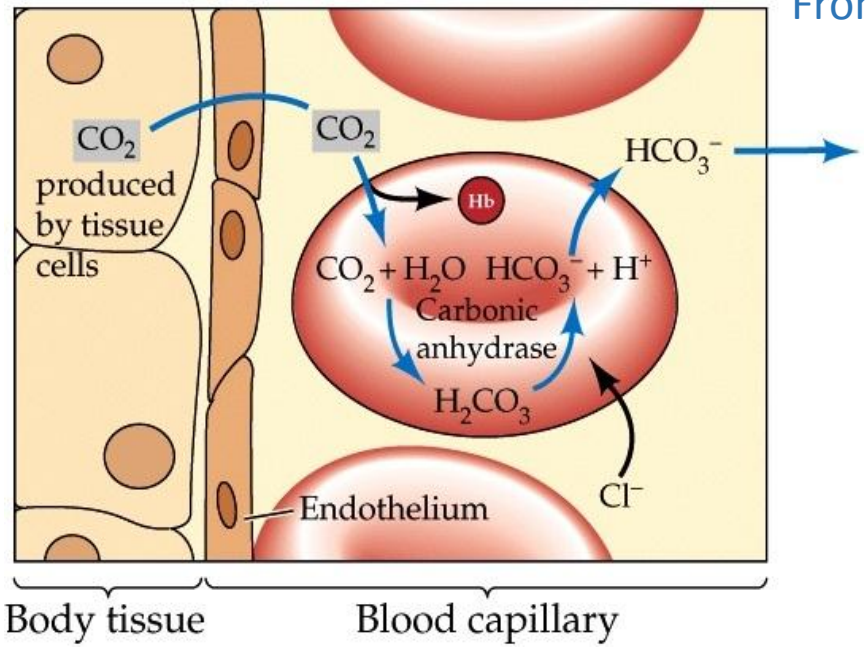
# Functions of Red Blood Cells

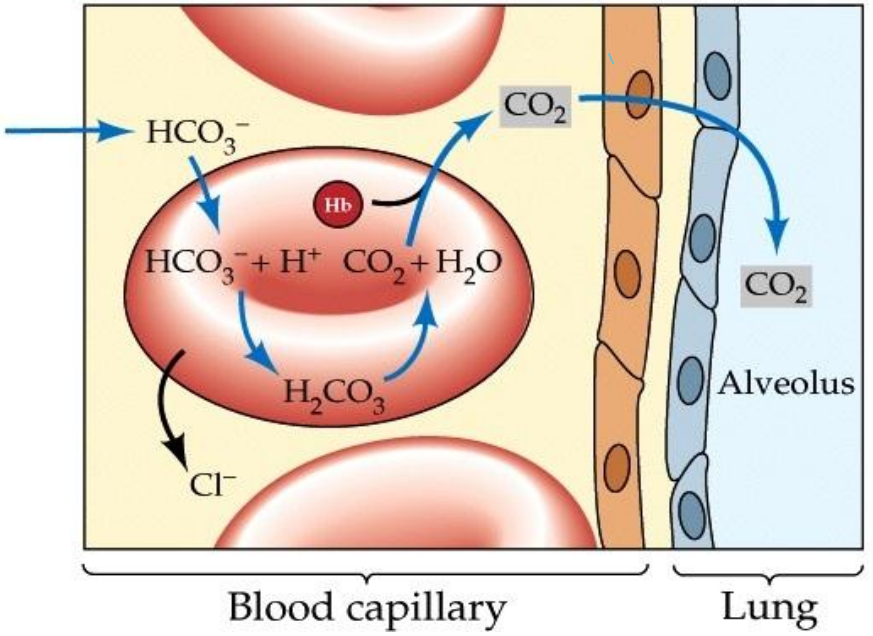
From male slides

- 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.

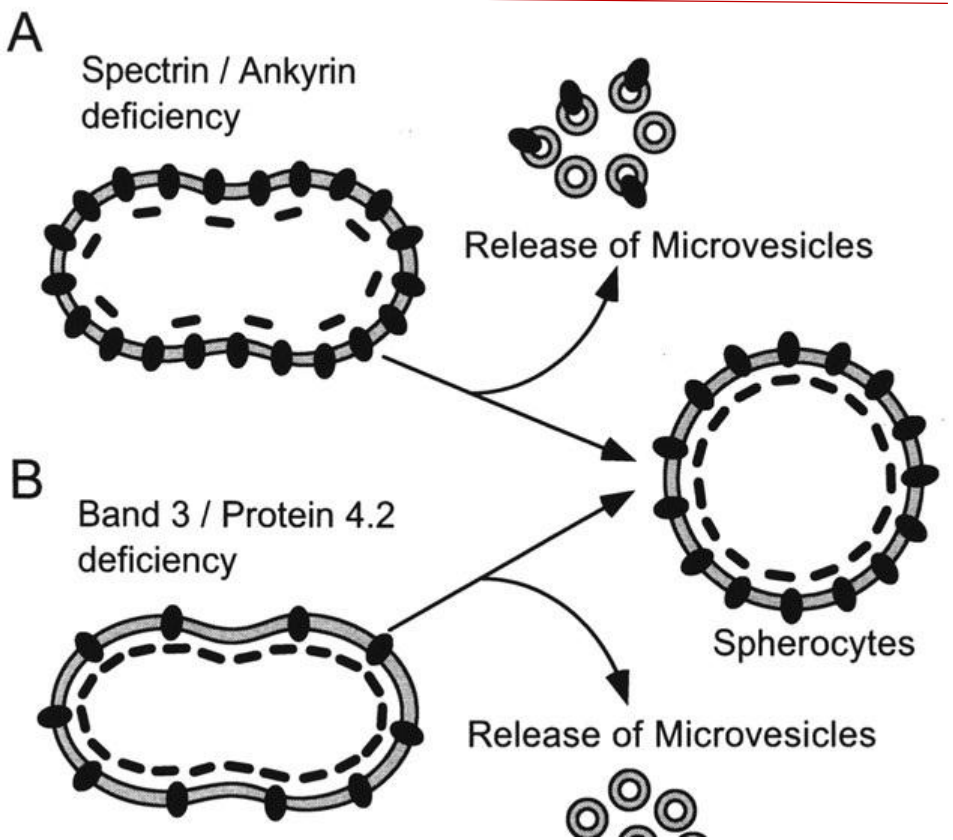
- The hemoglobin in the cells is an excellent *acid-base buffer* (as is true of most proteins), so the red blood cells are responsible for most of the acid-base buffering power of whole blood.

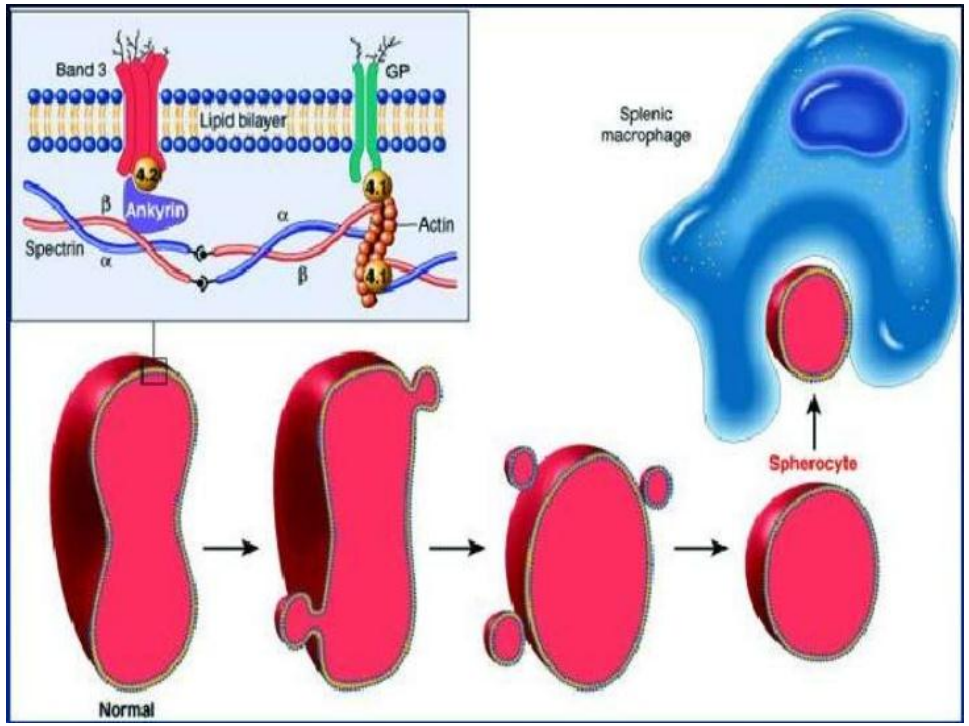


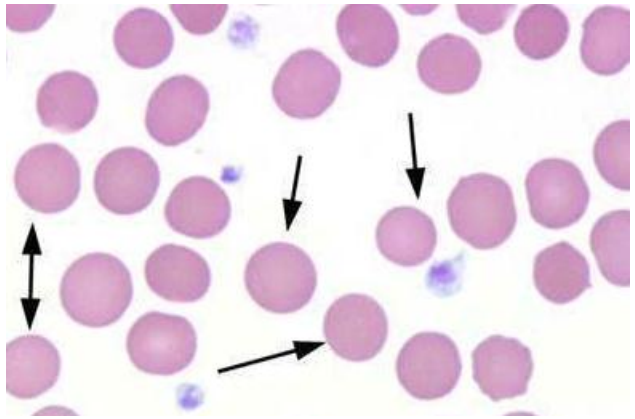



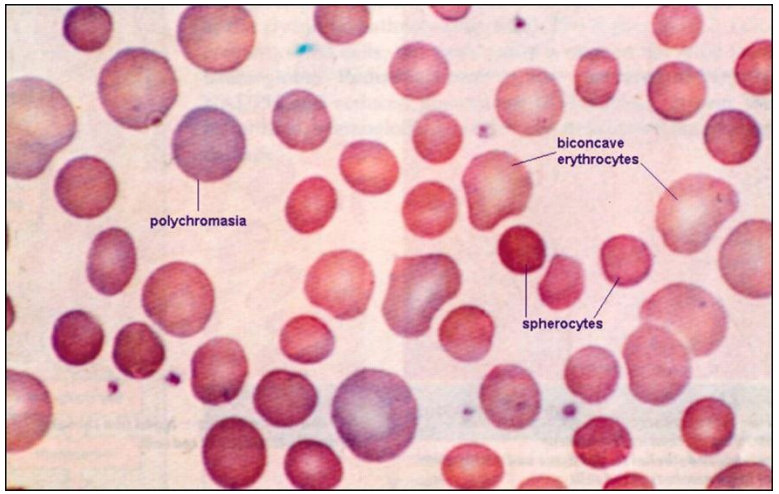
# Hereditary Spherocytosis

From male slides





# Haematological indices

From male slides

## Mean corpuscular Hb concentration (MCHC):

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

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

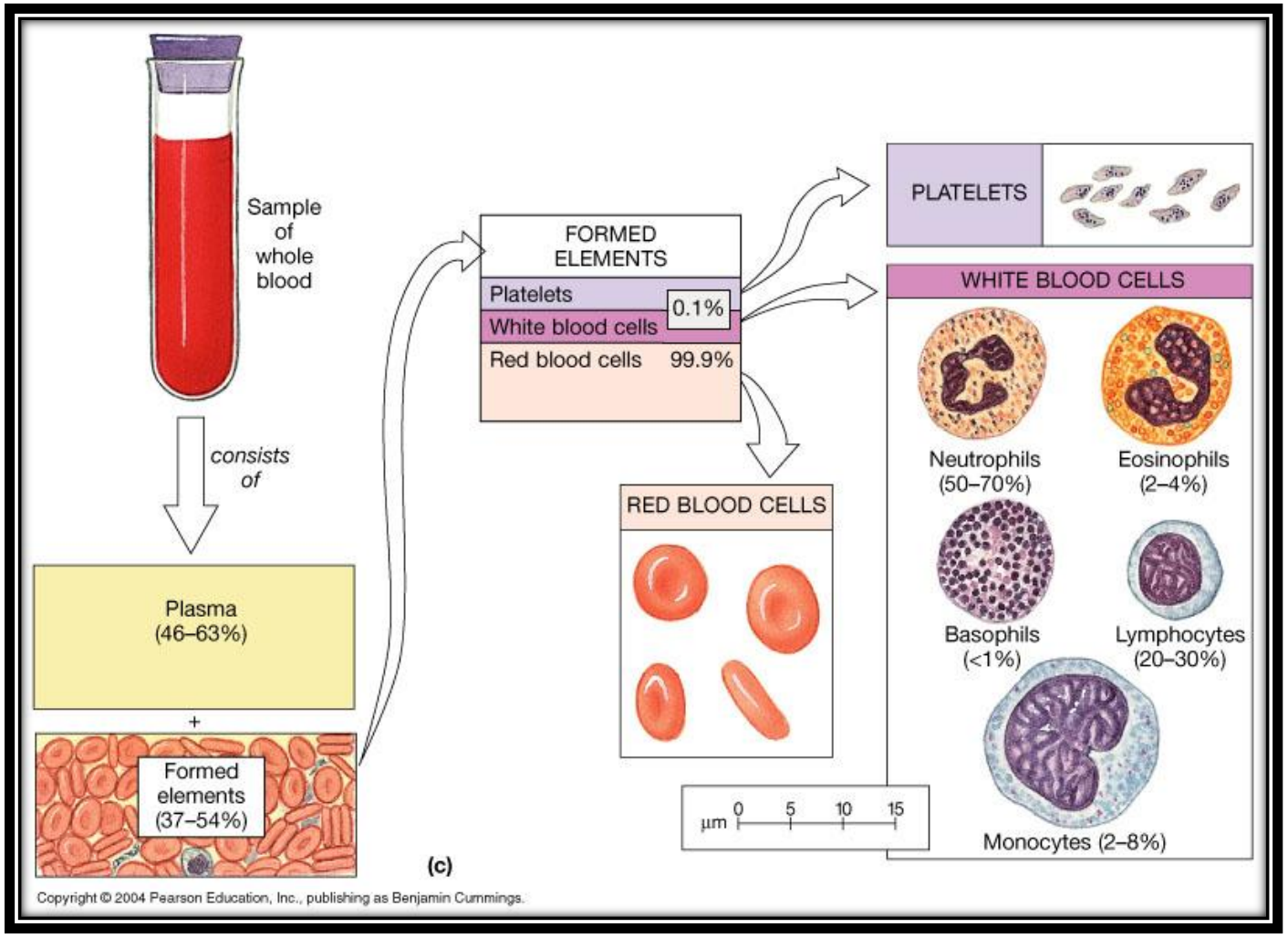
**- Normal value: 32- 35 g/dl of RBCs**

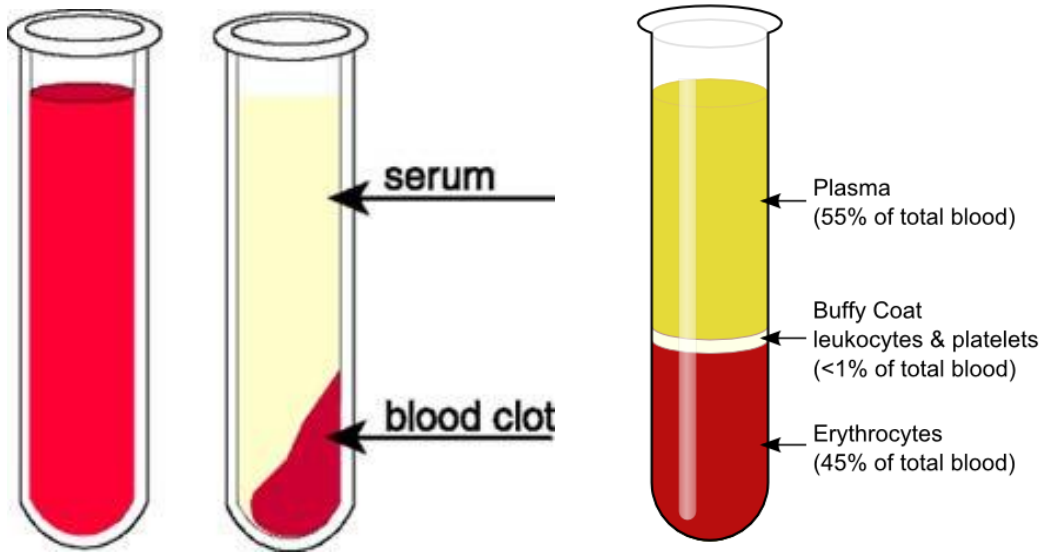
| Indices | | Males | Females |
|---|---|---|---|
| Hematocrit (Hct) (%) (RBC) | | 47 | 42 |
| Red blood cells (RBC) ($10^6$/L) | | 5.4 | 4.8 |
| Hemoglobin (Hb) (g/dL); dL = 100 milliliters | Each gram of pure hemoglobin is capable of combining with 1.34 ml of oxygen | 16 | 14 |
| Mean corpuscular volume (MCV) (fL) [a] (volume of RBC in fL) | $= \frac{Hct \times 10}{RBC\ (10^6/\mu L)}$ | 90 - 95 | 90 - 95 |
| Mean corpuscular hemoglobin (MCH) (pg) (Hemoglobin in RBC in 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 |

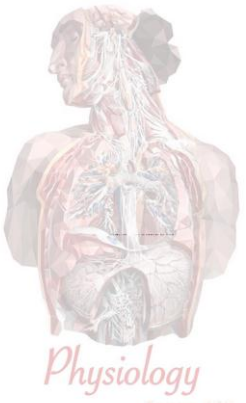
[a] Cells with MCVs > 95 fL are called macrocytes; cells with MCVs < 80 fL are called microcytes.

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

# Blood composition



# Blood cells formation

| term | Formation of ……. |
|---|---|
| Erythropoiesis | RBC ( erythrocytes ) |
| Leucopoiesis | WBC ( leucocytes ) |
| Thrombopoiesis | Platelets ( thrombocytes ) |
| **Hematopoiesis.** | Blood |

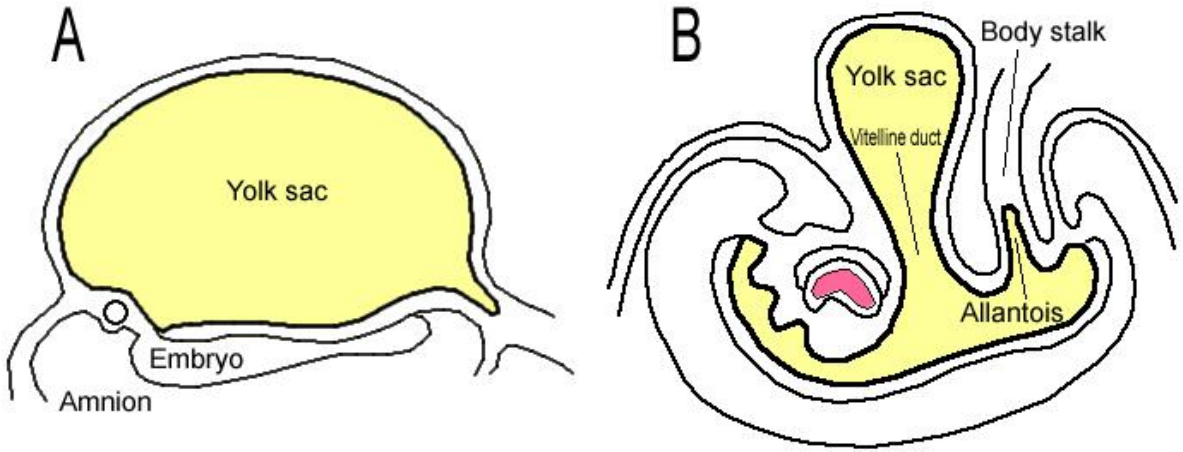
## Production of **RBC**

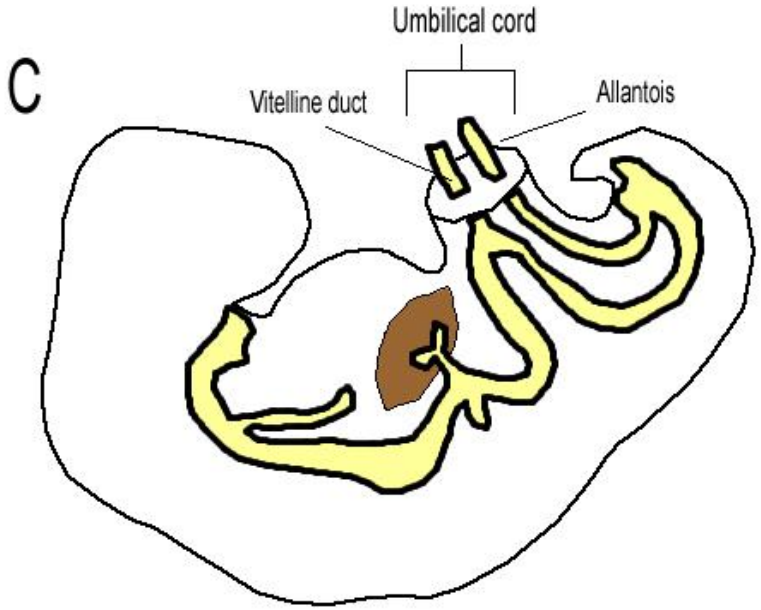
### In-utero

- 1st 8 weeks: embryo nucleated RBCs are formed in **yolk sac**
- Middle trimester (2nd to 5th months) mainly in **liver& spleen & lymph nodes**
- Last months RBCs are formed in bone marrow of all bones

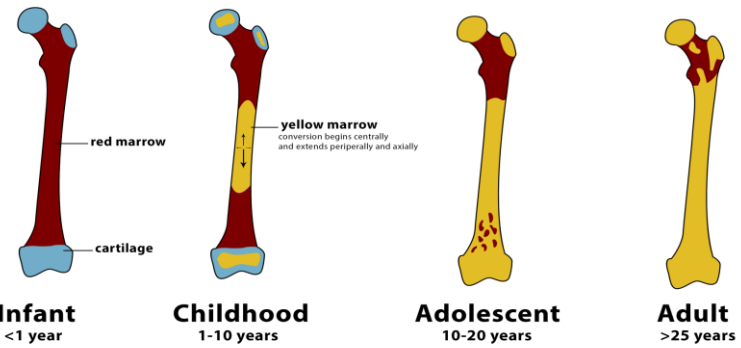
### After birth

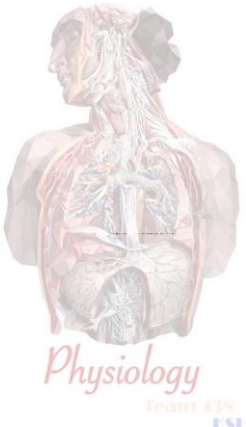
- Bone marrow of flat bones (scapula) continue to produce RBC into adult life
- Shaft of long bone stop to produce RBC at puberty while epiphysis continued




## Normal bone marrow conversion



From male slides

# Erythropoiesis

## Location

- All bone Marrow till 5 yrs
- Proximal portion of long bones: after 20 yrs
- After 20 yrs: cont. vertebra, sternum, and ribs

Note: Yellow marrow → Red marrow if needed

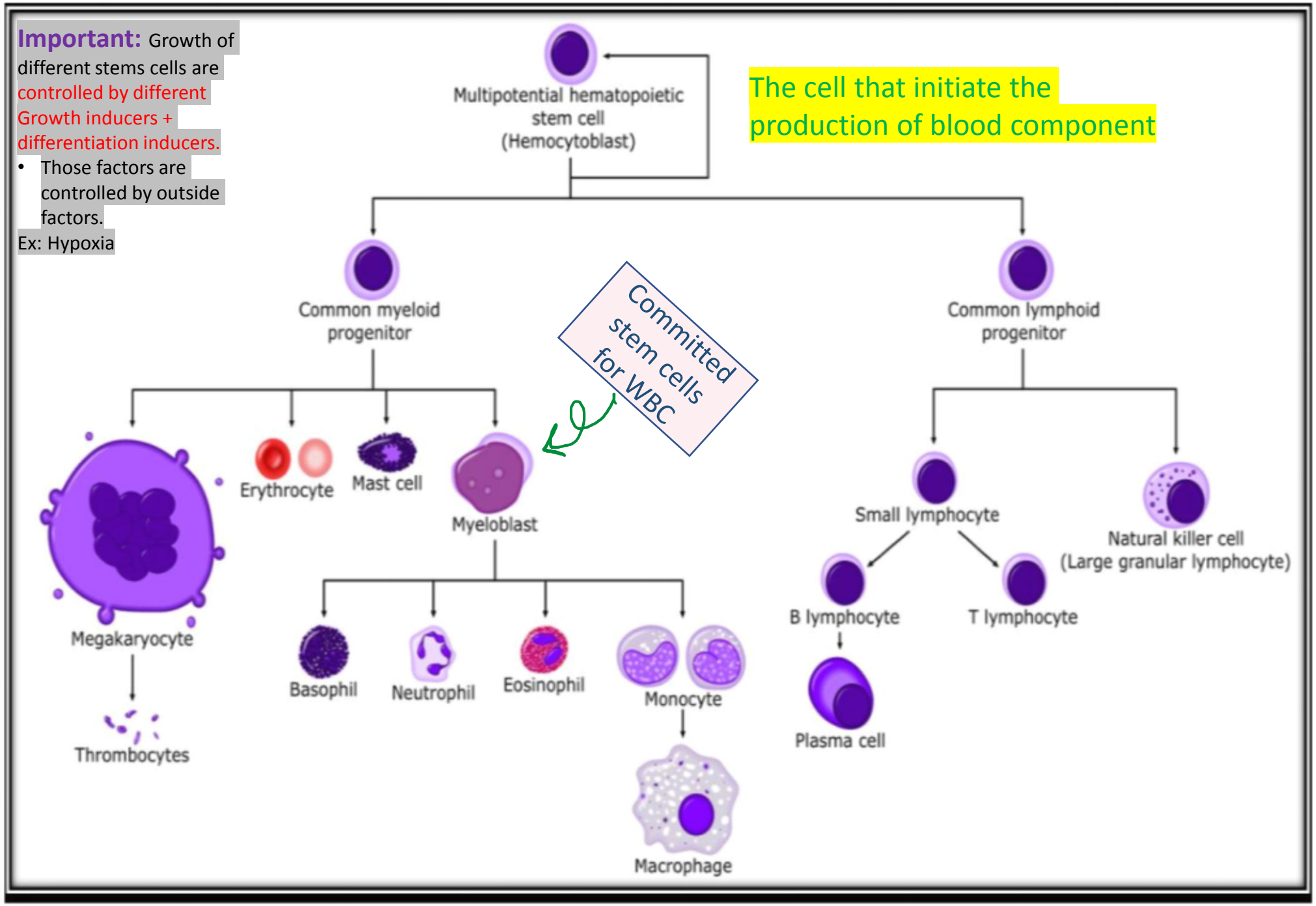
## Stages

1. P***luripotential (pluripotent) Hematopoietic Stem Cell (PHSC); hemocytoblast***
2. Uncommitted stem cells
3. Committed stem cells
4. Colony forming Unit

**Important:** Growth of different stems cells are controlled by different Growth inducers + differentiation inducers.

- Those factors are controlled by outside factors.

Ex: Hypoxia

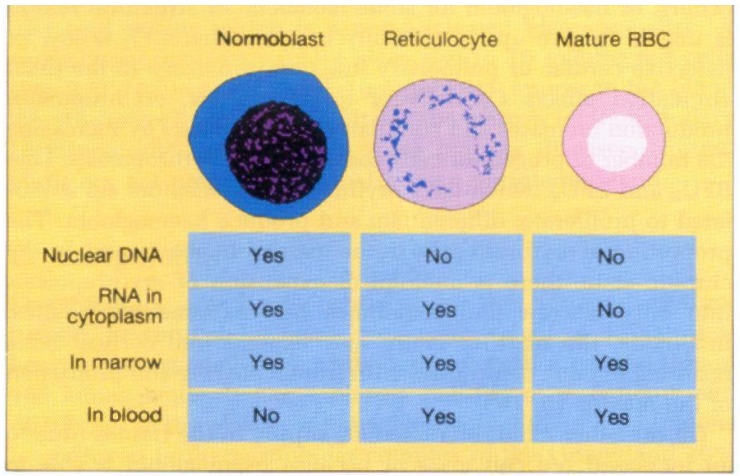


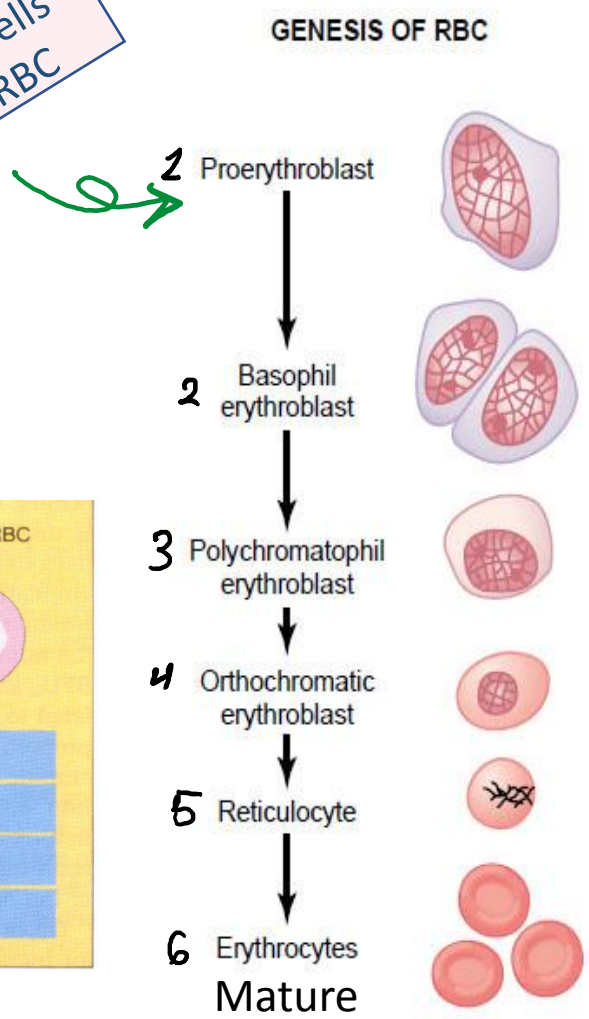
# Stages of differentiation of RBCs:

very important

Committed stem cells for RBC

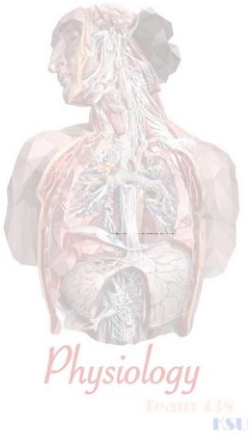
**Important :** In cases of rapid RBC production → ↑ reticlocytes in the circulation.




- **RBC development is characterize by:**
  - decrease in cell size.
  - disappearance of nucleus.
  - appearance of hemoglobin (Hb)

**Required Growth factors:**
- **Erythropoietin**
- **Colony stimulating factors**
- **Interleukins**
- **Thrombopoietin**



**How does the production of Red Blood Cells begin?**

Erythropoiesis is stimulated by erythropoietin hormone produced by the kidney.

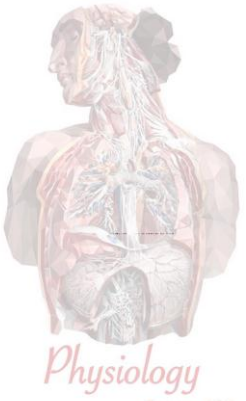
**Why is erythropoietin hormone produced ?**

It is produced in response to hypoxia (low oxygen in the blood)

**Hypoxia ( oxygen) caused by:**

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

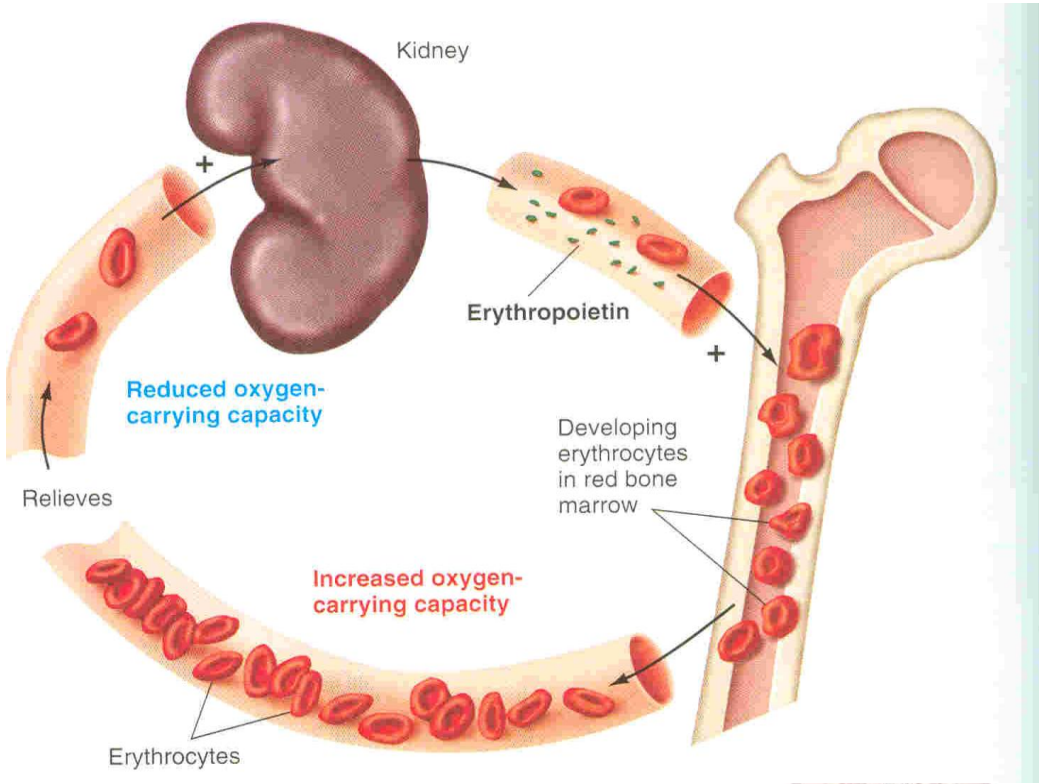
These conditions Result in High erythropoietin levels and polycythemia



# Erythropoietin

My name is erythropoietin…
I am a Glycoprotein.
(90% from renal cortex 10% liver.)
I stimulate the growth of early stem cells.
I do not affect maturation process.
I can be measured in plasma & urine.


## ROLE OF THE KIDNEYS IN RBC FORMATION




# Quiz

| Q1- Which of the following is **NOT** a function of blood? | | | |
|---|---|---|---|
| A) Transport of nutrients | B) Transport of sensory information | C) Protection against infections | D) Regulation of pH |

| Q2- What is the process of forming white blood cells called? | | | |
|---|---|---|---|
| A) Erythropoiesis | B) Thrombopoiesis | C) Leukopoiesis | D) Osteopoiesis |

| Q3- Which of the following is **CORRECT**? | | | |
|---|---|---|---|
| A) RBCs are formed in the bone marrow in the first trimester | B) RBCs are formed in the spleen in the last trimester | C) RBCs are formed in the spleen and liver in the middle trimester | D) RBCs are formed in the yolk sac in the last trimester |

| Q4- Erythropoesis is stimulated by: | | | |
|---|---|---|---|
| A) Hypoxia | B) cAMP | C) High number of RBCs | D) Glycolysis |

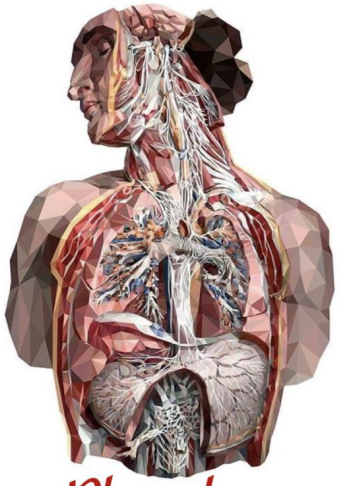
| Q5- Where is erythropoietin synthesized? | | | |
|---|---|---|---|
| A) Liver | B) kidney | C) Spleen | D) bone marrow |

Key answers:

1) B
2) C
3) C
4) A
5) B

# Thank you

| Boys team members | Girls team members |
| --- | --- |
| • عمر الدوسري | • اروى الامام |
| • زياد الدوسري | • ديما المزيد |
| • جهاد العريني | • جود الخليفة |
| • محمد الحمد | • جود العتيبي |
| • عوض العنزي | • رغد المبارك |
| • فيصل القفاري | • ريناد المطوع |
| • عبدالله باسمح | • ريما المطوع |
| | • طرفة آل كلثم |
| | • مي بابعير |
| | • نجود العلي |
| | • نورة المزروع |




**Team leaders:**

- **عمر الشيناوي**
- **ايلاف المسيحل**

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