

BLOOD PHYSIOLOGY

Lecture 2

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Objectives

At the end of this lecture you should be able to:

- 1. Describe essential elements needed for RBC formation.**
- 2. Describe the process of Vit B12 absorption and its malabsorption.**
- 3. Recognize haemoglobin structure and its functions.**
- 4. Discuss iron metabolism (absorption, storage and transport)**

Objectives - cont.

5. Describe the fate of old RBC.
6. Describe anemia and its causes.
7. Recognize causes of polycythemia.

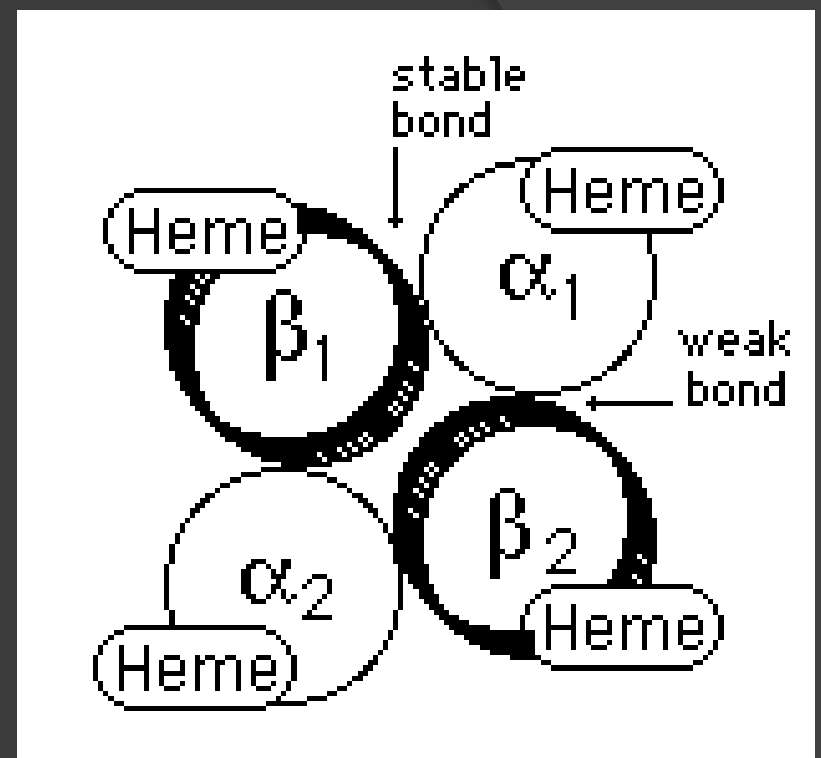
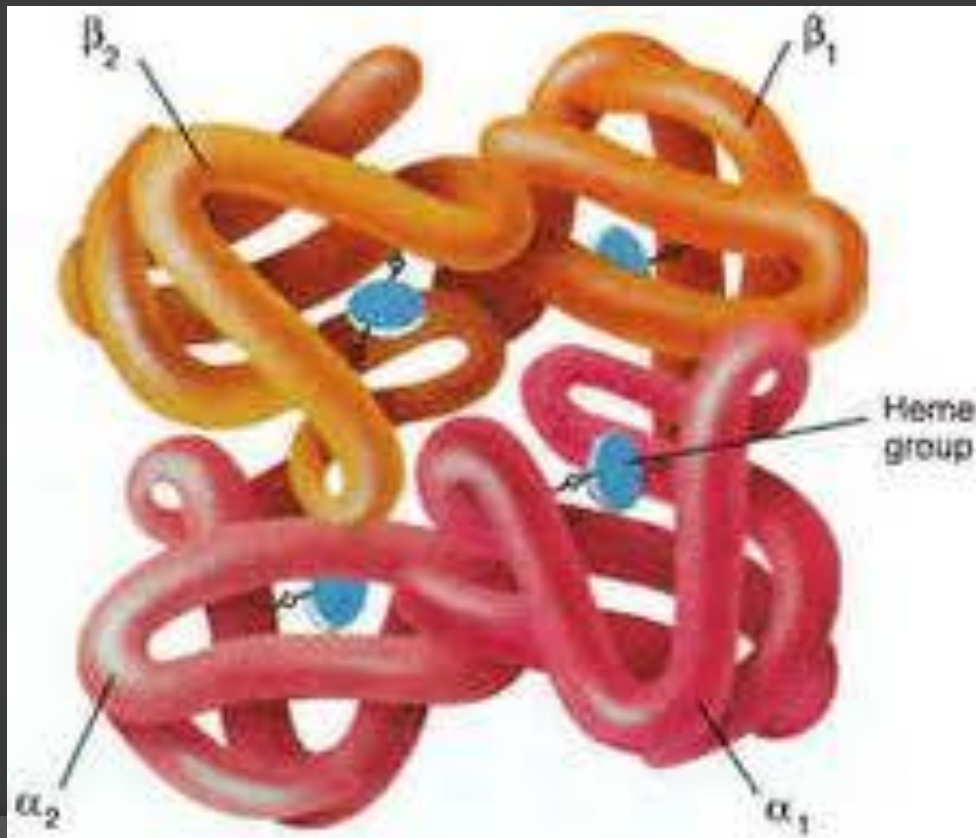
Topics:

1. Essential elements for RBC formation
 - ⊙ **Proteins**
 - ⊙ **Vitamins: B12, Folic acid, Vit C ...)**
 - ⊙ **Iron** Metabolism.
2. Anemia
3. Polycythemia
4. Structure & functions of Hb

Essential elements for RBCs formation and Maturation

Certain elements are essential for RBC formation and maturation:

1. **Amino acids**: formation of **globin** in haemoglobin
 - sever protein deficiency → anaemia
2. **Iron**: formation of haemoglobin
 - Deficiency → anaemia



Essential elements for RBCs formation and Maturation

cont.

3. **Vitamins:**

- **Vit B12 and Folic acid**
 - Synthesis of nucleoprotein
 - Deficiency → anemia
- **Other :Vit B6, Riboflavin, nicotinic acid, biotin, Vit C, Vit E**

4. **Essential elements**

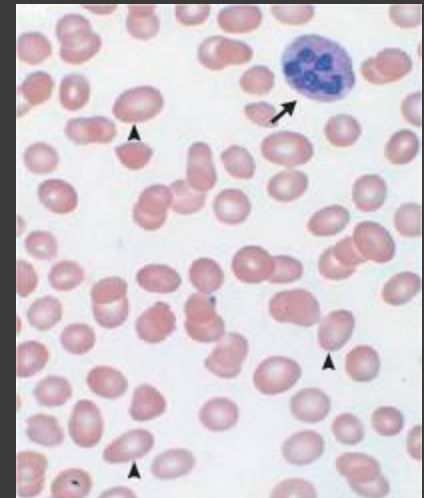
- Copper, Cobalt, zinc, manganese

5. **Hormones**

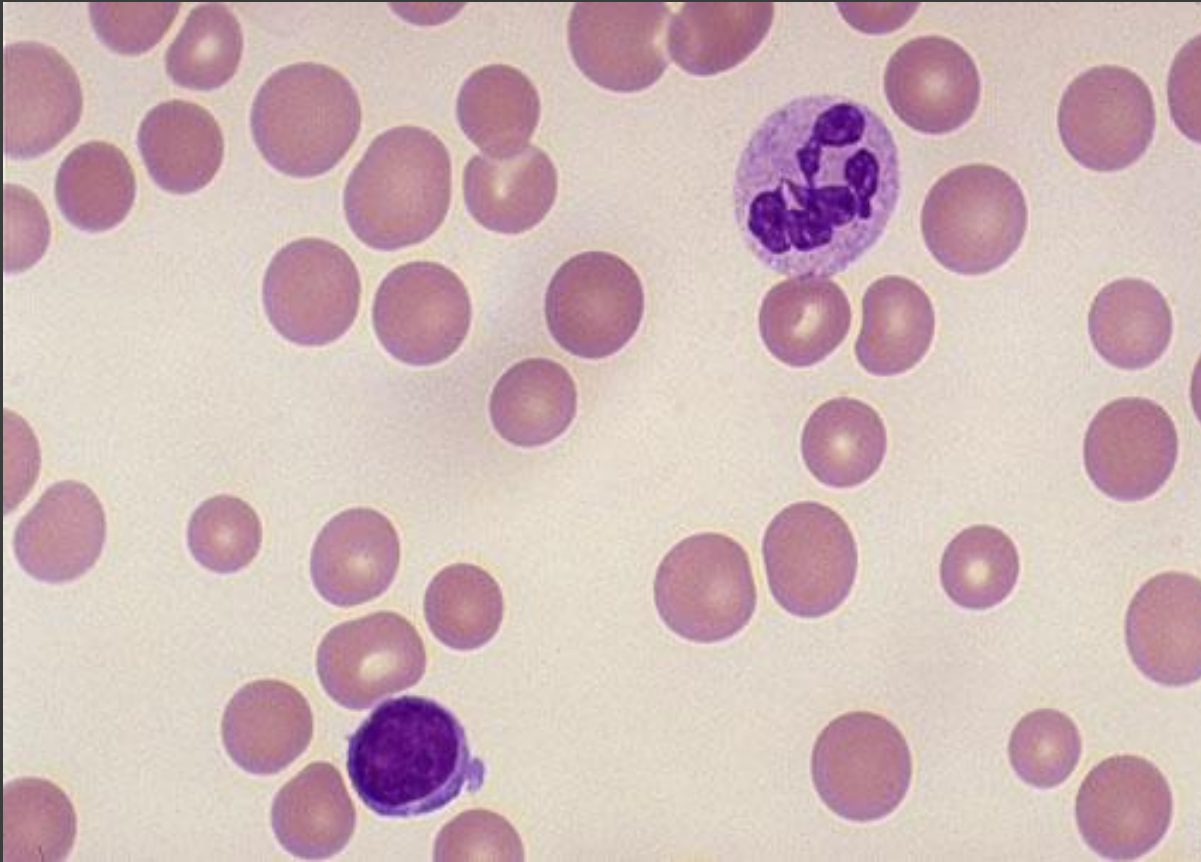
- Androgens, Thyroid, cortisol & growth hormones
- Deficiencies of any one results in anaemia

Vitamin B12 & Folic acid

- ⦿ Important for DNA synthesis and final maturation of RBC.
- ⦿ Dietary source: meat, milk, liver, fat, green vegetables.
- ⦿ Deficiency leads to:
 - Failure of nuclear maturation & division
 - Abnormally large & oval shape RBC
 - Short life span
 - reduced RBC count & Hb
 - **Macrocytic (megaloblastic) anemia**

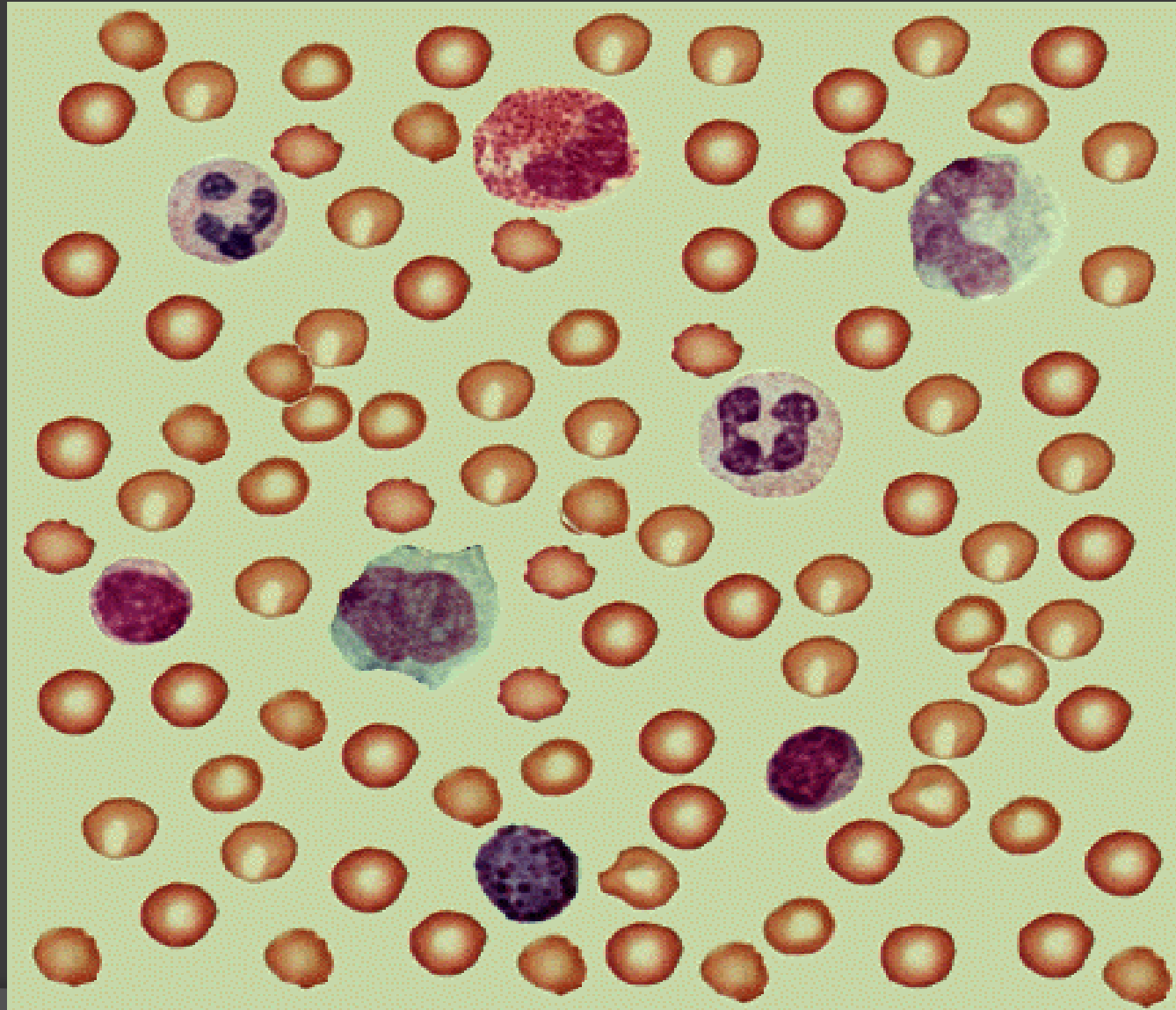


Macrocytic anemia

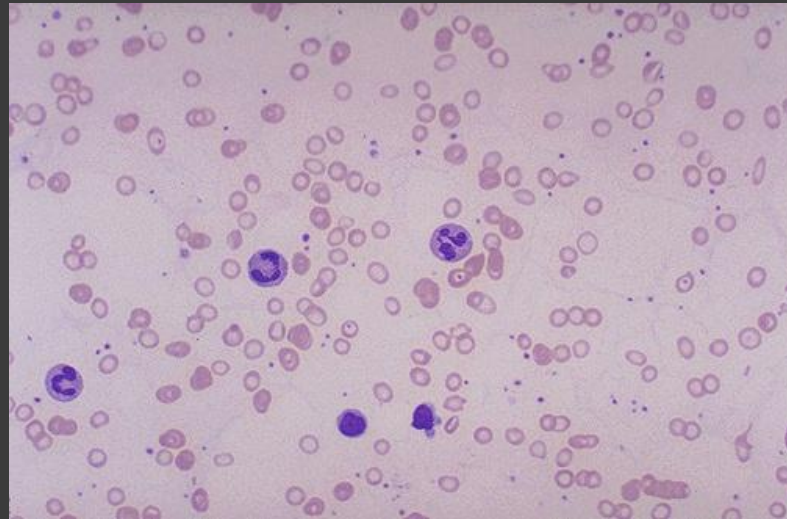


Note the hypersegmented neutrophil and also that the **RBC** are almost as large as the lymphocyte. Finally, note that there are **fewer RBCs**.

Blood Film

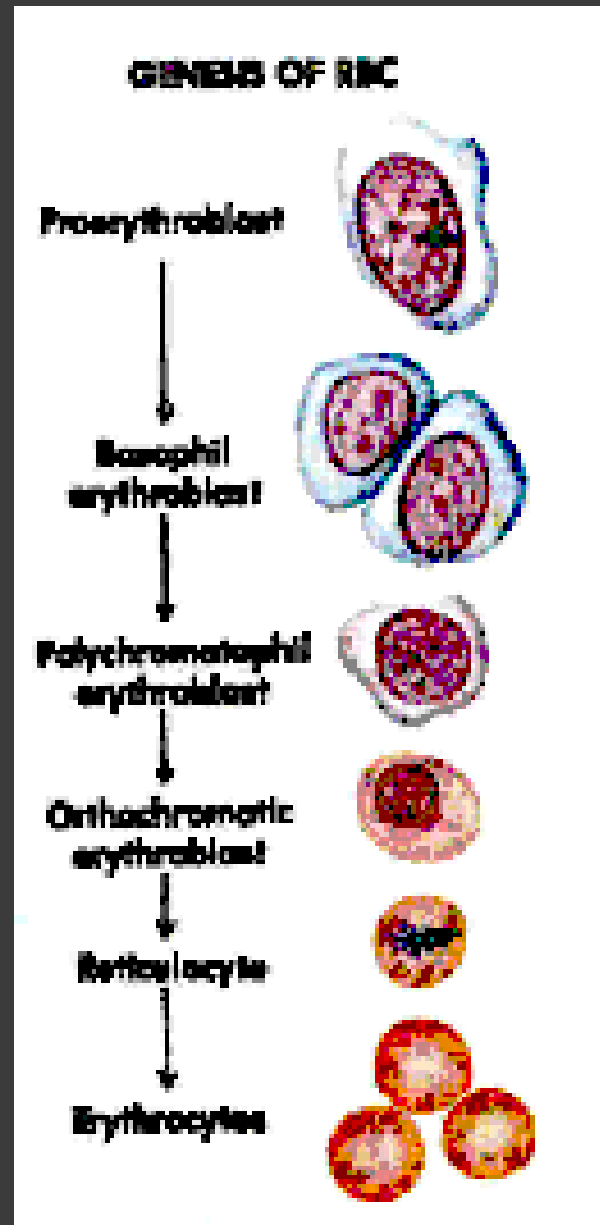


Microcytic hypochromic anemia



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

Stages of differentiation of RBC



Malabsorption of Vit. B12

Pernicious Anemia

- VB12 absorption needs **intrinsic factor** secreted by **parietal cells** of stomach.
- VB12 + intrinsic factor is absorbed in the **terminal ileum**.
- Deficiency arise from (Causes of deficiencies):
 - **Inadequate** intake
 - **Poor absorption** due to Intestinal disease

Iron metabolism (Fe)

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

- ⊙ **Total Iron in the body = 4-5g**
 - **65%** Haemoglobin
 - **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.

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, Vitamin C.**
- ⦿ **Rate** of iron absorption depend on the amount of iron **stored**

Transport and storage of iron

- ◎ Iron is transport in plasma in the form of **Transferrin** (apotransferrin + iron).
- ◎ Iron is stored in two forms:
 - **Ferritin** (apoferritin + iron)
 - **Haemosiderin** (insoluble complex molecule, in liver, spleen, bone marrow)
- ◎ Daily loss of iron is 0.6 mg in male & 1.3mg/day in females.

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 (and spleen).
- Released Hb is taken up by **macrophages** in **liver, spleen & bone marrow**:
 - **Hb** is broken into its component:
 - Polypeptide—amino acids (protein pool = storage)
 - Iron ---- ferritin
 - **Haem (Porphyrin)>>—bilirubin>>—secreted by the liver into bile. [excess destruction of RBC → Jaundice]**

ANAEMIAS

- **Definiation**
 - Decrease number of RBC
 - Decrease Hb
 -
- **Symptoms:** Tired, Fatigue, short of breath, heart failure.

Causes of anaemia

1. Blood Loss

- acute → accident (RBC return to normal 3-6w)
- Chronic → microcytic hypochromic anaemia (ulcer, worms)

2. Decrease RBC production

- Nutritional causes:
 - Iron → microcytic hypochromic anaemia.
 - Vit B12 & Folic acid → megaloblastic anaemia .
- Bone marrow failure: destruction by cancer, radiation, drugs
Aplastic anaemia.

3. Haemolytic → excessive destruction

- Abnormal cells or Hb
 - Spherocytosis
 - sickle cells
- Incompatible blood transfusion.
- Erythroblastosis fetalis .

Polycythemia

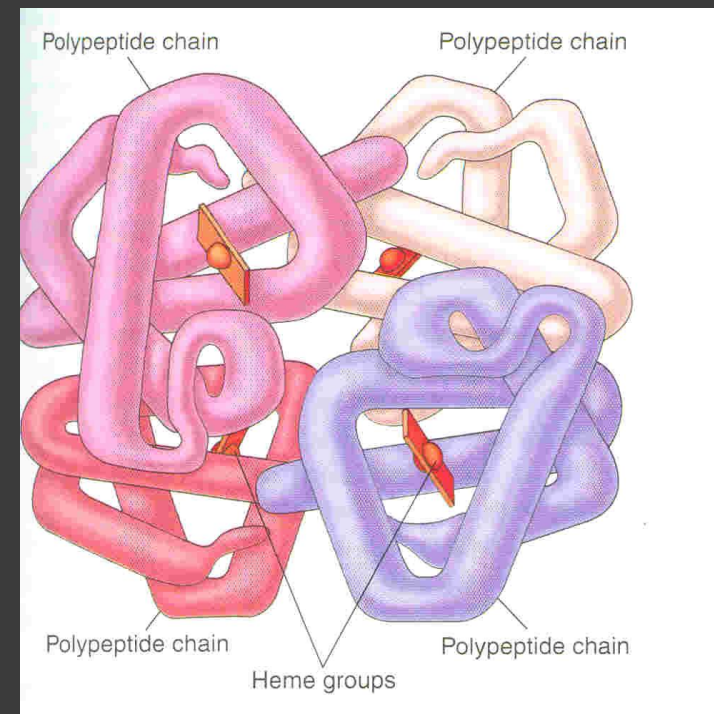
Increased number of RBC

Types:

1. **Primary** (Polycythemia Rubra Vera - PRV): uncontrolled RBC production.
2. **Secondary** to hypoxia: high altitude (physiological), chronic respiratory or cardiac disease

HAEMOGLOBIN

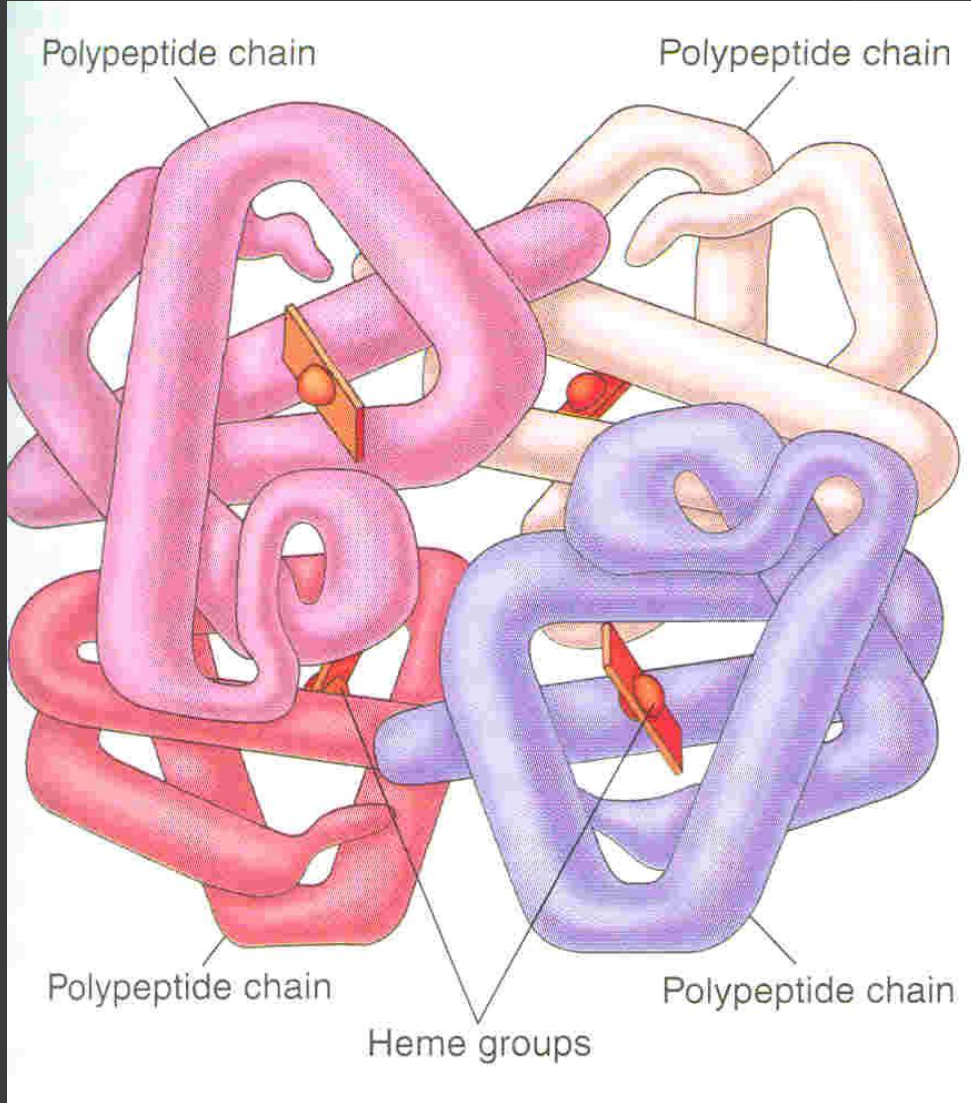
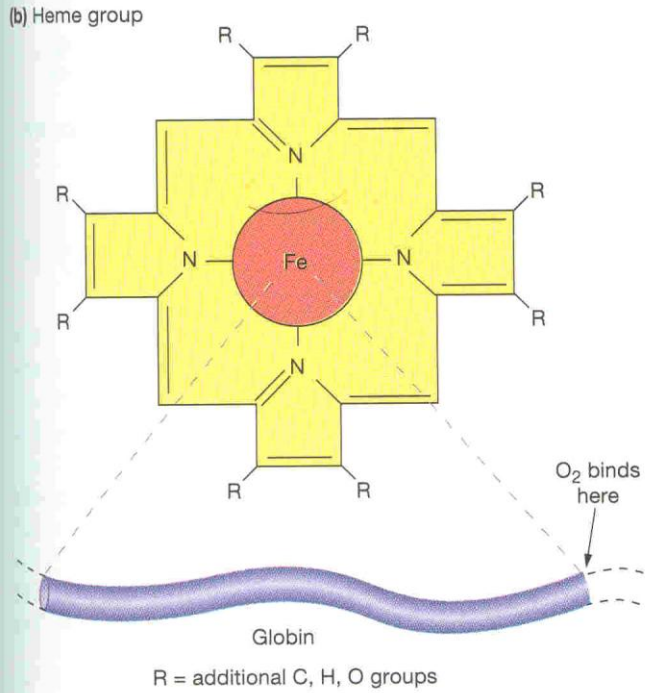
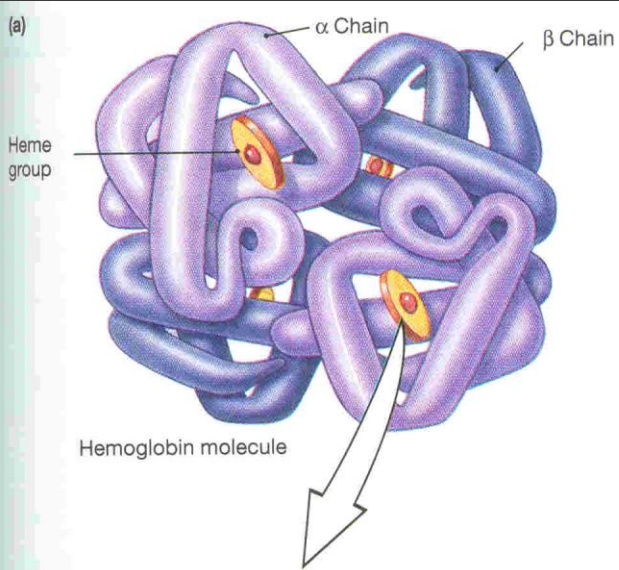
- ⦿ Hb molecules consist **4** chains each formed of **heme** & polypeptide chain (**globin**)
- ⦿ **Heme** consist of **protoporphyrin ring** + **iron (F^{2+})**



Types of normal Hb.:

- Hb A (2 α & 2 beta chains) (adult Hb) (98%).
- Hb A2 (2 α & 2 delta chains) (2%)
- Hb F (2 α & 2 γ chains) (Hb of intrauterine life).

-Abnormality in the polypeptide chain - abnormal Hb (hemoglobinopathies) e.g thalasseмииs, sickle cell (HbS).



Functions of Hemoglobin

⦿ Carriage of O_2

- Hb reversibly bind O_2 to form oxyhemoglobin, affect by pH, temperature, H^+

⦿ Carriage of CO_2

- Hb bind CO_2 = carboxyhemoglobin

⦿ Buffer