AL-mustaqbal university

College Of Health and Medical Techniques

Department of kidney dialysis techniques

Hematology

2nd stage

Lec.4

Haemoglobin

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1. Hemoglobin (Hb)

is a complex iron-containing protein found in red blood cells (RBCs). It plays a vital role in the transport of oxygen from the lungs to body tissues and the return of carbon dioxide from tissues to the lungs. The presence and proper functioning of hemoglobin are essential for maintaining life and cellular metabolism.

2. Structure of Hemoglobin

A. Basic Composition

Hemoglobin is a conjugated protein, composed of:

- Globin (protein part) – made of four polypeptide chains.
- Heme (non-protein part) – an iron-containing porphyrin ring.

B. Types of Globin Chains

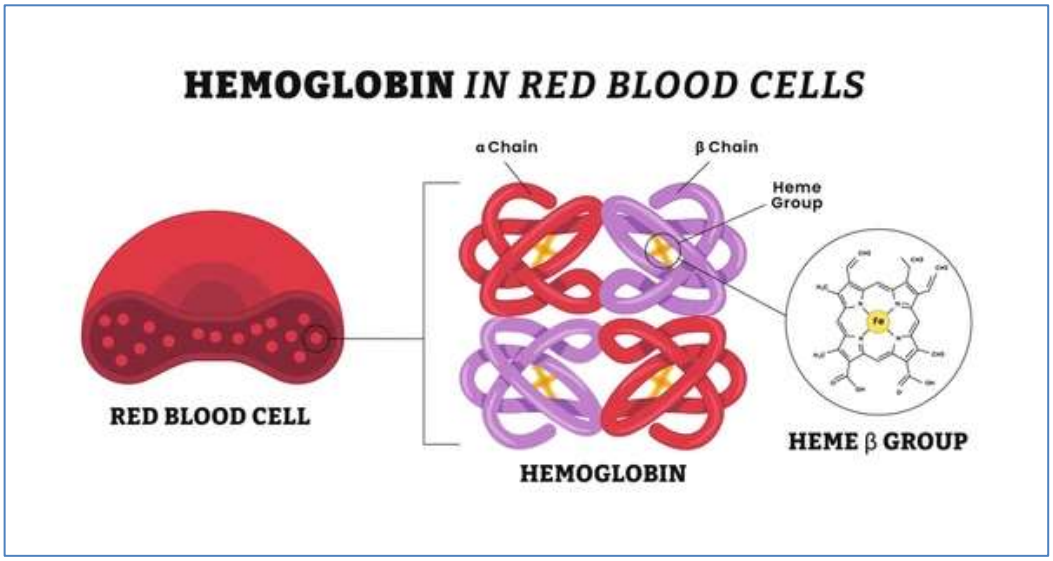
• Adult Hemoglobin (HbA): $\alpha_2\beta_2$ (2 alpha and 2 beta chains)
• Fetal Hemoglobin (HbF): $\alpha_2\gamma_2$ (2 alpha and 2 gamma chains)
• Minor adult hemoglobin (HbA_2): $\alpha_2\delta_2$ (2 alpha and 2 delta chains)

C. Heme Group

Each heme group contains a ferrous iron (Fe^{2+}) atom at its center. Each hemoglobin molecule has four heme groups, allowing it to bind four oxygen molecules (O_2).

D. Quaternary Structure

The four subunits are held together by weak non-covalent bonds. Hemoglobin's structure allows cooperative binding—the binding of one oxygen molecule increases the affinity for the next.



3. Synthesis of Hemoglobin

A. Site of Synthesis

Hemoglobin synthesis occurs in developing **erythroid cells** within the bone marrow (mainly in normoblasts and reticulocytes).

B. Steps of Synthesis

1. Formation of Porphyrin Ring (Heme synthesis)

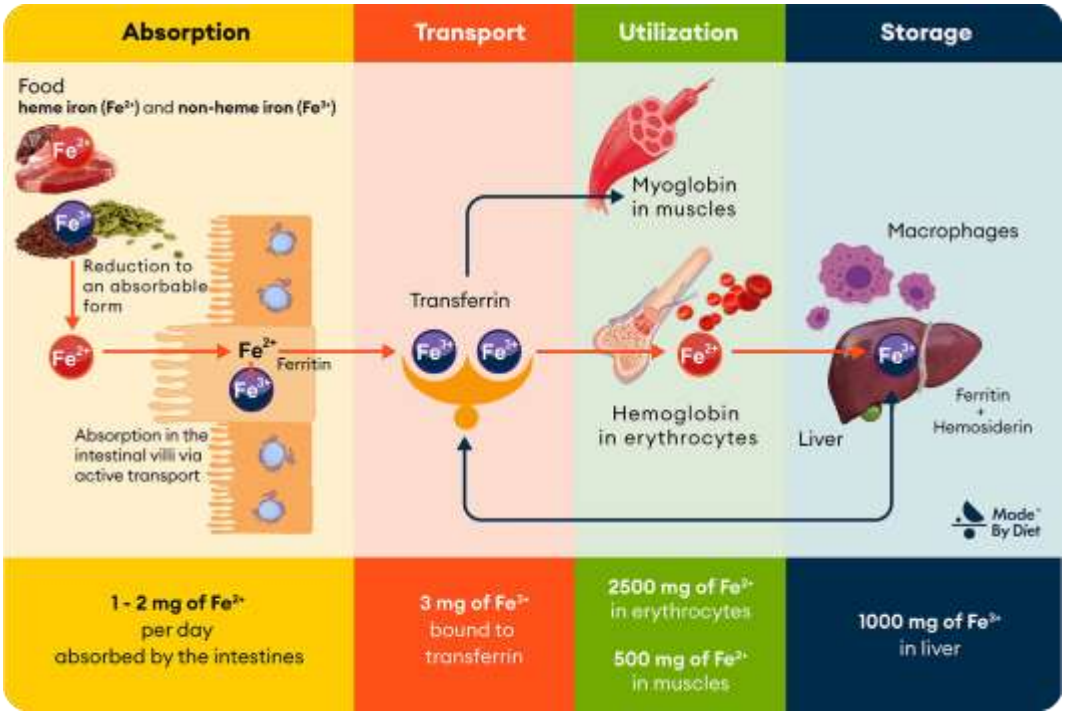
- Begins in the **mitochondria** and continues in the cytoplasm.
- **Key precursors**: glycine and succinyl-CoA.
- **Important intermediate**: δ-**aminolevulinic acid** (ALA).
- **Final product**: heme (protoporphyrin IX + Fe^{2+}).

2. **Globin Chain Synthesis**

- Occurs on **ribosomes** in the cytoplasm.
- The globin genes (α, β, γ, δ) are expressed at different developmental stages.

3. Assembly of Hemoglobin Molecule

- Heme combines with globin chains to form functional hemoglobin.
- The newly formed Hb is then packed into red blood cells.



4. Regulation of Hemoglobin Synthesis

- **Iron availability**: Required for heme synthesis.
- **Erythropoietin** (EPO): Stimulates RBC production in response to hypoxia.
- **Vitamin B6 (pyridoxine)**: Essential for ALA formation.
- **Genetic regulation:** Mutations can cause abnormal hemoglobins (e.g., sickle cell anemia, thalassemia).

5. Normal Levels of Hemoglobin

Each RBC contains approximately 270 million hemoglobin molecules. Hemoglobin accounts for about one-third of the total RBC weight.

Category	Normal Range (g/dL)
Adult males	13.5 – 17.5
Adult females	12.0 – 16.0
Newborns	14 – 20
Children	11 – 13

6. Functions of Hemoglobin

- Oxygen transport (lungs → tissues)
- Carbon dioxide transport (tissues → lungs)
- Buffering action: Helps maintain blood pH.
- Facilitates oxygen release in tissues with low oxygen tension.

7. Clinical Significance

- Anemia: Decreased hemoglobin concentration.
- Polycythemia: Elevated hemoglobin level.
- Abnormal hemoglobins:
  - HbS: Sickle cell hemoglobin (valine replaces glutamic acid in β-chain)
  - HbC, HbE: Other variants leading to hemolytic disorders.
- Iron deficiency or vitamin deficiencies impair synthesis.