

Classification of proteins

Simple proteins: These contain only amino acids. The following are the different types of simple proteins.

1. **Albumins:** These are soluble in water and dilute salt solutions, coagulated by heat and precipitated by the full saturation of their aqueous solutions with solid ammonium sulphate. This indicates that they are profusely hydrated. Serum albumin, lactalbumin and ovalbumin are examples.
2. **Globulins:** These are insoluble in water but soluble in dilute neutral salt solutions. These are coagulated by heat, and precipitated by half saturation with ammonium sulphate solution. These are less hydrated than albumins. Examples are ovoglobulin and serum globulins.
3. **Glutelins:** These are soluble in dilute acids and alkalies, insoluble in water and neutral solvents, and are coagulated by heat, e.g., glutelin from wheat.
4. **Prolamines:** Soluble in about 70 per cent alcohol, insoluble in water, absolute alcohol and other neutral solvents. They are rich in proline. Zein of corn and gliadin of wheat are good examples.
5. **Histones:** These are soluble in water and very dilute acids, insoluble in dilute NH_4OH and not coagulated by heat. They are strongly basic and occur in nucleoproteins.
6. **Globins:** They are referred to as examples of histones but are classified separately since they are not basic like histones and are not precipitated by ammonium hydroxide, e.g., globins of hemoglobin.
7. **Protamines** are the simplest of proteins and may be regarded as large polypeptides, rich in basic amino acids. They are soluble in water or ammonium hydroxide and not coagulated by heat. They resemble histones but are soluble in NH_4OH . Protamines occur in sperm cells.
8. **Albuminoids** (Sclero proteins): These are insoluble in all neutral solvents, dilute acids and alkalies, and are present in supporting tissues like bone, cartilage, horn, hair, etc.(e.g., keratin, collagen). Gelatin is derived from collagen.

Classification of proteins

Conjugated proteins (compound proteins): These are composed of simple proteins in association with some non-protein substance as the prosthetic factor.

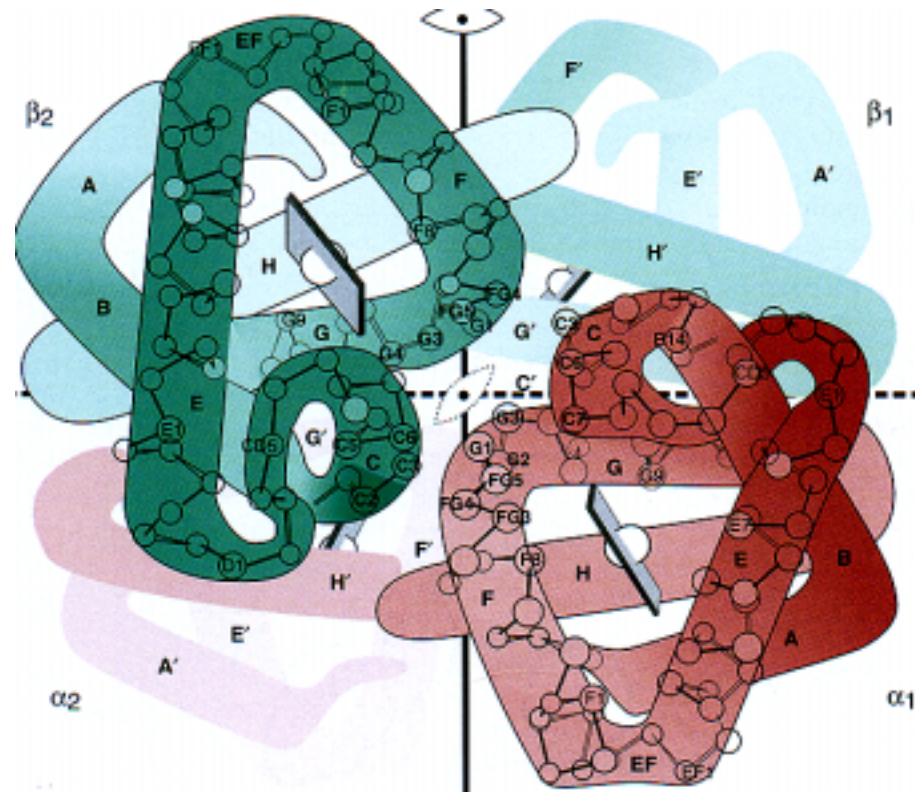
1. **Nucleoproteins** are combinations of simple basic proteins, i.e., protamines or histones with nucleic acids (DNA or RNA). These are soluble in dilute NaCl. The chromatin of cell nuclei and the viruses are nucleoproteins.
2. **Glycoproteins and mucoproteins:** These are simple proteins combined with carbohydrates (glycosaminoglycans) and on hydrolysis give amino acids, amino sugars and uronic acids. The glycosaminoglycans may be hyaluronic acid, chondroitin sulphates and heparin. Glycoproteins contain less than four per cent carbohydrate. Some of the plasma proteins like fibrinogen, transferrin, ceruloplasmin and immunoglobulins are glycoproteins containing different amounts of carbohydrates. Mucoproteins contain more than four per cent. Most of the mucoproteins are soluble in water, e.g., serum mucoproteins, ovomucoid of egg white and mucin of saliva. They are important constituents of the ground substance of connective tissue and are present as tendomucoid, osseomucoid and chondroproteins in tendons, bones and cartilage, respectively.
3. **Phosphoproteins:** These contain phosphoric acid. Casein of milk and vitellin of egg yolk are phosphoproteins. The phosphoric acid is combined with serine of the proteins.
4. **Chromoproteins** are simple proteins united with coloured prosthetic groups (chromophoric or colour-producing), e.g., hemoglobin, flavoproteins, cytochromes, visual purple of the retina and catalase.
5. **Lipoproteins** are proteins conjugated to a lipid-like lecithin, cephalin, neutral fat, fatty acid or cholesterol. Lipoproteins are different from proteolipids in that the latter are soluble in organic solvents and insoluble in water. Lipoproteins occur in the blood and cell membranes.
6. **Metalloproteins** are proteins containing metallic elements such as iron, cobalt, manganese, zinc, e.g., ceruloplasmin (copper), siderophilin (iron). Iron-containing heme proteins which are classified as chromoproteins are also metalloproteins.

Hemoglobin and Myoglobin

- Primary function of myoglobin is to store oxygen in muscle for release during periods of oxygen deprivation
 - Monomeric protein with heme
- Primary function of hemoglobin is to carry O₂ from lungs to tissues
 - Composed of 2 α and 2 β subunits with hemes

HEMOGLOBIN

A Model for the Study of Structure - Function Relationships



Hemoglobin Properties

Tetramer of 2 α and 2 β subunits.

O₂ binds to iron protoporphyrin IX.

Binding exhibits cooperativity.

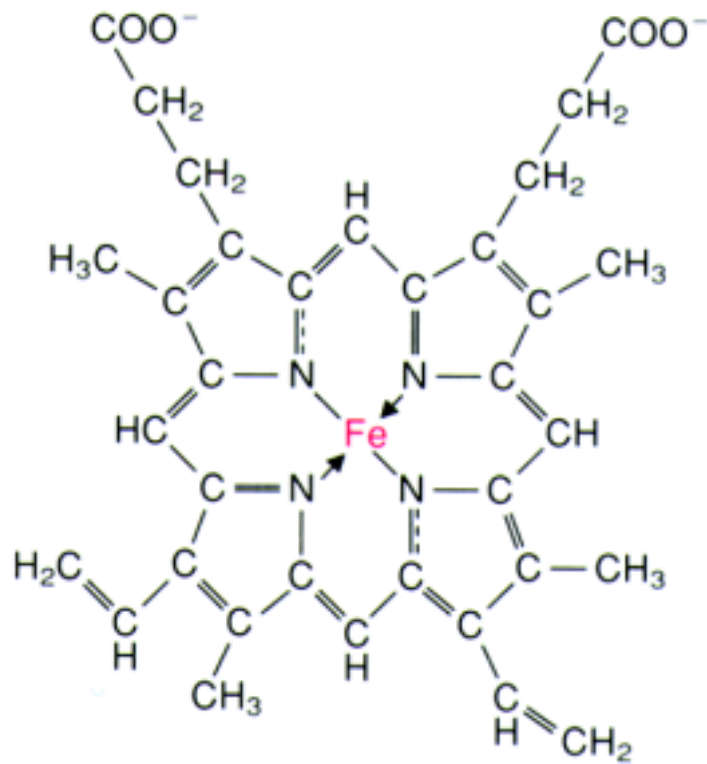
Four primary regulators of O₂ binding.

CO₂, 2,3-BPG, H⁺ and Cl⁻

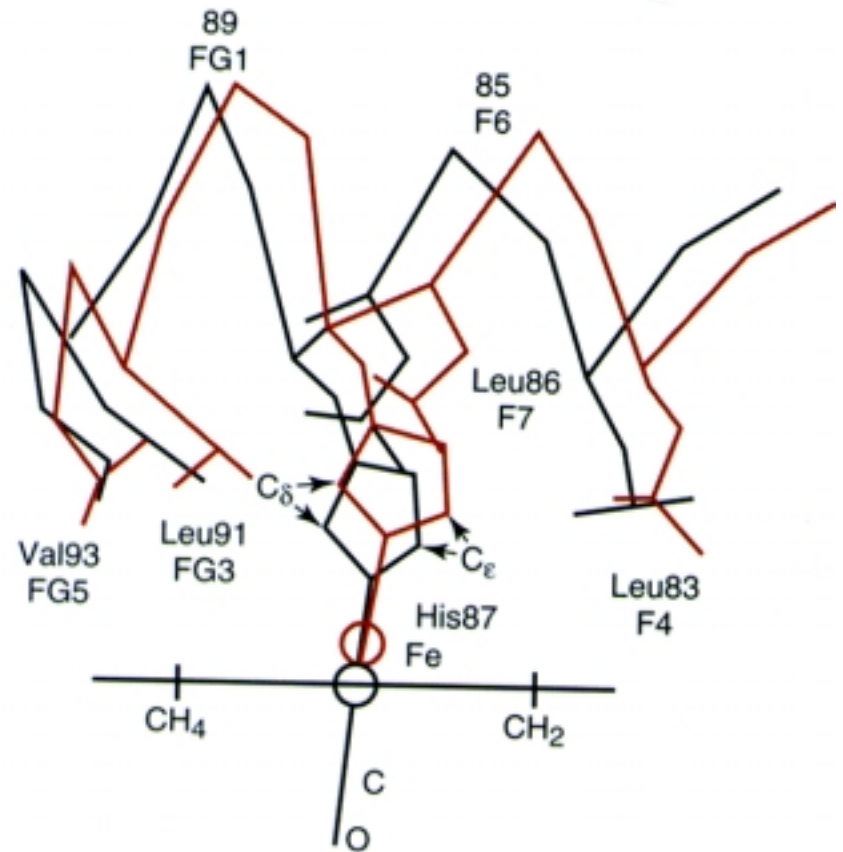
Hemoglobin Physical Properties

- Deoxyhemoglobin tetramers exist in the T state = reduced affinity for O_2 .
- Oxyhemoglobin tetramers exist in the R state = increased affinity for O_2 .
- CO_2 , 2,3-BPG, H^+ and Cl^- all increase the proportion of T state monomers.

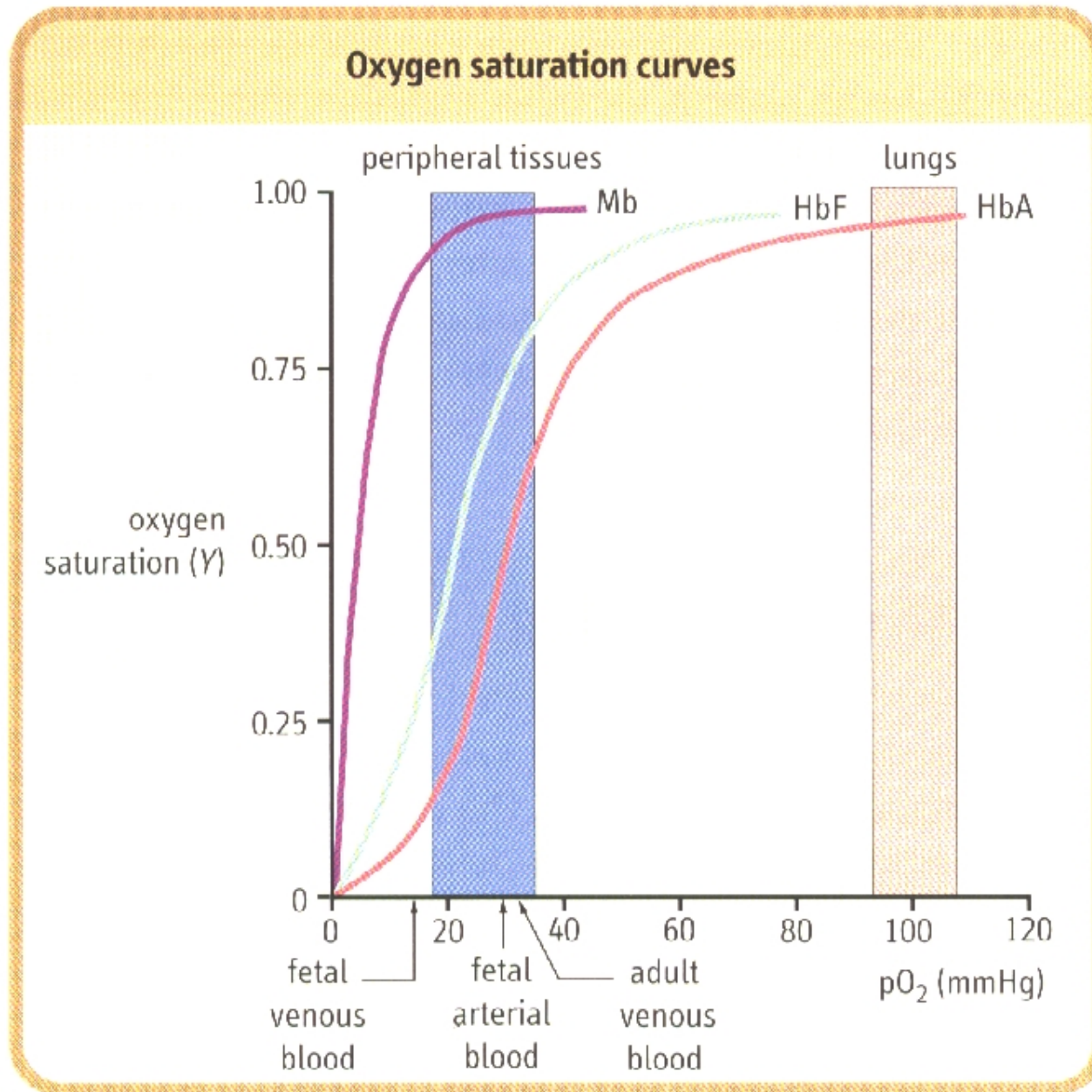
Heme and its role in modulating protein structure



Heme
(Fe-protoporphyrin IX)



Allosteric Properties of Hemoglobin



Hemoglobin as CO₂ Carrier

- Hemoglobin is involved in transporting CO₂ from tissues to the lungs
- N-terminal residues of T-state hemoglobin react with CO₂ forming **carbamino-Hb**
- Accounts for approx. 15% of CO₂ transport to the lungs
- In lungs, high pO₂ favors R-state and leads to release of the bound CO₂



Production and Role of 2,3-Bisphosphoglycerate, 2,3-BPG

1/2 Glucose → **Glyceraldehyde-3-phosphate**

*Glyceraldehyde-3-phosphate
Dehydrogenase*

Pi

NAD⁺

NADH + H⁺

**1,3-Bisphospho-
glycerate**

*Bisphosphoglycerate
mutase*

**2,3-Bisphospho-
glycerate**

ADP + Pi

*Phosphoglycerate
kinase*

ATP

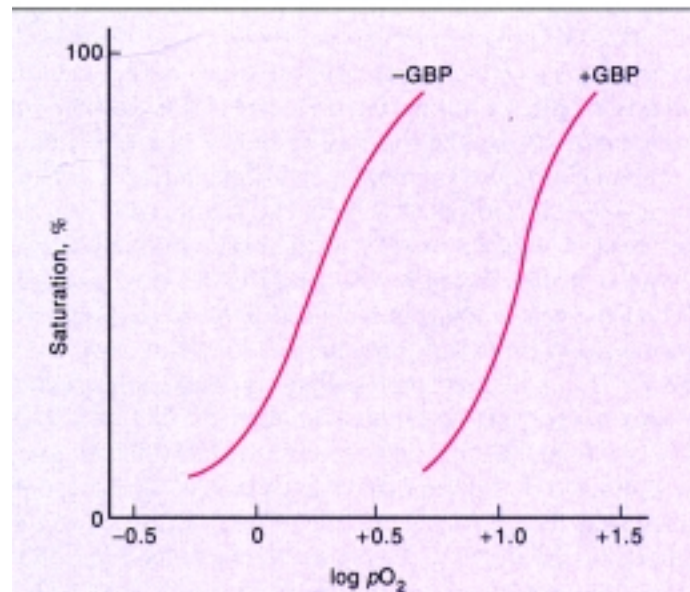
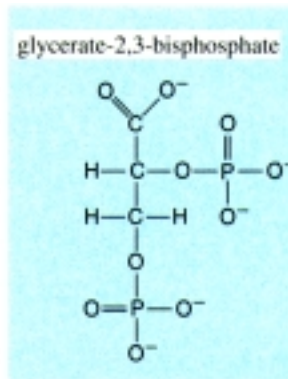
*2,3-Bisphosphoglycerate
Phosphatase*

3-Phosphoglycerate

Pi

Pyruvate

Effects of 2,3-BPG



The Bohr Effect

When O₂ binding leads to the T to R transition, N-term amino groups of a chains, imidazole groups of His in α and β chains ionize

Protons are also released when hemoglobin carbamate is formed

Both reactions demonstrate that conformation and oxygen binding of hemoglobin are sensitive to hydrogen ion concentration

Transport of CO₂ and the Bohr Effect

Tissue

Plasma

RBC

O₂

O₂

Chloride shift

HbH(+)

HbO₂

HCO₃⁻

HCO₃⁻

Cl⁻

Cl⁻

H⁺

H₂O

H₂O

H₂CO₃

carbonic anhydrase

CO₂

CO₂ + H₂O

