UNIVERSITI SAINS MALAYSIA

WEBEX 3 PPPJJ, USM

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JIB 321
Biochemistry

Chapter 4
The Three-Dimensional Structure of Proteins

Topic learning outcome (TLO)

At the end of this chapter student must able to:

- TLO1: describe the important of primary structure and compare it's α-helix and β-sheet structure
- TLO2: describe the interactions in tertiary structure formation
- TLO3: compare between myoglobin and hemoglobin

The levels of protein structure

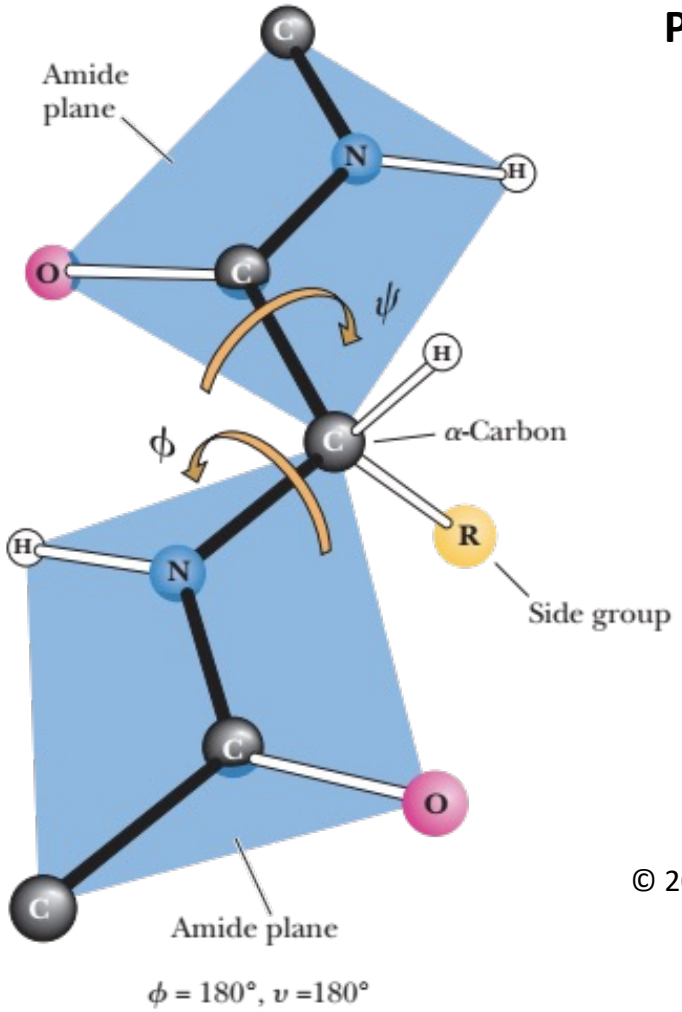
An order in which amino acid covalently bond
(Primary)

The arrangement in space of the atoms in the peptide backbone
(Secondary)

The three-dimensional arrangement of all the atoms in the protein
(Tertiary)

The arrangement of subunits with respect to one another
(Quaternary)

Leu—Gly—Thr—Val—Arg—Asp—His

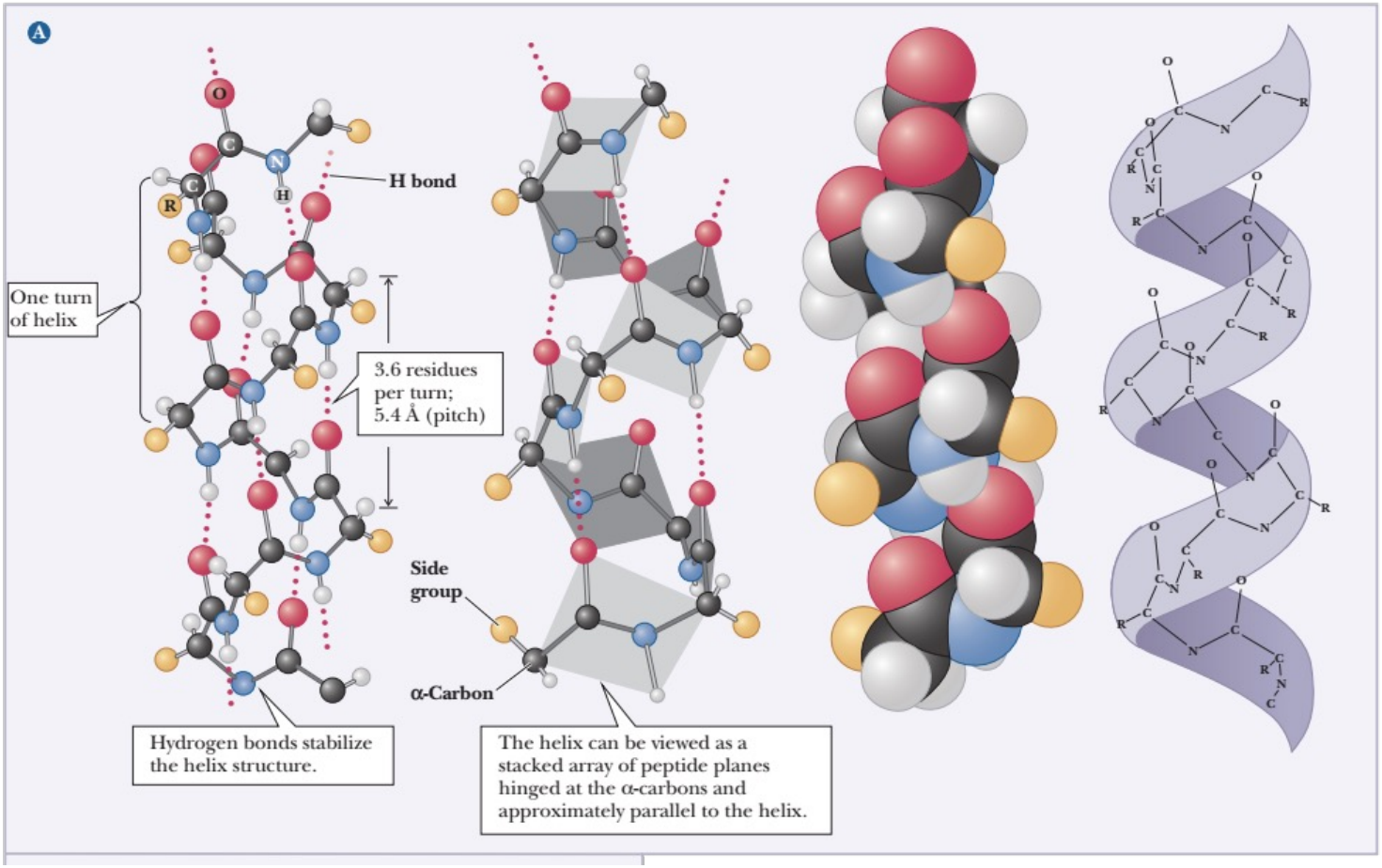


Primary structure

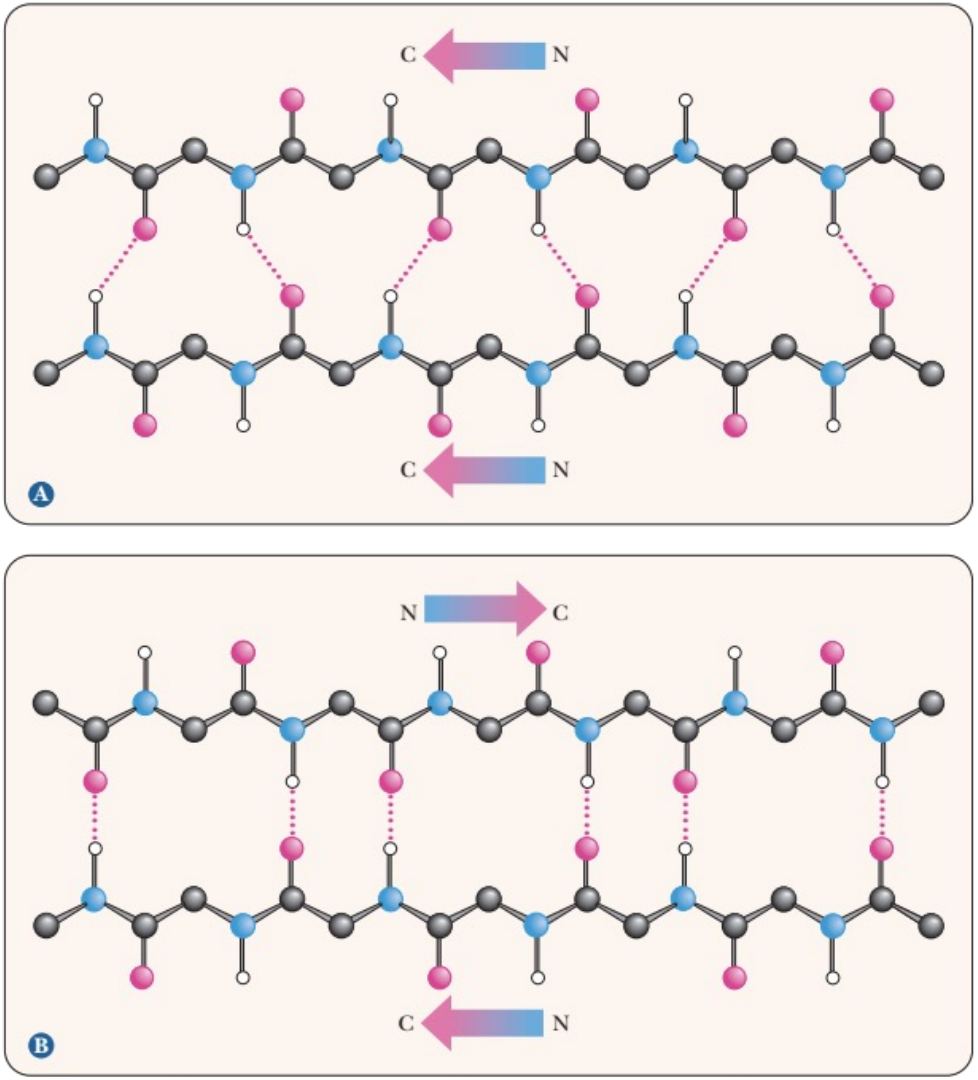
Angles in polypeptide chains

■ **FIGURE 4.1 Phi and psi angles of the peptide backbone.** Definition of the angles that

The α-helix



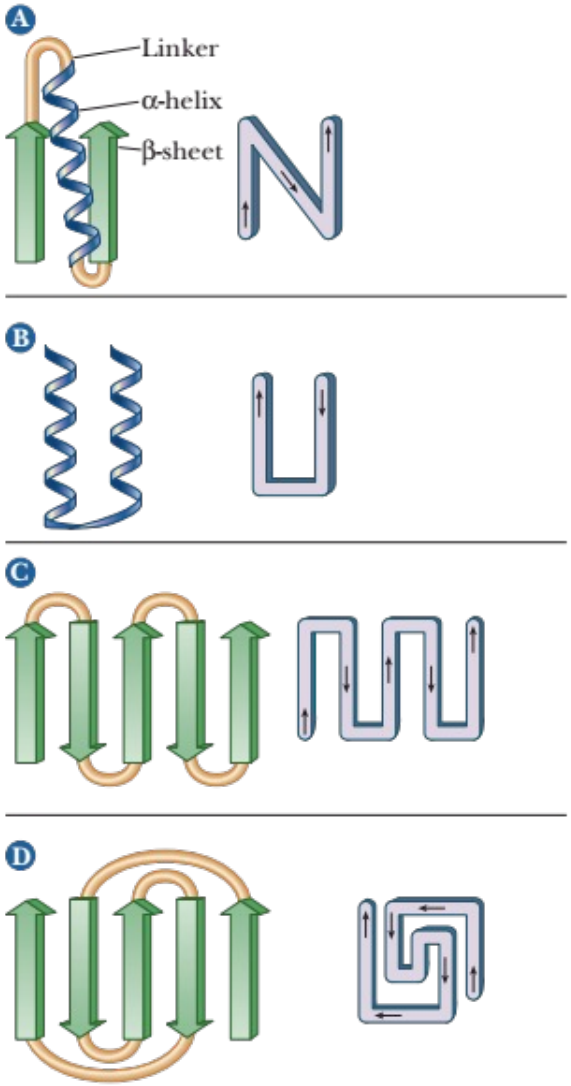
■ **FIGURE 4.2 The α-helix.** (a) From left to right, ball-and-stick model of the α-helix, showing terminology; ball-and-stick model with planar peptide groups shaded; computer-generated space-filling model of the α-helix;



β-pleated sheet

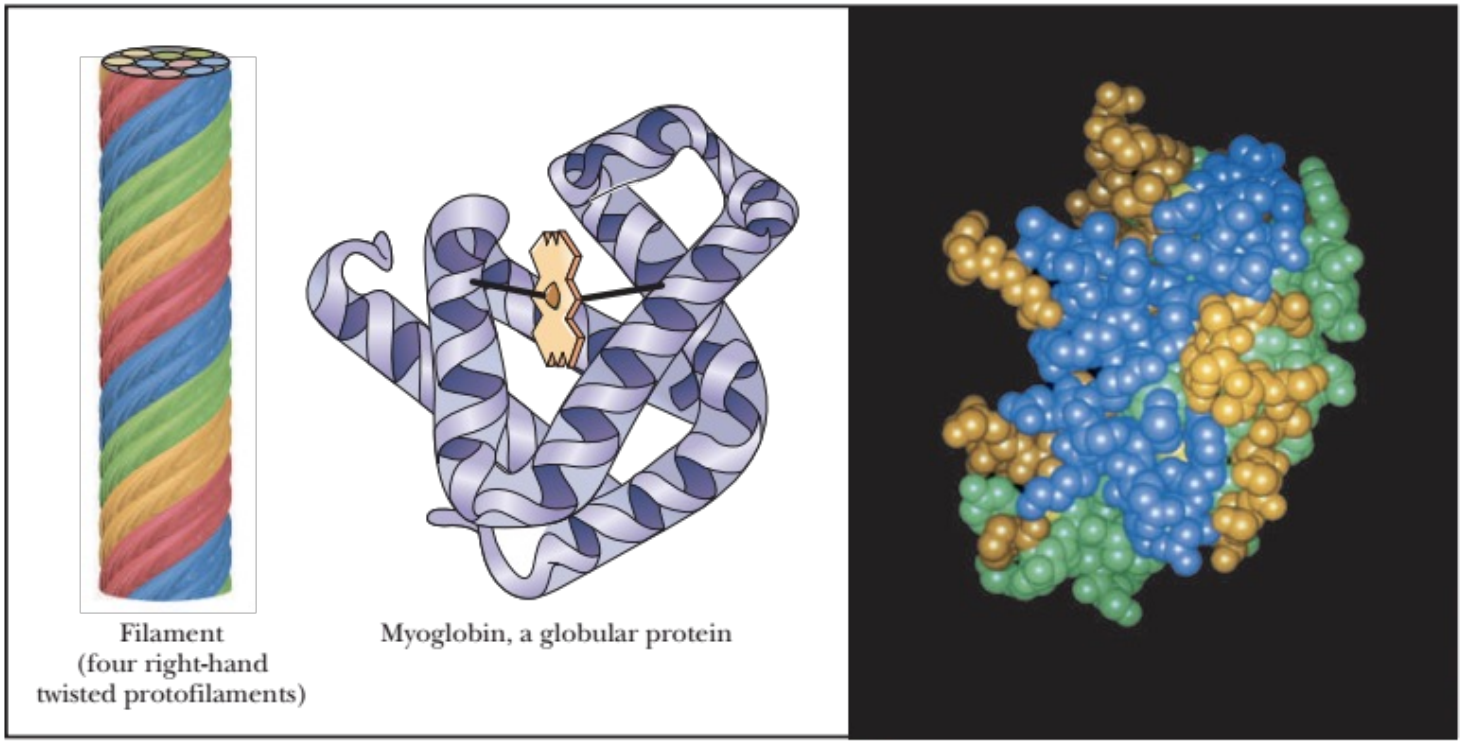
■ **FIGURE 4.4 Hydrogen bonding in β-pleated sheets.** Ball-and-stick diagram showing the arrangement of hydrogen bonds in (a) parallel and (b) antiparallel β-pleated sheets.

■ **FIGURE 4.8 Schematic diagrams of supersecondary structures.** Arrows indicate the directions of the polypeptide chains. (a) A $\beta\alpha\beta$ unit, (b) an $\alpha\alpha$ unit, (c) a β-meander, and (d) the Greek key. (e) The Greek key motif in protein structure resembles the geometric patterns on this ancient Greek vase, giving rise to the name.



Supersecondary structure

Motif and modul

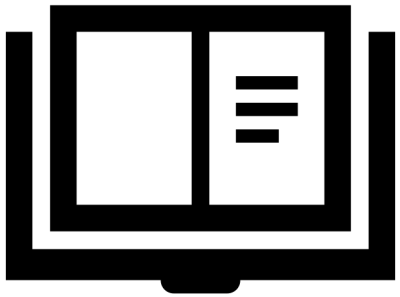


A Schematic diagrams of a portion of a fibrous protein and of a globular protein.

B Computer-generated model of a globular protein. Alpha-helices are shown in blue, beta-sheets are green, and random coil is gold.

■ **FIGURE 4.12 A comparison of the shapes of fibrous and globular proteins.**

Type of Protein conformations

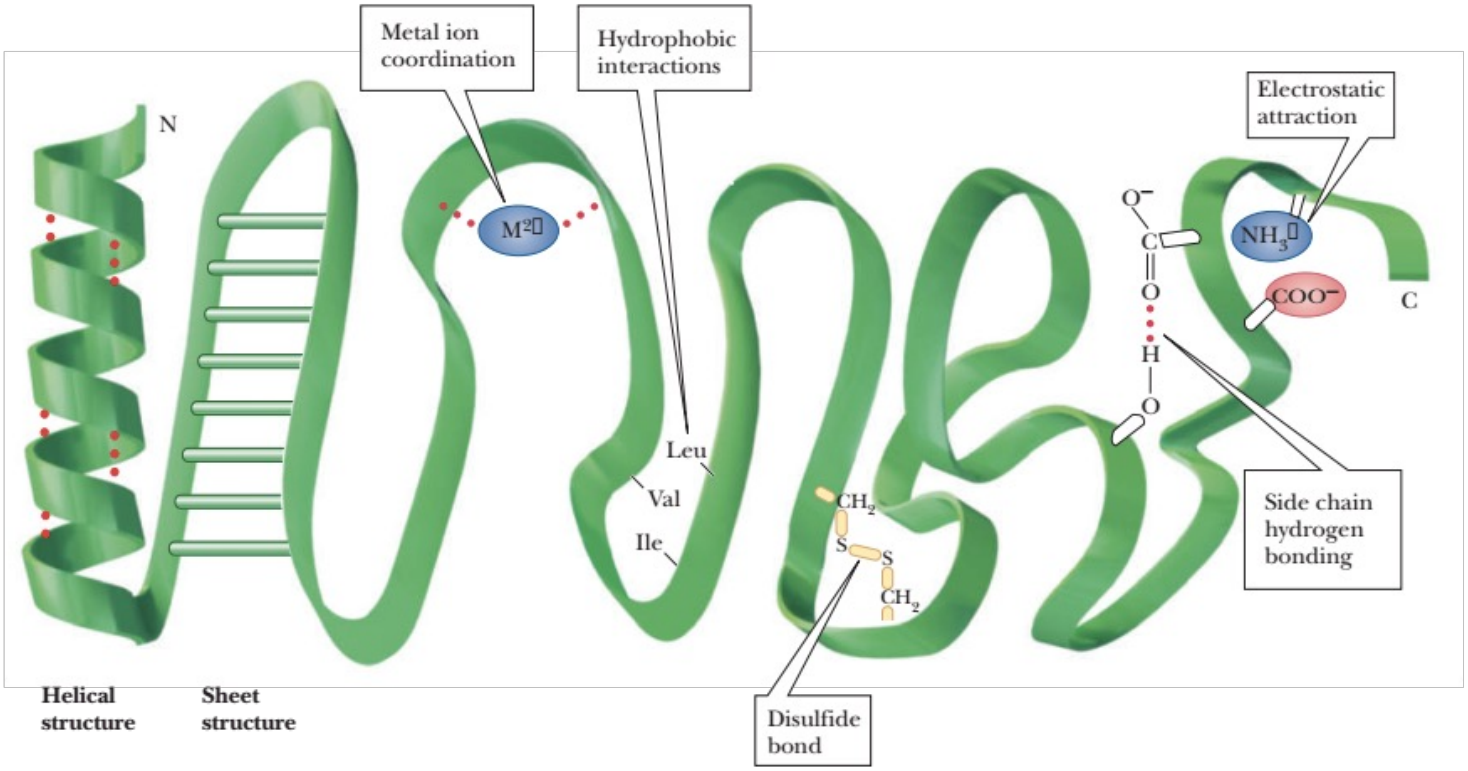


Finding information via Topic 3 SIM

And reliable internet sources as below:

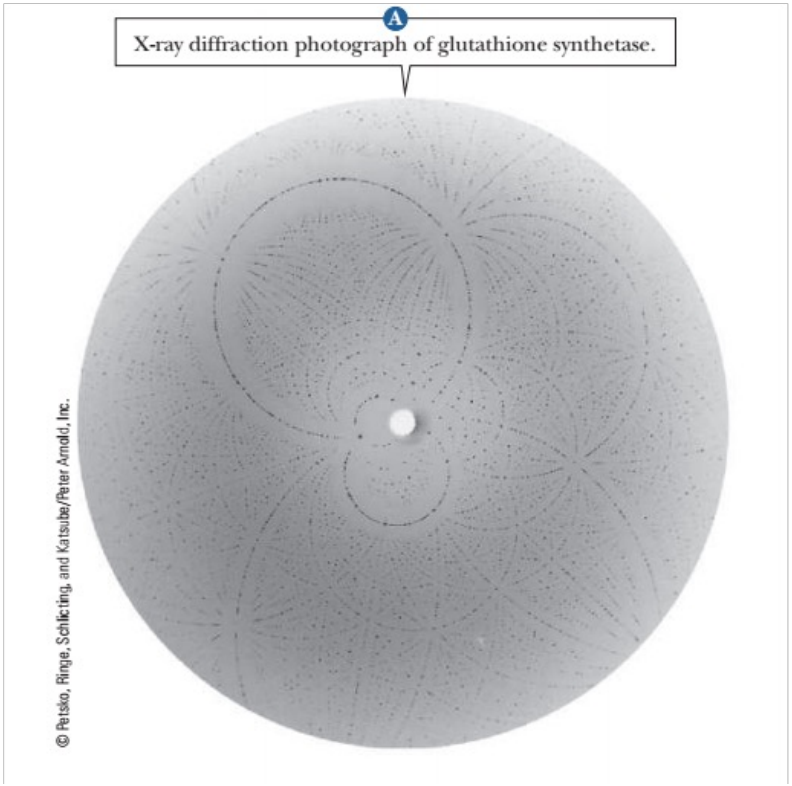
https://www.youtube.com/watch?v=PeFdl6KmxYM

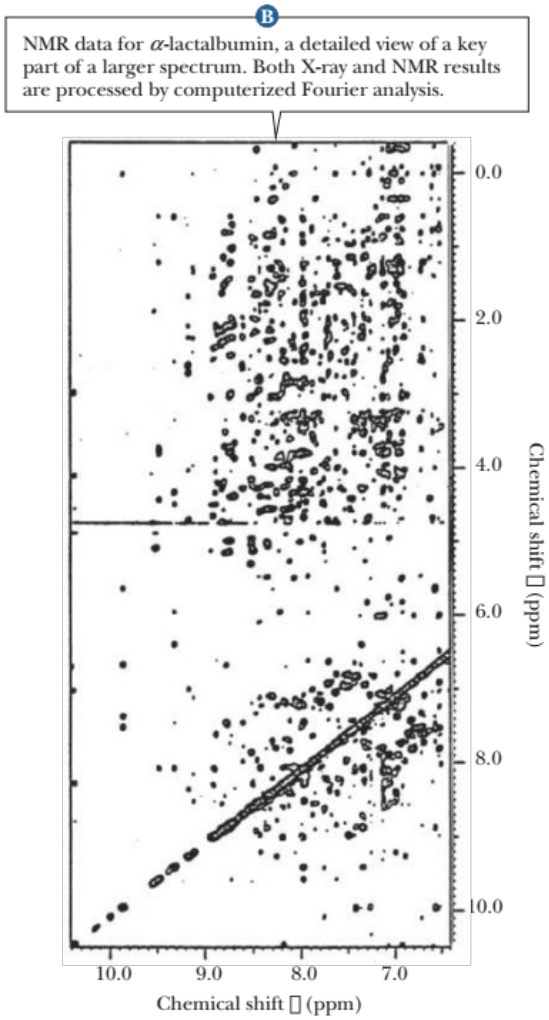
https://www.youtube.com/watch?v=TDKJ5BE1JYQ



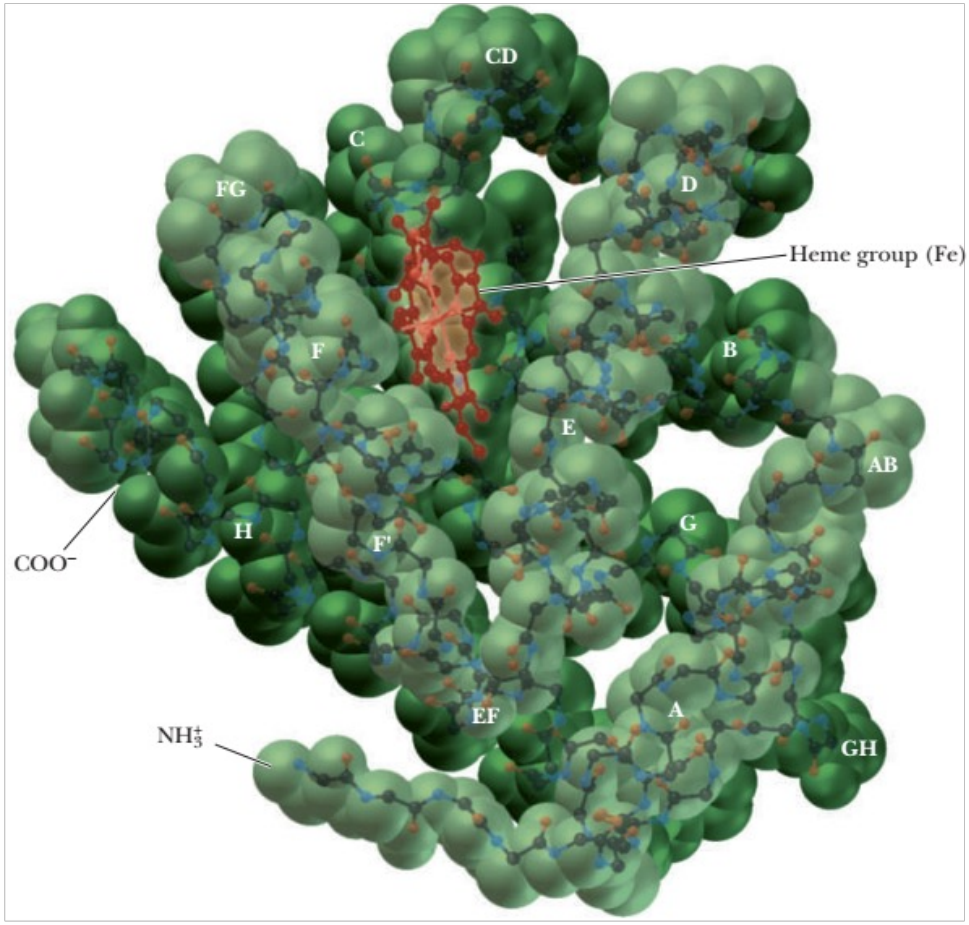
■ **FIGURE 4.13 Forces that stabilize the tertiary structure of proteins.** Note that the helical structure and sheet structure are two kinds of backbone hydrogen bonding. Although backbone hydrogen bonding is part of secondary structure, the conformation of the backbone constrains the possible arrangement of the side chains.

The tertiary structure

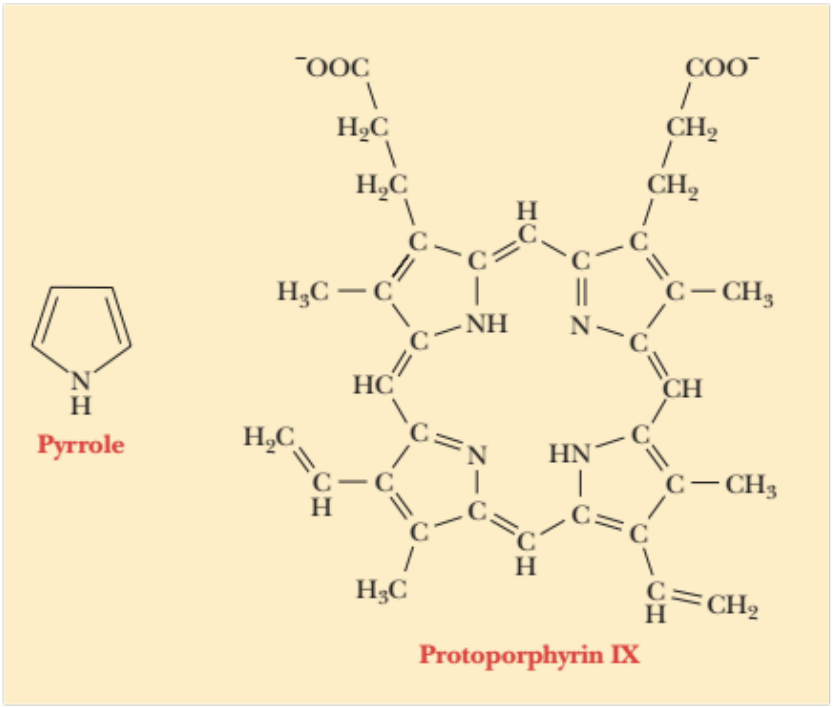


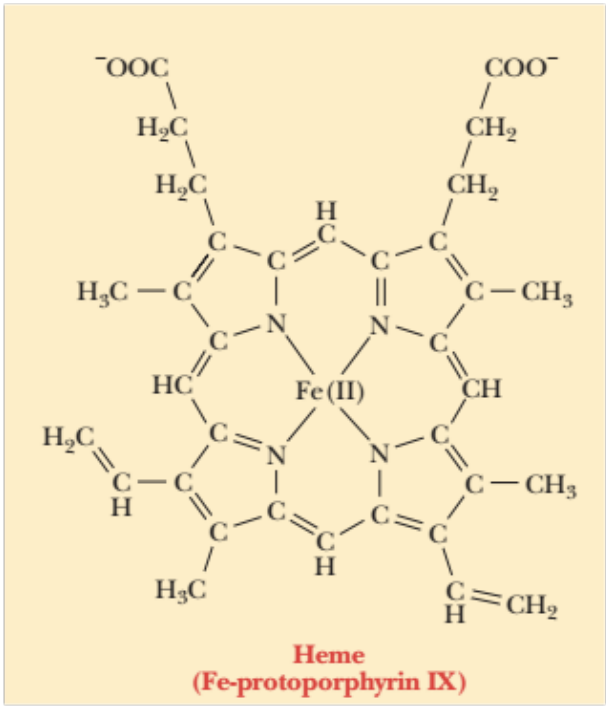


Experimental techniques for Tertiary structure determination

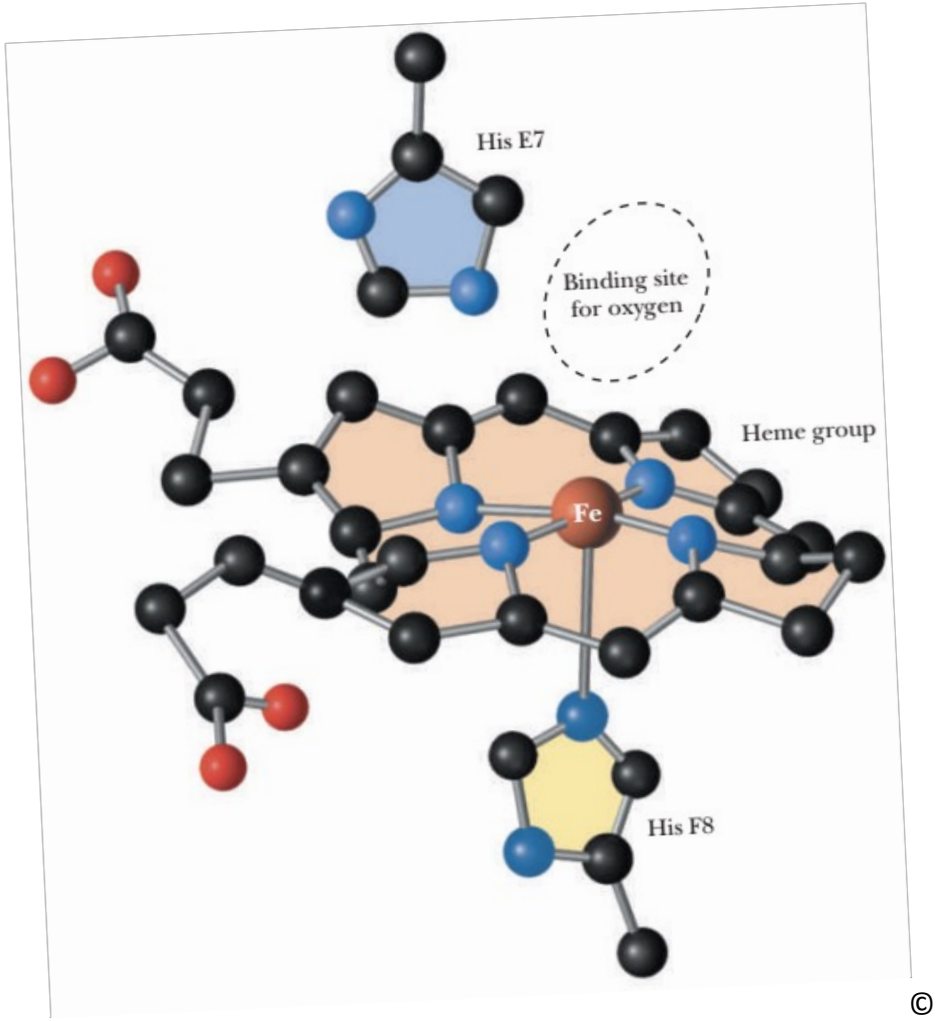


Tertiary structure Example
Myoglobin





Heme group



Binding of oxygen in Heme group

Assignment JIB321

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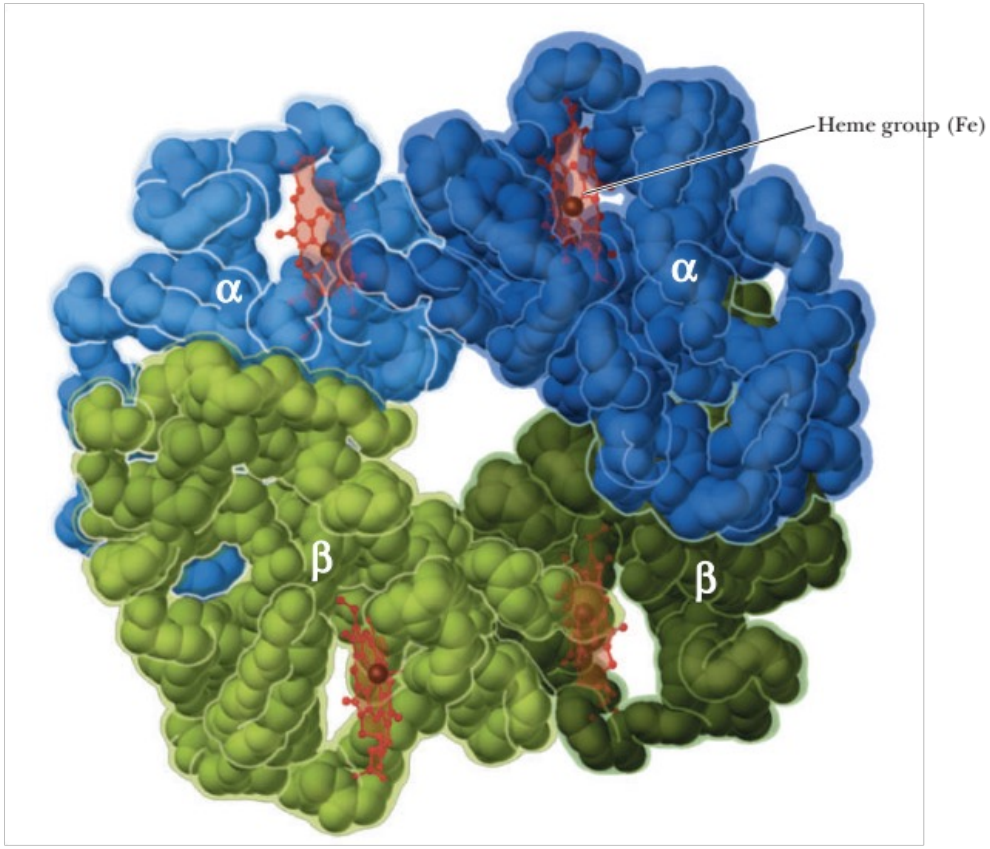


FIGURE 4.21 The structure of hemoglobin. Hemoglobin ($\alpha_2\beta_2$) is a tetramer consisting of four polypeptide chains (two α-chains and two β-chains).

Quaternary Structure
Hemoglobin

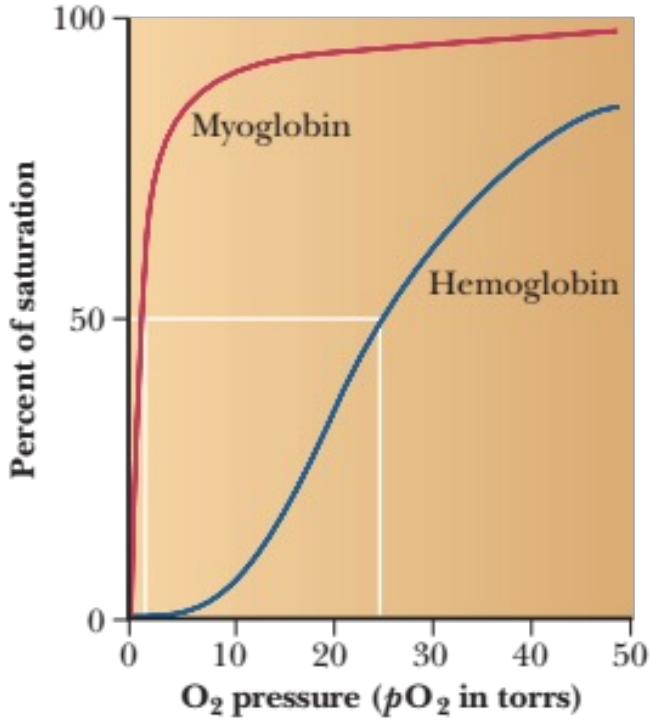


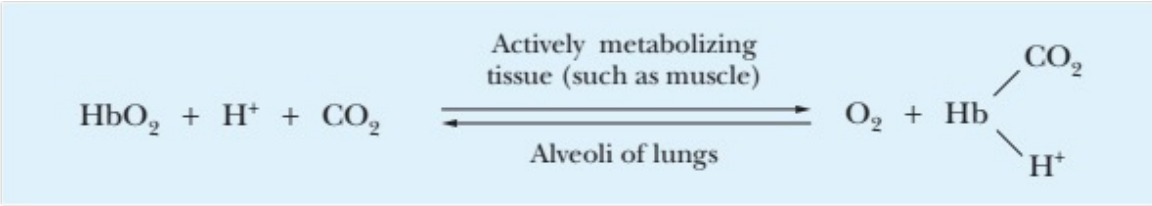
FIGURE 4.22 A comparison of the oxygenbinding behavior of myoglobin and hemoglobin. The oxygen-binding curve of myoglobin is hyperbolic, whereas that of hemoglobin is sigmoidal. Myoglobin is 50% saturated with oxygen at 1 torr partial pressure; hemoglobin does not reach 50% saturation until the partial pressure of oxygen reaches 26 torr.

Graph of oxygen binding

Bohr Effect

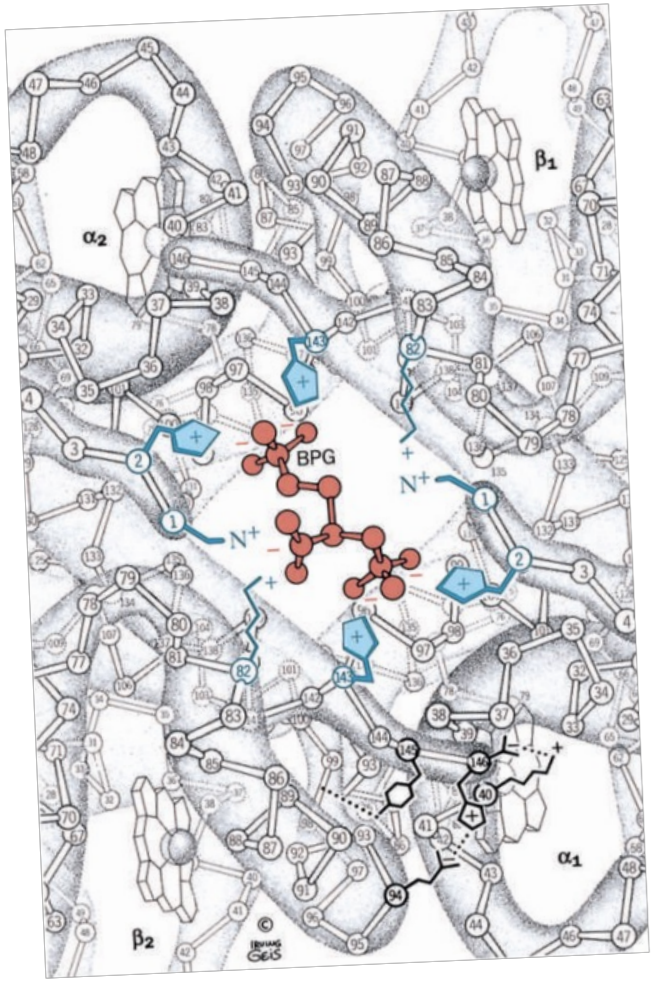
TABLE 4.1

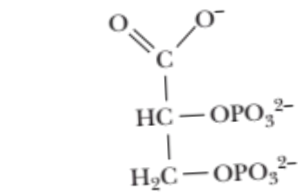
A Summary of the Bohr Effect	
Lungs	**Actively Metabolizing Muscle**
Higher pH than actively metabolizing tissue	Lower pH due to production of H^+
Hemoglobin binds O_2	Hemoglobin releases O_2
Hemoglobin releases H^+	Hemoglobin binds H^+



■ **FIGURE 4.24 The general features of the Bohr effect.** In actively metabolizing tissue, hemoglobin releases oxygen and binds both CO_2 and H^+. In the lungs, hemoglobin releases both CO_2 and H^+ and binds oxygen.

Other ligand binds Hemoglobin





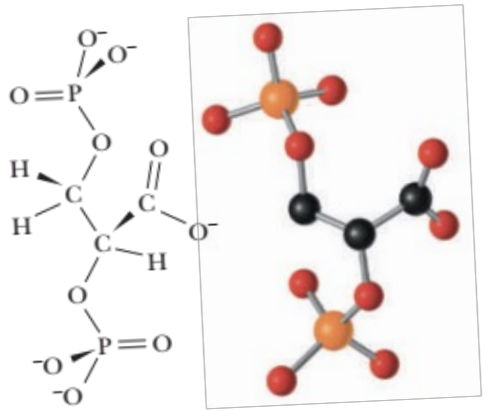


FIGURE 4.26 The structure of BPG. BPG (2,3-*bis*phosphoglycerate) is an important allosteric effector of hemoglobin.

Other type of Hemoglobin

Fetal hemoglobin (Hb F)

- Higher oxygen-binding affinity than adult Hb
  - Present of gamma chain
  - BPG binding is weak (H143S)

Sickle-cell haemoglobin (Hb S)

- Mutation of G6V/W
  - Polar → nonpolar
  - On surface → aggregates of molecules
- Sickling of the blood cells

Thank You

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