Biochemistry 3

Proteins

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Biology Department, College of Sciences,
Mustansiriyah University

2018-2019

الكيمياء حياتية 3

البروتينات

المرحلة الثانية- قسم علوم الحياة
الجامعة المستنصرية

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Proteins

Proteins are organic molecules with large molecular weight compose of multiple chains of A.As. Proteins are one of the most abundant molecules in the life, with a very stable and diverse structure make proteins more functional than other classes of macromolecules. One living cell could involve thousands of different proteins, each with a unique function.

Proteins represents over 50% of the dry weight of the cell and are responsible on variety of functions, such as:

1. Catalytic function: Specific type of proteins could catalyze and accelerate lots of biochemical reactions within and outside cells, such as digestions, hydrolysis, biosynthesis, oxidation and reduction, muscle contraction and so on.

2. Structural proteins: Some proteins provide rigidity and stiffness for cells, such as keratin (hair and nails), collagen (bones, ligaments and skin), and elastin (more flexible than collagen).

3. Transport and store: Some proteins carry substances, nutrition and drugs through the blood stream into cells or out of cells. Proteins can transport sugars, cholesterol or oxygen, such as hemoglobin, which carries oxygen from lungs to body tissues. The lipoproteins LDH and HDL transport the insoluble form of cholesterol form liver to the tissues. Transporting proteins are specific, which means that the protein binds sugar to move it away the blood, is specific for sugar and cannot binds cholesterol molecule.

4. Defense proteins: Some proteins help to protect the body against virus or to fight infections. These proteins can form immunoglobulins or antibodies. Once the foreign harmful molecule enters the cell, the body will produce antibodies to fight this strange molecule and then eliminate it. The blood clotting process is an example, where the inactive protein "fibrinogen" is converted into the active form "fibrin" as a colt to prevent blood loss or damage the vessel.

5. Regulating proteins: Some proteins help to maintain the acid-base balance of fluids inside the body, such as Albumin and Globulin. Proteins can bind hormones for regulating purposes, such as hormones insulin and glucagon, which are proteins regulate blood sugar.

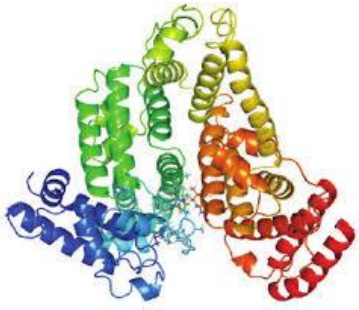
Classification of proteins

Proteins could be classified according to their composition or to the shape.

1. According to the composition

Proteins are either simple or conjugated.

a) Simple proteins: On hydrolysis, this type of proteins will be dissociated into its fundamental units "A.As" and simple carbohydrates, such as albumin, globulin and glutlins.



Albumin

b) Conjugated proteins: Simple proteins combined some non-protein molecules like sugar, nucleic acid or lipids to produce nucleoproteins, lipoproteins, phosphoprotein, metalloprotein, and glycoprotein.

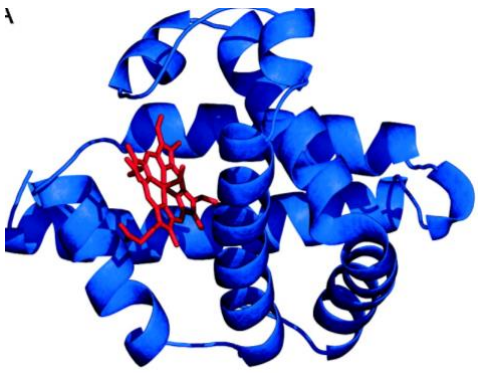
* Nucleoproteins: protein + nucleic acids, such as ribosomes and viruses.
* Lipoproteins: protein + lipids, such as chylomicron.
* Phosphoproteins: protein + phosphoric acid, such as casein.
* Metalloproteins: protein + metal ion, such as hemoglobin.
* Glycoproteins: protein + poly saccharides, such as mucins.

2. According to the shape

Proteins are either fibrous or globular.

a) Fibrous proteins: String and water-insoluble proteins, such as α-keratin in the hair and nails and collagen in tendons
b) Globular proteins: Water-soluble proteins, which are folded into spherical shape, such as myoglobin and hemoglobin.

collagen



Myoglobin

Forces stabilize the protein structure

There are several forces and interactions between A.As to make the protein molecule be very stable and strong. These forces are:

1. The peptide bond: A chemical bond links two A.As, if the carboxylic group of the first A.A reacts with the amino group of the second A.A and a water molecule liberates. This bond is rigid, planar and strong bond, called a peptide bond (C=O - NH), see Figure 1.

Amino acids bound by the peptide bond will form a chain of A.As and the resulted molecule will be called a peptide or a strand.

The peptide could be a dimer (2 linked A.As), trimer (3 linked A.As), tetramer (4 A.As), penta peptide (5 A.As), oligopeptide (2- 20 A.As) or polypeptide (multiple chains of peptides).

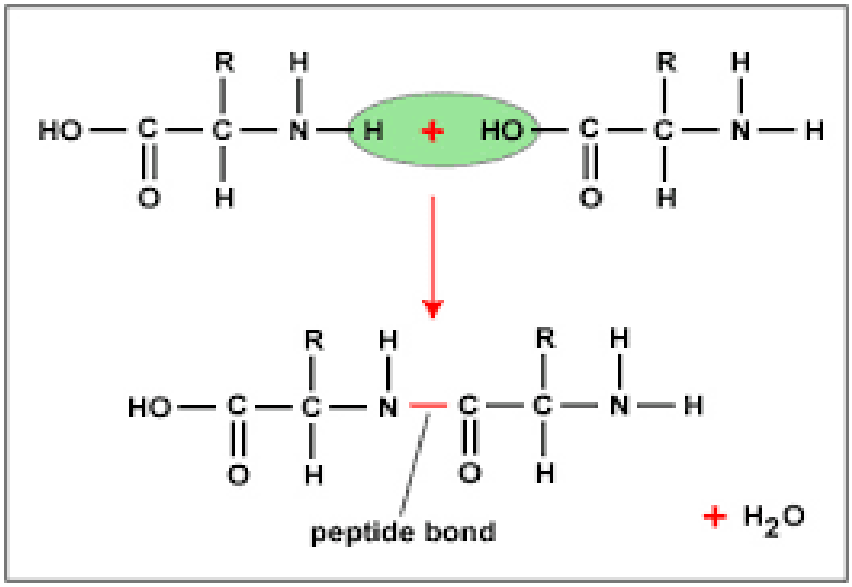


Figure 1. Formation of the peptide bond between two A.As.

2. Disulfide bond: A chemical bond links sulfur-containing A.As " Cys" to join two chains of peptides. This bond is also called di-sulfide linkage, or S-S bond. When two Cysteines link by disulfide bond, the resulted dimer is called Cystine, see Figure 2.

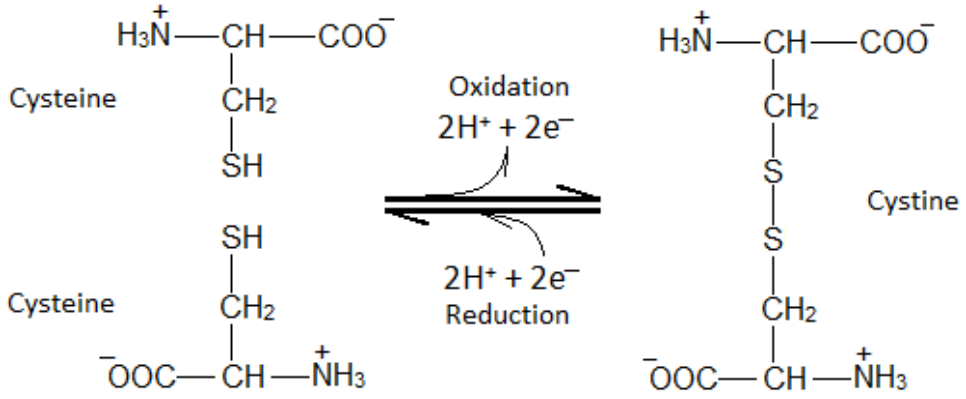


Figure 2. Formation of the disulphide bond between two sulphur-containing A.As.

3. Hydrogen bond: This bond forms between the oxygen atom of C=O of one strand and the hydrogen atom of N-H group of the adjacent strand, see Figure 3. This hydrogen bonding stabilizes plays a role in the protein folding and stability. It could occur within the protein molecule or between water and the protein.

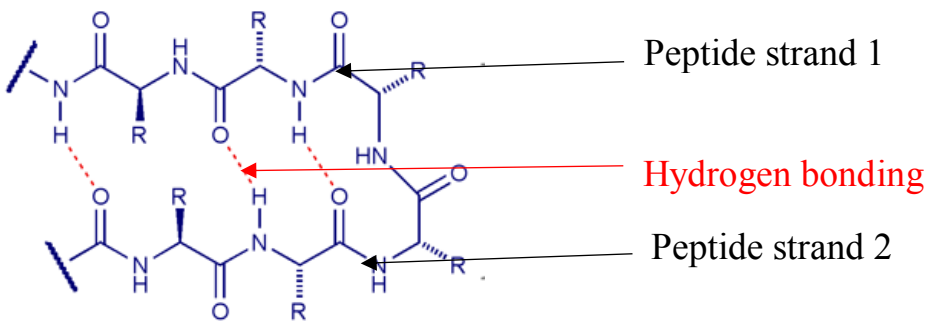


Figure 3. The hydrogen bonding between amid groups of adjacent strands.

4. Electrostatic interactions: A.As with opposite charges are interacted with each other to form a charge-charge interaction. This interaction occurs between the positively and negatively charged A.As, such as Lys with Glu and Arg with Asp, see

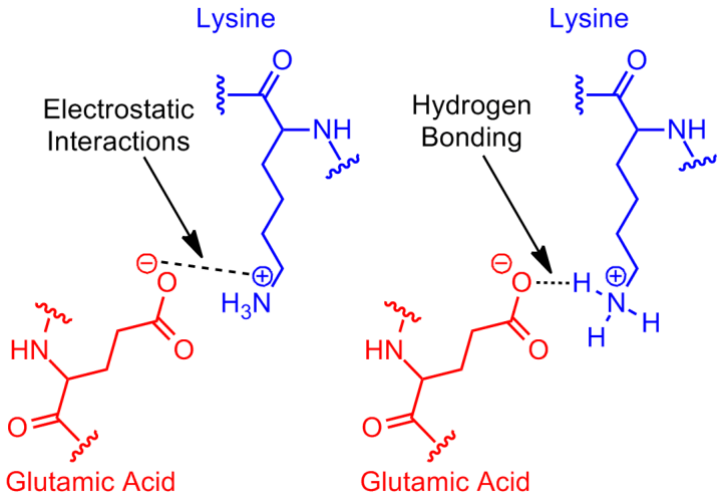


Figure 4. Electrostatic interactions between the opposite charged A.As.

5. Hydrophobic interactions: The hydrophobic side chains of water-dislike A.As are interacted through van der-Waals force to form a very stable protein structure. The alkyl A.As such as Ala, Val, Ile, Leu are forming hydrophobic interactions. The aromatic A.As, such as Phe and Trp are interacted through the electrons of the aromatic rings (π) to form pi-pi stacking interactions (π-π stacking). Figure 5 shows different forces that stabilize the protein structure.

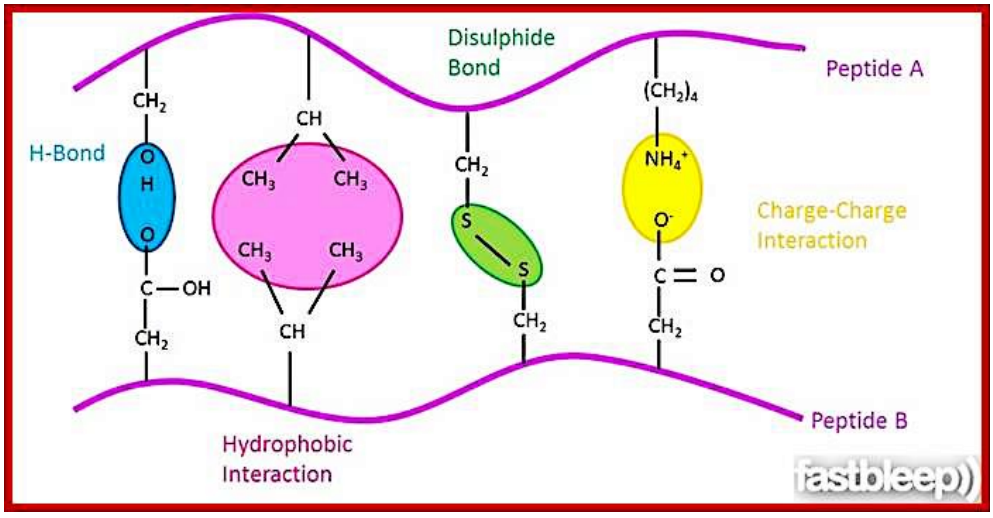


Figure 5. The possible interactions between A.As.

Levels of the protein structure

The protein structure is a 3-dimentional arrangement of multiple chains of A.As range from tens to thousand A.As. The protein structure build-up by four distinct levels:

1. The primary structure: A chain of linked A.As, which determines the final properties of the protein, see Figure 6. The primary structure of any protein is controlled by the corresponding gene in the DNA.

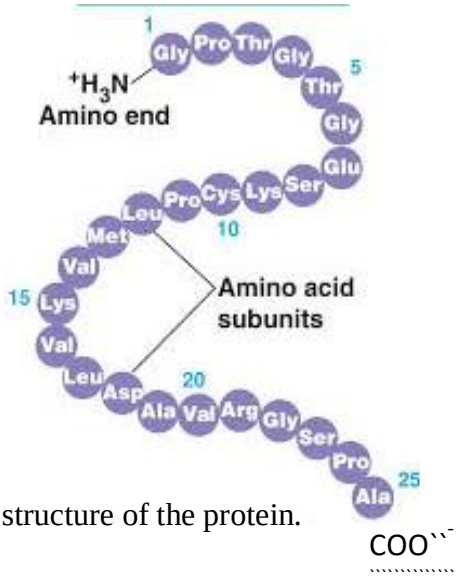


Figure 6. The primary structure of the protein.

2. The secondary structure: This structure represents the backbone of the protein and it stabilized by inter and intramolecular hydrogen bonding between amid groups. There are two main arrangements of the secondary structure, either α-helix or β-sheets, see Figure 7a and b.

These two types are defined by the pattern of hydrogen bonding between the peptide groups. If the NH group of an A.A binds the C=O of another A.A, which is at a distance of four A.As, then α-helix forms, see Figure 7a. Collagen is an example of a protein has α-helix arrangement.

The β-sheets arrangement resulted from hydrogen bonding of two or more β-strands which are arranged either parallel or anti-parallel. The β-strands resulted from an alternative sequence of A.A. Hydrogen bonding between NH groups of A.As in one stand with C=O of A.A in the adjacent strand will form β-sheets see Figure 7b. Silk protein in spiders has a secondary structure of β-sheets.

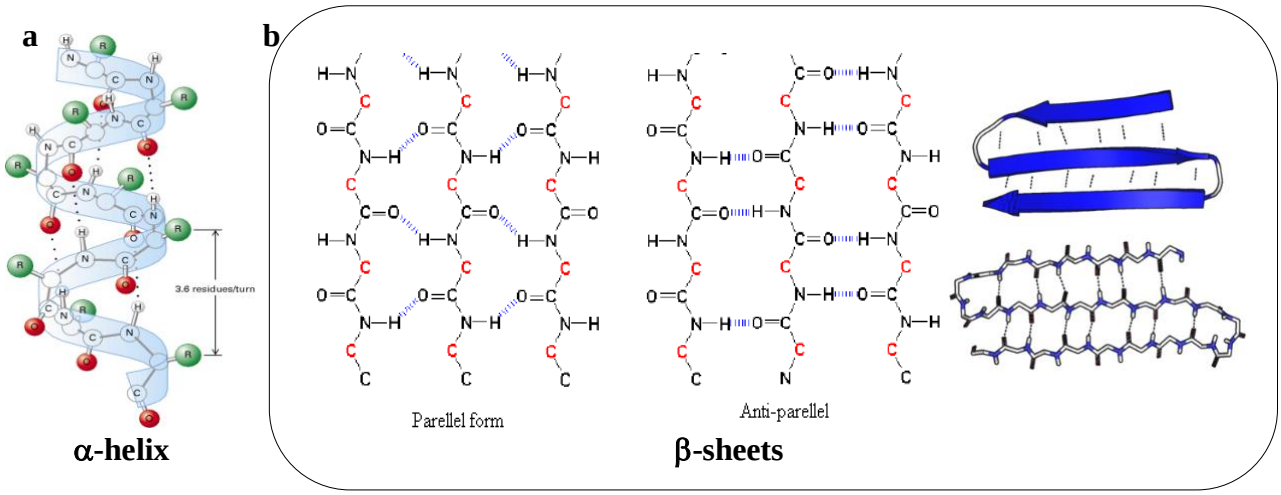
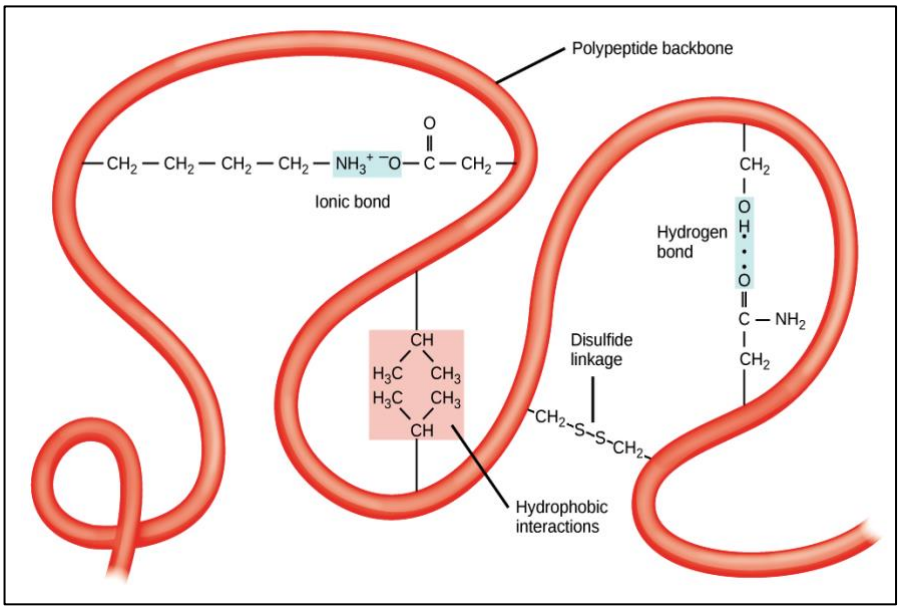


Figure 7. The secondary structure of the protein. (a) α-helix and (b) β-sheets.

3. The tertiary structure: It is a 3-dimentional structure results driven by different interactions between R groups of the A.As, such as ionic interactions, hydrogen bonding, S-S bonding, as well as the hydrophobic interactions. Basically, the tertiary structure rises from both the primary and the secondary structure and found in most types of proteins, see Figure 8.



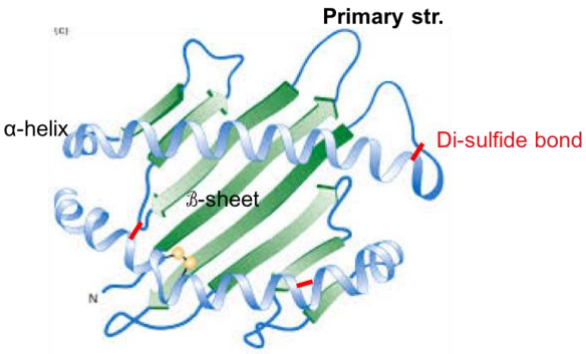


Figure 8. The tertiary structure of the protein.

4. The quaternary structure: Some proteins have a poly peptide with a tertiary structure, but some proteins are folded into a larger 3-dimensional structure called quaternary structure. The possible interactions held this structure are similar to those in the tertiary structure. As an example, the hemoglobin consists of 4 subunits, see Figure 9.

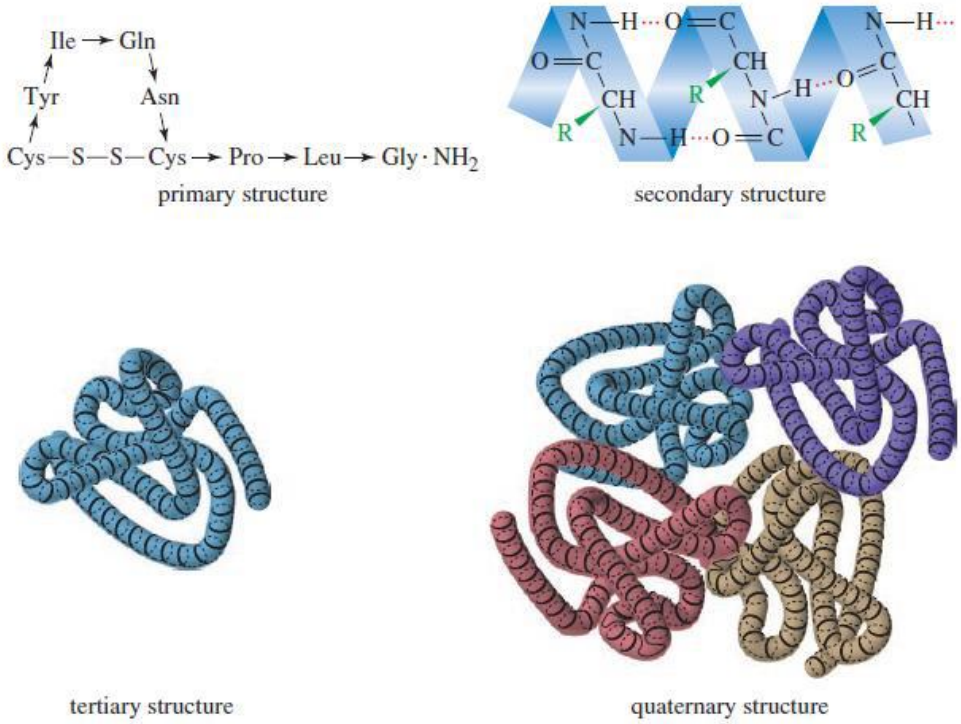


Figure 9. All structures of the protein.