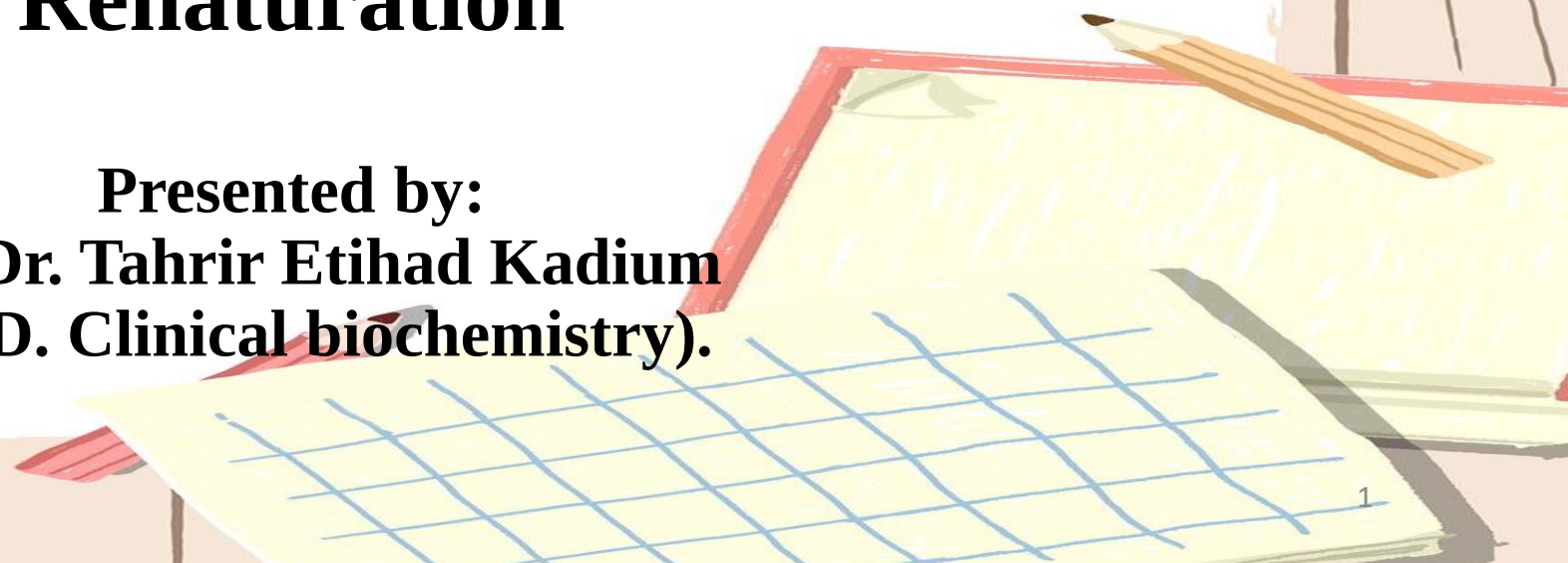
Biochemistry For First Year Medical Students

Lecture 4: Proteins II Classification & Functions of Proteins - Denaturation & Renaturation

Presented by:
A.P.Dr. Tahrir Etihad Kadium
(Ph.D. Clinical biochemistry).



Learning Objectives :

- **Classify proteins.**
- **Identify Simple , conjugated and derived proteins.**
- **List the General Functions of Proteins.**
- **Define denaturation of protein.**
- **State various factors that cause denaturation, its application.**

Classification based on Composition and Solubility:

1. **Simple Proteins:** They contain only amino acids.

i. Albumins: Human serum albumin , egg albumin.

ii. Globulins: Examples are egg globulin, serum globulins.

2. Conjugated Proteins:

They are combinations of protein with a non-protein part, called **prosthetic group**. Conjugated proteins may be classified as follows:

i. Glycoproteins: These are proteins combined with carbohydrates. **Blood group antigens** and many serum proteins are glycoproteins. They are sometimes known as **mucoproteins** or **proteoglycans.**

ii. Lipoproteins: These are proteins loosely combined with lipid components. They occur in blood and on cell membranes. e.g. Serum lipoproteins.

iii. Nucleoproteins: These are proteins attached to nucleic acids, e.g. Histones.

iv. Chromoproteins: These are proteins with colored prosthetic groups. Hemoglobin (Heme, red).

v. Phosphoproteins: These contain phosphorus. **Casein** of milk .

vi. Metalloproteins: They contain metal ions. Examples are Hemoglobin (Iron), Cytochrome (Iron), Tyrosinase (Copper); ceruloplasmin (Copper).

3. Derived Proteins:

They are degradation products of native proteins. Progressive hydrolysis of protein results in smaller and smaller chains:

Protein → peptones → peptides → amino acids.

Classification Based on the Shape:

Globular Proteins:

are made up of one or more helices tightly rolled into a compact sphere (They are spherical or oval in shape) . Globular proteins are usually soluble in water. Globular proteins have roles in metabolic reactions, hemoglobin binds to oxygen to transport it around body. Most enzymes, hormones, and antibodies , Albumin , globulins and protamines are globular proteins.

Fibrous Proteins:

are made up of polypeptide chains that run parallel to an axis and are held together by hydrogen and disulfide bonds (The molecules are elongated or needle shaped). Fibrous proteins have Structural functions. Examples of such proteins are collagen, silk, and the elastin , α-keratin of hair and wool.

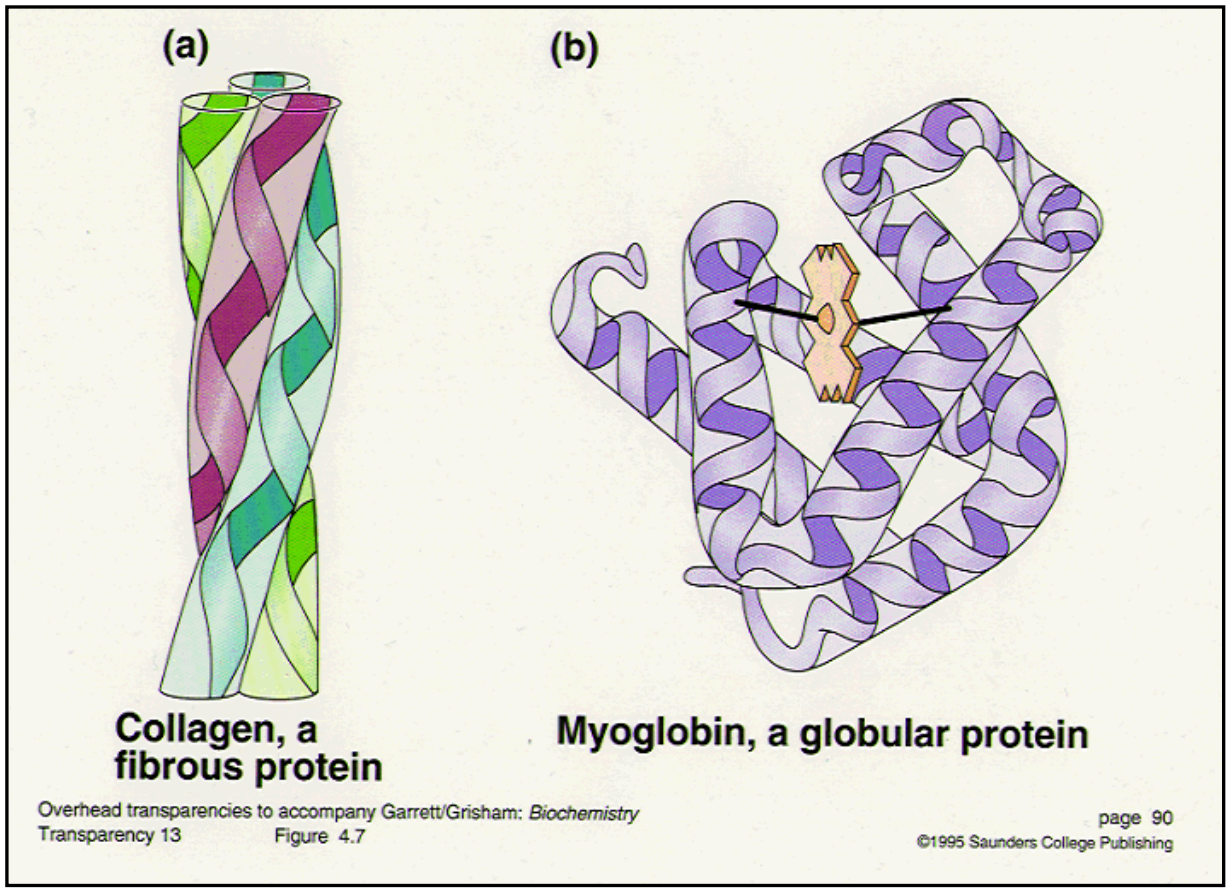


Figure: Fibrous and globular proteins

Classification Based on Nutritional Value:

1. Nutritionally Rich Proteins:

They are also called as **complete proteins or first class proteins**. They contain all the essential amino acids in the required proportion.. A good example is **casein** of milk.

2. Incomplete Proteins:

They **lack one essential amino acid.** They cannot promote body growth in children; but may be able to sustain the body weight in adults. Proteins from **pulses (lentils, chickpeas, dry peas, dry beans) are deficient in methionine**, Proteins of **cereals lack in lysine**. If both of them are combined in the diet, adequate growth may be obtained.

3. Poor Proteins:

They **lack in many essential amino acids** , Zein from corn lacks tryptophan and lysine.

Biologically Important Peptides:

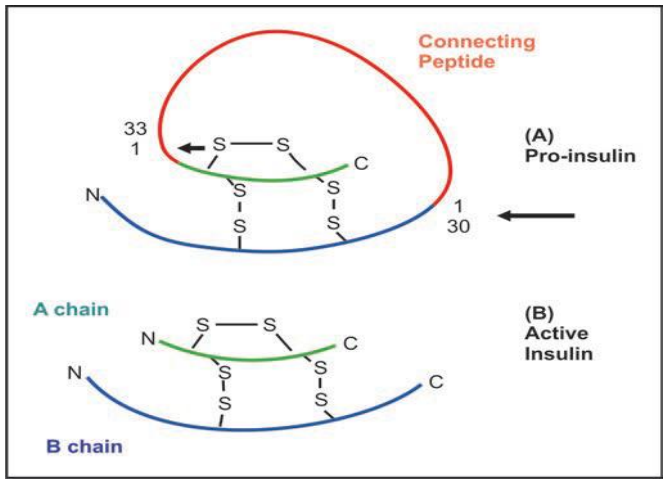
Some of oligopeptides are biologically active. A few examples are given below:

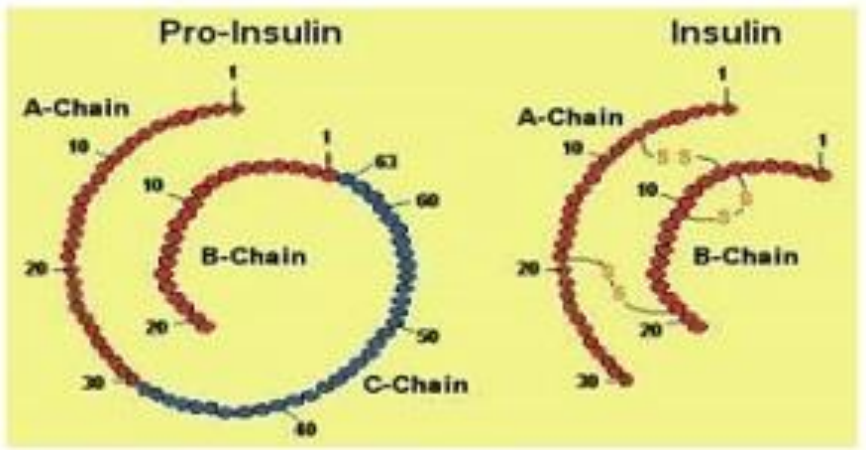
- **Glutathione** is a tripeptide. It is gamma glutamyl cysteinyl glycine. It is involved in erythrocyte membrane integrity and is important in keeping enzymes in active state.

- **Oxytocin** : is a peptide hormone with 9 amino acids and neuropeptide. It is normally produced in the hypothalamus and released by the posterior pituitary. It plays a role in social bonding, reproduction, childbirth, and the period after childbirth. Oxytocin is released into the bloodstream as a hormone in labor.

As an example a protein, the hormone insulin :

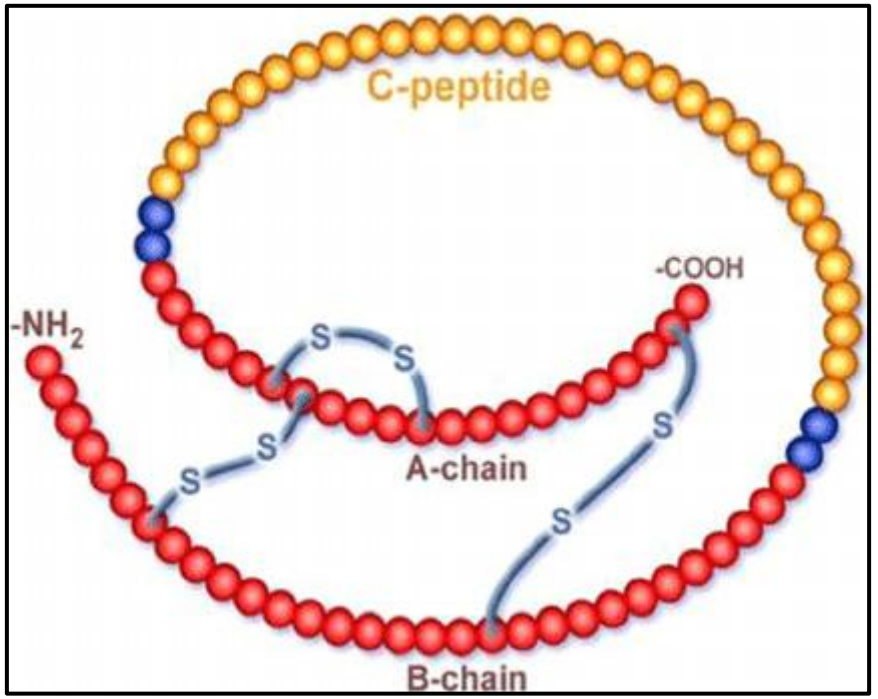
- Insulin is a peptide hormone produced by beta cells of the pancreatic islets.
- It regulates the metabolism of carbohydrates, fats and protein by promoting the absorption of glucose from the blood into liver, fat and skeletal muscle cells.
- Insulin has **two polypeptide chains.** The A chain (**Glycine** chain) has 21 amino acids and B (**Phenyl alanine**) chain has 30 amino acids.
- They are held together by **two interchain disulphide bonds.**





Biologically active insulin:

Beta cells of pancreas synthesize insulin as a prohormone. Proinsulin is a **single polypeptide chain** with 86 amino acids. (2 chains) is formed by removal of the central portion of the pro-insulin before release. The **C-peptide** (connecting peptide) is also released into the circulation.



Classification based on functions:

The following are a few of the functions of proteins:

1. **Enzymes: Biological catalysts those are vital to all living systems. They are all simple or conjugated proteins.**
2. **Structural proteins: Proteins that hold living systems together. The most common example is collagen.**
3. **Hormones: Proteins that act as messengers. The hormone insulin is an example.**
4. **Transport proteins: Proteins that carry molecules and ions from one place to another in the living system. Hemoglobin is an example; it carries oxygen from the lungs to cells.**
5. **Protective proteins: Proteins that destroy any foreign substance released into the living system by an infectious agent. An example is gamma globulin (immunoglobulins).**
6. **Toxins: Proteins that are poisons. Snake venom is an example.**
7. **Nutrition and storage proteins: ovalbumin (egg), casein (milk). Iron is carried in the plasma of blood and is stored in the liver as a complex with ferritin (storage protein).**
8. **Genetic proteins: e.g. histones.**
9. **Contractile proteins: e.g. myosin, actin.**

Denaturation of Proteins:

All Proteins can undergo denaturation under certain conditions. The proteins are extremely sensitive to small changes in their environments. When these changes occur, proteins lose all or part of their biological activity. That is, the proteins are denatured.

Denaturation occurs at the molecular level by disruption of the attractive forces (hydrogen bonds, disulfide bonds, hydrophobic attractions, and salt bridges) that maintain the unique secondary and tertiary structures of proteins.

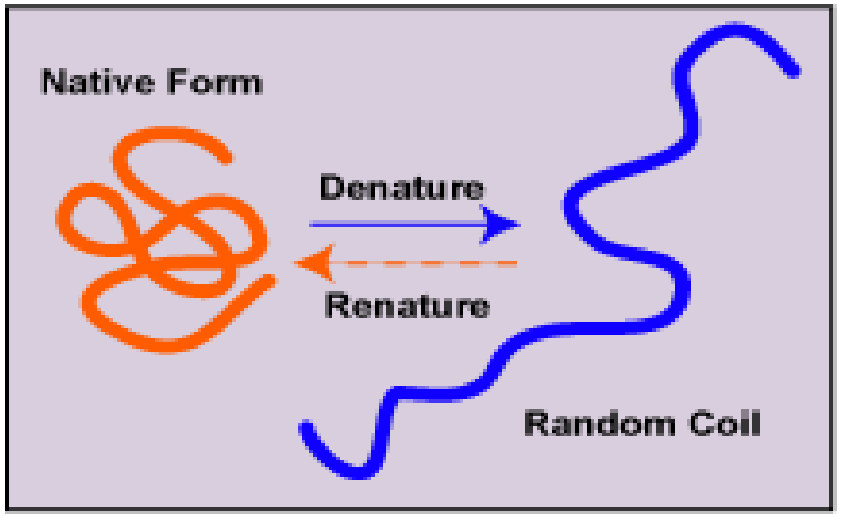


Figure: the denaturation and renaturation of proteins (required).

The following are the most common chemicals or conditions are known to denature proteins:

1-Acids or bases: **The addition of large quantities of acids or bases causes changes in the state of ionization of the carboxyl and amino groups on the side chains of proteins.**

2-Heat and ultraviolet light: **Heat and ultraviolet light cause proteins to coagulate, that is, to form an insoluble mass. For example, boiling or frying an egg .**

3-Organic solvents: **Solvents like ethyl alcohol, acetone form intermolecular hydrogen bonds with proteins. As a result, they replace the intramolecular hydrogen bonds of the protein, resulting in loss of its three-dimensional structure.**

4-Heavy metal ions: **Cations such as Hg^{+2}, Ag^{+}, and Pb^{+2} react with the carboxylate ions and the thiol groups of the side chains of the proteins. This not only causes a disruption in the salt bridges and disulfide bonds, but also causes the protein to precipitate from solution.**

5-Vigorous agitation: **Denaturation of many proteins occurs by violently whipping or shaking them. An example is beating egg white.**

6-Urea: **A solution of urea disrupts the intramolecular hydrogen bonds of proteins. Urea acts much like an alcohol because it also can form intermolecular hydrogen bonds with proteins.**

The denaturation of a protein is sometimes reversible.

Many examples are known in which a denatured protein molecule spontaneously regains its biological activity once it is returned to its natural environment. Such a process, called *renaturation*, returns the protein to its original structure.

It is known that the amino acid sequence of the polypeptide chain (its primary structure) contains the necessary information to form its three-dimensional structure spontaneously. Furthermore, this structure determines its biological activity.

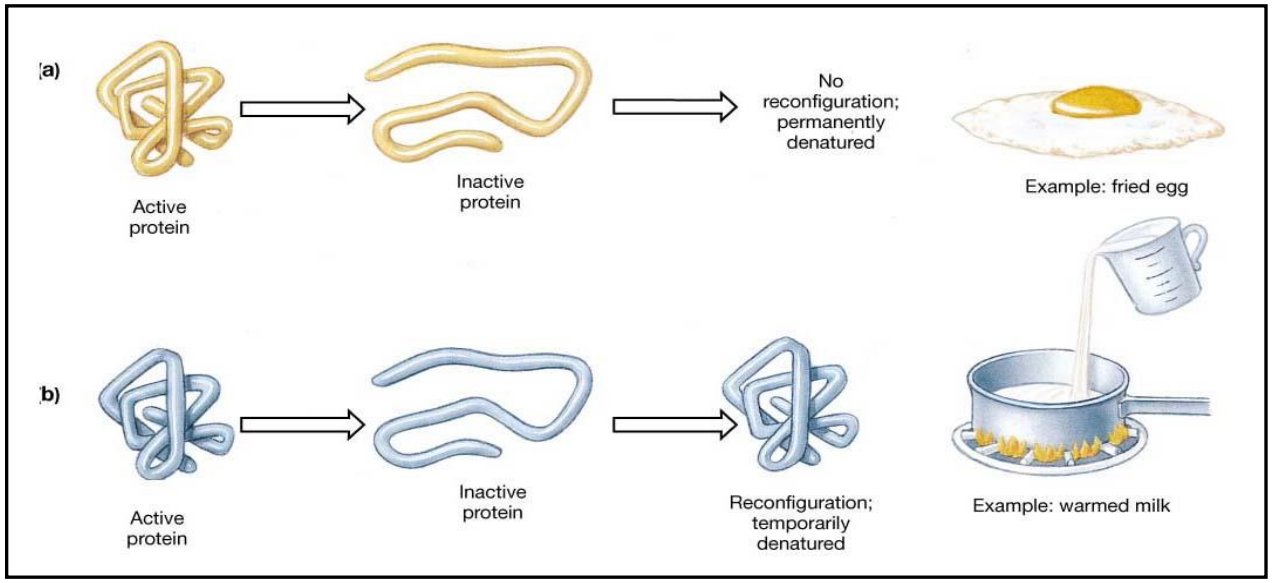


Figure: examples on denaturation and renaturation of proteins.

Assessment and Evaluation:

Q: Compare between fibrous and Globular proteins?

Q: Classify proteins according to their functions?

Q: What is the denaturation and renaturation of proteins?

Q: State various factors that cause denaturation?

Good Luck