Lecture 12

Proteins

Classification of protein

Proteins are classified based on their

- Solubility and composition
- Function
- Shape & size

A. Classification based on solubility and composition

According to this classification, proteins are divided into three main groups as **simple, conjugated and derived proteins**.

(i) Simple proteins

- Simple proteins yield on hydrolysis, **only amino acids.**
- These proteins are further classified based on their solubility in different solvents as well as their heat coagulability.

Albumins

- Albumins are readily soluble in water, dilute acids and alkalies
- coagulated by heat.
- Seed proteins contain albumin in lesser quantities.
- Albumins may be precipitated out from solution using high salt concentration, a process called **'salting out'**.
- They are deficient in **glycine.**
- Serum albumin and ovalbumin (egg white) are examples.

Globulins

- Globulins are **insoluble or sparingly soluble in water**, but their solubility is greatly increased by the addition of neutral salts such as sodium chloride. These proteins are coagulated by heat.
- They are deficient in **methionine**.
- Serum globulin, fibrinogen, myosin of muscle and globulins of pulses are examples.

Prolamins

- Prolamins are insoluble in water but soluble in 70-80% aqueous alcohol.
- Upon hydrolysis they yield much proline and amide nitrogen, hence the name prolamin.

- They are deficient in **lysine**.
- Gliadin of wheat and zein of corn are examples of prolamins.

Glutelins

- Glutelins are **insoluble in water** and **absolute alcohol but soluble in dilute alkalies and acids.**
- They are **plant proteins** e.g., glutenin of wheat.

Histones

- Histones are small and stable basic proteins
- They contain fairly large amounts of basic amino acid, **histidine**.
- They are soluble in water, but insoluble in ammonium hydroxide.
- They are not readily coagulated by heat.
- They occur in **globin of hemoglobin and nucleoproteins**.

Protamines

- Protamines are the simplest of the proteins.
- They are **soluble in water and are not coagulated by heat**.
- They are basic in nature due to the presence of large quantities of **arginine.**
- Protamines are found in association with nucleic acid in the sperm cells of certain fish.
- **Tyrosine and tryptophan** are usually absent in protamines.

Albuminoids

- These are **characterized by great stability and insolubility in water and salt solutions.**
- These are called albuminoids because they are essentially similar to albumin and globulins.
- They are highly resistant to proteolytic enzymes.
- They are fibrous in nature and form most of the supporting structures of animals.
- They occur as chief constituent of exoskeleton structure such as hair, horn and nails.

ii. Conjugated or compound proteins

- These are **simple proteins combined with some non-protein substances known as prosthetic groups.**
- The nature of the non-protein or prosthetic groups is the basis for the sub classification of conjugated proteins.

Nucleoproteins

- Nucleoproteins are simple basic proteins (protamines or histones) in salt combination with nucleic acids as the prosthetic group.
- They are the important constituents of nuclei and chromatin.

Mucoproteins

- These proteins are composed of **simple proteins in combination with carbohydrates** like **mucopolysaccharides**, which include **hyaluronic acid and chondroitin sulphates.**
- On hydrolysis, mucopolysaccharides yield more than 4% of amino-sugars, hexosamine and uronic acid e.g., **ovomucoid** from egg white.
- Soluble mucoproteins are neither readily denatured by heat nor easily precipitated by common protein precipitants like trichloroacetic acid or picric acid.
- The term **glycoproteins** is restricted to those proteins that contain small amounts of carbohydrate usually less than 4% hexosamine.

Chromoproteins

- These are proteins containing **coloured prosthetic groups** e.g., haemoglobin, flavoprotein and cytochrome.

Lipoproteins

- These are proteins conjugated with **lipids such as neutral fat, phospholipids and cholesterol**

Metalloproteins

- These are **metal-binding proteins**.
- A □-globulin, termed **transferrin** is capable of combining with **iron, copper and zinc.**
- This protein constitutes 3% of the total plasma protein.
- Another example is **ceruloplasmin**, which contains **copper.**

Phosphoproteins

- These are proteins containing **phosphoric acid**.
- Phosphoric acid is linked to the hydroxyl group of certain amino acids like serine in the protein e.g., casein of milk.

iii. Derived proteins

- These are proteins derived by partial to complete hydrolysis from the simple or conjugated proteins by the action of acids, alkalies or enzymes.

- They include two types of derivatives, **primary-derived proteins and secondary-derived proteins.**

Primary-derived proteins

- These protein derivatives are formed by processes causing only slight changes in the protein molecule and its properties.
- There is little or no hydrolytic cleavage of peptide bonds.

Proteans

- Proteans are insoluble products formed by the action of water, dilute acids and enzymes.
- These are particularly formed from globulins but are insoluble in dilute salt solutions
- e.g., **myosan from myosin, fibrin from fibrinogen**.

Metaproteins

- These are formed by the action of acids and alkalies upon protein.
- They are insoluble in neutral solvents.

Coagulated proteins

- Coagulated proteins are insoluble products formed by the action of heat or alcohol on natural proteins
- e.g., cooked meat and cooked albumin.

Secondary-derived proteins

- These proteins are formed in the progressive hydrolytic cleavage of the peptide bonds of protein molecule.
- They are roughly grouped into **proteoses, peptones and peptides according to average molecular weight.**
- Proteoses are hydrolytic products of proteins, which are soluble in water and are not coagulated by heat.
- Peptones are hydrolytic products, which have simpler structure than proteoses.
- They are soluble in water and are not coagulated by heat.
- Peptides are composed of relatively few amino acids.
- They are water-soluble and not coagulated by heat.
- The complete hydrolytic decomposition of the natural protein molecule into amino acids generally progresses through successive stages as follows:

  Protein -----> Protean -------> Metaprotein

  Proteoses ------>Peptones ------->Peptides ------> amino acids

b. Classification of proteins based on function

Proteins are classified based on their functions as:

Catalytic proteins – Enzymes

- The most striking characteristic feature of these proteins is their ability to **function within the living cells as biocatalysts.**
- These **biocatalysts** are called as enzymes.
- Enzymes represent the largest class.
- Nearly 2000 different kinds of enzymes are known, each catalyzing a different kind of reaction.
- They **enhance the reaction rates** a million fold.

Regulatory proteins - Hormones

- These are polypeptides and small proteins found in relatively lower concentrations in animal kingdom but **play highly important regulatory role in maintaining order in complex metabolic reactions**
- e.g., growth hormone, insulin etc.

Protective proteins - Antibodies

- These proteins have **protective defense function**.
- These proteins combine with foreign protein and other substances and fight against certain diseases.
- e.g., immunoglobulin.
- These proteins are produced in the spleen and lymphatic cells in response to foreign substances called antigen.
- The newly formed protein is called **antibody** which specifically combines with the antigen which triggered its synthesis thereby prevents the development of diseases.
- **Fibrin** present in the **blood** is also a protective protein.

Storage proteins

- It is a major class of proteins which has the function of **storing amino acids as nutrients and as building blocks for the growing embryo**.
- Storage proteins are **source of essential amino acids**, which cannot be synthesized by human beings.
- The major storage protein in pulses is **globulins and prolamins in cereals.**
- In rice the major storage protein is glutelins.
- Albumin of egg and casein of milk are also storage proteins.

Transport proteins

- Some proteins are capable of binding and transporting specific types of molecules through blood.
- **Haemoglobin** is a conjugated protein composed of colourless basic protein, the **globin** and **ferroprotoporphyrin or haem**.
- It has the capacity to bind with oxygen and transport through blood to various tissues.
- **Myoglobin,** a related protein, transports oxygen in muscle.
- **Lipids** bind to serum proteins like albumin and transported as lipoproteins in the blood.

Toxic proteins

- Some of the proteins are toxic in nature.
- **Ricin** present in **castor bean** is extremely toxic to higher animals in very small amounts.
- **Enzyme inhibitors such as trypsin inhibitor** bind to digestive enzyme and prevent the availability of the protein.
- **Lectin**, a toxic protein present in legumes, **agglutinates red blood cells**.
- A bacterial toxin causes cholera, which is a protein.
- **Snake venom** is protein in nature.

Structural proteins

- These proteins serve as **structural materials or as important components of extra cellular fluid.**
- Examples of structural proteins are **myosin of muscles, keratin of skin and hair and collagen of connective tissue.**
- Carbohydrates, fats, minerals and other cellular components are organized around such structural proteins that form the molecular framework of living material.

Contractile proteins

- Proteins like **actin and myosin** function as essential elements in contractile system of skeletal muscle.

Secretary proteins

- **Fibroin** is a protein secreted by spiders and silkworms to form webs and cocoons.

Exotic proteins

- Antarctic fishes live in -1.9oC waters, well below the temperature at which their blood is expected to freeze.
- These fishes are prevented from freezing by **antifreeze glycoproteins** present in their body.

C. Classification based on size and shape

Based on size and shape, the proteins are also subdivided into **globular and fibrous proteins.**

- **Globular proteins** are mostly water-soluble and fragile in nature e.g., **enzymes, hormones and antibodies.**
- **Fibrous proteins** are tough and water-insoluble.
- They are used to build a variety of materials that support and protect specific tissues, e.g., skin, hair, fingernails and keratin