PROTEINS

PART-I

(Definition, classification of proteins based on composition and solubility with examples)

Proteins are macromolecules made up of monomers called amino acids. Amino acids are the building block of all proteins.

Proteins are very large molecules composed of basic units called amino acids. Proteins contain carbon, hydrogen, oxygen, nitrogen, and sulphur.

CLASSIFICATION OF PROTEIN

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.

CLASSIFICATION OF PROTEIN

Classification based on solubility and composition

(i) Simple proteins

1. Albumins
2. Globulins
3. Prolamins
4. Glutelins
5. Histones
6. Protamines
7. Albuminoids

ii. Conjugated or compound proteins

1. Nucleoproteins
2. Mucoproteins
3. Chromoproteins
4. Lipoproteins
5. Metalloproteins
6. Phosphoproteins

iii. Derived proteins

Primary-derived proteins

1. Proteans
2. Metaproteins
3. Coagulated proteins

Secondary-derived proteins

- 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.
- Ex. Serum albumin and ovalbumin (egg white).

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.
- Examples: Serum globulin, fibrinogen, myosin of muscle and globulins of pulses.

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 serin 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:

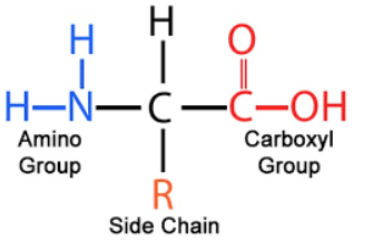
  Protein -----> Protean -----→Metaprotein

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

PART-II

(Definition, classification of amino acids based on chemical nature and nutritional requirements with examples)

Amino acids are organic compounds containing amine [- NH_2] carboxyl [-COOH] side chain [R group] . The major key elements if amino acids are carbon, hydrogen, nitrogen, oxygen. About 500 amino acids are known (though only 20 appear in the genetic code) and can be classified in many ways.



Classification Of Amino Acids Based on Chemical Nature

Simple amino acids:

these have no functional group in their side chain.

Example: glycine, valine, alanine, leucine, isoleucine

Hydroxy amino acids:

these have a hydroxyl group in their side chain

Eg: serine, threonine

Sulfur containing amino acids:

have sulfur in their side chain

Eg: cysteine, methionine

Aromatic amino acids:

have benzene ring in their side chain

Eg: phenylalanine, tyrosine

Heterocyclic amino acids:

having a side chain ring which possess at least on atom other than carbon

Eg: Tryptophan, histidine, proline

Amine group containing amino acids:

derivatives of amino acids in which one of carboxyl group has been transformed into an amide group.

Eg: Asparagine, glutamine

Branched chain amino acids:

A branched-chain amino acid (BCAA) is an amino acid having aliphatic side-chains with a branch.

Eg: leucine, isoleucine, valine

Acidic amino acids:

It have carboxyl group in their side chain

Eg: Aspartic and Glutamic acid

Basic amino acids:

It contain amino group in their side chain

Eg: Lysine, Arginine

Imino acid:

Amino acids containing a secondary amine group

Eg: Proline

Classification of amino acids based on nutritional requirements

Essential amino acids

- Essential amino acids cannot be made by the body. As a result, they must come from food.
- The essential amino acids are:

Ex. Arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Non essential amino acids

An amino acid that can be made by humans and so is essential to the human diet. The nonessential amino acids: Alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, and tyrosine.

Summary

Sr No.	Essential Amino Acids:	Nonessential Amino Acids:
1	Valine	Glycine
2	Leucine	Alanine
3	Isoleucine	Tyrosine
4	Phenylalanine	Aspartic Acid
5	Tryptophan	Glutamic Acid
6	lysine	Asparagine
7	Arginine	Glutamine
8	Histidine	Cysteine
9	Methionine	Serine
10	Threonine	Proline

PART 111: Structure of proteins (four levels of organization of protein structure)

The structure of proteins can be divided into four levels of organization:

1. **Primary Structure.**
2. **Secondary Structure.**
3. **Tertiary Structure.**
4. **Quaternary Structure.**

Primary Structure

1. The primary structure of a protein consists of the amino acid sequence along the polypeptide chain.
2. Amino acids are joined by peptide bonds.
3. The charges on a polypeptide chain are due only to the N-terminal amino group, the C-terminal carboxyl group, and the side chains on amino acids.
4. The primary structure determines the further levels of organization of protein molecules.

Secondary Structure

1. In a protein molecule, the polypeptide is present in different geometric configurations.
2. These arrangements are due to hydrogen bonding between carboxyl groups and amino groups of the peptide bonds.
3. The atoms of the side chains are not involved.
4. This is called the secondary structure of the protein.

It is of two types

Alpha-helix

- The α-helix is a right-handed coiled strand.
- The side-chain substituents of the amino acid groups in an α-helix extend to the outside.

Beta-helix

In this arrangement, the polypeptide chains are stretched out beside one another and then bonded by intermolecular H-bonds.

Tertiary Structure

- This structure arises from further folding of the secondary structure of the protein, due to sidechain interactions.
- H-bonds, electrostatic forces, disulphide linkages, and Vander Waals forces stabilize this structure.

Quaternary Structure

- Quaternary structure refers to the interaction of one or more subunits to form a functional protein, using the same forces that stabilize the tertiary structure.
- It is the spatial arrangement of subunits in a protein that consists of more than one polypeptide chain.

e.g. Hemoglobin ($\alpha_2\beta_2$).

Qualitative tests and biological role of proteins and amino acids

Heat Test

When a protein solution is heated it causes loss of its protein structure which results in denaturation losing its biological activity.

Test with Trichloroacetic Acid (TCA)

TCA causes denaturation of protein and is used for deproteinization.

Biuret Test

- It is also known as Piotrowski's test, is a chemical test used for detecting the presence of peptide bonds.
- In the presence of peptides, a copper(II) ion forms violet colored complexes in an alkaline solution.
- Biuret reagent contains copper sulphate in an alkaline medium, it reacts with protein solution forming violet color.

Xanthoprotic Test

- The xanthoproteic test is performed for the detection of aromatic amino acids (tyrosine, tryptophan, and phenylalanine) in a protein solution.
- The nitration of the aromatic amino acid chain occurs due to reaction with nitric acid, giving the solution yellow coloration.

Millon's Test

- Millon's test is an analytical test used for the detection of the amino acid tyrosine.;

- Millon's test is based on the principle of nitrification of the phenol group in tyrosine, which then forms complexes with heavy metals like mercury.
- The reagent used for the test is called Millon's reagent, and it consists of mercuric nitrate and mercurous nitrate that is dissolved in concentrated nitric acid.

Precipitation Test

Proteins get precipitated by various agents like salts, heavy metals, tannins, organic solvents etc.

Diseases related to malnutrition of proteins

Following are two main deficiency disorders of proteins.

- **Marasmus.**
- **Kwashiorkor.**

Marasmus

- Marasmus is a severe form of protein-energy malnutrition that results when a person does not consume enough protein and carbohydrates.
- Without these vital nutrients, energy levels become dangerously low and vital functions begin to stop.

Causes:

Not having enough nutrition or having too little food: Mainly happens in poor people.

Symptoms:

- Failure to grow, known as stunted growth.

- Wasting, or a loss of body tissue and fat.
- Bones become visible under their skin.
- persistent dizziness
- lack of energy
- dry skin
- brittle hair.

Treatment:

Diet rich in calories, proteins and other nutritional factors is the best treatment and a way to avoid Marasmus.

Kwashiorkor

- Kwashiorkor is a form of severe protein malnutrition characterized by edema and an enlarged liver.
- It is caused by sufficient calorie intake, but with insufficient protein consumption, which distinguishes it from marasmus.
- Kwashiorkor cases occur primarily in areas of poor food supply.

Causes

- Not having enough nutrition or having too little food: Mainly happens in poor people.
- Premature termination of breastfeeding.
- Over dilution of cow milk.

Symptoms

- Pitting edema: Swelling of ankles and feets.

- Distended abdomen,
- An enlarged liver,
- Thinning of hair,
- Loss of teeth,
- Skin or hair depigmentation,
- Dermatitis.
- Anorexia (Loss of appetite)
- Irritability.

Treatment

Diet rich in proteins and other nutritional factors is the best treatment and a way to avoid Kwashiorkor,