

Chapter-3 | Proteins | Biochemistry and Clinical Pathology

Topic In this Notes

Proteins

- Definition, classification of proteins based on composition and solubility with examples
- Definition, classification of amino acids based on chemical nature and nutritional requirements with examples
- Structure of proteins (four levels of organization of protein structure)
- Qualitative tests and biological role of proteins and amino acids
- Diseases related to malnutrition of proteins

Definition.

- **Proteins** are naturally occurring polymers made up of amino acids.
- Almost everything that occurs in the cells involves one or more Proteins.
- Proteins provide structure, cellular reaction and carried out the tasks.
- 20 amino acids are found in protein and they are called standard amino acid. These amino acids contain the carboxyl group and the amino group attached to α carbon.

Role of protein.

- Protein performs difference role in the living system.
- Proteins which catalyse by your chemical reactions are called enzymes.
- Proteins are responsible for transportation of metabolites fructose, Glucose or Gases (like Oxygen, Carbon dioxide) are called transport proteins.
- Protein which are responsible for to protect from infection and other toxic

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- substances are called antibiotics or defense proteins.
- Proteins which are required to give strength to cells or tissue are called structural proteins.
- Proteins which are required to carry out mechanical work are called muscle proteins.

Classification of proteins based on composition.

1. Complete Proteins: – Proteins which contain all the essential amino acids in required quantity are called complete Proteins.

2. Incomplete Proteins: - Proteins not containing all the essential amino acid are called incomplete protein.

Also classified as-

1. Simple Proteins 2. Conjugated Proteins 3. Derived Proteins

1. Simple Proteins: - Simple protein contain only amino acid residue and other intimately bound material. Ex- Albumins, globulins, glutelin etc.

2. Conjugated Proteins: – Conjugated proteins contain in addition to polypeptide chain others substance or groups which impart characteristics properties. Ex- Nucleoproteins, Glycoproteins, Haemoglobin, Phosphoproteins etc.

3. Derived Proteins: - Derived protein are derived from partial to complete hydrolysis from the simple or conjugated proteins by the action of acids, alkalis or enzymes. Ex- Peptones, peptides, proteoses etc.

Classification of protein based on solubility.

It is divided into two types-

- a. Globular protein— It is made by the irregular amino acid sequence and forms the rounded or spherical structure.
 - It is generally soluble in water.
 - It is also called as functional protein and it is more sensitive towards PH and temperature change.
- b. Fibrous protein— It is made by same type of amino acid sequence and forms the long narrow structure.

- It is generally Insoluble in water.
- It is also called as structural protein and it is less sensitive towards PH and temperature change.

AMINO ACIDS

Definition

- Amino acids are building blocks of protein.
- Amino acids are compound that contain an amino group and a carboxyl group and the amino group is attached to the alpha carbon.
- The key elements of an amino acid are Carbon (C) Hydrogen (H) Oxygen (O) and nitrogen (N).
- There are 20 amino acids present in our body, of which 9 are essential and 11 are non-essential amino acids.

Properties of Amino Acids

A. Physical properties of the Amino acids.

1. Solubility.

- All amino acids are Soluble in water but their Solubility varies to a great extent.
- Solubility depends on the nature of the R- group. i.e., polarity of the amino acid.
- Polar amino acids are highly Soluble in water.
- Non-polar amino acids are highly Soluble in organic solvents like chloroform, ether etc.

2. Acid and base behaviours.

- Amino acids contain the acidic carboxyl group (-COOH) and the basic group amino (-NH₂). Hence amino acids are called as amphoteric molecules or ampholytes (i.e., Amphoteric electrolytes).

3. Optical activity.

- All standard amino acids except glycine have an asymmetric carbon atom due to which these amino acids are optically active.

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B. Chemical properties of the Amino acids.

1. Ninhydrin reaction:

Amino acid + Ninhydrin \longrightarrow Purple/Blue Pigment + Aldehyde

2. Reaction with Dansyl Chloride:

Amino acid + Dansyl Chloride \longrightarrow Fluorescent Dansyl derivative
Of amino acids.

3. Reaction due to COOH Group: -

- Salt formation with alkalis.
- Ester formation with alcohols.
- Amide formation with amines and decarboxylation

Classification of amino acids based on chemical nature.

On the basis of chemical nature amino acids are divided as-

- a. Acidic amino acid- Ex- Aspartic acid, Glutamic acid.
- b. Basic amino acid- Ex- Histidine, Lysine, Arginine.
- c. Hydrophilic amino acid- Ex- Asparagine, Glutamine.
- d. Hydrophobic amino acid-Ex- Leucine, isoleucine, valine.
- e. Sulphur containing amino acid- Ex- cystine, Methionine.
- f. Aromatic amino acid- Ex- Phenylalanine, Tyrosine.

Classification of amino acids based on nutritional requirements

1. Essential Amino Acids.

- The amino acids which cannot be synthesized in the body but are required for normal function of body are called as essential amino acids.
- These amino acids should be supplied through diet.

2. Non-Essential Amino Acids.

- The amino acids which are synthesized in the body are called as non-essential amino acids.

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S. N	Essential Amino acids	Non-Essential Amino acids
1.	Valine	Alanine
2.	Histidine	Asparagine
3.	Leucine	Aspartic acid
4.	Phenylalanine	Cysteine
5.	Tryptophan	Glutamic acid
6.	Lysine	Glutamine
7.	Arginine	Glycine
8.	Methionine	Cysteine
9.	Threonine	Proline
10.	Isoleucine	Serine

Structure of proteins (four levels of organization of protein structure).

Due to arrangement of the amino acids in the protein, we find the four level of organisation/modification in the proteins.

- 1. Primary protein:** - It is the simple/basic/polypeptide chain like proteineous structure formed by the joining of amino acid by the help of covalent or peptide bond. Its biological activity mainly depends on the, types of amino acids. Many of genetic disorders are occurs due to changes in the primary protein structure.
- 2. Secondary protein:** - Secondary structure forms by the interaction between the polypeptide chain of primary protein amino group and carboxyl group. It mainly presents two structural forms-
 - α secondary protein (Helix Form).
 - β secondary protein (Sheet/Plate form).
- 3. Tertiary protein:** - Tertiary protein form by the further chemical modification between the secondary protein. It is stabilized due to presence of the H-bond, electrostatic forces, disulphides bonds, and Vander walls forces.
- 4. Quaternary protein:** - The quaternary structure of a protein is the association of several protein chains or subunits into a closely packed arrangement.

Qualitative tests for Proteins and Amino acids.

1. Heat test: -

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- When protein solution is heated in boiling water both the protein gets coagulated and lose their biological activity.
- This is called thermal denaturation of proteins.
- e.g. – Boiling the eggs.

2. Test with trichloroacetic acid (TCA)-

- TCA is normally used to precipitate proteins from their solution. TCA denatures the proteins.

3. Biuret Test: -

- Biuret reagents consists of copper sulphate in an alkaline medium when proteins are treated with Biuret reagent it's shows a violet colour.

4. Hydrolysis Test: -

- Proteins on hydrolysis gives free amino acids Hydrolysis can be carried out by acids like HCL, H₂SO₄, etc. Or Alkalis like – NaOH, KOH etc.

5. Xanthoproteic test: -

- Nitration of aromatic amino acids of protein give yellow colour concentrated nitric acid is used for Nitration.

6. Millon's Test: -

- Phenolic group of tyrosine of proteins react with mercuric sulphate in the presence of sodium nitrate and sulphuric acid to give red colour.

7. Precipitation test: -

- Protein are Precipitated by using different agents the common precipitation agents are salt, Organic solvent heavy metal ion, acids etc.
 - Salt – Ammonium sulphate, Sodium chloride.
 - Acids – Trichloroacetic acid (TCA), Acetic acid, Hydrochloric acid.
 - Organic solvents – Acetone alcohol
 - Heavy metal ions – Ammonium molybdate, Copper or Mercury salts.

Biological role of proteins and amino acids.

- Proteins give amino acids on hydrolysis during digestion and amino acids are the building blocks required for a cell to synthesis for proteins.
- Proteins are the structural component of protoplasm cell and tissues.

- Enzymes and few hormones are Proteins in nature antibiotics, haemoglobin are also Proteins.
- Protein is one of the important components of diet it is required to maintain growth and healthy functioning of the body.
- In the cell, cell membrane is also made up by the protein, protein play the role in the transporting the cellular and outer material through the active or passive transport.
- In our body some amount of protein stored, for the starvation, critical condition for energy.
- During the clinical condition protein also play the major role (protein excrete in urine, during blood examination)

Diseases related to malnutrition of proteins.

A. Kwashiorkor: -

- The symptoms of the diseases slow down the growth, oedema and change in skin, hair pigmentation and texture.
- Frequently there is liver enlargement there is vomiting and diarrhoea and stools contain much undigested food.
- The course of this disease due to large family size, poor mental health, poor environmental conditions and delayed supplementary feeding.

Note: - This disease appears most commonly in children between the ages of 1 to 4 year.

B. Nutritional oedema: -

- It results from long contained loss of protein and usually occurs in famine areas. The Proteins deficiency in adults is very rare.
- The deficiency symptoms include loss of weight reduced fat, infections, frequent loose stools delay in healing of wounds and Oedema.
- Use of soybean, milk and eggs and other nutritious diet can cure the Protein deficiency syndrome in adults.

C. Marasmus: -

- It is a disease of infants below one year of age.
- Its cause is Proteins and carbohydrate or other nutritional factor deficiencies.
- Proteins and energy deficiency disease is also known as **Marasmus kwashiorkor**. Marasmus is more likely to occur in poor people.