BIOMOLECULES

Biomolecules are the chemical compound found in living organism, involved in the maintenance and metabolic process of living organism.

Cells are basic structural and functional units of living organisms, are highly organized and constant source of energy, required to maintain the life.

Biochemical organization of Cell: Atoms are organized into molecules, molecules into organelles, organelles into cells, cell organized to form tissue, tissue organized to form organ, organ to organ system and organ system organized to form organism.

Biomolecules are defined as any organic molecule present in a living cell. Biomolecules are mainly composed of major six elements, **carbon, hydrogen, oxygen and nitrogen, sulphur and phosphorus**. The next major elements are sodium, chlorine, potassium, calcium and magnesium. These make up to 3-5 % of living thing. Trace elements present at low level (1%) of living cell includes iron, iodine, manganese, molybdenum, selenium, silicon, tin, vanadium, boron, chromium, cobalt, copper and fluorine.

Each Biomolecules is essential for body functions. They have wide range of size, structure and perform various types of function.

The four major types of Biomolecules are:

1. **CARBOHYDRATES**
2. **LIPIDS**
3. **PROTEIN**
4. **NUCLEIC ACID**

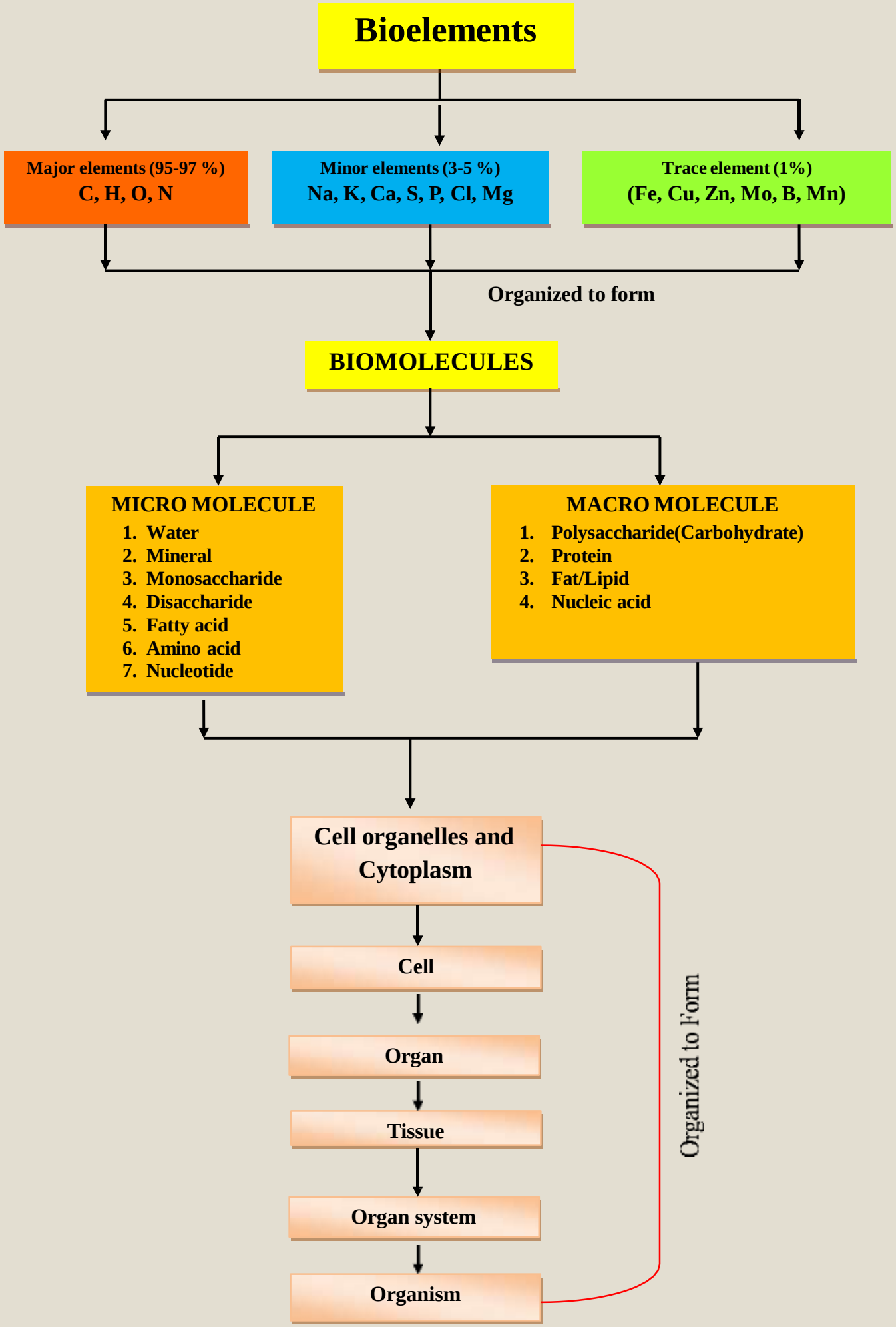


Figure1: Biochemical organization of cell

CLASSIFICATION OF CARBOHYDRATE (CHEMICAL NATURE)

- **MONOSACCHARIDES**
  - Contain only one sugar molecule
  - Cannot be hydrolyzed
    - Aldoses
      - Contain Aldehyde
        - E.g. Galactose Ribose, Glucose
    - Ketoses
      - Contain Ketone
        - E.g. Ribulose, Fructose
- **OLIGOSACCHARIDES**
  - Polymers of monosaccharide contain 2-10 sugar units (molecules)
    - Disaccharide
      - Yield two monosaccharide on hydrolysis
        - E.g. Maltose (Glucose + Glucose), Sucrose (Glucose + Fructose)
    - Trisaccharide
      - Yield three monosaccharide on hydrolysis
        - E.g. Raffinose (Glucose + Fructose + Galactose)
    - Tetrasaccharide
      - Yield four monosaccharide on hydrolysis
        - E.g Stachyose (Glucose + Fructose + Galactose + Galactose)
- **POLYSACCHARIDES**
  - Long chain polymer of monosaccharide either straight chain or branched
    - Homo polysaccharide
      - On hydrolysis gives single monosaccharide unit
        - E.g. Starch, Glycogen
    - Hetero polysaccharide
      - On hydrolysis gives multiple monosaccharide unit
        - E.g. Hyaluronic acid

CLASSIFICATION OF PROTEIN (Physical and chemical nature)

- **SUGAR**
  - Reducing sugar
    - Sweet and soluble in water. Reduce Fehling and Benedict reagent.
      - E.g. Glucose, Fructose, Lactose, Maltose
  - Non reducing sugar
    - Sweet and soluble in water. Donot Reduce Fehling and Benedict reagent.
      - E.g. Sucrose
- **NON SUGAR**
  - Non sweet and insoluble in water. Donot Reduce Fehling and Benedict reagent.
    - E.g. Starch, Glycogen, Cellulose

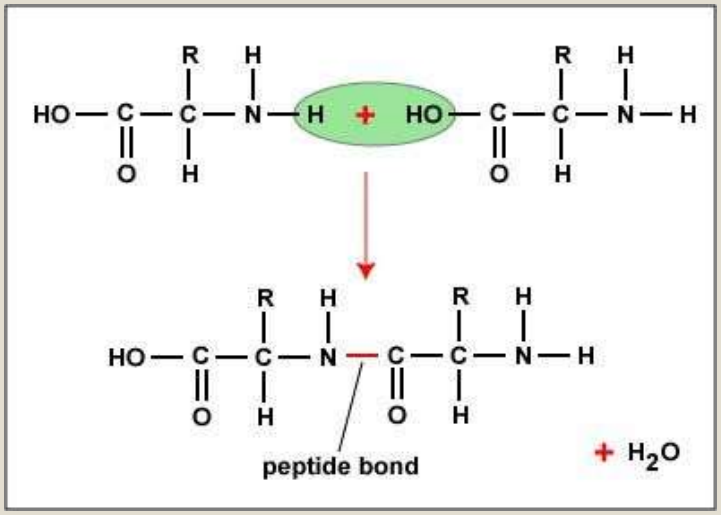
PROTEIN

Proteins are nitrogenous organic compounds of high molecular weight which play a vital or prime role in living organisms.

INTRODUCTION

The proteins are most abundant macro molecules in the cells and they constitute over half the dry weight of most of the organism. They are made up of 20 standard a-amino acids. They are mainly composed of C, H, O, N elements. Some proteins also contain S, P element also.

Chemically proteins are polymers of L-α-amino acids. Amino acids are polymerized through formation of number of peptide linkages. Protein molecule consists of very long chains having about 100-1000 amino acids unit joined by Peptide linkages. Cell contains 100 or 1000 of different protein, each with different function and biological activity.



PROPERTIES OF PROTEIN

1. Solubility: Form colloidal solution in water

2. Molecular weight: Majority of amino acid consist of 40-4000 amino acid. Molecular weight (4000- 44000).

3. Shape: Globular (Insulin, enzymes), Oval (Albumin), Fibrous/Elongated (Fibrinogen).

4. Isoelectric pH: Protein exists as Zwitter ion or dipolar ion. The pH at which a protein has equal number of positive and negative charges is known as isoelectric pH. When subjected to an electric field the proteins do not move either towards anode or cathode, hence this property is used to isolate proteins. The proteins become least soluble at

Isoelectric pH and get precipitated. The Isoelectric pH of casein is 4.5 and at this pH the casein in milk curdles producing the curd.

5. Precipitation of protein: By dehydration or neutralization.

6. Precipitation by salting out: Sodium sulphate and ammonium sulphate.

7. Precipitation by heavy metal: Pb^{2+}, Hg^{2+}, Fe^{2+} ,$Zn^{2+,}$ Cd^{2+}.

8. Precipitation by anionic or alkaloidal reagent: Tannic acid, Trichloro acetic acid and sulphosalicylic acd etc.

9. Denaturation: Partial or complete unfolding (disorganization) of the native (natural) protein structure is known as denaturation. This is caused by heat, acids, alkalies, alcohol, acetone, urea, beta- mercaptoethanol.

10. Coagulation: When proteins are denatured by heat, they form insoluble aggregates known as coagulum. All the proteins are not heat coagulable, only a few like the albumins, globulins are heat coagulable.

CLASSIFICATION OF PROTEINS:

Proteins are classified based upon:

1. Solubility
2. Structural complexity

Classification based upon Solubility:

1. Fibrous proteins: These are insoluble in water. They include the structural proteins. They have supportive function (e.g., collagen) and/or protective function (e.g., hair keratin and fibrin).
2. Globular proteins: They are soluble in water. They include the functional proteins, e.g., enzymes, hemoglobin, etc.

Classification based upon Structural Complexity:

1. **Simple**
2. **Conjugated**
3. **Derived proteins**

1. **Simple proteins:** Proteins which are made up of amino acids only are known as simple proteins.

   They are further sub-divided into:

   a. Albumins:

   They are water soluble, heat coagulable and are precipitated on full saturation with ammonium sulphate,

   Example: Serum albumin, lactalbumin and ovalbumin.

   b. Globulins:

   They are insoluble in water, but soluble in dilute salt solutions. They are heat coagulable and precipitate on half-saturation with ammonium sulphate.

   Example: erum globulin and ovo-globulin.

   c. Glutelins:

   They are insoluble in water and neutral solvents. Soluble in dilute acids and alkalis. They are coagulated by heat,

   Example: Glutelin of wheat.

   d. Prolamines:

   Water insoluble but soluble in 70% alcohol,

   Example: Gliadin of wheat, proteins of corn, barley, etc.

   e. Histones:

   Water soluble, basic in nature due to the presence of arginine and lysine, found in nucleus. They help in DNA packaging in the cell. They form the protein moiety of nucleoprotein.

   f. Protamine's:

   Water soluble, basic in nature, not-heat coagulable. Found in sperm cells, hence component of sperm nucleoprotein.

   g. Globin's:

   They are water soluble, non-heat coagulable.

   Example: Globin of haemoglobin.

   h. Albuminoids or scleroproteins:

   Insoluble in all neutral solvents, dilute acids or alkalis,

   Example: keratin of hair and proteins of bone and cartilage.

2. **Conjugated proteins:** Proteins which are made up of amino acids and a non-amino acid/protein substance called the prosthetic group are known as conjugated proteins.

   The various types of conjugated proteins are:

a. Chromo proteins: The non-protein part is a colored compound in addition to the protein part. Example: Haemoglobin has heme as the prosthetic group and cytochromes also have heme.

b. Nucleoproteins:
These proteins are bound to nucleic acids.
Example: chromatin (histones + nucleic acids).

c. Glycoproteins: When a small amount of carbohydrate is attached to a protein it is known as glycoproteins,
Example: mucin of saliva.

d. Phosphoprotein: Phosphoric acid is present with the protein.
Example: Milk casein and egg yolk (vitellin).

e. Lipoproteins: Proteins in combination with lipids,
Example: LDL, HDL.

f. Metalloproteins: They contain metal ion in addition to the amino acids,
Example: hemoglobin (iron), ceruloplasmin (copper).

3. **Derived proteins**: They are the proteins of low molecular weight produced from large molecular weight proteins by the action of heat, enzymes or chemical agents.

Proteins → Proteans → Proteoses → Peptones → Peptides → Amino acids

Nutritional classification of protein:

1. **Complete protein:** Have all the ten essential amino acids. Promote good growth.
   Example: Albumin (egg), Casein (Milk)
2. **Partially complete protein:** Partially lack one or more essential amino acid. Can promote moderate growth.
   Example: Wheat and rice protein (lack Lysine and threonine)
3. **Incomplete protein:** Completely lack one or more essential amino acid. Do not promote growth.
   Example: Gelatin (lack tryptophan), Zein (lack tryptophan, lysine)

BIOLOGICAL ROLE OF PROTEIN

1. **Structural function**

   Structural protein: They give biological structure, strength or protection to the body tissue system.
   Example: Collagen, Gelatin, in bones and tendon, Elastin in ligaments and Keratin in epidermal tissue (skin, hair, nails)
   Contractile Proteins: Fibrous protein functioning in the contractile system of skeletal muscles
   Example: Myosin

2. **Dynamic Function:** Protein acting as enzyme, hormones, blood clotting factor, immunoglobulin.

a. Enzymes : Highly specialized protein, catalyze most of the chemical reactions of organic Biomolecules in cell, tissue and systems
Example: Pepsin, trypsin, hexokinase

b. Transport protein: Carry specific ions or molecules from one organ to another.
Example: Hemoglobin: carrier of oxygen and carbon dioxide.
Lipoprotein (Serum albumin): carrier of lipids from liver to the other organ.
Myoglobin (hemoglobin, serum albumin): Molecules and ions from one organ to the other.

c. Nutrient and storage protein: They store and provide nutrients.
Example: Seed protein of wheat, corn and rice, albumin of egg white, casein of milk.

d. Defense protein: They defend (protect) the body from harmful foreign organisms, (bacteria, virus, foreign substance)
Example: Immunoglobulin's

e. Regulatory protein: They help to regulate cellular or physiological activity,
Example: Hormones like insulin, Pituitary, parathyroid, growth hormones etc.

CLASSIFICATION OF PROTEIN
(Chemical nature & Composition)

SIMPLE PROTEINS

Composed of only amino acid residues

- **Globular proteins** — Albumins, Globulin Glutelin, Histones, Prolamines, Globin, Lectins, Protamines
- **Scleroprotein** — Collagens, Elastins, Keratins

CONJUGATED PROTEINS

Composed of **prosthetic group (non protein group)** with amino acids

- **Glycoproteins** — Prosthetic group is carbohydrate — E.g. Mucin (saliva)
- **Phosphoproteins** — Prosthetic group is Phosphoric acid — E.g. Casein (milk)
- **Chromoproteins** — Prosthetic group is iron pigments — E.g. Haemoglobin

Other conjugated protein: Nucleoprotein, Mucoprotein, Lipoprotein, Metalloprotein

DERIVED PROTEINS

Denatured or degraded product of hydrolysis of simple & conjugated protein

- **Primary** — Coagulated protein, Proteans, Metaproteins
- **Secondary** — Proteoses, Peptones, Polypeptides, Peptides

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CLASSIFICATION OF PROTEIN
(Physical nature)

FIBROUS PROTEINS

Molecule is fiber shaped
Insoluble in water
Structural component of the body

E.g. Keratin, Myosin, Gelatin, Collagen

GLOBULAR PROTEINS

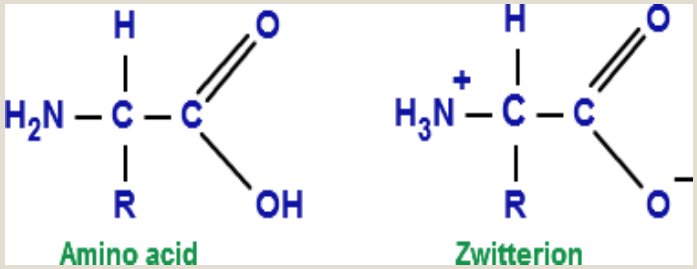
Molecule is globular or spherical
Soluble in water
Regulation and maintenance of life process

E.g. Enzymes, Hormones, Haemoglobin

AMINO ACIDS

Amino acids are a group of organic compound contains two functional groups: Amino- NH_2 (Basic) and Carboxyl group-COOH (Acid).

Amino acids exist as Zwitterions ion in biological system. Chemically proteins are polymers of L-α-amino acids. Amino acids are polymerized through formation of number of peptide linkages.



CLASSIFICATION OF AMINO ACID

On the basis of polarity:

1. Non polar amino acid - No charge on R group, hydrophobic (water hating). alanine, leucine, isoleucine, valine, methionine, phenylalanine, tryptophan, proline.

2. Polar amino acid with no charge on R group: Glycine, serine, threonine, cysteine, glutamine, asparginine, tyrosine.

- On the basis of structure:

1. Amino acid with aliphatic side chain: Glycine, alanine, valine, leucine and isoleucine
2. Hydroxyl group containing amino acid: Serine, threonine, tyrosine
3. Sulfur containing amino acid- Cysteine, cystine, methionine
4. Acidic amino acid and their amides: Aspartic acid, asparginine, glutamic acid, glutamine
5. Basic amino acid: Lysine, arginine, histidine
6. Aromatic amino acid: Phenylalanine, tyrosine and tryptophane
7. Imino acid: Proline

3. Polar amino acid with positive charge on R group: Lysine, arginine, histidine.
4. Polar amino acid with negative charge on R group: Glutamic acid, aspartic acid

On the basis of Nutritional requirement:

20 amino acids are required for the synthesis of variety of protein.

1. **Essential Amino acids:**
   Amino acid cannot be synthesized by the body and need to be supplied from the diet is called essential amino acid. The 10 essential amino acids are (A.V. HILL, MP, T.T.) arginine, valine, histidine isoleucine leucine and lysine, methionine phenylalanine, threonine, tryptophane. Arginine and histidine (semi essential amino acid, synthesized by adult not by growing children).

2. **Non Essential amino acids:** The body can synthesize about 10 amino acids to meet the biological need and need not to be consumed from the diet are called non essential amino acid. Glycine, alanine, serine, tyrosine, cystine, asparginine, glutamic acid, glutamine, aspartate, and proline.

On the basis of their metabolic fate:

1. Glycogenic amino acid: Serve as precursor for formation of glucose or glycogen. Example: Alanine, aspartate, glycine, methionine.
2. Ketogenic amino acid: Amino acids which synthesize fat. Example: Leucine and Lysine

PROPERTIES OF AMINO ACID

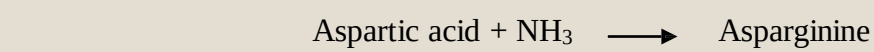
Physical Properties of amino acid

1. Solubility: Usually soluble in water insoluble in organic solvent
2. Melting point: Melt at higher temperature.> 200oC
3. Taste: Sweet (Glycine, alanine, valine), Bitter(Arginine, Isoleucine), Tasteless(Leucine)
4. Optical properties : Except glycine
5. Ampholytes: Contain both acid and basic group. Donate proton and accept proton.
6. Zwitter ion or dipolar ion: Contain positive and negative ionic group

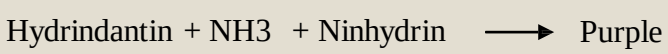
Chemical properties of amino acid:

1. Amino acid react with base to form salt (-COONa)

2. Amino acid react with alcohol to form ester (-COOR)
3. Decarboxylation: Produce corresponding amines
4. Amino acid reacts with ammonia to form Amide.



5. React with ninhydrin reagent gives purple (Ruhemann's purple), blue or pink color



6. Transamination: Transfer of an amino acid group from an amino acid to a ketoacid to form a new amino acid.
7. Oxidative deamination: Liberate ammonia