Lecture 6

Proteins

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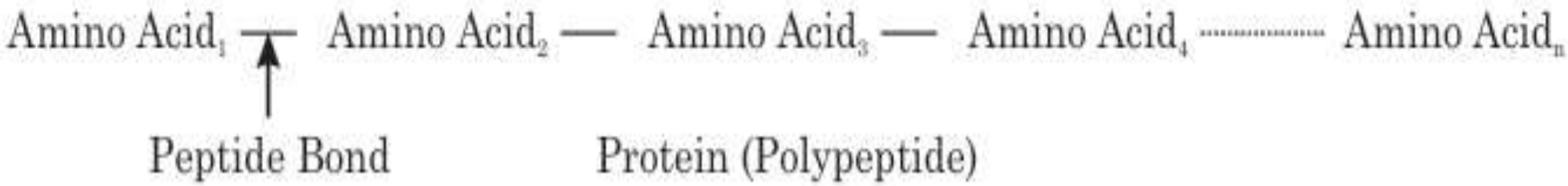
Proteins

Proteins are polymers of amino acids. The amino acids are joined by peptide bonds. Hence they are also called as polypeptides.



Functions of Proteins:

1. Proteins are present in body. They are structural components of tissues, cells etc.
2. Proteins function as hormones
3. Proteins functions as enzymes
4. Proteins regulate gene expression.
5. Proteins are involved in muscle contraction

6. Proteins perform transport functions.
7. Proteins are used as nutrients.
8. Proteins act as buffers.
9. Proteins act as reservoir of minerals
10. Proteins act as infective agents.

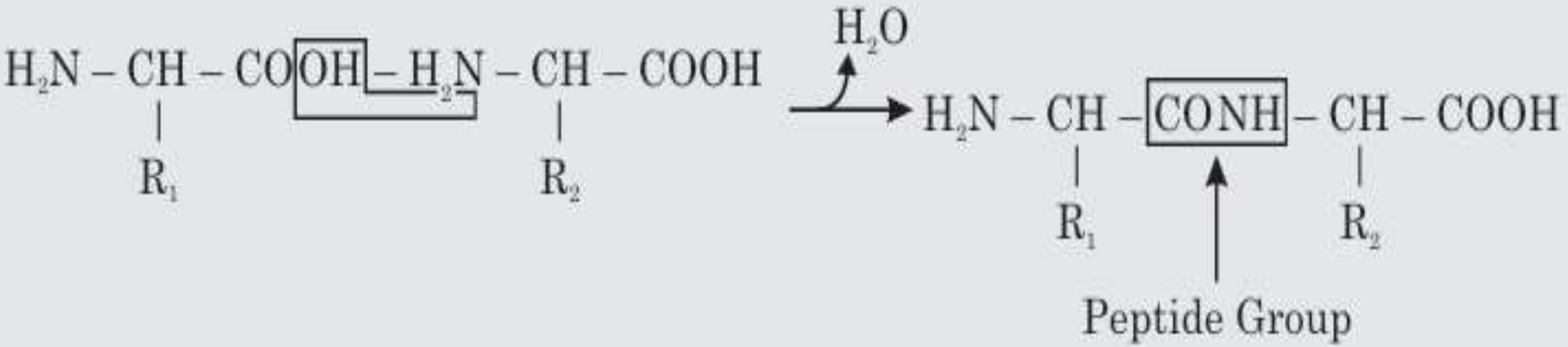
peptide (< 50 amino acids)
protein (> 50 amino acids)

Peptides are compounds containing peptide bonds.

Peptides are formed due to inter action between carboxyl group of one aminoacid with amino group of other amino acids.

Peptide bond formation involves loss of one water molecule.

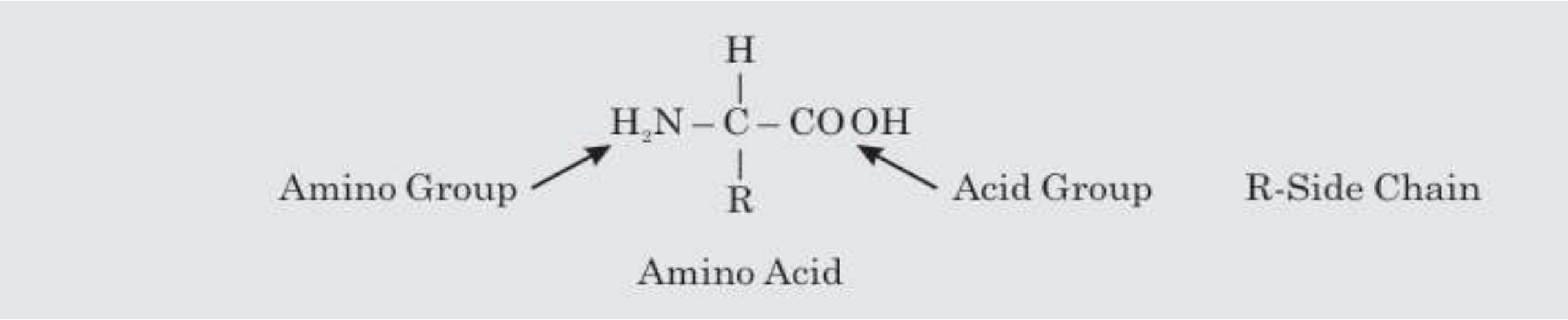
Glutathione, thyrotrophin releasing hormone, enkaphalins, oxytocin, vasopressin are examples for peptides.



There are 20 genetically encoded α-amino acids found in peptides and proteins

19 are primary amines, 1 (proline) is a secondary amine
19 are “chiral”, 1 (glycine) is achiral; the natural configuration of the α-carbon is L.

Amino acids: are acids containing amino groups. They are building blocks of proteins and peptides present in humans and other living organisms.



Functions: Free amino acids are found in blood and cells of humans. Hormones, purines, pyrimidines, heme, some vitamins, creatine, etc. found in body are derived from amino acids.

Functions of Amino Acid

1. **Build Protein:** When cells need protein, they follow instructions from DNA that define the specific amino acids and the order in which they must connect to build the protein.

2. **Synthesize Neurotransmitters:** Several amino acids produce neurotransmitters like GABA

3. **Protect Cardiovascular Health:** the body uses the amino acid arginine to make nitric oxide. Nitric oxide helps lower blood pressure by relaxing muscles in your blood vessels.

AMINO ACID

Based on structure

1. Aliphatic amino acid
2. Aromatic amino acid
3. Amino acid-containing hydroxyl group
4. Sulfur containing amino acid
5. Acidic amino acid
6. Basic amino acid
7. Imino acids

Based on polarity

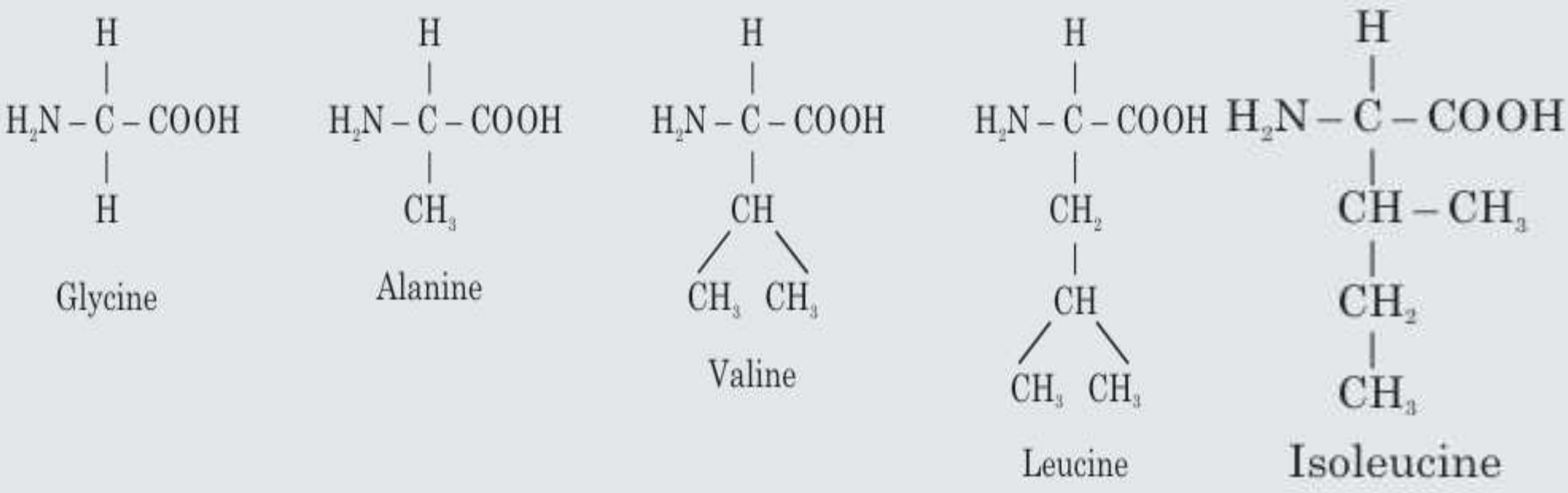
1. Non-polar amino acid
2. Polar amino acid

Nutritional classification

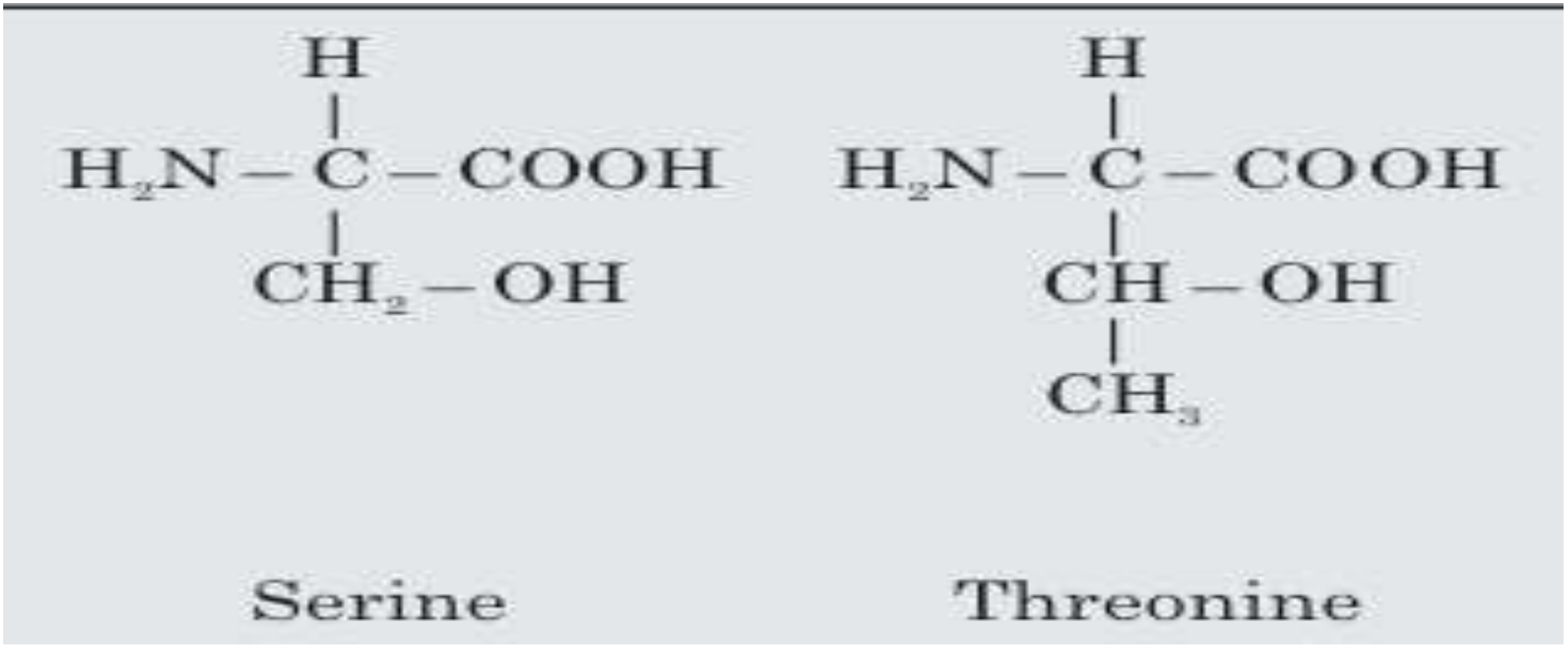
1. Essential amino acid
2. Non-essential amino acid

Amino acids are classified into seven major classes based on side chains.

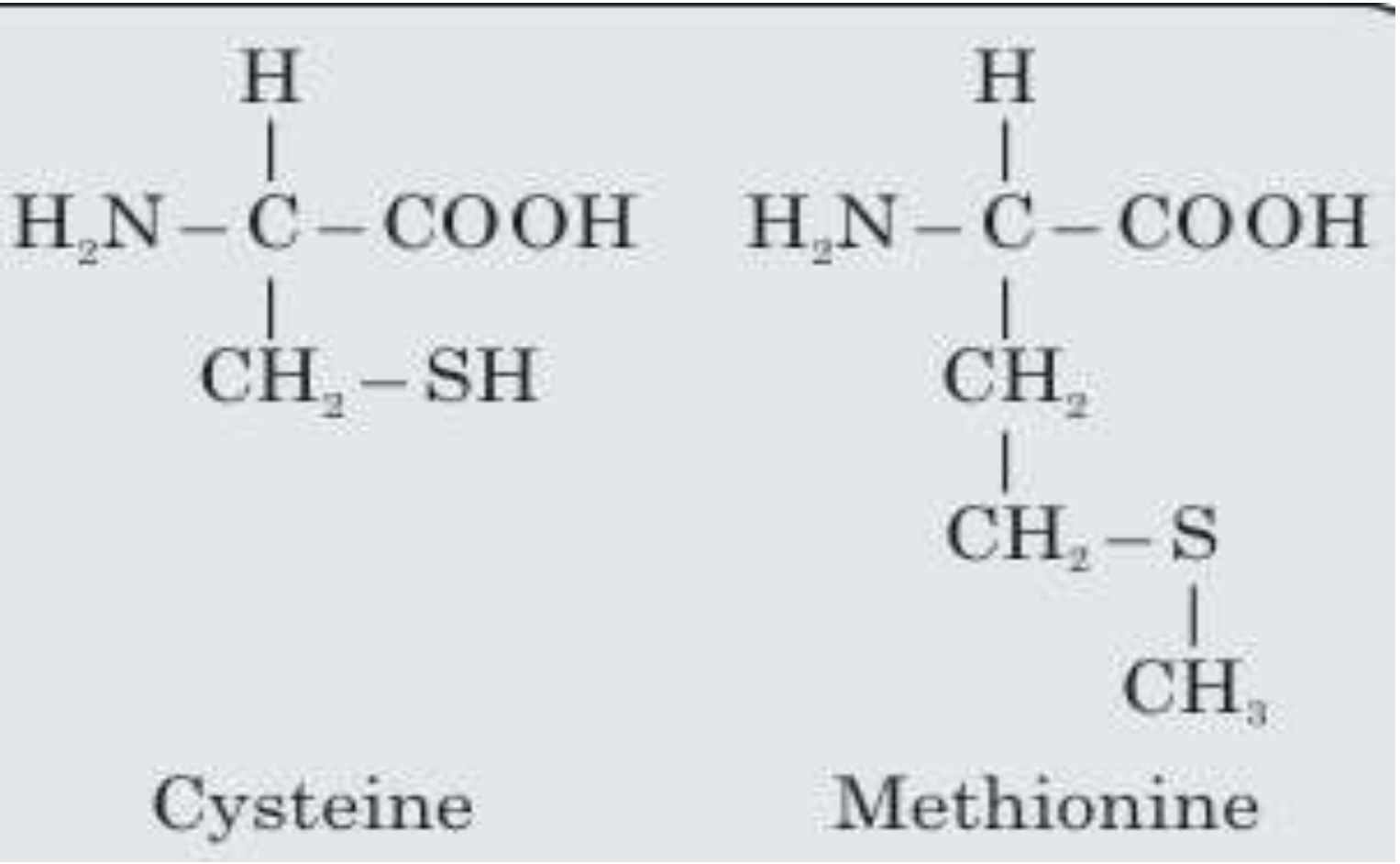
a) **Aliphatic amino acids:** Are those which contain aliphatic side chains. **Glycine**, **alanine**, **valine, leucine** and **isoleucine** are examples for aliphatic amino acids. The latter three amino acids are also known as branched chain amino acids.

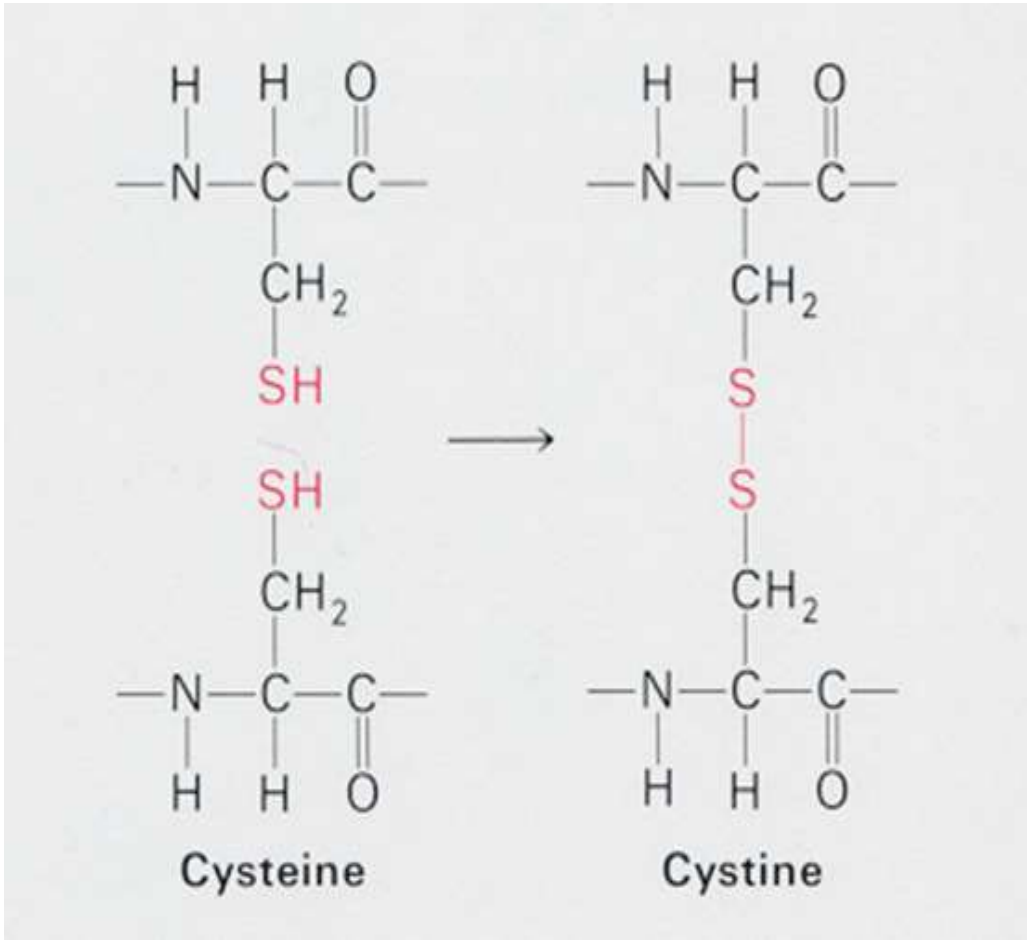


b**) Hydroxyl amino acids** :Are those amino acids that contain hydroxyl groups in side chain. **Serine** and **threonine** are examples for hydroxyl amino acids.

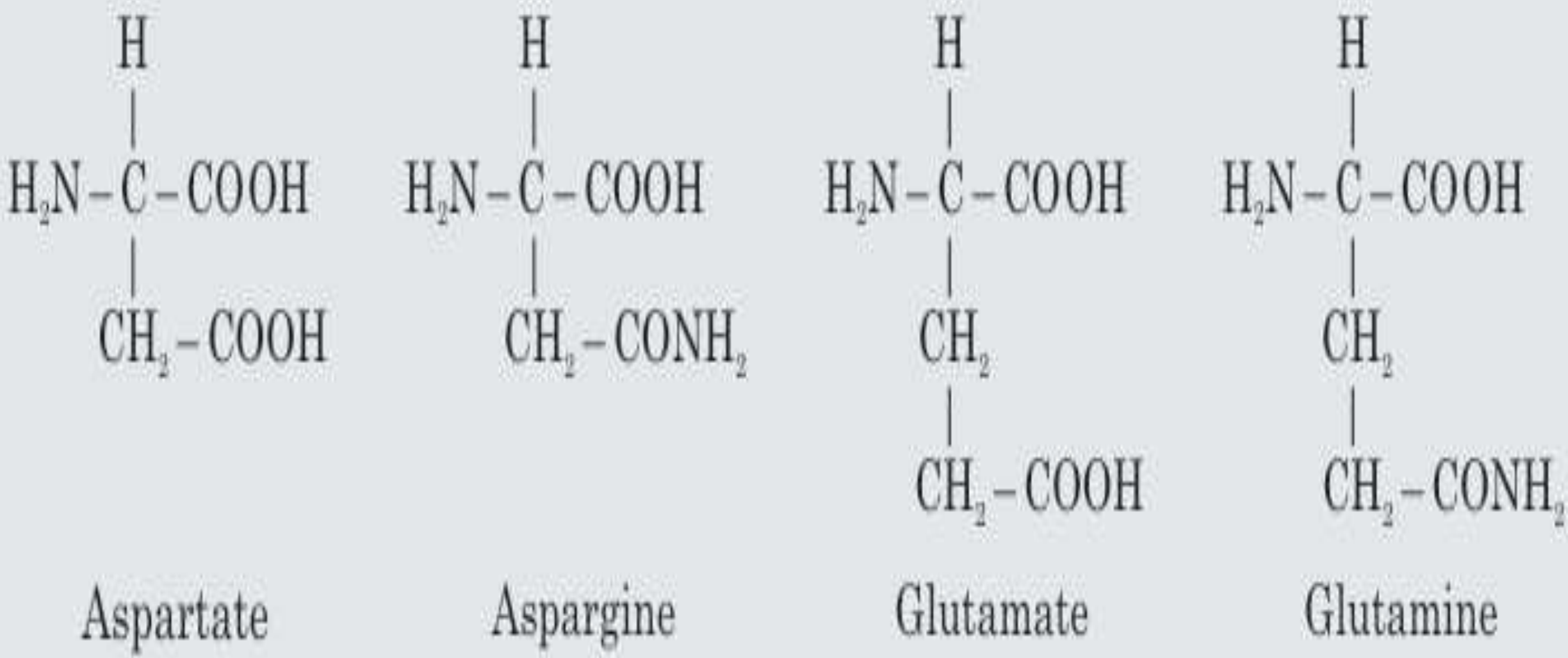


c) **Sulfur containing amino acids :** These aminoacids contain sulfhydryl groups in side chain. They are **cysteine, methionine** and **cystine.**

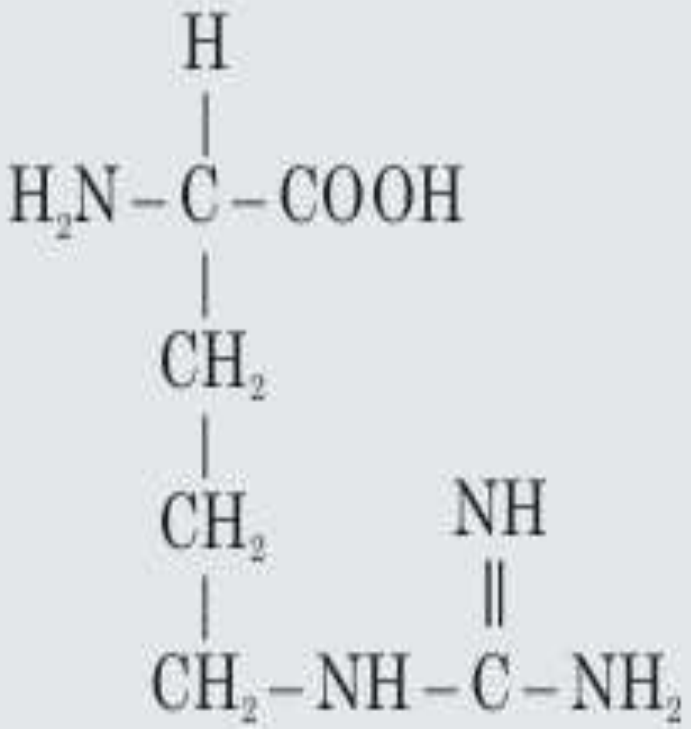




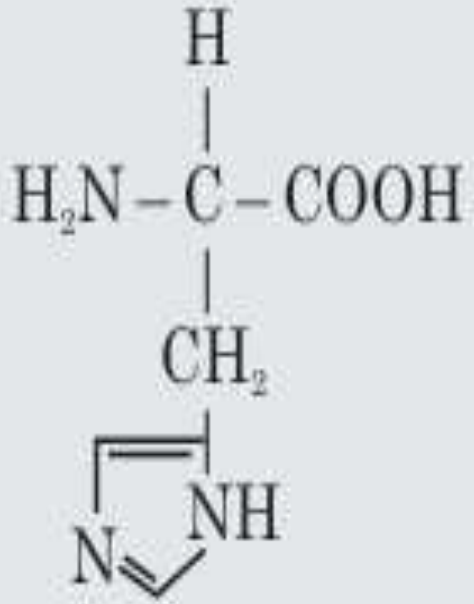
d) **Acidic amino acids :** Side chains of these amino acids contain acidic groups or their amides. They are glutamate, glutamine, aspartate and aspargine.



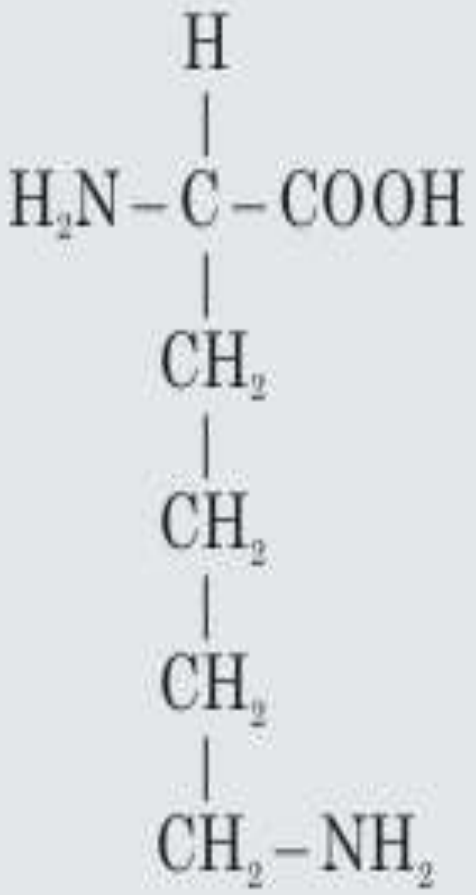
e) **Basic amino acids:** Basic groups are present in side chains of these amino acids. They are **arginine, lysine, hydroxyl lysine and histidine**.



Arginine

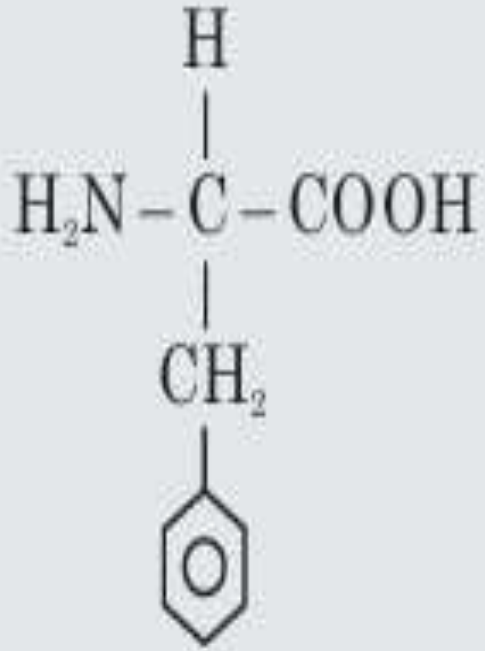


Histidine

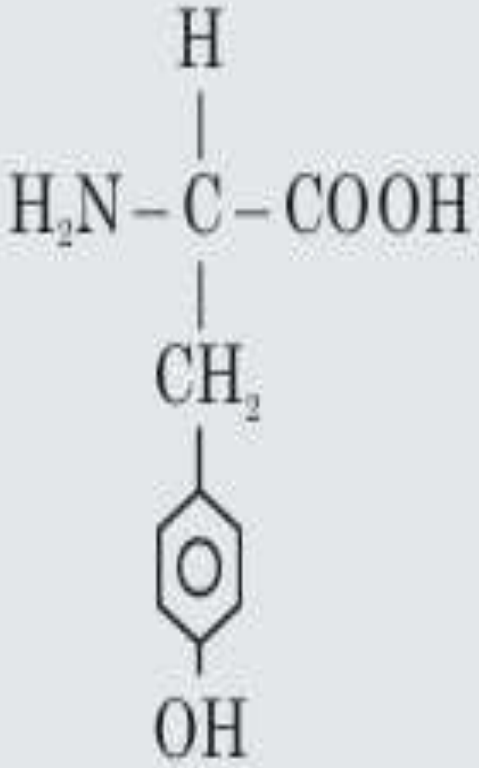


Lysine

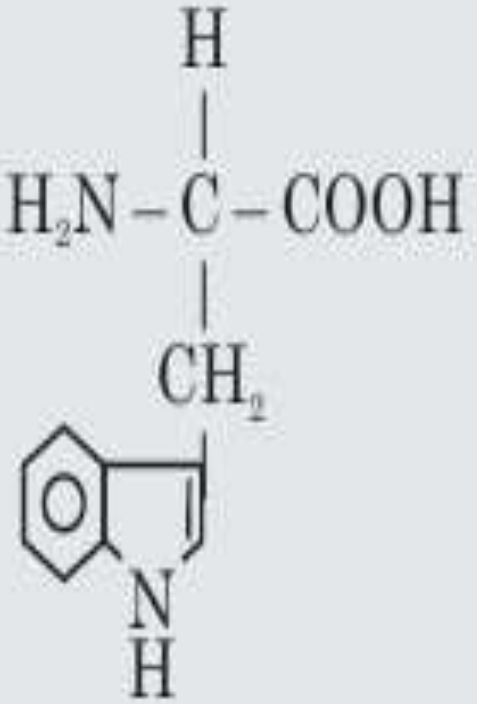
f) **Aromatic amino acids :** Aromatic rings are present in the side chains of these amino acids. They are phenylalanine, tyrosine and tryptophan.



Phenyl Alanine

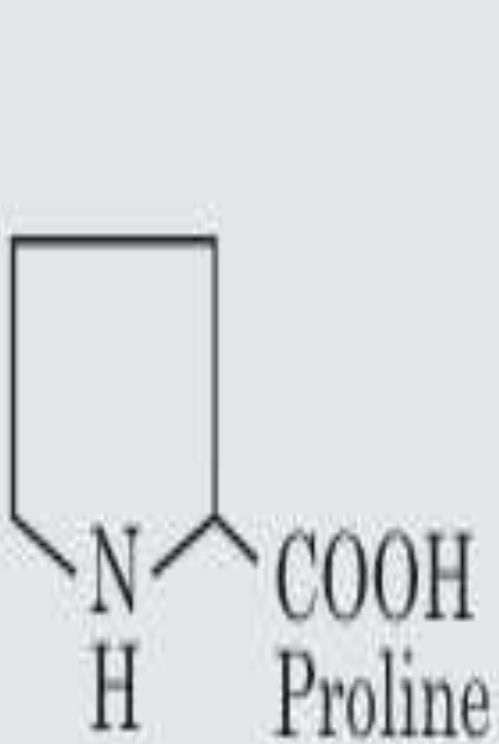


Tyrosine

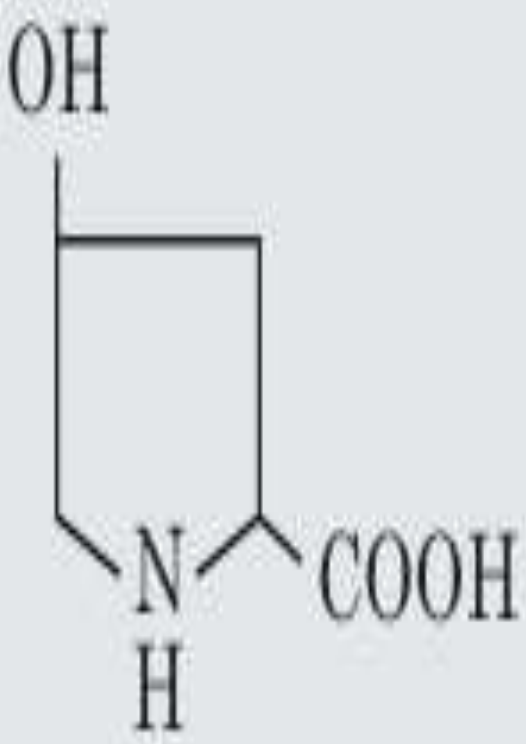


Tryptophan

g) **Imino acids:** Are those amino acids in which amino group is replaced by imino group. They are proline and hydroxy proline.



Proline



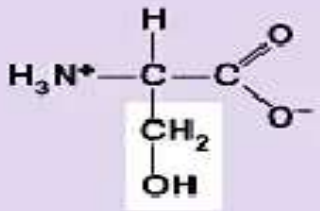
Hydroxy Proline

CLASSIFICATION OF AMINO ACIDS BASED ON POLARITY

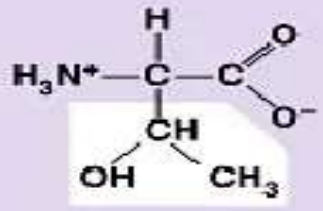
Nonpolar amino acids: These amino acids are also known as hydrophobic or water-hating. They have no charge on the R group. Examples: alanine, valine, and leucine.

Polar amino acids: These amino acids are also known as hydrophilic or water-loving. They have a charge on the R group. Examples: glycine, serine, cysteine.

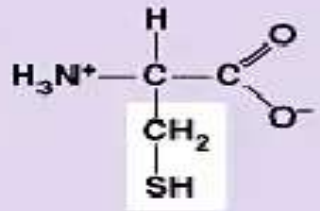
Polar



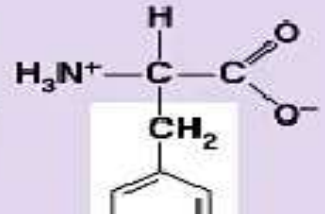
Serine (Ser)



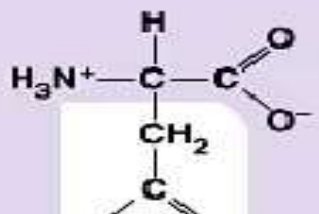
Threonine (Thr)



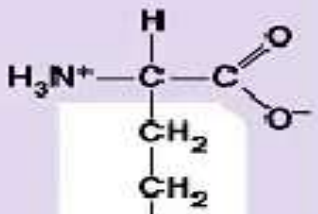
Cysteine (Cys)



Tyrosine (Tyr)

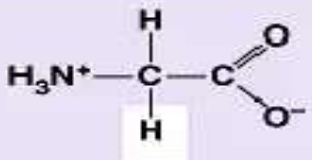


Asparagine (Asn)

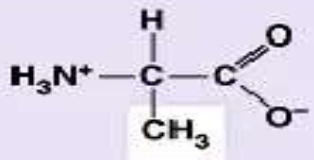


Glutamine (Gln)

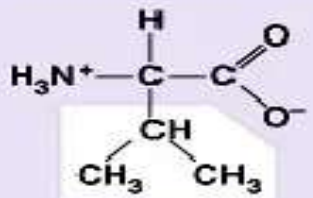
Nonpolar



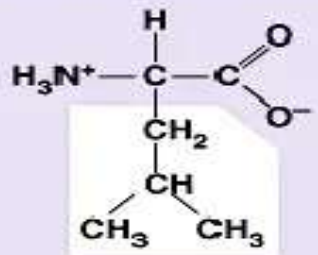
Glycine (Gly)



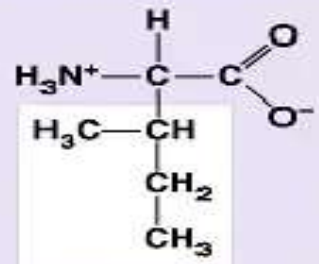
Alanine (Ala)



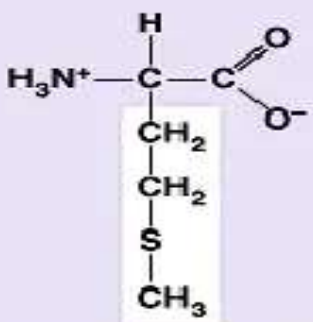
Valine (Val)



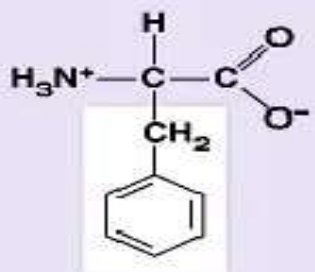
Leucine (Leu)



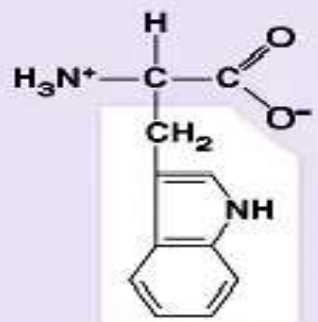
Isoleucine (Ile)



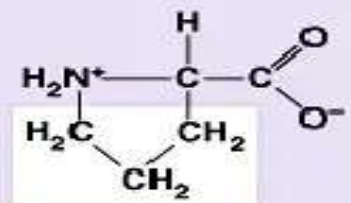
Methionine (Met)



Phenylalanine (Phe)



Tryptophan (Trp)



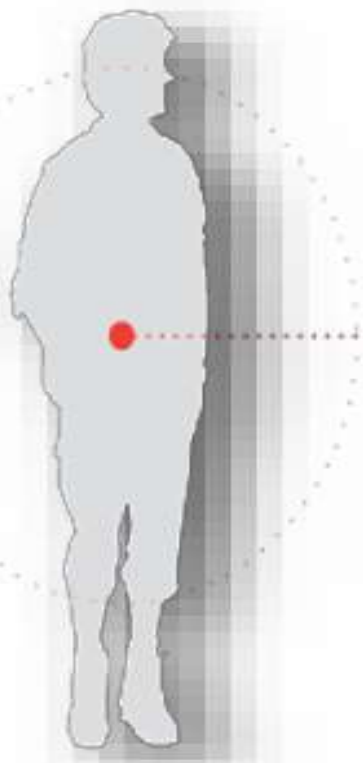
Proline (Pro)

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: **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.**



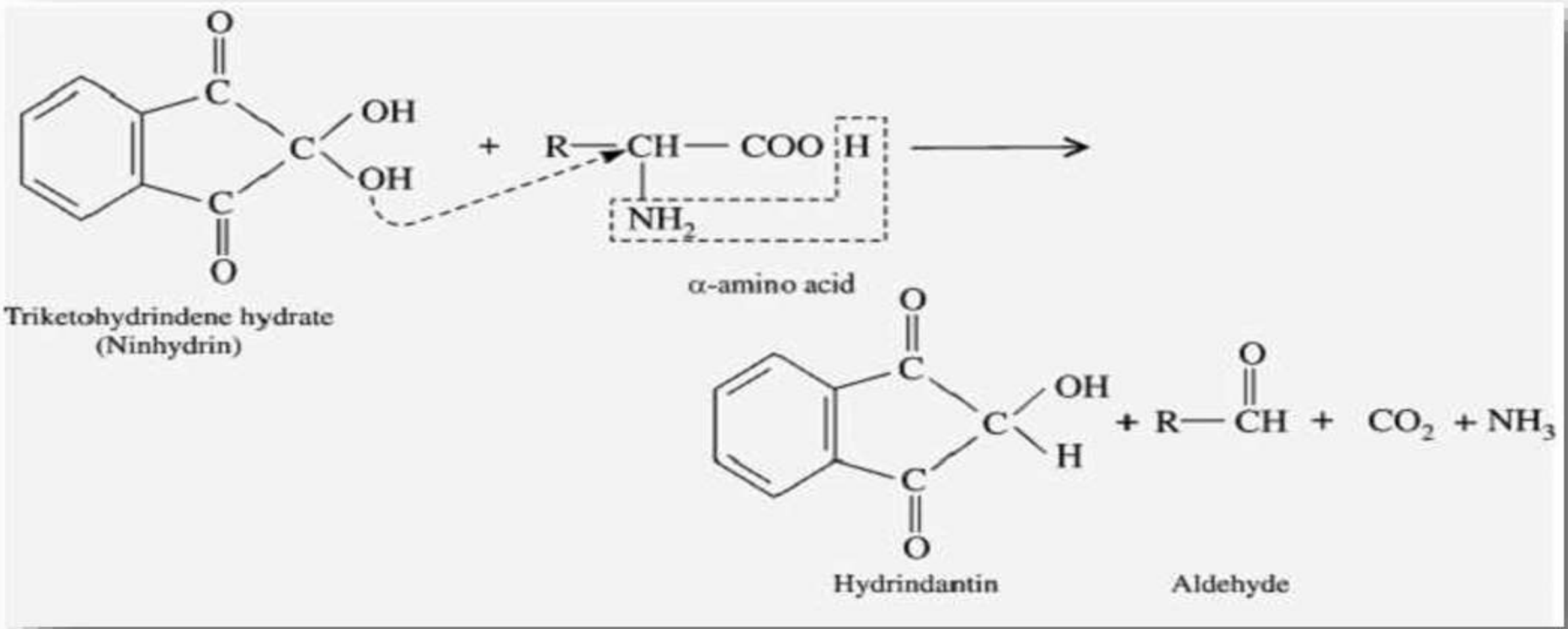
NON ESSENTIAL	ESSENTIAL
Alanine	Histidine
Arginine	Isoleucine
Asparagine	Leucine
Aspartate	Lysine
Cystine	Methionine
Glutamic	Phenylalanine
Glycine	Threonine
Ornithine	Tryptophan
Proline	Valine
Serine	
Tyrosine	

Properties : Physical

- Colourless
- Crystalline in nature
- Tasteless[tyrosine], sweet[glycine, alanine]
- Melting point above 200•C
- Soluble in polar solvent and Insoluble in non polar solvent
- Have absorbance at 280nm

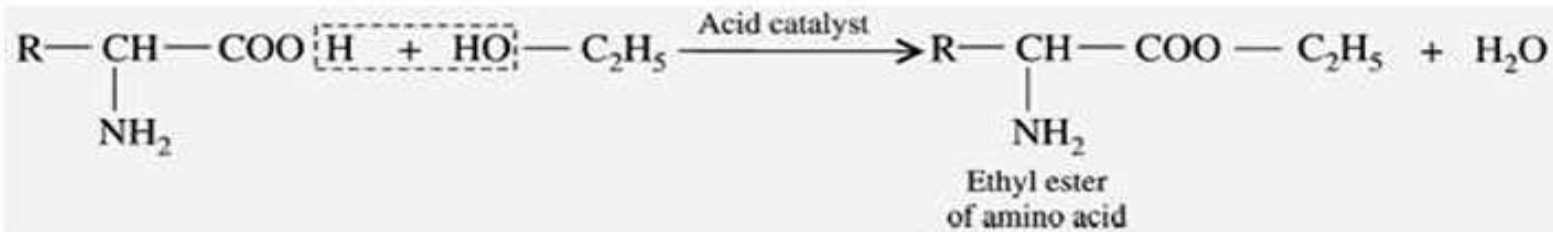
- Mol wt: 100 – 50,000Dt
- All amino acids possess optical isomers due to the presence of asymmetric α-carbon atoms.
- Some are structurally stable and sterically hindered [Glycine]
- Amino acids [proteins]posses enzymatic activities
- Amino acids exhibit colloidal nature and denaturing property

- Reaction with Ninhydrin:



- **Reaction with Alkalies (Salt formation):**
- The carboxyl group of amino acids can release a H^+ ion with the formation of Carboxylate (COO^-) ions.

- **Reaction with Alcohols (Esterification) :**
- the amino acids is reacted with alcohol to form, "Ester". The esters are volatile in contrast to the form amino acids.



- **Reaction with DANSYl Chloride:**

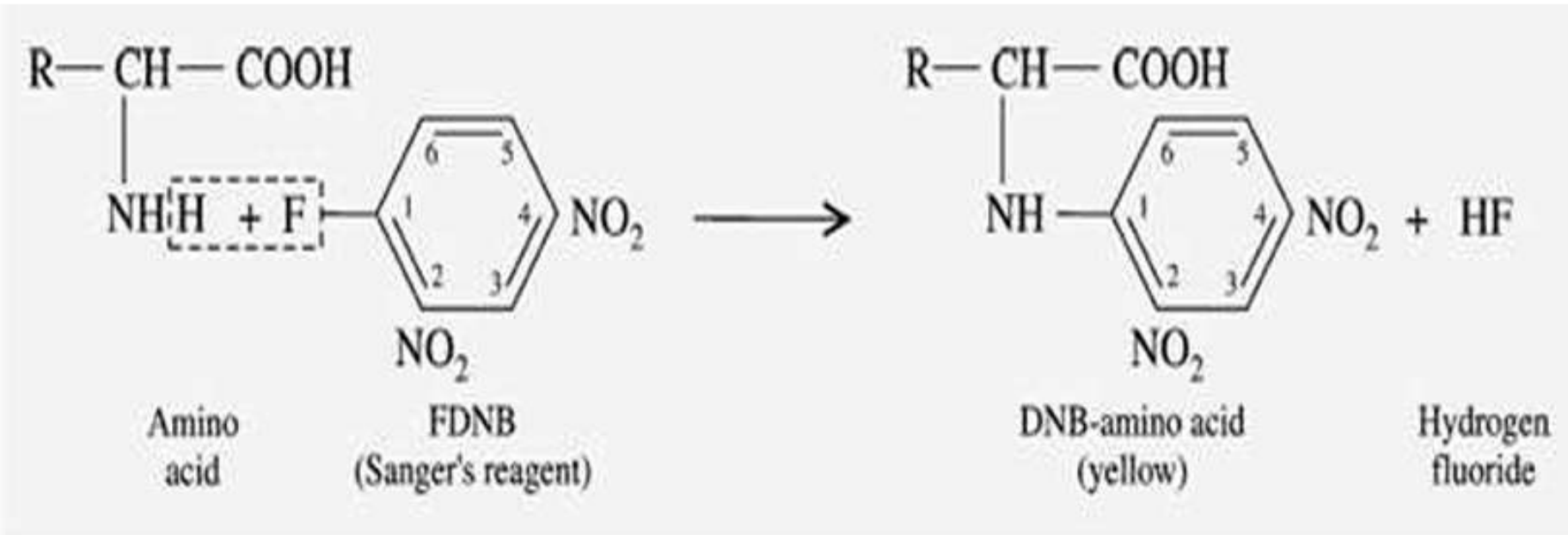
DANSYl chloride means “Dimethyl Amino Naptha Sulphonyl Chloride”.

When the amino acid reacts with DANSYl chloride reagent, it gives a “Flourescent DANSYl derivative

- **Reaction with acylating agents (Acylation):**

When the amino acids react with “Acid chloride” and acid anhydride in alkaline medium it gives “pthaloyl amino acid

- **<u>Reaction with Sanger's reagent:</u>**
- "1-flouro-2,4-dinitrobenzene" is called Sanger's reagent (FDNB).sanger's reagent reacts with α-amino acid to produce Yellow coloured derivative, DNB-amino acid.



PROTEINS & ITS STRUCTURE

- Proteins are polymers of α-amino acids.
- Proteins have a complex structure and can be divided into four structures.
- The term protein is used for polypeptides containing more than 50 amino acids.

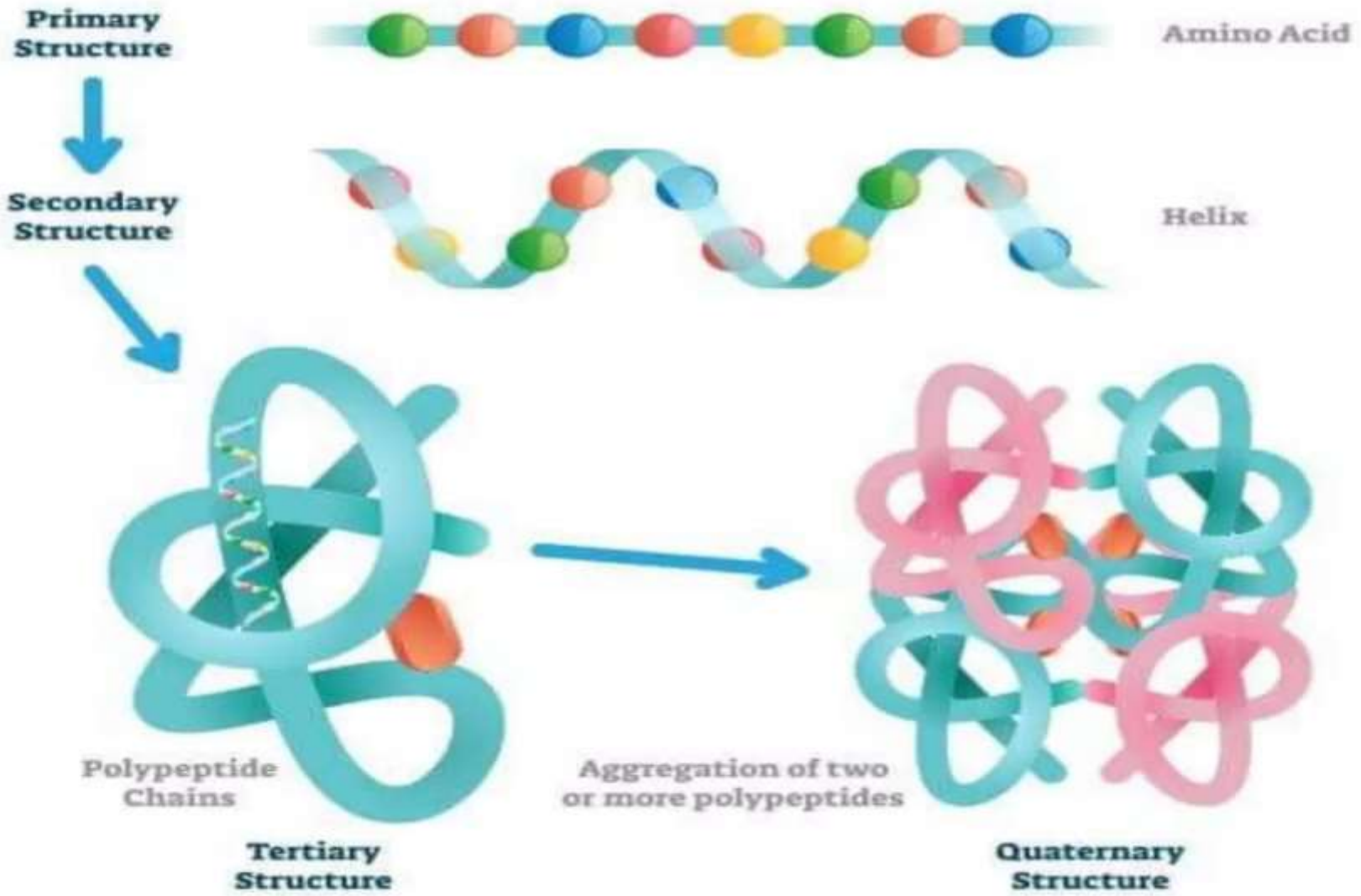
a) **Primary structure:** It is a linear structure of protein and forms the backbone of proteins.

b) **Secondary structure:** It is the arrangement of protein structure in space (spatial arrangement) by twisting the polypeptide chain.

c) **Tertiary structure:** It is the three-dimensional structure of proteins.

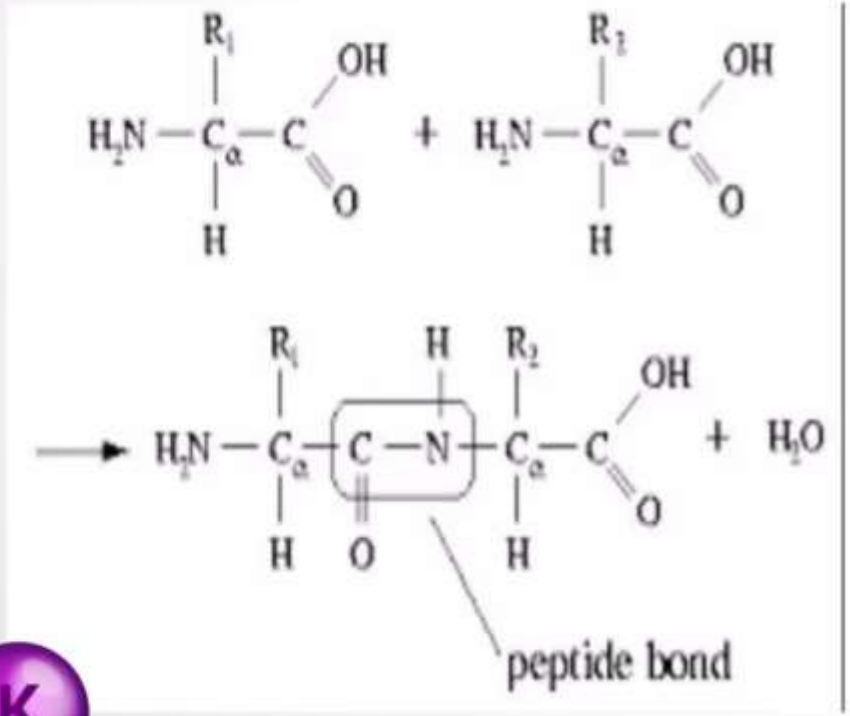
d) **Quaternary structure:** Composed of two or more polypeptide chains known as subunits the spatial arrangements of these subunits is known as quaternary structure.

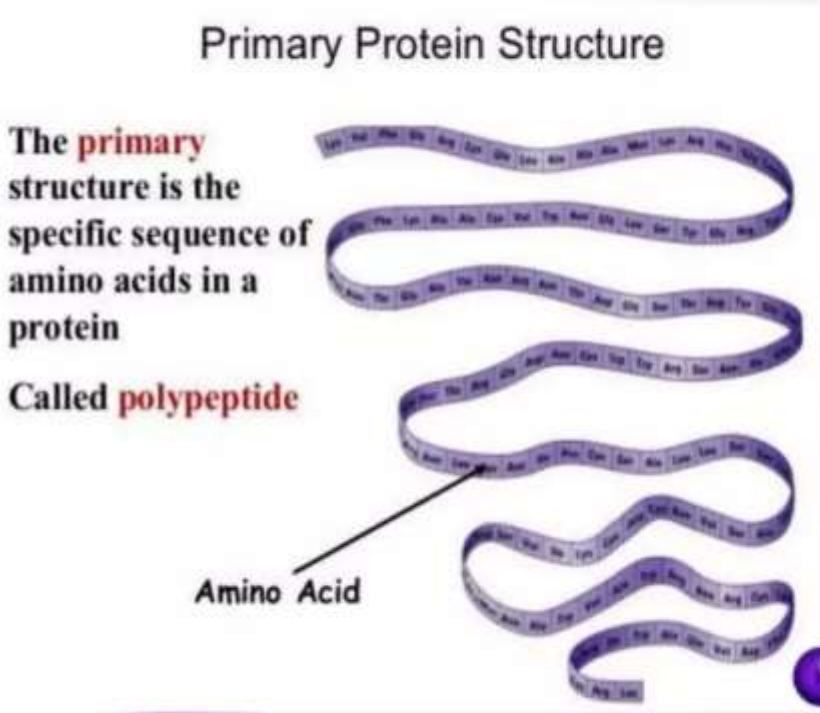
PROTEIN STRUCTURE



PRIMARY STRUCTURE OF PROTEIN

- The primary structure of proteins is responsible for functions.
- Each protein has a unique sequence of amino acids linked together by peptide bonds.
- Abnormal amino acid sequencing causes various illnesses.
- Peptide bonds form when amino and carboxyl groups of two amino acids interact.





SECONDARY STRUCTURE OF PROTEIN

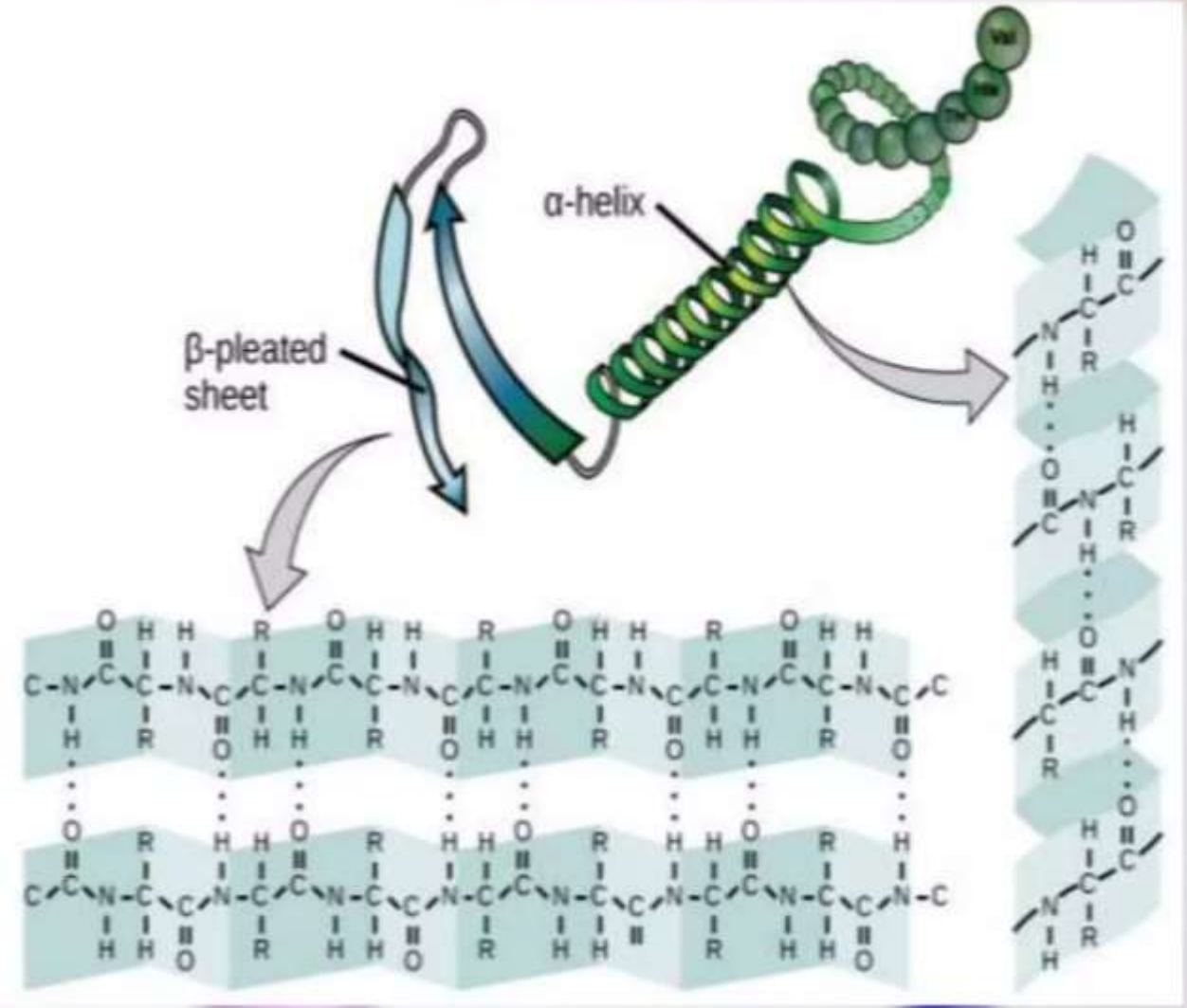
- The secondary structure is the shape of the polypeptide chain through twisting and folding.
- There are two types of secondary structures:

1. α-helix (alfa-helix)
2. β-sheet (beta-sheet)

1. Alfa-helix

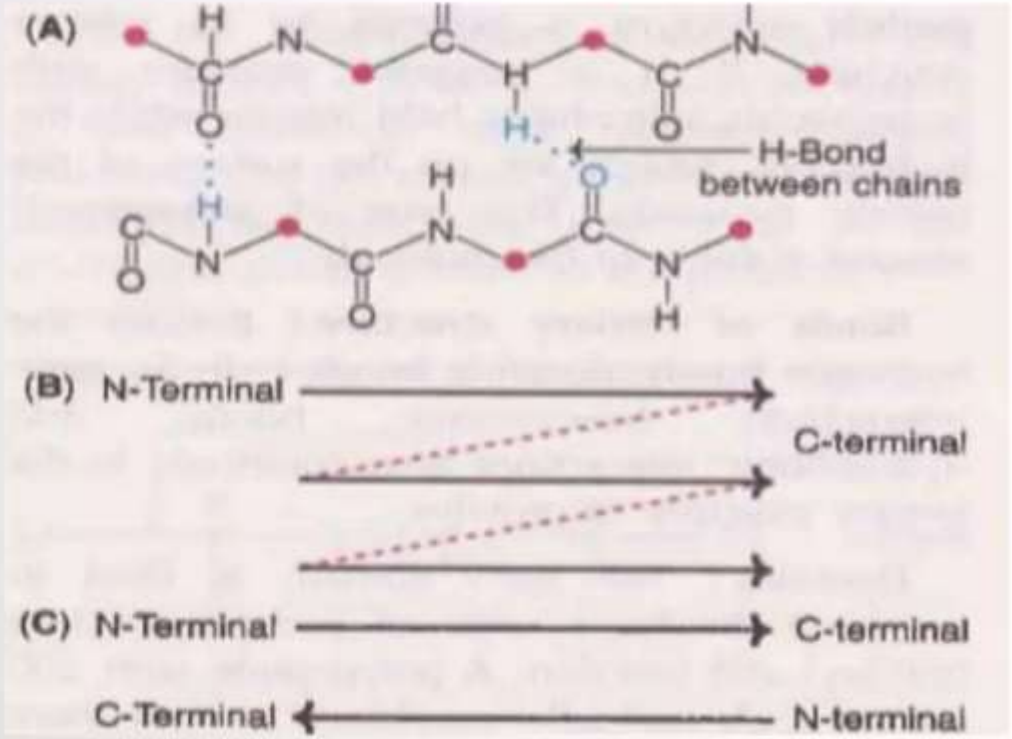
- It is the most common spiral structure of the protein in which the amino acids are tightly packed and coiled.

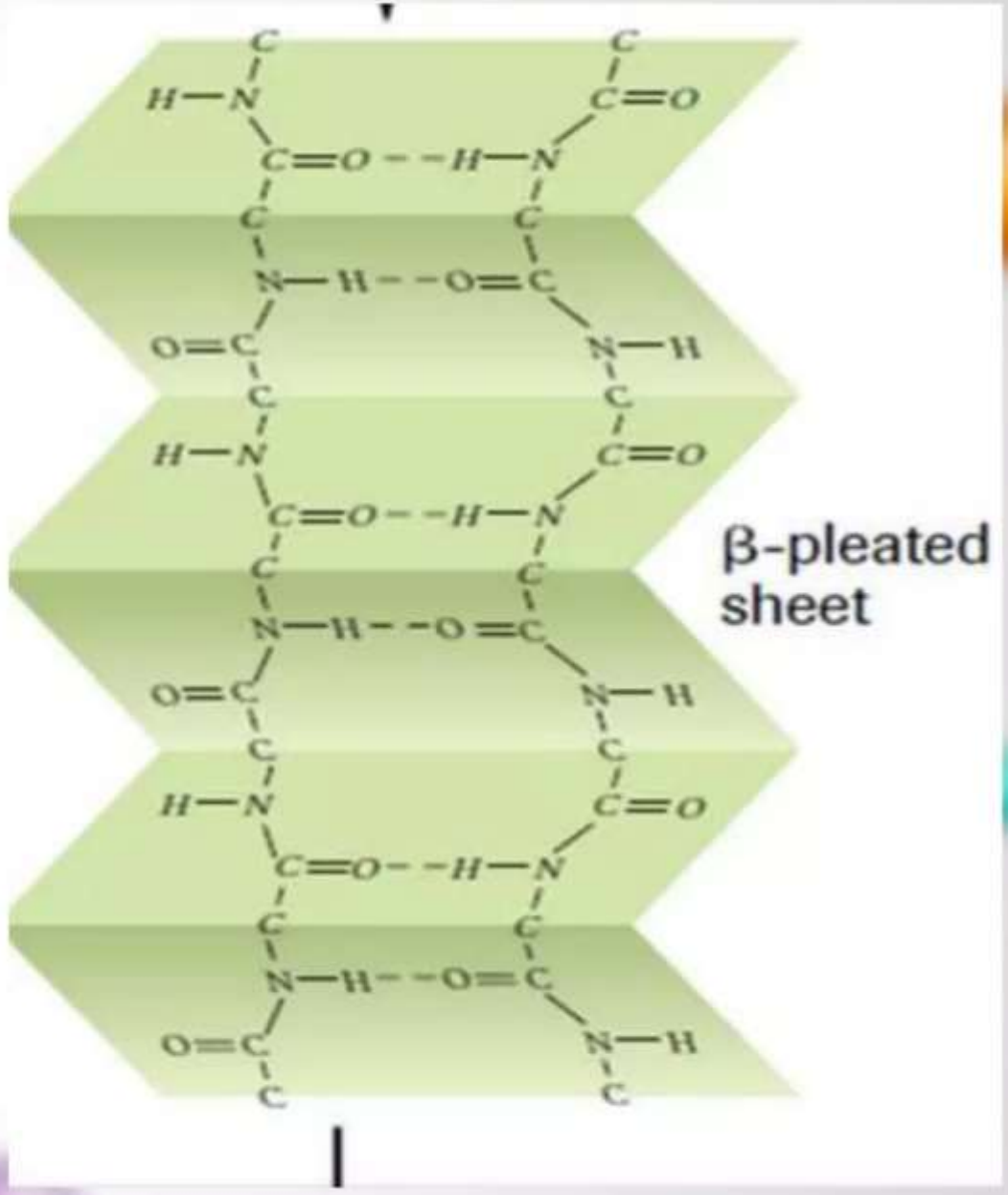
- The formation of alfa-helix requires the lowest energy.



2. Beta-sheet or beta-pleated sheet

- In this, hydrogen bonds are formed between the neighbouring segments of polypeptides.
- The peptide is held together giving a sheet-like structure.
- Can be parallel (same direction) or antiparallel (opposite direction).

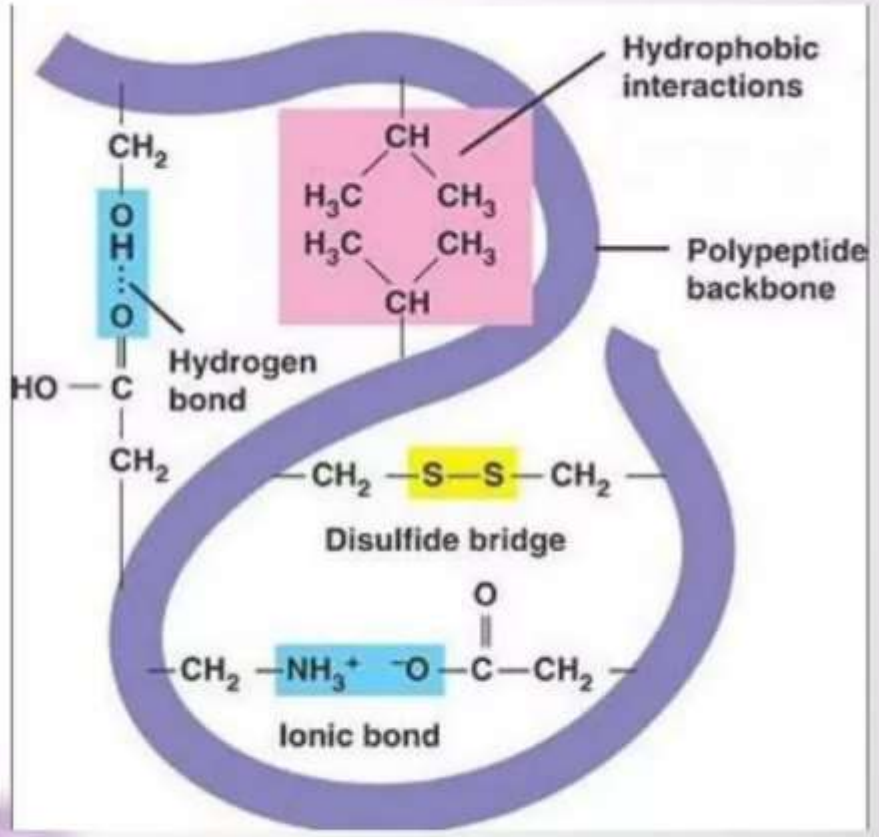




TERTIARY STRUCTURE OF PROTEINS

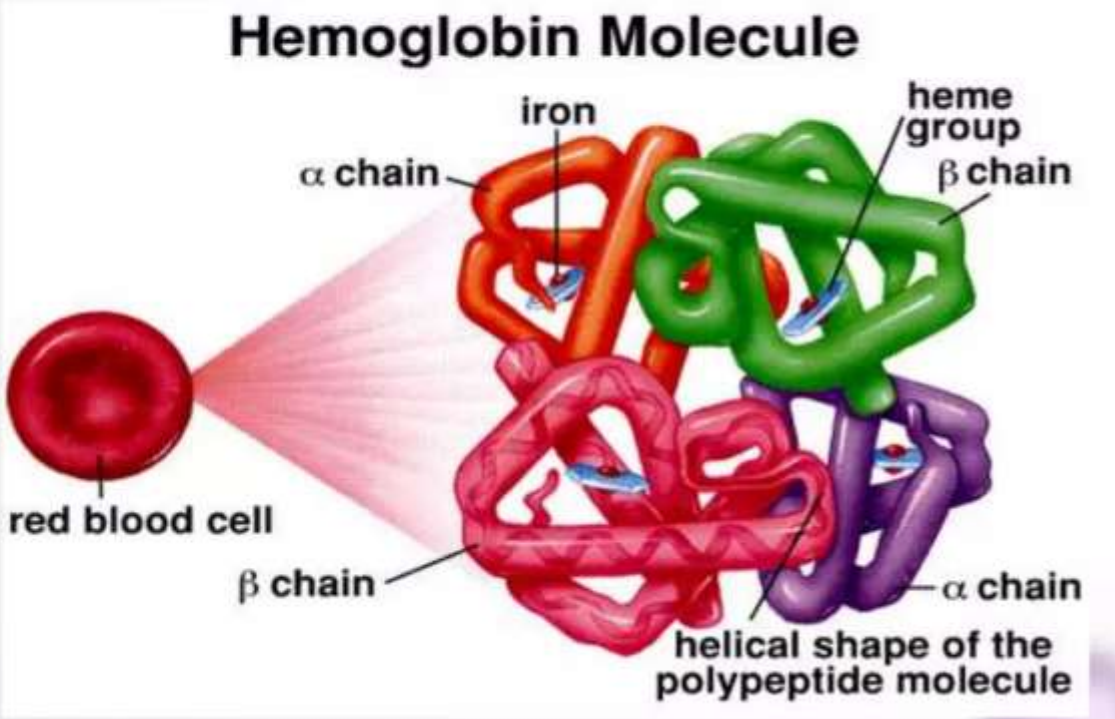
- It is the three-dimensional arrangement of protein structure.
- In this, the hydrophobic side chain is held inside and hydrophilic groups are held outside (surface).
- The above arrangement gives stability to the molecule.
- The interactions include:

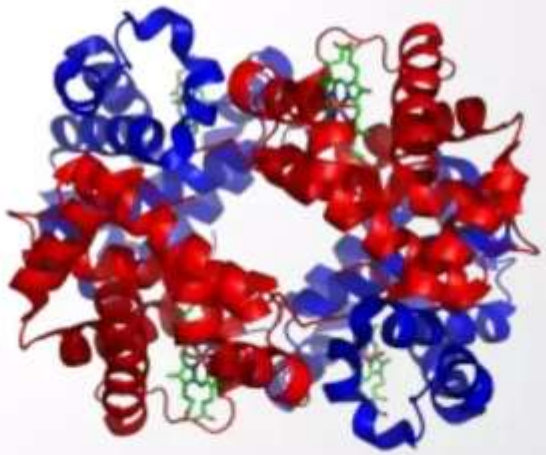
➢ Hydrogen bonds
➢ Hydrophobic bonds
➢ Ionic bonds
➢ Di-sulphide bonds



QUATERNARY STRUCTURE OF PROTEINS

- Some proteins contain 2 or more polypeptides held together by non-covalent bonds.
- These 2 polypeptide chains are called oligomers and a single polypeptide is called a monomer.
- Haemoglobin has 4 polypeptides.
- Bonds can be hydrogen, ionic or hydrophobic.



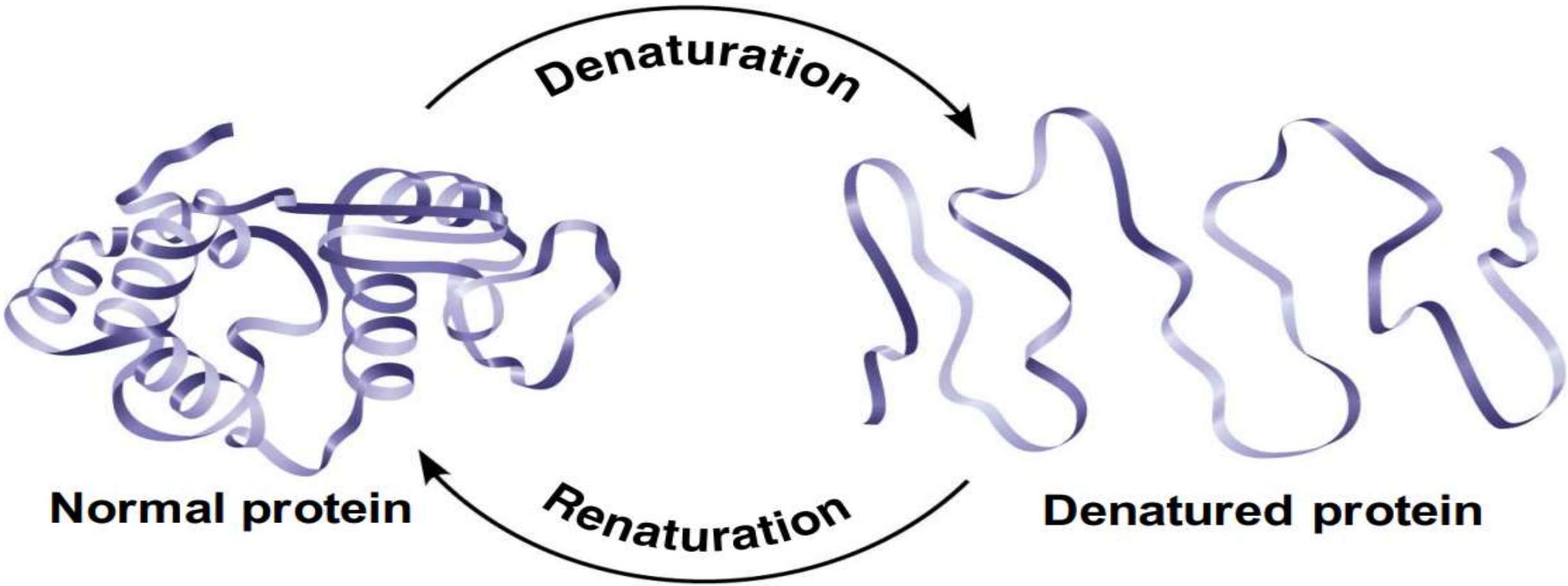


Denaturation

This loss of a protein's native structure is called
denaturation
- A denatured protein is biologically inactive

Protein found in a biological system with a unique three-dimensional structure and biological activity is called a native protein. When a protein in its native form, is subjected to physical change like change in temperature or chemical change like change in pH, the hydrogen bonds are disturbed. Due to this, globules unfold and helix get uncoiled and protein loses its biological activity. This is called **denaturation** of protein.

During denaturation secondary and tertiary structures are destroyed but primary structure remains intact. The coagulation of egg white on boiling is a common example of denaturation. Another example is curdling of milk which is caused due to the formation of lactic acid by the bacteria present in milk.


Denaturation
Normal protein
Renaturation
Denatured protein

DISORDERS OF PROTEIN DEFICIENCY

A deficiency of protein from early childhood is regarded as a disease.

1. **Kwashiorkor** is a severe protein malnutrition disease. Appears at the age of 1-4 years.

- **Symptoms:** Retarted growth, Edema (excess water in the body tissues which results in swelling of the body), Alterations in the skin. (patches or redness on the skin) Hair pigmentation and texture changes. (which means the colour of the skin becomes dark or changes), Liver enlargement Vomiting and diarrhoea and stools contain undigested food.

- **Causes:** Poor maternal (mothers) health, Large family size Termination, or delayed breastfeeding. Environmental conditions. Over diluted cow's milk.

- **Cure:** Diet rich in protein such as milk and eggs. Soya beans are the best vegetable source of protein.

2. **Marasmus:** This disease is the same as kwashiorkor but occurs before in infants i.e. below 1 year of age.

- **Causes:** Due to nutritional deficiency in carbohydrates, proteins, etc. Stoppage of early breastfeeding is the most important cause.
- **Cure:** Providing a diet rich in proteins.

3. **Nutritional oedema:** It is a swelling caused due to insufficient protein intake.

- **Causes:** Long continuous deprivation of proteins in the diet. This deficiency in adults is rare.
- **Symptoms in adults:** Loss of weight, Anemia, Constant infection, Frequent loose stools, and Delay in healing wounds.
- **Cure:** Diet rich in proteins, Soyabean, milk and eggs in the diet.

THANKS!