

PROTEINS

Proteins are complex organic compounds of large molecular mass made up of small units called **amino acids**. They are composed mainly of carbon, hydrogen, oxygen, and nitrogen and sometimes Phosphorous and Sulphur. The variety of proteins is unlimited because the sequence of amino acids in each protein molecule which is genetically determined by DNA within cells during protein synthesis.

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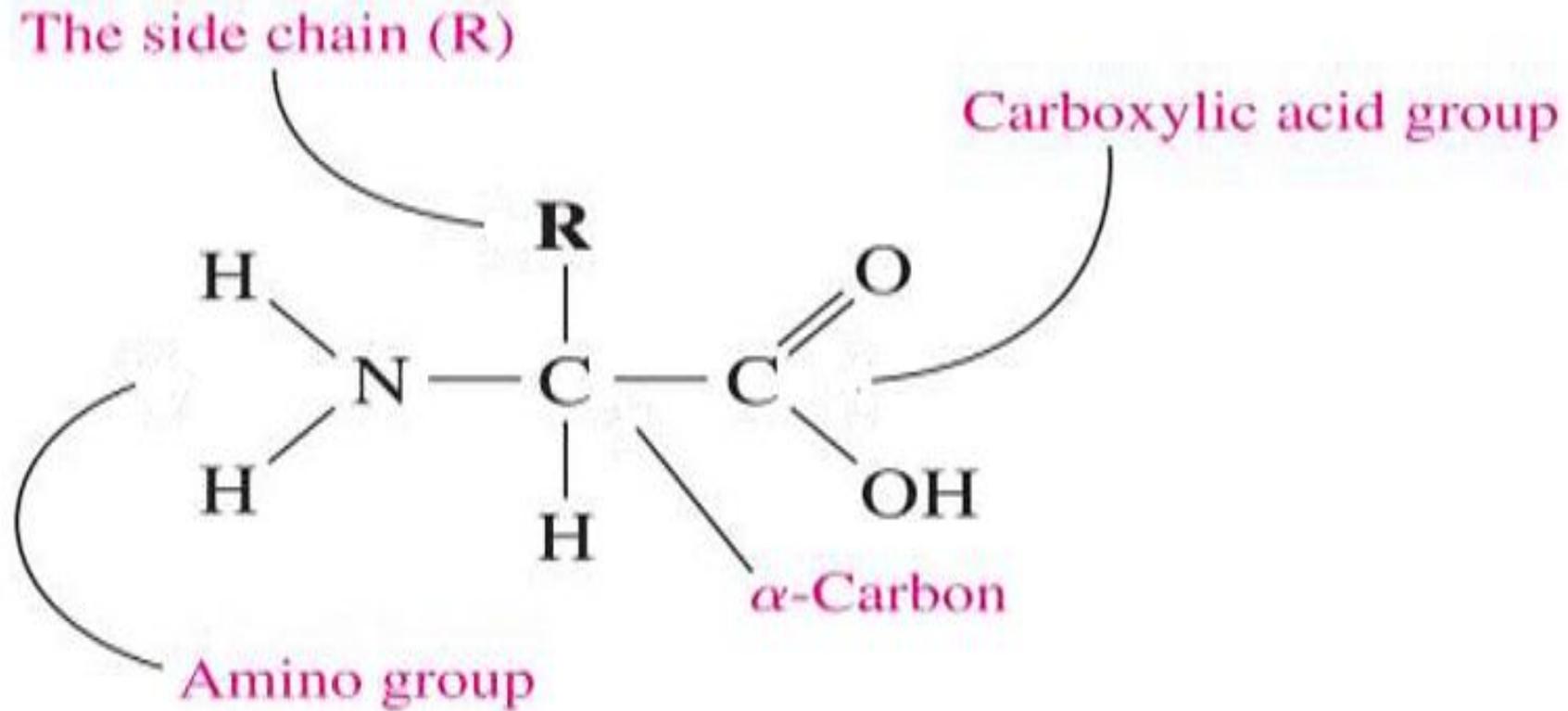
- The structural diversity of proteins enables them provide a range of structural and metabolic activities within the organisms.
- The number of amino acid sub-units may range between several thousands to millions E.g. β - lactoglonin found in milk has a molecular formula of **C1642H2652O492N420S18**

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- Proteins are the most abundant molecules to be found in the cells and comprise over 50% of their total dry weight. They are therefore an essential component of the diet of animals and may be converted to both fats and carbohydrates by the cells.
- All proteins are composed of basic structural molecules known as amino acids

AMINO ACIDS

GENERAL STRUCTURE OF AMINO ACIDS



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- Proteins are built from amino acids and there are over 100 naturally occurring amino acids of which 20 commonly occur in proteins. General formula $RCHNH_2COOH$
- All amino acids have an amino group ($-NH_2$) and a carboxyl group ($-COOH$).
- Majority of amino acids possess one acidic or carboxylic group and one basic or amino group and hence they are termed as neutral amino acids.

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- However, in some cases there may be more than one amino group present, giving rise to basic amino acids or more than one carboxylic group giving rise to acidic amino acids.
- Amino acids differ in the nature of the R- group and it is responsible for the unique properties they display.
- The simplest amino acid is **glycerine** where the R – group is H- atom.
- In alanine, the R –group is CH₃ and when R is substituted with C₃H₇, the amino acid formed is **Valine**

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- Amino acids are soluble in water but insoluble in organic solvents. At neutral pH (found in most living organisms), the groups are ionized as shown above, so there's a positive charge at one end of the molecule and a negative charge at the other end. The overall net charge on the molecule is therefore zero.

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- The presence of an amino group which is basic and a carboxyl group which is acidic in all amino acids accounts for the name amino acids and also confer on the amino acids an amphoteric nature i.e. amino acids have both acidic and basic properties.
- This implies that amino acids can donate hydrogen ion (protons) as acids do and also can accept hydrogen ions (protons) as bases do.
- In amino acids, these abilities to donate or receive protons are conferred by a carboxyl and amino groups respectively.

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- Their amphoteric nature is useful biologically as it means that they can act as buffers in solutions thereby resisting changes in the pH of the solution.
- A buffer solution is the one which is able to resist changes in the pH of the solution.
- Amino acids therefore can donate hydrogen ions as the pH increases so as to lower the pH and also accept hydrogen ions from the solution as the pH decreases so as to raise the pH.

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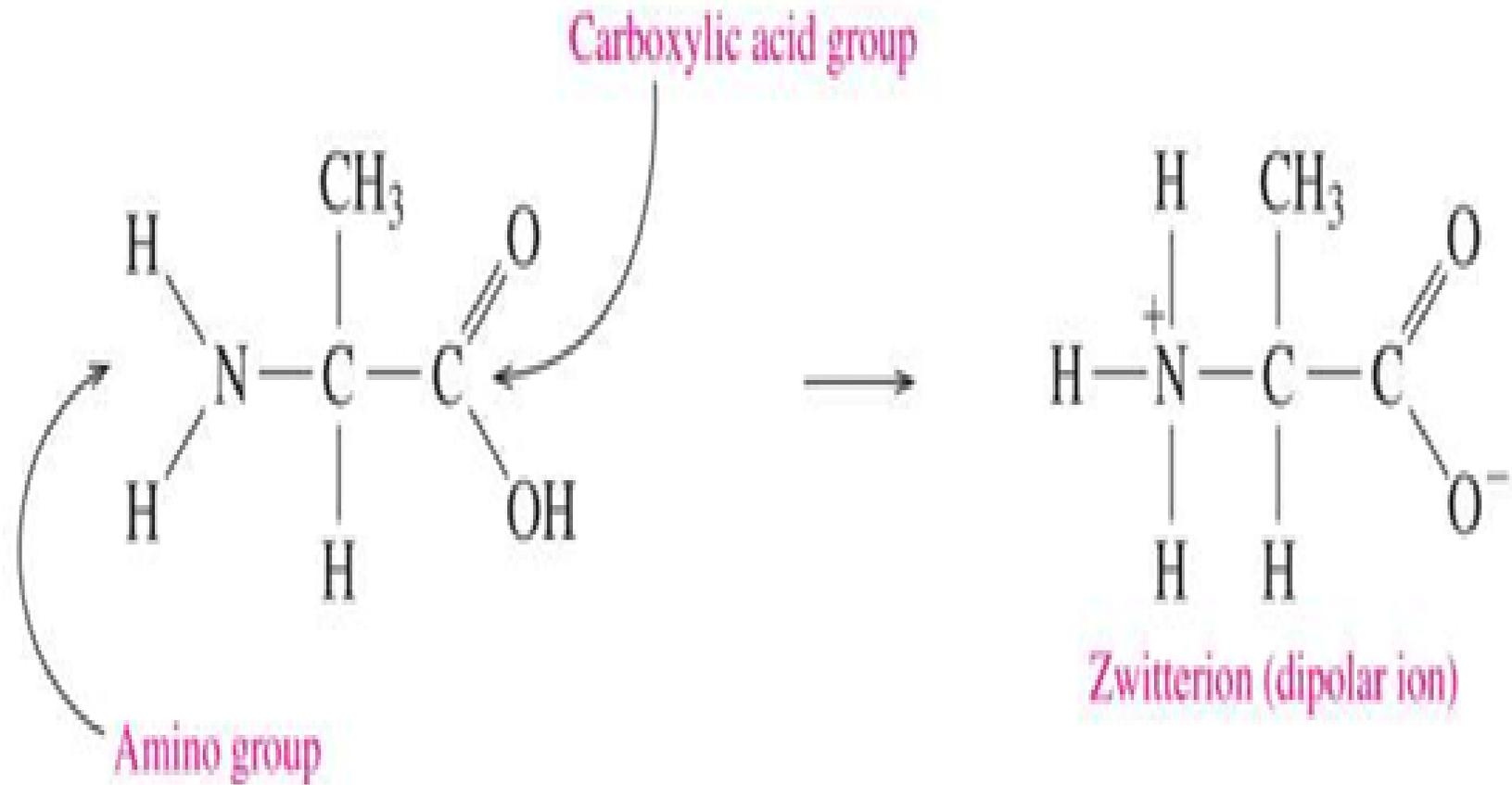
- Amino acids therefore play an important role as buffer in the tissue fluid and in the cytoplasm of most cells thereby maintaining the pH within the narrow limits needed for normal metabolism and efficient enzyme functioning. This is because changes in pH denature enzyme which can be fatal to the living organism.

PROPERTIES OF AMINO ACIDS

- They are colourless crystalline solids
- They are generally soluble in water but insoluble in organic solvents
- They are amphoteric in nature i.e. possess both basic and acidic groups.
- Amino acids are also amphipathic i.e. show hydrophilic and hydrophobic properties.
- They can donate a proton like acids and also accept protons like bases. The amphoteric nature is used biologically in PH buffering in body solutions. They do this by accepting protons as pH decreases and donating protons as pH increases, so that the pH is kept optimum or near neutral.

AMINO ACIDS AS BUFFERS

- Amino acids are amphoteric because they have both basic and acidic properties. The acidic property is derived from the carboxyl group (-COOH) which donates a proton (H^+) so that the molecule becomes negatively charged.
- The basic property is derived from the amino group (-NH₂) which can take up a proton so that the molecule becomes positively charged therefore the amino acid carries a (+) amino group and a (-) carboxyl group which qualifies it to be a dipolar substance. And because of the above property the amino acid buffer solutions. In this form, they form Zwitterions.



Amino acids are also amphipathic i.e. show hydrophilic and hydrophobic properties.

CLASSIFICATION OF AMINO ACIDS

- The 20 common Amino acids are classified as essential or non-essential. The essential amino acids are important in the body but cannot be synthesized by body or their rates of synthesis are not sufficient to meet the body needs. They have to be got from the diet.

Give examples of essential proteins

- NB: Histidine and Arginine are only essential in children.

Foods containing all the amino acids are known as first class proteins and they include all animal proteins and some plant proteins. Foods lacking one or more amino acids are second class proteins.

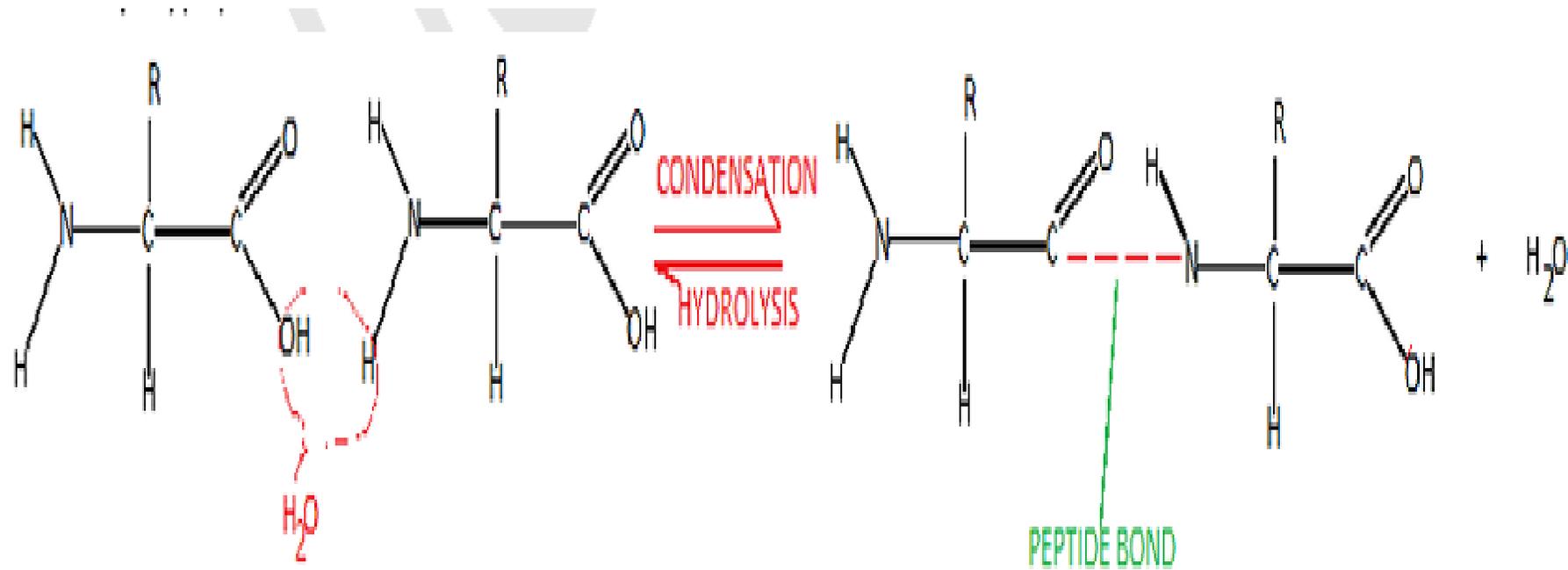
Non-essential amino acids

- These can be synthesized in sufficient amounts in the body of animals and therefore are not required in diet. They are as useful as the essential amino acids and absence of one or more results in retarded growth. The process of synthesis of amino acids involve a process called Transamination which is carried out by transaminase enzymes. The raw materials for the process are the essential amino acids provided in the diet and carbohydrate derivatives (keto- acids) like the intermediate compounds of carbohydrate metabolism e.g. Pyruvic acid.
- **Examples of Non-essential amino acids**

Building up /formation of proteins

- Amino acids combine to form dipeptides by condensation reaction, releasing water molecules and forming peptide bonds. The first step involves the combination of two amino acids. A reaction occurs between the amino group of one and the carboxylic group of another.
- A molecule of water is removed i.e. condensation. Continued condensation leads to the addition of more amino acids resulting into the formation of a long chain called a polypeptide.

It is illustrated below.



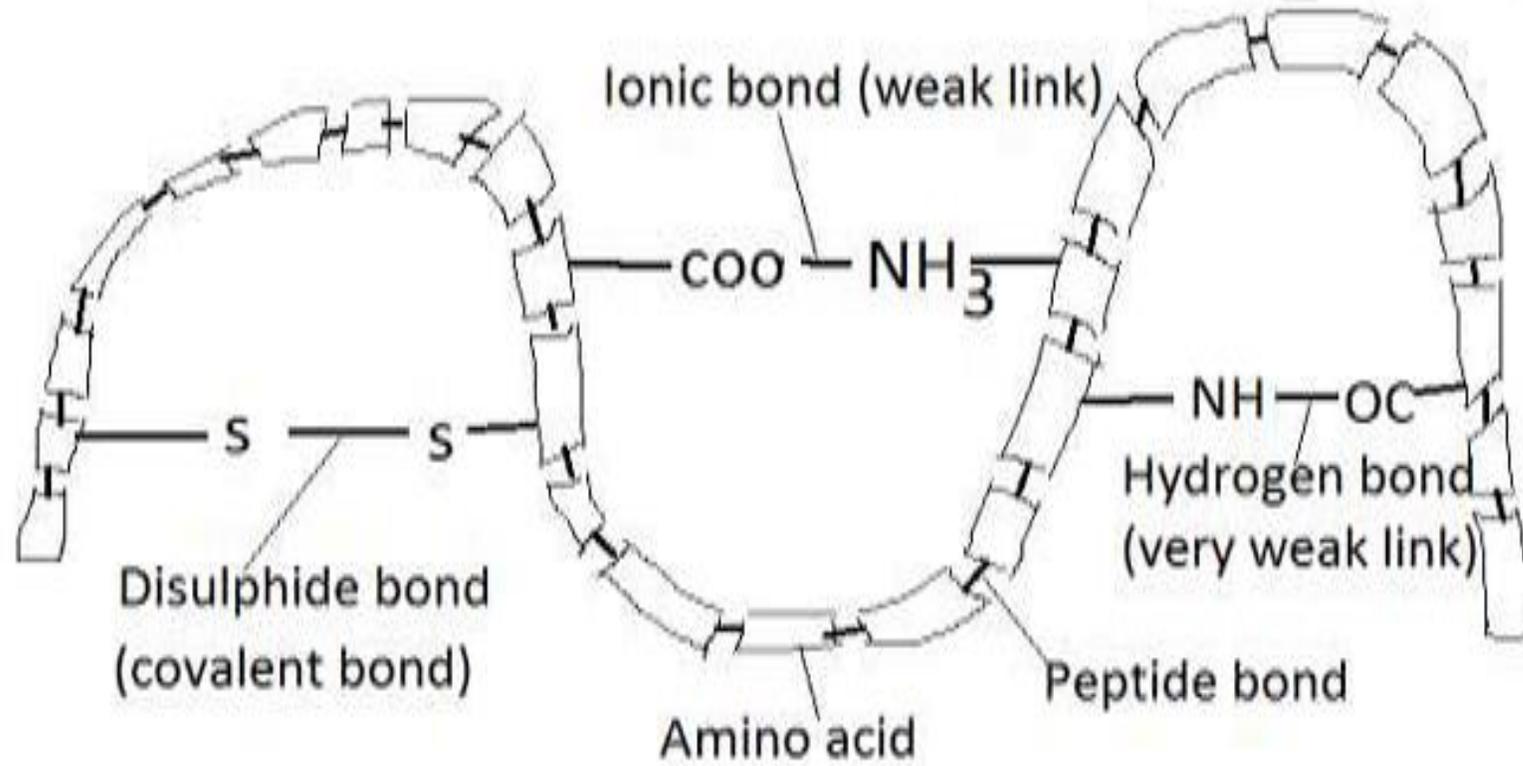
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- A protein may consist of several polypeptide chains which may be straight, folded, branched or cross linked at intervals. Apart from the peptide bonds, amino acids are able to form a variety of other chemical.
- bonds with other reactive groups and this is what leads to further elaboration in the polypeptide chain to form a protein.

LINKAGES IN POLYPEPTIDES

- Disulphide bonds.
- Ionic bonds.
- Hydrogen bonds.
- Hydrophobic interactions

Illustration



Ionic bond

- At a suitable pH, an interaction may occur between joined amino acid and a carboxylic group and the result is the formation of an ionic bond.
- Ionic bonds give a polypeptide molecule its particular shape. These bonds are relatively weaker than covalent bonds.

Disulphide bonds

- Some amino acids have a Sulphur group on the R-Group. When 2 molecules with a Sulphur group are lined up alongside each other, the S-H groups are oxidized to form a disulphide bond e.g. in when cysteine amino acids come together.
- The disulphide bonds make the molecule fold into a particular shape such that these molecules are strong and not easily broken.
- The bonds can be formed between different amino acids or between different parts of the same amino acid chain. Disulphide bonds are very strong.

HYDROGEN BOND

- When hydrogen is part of the P-H / N-H groups taking part in a reaction, it becomes slightly positive charged and is therefore attracted to the negatively charged neighboring oxygen atom.
- The hydrogen bond is very weak but plays a role in maintaining the shape and stability of the polypeptide molecule

HYDROPHOBIC INTERACTION

- Within a polypeptide chain, hydrophobic interactions or bonds can be registered. They arise in situations where the R-groups are non-polar and therefore hydrophobic. The polypeptide chain will tend to fold so that the maximum number of hydrophobic groups come into close contact and exclude water. This is how many globular proteins fold up.

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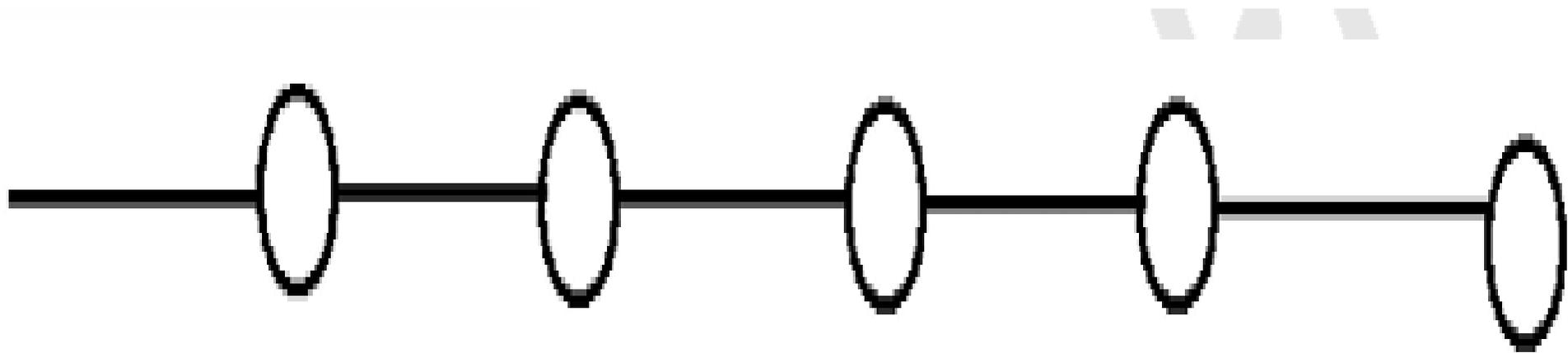
- The hydrophobic groups tend to point inwards towards the center while the hydrophilic groups face outwards in the aqueous environment making protein soluble. They are also weak bonds.

Classification of proteins

- Proteins can be classified according to structure, composition and function.
- According to structure proteins are classified into the following;

Primary structure

- This structure shows the number and sequence of amino acids in the protein molecule, held together by peptide bonds in a polypeptide chain. It is determined by the specific DNA sequence of that protein. E.g. the primary structure of Myoglobin is composed of a single polypeptide chain of 153 amino acids, the haemoglobin molecule is made up of four polypeptide chains: two alpha chains of 141 amino acid residues each and two beta chains of 146 amino acid residues each. The alpha and beta chains have different sequences of amino acids, but fold up to form similar three-dimensional structures



Cysteine	Alanine	Valine	Lysin	Alanine
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NICE WEEKEND TO YOU ALL