Chapter 14

Polymers

Overview of Polymers: Addition & Polymerization

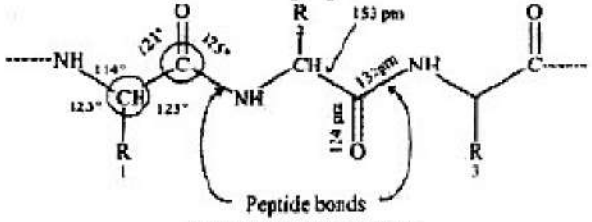
POLYMERS AND POLYMERIZATION:

Macromolecules, both natural and man-made, own their great size to the fact they are polymers (Greek: many parts); that is, each one is made up of a large number of simpler units - identical to each other or at least chemically similar - joined together in a regular way. They are formed by a process we touched on earlier: polymerization. The joining together of many small molecules to form very large molecules. The simple compounds from which polymers are made are called monomers.

Petides and Proteins:

In the last section, you studied the polymers of monosaccharides which act as structural components in plants and serve as energy storage in animals. In this section, you will study another kind of natural polymers called peptides and proteins.

Peptides are biologically important polymers in which 2-amino acids are joined by the amide linkages, formed by the reaction of the carboxy group of one amino acid with the amino group of another amino acid. These amide linkages are also called peptide bonds. The general structure of a peptide is shown below:



General Peptide Structure

Peptides can be classified as dipeptides, tripeptides and tetrapeptides, depending on whether the number of amino acids are two, three or four, respectively. Peptides containing upto 50 amino acids are called polypeptides. Bradykinin is an important naturally occurring nonapeptide which is present in blood plasma and is involved in the regulation of blood pressure.

Bradykinin:

Arg—Pro — Pro — Gly — Phe — Ser — Pro — Phe — Arg

Configuration of proteins:

(a) Biological nature or function of protein was confirmed by its conformation.
(b) This conformation is of 4 types:

Primary Secondary Tertiary Quatemany

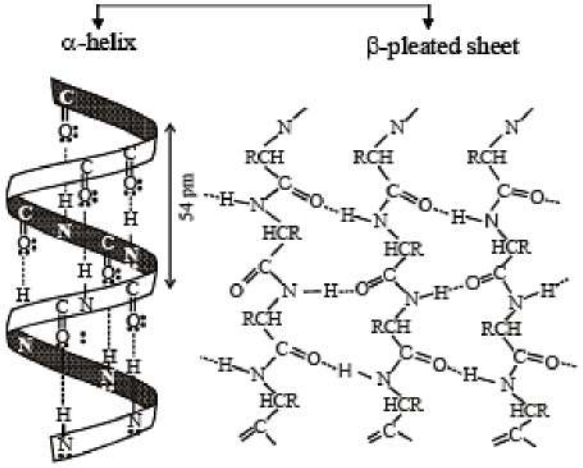
Primary Structure:

This type of structure was given by **Friedrich Sanger** in 1953 in Insulin (of one chain).

- Primary structure is conformed by a single polypeptide chain in a linear manner.
- All amino acids are attached in a straight chain by peptide bond.
- No biological importance & soon changed to other forms.

Secondary Structure:

- In it, structure of straight chain from irregular changes to form coils.
- H-bond peptide bond present in secondary structure.
- This H bond is present between hydrogen of Amino group and oxygen atom of carboxylic acid group.
- This structure is of two types:



(i) α-helix

- Chain is spiral.
- 3.7 atoms in one coiling.
- Right handed circular.

Eg. Myosin, Keratin etc.

(ii) β-pleated sheet

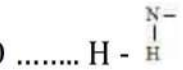
- Structure of protein is not arranged in a sequence.
- Polypeptide chain are parallel to each other.
- H - bond form by near chains.

Eg. Silk fibres.

Tertiary structure:

In this structure of protein, atoms are highly coiled and form a spherical form
Ex. Albumin
This structure is formed by 4 regular hydrogen bonds which makes a regularity in it.

(i) Hydrogen bond:


Hydrogen bond
They are formed between oxygen of acidic amino acid and H of basic amino acid.

(ii) Hydrophobic bond -

- Non - polar side chains of neutral amino acid tends to be closely associated with one another in proteins.
- Present in between the amino Acid.
- These are not true bonds.

(iii) lonic bond:

-COO-.....H_3 $^+$N-
Ionic bond
These are salt bonds formed between oppositely charged groups in side chains of Amino acids.
Eg. Aspartic acid
Glutamic acid

(iv) Disulphide bonds:
| ——— S - S —— |

- Relatively stable bond and thus is not broken readily under usual conditions of denaturation.
- Formed between the -SH group of Amino acid Ex. Cystine and Methionine.

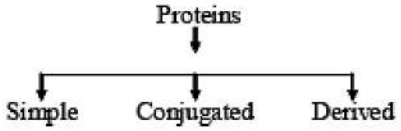
Quaternary structure:

- When 2 or more polypeptide chains are united by forces other than covalent bonds (i.e. not peptide and disulphide bonds) are called Quaternary structure.
- It is most stable structure.

Ex. Haemoglobin

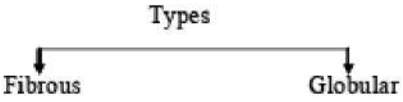
Types of proteins:

Classification of protein is based upon three general properties shape, Solubility and Chemical composition.



Simple proteins-

It is formed of only Amino Acids.



(A) Fibrous :

- It is insoluble
- It is of elongated shape.
- It is highly resistant to digestion by proteolytic enzymes.
- Their main function - Protection.

Ex. Collagen, Keratin etc.

(B) Globular :

- These are spherical and oval in shape. Chains are highly coiled.
- These are soluble.

Ex. Albumin.

Conjugated Proteins:

- These are complex proteins in which protein molecule is combined with characteristic non-amino acid substance.
- Non-amino acid or Non - Protein part is called as prosthetic group.

Ex. Nucleoproteins.
(Protein Nucleic acid), Phosphoproteins (Protein $(PO_3)^{2-}$).
Eg. Casein of milk., Vitelline of egg - yolk.

Derived proteins:
(a) These are obtained as a result of partial hydrolysis of natural proteins.
Eg. → Proteose, Metaproteins, Peptones

(b) **Denaturation of Proteins**
When a protein in its native form, is subjected to a physical change like change in temperature, or a chemical change like change in pH, the native conformation of the molecule is disrupted and proteins so formed are called denaturated proteins.
The denaturation may be reversible or irreversible. The coagulation of egg on boiling is an example of irreversible protein denaturation.
However, it has been shown now that in some cases, the process is actually reversible. The reverse process is called **renaturation**.

Test of Protein:

(a) With conc. HNO_3 on heating give yellow ppt. which on more heating gives solution on adding NH_4OH. Red colour appears. It is **Xanthoprotic test**.
(b) Dil. $CuSO_4$ protein give Blue violet colour. It is a **Biuret test**.
(c) **Millon reaction:** Proteins on adding Millon's reagent (a solution of mercuric and mercurous nitrates in nitric acid containing a little nitrous acid) followed by heating the solution gives red precipitate or colour.

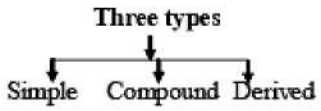
(d) **Ninhydrin reaction**. Proteins, peptides and α-amino acids give a characteristic blue colour on treatment with ninhydrin.

Biological Importance of protein:

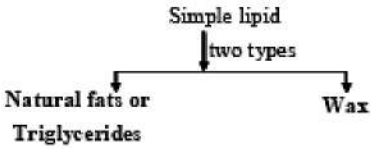
(a) Component of plasma membrane.
(b) All enzymes are proteins.
(c) Many hormones are proteins.
(d) Antigen and antibodies are protein.
(e) Actin and myosin proteins are important in muscle contraction.
(f) Proteins are important in growth, regeneration and repairing.
(g) Calorific value- 4.0 kcal.

Lipids
(a) 'Lipid' word is derived from Greek word lipos which means fat.

(b) Lipids are heterogeneous group of substances which have common property of being relatively insoluble in water and soluble in non-polar solvents such as ether, Chloroform etc.
(c) Form 3-5% part of protoplasm.
(d) $H_2O \neq 2:1$ (different from water)
(e) Ratio of oxygen is less.
(f) Specific gravity < 1

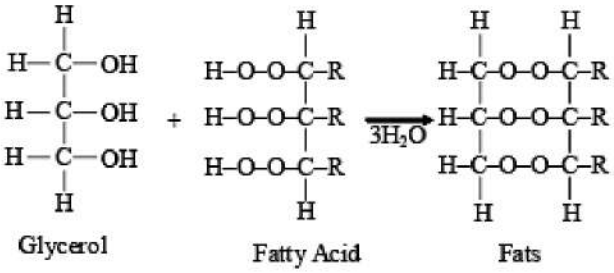


Simple lipid :

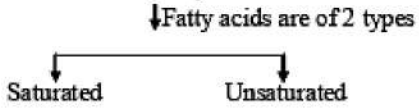


Triglycerides

(a) These are esters of fatty acids with glycerol.
Ester bond is present.
(b) Synthesis is of following type-



(c) Fatty acids which occur in natural fats usually contain an even number of carbon atoms (4 to 30) in straight chains.
(d) Simplest fatty acid HCOOH.
(e) More complex fatty acid are formed by successive addition of $-CH_2$ groups.



(i) Saturated:
⇒ Only single bond is present in them.
⇒ First member is CH_3COOH.

Other examples:
⇒ Palmitic acid - $C_{15}H_{31}COOH$

→ $CH_3(CH_2)_{14}$ COOH
⇒ Stearic acid - $C_{17}H_{35}COOH$
→ $CH_3(CH_2)_{16}COOH$
⇒ Palmitic and stearic acid is found in fats of animals in less amount.
⇒ These are solid and are found in fats.

(ii) Unsaturated:
⇒ Double bond is present in these fatty acid chains.
⇒ These are liquids at room temperature. Found in Oils.
⇒ These are of two types:

Monounsaturated - 1 Double bond is present.
Eg. Oleic acid.
⇒ Oleic acid is present in more amount in nature.

Polyunsaturated - More than two double bonds
Eg. Linoleic acid with two double bonds.
Linoleinic acid with three double bonds.
Arachidonic acid with four double bonds (Groundnut).

Wax:

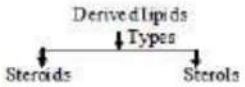
⇒ These are esters of other alcohols of high molecular weight instead of glycerols.
⇒These are insoluble in water.
⇒ These are monohydric alcohols.
⇒ Some examples of waxes -
Myricye palmitate (Honeybee wax) Cetyl palmitate (Dolphin and whale wax)
Cerumen (ear wax)

Compound Lipid- Are of 4 types:
(a) Phospholipids. (b) Glycolipids.

Phospholipids:
Phosphorous is present.
ex. cell wall

Glycolipids:
⇒ Lipid Sugar = Glycolipids
⇒ Present in brain, Adrenal glands, kidney, WBC liver, thymus, Spleen, Lungs, egg yolk.
⇒ Glycolipids = 2 Fatty acid 1 sphinocine 1 galactose.

Derived lipids:
⇒ By hydrolysis of fats, they are obtained.



Steroids:
⇒ These are different from other fats.
⇒ It is insoluble in water.

(i) Bile acids:
⇒ Present in secretion of liver.

(ii) Sex hormones:
⇒ These are androsterones.

(iii) Adrenal hormone- Eg : Aldosterone

Sterols:
⇒ They have -OH groups.
⇒ They are complex monohydroxy alcohols.
(i) Cholesterol - It is widely distributed in all cells of body.

Biological importance of Fats:

⇒ It is source of energy.
⇒ It is important for absorption of vitamin A, D, E and K.
⇒ It is important component of plasma membrane.
⇒ It act as shock absorber of body.
⇒ Calorific value: 9.3 kcal.