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Topic - Biomolecules: Structure and functions

For

Undergraduate Students (B.Sc. Zoology)

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Carbohydrates - defined as - polyhydroxyaldehydes or Ketones & derivatives of them.

Unit IV - Macro molecules

1. General chemistry & Classification of Carbohydrates Lipids & proteins -

(1) Carbohydrates $C_m(H_2O)_2$ - is General formula Hydrates of Carbon.

Carbohydrates are substances contains carbon, Hydrogen & oxygen in the ratio of 1:2:1.
Eg. Glucose $C_6H_{12}O_6$, fructose, Starch etc

Classification: Carbohydrates are classified on the basis complexity -

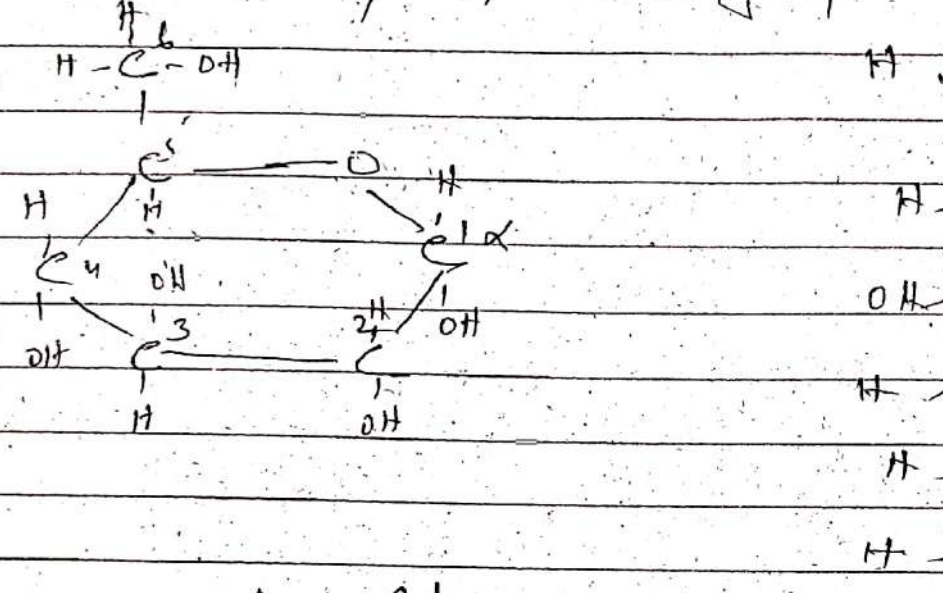
1 Monosaccharides - or Simple sugars
Eg. Glucose, fructose, Galactose

2 Disaccharides & Oligosaccharides -
- Disaccharides - Maltose, Lactose, Sucrose
- 3-10 monosaccharides form - Oligosaccharides.
Ex - Raffinose

3 - Polysaccharides :- - Eg Starch, Glycogen, Cellulose Insulin, chitin,

(1) Monosaccharides: These are simple, colourless, soluble & sweet carbohydrates so called sugars. Monosaccharides contains 1-7 carbon atoms.
Eg. Monose (1 carbons), dioses (2 Carbon),

, trioses (3 Carbon), tetroses (4 Carbon), Pentoses (5 Carbon), Hexoses (6 Carbons), & heptoses (7 Carbo
Hexoses are - Glucose, fructose & Galactose.
With chemical formula - $C_6H_{12}O_6$, These are different in arrangement of carbonil group (C=O), or hydroxyl (OH-) group.



D - Glucose - Structure
Most abundant sugar - used for energy production in living organisms.

Pentoses are - Ribose ($C_5H_{10}O_5$) & deoxyribose $C_5H_{10}O_4$ - important for DNA & RNA structure.

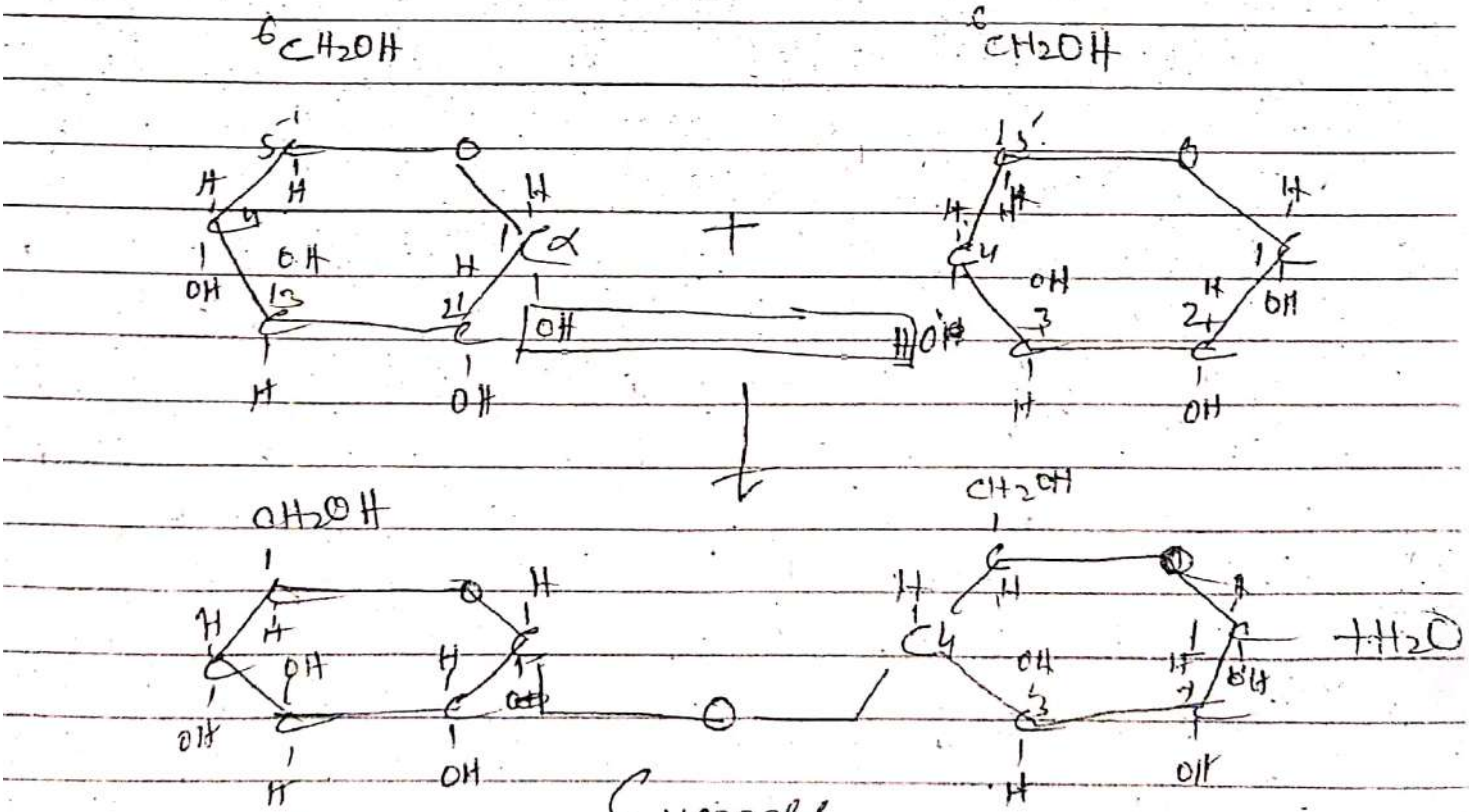
(2) Disaccharides:- formed by condensation of two monomers of monosaccharides. which are linked together by glycosidic bond - α-1,4.

$$C_6H_{12}O_6 + C_6H_{12}O_6 \longrightarrow C_{12}H_{22}O_{11} + H_2O$$

General formula - $C_n(H_2O)_{n-1}$.

Ex. Disaccharides are sweet, & water soluble sugar of 3 types.
Maltose, Sucrose & Lactose.
Maltose & Sucrose - in plants & Lactose in animals.
- Maltose - Glucose + Glucose
Sucrose - Glucose + fructose
~~Lata~~ Lactose - Glucose + Galactose

- Maltose occurs in germinating seeds (malt sugar), Sucrose in cane sugar, lactose occurs in milk sugar. Lactose or milk sugar is found in milk & synthesise in mammary gland.



Sucrose

α-1-4 glycosidic bond

Oligosaccharides – Mannotriose
Rabinose, Raffinose

(3) Polysaccharides:- Polysaccharides are long chain, insoluble, complex macromolecules. These are formed by condensation & polymerisation of large number of monosaccharide molecules. General formula of polysaccharides is $(C_6H_{10}O_5)_n$. n is the number of monosaccharides.

$n(C_6H_{12}O_6) \rightleftharpoons n(C_6H_{10}O_5) + n H_2O$

Ex Starch, glycogen, Cellulose.

Starch is chief storage product in plants. Glycogen is known as animal starch & stored in liver cells.

Cellulose is a very stable polysaccharide. Cellulose forms supporting tissues of the plants. Inulin is a polysaccharide made up of D-fructose units.

Cellulose is the most abundant organic compound & polysaccharide in nature. Chitin is nitrogenous polysaccharide & forms exoskeleton of insects & other arthropods.

– Functions of Carbohydrates –

1. Energy production in form of Glucose
2. Reserve food material in the form of Starch, Glycogen

3- Roy Saccenarious form structure of cell membrane & connective tissue.
4- Cell wall formation in Plant Cell. Exoskeleton of animals.
5- DNA & RNA - structure formation.

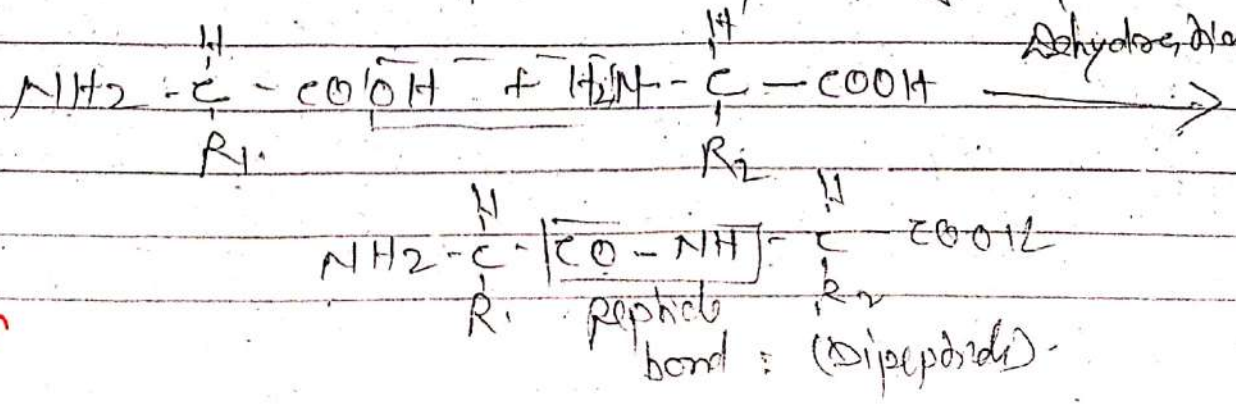
2- Proteins

Proteins are polypeptides. They are linear chains of amino acids linked by peptide bonds.

Each protein is a polymer of amino-acids. There are 20 types of amino-acids such as Alanine, cysteine, proline, tryptophan, lysine etc.) in proteins. A protein is a heteropolymer or a homopolymer. Homo-polymer has only one type of amino acid with repeating numbers.

Proteins are important for many functions such as transport of nutrients across cell membrane, immune system, some hormones & enzymes. Proteins are building material of organisms body. These forms 1/4th living body part & 75% of dry wt of organism.

Each amino acid molecule is a tetrahedral structure which has a central Alpha α carbon. α carbon atom has covalent bonding with a hydrogen bond, Amino group ($-NH_2$), a carboxyl group ($-COOH$) & a side-chain of carbon compound - R-group). Each amino-acid is different by R-group.



- All amino acids are colourless & soluble in water. Due to presence of a positive basic amino group & a negative acidic group -COOH (Carboxyl group), ~~protein~~ amino acids are amphoteric ions or zwitter ions.

Amino acids linked together & forms polypeptide by formation of peptide bond, polypeptides linked to forms peptones & proteoses & finaly proteins.

Proteins are grouped in three types

1- Simple or pure protein.

E. (a) Globular proteins -

(All enzymes, some hormones, antibodies, Albumin & globulins, globin of Haemoglobin, myoglobin, histones, glutenins in cereals, fibrinogen in plasma, prolamines in pulses.

(b) fibrous proteins - Collagen, Elastin, reticulum, keratin, fibroin of silk, actin & myosin of muscles, fibrin.

(2) Conjugated Proteins -

- Phosphoproteins, Nucleoproteins, Glycoproteins or mucoproteins. mucus & globulin. Chromoproteins - Haemoglobin, Haemocyanin & cytochromes. etc

Lipoproteins - Lipovitillin of egg yolk & lipoproteins in blood circulation.

③ Derived proteins - Small polypeptide chains - Proteoses & peptones.
- Amino acids → peptides → peptones → proteases → proteins.

① Simple Protein :- These are formed by amino acid monomers only. These are of two types on the basis of structure & shape of molecules-
a - Globular proteins - These are complex in structure, & folded & coiled molecules. & These are soluble in water. These are important in metabolic activities.
Ex. All enzymes, most hormones (Insulin, thyroxin, ACTH etc), Antibodies, Albulin, globulin, histones, myoglobin, fibrinogen etc.

b. fibrous proteins. These are insoluble in water & takes part in structure of body. Ex Collagen & elastin, reticulin, Keratin, fibroin, fibrin, actin & myosin etc. The molecules of these proteins are long, thread like & contractile.

② Conjugated protein :- These are formed by simple protein & some other group. The other group is called prosthetic group.
Ex Phosphoproteins - Phosphorous + protein.
Nucleoproteins - Histone + Nucleic acid. - Chromat.

- Glycoproteins - Glucose + proteins.
  Ex. mucus & globulin.
- Chromoproteins - Proteins + pigment -
  Haemoglobin & Haemocyanin + Cytochrome.
- Lipoproteins - lipid + Proteins -

(5) Derived Proteins - These are small polypeptides formed by simple or conjugated proteins by ~~from~~ the incomplete hydrolysis -

Functions of Proteins -

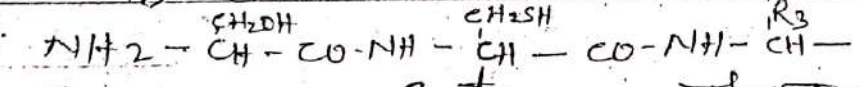
1 - Building blocks of body -
2 - fibrous proteins - forms - organelles of cells & tissue structure.
3. In metabolic activities as a enzymes.
4. Regulates body activities in the form of Hormones
5 - For energy production by deamination of amino ~~group~~ acids.
6 - transport of materials by Haemoglobin & across cell membranes.
7 - Defense of body by antibodies.
8. Control on heredity by nucleoproteins
9. Muscle contraction by actin & myosin.
10. Blood clotting by - fibrinogen & thrombin.
11 - Acid - base balance in body. ok.

Structure of Proteins -

Proteins are heteropolymers of amino acids. Structure of proteins are studied in different steges -

1. Primary structure
2. Secondary "
3. Tertiary "
4. Quaternary "

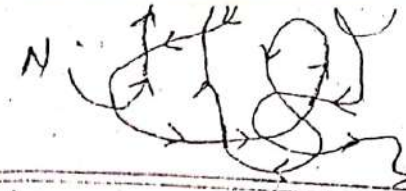
(1) Primary structure :- The sequence of amino-acids & positional information in a protein - which is first amino acid & which is second amino acids - and - so on - is called primary structure of a protein. In this structure amino-acids are arranged linear position. The left end is represented by first amino acid & right end represented by last amino-acid. The first amino acid is also called N- terminal amino acid. The last amino-acid is called - C-terminal amino-acid.



Serine — Cysteine — ~~Tryp~~ Tyrosine — Glutamic acid.

Terminal - N — 1 — 2 — 3 — C terminal

(2) Secondary structure :- A protein thread does not exist throughout as an extended rigid rod. The thread in form of a helix, only right handed helices are found in proteins. This folded form structure is



Tertiary Structure of Protein.

Secondary Structure of protein.

called secondary structure structure maintain by hydrogen bonds.

(3) Tertiary structure - The long chain of poly is also folded upon itself to form globular structure. This form of structure is called tertiary structure & maintained by - hydrogen bonds, disulphide bond & hydrophobic interactions.

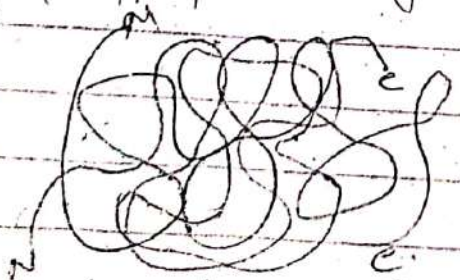
Tertiary structure is important for biological activity of proteins.

Ex- Myoglobin protein.

(4). Quaternary structure:

Highly complex protein consists of more than one polypeptide chain. The separate chains are held together by hydrophobic interactions & hydrogen & ionic bonds. Their pattern of arrangement of polypeptide is called Quaternary structure of proteins.

Ex Haemoglobin protein consists of 4 polypeptides - Two α type & two β - polypeptides. Togethese these α & β polypeptides form Haemoglobin protein.



Two polypeptide chain

Quaternary Structure of Protein

3- Lipids

Lipids (Gr. Lipos = fat).

Lipids are organic substances insoluble in water but soluble in organic solvents like alcohol, chloroform & ether. These are also compounds of H, C & O but amount of H & C is very high & O is very low.

Lipids are important to body because they are the chief storage form of energy and also necessary for cellular structure.

Classification of lipids:

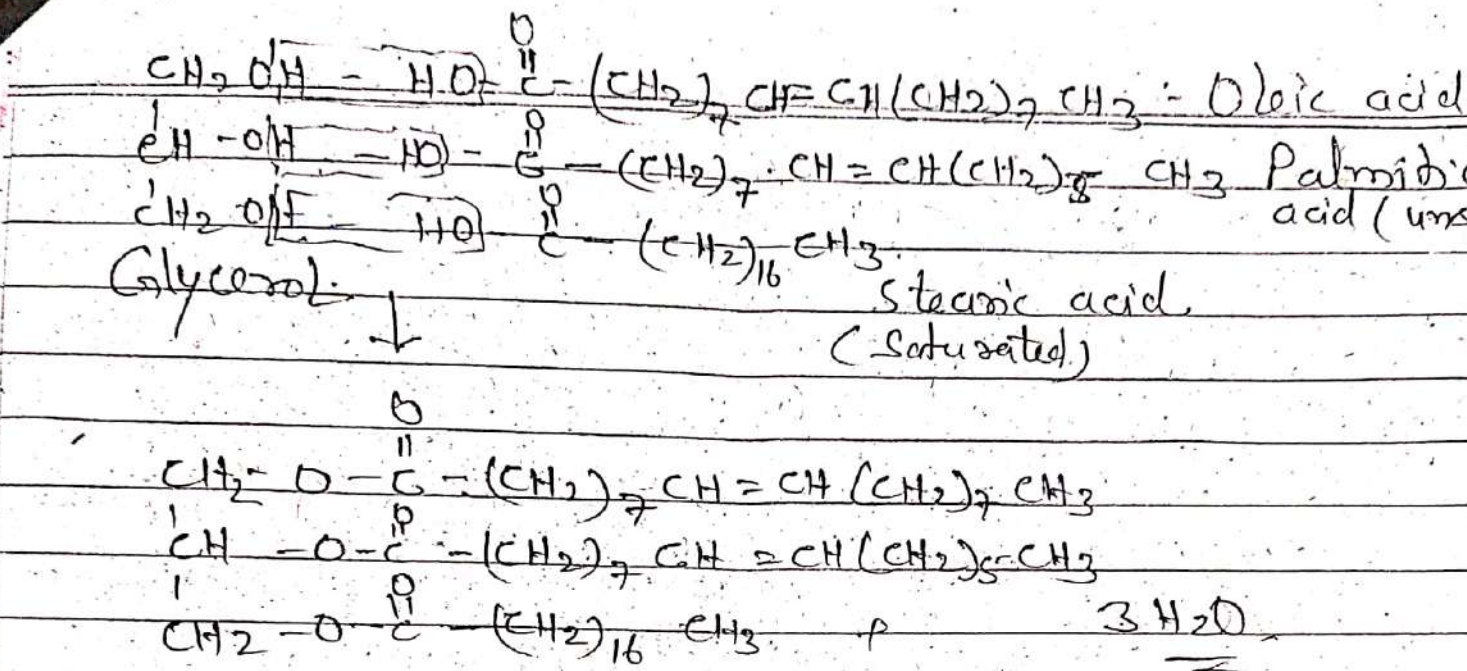
Lipids are classified into simple, complex & derived lipids-

(1) Simple lipids or True fats:

These are esters of fatty acids with alcohols. These are synthesized by one molecule of glycerol & 3 molecules of fatty acids. The Glycerol & fatty acids are linked by ester linkages. So these are also called triglycerides.

Ex. Palmitic acid, Stearic acid, oleic acid. fatty acids are linked to glycerol...

Phospholipids – Lecithin & Cephalin –



Some fatty acids have double bonds & called unsaturated fatty acid. The fatty acid with double & triple bond are called saturated fatty acids. Ex. vegetable ghee. Most animal fats are unsaturated. Ex. ghee, butter etc. In normal condition these are solid or semisolids.

(2) Complex lipids (Compound or conjugated lipids).

Complex lipids includes – phospholipids, glycolipids & wax.

Phospholipids – contains alcohol and fatty acids with phosphoric acid and a nitrogenous base. These are important for cell membrane & cell organelles structure.

Glycolipids contain a fatty acid, carbohydrate & nitrogenous base. Ex. Cerebrosides & Gangliosides.

Lipoproteins are complex lipids contains- lipids & proteins.
Waxes contains a fatty acid molecule & a alcohol molecule.

(3) Derived lipids:
These are fat soluble lipids but without fatty acids.
Eg. These are products of hydrolysis of simple & conjugated lipids. cholesterol.
Eg Glycerol polyhydric alcohol, lipid soluble vitamins, steroid hormons etc.
— cholesterol

Functions of lipids:

→1. Triglycerides are important for energy production in body.
2. Phospholipids & cholesterol are important components of cell membrane & cell organelles.
3. Lipids are a source of fat soluble vitamins like -K, E, D & A.
4. Steroid hormons ~~in~~ are important for regulation of Cellular metabolism.
5. Lipids serve as insulating material & protects the internal body parts.
6. Phospholipids of mitochondrial membrane help in Electron transport system. (ETS.)