Carbohydrates:

Carbohydrates are the most abundant class of organic compounds found in living organisms. Carbohydrate consists of the elements carbon (**C**), hydrogen (**H**) and oxygen (**O**). The general formula of carbohydrate is $\mathbf{C_n(H_2O)_n}$. Carbohydrates are a major source of metabolic energy for both plant and animals. Carbohydrates include sugars, starches, cellulose, and many other compounds found in the living organisms. The complex carbohydrates (starch, cellulose, glycogen etc.) are polymers of simple sugars, which are called monosaccharides. These monosaccharides may have a chain of 3-9 carbon atoms. To or more such units may combine to form oligosaccharides and when they polymerise in large numbers, they are known as polysaccharides. All carbohydrates units may be described as polyhydric alcohols with functional group being an aldehyde **(-CHO)** or ketone **(>C=O).**

1. **Monosaccharides:**

   The monosaccharides are the simples units of carbohydrates. Each unit has a number of hydroxyl groups. Each carbon atom of the chain is linked to a hydroxyl group and hydrogen except usually the terminal carbon which is present as aldehyde or ketone. Depending upon the number of carbon atoms, these monosaccharides are named as trioses (3), tetroses (4), pentoses (5), hexoses (6) and heptoses (7) and so on. Futher they are also recognized on the basis of the functional groups as aldoses (-CHO) and ketoses (>C=O).

Number of carbon	**Category/ name**	**Aldoses**	**Ketoses**
3	Trioses	Glyceraldehyde	Dihydroxyacetone
4	Tetroses	Erythrose Threose	Erythrulose
5	Pentoses	Ribose Arabinose Xylose	Ribulose Xylulose
6	Hexoses	Allose Gulose Altrose Galactose Glucose Iodose Mannose Talose	Psicose Fructose Sorbose Tagatose
7	Hetoses		Sedoheptulose

All these molecules are commonly known as sugars. The four carbon aldoses and D-erythrose and D-threose and five carbon aldoses are named D-ribose, D-arabinose, D-

xylose and D- lyxose. The keto forms of 4 and 5 carbon sugars are named by adding –ulose in place of –ose. Thus the keto form of D-erythrose is called D-erythrulose and that of D-ribose and D-xylose are called D-ribulose and D-xylulose respectively. The hexoses, however have separate name.

Whereas most sugars are metabolic intermediates, the most common pentose, D-ribose, is the constituent of nucleotides and nucleic acids. Among the hexoses, D-glucose, D-mannose and D-galactose are common aldoses and D-fructose is the most abundant ketohexose.

2. **Oligosaccharides:**

Oligosaccharides are the chains of monosaccharides linked together by glycosidic bonds. The monosaccharides have hydroxyl groups attached to carbon. One hydroxyl group of a monosaccharide may combine with the hydroxyl group of some alcohol or some other monosaccharide releasing a molecule of water. The resulting linkage is known as glycosidic bond.

A bond between –C-OH and –C-OH would give C-O-C linkage and is known as O-glycosidic bond. When a similar linkage is produced between C-OH and HN<, it forms –C-N< bond. This bond, where the sugar is linked to N is known as N-glycosidic bond. In short it can be said that, when a monosaccharide is linked to the other through –O, it is O-glycosidic bond but when it is linked to other molecule through –N, it is N-glycosidic bond.

Two monosaccharide residues may join to form a disaccharide. Chains with three, four or five monosaccharides are known as tri, tetra or pentasaccharides respectively. In general molecules upto eight residues are called oligosaccharides although some authors prefer to include short chains upto 30 residues into oligosaccharides. Long chains, which may be branched or unbranched, are called polysaccharides.

Disaccharides are the oligosaccharides with only two monosaccharide residues. Some important disaccharides are-

Sucrose = Glucose + fructose (Sugar cane, beet root)

Maltose = Glucose + glucose (Starch hydrolysis)

Lactose = Galactose + glucose (milk sugar)

3. **Polysaccharides:**

The most complex and important of the carbohydrates are the polysaccharides. These are long chains of monosaccharides linked by glycosidic bonds. These may be branched or unbranched. Invariably they have very high molecular weight. The

polysaccharides are also called glycans. Depending upon the component monosaccharides, three types of polysaccharides have been recognised.

A. Homoglycans
B. Heteroglycans
C. Conjugated glycans

A. **Homoglycans:** This includes all those polysaccharides which have only one type of monosaccharide residues in the chain. Cellulose, chitin, starch, glycogen, inulin and agar-agar are homoglycans.
B. **Heteroglycans:** The heteroglycans have two or more different monosaccharides linked to form a polysaccharide. Usually these are repeating units of disaccharides although in some cases the polymer has two alternating disaccharides. Some important heteroglycans are glycosaminoglycans, Carrageenan, pectin, glucomannans etc.

   Glucomannan is a fibrous polysaccharide which is a strong absorbent; hence it is used in making disposable diapers and sanitary napkins.

   Glycosaminoglycans are present on the animal cell surface and in the extracellular matrix. It is found in the lubricating fluids of the joints and as component of cartilage, bones etc.

   Pectin is an important cementing material in plant tissues and is the main constituent of the middle lamella.
C. **Conjugated glycans:** There are a number of carbohydrates, large heteroglycans or small oligosaccharides, which are found in association with molecules other than carbohydrates (lipids or proteins). These conjugated forms are known as proteoglycans, glycoproteins or glycolipids.

Function of carbohydrates:

Solar energy is the sole source of biological energy on this earth. The carbohydrates are the first product to be synthesized where this energy is stored. Thus, the carbohydrates are the prime molecules where the energy is stored. They also play some important role in the living system.

1. **Energy storage:**

   The carbohydrate like starch (amylase and amylopectin in plants and glycogen in animals) and sugars (mainly sucrose and glucose) store the sun energy and make it

available for our consumption as food. The cellulose, which is more a structural molecule, is also a source of energy for ruminants. Dextran is the nutritional reserve in yeast.

2. **Structural elements:**

   Cellulose, the most abundant carbohydrate on earth is main constituent of plant cell walls and provides them protection and rigidity. A number of other carbohydrates are also known to form structures e.g., chitins form the exoskeleton of arthropods. The heteroglycans N-acetyl glycosamine β (1- 4) N-acetyl muramic acid is the structural molecule forming the bacterial cell wall.

3. **Structure of Nucleic acids:**

   Pentose like ribose and deoxyribose are important components of nucleic acids (DNA and RNA). As a component of nucleotides the carbohydrates are also involved in a number of biological activities. ATP and ADP are the important molecules serving as energy currency in living systems.

4. **Metabolic intermediates:**

   Since the carbohydrates are the first product of photosynthesis, these provide the basic material (carbon source) for the synthesis of other complex molecules including proteins, lipids, hormones, vitamins, alkaloids, flavonoids etc. All these molecules are synthesized in several steps hence a large number of intermediates are available which can be channelized to several other pathways.

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