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Topic: Carbohydrate—Structure & classification.

CARBOHYDRATES

Carbohydrates are among the most widely distributed compounds in the both plant and animal kingdoms. Plants can build up carbohydrates from carbon dioxide by photosynthesis. Many plants and animals contain large quantities of Carbohydrates as reserve food material. Carbohydrates are also important structural components.

Carbohydrate (“hydrates of carbon”) are so called because it was once thought that they could be expressed by the molecular formula $C_x(H_2O)_y$. Although this is true for a larger number of carbohydrates, some compound like methyl pentoses and uronic acids do not conform to the formula, although they are regarded as carbohydrates. Not all carbohydrates are composed entirely of C, H and O, and in the proportions indicated by the formula. The proportion of oxygen is lower in a few carbohydrates.

Carbohydrates are aldehyde and ketone derivatives of polyhydroxyalcohol. Each carbohydrate therefore contains an aldehyde or a ketone group and is known as aldose or a ketose.

- ❖ Carbohydrates are nature's most abundant organic substance.
- ❖ The principal source of energy for the body is carbohydrates.
- ❖ Our food mainly contains carbohydrates.
- ❖ Carbohydrates make up 75% of the dry weight of the plant world, upon which animal life primarily depends.
- ❖ Carbohydrates contain carbon combined with hydrogen and oxygen often in the same ratio as in water (1C: 2H: 1O).
- ❖ Carbohydrates are usually divided into the following three classes:

1. Monosaccharides or simple sugars

2. Oligosaccharides

3. Polysaccharides

Classification of Carbohydrates

1. Monosaccharides

A. Trioses ($C_3H_6O_3$)

- a) Glyceraldehyde
- b) Dihydroxyacetone

B. Tetroses ($C_4H_8O_4$)

- a) Erythrose

C. Pentoses ($C_5H_{10}O_5$)

- b) Ribose
- c) Arabinose

- d) Xylose
- e) Xylulose

D. Hexoses

- (a) Glucoses
- (b) Galactose
- (c) Fructose
- (d) Mannose

2. Oligosaccharides

A. Disaccharides ($C_{12}H_{22}O_{11}$)

- i. Sucrose
- ii. Maltose
- iii. Lactose
- iv. Cellobiose

B. Trisaccharides ($C_{18}H_{32}O_{16}$)

- i. Raffinose

(3). Polysaccharides

A. Homoglycan

1) Pentosans ($C_5H_8O_4$)_n

- i. Arabans
- ii. Xylans

2) Hexosans ($C_6H_{10}O_5$)_n

1) Glucans

- i. Starch, α - linked
- ii. Dextrins, α - linked
- iii. Glycogen, α - linked
- iv. Cellulose, β - linked

2) Fructans

- i. Inulin
- ii. Levan

3) Galactans

4) Mannans

B) Heteroglycan

- i. Pectins (α - linked)
- ii. Hemicellulose (β - linked)
- iii. Mucopolysaccharides

(4) specialized compounds

- i. chitin

Monosaccharides

- ❖ Most sugars have the general formula CH_2O .
- ❖ Sugars containing three carbons are known as **Trioses**, those with four carbons as **Tetroses**, those with five carbons as **pentoses**, and those with six carbons as **hexoses**.

- ❖ Two **Trioses** namely **glyceraldehydes** and **dihydroxyacetone** are crucial intermediates in the metabolism of glucose in glycolytic cycle.
- ❖ **Erythrose** is a **Tetroses** which forms the raw material for synthesis of anthocyanin and lignin.
- ❖ Pentose sugar **ribose** is found in every animal cell. It occurs in a number of compounds which play crucial roles in metabolism, e.g. ,ATP, ADP, riboflavin and RNA . its reduced form **deoxyribose** is found in DNA.
- ❖ The **hexoses** comprise a large group of sugars, several of which play a significant role in nutrition.
- ❖ All hexoses are aldoses (glucose, galactose and mannose),except fructose which is a ketose.
- ❖ The hexose glucose is the most important carbohydrate in the living world.
- ❖ The most important sugar occurring in animals is glucose.
- ❖ Simple sugar of the blood is glucose
- ❖ Immediate source of energy is glucose.
- ❖ Glucose is stored as glycogen in liver and muscles.
- ❖ Fructose is the fruit sugar; it is the sweetest among naturally occurring sugars.
- ❖ Sugars having a free aldehyde or ketone group can reduce Cu^{2+} to Cu^+ . These are called reducing sugars.
- ❖ This property is the basis of **Benedict's** and **Fehling's test** to detect the presence of glucose in urine.
- ❖ Galactose occurs in milk as a component of the milk sugar, lactose.

Oligosaccharides

- ❖ Oligosaccharides are formed by condensation of 2-10 monosaccharides.
- ❖ Disaccharides are oligosaccharides with a combination of two molecules of monosaccharides.
- ❖ When two monosaccharide molecules link by means of a 1-4 glycosidic bond, a molecule of water is released a disaccharide molecule is formed.
- ❖ The common disaccharides are **sucrose, maltose, lactose** and **cellobiose**.
- ❖ Sucrose is made up of glucose + fructose; it occurs in sugar cane and sugar beets, sources of commercial sugar.
- ❖ Sucrose has no free aldehyde or ketone groups; sucrose is not a reducing sugar.
- ❖ Maltose or malt sugar is found during germination of starchy seeds.
- ❖ A disaccharide that gives two molecules of glucose on hydrolysis is maltose.
- ❖ Lactose (glucose + galactose) is present in milk.
- ❖ Lactose does not occur in nature except as a product of the mammary gland.
- ❖ Compared to the milk of cow, buffalo and goat, lactose is highest in human milk .saccharin has a sweet taste, but not a sugar.

Polysaccharides

- ❖ Polysaccharides are polymers of monosaccharides.

- ❖ Glycogen and starch are both polymers of α - glucose.
- ❖ Starch common in plants and glycogen in animals are two food storage polysaccharides.
- ❖ Glycogen is known as '**animal starch**'.
- ❖ Glycogen found in liver and muscles store energy mammals.
- ❖ Glycogen is broken down by the hormone **glucagon** secreted by **islets of Langerhans**.
- ❖ Glycogen is water soluble gives a red colour with **iodine**.
- ❖ Most plants store their chemical energy in the form of starch.
- ❖ Starch is actually a mixture of two different polymers, **amylose** and **amylopectin**.
- ❖ **Cellulose** and **chitin** are two structural polysaccharides.
- ❖ Cellulose is an unbranched chain of glucose units joined by β (1-4) linkages.
- ❖ Cellulose is digested by termites and sheep by harbouring bacteria and protozoa that synthesize the necessary enzyme, cellulase.
- ❖ Man cannot digest cellulose.
- ❖ Cellulose is a **homoglycan hexosan**.
- ❖ Chitin is a polysaccharide and is the principal component of the exoskeleton of insects and crustaceans; it is a polymer of **N-acetyl glucosamine**.
- ❖ **Inulin** (Dahlia starch) is a carbohydrate, polymer of **fructose**.