Carbohydrates:

Carbohydrate is a biomolecule mostly consist of Carbon, Hydrogen and Oxygen atoms. Usually in which carbon and Hydrogen ratio is 2:1 like in water. These are also called polyhydroxy aldehyde or polyhydroxy ketenes. Tem of sugar is applied to carbohydrates which soluble in water. Their general formula is $(CH_2O)n$. There is various exceptions to this formula. Let's take an example of acetic acid which is CH_3COOH. It will fit in general formula but it is not a carbohydrates. Formaldehyde is also under this category but it is also not a carbohydrates.

Carbohydrates are also called hydrates of carbon. " Which means carbon with water like in sugar, $C_6H_{12}O_6 \rightarrow C_6 + H_{12}O_6$ or $6(H_2O)$. These are also known as "Saccharides" it is derivative of Greek word "Sakcaron" meaning sugar. Some of most carbohydrates that we used in our daily life are in form of sugar, glucose, fructose, sucrose, maltose, cellulose etc.

Functions of carbohydrate:

Carbohydrates provide wide range of functions.

- These are abundant dietary source of energy for all organisms.
- These are precursors for many organic compounds (Fats, Amino acid).
- As a glycoproteins and glycolipids carbohydrates participate in the structure of cell membrane and cellular function such as cell growth, adhesion and fertilization.
- They are structural components of many organisms. These include cellulose of plants, exoskeleton of some insects and the cell wall of microorganism.

- They also serve as storage form of energy(glycon) to meet the immediate energy demand of body.

Classification of carbohydrates:

Carbohydrates are classified on the basis of hydrolysis. This classification as follows

Monosaccharides:

These are simplest form of sugar which does not further hydrolyzed. General formula of monosaccharide is Cn(H2O)n. Where n is three or more. A monosaccharide has structure H-(CHOH)x(C=O)-(CHOH)y-H, that is an aldehyde or ketone with many hydroxyl groups added, usually one each carbon atom that is not part of aldehyde or ketone functional group. Monosaccharides are building blocks of disaccharides and polysaccharides.

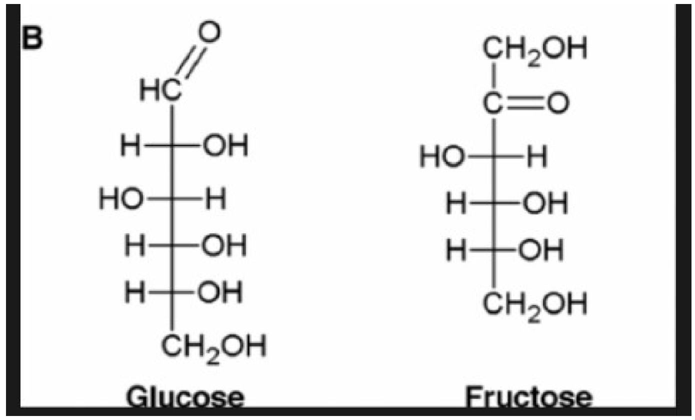
Classification of monosaccharide:

On basis of number of carbon atom:

- Triose: Monosaccharide contains three carbon atom.
- Tetrose: monosaccharide contains four carbon atom.
- Pentose: these contain five carbon atoms.

On basis of functional group:

- Aldose: aldehyde group present in monosaccharide. E.g. glyceraldehydes, glucose.
- Ketose: ketone group present in monosaccharides. E.g. dehydroxyacetone, fructose.



Hemiacetals and Hemiketals are formed when cyclic monosaccharide can react with alcohol. This alcohol is actually a carbohydrate since they function very similarly to alcohols. So when this happens individual monosaccharide link together to make an acetal. This linkage is known as *glycosidic linkage. It is sweet sugar or table sugar*

Oligosaccharide:

Oligosaccharides derived from Greek word Oligos. Those Carbohydrates that on hydrolysis gives two to ten smaller units or monosaccharides are oligosaccharides. They are a large category and further divided into various sub categories disaccharides and trisaccharides.

Disaccharides:

Oligosaccharides on further classification, It give two units of the same or different monosaccharide’s on hydrolysis. For example Glucose or Fructose are formed by the hydrolysis of one molecule of sucrose on hydrolysis. Where as maltose on hydrolysis gives two molecules of only glucose.

Trisaccharides:

Carbohydrates that on hydrolysis gives three molecule of monosaccharides, where same or different .example: is Raffinose

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Examples of disaccharides:

Sucrose:

It is important disaccharide. It is also known as *table sugar.* Sucrose is also present in all photosynthetic plants. We get it commercially from sugarcane and sugar beets by industrial process. The molecular formula of sucrose is $\mathbf{C_{12}H_{22}O_{11}}$**.**

Lactose:

It is also disaccharide. Lactose is found in milk of mammals. Mostly these are not sweet in taste. Lactose contains one glucose carbohydrate and one glactose carbohydrates. They are combine together by 1-4 glycosidic bond in beta orientation

Maltose:

Another disaccharide which is commonly found is maltose. It has two monosaccharide glucose molecules bound together through a Link between the first carbon atom of glucose and the fourth carbon of another glucose molecule. This, as you know, is the one-four glycosidic linkage.

Polysaccharides:

Polysaccharides derived from Greek word (poly means many). When carbohydrates undergo hydrolysis they produce large number of monosaccharide, These are not sweet in taste and are also known as non-sugars. Some common examples are glycogen or starch.

Oligosaccharides:

Oligosaccharide derived from Greek word “Oligos” a sacchar is a saccharide polymer containing small number of monosaccharides. Oligosaccharides are short polymer containing 2-10 monosaccharides residues. The residues bonded to each other by glycosidic bonds

Glycosidic bonds;

A glycosidic bond is the type of ether linkages formed when an acetal is made by reacting a hemiactal of a monosaccharide with a hydroxyl on another sugar.

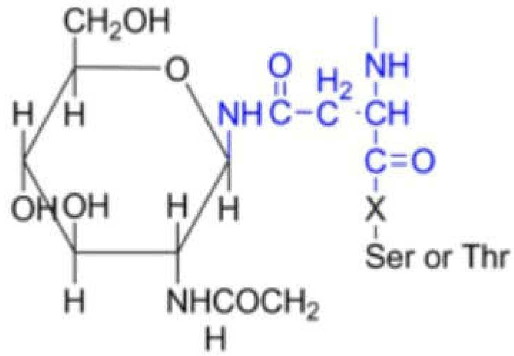
Oligosaccharides have many function including cell recognition and cell binding. For example, Glycolipids perform active role in immune response. They are present as glycon normally. Chains of oligosaccharide binds to lipids or to compatible amino acid side chains in proteins, by N- or O-glycosidic bonds. N-Linked oligosaccharides are always pentasaccharides attached to asparagine via beta linkage to the amine nitrogen of the side chain. Alternately, O-linked oligosaccharides are generally attached to threonine or serine on the alcohol group of the side chain. All natural oligosaccharides can not occur as components of glycoprotein or glycolipids. Some such as the raffinose, occur as storage or transport carbohydrates in plants.. Others, such maltodextrins or cellodextrins, result from the microbial breakdown of larger polysaccharides such as starch or cellulose.

Glycosylation:

Glycosylation is the process in which a carbohydrate is bonded covalently to an organic molecule by making structures such as glycoprotein and glycolipids.

N-Linked oligosaccharides:

N-Linked glycosylation involves oligosaccharide binding to asparagine through a beta linkage to the amine nitrogen of the side chain. The process of *N*-linked glycosylation occurs cotranslationally while the protein is being translated. Since it is added cotranslationally, it is



An example of an *N*-linked oligosaccharide, shown here with GlcNAc. X is any amino acid except proline.

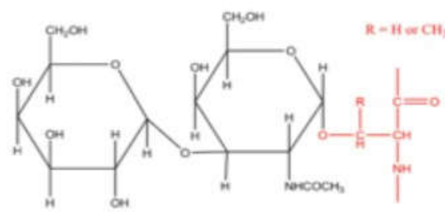
believed that this linkage helps to determine the folding of polypeptides due to the hydrophilic nature of sugars. All *N*-linked oligosaccharides are pentasaccharides: five monosaccharides long.

In N-glycosylation for eukaryotes, the oligosaccharide substrate is come together right at the membrane of the endoplasmatic reticulum. For prokaryotes, this process take place in plasma membrane. In both cases, the acceptor substrate is an asparagine residue. The asparagine residue linked to an *N*-linked oligosaccharide usually occurs in an order Asn-X-Ser/Thr, where X can be any amino acid except for proline, although it is rare to see Asp, Glu Leu, or Trp in this position.

O-linked oligosaccharides:

Those oligosaccharides which participate in O-linked glycosylation are linked to threonine or serine on the hydroxyl group of the side chain. This type of glycosylation takes place in the Golgi apparatus, where monosaccharide units are added to a complete polypeptide chain.

Extracellular protein and cell surface proteins and extracellular proteins are O-glycosylated. Glycosylation sites in O-linked oligosaccharides are determined by the secondary structure of polypeptide which dictates where glycosyltransferases will, adds sugar.



An example of an *O*-linked oligosaccharide with β-Galactosyl-(1n3)-α-*N*-acetylgalactosaminyl-Ser/Thr.

Glycosylated biomolecule:

Glycoprotein and glycolipids are covalently bonded to carbohydrates. On the surface of the cell they are large in number. Their interactions contribute to the overall stability of the cell.

Glycoprotein:

Oligosaccharide structures have significant effects on many of their properties, affecting critical functions such as antigenicity, solubility, and resistance to proteases. Glycoprotein are relative as cell-surface receptors, cell-adhesion molecules, immunoglobulins, and tumor antigens.

Glycolipids function:

- Cell recognition:
- Cell adhesion:

For cell recognition glycolipids are important, and are important for modulating the function of membrane proteins that act as receptors. Glycolipids are lipid molecules bound to oligosaccharides, generally present in the lipid bilayer. Additionally, they can serve as receptors for cellular recognition and cell signaling. The head of the oligosaccharide serves as a binding partner in receptor activity.

The binding mechanisms of receptors to the oligosaccharides depend on the composition of the oligosaccharides that are exposed or presented above the surface of the membrane. There is great diversity in the binding mechanisms of glycolipids, which is what makes them such an important target for pathogens as a site for interaction and entrance. For example, the chaperone activity of glycolipids has been studied for its relevance to HIV infection.

Function of oligosaccharide:

Cell recognition:

In glycoproteins or glycolipids all cells are coated, both of which help determine cell types of Lactins, or proteins that bind carbohydrates, can recognize specific oligosaccharides and provide useful information for cell recognition based on oligosaccharide binding. An important example of oligosaccharide cell recognition is the role of glycolipids in determing in blood types. The various blood types are differentiated by the glycan modification present on the surface of blood cells. These can be visualized using mass spectrometry. The oligosaccharides found on the A, B, and H antigen present on the non-reducing ends of oligosaccharides. The H antigen (which recommend an O blood type) serves as a precursor for the A and B antigen therefore, a person with A blood type have A antigen and H antigen present on the glycolipids of the red blood cell plasma membrane. A person with B blood type will have the B and H antigen present. A person with AB blood type will have A, B, and H antigens present. And finally, a person with O blood type will only have the H antigen present. This means all blood types have the H antigen, which shows why the O blood type is known as the "universal donor.

Vesicles are directed by many ways, but the two main ways are:

1- *The sorting signals encoded in the amino acid sequence of the proteins.*
2- *The Oligosaccharide attached to the protein.*

The sorting signals are recognized by specific receptors that reside in the membranes or surface coasts of budding vesicles, ensuring that the protein is transported to the appropriate destination.

Cell Adhesion:

Many cells produce specific carbohydrate-binding proteins known as lectins, which interfere cell adhesion with oligosaccharides. Selectins, a family of lectins, mediate certain cell–cell adhesion processes, including those of leukocytes to endothelial cells. In an

Immune response, endothelial cells can express certain selectins temporarily in response to damage or injury to the cells. In response, a reciprocal selectin–oligosaccharide interaction will occur between the two molecules which allow the white blood cell to help eliminate the infection or damage. Protein-Carbohydrate bonding is often mediated by hydrogen bonding and van der Waals forces.

Dietary oligosaccharides:

Fructo-oligosaccharides which are found in many vegetables are short chains of fructose molecules. They differ from fructans and inulin, which have a much higher degree of polymerization than FOS and is therefore a polysaccharide, but like fructans and inulin, they are considered soluble dietary fibre. Galactooligosaccharides (GOS), which also occur naturally, consist of short chains of glactose molecules. These compounds cannot be digested in the human small intestine, and instead pass through to the large intestine where they promote the growth of Bifidobacteria, which are beneficial to gut health.

Source:

Oligosaccharides are component of fibers from plants tissue. Fructose oligosaccharides and inulin are present in Jerusalem artichoke, burdock, chicory, leeks, onion, and asparsgus.inulin is
a significant part of the daily diet of most of world population. By enzyme of a fungus.

Aspergillus niger fructose oligosaccharides can be synthesized.GOC is naturally found in Soyabean and can be synthesized from lactose. FOS, GOS, and inulin are also sold as nutritional supplements.

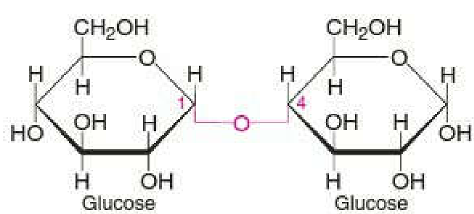
Disaccharide:

Among the oligosaccharides disaccharides are more common. As it is evident from name, disaccharide units held together by glycosidic bond. they are crystalline water soluble and sweet in taste. Disaccharides are of two types

- Reducing disaccharides with free aldehyde or keto group e.g. maltose, lactose
- Non reducing disaccharides with no free aldehyde or keto group e.g. sucrose, trehalose.

Maltose:

It is made up of two alpha-D-glucose held together by alpha (1→4) glycosidic bond. The free aldehyde group present on C1 of second glucose answers the reducing reaction besides the Osazone formation. Maltose can be hydrolysed by dilute acid or the enzyme maltase to liberate two molecules of alpha-D-glucose. In isomaltase, the glucose units are held together by a (1-6).

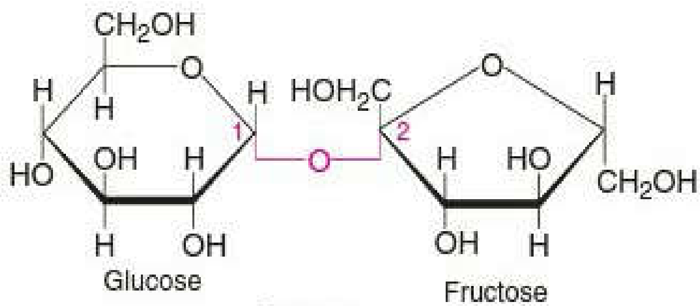


Maltose
(α-D-glucosyl (1 → 4) α-D-glucose)

Cellobiose is an other disaccharides, identical in structure with maltose, except that the former has (1→4) glycosidic linkages. Cellobiose is formed during the hydrolysis of cellulose glycosidic linkage.

Sucrose:

Sucrose is also called cane sugar because it is mostly made from sugar cane and beets. Sucrose is mostly made up of alpha-D-glucose and beta-D-fructose. The two monosaccharide held together by glycosidic bond (alpha1-beta1) between C1 of alpha-glucose and C2 of beta-fructose. The reducing groups of glucose and fructose are involved in glycosidic bond, hence sucrose is a non reducing sugar, and it can form Osazone.

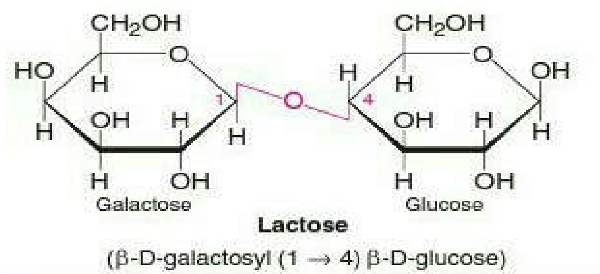


Sucrose
(α-D-glucosyl (1 → 2) β-D-fructose)

Sucrose is an important source of dietary carbohydrates . It is sweeter than most other common sugar namely glucose, Lactose and maltose. Sucrose is employed as a sweeting agent in food industry. The intestinal enzyme –sucrose –hydrolyses sucrose to glucose and fructose which are absorbed

Inversion of sucrose:

Sucrose such is dextrorotatory at (+66.5). But when hydrolysed, sucrose becomes levorotatory (-28.2). The process of change in optical rotation from dextrorotatory (+) to levorotatory (-) is referred to as inversion. The hydrolysed mixture of sucrose, containing glucose and fructose, is known as invert sugar. The process of inversion is explained below. Hydrolysis of enzyme is take place by enzyme sucrase (invertase) or dilute acid liberates one molecule each of glucose and fructose. It is postulated that sucrose is a first split into alpha_D-glucopyranose and beta –D-fructopyranose, both being dextrorotary is less stable and immediately gets converted into beta – D-fructopyranose which is strongly levorotatory (-92). The overall effects is the dextro sucrose (+66.5) on inversion is converted to levo form (-28.2).



Lactose:

Is a disaccharide found in milk

- *Lactose consist of glactose connected to glucose residue by a β(1→4) glycosidic bonds.*
- *The anomeric C1 glucose is free ,hence lactose exhibits reducing properties and form Osazone*
- *Lactose of milk is most important carbohydrates in the nutrition of young animals*
- *It is hydrolysed by enzyme Lactase to glucose and glactose. .*

Most common disaccharide are oligosaccharides:

- Raffinose
- Stackhouse
- Verbascose

- These oligosaccharides are indigestible since they contain glactopyranose residues involved in alpha glycosidic bonds that humans lack the enzyme to hydrolyze.