Aesthetic and Laser Techniques Department

First Semester

General Chemistry (2024-2025) lecture (4)

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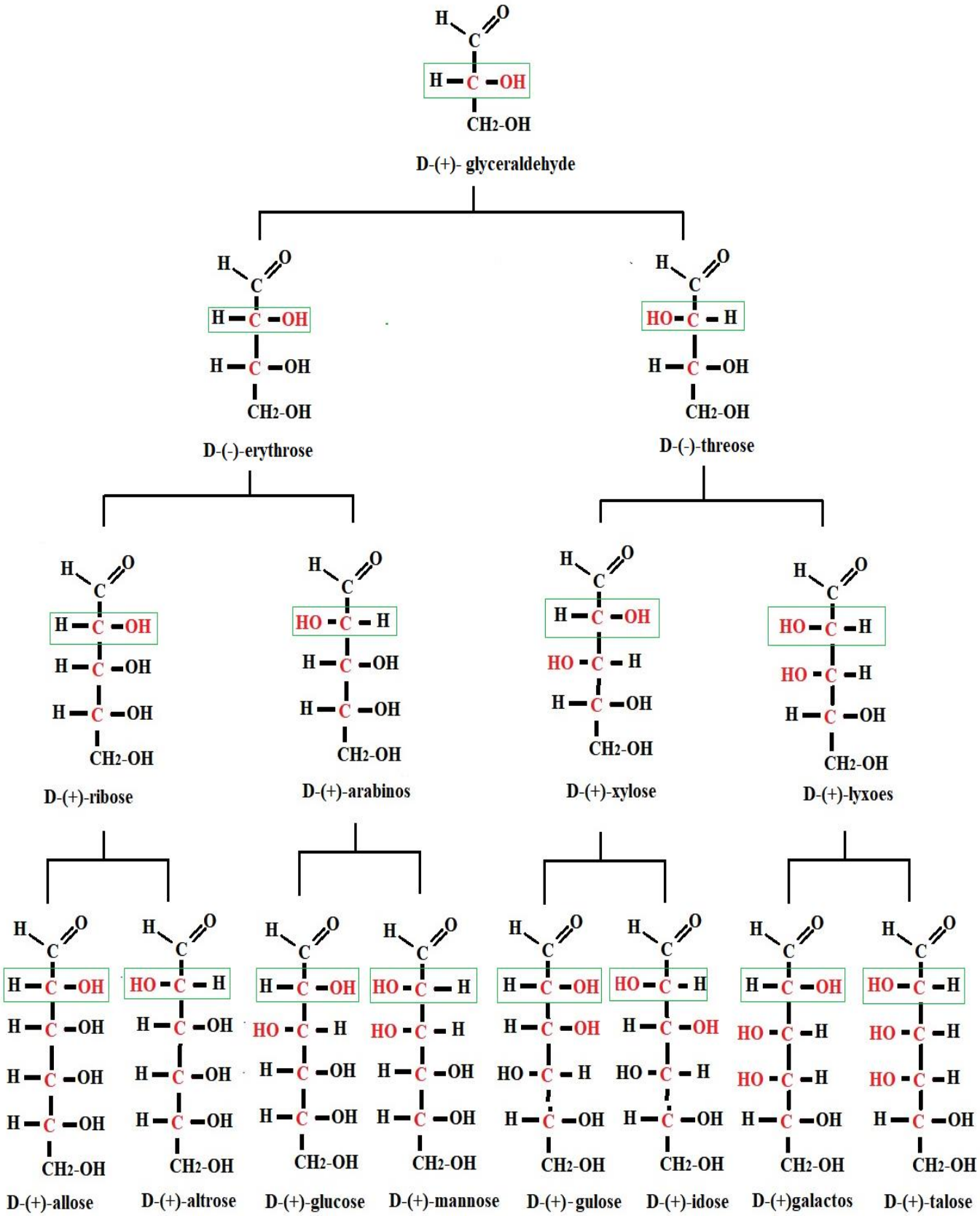
Carbohydrates classification reactions, main carbohydrates in human body.

Definition of carbohydrates

They are polyhydroxylic aldehydes or ketones with the formula. In organic chemistry, a carbohydrate is a biomolecule consisting of carbon (C), hydrogen (H) and oxygen (O) atoms, usually with a hydrogen–oxygen atom ratio of 2:1 and thus with the empirical formula $Cm(H_2O)n$ (where m may or may not be different from n), which does not mean the H has covalent bonds with O (for example with CH_2O, H has a covalent bond with C but not with O). However, not all carbohydrates conform to this precise stoichiometric definition (e.g., uronic acids, deoxy-sugars such as fucose),
The term is most common in biochemistry, where it is a synonym of saccharide 'sugar 'a group that includes sugars, starch, and cellulose.

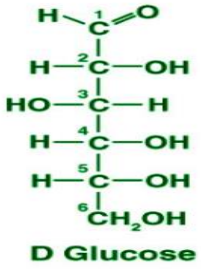
Classification of carbohydrates

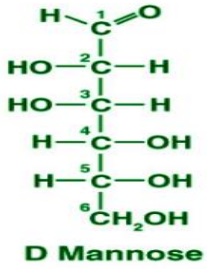
Carbohydrates can be classified according to :-
1- according to the number of carbon atoms that make up the sugars,
Divide monosaccharides according to the number of carbon atoms
a- Trisaccharides (glyceraldehyde) are intermediates during the vital reactions of carbohydrates.
b- The Quaternary Tetroses (Erythyrose)
c- The five pentoses (ribose) are included in the formation of nucleic acids
d- The hexoses (glucose and fructose) are the most common monosaccharides


D-(+)- glyceraldehyde
D-(-)-erythrose
D-(-)-threose
D-(+)-ribose
D-(+)-arabinos
D-(+)-xylose
D-(+)-lyxoes
D-(+)-allose
D-(+)-altrose
D-(+)-glucose
D-(+)-mannose
D-(+)-gulose
D-(+)-idose
D-(+)galactos
D-(+)-talose

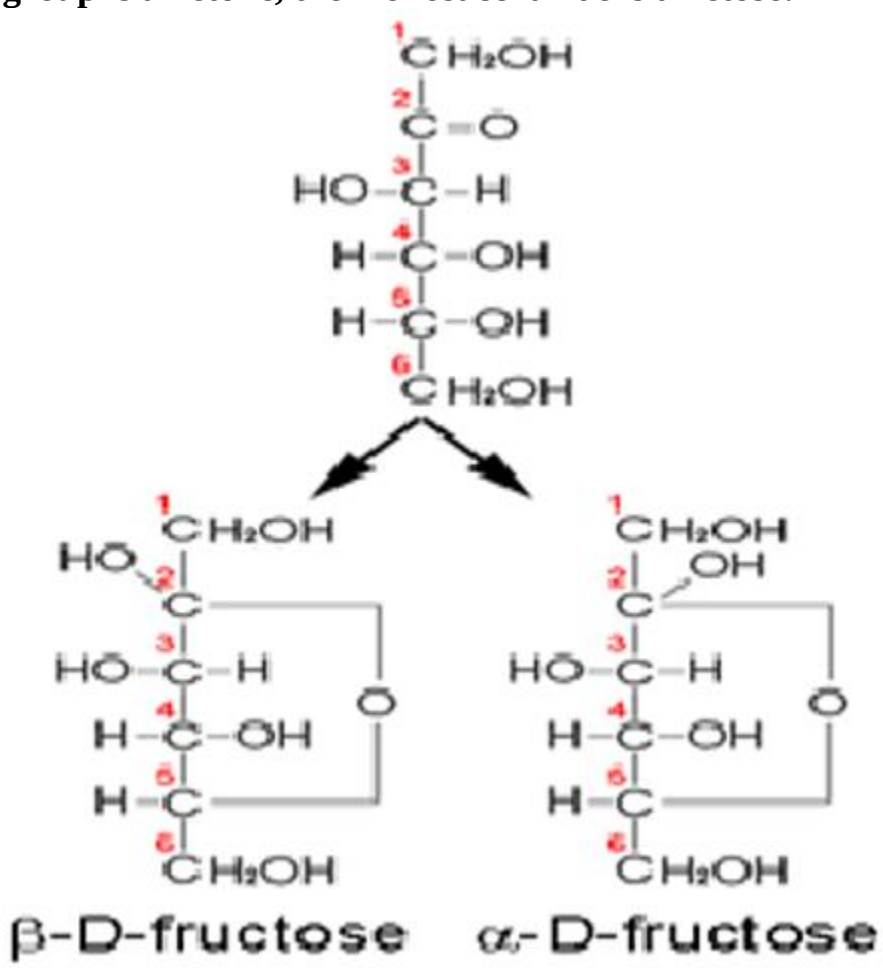
1-Monosaccharides:

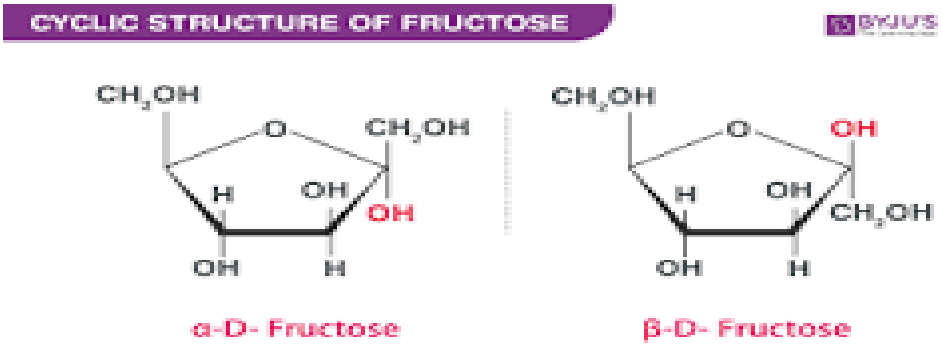
Monosaccharides are classified according to three different characteristics: the placement of its carbonyl group, the number of carbon atoms it contains, and its chiral handedness. If the carbonyl group is an aldehyde, the monosaccharide is an aldose; for example





If the carbonyl group is a ketone, the monosaccharide is a ketose.





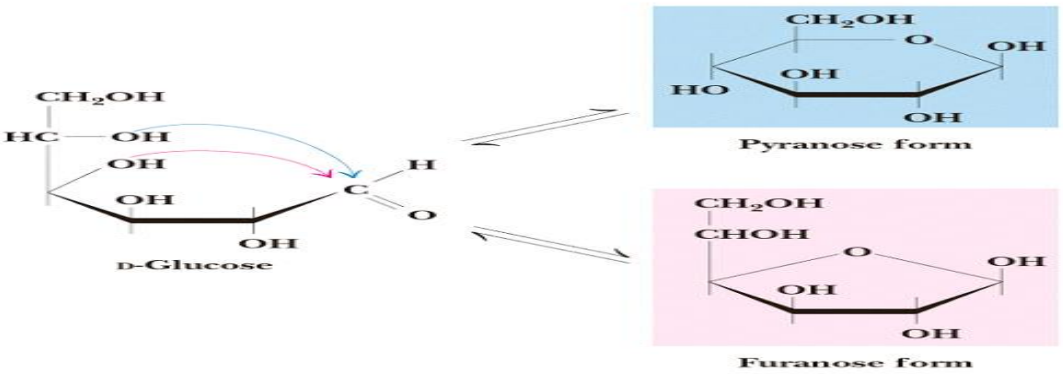
Properties of monosaccharides:-

1- Optical activity of monosaccharides
2- Cyclic structure of monosaccharides (furanose , pyranose)
3- Formation of the glycosidic bond

Optical activity of monosaccharides

-If the compound contains one or more asymmetric carbon atoms, the compound is actually visual, as is the case with amino acids.
-When a beam of polarized light passes from the polarimeter device on the solution, the polarized light beam either rotates to the right, so the compound is right-rotated and is symbolized by (+ or d), or it rotates left, so the compound is left-rotation and is symbolized by (- or l).

Cyclic structure of monosaccharides (furanose , pyranose)

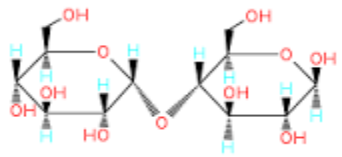


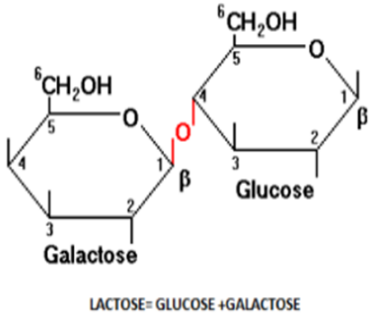
Isomers of Glucose

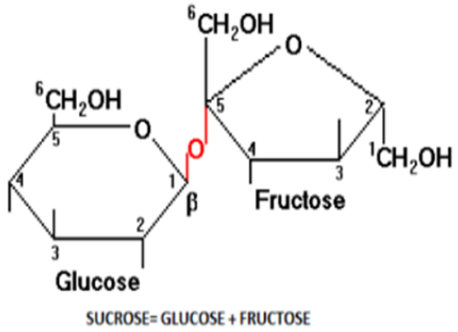
Cyclic structure of Glucose posses 5 asymmetric carbon atoms
The number of isomers = 2^n (where n is the number of asymmetric centers)
The number of isomers = 2^5 = 32 isomer
Then Glucose posses 32 possible Isomers.

2-Disaccharides:

Disaccharides, the smallest (lower molecular weight). It is a result of the union of two parts of hexagonal monosaccharides . The most important of which are sucrose, maltose and lactose for example sucrose and lactose







Maltose (Glu-Glu) **Lactose (Glu-Gal)** **Sucrose (Glu-Fru)**

3-Oligosaccharides:

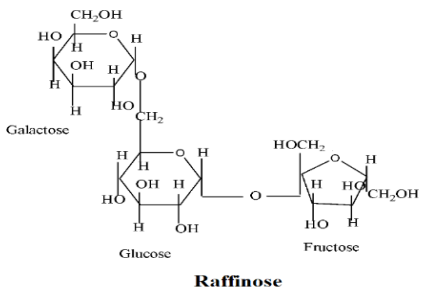
Oligosaccharide Definition: - oligosaccharide means a few saccharides . A saccharide refers to the unit structure of carbohydrates. Thus, an oligosaccharide is a carbohydrate comprised of a few saccharides, about three to ten (mono)saccharide units. The number of monomer units in an oligosaccharide is not rigorously defined.

Similar to other carbohydrates, oligosaccharides are made up of hydrogen, carbon, and oxygen, and the ratio of hydrogen atoms to oxygen atoms is often 2:1, which explains why they are referred to as hydrates of carbon. And because of the presence of carbon , C-C and C-H covalent bonds, oligosaccharides, just as the other carbohydrates are organic compounds.
The oligosaccharide is formed by the joining of monosaccharide units via glycosidic bonds. Glycosidic bonds are covalent bonds that may form between the hydroxyl groups of two monosaccharides.

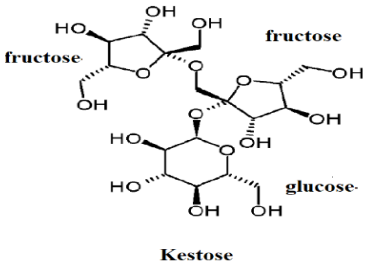
Classifications of Oligosaccharides:-

Oligosaccharides may be classified based on the number of monosaccharides they contain. Some of them are described below.
1-Trisaccharides are oligosaccharides comprised of three monosaccharides. Examples include:
a- Nigerotriose – 3 glucose units joined by α-(1→3) glycosidic linkage
b- Maltotriose – 3 glucose units joined by α-(1→4) glycosidic linkage
c- Melezitose (glucose-fructose-glucose)

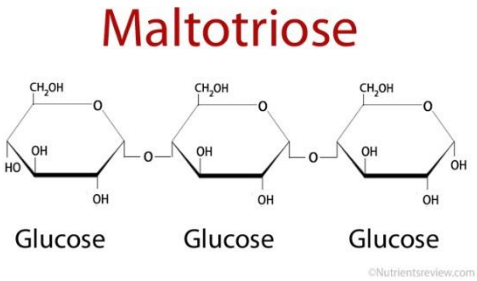
d- Raffinose (galactose-glucose-fructose)
e- Kestose (glucose-fructose-fruct)



Raffinose



Kestose



2-Tetra saccharides are oligosaccharides comprised of four monosaccharides.
Examples are:
a- Nigerotetraose contains 4 glucose units joined by α-1, 3 glycosidic linkage.
b-Maltotetraose contains 4 glucose units joined by α-1, 4 glycosidic linkage
c- Lychnose (galactose-glucose-fructose-galactose)
d-Nystose (glucose-fructose-fructose-fructose)

3-Pentasaccharides are those comprised of five sugar units. N-linked oligosaccharides are mostly pentasaccharide.

4-Hexasaccharides are oligosaccharides comprised of six sugar units. α-Cyclodextrin is an example. It consists of six glucose units linked via α-1, 4 linkages.

5-Heptasaccharides are oligosaccharides containing seven sugar units,

6. Octasaccharides contain eight, Nona saccharides have nine, Dec saccharides have ten, and so on.

4- Polysaccharides:

Polysaccharides are the most important carbohydrate in animal feed. Polysaccharides are composed of many single monosaccharide units linked together in long, complex chains.
Polysaccharides can be homopolysaccharides or heteropolysaccharides.

a. Homopolysaccharide : Contains only one type of saccharide unit.

Examples of homopolysaccharides that are important in animal nutrition include;
Starch (nonstructural form), glycogen (animal form), and cellulose (plant structural form).

1-Starch:

Principal sugar form of carbohydrate in cereal grains (seed energy storage). The basic unit is α-D-Glucose. Forms of starch in cereal grains include:-

a- Amylose : is the simplest of the polysaccharides, being comprised solely of glucose units joined in an α 1,4 linkage . Amylose is water soluble and constitutes (15% - 30%) of total starch in most plants.

b-Amylopectin: differs in how the glucose units are joined together. α 1,4 linkages predominate, but a "branch" arises from an α 1,6 linkage. Such branches make the structure of amylopectin more complex than that of amylose. Amylopectin is not water soluble and constitutes (70% - 85%) of total starch in plant cells.

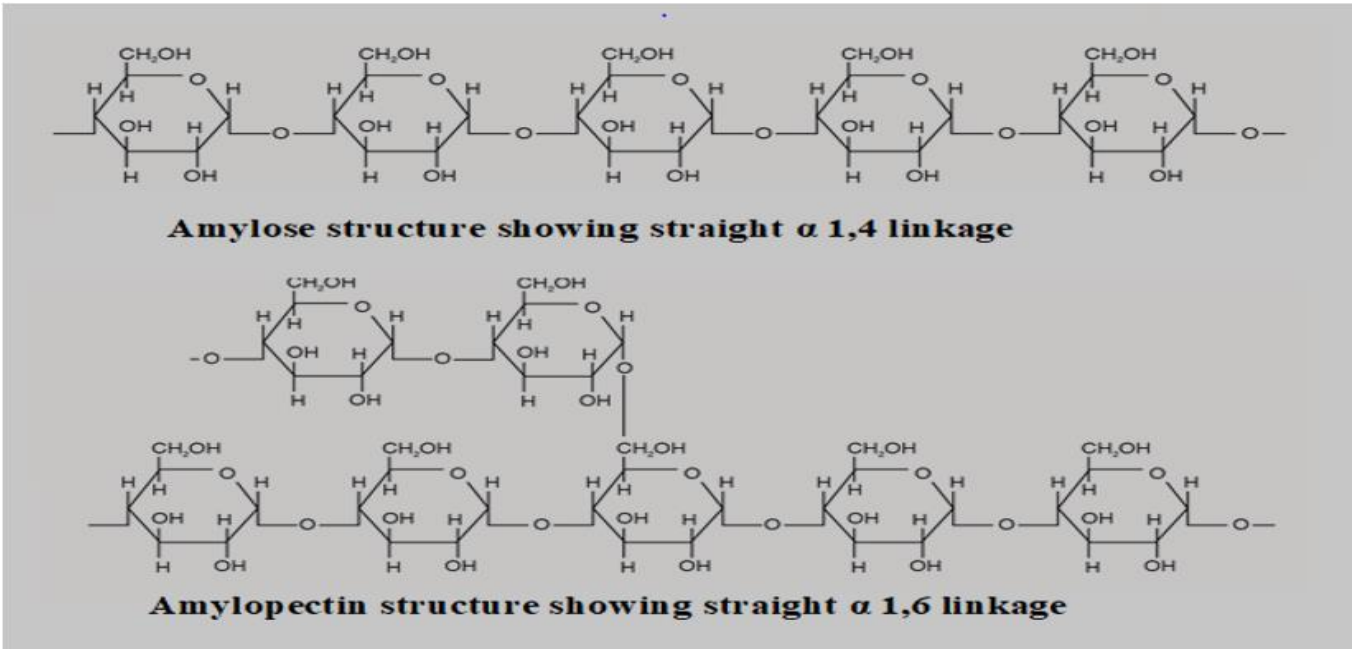


Figure : Structure of starch

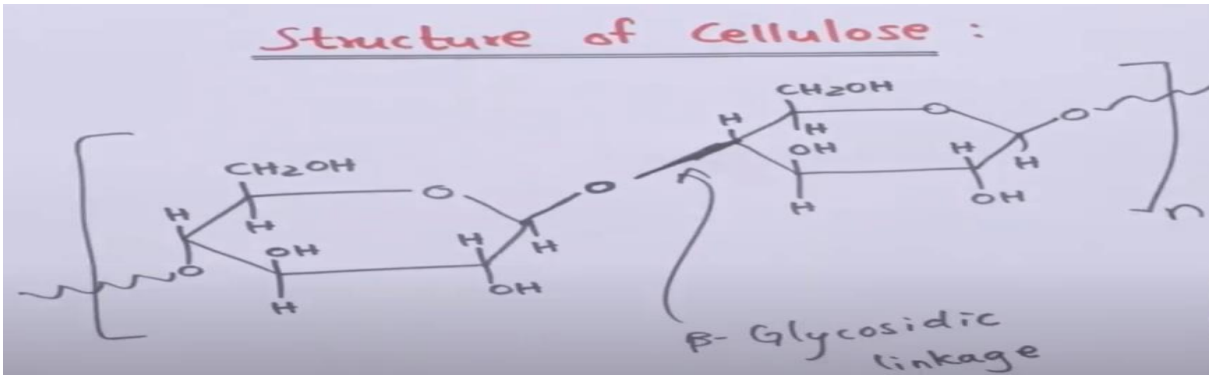
2- Glycogen:-

Is a form of starch found in animal tissue and is hence called animal starch. Glycogen is a polysaccharide that is physically related to amylopectin with basic α -D-Glucose but has a mix of α-1,4 and α-1,6 bonds forming a branched structure . Glycogen exists in a small amount (< 1%) in liver and muscle tissue.

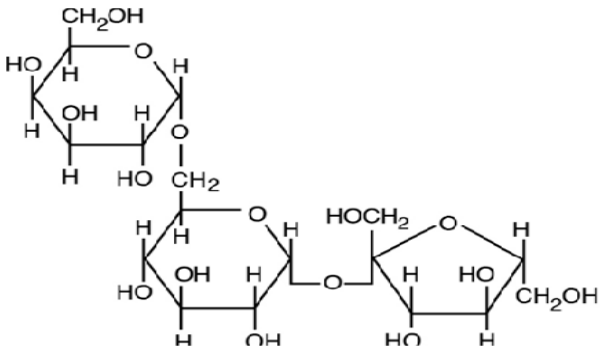
3-Cellulose :

Is the most abundant carbohydrate in nature. It provides structural integrity to plant cell walls. The basic unit is β-1,4 linkage, straight chain, Nonbranching Cellulose is highly stable. No animal enzyme can break it; only microbial cellulase can degrade it. Ruminant animals such as cattle, however, have bacteria in their rumen that contain the enzyme

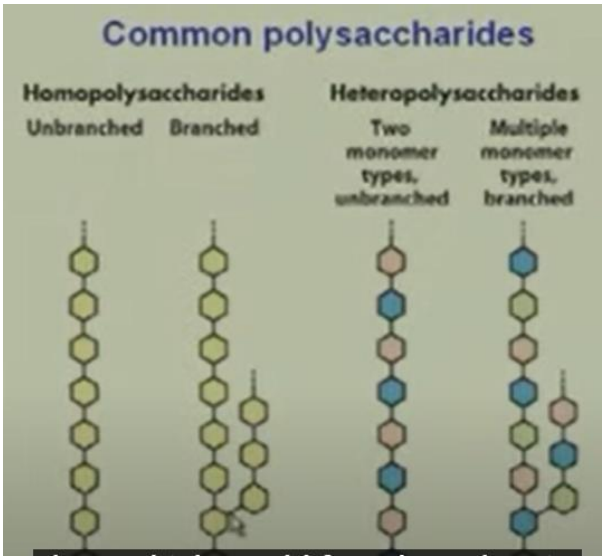
cellulase. It breaks the β-1,4 links of the glucoses in cellulose to release the sugar for energy.



b: Heteropolysaccharide : A component of plant cell walls with a mix of 5 C and 6 C sugars (e.g., hemicellulose and pectin, a mixture of pentose and hexose units).



Heteropolysaccharide structure showing a mix of 6 and 5 C sugars Source:



Types of polysaccharides

1. **Storage polysaccharides**
   There are Energy Storage polysaccharide

a. **Starch (stored in plant cells)**
b. **Amylose(un branched)**
c. **Amylopectin (branched)**
d. **Glycogene (stored in animal cells)- highly branched**

2. **Structural polysaccharide (not branched) – cellulose- are used to produce a protective walls or coatings to cells .**