Practical General Chemistry

Lecture notes

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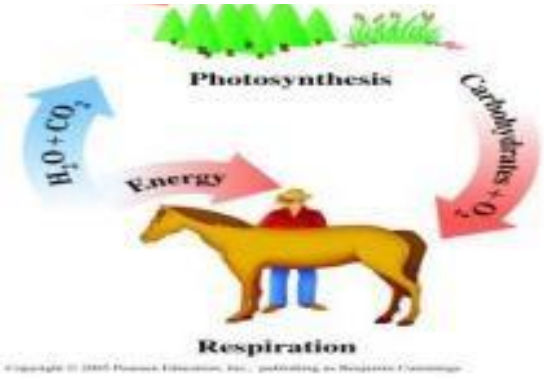
Sixth Lecture: Carbohydrates

Definition:-

Carbohydrates may be defined chemically as aldehyde or ketone derivatives of polyhydroxy alcohols or as compounds that yield these derivatives on hydrolysis Carbohydrates are

- A major source of energy from our diet.
- Composed of the elements C, H, and O.
- Also called saccharides, which means “sugars.”
- Carbohydrates are produced by photosynthesis in plants.

glucose is synthesized in plants from CO_2, H_2O, and energy from the sun then oxidized in living



cells (respiration) to produce CO_2, H_2O, and energy.

Functions of Carbohydrates:

1 - Source of energy for living beings, e.g. glucose

2 - Storage form of energy, e.g. glycogen in animal tissue and starch in plants

3 - Serve as structural component, e.g. glycosaminoglycans in humans, cellulose in plants and chitin in insects

4 - Non-digestable carbohydrates like cellulose, serve as dietary fibers

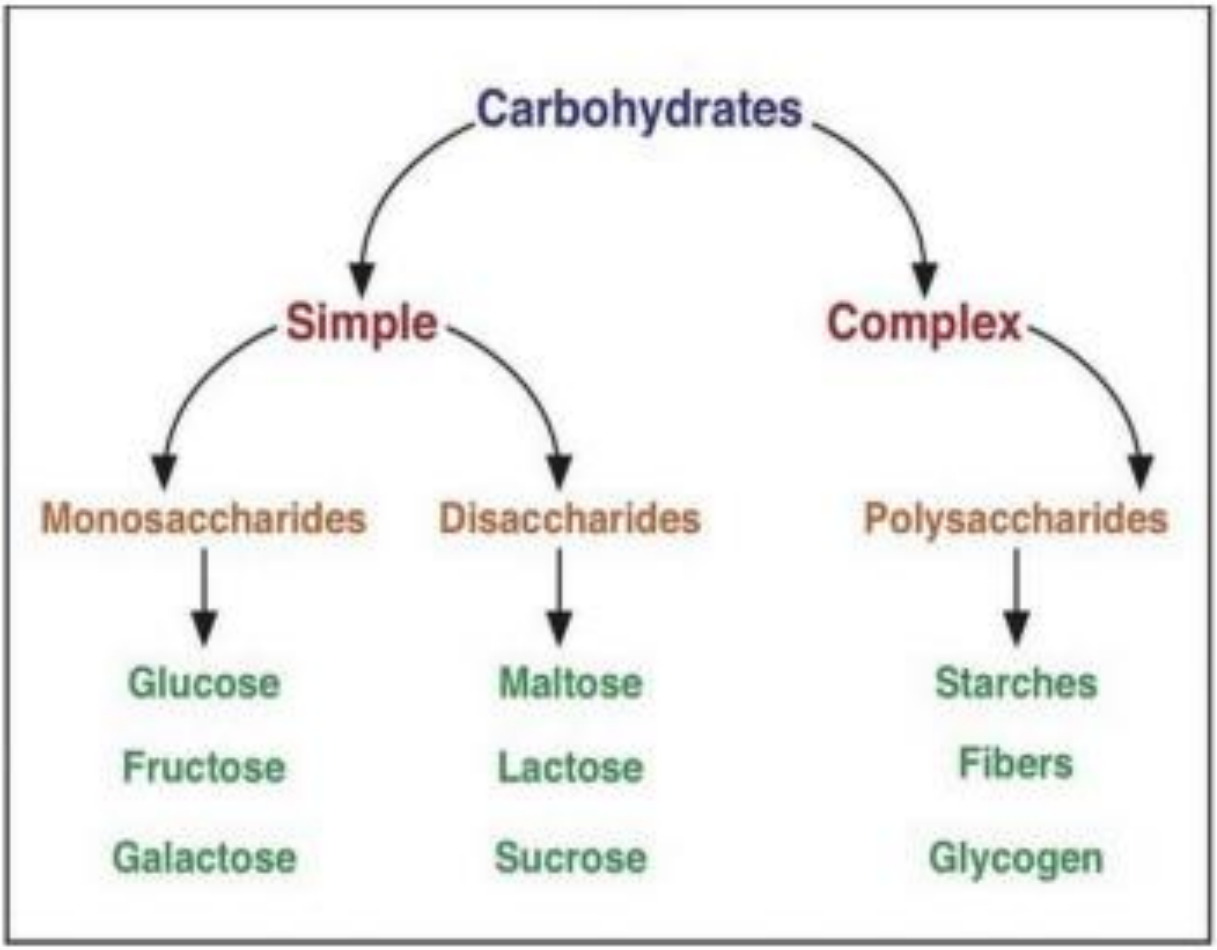
5 - Constituent of nucleic acids RNA and DNA, e.g. ribose and deoxyribose sugar

6 - Play a role in lubrication, cellular intercommunication and immunity

7 - Carbohydrates are also involved in detoxification, e.g. glucuronic acid

What happens to your body if you do not eat enough carbohydrates?

If you do not eat enough carbohydrates, your body must use fats and proteins for energy, but neither protein nor fats are sufficient sources of energy, and this is what happens.



Scheme for identification of carbohydrate

Classification of Carbohydrates

Carbohydrates are classified into three groups:

1. Monosaccharides=single unit
2. Oligosaccharides =3-10 units
3. Polysaccharides >10 units

The suffix **ose** indicates that a molecule is a carbohydrate .e.g maltose, glucose, lactose,
fructose ,ribose

Monosaccharides (Greek: Mono = one)

• Monosaccharides are also called simple sugars. The term sugar is applied to carbohydrates that are soluble in water and sweet to taste

• They consist of a single unit

• polyhydroxy aldehyde or ketone unit, and thus cannot be hydrolyzed into a simpler form.

Monosaccharides may be subdivided into two groups as follows:

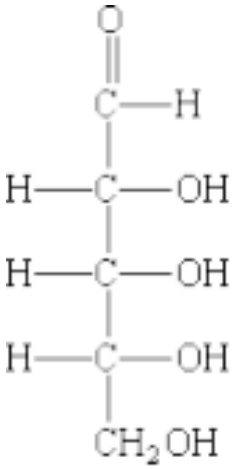
1. Depending upon the number of carbon atoms they possess, e.g.

- **Trioses** **3 carbon**
- **Tetroses** **4 carbon**
- **Pentoses** **5 carbon**
- **Hexoses** **6 carbon**
- **Heptoses.** **7 carbon**

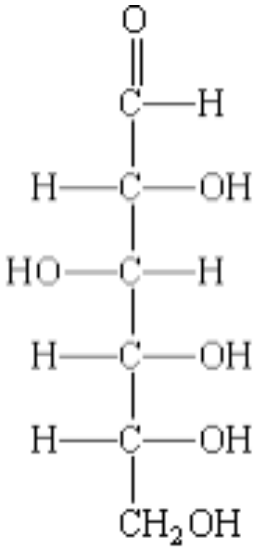
2. Depending upon the functional aldehyde (CHO) or ketone (C=O) group present:

- **Aldoses CHO**
- **Ketoses C=O**

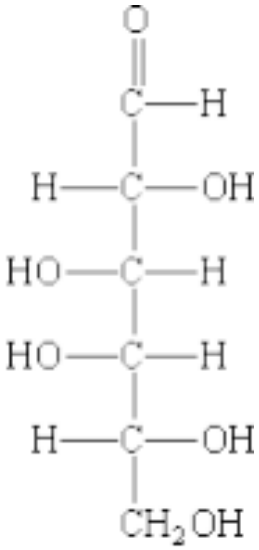
ALDOSES:



D-ribose

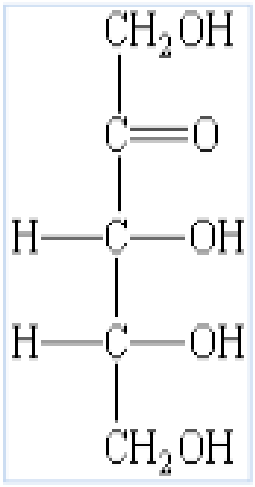


D-glucose

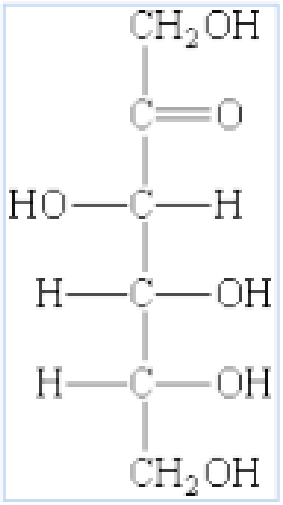


D-galactose

KETOSES:



D-ribulose



D-fructose

GLUCOSE

- Physiologically and biomedically , glucose is the most important monosaccharide
- It is called blood sugar
- $C_6H_{12}O_6$
- It is monosaccharide (aldose)
- It is source of energy
- It is produced by hydrolysis of glycogen

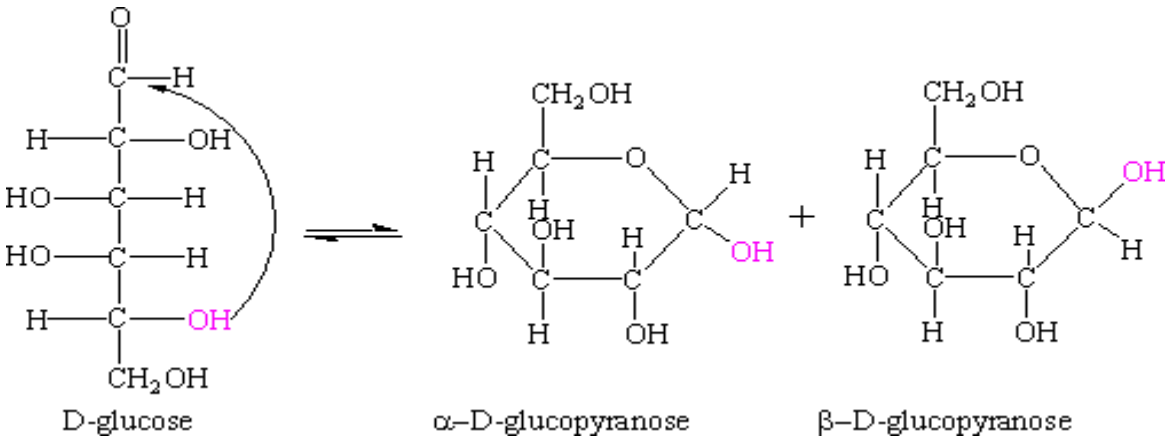
Anomerism

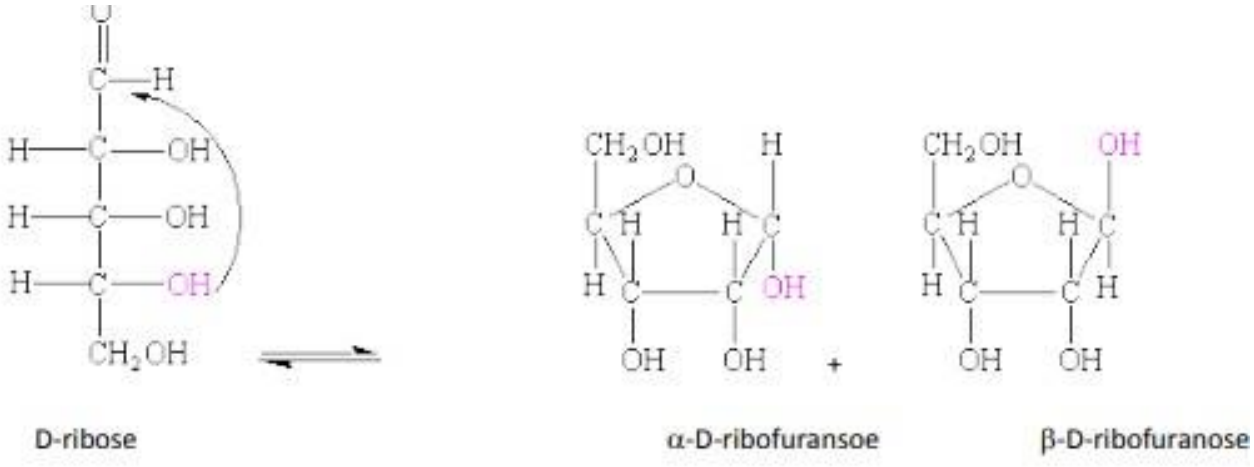
α and β Anomerism

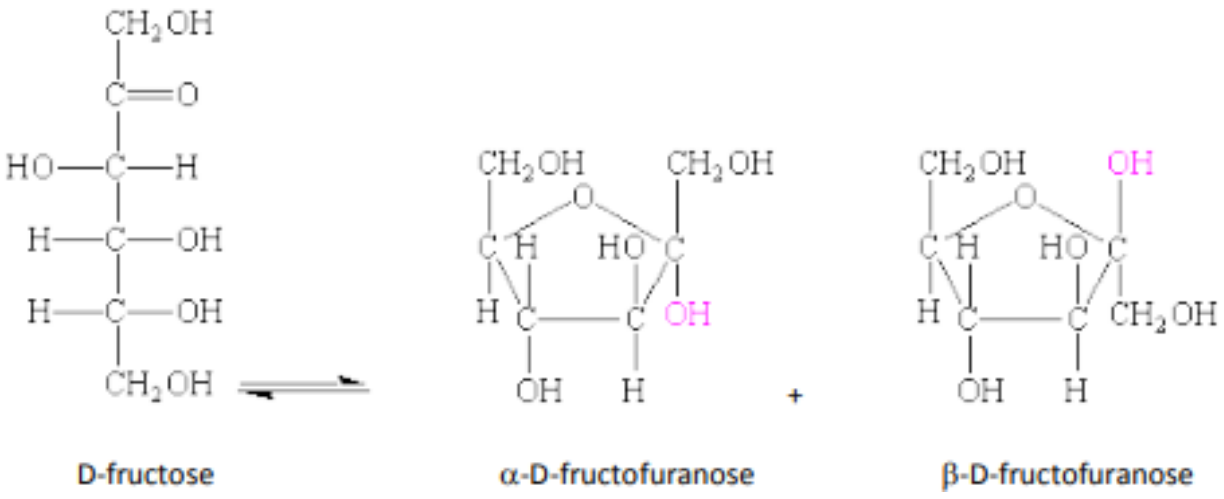
- The predominant form of glucose and fructose in a solution are not an open chain. Rather, the open chain form of these sugar in solution cyclize into rings. An additional asymmetric center is created when glucose cyclizes. Carbon-1 of glucose in the open chain form,becomes an asymmetric carbon in the ring form and two ring structures can be formed. These are:

- **α-D-glucose**
- **β-D-glucose.**

• The designation α means that the hydroxyl group attached to C-1 is below the plane of the ring, β means that it is above the plane of the ring. The C-1 carbon is called the anomeric carbon atom and so, α and β forms are anomers







- Glucose and fructose are isomers of each other having the same chemical (molecular) formula C6H12O6, but they differ in structural formula There is a keto group in position 2 of fructose and an aldehyde group in position 1 of glucose. Thistype of isomerism is known as ketose-aldose isomerism

GLYCOSIDE FORMATION: Glycosides are formed when the hydroxyl group of anomeric carbon of a monosaccharide reacts with OH or NH group of second compound that may or may not be a carbohydrate. The bond so formed is known as glycosidic bond.

- The monosaccharides are joined by glycosidic bonds to form **disaccharides,oligosaccharides** and **polysaccharides**.

Asymmetric carbon: Asymmetric carbon: carbon atom which attached to four(4)different groups

D and L isomerism

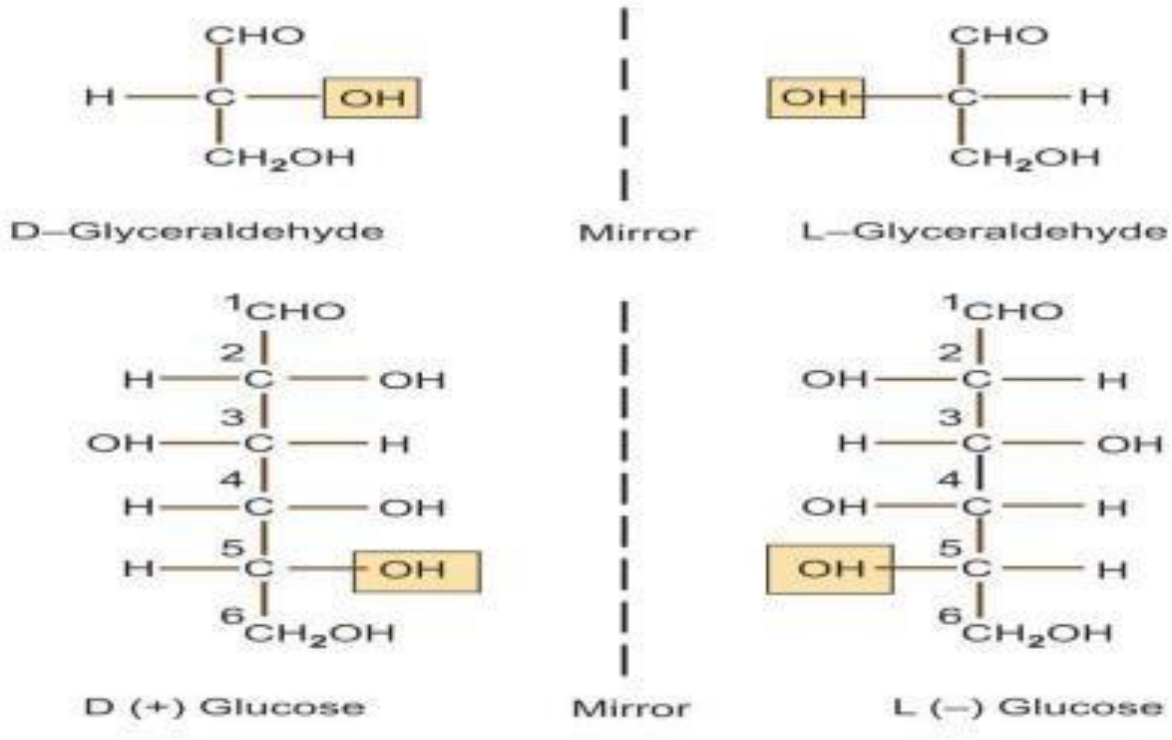
D and L isomerism depends on the orientation of the H and OH groups around the asymmetric carbon atom adjacent to the terminal primary alcohol carbon, e.g. carbon atom number 5 in glucose determines whether the sugar belongs to D or L isomer.

- When OH group on this carbon atom is on the right, it belongs to **D-series**, whenit is on the left, it is the member of the **L-series**.

The structures of D and Lglucose based on the reference monosaccharide, D and L

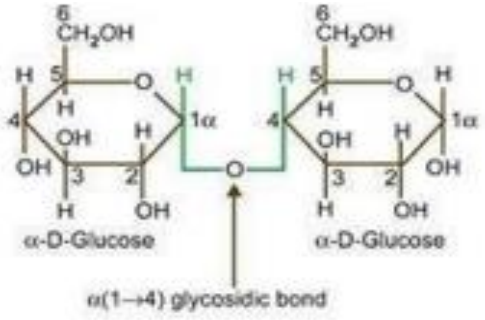
- glyceraldehyde, a three carbon sugar

D and L isomerism

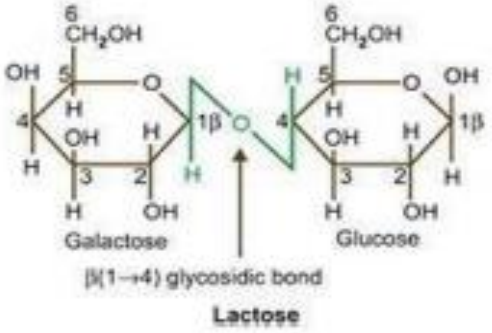


Disaccharides

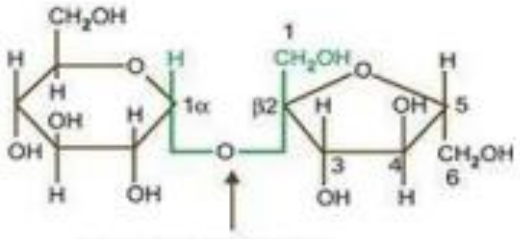
consist of two monosaccharide units linked together by a covalent bond (e.g., sucrose). Two monosaccharides can be linked together through a glycosidic linkage to form a disaccharide



Maltose



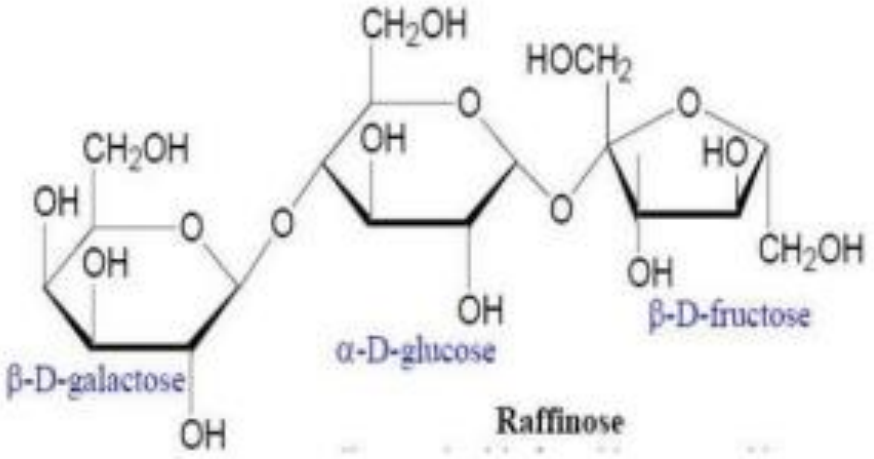
Lactose



Sucrose

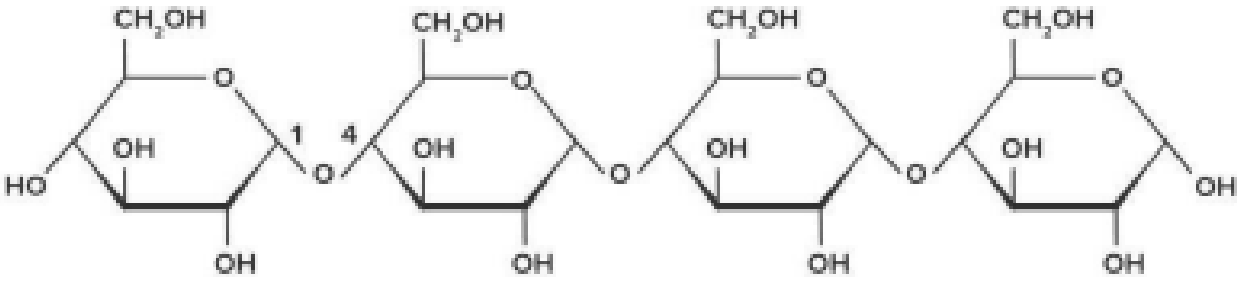
Oligosaccharides

contain from 3 to 10 monosaccharide units (e.g., raffinose)



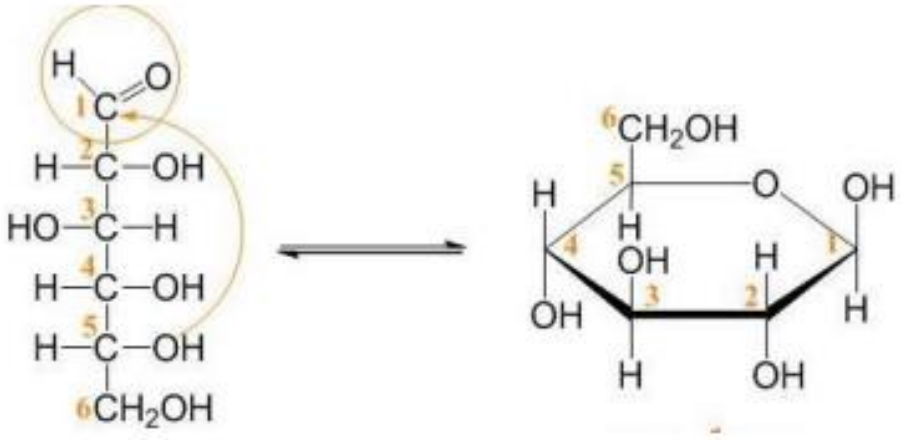
Polysaccharides

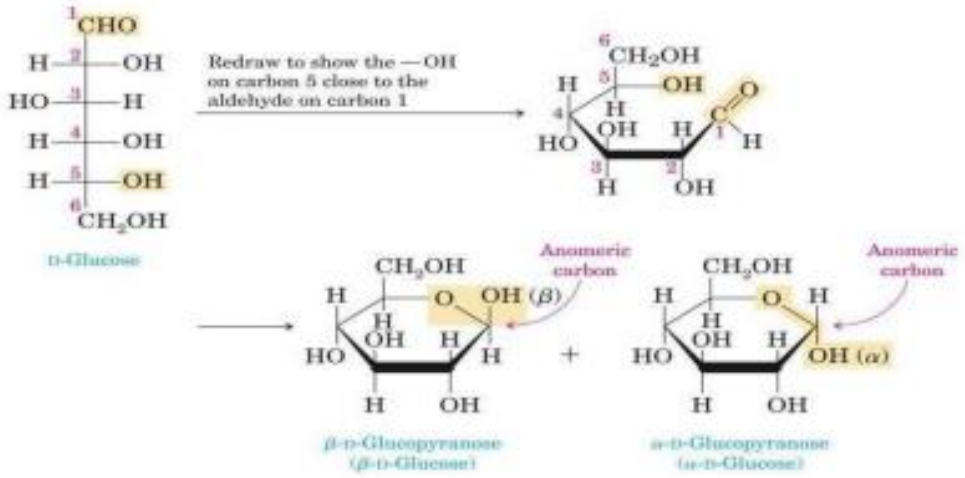
contain very long chains of hundreds or thousands of monosaccharide units, which may be either in straight or branched chains (e.g., cellulose, glycogen,starch).



Open Chain to Cyclic Form Mechanism

The mechanics of glucose





The mechanics of fructose