Department of Biology

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((BioChemistry))

Stage (-2-)

LEC- ((2))

Isomerism in Sugars

By

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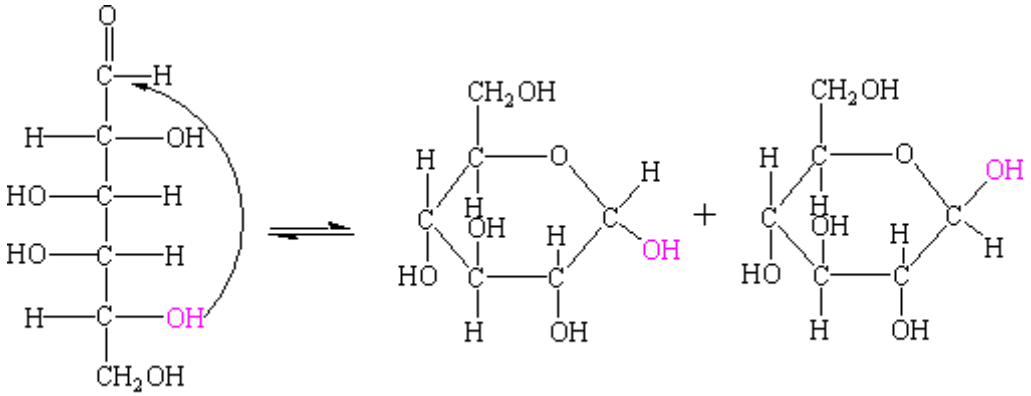
GLUCOSE

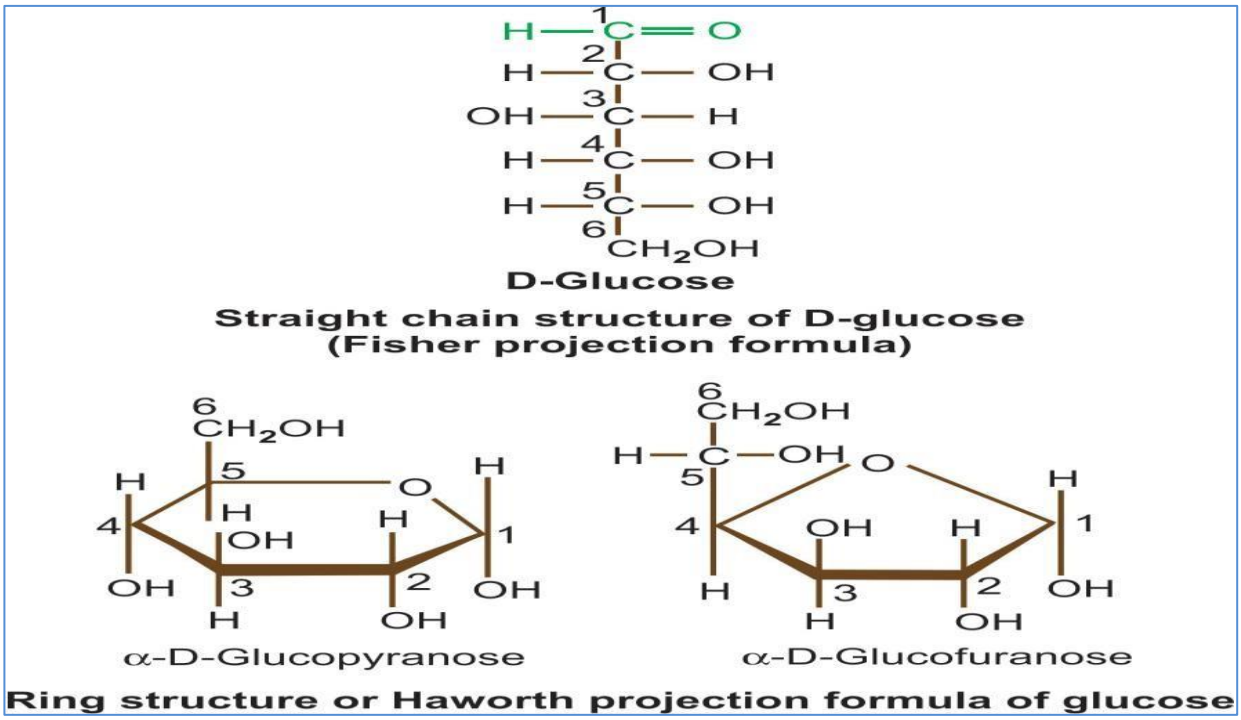
- Physiologically and biomedically , glucose is the most important monosaccharide
- It is called blood sugar
- $C_6H_{12}O_6$
- It is monosaccharide (aldose)
- It is source of energy
- It is produced by hydrolysis of glycogen

Anomerism

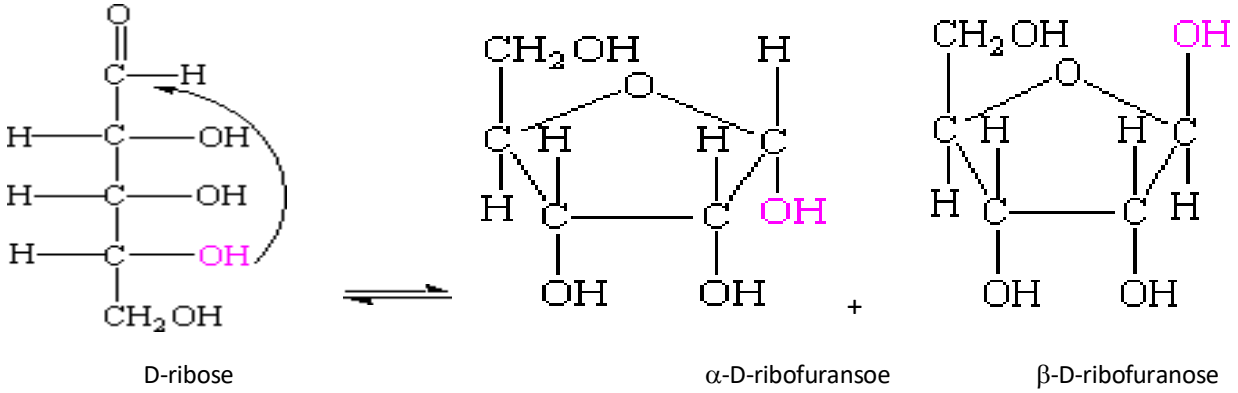
α and β Anomerism

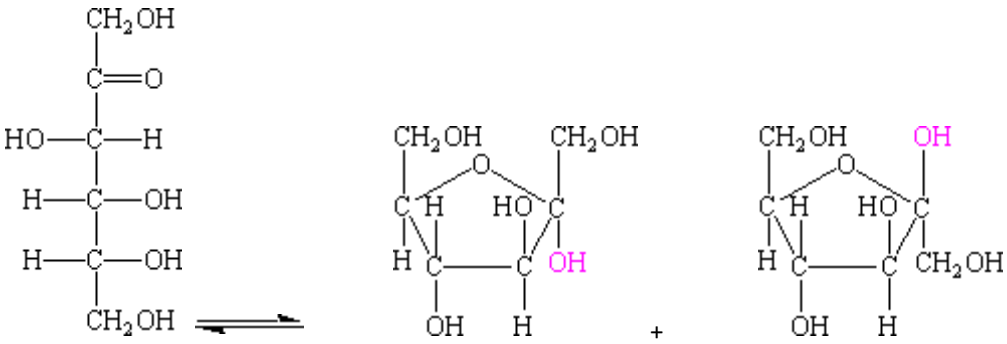
- The predominant form of glucose and fructose in a solution are not an open chain. Rather, the open chain form of these sugar in solution cyclize into rings. An additional asymmetric center is created when glucose cyclizes. Carbon-1 of glucose in the open chain form,becomes an asymmetric carbon in the 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 <u>below</u> the plane of the ring, β means that it is <u>above</u> the plane of the ring. The C-1 carbon is called the ***anomeric carbon atom*** and so, α and β forms are anomers





When a five-membered ring is formed, it is called a *furanose*, shown in the figure below





D-fructose α-D-fructofuranose β-D-fructofuranose

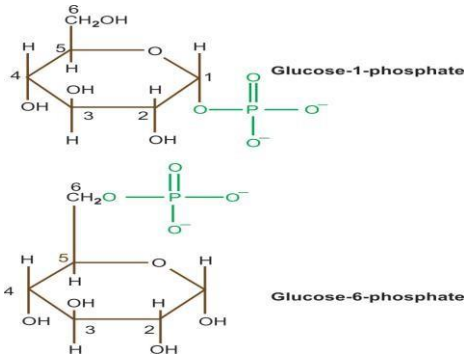
- ***isomerism***

- Glucose and fructose are isomers of each other having the same chemical (molecular) formula $C_6H_{12}O_6$, 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. This type 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.**

Phosphoric acid ester of glucose



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

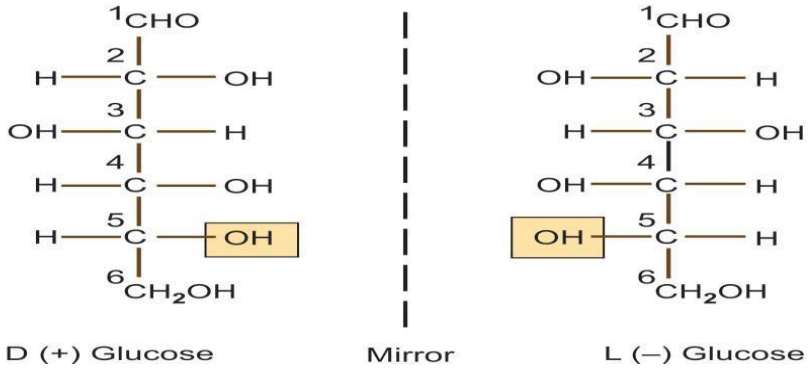
D and L isomerism

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,** when it 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

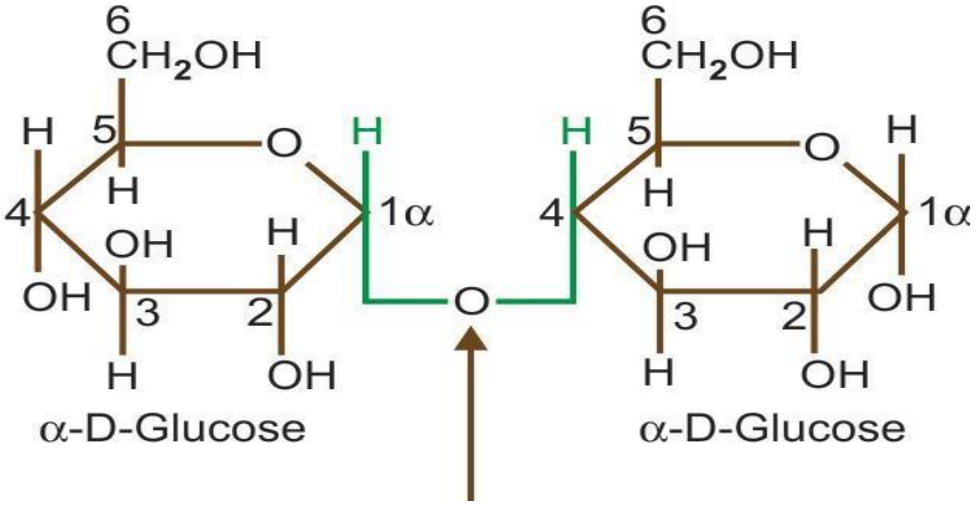
- Disaccharides consist of two monosaccharide units.

- They are crystalline, water soluble and sweet to taste. they are divided to:

1. Reducing disaccharides with free carbonyl group , e.g. maltose, lactose
2. Non-reducing disaccharides with no free carbonyl group, e.g. sucrose.

Maltose

- Maltose contains two glucose residues, joined by glycosidic linkage between C-1 (the anomeric carbon) of one glucose residue and C-4 of the other ,leaving one free anomeric carbon of the second glucose residue, which can act as a reducing agent. Thus, maltose is a ***reducing disaccharide***.



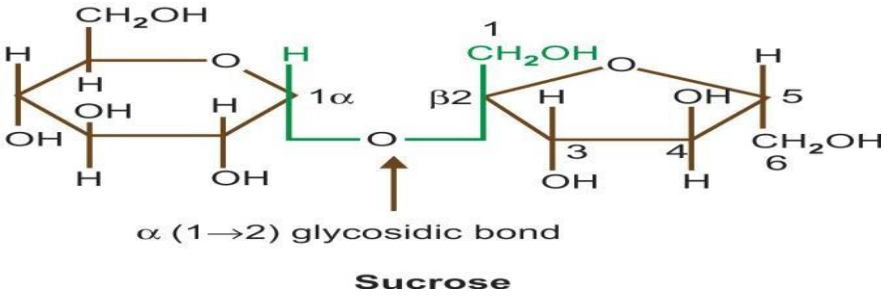
- Maltose=Glucose + Glucose it is reducing sugar

Sucrose (Common Table Sugar)

- Sucrose is **a <u>disaccharide</u>** of **<u>glucose</u>** and **<u>fructose</u>**. it is formed by plant but not by human beings. Sucrose is the commonly used **table sugar.** In contrast to maltose and lactose, sucrose is **<u>non reducing</u>** sugar (why?)

  becaue sucrose contains no free anomeric carbon atom the anomeric carbon of both glucose and fructose are involved in the formation glycosidic bond.

  Sucrose= Glucose + Fructose



<u>Oligosaccharides</u> (Greek: oligo = few)

- Oligosaccharides consist of a short chain of monosaccharide units (2 to 10 units), joined together by a characteristic bond called ***glycosidic bond*** which, on hydrolysis, gives two to ten molecules of simple sugar (monosaccharide) units.

Polysaccharides

Carbohydrates composed of ten or more units of monosaccharide

- Polysaccharides are colloidal in size. In polysaccharides, monosaccharide units are joined together by glycosidic linkages. Another term for polysaccharides is a "glycans Polysaccharides are subclassified in two groups :-

  1. **Homopolysaccharides** (Homoglycans): When a polysaccharide is made up of several units of one and the same type of monosaccharide unit only, it is called homopolysaccharide.e.g. starch ,glycogen

  2. **Heteropolysaccharides** (Heteroglycans): They contain two or more different types of monosaccharide units or their derivatives. e.g.hyaluronicacid.

  Starch

- It is the storage form of glucose in plants, e.g. in potato. Starch is composed of two constituents. 1- ***amylose*** and***.*** ***2- amylopectin***

  Amylose is a linear polymer of D-glucose units joined by α-1 → 4 glycosidic linkages

- Amylopectin: amylopectin is a **branched** polymer,it is structurally identical to those of amylose (α-1→ 4 glycosidic linkages) but with side chains joining them by α-1→ 6 linkages.Thus, having both α-(1 → 4) and α-(1 → 6) linkages.

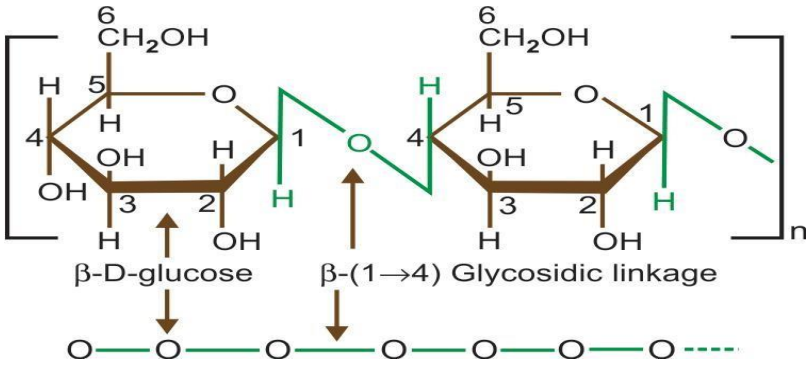
- **Glycogen (Animal Starch)**
- Glycogen is the major storage form of carbohydrate(glucose) in animals, found mostly in liver and muscle.
- It is often called ***animal starch****.*
- The structure of glycogen is similar to that of amylopectin, except that it is more highly branched,

  Functions of **glycogen**

- The function of muscle glycogen is to act as a readily available source of glucose for energy within muscle itself.
- Liver glycogen is concerned with storage and maintenance of the blood glucose

Cellulose

- Cellulose is the chief constituent of cell wall of plants.
- It is an unbranched *polymer* of glucose and consists of long straight chains which are linked by β-(1→4) glycosidic linkages and not α-(1→ 4) as in amylase.
- Since humans lack an enzyme **cellulase** that can hydrolyze the β-(1→ 4) glycosidic linkages, ***cellulose cannot be digested and absorbed*** and has no food value unlike starch. However, the ruminants can utilize cellulose because they have in their digestive tract microorganisms whose enzymes hydrolyze cellulose



Structure of cellulose