structure of carbohydrates

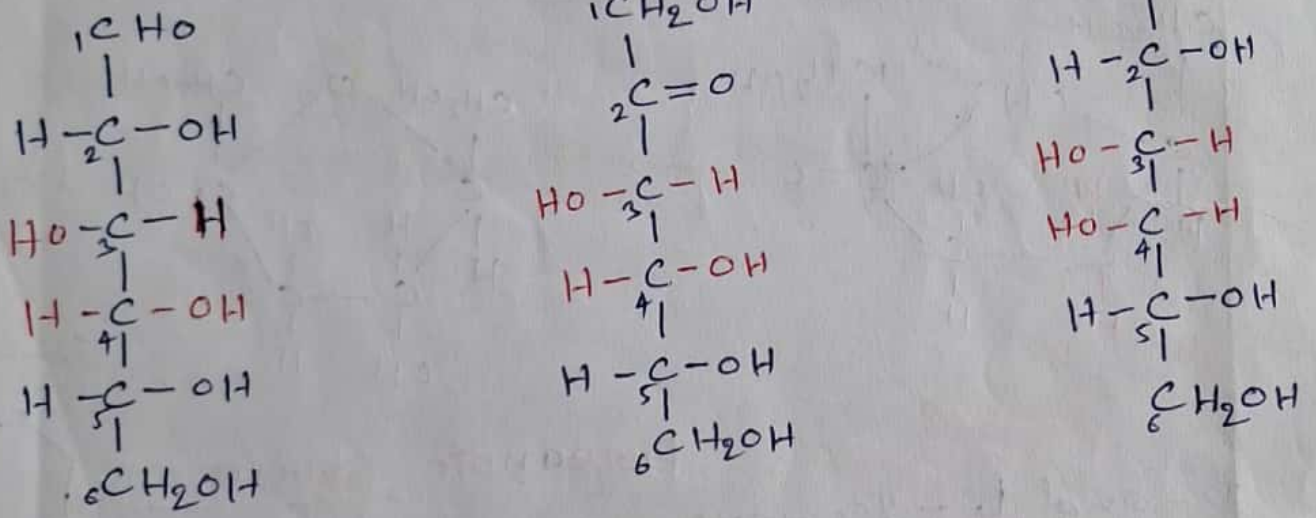
1) **Monosaccharides** :- structure of Hexose having 6 carbon. Two types of structure → Linear and cyclic structure

Molecular formula : $C_6H_{12}O_6$

i) **Linear structure** :-

Monosaccharides (Linear structure)

- Glucose
- Fructose
- Galactose



Fischer Projection (Linear structure 2 to 3%)

ii) cyclic ~~cyclic~~ **structure** :- The molecules Glucose, Fructose & Galactose are usually remain in cyclic form (in solution) called Haworth Projection.

cyclic structure

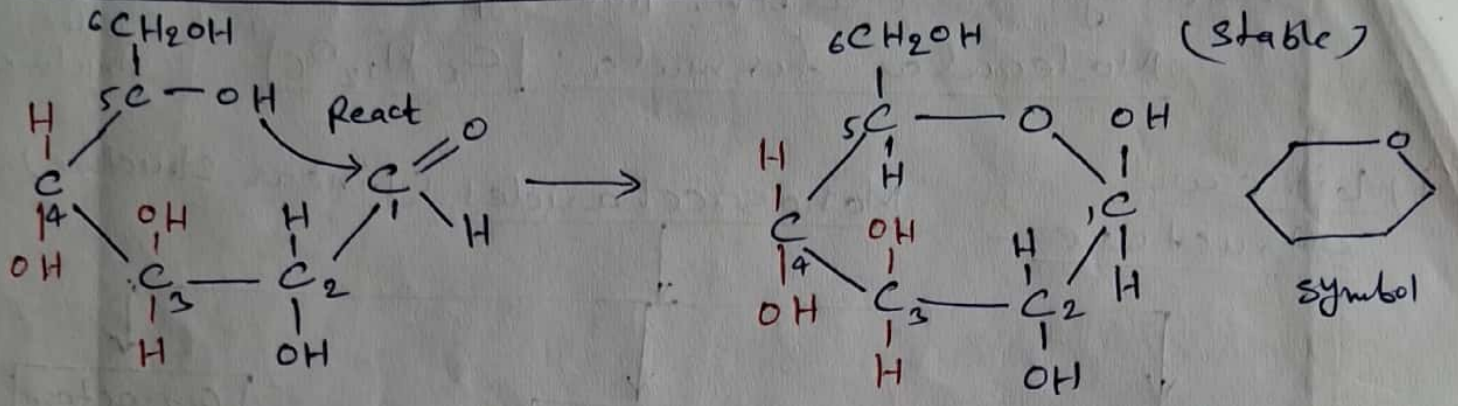
- Pyranose structure
- Furranose structure

(2)

Ex:- Pyranose → Glucose, Galactose

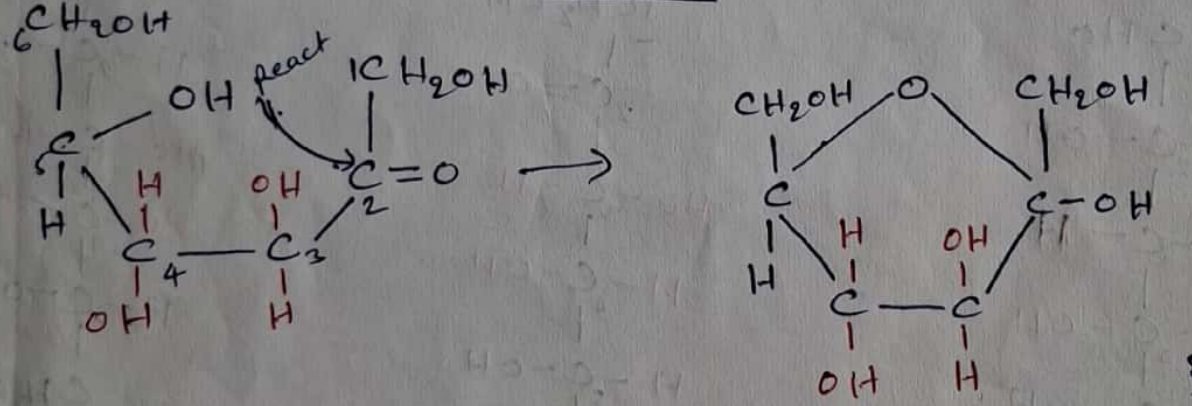
Furranose → Fructose

Cyclic Structure of Glucose:



Pyranose structure

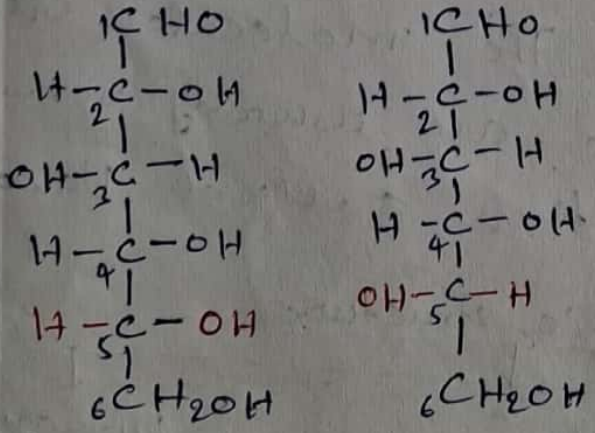
Cyclic structure of Fructose:



Furranose structure

D- and L-Isomers:

- orientation of -H & -OH groups on the 5th carbon determines D and L isomers.



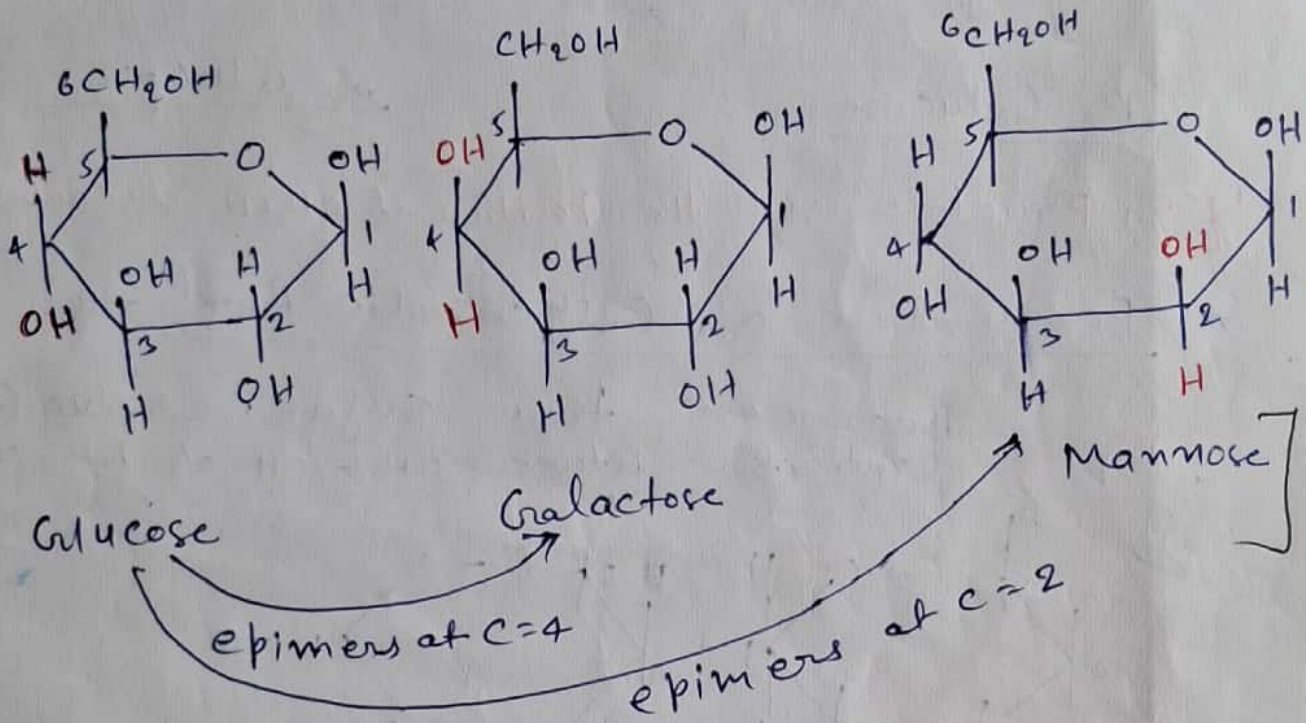
D-Glucose L-Glucose

-OH group at right on 5th carbon → D-isomer

-OH group at left on 5th carbon → L-isomer

[Mannose, Glucose, Galactose all are epimers of each other (i.e isomers → molecular formula same)

Epimers → Isomers in which orientation of -H or -OH is different at a particular carbon.



Anomers :-

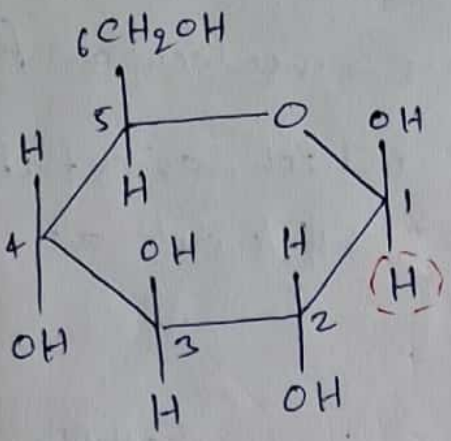
Anomers (Isomers)
(see position of H at C-1)

α-forms
(-H is above)

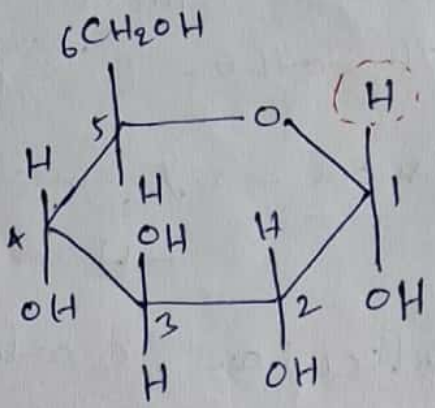
β-forms
(-H is below)

④ β - below (H)
α - above (H)

See Position of H at Carbon 1



β - Glucose

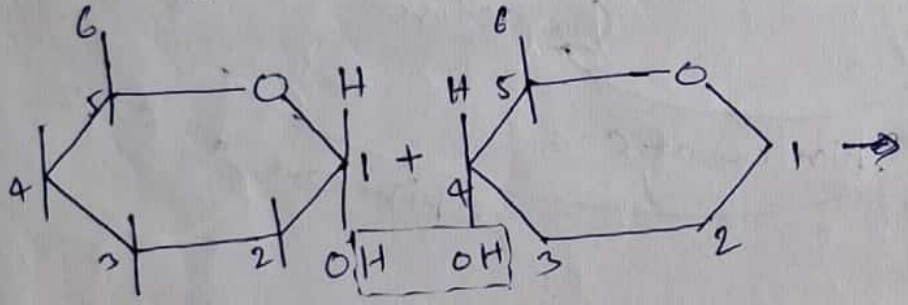


α - Glucose

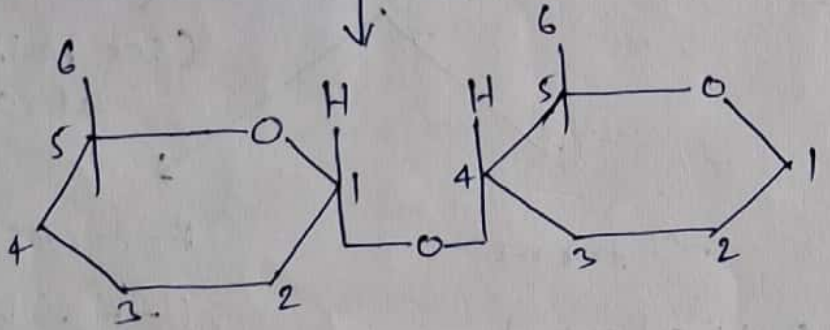
[In Fructose see the position of CH_2OH at carbon 1]

Formation of Glycosidic Bond →

Between two sugar residues (or Molecules)
(Interaction between OH & OH of both sugar)



$-H_2O$

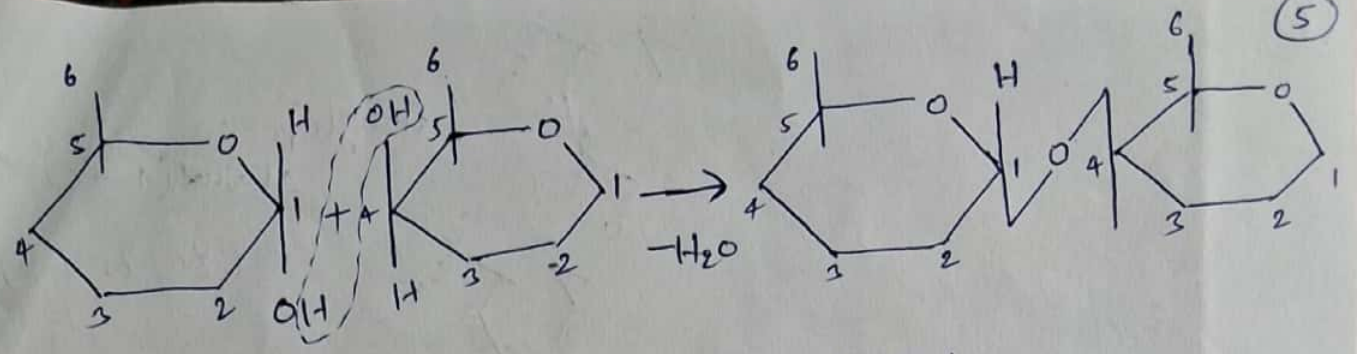


α (1-4) linkage

- H from ④ sugar 1

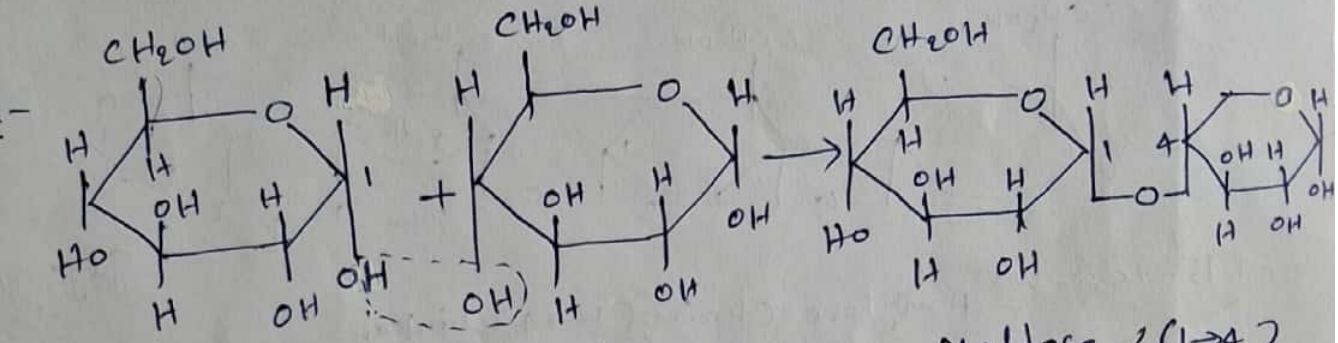
H_2O molecule removed.

- OH from sugar 2



β(1→4) linkage

Ex:-



α-Glucose + α-Glucose → Maltose α(1→4) linkage

Polysaccharides:- Ex:- starch (stored form of sugar in plant)

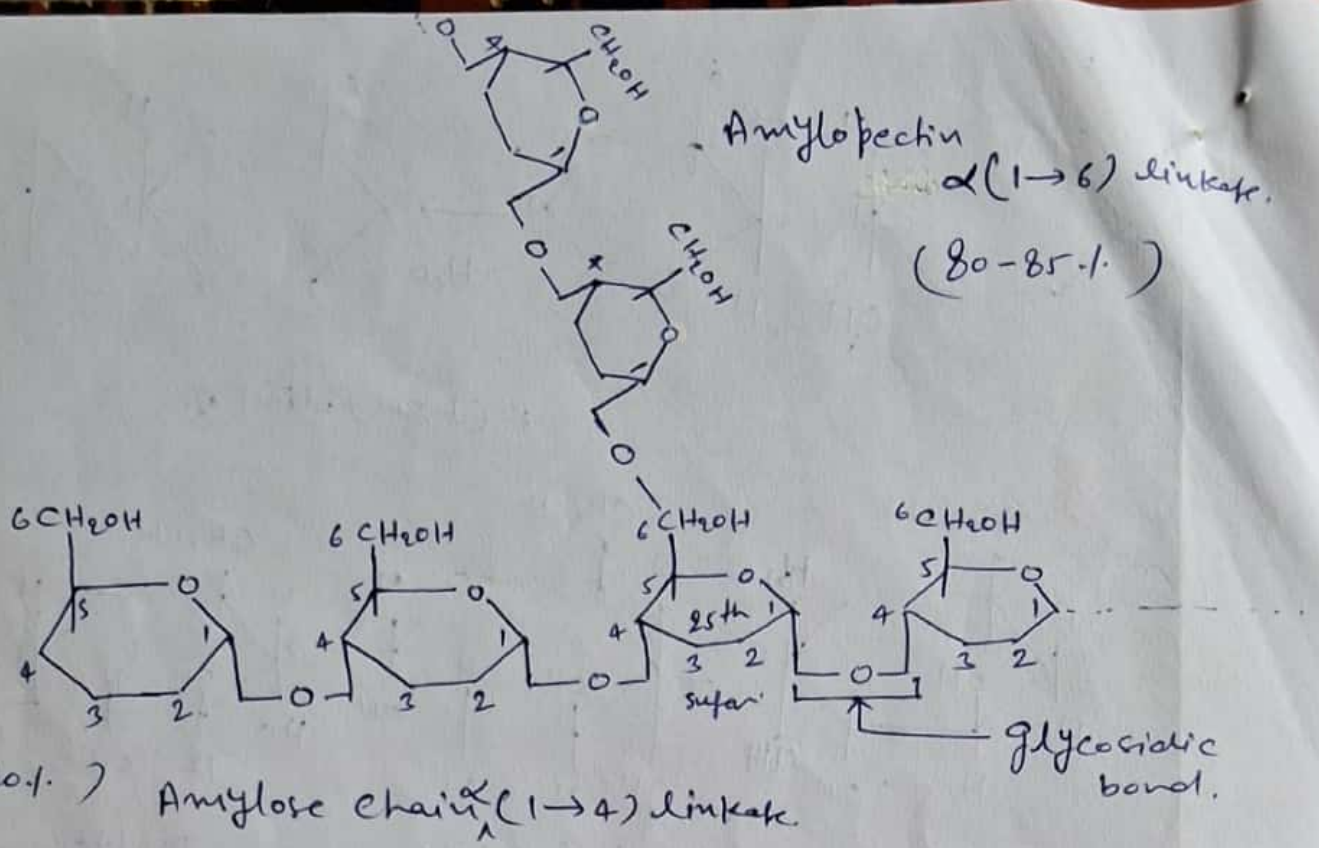
[⇒ The two main constituents are amylose (15-20%) which has non-branching structure. Glucose molecules united by α(1→4) linkage.

⇒ And amylopectin (80-85%) which consists of branched chains composed of 24-30 glucose molecules united by α(1→4) linkage in chain & by α(1→6) linkage at the branch points]

Starch is a Homopolysaccharides

Monomer: α-Glucose

P.T.O



[Glycogen (Animal starch) :-

⇒ It is highly branched than amylopectin.

⇒ It is the storage polysaccharide in human/animals.

⇒ It is a homopolymer of α-glucose in α-(1→4) linkage

⇒ It is highly branched, with α-(1→6) branch linkage occuring every (8-11) Molecules (or residues).

Cellulose (Plant)

⇒ Insoluble polysaccharides.

⇒ It consist of β-Glucose molecules linked by β(1→4) bonds to form long, straight-chains.

⇒ Cellulose cannot be digest by human because of the absence of an enzyme that hydrolyzes the β-linkage.]

Structure - based Function of carbohydrates:

Carbohydrates are essential biomolecules in our bodies and other living organisms. Their structure directly affects their function in several ways:

1) **Energy source:-**

i) **Monosaccharides (simple sugars):-** simple sugars like Glucose provide quick energy because they are easily broken down.

ii) **Polysaccharides (complex sugars):-** Like starch in plants and glycogen in animals, store energy for later use.
Their branch structures allow for quick energy release when needed.

2) **structural support:-**

i) **Cellulose:-** Found in plant cell walls, gives plants their strength. Its long chains of sugar molecules form strong fibers.

ii) **Chitin:-** Found in the exoskeletons of insects and in fungal cell walls, provides toughness and flexibility

(6) 3) Cell communication :-

Glycoproteins and Glycolipids :- These are sugars attached to proteins and fats on cell surfaces. These are oligosaccharides. They help cells recognize each other, communicate and interact, which is important for immune response and harmone functions.

4) Protection & Lubrication :-

Mucopolysaccharides :- These are long unbranched polysaccharides. Like hyaluronic acid, found in joints and connective tissues, help retain water and provide lubrication and shock absorption in joints.

5) Building blocks for other Molecules :-

Nucleic Acids :- sugar like ribose and deoxyribose are part of DNA & RNA, which are essential for genetic information storage and transfer.

6) Diversity & specific Functions :- The ability of Carbohydrate to form different structures (form various isomers), allows them to perform a wide range of function. from providing energy to supporting cell structure.

There are various applications of carbohydrates in engineering:

1) **Biopolymers** :- Polysaccharides like cellulose, starch and chitin are used as biodegradable polymers in engineering applications such as packaging materials, biomedical devices and construction materials.

2) **Biofuels** :- Carbohydrates serve as a feedstock for biofuel production through fermentation or enzymatic processes, contributing to renewable energy sources.

3) **Adhesives** :- Carbohydrate-based adesives are used in wood products, paper manufacturing and textiles due to their biocompatibility and sustainability.

4) **Water Treatment** :- Polysaccarides (like alginate and chitosan) are employed in water treatment processes for their ability to absorb heavy metals and pollutants.

5) **Food Engineering** :- Carbohydrates play a crucial role in food engineering, serving as thickeners, stabilizers and texture modifiers in various food products.

6) Drug Delivery systems:

Carbohydrate-based nanoparticles are utilized in drug delivery systems due to their biocompatibility and ability to target specific tissues or cells.

These applications highlight the importance of carbohydrates in engineering.