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# **CARBOHYDRATES**

## **Structure and properties**



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## Importance

- Comprise one of the major groups of naturally occurring bio-molecules
- Structural material in plants is mainly cellulose and hemicelluloses
- Contain carbon, hydrogen, and oxygen and is represented by the formula  $C_x(H_2O)_y$
- Starch is the important form of storage polysaccharide in plants, and pectins (sucrose) and sugars (glucose)
- Non-carbohydrate organic molecules are conjugated with sugars – glycosides
- Carbohydrates with proteins in animals - glycoproteins



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## Properties and Importance

- Some may contain nitrogen, sulfur, and phosphorus.
- Chemically defined as polyhydroxy aldehydes or ketones, their derivatives and their polymers.
- Storage form of carbohydrates in animals – glycogen
- Chitin found in exoskeleton of lower animals is a polymer of N-acetyl glucosamine.
- Fatty acid esters of sugar alcohol – glycerol
- Ribose and deoxyribose – constituents of nucleic acids.
- Basic raw material for sugar and sugar products, paper and wood pulp, textiles, plastic, food processing.



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## Classification of Monosaccharides

- Classified into three major groups:
  - Monosaccharides
    - Simplest forms, low molecular weight, consisting of a single polyhydroxy aldehyde or ketone unit
    - Crystalline, soluble in water, and sweet in taste
    - Classified as triose, tetrose, pentose based on the number of carbon atoms
    - All monosaccharides are reducing in nature
    - Classified further into simple monosaccharides, and derived monosaccharides



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## Structure of Monosaccharides

- Represented by three types of formula:
  - Fischer projection – constructed on the convention that the tetrahedral apexes connecting the asymmetric carbon atoms be in a line in the plane of projection
  - Haworth represented carbohydrates as cyclic compounds
  - Stable conformational formulae are of chair conformations
- Biose ( $C_2H_4O_2$ ) – glycolic aldehyde is the only member, crystalline, sweet and readily soluble in water
- Trioses ( $C_3H_6O_2$ ) – occur in plant and animal tissues in small amounts and derived from breakdown of glucose
- Tetroses ( $C_4H_8O_4$ ) – Erythrose and threose



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## Structure of Monosaccharides

- Tetroses ( $C_4H_8O_4$ ) – Erythrose and threose
- Pentoses ( $C_5H_{10}O_5$ ) – Ribose, arabinose, and ribose, and deoxyribose
- Hexoses ( $C_6H_{12}O_6$ ) – glucose (dextrose) – main source of energy, occurs in the free state in many fruits (2 -6%), fructose (fruit sugar), galactose (does not occur free in nature but occurs as a constituent of lactose)



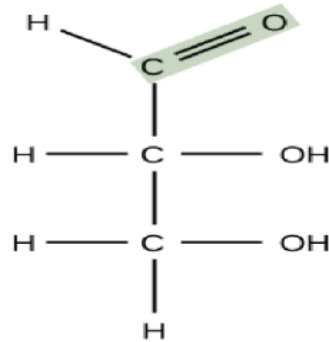
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# Structure of Monosaccharides

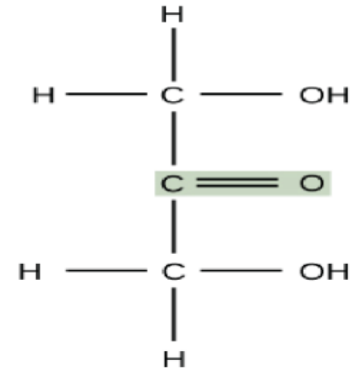
## MONOSACCHARIDES

**Glyceraldehyde**



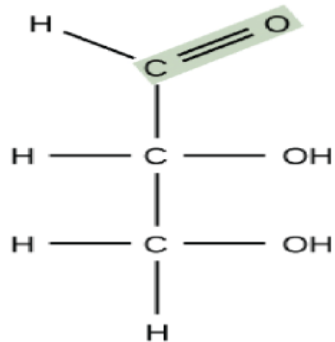
**Aldose**

**Dihydroxyacetone**



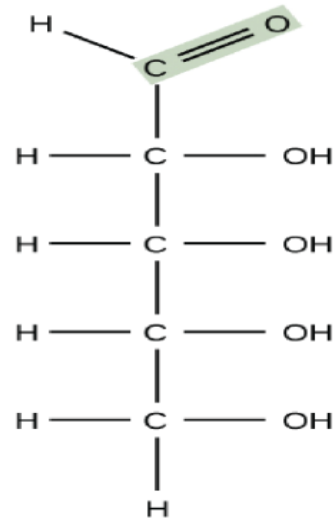
**Ketose**

**Glyceraldehyde**



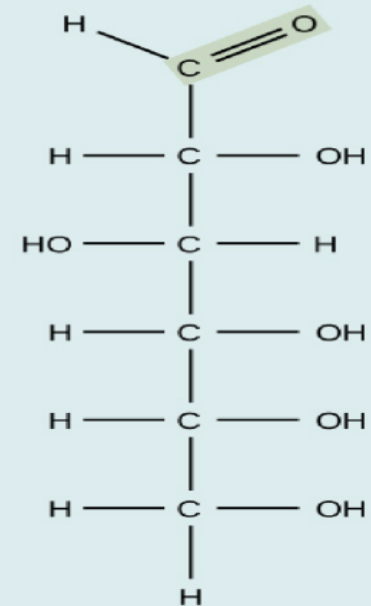
**Triose**

**Ribose**



**Pentose**

**Glucose**



**Hexose**



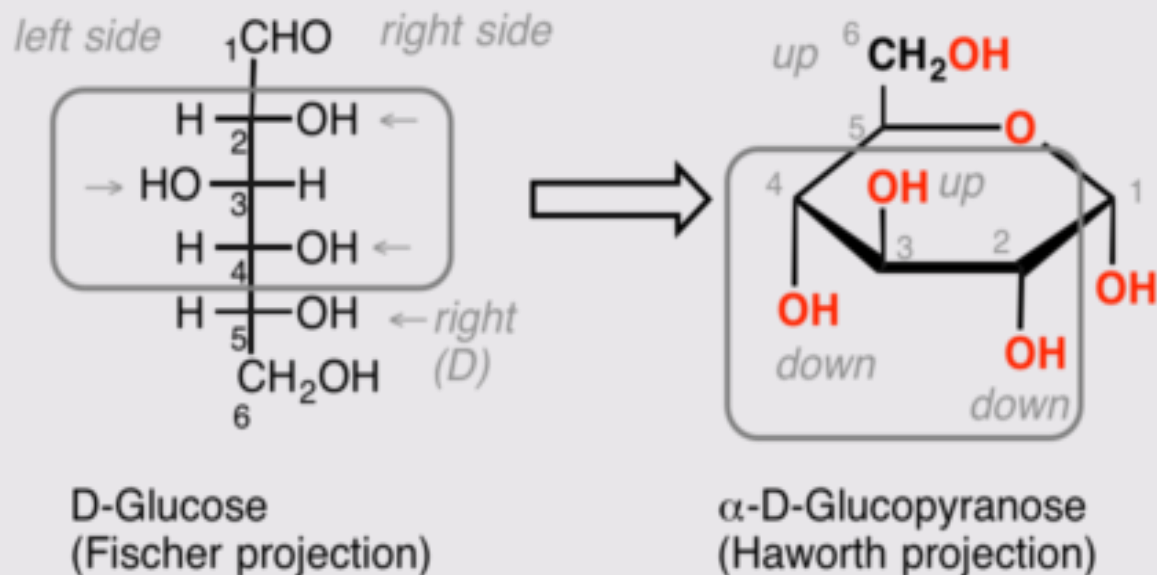
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# Structure of Glucose

## Converting a Fischer Projection to A Haworth Projection

e.g. "convert D-glucose to the cyclic  $\alpha$ -pyranose form as a Haworth projection"



## Some "tricks" for converting a Fischer to a Haworth

For  $C_2$ ,  $C_3$ , and  $C_4$  : right side  $\rightarrow$  down (e.g.  $C_2$ ,  $C_4$ )  
left side  $\rightarrow$  up (e.g.  $C_3$ )

For  $C_5$  : if OH is on right, it's a D-sugar ( $\text{CH}_2\text{OH} \rightarrow$  up)

For  $C_1$  : the  $\alpha$  anomer has OH  $\rightarrow$  down (for D-sugars)  
the  $\beta$  anomer has OH  $\rightarrow$  up (for D-sugars)



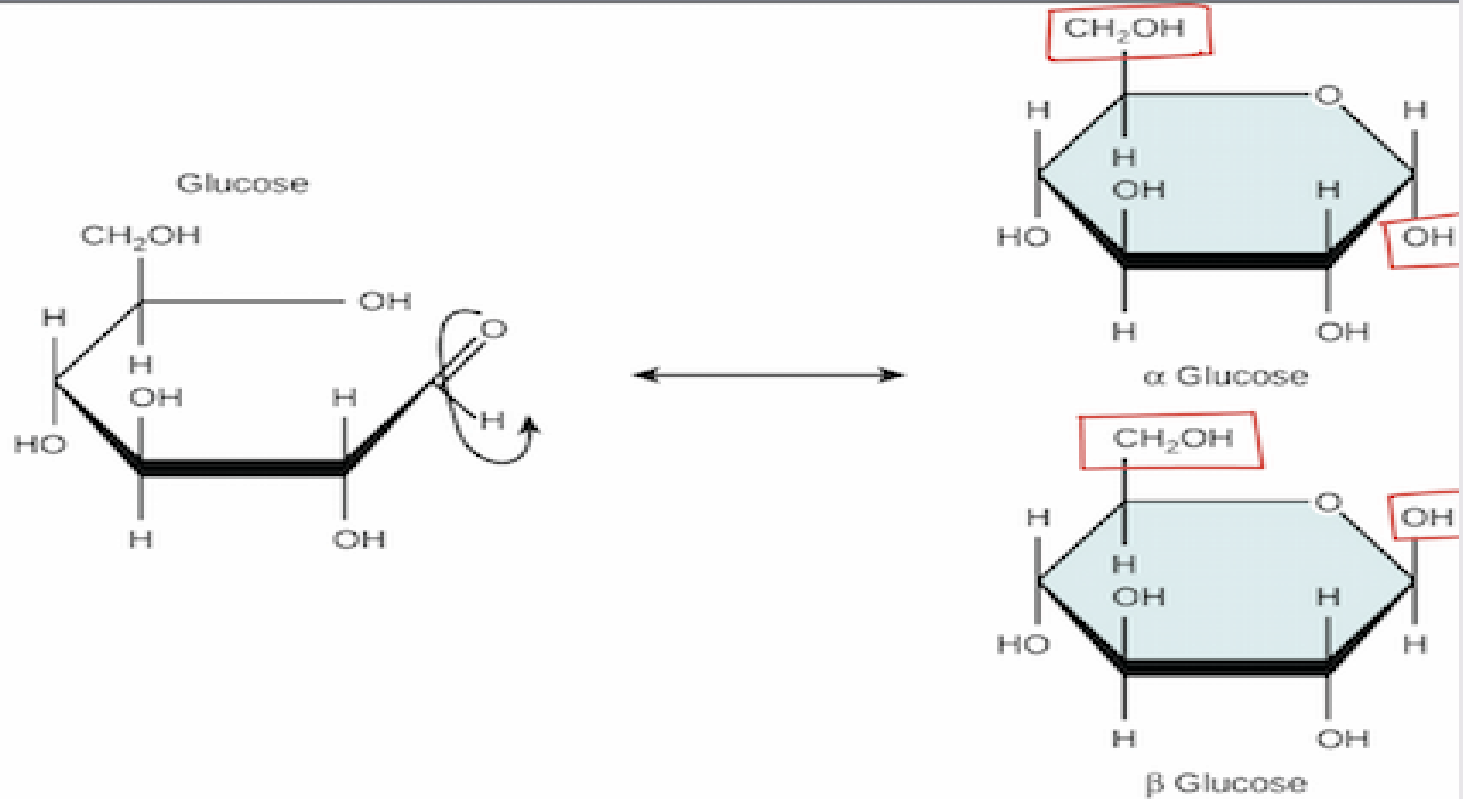


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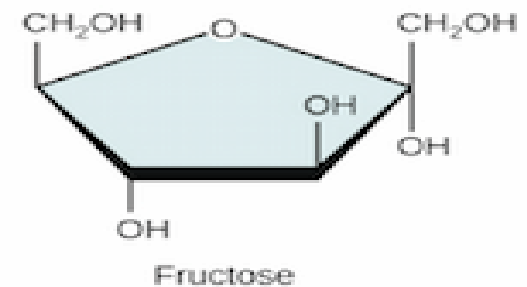
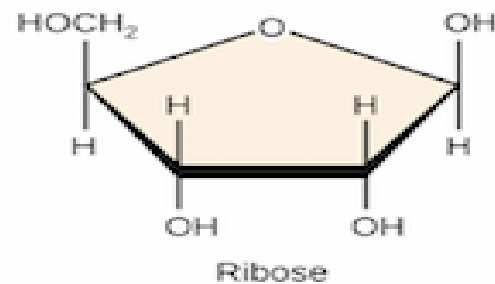
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# Structure of Glucose

## Conversion between Linear and Ring Forms of Glucose



## Ring forms of ribose and fructose





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## Oligosaccharides

- Contain two to ten monosaccharide units joined by glycosidic linkages that can be easily hydrolyzed
- Physiologically important disaccharides are maltose, lactose, sucrose
- Disaccharides consist of two monosaccharides joined covalently by an O-glycosidic bond
- When only one anomeric carbon is involved in glycosidic bond formation, reducing disaccharides are formed
- In case of reducing disaccharides, one end of the molecule having free anomeric carbon is called reducing end and the other end is called non-reducing end