



# Biochemistry of Carbohydrates II



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# Anomers

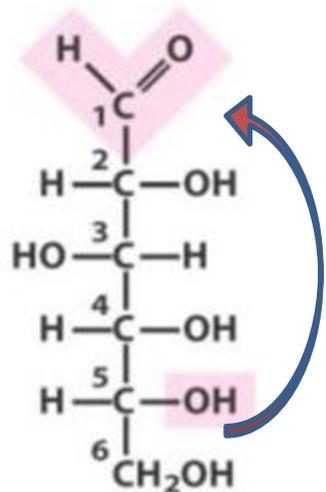


- Anomers are pair of stereoisomers that differ in spatial arrangement of atoms at the anomeric carbon

# Monosaccharide cyclization

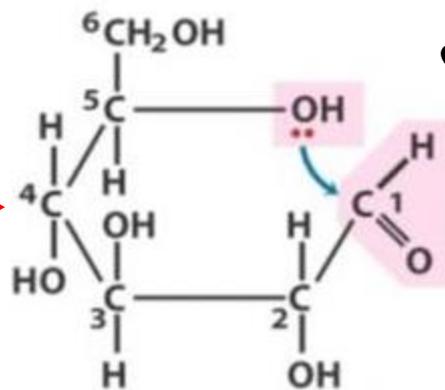


Linear form



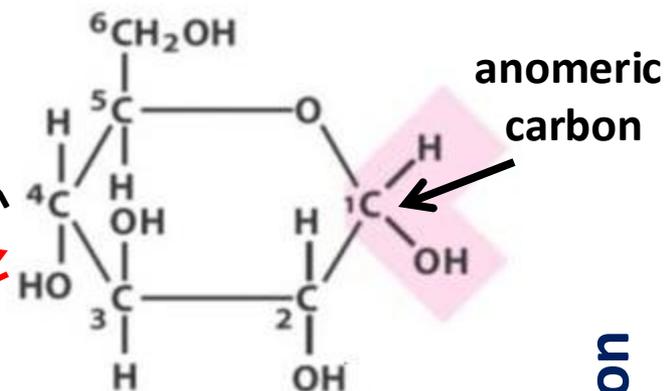
D-glucose

Fisher projection

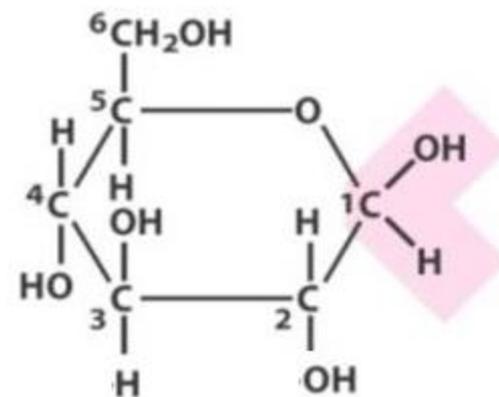


cyclization

cyclization



$\alpha$ -D-glucose



$\beta$ -D-glucose

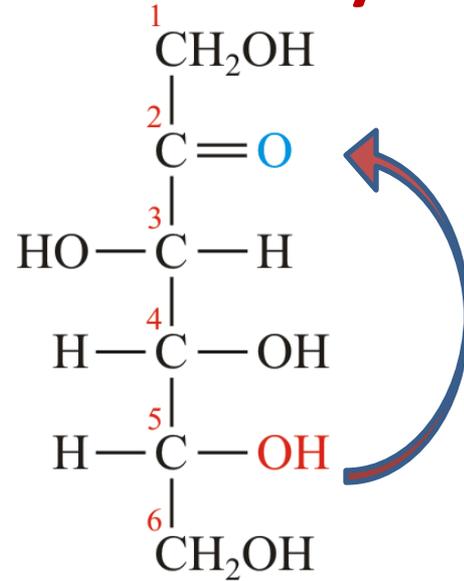
Haworth projection

# Anomers

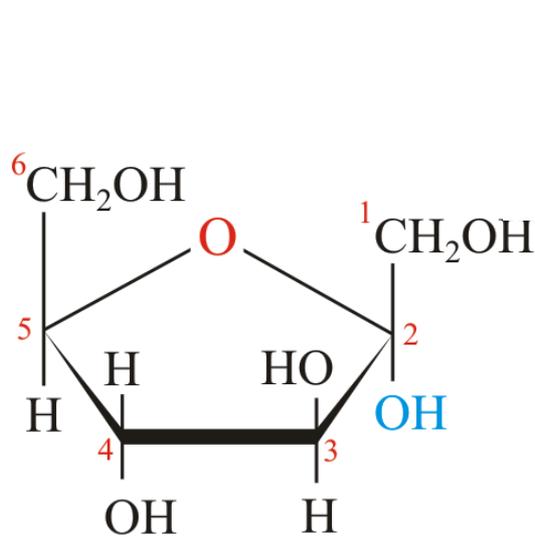


- ❑ Anomers are pair of stereoisomers that differ in spatial arrangement of atoms at the anomeric carbon
- ❑ In cyclic sugars, the carbonyl carbon becomes chiral center (asymmetric carbon) with two possible configurations:  $\alpha$  and  $\beta$ . This new carbon is called anomeric carbon.
- ❑ In  $\alpha$ -anomer, the OH group of the anomeric carbon is projecting down the plane of the ring and on the opposite side of the terminal  $\text{CH}_2\text{OH}$  group (in Fisher projection) and vice versa in  $\beta$ -anomer.
- ❑ The anomers freely interconvert in aqueous solution, e.g. at equilibrium D-glucose is a mixture of  $\beta$ -anomer (63.6%),  $\alpha$ -anomer (36.4%) and extremely tiny amounts of the straight chain.

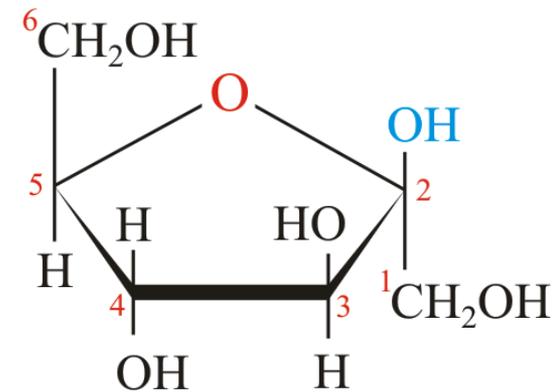
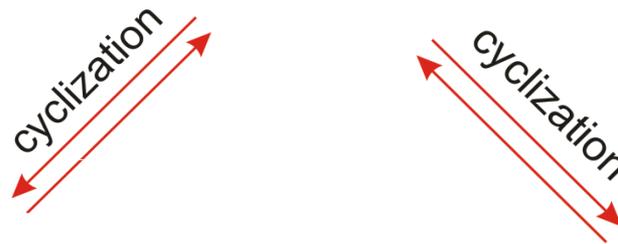
# Monosaccharide cyclization



**D-fructose**  
**Linear form**



**α-D-fructose**

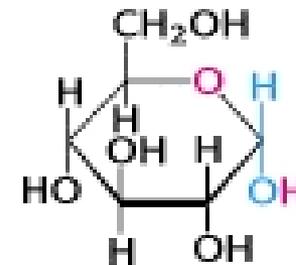
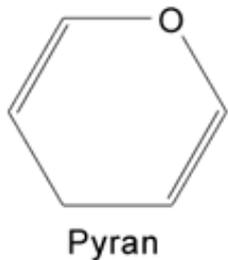


**β-D-fructose**

# Pyranoses & Furanoses

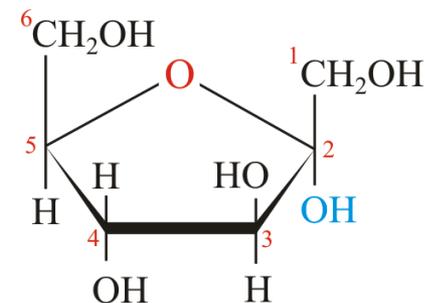
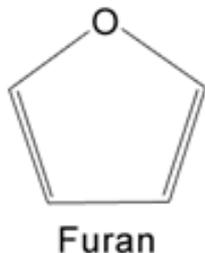


- ❑ Sugars with six-membered rings are known as pyranoses (e.g. glucopyranose) as they resemble the heterocyclic compound pyran.



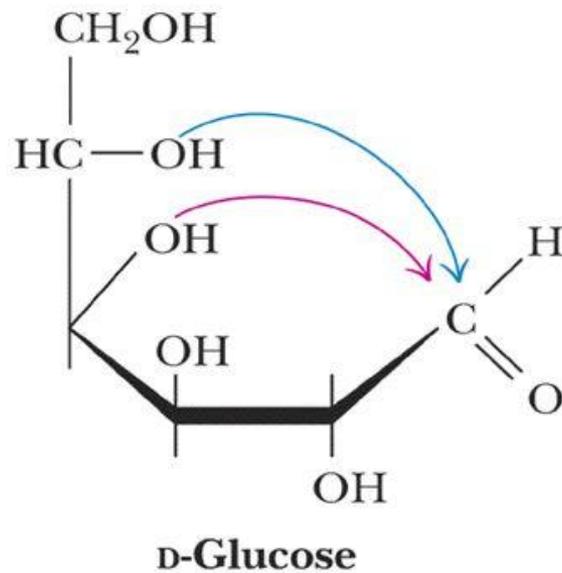
**$\alpha$ -D-glucopyranose**

- ❑ Sugars with five -membered rings are known as furanoses (e.g. fructofuranose) as they resemble the heterocyclic compound furan.

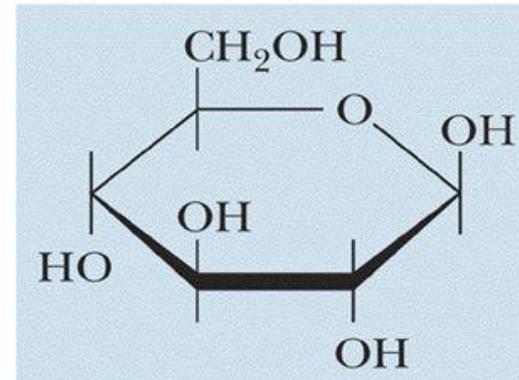


**$\alpha$ -D-fructofuranose**

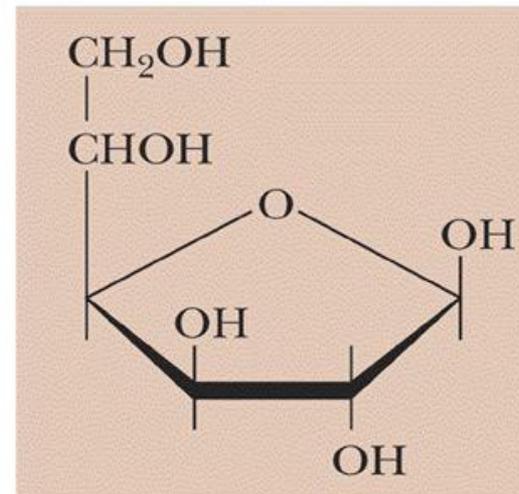
# Pyranoses & Furanoses



D-glucose can cyclize in two ways forming either furanose or pyranose structures



**Pyranose form**  
 $\beta$ -D-glucopyranose

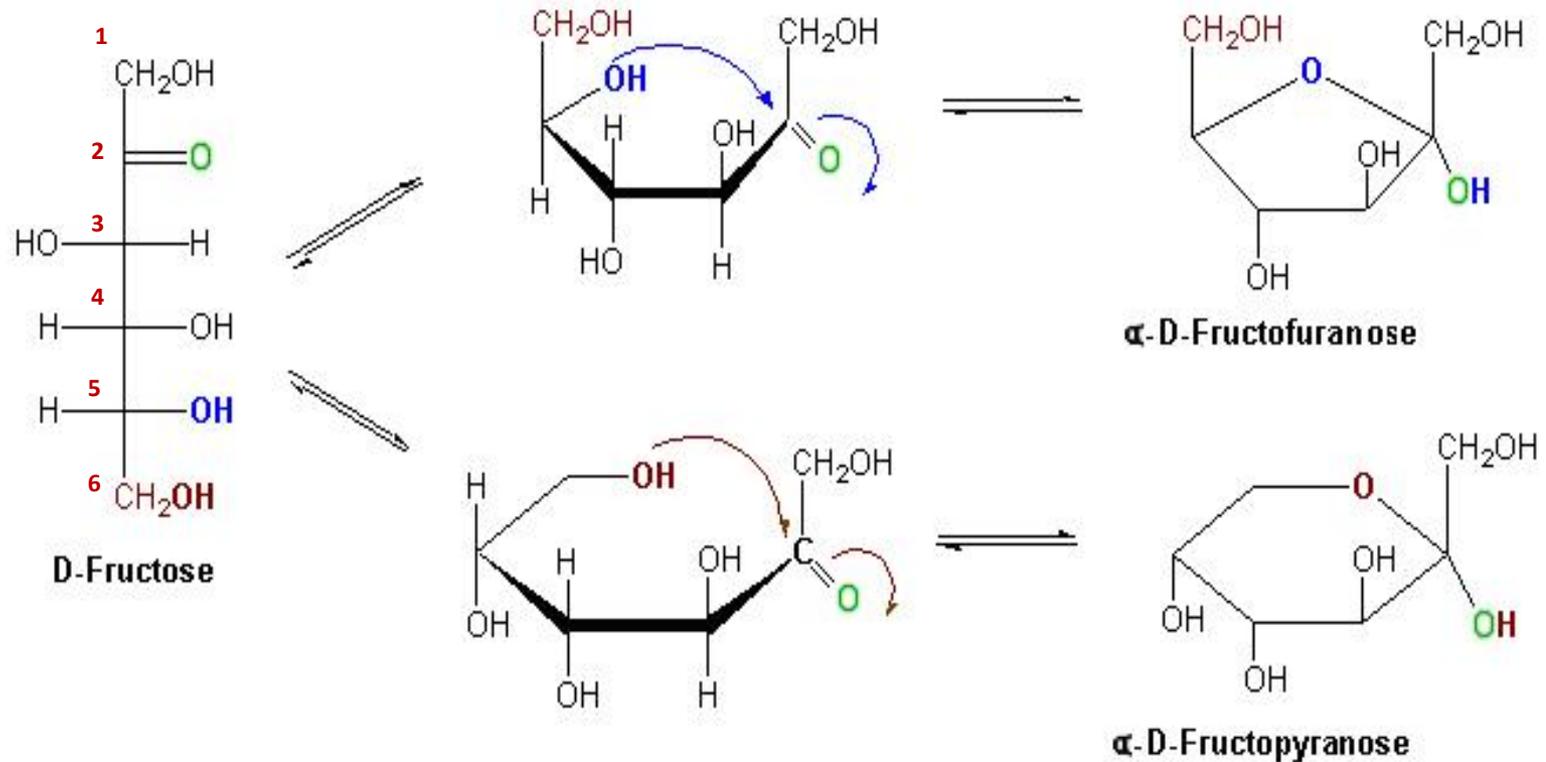


**Furanose form**  
 $\beta$ -D-glucofuranose

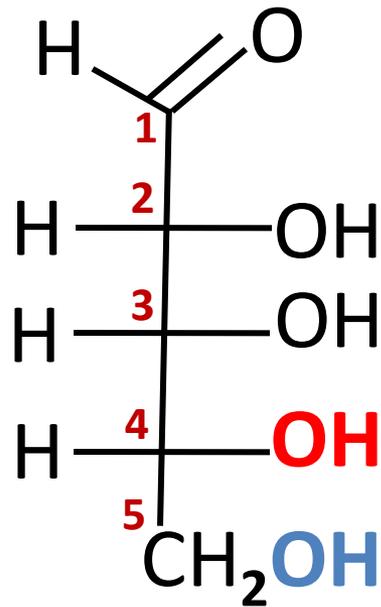
# Pyranoses & Furanoses



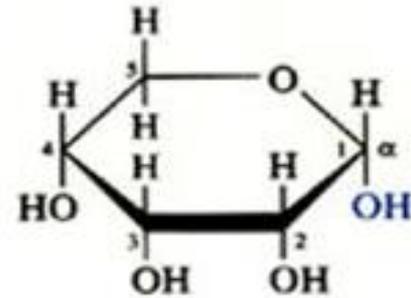
## Isomeric Forms of Fructose



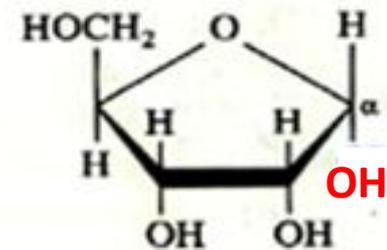
# Pyranoses & Furanoses



**D-ribose**  
**Fisher projection**



**$\alpha$ -D-Ribopyranose**  
(Haworth projection)



**$\alpha$ -D-Ribofuranose**  
(Haworth projection)

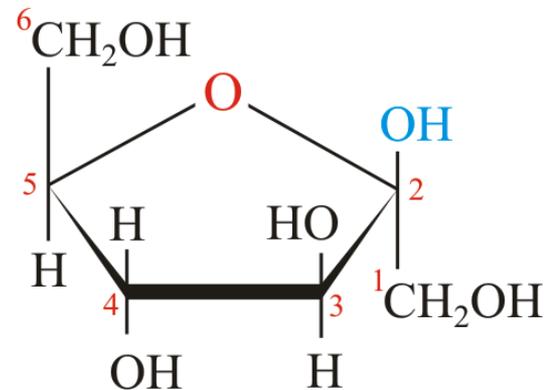
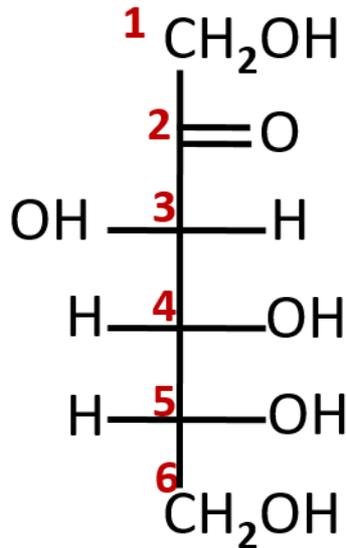
□ Hexose or pentose can exist in pyranose and furanose forms (the most stable rings). e.g. in solution, glucose and fructose are **mostly** pyranoses whereas ribose is **mostly** furanose

# Haworth Projection



- Haworth projection is a simple 3D way to represent the cyclic monosaccharides.

Fisher projection



$\beta$ -D-fructose

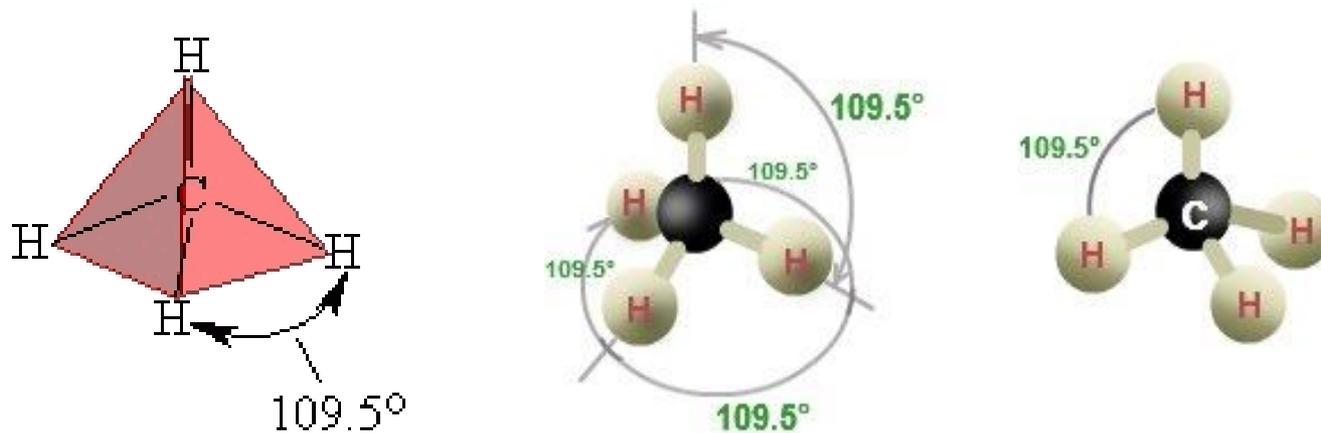
Haworth projection

# Conformers

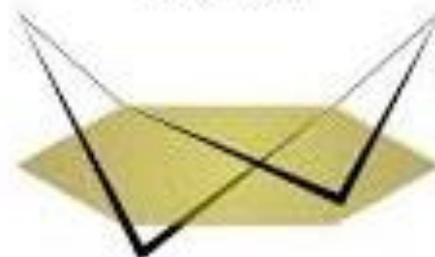
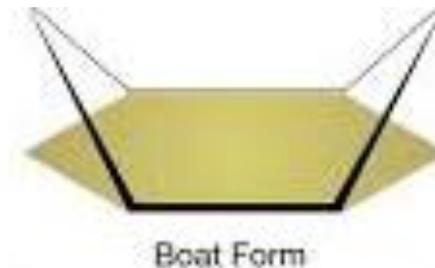
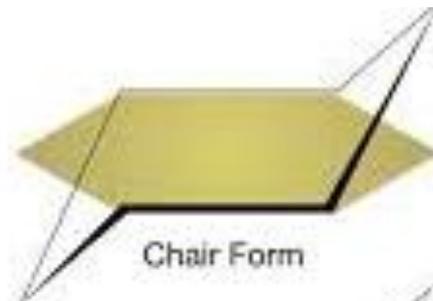


- The geometry of the carbon atoms of monosaccharide ring is tetrahedral (bond angles are close to  $109.5^\circ$ ), so sugar rings are not actually planar. For example, pyranoses take on either **Chair** or **Boat** conformations (conformational isomers or conformers).

# Conformers



**Carbon atoms are tetrahedral**

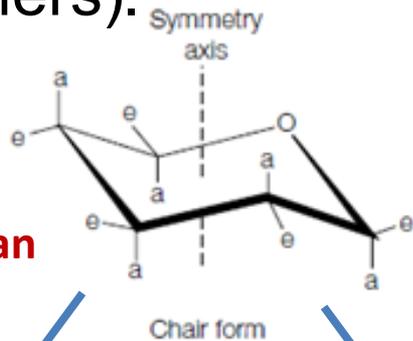


**Conformers are stereoisomers with different rotations about single bonds**

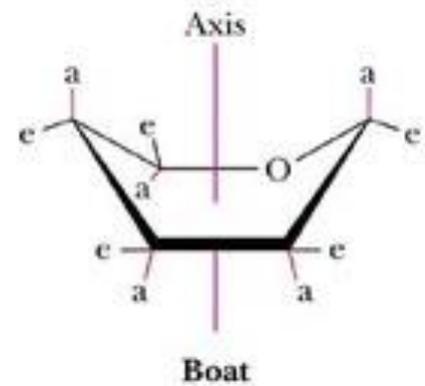
# Conformers



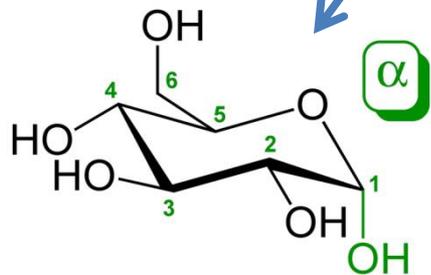
□ The geometry of the carbon atoms of monosaccharide ring is tetrahedral (bond angles are close to  $109.5^\circ$ ), so sugar rings are not actually planar. For example, pyranoses take on either **Chair** or **Boat** conformations (conformational isomers or conformers).



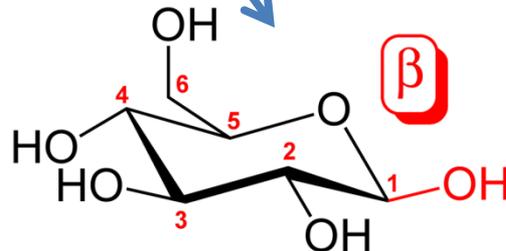
a: axial  
e: equatorial



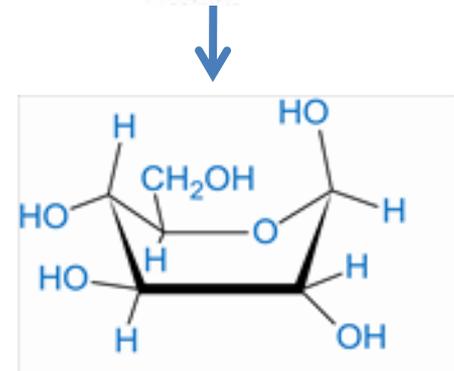
**$\alpha$  is Less stable than  $\beta$  due to steric repulsion**



Chair form of  $\alpha$ -D-glucose



Chair form of  $\beta$ -D-glucose



Boat form of  $\beta$ -D-glucose

# Sugar Modification

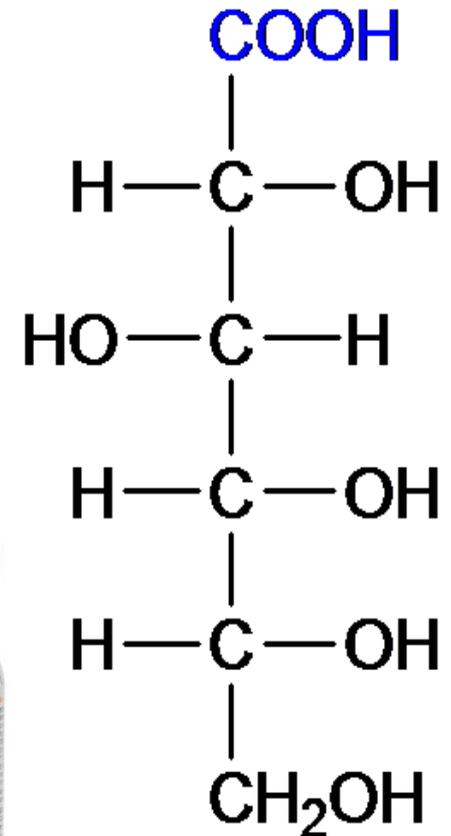


1. **Aldonic acids** : oxidation of aldehyde (C1) to carboxylic acid; e.g. D-gluconic acid

- **Uses:**

- Some drugs are injected in the form Of **gluconate** (the salt of gluconic acid)

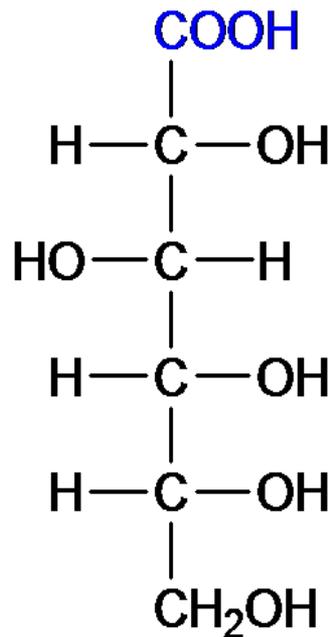
- **Calcium gluconate solution (I.V)** as cardioprotective agent in patients with high blood level of  $K^+$  (6.5 mmol/L) occurring due to kidney failure



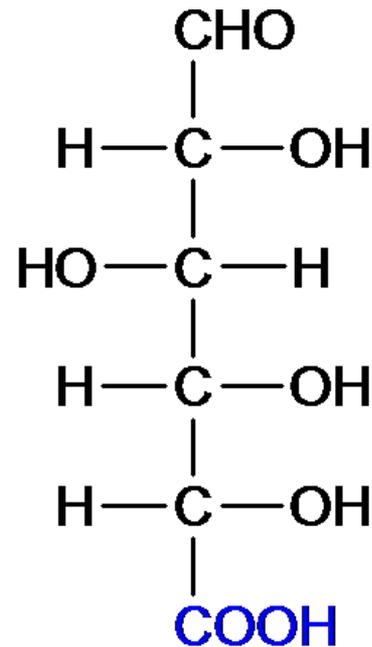
# Sugar Modification



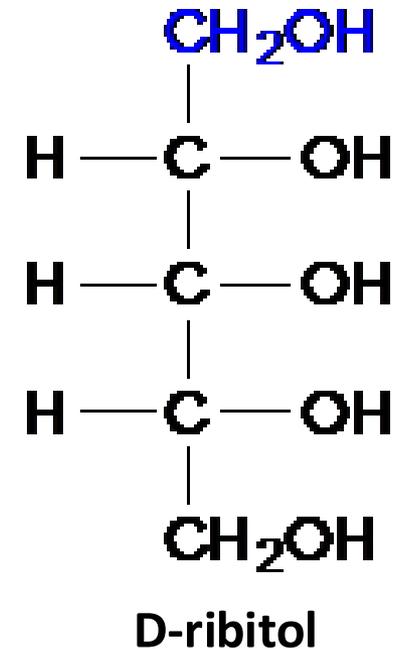
1. Aldonic acids : oxidation of aldehyde (C1) to carboxylic acid; e.g. D-gluconic acid



2. Uronic acids : oxidation of OH at (C6) to carboxylic acid; e.g. D-glucuronic acid



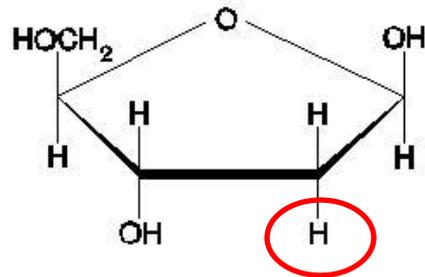
3. Alditols : reduction of carbonyl group to alcohol; e.g. D-ribitol, D-glycerol and D-sorbitol (sweetener)



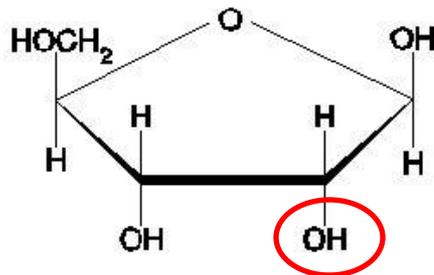
# Sugar Modification



4. Deoxy sugars : OH group is replaced by H; e.g.  $\beta$ -D-2-deoxyribose



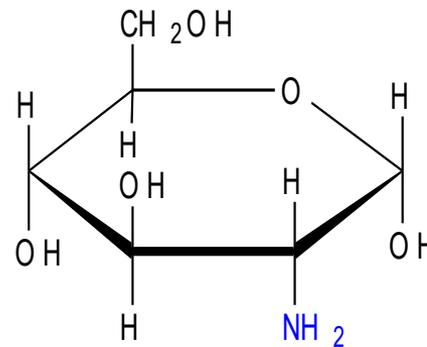
**Deoxyribose**



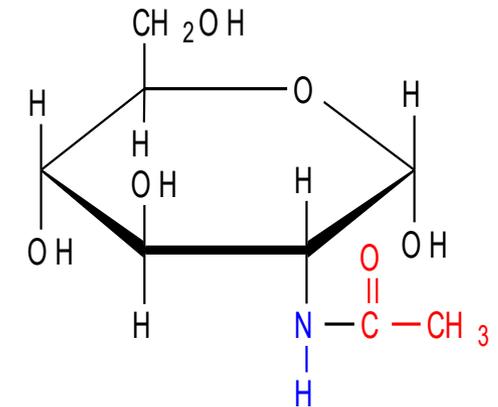
**Ribose**

4. Amino sugars : one or more OH groups are replaced by **amino group** which is often **acetylated**;

- $\alpha$ -D-glucosamine (rebuild cartilage in osteoarthritis & osteoporosis) and  $\alpha$ -D-N-acetylglucosamine (both are derivatives of  $\alpha$ -D-glucose)



$\alpha$ -D-glucosamine



$\alpha$ -D-N-acetylglucosamine

