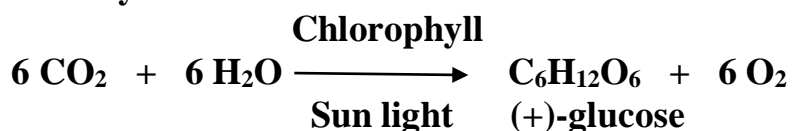


## Carbohydrates

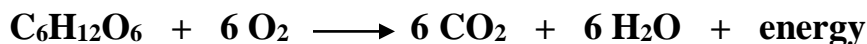
Carbohydrates are a major source of energy from our diet, Composed of The two elements C, H, and O. called saccharides, which means “sugars”

**Carbohydrates** are produced by photosynthesis in plants. Such as glucose are synthesized in plants from CO<sub>2</sub>, H<sub>2</sub>O, and energy from the sun .are oxidized in living cells (respiration) to produce CO<sub>2</sub>, H<sub>2</sub>O, and energy.

## Photosynthesis



## Respiration



**Carbohydrates can be define as a Polyhydroxy aldehydes or polyhydroxy-ketones of, or compounds that can be hydrolyzed to them.**

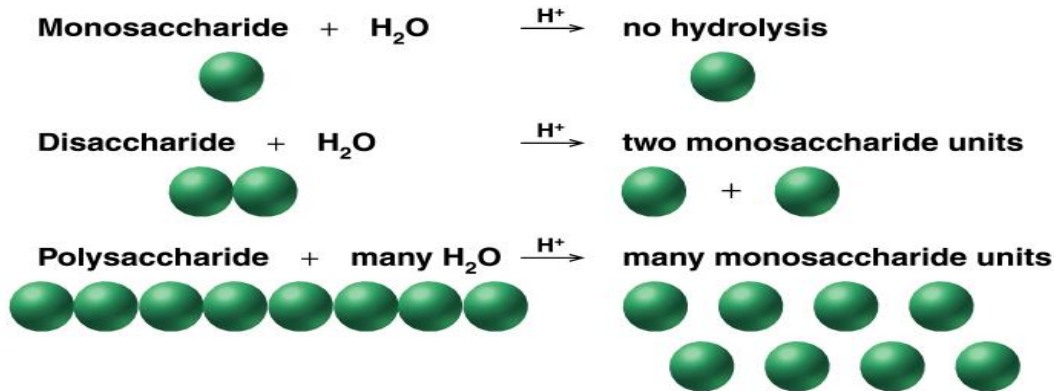
There are two type of carbohydrate upon the functional group :-

- Aldose – polyhydroxy aldehyde, eg . glucose
- Ketose – polyhydroxy ketone, eg . fructose

## *Types of Carbohydrates*

The types of carbohydrates are

- Monosaccharides, the simplest carbohydrates.
- Disaccharides, which consist of two monosaccharides.
- Oligosaccharides which consist of 3 to 10 monosaccharides
- Polysaccharides, which contain many monosaccharides.



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### Monosaccharides

Carbohydrates that cannot be hydrolyzed to simpler carbohydrates; eg. Glucose or fructose.

consist of

- 3 to 6 carbon atoms, typically.
- A carbonyl group (aldehyde or ketone).
- Several hydroxyl groups.

### Aldoses

Aldoses are monosaccharides

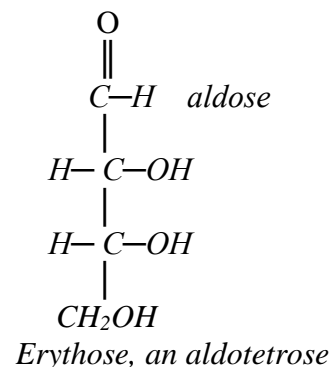
- With an aldehyde group.
- With many hydroxyl (—OH) groups.

*triose* (3 C atoms)

*tetrose* (4 C atoms)

*pentose* (5 C atoms)

*hexose* (6 C atoms)



**Ketoses** are monosaccharides

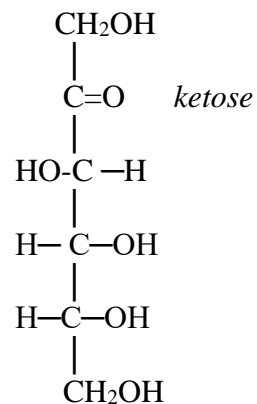
- With a ketone group.
- With many hydroxyl (—OH) groups.

*triose* (3 C atoms)

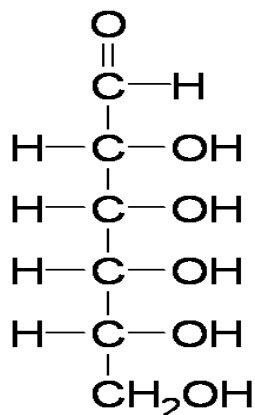
*tetrose* (4 C atoms)

*pentose* (5 C atoms)

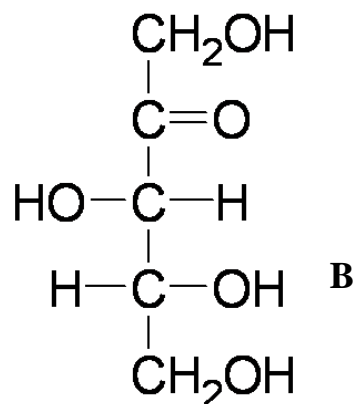
*hexose* (6 C atoms)



Q/ Identify each as aldo- or keto- and as tetrose, pentose, or hexose:



A



B

**Solution**

**A. aldohexose**

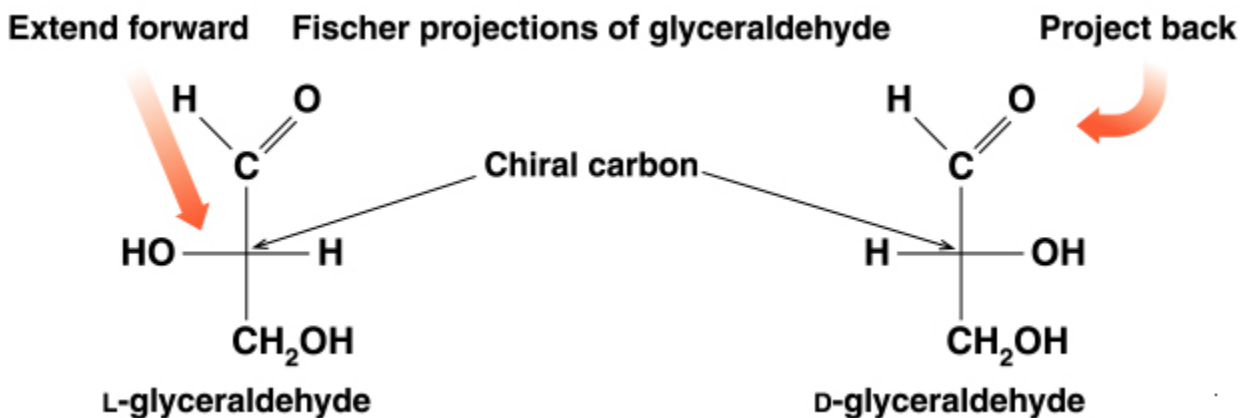
**B. ketopentose**

### *Structures of Monosaccharides*

#### *A Fischer projection*

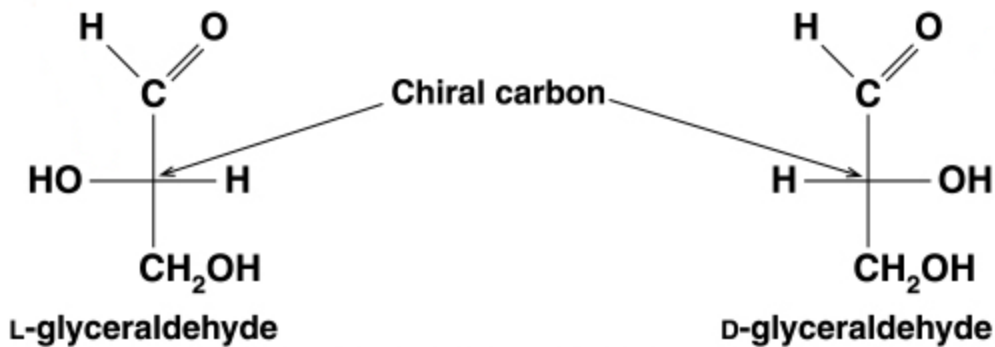
- Is used to represent carbohydrates.
- Places the most oxidized group at the top.

Show s chiral carbons as the intersection of vertical and horizontal lines.

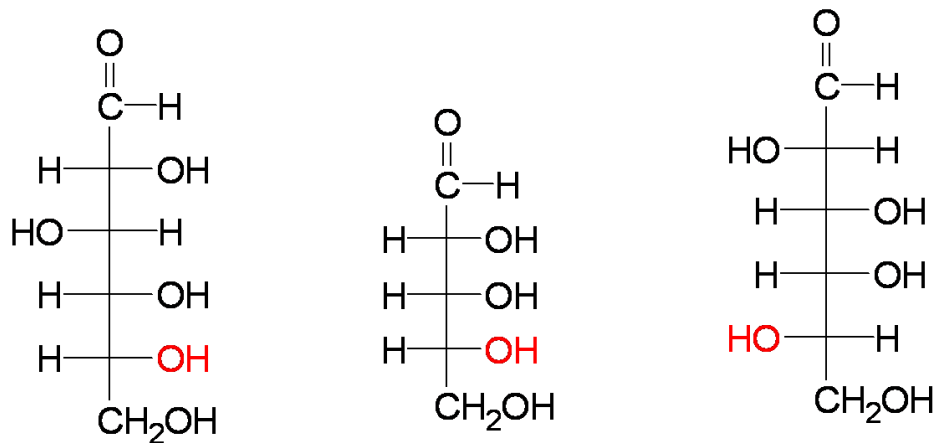


In a Fischer projection, the -OH group on the

- Chiral carbon *farthest from the carbonyl group* determines an L or D isomer.
- Left is assigned the letter L for the L-isomer.
- Right is assigned the letter D for the D-isomer.

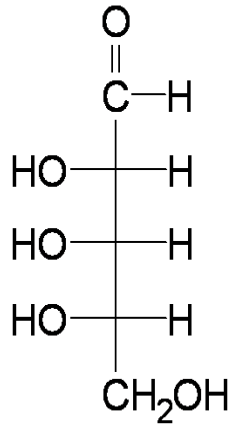


Examples of D and L Isomers of Monosaccharides:-



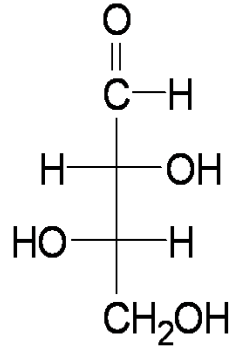
Q/ Identify each as the D or L isomer.

A.



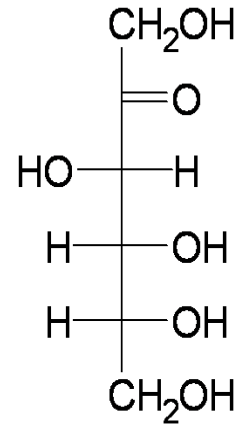
\_\_\_-ribose

B.



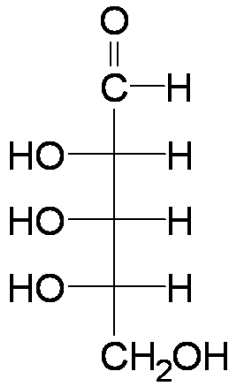
\_\_\_- threose

C.

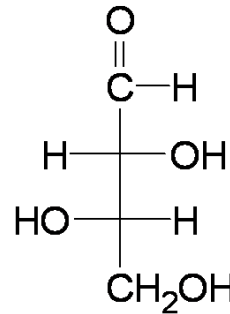


\_\_\_- fructose

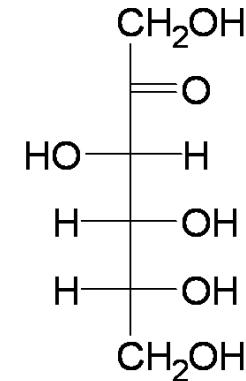
Solution



L-ribose



L-threose

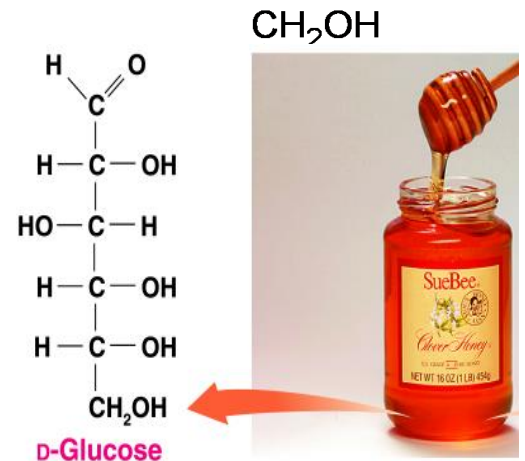


D-fructose

**D-Glucose**

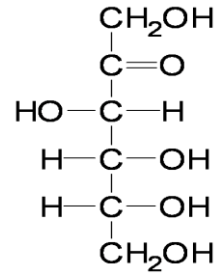
- Found in fruits, corn syrup, and honey.
- An aldohexose with the Formula  $\text{C}_6\text{H}_{12}\text{O}_6$ .
- Known as blood sugar in the body.
- The monosaccharide in polymers of starch, cellulose, and glycogen.

In the body, Glucose has a normal blood level of 70-90 mg/dL



### *D-Fructose*

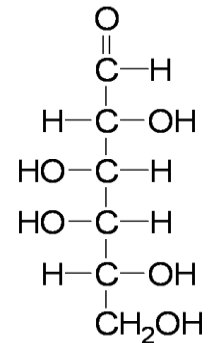
- Is a ketohexose  $C_6H_{12}O_6$ .
- Is the sweetest carbohydrate.
- Is found in fruit juices and honey.
- Converts to glucose in the body.



D-Fructose

### *D-Galactose*

- An aldohexose  $C_6H_{12}O_6$ .
- Not found free in nature.
- Obtained from lactose, a disaccharide.
- A similar structure to glucose except for the  $-OH$  on C4.

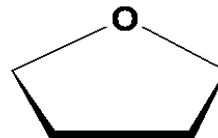
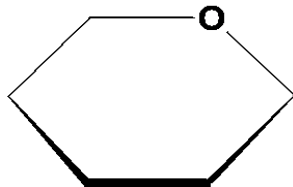


D-Galactose

Q / Draw the structure and Fischer projection of D-fructose

### *Cyclic structures*

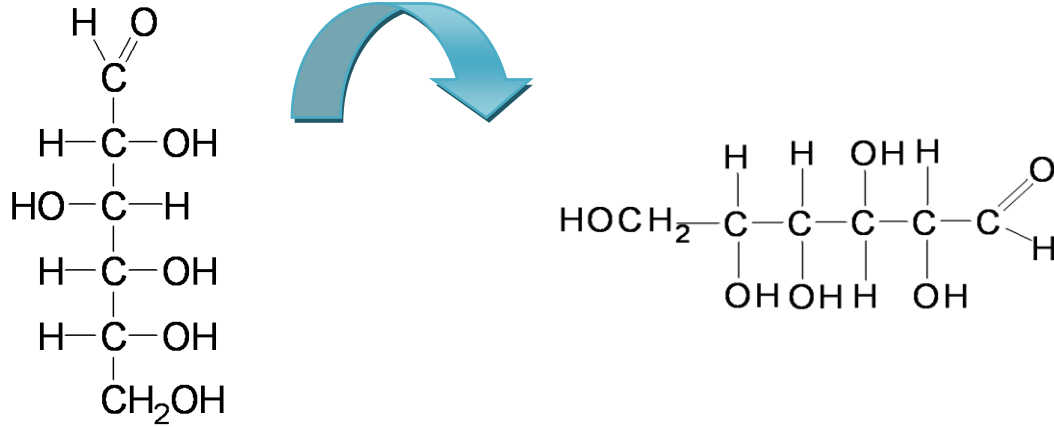
- Are the prevalent form of monosaccharides with 5 or 6 carbon atoms. (Pyranose and Furanose ).



- Form when the hydroxyl group on C-5 reacts with the aldehyde group or ketone group.

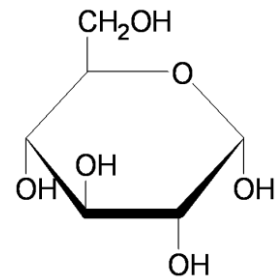
Q/ Drawing the Cyclic Structure for Glucose ?

**STEP 1** Number the carbon chain and turn clockwise to form a linear open chain.



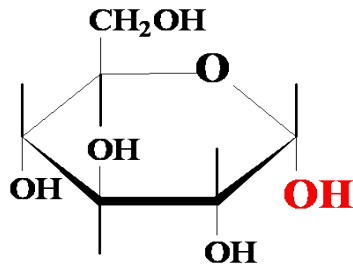
**STEP 2** Bend the chain to make a hexagon

- Bond the C5 –O– to C1.
- Place the C6 group above the ring.
- Write the –OH groups on C2 and C4 below the ring.
- Write the –OH group on C3 above the ring.
- Write a new –OH on C1.

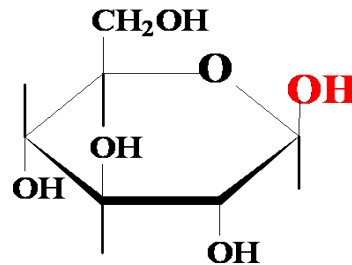


**STEP 3** The new –OH on C1 is drawn

- Down for the  $\alpha$  anomer.
- Up for the  $\beta$  anomer.

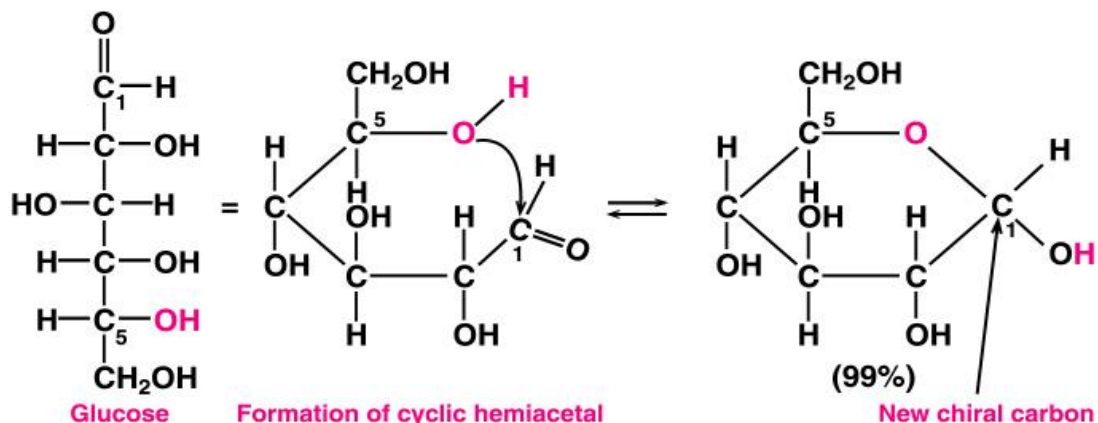


$\alpha$ -D-glucose



$\beta$ -D-glucose

## Summary of the Formation of Cyclic Glucose

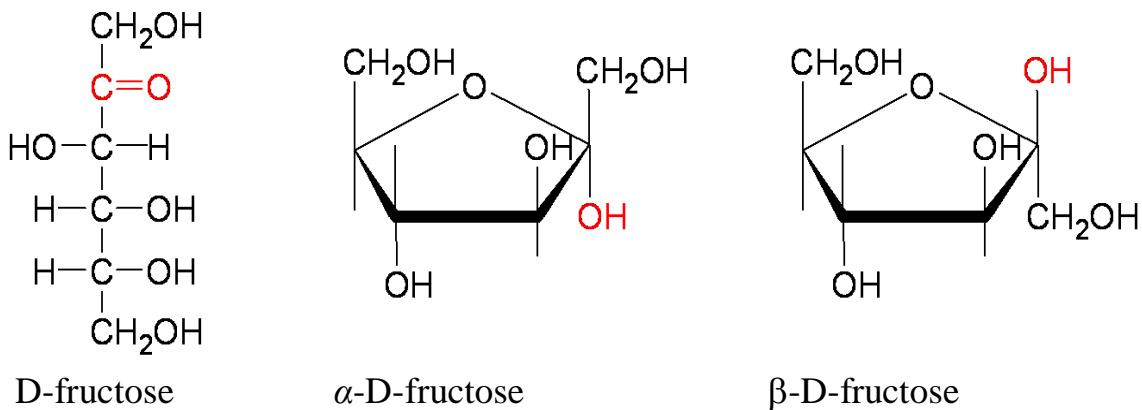


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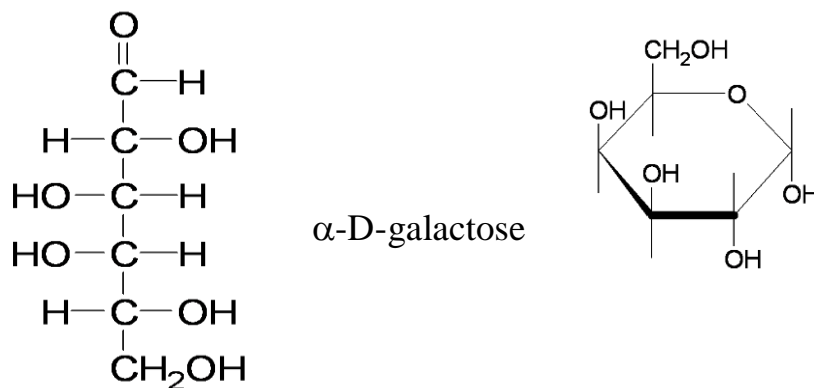
## Cyclic Structure of Fructose

- Is a ketohexose.
- Forms a cyclic structure.

Reacts the —OH on C-5 with the C=O on C-2



Q / Write the cyclic form of  $\alpha$ -D-galactose ?



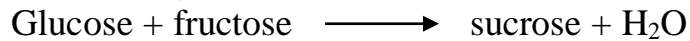
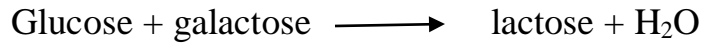
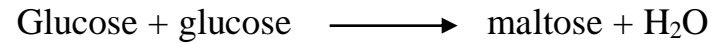


## Disaccharides

Carbohydrates that can be hydrolyzed into two monosaccharide units; eg. Sucrose, which is hydrolyzed into glucose and fructose.

A disaccharide with the formula  $C_{12}H_{22}O_{11}$

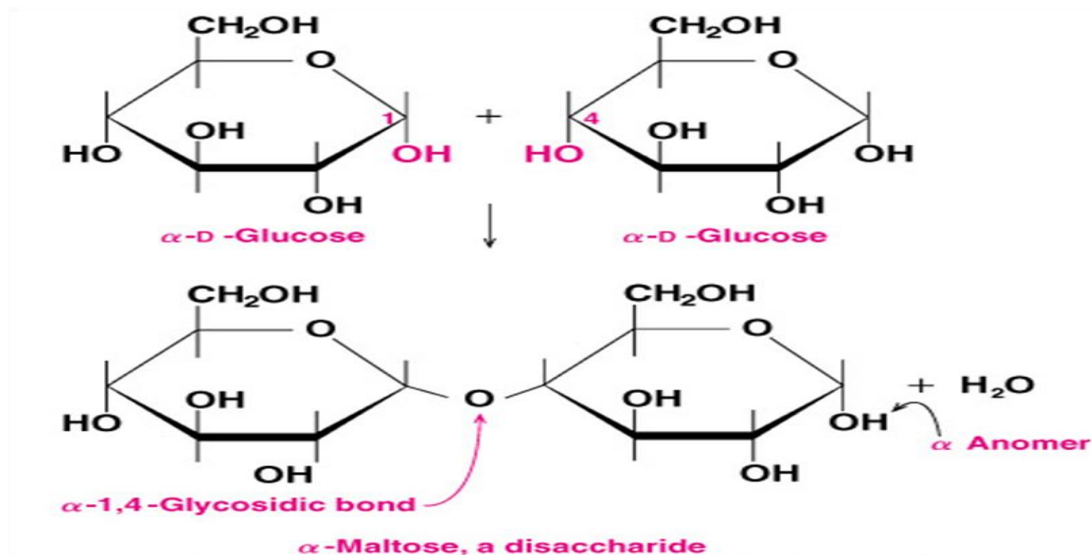
- Consists of two monosaccharides.



## Maltose is

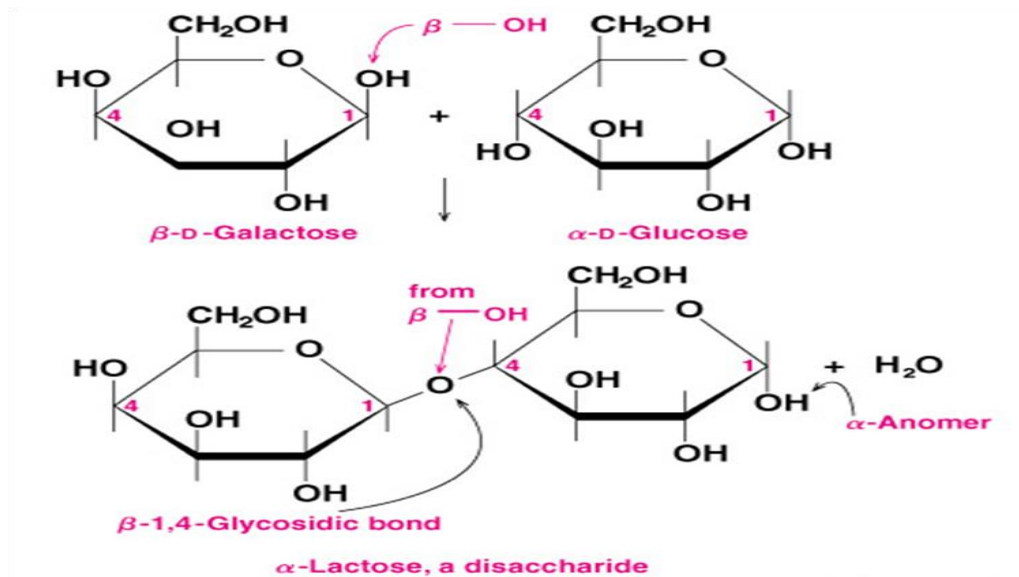
- A disaccharide also known as *malt sugar*.
- Composed of two D-glucose molecules.
- Obtained from the hydrolysis of starch.
- Linked by an  $\alpha$ -1,4-glycosidic bond formed from the  $\alpha$ -OH on C1 of the first glucose and -OH on C4 of the second glucose.
- Used in cereals, candies, and brewing.
- Found in both the  $\alpha$ - and  $\beta$ - forms

## Formation of Maltose



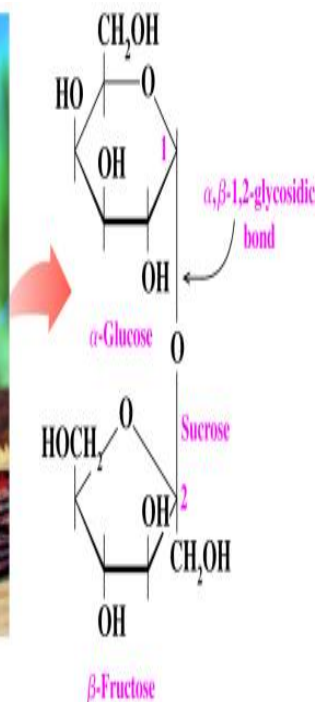
## Lactose

- Is a disaccharide of  $\beta$ -D-galactose and  $\alpha$ - or  $\beta$ -D-glucose.
- Contains a  $\beta$ -1,4-glycosidic bond.
- Is found in milk and milk products.



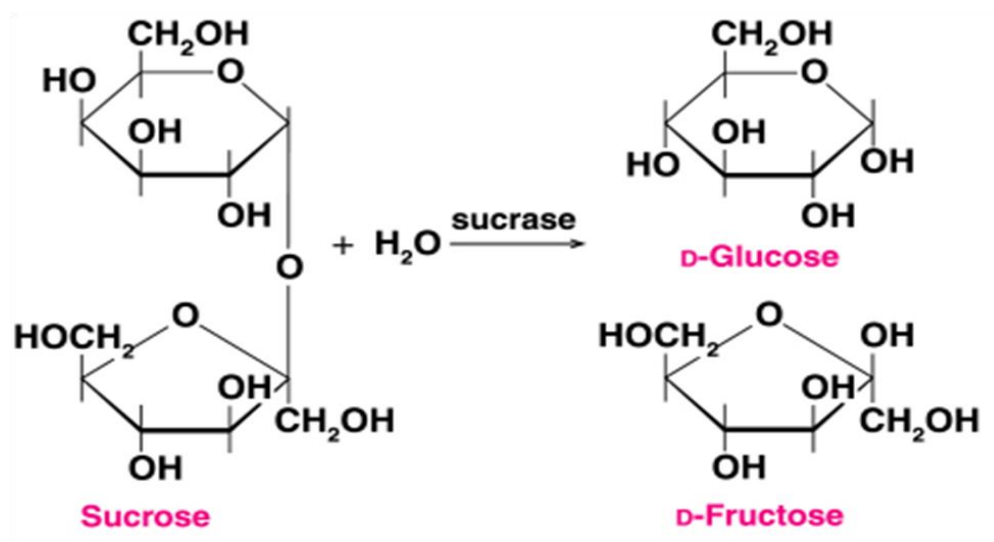
## Sucrose or table sugar

- Is obtained from sugar cane and sugar beets.
- Consists of  $\alpha$ -D-glucose and  $\beta$ -D-fructose..
- Has an  $\alpha,\beta$ -1,2-glycosidic bond.



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Q/ Write the structures and names of the two mono saccharides that form when sucrose is hydrolyzed.



Q/ Identify the monosaccharides in each of the following:

A. lactose

(1)  $\alpha$ -D-glucose      (2)  $\beta$ -D-fructose      (3)  $\beta$ -D-galactose

B. maltose

(1)  $\alpha$ -D-glucose      (2)  $\beta$ -D-fructose      (3)  $\beta$ -D-galactose

C. sucrose

(1)  $\alpha$ -D-glucose      (2)  $\beta$ -D-fructose      (3)  $\beta$ -D-galactose

**Solution**

A. lactose

(1)  $\alpha$ -D-glucose      (3)  $\beta$ -D-galactose

B. maltose

(1)  $\alpha$ -D-glucose

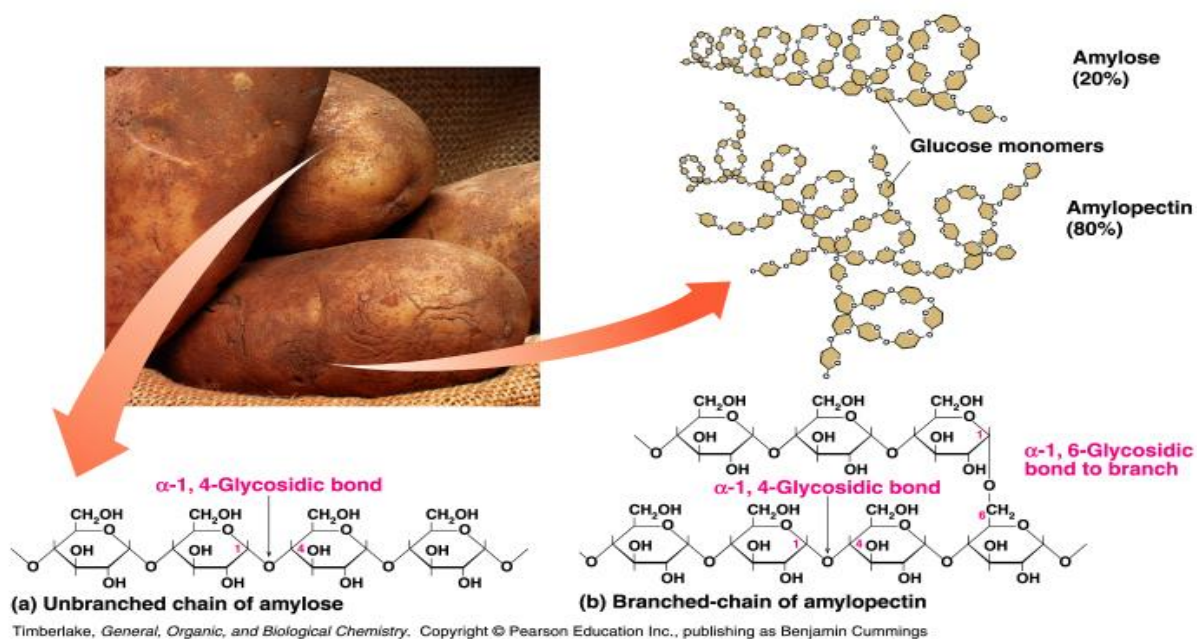
C. sucrose

(1)  $\alpha$ -D-glucose      (2)  $\beta$ -D-fructose

## *Polysaccharides*

- Are polymers of D-glucose.
- Include amylose and amylopectin, starches made of  $\alpha$ -D-glucose.
- Include glycogen (animal starch in muscle), which is made of  $\alpha$ -D-glucose.
- Include cellulose (plants and wood), which is made of  $\beta$ -D-glucose.

## *Structures of Amylose and Amylopectin*



### *Amylose is*

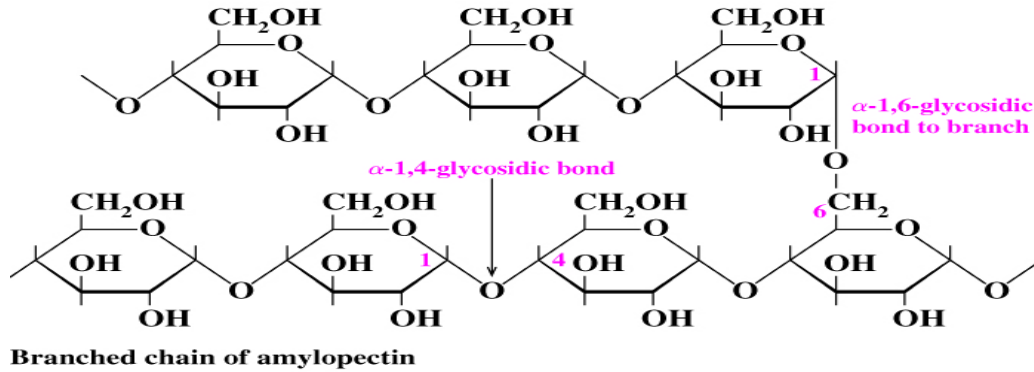
- A polymer of  $\alpha$ -D-glucose molecules.
- Linked by  $\alpha$ -1,4 glycosidic bonds.
- A continuous (unbranched) chain.

### *Amylopectin*

- Is a polymer of  $\alpha$ -D-glucose molecules.
- Is a branched-chain polysaccharide.
- Has  $\alpha$ -1,4-glycosidic bonds between the glucose units.



- Has  $\alpha$ -1,6 bonds to branches.



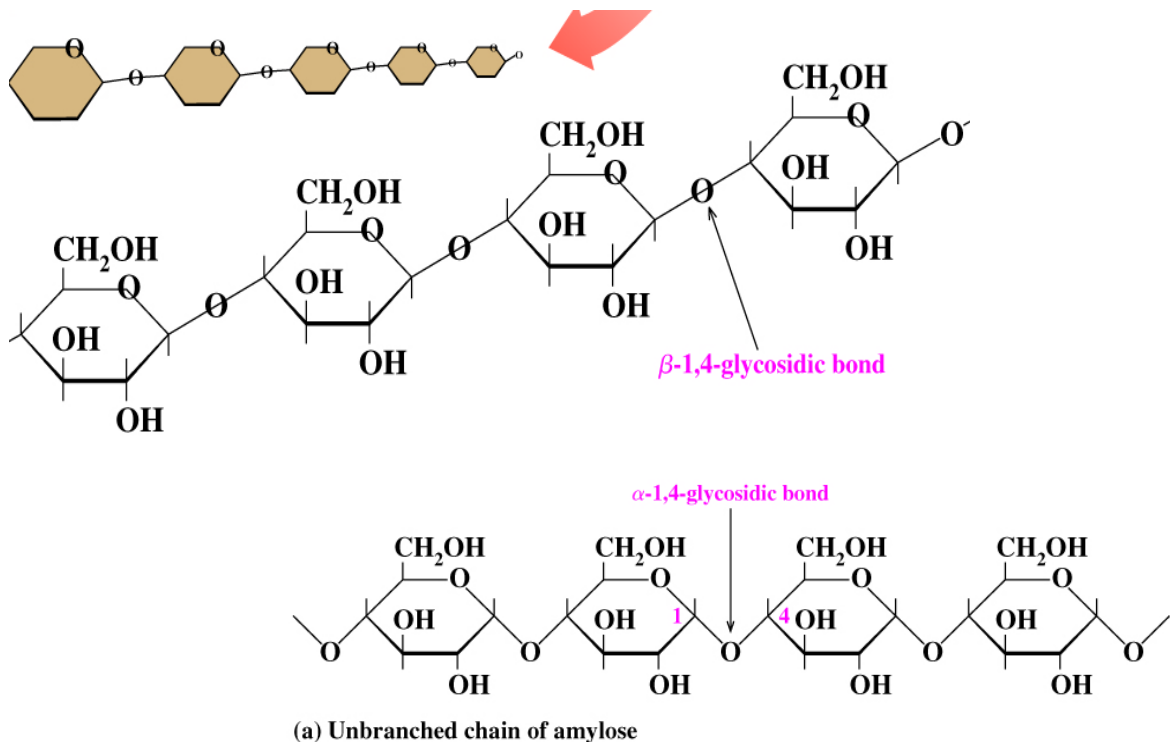
### Glycogen

- Is the polysaccharide that stores  $\alpha$ -D-glucose in muscle.
- Is similar to amylopectin, but is more highly branched.

### Cellulose

- Is a polysaccharide of glucose units in unbranched chains.
- Has  $\beta$ -1,4-glycosidic bonds.

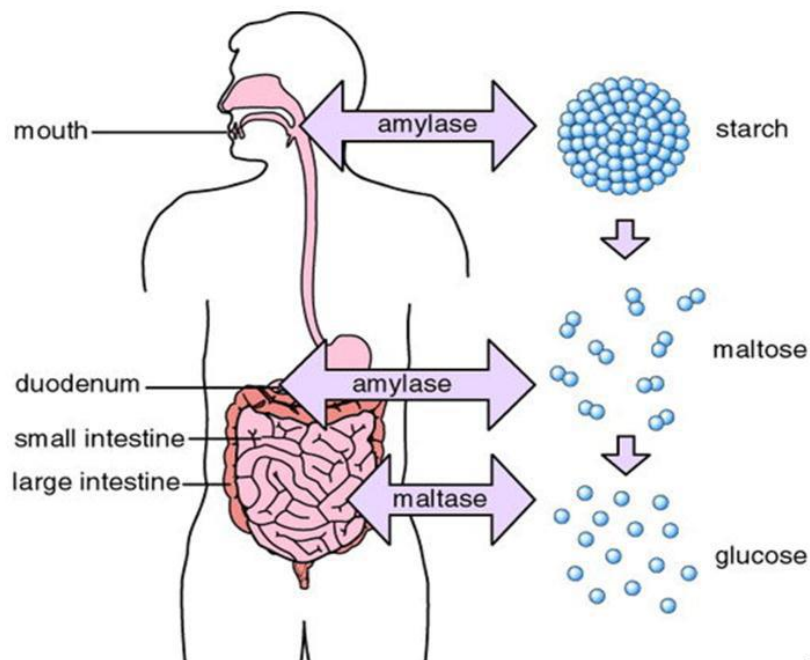
Cannot be digested by humans because humans cannot break down  $\beta$ -1,4-glycosidic bonds



## Oligosaccharides

- Contain 3 to 10 mono saccharid unit .
- Found in peas and beans( legumes).
- Largely undigested until reaching intestinal .
- They are the breakdown products of polysaccharides in the gut, but also occur naturally in foods such as (e.g., raffinose, stachyose, verbacose), and are added as dietary ingredients (e.g., inulin).
- Raffinose (  $\beta$ -D-Galactose +  $\alpha$ -D- Glucose +  $\beta$ -Dfructose)

## Digestion and Energy



**Chitin** is a long-chain polymer of *N*-acetylglucosamine, a derivative of glucose. This polysaccharide is a primary component of cell walls in fungi, the exoskeletons of arthropods, such as (lobsters, and crabs) and insects, the radulae of molluscs, and the scales of fish and skin of lissamphibians.

