

# Carbohydrates

- **Their role:**
  - Energy source
  - Energy storage
  - Carbon source
  - Structure / protection
  - Recognition / signaling
  - Attached to other macromolecules

1

- Carbohydrates (“hydrate of carbon”)



- **Monosaccharides** one monomeric unit
- **Oligosaccharides** ~2-20 monosaccharides
- **Polysaccharides** > 20 monosaccharides
- **Glycoconjugates** linked to proteins or lipids

2

**Monosaccharides**

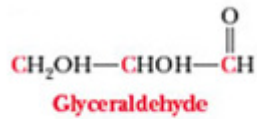
- **Aldoses** : polyhydroxy aldehydes
- **Ketoses** : polyhydroxy ketones

		Carbon number
$  \begin{array}{c}  \text{H} \quad \text{O} \\  \diagdown \quad // \\  \text{C} \\    \\  \text{H}-\text{C}-\text{OH} \\    \\  \text{HO}-\text{C}-\text{H} \\    \\  \text{H}-\text{C}-\text{OH} \\    \\  \text{H}-\text{C}-\text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $	$  \begin{array}{c}  \text{CH}_2\text{OH} \\    \\  \text{C}=\text{O} \\    \\  \text{HO}-\text{C}-\text{H} \\    \\  \text{H}-\text{C}-\text{OH} \\    \\  \text{H}-\text{C}-\text{OH} \\    \\  \text{CH}_2\text{OH}  \end{array}  $	1
		2
		3
		4
		5
		6
<p><b>D-Glucose</b> (an aldose)</p>	<p><b>D-Fructose</b> (a ketose)</p>	3

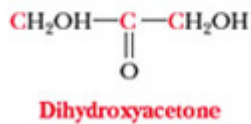
**Number of carbon in monosaccharides:**

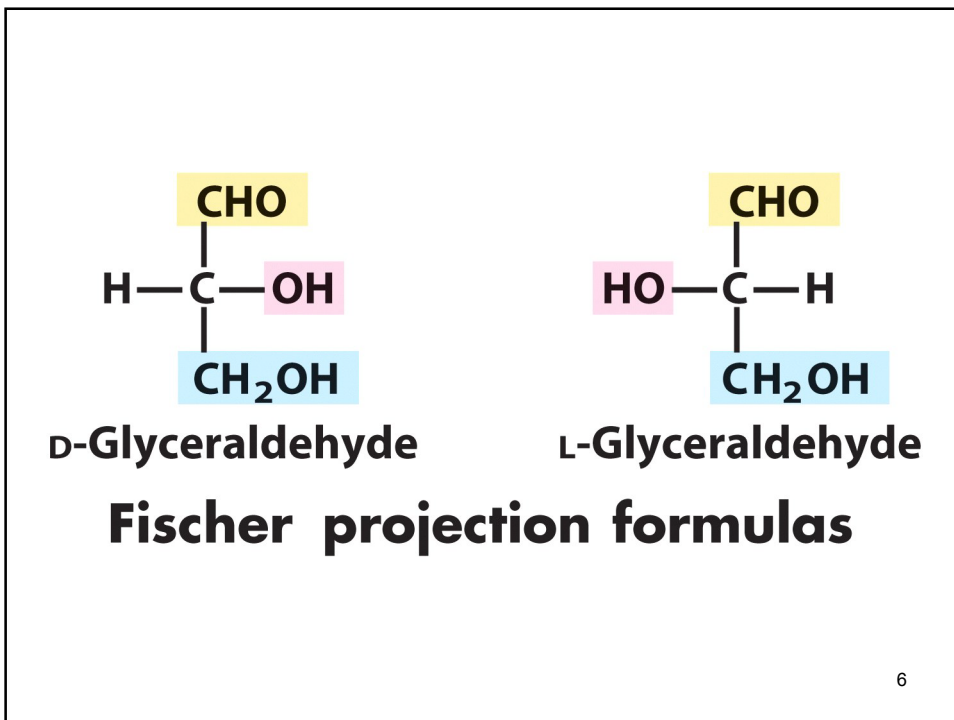
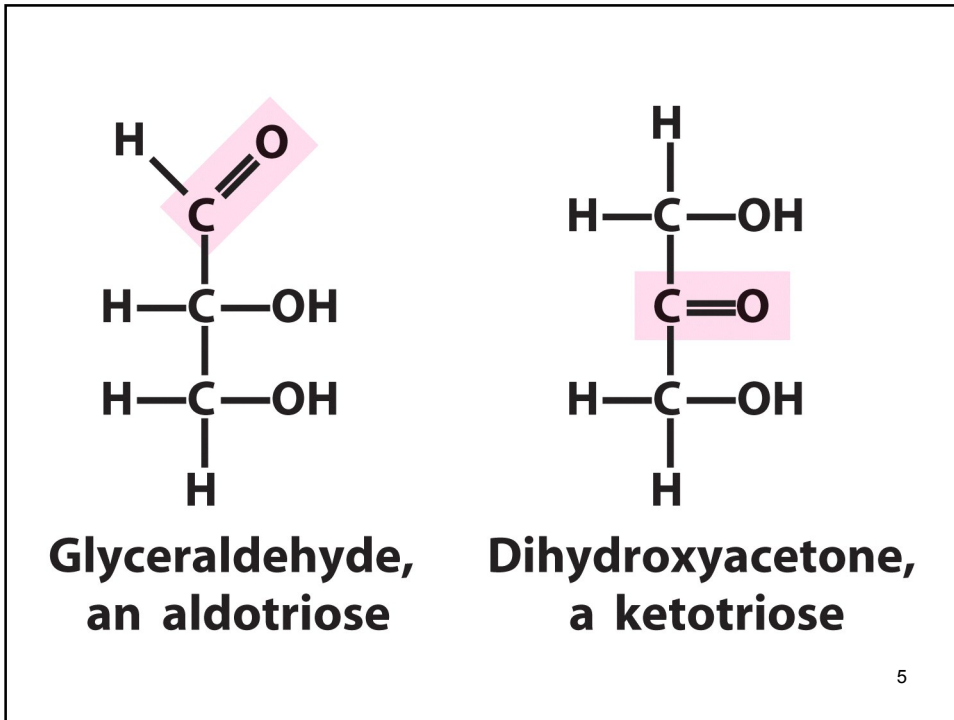
**Triose , Tetrose , Pentose , Hexose**

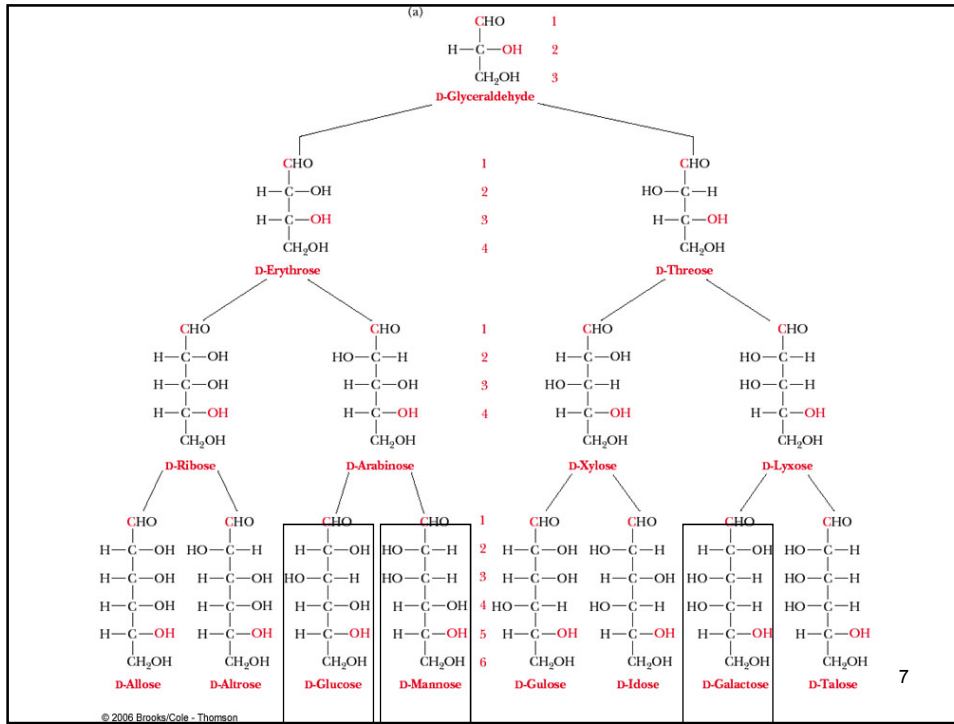
**Aldose**



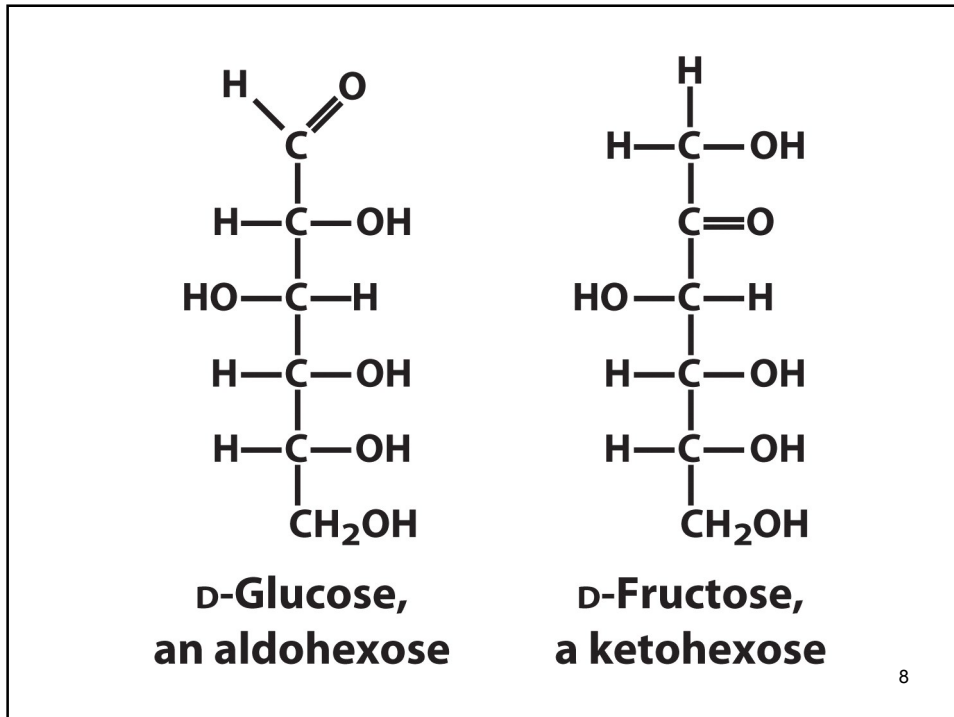
**Ketose**



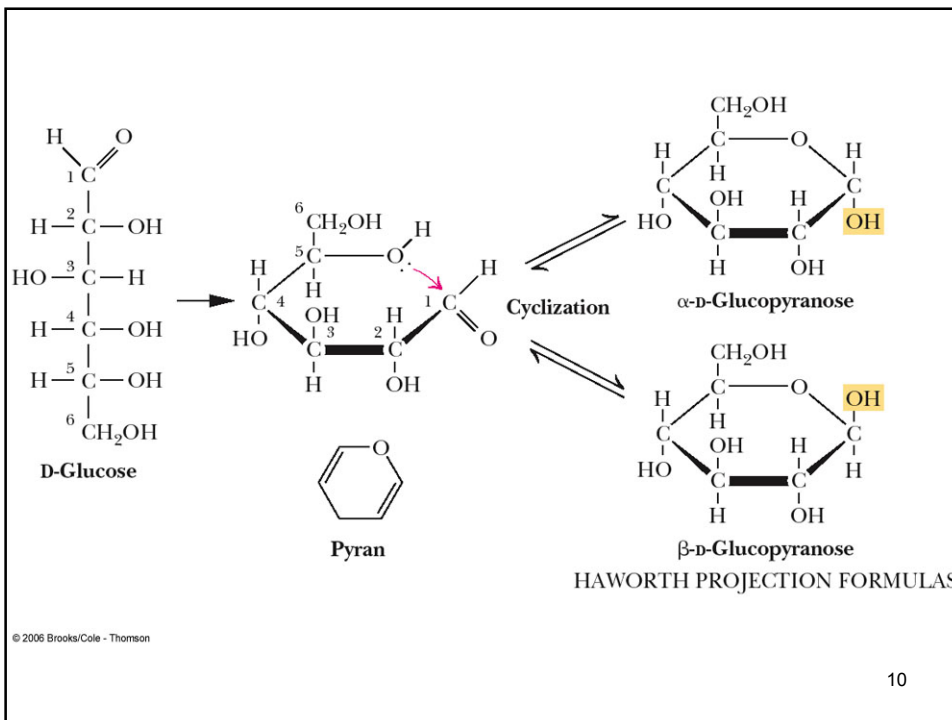
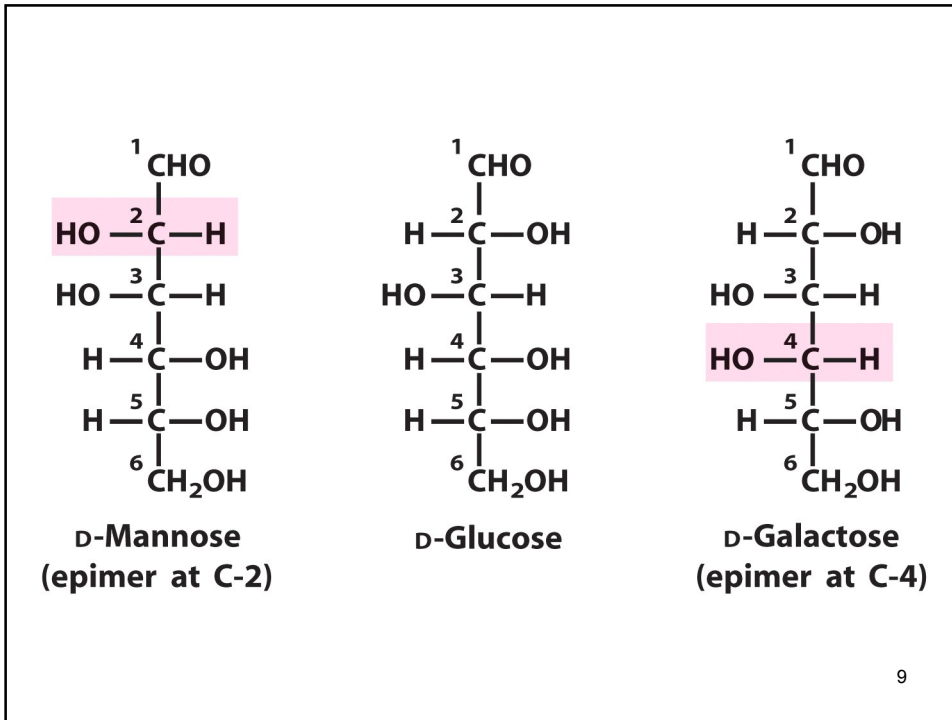


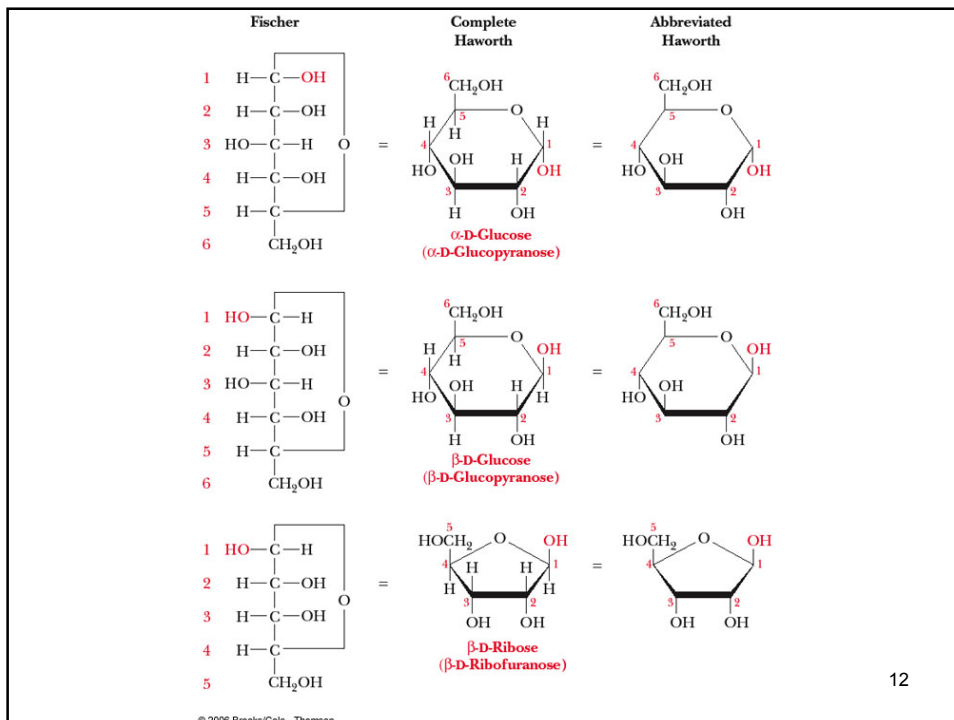
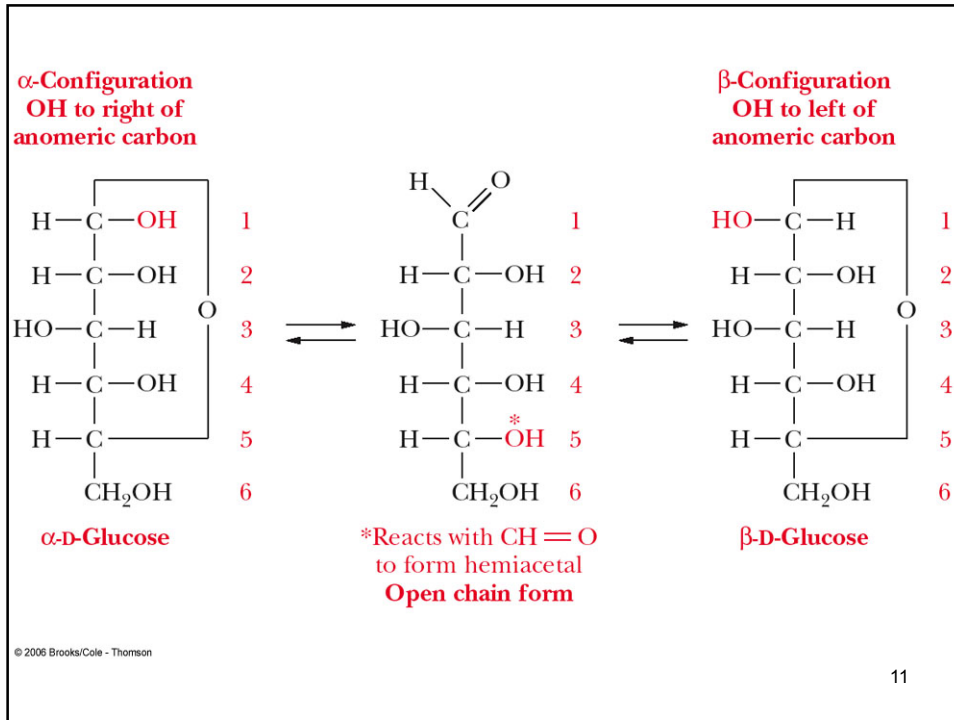


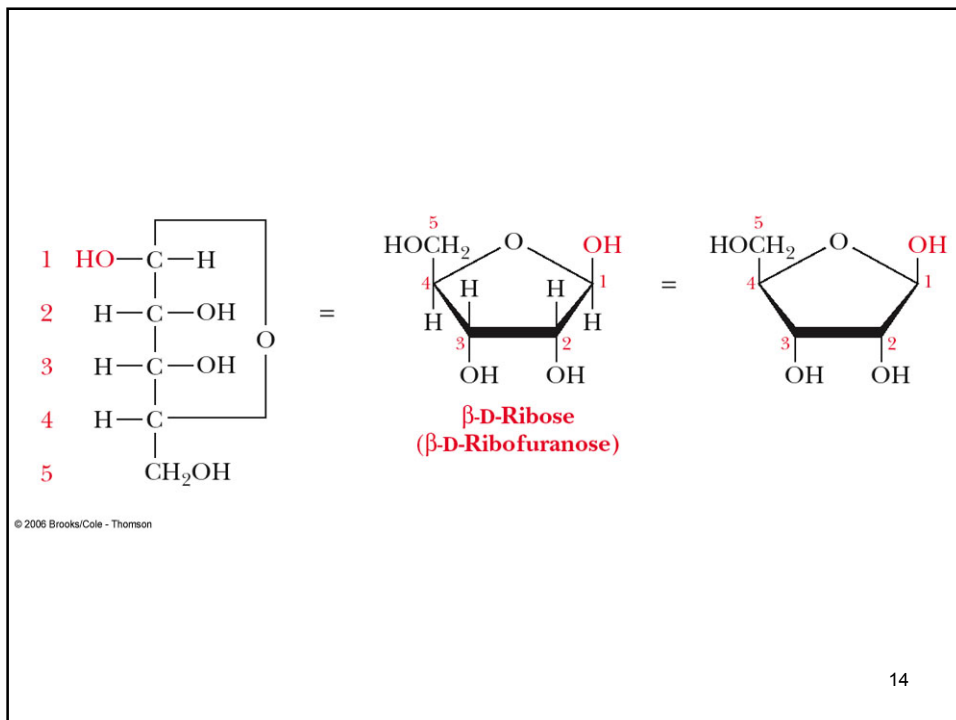
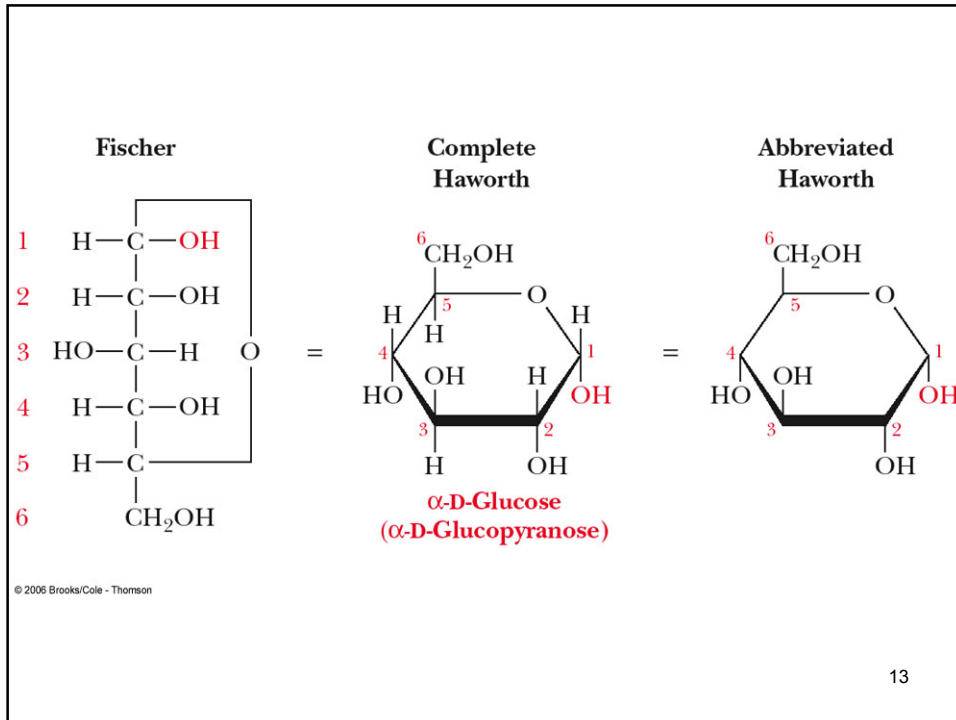
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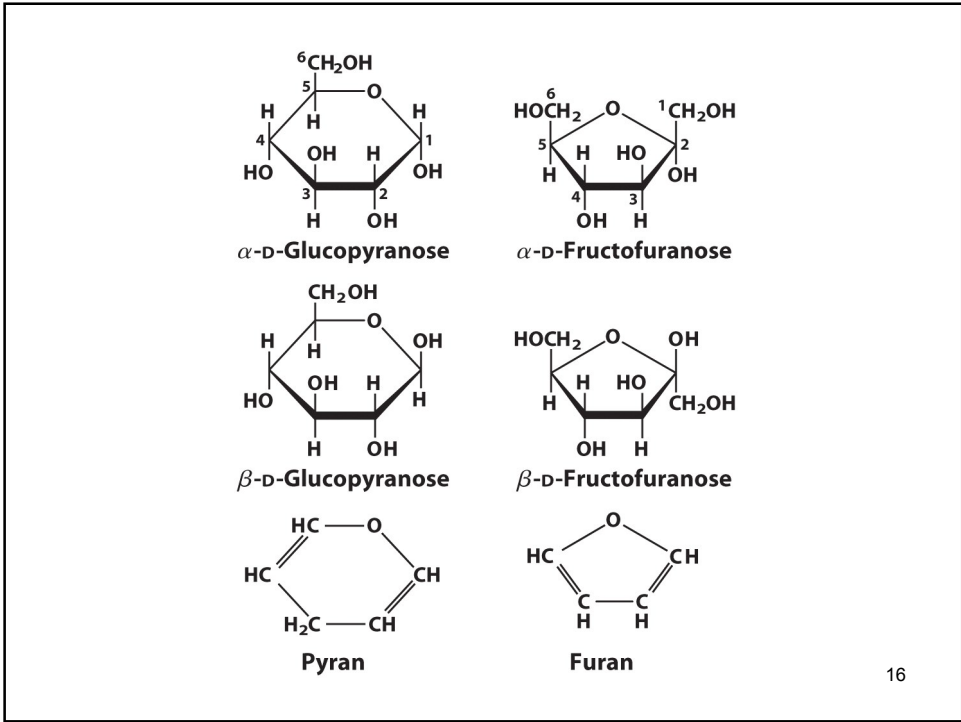
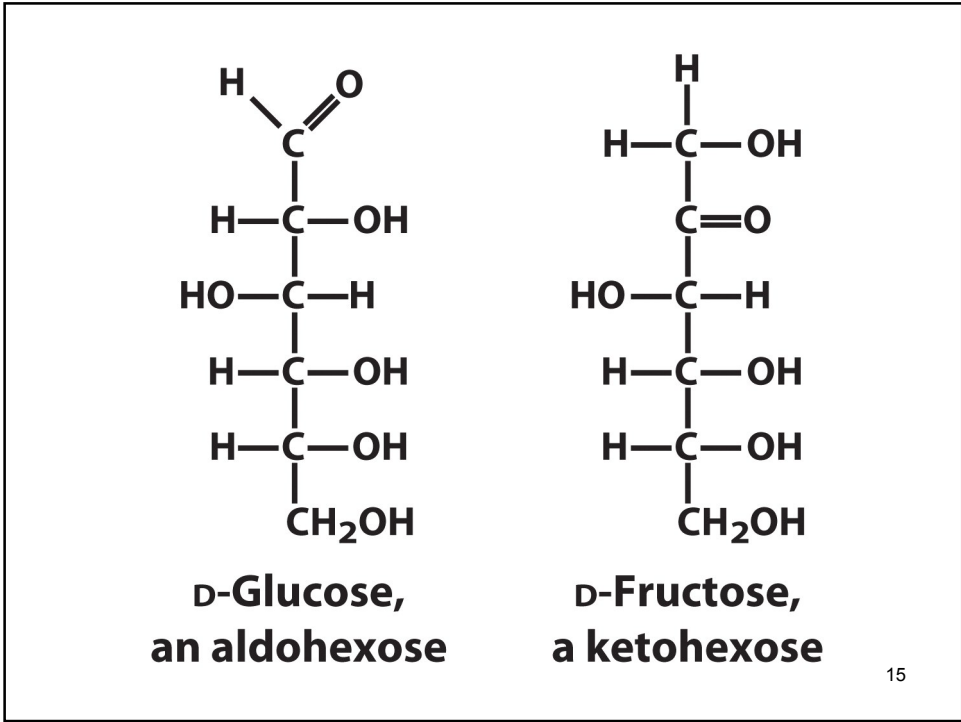


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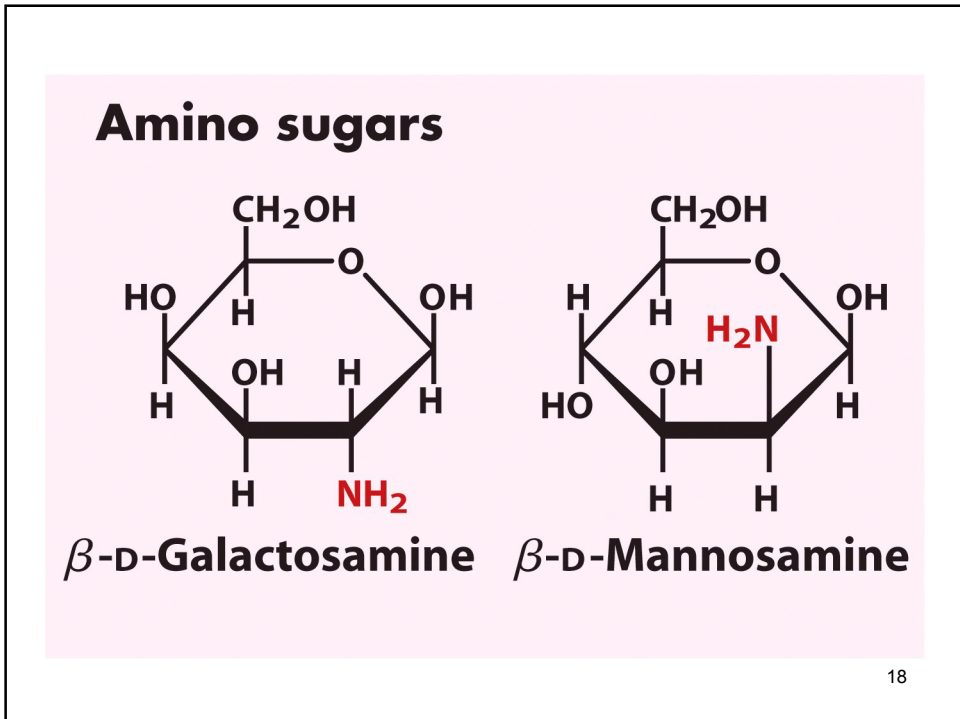
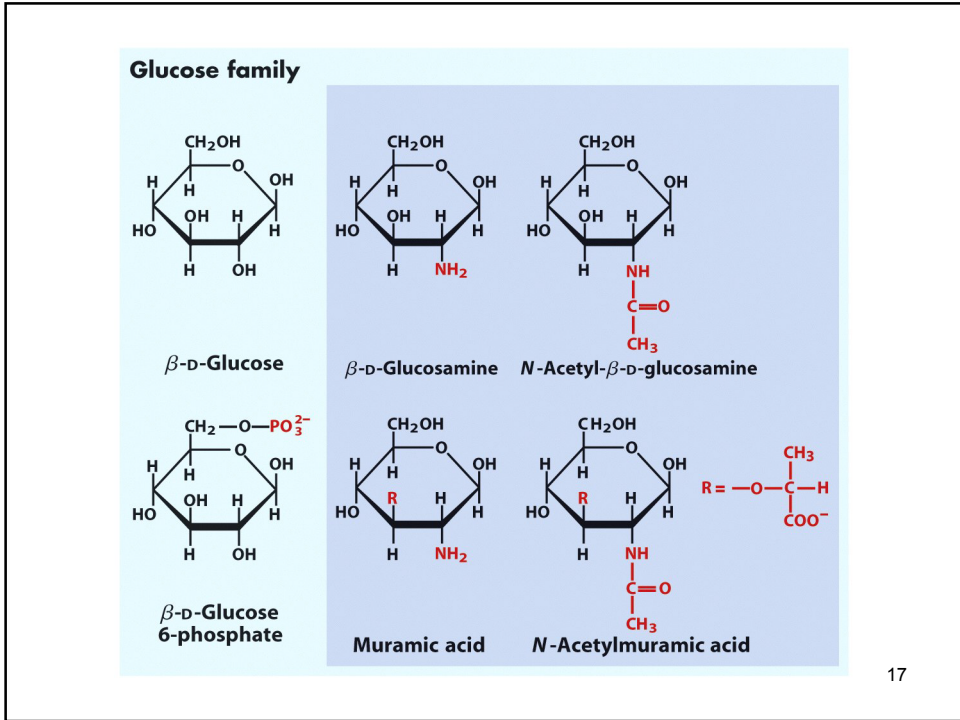


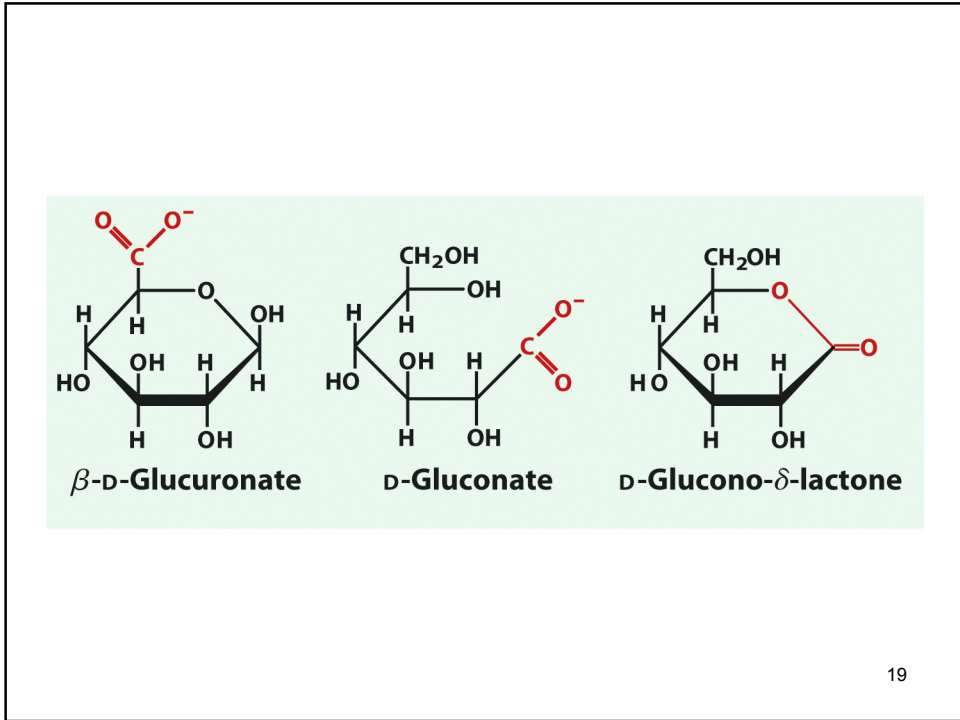




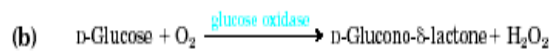
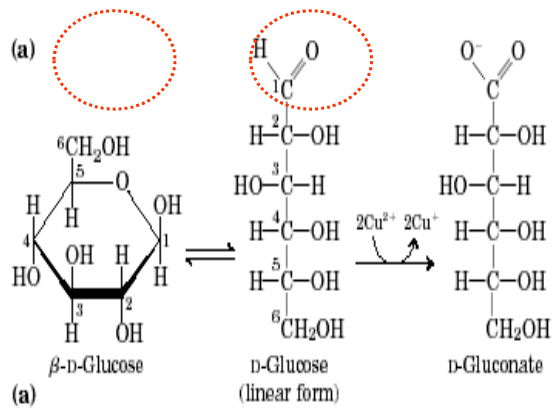


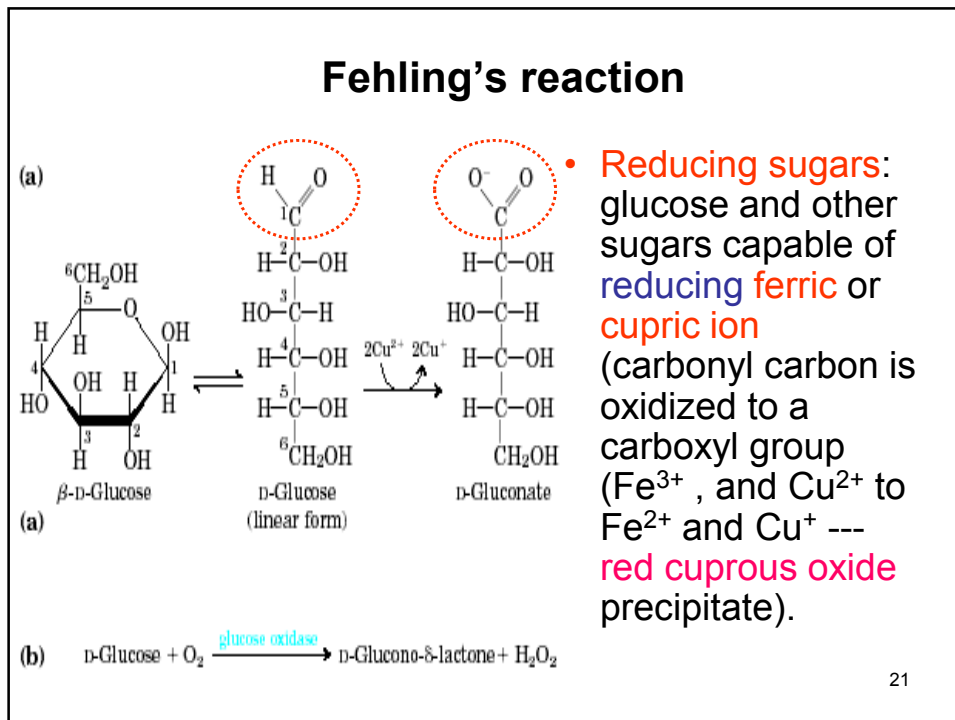






### Monosaccharides are reducing agents



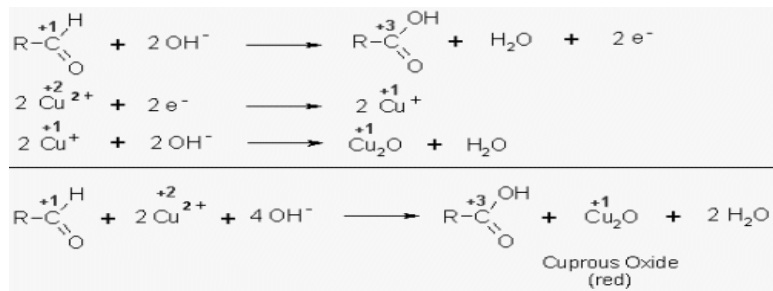


## Fehling's Test

- This test is used to differentiate between reducing and non reducing sugars.
- A reducing sugar reacts with Fehling's reagent in alkaline medium to form an orange to red precipitate.
- Fehling's reagent is commonly used for reducing sugars but is known to be not specific for aldehydes.
- Positive result is detected by reduction of the deep blue solution of cupric (II) to a red precipitate of insoluble cuprous oxide ( $\text{Cu}_2\text{O}$ ).

## Fehling's Test

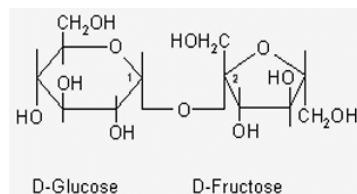
- Positive result is detected by reduction of the deep blue solution of cupric (II) to a red precipitate of insoluble cuprous oxide (Cu<sub>2</sub>O).



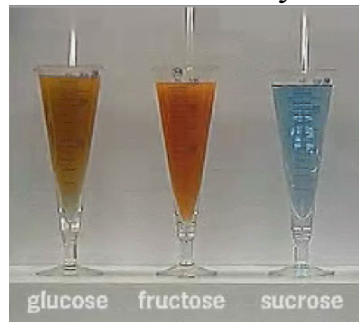
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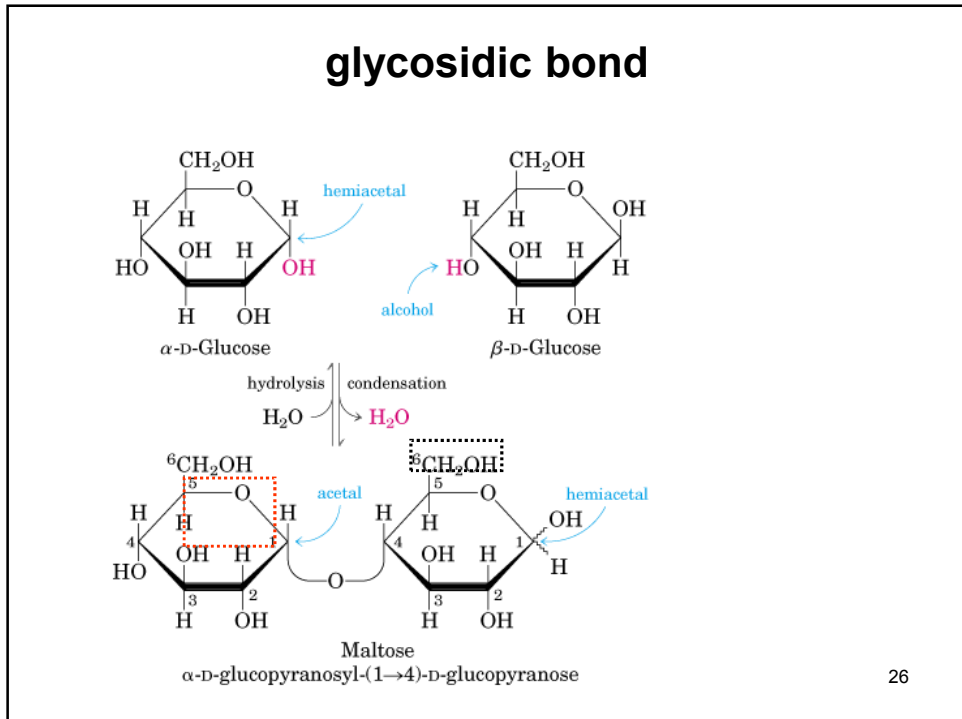
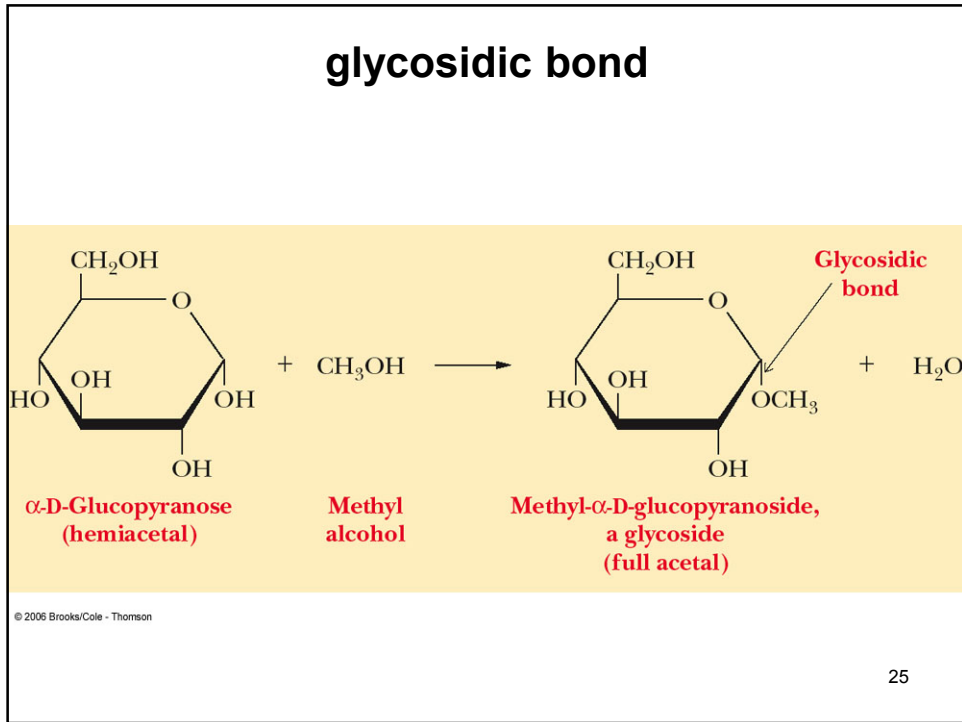
## Fehling's Test

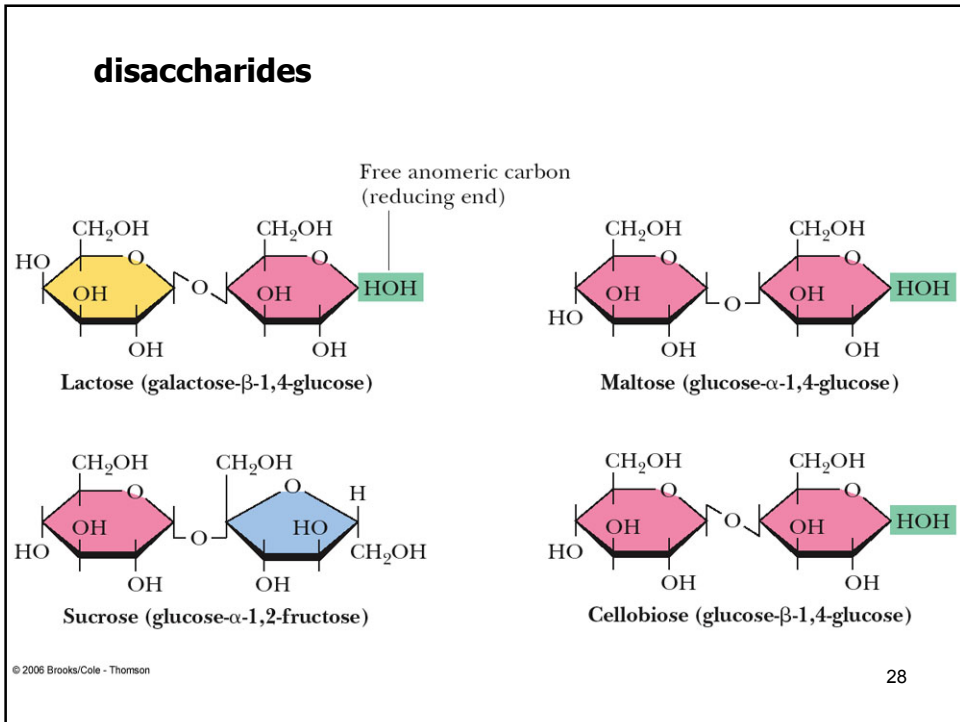
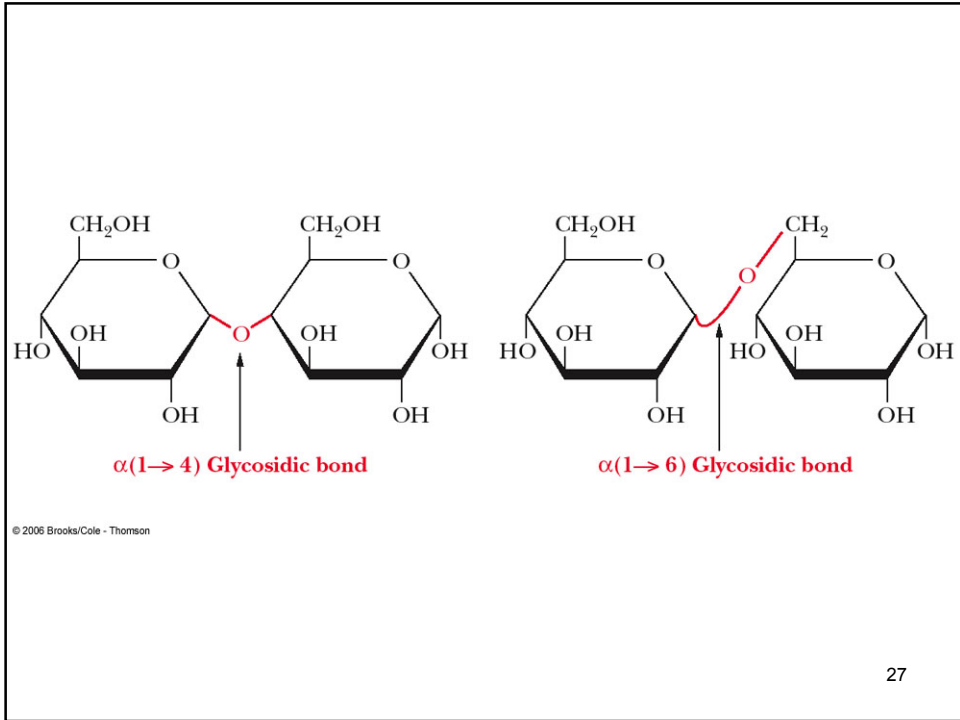
- The sucrose does not react with Fehling's reagent. Sucrose is a disaccharide of glucose and fructose. Most disaccharides are reducing sugars (e.g. lactose and maltose)
- Sucrose is non-reducing sugar because the anomeric carbon of glucose is involved in the glucose- fructose bond and hence is not free to form the aldehyde in solution.



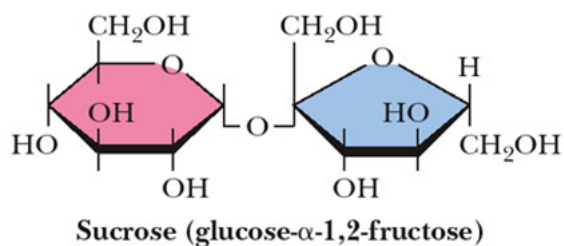
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## Sucrose

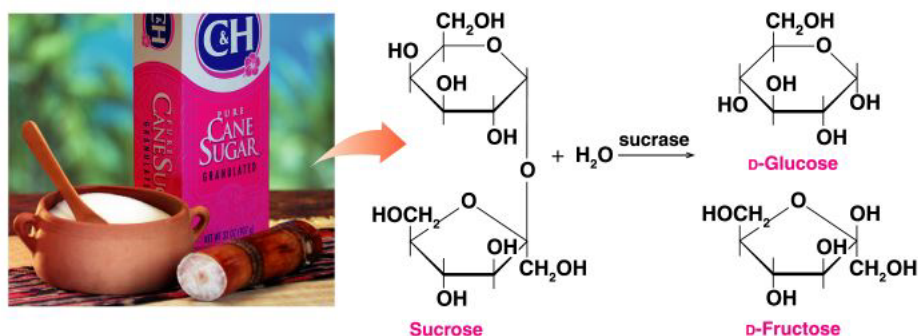


- Is a sugar used at home
- Also known as the cane sugar, table sugar
- is the most abundant disaccharide and is commercially produced from sugarcane and sugar beets
- When hydrolyzed, it forms a mixture of glucose and fructose.
- sucrose is not a reducing sugar.

29

## Hydrolysis of Sucrose

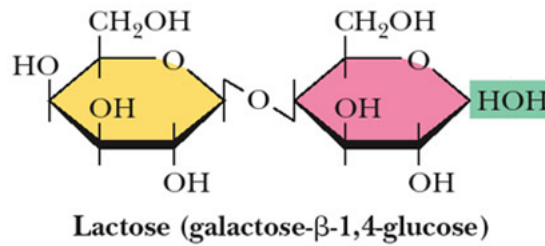
- Sucrose is hydrolyzed by the enzyme **sucrase**, which is secreted in the **small intestine**.
- The glucose and fructose can then be absorbed into the bloodstream (disaccharides are too large to be absorbed)



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30

## Lactose

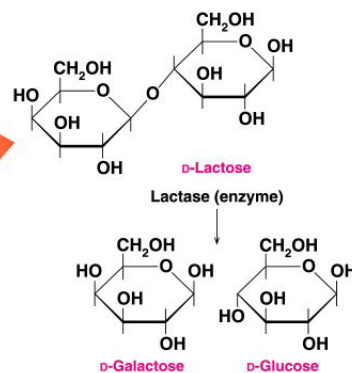


- Commercially known as milk sugar.
- Of animal origin (about 4-5% of cow's milk)
- Bacteria cause fermentation of lactose forming lactic acid.
- lactose is a reducing sugar

31

## Lactose Digestion

- **Lactase**
- lactase cuts the molecule into its two subunits, glucose & galactose. then be absorbed by the body.



32

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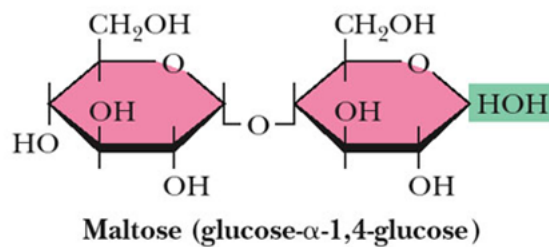


- **lactose intolerant**

- Some people don't produce enough lactase
- Many adults become lactose intolerant, and develop abdominal cramps, nausea and diarrhea
- Lactase can be added to milk products (or taken as a supplement) to combat this problem

33

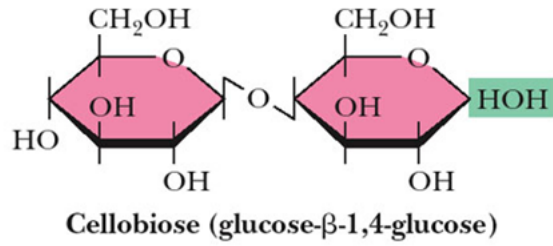
## Maltose



- Commonly known as malt sugar or corn sugar.
- Present in germinating grain
- Produced commercially by hydrolysis of starch by (amylase).
- maltose is a reducing sugar.

34

## Cellobiose



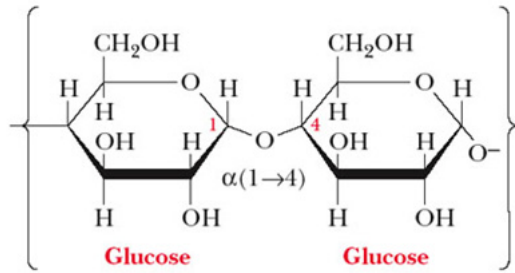
- It is a product of hydrolyzed cellulose
- Is a reducing sugar

35

## Polysaccharides

36

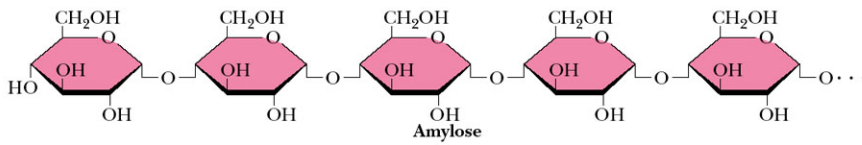
# Starch



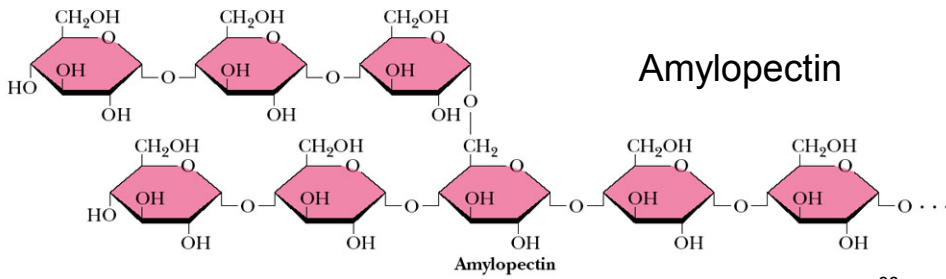
37

# Starch

## Amylose



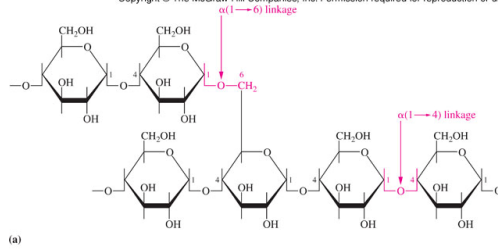
## Amylopectin



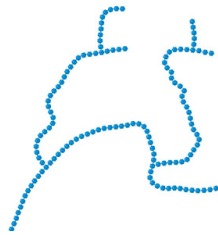
38

# Glycogen

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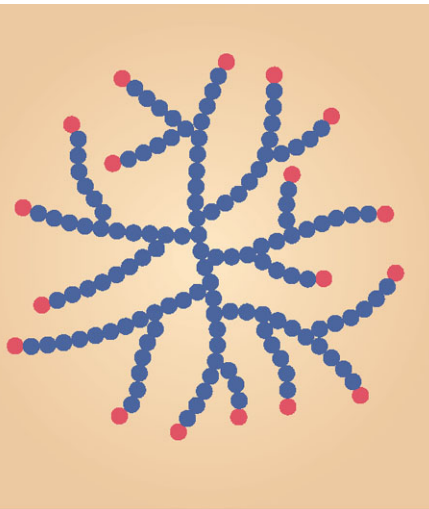
(a)



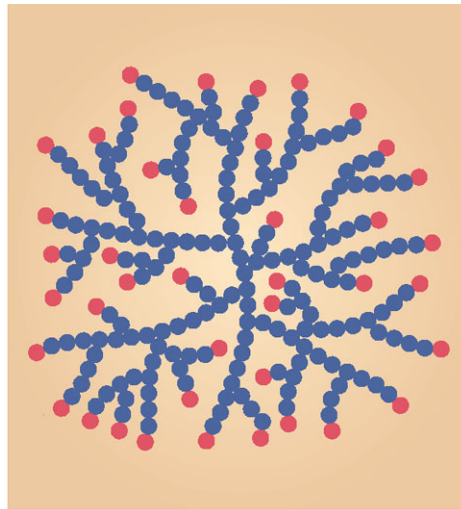
Amylopectin



Glycogen

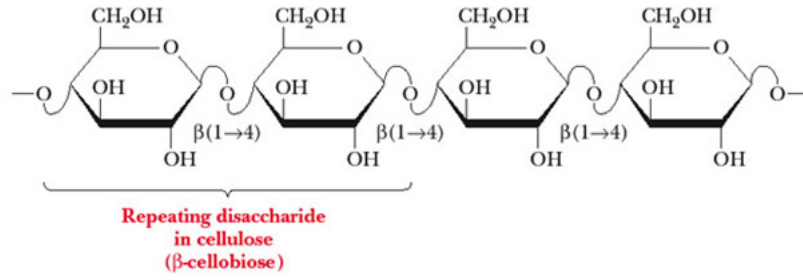


Amylopectin



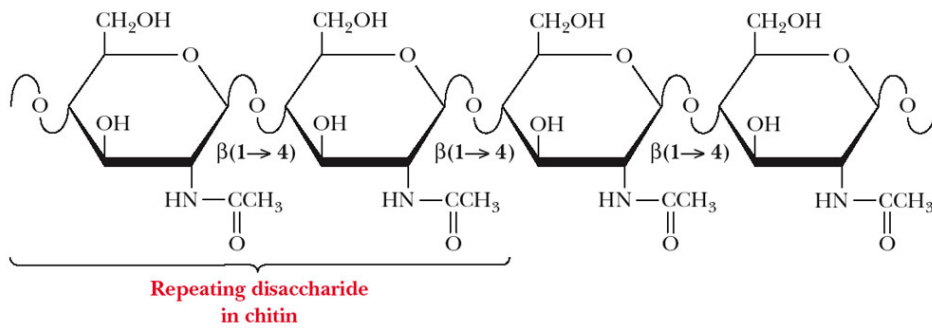
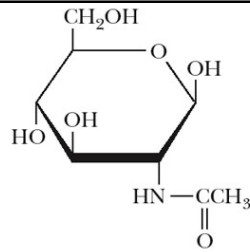
Glycogen

## Cellulose



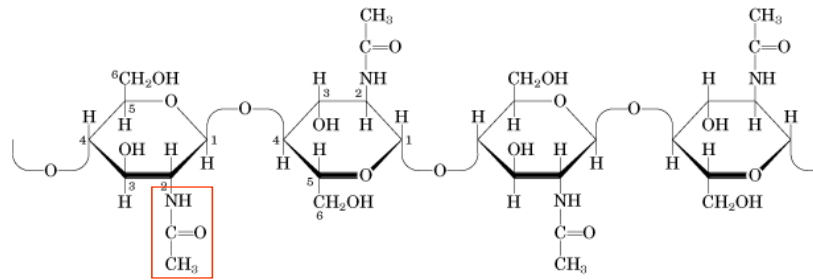
41

## Chitin



42

## Chitin



43

## Function of polysaccharides

TABLE 7-2 Structures and Roles of Some Polysaccharides

Polymer	Type*	Repeating unit <sup>†</sup>	Size (number of monosaccharide units)	Roles/significance
Starch				Energy storage: in plants
Amylose	Homo-	( $\alpha$ 1 $\rightarrow$ 4)Glc, linear	50-5,000	
Amylopectin	Homo-	( $\alpha$ 1 $\rightarrow$ 4)Glc, with ( $\alpha$ 1 $\rightarrow$ 6)Glc branches every 24-30 residues	Up to 10 <sup>6</sup>	
Glycogen	Homo-	( $\alpha$ 1 $\rightarrow$ 4)Glc, with ( $\alpha$ 1 $\rightarrow$ 6)Glc branches every 8-12 residues	Up to 50,000	Energy storage: in bacteria and animal cells
Cellulose	Homo-	( $\beta$ 1 $\rightarrow$ 4)Glc	Up to 15,000	Structural: in plants, gives rigidity and strength to cell walls
Chitin	Homo-	( $\beta$ 1 $\rightarrow$ 4)GlcNAc	Very large	Structural: in insects, spiders, crustaceans, gives rigidity and strength to exoskeletons
Dextran	Homo-	( $\alpha$ 1 $\rightarrow$ 6)Glc, with ( $\alpha$ 1 $\rightarrow$ 3) branches	Wide range	Structural: in bacteria, extracellular adhesive
Peptidoglycan	Hetero-; peptides attached	4)Mur2Ac( $\beta$ 1 $\rightarrow$ 4)GlcNAc( $\beta$ 1)	Very large	Structural: in bacteria, gives rigidity and strength to cell envelope
Agarose	Hetero-	3) <i>D</i> -Gal( $\beta$ 1 $\rightarrow$ 4)3,6-anhydro- <i>L</i> -Gal( $\alpha$ 1	1,000	Structural: in algae, cell wall material
Hyaluronate (a glycosaminoglycan)	Hetero-; acidic	4)GlcA( $\beta$ 1 $\rightarrow$ 3)GlcNAc( $\beta$ 1	Up to 100,000	Structural: in vertebrates, extracellular matrix of skin and connective tissue; viscosity and lubrication in joints

44