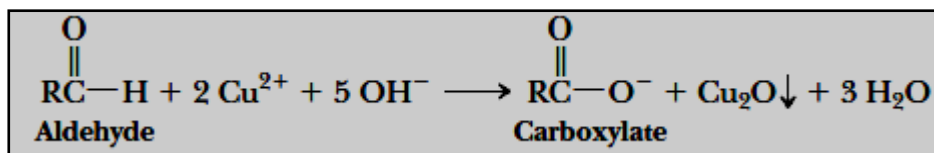


### Biologically Important Sugar (Glucose) Derivatives

Sugar derivatives of biological importance are sugar acids, sugar alcohol, deoxy sugars, sugar phosphates, amino sugars and glycosides.

#### 1. Sugar acids

Sugars with free anomeric carbon atoms are reasonably good reducing agents and will reduce hydrogen by certain metals ( $\text{Cu}^{2+}$  and  $\text{Ag}^+$ ) and other oxidizing agents. Such reactions convert the sugar to a sugar acid. For example, addition of alkaline  $\text{CuSO}_4$  (called *Fehling's solution*) to an aldose sugar produces a red cuprous oxide ( $\text{Cu}_2\text{O}$ ) precipitate:



and converts the aldose to an aldonic acid, such as gluconic acid (Fig. 1.8).

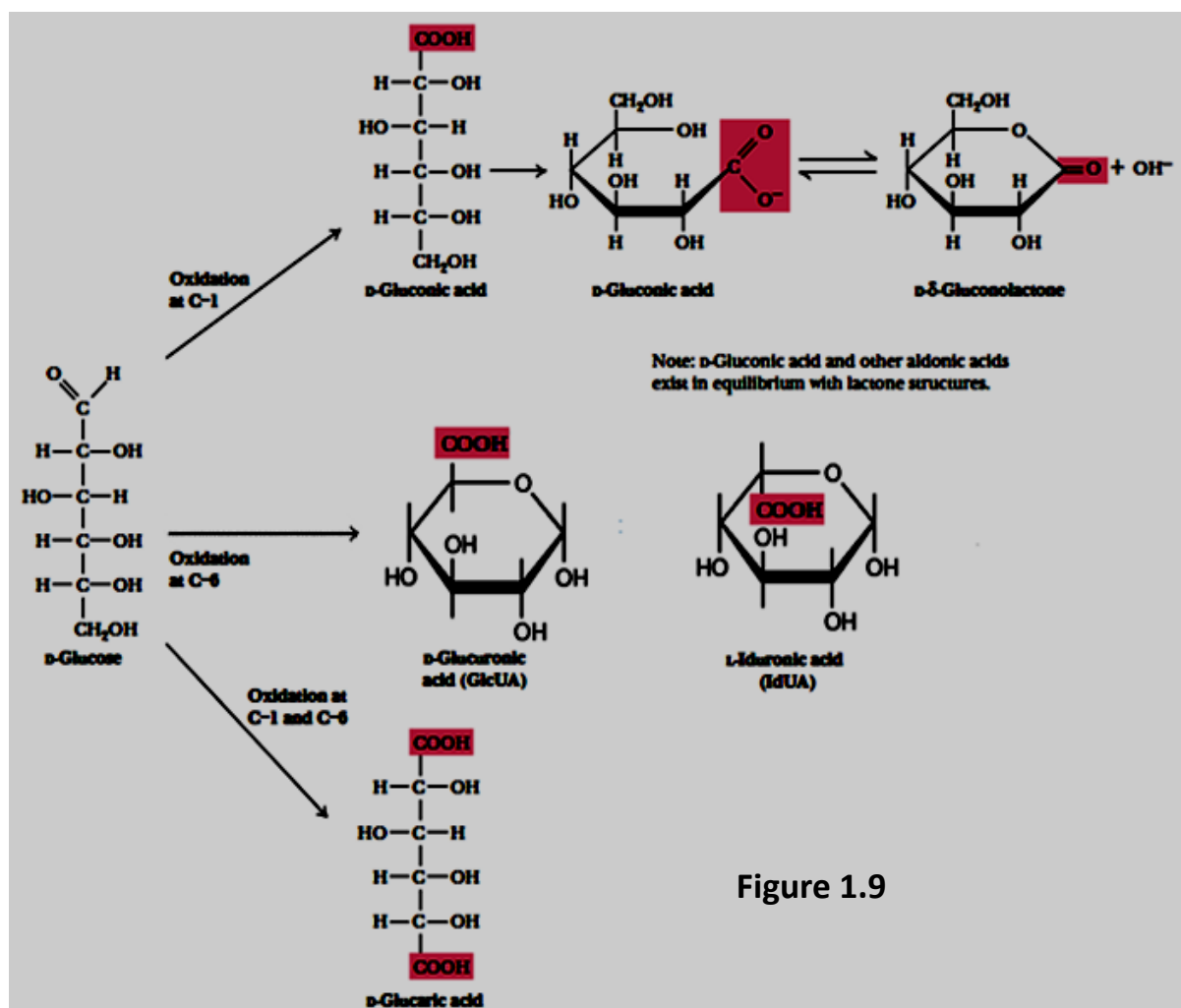


Figure 1.9

## Lecture No. 3

Formation of a precipitate of red  $\text{Cu}_2\text{O}$  constitutes a positive test for an aldehyde. Carbohydrates that can reduce oxidizing agents in this way are referred to as reducing sugars. By quantifying the amount of oxidizing agent reduced by a sugar solution, one can accurately determine the concentration of the sugar. *Diabetes mellitus* is a condition that causes high levels of glucose in urine and blood, and frequent analysis of reducing sugars in diabetic patients is an important part of the diagnosis and treatment of this disease. Over-the-counter kits for the easy and rapid determination of reducing sugars have made this procedure a simple one for diabetics. Monosaccharides can be oxidized enzymatically at C-6, yielding uronic acids, such as D-glucuronic and L-iduronic acids (Fig. 1.8). L-Iduronic acid is similar to D-glucuronic acid, except for having an opposite configuration at C-5. Oxidation at both C-1 and C-6 produces aldaric acids, such as D-glucaric acid.

## 2. Sugar alcohols

another class of sugar derivative, can be prepared by the mild reduction of the carbonyl groups of aldoses and ketoses. Sugar alcohols, or **alditols**, are designated by the addition of *-itol* to the name of the parent sugar. The alditols are linear molecules that cannot cyclize in the manner of aldoses. Other sugar alcohols are glycerol and inositol. The alcohols formed from glucose, galactose and fructose are sorbitol, galactitol and sorbitol respectively. Sorbitol buildup in the eyes of diabetics is implicated in cataract formation. Glycerol and myo -inositol, a cyclic alcohol, are components of lipids. There are nine different stereoisomers of inositol. The one shown in Figure 1.9 was first isolated from heart muscle and thus has the prefix myo- for muscle.

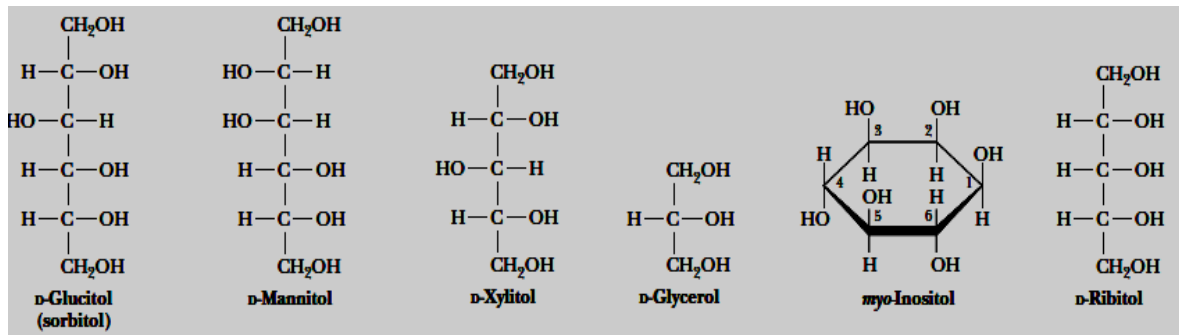


FIGURE 1.10 Structures of some sugar alcohols

**3. Sugar phosphates:** Breakdown of sugar in animals involves formation of sugar phosphates. Glucose-6-phosphate is an example for sugar phosphate.

**4. Deoxy Sugars**

The **deoxy sugars** are monosaccharides with one or more hydroxyl groups replaced by hydrogens. 2-Deoxy-D-ribose is a constituent of DNA in all living things. Deoxy sugars also occur frequently in glycoproteins and polysaccharides. L-Fucose and L-rhamnose, both 6-deoxy sugars, are components of some cell walls, and rhamnose is a component of **ouabain**, a highly toxic *cardiac glycoside* found in the bark and root of the ouabaio tree.

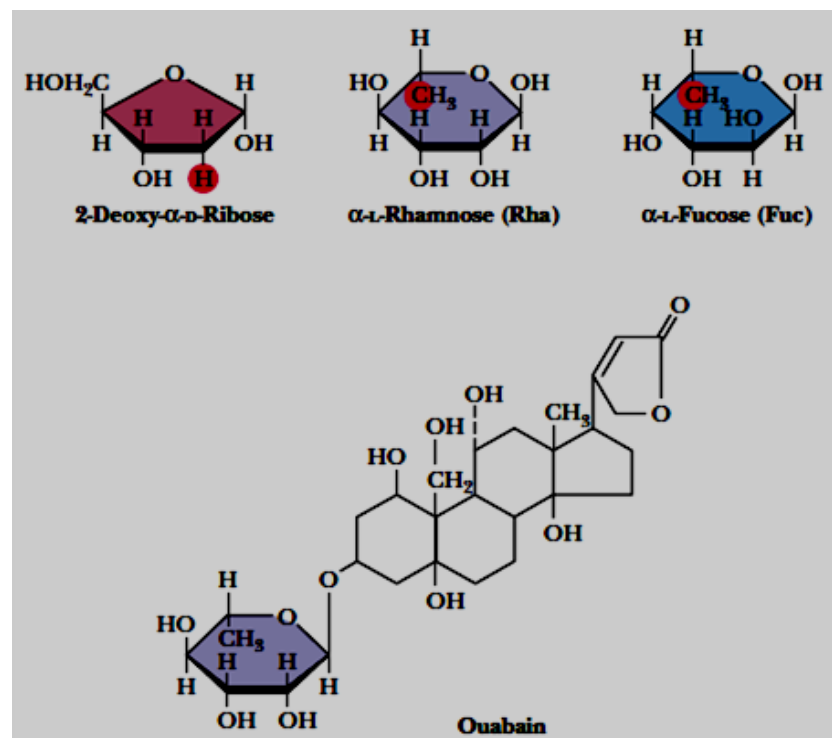


FIGURE 1.11 Several deoxy sugars and ouabain, which contains α-L-rhamnose (Rha).

## 5. Amino sugars

Including D-glucosamine and D-galactosamine (Fig. 1.11), contain an amino group (instead of a hydroxyl group) at the C-2 position. They are found in many oligo- and polysaccharides, including *chitin*, a polysaccharide in the exoskeletons of crustaceans and insects.

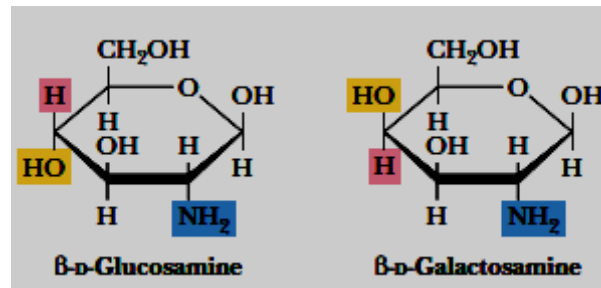


FIGURE 1.12 Structures of D-glucosamine and D-galactosamine.

## 6. Glycosides

Are two types:

(a) **O-glycosides.** When hydroxyl group on anomeric carbon of a sugar reacts with an alcohol (sugar) O-glycoside is formed. O-glycoside linkage is present in disaccharides and polysaccharides. So, disaccharides, oligosaccharides and polysaccharides are O-glycosides.

(b) **N-glycosides.** Are formed when hydroxyl group on anomeric carbon of sugar react with an amine. N-glycosidic linkage is presents in nucleotides, RNA and DNA. So, nucleotides, RNA and DNA are examples of N-glycosides.

## OLIGOSACCHARIDES

They consist of 2-9 monosaccharide units. The monosaccharides are joined together by glycoside bonds. Most important oligosaccharides are disaccharides.

### Disaccharides

They provide energy to human body. They consist of two monosaccharide units held together by glycosidic bond. So, they are glycosides. Most common disaccharides are maltose, lactose and sucrose (Figure 1.12).

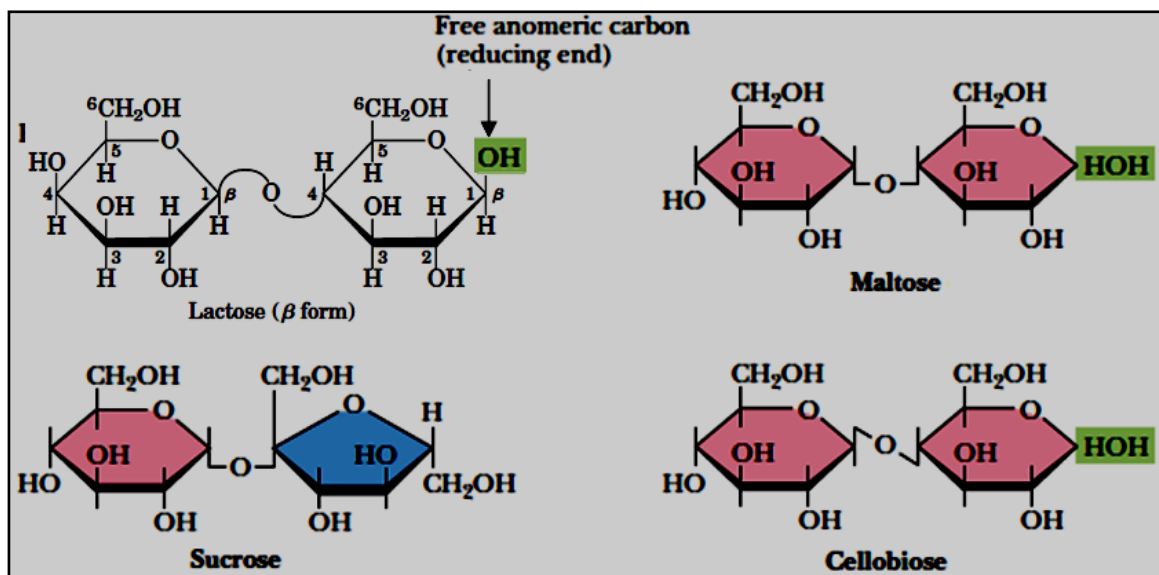


Figure 1.12 The Structures Of Several Important Disaccharides.

### Maltose

#### Structure

It contains two glucose units. The anomeric carbon atom of first glucose and carbon atom 4 of second glucose are involved in glycosidic linkage. The glycosidic linkage of maltose is symbolized as  $\alpha(1\rightarrow4)$ . In this symbol, the letter  $\alpha$  indicates the configuration of anomeric carbon atoms of both glucose unit and numbers indicates carbon atoms involved in glycosidic linkage. Systematic name for maltose is O- $\alpha$ -D-glycopyranosyl-(1 $\rightarrow$ 4)- $\alpha$ -D-glycopyranose. Maltose is reducing sugar because anomeric of second glucose is free.

#### Source of maltose

Maltose is present in germinating cereals and in barley. Commercial malt sugar contain maltose. It may be formed during the hydrolysis of starch.

**Lactose***structure*

it contains one glucose and one galactose. The anomeric carbon atom of galactose and carbon atom 4 of glucose are involved in glycosidic linkage. It is symbolized as  $\beta(1\rightarrow4)$ . The systematic name for lactose is O- $\beta$ -D-galactopyranosyl-(1 $\rightarrow$ 4)- $\beta$ -D-glucopyranose. Lactose is a reducing sugar because anomeric carbon of glucose is free.

*Source of lactose*

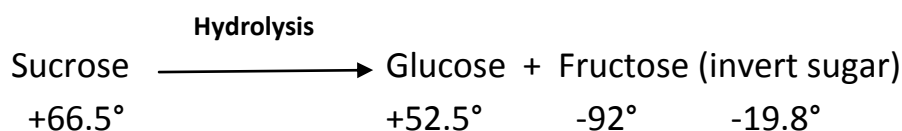
Lactose is synthesized in mammary gland and hence it occurs in milk.

**Sucrose**

It contains glucose and fructose. The anomeric carbon of glucose and anomeric carbon of fructose are involved in glycosidic linkage. Further, glucose is in  $\alpha$ -form whereas fructose is in  $\beta$ -form in sucrose. Hence the glycosidic linkage of sucrose is designated as  $\alpha, \beta(1\rightarrow2)$ . Its systematic name is O- $\alpha$ -D-glucopyranosyl-(1 $\rightarrow$ 2)- $\beta$ -D-fructofuranose. Sucrose is a non reducing sugar because both the functional groups of glucose and fructose are involved in glycosidic linkage.

*Invert sugar*

Sucrose has specific optical rotation of  $+66.5^\circ$ . On hydrolysis, it changes to  $-19.8^\circ$ . this change in optical rotation from dextro to levo when sucrose is hydrolyzed is called as *inversion*. The hydrolysis mixture containing glucose and fructose is called as invert sugar. The change in optical rotation on hydrolysis is because of fructose which is more levo rotatory than dextro rotator glucose.

**Other Disaccharides***Isomaltose*

It contain two glucose units. Glycosidic linkage is  $\alpha(1\rightarrow6)$ . Isomaltose is the disaccharide unit present in glycogen, amylopectin and dextrane.

