Chemistry of Carbohydrates

Learning Outcomes:

Students will be able to:

1. distinguish between mono-, di- and tri-saccharides.
2. check the relative solubility in water of starch and sugar.
3. explain the use of dextrose strip.

What Are Carbohydrates?

The literal meaning of the word *"Carbohydrate"* is hydrate of carbon. This name was given by the early scientists because the carbohydrates decompose on heating to give carbon and water. On this basis the carbohydrates can be given general formula $C_x(H_2O)_y$. Howevere, this meaning of 'Carbohydrate' is only of historical interest, because it is known that many carbohydrates also contain nitrogen and sulphur in addition to C,H and O. Moreover, there are several compounds like acetic acid, $C_2H_4O_2$, which have similar formulas, but are

not carbohydrates.
Carbohydrates are now defined as follows: *"Carbohydrates are polyhydroxy aldehydes or ketones".*
Most carbohydrates consist of C,H and O, but a few are known to contain N and S as well. Carbohydrates are major constituents of most plants which constitute about 60% to 90% of thier dry mass-mostly cellulose. Animals contain less than 1% of these substances. Plants can synthesize carbohydrates from CO_2 and water(from air) in the presence of sunlight and

chlorophyll. This process is called *photosynthesis*. Animals depends on plants for their needs of carbohydrates.

Digestion of Carbohydrates:

The digestion of carbohydrates begins in the mouth where the enzyme, *ptyalin* , is presnt in the saliva. Ptyalin acts in neutral or slightly acidic medium (ph 6.0 - 7.1) and hydrolyzes starch to maltose.

$$\underset{\text{starch}}{2(C_6H_{10}O_5)n} + nH_2O \xrightarrow{\text{ptyalin}} \underset{\text{maltose}}{nC_{12}H_{22}O_{11}}$$

This process contiues in the stomach. As the food moves down into the intestines, other enzymes, produced by pancreas and intestinal glands, acts on it and convert it finally, into

glucose and other simpler products.

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$$

glucose

Glucose is then carried to liver and muscles by capillary blood vessels. Glucose in the liver is stored as glycogen ($C_6H_{10}O_5$), while in the muscles it is oxidized during respiration to release energy. The products of respiration are CO_2 and H_2O, which are exhaled out. A summary of digestion of carbohydrates is given below:

Classification of Carbohydrates:

Carbohydrates are classified into three main classes:

1. Monosaccharides
2. Disaccharides
3. Polysaccharides

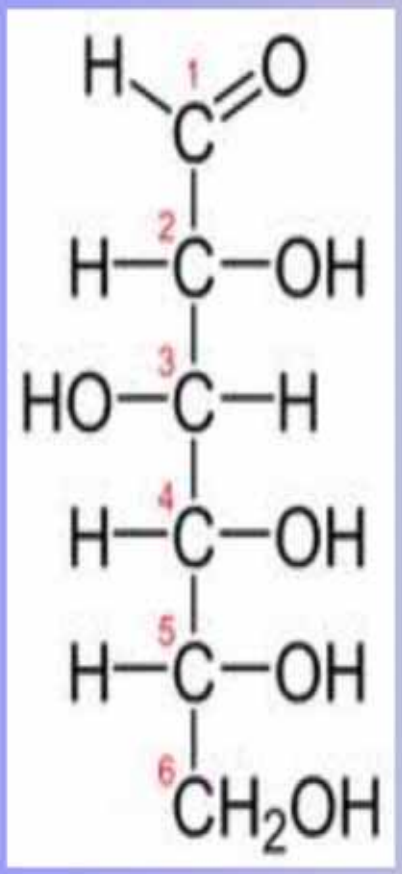
1. Monosaccharides:

These are the simplest carbohydrates and cannot be hydrolyzed further. They may contain from three to nine carbon atoms, but the important ones contain six carbon atoms.

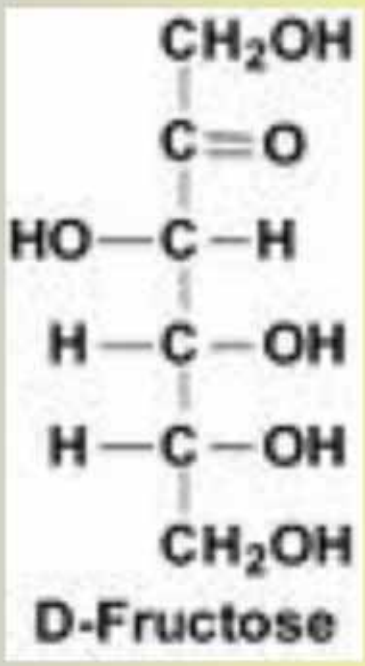
Monosaccharides are further classified

according to the number of carbon atoms in their molecules. Thus, the monosaccharides containing three or more carbon atoms are named as *trioses*, *pentoses*, *hexoses* etc. Important monosaccharides are the hexoses- glucose, fructose, galactose and mannose.

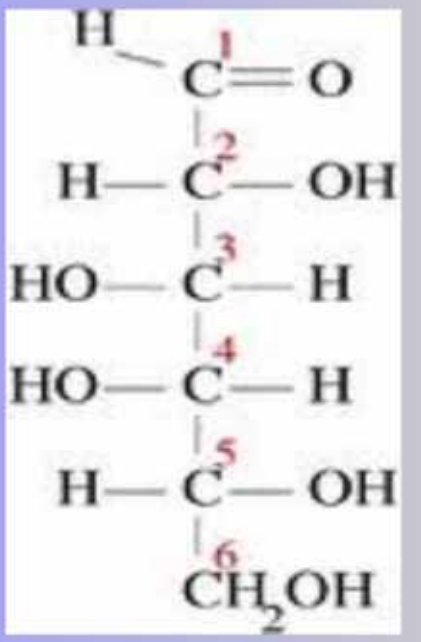
Glucose is a pentahydroxy aldehyde while fructose is a pentahydroxy ketone. The two are isomeric having the molecular formula $C_6H_{12}O_6$. They exist both as open-chain and cyclic structures. These structures are given below:



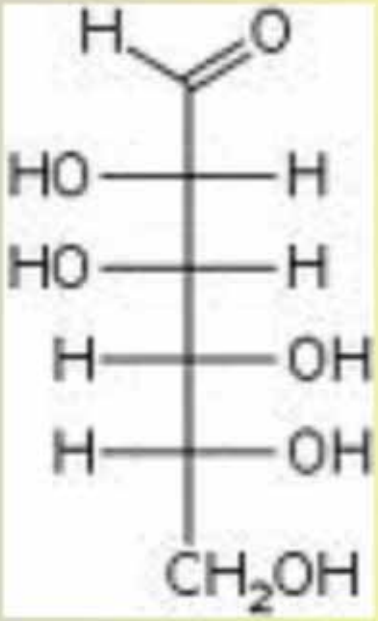
glucose



fructose



galactose



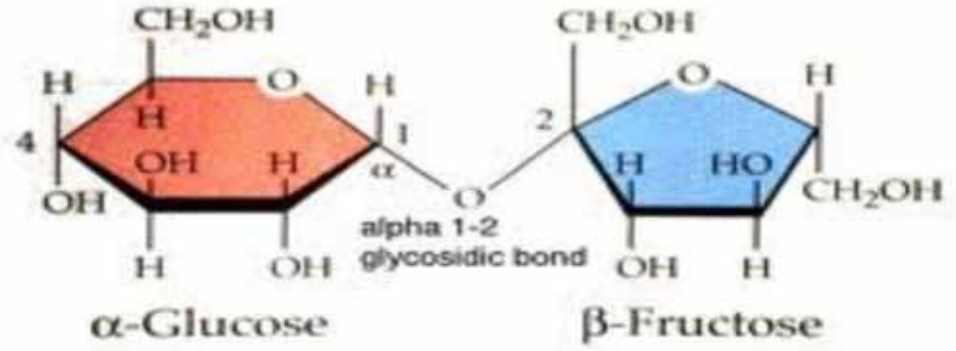
mannose

Disaccharides:

"These sugars produce two monosaccharides on hydrolysis"

The most common disaccharide is *sucrose* which on hydrolysis produce one unit of *glucose* and one unit of *fructose*.

Sucrose has the molecular formula $C_{12}H_{22}O_{11}$

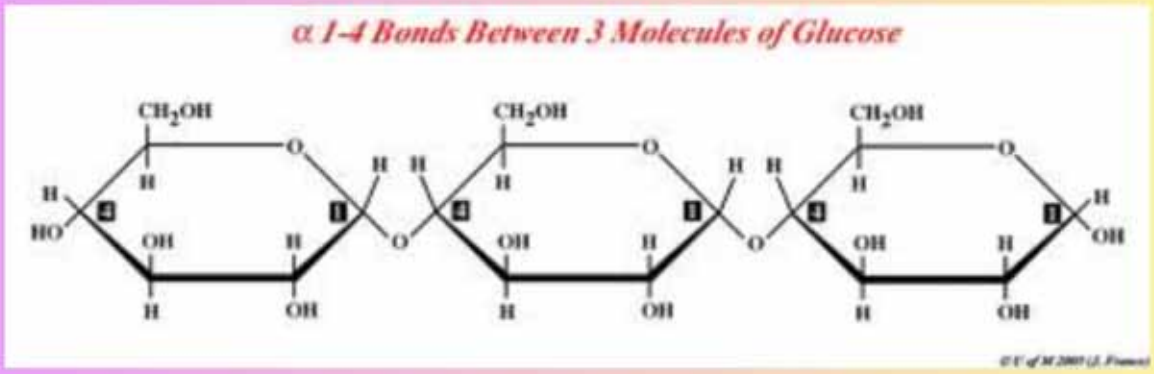


Sucrose

Polysaccharides:

These are macromolecular carbohydrates and consist of hundreds or thousands of monosaccharide units.

Starch and cellulose belong to this class.



Solubility of Sugar in water:

Sugar or sucrose, is a water soluble carbohydrate, that occurs naturally in every fruit and vegetable in the plant kingdom. It is the major product of photosynthesis, the process by which plants transform the sugar energy into food.

Starch:

As starch is not soluble in water, it can easily extracts in water from the storage in plant. Its suspension starts to become viscous by heating and turns to transparent paste. It means amylopectin forms crystallized micelle and amylose arranges orderly around the gaps of the micelles in starch particle. This is why starch is not soluble in cold water. However, water molecules are getting into micelles gradually when heating the solution and resulting to loosen hydrogen bond and short molecules of amylose starts to dissolve, then amylopectin swells up.

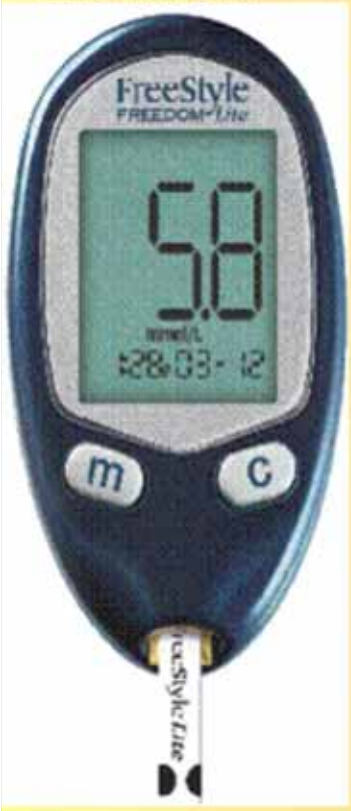
Pure starch is a white, tasteless and odorless powder that is insoluble in cold water or alcohol. It consists of two types of molecules: the linear and helical amylose and the branched amylopectin. Depending on the plant, starch generally contains 20 to 25% amylose and 75 to 80% amylopectin.

Use Of Dextrose Strips(Diabetes test strips)

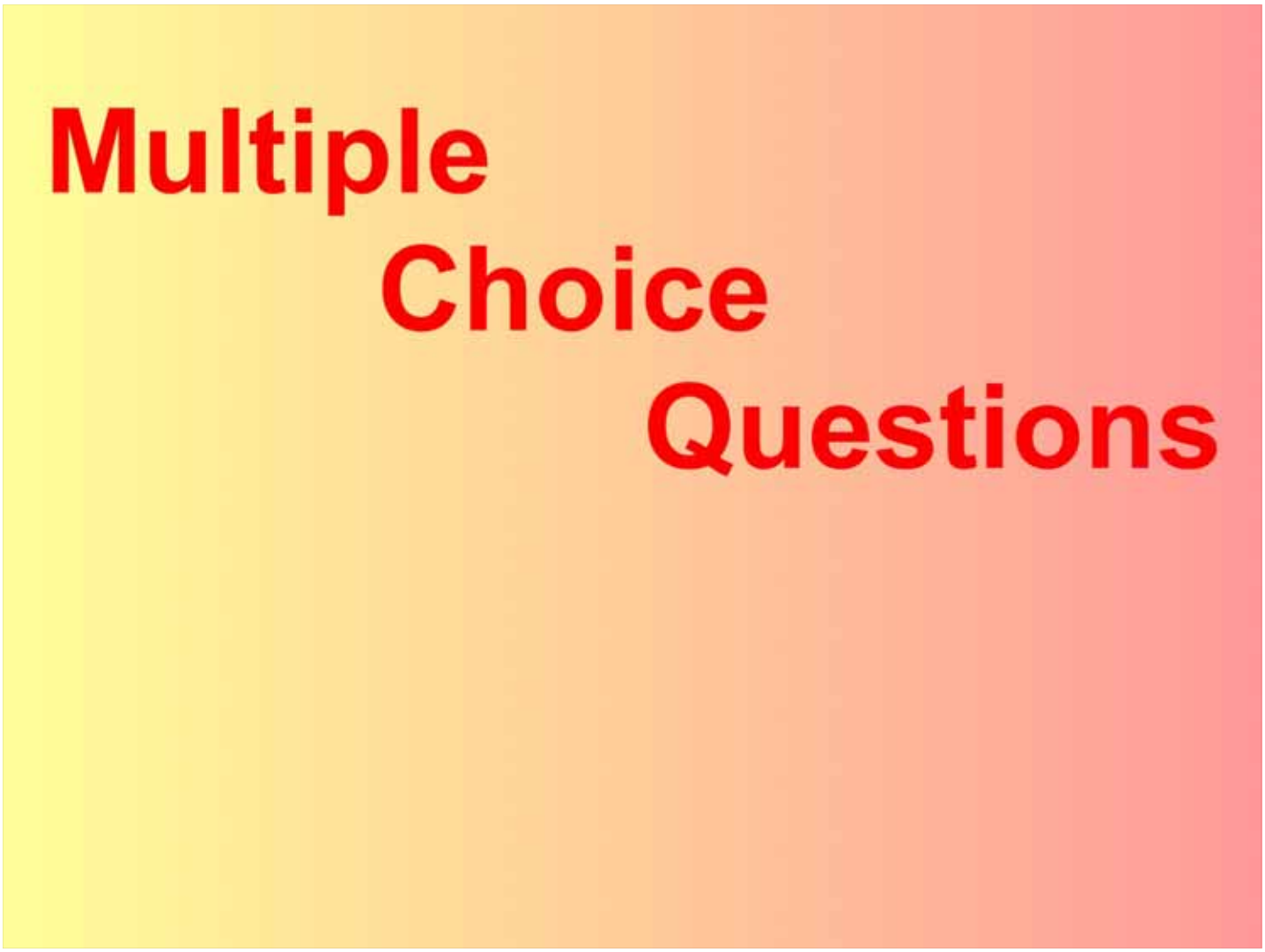
Diabetes is a condition in which the body either does not produce enough, or does not properly respond to, insulin, a hormone produced in the pancreas that enables cells to absorb glucose in order to turn it into energy. In diabetes, the body either fails to make enough insulin (Type 1 diabetes), or does not properly respond to its own insulin (Type 2 diabetes). This causes glucose to accumulate in the blood, leading to complications of the eyes, kidney, heart and circulatory system, among others.

Blood glucose test strips (diabetes test strips) are one of the components of a diabetes monitoring system. Diabetic test strips are an essential part of monitoring blood glucose.

Diabetes test strips do not work on their own, they are used in conjunction with a blood glucose monitor.



A diabetic pricks themselves in order to draw blood, which is then applied to the test strip. The blood glucose monitor is then able to detect how much blood glucose is present.


Multiple
Choice
Questions

1. Which of the following carbohydrates can not be further hydrolyzed into simpler forms?

A. Polysaccharides
B. Oligosaccharides
C. Disaccharides
D. Monosaccharides

2. Which of the following linkage unite monosaccharide units to produce higher carbohydrates?

A. Ether linkage
B. Ester linkage
C. Glycosidic linkage
D. Peptide linkage

3. Which of the following can form a colloidal solution when dissolved in water?

A. Glucose
B. Sucrose
C. Starch
D. Cellulose