# CARBOHYDRATES

## COMMON SOURCES

- Bread, pasta and fruits

## CHEMICAL COMPOSITION

- All carbohydrates contain the elements **carbon**, **hydrogen** and **oxygen.**
- They have the general formula **C x ($H_2O$) y** or **(C $H_2O$) x**.

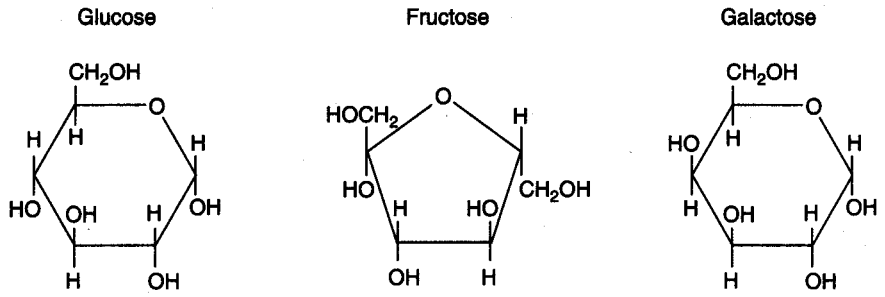
There are 3 different types of carbohydrates: **Monosaccharides, Disaccharides** and **Polysaccharides.**

## 1. MONOSACCHARIDES

The monosaccharides are also known as **simple sugars.** The 3 main examples that we should be familiar with are:

**Glucose** which is found in fruit juice;
**Fructose** which is found in fruit juices and honey and
**Galactose** which does not occur naturally.

All these monosaccharides have the have same molecular formula of **$C_6H_{12}O_6$**. However they have slight variations in their structural formulae so they are structural isomers of each other. The structures of these 3 monosaccharides are shown below:

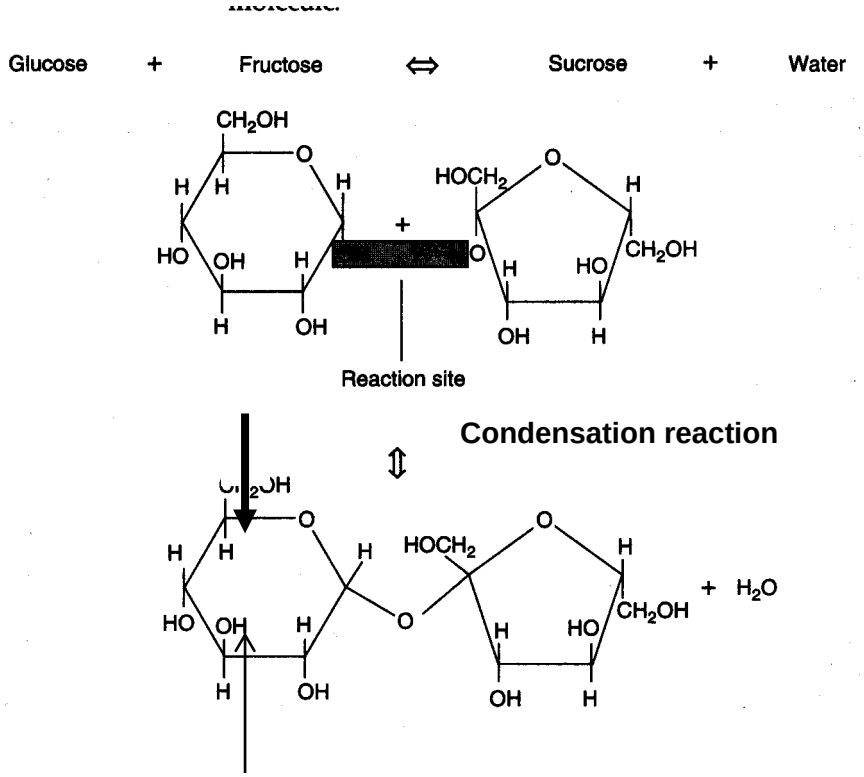



The ends of these molecules are joined together to from cyclic structures. The lines that make up the pentagonal structure of the fructose and hexagonal structure of the glucose and galactose are single covalent bonds. The union of any 2 lines on these structures represents carbon atoms. If you add up all the C, H and O atoms in these structures you will get a molecular formula of $C_6H_{12}O_6$.

Monosaccharides contain a number of polar hydroxy (OH) functional groups enabling them to form hydrogen bonds with water. As a result, monosaccharides are highly soluble in water.

## 2. DISACCHARIDES

Monosaccharides are simple building blocks for more complex carbohydrates such as disaccharides and polysaccharides. If two monosaccharides join together they will produce a molecule that is known as a **disaccharide**. They join together by undergoing a **condensation reaction** where a water molecule is eliminated. If a glucose monosaccharide reacts with a fructose the resulting disaccharide is called sucrose (table sugar). The region where the 2 molecules join together is known as an **ether linkage**.




**Ether linkage or glycosidic bond**

The disaccharides that we should be familiar with are:

**Maltose**, which is formed from glucose and glucose
**Sucrose (table sugar)**, which is formed from glucose and fructose
**Lactose**, which is formed from glucose and galactose

## 3. POLYSACCHARIDES: THE COMPLEX CARBOHYDRATES

Polysaccharides are made by linking a large number of monosaccharides together to form long chained molecules. As a result polysaccharides are polymers. As is the case with disaccharides, polysaccharides are formed by a condensation reaction. Polysaccharides are not very soluble in water because most of the hydroxy groups have been used up in forming **ether linkages**.

The most important polysaccharides that we should be familiar with are:

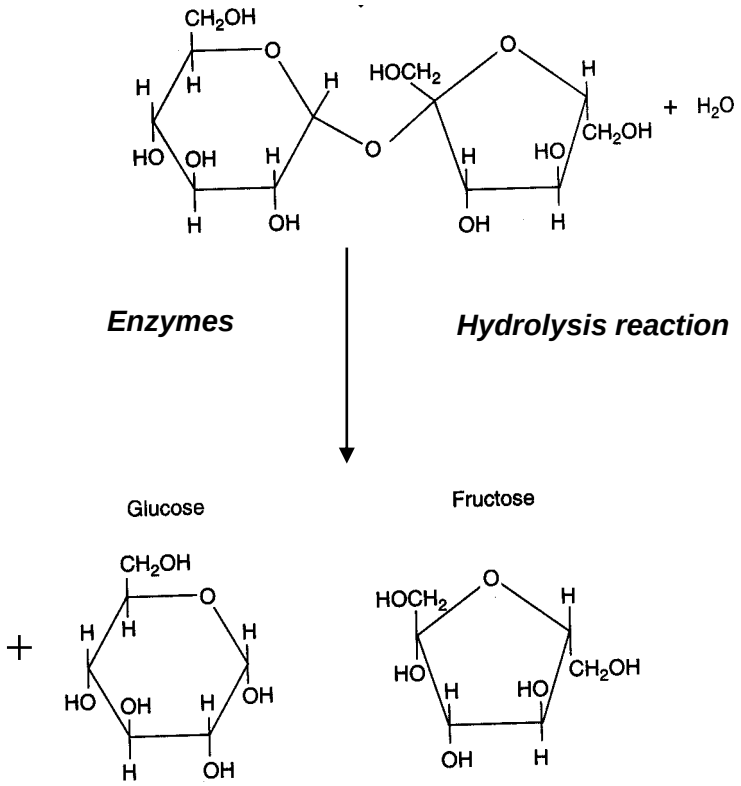
**Glycogen:** Used as a storage for glucose in most animals. It is stored in liver and muscle tissue.

**Starch:** Stores glucose in plants. Potatoes are rich in starch.

**Cellulose:** The main structural material in plants. Cannot be digested by humans.

The main function of carbohydrates is to act as a fuel for the process of cellular respiration, which produces all the energy required for our important day to day life functions. The monosaccharide glucose is the main fuel used for this purpose. The disaccharides and polysaccharides that we eat need to be broken down by our digestive system into the monosaccharides (such as glucose) that came together to make them up in the first place. The digestion of carbohydrates starts in the mouth and is completed in the small intestine.

The equation below shows the digestion of the disaccharide sucrose.



This reaction is the *reverse* of the condensation reaction that produced the disaccharide. The break down of a disaccharide into 2 monosaccharides is called a **hydrolysis** reaction because water is required as a reactant during the reaction. **Enzymes** are also needed. Enzymes are organic catalysts that are produced by the body. Every chemical reaction that occurs in the body requires an enzyme. Like all catalysts, enzymes work by lowering the activation energy of a reaction and hence increase the rate of a chemical reaction. The glucose produced enters the blood stream through the walls of the small intestine. It is transported to all the cells of the body and used for the energy producing process of cellular respiration.

$$\mathbf{C_6H_{12}O_{12}\ (aq)\ +\ 6O_2\ (g) \rightarrow 6CO_2\ (g)\ +\ 6H_2O\ (l)\quad \Delta H = -}$$

**EXAMPLE 1**
Which of the following is the formula of a carbohydrate?

A $NH_2CH_2COOH$
B $C_3H_{36}O_2$
C $C_{12}H_{22}O_{11}$
D $C_3H_8O_3$

***Solution***

Answer is C

$C_{12}H_{22}O_{11}$ has the general formula C x $(H_2O)$ y or $(C\ H_2O)$ x. The easiest way to tell is by looking at the $H_{22}O_{11}$ part of the molecule. This has an empirical formula of $H_2O$.

**EXAMPLE 2**
Maltose is a disaccharide formed from glucose molecules. What type of reaction occurs when glucose is converted into maltose? Suggest a molecular formula for maltose and write a chemical equation for the conversion of glucose into maltose using molecular formulae.

***Solution***

The reaction is a condensation one because water is always produced when monosaccharides react to produce a disaccharide.

The molecular formula of glucose is $C_6H_{12}O_6$. Since 2 glucose molecules come together to make 1 maltose molecule, the molecular formula of maltose must contain twice the number of atoms present in a glucose molecule minus 2 hydrogen atoms and 1 oxygen atom because $H_2O$ is eliminated.

$$2 \times C_6H_{12}O_6 = C_{12}H_{24}O_{12} - H_2O = C_{12}H_{22}O_{11}$$

$$C_6H_{12}O_6\ (aq)\ +\ C_6H_{12}O_6\ (aq)\ \rightarrow\ C_{12}H_{22}O_{11}\ (aq)\ +\ H_2O\ (l)$$