Tikrit University

College of Nursing

Basic Nursing Sciences

1st stage - 2023-2024

Biochemistry

(Lecture (2) carbohydrates)

by:

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Carbohydrates

Carbohydrates (also called saccharides) are molecular compounds made from just three elements: carbon, hydrogen and oxygen. Monosaccharides (e.g. glucose) and disaccharides (e.g. sucrose) are relatively small molecules. They are often called sugars. Other carbohydrate molecules are very large (polysaccharides such as starch and cellulose).

Carbohydrates are:

• a source of energy for the body e.g. glucose and a store of energy, e.g. starch in plants

• building blocks for polysaccharides (giant carbohydrates), e.g. cellulose in plants and glycogen in the human body

• components of other molecules e.g. DNA, RNA, glycolipids, glycoproteins, ATP

Monosaccharides

Monosaccharides are the simplest carbohydrates and are often called single sugars. They are the building blocks from which all bigger carbohydrates are made.

Monosaccharides have the general molecular formula $(CH_2O)_n$, where n can be 3, 5 or 6. They can be classified according to the number of carbon atoms in a molecule:

$n = 3$	trioses, e.g. glyceraldehyde
$n = 5$	pentoses, e.g. ribose and deoxyribose ('pent' indicates 5)
$n = 6$	hexoses, e.g. fructose, glucose and galactose ('hex' indicates 6)

There are more than one molecule with the molecular formula C5H10O5 and more than one with the molecular formula C6H12O6. Molecules that have the same molecular formula but different structural formulae are called structural isomers.

Glyceraldehyde's molecular formula is C3H6O3. Its structural formula shows it contains an aldehyde group (-CHO) and two hydroxyl groups (-OH). The presence of an aldehyde group means that glyceraldehyde can also be classified as an aldose. It is a reducing sugar and gives a positive test with Benedict's reagent.

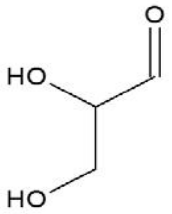
CH2OHCH(OH)CHO is oxidised by Benedict's reagent to CH2OHCH(OH)COOH; the aldehyde group is oxidised to a carboxylic acid and Benedict's reagent is reduced (Cu2+ to Cu+).

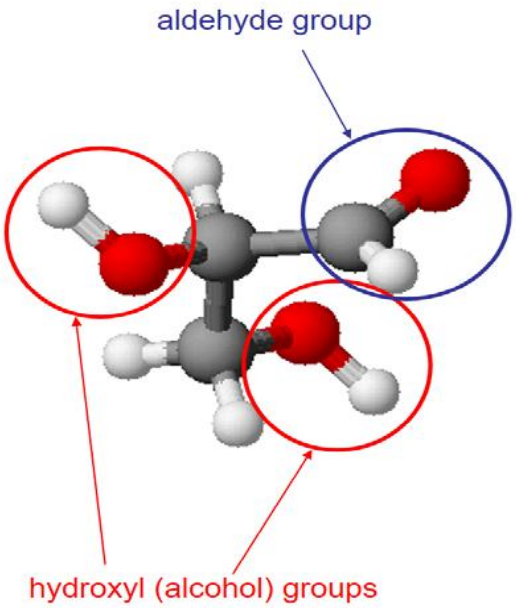
Glyceraldehyde, $C_3H_6O_3$

Glyceraldehyde is a triose because there are three carbon atoms in each molecule

It is also called an aldose because of the presence of an aldehyde group in the molecule

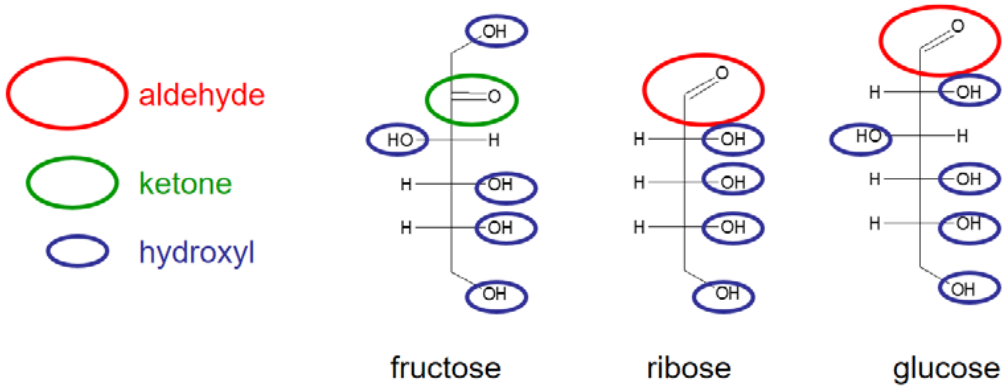
Its skeletal formula is





Pentoses and hexoses can exist in two forms: cyclic and non-cyclic. In the non-cyclic form their structural formulae show they contain either an aldehyde group or a ketone group.

Non-cyclic forms of carbohydrates

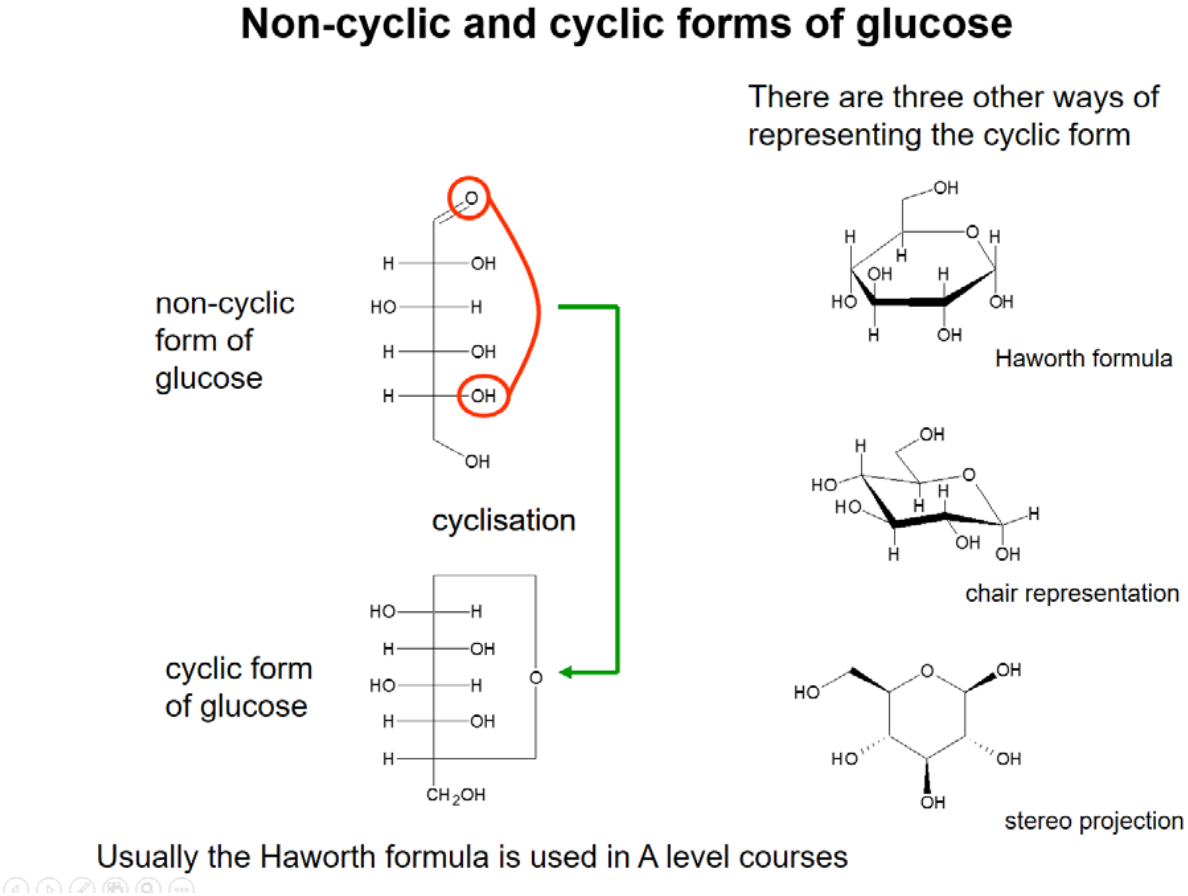


Here are the non-cyclic forms of:

- fructose (a ketose, i.e. contains a ketone group)
- ribose
- glucose

(both aldoses, i.e. contain an aldehyde group)

Monosaccharides containing the aldehyde group are classified as aldoses, and those with a ketone group are classified as ketoses. Aldoses are reducing sugars; ketoses are non-reducing sugars. This is important in understanding the reaction of sugars with Benedict's reagent.



However, in water pentoses and hexoses exist mainly in the cyclic form, and it is in this form that they combine to form larger saccharide molecules.

Glucose

Glucose is the most important carbohydrate fuel in human cells. Its concentration in the blood is about 1 gdm-3. The small size and solubility in water of glucose molecules allows them to pass through the cell membrane into the cell. Energy is released when the molecules are metabolised (C6H12O6 + 6O2 6CO2 + 6H2O). This is part of the process of respiration.

> See the topic about Respiration

> See the topic about In and out of cells

There are two forms of the cyclic glucose molecule: α-glucose and β-glucose.

Two glucose molecules react to form the disaccharide maltose. Starch and cellulose are polysaccharides made up of glucose units.

Galactose

Galactose molecules look very similar to glucose molecules. They can also exist in α and β forms. Galactose reacts with glucose to make the disaccharide lactose.

However, glucose and galactose cannot be easily converted into one another. Galactose cannot play the same part in respiration as glucose.

This comparison of glucose and galactose shows why the precise arrangement of atoms in a molecule (shown by the displayed formula) is so important.

Fructose

Fructose, glucose and galactose are all hexoses. However, whereas glucose and galactose are aldoses (reducing sugars), fructose is a ketose (a non-reducing sugar). It also has a five-atom ring rather than a six-atom ring. Fructose reacts with glucose to make the disaccharide sucrose.

Ribose and deoxyribose

Ribose and deoxyribose are pentoses. The ribose unit forms part of a nucleotide of RNA. The deoxyribose unit forms part of the nucleotide of DNA.