Lesson 2

LIPIDS & PROTEINS

Aim

Explain the characteristics of major biochemical groups including carbohydrates, lipids and proteins.

CARBOHYDRATE

Carbohydrates are compounds that contain carbon combined with hydrogen and oxygen. They are one of the most significant groups of organic compounds that are made (synthesised) by living systems (within the tissues of plants or animals). Carbohydrates are significant both in terms of both quantity made and the importance of their use in living organisms.

Carbohydrates are compounds which, when analysed, give empirical formulae which are multiples of the simple formula CH_2O. Chemically, carbohydrates are defined as polyhydroxy (poly = many, hydroxyl refers to the OH groups which are bonded to the carbon atoms of the molecules backbone) aldehydes or ketones (depending on the location of a double bonded oxygen atom (refer to the structural diagrams in the previous lesson. A saccharide aldehyde is an aldose, a saccharide ketone is a ketose. Saccharides typically exist as cyclic molecules. Examples of carbohydrates include sugars, starch, glycogen, cellulose and chitin. Carbohydrates are made or synthesised in plants by the process of photosynthesis.

Types of Carbohydrate

Carbohydrates may be broken down into three groups:

Monosaccharides

These are the simplest carbohydrates. They are made up of a chain of carbon atoms to which hydrogen and oxygen atoms are attached in the proportion of 1 carbon atom to 2 hydrogen atoms to 1 oxygen atom (CH_20). Monosaccharides can not be hydrolysed to give smaller molecules, they are as small as saccharides get, and are considered to be one saccharide unit, hence the name mono (meaning 1) saccharide. (Hydrolysis is the process of splitting one molecule into two by the addition of H^+ and OH^- ions of water and is depicted in the diagram at the end of this section).

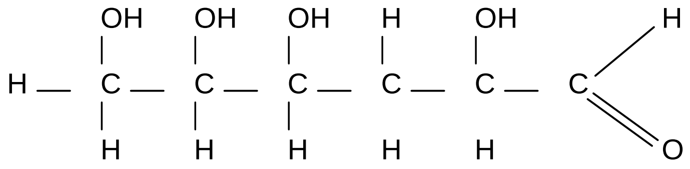
Glucose is a monosaccharide and is the form of sugar which is most often transported through animal systems. A combination of glucose and fructose forms sucrose, which is the form that plants use.

There are four common monosaccharides found in nature:

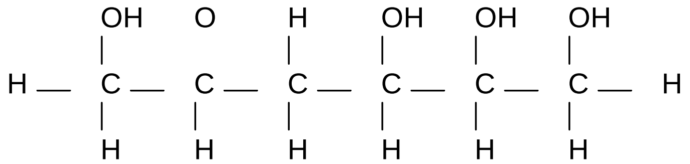
- Glucose -Contains six carbon, six oxygen and twelve hydrogen atoms; it is a building block for many other compounds, and is one of the most common compounds on earth.

- Fructose -Contains six carbon, six oxygen and twelve hydrogen atoms, the same as glucose, but arranged or bonded together in a different pattern; found together with glucose in honey and fruit juices.

- Ribose -occurs naturally as part of vitamin B_{12} and the ribonucleic acids (RNA)
- 2-Deoxyribose -occurs naturally as part of DNA (Deoxyribonucleic acid) which is an essential part of the genetic material found in all living organisms.



Glucose



Fructose

While they have the same chemical formula, glucose is an aldose and fructose is a ketose. This affects how the body metabolises each, and fructose takes much longer to metabolise than glucose.

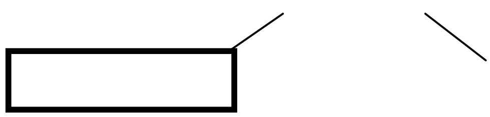
Oligosaccharides

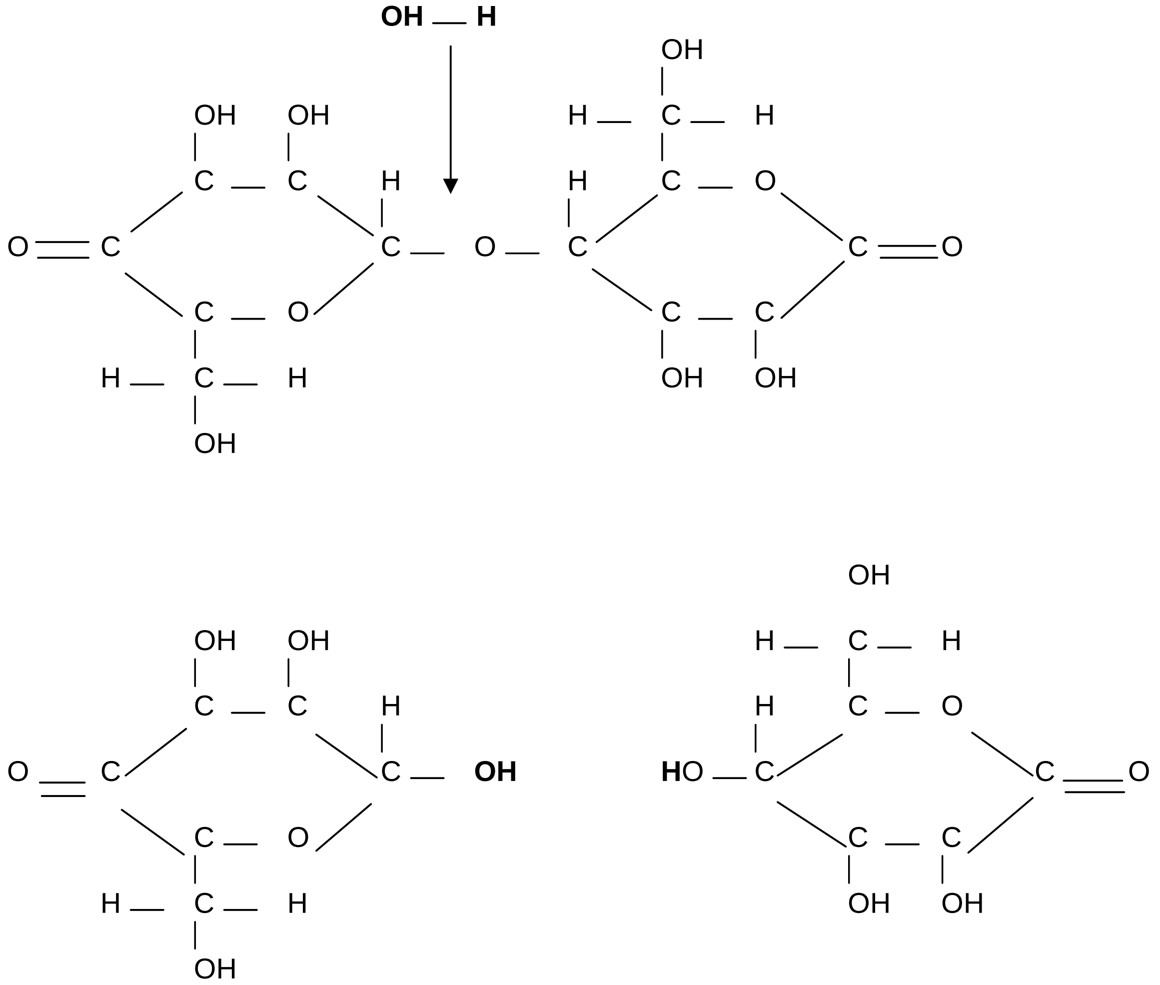
These are compound sugars which, when hydrolysed, will yield two to six saccharide molecules. Disaccharides for example, are oligosaccharides which yield two monosaccharide molecules when they are hydrolysed.

Polysaccharides

These are made up of monosaccharides linked together in long chains. They yield a large number of monosaccharides when they are hydrolysed. Starch, which is made of many glucose molecules, is the main storage form of sugar in plants. (Glycogen is the common storage form of sugar in animals.) They must be hydrolysed before they can be used as energy sources for living systems.

Hydrolysis of a disaccharide to give two monosaccharides:





Hydrolysis of a Disaccharide
The glycosidic bond joining the two monosaccharides is shown in the box. Water attacks this bond, and is itself 'added' across it, with the hydroxide ion bonding to one of the carbons and the remaining H+ ion bonding to the oxygen molecule which remains attached to the other carbon.

Carbohydrate Function

- Carbohydrates store energy from light in plants.

During photosynthesis light energy is accepted by the plant cell and transformed into a chemical energy which is used to bond atoms of hydrogen, oxygen and carbon together to produce sugars. The hydrogen, oxygen and carbon come from water (extracted from the soil) and carbon dioxide (extracted from the air). Plants can build up complex carbohydrates and store them as starch in their tissues. Humans cannot do this. Starch must be broken down into simple sugars before being used by human tissue.

- Carbohydrates release energy.

The photosynthesis explained above can be reversed in a plant in order to supply energy (with by products of carbon dioxide and water). This process is called plant respiration.

- Energy Supply in Animals/Humans

Carbohydrates are a major energy source for most animals. They can be metabolised; (transformed into usable end products by chemical reactions in living cells) breaking down chemical bonds making large compounds into smaller compounds, and in the process releasing energy. This energy is then used by the cell as a power source, allowing it to perform required functions.

LIPIDS

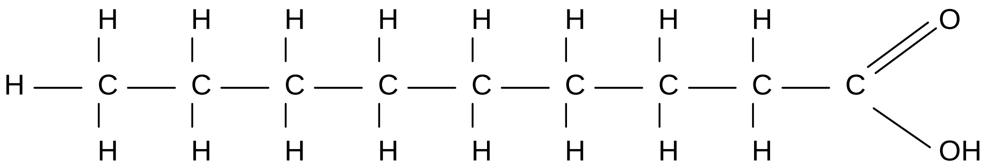
Lipids are organic fats and oils. Group of biomolecules that are grouped under this classification based on their solubility properties – they are all water insoluble, or at least partially insoluble in water, however they are readily soluble in organic solvents, such as hot alcohol, benzene or ether. Lipids occur in both plants and animals, and are among other things, used to store chemical energy. Fats and oils are distinguishable by their melting points, fats (such as lard and butter) are solid at room temperature, and oils (canola, olive etc) are liquid. Some common lipid biomolecules that are found in animals are described below including fatty acids, triglycerides, phospholipids and sterols.

Fatty Acids

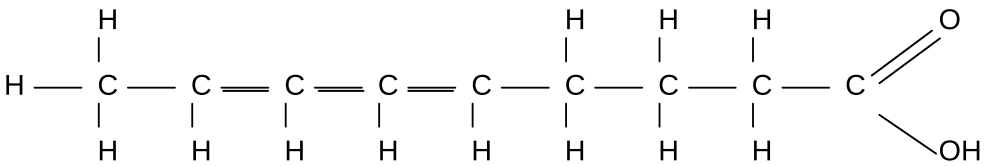
These are carboxylic acids with long hydrocarbon chains tails. They may be saturated (all single bonds between the carbon atoms of the backbone) or unsaturated (double or triple bonds between the carbon atoms). Monounsaturated means there is only one double or triple bond in the hydrocarbon tail, polyunsaturated means there is more than one double bond on the hydrocarbon tails. When a hydrocarbon chain is saturated (no double bonds) it lies straight. This means that the molecules in a saturated fat can pack in tight to each other. This is why saturated fats are commonly found to be hard at room temperature. In either a mono or polyunsaturated fat, the hydrocarbon tails are kinked and they cannot pack in closely to each other. This is why these types of oils are commonly found to be liquid at room temperature.

The head of the fatty acid, the carboxylic acid is very hydrophilic (water hating). The hydrocarbon chain (the tail) is very hydrophobic (water hating). A molecule like this, which is both water hating and loving is called amphipathic. This property is extremely important in the structure of cell membranes.

Fatty acids are typically written with the number of carbons, followed by a colon (:) and then the number of double bonds in the molecule. So, 18:1 means the fatty acid has 18 carbons, with one double bond (oleic acid). The general structure of a saturated and polyunsaturated fatty acid is shown in the following diagram.



Saturated (9:0)



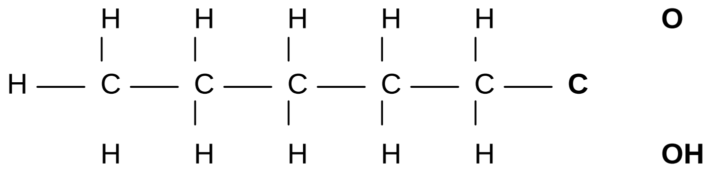
Polyunsaturated (9:3)

Triglycerides

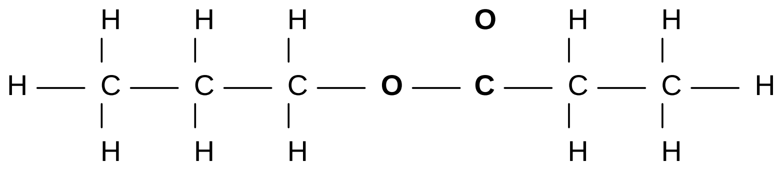
You will also see these referred to as triacylglycerols. A triacylglycerol is a compound comprised of glycerol with three fatty acids attached. The glycerol and the fatty acids about joined by ester bonds. An ester bond (or esterification as the process is called) is where H from the carboxylic acid (-COOH) found on the fatty acid is replace by a bond to the glycerol.

The diagram below shows the structure for both an ester and a carboxylic acid so you can compare the difference, along with the more complex structure of a triglyceride.

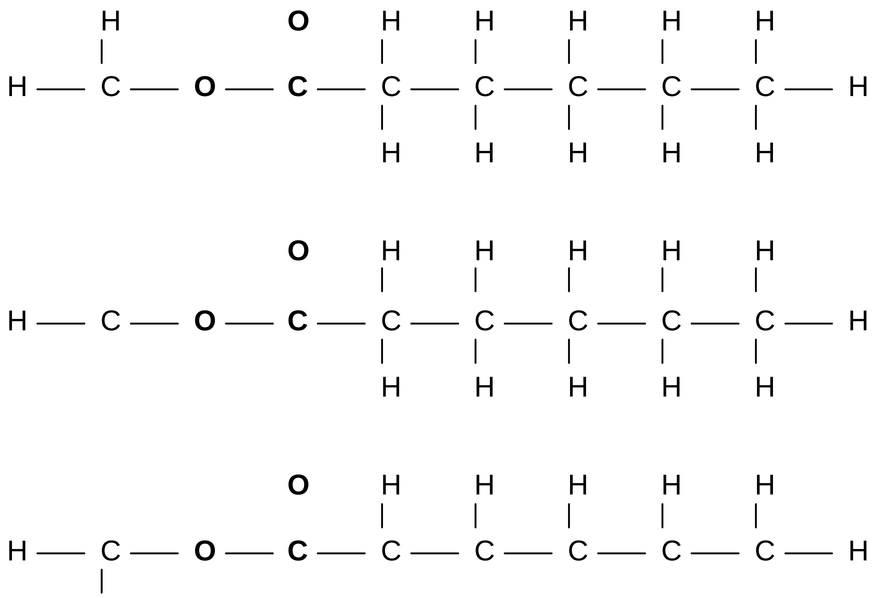
The fatty acids tails in one triacylglycerol molecule could all be the same as each other, or they could all be different. Triglycerides are a source of energy in living systems. They are stored primarily in the fat tissue and the body can get more than twice as much energy from a molecule of triacylglycerol than it can from a carbohydrate or protein molecule.



Carboxylic acid



Ester



Triacylglycerol

(glycerol – blue)
(ester bonds – red)
(fatty acids – yellow)

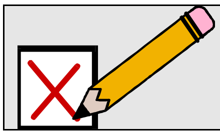
The body has limited powers of converting one amino acid into another as the need arises. While there are 20 amino acids, 8 of them cannot be manufactured by the body in sufficient quantities, and these 8 are known as "essential amino acids". They MUST be provided in the diet of every adult human.

The essential amino acids for adults are:

- Isolencine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine

In addition one other amino acid, **histidine**, is essential for growth in children.

Proteins can also be an energy source; however, they are more important for other purposes and are metabolized for energy only as a very last resort when carbohydrates and fats are not available.



SELF ASSESSMENT
Perform the self assessment test titled 'Self Assessment Test 2.1'
If you answer incorrectly, review the notes and try the test again.

ASSIGNMENT
Download and do the assignment called 'Lesson 2 Assignment'.