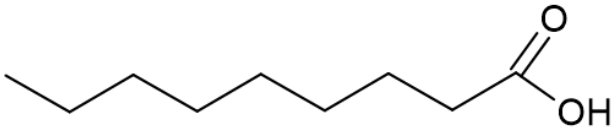
BIOLOGY
Topic Summary

LT3 - SATURATED AND UNSATURATED LIPIDS

Fatty acids can be either saturated or unsaturated which can lead to lipids with different properties and therefore different health implications.

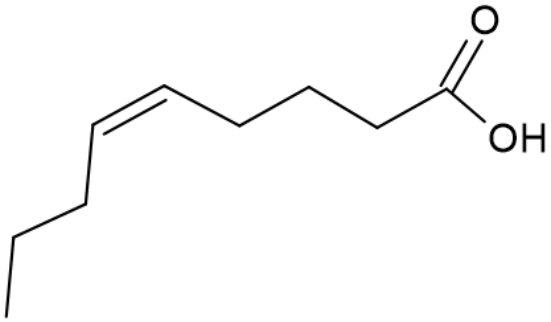
Saturated vs unsaturated:

A saturated fatty acid chain has no double bonds present, meaning there are only single bonds in the chain. Because there are only single bonds the fatty acid chain is 'straight' which means many saturated molecules can pack tightly together.

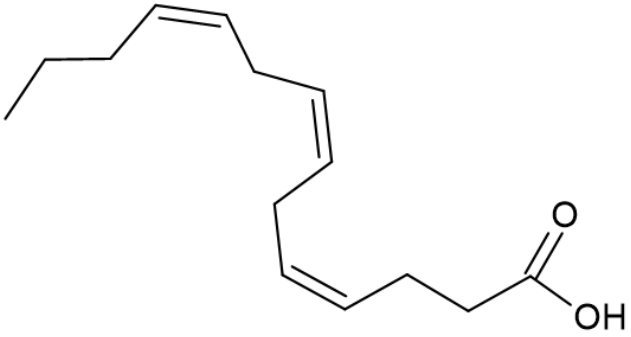


▲ *A saturated fatty acid, no double bonds are present.*

An unsaturated fatty acid has one or more double bonds present. Unsaturated fatty acids can be monounsaturated (meaning they have one double bond), or polyunsaturated (meaning they have multiple double bonds). Double bonds cause the fatty acid chain to bend which means the molecules cannot pack as closely together.



▲ *A monounsaturated fatty acid, one double bond is present causing a bend in the chain*



▲ *A polyunsaturated fatty acid, three double bonds are present causing multiple bends in the chain*

If the fatty acid chains on a triglyceride are all saturated, it is classed as a saturated lipid. However, if the chains are unsaturated then it is classed as an unsaturated lipid (or polyunsaturated if there is more than one double bond).

Saturated lipid molecules can pack closer together because they only contain straight fatty acid chains. This means the intermolecular forces between them are stronger and so their melting point is higher. On the other hand, unsaturated lipid molecules cannot pack as closely together due to the bends in their fatty acid chains. The intermolecular forces are weaker so their melting points are lower. Consequently, most fats are made of saturated (or weakly unsaturated) lipids as they are solid at room temperature, whilst most oils are made of highly unsaturated lipids as they are liquids at room temperature.

NOTE FOR CHEMISTS:
The intermolecular forces acting between each lipid molecule are actually Van der Waals (or London dispersion) forces. These occur when electrons in one molecule randomly collect at one side of the atom creating a temporary dipole. Electrons on other molecules nearby will be attracted towards the positive pole which creates an induced dipole in those molecules. The atoms are therefore weakly attracted to each other due to their dipoles. This attraction is reduced if the molecules are further apart.

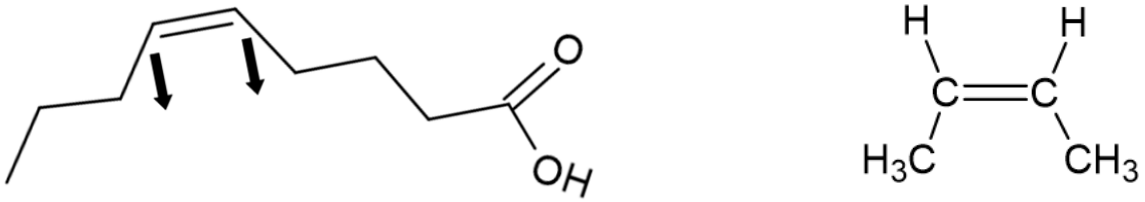
Produced by Ryan Hall at Newcastle University as part of a Nuffield Future Researchers Project

Health implications:

Saturated fatty acids are often very unreactive and do not break apart easily which makes them harder to oxidise in the body. Consequently, some saturated lipid molecules can go unreacted and start to build up in blood vessels. If enough builds up this can lead to arteries becoming blocked or constricted which will increase the risk of serious health complications like coronary heart disease or strokes. Saturated lipids may also be linked to an increase in LDL (Low Density Lipoproteins) concentration and a decrease in HDL (High Density Lipoproteins) concentration, which can lead to a build-up of cholesterol in the blood, causing further health complications.

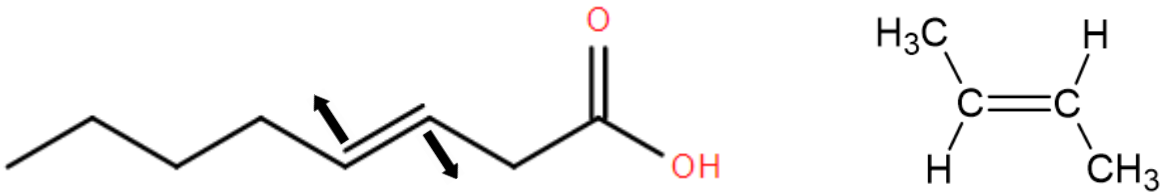
Unsaturated fatty acids are generally much more reactive than saturated fatty acids which means they are much more readily oxidised in the body. In this way they are generally considered more healthy because they don't build up in the blood. Unsaturated lipids also do not have any link to increased concentrations of LDL in the blood.

However, certain unsaturated lipids called trans-fats are very harmful to the body. Unsaturated fatty acid molecules can have two isomers called 'cis' and 'trans' because they have double bonds which prevent the rotation of groups around the bond. A 'cis' isomer has both carbon chains on the same side of the double bond, for example:



▲ *An example of a 'cis' fatty acid isomer, both carbon chains are on the same side of the double bond causing a bend in the chain.*

However, a 'trans' isomer has its carbon chains on opposite sides of the double bond, for example:



From the LIPID MAPS database at: https://www.lipidmaps.org/data/LMSDRecord.php?LMID=LMFA01030020

▲ *An example of a 'trans' fatty acid isomer, the carbon chains are on opposite sides of the double bond. There is no bend in the chain.*

This forms an unsaturated lipid that still has a straight chain and the properties of saturated lipids. Trans isomers are very rare in nature and so our bodies' enzymes cannot bind to these chains to break them down. Consequently they build up in the blood and can cause a lot of damage in large enough quantities.

NOTE FOR CHEMISTS:
Cis/trans isomerism is a special case of stereoisomerism where two of the groups on the double bond are hydrogen atoms, which works in this case. However, the standard now in chemistry is to use E/Z isomerism which works for any groups on the double bond. E is used when the two heaviest groups are on opposite sides of the bond (Epposite), and Z is used when the two heaviest groups are on the same size (Zame Zide).