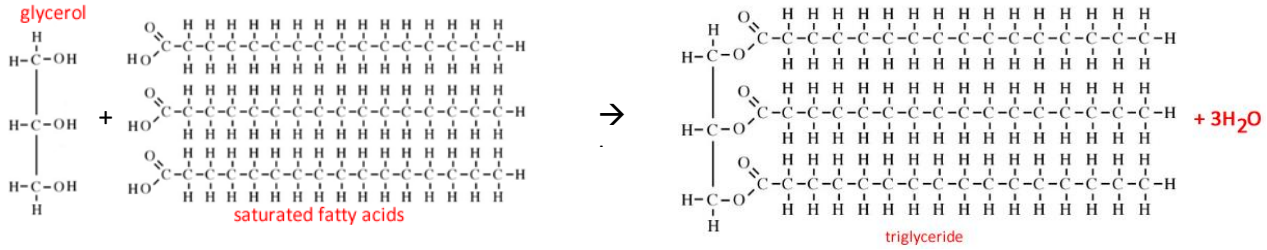
Lesson 1-fats

Click to revise fats and oils

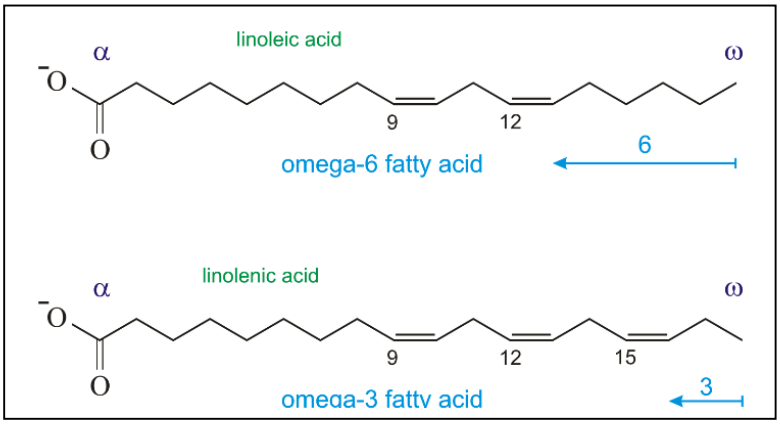
Fats and oils have the same chemical structures and differ only their states at room temperature.
Fats and oils contain large numbers of molecules called ***triglycerides.***
A typical triglyceride is made up of a glycerol molecule attached to three fatty acid molecules, not all of which have to be the same. The fatty acids may differ in length as well as degree of saturation.
The reaction is a condensation reaction, known as esterification, with the formation of water and three ester functional groups.



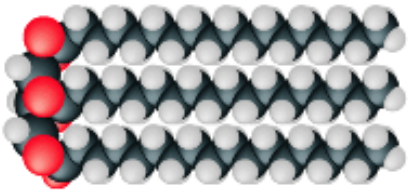
Saturated fatty acids have single C-C bonds, while monounsaturated fatty acids contain one C=C double bond and polyunsaturated fatty acids have more than one C=C double bond.
the general formula of each type of fatty acid is shown below.
Saturated = $C_nH_{2n+1}COOH$
Monounsaturated = $C_nH_{2n-1}COOH$
Polyunsaturated = $C_nH_{2n-3}COOH$
For every double C=C bond present in the hydrocarbon the general formula $C_nH_{2n+1}COOH$ loses two hydrogens.
Saturated fats are usually unreactive and exist as waxy solids at room temperature. They are usually present in high proportion in solid animal fats.

Omega-3 fatty and omega-6 fatty acids are considered to be a healthy option and a valuable source of dietary unsaturated fatty acids.

The number in the name of the omega acid is taken as the number of the carbon that the double bond originates from starting from the end methyl group known as the omega carbon.

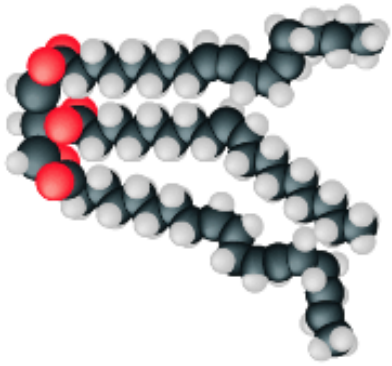


Whether the triglyceride is a liquid (oil) or solid (fat) at room temperature depends on the length of the fatty acids and the degree of unsaturation.
The number of double bonds present in the molecule the greater the bending of the hydrocarbon chain.
Notice how the saturated fatty acids line up close to each other where the dispersion forces can take hold and bind the molecules together.



saturated triglyceride

On the other hand unsaturated molecules predominantly have a cis configuration around the double bonds. This results in the formation of permanent kinks in the molecule. Notice how bent unsaturated molecules are unable to pack tightly together and hence the dispersion forces are unable to bind these molecules tightly. Hence at room temperature the unsaturated triglycerides exist in liquid form (oil).



Unsaturated triglyceride

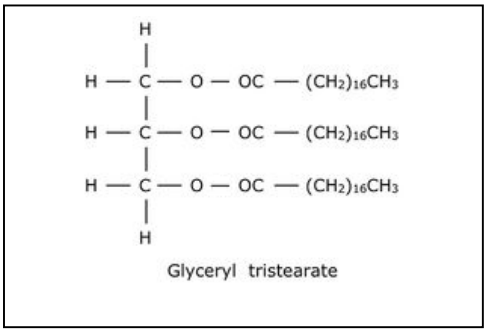
Humans can produce some fatty acids which may be in short supply in the diet. These fatty acids are known as non-essential fatty acids.
Some of the fatty acids that must be taken in the diet of humans are known as essential fatty acids and include all the polyunsaturated fatty acids such as omega-3 and omega-6 fatty acids.

1) Give the IUPAC name of glycerol.
   propane-1,2,3-triol
2) What functional groups are present in a triglyceride?
   Ester functional group ($RCOOR_1$)

3) What two functional groups are necessary for the formation of a triglyceride?
   OH and COOH
4) What type of reaction is involved in the production of a triglyceride?
   Condensation (Esterification)

5) Place the following molecules in order of increasing melting temperature.
   The bigger the molecule the greater the melting point due to greater dispersion forces.
   The greater the degree of unsaturation the greater the bend in the molecule hence the lower the melting temperature due to inability to pack close together.
   i < iii< ii
   i. $CH_3(CH_2)_5COOH$
   ii. $C_{15}H_{31}COOH$
   iii. $C_{15}H_{25}COOH$

6) Draw the structure of glyceryl tristearate using stearic acid = $CH_3(CH_2)_{16}$**COOH**



Glyceryl tristearate

7) Classify the following as *saturated, monounsaturated, polyunsaturated.*

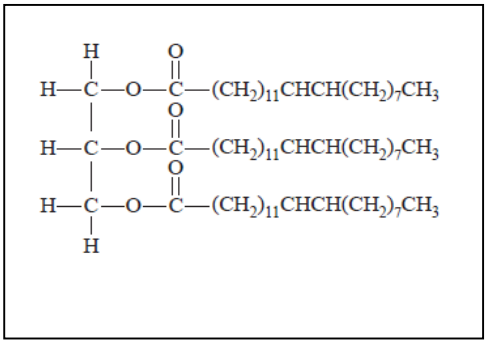
i. $C_{13}H_{27}COOH$ *saturated*

ii. $C_{12}H_{21}COOH$ *polyunsaturated*

iii. $C_{11}H_{21}COOH$ *monounsaturated*

iv. $CH_3(CH_2)_{10}CHCH(CH_2)_5COOH$ *monounsaturated*

8) Consider the molecules shown on the right.



a) To what class of compound does it belong to?

b) When hydrolysed this class of compound yields an alcohol and a fatty acid.
How would you categorise the fatty acid using the words, monounsaturated, saturated and polyunsaturated.

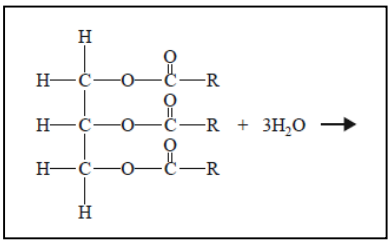
c) Name the alcohol. *Glycerol*

d) What type of bonds are broken in hydrolysis of this molecule? *Ester bonds*

e) This fatty acid produced in b) above is mixed with methanol and a suitable catalyst to produce biodiesel.
Write a balanced chemical equation using semistructural formulae for the formation of bidiesel from this fatty acid. States not required.

$$CH_3(CH_2)_7CHCH(CH_2)_{11}COOH + CH_3OH \rightarrow CH_3(CH_2)_7CHCH(CH_2)_{11}COOCH_3 + H_2O$$

9) Consider the hydrolysis reaction of the molecule on the right.



a) Draw the products of this reaction.