Lipids

Objectives :

- *Describe the functions of lipids*
- *Learn how to draw the structure of a triglyceride*
- *Learn how to draw the condensation reactions that form a triglyceride*
- *State that the bond formed between fatty acids and a glycerol molecule is called ester bond*
- *Explain that fatty acids can be saturated and unsaturated*
- *Distinguish between Cis and trans unsaturated fatty acids*
- *Evaluate the evidence and the methods used to obtain the evidence for health claims made about lipids.*
- *Determine the body mass index by calculation or use of a nomogram.*
- *Describe the functions of phospholipids, waxes and steroids.*
- *Practical skill : Testing for lipids using emulsion test*

Resources :

Book pages 29 , 30 , 31

- ✓ Lipids include a wide range of compounds that are hydrophobic (water fearing) and thus insoluble in water.
- ✓ Lipids include fats, oils, waxes, phospholipids and steroids. The different types of lipids have different structures and perform different functions in organisms.
- ✓ Lipids can be used as long-term energy storage in the form of fats.
- ✓ Lipids provide heat insulation for animals that have a large fat layer under their skin.
- ✓ Lipids allow buoyancy as they are less dense than water and therefore enable animals to float on water.
- ✓ Lipids form many hormones in the body such as testosterone.
  Phospholipids are an important constituent of the plasma membrane.

The structure of a triglyceride

Fats are also known as triglycerides, they consist of two main parts: **a glycerol molecule and three fatty acids.**

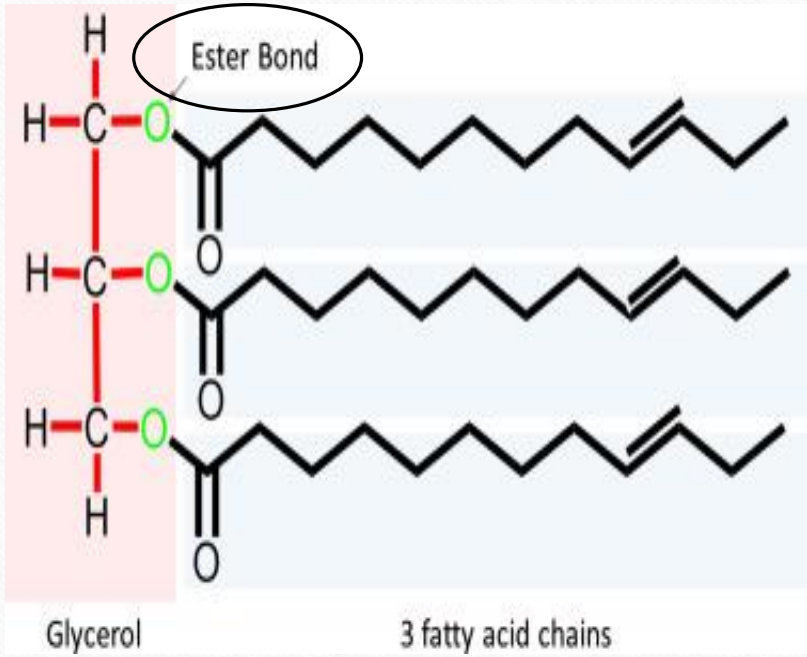
The **glycerol** molecule is a small organic molecule that is made of three carbon atoms, five hydrogen atoms, and three hydroxyl (-OH) groups.

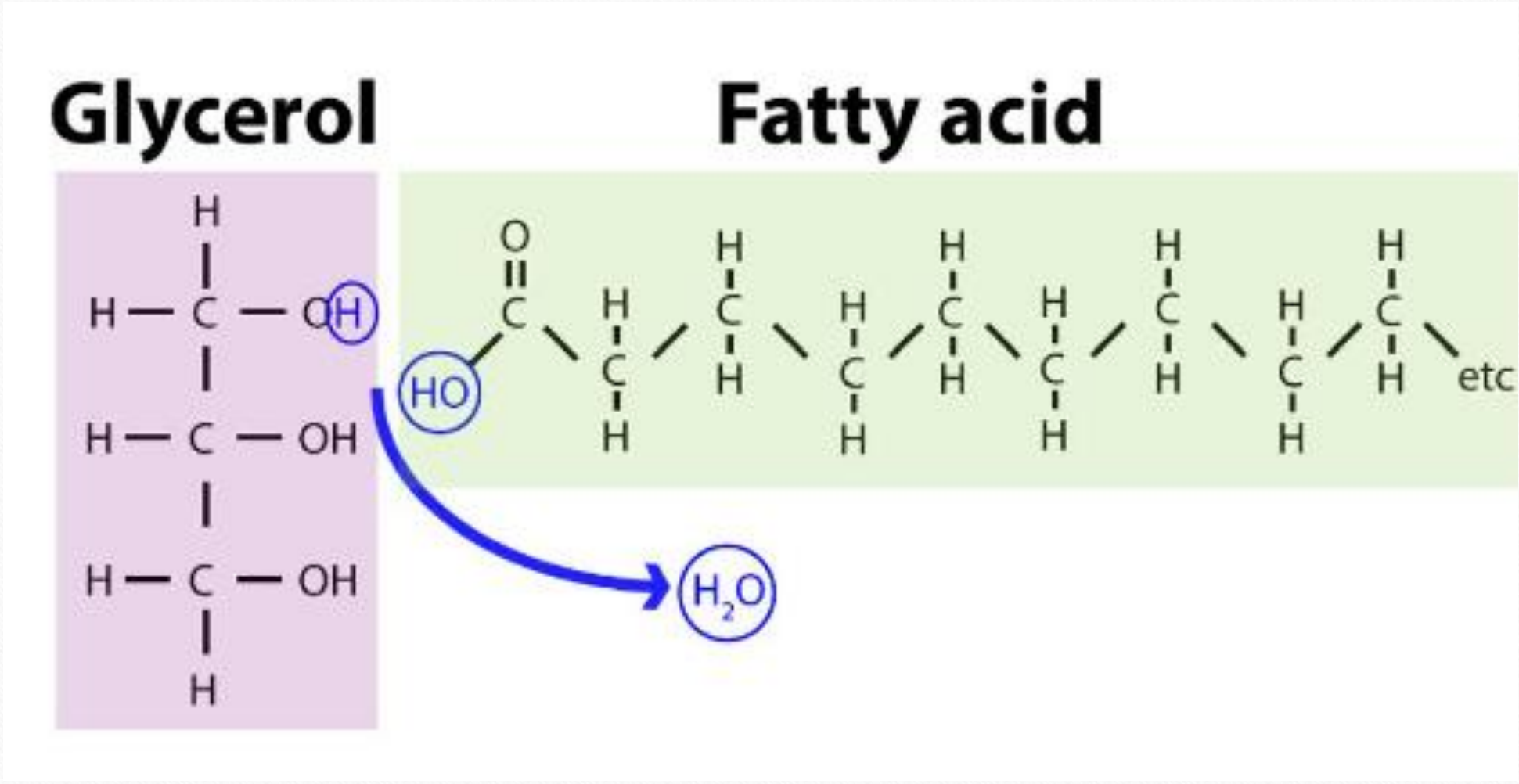
Fatty acids consist of a **long chain of carbon atoms that are joined to hydrogen atoms** . Chains like this are called hydrocarbon chains (short and longe chain fatty acids are found).

At one end of the chain is a carboxyl group (COOH) and at the other a methyl (CH3) group

Fatty acids may contain up to 36 carbon atoms.

In a fat molecule (a triglyceride), a fatty acid is attached to the glycerol molecule at each of the three hydroxyl (-OH) groups via a covalent bond.

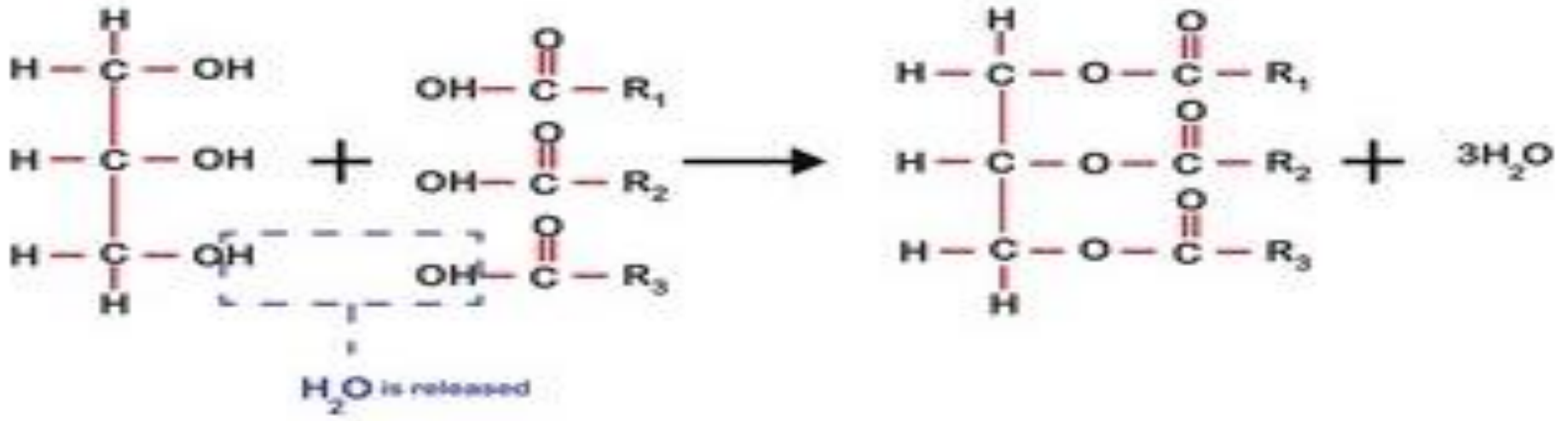



Glycerol
Fatty acid
H
H — C — OH
H — C — OH
H — C — OH
H
O
C
HO
H
C
H
etc
H_2O

Chemical reaction

TRIGLYCERIDEs

glycerol + 3 fatty acids → triglycerides



Saturated and unsaturated fatty acids

Fatty acids are the main components of most lipids. They consist of a covalently bonded carbon chain, and at one end they have a methyl group (-CH.), while at the other end they have a carboxyl (-OOH) group .

Fatty acid chains may differ in :

- ✓ Length (number of carbon atoms)
- ✓ The presence and location of double bonds.

The C- bond holds a great deal of energy. Therefore, the longer the fatty acid chain, the more energy it holds. Fatty acids are categorized into two main groups:

Saturated fatty acids and Unsaturated fatty acids

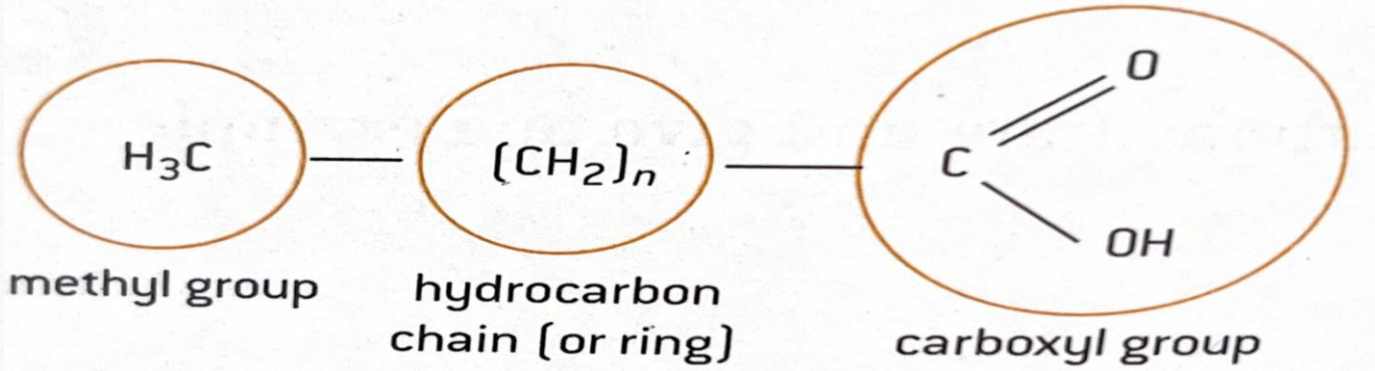
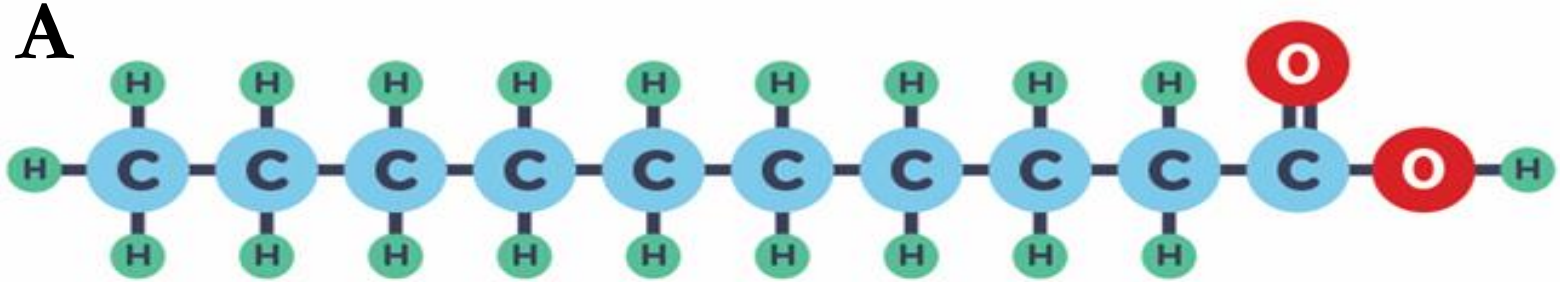


Figure 9. The basic structure of fatty acids

Find the difference between fatty acids A and B

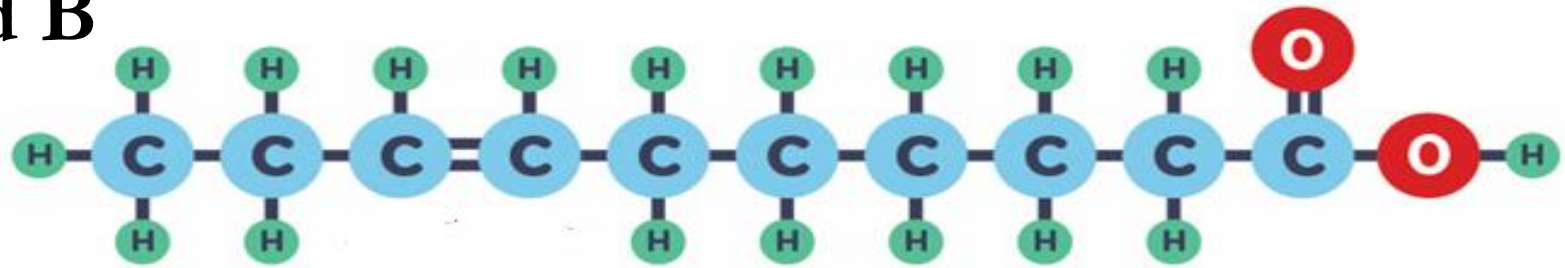
Fatty acid A

Saturated



Fatty acid B

Unsaturated



Saturated fatty acids:

They have only **single bonds** between neighboring carbon atoms in the hydrocarbon chain. This means that they are **saturated with hydrogen**. Saturated fats are **solid at room temperature** and are usually found in foods such as meat and butter.

Unsaturated fatty acids :

They have **one or more double bonds** between neighboring carbon atoms in the hydrocarbon chain. This means that they have **fewer hydrogen atoms** and therefore can gain hydrogen atoms (or be hydrogenated).

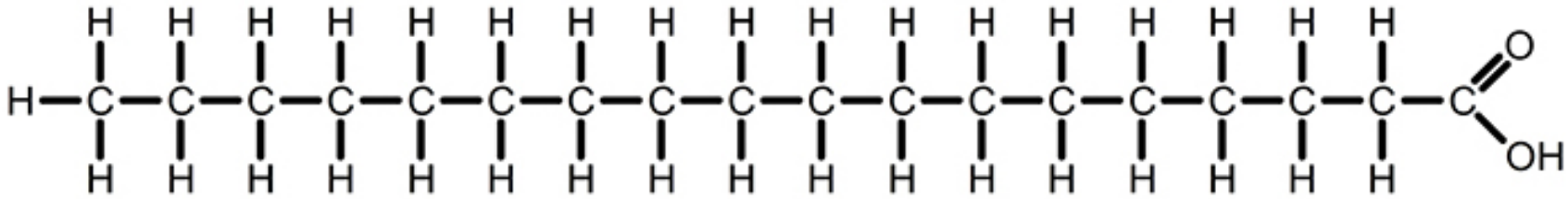
- ***If the unsaturated fatty acid has just one double bond, it is monounsaturated***
- ***If it has multiple double bonds, it is polyunsaturated.***

Most **unsaturated fats are liquid** at room temperature and are found in oils such as vegetable and fish oil.

Find the difference :)

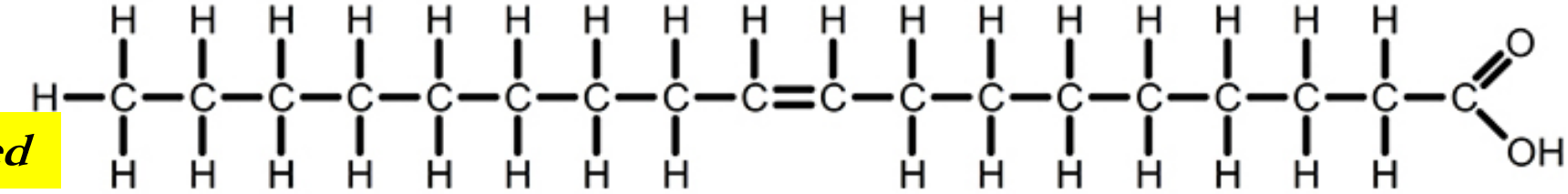
Fatty acid A

Saturated



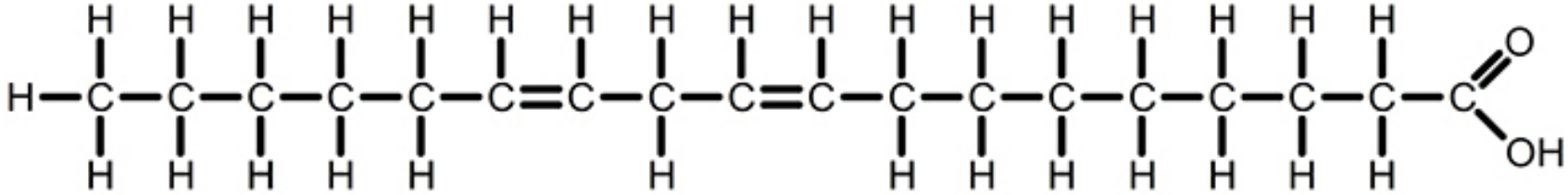
Fatty acid B

Monounsaturated



Fatty acid C

Polyunsaturated



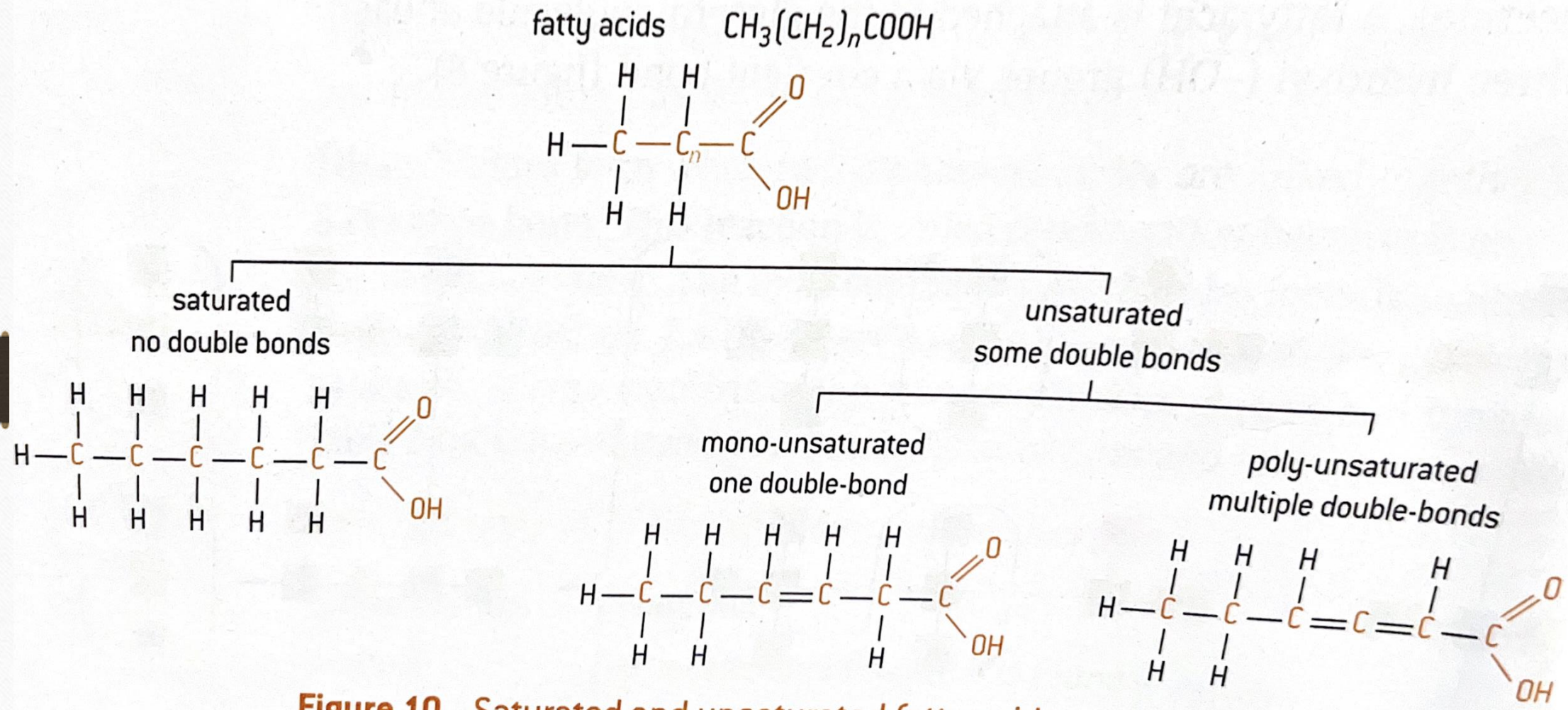
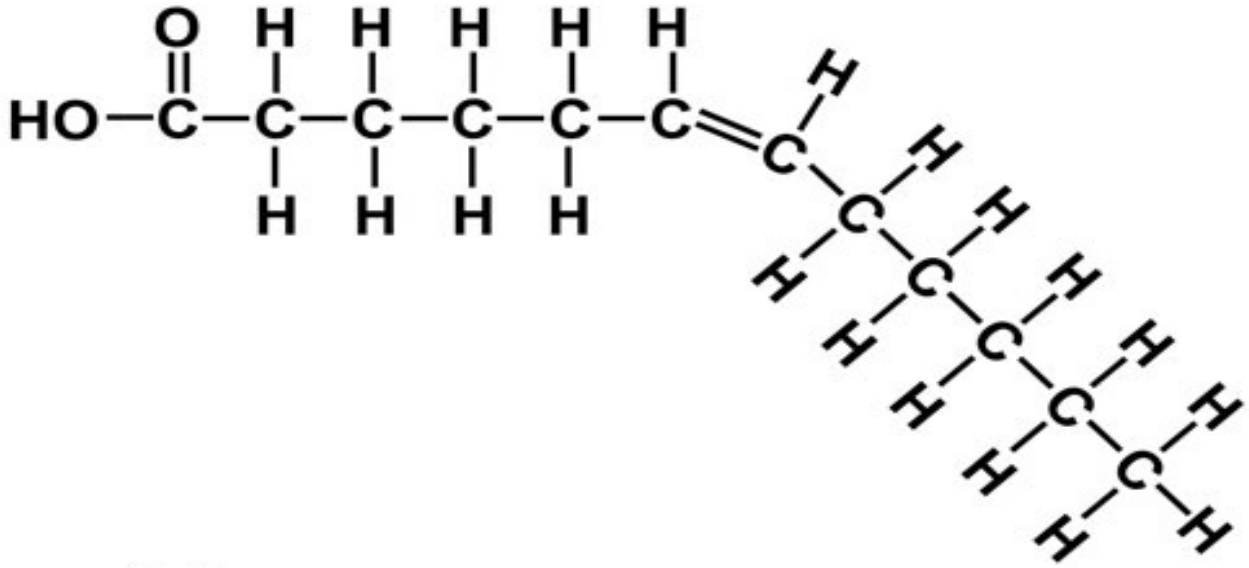


Figure 10. Saturated and unsaturated fatty acids

Find the difference :)

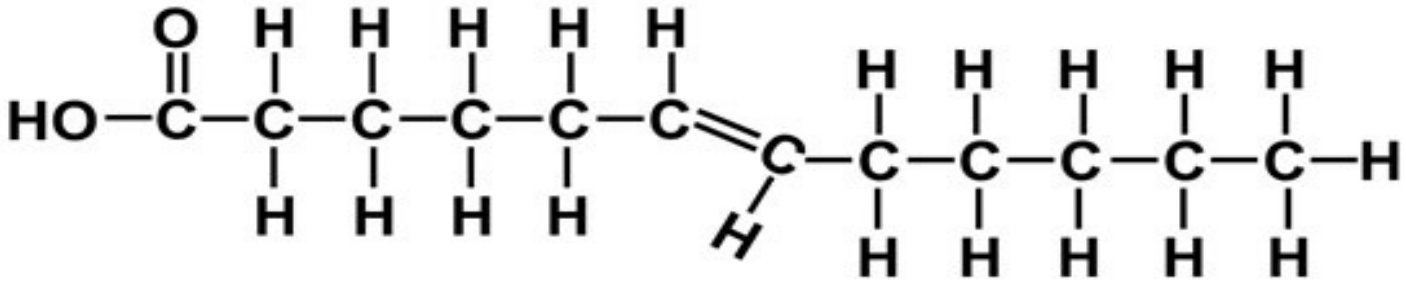
Fatty acid A

Cis isomer



Fatty acid B

Trans isomer



There are **two configurations for the unsaturated fatty acids based on the location of hydrogen atoms** in the double bond: the cis configuration and the trans configuration

Cis unsaturated fatty acids: Where the hydrogen atoms **are on the same side of the double bond**. A cis configuration will cause a twist at the double bond, a feature that results in the cis unsaturated being **liquid** at room temperature. Cis unsaturated fats are **naturally** found in food such as olive oil.

Trans unsaturated fatty acids: Where the **hydrogen atoms are on the opposite side of the double bond**. A trans configuration will cause the fatty acid to be straight and therefore the molecules pack tightly against one another. This will cause the trans unsaturated fatty acids to be **solid** at room temperature.

Trans unsaturated fatty acids are **artificially made** in the food industry by hydrogenating the unsaturated fats.

During the hydrogenation process, the naturally occurring cis configuration is converted to the trans configuration. Trans unsaturated fats include the hydrogenated oils found in some processed foods like margarine.

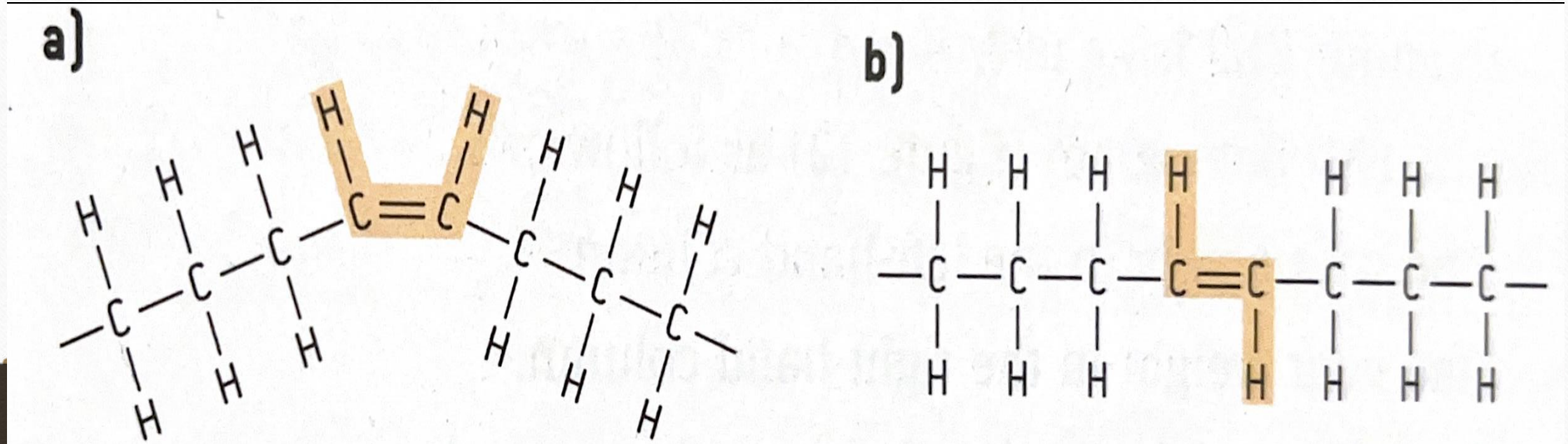


Figure 11. **a)** Cis configuration and **b)** trans configuration of fatty acids

	Cis-fatty acids	Trans-fatty acids
Health Effect	Generally good for health unless consumed in unreasonably high quantities.	Detrimental — lowers good cholesterol and increases the level of **bad cholesterol** in the body. Increases risk of heart disease.
Occurs naturally	Yes	While some natural trans fats occur in meat and dairy products, the majority of trans fats come from processed foods (i.e., hydrogenated oils).
Arrangement of atoms	The chains of carbon atoms have hydrogen atoms on the same side of the double bond, resulting in a bend.	Hydrogen atoms are on the opposite side of the double bonds of the carbon chain, making the fat molecule straight.
Melting Point	Usually low. Some cis fats are liquid at room temperature.	Usually high. Trans fats, like **saturated fats**, are solid at room temperature.

Other forms of fats :

Phospholipids	Waxes	Steroids
Has both hydrophobic and hydrophilic regions	It is a hydrophobic liquid	It is a hydrophobic liquid
Found in cell membranes	Forms a protective coat on the surface of the leaves of many plants	Cholesterol (is an example) it is synthesized in the liver and is a key component in the formation of bile and plasma membranes of animal cells .

Body mass index (BMI)

Body mass index (BMI) is a measure of body fat based on **weight in relation to height**. It is a screening tool that can be used to identify possible weight problems in adult men and women. *BMI is not a direct measure of body fat, but it correlates to the amount of fat in the body.*

However, BMI does not account for factors such as age, gender and muscle mass. BMI is interpreted by the categories shown in table 5.

Table 5. BMI categories

BMI	Category
Below 18.5	Underweight
18.5–24.9	Normal
25.0–29.9	Overweight
30.0 and above	Obese

Maths skills: How to determine your body mass index (BMI)

BMI can be determined in two ways:

1. Calculate your BMI using the formula below:

$$\text{BMI} = \frac{\text{body mass (kg)}}{(\text{height})^2\ (\text{m}^2)}$$

The unit for BMI is kg m^{-2}.

2. Use the BMI nomogram (figure 12) as follows:
   - Find your height in the left-hand column.
   - Find your weight in the right-hand column.
   - Use a ruler to draw a line between the two values.
   - The value of intersection is your BMI.

intersection is your BMI.

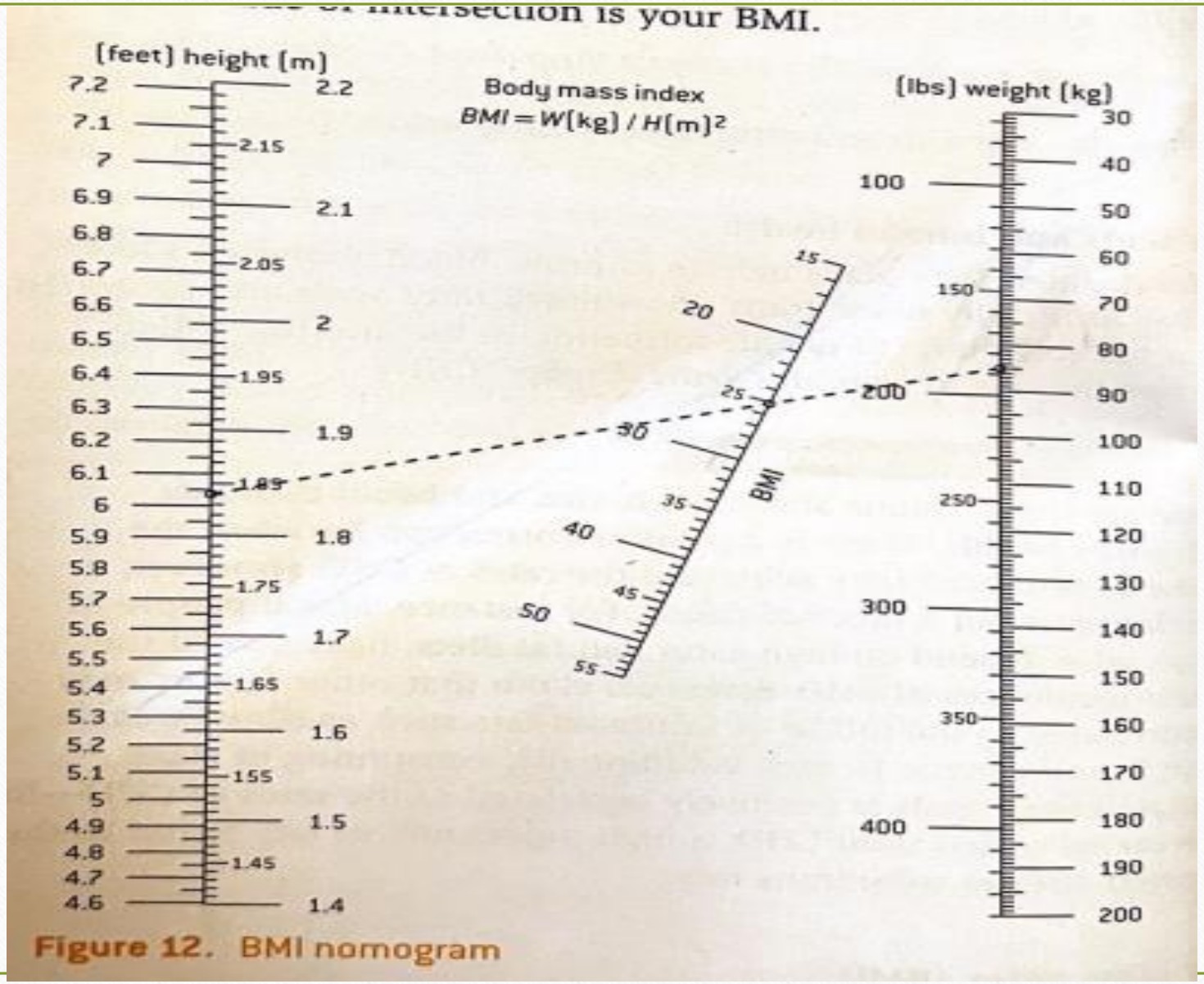


Figure 12. BMI nomogram

Example 1 :

Calculate the BMI for a person whose weight is 70 kg and height is 1.75 m. To which BMI category does he belong to?

22.8 (Normal)

Example 2 :

Using the BMI nomogram in figure 12, find the BMI for a person whose weight is 103 kg and height 1.95 m. To which BMI category does he belong to?

27 (overweight)

Example 3 :

Calculate the BMI for a person whose weight is 65 kg and height is 1.80 m. To which BMI category do they belong to?

20 (Normal)

Example 4 :

An adult man whose weight is 90 kg and height is 1.7 m, is considered obese. Explain why, using the BMI nomogram.

31 (Obese)

Lab visit : Testing for Fat

Method no.1 :

- Take a small quantity of the food item to be tested.
- Wrap the food item in a piece of paper and crush it.
- Straighten the paper.
- Dry the paper by keeping it in sunlight for a while.
- Observe the paper.
- An oily patch on the paper indicates the presence of fats in the tested food item.

Method no. 2

1. Grind up the food and mixing it with water.(preparing a food sample as we took before in grade 7).
2. Add ethanol to a very small amount of the prepared sample in the test.
3. Shake well .
4. Filter or dilute the food and ethanol mix so that you get a clear liquid (a solution of fat in ethanol).
5. Add this to a test tube of water.

A white (milk-like) emulsion indicates the presence of fats or oils.