Food Basics

Section 1: Carbohydrates and Fats

• What are carbohydrates?

Carbohydrates are compounds of carbon, hydrogen and oxygen. Glucose $C_6H_{12}O_6$ is one example of a carbohydrate; sucrose $C_{12}H_{22}O_{11}$, the sugar we use in cooking, is another. (Notice that in both cases the ratio of hydrogen atoms to oxygen atoms is 2:1, exactly the same as in water H_2O, which is why we us the "-hydrate [= water]" part of the name 'carbohydrate').

Carbohydrates are one of the sources of energy in the food we eat. They are broken down into glucose in the digestion process, and during aerobic (which means with oxygen) respiration in our cells. The glucose is then converted into carbon dioxide and water. Energy is also released.

GLUCOSE + OXYGEN → CARBON DIOXIDE + WATER + energy

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

Sugars are much simpler, smaller molecules than starches. Starches are polymers, built out of sugar molecules, with many thousands of atoms per molecule. Starches are insoluble in water, and their molecules are much too large to pass through cell membranes. During digestion, the huge starch molecules are broken down by amylase enzymes in the saliva and small intestine, first into smaller sugar molecules, and eventually into glucose. Glucose molecules are quite small and are able to pass through cell membranes into the blood. This process of digestion is quite slow, therefore starches release their energy much more slowly than sugars.

Some foods rich in carbohydrates

• Suggested Films

- Food Basics: Carbohydrates
- How Do Carb-Free Diets Work?

Many other important biological molecules are polymers of sugars, such as cellulose (in plant cell walls), glycogen (which plays a similar role in animals to that of starch in plants, by storing energy), and chitin (in the exoskeletons of insects).

Extension Question

Q1. Why are starchy foods good as fuel for a marathon?

Starchy foods give us energy much more slowly than sugary foods, because the molecules take far longer to digest.

• What are fatty acids?

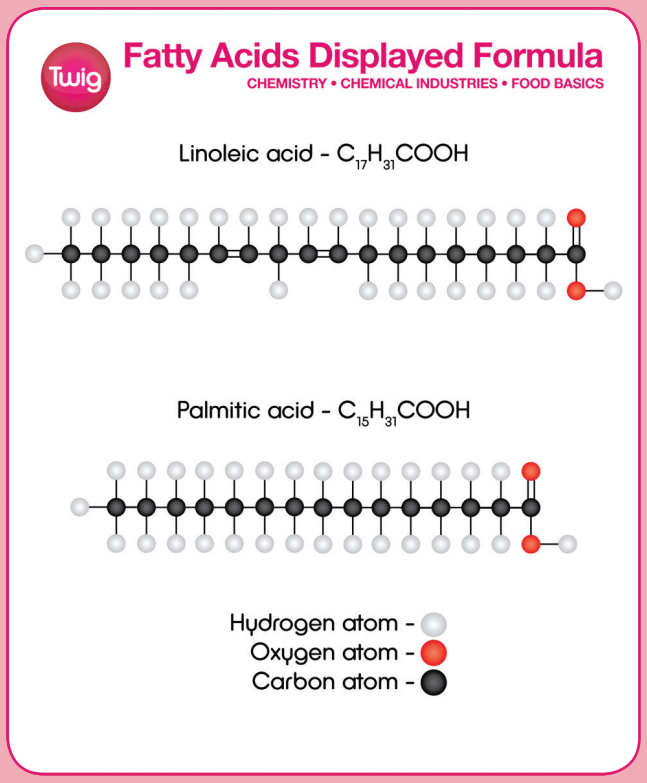
Fatty acids are also known as carboxylic acids. They contain long chains of carbon atoms, with a –COOH group at one end, for example palmitic acid $C_{15}H_{31}$–COOH

Palmitic acid is a saturated fatty acid because it only has single covalent carbon-carbon (C-C) bonds in the chain. Some other fatty acids are unsaturated, for example, linoleic acid $C_{17}H_{31}$–COOH has two carbon-carbon (C=C) bonds in its chain.

Linoleic acid is an essential fatty acid, which means we must take in linoleic acid in our diet, as our bodies cannot make it from the other foods we eat.

3-dimensional fatty acid structure

DIAGRAM 01:



• What are fats and oils?

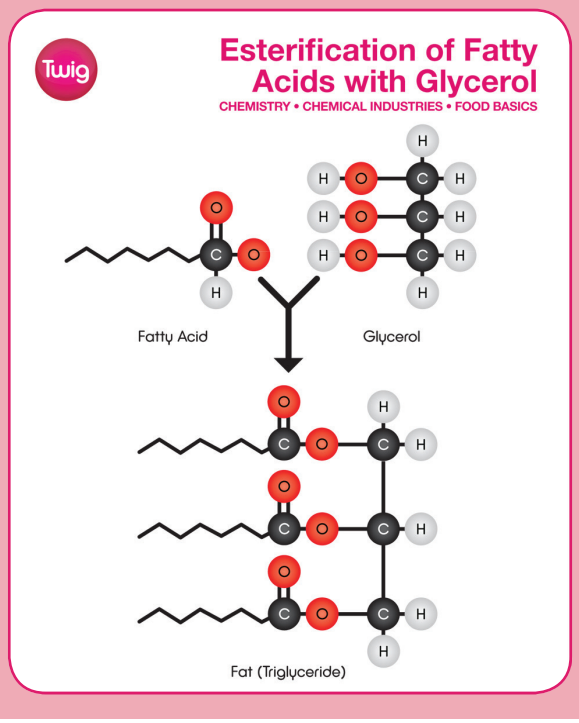
Fats and oils also contain carbon, hydrogen and oxygen. If they are solids at room temperature they are called fats; if they are liquids they are called oils. Oils and fats are triesters of glycerol.

Glycerol is a type of alcohol with three –OH groups. Each –OH group forms an ester linkage –O –(C=O) - with a carboxylic acid such as palmitic acid, so three ester linkages are formed.

FAT → GLYCEROL + FATTY ACID

Cooking oils are triesters that are liquid at room temperature

DIAGRAM 02:



Fats are rich sources of energy, but they also play many other roles in our bodies. They are stored beneath the skin, keeping us warm, as they are good insulators; they are needed to make cell membranes; they protect vital organs such as the kidneys and the brain; and they also act as solvents for important vitamins such as vitamins A, D, E and K.

In the small intestine, fats are slowly broken down by enzymes called lipases to make glycerol and a fatty acid.

FAT → GLYCEROL + FATTY ACID

The liver then converts glycerol into glucose and, hence, releases energy in the same way as carbohydrates.

• Suggested Films

- **Esters and Perfumes**
- **Omega-3: Healthy Fat?**

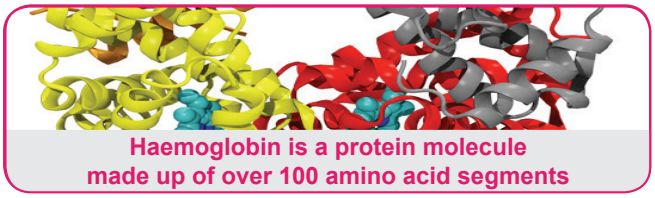
Section 2: Proteins

• What are proteins?

Proteins are compounds containing carbon, hydrogen, oxygen and nitrogen. Proteins are polymers of amino acids linked together in a long chain.

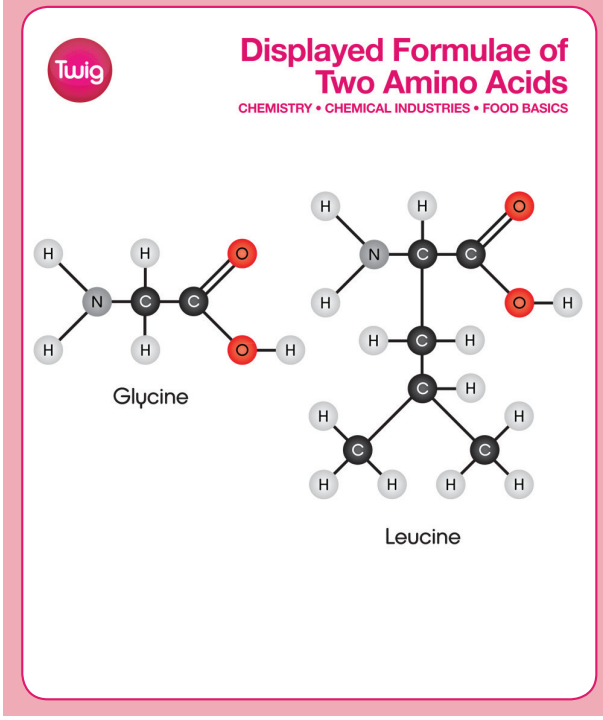
In a protein molecule, amino acids such as glycine and alanine link together to form long polymer molecules containing thousands of atoms. There are 20 types of amino acids, and their many combinations generate the different types of protein found in the body.

Proteins play a vast range of vital roles in the body. They can release energy during respiration, they can be hormones (such as insulin) or enzymes (such as amylase), and they are needed for the growth and repair of cells. They also help with the transport of materials around the body (haemoglobin transports oxygen from the lungs to the rest of the body), and in making structures such as hair, nails and muscles.



Haemoglobin is a protein molecule made up of over 100 amino acid segments

DIAGRAM 03:



• What is a balanced diet?

Doctors recommend a balance of lots of different food types

A balanced diet is a diet in which we eat all the nutrients we need to stay healthy in appropriate proportions. A balanced diet should include these components: water, carbohydrates, fats, proteins, minerals, vitamins, trace elements and fibre.

A balanced diet also needs to balance the total amounts of energy intake (through eating carbohydrates, proteins and fats) and the amount of exercise a person is taking.

• Suggested Films

- **Food Basics: Proteins**
- **Food Basics: Carbohydrates**
- **Food Basics: Fats**
- **Nitrates: Food Preservatives**
- **Natural Versus Artificial**
- **Salt: Food Preservatives**

Extension Questions

Q2. A label on some food claims that it is '100% natural'. What does this mean?

This means that the chemicals within the food can be found in the natural world, and that the molecules have not been designed within a laboratory. However, just because something is natural, this does not mean it is necessarily healthier for you. There are plenty of natural foods that are actually harmful or even very poisonous.

Q3. Is it possible to eat only food that contains no chemicals?

Absolutely not. All materials are made of chemicals, therefore all foods and even water is a chemical. Our bodies are full of chemicals. Some chemicals are harmless, some may be harmful, it depends on the exact nature of the chemical itself.

• What are minerals, vitamins and fibre?

Minerals are elements we need for our bodies to work properly. They include calcium and phosphorus (to make bones and teeth), iron (to make haemoglobin in red blood cells), magnesium, potassium, sodium and sulphur. We also need very small amounts of trace elements such as boron, cobalt, copper, chromium, fluorine, iodine, manganese, molybdenum, selenium, silicon and zinc.

Vitamins are substances needed in small amounts in our diet if we are to keep healthy. Some are water-soluble such as vitamin C, others are fat-soluble such as vitamin D. Without vitamins we can suffer from vitamin-deficiency diseases such as scurvy and rickets, caused by lack of vitamin C and vitamin D, respectively.

Fibre includes the material in plants which we cannot digest, it therefore passes right through the body, and is expelled as faeces. Fibre helps the body to pass wastes along the intestines by absorbing water, making the stool bulkier and softer. It is also believed to help prevent constipation and bowel diseases such as cancer.

• Suggested Activity

- **Ask the students to find a historical connection between limes and scurvy**

Many minerals, vitamins and fibres can be found in fruit and vegetables

Section 3: Fermentation, Alcohol and Ripening

• What is fermentation?

Fermentation is a chemical process in which carbohydrates are broken down into ethanol and carbon dioxide through the action of enzymes, which can come from microorganisms such as yeast, or from bacteria. The enzymes act as catalysts for the fermentation reaction.

This process releases energy and is known as anaerobic (which means no oxygen) respiration. Fermentation therefore releases energy, and for some organisms (such as some bacteria and fungi) fermentation is their main source of energy. The classic case is the fermentation of sugar into ethanol and carbon dioxide in the presence of an organism called yeast, which releases an enzyme called zymase:

GLUCOSE → CARBON DIOXIDE + ETHANOL + ENERGY

$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$

The ideal conditions for fermentation are: solution in water; no oxygen; and warm, but not too hot conditions (above a certain temperature the enzyme is damaged or denatured and can no longer catalyse the reaction). Fermentation is used in making many foods and drinks, such as bread, yoghurt, tea, beer, wine, cider and soy sauce.

• Suggested Film

- Fermentation

Fermentation of beer

Extension Question

Q4. What are extremophiles and how do they respire?

Extremophiles are organisms living in extreme conditions, such as in the depths of the ocean, at very high temperatures in hot volcanic springs, or in liquids with very low (highly acidic) pH values. For example, bacteria living near hydrothermal vents on the mid-ocean undersea ridges get their energy from anaerobic respiration, using the sulphur compounds that come out of the vent. There is the possibility that life on other planets, or their moons, exists in the form of such extremophiles.

• What is alcohol?

'Alcohol' is the common name for ethyl alcohol or ethanol C_2H_5OH, which is present in all alcoholic drinks.

A dilute solution of ethanol is made by the fermentation of sugars from sources such as grapes, apples and pears, making drinks including wine and beer. A more concentrated solution of ethanol can then be made by distillation, to make 'spirits' including whisky, gin, rum and vodka.

Ethanol burns in air. In plenty of oxygen, it burns with a blue flame and makes carbon dioxide and water.

ETHANOL + OXYGEN → CARBON DIOXIDE + WATER

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

Yeast is used to create ethanol from glucose by anaerobic respiration

Bioethanol is made by fermenting waste materials, such as sugarcane, and is used as a fuel in some places in place of petrol. It has the advantage of being a renewable fuel (as more sugarcane can be grown), reducing our reliance on fossil fuels. However, it still makes the greenhouse gas carbon dioxide, and may encourage deforestation if large areas of land are devoted to crops used to make bioethanol.

Ethanol is toxic and can kill us if we take too much at one time. It is a depressant drug, meaning that it slows down the body's processes, including our thought processes and reaction times. This can lead to poor judgement and can cause accidents. In the long term, it can lead to serious addiction known as alcoholism.

Extension Question

Q5. Bioethanol can be used in cars instead of petrol. What effect can this have on the environment?

The **positive** effects of using bioethanol instead of petrol are that

1. using ethanol reduces the use of fossil fuels like petrol.

2. bioethanol can be carbon-neutral, which means that the carbon it emits in being burned balances the amount of carbon taken in when the plants used to make it are grown.

3. ethanol burns cleanly, so there is little pollution by soot particles.

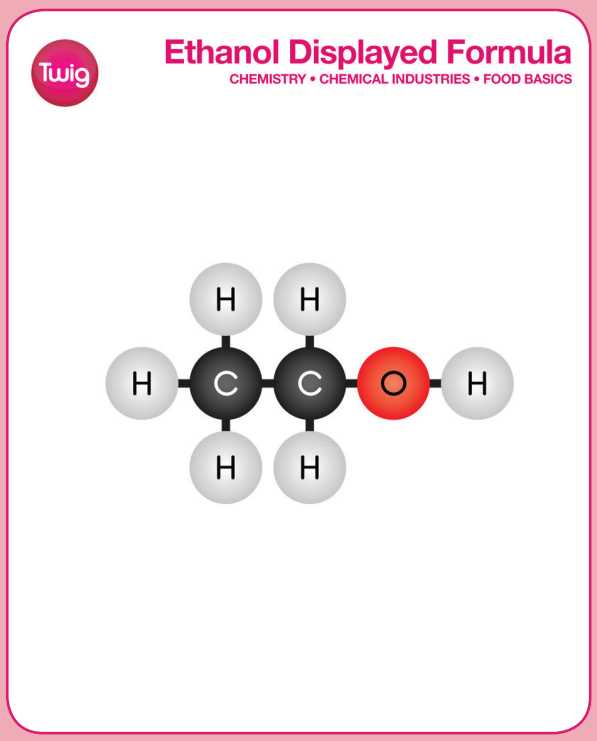
The **negative** effects of using bioethanol instead of petrol are that

1. ethanol still makes carbon dioxide when it burns.

2. land may be deforested to make room for these crops that produce bioethanol.

3. the prices of maize and potatoes may rise, affecting certain world populations.

DIAGRAM 04:



• What is ripening?

When fruits, such as apples, ripen, the starch in the fruit is converted into sugars which give them their sweet taste. One common way that fruits ripen naturally is that they release a hormone, in this case not a protein but a hydrocarbon, ethene gas C_2H_4, which triggers the process of ripening in neighbouring fruits.

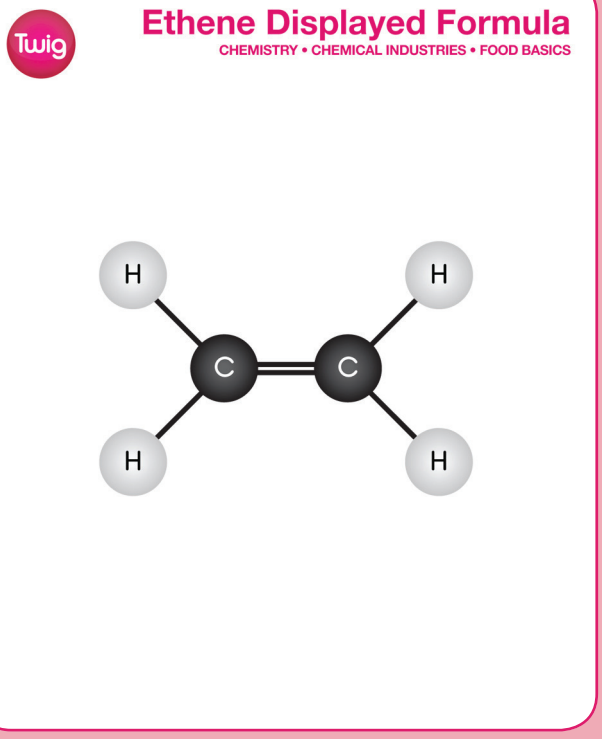
Ethene gas signals the plant to release enzymes which break starch down into sugars, and may also change the pigments in the outer part of the fruit. Tomatoes, for instance, change from green to red as they ripen. Large molecules in the fruit are broken down into smaller ones that are more volatile (can evaporate easily), so we can often smell when a fruit is ripe. Pectins, compounds which bind the plant cells together in the unripe fruit, are also broken down, making the flesh of the fruit soft and easy to eat.

Ripening is a natural process, but supermarkets use the same chemistry to produce fruit that is ripe at the ideal time to sell to their customers. Bananas are transported long distances in their green state, when they are still hard and will not bruise easily. Just before the bananas are sold, ethene gas is pumped around them. They begin to ripen and turn yellow, ready to be put on the shelves and sold.

The green bananas are unripe and the yellow bananas are ripe

- **Suggested Film**
  - Ripening Fruit

DIAGRAM 05:



• Quizzes

Carbohydrates

Basic

• What percentage of our diet should be carbohydrates?

A – 10%

B – 30%

C – 60%

D – 90%

• Which of these elements are found in all carbohydrates?

A – carbon and hydrogen

B – carbon, hydrogen and oxygen

C – carbon, hydrogen and nitrogen

D – nitrogen and oxygen

• Which sugar do we usually put in our tea and coffee?

A – glucose

B – fructose

C – sucrose

D – lactose

• Carbohydrates help us by providing

A – a quick release of energy

B – nutrients for cell growth

C – a slow release of energy

D – insulation for vital organs

Advanced

• Starchy foods provide a slower release of energy than sugars because

A – they contain more carbon atoms per molecule

B – they take longer to digest than sugars

C – they contain smaller molecules than sugars

D – they contain more oxygen atoms per molecule

• Which of these foods is NOT a rich source of carbohydrates?

A – rice

B – pasta

C – bread

D – grapes

• The digestion of carbohydrates takes place mainly in the

A – oesophagus

B – small intestine

C – large intestine

D – stomach

• Which of these statements is NOT true?

A – plant cell walls are made of a polymer of glucose

B – starch molecules are absorbed into the bloodstream during digestion

C – starch is broken down into glucose during digestion

D – milk contains a type of sugar

Fats

Basic

• Fats all contain

A – carbon and oxygen

B – carbon and hydrogen

C – carbon, hydrogen and oxygen

D – carbon, hydrogen and nitrogen

• What percentage of our diets should be fats?

A – 10%

B – 30%

C – 50%

D – 70%

• At room temperature, saturated fats are usually

A – solids

B – liquids

C – gases

D – solutions

•Within the chains of carbon atoms in their molecules, unsaturated fats have at least one

A – double bond

B – single bond

C – triple bond

D – ionic bond

Advanced

• Which of the following is NOT one of the roles for fats?

A – to store energy

B – to provide insulation

C – to build cell membranes

D – to transport oxygen

• Saturated fats have

A – only single bonds between carbon atoms

B – only double bonds between carbon atoms

C – both single bonds and double bonds between carbon atoms

D – neither single bonds nor double bonds between carbon atoms

• Which of these statements is NOT true?

A – unsaturated fats are usually liquids at room temperature

B – saturated fats can raise cholesterol levels and clog our arteries

C – fats and oils derived from vegetable sources and fish can help keep your body healthy

D – unsaturated fats usually have higher melting points than saturated fats

• Which of these statements is NOT true?

A – ideally, we should eat a completely fat-free diet

B – saturated fats are found in many meats and dairy products

C – fats dissolve and transport certain vitamins

D – sunflower oil, olive oil and fish are rich in unsaturated fats

Proteins

Basic

• What percentage of our diets should be proteins?

A – 10-15%

B – 30-35%

C – 50-55%

D – 70-75%

• Which of these foods is NOT a rich source of protein?

A – meat

B – fish

C – eggs

D – sugar

• Proteins all contain

A – carbon, nitrogen and oxygen

B – carbon, nitrogen and hydrogen

C – carbon, hydrogen, phosphorus and oxygen

D – carbon, hydrogen, oxygen and nitrogen

• The building blocks of proteins are called

A – amino acids

B – sugars

C – fats

D – carbohydrates

Advanced

• Which of the following is NOT one of the roles for proteins?

A – cell growth and repair

B – hormones

C – enzymes

D – thermal insulation

• During digestion, proteins are broken down into

A – fatty acids

B – glucose

C – starch

D – amino acids

• Which of these statements is NOT true?

A – enzymes are proteins

B – hair is made of protein

C – proteins can be a source of energy

D – our bodies can synthesise essential amino acids

• Which of these statements about protein digestion is NOT true?

A – protein digestion begins in the mouth

B – hydrochloric acid in the stomach breaks down proteins

C – enzymes called proteases break down proteins in the stomach and intestine

D – amino acids are absorbed into the bloodstream

• Answers

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