Energy and change

A project funded by the Nuffield Foundation

Theme G

Up and down in complexity

Theme G - Up and down in complexity

What is this theme about?

In the previous theme, we made a distinction between two different kinds of change:

- those in which the particles themselves do not change (e.g. squashing a piece of plasticene, chocolate melting, sugar dissolving in a cup of tea)
- those in which particles form new particles - by splitting, joining, re-combining (e.g. hydrogen and oxygen reacting to form water, starch being broken down to glucose)

This theme focuses on the second kind of change, introducing the idea that in a chemical reaction, particles do not appear or disappear but join together in new ways. It is intended that the activities take a rather broad view on the nature of different types of chemical change. They do not give details about particular chemical changes in terms of atoms and molecules - such material is readily available in existing text books, and may appropriately be used alongside these activities.

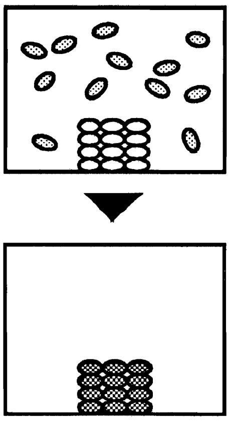
Earlier themes have made the point that changes tend to go in the direction in which *differences in concentration disappear* - i.e. particles become more spread out or more mixed together. Changes also tend to go in the direction in which *complexity disappears* - i.e. large particles break down to form more smaller ones. So, this theme is concerned with establishing a scale of complexity of molecules and identifying changes which go up or down the scale of complexity.

The activities

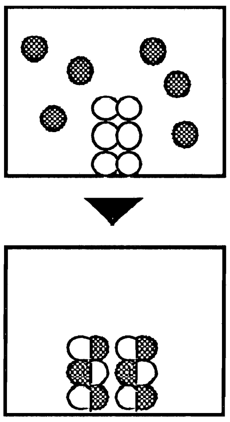
G1	A ladder of sizes
G2	Using the ladder of sizes
G3	Heating copper
G4	What happens when new substances are made?
G5	Joining and splitting, mixing and 'unmixing'
G6	Joining, splitting, mixing, 'unmixing' - some examples
G7	A ladder of molecules
G8	Building up and breaking down
G/ref	Reference - A ladder of molecules

Conventions used in this theme

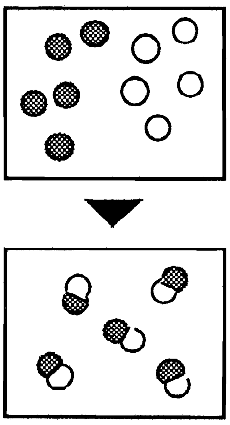
Different kinds of picture have been used in this theme in order to emphasise different aspects of chemical change. For example, all these pictures could represent copper reacting with oxygen to form copper oxide.



In this picture, the arrangement of the particles indicate the states of the substances (solid and gas). Different substances are represented by particles with different shadings.
(See activity G3.)



As before, the arrangement of the particles indicate the states of the substances. However, changes to substances are now indicated by the particles *joining together.*
(See activity G4.)



This picture also shows the change as particles *joining together.* However, this picture is used more generally to represent any change in which two substances react together to form a third, regardless of the states involves. For example, as well as the oxidation of copper it could also represent hydrogen and oxygen reacting to form water.
(See activities G5 and G6.)

Activity G1 - A ladder of sizes

This activity gives pupils experience in thinking about the relative sizes of things, especially those things which are to small to be seen with the naked eye. It makes a start on developing a 'scale of complexity'.

The activity could be introduced through looking at photographs and pictures of objects of a range of different sizes if these are available. A particularly useful source of such pictures is 'Powers of 10' in the Scientific American Library series. It would also be useful to have available microscopes and examples from four of the steps of the ladder - torn pieces of paper, needles, a suspension of yeast, and slides of bacteria.

Pupils should cut up the pictures on sheet 2 and place them in order of size. The larger things are fairly easy to order, but the very small things are less familiar and rather more difficult to order. Some information about very small things (e.g. bacteria, viruses, molecules) is given on sheet 1 to help pupils order the lower part of the ladder. They should check their answers before writing them up on sheet 3 which shows the ladder. This also includes the actual sizes in metres.

Answers:

E	the Earth
M	Britain
C	an English county
G	a small town
P	a street
A	Nelson's column
N	a house
J	a young child
O	a pencil
R	a 5p piece
B	the eye of a needle
F	thickness of a piece of paper
L	a yeast cell
D	a bacterium
I	a virus
H	a large molecule (e.g. a protein)
K	a small molecule (e.g. sugar)
Q	an atom (e.g. oxygen)

The ladder can form a useful starting point for a discussion of the sizes of other things such as specks of dust or blood cells, since most pupils lack experience in estimating the sizes of very small things. For older pupils the ladder could be extended upwards (Sun, solar system, galaxy, etc.) and downwards (nucleus of an atom, etc.).

Activity G2 - Using the ladder of sizes

In this activity, pupils use the ladder of sizes to work out the relative sizes of things.

Having constructed the ladder in activity G1, pupils can use it to compare the relative sizes of things. Sheet 1 may be used as an OHP to introduce pupils to how to work out how big one thing is compared to another. The main difficulty that pupils have is in understanding that if one step on the ladder means 10 times bigger, two steps means *100* times bigger (not *20*). The example showing a child, a house, and Nelson's column is intended to help in this explanation. (Note that these are comparisons of *linear dimensions*, not *volumes*. So, when we say a bacterium is 10 000 times the size of an atom, this does not imply that there are 10 000 atoms in a bacterium.)

Answers:

1 a) a child is 100 times bigger than a 5p piece
 b) Nelson's column is 1000 times bigger than a pencil
 c) thickness of a piece of paper is 10 times bigger than a yeast cell
 d) a yeast cell is 100 times bigger than a virus
 e) a large molecule is 100 times bigger than an atom
 f) a bacterium is 10 000 times bigger than an atom

2 a) an English county
 b) the Earth
 c) Nelson's column
 d) Britain

Activity G3 - Heating copper

The purpose of this activity and the following one is to introduce the idea that when substances react to form new substances, particles do not appear or disappear but join together in new ways.

This activity would be most appropriately used alongside a practical activity in which pupils heat copper in air and attempt to explain the reason for the black colour forming. Pupils need to find the picture which best matches what happens when the copper is heated in air. These particle pictures were introduced in Theme F 'Particles and change', and pupils should have had some experience of these before attempting this activity. This would be best done in small groups, with pupils giving their own reasons, in order to encourage discussion before a whole class discussion. After this pupils can be given an explanation of why it is picture '3' which represents the change.

Activity G4 - What happens when new substances are made?

This activity follows on from the previous one, and introduces the idea that in a chemical reaction, particles join together in new ways.

In activity G3, changes to substances are represented in the pictures as completely new particles being formed. This activity introduces pupils to the idea that in a chemical reaction, new substances are formed as the particles join together in new ways. Sheet 1 is an OHP which can be used for a class discussion about how new substances can form. This is distinguished from mixing, in which the particles do not join together.

Sheet 2 introduces a *new kind of particle picture* (the particles are shown as circles rather than ovals). These pictures are based on the idea that in a chemical reaction *particles join together in new ways.* Pupils need to find which of these new pictures best represent what happens when copper is heated in air, and this should be done in a similar way to the previous activity. After pupils have had a chance to write their own reasons, they can be told why it is '4' which represents the change. '1' shows a chemical reaction, but it is between two solids. '2' and '3' both show mixing. '5' is like the pictures the pupils were using before, but now they should choose a picture which does not show particles appearing or disappearing. '6' is similar to the right answer '4', but the numbers of each kind of particle do not stay the same during the change, and so it is wrong.

Thinking about chemical change as a re-arrangement of particles and representing them using these new pictures is a big step. This is why these last two activities have focused on just one 'case-study' in order to discuss the nature of a chemical reaction. In Theme F, pupils could choose appropriate pictures to represent chemical reactions based only on knowledge about the surface *features.* In using these new pictures, it is necessary to have some knowledge about what is happening at the *particle level.*

Activity G5 - Joining and splitting, mixing and 'unmixing'

This activity reinforces the idea from the previous activity that in a chemical reaction, particles may join together in new ways. It builds on this, introducing the idea that in some reactions particles may split to form new particles.

Sheet 1 can be used as an OHP. This makes the distinction between two substances mixing (where no new substance is formed - the particles simply mix together) and joining (when a new substance is formed - the particles join together in a new way). It also shows pictures which represent the reverse changes - 'unmixing' and 'splitting'. Note that these pictures are rather more schematic than the earlier ones for copper oxide - there is no intention to represent the distinction between solid, liquid and gas.

Sheet 2 is not so much an activity, but more a set of resources for a 'case-study' approach. When pupils come across a change of one of these types they can cut out one of the pictures and stick it in their books. A 'blown-up version' of sheet 1 could also be used as a class poster so that changes could be written here as well and built up over time for the whole class to see.

Activity G6 - Joining, splitting, mixing, 'unmixing' - some examples

This activity gives pupils further practice in identifying what happens to the particles in a range of different kinds of changes.

After pupils have looked at a few 'case-studies' as described in activity G5, they could attempt this matching activity. They will need to use sheet 1 from the previous activity which shows the particle pictures, as well as the sheet from this activity which shows a number of different changes. Some of these examples they may have come across already, others they may not. Accompanying the changes is some information about the changes to help pupils to find an appropriate match.

Answers:

1 A D F I	2 C J L
3 B H	4 E G K

Activity G7 - A ladder of molecules

In this activity pupils learn about the variation in sizes of some common molecules.

A useful start would be a class discussion, looking at a few different models of molecules (preferably space-filling), and noting that there is a very wide range of sizes - i.e. the number of atoms they are made from. Suitable examples might be water and a segment of polythene.

In the first task on the sheet, pupils will need to be provided with a number of models of molecules. They identify these using the 'ladder of molecules' at the end of this theme. Counting the number of 'atoms' in the model is a useful way of doing this since it helps them to interpret what the models represent. Suitable examples might be carbon dioxide, water, methane, acetic acid, ethanol, lactic acid and glucose.

In the second task, they identify which molecule of a pair is bigger. This is intended to help them remember how big some of these molecules are, so that they have a better idea in the next activity about those reactions which involve molecules being 'built up' and those in which molecules are 'broken down'.

Activity G8 - Building up and breaking down

Many important chemical changes involve small molecules joining to form large ones, or large molecules splitting to form small ones.

Sheet 1 shows picture representations of two kinds of change - 'building up' and 'breaking down'. There are similarities which should be drawn here to the pictures introduced in activity G5 of 'joining' and 'splitting'. Pupils need to match examples from a range of chemical reactions - mainly biological but some non-biological - to the pictures of 'building up' and 'breaking down'. They need to use the information about the sizes of molecules from the atlas, and one example should be discussed with the class to show pupils how to do this.

One of the questions on the sheet asks pupils to consider whether it is easier to 'build up' or 'break down' molecules. The direction in which such changes tend to go will be dealt with explicitly in theme J, but there could be a discussion of this here. The analogy of breaking a bottle and mending a broken bottle could be used to explain why reactions tend to result in molecules breaking down rather than building up.

Answers:
Building up: A B D E (G) (K) P
Breaking down: (C) F H I J L M (N) O
(The letters in brackets are non-biological changes.)

Reference - A ladder of molecules

These sheets give some information about various molecules ranging in size from nitrogen to DNA. Pupils will need to use these sheets in activities G7 and G8.

A ladder of sizes

Sheet 1

If you could make yourself smaller and smaller, what do you think you would be able to see? In this activity, you will build a 'ladder' to help you think about the sizes of very small things.

1. Cut up the pictures on sheet 2.

2 Put them in order of size. Use the information in the box below to help you.

3 Once you have checked the order, you can build your ladder. Write your answers in the spaces on sheet 3.

Information about very small things

Living things

Many living things are so small that they can only be seen with a microscope. They are called microbes. Microbes may be harmful and cause diseases, but there are many useful microbes as well.

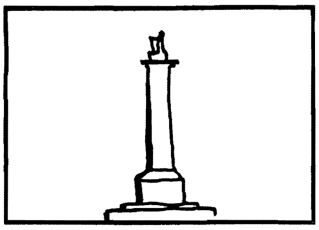
Examples of microbes are yeast, bacteria and viruses. Yeast cells can be seen quite easily under a microscope. Bacteria are smaller, but can also be seen under a microscope. Viruses can only be seen with a powerful microscope.

Atoms and molecules

If we look at things with special microscopes which are very powerful,we can see molecules. Everything is made of molecules - water is made of water molecules, sugar is made of sugar molecules, and so on. Molecules come in very different sizes.

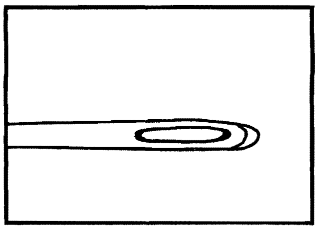
Molecules are made of collections of smaller particles called atoms. Some molecules are made from just two or three atoms. Large molecules may be made from thousands of atoms.

A



Nelson's column

B

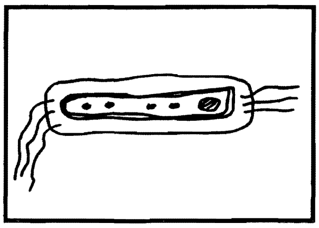


the eye of a needle

C

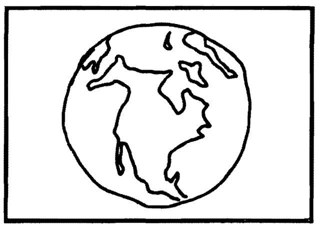
an English county

D



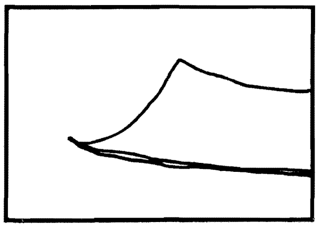
a bacterium

E



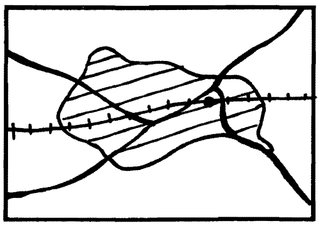
the Earth

F



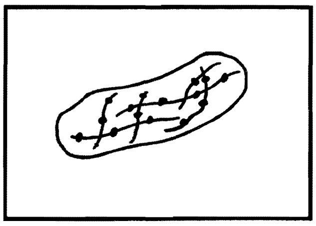
thickness of a piece of paper

G



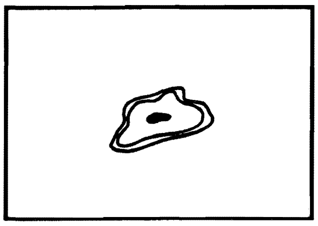
a small town

H



a large molecule (eg a protein)

I

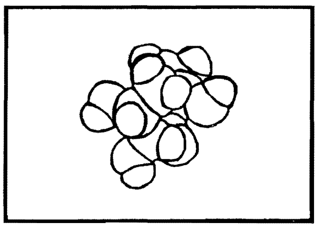


a virus

J

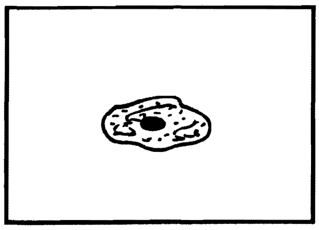
a young child

K



a small molecule (eg sugar)

L

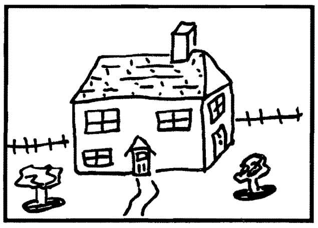


a yeast cell

M

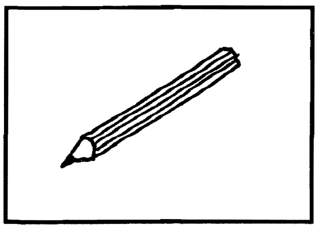
Britain

N



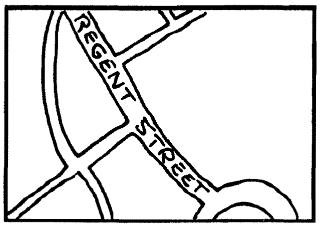
a house

O



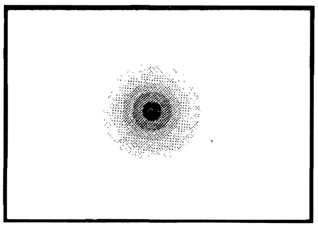
a pencil

P



a street

Q



an atom (eg oxygen)

R

a 5p piece

10 000 000 m	
1 000 000 m	
100 000 m	
10 000 m	
1 000 m	
100 m	
10 m	
1 m	
$\frac{1}{10}$ m	
$\frac{1}{100}$ m	
$\frac{1}{1\,000}$ m	
$\frac{1}{10\,000}$ m	
$\frac{1}{100\,000}$ m	
$\frac{1}{1\,000\,000}$ m	
$\frac{1}{10\,000\,000}$ m	
$\frac{1}{100\,000\,000}$ m	
$\frac{1}{1\,000\,000\,000}$ m	
$\frac{1}{10\,000\,000\,000}$ m	

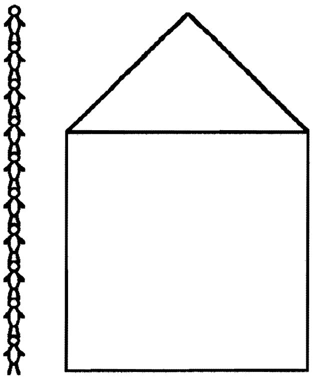
Using the ladder of sizes

Sheet 1

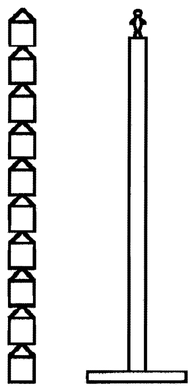
A We can use the ladder to compare how much bigger one thing is than another:

1 step up on the ladder means	10 times bigger
2 steps up on the ladder means	100 times bigger
3 steps up on the ladder means	1 000 times bigger
4 steps up on the ladder means	10 000 times bigger

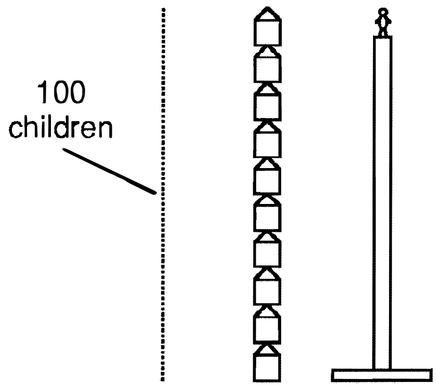
For example, comparing a child to Nelson's column:



a house
is 10 times taller
than a child
(1 step on the ladder)

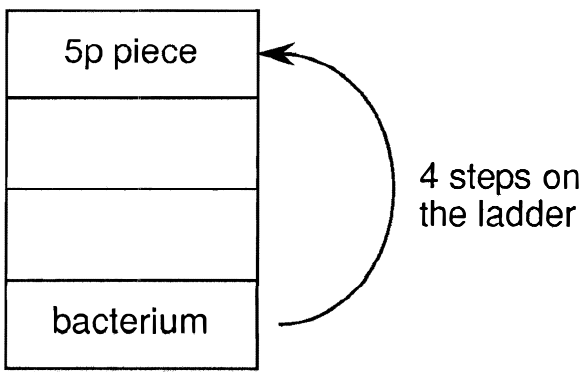


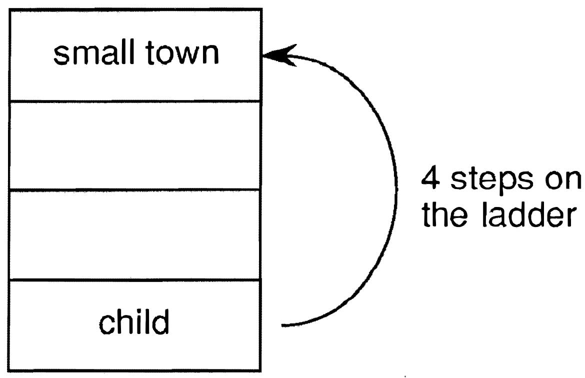
Nelson's column
is 10 times taller
than a house
(1 step on the ladder)



Nelson's column
is 100 times taller
than a child
(2 steps on the ladder)

B Imagine that a child was shrunk to the size of a bacterium. The a 5p piece would look the size of a small town!





Using the ladder of sizes

Sheet 2

1 We can use the ladder to compare how much bigger one thing is than other.

E.g.	the height of Nelson's column	is about 100 times	the height of a child	(2 steps up on the ladder)

Do the following in the same way:

a) a child, a 5p piece
b) Nelson's column, a pencil
c) thickness of a piece of paper, a yeast cell
d) a yeast cell, a virus
e) a large molecule, an atom
f) a bacterium, an atom

2. We can use it to compare differences in the sizes of things. For example, a 5p piece is bigger than a bacterium. It is four steps up the ladder (10 000x bigger). This can be easier to think about like this. Four steps up the ladder from a child is a small town (10 000x bigger). So:

a bacterium to a 5p piece	is the same as	a child to a small town

Imagine that the child was shrunk to the size of a bacterium. Then a 5p piece would look the size of a small town!

Try these others:

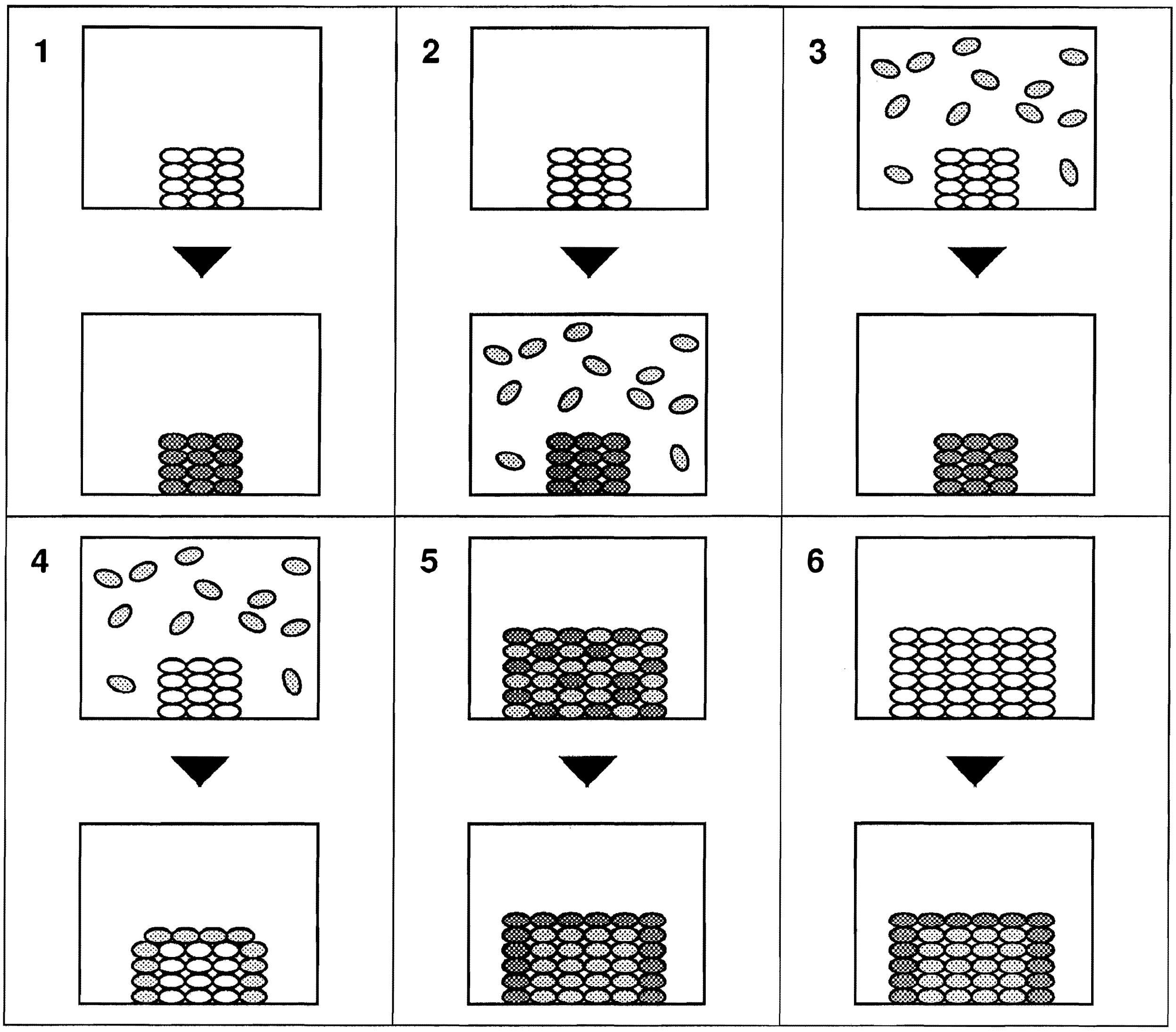
a)	a yeast cell to a child	is the same as	a child to ?
b)	a virus to a child	is the same as	a child to ?
c)	an atom to a bacterium	is the same as	a 5p piece to ?
d)	an atom to a 5p piece	is the same as	a 5p piece to ?

Try some more of your own.

Heating copper

When copper is heated in air, it turns black.

Which picture do you think shows the change best?



1. Work in pairs. Choose the picture you think best shows what happens when copper is heated in air.

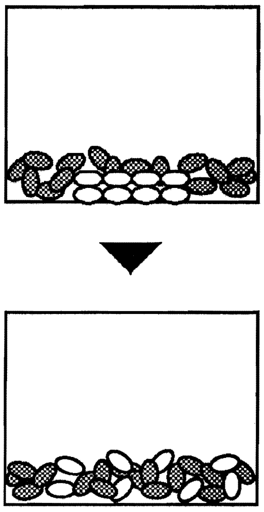
2. After you have chosen, write about why you made this choice.

3. For each of the other 5 pictures, explain what it shows and why you did *not* choose it.

4. After discussing with other groups or with your teacher, you may want to change your mind. If you do, write about your new reasons.

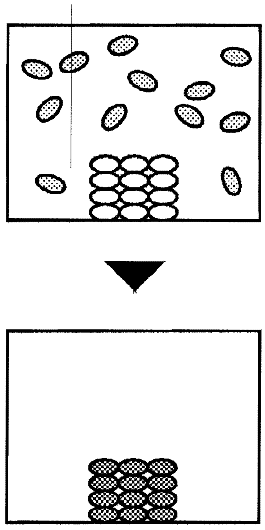
What happens when new substances are made? Sheet 1

When sugar dissolves in water the particles **mix** together. They form a **mixture.**

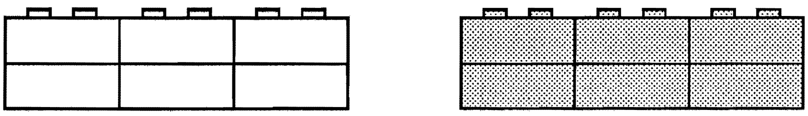


When copper is heated in oxygen, the particles **react** together. They form a **new substance.**

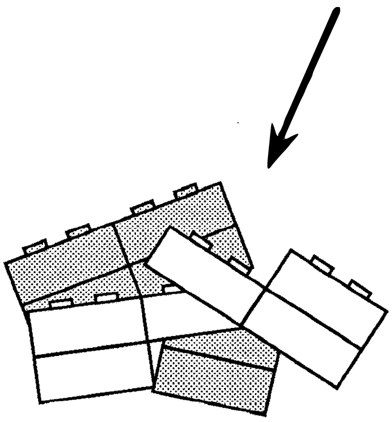
How do they do this?



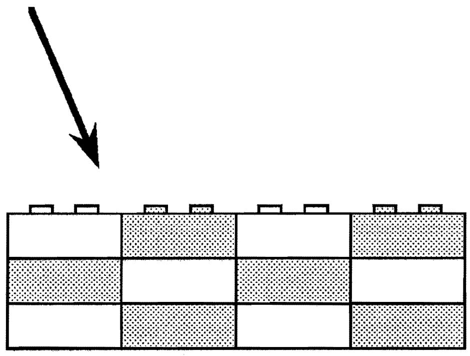
Imagine that you have got some building bricks. There are two colours.



Two ways of 'bringing them together'



Mix them up



Join them together in a new way

When substances mix, this is a bit like the first way of bringing the bricks together. The particles of the substances **mix.**

When substances react, this is a bit like the second way of bringing the bricks together. The particles of the substances **join together** in a new way.

What happens when new substances are made? **Sheet 2**

This picture has been used so far to represent two particles reacting together to form a particle of a new substance.

What really happens when a new substance is made?
The particles **join together.**

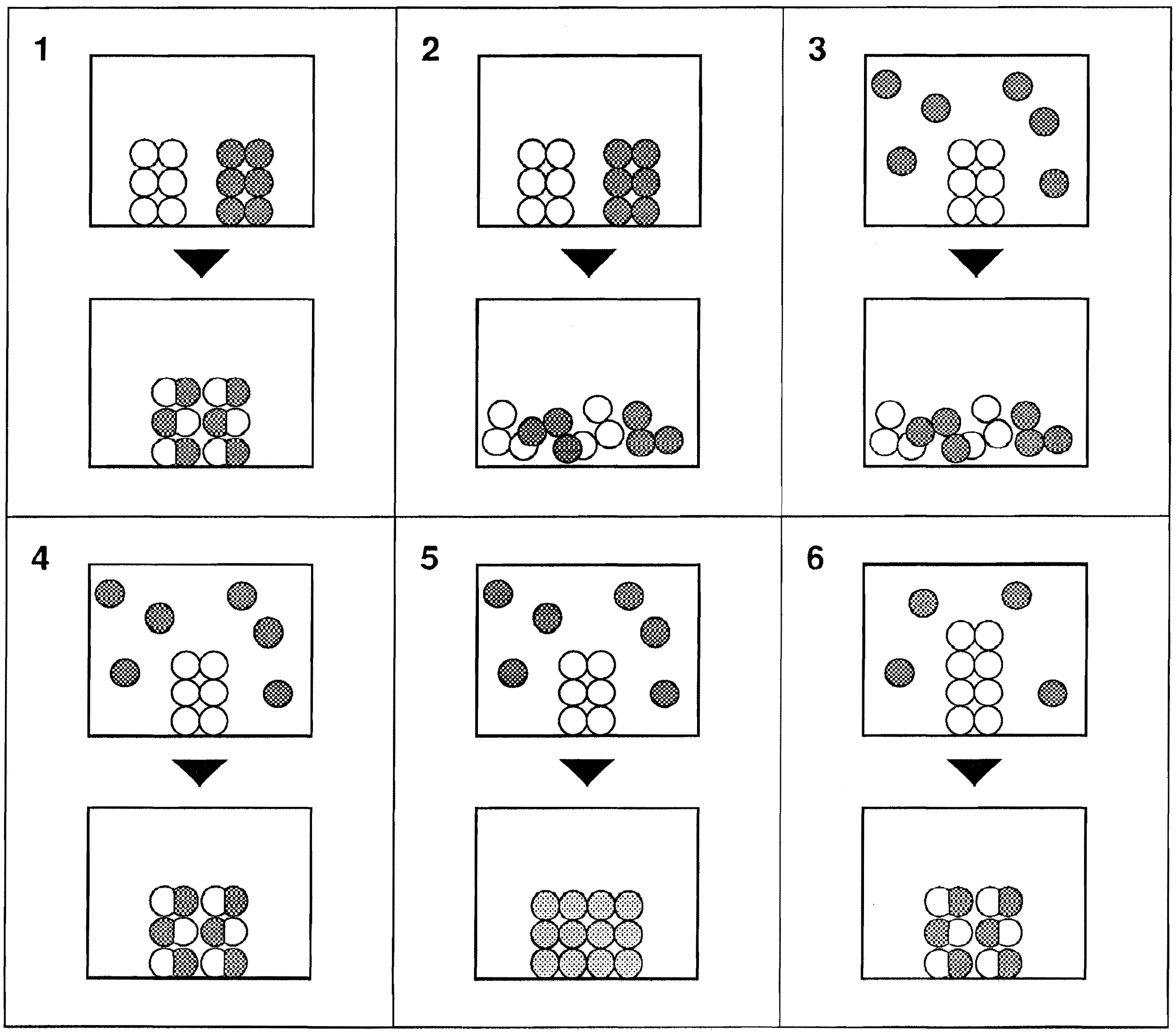
When substances react, particles do not appear or disappear. They **join together** in new ways.

1 Work in pairs. Choose the picture you think best shows what happens when copper is heated in air.

2 After you have chosen, write about why you made this choice.

3 For each of the other 5 pictures, explain what it shows and why you did *not* choose it.

4 After discussing with other groups or with your teacher, you may want to change your mind. If you do, write about your new reasons.



Joining and splitting, mixing and 'un-mixing'

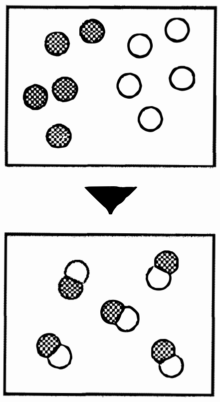
Sheet 1

Changes to two substances:

- mixing - no new substance is formed - the particles simply mix together
- joining - a new substance is formed - the particles join together in a new way

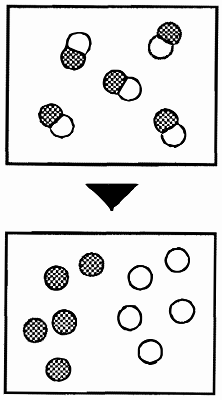
1

Joining



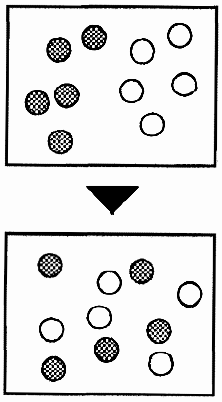
2

Splitting



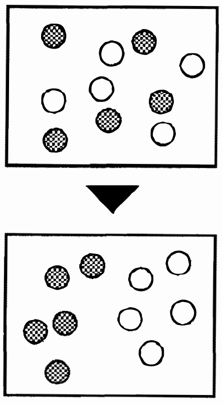
3

Mixing



4

'Un-mixing'



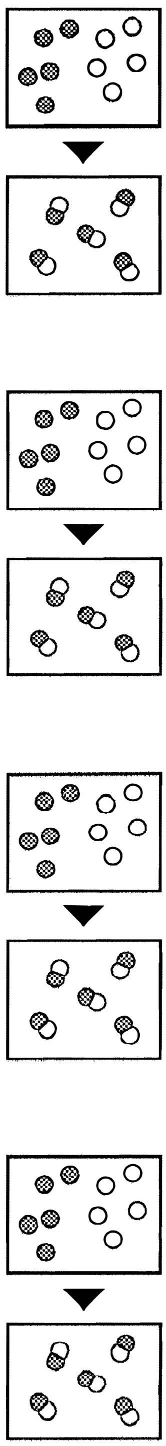
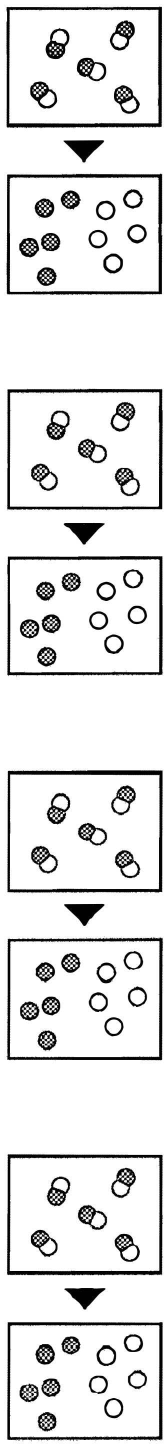
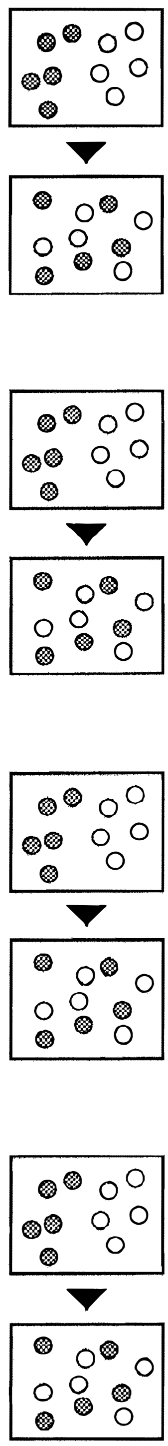
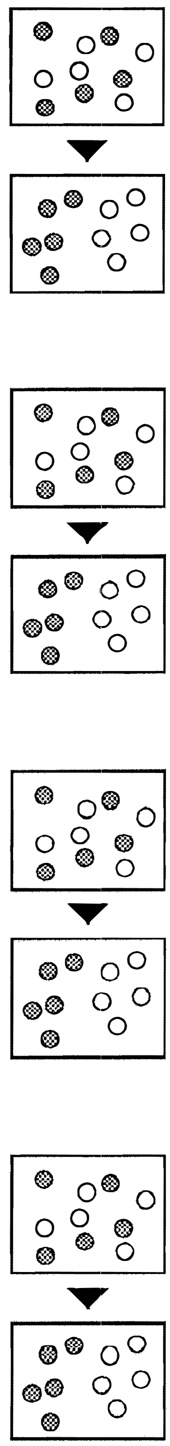
Joining and splitting, mixing and 'un-mixing'

Sheet 2

1 Here are some pictures. They show some of the different kinds of changes to substances.

2 Every time you come across a new change, think about what picture it is most like.

3 Stick the picture next to your writing about the change, and explain why you chose it.

Joining	Splitting	Mixing	'Un-mixing'
			

Joining, splitting, mixing, 'un-mixing' - some examples

Sheet 1

1 Cut out the changes below.

2 Match them to the pictures that you think show the changes best.

3 Write about the reasons you made the matches.

A Rusting When iron rusts, it reacts with oxygen in the air to form iron oxide (rust).	**B Dissolving sugar** If you add sugar to water, it will dissolve forming sugar solution.
C Electrolysis of water You can electrolyse water (with a little acid added). At one electrode you get hydrogen gas, and at the other electrode you get oxygen gas.	**D Heating copper** If you heat a piece of copper foil it turns black. The copper reacts with oxygen in the air to form copper oxide (which is black).
E Purifying rock salt Rock salt contains salt and impurities. You can make pure salt by dissolving the rock salt in water, filtering and evaporating.	**F Hydrogen and oxygen** If you mix together hydrogen and oxygen gases, and light it, you get an explosion. Water is formed.
G Getting iron from a mixture You have a mixture of iron and copper. You can get the iron out by using a magnet, leaving the copper behind.	**H Iron and sulphur** If you stir together some iron filings (dark gey) and sulphur powder (yellow), you get a dirty yellow mixture.
I Heating iron and sulphur If you heat together some iron filings (dark gey) and sulphur powder (yellow), you get a black compound called iron sulphide.	**J Making iron** Iron is made from iron ore in a blast furnace. Iron ore contains a compound of iron and oxygen (iron oxide). Carbon is used to remove the oxygen from the ore.
K Purifying water In some countries, there is not much fresh water for growing crops. However, sea water can be used if it is purified by removing the salt from it, eg by distillation.	**L Making copper** Copper is made from copper ore, which contains copper oxide. After reacting it with acid, it is electrolysed. Copper forms at one electrode (and oxygen at the other).

Molecules

Sheet 1

Molecules can be of very different sizes. Some molecules, like water, consist of only a few atoms. Other molecules, such as proteins, can consist of many thousands of atoms.

The 'ladder' of sizes shows pictures of some selected molecules, and gives the number of atoms in each molecule. The 'ladder' shows the molecules in order of size. Using it will give you an idea about the sizes of a range of important molecules.

1 You will be given some models of molecules. Use the ladder to identify which molecules the models represent. To help you do this, you could count the number of atoms, or you could try to recognise the shape.

2 Here are a list of pairs of molecules. For each pair, which molecule is bigger?

A	Ethanol	Soap
B	Nylon	Ethene
C	Water	Cellulose
D	Oxygen	Octane
E	Cholesterol	Ammonia
F	Lactic acid	Glucose
G	Starch	Acetic acid
H	Propane	DNA
I	Methane	Sucrose
J	Soap	Sulphur dioxide
K	Amino acid	Nitrogen
L	Protein	Fructose
M	Polythene	Carbon dioxide
N	Styrene	Polystyrene
O	Butane	Ozone

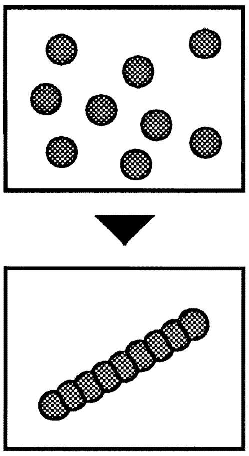
3 Now go over the list again, this time without using the ladder. How many can you get right from memory?

Building up and breaking down molecules

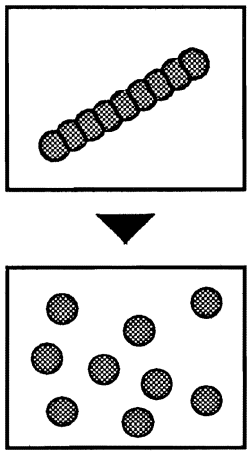
Sheet 1

1 In some reactions, large molecules are *built up* from lots of smaller molecules. In other reactions, large molecules are *broken down* into lots of smaller molecules:

building up



breaking down



2 Cut up the boxes below showing different kinds of changes. Sort them into two groups - 'building up' and 'breaking down'. (You need to use the ladder of molecules to find out the sizes of the molecules involved in the changes - these are shown in *italics.)*

Questions

1 Most of the changes are *biological.* Can you find two examples of 'building up' changes that are *non-biological*?

2 Can you find two examples of 'breaking down' changes that are non-biological?

3 Do you think it is easier to build up molecules or break down molecules? Why?

A Making proteins

Many of the parts of our bodies are made from *proteins* - muscles, skin, hair and nails. Enzymes are also proteins. We make proteins from *amino acids* which we get from our food.

B Photosynthesis

Plants use sunlight to make *glucose* (a sugar). They make this using *carbon dioxide* (which they get from their leaves) and *water* (which they get from their roots). During photosynthesis, plants also produce *oxygen.*

C Burning petrol in an engine

When fuels burn, they react with oxygen. For example, a car engine burns petrol which contains *octane.* When this reacts with *oxygen* it produces *carbon dioxide* and *water.*

D Plants storing food

Making *starch* is a good way for a plant to store food, because it is insoluble. A plant makes starch from *glucose* (a sugar which is soluble).

E Plants making cellulose
Cellulose is the 'building material' of plants. It is what gives strength and shape to the stems, roots and leaves of green plants. Plants make cellulose from *glucose.*

F Digesting starch
Many foods contain starch, but we are not able to use this starch until we digest it. Starch is insoluble. In a human's small intestine, *starch* is changed into *glucose.* Glucose is soluble and passes into the bloodstream.

G Making polythene
Polythene is a synthetic material - it is not found in nature. It is a long chain molecule made by joining together *ethene* molecules.

H Respiration in animals
We use *glucose* in our bodies as a fuel, for example to make our muscles move. Glucose reacts with the *oxygen* in our blood and forms *carbon dioxide* and *water.*

I Respiration in plants
At night, when there is no sunlight, plants also respire - reacting *glucose* with *oxygen* to form *carbon dioxide* and *water.*

J Respiration in bacteria
Many bacteria can respire in the same way as humans - by reacting *glucose* with *oxygen* to form *carbon dioxide* and *water.*

K Making polystyrene
Polystyrene is a synthetic material - it is not found in nature. It is a long chain molecule made up by joining smaller molecules together. These are *styrene* molecules.

L Digesting protein
Many foods contain *protein.* In order to use this protein, we need to digest it. This is done in the stomach. Proteins are broken down into *amino acids.*

M Fermentation
Yeast, like humans, can use glucose as a fuel. However, they do not need oxygen. They change *glucose* into *ethanol* (or alcohol) and *carbon dioxide.* This process is called fermentation, and is used in making alcoholic drinks and bread.

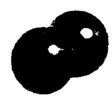
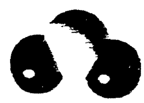
N Burning gas in a camping stove
The gas in the cylinders which are used for camping stoves is *butane.* When it burns it reacts with *oxygen* to form *carbon dioxide* and *water.*

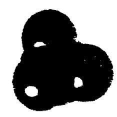
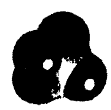
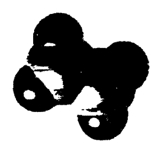
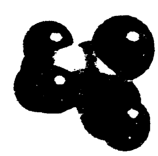
O Making 'biogas'
Some bacteria can live without oxygen, changing dead plant material, which contains a lot of *cellulose,* into *methane* and *water,* as well as other substances. These bacteria are used in 'biogas' fermenters, which provide gas for cooking and heating.

P Growth of bacteria
Like humans, bacteria need to make *proteins* in order to grow. They make the proteins from *amino acids.*

A ladder of molecules

Sheet 1

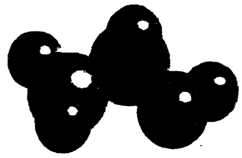
Nitrogen Nitrogen is the commonest gas in the air. In every breath we take, over three quarters of it is nitrogen. 2 atoms	
Oxygen Oxygen is a gas which is essential for us. We breathe to take in oxygen. About 20% of the air consists of oxygen. It is also needed by fires to keep them burning. 2 atoms	
Carbon dioxide Carbon dioxide is a gas that we breathe out. It is very important for plants since they use it to make food from it. Only about 0.03% of the air is carbon dioxide. 3 atoms	
Ozone Ozone consists of just three oxygen atoms, but it is very different from oxygen. It has a very strong smell. There is a layer of ozone in the upper atmosphere, which shields us from ultraviolet radiation. There is concern that the layer is being destroyed by CFC's. 3 atoms	
Sulphur dioxide This is a gas which has a strong unpleasant smell. It is produced as pollution when coal is burnt, and there are small quantities in the air. As the rain falls it dissolves sulphur dioxide forming acid rain. This can damage forests. 3 atoms	

Water Water is, of course, everywhere. Most of it is in the oceans but it also exists in the air as water vapour and in the ground. About 90% of our bodies consist of water. 3 atoms	
Ammonia Ammonia is used in cleaning fluids, and has a strong smell. It is very important in the chemical industry as it is used to make many other kinds of molecules. Decaying foods also produce ammonia. 4 atoms	
Methane This is a gas which burns and has no smell. It is the gas which we use in our homes for cooking and heating. It is piped from the North Sea, and is called 'natural gas'. 5 atoms	
Ethene Ethene is a gas which is made in huge amounts by the oil industry. It used to make a wide range of different chemicals including plastics and synthetic rubbers. 6 atoms	
Acetic acid When wine is left open to the air its taste becomes acidic. This is because bacteria change the alcohol to acetic acid. Acetic acid is what gives vinegar its flavour (the word vinegar comes from the French vin aigre meaning 'sour wine'). 8 atoms	

Ethanol

Ethanol is the scientific name for what we usually call 'alcohol'. Wine and beer contain ethanol which has been formed by the action of yeast. The yeast change sugar molecules into ethanol.

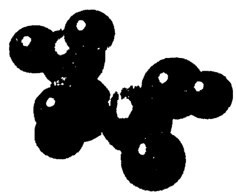
9 atoms



Amino acid

When we digest our food, amino acids are one kind of molecule which are produced. We absorb these into our blood and use them to make proteins. We need about twenty different kinds of amino acids. The one shown here is called 'glycine'.

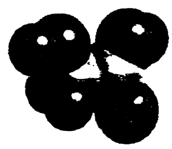
10 atoms



Lactic acid

When milk is left it goes sour. It tastes acidic because bacteria produce lactic acid. This also happens when milk forms yoghurt. When we exercise for a long time, our muscles begin to ache - this is also because of lactic acid produced in our muscle.

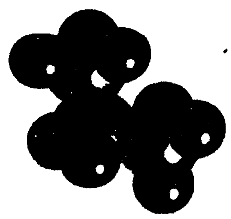
11 atoms



Propane

Propane is a gas which has no smell and which burns. It is similar to 'natural gas', but its molecules are a bit bigger. Propane is the gas which comes in bottles and cylinders for burning in portable fires.

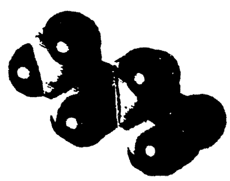
11 atoms

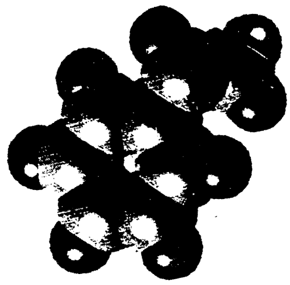
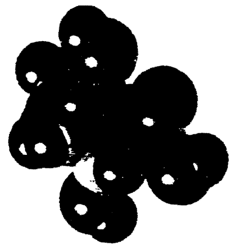
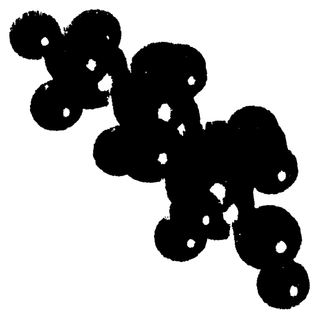
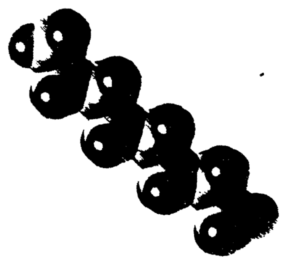


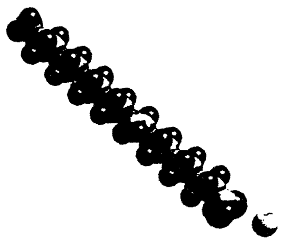
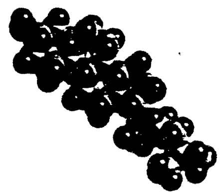
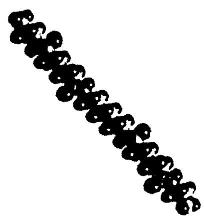
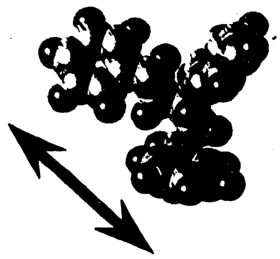
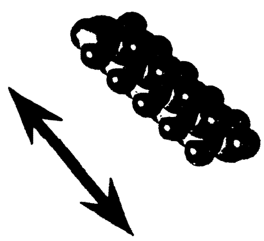
Butane

Butane is similar to propane, but its molecules are a bit bigger. It is a flammable gas, and it can be easily liquefied when compressed. It is used, for example, in cigarette lighters and the gas cylinders for camping stoves.

14 atoms



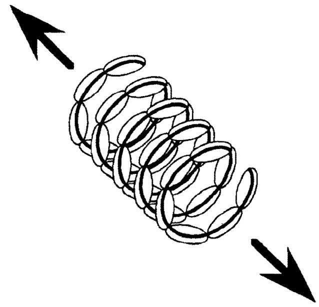
Styrene Styrene is a colourless liquid which is manufactured from crude oil. It is an important chemical in industry, as it is used in the manufacture of plastics and synthetic rubber. 16 atoms	
Fructose Fructose is a sugar which is found in many fruits and vegetables, and in honey. It is sweeter than ordinary sugar, so it is useful in 'low-calorie' diets. 24 atoms	
Glucose Glucose is a sugar which is used directly by the muscles of the body. When we eat other kinds of sugar, they need to be converted to glucose before they can be used by the body. Eating foods with glucose in them means that we can use the sugar straight away. 24 atoms	
Octane Octane is a liquid and it burns very easily. It is a very good fuel for car engines and is found in petrol. 26 atoms	
Sugar (sucrose) Sucrose is the scientific name for what we usually call just 'sugar'. It comes from sugar cane and from sugar beet. 45 atoms	

Soap This works by dissolving grease which would not dissolve in water. The disadvantage of soap is that it forms a 'scum' with hard water. This can be avoided by using a detergent. 56 atoms	
Cholesterol Cholesterol is found in the blood and is a very important substance in the body. It is used to make a number of important hormones. Some people worry that the level of cholesterol in their blood is too high. 74 atoms	
Nylon Nylon was the first synthetic fibre - ie one made by people and not by nature. It was called Nylon because it was discovered at the same time in New York (ny) and London (lon). about 5000 atoms	
Polystyrene This is a very long molecule - only a very small part of it is shown here. Much of it is used for making packaging material as expanded polystyrene. about 5000 atoms	
Polythene This is a very long molecule - only a very small part of it is shown here. It is used for making many everyday objects - from plastic bags to buckets. about 5000 atoms	

* Starch

This is a very long molecule - only a very small part of it is shown here. It is made by plants and stored by them as a fuel supply. It is formed by putting together many glucose molecules into a long chain, which forms a coil (or helix).

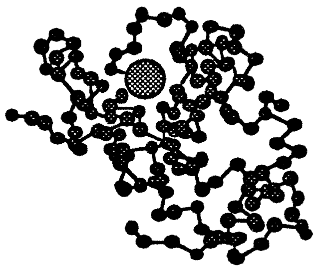
about 10 000 atoms



* Protein - haemoglobin

Proteins are formed by putting together many amino acids together into long chains. There are many different kinds of protein, and the chains may be coiled or folded around each other in many different ways. Haemoglobin (the molecule which carries oxygen in the blood) contains four protein molecules. One of these molecules is shown here.

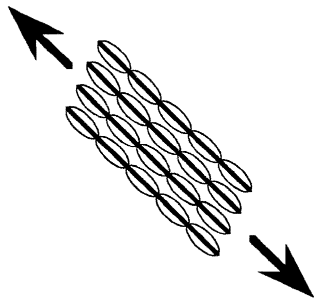
about 10 000 atoms



* Cellulose

This consists of very long molecules - only small parts are shown here. It is formed by putting together many glucose molecules into long chains which form ribbon-like bundles. There are large quantities of cellulose in plants - it is used as the 'building material' for the cell walls.

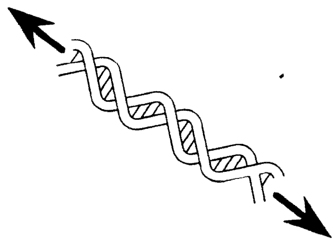
about 50 000 atoms



* DNA

This is an extremely long spiral molecule - only a very, very small part is shown here. DNA is found in every cell in every living thing. Genes consist of DNA, and these molecules contain the information which is passed from parents to children - like the colour of eyes or hair.

millions of atoms



* Note that the molecules shown on this page are very large. Individual atoms are not shown. The pictures represent the overall structure of the molecule by showing how *groups of atoms* are arranged.