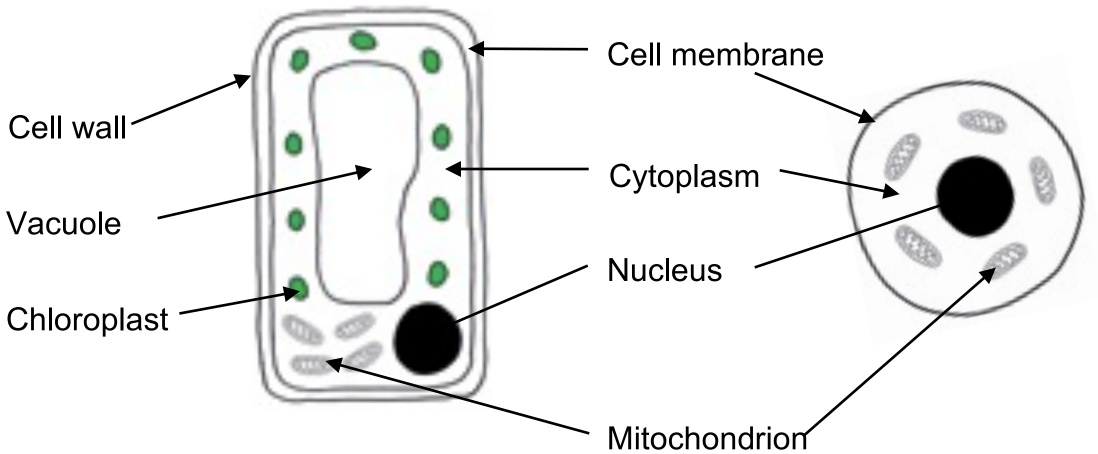
GCSE Science:
Unit 1 Revision Book - Double Award / Biology

Contents

Plant and Animal Cells

Every organism, except viruses, contains one or more cells.
The size of the organism depends on the number of cells and not the size of the cells.



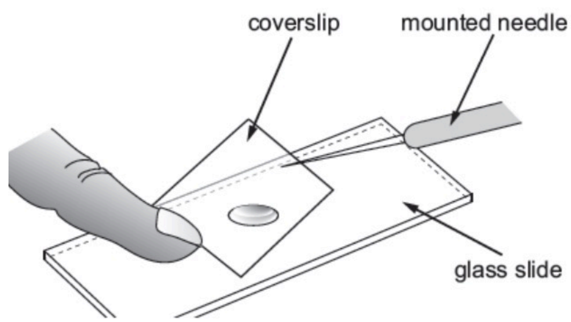
Plant Cells	Animal Cells
Cell wall present	No cell wall present
Chloroplast present	No chloroplasts present
Large permanent vacuole present	No permanent vacuole present

Function of cell parts

Part of cell	Function
Cell membrane	Controls substances entering and leaving the cell
Cytoplasm	Where most chemical reactions take place
Nucleus	Contains chromosomes which carry genetic information and controls the activities of the cell
Cell wall	Contains cellulose; it supports the plant's structure
Chloroplast	Absorb light for photosynthesis
Vacuole	Space filled with cell sap (a dilute solution of sugars and mineral salts)
Mitochondria	Site of aerobic respiration

Examination of Animal and Plant Cells Using a Light Microscope

Examination of Cheek Cells
1. Put a drop of methylene blue on a glass slide.
2. Gently rub the inside of your cheek with a cotton bud.
3. Wipe the end of the cotton bud in the drop of methylene blue on the glass slide.
4. Place the cotton bud in a beaker of disinfectant.
5. Use a mounted needle to gently lower a coverslip onto the glass slide.
6. Use a light microscope to examine the slide.



Examination of Onion Cells
1. Using forceps, peel a thin layer of epidermis from the inside of a freshly cut piece of onion.
2. Lay the epidermis onto a glass slide.
3. Add a drop of iodine solution to the onion epidermis on the glass slide.
4. Use a mounted needle to gently lower a coverslip onto the glass slide.
5. Use a light microscope to examine the slide.

How to calculate magnification of a drawing or picture

If the real length of A – B = 42um, what is the magnification of the picture?

Step 1
Measure length of A – B on picture (in mm)

= 47mm

Step 2
Convert millimetres(mm) to micrometres(μm)
(1mm = 1000μm)

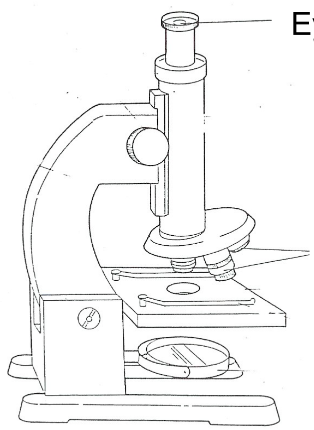
= 47mm x 1000 = 47000μm

Step 3
Calculate magnification

$$\text{Magnification} = \frac{\text{length of A – B on picture}}{\text{Real length of A – B}} = \frac{47000\mu m}{42\mu m} = \times 1119.048 = \times 1119$$

Microscopy

Light Microscopes
Light microscopes allow you to see the image because light passes through it. The properties of light mean that it is impossible to magnify an image by more than *x1000*.



Magnification

Total magnification is achieved by the multiplication of the power of the eyepiece lens by the power of the objective lens

	Magnifying Power		Total magnification
	Eyepiece lens	Objective lens	
Low Power	X10	X4	X40
High Power	X10	X20	X200

Electron Microscopes
The electron microscope was developed in the 1930s.
It uses a beam of electrons instead of light.
It is possible to get much larger magnifications, up to *x50,000,000*.
Because you can't see electrons, the image is displayed on a monitor.
The disadvantage of electron microscopes is that you can only study dead cells.
Electron microscopes allowed scientists to discover the internal structures of cells.

Biological Staining
Stains are used to help us see cells in greater detail. The two most commonly used in school laboratories are:

- **Iodine solution**
  It makes the nucleus more obvious and stains any starch present. Mostly used to stain plant cells.
- **Methylene blue**
  Stains acidic parts of the cell blue. Makes the nucleus more obvious. Mostly used to prepare slides of animal cells and bacteria.

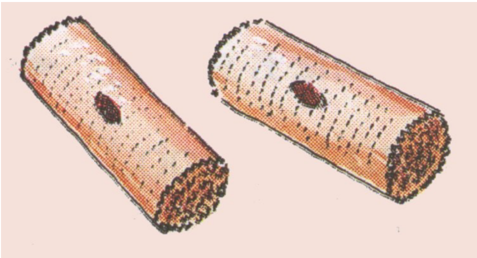
Specialised Cells

The simplest forms of living organisms are mode of only one cell. They are called **unicellular** organisms.

Organisms that consist of many cells are called **multicellular.**

Scientists have recently estimated that human beings are made up of approximately 34 to 37 trillion cells. Not all cells however are the same. Cells specialise to carry out specific functions more efficiently than non-specialised cells, e.g. red blood cells carry oxygen.

Levels of organisation within organisms



Specialised cells

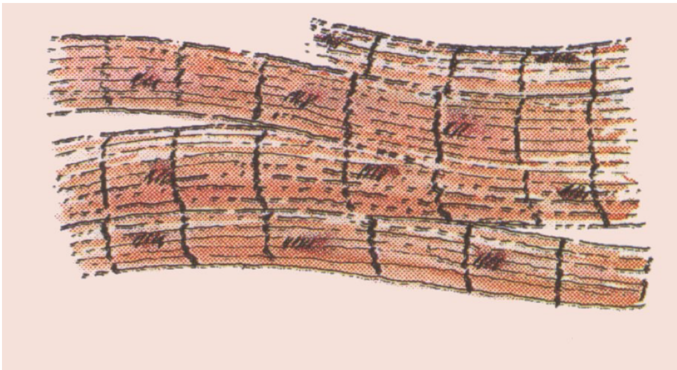
Cells differentiate to cells with a specific function.

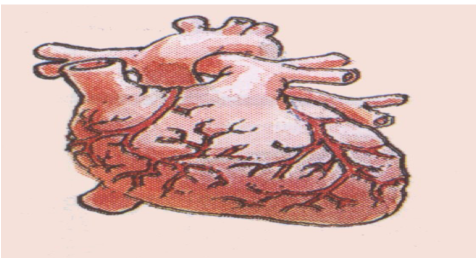
E.g. muscle cells.

Tissues

Groups of similar cells with a similar function.

E.g. muscle cells contract and therefore shorten.





Organ

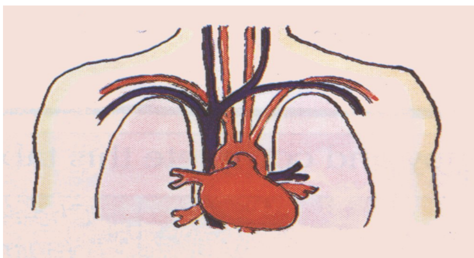
Several tissues performing specific functions.

E.g. the heart pumps blood.

Organ System

A number of organs working together to carry out specific functions.

E.g. the circulatory system carries substances around the body.

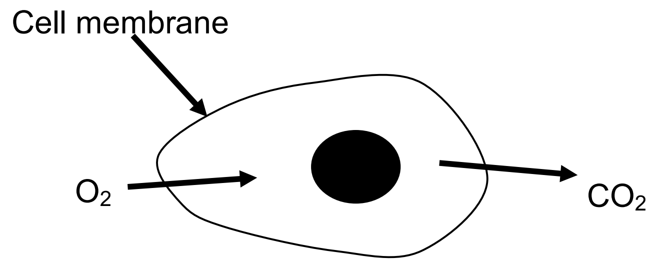


Diffusion

Molecules are constantly moving.

Molecules of liquids and gases collide against each other all the time.

We see this process of **mixing** and **moving** in **diffusion**.



Oxygen and carbon dioxide pass through the cell membrane by diffusion.

Molecules diffuse from an area of high concentration to an area of low concentration.
This process does not require energy.

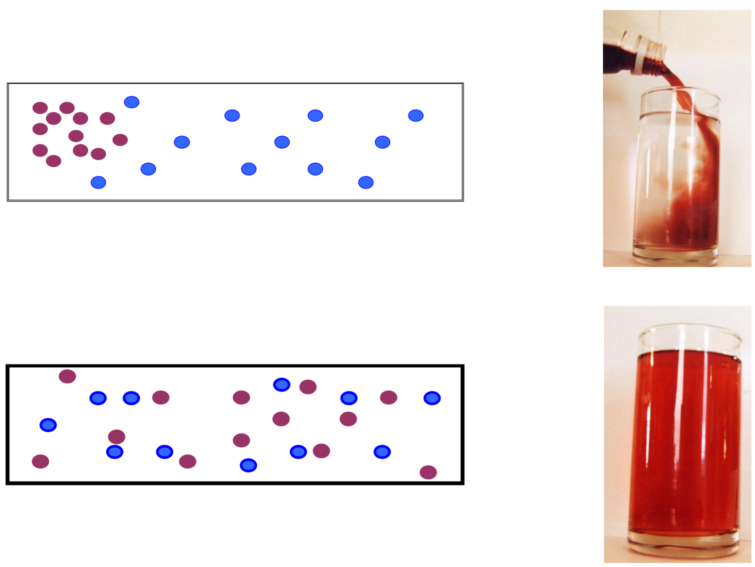


Fig. 1
Diffusion.
All liquid and gas molecules have kinetic energy; they are constantly moving and mixing.

The rate of diffusion can be affected by the following factors:

1. **Concentration**

The greater the difference in concentration between two areas (the concentration gradient), the faster the rate diffusion happens.

2. **Temperature**

As the temperature increases, the rate of diffusion increases too (molecules have more kinetic energy).

3. **Pressure**

If there is high pressure, the molecules will quickly move from the area of high pressure to low pressure.

How does the cell membrane control movement in and out of cells?

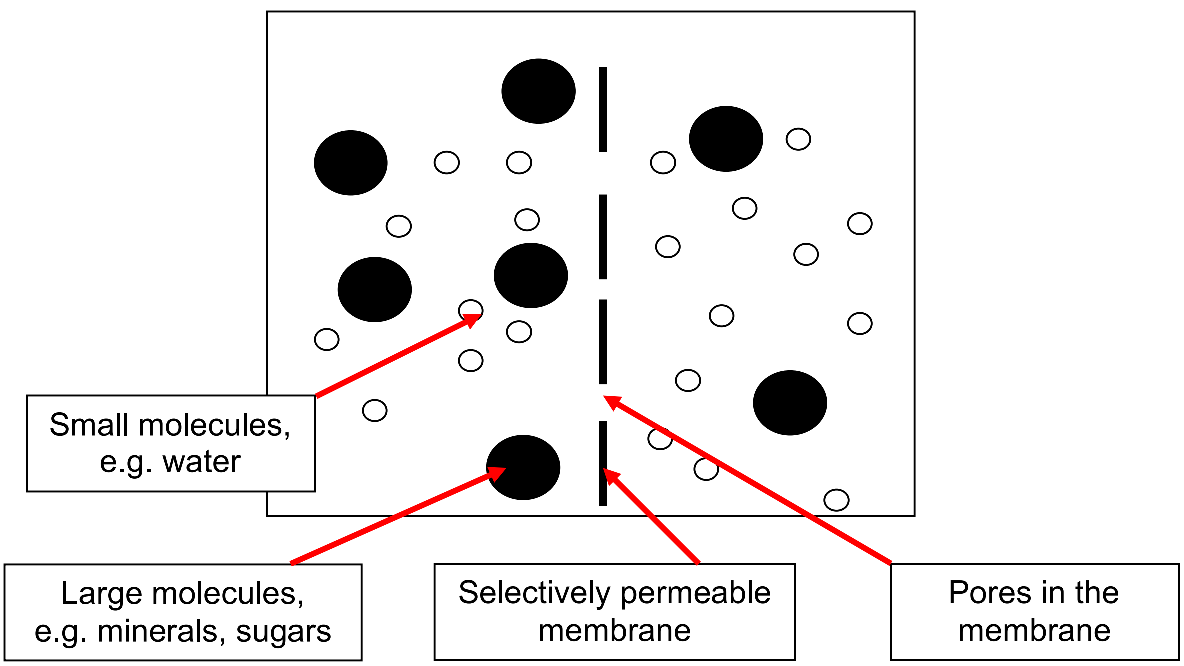
Every substance that enters or leaves a cell must cross the cell membrane. Some molecules will pass easily through the cell membrane whilst others are unable to pass through at all.

Structure of the cell membrane

It appears that there are many pores in the surface of the cell membrane. Molecules that are small enough can pass directly through these pores. Large molecules are prevented from passing through these pores.

The cell membrane is **a selectively permeable membrane**; it allows certain molecules to pass through, but not others.

Pores in the membrane allow small molecules to pass through.
Large molecules are too big to pass through the pores in the membrane.

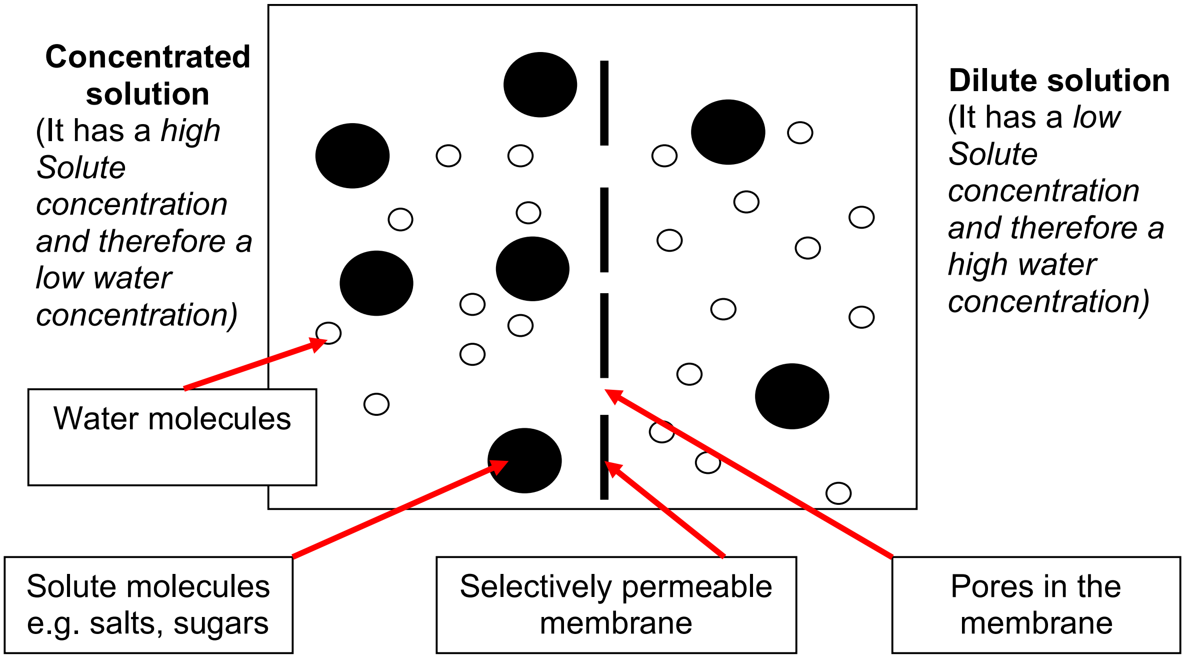


It is possible to use **Visking tubing** to model how the cell membrane works.

Osmosis

Osmosis is the **diffusion of water molecules** from an area of high water concentration (low solute concentration) to an area of low water concentration (high solute concentration) **through a selectively permeable membrane**.

The cell membrane is a **selectively permeable membrane**; it lets some molecules through but not others.



The pores in the membrane allow small water molecules to pass through. The solutes are too large to pass through the pores in the membrane.

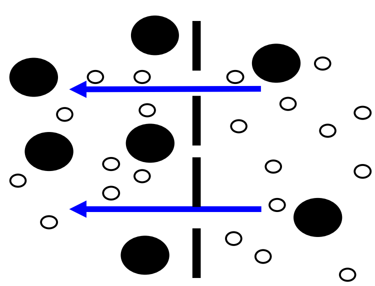


Fig.1
The arrows show the movement of water down a concentration gradient from an area of high water concentration to an area of low water concentration through a selectively permeable membrane.

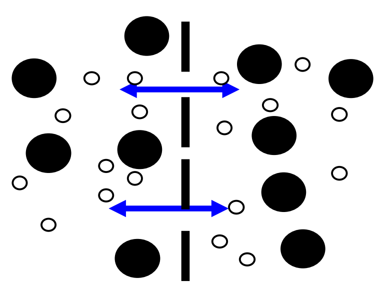


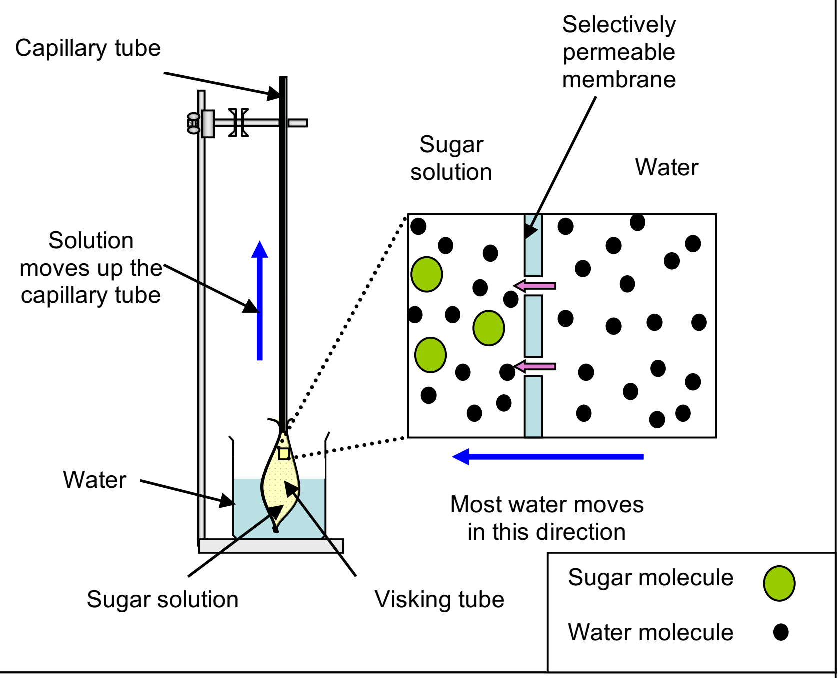
Fig. 2
No net movement of water.
The concentration of water on both sides of the membrane is equal. The same numbers of water molecules move in both directions.

Osmosis Investigations 1 – Modelling Living Material

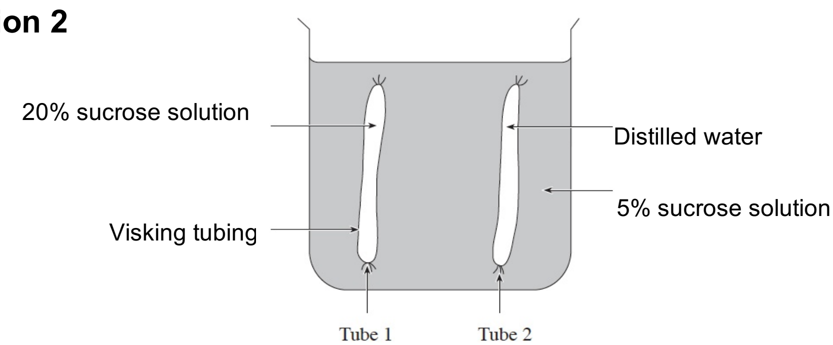
Visking tubing is very similar to the cell membrane.
It is also a selectively permeable membrane.
It has tiny holes (pores), which allow small molecules through, but stop molecules that are too large to fit through them.

Investigation 1

The concentration of water outside the visking tubing is higher than the concentration of water inside the visking tubing.
Water moves in through the pores in the selectively permeable membrane by osmosis.
This increases the pressure inside the visking tubing causing the solution to move up the capillary tube.



Investigation 2



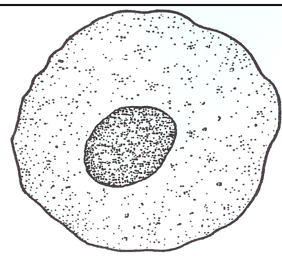
Tube 1
Gets bigger (becomes turgid).
The **concentration of water outside** the visking tubing is **higher** than the **concentration of water inside**.
Water has moved in through the selectively permeable membrane by osmosis.

Tube 2
Gets smaller (becomes flaccid).
The **concentration of water inside** the visking tubing is **higher** than the **concentration of water outside**.
Water has moved out through the selectively permeable membrane by osmosis.

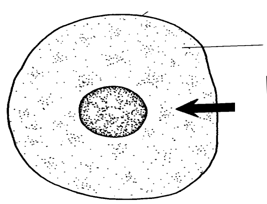
Osmosis and Living Cells

What happens to living cells placed in solutions with different concentrations?

Animal cells

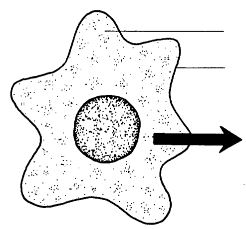


Dilute solution
(Low solute concentration)
(High concentration of water)
Water moves in to the cell through the selectively permeable cell membrane.
The cell swells and **may burst** because there is no cell wall.



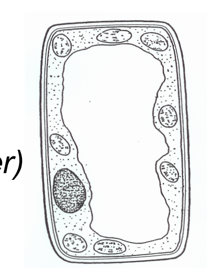
Water in

Concentrated solution
(High solute concentration)
(Low concentration of water)
Water moves out of the cell through the selectively permeable cell membrane.
The cell **shrivels**.



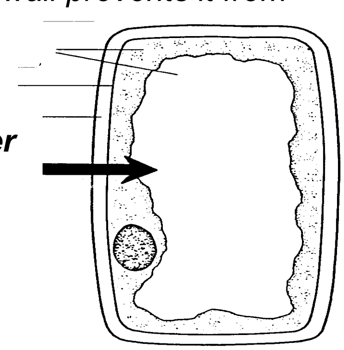
Water out

Plant cells

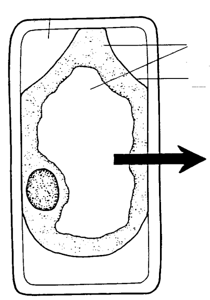


Dilute solution
(Low solute concentration)
(High concentration of water)
Water moves in to the cell through the selectively permeable cell membrane.
The cell becomes **turgid**.
(The cell wall prevents it from bursting)

Water in



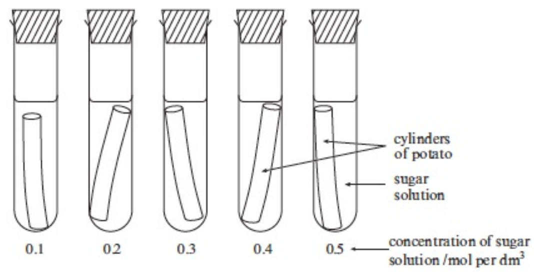
Concentrated solution
(High solute concentration)
(Low concentration of water)
Water moves out of the cell through the selectively permeable cell membrane.
The cell becomes **flaccid**.
(It doesn't shrivel because it has a cell wall.)



Water out

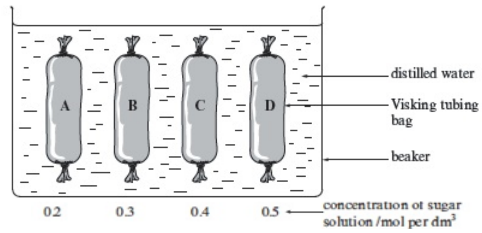
More Osmosis Investigations

Investigation 3



- Potato cylinders of **the same length (**30mm**)** are **dried** and then **weighed.**
- They are placed in different concentrations of blackcurrant squash (a sugar solution).
- They are left for the **same length of time (30 minutes).**
- They are dried and then weighed again.
- The % change in mass is calculated (because all cylinders have a different mass – this allows a fair comparison).
- The results are plotted as a line graph.

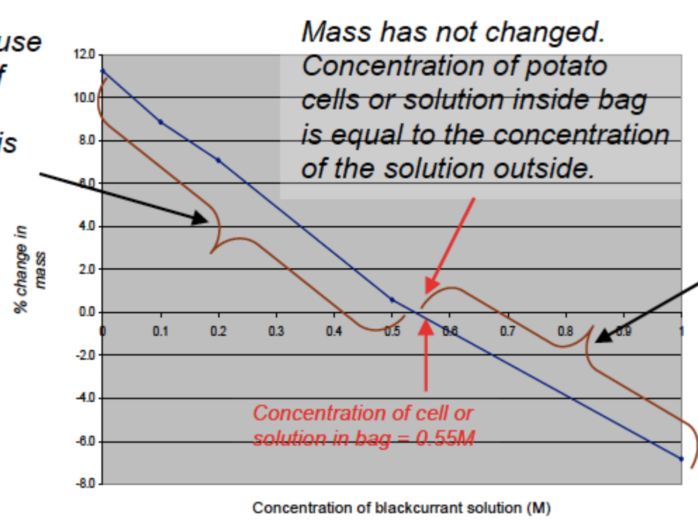
Investigation 4



- Identical Visking tubes are filled with the same volume (10ml) of a sugar (or salt) solution.
- Each bag contains a different concentration of the solution.
- The ends of the bags are tied.
- The outsides of the bags are dried and then weighed.
- They are left for the **same length of time (30 minutes).**
- The outsides of the bags are dried and then weighed again.
- The % change in mass is calculated (because all bags have a different mass – this allows a fair comparison).
- The results are plotted as a line graph.

Both investigations produce a similar graph and the conclusions are identical.

Mass has increased because concentration of water outside cylinder or bag is higher than the concentration inside.
Water has moved in through the selectively permeable membrane by osmosis.



Mass has decreased because concentration of water outside cylinder or bag is lower than the concentration inside.
Water has moved out through the selectively permeable membrane by osmosis.

Active Transport (Higher Tier Only)

When the concentration of a material is lower outside the cell it must be **actively transported** into the cell (sometimes referred to as **active uptake**).

During active transport, salts or ions are pumped from an area of low concentration to an area of higher concentration.
This process requires energy released by the cell.

Example – Uptake of nitrate ions by root hair cells

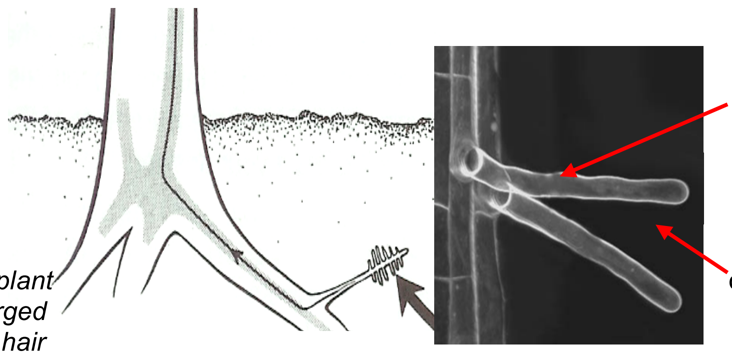


Fig. 1
Diagram of a plant root with enlarged view of a root hair cells.

- Nitrate ions cannot move in by diffusion.
- Nitrate ions must be actively transported from the soil water (an area of low nitrate concentration) to the inside of the plant cells (an area of high nitrate concentration).

Other examples of active transport include:

- Glucose actively transported from the small intestine into the blood.
- Marine algae can use active transport to concentrate iodine in their cells to concentrations a million times greater than surrounding sea water.

Factors affecting active transport

- Active transport needs **energy**.
- **Respiration** provides the energy required in the form of **ATP**.

Any factor that affects the rate of respiration will affect the rate of active transport:

- **Glucose concentration –** respiration needs glucose.
- **Oxygen –** aerobic respiration needs oxygen.
- **Temperature –** affects the enzymes controlling respiration.
- **Toxic substances –** e.g. cyanide stops respiration.

How are the activities of a cell controlled? (Higher Tier Only)

All the activities of a cell depend on chemical reactions, which are controlled by special molecules called **enzymes**.

Enzymes are **proteins**.
Proteins have a number of important functions:

- enzymes,
- hormones (e.g. insulin)
- muscle tissue

The structure of proteins
Proteins are made of different **amino acids** linked together to form a **chain**:

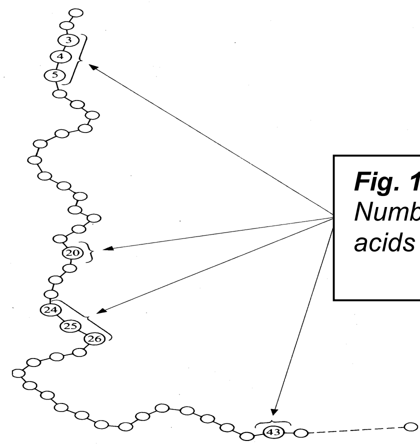


Fig. 1 – amino acid chain.
Numbers refer to the sequence of the amino acids in the protein chain.

The chain is then **folded** to form a **specific shape**:
The sequence of amino acids is important in determining the protein structure and its function.

Active site of enzyme.
A groove in the protein where a specific substrate 'fits'

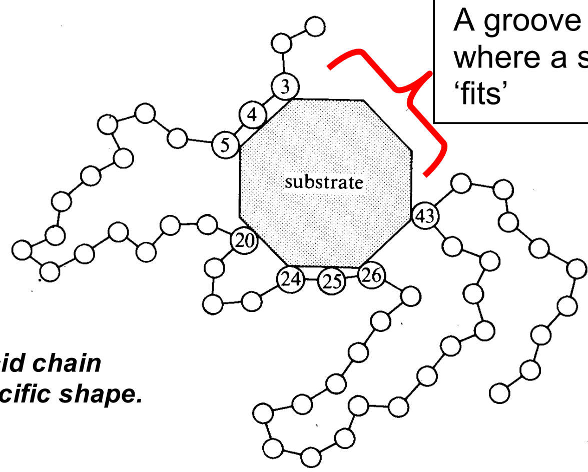


Fig. 2 – amino acid chain folded into a specific shape.

The active site of an enzyme depends on the shape (of the protein), which is held by the chemical bonds.

Enzymes

An enzyme is a biological catalyst; it speeds up a reaction, but it does not take part in the reaction.

Metabolic reactions involve building large molecules from small ones as well as breaking down large molecules into smaller ones.

These reactions are controlled by a special type of molecule called an enzyme.

How do enzymes work?

The way enzymes work is described by the **lock and key** model.

A substrate is held in an active site; this increases the probability that a reaction will take place.

The Lock and Key Model

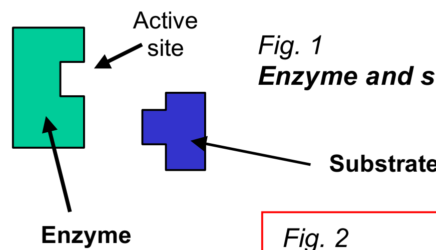


Fig. 1
Enzyme and substrate

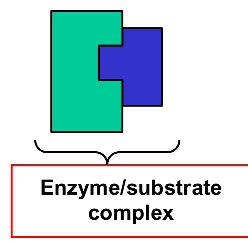


Fig. 2
Enzyme/substrate complex.
Only a substrate with a specific shape can 'fit' into the active site.
*The enzyme is **specific** to a certain substrate.*

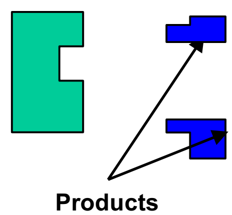


Fig. 3
Enzyme and products
Enzyme unchanged at the end of the reaction.

Properties of enzymes

1. Enzymes are **proteins**
2. Enzymes speed up/catalyse the rate of a chemical reaction.
3. All enzymes are **specific** and can only catalyse **one type** of molecule.
   (See lock and key model above).
4. Enzymes work best at a particular temperature – the **optimum temperature**.
   - If the temperature is higher or lower than this temperature the enzymes will catalyse the molecule at a much slower rate.
   - If the temperature gets too high the enzyme's active site will change shape and stop working – this is called **denaturation**.
5. Enzyme work best at a particular pH – the **optimum pH**.

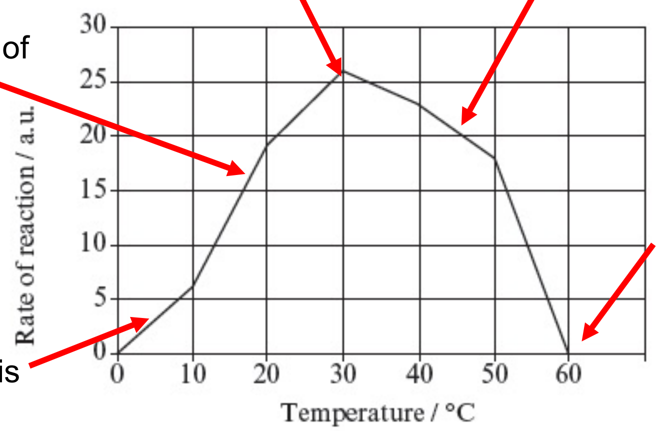
Interpreting Enzyme Activity

Effects of temperature on enzymes

Enzyme and substrate have more kinetic energy and collide more often. The rate of reaction is increasing.

Optimum temperature

The enzyme starts to denature.

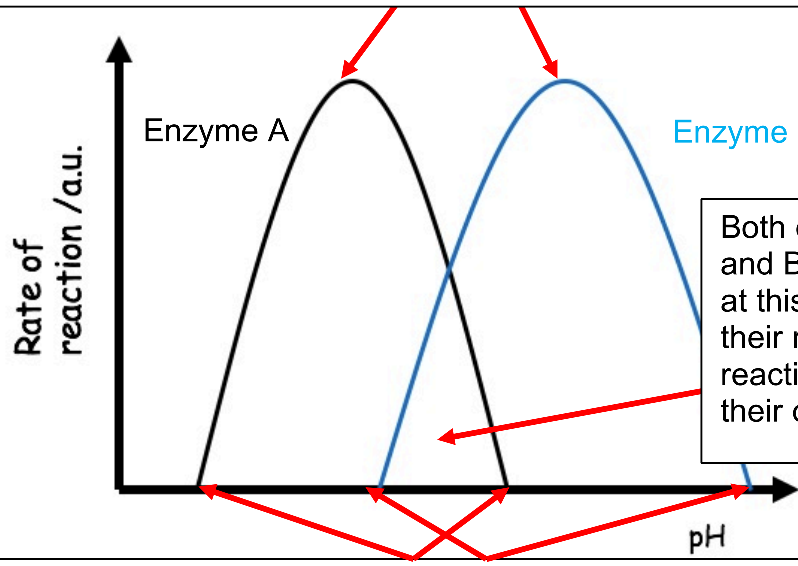


High temperatures cause the specific shape of the active site to be destroyed. The enzyme can no longer bind with its substrate. No reaction can occur. The enzyme is **denatured**.

Kinetic energy is low. There are fewer collisions between the enzyme and substrate

Effects of pH on enzymes

The **optimum pH** varies according to where the enzyme is found, e.g. pH 2 in the stomach, but pH 10 in the small intestine.



Both enzyme A and B can work at this pH, but their rate of reaction is below their optimum.

When the pH is far below or above the optimum the enzyme is denatured. No reaction can occur.

Aerobic Respiration

Releasing energy from food (glucose) using oxygen

Aerobic respiration is a process that happens in cells when oxygen is available.
It is a series of reactions controlled by enzymes.
Through aerobic respiration a cell gets its energy to do work or grow.
Respiration occurs all the time (day and night) in all plant and animal cells.

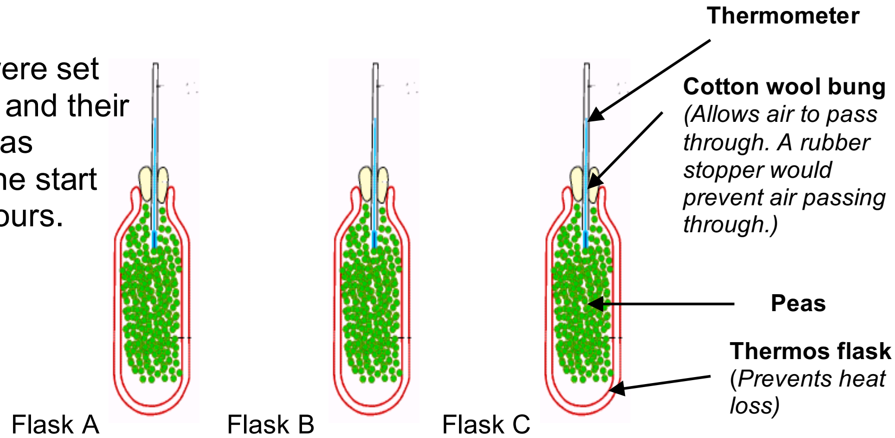
Glucose + Oxygen ⟶ Carbon Dioxide + Water + ENERGY

The energy is released in the form of **ATP** molecules.

Water and carbon dioxide are the **waste products** that the body must get rid of.
In animals, muscle cells use energy to contract and move.
Some of the energy released during respiration is lost as heat energy.

Investigating the energy released as heat during respiration.

Three flasks were set up (as shown) and their temperature was measured at the start and after 24 hours.



Flask	Contents of flask	Flask temperature (°C)	
		At start	At the end
A	Pea seeds washed in strong disinfectant	20	32
B	Boiled pea seeds	20	28
C	Boiled pea seeds washed in strong disinfectant	20	20

Flask A – Temperature has increased because heat is released during respiration from the living cells of the peas.
Flask B – Temperature has increased because microbes such as bacteria are present on the surface of the peas. These release heat during respiration in their cells.
Flask C – A **control** flask. It shows the difference between living and dead peas. (The disinfectant has killed all the bacteria).

Anaerobic Respiration

Releasing energy from food without using oxygen

This is what happens when there is not enough oxygen available.

Anaerobic respiration is less efficient than aerobic respiration because less ATP is produced per molecule of glucose. This is because the glucose molecule is not completely broken down.

Glucose ⟶ **Lactic acid**

Advantage of anaerobic respiration

- Muscles can release energy for a short period when not enough oxygen is available, e.g. 100m sprints.

Disadvantage of anaerobic respiration

- Lactic acid is released which is harmful to the body. In the muscles, lactic acid can cause pain (cramp).
- It is not suitable for activities that require energy release over a long period of time, e.g. a long-distance run.

What is an 'oxygen debt'?

After using anaerobic respiration to release energy, an '**oxygen debt'** is created.
Breathing deeply after finishing exercise, to get oxygen to the muscle, breaks down lactic acid to water and carbon dioxide.

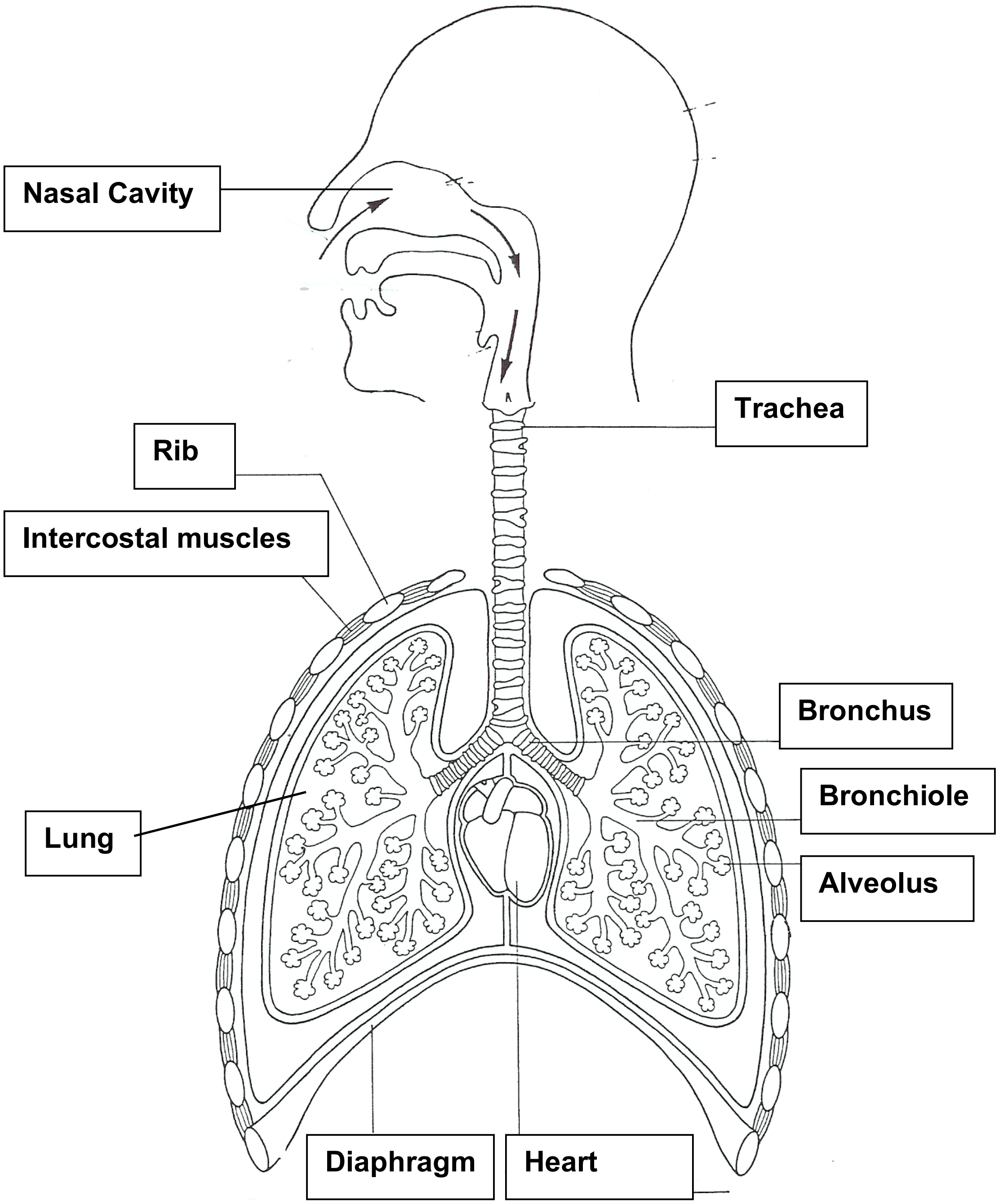
It is a good measure of fitness to see how quickly you can recover from an 'oxygen debt'.
A fit person can:

- Breathe in a greater volume of air.
- Produce less lactic acid,
- Break down lactic acid faster.

The Respiratory System

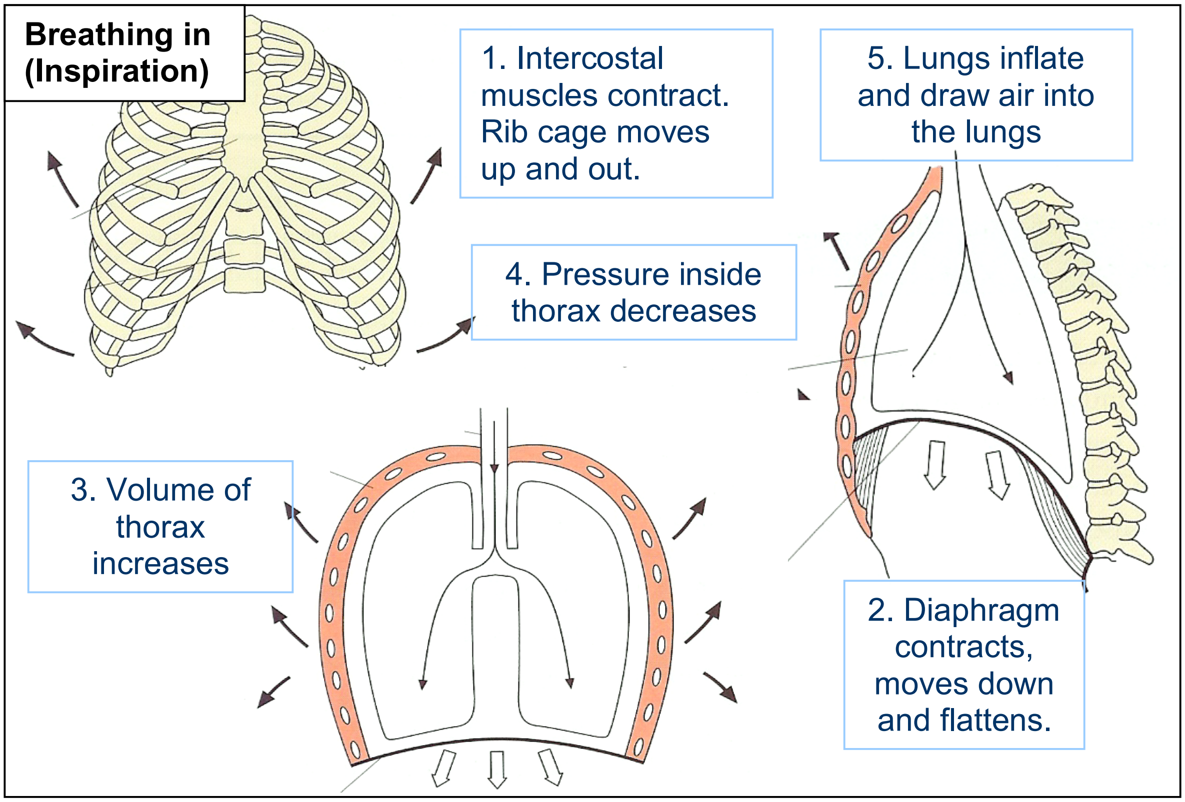
Large organisms require a complex respiratory system in order to obtain sufficient volume of oxygen to maintain a high level of aerobic respiration and to remove an equivalent volume of waste carbon dioxide.
The function of the respiratory system is to:

- get oxygen into the blood
- remove carbon dioxide from the blood.

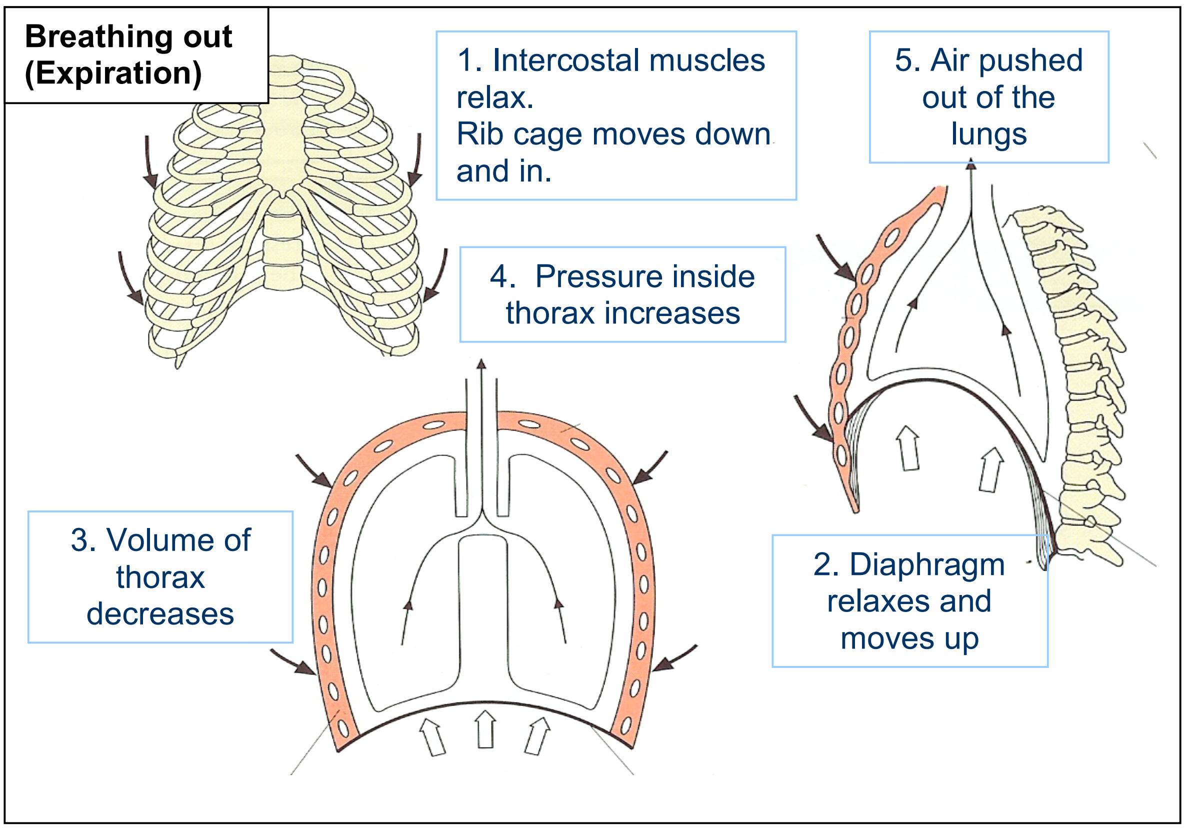


Breathing

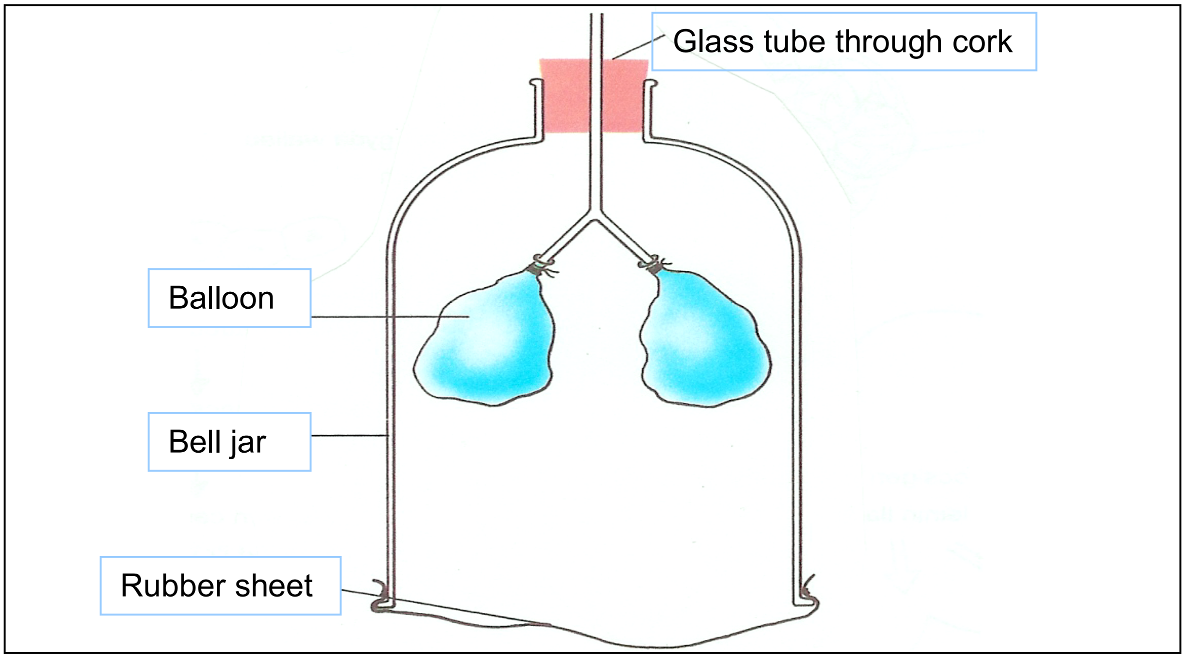
Breathing in (Inspiration)



Breathing out (Expiration)



Model of the Respiratory System



Part of model	**Part of real body**	**How model is the same as the body**	**How the model is different from the body**
Bell jar	Ribcage	Approximately the same shape.	Has no muscles attached to 'ribs' and so is rigid and cannot move up and down/ in and out.
Balloon	Lung	Inflates and deflates.	• balloon is a single bag, not a series of tubes with terminal alveoli; • balloon does not fill the space inside the bell jar;
Rubber sheet	Diaphragm	Domed up position matches position when air is exhaled.	• pulls down further than flat; • has to be pushed in and out by us;
Tube into balloon	Trachea	The windpipe is a relatively wide tube conducting air into the lungs.	Is not held open by horseshoe shaped stiffening rings.

Gaseous Exchange in the Alveoli

The alveoli are the **respiratory surface** of the lungs.
The alveoli are full of air and are covered on the outside by blood capillaries.

Oxygen **diffuses** across the walls of the alveoli from the air into the blood.
Carbon dioxide **diffuses** across the walls of the alveoli from the blood into the air in the alveoli.

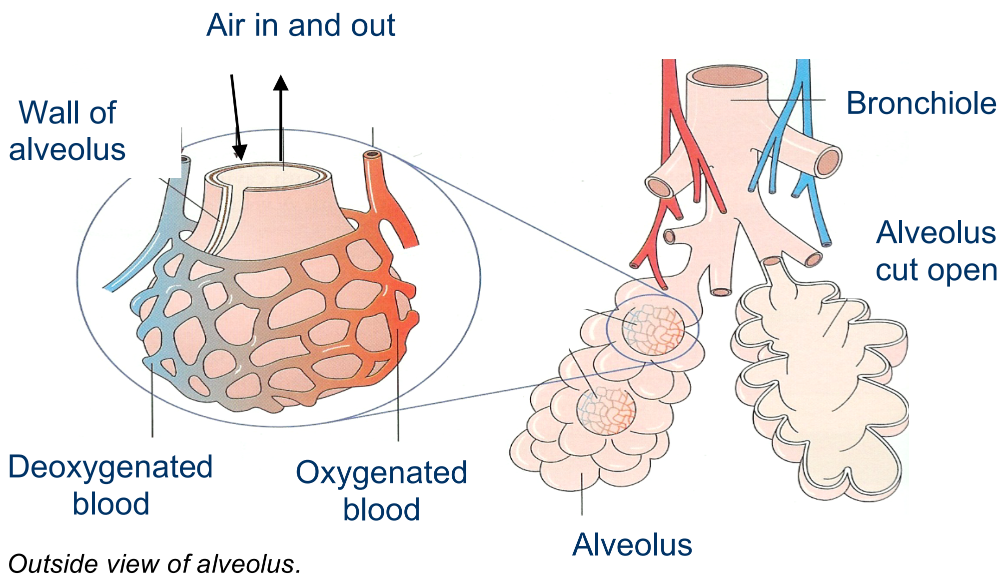


Fig.1 *Outside view of alveolus.*

How are alveoli adapted for gaseous exchange?

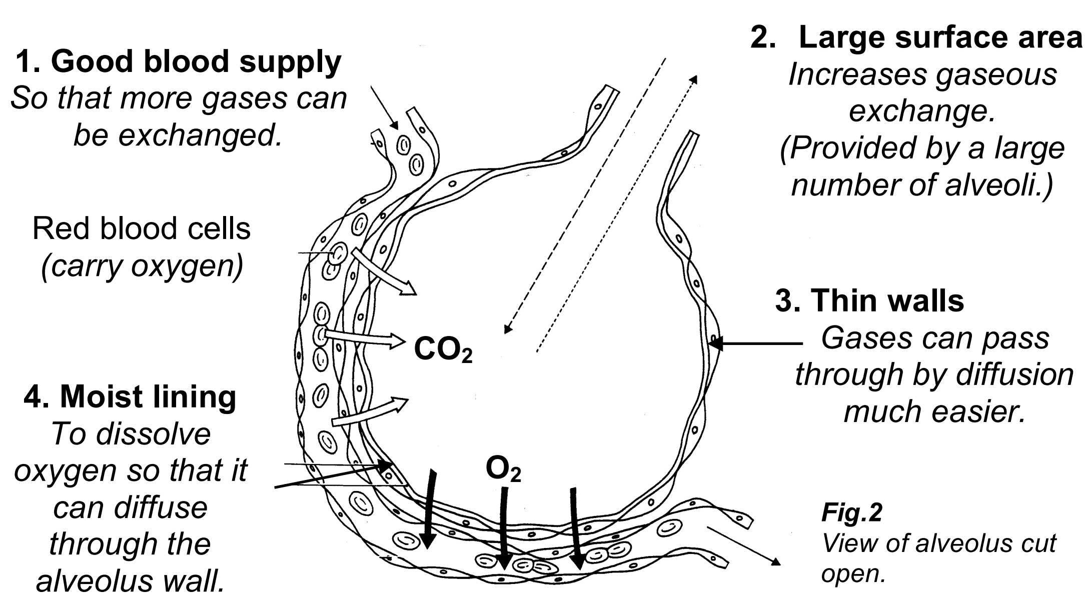


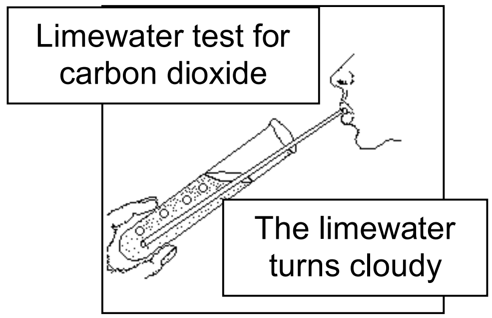
Fig.2
View of alveolus cut open.

Differences Between Inspired and Expired Air

Inspired air is breathed in and expired air is breathed out.
The body absorbs oxygen from inspired air and adds carbon dioxide and water vapour to expired air.

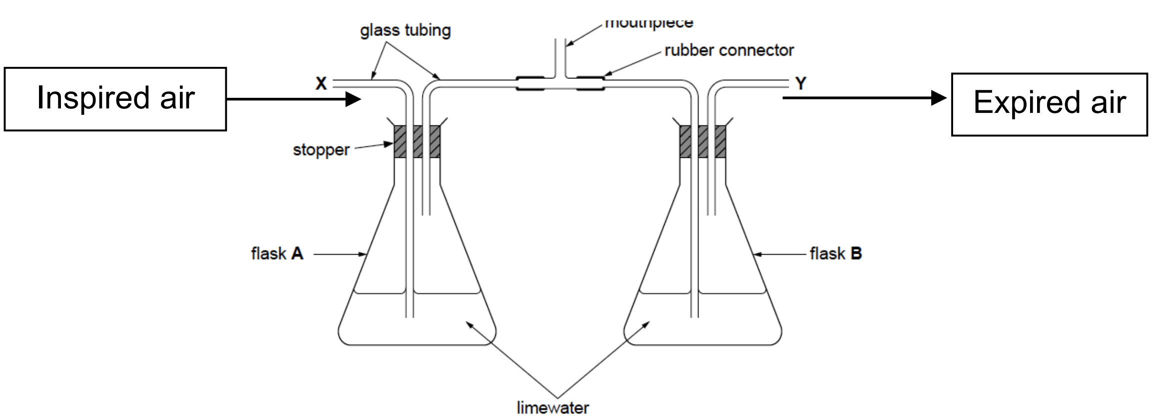
- Expired air has less oxygen than inspired air.
- Expired air has more carbon dioxide than inspired air.
- Expired air has more water vapour than inspired air.

	Inspired air	Expired air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Water vapour	Varies	Saturated
Nitrogen	79%	79%



Comparing the carbon dioxide content of inspired and expired air.

It's possible to use a simple 'huff-puff' apparatus with lime water to detect relative carbon dioxide levels in inspired and expired air.



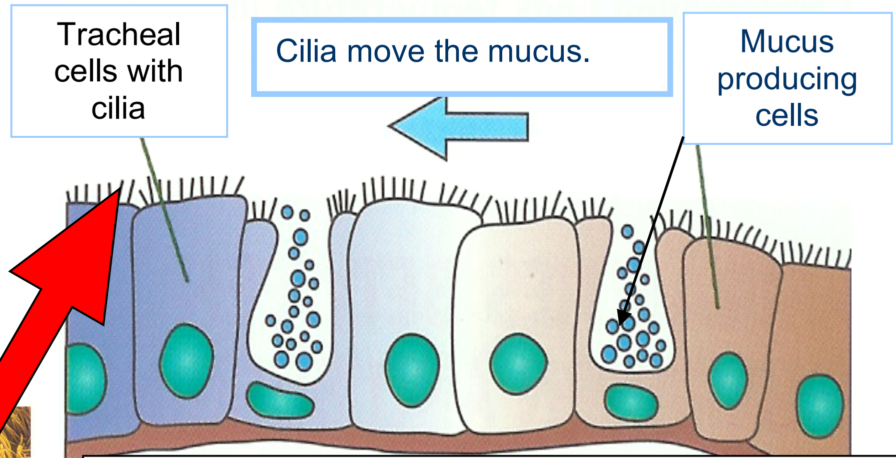
Results

	Flask A	Flask B
Appearance of lime water after 1 minute	Slightly cloudy	Very cloudy

Explanation
Expired air contains more carbon dioxide compared to inspired air, therefore the lime water turns cloudier faster in flask B.

Keeping the Lungs Clean

The air you breathe contains dust, bacteria and viruses.
The alveoli are very delicate, so the air has to be 'cleaned' before it reaches them.

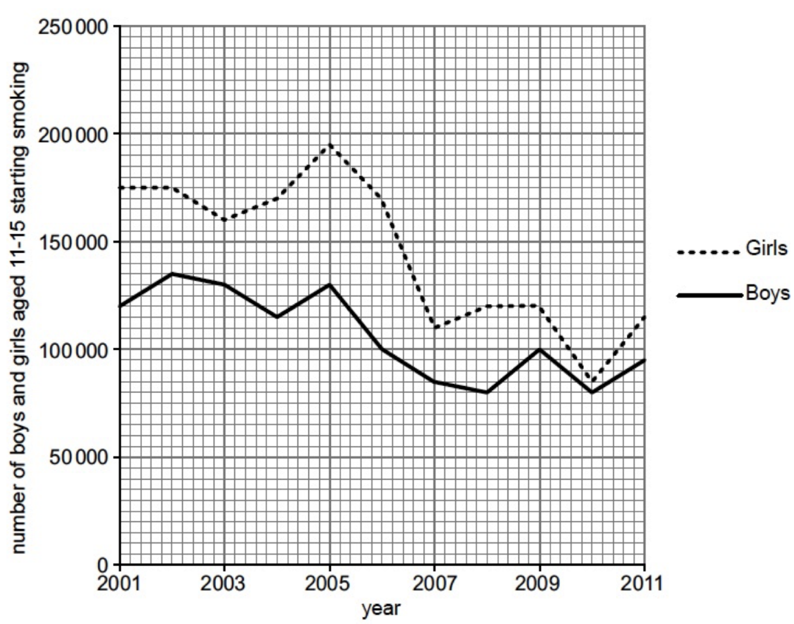


Electron micrograph showing tracheal cells with cilia.

The **mucus traps** any **dust** and **bacteria** in the air.

- The **cilia move the mucus** out of the lungs into the back of your throat in a wave like motion (like a Mexican wave).
- You swallow the mucus and acid in the stomach destroys any bacteria.

You will probably be asked to analyse a smoking related graph such as the one below.



Remember

- Always read the **labels** on the x and y axis carefully.
- Calculate the **scale** of the axis.
- If there is more than one line, study the **key**.

What is a trend?
A trend is a pattern or change over a long period of time

Example – What two trends are shown in the graph above?

1. The numbers of boys and girls aged 11-15 starting smoking are decreasing.
2. The difference between the numbers of boys and girls starting smoking is decreasing.

Effects of tobacco smoke on the body

Effects of smoking on cilia and mucus

Smoke from tobacco paralyses cilia in the trachea and bronchi for about an hour after a cigarette has been smoked.

Dry dust and chemicals in the smoke irritate the lungs, and clog up the mucus. Cilia normally sweep this mucus away, but smoke has paralysed them. Mucus builds up and if this becomes infected it can cause bronchitis.

Coughing causes damage to the alveolar walls, this reduces their surface area for gas exchange and results in the sufferer being short of oxygen.

Tobacco smoke contains many chemicals

Tar is a dark brown, sticky substance, which collects in the lungs as the smoke cools. It contains **carcinogens** – chemical substances known to cause cancer.

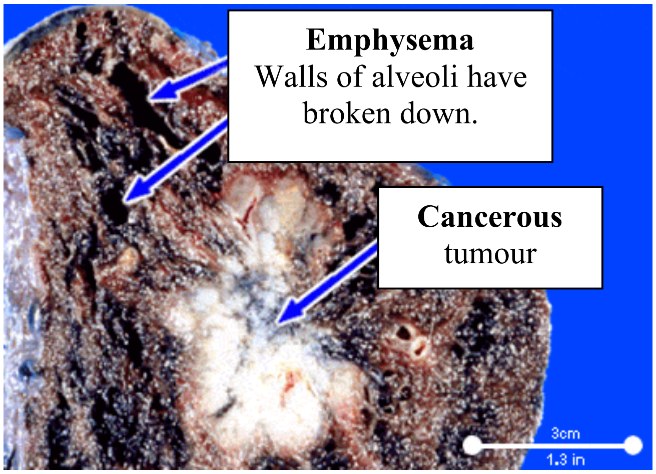
Carbon monoxide is a gas that combines with haemoglobin, and reduces the oxygen-carrying capacity of the blood by as much as 15% in heavy smokers.

Nicotine is the addictive drug that makes smoking such a hard habit to give up. Nicotine makes the heart beat faster and the blood pressure rise.

Smoking related diseases

Lung cancer
90% of lung cancers are thought to be caused by smoking.
One in ten moderate smokers, and one in five heavy smokers die from the disease.

Emphysema
The chemicals in tobacco smoke damage the walls of the alveoli, and they eventually break down. This reduces their surface area for gas exchange and results in the sufferer being short of oxygen.



The Digestive System

To be of use to the body, food must move from the digestive system into the blood.

- The molecules of food must be **small** enough and **soluble** to pass through:
  e.g. vitamins, minerals, water
- Other molecules are too **large** and **insoluble**:
  e.g. starch, proteins, fats

Before these molecules can be absorbed into the blood, they must be **digested** to **small, soluble molecules**.

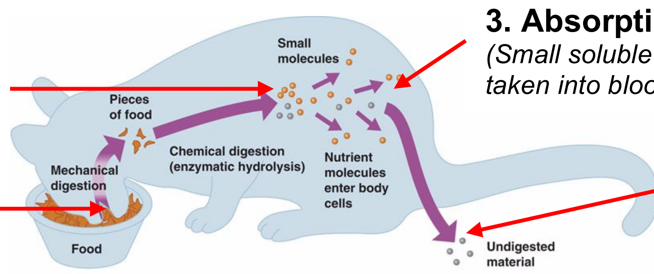
Fibre is egested from the body as faeces as it is not possible to digest and absorb it into the blood.

Functions of the Digestive System:

- **Digest large insoluble molecules to small soluble ones by using enzymes.**
- **Absorb small soluble molecules into the blood.**

2. Digestion
(Large insoluble molecules broken down into small soluble molecules)

1. Ingestion



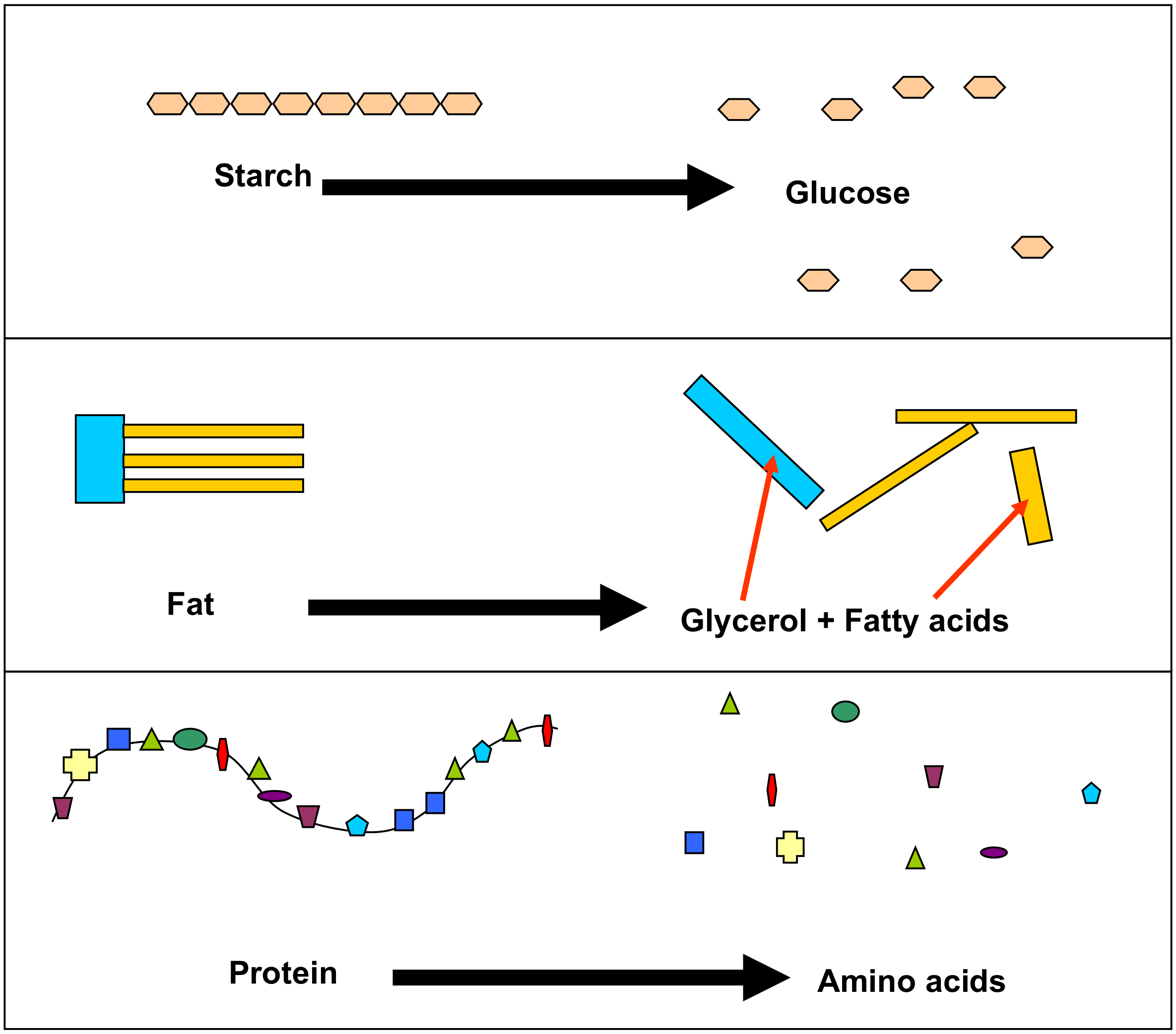
3. Absorption
(Small soluble molecules taken into blood stream)

4. Egestion
(Undigested food passed out)

Digestive Enzymes
Enzymes speed the process of breaking down large insoluble molecules to small, soluble molecules. Every enzyme is specific to only one food group.

Food	Digestive Enzyme	Product	Used for
Starch	Carbohydrase	• Glucose	Provide energy
Proteins	Protease	• Amino acids	Making proteins for growth and repair
Fats	Lipase	• Fatty acids • Glycerol	Provide energy

Digestion of Fats, Proteins and Carbohydrates

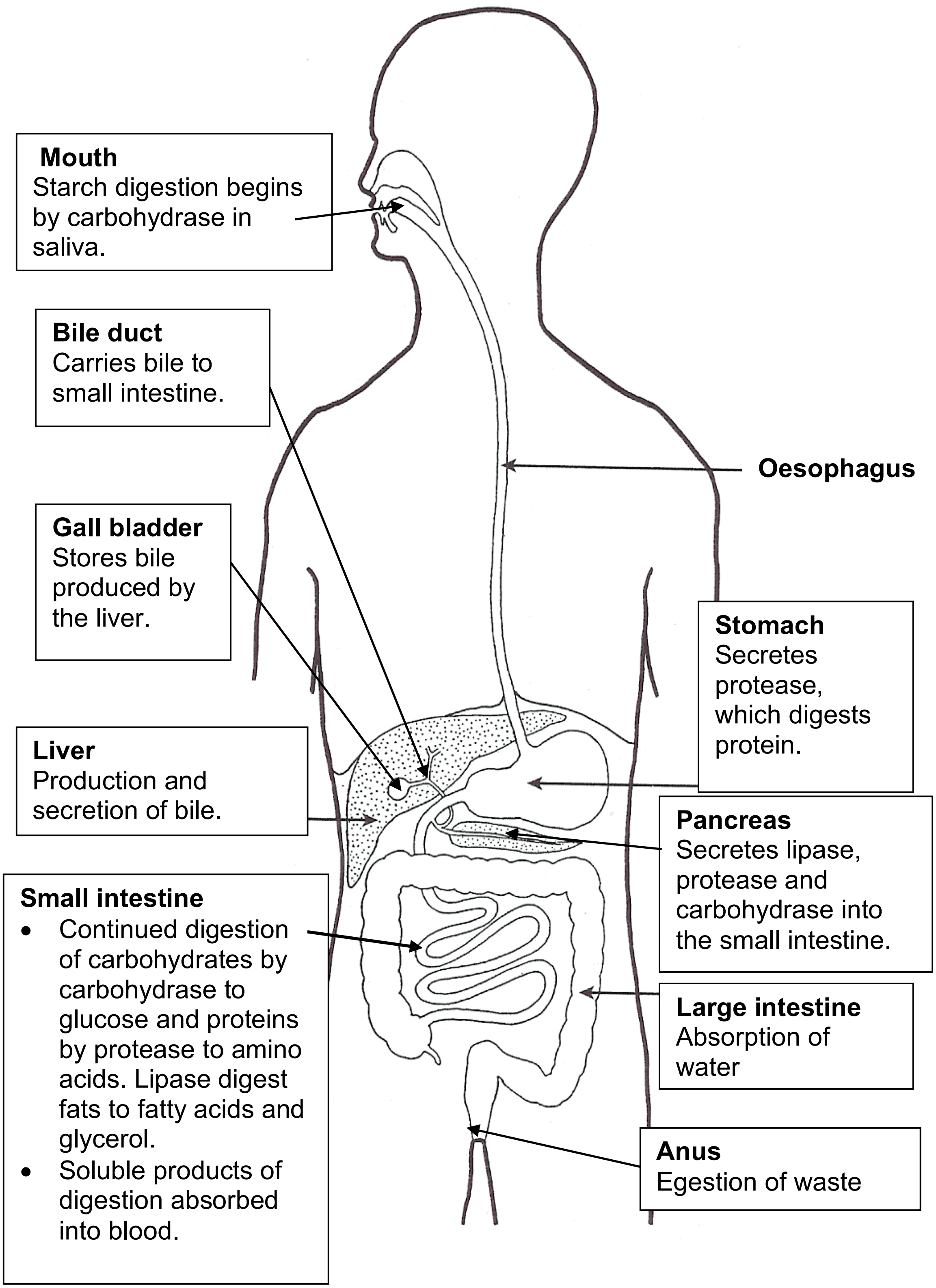


Testing for Products of Digestion

Food	Reagent	Method	Positive Result
Protein	Biuret	• Add **blue** Biuret to some food in a test tube.	**Lilac** colour
Glucose	Benedict's	• Add **blue** Benedict's to some food in a test tube. • Place the test tube in boiling water bath for 5 minutes.	Turns **green**, **orange** then **brick red**. (Colour change depends on concentration of glucose)
Starch	Iodine	• Add **brown** iodine to some food.	**Blue-black** colour.

Digestion and the Digestive System in Humans

Organs of the Digestive System and their Functions



How is food moved along the digestive system?

Food is moved along the digestive system by the contraction of muscles in the gut wall. This movement is called **peristalsis**.

The gut walls contain two layers of muscles running in different directions:

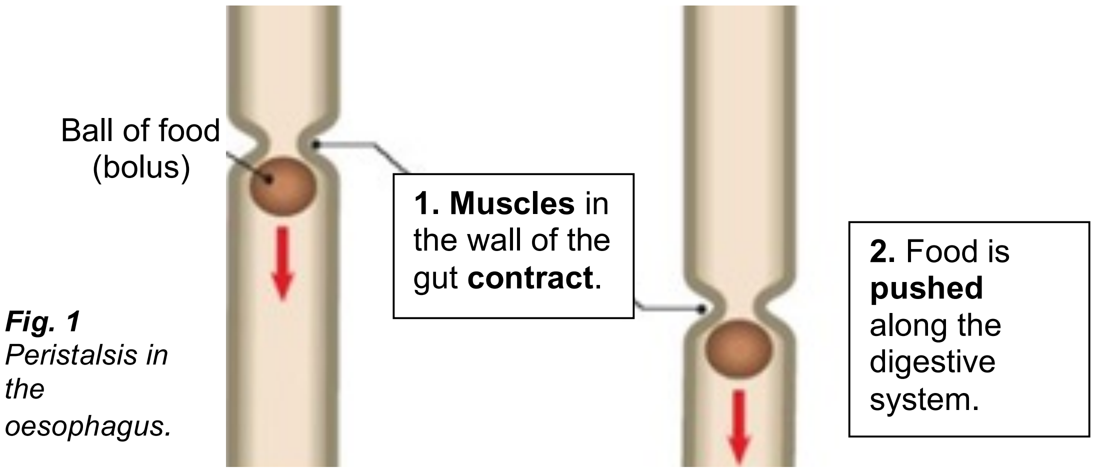
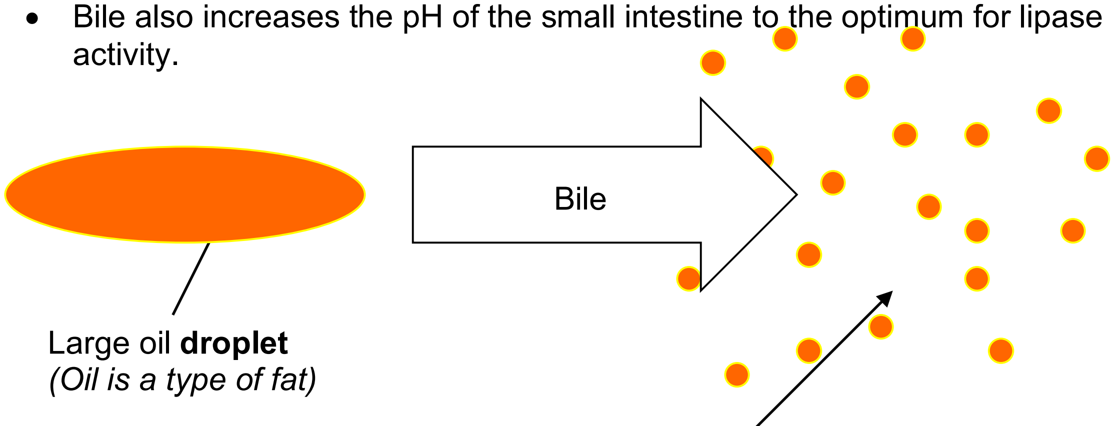


Fig. 1
Peristalsis in the oesophagus.

What does bile do?

Bile is produced in the liver and stored in the gall bladder.
Bile is not an enzyme.

- Bile **emulsifies** fats, which means breaking down large droplets of fat to smaller droplets (a physical change not a chemical change).
  This increases the surface area of the fats for the enzyme lipase to work on.
- Bile also increases the pH of the small intestine to the optimum for lipase activity.



- ***Bile will speed up the rate of reaction of any investigation using lipase.***

Absorption of food in the small intestine

Small soluble food molecules diffuse into the bloodstream in the small intestine.
The concentration gradient for diffusion is maintained by:

- A relatively large surface area produced by the villi.
- A rich blood supply which carries small soluble molecules away to the rest of the body.

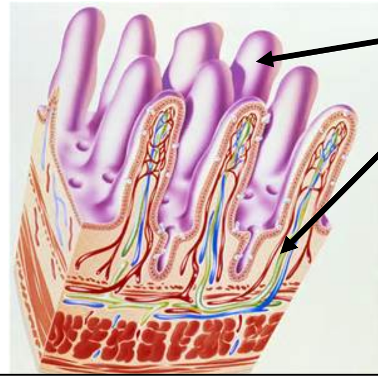
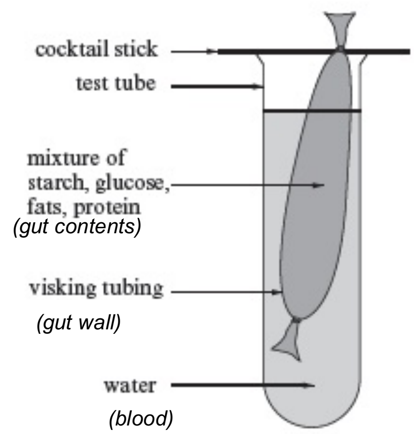


Fig. 1 – Section through the wall of the small intestine showing villi and blood supply.

Evaluating Visking tubing as a model for a gut

1. A visking tube is filled with a mixture of starch, glucose, fats and proteins and left for 30 minutes.
2. The water is then tested for starch, glucose, fats and proteins.



Results

	Content of water	
	At start	**After 30 minutes**
Starch	-	-
Glucose	-	+
Fat	-	-
Protein	-	-

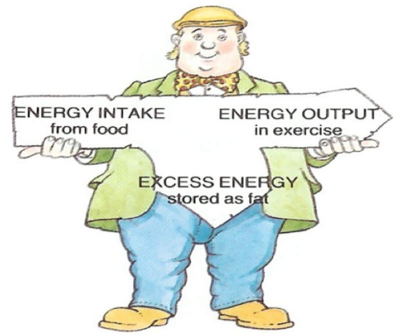
\- = absent
\+ = present

Conclusion
Starch, fat and protein molecules are too big to pass through the holes in the Visking membrane.
Glucose molecules are small enough to pass through the holes in the Visking tubing.

Similarities of model	Limitations of the model
The food molecules are contained in a tube whose walls are permeable only to small molecules.	The Visking tubing membrane is smooth, a gut lining is folded and folded again with a larger surface area for its length
The food in the tube is a mixture of large and small molecules.	A real gut is surrounded by blood flowing in vessels that take away the soluble products of digestion. This maintains a concentration gradient between the gut contents and the surrounding blood.
The tube is surrounded by liquid that contains a low concentration of food molecules.	The visking tubing does not move the food around by muscular contractions.

Balanced Diet

A balanced diet involves eating the right amounts of the essential food groups.
Overeating can lead to serious dietary diseases.



The energy content in food eaten must be balanced with the energy used,
Obesity is caused by a person's energy intake being greater than the energy output.

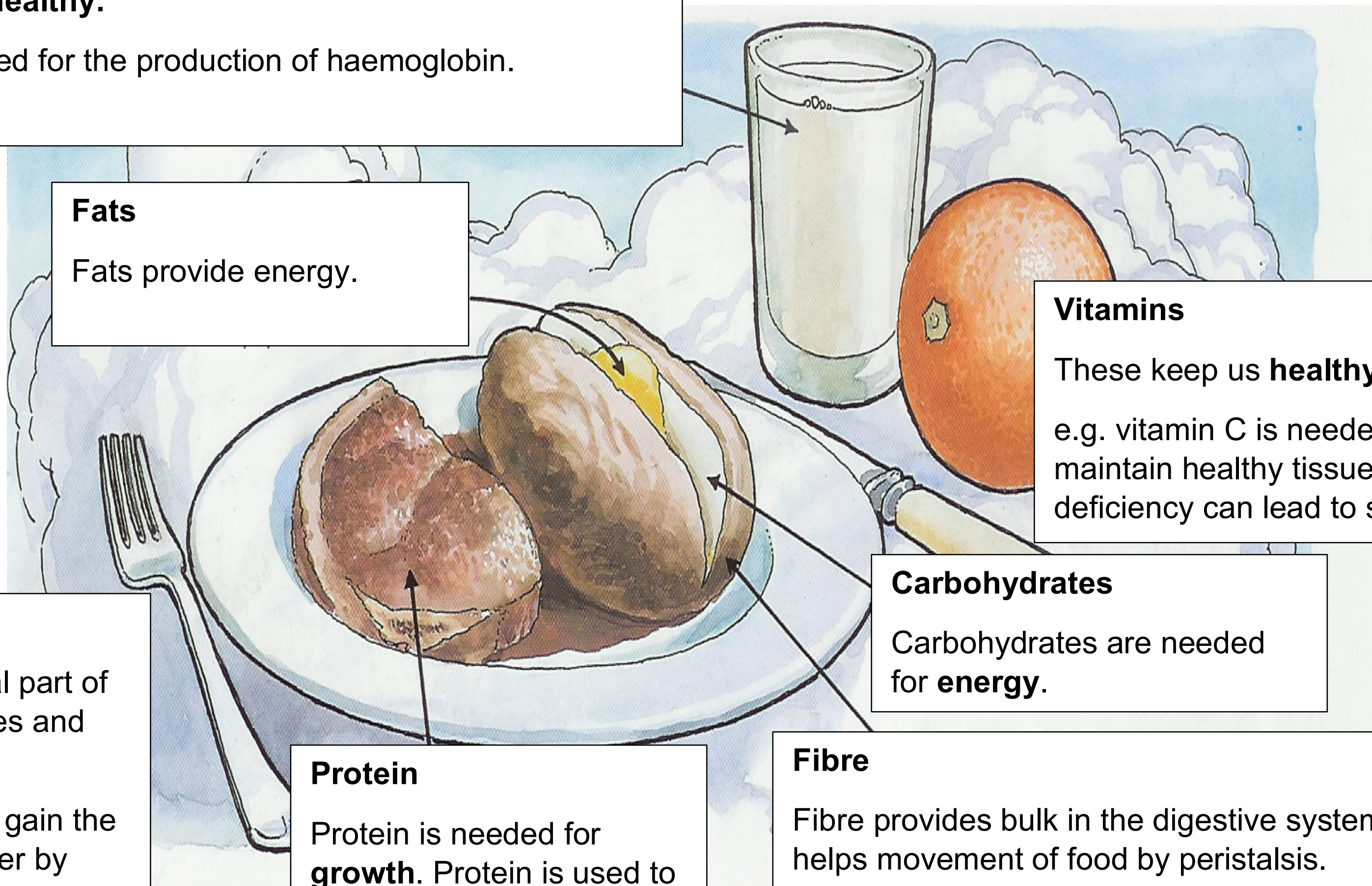
Excess (too much) energy is stored as fat.
The most fattening foods are therefore those that provide most energy.

Carbohydrate foods contain a lot of energy.
Foods that contain **fat** contain a lot of energy because 1g of fat has twice as much energy than 1 g of carbohydrate.

Eating too much
You are eating too much if the energy value of the food you eat each day is more than the amount of energy you use in that time.
Eating too much can lead to **weight increase** and **obesity**.

Obesity can contribute to **heart disease**, **high blood pressure**, **diabetes** (type 2), **gall bladder disease**, **cancer of the bowel** and also **breast** and **womb cancer**.

Dietary Nutrients



Minerals

These keep us **healthy.**

e.g. iron is needed for the production of haemoglobin.

Fats

Fats provide energy.

Vitamins

These keep us **healthy**.

e.g. vitamin C is needed to maintain healthy tissue. Vitamin C deficiency can lead to scurvy.

Carbohydrates

Carbohydrates are needed for **energy**.

Water

Water is an essential part of many body processes and functions.

Individuals needs to gain the same volume of water by eating and drinking as they lose by sweating and excretion.

Protein

Protein is needed for **growth**. Protein is used to produce new cells and repair the body.

Fibre

Fibre provides bulk in the digestive system and helps movement of food by peristalsis.

A lack of fibre can lead to constipation.

Food Labelling

Nutrition information on labels is provided ‘per 100g’ (or ‘per 100ml’ for liquids) and usually per serving too.
Looking at the nutrients ‘per 100g’ helps you compare the levels of nutrients in different products.

Too much sugar can lead to an **increased chance** of developing
- type 2 diabetes
- obesity
- tooth decay

Saturated fat tends to be from animal fat.
It is high in cholesterol and **increases the chances** of developing
- heart disease
- obesity
- circulatory diseases

NUTRITION			GDA	
Typical values	per 100g	per pack	adult	per pack
Energy kJ	450	1345		
Energy kcal	105	315	2000	16%
Protein	7.9g	23.7g	45g	53%
Carbohydrate	8.8g	26.4g	230g	11%
of which sugars	1.2g	3.6g	90g	4%
Fat	4.2g	12.6g	70g	18%
of which saturates	2.7g	8.1g	20g	41%
Fibre.	1.2g	3.6g	24g	15%
Sodium	0.24g	0.72g	2.4g	30%
Equivalent as salt	0.60g	1.80g	6g	30%
GDA = Guideline daily amount				

A **high salt diet** can **increase blood pressure**.

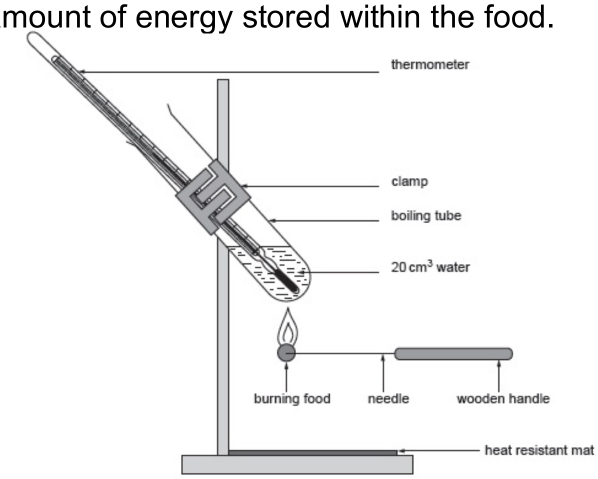
High blood pressure is linked to an **increased chance** of a **heart attack**, **stroke** or **kidney disease.**

- Knowing how much energy is in food helps people control their diet, especially if they want to lose weight.
- Information of food additives helps inform people with food allergies.

Investigation of the energy content of foods

Different foods have different energy contents. The energy content of a food can be released by burning it.

When you hold a burning food underneath a known volume of water, the temperature increase can be measured. A simple calculation can then be used to estimate the amount of energy stored within the food.



Method *(you need to learn this)*

1. Measure 20 cm^3 of water into a boiling tube.
2. Clamp the boiling tube to the clamp stand.
3. Record the temperature of the water using a thermometer.
4. Choose a piece of food and record its mass.
5. Place food onto a mounted needle.
6. Hold the food in the Bunsen burner flame, until it starts burning.
7. As soon as the food is burning, hold it under the boiling tube of water. Keep the flame directly underneath the tube.
8. Hold the food in this position until it has burnt completely. If the flame goes out, but the food is not completely burnt, quickly light it again using the Bunsen burner and hold it directly underneath the boiling tube.
9. When the food has burned completely, and the flame has gone out, immediately record the temperature of the water.
10. Repeat steps 1-9 for other foods.

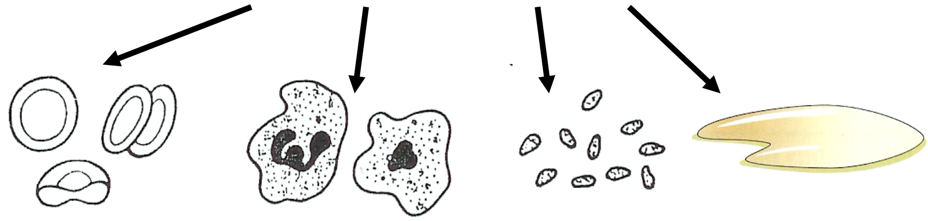
Analysis

1. Calculate the increase in temperature each time.
2. Calculate the energy released from each food using the formula:

$$\text{Energy released from food per gram (J)} = \frac{\text{mass of water (g)} \times \text{temperature increase (°C)} \times 4.2}{\text{mass of food sample (g)}}$$

Blood

Blood is made up of



Red blood cells carry oxygen	**White blood cells** defend the body against pathogens	**Platelets** clotting of blood	**Plasma** carries dissolved substances

Fig. 1 – Illustration of the four main parts of blood.

Examining blood smears

(These are diagrams you should be able to label).

Fig 2. Micrograph of a blood smear.
The centre of red blood cells appear paler because they have no nucleus and therefore more light from the microscope passes through them.

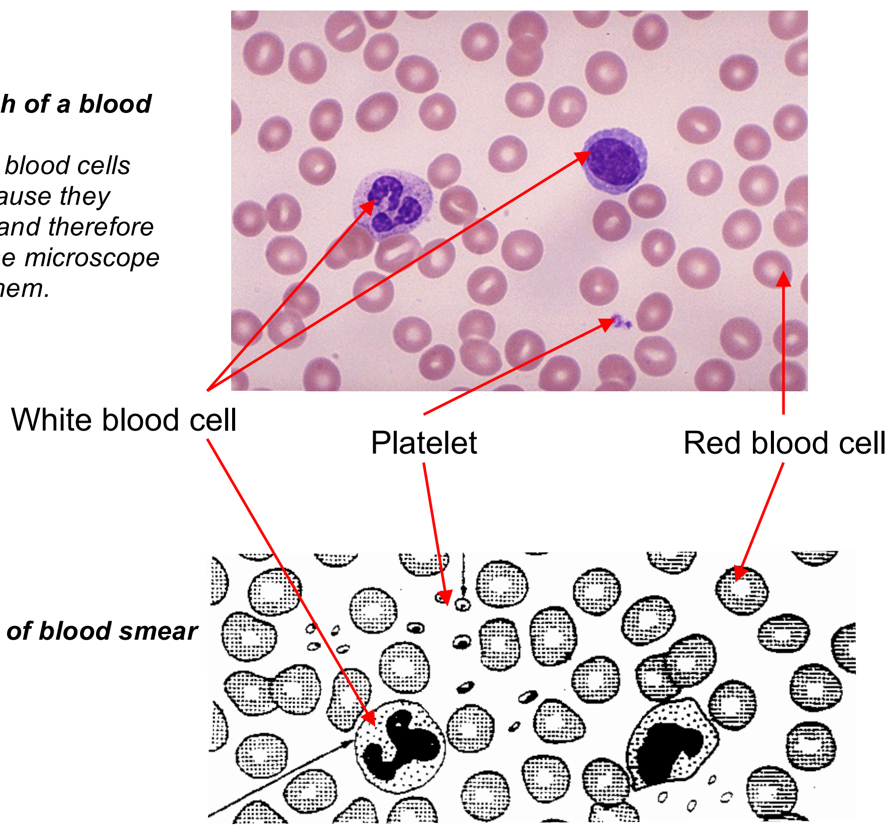


Fig.3 – Illustration of blood smear

Blood

Red Blood Cells.
These cells **carry oxygen** around the body.

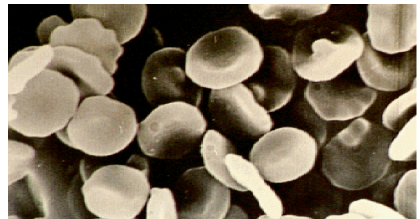


Fig. 1 – micrograph of red blood cells

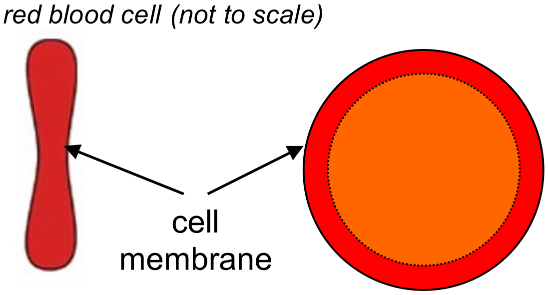
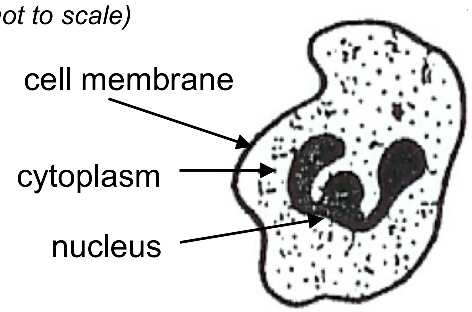
They are flattened, biconcave, disc shaped cells; they are red in colour because of a pigment called **haemoglobin**. This joins with oxygen to transport it around the body.
Red blood cells don't have a nucleus.

Iron is needed to produce haemoglobin. If there is a shortage of iron a person won't have enough red blood cells, this is called **anaemia**, less oxygen will be carried around the body.

White blood cells
These cells **defend the body against pathogens** (microbes that cause disease)**.**

They are bigger than red blood cells, and have a nucleus, but don't contain a pigment so are colourless.
If you have an infection the number of white blood cells in you body increases rapidly.

Comparing red and white blood cells
(You should be able to draw, label and compare a red and white blood cell)

Red blood cells ***Fig. 2 –** side view (left)and front view (right) of red blood cell (not to scale)* 	**White blood cells** ***Fig. 3 –**white blood cell (phagocyte) (not to scale)* 
No nucleus present	Nucleus present
Regular disc shaped	Irregular shape
Smaller than white blood cells	Larger than red blood cells

Platelets
Platelets **clot the blood.**

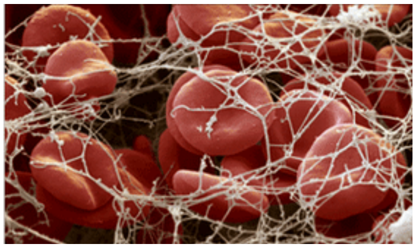


Fig. 1 – micrograph showing red blood cells clotting.

When the skin is cut you bleed.
Platelets make the blood clot, forming a thick jelly. This hardens to form a scab, **preventing bleeding and blood loss**.
The scab keeps the wound clean as new skin grows underneath.
This prevents pathogens from entering the body and bacterial infection.

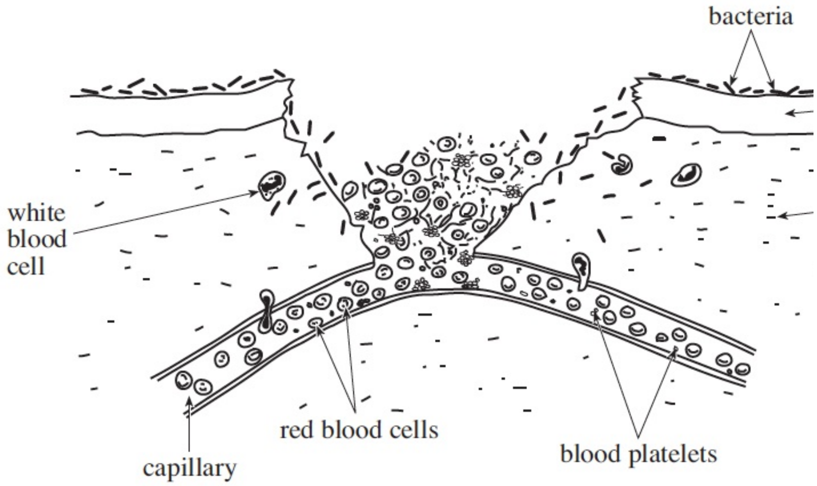


Fig 2. – Illustration of blood clotting in a wound

Plasma

Plasma **carries dissolved substances**.

This is the liquid part of blood. It is pale yellow in colour and is 90% water.

Plasma carries many dissolved substances around the body:

- Small soluble food molecules, e.g. **glucose**, **amino acids**, etc.
- Waste chemicals produced by the body, e.g. **carbon dioxide** from respiration and **urea** produced by the liver.
- **Hormones** carried from the endocrine glands to their target organs, e.g. insulin.
- **Mineral salts**, e.g. sodium ions.

Plasma also **distributes heat** around the body.

Circulatory System in Humans

The Human Circulatory System - A double circulatory system.
The blood must pass through the heart twice before completing one whole circuit of the body.

The Pulmonary circulation
Blood pumped form the heart to the lungs and back to the heart.

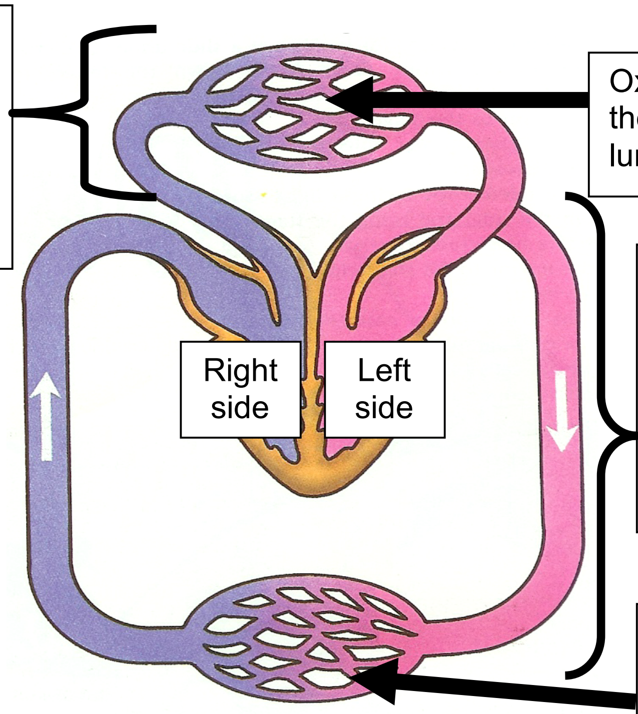


Fig. 1
Diagram showing a double circulatory system.

Oxygen enters the blood in the lungs.

The Systemic Circulation
Blood pumped form the heart to the body and then back to the heart.

Oxygen enters the blood in the lungs.

Oxygenated blood

Deoxygenated blood

Structure of the Heart

The function of the heart is to pump blood.
The heart is made of a special muscle called cardiac muscle.

There are blood vessels on the outside of the heart – the **coronary arteries**.
These supply oxygen and glucose to the heart muscle.
Without a steady supply of oxygenated blood the heart muscle couldn't keep contracting and pumping blood.

If a blood clot blocks a coronary artery, the heart muscles won't get enough oxygen and will stop working – this is a heart attack.

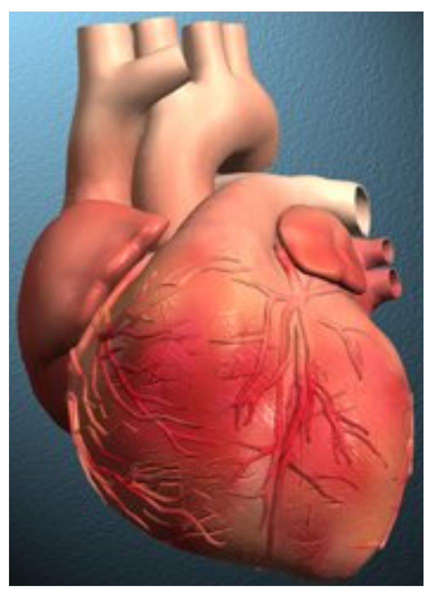


Fig. 2 – Photograph showing the outside of a human heart. The blood vessels shown are the coronary arteries.

The Heart

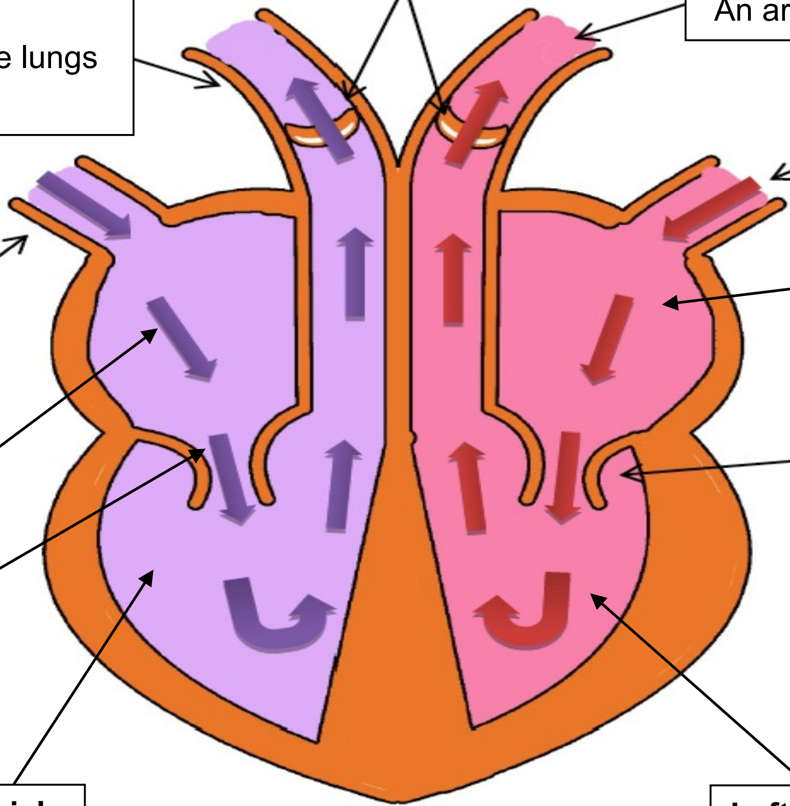


Fig. 1 – illustration showing internal structure of the heart.

Flow of Blood Through the Heart

- The **vena cava** carries blood from the organs of the body to the **right atrium**.
- Blood passes through the **right atrio-ventricular valve** to the **right ventricle**.
- The **right ventricle** contracts, pumping blood through a **semi-lunar valve** into the **pulmonary artery**.
- The **pulmonary artery** carries the blood to the **lungs** where it is oxygenated.
- The **pulmonary vein** carries blood back from the **lungs** to the **left atrium**.
- Blood passes through the **left atrio-ventricular valve** into the **left ventricle**.
- The **left ventricle** contracts, pumping blood through a **semi-lunar valve** into the **aorta**.
- The **aorta** carries blood form the heart to the organs of the **body**.

QER questions sometimes ask you to describe the flow of blood through the heart. Always check to see where you need to start and finish.

Facts you must learn about the heart:

- The heart is made of muscle which contracts to pump blood around the body.
- The heart is divided into 2 halves.
- Blood flows in one direction through each half of the heart.
- There are atrio-ventricular valves between the atria and ventricles. These can close to stop backflow of blood when the ventricles contract.
- There are semi-lunar valves at the bottom of the pulmonary artery and aorta to prevent backflow of blood to the ventricles when they relax.
- There are tendons attached to the valves so they don't get pushed inside out.
- The right side of the heart pumps blood to the lungs.
- The left side of the heart pumps blood to the body.
- The atria *(more than one atrium)* have thin walls because they only pump blood to the ventricles.
- The ventricles have thick muscular walls, because when they contract they have to pump blood out of the heart.
- The left ventricle has a thicker muscular wall than the right ventricle because it pumps blood to all parts of the body – the right ventricle only pumps blood to the lungs.

Blood Vessels

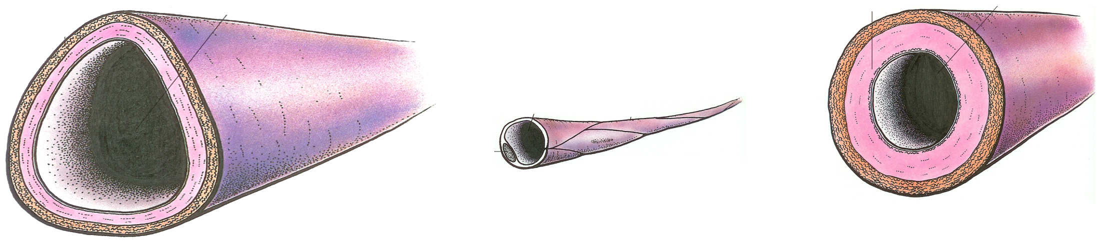


Fig.1 – (Right to left) Illustration of an artery, capillary and vein (not drawn to scale).

- **Arteries** have thick walls because they carry blood under pressure **away from the heart**.
- **Veins** have thins walls because they carry blood under low **pressure back to the heart**.

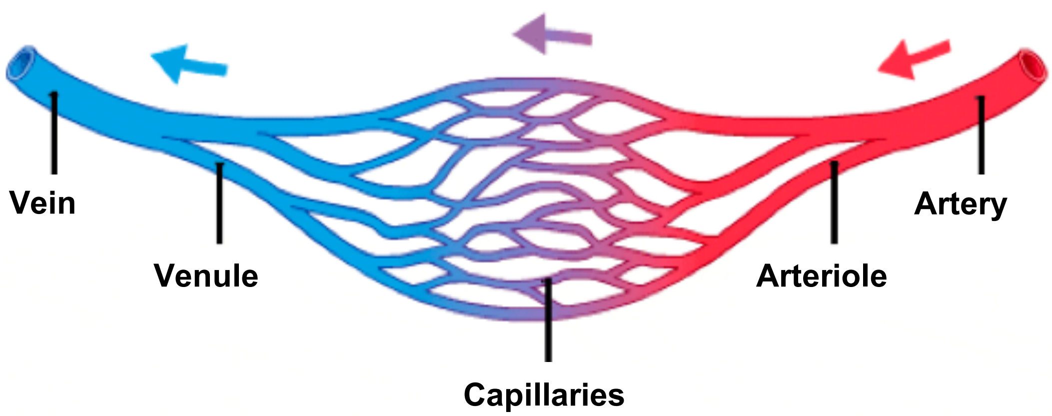


Fig. 2 Illustration showing structural relationship between blood vessels.

Capillaries are the smallest blood vessels that carry blood through the organs of the body. Substances needed by cells pass out of the blood to the tissues and substances produced by the cells pass into the blood through the walls of the capillaries.

- They form extensive networks so that no cell is far away from a capillary.
- Their walls are very thin to allow materials to diffuse easily between the blood and the body cells.

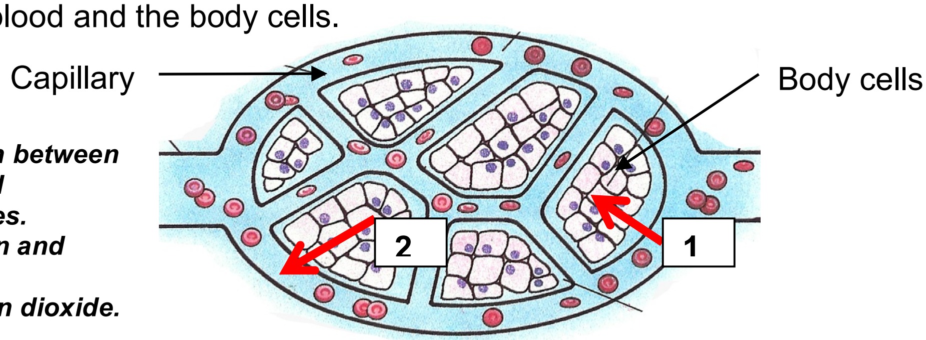


Fig. 3 Diffusion between cells and capillaries.
1 Oxygen and glucose.
2. Carbon dioxide.

Cardiovascular disease (CVD)

CVD includes all the diseases of the heart and the circulatory system, including:

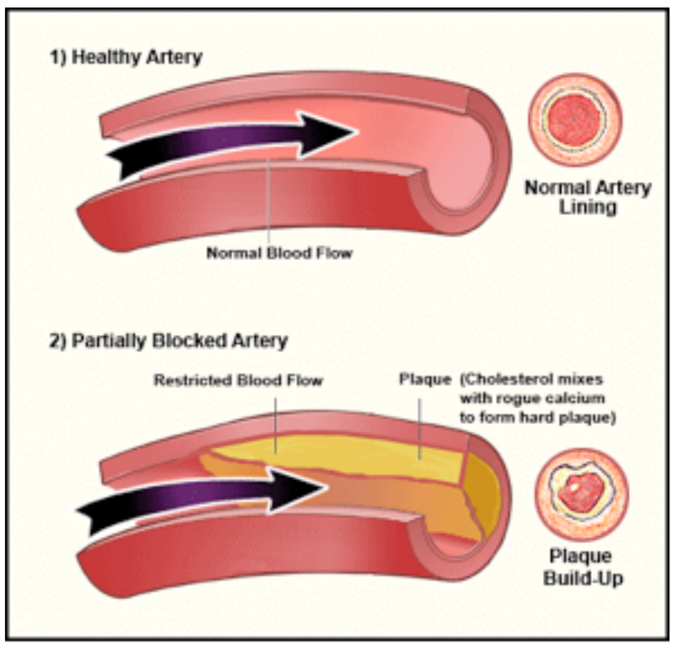
- Coronary heart disease
- Heart attacks
- Angina
- Strokes

Risk factors for cardiovascular disease

- High levels of fat and salt in the diet
- High blood pressure
- High blood cholesterol
- Smoking
- Genetic factors
- Lack of exercise

CVD is usually linked to a process called atherosclerosis.

Atherosclerosis is a potentially serious condition where arteries become clogged with fatty substances called plaques, or atheroma.



Effects of an atheroma

- Makes it more difficult for blood to flow through arteries which makes it more likely **blood clots** will form.
- Small arteries may become blocked; in the coronary arteries, this can result in a **heart attack** or **angina**.
- **Stroke** – if arteries in the brain become blocked.

Advantages and Disadvantages of Treatments for Cardiovascular Disease

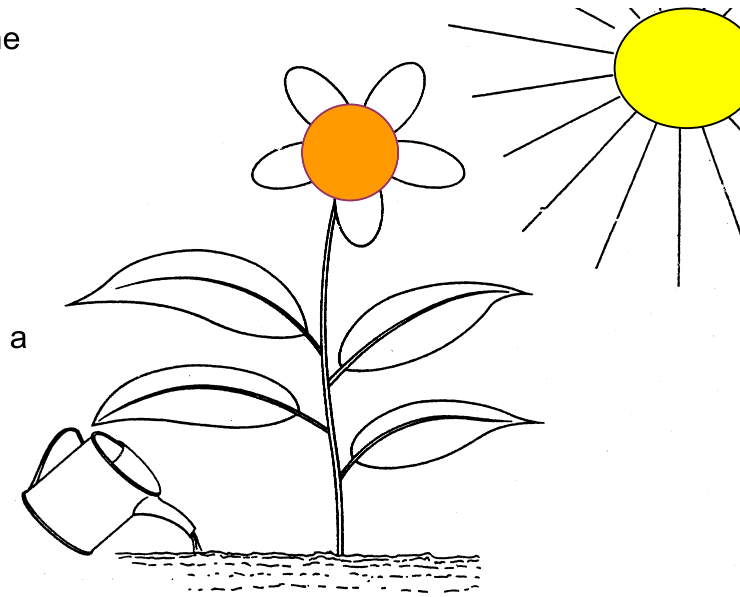
Treatment	Method	Advantages	Disadvantages
Statins	Drugs taken daily	Blood cholesterol levels are controlled	May cause side effects
Angioplasty	Surgery to place a small balloon in a blood vessel, which is inflated to remove a blockage	Improved blood flow in coronary vessels	Sometimes only a temporary remedy
Changes to diet / lifestyle	• stopping smoking • starting regular exercise • eating more healthy food	• reduce risk of cardiovascular disease • lowering blood pressure	• high level of self-discipline needed • changes must be long-term

Photosynthesis

Photosynthesis is the process that 'produces food' in green plants and other photosynthetic organisms (e.g. algae)

Photosynthesis takes place in the green parts of plants – mostly in leaves.

- Chlorophyll (found in the chloroplasts) absorbs light energy.
- This energy is used to convert carbon dioxide and water into glucose.
- Oxygen is produced as a by-product.



The word equation for photosynthesis:

Carbon dioxide + Water ⟶ Glucose + Oxygen

Enzymes control the chemical reactions of photosynthesis.

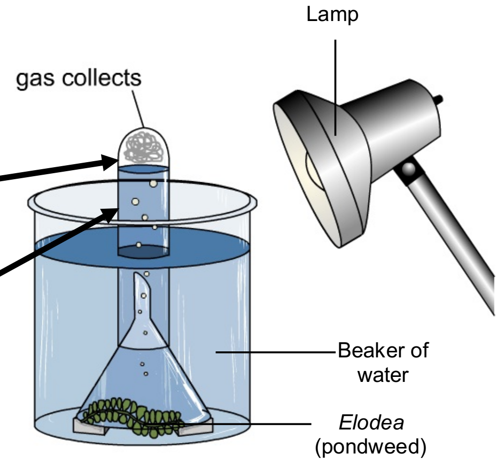
Investigating the Conditions Needed for Photosynthesis

As oxygen is given off during photosynthesis, its rate of production can be used to measure the rate of photosynthetic activity.

This is made possible by using a plant that grows in water, e.g. *Elodea* (also called pondweed) and measuring:

- The **volume** of oxygen produced **per minute**

  OR
- The **number** of oxygen **bubbles** produced **per minute**



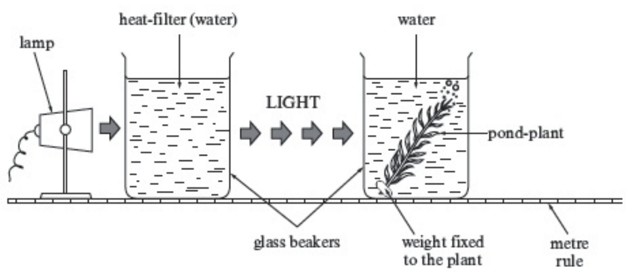
This allows us to compare results under different conditions.

Investigation – Effect of Light Intensity on the Rate of Photosynthesis

- Measure and record the distance of the lamp from the plant (e.g. 10cm);
- Count the number of bubbles given off every minute;

  OR

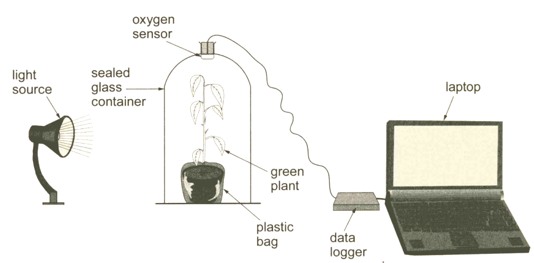
  Measure volume of gas produced every minute.



- Repeat experiment to check the repeatability of the results;
- Redo the experiment at different distances by moving the lamp a further 10cm from the plant each time.

The rate of photosynthesis can also be measured by using oxygen or carbon dioxide sensors and data loggers to measure:

- Oxygen produced per minute;
- Carbon dioxide used up per minute;

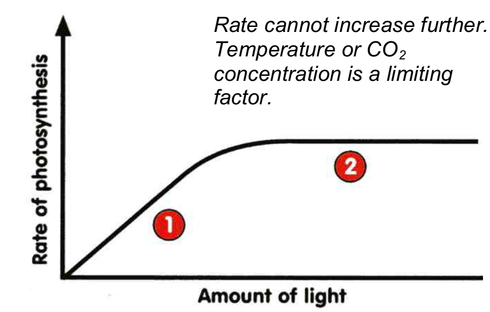


Some other factors we can investigate with this experiment:

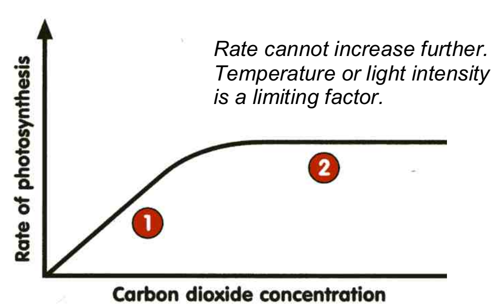
Independent variable	How to change independent variable	Dependent variable	Controlled variables
Carbon dioxide levels	Different concentrations of sodium hydrogen carbonate solutions.	Volume of oxygen produced every minute **OR** Number of bubbles of oxygen produced every minute	• Temperature. • Distance of light • Same species of plant.
Temperature	Carry out experiment in water baths at different temperatures.		• Distance of light. • Same species of plant. • Mass of sodium hydrogen carbonate in water.
Species of plant	Using different species, e.g. *Elodea* (pondweed), *Cabomba*, etc.		• Distance of light. • Mass of sodium hydrogen carbonate in water. • Temperature.

Environmental Factors Affecting the Rate of Photosynthesis

Temperature
This affects the enzymes controlling photosynthesis.
(See page 15 for explanation of effects of temperature on enzymes)



Light intensity
This provides energy for photosynthesis. Increasing light intensity will increase rate of photosynthesis (1) up to a point when another factor will be **limiting** (2).



Carbon dioxide concentration
Increasing carbon dioxide concentration will increase rate of photosynthesis (1) up to a point when another factor will be **limiting** (2).

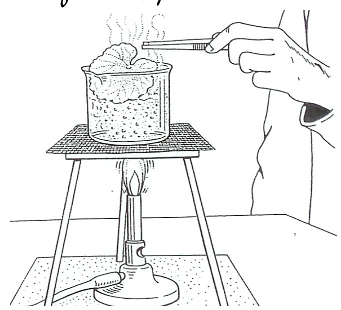
A **limiting factor** is the factor that is controlling the rate of photosynthesis at a given time. Increasing this factor will increase the rate of photosynthesis.

Testing a Leaf for the Presence of Starch

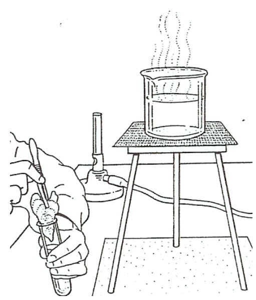
- Glucose produced during photosynthesis cannot be stored and is either used up or stored as insoluble starch.
- We can test a leaf to see if photosynthesis has happened by testing for the presence of starch.
- The plant must be kept in the dark for 24-48 before the experiment. This is so that the plant will use up its store of starch.
- Any starch found afterwards must have been formed by photosynthesis during the experiment.

You need to learn how this experiment works and explain the importance of each step.

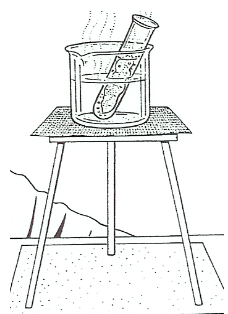
1. **The leaf is placed in a beaker of boiling water for 1 minute.**
   (This breaks down the cell membrane, making it easier for iodine to enter the cell and to remove the chlorophyll in step 3).



2. **The leaf is removed from the water and put into a boiling tube half full of ethanol.**

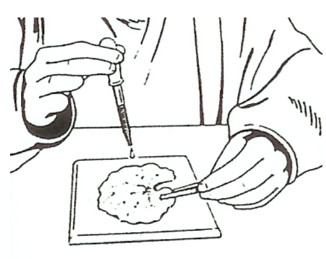


3. **The boiling tube containing the leaf and ethanol is placed in the hot water for 10 minutes.**
   (The boiling ethanol will dissolve the chlorophyll. This removes the green colour from the leaf.)



4. **The leaf is removed from the boiling tube and washed in the beaker of water.**
   (This softens the leaf)

5. **The leaf is placed on a white tile and covered in iodine.**
   (Any parts containing starch will be coloured dark blue-black).



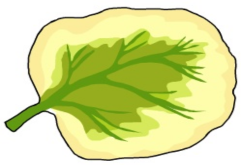
Identifying the Conditions Needed for Photosynthesis

Testing leaves for the presence of starch can be used to show how photosynthesis is affected by:

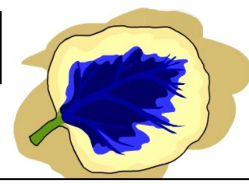
- the presence of chlorophyll in the cells of a leaf;
- light reaching a leaf;
- carbon dioxide in the atmosphere around a leaf.

Experiment 1 – To show that chlorophyll is needed for photosynthesis
We can test a plant to show it needs **chlorophyll** for photosynthesis by using a **variegated leaf** and testing it for the presence of starch.

Before



After

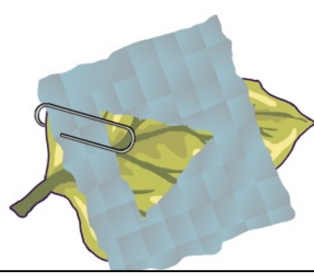


Result:
Green parts containing chlorophyll; stained blue-black - starch is present.
Light parts of plant with no chlorophyll; iodine remains orange – no starch present.
Conclusion:
Chlorophyll must be present in leaf cells for photosynthesis to occur.

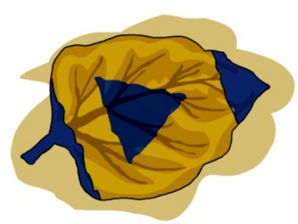
Experiment 2 – To show that light is needed for photosynthesis
We can deprive a part of a leaf of light and then test it for the presence of starch.

A tin foil stencil is cut out and put on one of the leaves of a plant.
This excludes all light, except at the edges and on the pattern.

Before

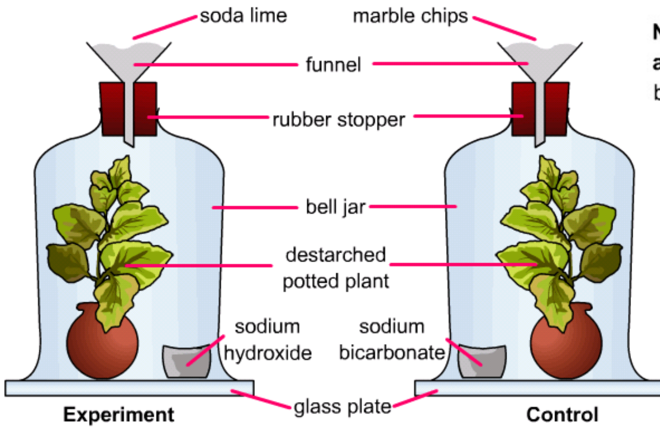


After



Result:
Parts exposed to light; stained blue-black - starch is present.
Parts excluded from light; iodine remains orange – no starch present.
Conclusion:
Leaves must be exposed to light for photosynthesis to occur.

Experiment 3 – To show that carbon dioxide is needed for photosynthesis
We can deprive a plant of carbon dioxide and then test it for the presence of starch.



Note - Soda lime (sodium hydroxide) **absorbs** carbon dioxide, while sodium bicarbonate **releases** carbon dioxide.

Into the funnel of the experiment (the one with sodium hydroxide solution), place soda lime granules to absorb any carbon dioxide that passes into the funnel from the atmosphere. Into the other funnel, the control, place a few marble chips or keep open to the atmosphere.

Result:
Leaves of plant from bell jar with sodium bicarbonate (plenty of carbon dioxide) stained blue-black - starch is present.
Leaves of plant from bell jar with sodium hydroxide (no carbon dioxide) iodine remains orange – no starch present.
Conclusion:
Plants need carbon dioxide to be able to photosynthesise.

Does the presence or absence of water affect photosynthesis?
It is difficult to set up an experiment to prove that water is needed for photosynthesis because you cannot easily remove water from the system.
If you remove water from a plant it will die.
To follow how water is used in photosynthesis you need to use water containing radioactive isotopes of hydrogen or oxygen.

Uses of glucose produced in photosynthesis:

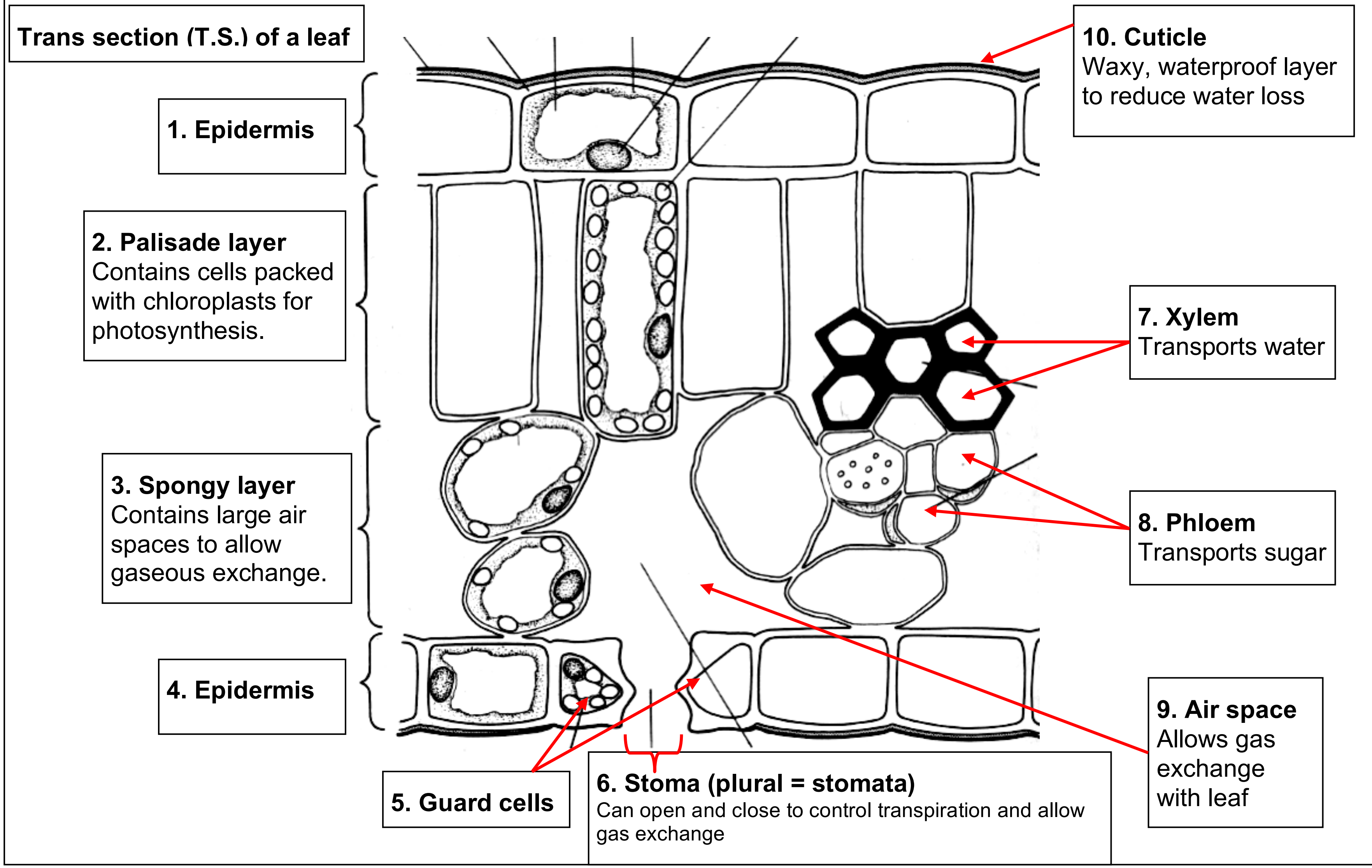
1. Glucose is used to **release energy** in respiration
   Respiration is taking place all the time in plant cells.

2. Glucose can be changed to **starch** and **stored**.

3. Glucose can be used to **make cellulose** which make up the body of plants (e.g. cell walls)

4. Glucose can be used to **make proteins**, which also make up the body of plants, and also **oils**.

Structure of a Leaf



The Transpiration Stream

There is a constant flow of water through a plant; this is called the **transpiration stream**.

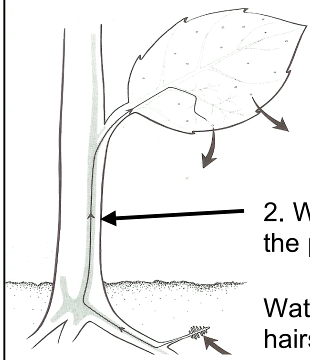


Fig. 1 The transpiration stream

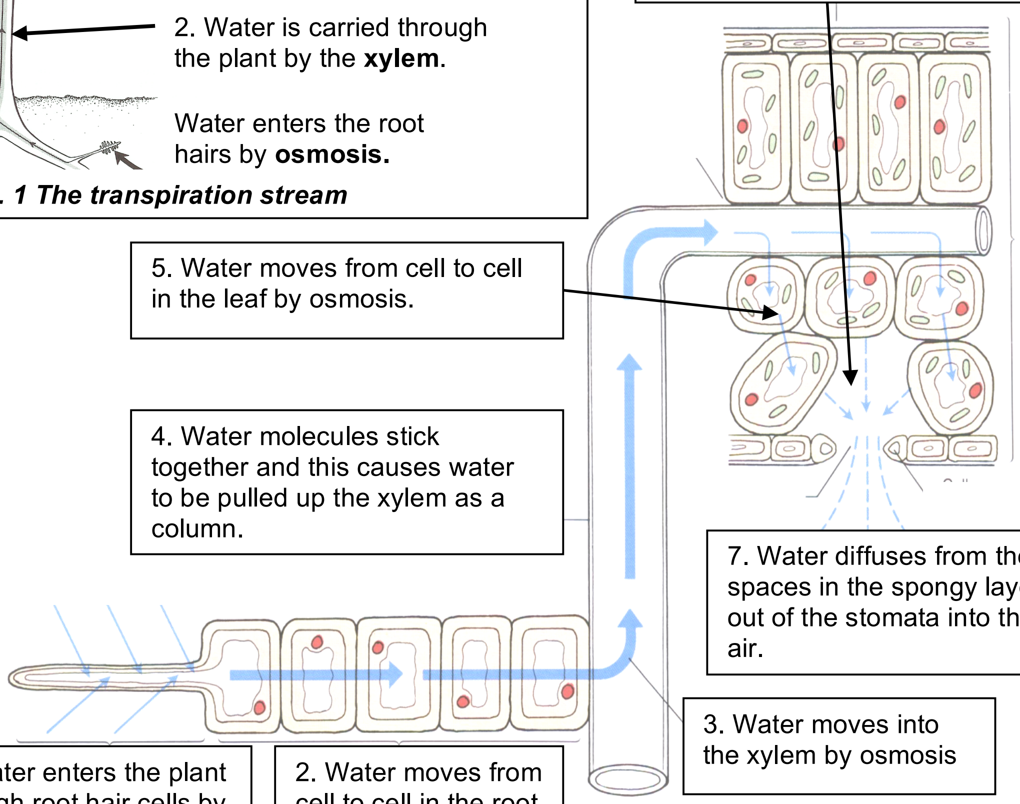


Fig. 2 Annotated illustration of the transpiration stream

Observation of root hair cells

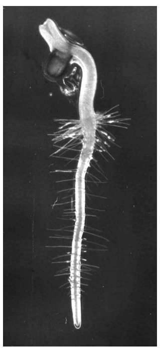


Fig. 3 Root with root hairs (left) and magnified view of root hair (above).

Water enters the plant from an area of high concentration of water in the soil to an area of lower water concentration inside the root hair cell, through it's selectively permeable membrane, by osmosis.

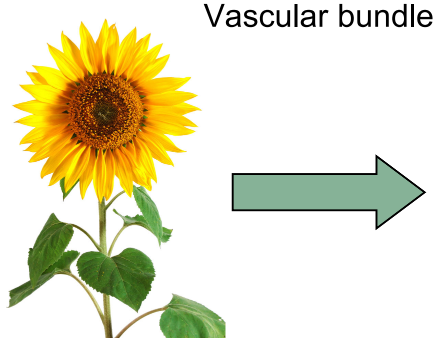
The **increased surface area** of the root hair cell allows the plant to **take in more water faster** by osmosis.

Plant Transport Systems

Plants have two separate transport systems.

- **Phloem vessels** (tubes) **– transport sugar** and other substances that are produced by cells to all the other parts of the plant.
- **Xylem vessels** (tubes) – **transport water** and **mineral ions** from the roots to the rest of the plant.

Phloem and xylem vessels usually run together side by side.
Groupings of phloem and xylem vessels are called **vascular bundles**.



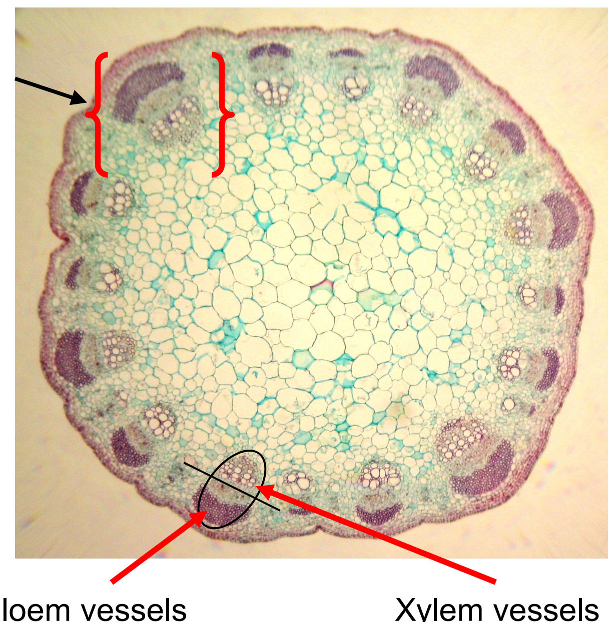


Fig. 1 – T.S. of a sunflower stem showing positions of vascular bundles.

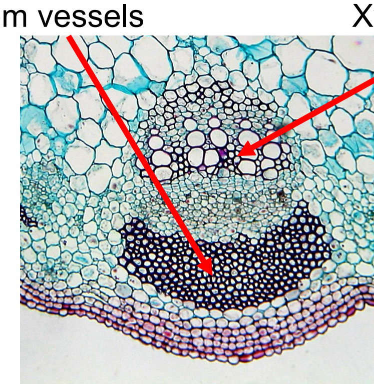


Fig. 2 – T.S. of a sunflower stem showing a single vascular bundle.

Phloem Vessels

Phloem carries sugar from the photosynthetic areas to other parts of the plant. **Sugar** is moved to other parts of the plant for **use in respiration** and converted into **starch for storage**.

The transport of sugar is not fully understood so plant scientists are still investigating it.

Xylem Vessels
The function of xylem vessels are:

1. **Transport of water –** from the roots to the rest of the plant.
2. **Transport minerals –** minerals such as nitrates phosphates and potassium are transported by xylem around the plant dissolved in water.
3. **Support the plant –** the xylem vessels in the shoots and roots of mature plants are inflexible and strong and give support to the plant.

Investigation into the movement of a dye through a flowering plant

1. Take a white flower with a long stalk, e.g. a chrysanthemum and cut the stalk carefully lengthwise.
2. Put each half of the stalk into a measuring cylinder (or boiling tube) containing either plain water or water to which food dye has been added.
3. Tape the measuring cylinders to a plastic tray so that they don't fall over.
4. Leave the flower for a few hours.
5. Observe where the dye ends up in the flower head.

Fig. 1 Flower at beginning.

Fig. 2 Flower after a few hours.

Explanation
Water and dye are pulled up through xylem vessels.
When they reach the flower petals the water evaporates from pores in the petal surface but the dye remains in the cells of the petals.
The petals become coloured as dye accumulates in them.
This procedure could be useful for producing quantities of unusually coloured flowers.

The Importance of Water
Water is important to the plant for:

1. Use in photosynthesis;
2. Transport of minerals;
3. Support.

How does water support the structure of plant?
Water provides support due to the pressure of the vacuoles pushing against the cell walls and this keeps the cells turgid and prevents cells becoming flaccid and plants wilting.

Water moving in by osmosis

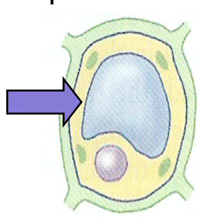


Fig. 3 Turgid cell

Water moving out by osmosis

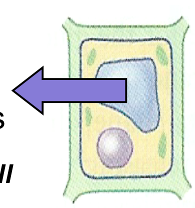


Fig. 4 Flaccid cell

Using a Potometer to Measure Transpiration Rate.

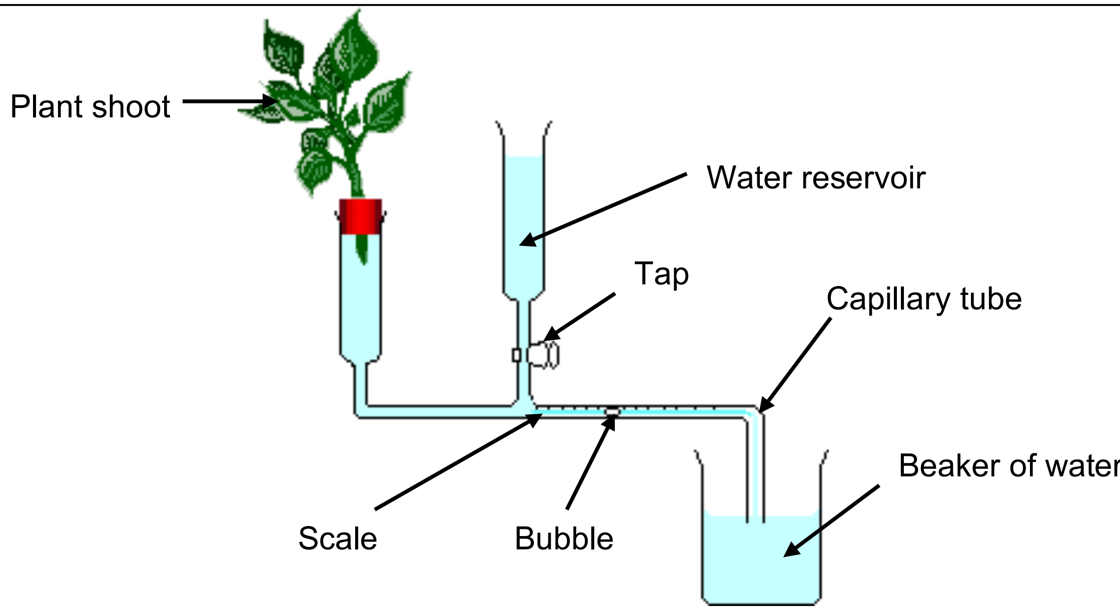


Fig. 1 **A simple potometer.**
An air bubble is introduced into the capillary tube at the start of the investigation. As water evaporates through the stomata of the leaves water is drawn up the capillary tube causing the bubble to move.
The investigation makes the assumption that water uptake is equal to the transpiration rate. However not all water is lost from the leaves, some is taken up by leaf tissue or used for photosynthesis.

Method

1. Set the bubble to it's starting position by using the tap to release water from the water reservoir.
2. Measure the time taken for the bubble to move a set distance

   OR

   Measure how far the bubble moves in a set period of time.
3. Record the results.
4. Repeat the experiment.

Environmental factors that affect water loss from a plant

- **Temperature** – as temperature increases water molecules have more kinetic energy and therefore move faster. This increases transpiration.
- **Humidity** - increasing humidity reduces the concentration gradient of water between the air and the intercellular spaces in the spongy layer of the leaf – this decreases the diffusion of water out of the stomata.
- **Wind speed** – increasing wind speed carries away more water vapour from near the leaf surface and increases the rate of diffusion of water vapour out of the stomata.

Healthy Plant Growth

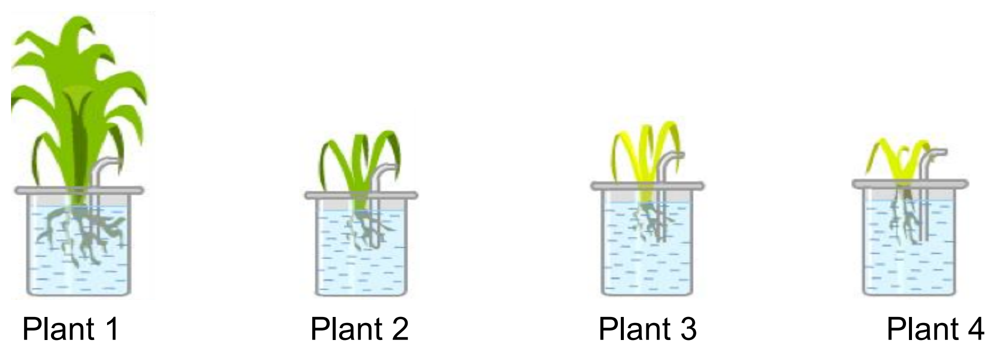
Plants can only grow well if they are in a soil rich in **mineral** nutrients.
Plant roots absorb the minerals from the soil and use them to produce materials that they need to grow.

Three main minerals are needed:

- **Nitrates**
- **Potassium**
- **Phosphates**

Investigating Plant Nutrient Requirements

1. Three healthy plants of the same species and age are grown in an equal volume of aerated mineral solutions.
2. After eight weeks the growth of the plants are observed.



Analysis

Plant	Description	Explanation
1	Healthy growth	Complete solution of minerals
2	Poor growth	Nitrogen deficiency
3	Yellowing of leaves	Potassium deficiency
4	Poor root growth	Phosphate deficiency

NPK fertilisers that contain nitrates, phosphates and potassium can be added to soil to increase the mineral content.

Energy and Nutrient Transfer

Light energy from the sun is the source of all energy for all living things on the planet.
Green plants absorb only a small percentage of this energy (about 1%), using the chlorophyll in their chloroplasts. The rest of the light is either reflected or is at the wrong wavelength.

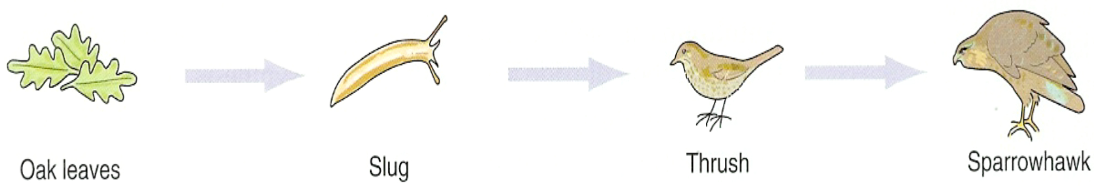
The **absorbed energy** is **used** for **photosynthesis** to produce substances that become part of the cells. These **increase the biomass** of the plant.

- Biomass is the mass of living material in plants and animals.

Food Chains – Glossary of terms

Some organisms can be described using more than one label.
E.g. an herbivore can also be described as a first stage consumer.

Producer	Herbivore	Carnivore	Carnivore



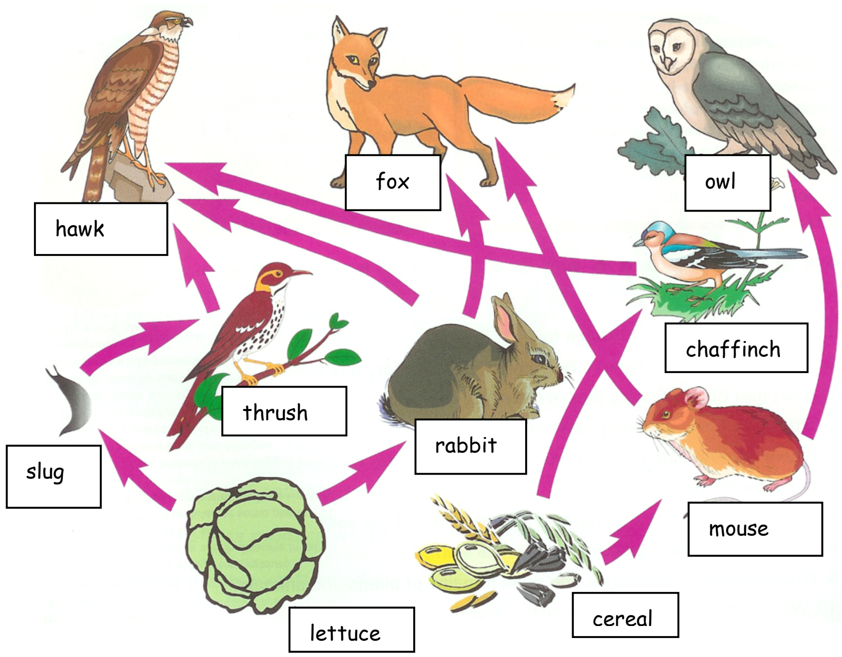
	First stage *(primary)* consumer	Second stage *(secondary)* consumer	Third stage *(tertiary)* consumer

- The **arrows** in a food chain show **energy being passed** from one living thing to the next. (*This is sometimes described as a **flow of energy***).

Producer	Makes its own food by photosynthesis.
Consumer	An organism that eats other organisms.
First stage consumer	The first organism that is ‘eating’ in a food chain.
Second stage consumer	The second organism that is ‘eating’ in a food chain.
Third stage consumer	The third organism that is ‘eating’ in a food chain.
Herbivore	An organism that only eats plants.
Carnivore	An organism that only eats animals.
Omnivore	An organism that eats both animals and plants.

Food Webs

Food webs are made from a number of different food chains linked together.



In the exam, you may be asked to explain what happens if an animal is removed from the chain.

Example
All the rabbits die from a disease.

1. What effect would this have on the foxes?

- *The **number** of foxes would **decrease**.*

b) Why?

- *There is **less food** for the foxes **to eat.***

2. a) What effect would this have on lettuce production?

- *The **number** of lettuce would **increase**.*

b) Why?

- *There are **less** rabbits **eating** the lettuce.*

3. Explain in full the effect on the mice. (*Notice, the mouse is not part of the same food chain*).

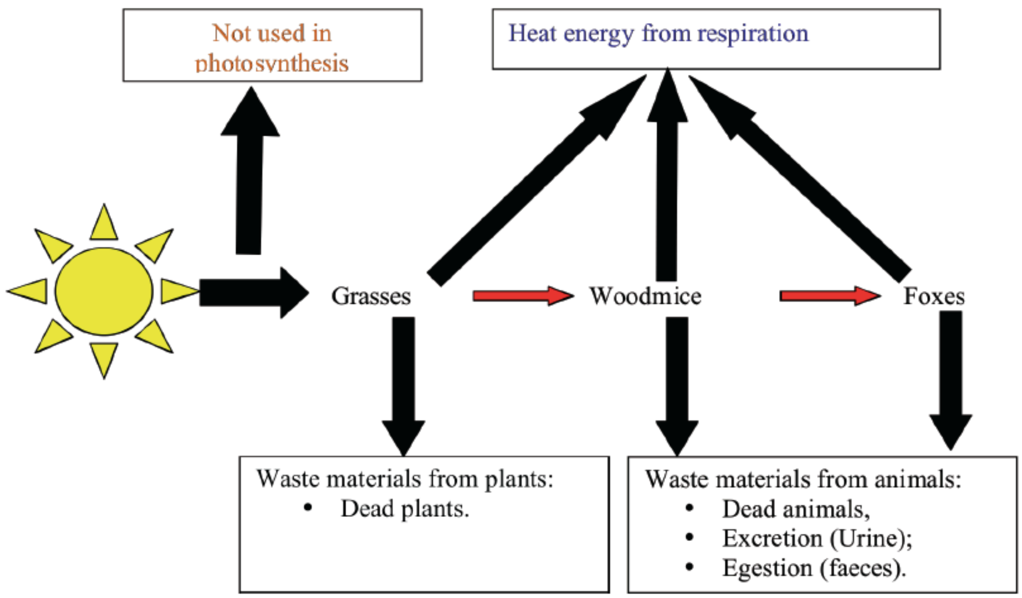
- *The number of mice would decrease because the foxes have less rabbits to eat therefore they eat more mice.*

Remember to think carefully

- what eats what?
- which animals will have less food?
- what will be the effect on other animals?

Energy Flow Through a Food Chain

There is energy lost at each step of a food chain, so there's less available for the next animal. This is why the numbers of organisms in a food chain is limited. The more energy lost every step, the shorter the food chain.

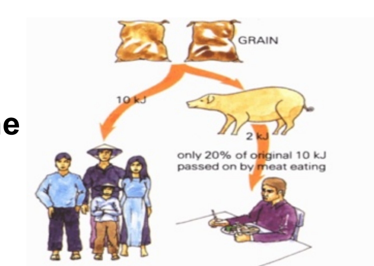


Some things to consider about energy lost as heat during respiration.

- Animals lose more heat from respiration than plants because their metabolism is higher (the amount of chemical activity in cells).
- Animals lose more heat from respiration than plants because they move around; plants don't.
- Warm-blooded animals (mammals and birds) lose more heat from respiration than cold-blooded animals (all the others) because they need to keep their body temperature constant.
- Land animals lose more energy from respiration than animals in water, because they have to support their bodies. E.g. we humans have to stand, a jellyfish just floats!

Efficient Food Production

More food can be produced from an area of land if it is used for growing crops rather than grazing animals.
Less energy is lost if people eat plants, because the food chain is shorter.
However, potatoes wouldn't grow on a mountain, but sheep can graze there, so no need to stop all animal production.



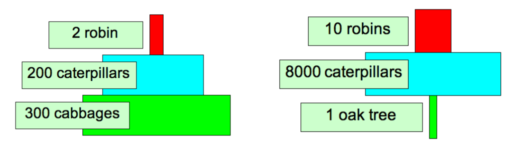
Food Pyramids

Pyramids of number show the **number of organisms in a given area** or volume for every feeding level.

Rules for pyramids of number:

1. The producer is always at the bottom.
2. The size of every block (area or volume) shows the **number** of plants or animals in the food chain.

Pyramids of numbers can be misleading. The pyramid on the left represents a cabbage field, and the one on the right woodland. Their shapes are different even though they show the number of individual organisms. A tree can support thousands of animals; therefore, the base of the pyramid is smaller than the levels above.



Pyramids of biomass shows the **dry mass of organisms in a given area** or volume for every feeding level.

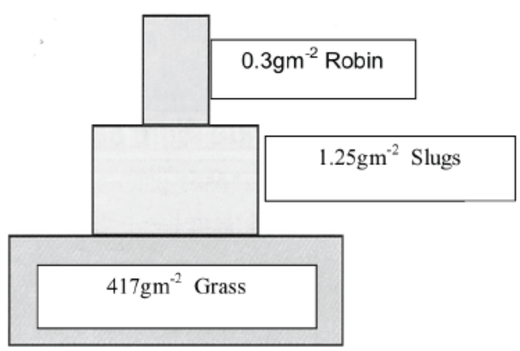
Rules for pyramids of biomass:

1. The producer is always at the bottom.
2. The size of every block (area or volume) shows the **dry mass of the** of **plants** or **animals** in the food chain

The shape of a pyramid of biomass can change during the year, depending on the time a survey is carried out.

The pyramid on the right has been drawn from grassland during May.

If a survey were carried out in December the mass of grass would be less.
During the winter it is colder and there is less sunlight, therefore the grass would be producing less biomass by photosynthesis.

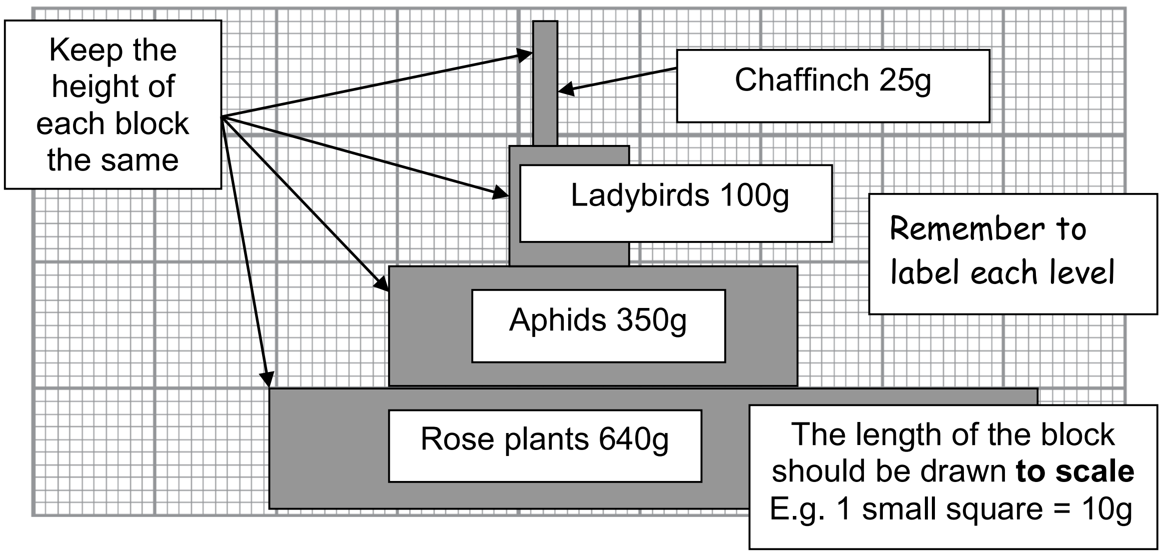


Remember
A pyramid of biomass will always be pyramid shaped.

Building Food Pyramids
Organisms are represented as small squares on graph paper. Drawing a line around all the small squares will give a box that represents the numbers or biomass of an organism.

Organism	**Number** in the food chain	**Mass** of each organism (g)	Total biomass of organisms (g)
Rose plants	1	640	640
Aphids	7000	0.05	350
Ladybirds	400	0.25	100
Chaffinch	1	25	25

=Number x mass



Calculating efficiency of energy transfers between trophic levels

Trophic level	**Total energy, in kJ/m^2**
producer	1306
First stage consumer	217
Second stage consumer	26
Third stage consumer	1

The efficiency of energy transfer at any stage can be calculated as follows:

$$\text{Trophic efficiency} = \frac{\text{energy in later stage}}{\text{energy in earlier stage}} \times 100\%$$

e.g. trophic efficiency of first stage consumer = 217 ÷ 1306 x 100%
= 16.6%

Natural Recycling

Not all animals and plants are eaten, but micro-organisms feed on their bodies when they die. These micro-organisms are called decomposers.

- **Decomposers** are **bacteria** and **fungi**.
- Micro-organisms, such as bacteria and fungi, digest material from their environment for growth and other life processes.
- Materials are returned to the environment either in waste products or when living things die and decay.
- Minerals such as nitrates and phosphates are released to the soil, and are then used by plants for growth.
- Micro-organisms release carbon dioxide into the air as they respire.
- When decay is prevented, fossil fuels such as coal, oil and gas are formed and these store energy in carbon compounds.

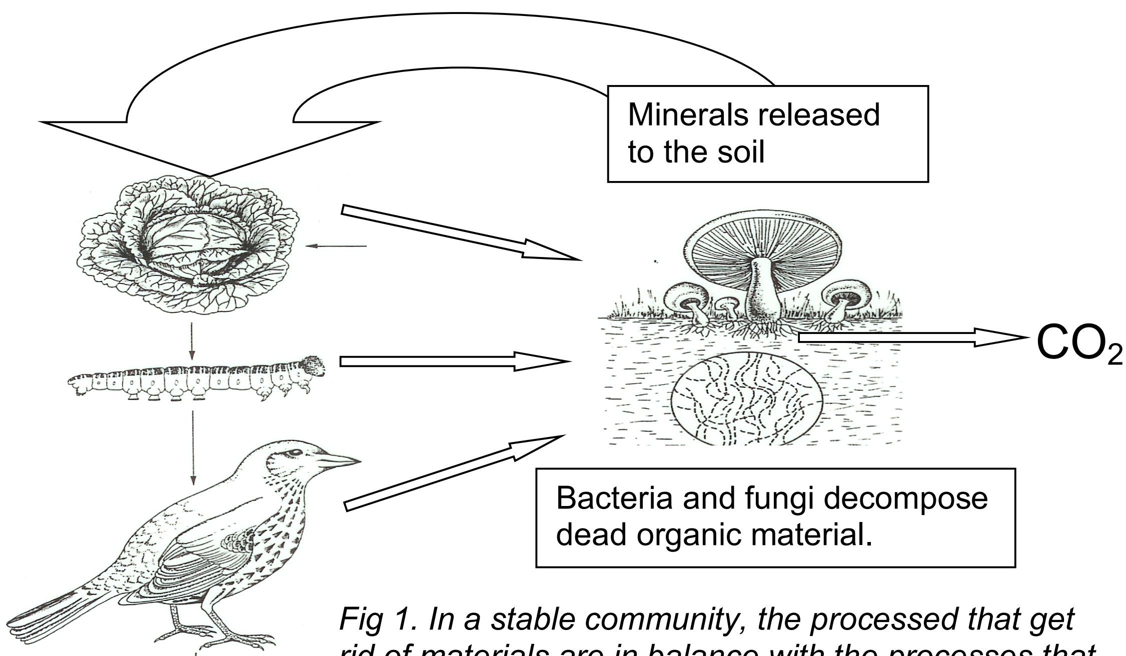


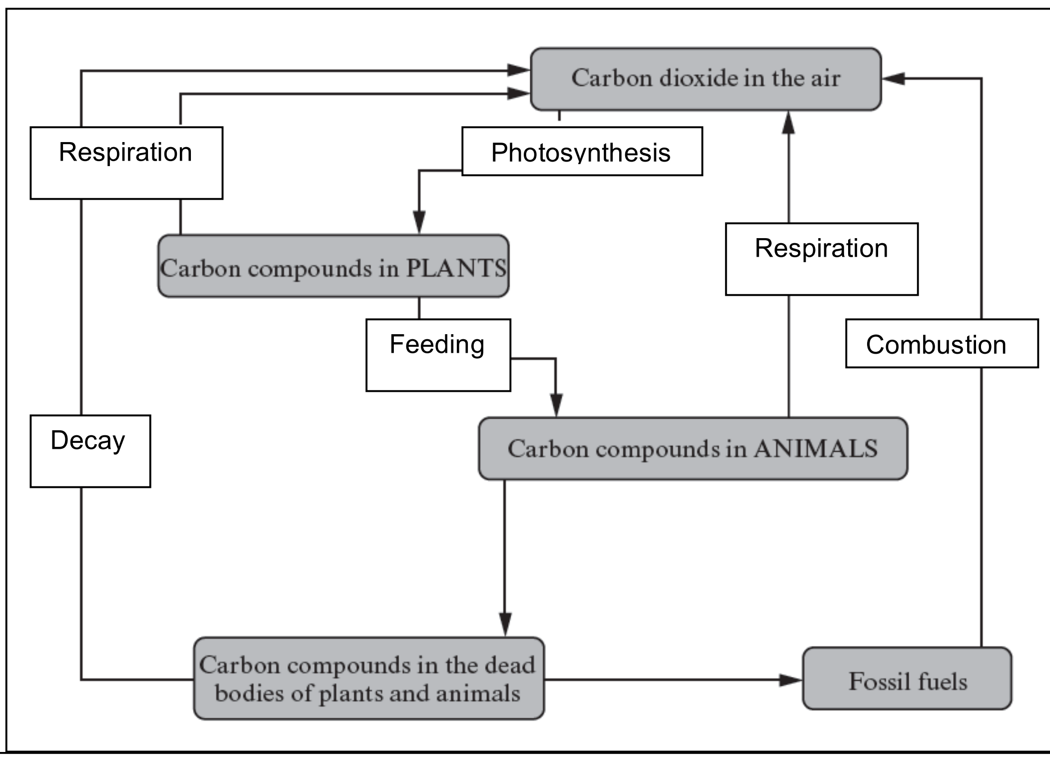
Fig 1. In a stable community, the processed that get rid of materials are in balance with the processes that return material.

Factors that affect the activity of decomposers (bacteria and fungi):

- Temperature
- Oxygen
- pH
- Heavy metals

The Carbon Cycle

- Carbon enters the food chain via **photosynthesis**.
- Some of this carbon then becomes carbohydrates, fats and proteins in plants.
- The carbohydrates, fats and proteins are passed along the food chain when animals are **feeding** (consuming).
- Some carbon is converted to carbon dioxide during **respiration** by plants and animals.
- Carbon is returned to the environment when living things die or produce waste material, e.g. faeces.
- **Decomposers** (micro-organisms such as **bacteria** or **fungi**) feed on dead organisms and the waste material for growth and other life processes. This is called decomposition or decay.
- Carbon is released to the atmosphere as carbon dioxide when decomposers respire.
- When decay is prevented substances such as peat, coal, oil and gas are formed and these store energy in carbon compounds.
- Energy and carbon dioxide are released when these fossil fuels are burnt



Human effects on the carbon cycle

- **Combustion** (burning) of fossil fuels has increased the concentration of carbon dioxide in the environment.
- **Combustion** of fossil fuels also releases sulphur dioxide that leads to acid rain.

The Nitrogen Cycle

- Living organisms need nitrogen to make **proteins**.
- 79% of the air is nitrogen, but plants and animals can't use nitrogen gas.
- Nitrogen must be changed into **nitrates** before plants can use it.

Nitrates can be absorbed by plant roots and used to make proteins. This protein then becomes food for animals as it is passed on along food chains.

How does the nitrogen cycle work?

- When a plant or animal dies,
- Soil bacteria and fungi act as decomposers,
- They convert protein (and urea from urine) into ammonia,
- Micro-organisms can also transform urea in excreted waste (urine) to ammonia.
- The ammonia is then converted to nitrates in a process called nitrification.
- Nitrifying bacteria carry out nitrification.
- The nitrates are then absorbed (taken up) by plant roots.
- The nitrates are used to make amino acids.
- The amino acids are then used to make new proteins.
- Nitrogen can be fixed (transformed from nitrogen in the air to nitrates) by nitrogen fixing bacteria that are free-living in the soil or in the root nodules of leguminous plants, e.g. beans and clover.
- Denitrifying bacteria transform nitrates back into nitrogen gas in the air.

Factors that affect the nitrogen cycle:

- **Nitrification** happens under **aerobic conditions** (oxygen is present), e.g. in soil that has been ploughed or is well drained.
- **Denitrification** happens under **anaerobic conditions** (oxygen not present), e.g. marshes, flooded soiled.

These factors also influence the process of decomposition in compost heaps and landfill sites.

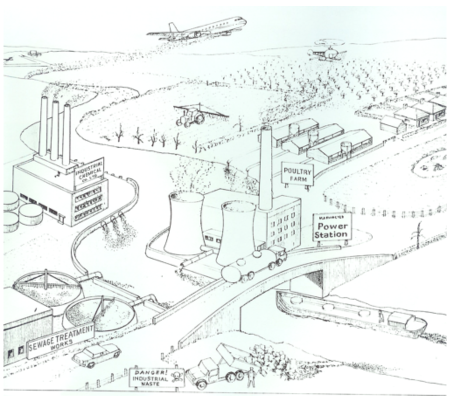
Factors that affect the activity of decomposers (bacteria and fungi):

- Temperature
- Oxygen
- pH
- Heavy metals

What effects do humans have on the environment?

When the human population was less, the effect of human activity on the environment was lower and localised. As populations have increased, the effects on the environment have increased also.

These days more and more species are becoming extinct because man is destroying their habitats.



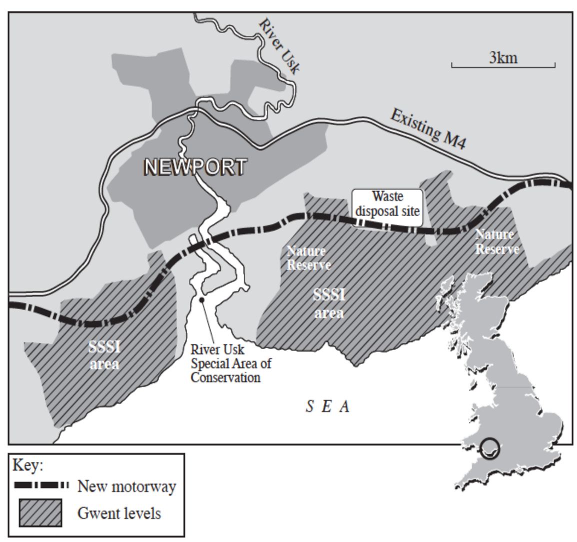
Habitats are being destroyed because of **increases in the use of land** for:

- Housing
- Industry
- Agriculture

Assessing Environmental Effects
During the planning process, developers must carry out an **environmental impact assessment** for each development to show the local authority before starting work. There can be a large fine for failing to do this.
The assessment is used to decide whether the development should be allowed to go ahead, be refused or modified to reduce the effect on wildlife.

The purpose of the environmental impact assessment is:

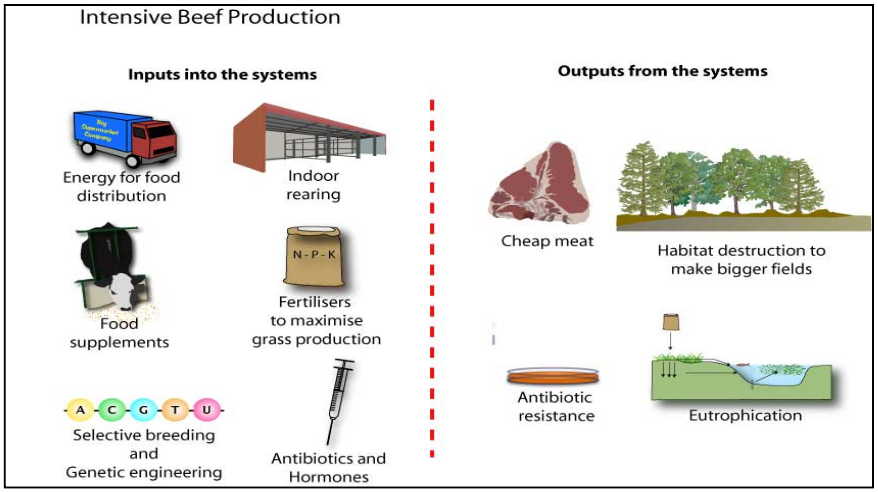
1. ensure the timing of any development has the least possible impact on wildlife;
2. show if any rare or endangered species are present;
3. show if it is possible to reduce the environmental effects through adapting the plans to suit the habitat's needs;
4. monitor long term changes that might develop.



In Wales, the government agency responsible for monitoring, improving and protecting the environment is called **Natural Resources Wales.**

Intensive farming methods

In order to feed the growing world population, we need get more yield (from plants or animals) from **less land**.



You need to be able to name **methods** of intensive farming and describe their **advantages** and **disadvantages**:

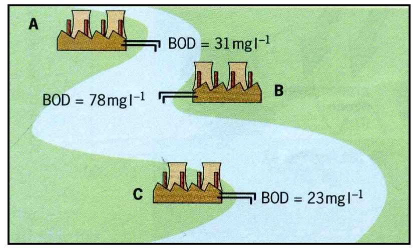
Methods	Advantages	Disadvantages
Fertilisers	Increase plant yield.	Can wash out of soils and cause rapid growth of plants and algae in rivers and streams.
Pesticides	Increases yield by stopping pests from eating or competing with crop plants.	• Can wash out of soils and lead to bioaccumulation. • Can destroy non-pest species.
Disease control (e.g. using antibiotics to prevent bacterial infection from starting)	Increases yields by preventing losses of plants and animals.	Antibiotics could be present in meat, if used excessively, and cause increased antibiotic resistance in bacteria.
Battery methods	Less room to move. Less energy wasted. Less food needed. Reduced costs.	Negative impact on welfare and quality of life for animals.

Measuring pollution in rivers and streams

Populations can be upset by the introduction of harmful materials into the environment, which results in pollution.

Pollution in rivers and streams can be measured using:

- Changes in pH levels
- Changes in oxygen levels
- Indicator species



- **Changes in pH**

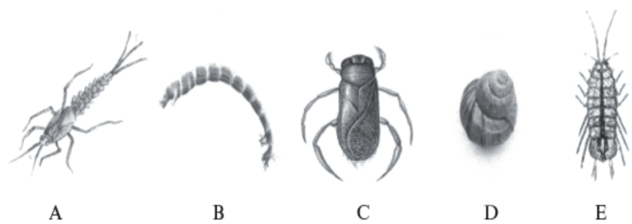
Acidification of rivers and streams is due to acid rain and run-off from surrounding land. Below pH 4.5-5 aluminium is released from rocks. This is toxic to fish.

- **Changes in oxygen levels**

The change in oxygen concentration shows how much bacteria there is in the water. The more bacteria there are, the more polluted the water is.

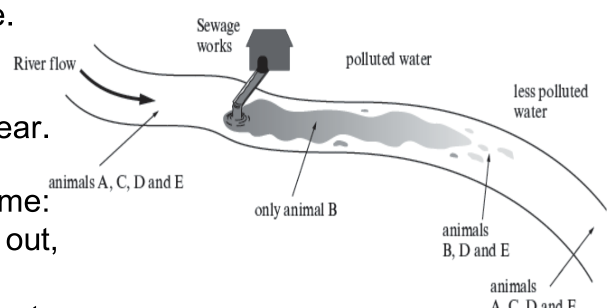
- **Indicator species**

You can estimate the amount of pollution by recording the presence or absence of certain indicator species.



- **Carrying out a survey**

A survey should be a **fair test**. Therefore, only one factor should change (the independent variable).
Everything else should stay the same.



Example of an annual survey

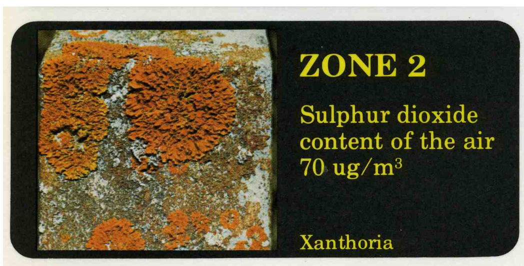
- The independent variable is the year.

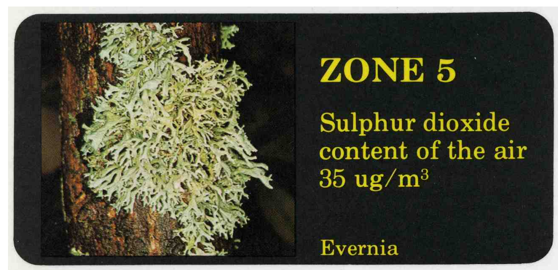
The variables that should stay the same:

- Time of year the survey is carried out,
- Same locations sampled,
- Time of day the survey is carried out,
- Volume of water sampled,
- Method of sampling,
- Same water conditions, e.g. temperature, flow rate, turbidity.

Measuring Air Pollution

The **abundance** and **distribution** of lichen can be used as an indicator of air pollution.
Lichens are indicator species. They are sensitive to **sulphur dioxide** gas (produced form burning fossil fuels).
Some species are so sensitive that a very low concentration of the gas will kill them.
Lichen found growing on trees or rocks could be used to indicate the concentration of sulphur dioxide in the air.





Zone	Description	Sulphur dioxide content of the air (ug/m^3)
0	Heavy Pollution	High sulphur dioxide concentration
1	↓	↓
2		
3		
4		
5		
6	Clean Air	Low sulphur dioxide concentration

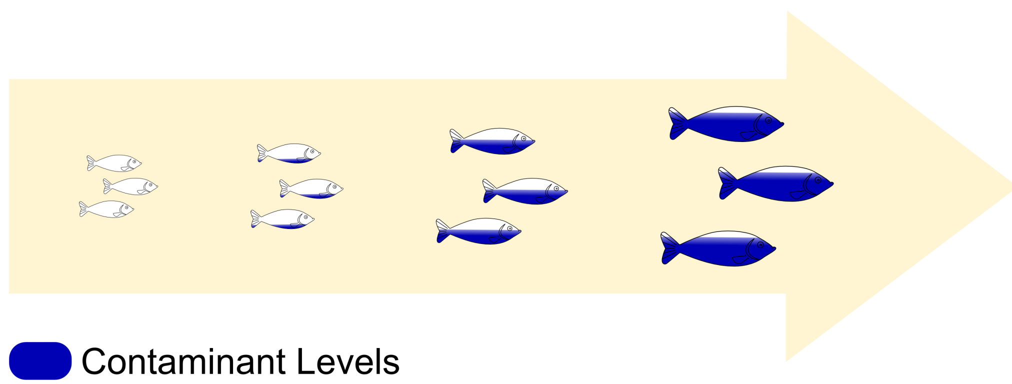
Note, some of the species found in more polluted air can also be found in purer air. Always look for the lichen giving the *highest* zone reading on the scale.

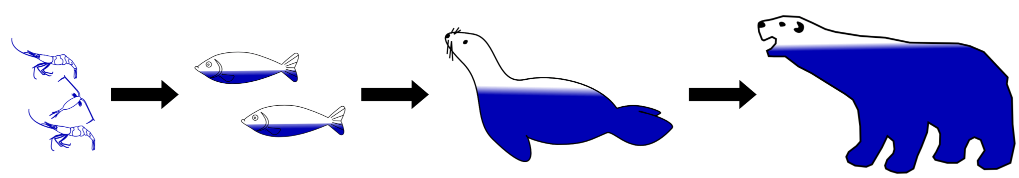
Pesticides in Food Chains

These are chemicals that farmers use to control pests and diseases on crop plants.

- **Insecticides** kill insect pests feeding on plants.
- **Herbicides** (weed killers) reduce competition for water and light between pest plants and crops.
- **Fungicides** kill fungi that cause plant diseases.

Environmental Effects of Pesticides - Bioaccumulation





https://socratic.org/questions/what-is-bioaccumulation-1

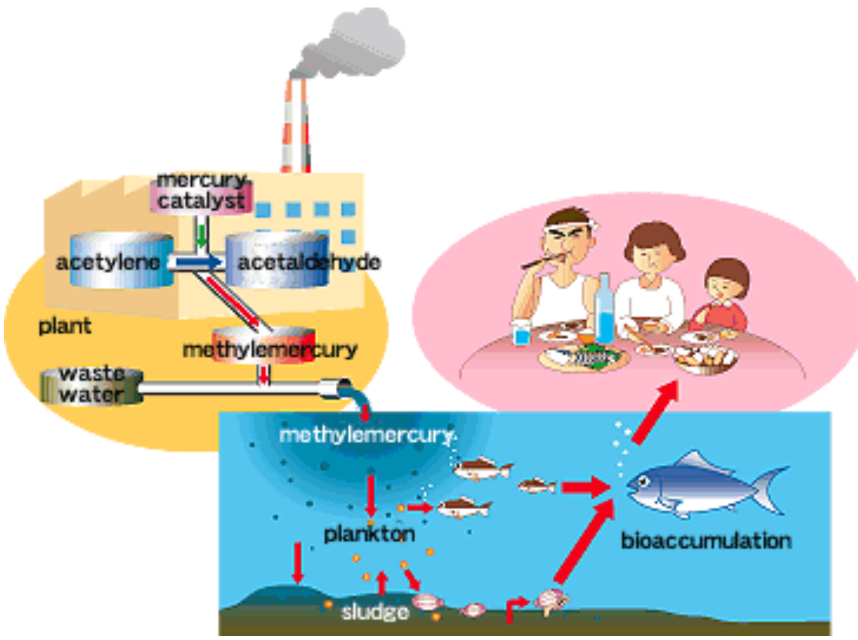
Pesticides can be sprayed on crops.
Pesticides from crops may be washed into lakes, rivers and natural underground water stores and so contaminate drinking water.

Some chemicals are not broken down by the cells of living organisms and therefore enter the food chain.
The **further along a food chain** an organism is, the more **chemicals accumulate in its tissues**. The scientific name for this is **bioaccumulation**.
The organism at the end of a food chain will receive a **toxic dose** that has harmful effects, e.g. **reducing fertility** or **death**.

Heavy Metals in Food Chains

In the year 2000 new laws were passed to reduce the level of pollution by industry.
Many industries (**oil refineries**, **chemical works**, **steel plants** and **paper mills**) used to release chemicals into rivers and the sea. These chemicals included **heavy metals** such as **lead**, **mercury**, **cadmium** and **tin**.

A well-known case of industrial pollution is the tragedy of Minamata, a fishing village in Japan.



http://www.nimd.go.jp/archives/english/tenji/a_corner/a06.html

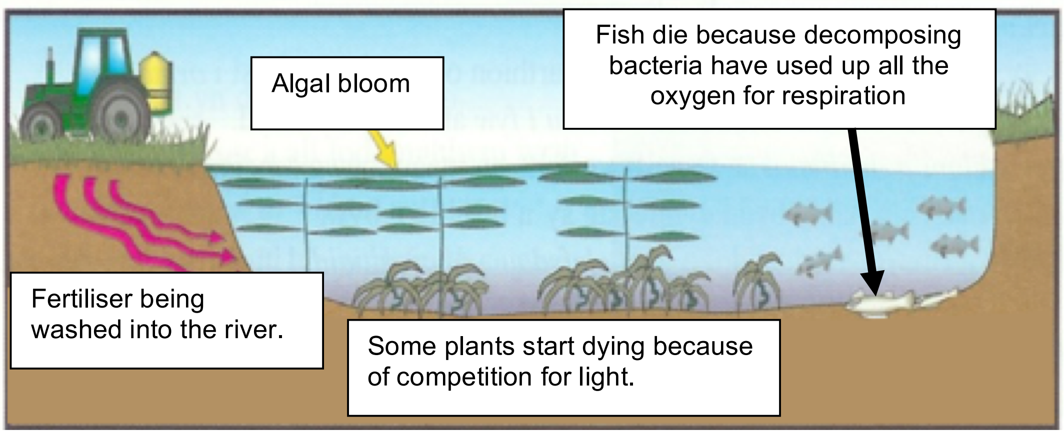
52 people died from mercury poisoning. Others were paralysed and babies were born with brain damage. Mercury affects the nervous system.

Explanation

- A plastics factory released mercury compounds into the sea.
- Plant plankton (microscopic plants) absorbed mercury.
- Animal plankton (microscopic animals) ate a lot of the plant plankton, and mercury built up inside them.
- Fish ate a lot of the animal plankton. Because they could not excrete the mercury (get rid of it from their bodies), the concentration increased inside them.
- When people ate a lot of the fish they received a very high concentration of mercury.
- This toxic or poisonous dose was enough to kill them or make them very ill.

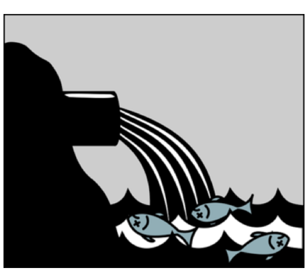
Effect of Fertilisers and Sewage on the Environment

Fertilisers contain the minerals that crop plants need to grow, e.g. **nitrates** and **phosphates**. Chemical fertilisers are important in intensive farming, but they must be used carefully especially near streams, rivers and ponds.



Explanation – ***(Quality of extended response(QER) question model answer)***

- Fertilisers containing nitrates and phosphates are washed into streams, rivers, ponds and the sea.
- Nitrates and phosphates cause an increase in the growth of water plants or algal blooms.
- Some plants start dying because there is increased competition for light.
- Decomposing bacteria decompose (rot) the dead plants.
- The number of decomposing bacteria increases.
- The decomposing bacteria use up the oxygen in the water for respiration.
- There is less oxygen in the water.
- Animals, such as fish, die because there is not enough oxygen in the water.



What about sewage?

- Untreated sewage causes an increase in the growth of water plants. (It has the same effect as fertilisers).
- Bacteria in the water also feed on untreated sewage, using up the oxygen in the water for respiration.