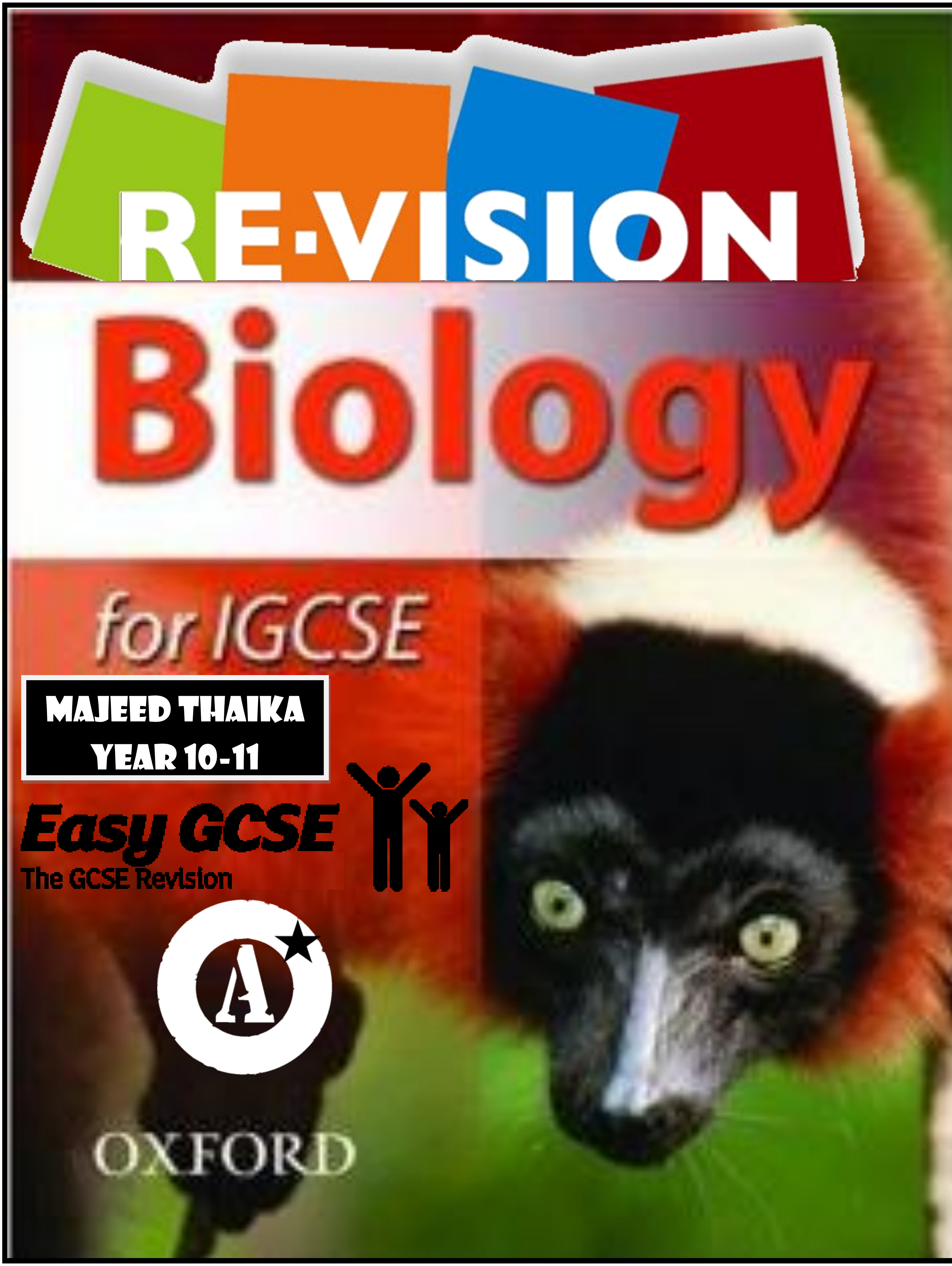

RE-VISION
Biology
for IGCSE
MAJEED THAIKA
YEAR 10-11
Easy GCSE
The GCSE Revision
A*
OXFORD

Contents

CELLS

All animals and plants are made of cells. Animal cells and plant cells have features in common, such as a nucleus, cytoplasm, cell membrane, mitochondria and ribosomes. Plant cells also have a cell wall, and often have chloroplasts and a permanent vacuole. Note that cells may be specialized to carry out a particular function.

Dissolved substances pass into and out of cells by diffusion. Water passes into and out of cells by osmosis.

Animal and plant cells

Function of cells which animal and plant cells have in common:-

Part	Function
nucleus	contains genetic material, which controls the activities of the cell
cytoplasm	most chemical processes take place here, controlled by enzymes
cell membrane	controls the movement of substances into and out of the cell
mitochondria	most energy is released by respiration here
ribosomes	protein synthesis happens here

Extra parts of plant cells:-

Part	Function
cell wall	strengthens the cell
chloroplasts	contain chlorophyll, which absorbs light energy for photosynthesis
permanent vacuole	filled with cell sap to help keep the cell turgid

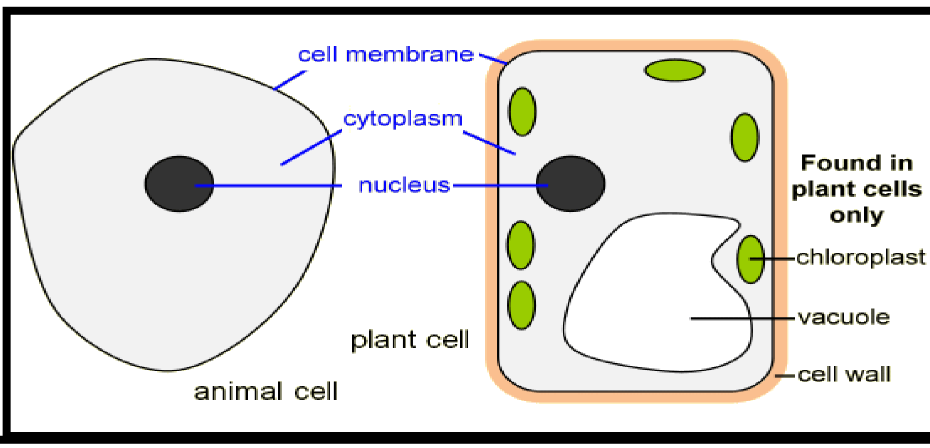
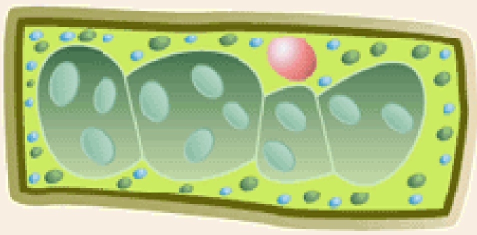
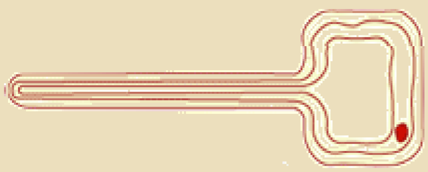
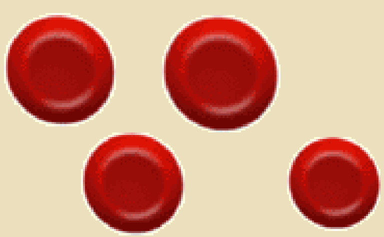


Diagram: Generalized animal and plant cell

Specialised cells

Cells may be specialized for a particular function. Their structure will allow them to carry this function out. Here are some examples:

Examples of the functions of cells:-

Cell	Function	Adaption
 Leaf cell	Absorbs light energy for photosynthesis	Packed with chloroplasts. Regular shaped, closely packed cells form a continuous layer for efficient absorption of sunlight.
 Root hair cell	Absorbs water and mineral ions from the soil	Long 'finger-like' process with very thin wall, which gives a large surface area.
 Sperm cell	Fertilizes an egg cell - female gamete	The head contains genetic information and an enzyme to help penetrate the egg cell membrane. The middle section is packed with mitochondria for energy. The tail moves the sperm to the egg.
 Red blood cells	Contain haemoglobin to carry oxygen to the cells.	Thin outer membrane to let oxygen diffuse through easily. Shape increases the surface area to allow more oxygen to be absorbed efficiently. No nucleus, so the whole cell is full of haemoglobin.

Diffusion

Dissolved substances have to pass through the cell membrane to get into or out of a cell. Diffusion is one of the processes that allow this to happen.

Diffusion occurs when particles spread. They move from a region where they are in high concentration to a region where they are in low concentration. Diffusion happens when the particles are free to move. This is true in gases and for particles dissolved in solutions. Particles diffuse down a concentration gradient, from an area of high concentration to an area of low concentration. This is how the smell of cooking travels around the house from the kitchen, for example.

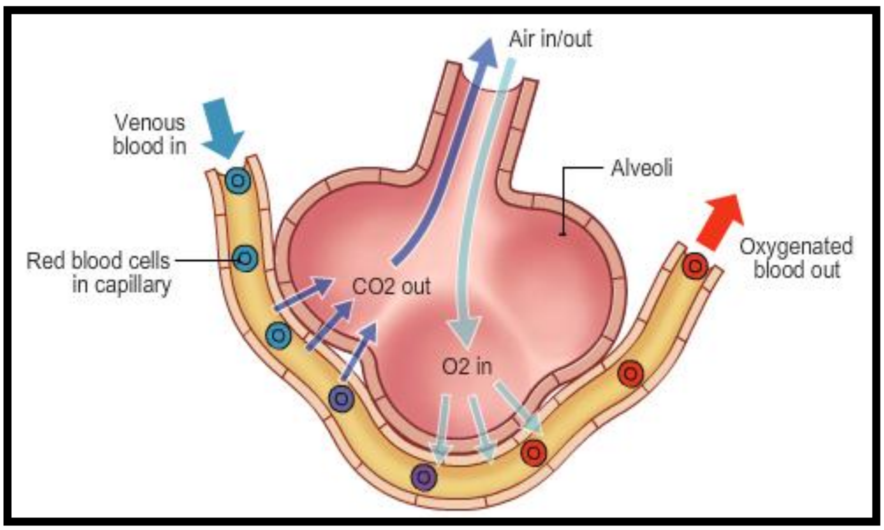
Examples of diffusion

Two examples of diffusion down concentration gradients:-

Location	Particles move	From	To
Gut	digested food products	gut cavity	blood in capillary of villus
Lungs	oxygen	alveolar air space	blood circulating around the lungs

Remember, particles continue to move from a high to a low concentration while there is a concentration gradient.

In the lungs, the blood will continue to take in oxygen from the alveolar air spaces provided the concent-ration of oxygen there is greater than in the blood. Oxygen diffuses across the alveolar walls into the blood, and the circulation takes the oxygen-rich blood away.



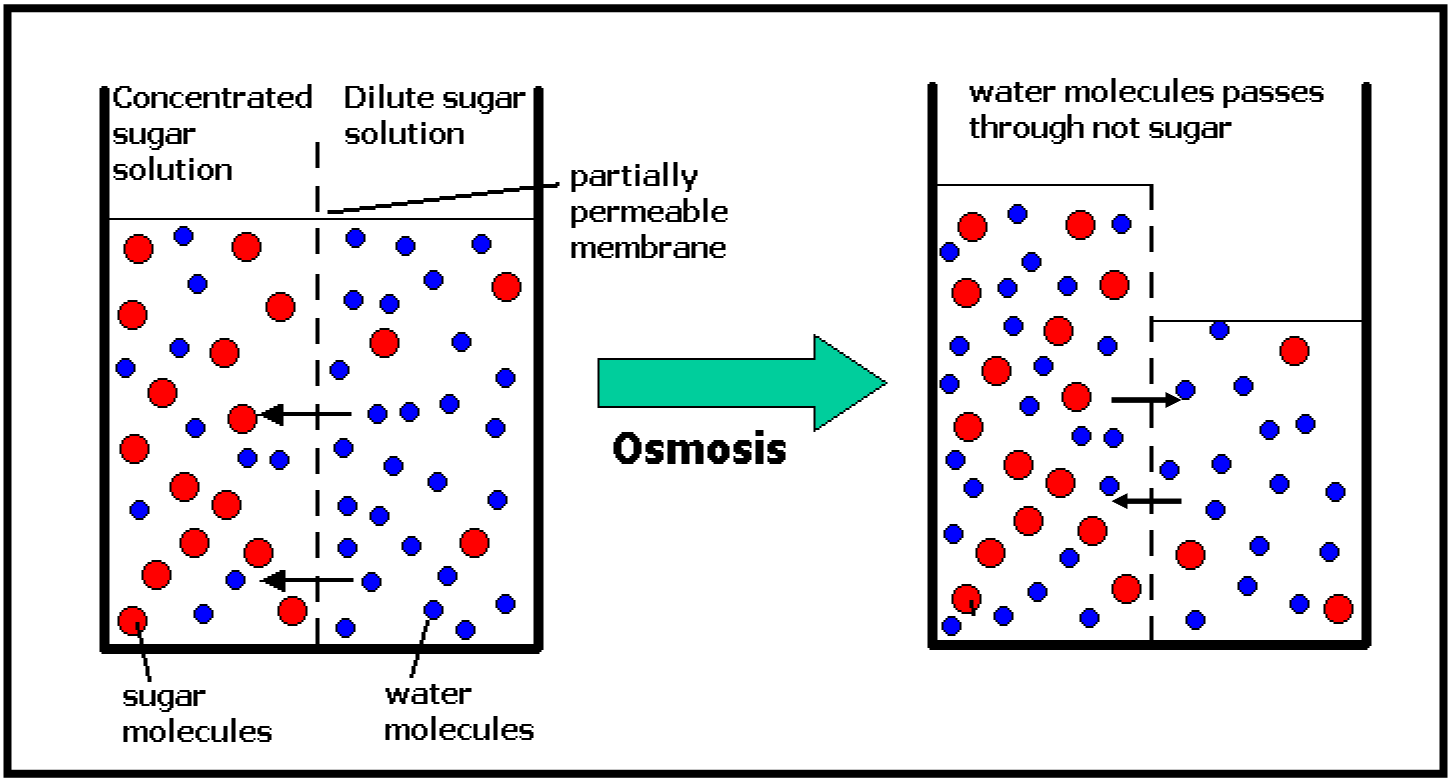
Osmosis

Water can move across cell membranes because of osmosis. For osmosis to happen you need:

- two solutions with different concentrations
- a partially permeable membrane to separate them

Partially permeable membranes let some substances pass through them, but not others. The animation shows an example of osmosis.

Osmosis is the movement of water from a less concentrated solution to a more concentrated solution through a partially perm-eable membrane.



The picture above shows how osmosis works. Eventually the level on the more concentrated side of the membrane rises, while the one on the less concentrated side falls. When the concentration is the same on both sides of the membrane, the movement of water molecules will be the same in both directions. At this point, the net exchange of water is zero and there is no further change in the liquid levels.

Osmosis is important to plants. They gain water by osmosis through their roots. Water moves into plant cells by osmosis, making them turgid or stiff so they that able to hold the plant upright.

PLANTS

Green plants absorb light energy using chlorophyll in their leaves. They use it to react carbon dioxide with water to make a sugar called glucose. The glucose is used in respiration, or converted into starch and stored. Oxygen is produced as a by-product.

This process is called photosynthesis. Temperature, carbon dioxide concentration and light intensity are factors that can limit the rate of photosynthesis.

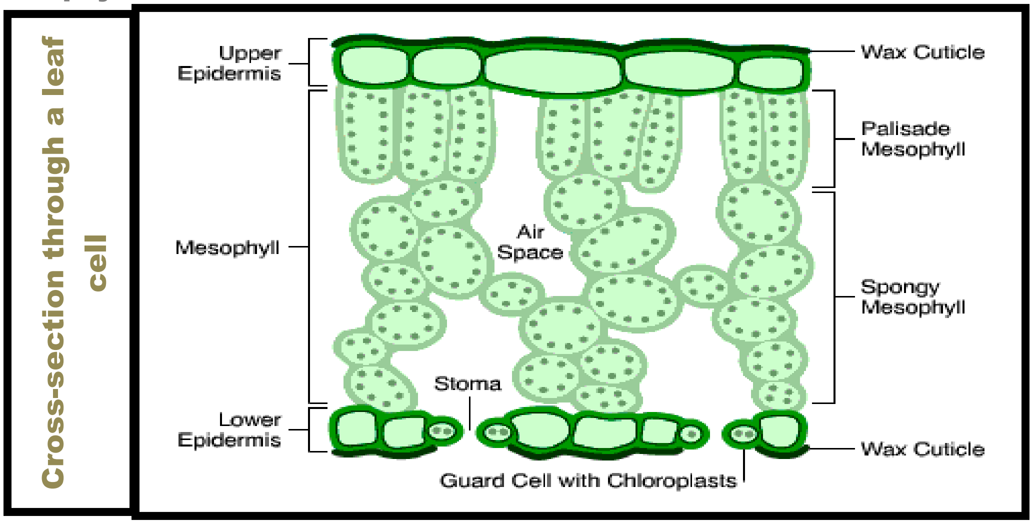
Plants also need mineral ions, including nitrate and magnesium, for healthy growth. They suffer from poor growth in conditions where mineral ions are deficient.

Photosynthesis

Photosynthesis is the chemical change which happens in the leaves of green plants. It is the first step towards making food - not just for plants but ultimately every animal on the planet.

During this reaction, carbon dioxide and water are converted into glucose and oxygen. The reaction requires light energy, which is absorbed by a green substance called chlorophyll.

Photosynthesis takes place in leaf cells. These contain chloroplasts, which are tiny objects containing chlorophyll.



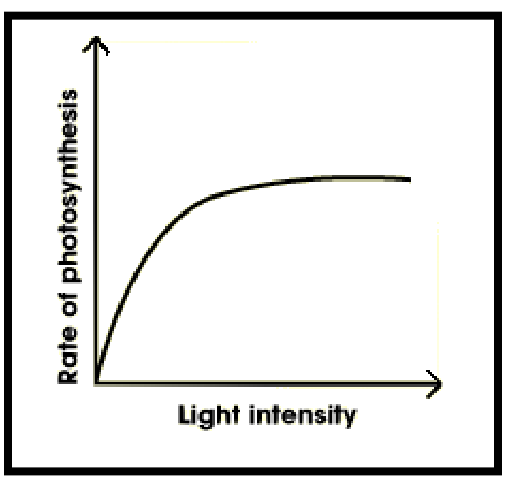
The equation for photosynthesis is:-

$$\text{carbon dioxide + water} \xrightarrow{\text{light energy}} \text{glucose + oxygen}$$

Plants absorb water through their roots, and carbon dioxide through their leaves. Some glucose is used for respiration, while some is converted into insoluble starch for storage. The stored starch can later be turned back into glucose and used in respiration. Oxygen is released as a by-product of photosynthesis.

Factors limiting photosynthesis

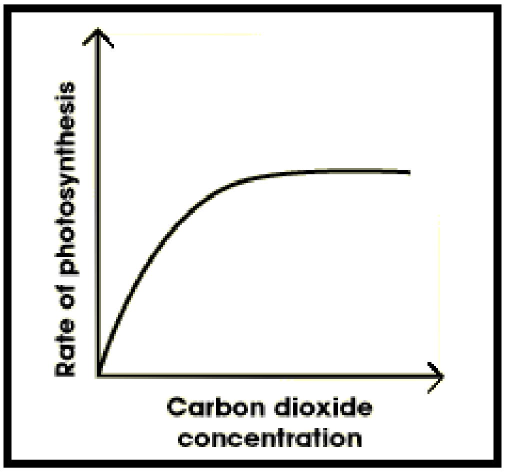
Three factors can limit the speed of photosynthesis - light intensity, carbon dioxide concentration and temperature.



Light intensity

-Without enough light, a plant cannot photosynthesise very quickly, even if there is plenty of water and carbon dioxide.

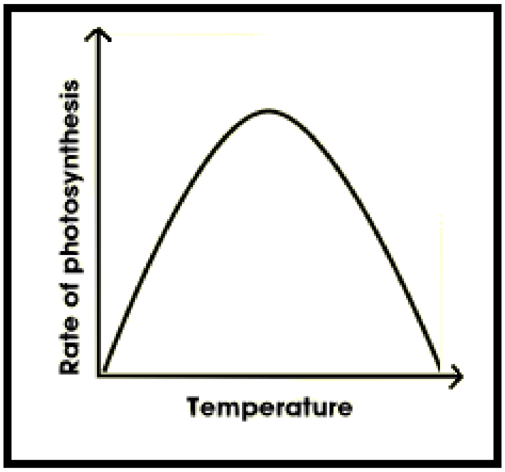
-Increasing the light intensity will boost the speed of photosynthesis.



Carbon dioxide concentration

Sometimes photosynthesis is limited by the concentration of carbon dioxide in the air.

Even if there is plenty of light, a plant cannot photosynthesise if there is insuff-icient carbon dioxide.



Temperature

-If it gets too cold, the rate of photosynthesis will decrease. Plants cannot photosynthesise if it gets too hot.

-If you plot the rate of photosynthesis against the levels of these three limiting factors, you get graphs like the ones above.

-In practice, any one of these factors could limit the rate of photosynthesis.

Maximizing growth

Farmers can use their knowledge of these limiting factors to increase crop growth in greenhouses. They may use artificial light so that photosynthesis can continue beyond daylight hours, or in a higher-than-normal light intensity. The use of paraffin lamps inside a greenhouse increases the rate of photosynthesis because the burning paraffin produces carbon dioxide and heat too.

Plants and minerals

Plants need to take in a number of elements to stay alive. The most important are:

- carbon
- hydrogen
- oxygen

Plants get hydrogen and oxygen from water in the soil, and carbon and oxygen from carbon dioxide and oxygen in the atmosphere. Water and carbon dioxide are used to synthesise food during photosynthesis. Oxygen is used to release energy from food during respiration.

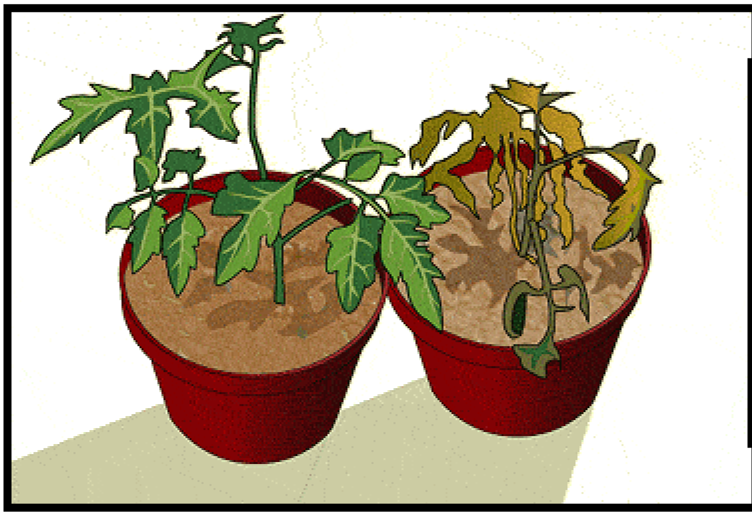
In addition to these three elements, plants need a number of minerals for healthy growth. These are absorbed through the roots as mineral ions dissolved in the soil water. Two important mineral ions needed by plants are:

- Nitrate - for making amino acids, which are needed to make proteins

- Magnesium - for making chlorophyll

If a plant does not get enough minerals, its growth will be poor. It will suffer from deficiency symptoms:

- deficient in nitrate - it will suffer from stunted growth
- deficient in magnesium - it's leaves will turn yellow



The tomato plant on the left is healthy; the one on the right is growing in conditions where mineral ions are deficient

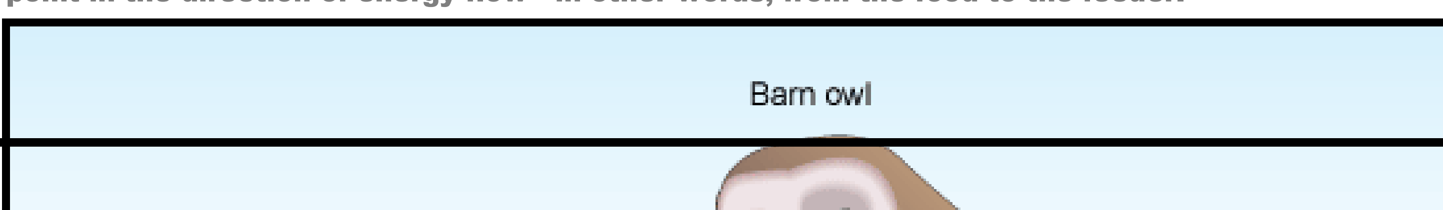
FOOD CHAINS AND CYCLES

Food chains show the feeding relationships between living things. Pyramids of biomass reveal the mass of living material at each stage in a chain. The amount of material and energy decreases from one stage to the next. Food production is more efficient if the food chain is short, or if energy losses from animals are reduced.

The carbon cycle shows how carbon moves from the atmosphere, through various animals and plants, then back to the atmosphere again.

Food chains

A food chain shows what eats what in a particular habitat. For example, grass seed is eaten by a vole, which is eaten by a barn owl. The arrows between each item in the chain always point in the direction of energy flow - in other words, from the food to the feeder.



The Sun is the ultimate source of energy for most communities of living things. Green plants absorb some of the Sun's light energy to make their own food by photosynthesis. The other organisms in a food chain are consumers, because they all get their energy and biomass by consuming - eating - other organisms.

It helps if you can recall the meaning of some common words used with food chains.

Common words used with food chains and their meaning

Word	Meaning
Producers	Green plants - they make food by photosynthesis.
Primary consumers	Usually eat plant material - they are herbivores. For example rabbits, caterpillars, cows and sheep.
Secondary consumers	Usually eat animal material - they are carnivores. For example cats, dogs and lions.
Predators	Kill for food. They are either secondary or tertiary consumers
Prey	The animals that predators feed on.
Scavengers	Feed on dead animals. For example, crows, vultures and hyenas are scavengers.
Decomposers	Feed on dead and decaying organisms, and on the undigested parts of plant and animal matter in faeces.

Energy transfer

Energy is transferred along food chains from one stage to the next. But not all of the energy available to organisms at one stage can be absorbed by organisms at the next one. The amount of available energy decreases from one stage to the next.

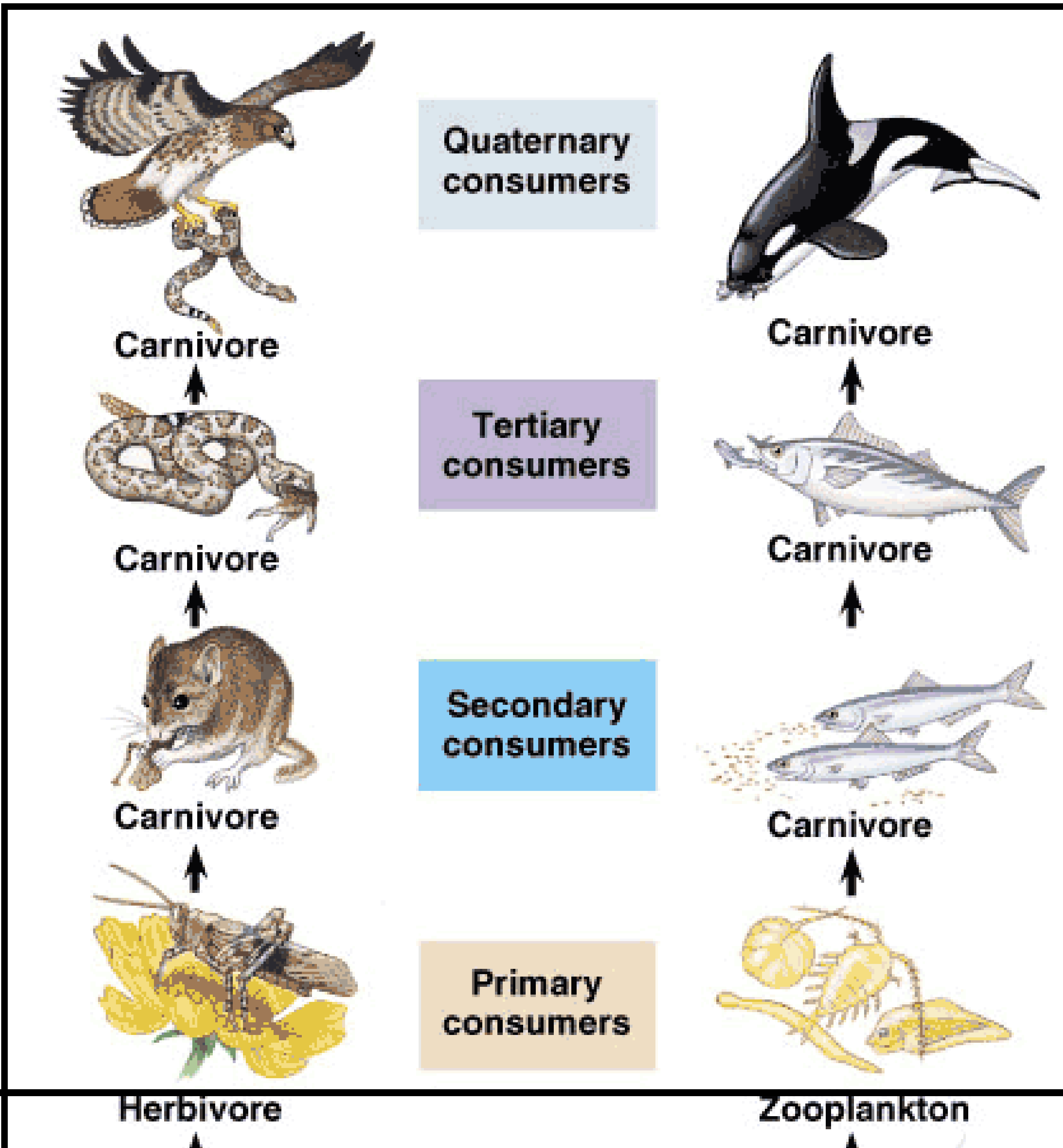
Some of the available energy goes into growth and the production of offspring. This energy becomes available to the next stage, but most of the available energy is used up in other ways:

- energy released by respiration is used for movement and other life processes, and is eventually lost as heat to the surroundings

- energy is lost in waste materials, such as faeces

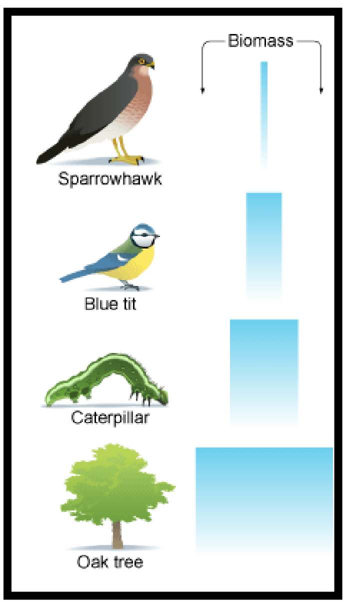
All of the energy used in these ways returns to the environment, and is not available to the next stage. The animation shows how the level of available energy goes down as it is transferred through a temperate forest food chain.

Most food chains are pretty short. There are rarely more than four stages, because a lot of energy is lost at each stage.



Pyramids of biomass

Biomass means the mass of living material at a stage in a food chain. The biomass goes down as you go from one stage to the next, just like the amount of energy.



A pyramid of biomass is a chart, drawn to scale, showing the biomass at each stage in a food chain. The bars become narrower as you reach the top. This pyramid of biomass is for the food chain:

Oak tree → caterpillar → blue tit → sparrowhawk

Note that you do not need to draw the organisms. But you must draw your pyramid of biomass to scale. Each bar should be labelled with the name of the organism.

Efficiency of food production

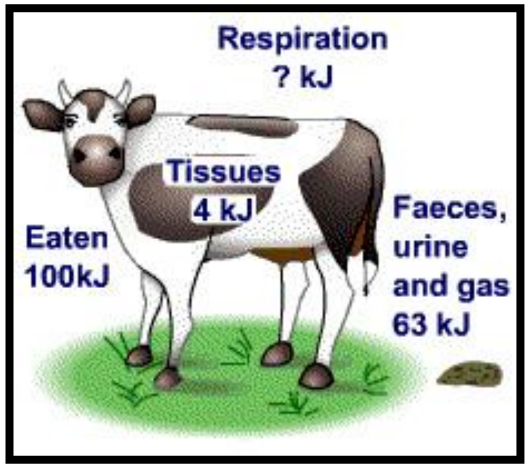
The efficiency of food production can be improved by reducing the amount of energy lost to the surroundings. This can be done by:

- **preventing animals moving around too much**

- keeping their surroundings warm

Mammals and birds maintain a constant body temperature using energy released by respiration. As a result, their energy losses are high. Keeping pigs and chickens in warm sheds with little space to move around allows more efficient food production. But this raises moral concerns about the lives of such animals. In reality, a balance must be reached between the needs of farmers and consumers and the welfare of the animals.

Calculating energy efficiency



This bullock has eaten 100 kJ of stored energy in the form of grass, and excreted 63 kJ in the form of faeces, urine and gas. The energy stored in its body tissues is 4 kJ. So how much has been used up in respiration?

The energy released by respiration = 100 - 63 - 4 = 33 kJ

Only 4 kJ of the original energy available to the bullock is available to the next stage, which might be humans. The efficiency of this energy transfer is:

Efficiency = 4/100 x 100 = 4%

Shorter food chains

Food production is more efficient if the food chain is short, because a higher percentage of energy is available to us.

The carbon cycle

All cells - whether animal, plant or bacteria - contain carbon, because they all contain proteins, fats and carbohydrates. Plant cell walls, for example, are made of cellulose - a carbohydrate.

Carbon is passed from the atmosphere, as carbon dioxide, to living things, passed from one organism to the next in complex molecules, and returned to the atmosphere as carbon dioxide again. This is known as the carbon cycle.

Removing carbon dioxide from the atmosphere

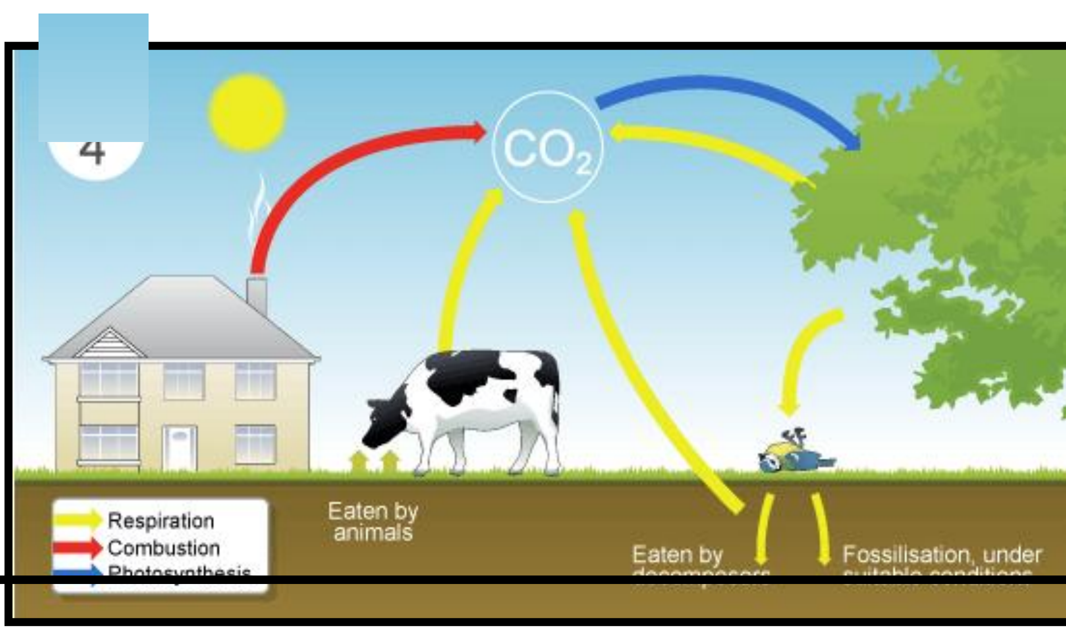
Green plants remove carbon dioxide from the atmosphere by photosynthesis. The carbon becomes part of complex molecules such as proteins, fats and carbohydrates in the plants.

Returning carbon dioxide to the atmosphere

Organisms return carbon dioxide to the atmosphere by respiration. It is not just animals that respire. Plants and microorganisms do, too.

Passing carbon from one organism to the next

When an animal eats a plant, carbon from the plant becomes part of the fats and proteins in the animal. Microorganisms and some animals feed on waste material from animals, and the remains of dead animals and plants. The carbon then becomes part of these microorganisms and detritus feeders.



Materials from living things decay because they are digested by microorganisms. This process happens faster in warm, moist conditions with plenty of oxygen. Decay can be very slow in cold, dry conditions, and when there is a shortage of oxygen.

ENZYMES AND DIGESTION

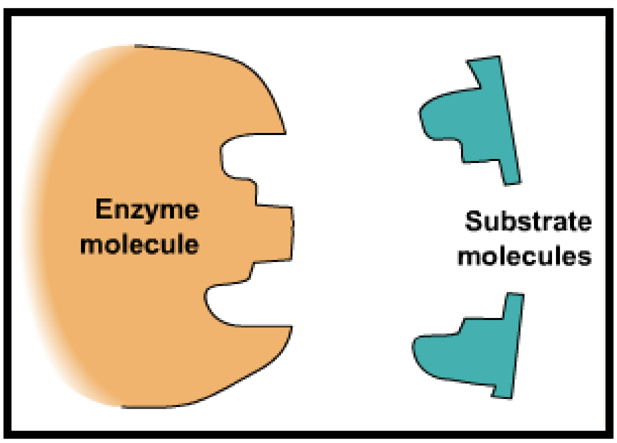
Enzymes are biological catalysts. There are optimum temperatures and pH values at which their activity is greatest. Enzymes are also proteins, and usually denatured above about 45ºC.

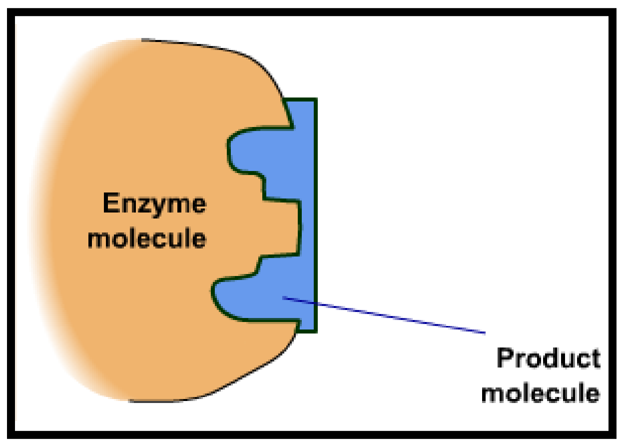
Enzymes are important in respiration. Aerobic respiration releases energy from glucose.

What are enzymes?

Enzymes are biological catalysts - catalysts are substances that increase the rate of chemical reactions without being used up. Enzymes are also proteins that are folded into complex shapes that allow smaller molecules to fit into them. The place where these substrate molecules fit is called the active site.

The pictures show how this works. In this example, two small molecules join together to make a larger one.



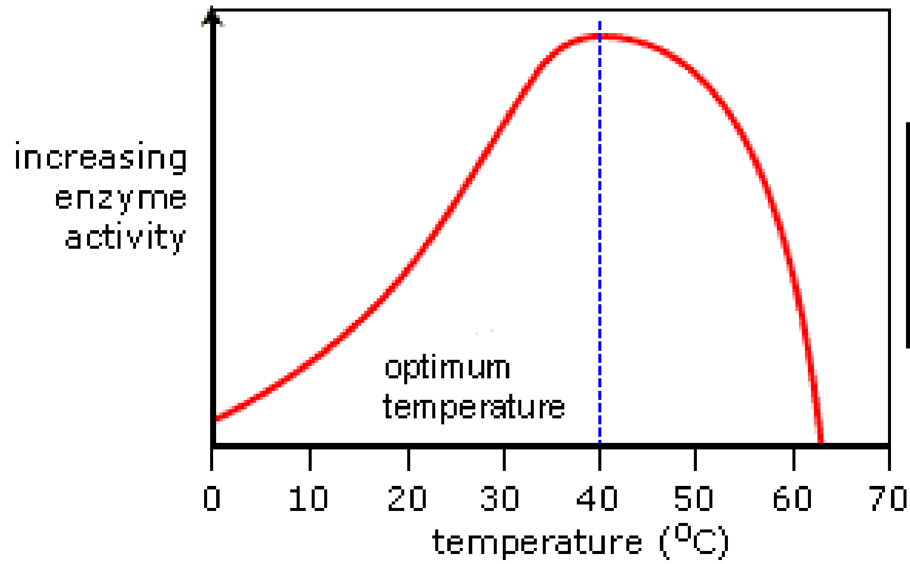


If the shape of the enzyme changes, it's active site may no longer work. We say the enzyme has been denatured. They can be denatured by high temperatures or extremes of pH. Note that it is wrong to say the enzyme has been killed. Although enzymes are made by living things, they are proteins, and not alive.

Temperature and enzymes

As the temperature increases, so does the rate of reaction. But very high temperatures denature enzymes.

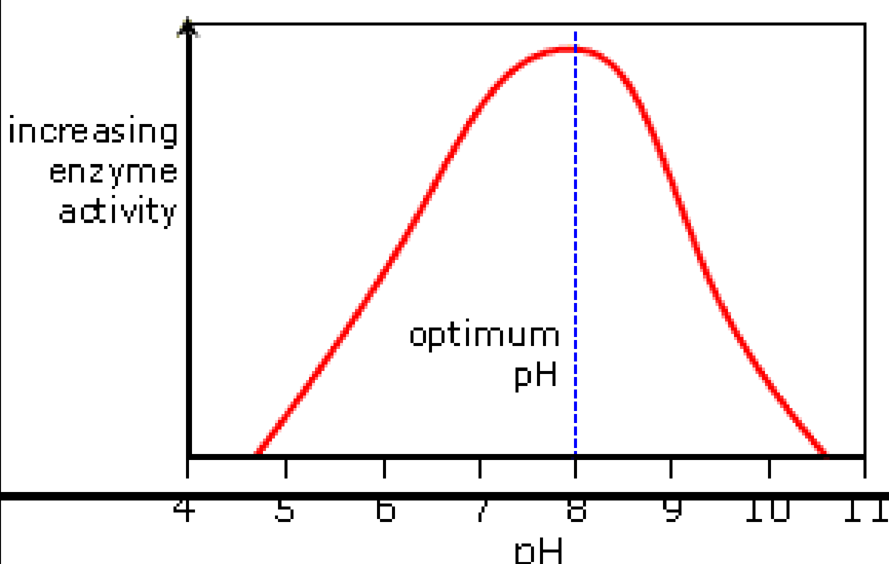
The graph shows the typical change in an enzyme's activity with increasing temperature. The enzyme activity gradually increases with temperature until around 37ºC, or body temperature. Then, as the temperature continues to rise, the rate of reaction falls rapidly, as heat energy denatures the enzyme.



Temper-ature and enzyme activity

PH and enzymes

Changes in pH alter an enzyme's shape. Different enzymes work best at different pH values. The optimum pH for an enzyme depends on where it normally works. For example, intestinal enzymes have an optimum pH of about 7.5. Enzymes in the stomach have an optimum pH of about 2.



pH and enzyme activitv

Enzymes and respiration

Enzymes in cells catalyse photosynthesis, protein synthesis - joining amino acids together, and aerobic respiration.

Aerobic respiration

Respiration is not the same thing as breathing. That is more properly called ventilation. Instead, respiration is a chemical process in which energy is released from food substances, such as glucose - a sugar.

Aerobic respiration needs oxygen to work. Most of the chemical reactions involved in the process happen in tiny objects inside the cell cytoplasm, called mitochondria.

This is the equation for aerobic respiration:

Glucose + oxygen $\longrightarrow$ carbon dioxide + water (+ energy)

The energy released by respiration is used to make large molecules from smaller ones. In plants, for example, sugars, nitrates and other nutrients are converted into amino acids. Amino acids can then join together to make proteins. The energy is also used:

- **to allow muscles to contract in animals**
- **to maintain a constant body temperature in birds and mammals**

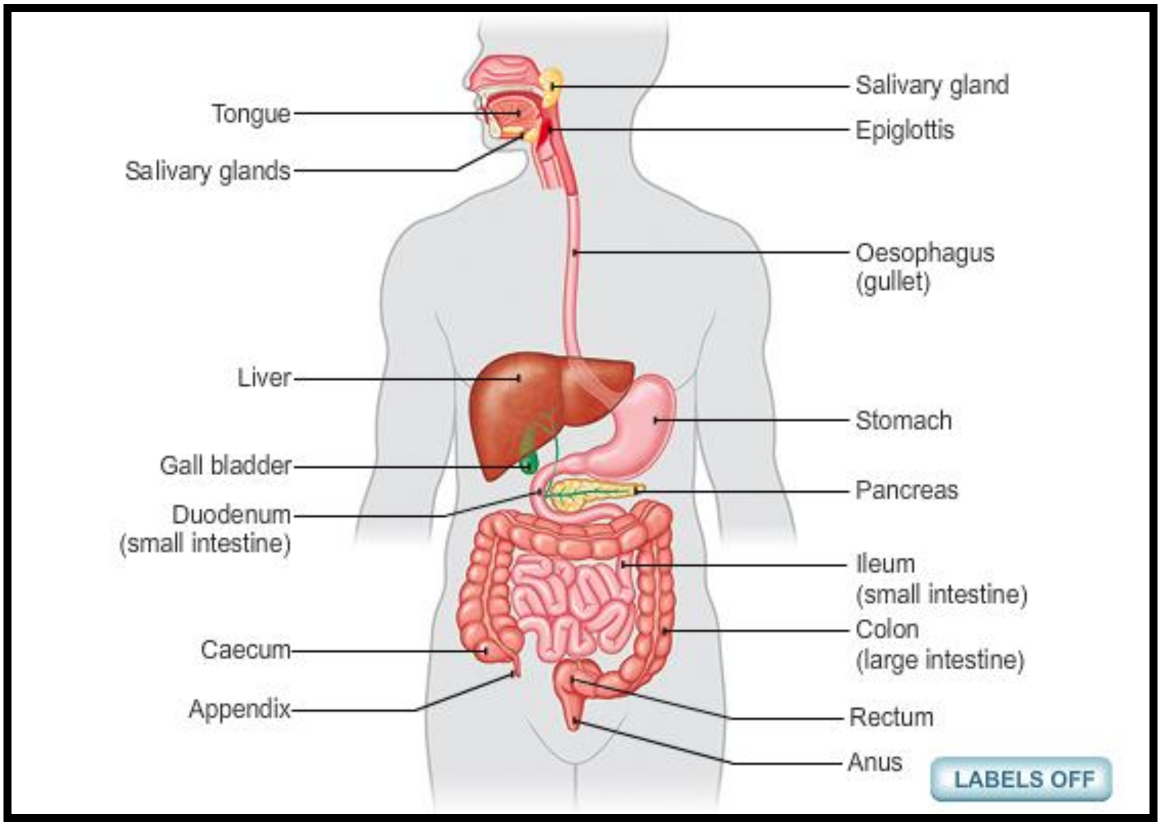
Enzymes are important in digestion. Digestion is the breakdown of carbohydrates, proteins and fats into small soluble substances that can be absorbed into the blood.

Lipases and proteases are used in biological detergents, and enzymes are used in the manufacture of food and drink.

The digestive system

Digestion is the breakdown of large molecules into smaller, soluble molecules that can be absorbed into the body. Digestion happens inside the gut, and relies on enzymes.

This diagram will show you of the main parts of the gut:



Enzymes and digestion

The enzymes involved in respiration, photosynthesis and protein synthesis work inside cells. Other enzymes are produced by specialised cells and released from them; the digestive enzymes are like this. They pass out into the gut, where they catalyse the breakdown of food molecules.

Different enzymes

Different enzymes catalyse different digestion reactions.

Enzymes and their reactions catalysed

enzyme	reaction catalysed
amylase	starch ⟶ sugars
protease	proteins ⟶ amino acids
lipase	lipids ⟶ fatty acids + glycerol

Amylase is an example of a carbohydrase. Lipids are fats and oils.

Different parts of the gut

Different parts of the gut produce different enzymes.

Where enzymes are produced

enzyme	where produced
amylase	salivary glands, pancreas, small intestine
protease	stomach, pancreas, small intestine
lipase	pancreas, small intestine

Summary

Overall, this means that:

- **Amylase catalyses the breakdown of starch into sugars in the mouth and small intestine.**
- **Proteases catalyse the breakdown of proteins into amino acids in the stomach and small intestine.**
- **Lipases catalyse the breakdown of fats and oils into fatty acids and glycerol in the small intestine.**

Other substances in digestion

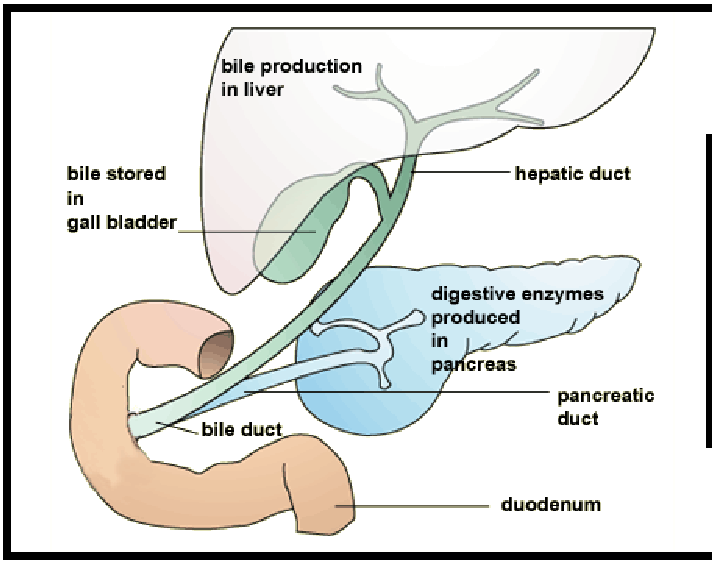
You should recall that different enzymes work best at different pH values. The digestive enzymes are a good example of this.

Enzymes in the stomach

The stomach produces hydrochloric acid. This helps to begin digestion, and it kills many harmful microorganisms that might have been swallowed along with the food. The enzymes in the stomach work best in acidic conditions - in other words, at a low pH.

Enzymes in the small intestine

After the stomach, food travels to the small intestine. The enzymes in the small intestine work best in alka-line conditions, but the food is acidic after being in the stomach. A substance called bile neutralises the acid to provide the alkaline conditions needed in the small intestine.



Bile and enzyme production in the liver and pancreas

Enzymes in industry

Enzyme names

The names of the different types of enzymes usually end in the letters -ASE. Three of the most common enzymes with their chemical actions are:

- lipase - breaks down fats
- protease - breaks down proteins
- carbohydrase - breaks down carbohydrates

Enzyme uses

Enzymes allow certain industrial processes to be carried out at normal temperatures and pressures, thereby reducing the amount of energy and expensive equipment needed. Enzymes are also used in the home, for example, in 'biological' detergents. The table shows some common enzyme uses you should be familiar with.

Uses of enzymes

Enzyme	Use
protease	used to pre-digest proteins during the manufacture of baby foods
lipase	used - together with protease - in biological detergents to break down - digest - the substances in stains into smaller, water soluble substances
carbohydrase	used to convert starch syrup, which is relatively cheap, into sugar syrup, which is more valuable - for example, as an ingredient in sports drinks
isomerase	used to convert glucose syrup into fructose syrup - fructose is sweeter than glucose, so it can be used in smaller amounts in slimming foods

HOMEOSTASIS

The conditions inside the body must be controlled within narrow limits. This is called homeostasis. These conditions include water content, ion content, body temperature and blood glucose concentration.

The thermoregulatory centre is the part of the brain that monitors and controls body temperature. The pancreas meanwhile monitors and controls blood glucose concentration. It produces a hormone called insulin that reduces blood glucose levels. Diabetes is a disease which can be caused by insufficient insulin.

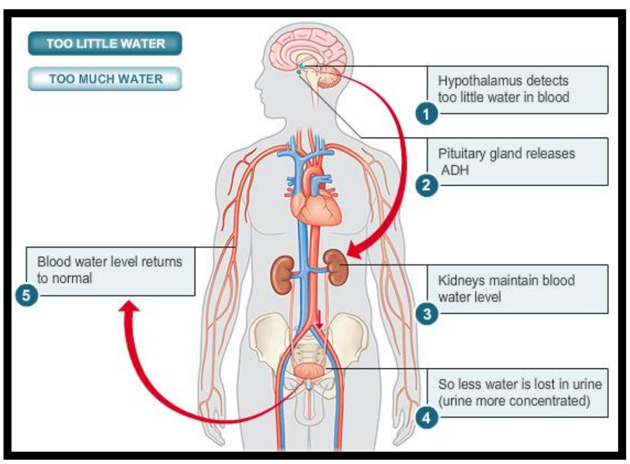
Removing waste products

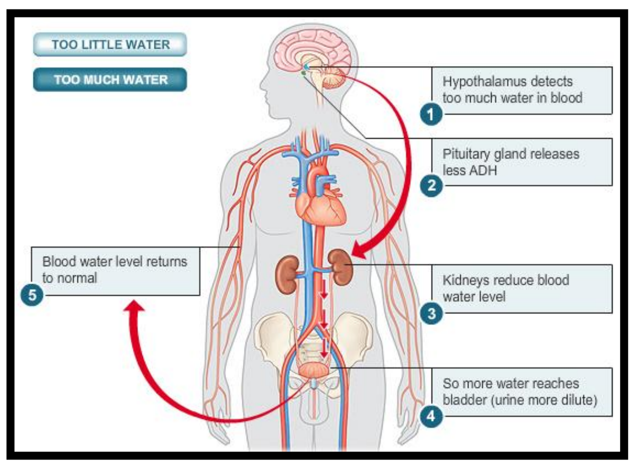
Waste products must be removed from the body. If they are not, they will increase in concentration and may interfere with chemical reactions or damage cells. Waste products that must be removed include carbon dioxide and urea.

Production and removal of waste products

Waste product	Why is it produced?	How is it removed?
carbon dioxide	it is a product of aerobic respiration	through the lungs when we breathe out
urea	it is produced in the liver when excess amino acids are broken down	the kidneys remove it from the blood and make urine, which is stored in the bladder temporarily

Water enters the body through food and drink. It is also a product of aerobic respiration in cells. If the amount of water in the body is wrong, cells can be damaged because too much water enters or leaves them. The pictures show how the amount of water lost as urine is controlled:



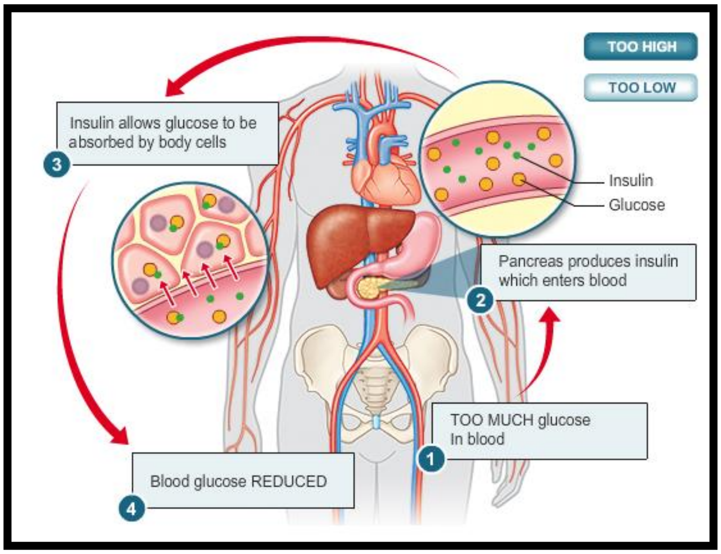


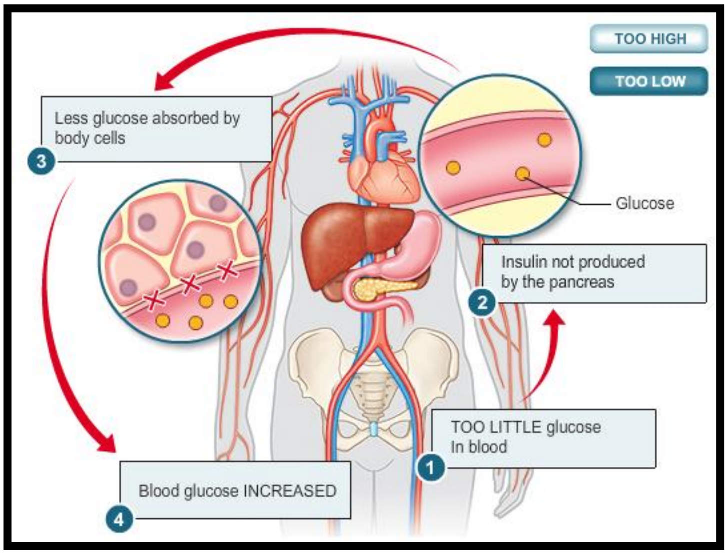
Controlling blood glucose

The pancreas and insulin

The pancreas monitors and controls the concentration of glucose in the blood. It produces a hormone called insulin. Insulin causes glucose to move from the blood into cells. It lowers the blood glucose concentration if it has become too high. This can happen after eating a meal that is rich in carbohydrates (for example, sweets, potatoes, bread, rice or pasta).

The pictures show how this works.





Diabetes

Diabetes is a disease where the concentration of glucose in the blood is not controlled properly by the body. In type 1 diabetes, the pancreas does not produce enough insulin. This can lead to high levels of glucose in the blood, which can be fatal.

Types of Diabetes

There are two types of treatment for diabetes:

- Careful monitoring of food intake, with particular care taken over carbohydrates - which are digested into glucose.

- Injecting insulin into the blood before meals. The extra insulin causes glucose to be taken up by the liver and other tissues. Cells get the glucose they need for respiration, and the blood glucose concentration stays normal.

Temperature regulation

Human enzymes work best at 37°C, so the body's temperature is controlled. A part of the brain called the thermoregulatory centre monitors and controls body temperature. It gathers information as nerve impulses from temperature receptors in:

- the brain - these are sensitive to the temperature of the blood flowing there

- the skin - these are sensitive to skin temperature

Sweating

Sweating is one way to help cool the body. We sweat more in hot conditions, so more water is lost from the body. This water must be replaced through food or drink to maintain the balance of water in the body.

Ions such as sodium ions and chloride ions are also lost when we sweat. They must be replaced through food and drink. If the body's ion content is wrong, cells can be damaged.

Temperature regulation - higher

If you become too hot or too cold, there are several ways in which your temperature can be controlled. They involve sweating, shivering, skin capillaries and hairs.

Too hot

When we get too hot:

- Sweat glands in the skin release more sweat. This evaporates, removing heat energy from the skin.

- Blood vessels leading to the skin capillaries become wider - they dilate - allowing more blood to flow through the skin, and more heat to be lost.

Too cold

When we get too cold:

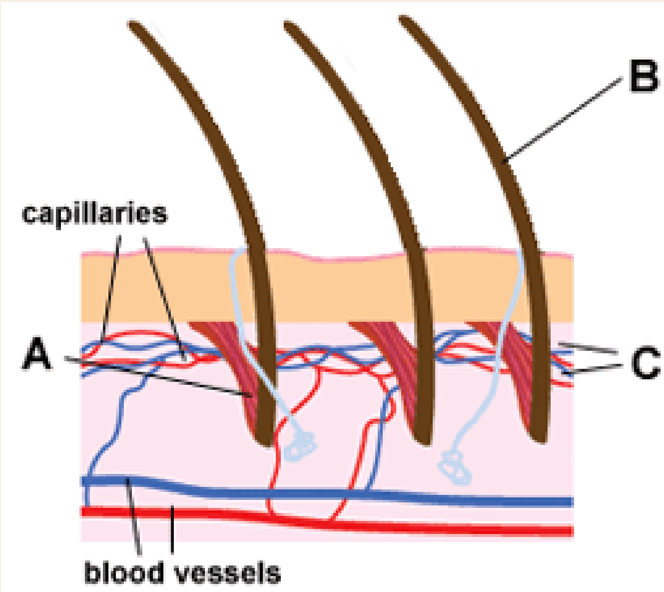
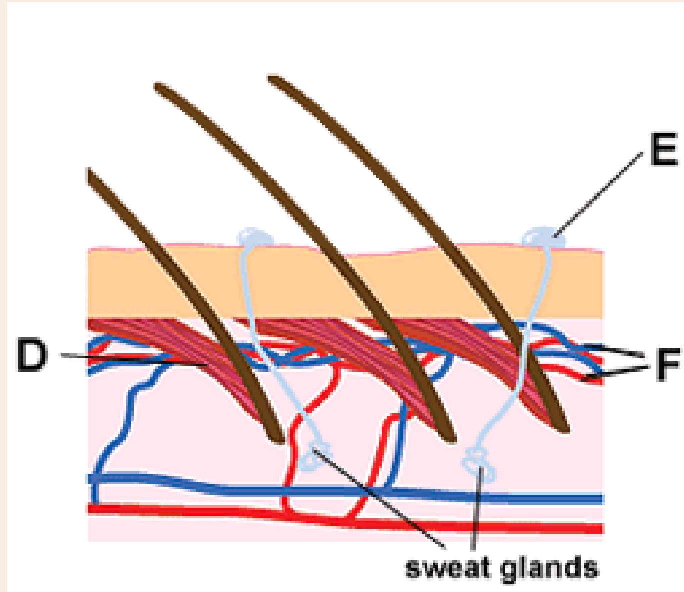
- Muscles contract rapidly - we shiver. These contractions need energy from respiration, and some of this is released as heat.

- Blood vessels leading to the skin capillaries become narrower - they constrict- letting less blood flow through the skin and conserving heat in the body.

The hairs on the skin also help to control body temperature. They lie flat when we are warm, and rise when we are cold. The hairs trap a layer of air above the skin, which helps to insulate the skin against heat loss.

Controlling temperature

Too cold	Too hot

Too cold	Too hot
	
A - Hair muscles pull hairs on end. B - Erect hairs trap air. C - Blood flow in capillaries decreases.	D - Hair muscles relax. Hairs lie flat so heat can escape. E - Sweat secreted by sweat glands. Cools skin by evaporation. F - Blood flow in capillaries increases.

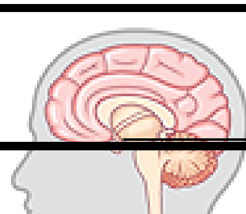
Remember: Capillaries do not move up and down inside the skin. Temperature is regulated by controlling the amount of blood which flows through the capillaries.

HORMONES

Hormones are chemical substances that help to regulate processes in the body. Hormones are secreted by glands and travel to their target organs in the bloodstream. Several hormones are involved in the female menstrual cycle. Hormones can be used to control human fertility and have advantages and disadvantages.

Hormones and glands

Hormones are chemicals secreted by glands in the body. Different hormones affect different target organs. The bloodstream transports hormones from the glands to the target organs.



Brain
Contains a sensitive centre called the hypothalamus, which controls the pituitary gland

Hormones regulate the functions of many cells and organs

The target organ and effects of glands and hormones

Gland	Hormone	Target organs	Effect
adrenal gland	adrenalin	vital organs, e.g. liver and heart	Prepares body for action - 'fight or flight'.
ovary	oestrogen	ovaries, uterus, pituitary gland	Controls puberty and the menstrual cycle in females; stimulates production of LH and suppresses the production of FSH in the pituitary gland.
ovary	progesterone	uterus	Maintains the lining of the womb - suppresses

Gland	Hormone	Target organs	Effect
			FSH production in the pituitary gland.
pancreas	insulin	liver	Controls blood sugar levels.
pituitary gland	anti-diuretic hormone (ADH)	kidney	Controls blood water level by triggering uptake of water in kidneys.
pituitary gland	follicle stimulating hormone (FSH)	ovaries	Triggers egg ripening and oestrogen production in ovaries.
pituitary gland	luteinising hormone (LH)	ovaries	Triggers egg release and progesterone production in ovaries.
testes	testosterone	male reproductive organs	Controls puberty in males.

Hormones in the menstrual cycle

The menstrual cycle in women is a recurring process in which the lining of the uterus - womb - is prepared for pregnancy, and if pregnancy does not happen, the lining is shed at menstruation.

Several hormones control this cycle, which includes controlling the release of an egg each month from an ovary, and changing the thickness of the uterus lining. These hormones are secreted by the ovaries and pituitary gland.

FSH

The hormone FSH is secreted by the pituitary gland. FSH makes two things happen:

1. it causes an egg to mature in an ovary
2. it stimulates the ovaries to release the hormone oestrogen

Oestrogen

The hormone oestrogen is secreted by the ovaries. Oestrogen makes two things happen:

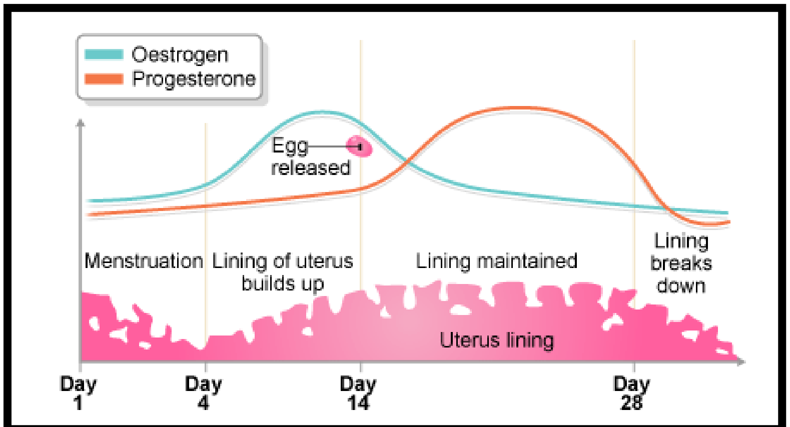
1. it stops FSH being produced - so that only one egg matures in a cycle
2. it stimulates the pituitary gland to release the hormone LH

LH

The hormone LH causes the mature egg to be released from the ovary.

This image shows how the level of oestrogen changes during the menstrual cycle. Progesterone is another hormone secreted by ovaries: it maintains the lining of the uterus and stays high during pregnancy.

Hormone levels during the menstrual cycle



Controlling fertility

Human fertility is controlled by hormones. This means that knowledge of hormones can be used to decide to increase, or reduce, the chances of fertilisation and pregnancy.

Oral contraceptives

The oral contraceptive, 'the pill', greatly reduces the chances of mature eggs being produced. The pill contains oestrogen, or oestrogen and progesterone. These hormones inhibit the production of FSH, which in turn stops eggs maturing in the ovaries.

Contraceptive pills

Fertility treatment

Some women have difficulty becoming pregnant because they don't produce enough FSH to allow their eggs to mature. 'Fertility drugs' contain FSH, which stimulates eggs to mature in the ovary.

THE NERVOUS SYSTEM

The nervous system allows the body to respond to changes in the environment. This is a process usually coordinated by the brain. Reflex actions are extra-rapid responses to stimuli, and this process also involves the nervous system, but bypasses the brain.

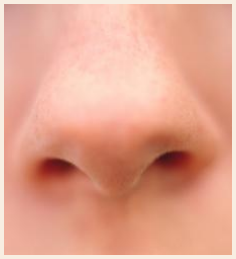
Receptors and effectors

Receptors

Receptors are groups of specialised cells. They can detect changes in the environment, which are called stimuli, and turn them into electrical impulses. Receptors are often located in the sense organs, such as the ear, eye and skin. Each organ has receptors sensitive to particular kinds of stimulus.

Receptors

sense organs	receptors sensitive to
 Skin	touch, pressure, pain and temperature
 Tongue	chemicals in food

sense organs	receptors sensitive to
 Nose	chemicals in the air
 Eyes	light
 Ears	sound and position of the head

The central nervous system - CNS - in humans consists of the brain and spinal cord. When a receptor is stimulated, it sends a signal along the nerve cells - neurones - to the brain. The brain, then co-ordinates the response.

Effectors

An effector is any part of the body that produces the response. Here are some examples of effectors:

- **a muscle contracting to move the arm**
- **a muscle squeezing saliva from the salivary gland**
- **a gland releasing a hormone into the blood**

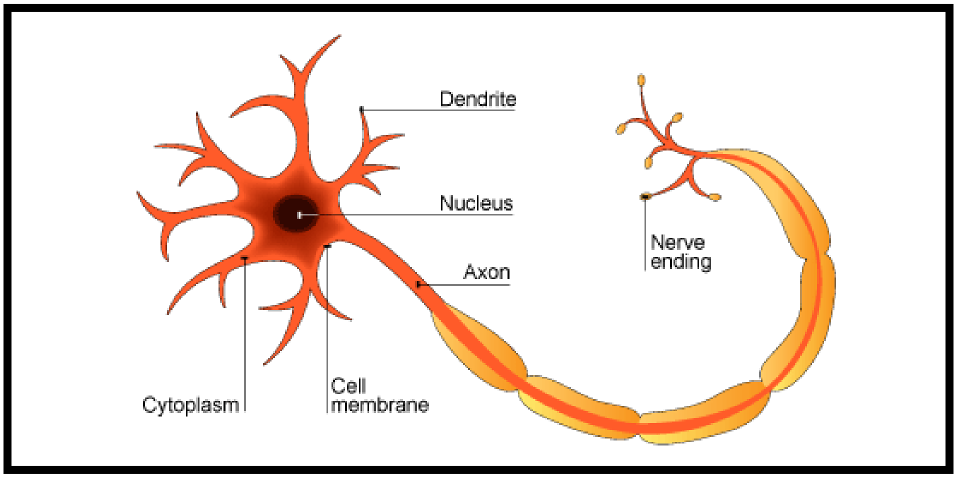
Neurones

Neurones are nerve cells. They carry information as tiny electrical signals. There are three different types of neurones, each with a slightly different function.

1. **Sensory neurons carry signals from receptors to the spinal cord and brain.**

2. **Relay neurons** carry messages from one part of the CNS to another.
3. **Motor neurons** carry signals from the CNS to effectors.

The diagram below shows a typical neuron - in this case, a motor neuron. It has tiny branches at each end and a long fibre carries the signals.



A motor neuron

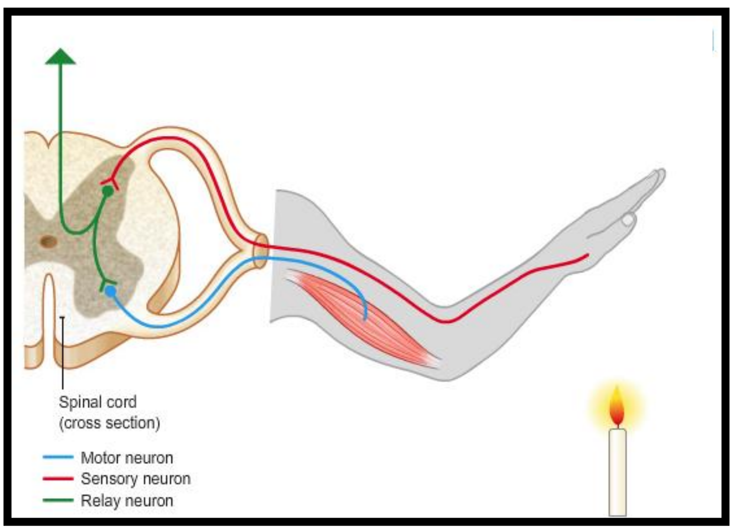
Synapses

Where two neurones meet, there is a tiny gap called a synapse. Signals cross this gap using chemicals. One neurone releases the chemical into the gap. The chemical diffuses across the gap and makes the next neurone transmit an electrical signal.

Reflex actions

When a receptor is stimulated, it sends a signal to the central nervous system, where the brain co-ordinates the response. But sometimes a very quick response is needed, one that does not need the involvement of the brain. This is a reflex action.

Reflex actions are rapid and happen without us thinking. For example, you would pull your hand away from a hot flame without thinking about it. The animation below allows you to step through each stage of the reflex arc.



This is what happens:

1. **receptor detects a stimulus - change in the environment**
2. **sensory neurone sends signal to relay neurone**
3. **motor neurone sends signal to effector**
4. **effector produces a response**

The way the iris in our eye adjusts the size of the pupil in response to bright or dim light is also a reflex action.

In bright light:

- **Radial muscles of the iris relax.**
- **Circular muscles of the iris contract.**
- **Less light enters the eye through the contracted pupil.**

In dim light:

- **Radial muscles of the iris contract.**
- **Circular muscles of the iris relax.**
- **More light enters the eye through the dilated pupil.**

DEFENDING AGAINST INFECTION

Pathogens are microorganisms - such as bacteria and viruses - that cause disease. Bacteria release toxins, and viruses damage our cells. White blood cells can ingest and destroy pathogens. They can produce antibodies to destroy pathogens, and antitoxins to neutralize toxins.

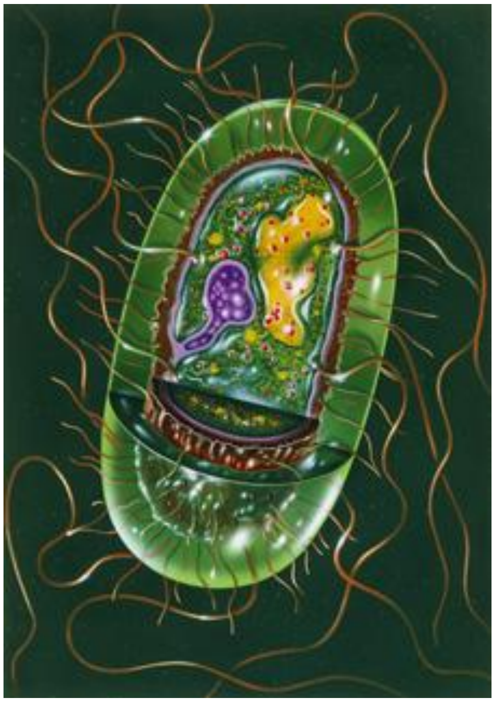
In vaccination pathogens are introduced into the body in a weakened form. The process causes the body to produce enough white blood cells to protect itself against the pathogens, while not getting diseased.

Antibiotics are effective against bacteria, but not against viruses. Some strains of bacteria are resistant to antibiotics.

Pathogens - bacteria

Pathogens are microorganisms that cause infectious disease. Bacteria and viruses are the main pathogens.

Bacteria

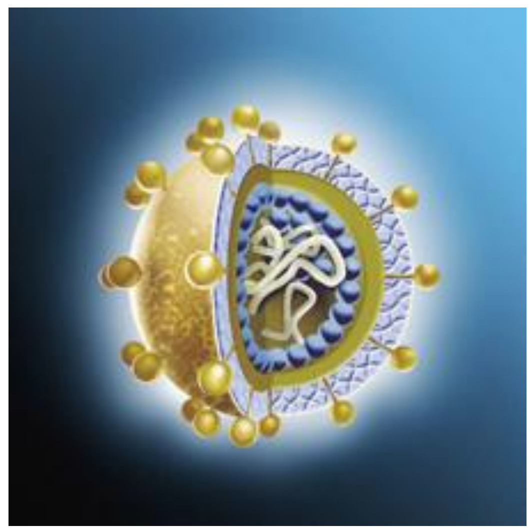


Bacteria are microscopic organ-isms. They come in many shapes and sizes, but even the largest are only 10 micrometres long - 10 millionths of a metre.

Bacteria are living cells and, in favourable conditions, can multiply rapidly. Once inside the body, they release poisons or toxins that make us feel ill. Diseases caused by bacteria include:-

-food poisoning
-cholera
-typhoid
-whooping cough
-gonorrhoea - a sexually transmitted disease

Pathogens - viruses



Viruses are many times smaller than bacteria. They are among the smallest organisms known and consist of a fragment of genetic material inside a protective protein coat.

Viruses can only reproduce inside host cells, and they damage the cell when they do this. A virus can get inside a cell and, once there, take over and make hundreds of thousands of copies of itself. Eventually the virus copies fill the whole host cell and burst it open. The viruses are then passed out in the bloodstream, the airways, or by other routes.

Diseases caused by viruses include:

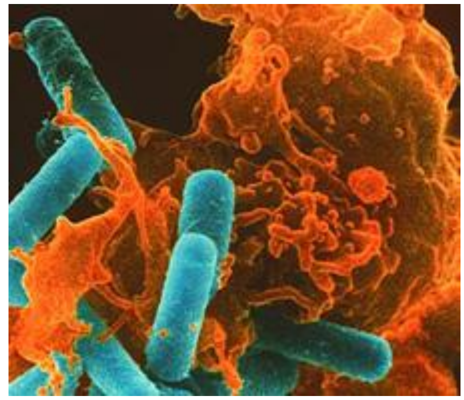
- influenza - flu
- colds
- measles
- mumps
- rubella
- chicken pox
- AIDS

White blood cells

The body has different ways of protecting itself against pathogens. The first defence is passive immunity. This is aimed at stopping the pathogen getting into the body in the first place. The body's passive immunity system includes the skin, mucus and cilia in the respiratory system, acid in the stomach, and enzymes in tears.

If a pathogen still manages to get into the body, the second defence takes over. This is called active immunity, and the white blood cells have key functions in this.

Functions of the white blood cells



White blood cells can:

- ingest pathogens and destroy them
- produce antibodies to destroy pathogens
- produce antitoxins that neutralise the toxins released by pathogens

In a written examination, it is easy to get carried away and waffle on about things such as invaders and battles, but stick to the point. Note that:

- the pathogens are not the disease – they cause the disease
- white blood cells do not eat the pathogens – they ingest them
- antibodies and antitoxins are not living things – they are specialised proteins

More about white blood cells

There are several different types of white blood cells, each with different functions, but they can be put into two main groups:

- phagocytes or macrophages
- lymphocytes

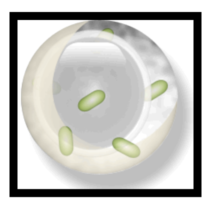
Phagocytes

Phagocytes can easily pass through blood vessel walls into the surrounding tissue and move towards pathogens or toxins. They then either:

- ingest and absorb the pathogens or toxins
- release an enzyme to destroy them

Having absorbed a pathogen, the phagocytes may also send out chemical messages that help nearby lymphocytes to identify the type of antibody needed to neutralise them.

Lymphocytes



Pathogens contain certain chemicals that are foreign to the body and are called antigens. Each lymphocyte carries a specific type of antibody - a protein that has a chemical 'fit' to a certain antigen. When a lymphocyte with the appropriate antibody meets the antigen, the lymphocyte reproduces quickly, and makes many copies of the antibody that neutralises the pathogen.

Antibodies neutralise pathogens in a number of ways:

- **they bind to pathogens and damage or destroy them**
- **they coat pathogens, clumping them together so that they are easily ingested by phagocytes**
- **they bind to the pathogens and release chemical signals to attract more phagocytes**

Lymphocytes may also release antitoxins that stick to the appropriate toxin and stop it damaging the body.

Vaccination

People can be immunised against a pathogen through vaccination. Different vaccines are needed for diffe-rent pathogens.

Vaccination involves putting a small amount of an inactive form of a pathogen, or dead pathogen, into the body. Vaccines can contain:

- **live pathogens treated to make them harmless**
- **harmless fragments of the pathogen**
- **toxins produced by pathogens**
- **dead pathogens**

These all act as antigens. When injected into the body, they stimulate white blood cells to produce antibodies against the pathogen.

Because the vaccine contains only a weakened or harmless version of a pathogen, the vaccinated person is not in danger of developing disease - although some people may suffer a mild reaction. If the person does get infected by the pathogen later, the required lymphocytes are able to reproduce rapidly and destroy it.

Vaccines and boosters

Vaccines in early childhood can give protection against many serious diseases. Sometimes more than one vaccine is given at a time, like the MMR triple vaccine against mumps, measles and rubella.

Sometimes vaccine boosters are needed, because the immune response 'memory' weakens over time. Anti-tetanus injections may need to be repeated every ten years.

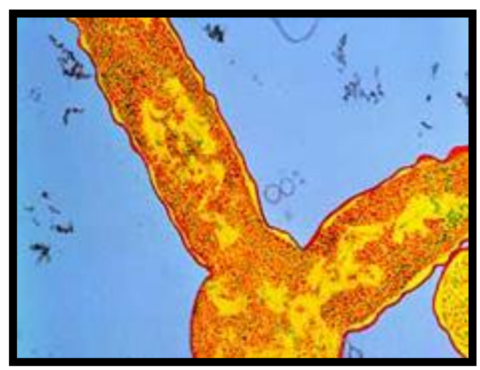
Antibiotics

Antibiotics are substances that kill bacteria or stop their growth. They do not work against viruses: it is difficult to develop drugs that kill viruses without also damaging the body's tissues.

How some common antibiotics work

antibiotic	how it works
penicillin	breaks down cell walls
erythromycin	stops protein synthesis
neomycin	stops protein synthesis
vancomycin	stops protein synthesis
ciprofloxacin	stops DNA replication

Penicillin



The first antibiotic - penicillin - was discovered in 1928 by Alexander Fleming. He noticed that some bacteria he had left in a petri dish had been killed by naturally occurring penicillium mould.

Since the discovery of penicillin, many other antibiotics have been discovered or developed. Most antibiotics used in medicine have been altered chemically to make them more effective and safer for humans.

Resistance

Bacterial strains can develop resistance to antibiotics. This happens because of natural selection. In a large population of bacteria, there may be some cells that are not affected by the antibiotic. These cells survive and reproduce, producing even more bacteria that are not affected by the antibiotic.

MRSA is methicillin-resistant staphylococcus aureus. It is very dangerous because it is resistant to most antibiotics. It is important to avoid over-use of antibiotics, so we can slow down, or stop, the development of other strains of resistant bacteria.

Cleanliness

One simple way to reduce the risk of infection is to maintain personal hygiene and to keep hospitals clean.

DIET AND EXERCISE

Regular exercise and a balanced diet are needed to keep the body healthy. Too little food leads to a person being underweight and prone to illness, while too much food and not enough exercise leads to a person being overweight and prone to other illnesses. Excess cholesterol increases the risk of heart disease, and excess salt causes high blood pressure and increases the risk of heart disease and stroke.

Nutrients

A mixture of different types of food in the correct amounts is needed to maintain health. The main food groups are:

The main food groups

food group	found in	required by our bodies for
	potatoes, pasta, bread, bananas, sugar and rice	A source of **energy** for other life processes. Sometimes referred to as **fibre**, which is actually just one - very common - type of carbohydrate.
	cheese, butter, margarine and oils	Fats are needed to make cell membranes and to **insulate** our bodies. They also contain important fat-soluble vitamins.
	meat, fish, eggs and cheese	Growth and repair.

food group	found in	required by our bodies for
	whole meal bread, fruit, vegetables and pulses	The fibre or roughage in our diet is not digested, but is important because it allows the muscles in our intestines to move food through our system by peristalsis.

Metabolic rate

A healthy diet contains all the different nutrients in the correct amounts, and provides the right amount of energy for each individual. An unbalanced diet can lead to a person becoming malnourished. They may be too thin or too fat as a result, and they may suffer from deficiency diseases.

Chemical reactions

Respiration is the chemical reaction that allows cells to release energy from food. The metabolic rate is the speed at which such chemical reactions take place in the body. It varies because of several factors, including:

- age
- gender - male or female
- the proportion of muscle to fat in the body
- the amount of exercise and other physical activity
- genetic traits

The metabolic rate increases as we exercise and stays high for a while afterwards.

The right amount of food

Not enough food

If you don't eat enough food, you will become too thin and may suffer from health problems. These include:

- irregular periods in women
- reduced resistance to infection
- deficiency diseases

Deficiency diseases include rickets - which affects proper growth of the skeleton and is caused by insufficient vitamin D - and kwashiorkor - which causes a swollen abdomen and is a result of insufficient protein.

Problems such as these are more likely to affect people in the developing world, where it can be more difficult to get enough food.

Too much food

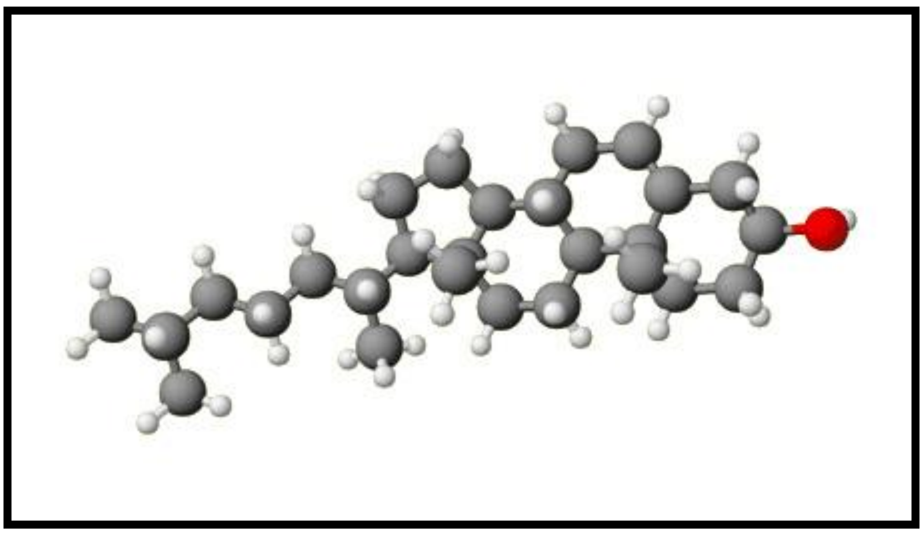
In warm weather, or when you don't do much exercise, you do not need to eat as much food as when it is cold or when you have exerted yourself physically. If you eat too much food without taking enough exercise, you will become overweight. Very fat people are described as obese. Overweight people may suffer from health problems, including:

- diabetes - an illness in which the body is unable to control the amount of sugar in the blood
- arthritis - an illness in which the joints become worn, inflamed and painful
- high blood pressure
- heart disease

The heart

The heart is an organ that needs its own supply of blood to keep it working. If the blood supply is reduced, the heart muscle will not work properly and will become weaker. A heart attack happens when part of the heart does not get any blood because of a blocked artery.

Cholesterol



Cholesterol is a substance found in the blood. It is made in the liver and is needed for healthy cell membranes. However, too much cholesterol in the blood increases the risk of heart disease, and of diseased arteries.

Good and bad cholesterol

The bloodstream transports cholesterol around the body attached to proteins. The combination of cholesterol and protein is called lipoprotein, and there are two types.

1. Low-density lipoproteins - LDLs - carry cholesterol from the liver to the cells.

2. High-density lipoproteins - HDLs - carry excess cholesterol back to the liver.

LDLs are often called 'bad' cholesterol because they lead to fat building up on artery walls, which causes heart disease. HDLs are often called 'good' cholesterol because they help to stop fat building up in the arteries.

Improving the balance

A high proportion of HDLs to LDLs is good for a healthy heart. Monounsaturated and polyunsaturated oils - as found in vegetable oils - help to reduce cholesterol levels in the blood, and also increase the proportion of HDLs compared with LDLs. Check your understanding of such oils by looking at Vegetable oils.

There are also drugs that can improve high blood pressure and high cholesterol levels.

Salt

Table salt is sodium chloride. Too much salt in the diet can lead to high blood pressure, which in turn leads to an increased risk of heart disease and strokes.

Salt is found naturally in many kinds of food, but more is added by food manufacturers - and many people add even more when they are eating. Processed foods often have a high proportion of salt and fat. Salt added to food during processing accounts for about two-thirds of the average salt intake.

ADAPTATION

Adaptations - cold climates

Every organism has certain features or characteristics that allow it to live successfully in its habitat. These features are called adaptations, and we say that the organism is adapted to its habitat. Organisms living in different habitats need different adaptations.

The polar bear

Polar bears are well adapted for survival in the Arctic. They have:

- a white appearance, as camouflage from prey on the snow and ice
- thick layers of fat and fur, for insulation against the cold
- a small surface area to volume ratio, to minimise heat loss
- a greasy coat, which sheds water after swimming

The snowshoe hare

The snowshoe hare has white fur in the winter and reddish-brown fur in the summer. This means that it is camouflaged from its predators for most of the year.

Arctic plants

The Arctic is cold and windy with very little rainfall. Plants in the Arctic often grow very close to the ground and have small leaves. This helps to conserve water and to avoid damage by the wind.

Adaptations – hot climates

The camel

Camels live in deserts that are hot and dry during the day, but cold at night. They are well adapted for survival in the desert. Camels have:

- Large, flat feet to spread their weight on the sand.
- Thick fur on the top of the body for shade, and thin fur elsewhere to allow easy heat loss.
- A large surface area to volume ratio to maximise heat loss.
- The ability to go for a long time without water (they don't store water in their humps, but they lose very little through urination and sweating).
- The ability to tolerate body temperaturesup to 42°C.
- Slit-like nostrils and two rows of eyelashesto help keep the sand out.

Desert plants

Cacti are well adapted for survival in the desert. They have:

- Stems that can store water.
- Widespread root systems that can collect water from a large area.

In addition, cacti have spines instead of leaves. These minimise the surface area and so reduce water loss by transpiration. The spines also protect the cacti from animals that might eat them.

Other adaptations

Animals and plants may have specific features that adapt them to their environment. These include barbs and spines, poisons and warning colours that deter predators and herbivores. Some harmless species may even resemble a poisonous or dangerous species to increase their chances of survival.

CHARACTERISTICS AND CLASSIFICATION

Genetic information from one species can be transferred to another species using genetic engineering. Selective breeding, also called artificial selection, involves people taking charge of selection to produce new varieties of various species. A variety is a type of a particular species that is different in some clear way from other varieties of that species. The characteristics of a species can be used to classify the species. This is sometimes difficult to do.

Genetic engineering

Genetic engineering is also called genetic modification (or GM). It is not the same as cloning. Although cloning techniques are used in genetic engineering, the two things should not be confused.

The table shows some of the differences.

Cloning	Genetic engineering
Produces exact copies.	Produces a unique set of genes.
Genes copied within the same species.	Genes can be swapped across species.

Selective breeding

Natural selection

Species gradually evolve by a process of natural selection. The individuals in any population with the inherited features best suited to the environment in which they live are most likely to survive and reproduce. When they do, they pass on the genetic information for these features to their offspring.

Over time, a species can change its appearance and may even become a new species, unable to reproduce successfully with individuals of the original species.

Artificial selection

Selective breeding, also called artificial selection, involves people taking charge of selection to produce new 'varieties' of various species. A variety is a type of a particular species that is different in some clear way from other varieties of that species.

For example, pedigree dogs come in lots of different varieties (or breeds) - they may be different colours and sizes, but they are all still dogs.

Suppose you wanted a variety of cow that produced a lot of milk. This is what you could do:

- choose or select the cows in your herd that produce the most milk
- only let these cows reproduce
- select the offspring that produce the most milk
- only let these offspring reproduce
- keep repeating the process of selection and breeding until you achieve your goal

The key here is to identify the feature you want, and only breed from the individuals that have that feature. Here are some examples of what selective breeding can produce:

- hens that lay big eggs of a particular colour
- cattle that produce lots of meat
- tomato plants that produce lots of tomatoes
- crops that are resistant to certain plant diseases

Changing the characteristics of a species

The characteristics of a species can be changed by:

- natural selection
- selective breeding
- genetic engineering.

The table shows some differences between these.

	Natural selection	Selective breeding	Genetic engineering
Number of generations needed	very many	many	one

	Natural selection	Selective breeding	Genetic engineering
for change			
Human intervention	not needed	needed	needed
Desired outcome known?	no	yes	yes
New species formed?	yes	no	no
Notes	This is the mechanism of change in Darwin's theory of evolution	This is how new varieties or breeds are usually produced	Genetic information can come from the same species or from a different one

In selective breeding and genetic engineering, there is a goal or desired outcome. For example, we may wish to produce a variety of cow capable of producing a lot of milk, or a bacterium capable of producing insulin.

There is no goal in natural selection: although we find that particular species are well adapted to their environments, natural selection does not 'know' what the species should be like. Individuals that are better suited to their environment are more likely to survive to reproduce, and so pass on their characteristics to the next generation, than those that are poorly suited.

Classification

You will remember from your Key Stage 3 studies that species with similar characteristics are put into groups, and that this is called classification. Remind yourself of the basics of classification by looking here.

Kingdoms

The first rank in this system is called a kingdom. There are five kingdoms, based upon what an organism's cells are like:

1. animals (all multicellular animals)
2. plants (all green plants)
3. fungi (moulds, mushrooms, yeast)
4. prokaryotes (bacteria, blue-green algae)
5. protoctists (Amoeba, Paramecium)

Further divisions

There are several further ranks before we reach a particular species. In order, these are:

- kingdom

- phylum
- class
- order
- family
- genus
- species

For example, lions have the following classification:

- kingdom - animal
- phylum - vertebrate
- class - mammal
- order - carniverous
- family - cat
- genus - big cat
- species - lion

Difficulties with classification

It can be easy to classify a species. For example, we are Homo sapiens.

Classification of species

rank	classification	notes
kingdom	animals	
phylum	chordates	animals with backbones
class	mammals	animals that are warm-blooded, have lungs and body hair, produce milk and give birth to live young
order	primates	ape-like animals
family	hominids	human-like animals
genus	homo	humans
species	sapiens	modern humans

It can also be difficult to classify a certain organism. For example, the single-celled organism called Euglena has some confusing characteristics. It has:

- chloroplasts, like a plant
- no cell wall, like an animal
- a flagellum to swim with, like some bacteria

A fifth kingdom, called the protoctists, was made for organisms like Euglena.

The Heart

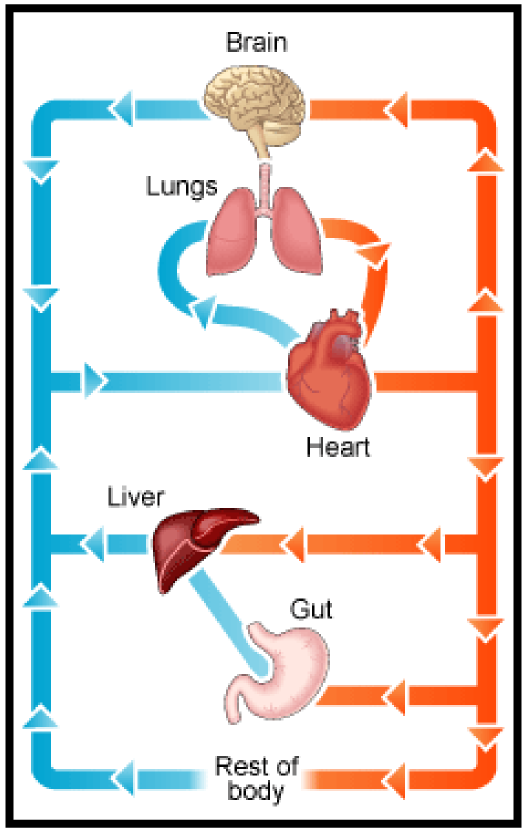
The heart requires its own constant blood supply in order to keep beating and this is delivered through the coronary arteries. Genetic and lifestyle factors can lead to the coronary arteries becoming blocked, and an increased risk of heart disease.

The circulatory system

Blood carries oxygen and nutrients to the body's cells, and waste products away from them. The circulatory system consists of:

- the heart, which is the muscular pump that keeps the blood moving
- the arteries, which carry blood away from the heart
- the veins, which return blood to the heart
- the capillaries, which are tiny blood vessels that are close to the body's cells

The diagram outlines the circu-latory system. To make things clear, oxygenated blood is shown in red, and deoxygenated blood in blue.



Arteries and veins

The arteries carry blood from the heart, while veins return blood to it. With both, their structure is related to their function.

Arteries

Blood in the arteries is under high pressure generated by the heart. The arteries have:

- thick outer walls
- thick layers of muscle and elastic fibres

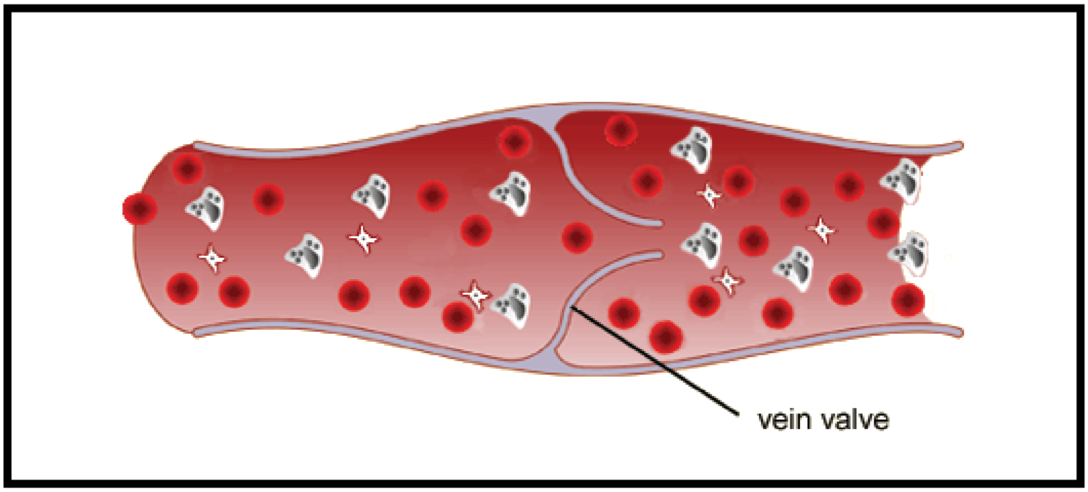
Veins

The blood in veins is under lower pressure than the blood in arteries. The veins have:

- thin walls

- thin layers of muscle and elastic fibres

Unlike arteries, veins have one-way valves in them to keep the blood moving in the correct direction.



The heart

The heart is a muscular organ. It keeps beating at about 70 times per minute. You can see how it pumps the blood to the lungs and the rest of the body by studying this animation.

The muscle cells in the heart need a constant supply of oxygen and nutrients, and for their waste products to be removed. So the heart requires its own blood supply in order to keep beating.

Blood vessels called the coronary arteries supply blood to the heart muscles. If they become blocked, a heart attack can happen.

Heart attacks

A heart attack can happen because:

1. Fatty deposits build up in the coronary arteries.
2. A blood clot can form on a fatty deposit.
3. The blood clot can block a coronary artery.
4. Some heart muscle cells do not get the oxygen and nutrients they need.
5. These cells start to die.

Causes of heart disease

Heart disease is not usually caused by micro-organisms. It is caused by:

- genetic factors, which show as a family history of heart disease
- lifestyle factors

Heart disease is more common in the UK than in non-industrialised countries, and many other indust-rialised nations. This is due to lifestyle factors including:

- smoking
- lack of regular exercise
- stress leading to a fast heart rate
- drinking a lot of alcohol
- poor diet

A lack of exercise and a diet that is high in salt and saturated fat cause people to:

- become overweight
- have high blood pressure
- have high levels of cholesterol in their blood

These factors contribute to an increased risk of heart disease.

EXTRA

Sex hormones

Changes occur at puberty because of sex hormones produced by the testes in boys, and the ovaries in girls. Some changes happen to everyone, both boys and girls, while others happen in one sex only.

Here are some changes that happen to both boys and girls:

- pubic hair grows
- underarm hair grows

Here are some changes that happen to boys only:

- voice breaks - gets deeper
- hair grows on face and body
- body becomes more muscular
- testes and penis get bigger
- testes start to produce sperm cells

Here are some changes that happen to girls only:

- hips get wider
- breasts develop
- ovaries start to release egg cells - periods start

Fertility in humans can be controlled by the artificial use of sex hormones, including contraceptive pills and fertility drugs.

Competition

Different species compete to survive and breed. The size of a predator population depends on the size of the prey population, and the reverse is true as well. Mutualism benefits both species involved in the relationship, but parasitism only benefits the parasite, not the host.

Habitats have limited amounts of the resources needed by living organisms. Organisms must compete with others in order to get enough of these resources to survive. If they are unsuccessful and cannot move to another habitat, they will die.

Animals

Some of the resources that animals compete for:

- food
- water
- space

Animals may also compete for mates so that they can reproduce.

Plants

Remember that plants make their own food using photo-synthesis, so they do not compete for food. Here are some of the things that plants do compete for:

- light
- water
- space
- mineral salts

Human beings

Human beings are very successful organisms. We compete with animals for food resources, and we compete with both animals and plants for space and water.

The nitrogen cycle

Seventy-nine per cent of the air around us is nitrogen. Living things need nitrogen to make proteins, but they cannot get it directly from the air because nitrogen gas is too unreactive to be used to make new compounds within an organism.

Plants can take up and use nitrogen when it is in a more reactive form - for example, in nitrates or ammonium salts. Changing nitrogen into a more reactive substance is called nitrogen fixation.

Nitrogen fixation

Nitrogen fixation happens in three different ways:

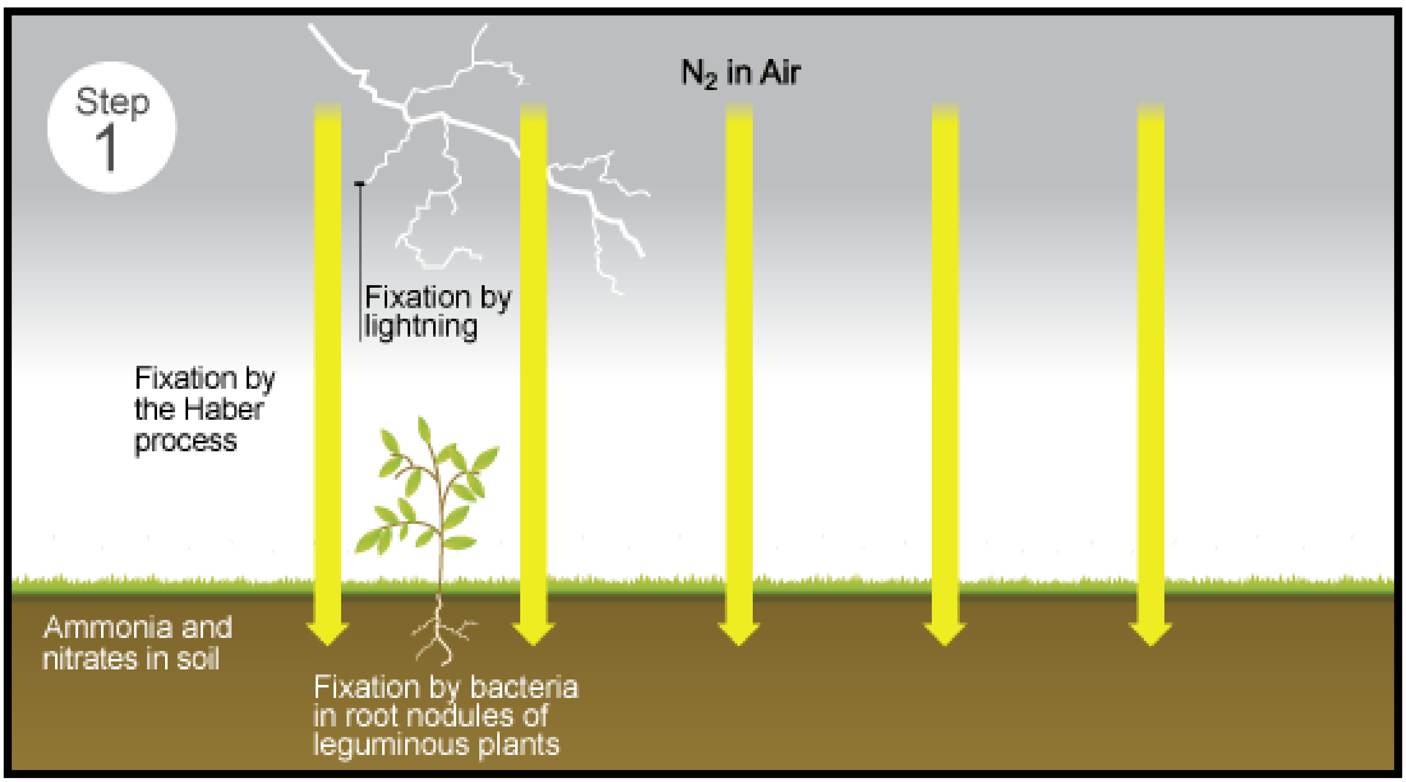
The energy in a lightning bolt can split nitrogen molecules in the air, allowing each nitrogen atom to react with oxygen to form nitrogen oxides. The rain washes these oxides to the ground, where they form nitrates.

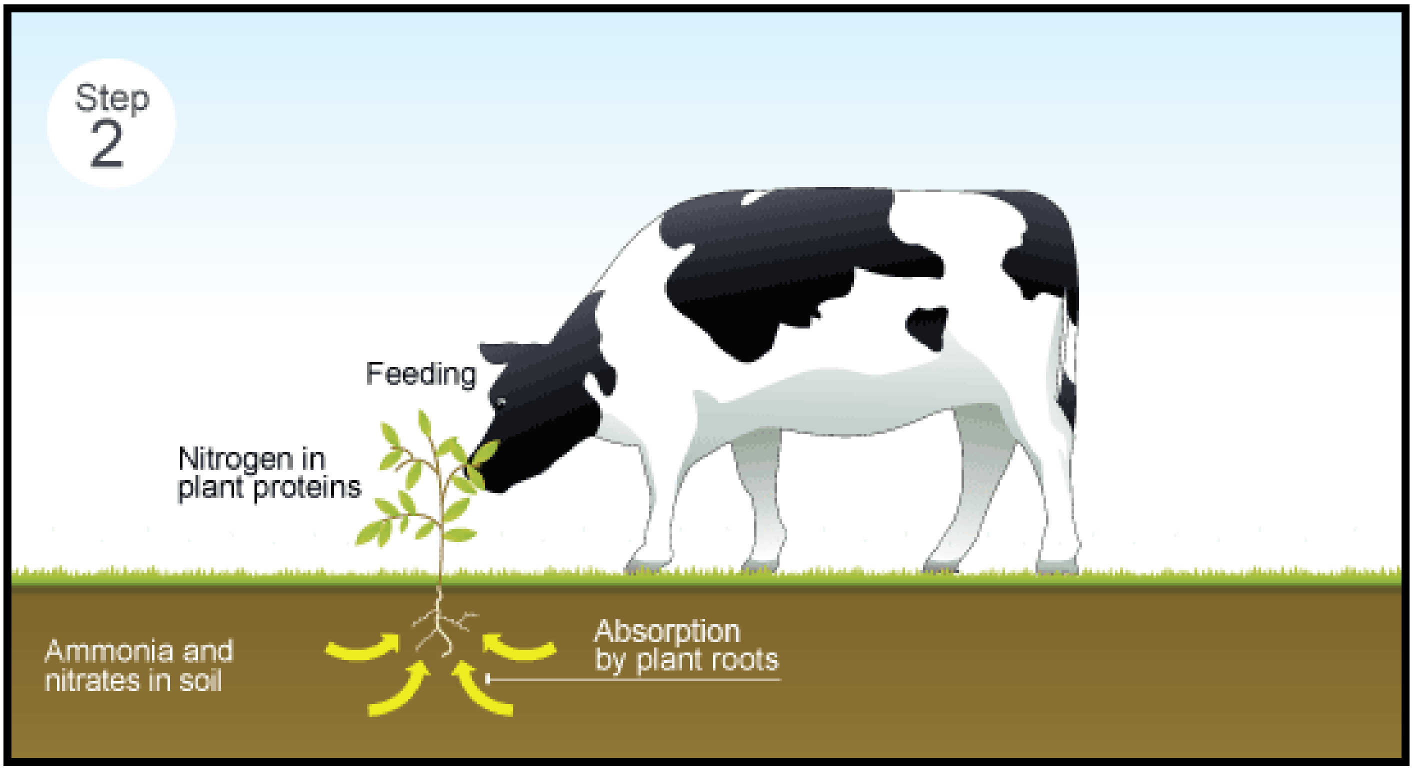
- The Haber Process is used by industry to produce ammonia from nitrogen. Ammonia is then used to make the fertiliser that farmers spread on the soil to feed their crops.
- Nitrogen-fixing bacteria found in both the soil and root nodules of leguminous plants fix nitrogen into a form that can be used by plants.

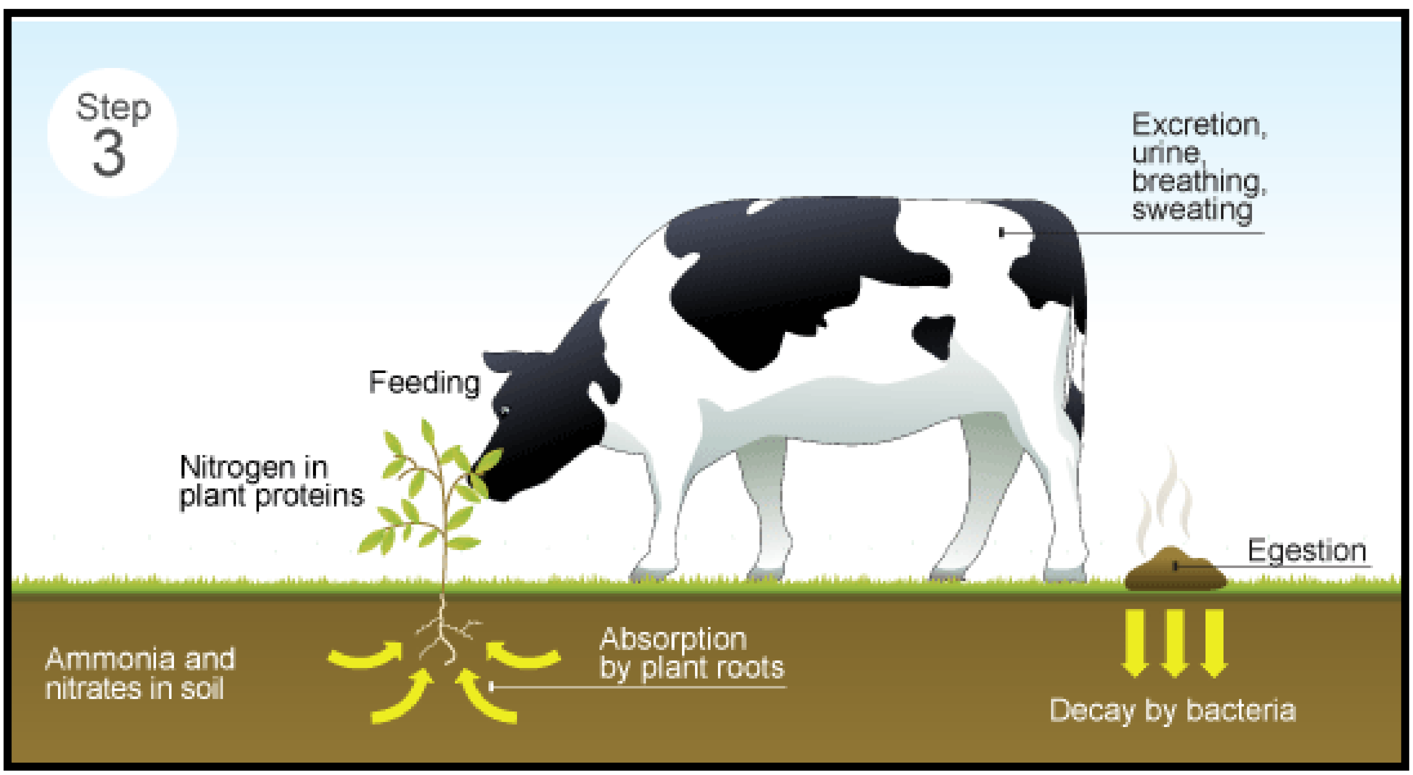
When plants are eaten by animals, the nitrogen compounds are passed on.

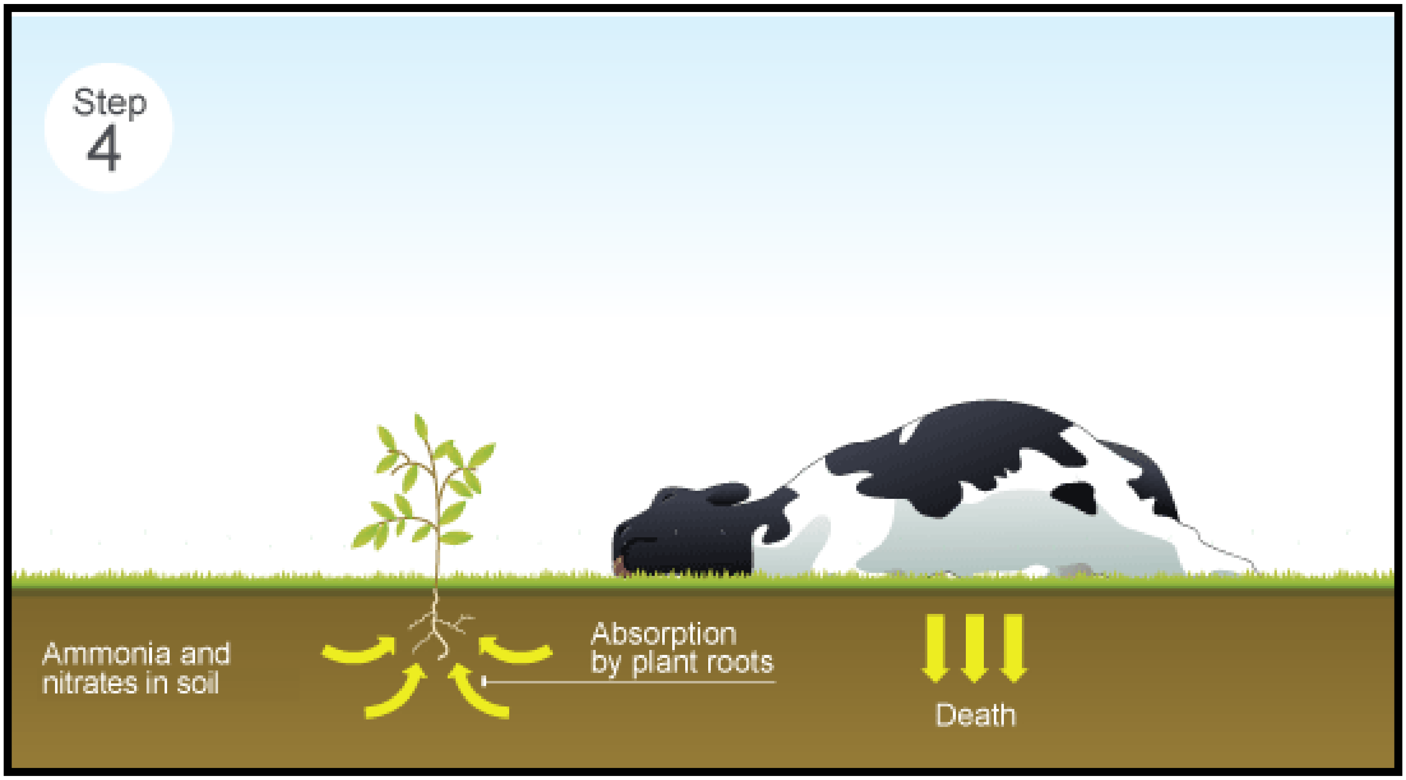
Nitrogen compounds are returned to the soil by excretion and egestion from animals, or when plants and animals die and decay.

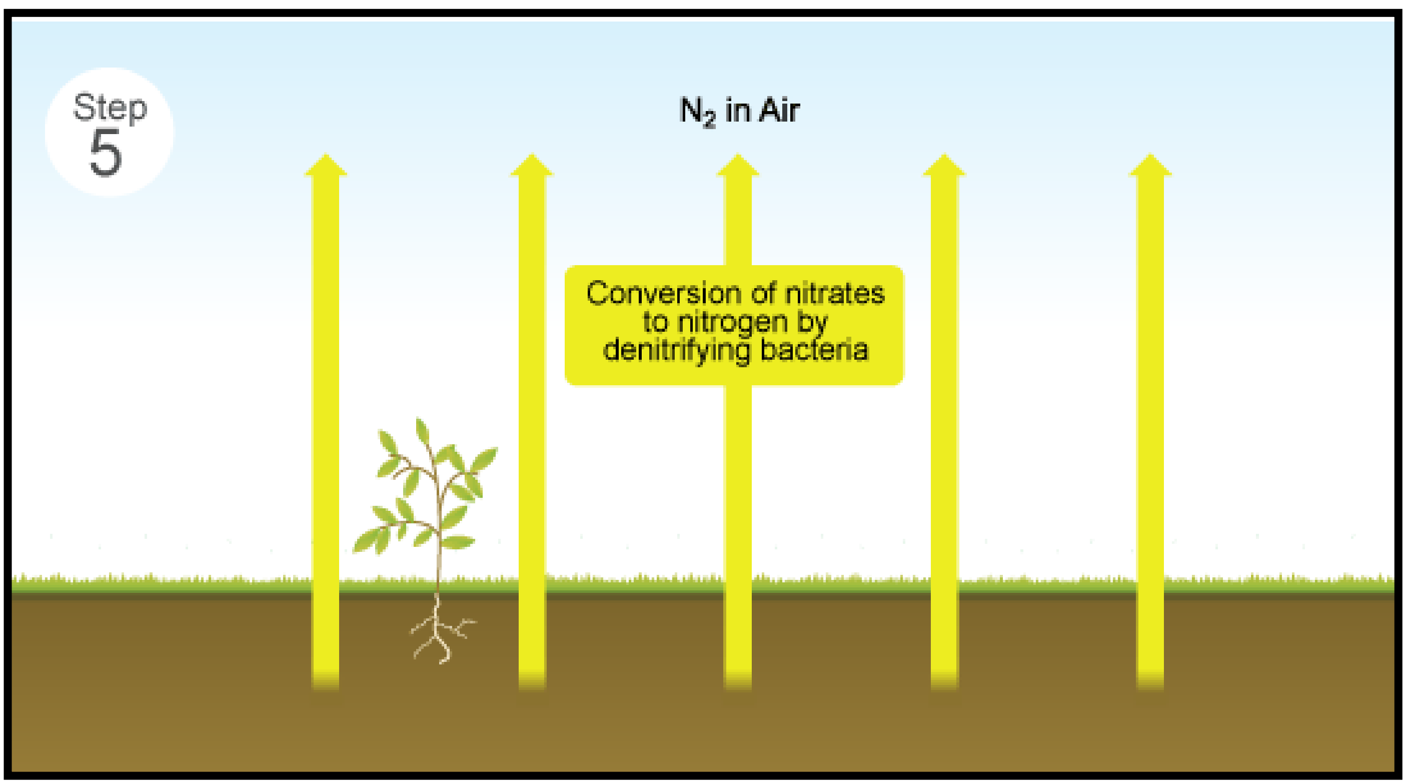
The nitrogen compounds returned in this way are changed back to nitrogen gas by denitrifying bacteria which live in the soil. This completes the cycle, so that the percentage of nitrogen in the air remains constant.




Step
2
Feeding
Nitrogen in
plant proteins
Ammonia and
nitrates in soil
Absorption
by plant roots


Step
3
Excretion,
urine,
breathing,
sweating
Feeding
Nitrogen in
plant proteins
Egestion
Ammonia and
nitrates in soil
Absorption
by plant roots
Decay by bacteria


Step 4
Ammonia and nitrates in soil
Absorption by plant roots
Death


Step 5
N2 in Air
Conversion of nitrates to nitrogen by denitrifying bacteria

The nitrogen cycle