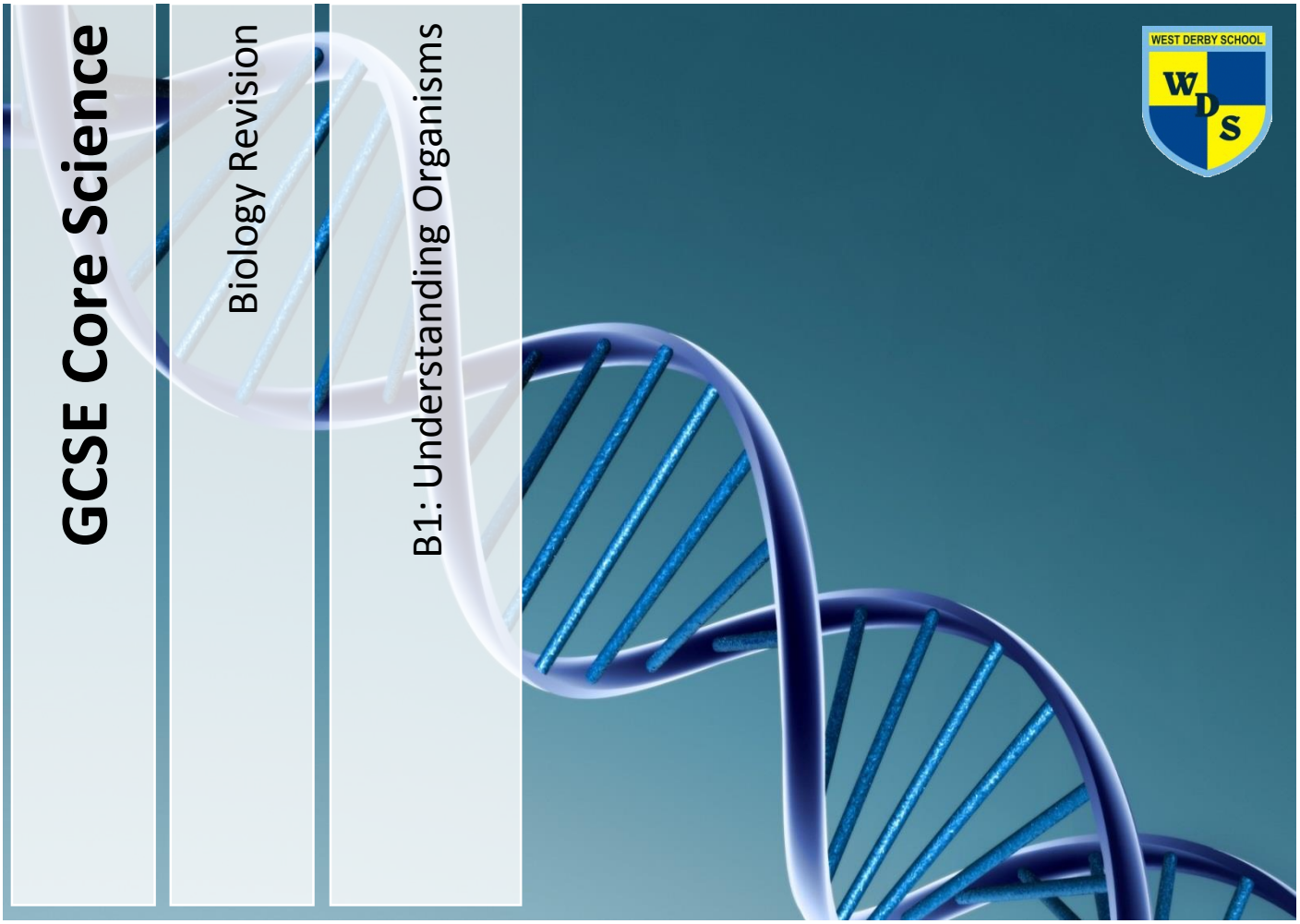


B1: Understanding Organisms

1. Fitness and health

Blood is under pressure in the arteries so that it reaches all parts of the body. Diet, exercise and other factors can affect the risk of heart disease developing.

Blood pressure

Arteries carry blood away from the heart. Blood in the arteries is under pressure because of the contractions of the heart muscles. This allows the blood to reach all parts of the body. You can see how the heart pumps the blood to the lungs and rest of the body by studying this animation:

Measuring blood pressure

Blood pressure is measured in millimetres of mercury, **mmHg**. There are two measurements:

- **systolic pressure** - the higher measurement when the heart beats, pushing blood through the arteries, and
- **diastolic pressure** - the lower measurement when the heart rests between beats

A young, fit person should have a blood pressure of about 120 over 70, which means their systolic pressure is 120 mmHg and their diastolic pressure 70 mmHg.

There are various factors that can increase blood pressure, including:

- smoking
- being overweight
- drinking a lot of alcohol
- stress.

A balanced diet and regular exercise can reduce high blood pressure.

Blood pressure - Higher tier

Extremes of blood pressure can create problems. High blood pressure can cause:

- kidney damage
- burst blood vessels
- damage to the brain, including strokes.

Low blood pressure can cause dizziness, fainting and poor blood circulation.

Fitness versus health

Fitness and health are not the same thing:

- fitness is the ability to do physical activity
- health is the amount of freedom from disease.

Fit people are able to carry out physical activities more effectively than unfit people. Their pulse rate is likely to return to normal more quickly after exercise.

Healthy people are free from disease and infection, but they may or may not be fit as well. It is possible to be fit but unhealthy, or healthy but unfit.

Measuring fitness

There are different ways to measure fitness. Factors include:

- strength
- stamina – endurance or staying power
- flexibility
- agility – how easily someone moves
- speed
- cardiovascular efficiency – how well a person's circulatory system works.

Smoking

Cigarettes contain about 4,000 different chemicals, most of which are harmful to the body. These include:

- nicotine - the addictive substance in tobacco smoke
- carbon monoxide.

Smoking and blood pressure

Smoking increases blood pressure by raising the heart rate.

Smoking can increase the risk of heart disease

Nicotine itself increases the heart rate and carbon monoxide reduces the oxygen-carrying capacity of the blood. It combines with haemoglobin in red blood cells, preventing oxygen combining with the haemoglobin. This causes an increase in heart rate to compensate for the reduced amount of oxygen carried in the blood.

Heart disease

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 after a sequence of events,

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.

In the UK about 300,000 people have a heart attack every year.

Factors for heart disease

The risk of developing heart disease is increased by several factors, including:

- smoking
- high blood pressure
- high levels of salt in the diet
- high levels of saturated fat in the diet.

  High levels of salt in the diet can lead to increased blood pressure. High levels of saturated fats in the diet lead to a build of cholesterol in the arteries, causing a plaque and narrowing of the arteries.

2. Human health and diet

Food provides the energy and materials needed by living things. Carbohydrates and fats are high-energy sources. Protein is needed for growth and repair. Protein deficiency leads to diseases such as kwashiorkor.

A balanced diet

The table below summarises the three main nutrients in food, what they are made from and why they are needed.

The main nutrients in food

nutrient	made from	main uses
 Carbohydrates	simple sugars such as glucose	high-energy source
 Fats	fatty acids and glycerol	high-energy source
 Proteins	amino acids	growth and repair

Proteins are also used as an 'emergency' energy source if a diet has insufficient carbohydrates and fats.

A **balanced diet** will also include nutrients that do not provide energy, such as:

- minerals, such as iron, to make the haemoglobin needed in red blood cells
- vitamins, such as vitamin C, which prevents a disease called scurvy
- fibre, which prevents constipation
- water.

A balanced diet is different for different people and will vary according to age, gender, physical activity and religion (certain foods may be banned, for example). Some people choose not to eat particular things - vegetarians and vegans avoid animal products, for example - while others may be allergic to certain foods.

Underweight, overweight

In warm weather, or when you are not doing 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, with very overweight people being 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
- heart disease
- breast cancer.

A diet leading to people becoming underweight or overweight may be caused by the person having low self-esteem and a poor self-image, which may themselves be influenced by body weight. A desire for 'perfection', such as a person comparing themself to an attractive celebrity, may lead to under-eating. Being underweight or overweight both carry health risks.

Body Mass Index

The Body Mass Index (BMI) is a guide to whether someone is underweight, normal weight or overweight. You can calculate the BMI using this formula:

BMI = mass in kg ÷ (height in m)^2

For example, what is the BMI of a 1.7 m person with a body mass of 60 kg?

BMI = 60 ÷ $(1.7)^2$ = 60 ÷ 2.89 = 20.8

In this example, the person would be at the ideal weight for their height. The table summarises the meanings of different BMIs.

The meaning of BMI's

BMI	meaning
under 18.5	underweight
between 18.5 and 24.9	normal
between 25 and 29.9	overweight
between 30 and 39.9	obese
over 40	very obese

Proteins

Teenagers are growing quickly and need plenty of protein in their diet, but people in developing countries may not get enough. This is called **protein deficiency**.

Protein deficiency

Kwashiorkor is a disease caused by protein deficiency. Symptoms include a badly swollen abdomen. Kwashiorkor is common in developing countries because people may not get enough protein in their diet. The reasons why are complex, but include:

- overpopulation (too many people for the land and resources available)
- limited investment in farming methods, for example few tractors or artificial fertilisers.

Estimated average daily requirement

You can calculate the estimated average daily requirement (EAR) for protein using this formula:

EAR in g = 0.6 × body mass in kg

For example, what is the EAR for a 60 kg person?

EAR = 0.6 × 60 = 36 g of protein

Proteins- Higher tier

The EAR is an estimated daily amount only. It is for an average person with a particular body mass, but some people may need more protein. For example, a growing teenager will need more protein in their diet than an adult with the same body mass. Pregnant women will also need more protein in their diet, as will new mothers who are breast feeding their baby.

The body does not store proteins but it can store fats and carbohydrates:

- fats are stored around organs and under the skin as adipose tissue
- carbohydrates are converted to fats, or stored as glycogen in the liver.
  Proteins from plants are ‘second class’ proteins. Proteins from animals are ‘first class’ proteins – they provide all the essential amino acids, including those that the body can't make.

3. Staying healthy

Pathogens are microorganisms that cause disease. The body has several defence mechanisms to prevent pathogens from entering the body and reproducing there. The immune system can destroy pathogens that manage to enter the body. New medical treatments and drugs must be tested before their use.

Pathogens

Pathogens are *organisms* that cause disease. They include microorganisms such as bacteria, viruses, fungi and protozoa. The table shows some of the diseases they cause.

Diseases pathogens cause

pathogen	disease
bacteria	cholera
viruses	influenza (flu)
fungi	athlete's foot
protozoa	malaria

Parasites

Parasites are organisms that live on or in a host organism. The parasite benefits from this arrangement, but the host suffers as a result. For example, tapeworms are parasites. They live inside another animal, attaching themselves to the host's gut and absorbing its food. The host loses nutrition, and may develop weight loss, diarrhoea and vomiting. Parasites do not usually kill the host, as this would cut off their food supply.

A tapeworm

Malaria

Malaria is a disease caused by a protozoan, a type of single-celled organism. The malaria parasite is spread from person to person by mosquitoes. These insects feed on blood and the malaria parasite

is passed on when the mosquito takes a meal. Organisms that spread disease, rather than causing it themselves, are called vectors. The mosquito is the vector for malaria.

Malaria- Higher tier

It is important to understand the life cycle of a pathogen and the way in which vectors spread the pathogen. This knowledge gives scientists ideas about how the spread of a disease might be controlled. In principal, if the life cycle of a pathogen can be broken, eventually all the individuals of that pathogen will die out, leaving a disease-free population.

For example, the spread of malaria can be controlled by avoiding contact with the vector. One way to do this is to avoid being bitten by mosquitoes, for example using mosquito netting at windows, doors and around beds. The mosquitoes may be killed using insecticides. The parasite itself can be killed by giving infected people drugs such as Lariam.

Infectious and non-infectious diseases

Some diseases are not caused by pathogens and so are not infectious. For example:

- scurvy is caused by vitamin C deficiency
- anaemia is caused by iron deficiency
- diabetes and cancer are disorders of the body.
  Some disorders are inherited, such as red-green colour vision deficiency.

Cancer

A cancer happens when cells begin to divide out of control. They form tumours that can sometimes be felt as an unusual lump in the body.

Diet and lifestyle can increase the risk of developing certain cancers. For example:

- smoking increases the risk of lung cancer
- using sunscreen reduces the risk of skin cancer
- eating more fruit and vegetables reduces the risk of bowel cancer.

Cancer- Higher tier

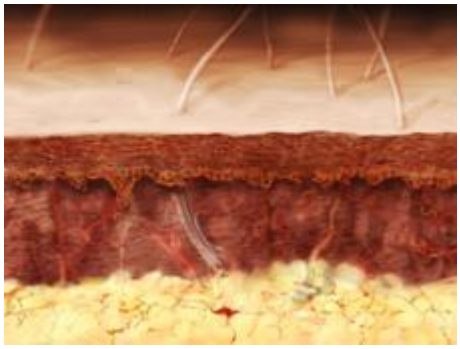
Tumours can be benign or malignant,

- benign tumours grow slowly and are usually harmless – warts are benign tumours
- malignant tumours often grow more quickly and may spread throughout the body.

Body defences

The body has several defences against pathogens so that we do not fall ill with the diseases they cause.

The skin



Cross-section of skin

The skin covers the whole body. It protects the body from physical damage, microbe infection and dehydration. Its dry, dead outer cells are difficult for microbes to penetrate, and the sebaceous glands produce oils that help kill microbes.

Blood clotting

If microorganisms get into the body through a cut in the skin, the most important thing to do is close the wound quickly so that no more microorganisms can enter. A scab does just that. The blood contains tiny structures called platelets, and a protein called fibrin. A scab is basically platelets stuck in a fibrin mesh.

Mucus

The respiratory system is protected in several ways. Nasal hairs keep out dust and larger microorganisms. Sticky mucus traps dust and microbes, which are then carried away by cilia. These are tiny hairs on the cells that line the respiratory system.

Stomach acid

Hydrochloric acid in the stomach kills harmful microorganisms that might be in the food or drink that we swallow.

Immunity

Once inside the body, pathogens reproduce. Viruses reproduce inside cells and damage them, while escaping to infect more cells. Bacteria produce toxins - poisons. Cell damage and toxins cause the symptoms of infectious diseases.

Once pathogens enter the body, the immune system destroys them. White blood cells are important components of the immune system.

White blood cells

White blood cells can:

- engulf pathogens and destroy them
- produce antibodies to destroy pathogens
- produce antitoxins that neutralise the toxins released by pathogens.
  Pathogens contain certain chemicals that are foreign to the body, called antigens. Some white blood cells can make antibodies. These are proteins that have a chemical 'fit' to a certain antigen. When a

white blood cell with the appropriate antibody meets the antigen, it reproduces quickly and makes many copies of the antibody to neutralise the pathogen.

Immunity

Once you have been infected with a particular pathogen and produced antibodies against it, some of the white blood cells remain. If you become infected again with the same pathogen, these white blood cells reproduce very rapidly and the pathogen is destroyed. This is **active immunity** because you make your own antibodies.

Sometimes you may be treated for infection by an injection of certain antibodies from someone else. This is **passive immunity** because you receive antibodies, rather than make them yourself.

Drug testing

Drugs are substances that cause changes to the body. Antibiotics are drugs that kill bacteria, but not viruses. Antivirals are drugs that prevent viruses reproducing.

New medical drugs have to be tested to ensure that they work, and are safe, before they can be prescribed. There are three main stages of testing.

1. The drugs are tested using computer models and human cells grown in a laboratory. Many substances fail this test because they damage cells or do not seem to work.
2. Drugs that pass the first stage are tested on animals. In the UK, new medicines have to undergo these tests. But it is illegal to test cosmetics and tobacco products on animals. A typical test involves giving a known amount of a substance to the animals, then monitoring them carefully for any side-effects.
3. Drugs that have passed animal tests are used in clinical trials. They are tested on healthy volunteers to check that they are safe. Very low doses of the drug are given to begin with. If there are no problems, further clinical trials are done to find the optimum dose for the drug.

Clinical trials are not without risk. Sometimes severe and unexpected side-effects occur. Most substances do not pass all of the tests and trials, so drug development is expensive and takes a long time.

Double blind trials- Higher tier

It is important to be certain that a drug really does have positive effects, rather than people feeling better simply because they expect to feel better if they take a medicine. This is called the ‘placebo effect’. Double blind trials aim to minimise the placebo effect. Some patients are given the drug while others are given a placebo. A placebo is designed to appear exactly the same as the drug itself, but it does not actually contain any of the drug. The doctors and patients are not told who have received the drug and who have received the placebo until the trial is over.

Immunisation- Higher tier

People can be immunised against a pathogen through vaccination. Different vaccines are needed for different 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 white blood cells are able to reproduce rapidly and destroy it.

Antibiotic resistance

Over time, bacteria can become resistant to certain antibiotics. MRSA is methicillin-resistant Staphylococcus aureus. It is very dangerous because it is resistant to most antibiotics. To slow down or stop the development of other strains of resistant bacteria, we should:

- avoid the unnecessary use of antibiotics
- always complete the full course.

4. The nervous system

The sense organs contain receptors that are sensitive to stimuli.

The nervous system consists of the central nervous system - brain and spinal cord -and peripheral nerves. Nerve impulses travel through the axons of neurones - nerve cells. Reflex actions are fast, automatic and protective responses.

Human vision is binocular, which gives us a good perception of depth. Vision defects include short-sightedness, long-sightedness and colour blindness.

Receptors

Receptors are groups of specialised cells. They can detect changes (stimuli) in the environment. 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. The table shows some receptors and the stimuli they detect.

Different receptors

receptors found in	receptors sensitive to
 Eyes	light

receptors found in	receptors sensitive to
 Ears	sound and position of the head
 Tongue	chemicals in food
 Nose	chemicals in the air

receptors found in	receptors sensitive to
 Skin	touch, pressure, pain and temperature

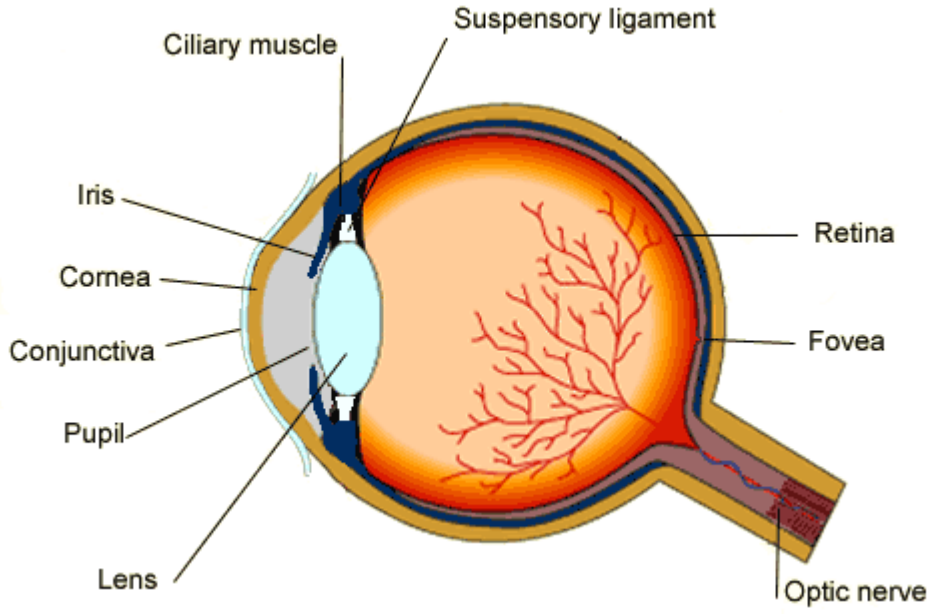
Cells

Most animal cells have a nucleus, cytoplasm and cell membrane. Light receptors have these cell components too.

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

The eye

You need to be able to name and locate the main parts of the eye.

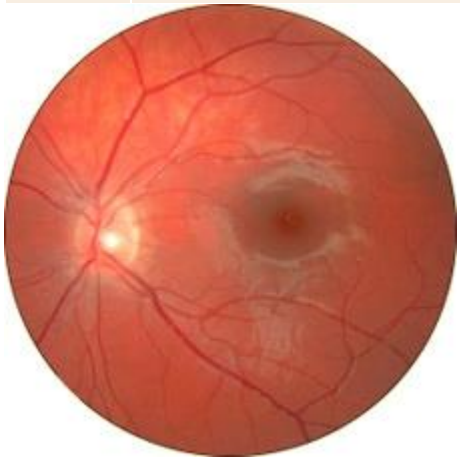


Structure of the human eye

You should also be able to describe the functions of the main parts of the eye.

The main parts of the eye and their function

part	description	function
Cornea	Front part of the tough outer coat, the sclera. It is convex and transparent.	refracts light - bends it as it enters the eye
Iris	Pigmented - decides the colour of your eyes - so light cannot pass through. Its muscles contract and relax to alter the size of its central hole or pupil.	controls how much light enters the pupil
Lens	Transparent, bi-convex, flexible disc behind the iris attached by the suspensory ligaments to the ciliary muscles.	focuses light onto the retina
Retina	The lining of the back of eye containing two types of photoreceptor cells - rods - sensitive to dim light and black and white, cones - sensitive to colour. A small area called the fovea in the middle of the retina has many more cones than rods.	contains the light receptors
Optic nerve	Bundle of sensory neurones at back of eye.	carries impulses from the eye to the brain

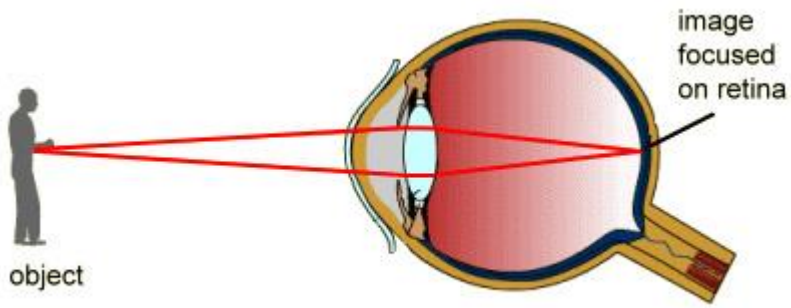


A photograph of a human retina seen through the eye

Vision

Pathway of light

Light passes through the eyeball to the retina. It is refracted (its rays are bent) by the cornea and lens, so that the light is brought to a focus on the retina.



Pathway of light

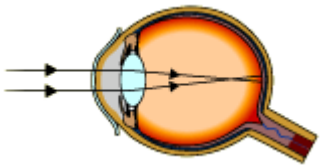
Binocular vision

Because our eyes sit side by side, each eye captures a slightly different view. This is called binocular vision. When signals from the two eyes reach the brain, they are superimposed and processed into a single picture with depth. As a result, we get a 3D picture and are able to judge distances well.

Most birds and lizards have monocular vision - their eyes are on each side of their head. This gives them a greater field of view, which is useful for spotting predators. However, they have poor depth perception.

Vision defects

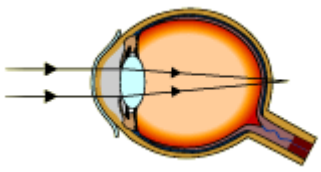
Short-sight



Myopia - short-sight

Someone with short-sightedness can see near objects clearly, but can't focus properly on distant objects. This is because the lens focuses the sharpest image in front of the retina, instead of on it.

Long-sight



Hypermetropia - long-sight

Someone with long-sightedness can see distant objects clearly, but can't focus properly on near objects. This is because the lens focuses the sharpest image behind the retina, instead of on it.

Colour blindness

Colour blindness is an inherited condition. The retina contains cells that are sensitive to red, green or blue light. People with colour blindness have a lack of receptors, or defects in them. People with red-green colour blindness, for example, have difficulty distinguishing shades of red and green.

The nervous system

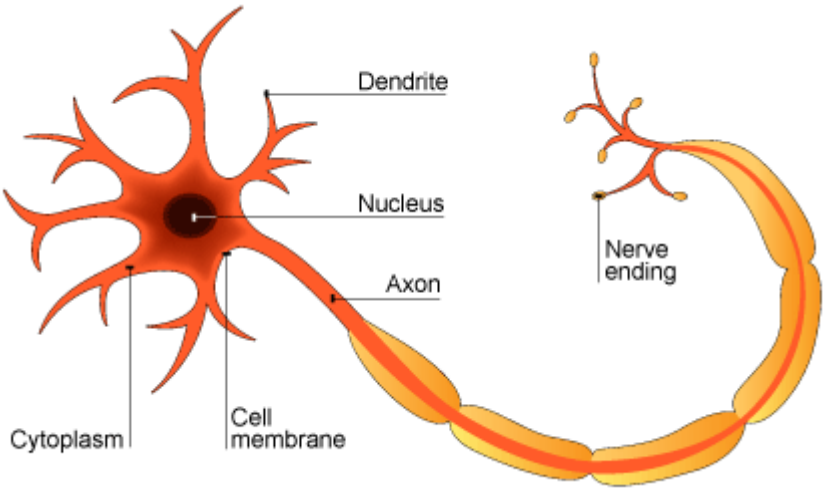
The main parts of the nervous system are the central nervous system - the **CNS** - the brain and spinal cord - and the peripheral nervous system. Nerve impulses are mainly electrical and carried in nerve cells, or **neurones**.

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:

- sensory neurones carry signals from receptors to the spinal cord and brain
- relay neurones carry messages from one part of the CNS to another
- motor neurones carry signals from the CNS to effectors.

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



A motor neurone

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.

Sequence

In a simple reflex action:

stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector

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

- a muscle contracting
- a gland releasing (secreting) a hormone or other chemical.
  Reflex actions are rapid and happen without us thinking. For example, you would pull your hand away from a flame without thinking about it. The animation below allows you to step through each stage of the reflex arc.

  This is what happens:

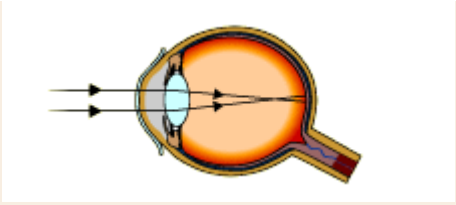
- Receptor detects a stimulus - change in the environment
- Sensory neurone sends signal to relay neurone
- Motor neurone sends signal to effector
- Effector produces a response.
  The way the iris in our eye adjusts the size of the pupil in response to bright or dim light is also a reflex action.

Vision defects - Higher tier

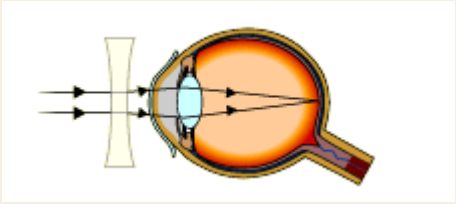
Short-sight and long-sight may be corrected by corneal surgery (‘laser surgery’), or by using appropriate lenses in spectacles or contact lenses.

Short-sight

Someone with short-sight can see near objects clearly, but can't focus properly on distant objects. This is caused by the eyeball being elongated, so that the distance between the lens and the retina is too great. It can be corrected by placing a concave lens in front of the eye.



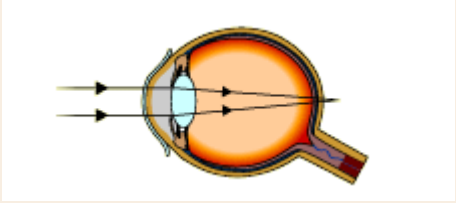
Short-sighted



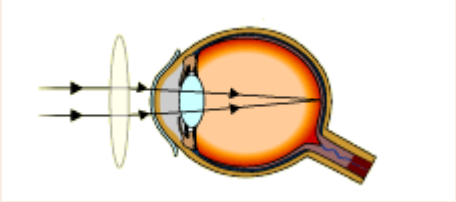
Concave lens corrects it

Long-sight

Someone with long-sight can see distant objects clearly, but can't focus properly on near objects. This is because the lens focuses the sharpest image behind the retina, instead of on it. This defect is often age-related, and due to a loss of elasticity in the lens. It is corrected by putting a convex lens in front of the eye.



long-sighted



Convex lens corrects it

5. Drugs and you

Drugs are chemicals that can alter the way the body works. There are different types of drugs, and they have different effects on the body. Tobacco and alcohol are legal recreational drugs which have potentially serious effects on the body. Illegal drugs are classified on a scale from Class A - the most dangerous - to Class C - the least dangerous.

Types of drug

Drugs alter the way the body works. Some are beneficial, while others are harmful.

The main types of drugs and their effects

type of drug	effect on the body	example
depressant	slows down brain activity	alcohol, solvents, temazepam
hallucinogen	alters what we see and hear	LSD
painkiller	blocks nerve impulses	aspirin, paracetamol
performance enhancer	improves muscle development	anabolic steroids
stimulant	increases brain activity	nicotine, caffeine, ecstasy

Classification of drugs

Some drugs are legal, such as tobacco and alcohol. Others are illegal, or must only be prescribed by a doctor. Some prescription drugs are misused and taken for recreational use, rather than for medical reasons. They become illegal under these circumstances.

Illegal drugs are classified from Class A to Class C. Class A drugs are the most dangerous, with the most serious penalties for possession or dealing. Class C are the least dangerous, with the lightest penalties, but this does not mean they are safe to use.

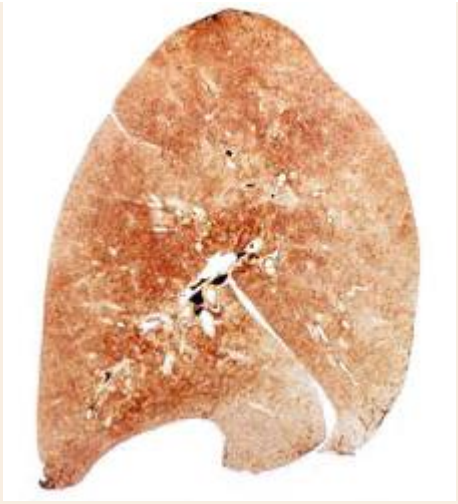
Stimulants and depressants - Higher tier

Stimulants and depressants affect the synapses between neurones in the nervous system:

- stimulants cause more neurotransmitter molecules to diffuse across the synapse
- depressants stop the next neurone sending nerve impulses – they bind to the receptor molecules it needs to respond to the neurotransmitter molecules.

- **Tobacco**
- 

- Warnings such as 'Smoking can cause a slow and painful death' are used to deter people from smoking
- Smoking can cause lung disease, heart disease and certain cancers, and around 114,000 people die every year as a result of smoking-related illnesses. All cigarettes sold in the UK now carry a prominent health warning.
- Cigarette smoke contains many harmful chemicals. The cells lining the trachea (windpipe), bronchi and bronchioles (the branches inside the lungs) are damaged by cigarette smoke. These epithelial cells have tiny hair-like cilia on their surface. Normally these cilia move to push mucus out of the lungs. Damaged cells cannot do this, leading to a build-up of mucus and a smokers' cough.
- **Nicotine**
- Nicotine is the addictive substance in tobacco. It reaches the brain within 20 seconds and creates a dependency so that smokers become addicted. Smokers can suffer from withdrawal symptoms if they try to give up cigarettes.
- **Carbon monoxide**
- Carbon monoxide combines with the haemoglobin in red blood cells and so reduces the ability of the blood to carry oxygen. This puts extra strain on the circulatory system, and can cause an increased risk of heart disease and strokes.
- Smoking during pregnancy is very dangerous. It reduces the amount of oxygen available to the growing fetus, which leads to an increased risk of low birth weights of babies.
- **Tars**
- Carcinogens are substances that cause cancer. Tobacco smoke contains many carcinogens, including tar. Smoking increases the risk of lung cancer, and cancer of the mouth, throat and oesophagus.
- The images below compare a healthy lung and a smoker's lung. You can see the deposits of tar and particulates (particles) in the smoker's lung.

- 
- A healthy lung
- 
- A smoker's lung, with tar deposits visible
- **Alcohol**
- The alcohol in alcoholic drinks - such as wines, beers and spirits - is called ethanol. It is a depressant. This means that it slows down signals in the nerves and brain.
- There are legal limits to the level of alcohol that drivers and pilots can have in the body. This is because alcohol impairs the ability of people to control their vehicles properly. Breath tests and blood tests are used by the police to see if a driver is over the limit.
- 
- Alcoholic drinks

- **Short-term effects**
- Alcohol has short-term effects such as sleepiness and impaired judgment, balance and muscle control. This leads to blurred vision and slurred speech. There is an increased flow of blood to the skin, which can cause it to become red.
- **Long-term effects**
- The long-term effects of alcohol include damage to the liver and brain.
- **Alcohol - Higher tier**
- The liver removes alcohol from the bloodstream. It has enzymes that break down alcohol but the products of the reactions involved are toxic. They damage the liver and over time this leads to cirrhosis.

6. Staying in balance

Conditions in the body are controlled to provide a constant internal environment. This is called homeostasis. The conditions that must be controlled include body temperature, water content, carbon dioxide level and blood sugar level.

Hormones are chemicals secreted by glands. They travel through the bloodstream and affect target organs.

Homeostasis

Maintaining a constant internal environment of the body is called homeostasis, and the nervous system and hormones are responsible for this. Here are some of the other internal conditions that are controlled.

Carbon dioxide

Carbon dioxide is a waste product of respiration. It travels in the bloodstream from cells to the lungs, where it leaves the body when we exhale. Carbon dioxide forms an acidic solution when it dissolves in water. Carbon dioxide levels must be controlled to avoid the blood becoming too acidic or too alkaline.

Body temperature

This is controlled to maintain the temperature at which enzymes work best, which is 37 °C. Body temperature can be controlled by:

- sweating
- shivering
- altering blood flow to the skin.

The body's water content

This is controlled to protect cells by stopping too much water from entering or leaving them. Water content can be controlled by altering water loss from the:

- lungs when we exhale
- skin by sweating
- body, in urine produced by the kidneys.

Controlling body temperature

Human body temperature can be measured in several places, including the ear, finger, mouth and anus. There are various ways to measure body temperature, including using a clinical thermometer, heat-sensitive strips, digital probes or thermal imaging cameras.

Extremes of body temperature are dangerous because:

- low temperatures can cause hypothermia and death if untreated
- high temperatures can cause dehydration, heat stroke and death if untreated.

Control mechanisms

Heat can be gained by respiration, shivering, exercise or by reducing the blood flow to the skin. Clothing also helps to retain heat.

If we get too hot, heat can be lost by reducing the blood flow to the skin or by sweating. Sweating increases heat loss by evaporation.

Control mechanisms- Higher tier

The body's temperature is monitored by a part of the brain called the hypothalamus. If you are too hot or too cold, it sends nerve impulses to the skin.

The blood vessels supplying blood to the skin can dilate or swell. This is called vasodilation. It causes more heat to be carried by the blood to the skin, where it can be lost to the surroundings.

Blood vessels can shrink down again. This is called vasoconstriction. It reduces heat loss from the skin once the body's temperature has returned to normal.

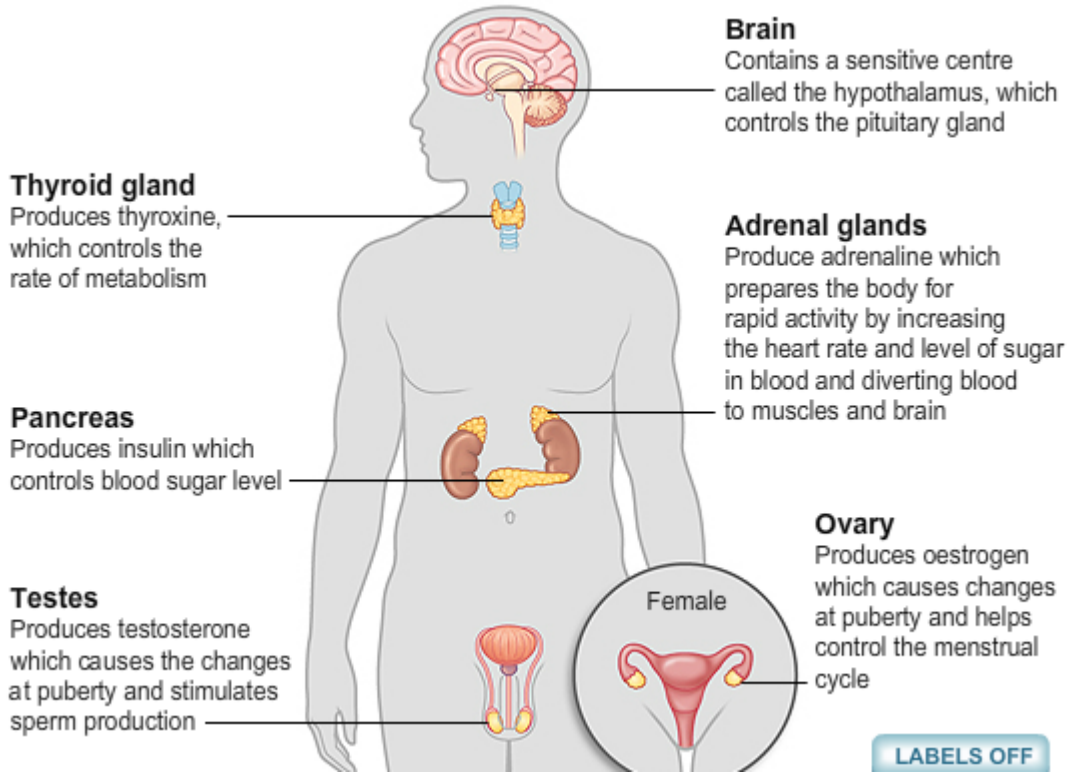
This sort of control is a 'negative feedback mechanism'. The body's internal environment is kept almost constant by causing cooling if it gets too hot, and warming if it gets too cold.

Hormones

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. Bodily reactions to hormones are usually slower and longer lasting than nervous reactions.

Move the mouse over the different glands to see what they do. You need to know the location of the pancreas, which produces the hormone insulin.



Controlling blood sugar levels

Glucose is a sugar needed by cells for respiration. It is important that the concentration of glucose in the blood is maintained at a constant level.

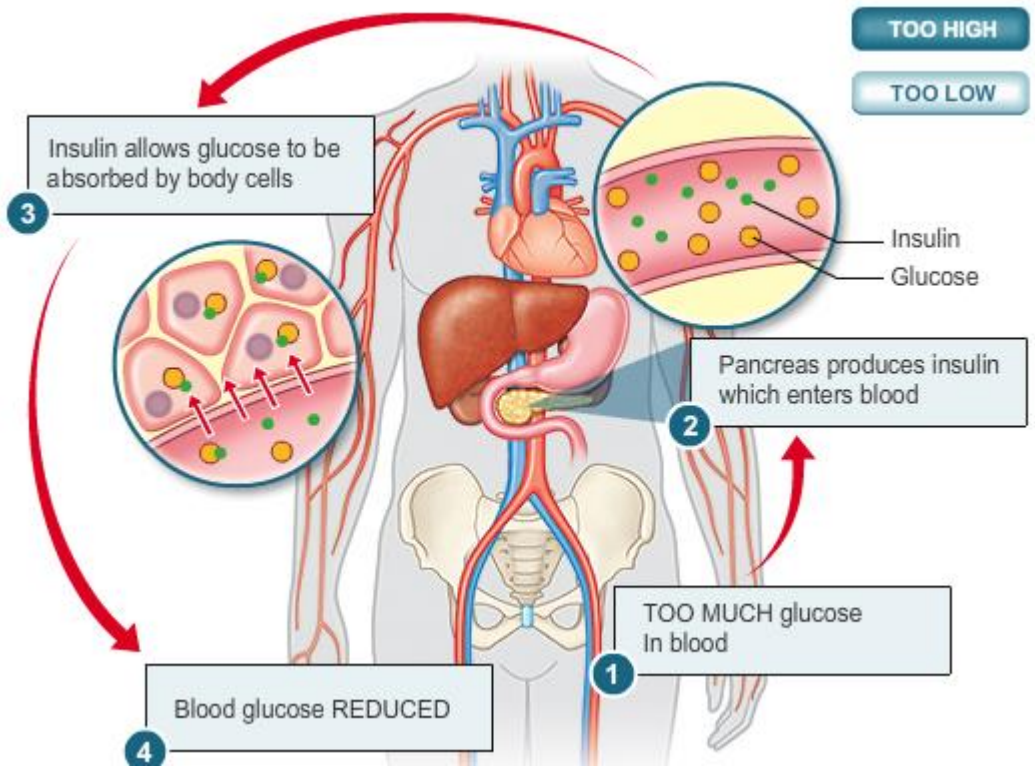
Insulin, a hormone secreted by the pancreas, controls blood sugar levels in the body. It travels from the pancreas to the liver in the bloodstream. As with other responses controlled by hormones, the response is slower but longer lasting than if it had been controlled by the nervous system.

Blood sugar levels- Higher tier

What happens when glucose levels in the blood become too high or too low

glucose level	effect on pancreas	effect on liver	effect on glucose level
too high	insulin secreted into the blood	liver converts glucose into glycogen	goes down
too low	insulin not secreted into the blood	liver does not convert glucose into glycogen	goes up

Use the animation to make sure you understand how this works.



Diabetes

Diabetes is a disorder in which the blood glucose levels remain too high. There are two main types of diabetes:

- Type 1, which usually develops during childhood
- Type 2, which usually develops in later life.

The table summarises some differences between Type 1 and Type 2 diabetes.

Some differences between Type 1 and Type 2 diabetes

	Type 1 diabetes	Type 2 diabetes
Who it mainly affects	Children and teenagers. Adults under the age of 40.	Adults, normally over the age of 40 (there is a greater risk in those who have poor diets and/or are overweight).
How it works	The pancreas stops making enough insulin.	The body no longer responds to its insulin.
How it is controlled	Injections of insulin for life and an appropriate diet.	Exercise and appropriate diet.

Blood sugar level meter and insulin shot pen

7. Controlling plant growth

A 'tropism' is a growth in response to a stimulus. Plants grow towards sources of water and light, which they need to survive and grow.

Auxin is a plant hormone produced in the stem tips and roots, which controls the direction of growth. Plant hormones are used in weedkillers, rooting powder and to control fruit ripening.

Tropisms

Plants need light and water for **photosynthesis**. They have developed responses called **tropisms** to help make sure they grow towards sources of light and water.

There are two main types of tropisms:

- positive tropisms – the plant grows towards the stimulus
- negative tropisms – the plant grows away from the stimulus.

Phototropism is a tropism where the stimulus is light. A geotropism is a tropism where the stimulus is gravity. The roots and shoots of a plant respond differently to the same stimuli. The table summarises these differences.

Responses to stimulus of different parts of the plant

part of plant	light	gravity
shoot	positive phototropism (grow towards the light)	negative geotropism (grow against the force of gravity)
root	negative phototropism (grow away from the light)	positive geotropism (grow in the direction of the force of gravity)

Positive phototropism in plant stems

The tropisms of shoots mean that they are likely to grow into the air, where there is light for photosynthesis.

The tropisms of roots mean that they are likely to grow into the soil, where there is moisture.

Tropisms are controlled by plant hormones called auxins. These water-soluble chemicals move through the plant in solution.

Uses of plant hormones

Plant hormones can be used in agriculture to control the rate of plant growth.

Weed killers

Selective weed killers attack some plants but not others. This can be useful for getting rid of dandelions in a lawn without killing the grass, or getting rid of thistles in a field without killing the wheat plants. The selective weed killer contains growth hormone that causes the weeds to grow too quickly. The weed killer is absorbed in larger quantities by the weeds rather than the beneficial plants.

Rooting powder

Rooting powder makes stem cuttings quickly develop roots. Rooting powder contains growth hormones.

Controlling fruit ripening

Some hormones slow the ripening of fruits and others speed it up. These hormones and their inhibitors are useful for delaying ripening during transport or when fruit is displayed in shops.

Dormancy

Dormancy stops seeds germinating until conditions are ideal for growth. Hormones can be used to remove the dormancy of a seed so it can germinate at all times of year. Buds and flowers can also be naturally dormant. Hormones can also be used to make plants grow bushier, make them flower or control the growth of hedge plants.

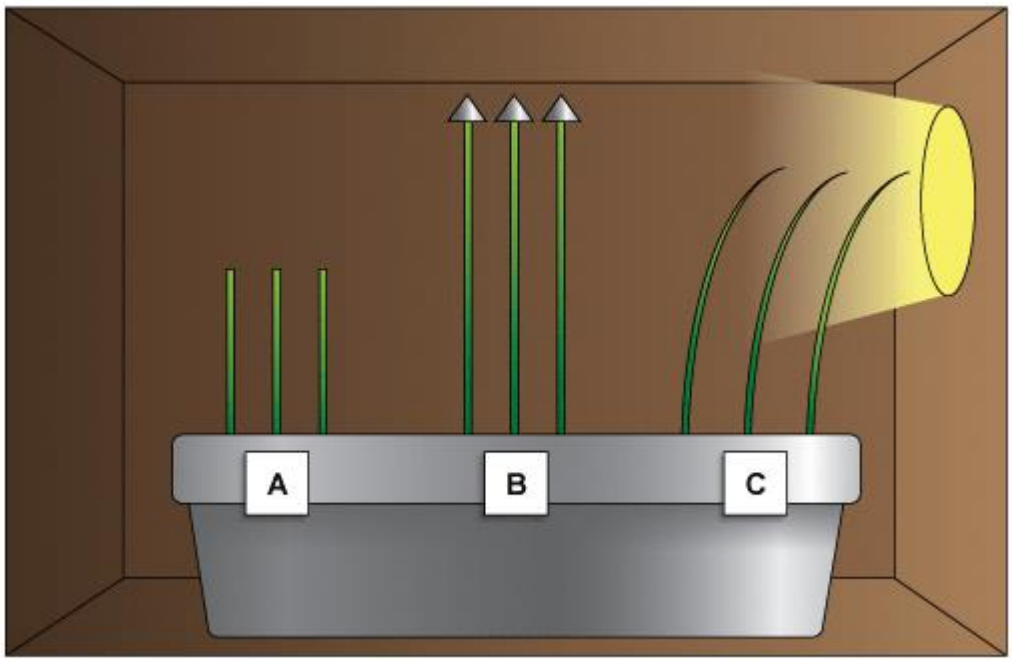
Auxins - Higher tier

Auxins are mostly made in the tips of the shoots and roots, and can diffuse to other parts of the plant. Auxins change the rate of elongation in plant cells, controlling how long they become. Shoots and roots respond differently to high concentrations of auxins:

- cells in shoots grow more
- cells in roots grow less.

Phototropisms

In a shoot, the shaded side contains more auxin. This means that the shaded side grows longer, causing the shoot to bend towards the light. The diagram shows the typical results seen when growing oat seedlings in a box, with a light at one side.



Auxin in different seedlings

Seedlings	Results and explanation
A	The tips have been removed. No auxin is produced and the shoots do not grow longer.
B	The tips have been covered so light cannot reach them. Auxin is in the same concentration on both sides of the shoots, so they grow longer evenly on both sides.
C	One side of the tips are in more light than the other side. Auxin is in a greater concentration on the shaded side, causing the cells there to grow longer than the cells on the light side.

Auxins have the opposite effect on root cells. In a root, the shaded side contains more auxin, but this time the shaded side grows less than the light side. This causes the root to bend away from the light.

Geotropisms

Auxins are also involved geotropisms. In a root placed horizontally, the bottom side contains more auxin than the top side. This makes the bottom side grow less than the top side, causing the root to bend in the direction of the force of gravity.

In a shoot placed horizontally, the bottom side contains more auxin than the top side. This makes the bottom side grow more than the top side, causing the shoot to bend and grow against the force of gravity.

8. Variation and inheritance

Some characteristics of a living thing are caused by the environment, some by inherited factors, while others are caused by a combination of environment and inherited factors.

Male mammals carry XY sex chromosomes - female mammals carry XX sex chromosomes. Inherited disorders are caused by faulty genes on these chromosomes.

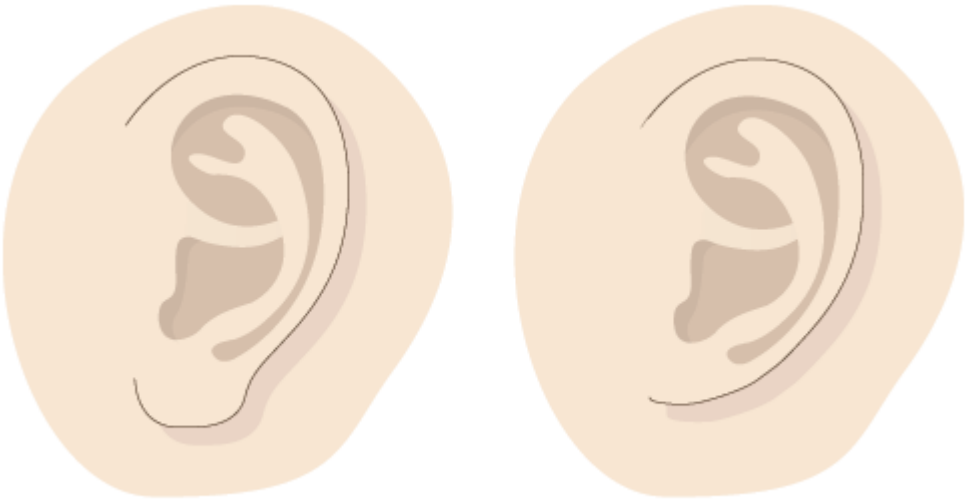
Different versions of a gene are called alleles, and these alleles can be dominant or recessive. Genetic diagrams can show the possible outcomes of a particular cross.

Environmental and inherited characteristics

Some characteristics of an individual are caused by the environment. For example, the language we use or whether we have scars are environmental characteristics. Other characteristics are inherited.

Examples of inherited characteristics include:

- the shape of the earlobes
- eye colour
- nose shape.



Lobed ear Lobeless ear

Whether you have lobed or lobeless ears is due to genetic causes

Some characteristics - including intelligence, body mass and height - are the result of both environmental and inherited factors. But there is debate about the relative importance of these two types of factor in some human characteristics, such as intelligence, health and sporting ability.

DNA, genes and chromosomes

DNA

DNA (deoxyribonucleic acid) molecules are large and complex. They carry the genetic code that determines the characteristics of a living thing.

Except for identical twins, each person's DNA is unique. This is why people can be identified using DNA fingerprinting. DNA can be cut up and separated, forming a sort of 'bar code' that is different from one person to the next.

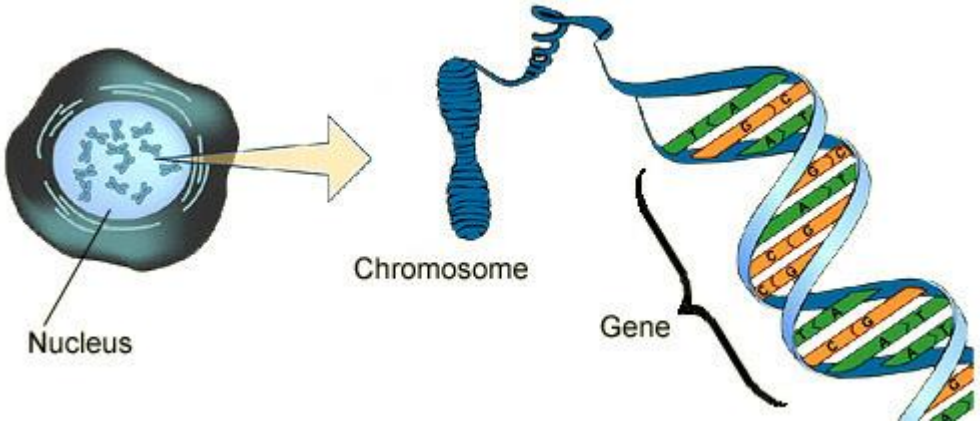
Genes

A gene is a short section of DNA. Each gene codes for a specific protein by specifying the order in which amino acids must be joined together.

Chromosomes

The cell's nucleus contains chromosomes made from long DNA molecules.

The diagram shows the relationship between the cell, its nucleus, chromosomes in the nucleus, and genes.



Nucleus, chromosome and gene

Sex determination

Most body cells contain chromosomes in matched pairs. The number of pairs of chromosomes varies between species. Human body cells have 23 pairs of chromosomes in the nucleus. One of these pairs controls the inheritance of gender - whether offspring are male or female,

- in males, the two sex chromosomes are different. They are XY
- in females, the two sex chromosomes are the same. They are XX.

A set of human chromosomes can be separated from its cell, spread out on a microscope slide and magnified many thousands of times. When stained and photographed, they look like this:

Chromosomes from a male

Chromosomes from a female

Gametes

Gametes are sex cells. The male gametes are the sperm, and the female gametes are the eggs.

Gametes contain half the number of chromosomes as body cells do. They contain half the genetic information that body cells do.

Alleles

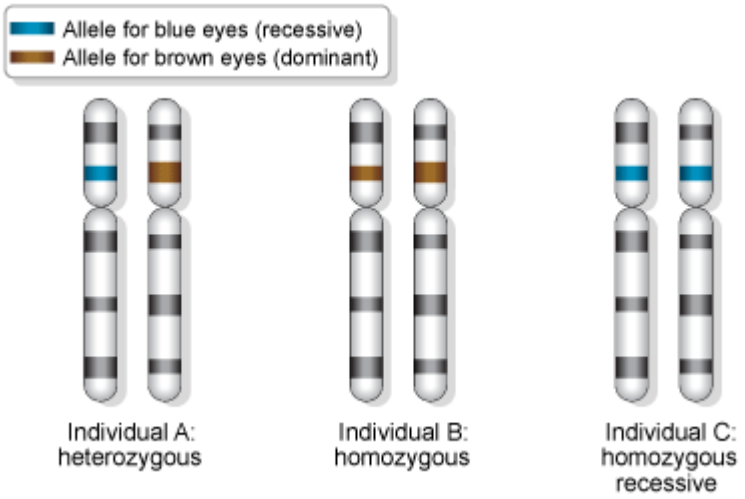
Some characteristics, such as eye colour and the shape of the earlobe, are controlled by a single gene. These genes may have different forms.

Different forms of the same gene are called alleles (pronounced al-eels). The gene for eye colour has an allele for blue eye colour and an allele for brown eye colour.

Alleles are dominant or recessive, meaning:

- the characteristic controlled by a dominant allele develops if the allele is present on one or both chromosomes in a pair
- the characteristic controlled by a recessive allele develops only if the allele is present on both chromosomes in a pair.

For example, the allele for brown eyes is dominant, while the allele for blue eyes is recessive. An individual who inherits one or two alleles for brown eyes will have brown eyes. An individual will only have blue eyes if they inherit two copies of the allele for blue eyes.



Individuals A and B have brown eyes - only individual C has blue eyes

Higher tier

An individual is homozygous for a certain gene if they have two identical alleles. They are heterozygous for a certain gene if they two different alleles.

The genotype is the genetic makeup of an individual. For example, it is the particular combination of alleles in each of the three examples above.

The phenotype is the characteristics expressed by an individual. For example, it is the actual eye colour for the three examples above.

Inherited disorders

Some disorders are inherited, such as:

- red-green colour blindness
- sickle cell anaemia
- cystic fibrosis.

Inherited disorders are caused by faulty genes, which are mostly (but not always) recessive alleles. For example, cystic fibrosis is an inherited disorder that affects the cell membranes, causing the production of thick and sticky mucus. It is caused by a recessive allele, which means that it must be inherited from both parents.

Genetic testing

Scientists are now able to test adults and unborn babies for alleles that can cause genetic disorders. However, the scientific information produced raises many issues that science cannot address. For example, should a couple with a one in four risk of having a child with cystic fibrosis take the gamble, or decide not to have any children at all? If a woman becomes pregnant with a child that is going to

have cystic fibrosis, should she have the child, or choose to have an abortion? These are questions about values that science cannot answer. Different people will have different views.

Genetic diagrams- Higher tier

Genetic diagrams are used to show the possible outcomes of a particular cross. A dominant allele is shown by a capital letter, and a recessive allele by a lower case letter.

Cystic fibrosis

Cystic fibrosis is an inherited disorder caused by a recessive allele. This genetic diagram shows the possible outcomes when both parents are heterozygous for the faulty allele. There is a one in four chance of the offspring being homozygous for the faulty allele, and so having cystic fibrosis.

f is the cystic fibrosis allele		mother	
		F	**f**
father	**F**	FF	Ff
	f	Ff	ff

Mother and father both have one F and one f allele

This genetic diagram shows the possible outcomes when only one parent carries the faulty allele. There is no chance of the offspring being homozygous for the faulty allele and therefore having cystic fibrosis.

f is the cystic fibrosis allele		mother	
		F	**F**
father	**F**	FF	FF
	f	Ff	Ff

Mother has two F alleles, father has one F and one f allele.

Gender determination

Female gametes (eggs) contain X chromosomes, while male gametes (sperm) contain either X chromosomes or Y chromosomes. This genetic diagram shows that equal numbers of male and female offspring should be produced.

Gender determination		mother	
		X	X
father	X	XX	XX
	Y	XY	XY

Females are XX and males are XY