AQA GCSE Biology Foundation Homeostasis and Response **Knowledge Organiser**

Key Words

central nervous system (CNS)	The brain and spinal cord.
coordination centre	An area that receives and processes information from receptors. Includes the brain, spinal cord and pancreas.
effector	A muscle or gland that brings about a response to a stimulus.
gland	A group of cells which secrete hormones.
homeostasis	The regulation of the internal conditions of a cell or organism to maintain optimum conditions for function in response to internal and external changes.
hormone	A chemical substance secreted by an endocrine gland that regulates the activity of cells.
neurone	A nerve cell. A specialised cell that transmits electrical impulses around the body.
receptor	A specialised cell of the nervous or endocrine system that detects a stimulus.
reflex action	An automatic and rapid response to a stimulus that does not involve the conscious part of the brain.
response	The way the body reacts to a stimulus.
stimulus (plural: stimuli)	A change in the internal or external environment.
synapse	A gap between two neurones. Impulses pass across it by diffusion of chemical neurotransmitters.

Homeostasis

Homeostasis is the regulation of **internal conditions** of a cell or organism to maintain **optimum conditions** for function in response to internal and external changes. Homeostasis maintains optimum conditions for **enzyme action** and **cell functions**.

In humans, homeostasis regulates:

- blood glucose concentration;
- body temperature;
- water levels.

Homeostatic processes are controlled **automatically**. They involve either a **nervous response** controlled by the nervous system or a **chemical response** controlled by the endocrine system.

All control systems include the following key components:

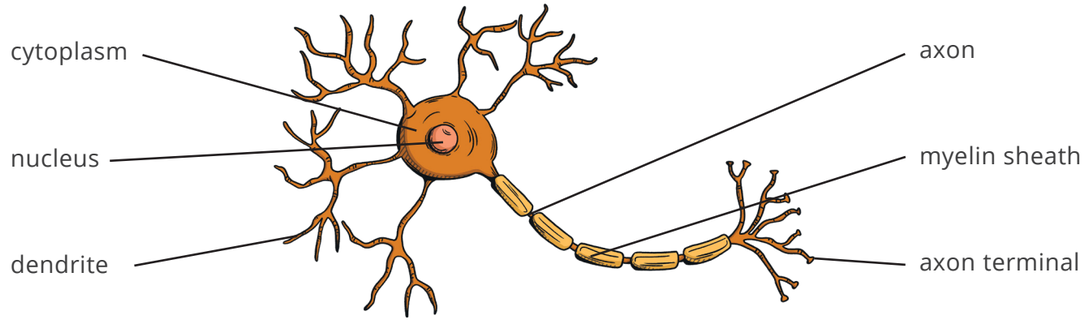
A **receptor** that detects changes in the environment called **stimuli**. The skin contains cells that act as receptors to the stimulus of pressure, for example.

A **coordination centre** such as the brain, spinal cord or pancreas, which processes the information it receives from the receptors.

An **effector** which carries out a **response**. The response restores internal conditions to optimal levels. Effectors are usually muscles or glands.

The Human Nervous System

In a nervous response, the key components of the control system are linked by nerve cells called **neurones**. Neurones are an example of **specialised cells**. They transmit electrical impulses through the nervous system to cause responses to occur.



Neurone Feature	Specialised Function
axon	A long, stretched-out fibre of cytoplasm which the electrical nerve impulse travels along.
axon terminal	Where chemicals called **neurotransmitters** are released. These pass across **synapses**, allowing the nerve impulse to pass between different neurones.
dendrite	Branches which receive neurotransmitter chemicals from other neurones. The dendrites convert these chemicals into electrical signals which travel down the body of the neurone.
myelin sheath	Layer of fatty tissue which surrounds the axon of some (but not all) neurones. It insulates the axon allowing the nerve impulse to be transmitted more efficiently.

There are three types of neurone:

1. **Sensory** neurones link the **receptor** to the **coordination centre**.
2. **Motor** neurones link the **coordination centre** to the **effector**.
3. **Relay** neurones are found within the coordination centre and connect the sensory and motor neurones.

Nerve impulses travel along the following pathway:

[stimulus] → receptor → sensory neurone → coordination centre → motor neurone → effector → [response]

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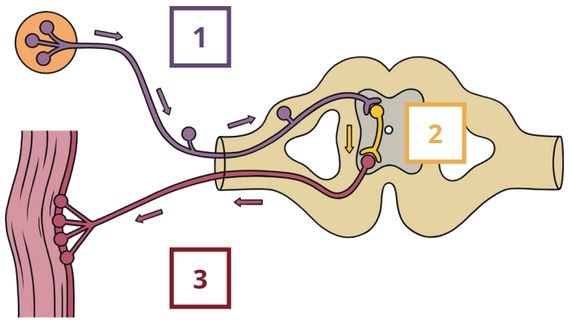
Reflex Arc

A reflex action occurs to prevent you from coming to harm. They do not require conscious thought: they are **rapid** and **automatic**.



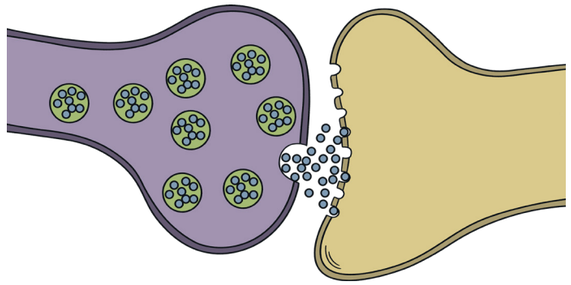
During a reflex action the nerve impulse travels along the following pathway:

1. The **receptor** detects a **stimulus** internally or from the environment. This causes a nerve impulse to travel along the **sensory neurone** to the closest part of the **central nervous system** (CNS). This is not always in the brain.
2. The CNS is the **coordination centre** for a reflex action and coordinates the response. This does not involve the conscious part of the brain to enable the response to be rapid. The **relay neurone** connects the **sensory neurone** to the **motor neurone**. The gaps between the neurones are called **synapses**.
3. The electrical impulse travels along the **motor neurone** to the **effector**. This causes a response to occur which prevents or reduces harm.

[stimulus] → receptor → sensory neurone → relay neurone → motor neurone → effector → [response]

Synapses

The small gaps between neurones are called **synapses**. The electrical nerve impulse cannot cross these gaps.



When the nerve impulse reaches the end of one neurone it causes chemicals called **neurotransmitters** to be released into the gap.

These **diffuse** across the gap and bind to receptor sites on the second neurone. This causes the second neurone to transmit an electrical nerve impulse.

Synapses account for a slight reduction in the speed of the transmission of nerve impulses.

Control of Body Temperature

The brain contains a **thermoregulatory centre** which is responsible for monitoring body temperature and coordinating a response if it gets too high or low. **Receptors** within the thermoregulatory centre monitor the temperature of the blood passing through it. Receptors in the **skin** are sensitive to changes in external temperature.

normal body temperature (37ºC) → change in body temperature detected by **receptors** → nerve impulses sent to **thermoregulatory centre** in the brain → responses return body **temperature** to normal

When the receptors detect an **increase** in body temperature, the responses brought about by the thermoregulatory centre include:

- causing **blood vessels** at the surface of the skin to **dilate** (vasodilation)
- the production of **sweat** from sweat glands in the skin

Both responses cause an **increase in the transfer of energy by radiation** from the skin to the environment. This causes the body to **cool**.

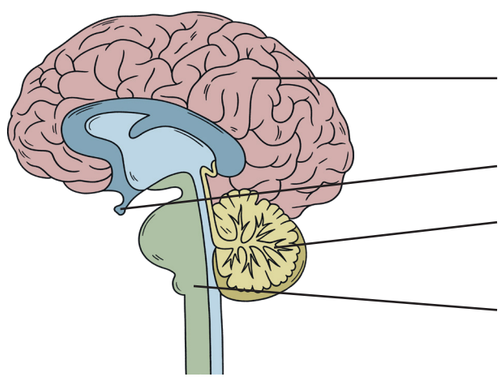
When the receptors detect a **decrease** in body temperature, the responses brought about by the thermoregulatory centre include:

- causing **blood vessels** at the surface of the skin to **constrict** (vasoconstriction)
- **shivering**: where the skeletal muscles contract and relax rapidly

Both responses cause the temperature of the body to **increase**.

The Brain

The brain is made of billions of **neurones** connected together. It controls all of our complex behaviours, both conscious and unconscious.
The different regions of the brain carry out different functions.



cerebral cortex: controls conscious activities and other functions including memory, language, speech and intelligence

pituitary gland: the 'master gland' which secretes many important hormones into the bloodstream

cerebellum: controls the coordination of muscles including fine motor skills, and supports the ability to balance

medulla: controls unconscious processes such as the regulation of your heartbeat and breathing rate

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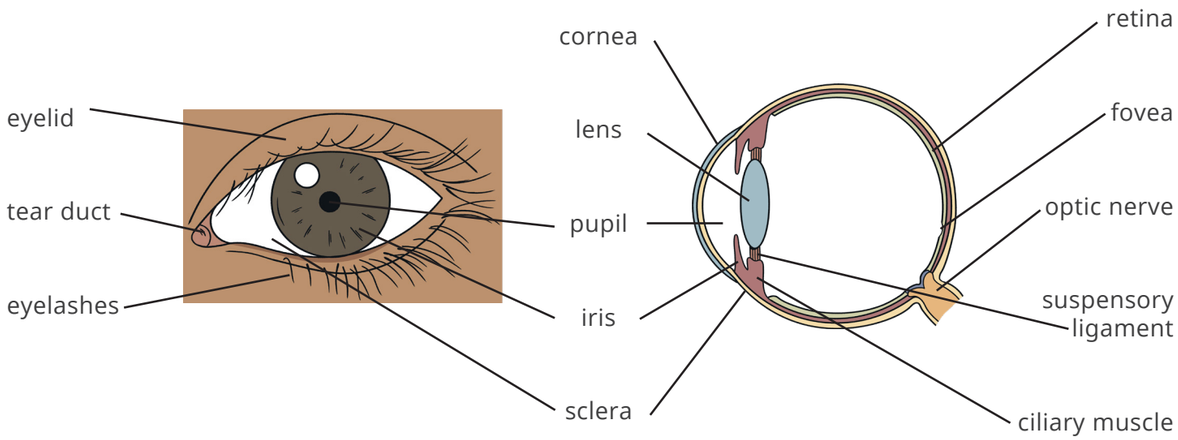
The Eye

The human eye contains **receptor cells** which detect the intensity and colour of light rays which enter the eye through the pupil. These receptor cells transmit electrical signals to the brain through the **optic nerve**. The brain then produces an image of what we see.

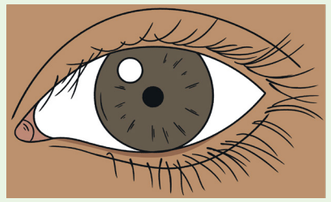


The Pupil Reflex

The size of the pupil can be changed to control the amount of light let into the eye. This allows clear images to be formed whilst preventing damage to the retina.

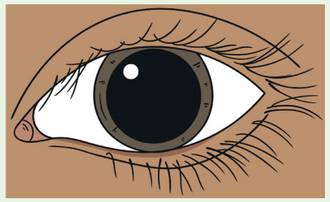
In **bright** light:

- radial iris muscles relax
- circular iris muscles contract
- the pupil constricts to become smaller
- less light is let into the eye



In **dim** light:

- radial iris muscles contract
- circular iris muscles relax
- the pupil dilates to become wider
- more light is let into the eye



Structures of the Eye

Feature	Function
ciliary muscle	A muscle which, along with the **suspensory ligaments**, changes the shape of the **lens** by contracting and relaxing. This process is known as **accommodation**.
cornea	A transparent continuation of the **sclera** which covers the front of the eyeball, refracting (bending) light as it enters through the **pupil**.
fovea	An indentation in the **retina** containing only **cone cells**.
iris	A coloured ring of circular and radial muscles which contract and relax to control the amount of light let into the eye through the **pupil**.
lens	A disc which further refracts (bends) light to focus it onto the **retina. Ciliary muscles** and **suspensory ligaments** change the shape of the lens in a process known as **accommodation**.
optic nerve	Contains **neurones** which transmit nerve impulses between the eye and the brain in response to the stimuli detected by the light-sensitive receptor cells in the **retina**.
pupil	A hole through which light rays can enter the eyeball.
retina	An internal layer of the eyeball containing the light-sensitive receptor cells called **rods** and **cones**.
sclera	The tough, opaque outer layer of the eyeball which protects it from damage.
suspensory ligament	Tissue which attaches the **ciliary muscle** to the **lens**.

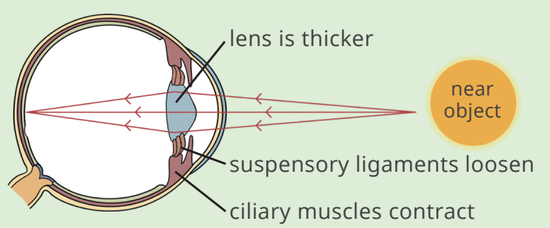
Accomodation

When objects are at different distances from the eye, the lens changes shape to focus the light rays onto the retina. This is called **accommodation**.

Near Objects

When the object is close to the eye the **ciliary muscles contract**. This causes the **suspensory ligaments** to **loosen**. These actions change the shape of the **lens** which becomes shorter and thicker.

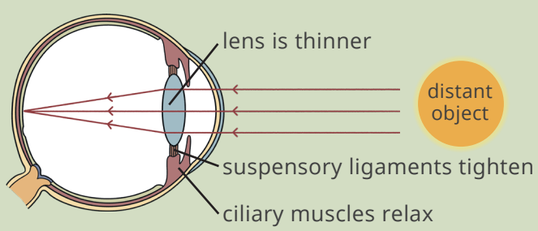
The thicker lens **refracts** (bends) the light more strongly. This enables the light rays to be focussed on the retina.



Distant Objects

When the object is far away from the eye the **ciliary muscles relax**. This causes the **suspensory ligaments** to **tighten**. These actions change the shape of the **lens** which becomes longer and **thinner**.

The thinner lens **refracts** (bends) the light less strongly. This enables the light rays to be focussed on the retina.



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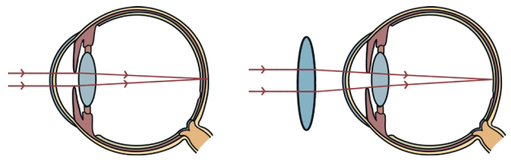
Defects of the Eye

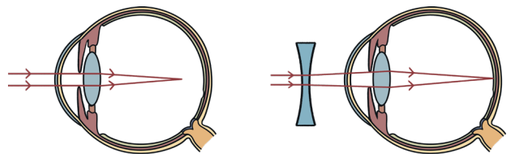
Sometimes light rays do not focus on the retina. This means a clear image cannot be formed. These defects are commonly treated by wearing **spectacles** with appropriate **lenses**.

Hyperopia, also known as 'long-sightedness,' is where the light rays focus at a point behind the retina. Near objects seem out of focus. Hyperopia can be caused by the eyeball being too short or the lens losing its elasticity. It is corrected using a **convex** lens.



hyperopia is treated using a **convex** lens

Myopia, also known as 'short-sightedness,' is where the light rays focus at a point in front of the retina. Distant objects seem out of focus. Myopia can be caused by having a longer eyeball or a lens which is too thick. It is corrected using a **concave** lens.



myopia is treated using a **concave** lens

Alternate treatments for eye defects include wearing **contact lenses** which refract light in the same way as spectacle lenses, or having **laser eye surgery** to change the shape of the **cornea** of the eye. Some people also have surgery to replace the **lens**.

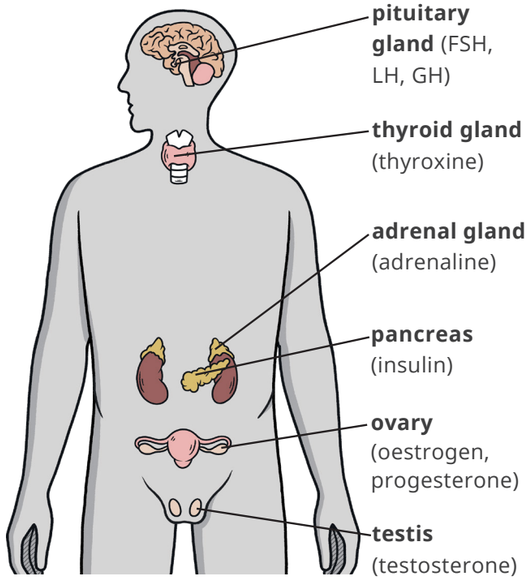
The Human Endocrine System

The endocrine system coordinates and controls the release of hormones from glands.

The **pituitary gland** is also known as the 'master gland' because it secretes many hormones which in turn control the function of other glands. These include follicle-stimulating hormone (FSH), luteinising hormone (LH) and growth hormone (GH).

Nervous vs Chemical Responses:

	Nervous	Chemical
signal type	electrical impulses	hormones
transmission medium	neurones	bloodstream
response speed	rapid	relatively slow
duration	relatively short (reflexes occur in less than a second)	relatively long (puberty occurs over many years)
target area	specific	large



Required Practical: Human Reaction Time

Aim: To investigate how handedness affects human reaction time.

Independent Variable: which hand is used

Dependent Variable: reaction time

Control Variables:

- starting position of the ruler
- use of cues (physical and verbal)
- practice
- starting position of thumb and first finger

Equipment:

- metre ruler
- table
- chair
- reaction time conversion table

Method:

1. Ask your partner to sit at a table with their dominant (writing) arm outstretched so their entire hand is hanging from the edge of the table.
2. Hold the metre ruler vertically between your partner's thumb and first finger. Their thumb and first finger should be held as far apart as possible.
3. Ensure that the 0cm mark on the ruler is pointing downwards and in line with the thumb.
4. Check that the person sitting is ready. Remind them that the aim is to catch the ruler as quickly as possible after it is dropped using their thumb and first finger.
5. Drop the metre ruler without warning your partner it is about to happen.
6. Read the measurement on the metre ruler from the top of your partner's thumb and record this in a results table.
7. Repeat this nine more times to get ten results in total for their dominant hand.
8. Repeat the investigation using your partner's non-dominant hand.
9. Use a reaction time conversion table to convert the measurement on the ruler to a reaction time.
10. Calculate the average reaction time for each hand, remembering to discount any anomalous results.

You can use a similar method when investigating how different independent variables affect human reaction time. For example, whether your partner has consumed caffeine.

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Control of Blood Glucose Concentration

The **pancreas** is both the **coordination centre** and the **effector** for maintaining a normal blood glucose concentration.

The pancreas releases the hormone **insulin** when the concentration of glucose in the blood is too high.

Insulin causes the cells to absorb the excess glucose, and this is converted to another molecule called **glycogen** by the **liver** and **muscles**. The liver and muscles then store the glycogen. They can convert it back to glucose when blood glucose levels become too low.

normal blood glucose concentration → blood glucose concentration becomes **too high** → **pancreas** releases **insulin** which causes the cells to **absorb** glucose → **liver** and **muscles** convert the glucose into **glycogen** to be stored → normal blood glucose concentration

Diabetes

There are two types of diabetes: **Type 1** and **Type 2**. Although both prevent the maintenance of blood glucose concentration, the risk factors and treatments for each are different.

Type 1 Diabetes:

- an autoimmune disorder;
- the cells in the pancreas which produce insulin are destroyed by the body;
- the body cannot produce enough insulin to regulate blood glucose concentration;
- treated using insulin injections;
- diet and exercise help to control blood glucose concentration;
- a lifelong condition;
- the cause is unknown, but is thought to be a combination of genetic and environmental factors.

Type 2 Diabetes:

- a metabolic disorder;
- body cells stop responding to the insulin produced by the pancreas, causing blood glucose concentration to increase;
- treated by following a carbohydrate-controlled diet, avoiding sources of dietary sugar, and exercising;
- can be reversed with a healthy lifestyle;
- risk factors include: being overweight or obese, having a high carbohydrate or sugar diet, not exercising, smoking and having high blood pressure.

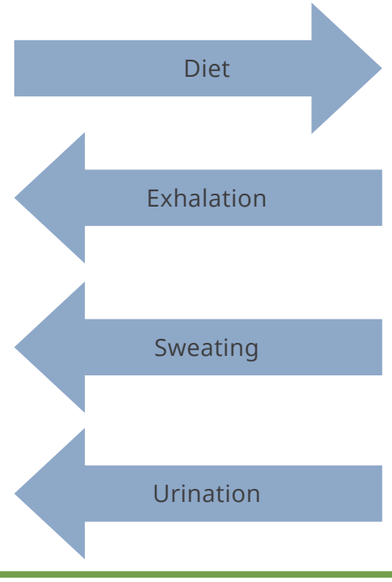
Maintaining Water Balance

The control of water balance within the body is known as **osmoregulation**.

When cells gain or lose too much water by **osmosis** they do not work efficiently. This means that the water entering and leaving the body is monitored and controlled.

The body **cannot control** the loss of water through the lungs during **exhalation** or the loss of water, ions and urea through the skin in **sweat**.

The body **can control** the water, ions and urea excreted in **urine**.



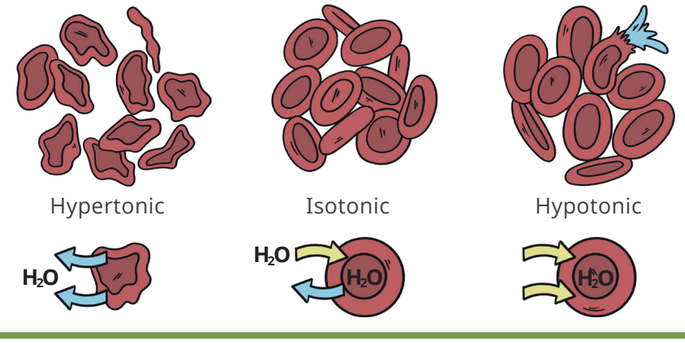
Water Balance in Animal cells

Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane. Animal cells do not have a cell wall. This means that they are sensitive to changes in the concentration of the solution around them.

A **hypertonic solution** has a **higher solute concentration** than inside the cell. Water moves by osmosis from the cell into the solution. The cell **shrivels**.

An **isotonic solution** has the **same solute concentration** as inside the cell. Water moves into and out of the cell by osmosis but there will be no overall change in concentration. The shape of the cell remains normal.

A **hypotonic** solution has a **lower solute concentration** than inside the cell. Water moves by osmosis from the solution into the cell. The cell **swells** and may **burst**.



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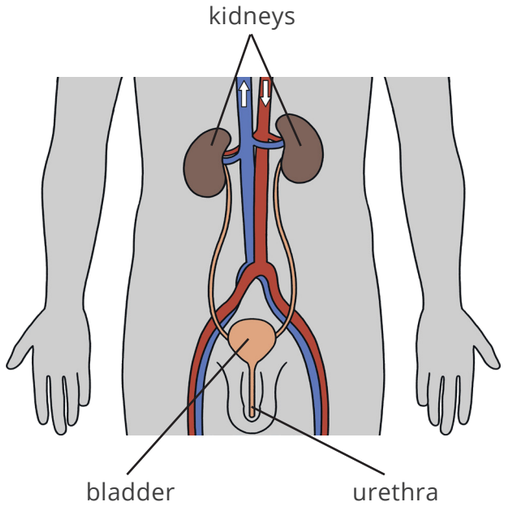
The Kidney

Water balance in the body is maintained by the **kidneys**. The kidneys **produce urine**. This happens in three stages:

1. **Filtration:** As blood passes through the kidneys, it is under **high pressure**. This forces **small molecules** including water, glucose, ions and urea to be filtered out of the blood and into the kidneys.
2. **Selective reabsorption:** Any filtered molecules which are useful to the body are reabsorbed back into the bloodstream. **All glucose molecules** are reabsorbed. Enough **water** and **ions** are reabsorbed as needed by the body to maintain water and mineral balance.
3. **Urine production:** Any molecules which have not been reabsorbed back into the blood and **all of the urea** passes into the bladder. It is then excreted through the urethra as **urine**.

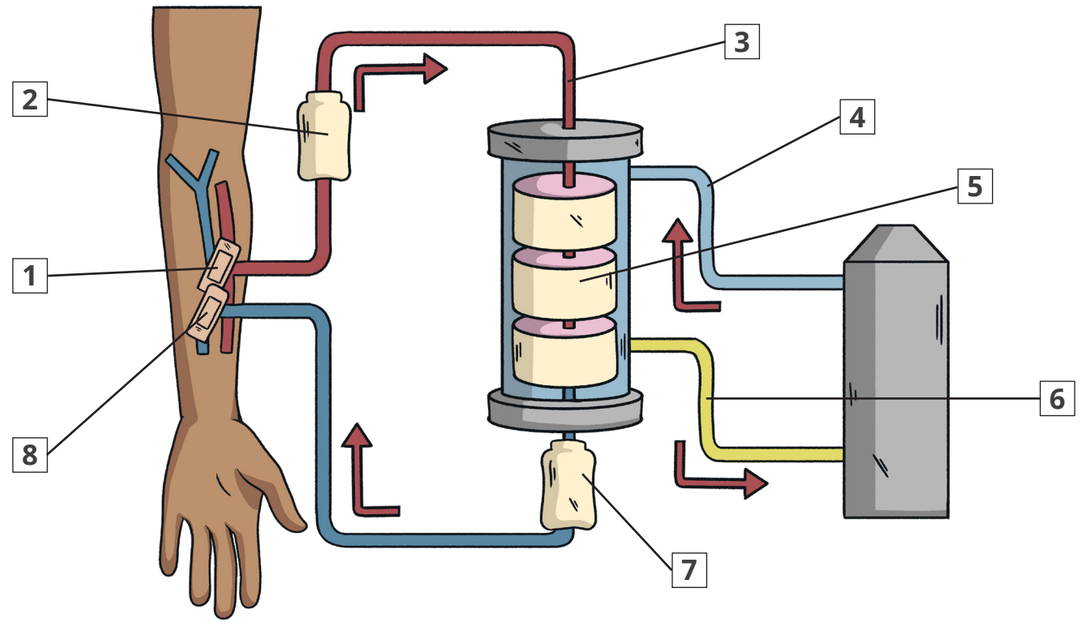


Evaluating Kidney Treatments

	Advantages	Disadvantages
kidney dialysis	• enables a patient with kidney failure to stay healthy whilst waiting for a kidney transplant • removes waste products like urea from the blood • maintains blood glucose concentration • maintains or restores the concentration of ions in the blood • available to all kidney patients	• time-consuming: usually takes four hours, three times a week • requires specialist equipment usually only found in hospital • patients need to limit the salt and protein in their diet • average life expectancy for patients remaining on dialysis is five to ten years • expensive for the NHS to carry out
kidney transplant	• patients can lead a relatively normal life following a kidney transplant • no special diet is required • no lengthy hospital treatments following recovery from surgery • less expensive for the NHS in the long-term • increased life expectancy	• a shortage of organ donors means there can be a long wait • must take immuno-suppressant medication for life to prevent the body rejecting the donated organ • immuno-suppressant drugs increase the risk of infections • all surgeries carry associated risks • donated kidneys only last on average between 10-15 years

Kidney Dialysis

If kidneys become very damaged they cannot filter waste products from your blood. This is known as **kidney failure**. People suffering from kidney failure require a **kidney transplant**. Until a donated kidney becomes available, patients are treated using **kidney dialysis**.



1. Blood which needs to be filtered leaves the patient. This is usually through a surgically placed access point in their arm.
2. **Anti-coagulants** are added to the blood to prevent it from clotting.
3. The patient's blood enters one part of the **dialysis machine**.
4. **Dialysis fluid** enters another part of the dialysis machine. It is separated from the patient's blood by a **partially permeable membrane**. The dialysis fluid contains **glucose** and **ions** at a concentration which is similar to that found in normal blood. Dialysis fluid contains **no urea**.
5. **Urea** will **diffuse** from the patient's blood into the dialysis fluid, across the partially permeable membrane. The dialysis fluid flows in the **opposite** direction to the patient's blood to maintain a **concentration gradient**. This ensures that all of the urea is filtered out of the patient's blood. There is **no net movement** of glucose. There will only be a net movement of ions if the patient's blood has too many or too few.
6. Dialysis fluid containing urea and other waste products is removed from the dialysis machine and disposed of.
7. As it exits the dialysis machine, the patient's blood passes through an air trap to prevent air bubbles moving into the patient's bloodstream.
8. The filtered blood returns to the patient's arm.

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Hormones in Human Reproduction

During **puberty**, secondary sex characteristics such as the development of breasts in females and the growth of facial hair in males are triggered by the release of reproductive hormones.

Hormone	Gland	Primary Function
follicle stimulating hormone (FSH)	pituitary gland	causes maturation of an egg in the ovary
luteinising hormone (LH)	pituitary gland	stimulates the release of the egg (ovulation)
oestrogen	ovary	thickens and maintains the lining of the uterus
progesterone	ovary	maintains the lining of the uterus
testosterone	testis	controls the production of sperm

The **menstrual cycle** occurs in females approximately every **28 days**, although this varies between women. It involves the process of building the lining of the **uterus** in preparation for it accommodating the egg cell released from the **ovary** during **ovulation**.

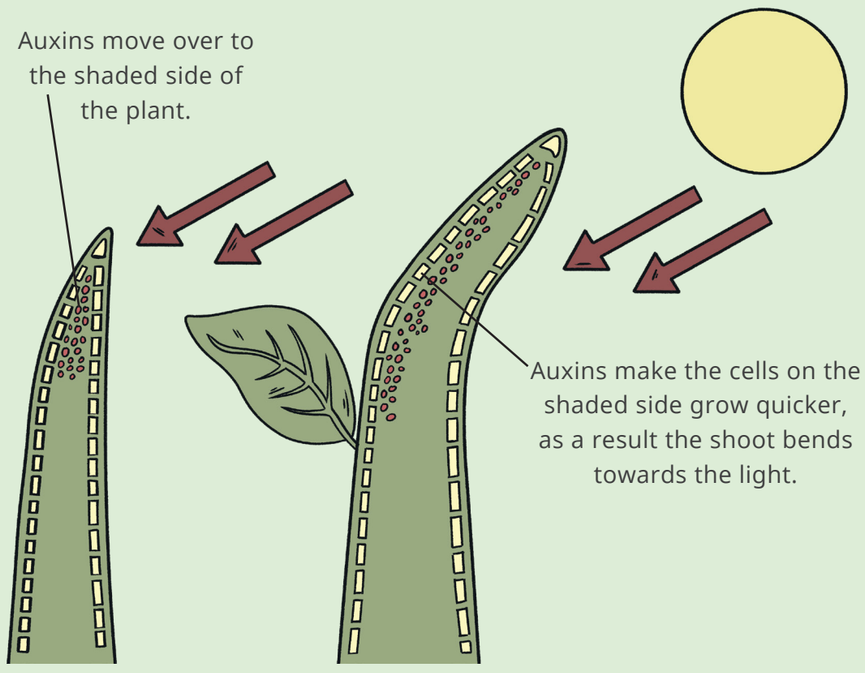
If the egg cell is not **fertilised** by a sperm cell then the lining breaks down, causing **menstruation** to occur. This is what is commonly called 'having a period.'

Plant Hormones

Plants produce hormones called **auxins** to control and coordinate the growth of shoots and roots in response to light and gravity.

When auxins are distributed unequally in a region of a plant it causes uneven rates of growth. The uneven distribution of auxins causes **tropisms**. A tropism is where a plant grows in a certain direction in response to an external stimulus.

Phototropism

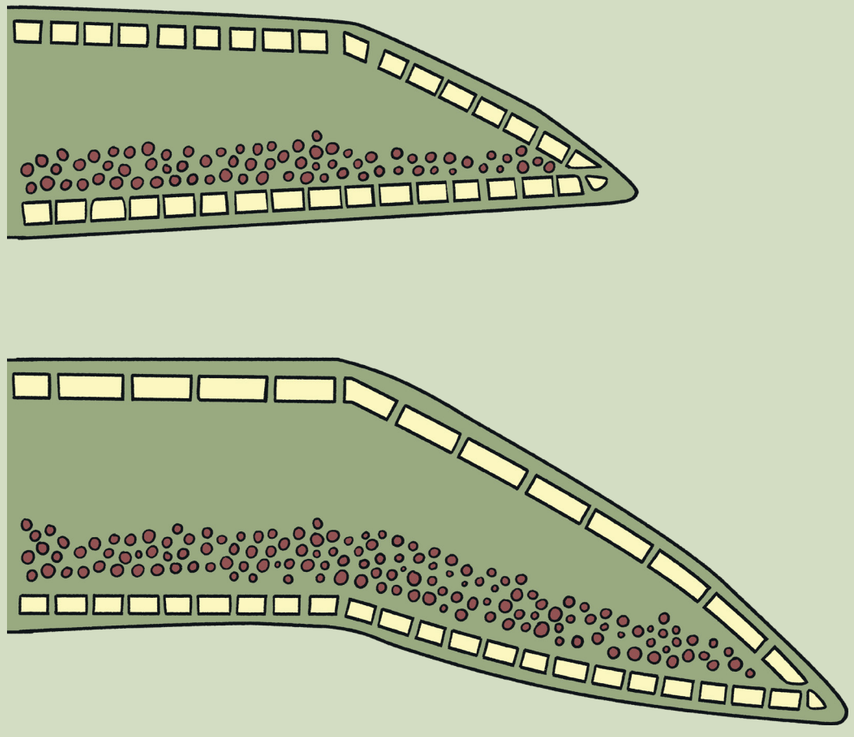


Phototropism is plant growth in response to **light**. Phototropism is plant growth in response to **light**. Auxins move to the shaded side of the plant.

In the plant **shoot**, excess auxin causes the cells on the shaded side to **elongate** which causes the stem to grow towards the light source. This is known as **positive phototropism**.

In the plant **root**, excess auxin on the shaded side **inhibits** the growth of cells. This causes the root to **grow away from** the light source and is known as **negative phototropism**.

Gravitropism



Gravitropism (also known as geotropism) is plant growth in response to **gravity**. Auxins move towards the bottom part of the plant.

In a horizontal plant **shoot** the greater distribution of auxin along the bottom edge causes the cells there to **elongate**. The stem grows **against** the direction of the force of gravity. This is known as **negative gravitropism**.

In a horizontal plant **root** the greater distribution of auxin along the bottom edge **inhibits** the growth of cells. This causes the root to **grow towards** the direction of the force of gravity and is known as **positive gravitropism**.

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Contraception

Method	Type	How It Works	Advantages	Disadvantages
oral contraceptives (the pill or the mini pill)	hormonal	Contains hormones that inhibit the production of FSH. This prevents eggs from maturing. The combined pill contains synthetic oestrogen and progesterone. The mini pill contains progesterone only. Contraceptive pills also work by thickening the cervical mucus, making it harder for the sperm to enter the uterus.	• easy to administer yourself • can reduce period pain • free and widely available • highly effective at preventing pregnancy when taken correctly	• have to remember to take it daily • does not protect against STIs • can have some side effects like headaches and nausea
contraceptive injection, implant or skin patch	hormonal	Contain the hormone progesterone which inhibits the maturation and release of eggs in the same way as the contraceptive pill. A new contraceptive patch is placed on the skin weekly. A contraceptive injection is carried out approximately every three months. The implant remains inserted for around three years.	• as above with the contraceptive pill • you do not have to remember to take it every day • highly effective at preventing pregnancy	• can have some side effects • does not protect against STIs • the implant may need minor surgery to remove
barrier methods including condoms and diaphragms	non-hormonal	When used correctly, barrier methods prevent the sperm from coming into contact with an egg. Condoms are placed over the penis to catch the semen released following ejaculation. Diaphragms are worn inside the vagina to prevent sperm passing through the cervix.	• protect against STIs when used correctly • no hormonal side effects • can be used by males and females • widely available and free from clinics	• can split or tear if used incorrectly • commonly made from latex which some people have allergies to (latex-free condoms are also available)
intrauterine devices and systems (IUD/IUS) (the coil)	both	A small T-shaped device containing copper (IUD) or a hormone similar to progesterone (IUS) which is placed into the uterus by a medical professional. Both make it difficult for sperm to reach the egg, and for a fertilised egg to implant into the lining of the uterus.	• lasts for up to ten years depending on the type • one of the most effective forms of contraception • suitable for women who cannot have oestrogen • can make periods lighter and less painful	• does not protect against STIs • has to be inserted and removed by a medical professional which can be uncomfortable • there is a risk of infections when the device is fitted
spermicidal agents	non-hormonal	A cream, foam or gel which kills or immobilises sperm. Condoms are often coated in a layer of spermicide to increase their effectiveness. Spermicide is rarely used as the sole method of contraception.	• effective when used with a barrier method like a condom or diaphragm • no hormonal side effects • easy to apply yourself	• not very effective at preventing pregnancy when used on its own • does not protect against STIs • not as widely available as other methods
abstaining from sexual intercourse (natural family planning)	non-hormonal	Partners abstain from sexual intercourse near and during ovulation. Fertility is tracked by keeping a record of the menstrual cycle, body temperature and cervical secretions in order to avoid pregnancy.	• does not cause any side effects • acceptable to all faiths and cultures • increases self-awareness of fertility, which can be useful for people who plan to get pregnant in the future	• does not protect against STIs • requires the commitment of daily monitoring of the menstrual cycle • fertility signs can be affected by stress and illness making this method less effective
surgical methods (sterilisation)	non-hormonal	In females, the oviducts are blocked using clips, tied or are cut. They can also be removed. This prevents sperm from coming into contact with an egg. In males, the tubes which carry the sperm to the penis, are cut, tied or sealed. This means there is no sperm present in the ejaculate.	• highly effective at preventing pregnancy • does not affect hormone levels or sex drive • it is very rare to have any long-term health effects after surgery	• does not protect against STIs • usually impossible to reverse so should be considered a permanent treatment • risk of surgical complications and infection

Required Practical: Measuring the Growth of Seedlings

Aim: To investigate the effect of light on the growth of newly germinated seedlings.

Independent variable: light intensity

Dependent variable: average length of seedlings

Control variables:

- volume of water provided
- whether the seeds have germinated
- type of seed
- room temperature
- time left to grow

Equipment:

- three plastic cups or similar containers
- cotton wool
- thirty cress seeds (or other rapidly germinating seeds)
- sheet of black paper or card
- sheet of white paper or card
- forceps
- ruler
- sticky tape or elastic bands

Method:

1. Place the same amount of cotton wool in the bottom of each of the three plastic cups.
2. Add 10ml of water to the cotton wool in each cup.
3. Place ten seeds onto the damp cotton wool in each cup. Try to spread these out as it will make the shoots easier to measure later on.
4. Place all three of the cups containing the seeds on a warm, sunny windowsill until most of the seeds have germinated. This usually takes a few days.
5. Ensure each cup has an equal number of germinated seeds. This may mean removing some as some of the seeds may not germinate.
6. Use the sheet of black paper or card to make a cover and lid for one of the cups. Use sticky tape or an elastic band to secure this in place.
7. Repeat step six with the piece of white paper or card for a second cup. Leave the third cup without a cover or lid.
8. Place each of the three cups back on the warm, sunny windowsill.
9. Every day for five days, measure and record the height of each of the seedlings in a results table. You may need to use forceps to gently extend the seedlings to their full height. Use a ruler to measure the length of each seedling from the base of the shoot to its tip.
10. After five days make a labelled observational drawing of the seedlings in each cup.
11. Calculate the average growth of the seedlings in each condition over the five days.

You can use a similar method when investigating how different independent variables affect the growth of newly germinated seedlings.
For example: the colour of the incident light or the effect of turning the seeds so their roots point upwards.