

5 · Homeostasis and response

AQA · GCSE · Biology

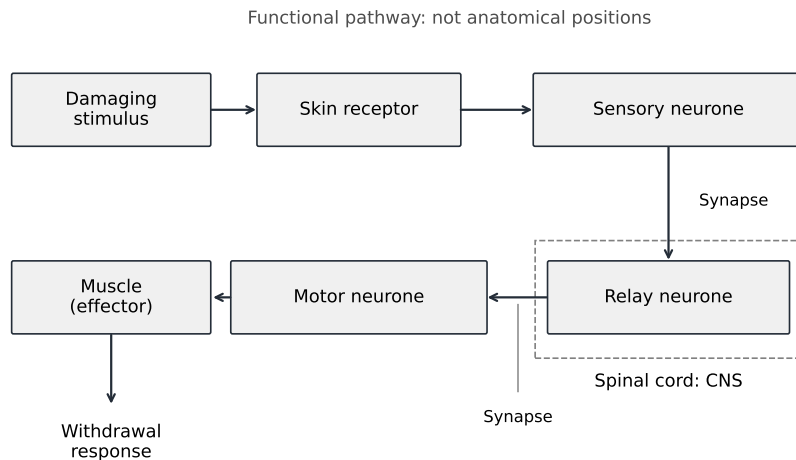
Homeostasis and response: keeping conditions steady

- **Homeostasis** is the regulation of the internal conditions of a cell or organism, to maintain **optimum conditions for enzyme action** and all cell functions, in response to internal and external changes.
- The body controls **blood glucose concentration**, **body temperature** and **water levels**.
- Every automatic control system has: **receptors** (detect stimuli), **coordination centres** (brain, spinal cord, pancreas – receive and process information) and **effectors** (muscles or glands – bring about the response that restores optimum levels).
- Nervous responses are generally rapid and short-lived; hormonal effects are usually slower and longer-lasting. Compare the signalling route as well: impulses along neurones versus hormones carried in blood.

Homeostasis and the nervous system (4.5.1–4.5.2.1, RP7)

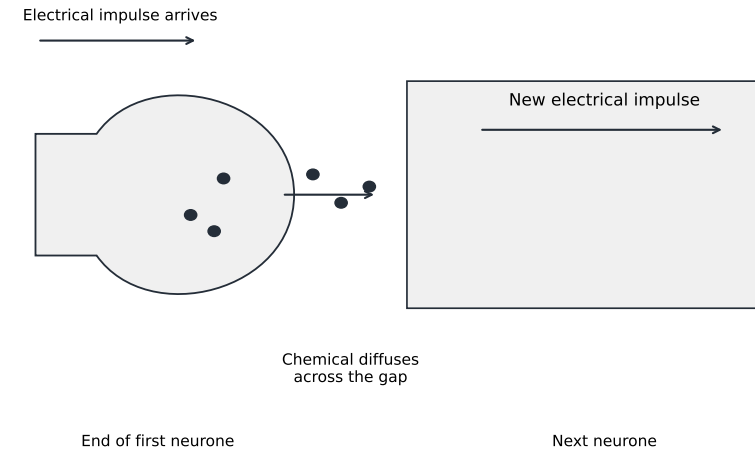
The pathway: stimulus → receptor → coordinator (CNS: brain + spinal cord) → effector (muscle contracts / gland secretes) → response.

Information passes along cells called **neurones** as **electrical impulses**. The CNS coordinates the response of effectors.

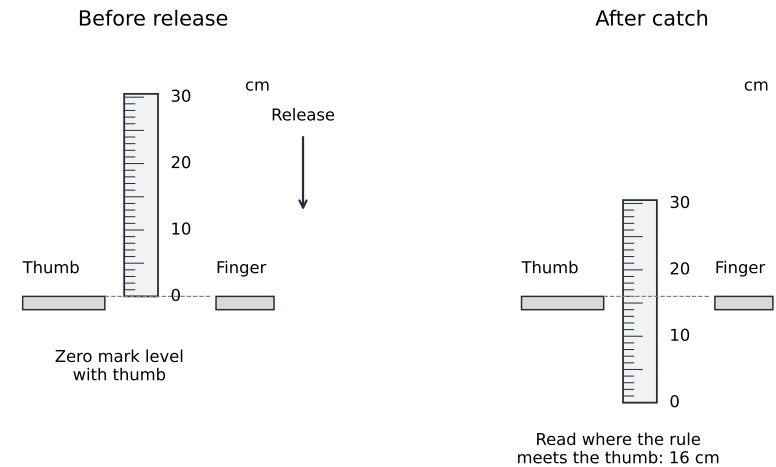


The reflex arc – automatic and rapid protection that does **not** involve the conscious part of the brain:

stimulus → receptor → **sensory neurone** → **synapse** → **relay neurone** (in CNS) → synapse → **motor neurone** → effector → response.



At a **synapse** the electrical impulse arrives at the end of a neurone and a chemical is released; it diffuses across the gap and triggers an electrical impulse in the next neurone.



RP7 – reaction time: Use listening to music versus silence as a factor. Support the same person's arm; hold the ruler vertically with its zero mark level with the top of the thumb and the same gap between finger and thumb. Release after a variable delay

without a countdown, and record catch distance. Repeat trials, keep the same hand, ruler and starting position, and keep the music condition fixed. Give practice trials first and vary/counterbalance condition order to reduce learning and order effects; these controls do not eliminate them. Convert readings using the supplied table or equation, then process the results as the task directs. For paired conditions, compare mean reaction times and state the limits of the conclusion.

■ Distinguish a withdrawal reflex from a visual reaction

For a withdrawal reflex, a receptor detects a damaging stimulus → a sensory neurone carries impulses to a relay neurone in the spinal cord → a motor neurone carries impulses to a muscle → contraction withdraws the limb. The rapid response does not wait for conscious decision; information can still reach the brain and become conscious afterwards. Do not claim that all reflexes exclude the brain: the pupil reflex is coordinated in the brain without conscious decision.

For catching a falling ruler, the stimulus is **movement detected by receptors in the retina**. Impulses travel along the optic nerve to the **brain**, pass through synapses and motor neurones, and reach the hand muscles, which contract. This is the pathway required by AQA June 2025 8461/2H Q07.4; a generic spinal reflex answer misses its context.

■ Worked reaction-time data

AQA June 2025 8461/2H Q07.1–07.2 gives catch distances of **18, 15, 12, 16, 14, 23, 14 cm**. In order these are **12, 14, 14, 15, 16, 18, 23 cm**: the fourth value is the **median**, 15 cm. The mean distance is $\bar{d} = 112/7 = 16$ cm.

The question supplies the following equation, with the numerical value of d in **cm** and t in **seconds**; use its given mean distance.

$$t = \sqrt{\frac{2d}{980}}$$

$$t = \sqrt{\frac{2d}{980}} = \sqrt{\frac{2 \times 16}{980}} = 0.18070 \dots \text{ s}$$

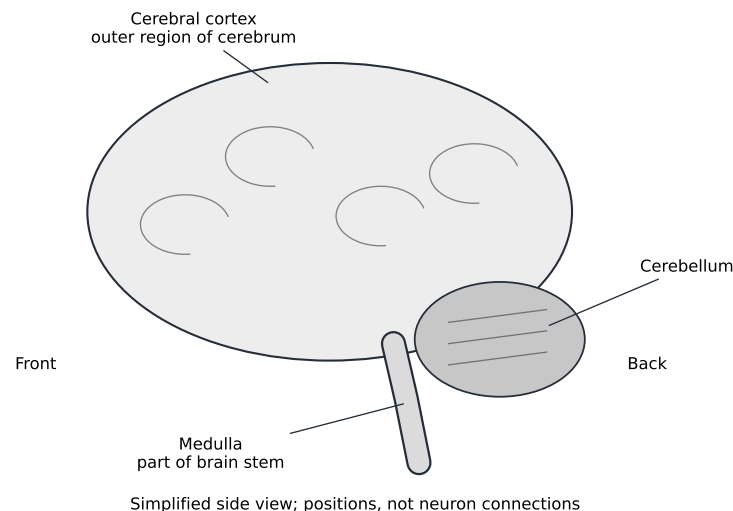
$$t_{\text{ms}} = 1000t = 1000 \times 0.18070 \dots = 180.70 \dots \text{ ms}$$

The final answer is **181 ms**, to 3 significant figures. Do not round to 0.18 s before converting. The official question defines its mean-time estimate through mean distance; this is not a general rule that converting an average always equals averaging converted readings. Do not discard the 23 cm result just because it is largest.

The brain, the eye and temperature – biology only (4.5.2.2–4.5.2.4)

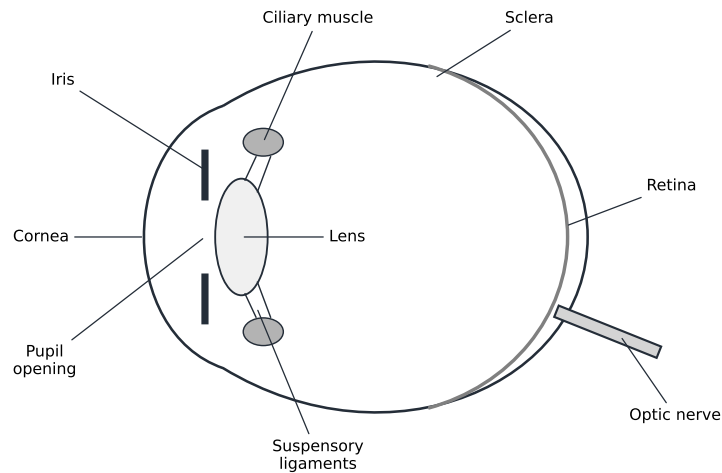
■ The brain

The brain contains billions of interconnected neurones. Identify the **cerebral cortex** (consciousness, memory and language), **cerebellum** (balance and coordination) and **medulla** (automatic heartbeat and breathing). These structures and functions are common-tier Biology knowledge.



Investigating the brain (HT). Damage associated with loss of a function helps map that function, but an injury may affect several connected areas. Electrical stimulation can reveal a response when a region is activated. MRI gives images that help locate structures or damage; an image alone does not prove that a region causes a particular behaviour. Brain tissue is complex, delicate and easily damaged. Evaluate a proposed procedure using its expected benefit, evidence, possible permanent harm and alternatives; do not conclude that all procedures are too risky.

■ The eye

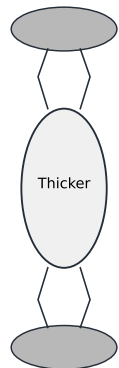


Retina : light-sensitive receptor cells detect intensity and colour. The **optic nerve** carries impulses to the brain. The **sclera** protects the eye; the transparent **cornea** refracts incoming light. The **pupil** is an opening, not a muscle or a black solid structure.

Iris and light level. In bright light, circular iris muscles contract and radial muscles relax; the pupil becomes smaller and less light reaches the retina. In dim light, radial muscles contract and circular muscles relax; the pupil widens and admits more light. This reflex is coordinated in the brain without conscious decision. The iris controls light entry; ciliary muscles change focus.

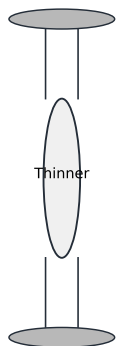
Accommodation changes lens shape so the image focuses on the retina.

Near object
Ciliary muscles contract



Ligaments slacken

Distant object
Ciliary muscles relax



Ligaments are pulled tight

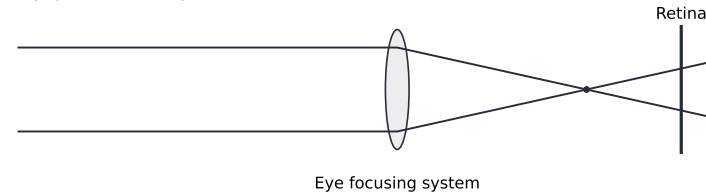
Mechanism model: ligament tension changes lens shape; not pupil size

Object	Ciliary muscles	Ligaments	Lens
Near	contract	slacken	thicker
Distant	relax	pulled tight	thinner

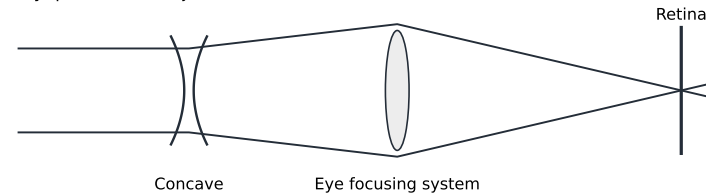
A thicker lens refracts rays more strongly; a thinner lens refracts them less strongly. A thin lens still refracts light. Ligaments transmit tension: they do not actively contract.

Myopia : rays from distant objects focus in front of the retina, for example if the eyeball is too long or focusing is too strong. A **concave** lens diverges incoming rays so the eye focuses them on the retina.

Myopia: distant object — uncorrected

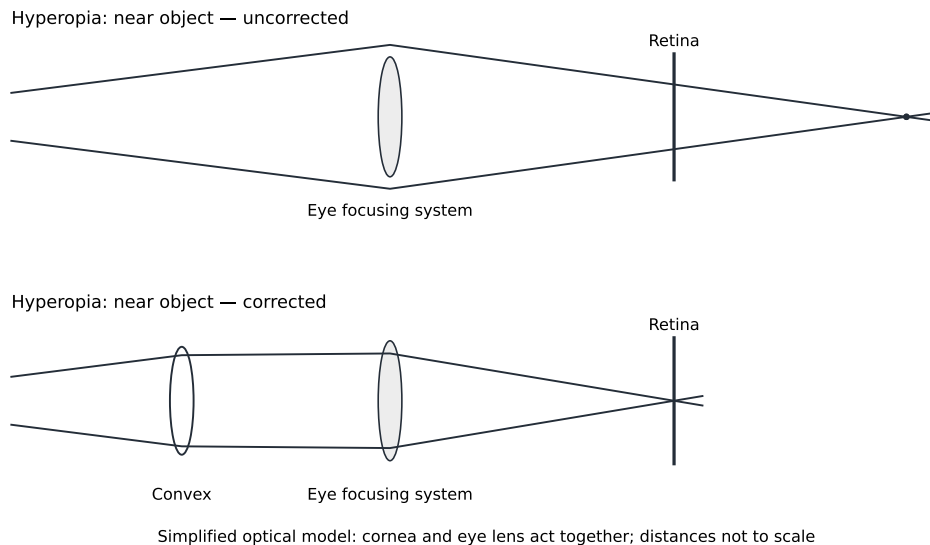


Myopia: distant object — corrected



Simplified optical model: cornea and eye lens act together; distances not to scale

Hyperopia : rays from near objects would focus behind the retina, for example if the eyeball is too short or focusing is insufficient. A **convex** lens provides extra convergence so the image focuses on the retina. The ray models combine the cornea and eye lens; they are not anatomical sections.



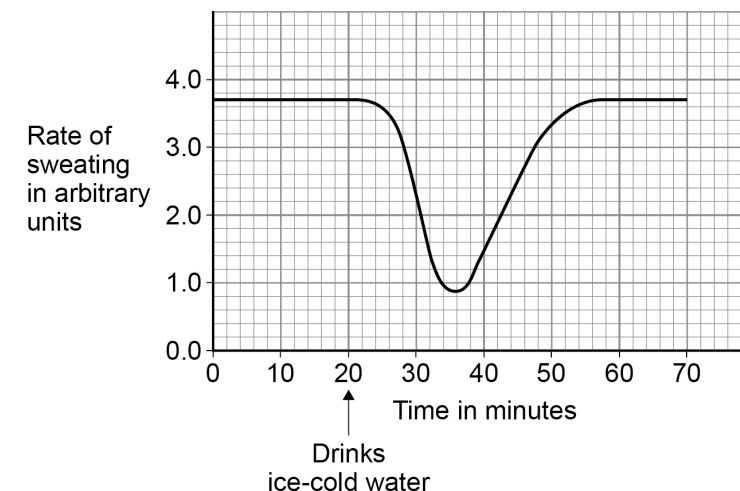
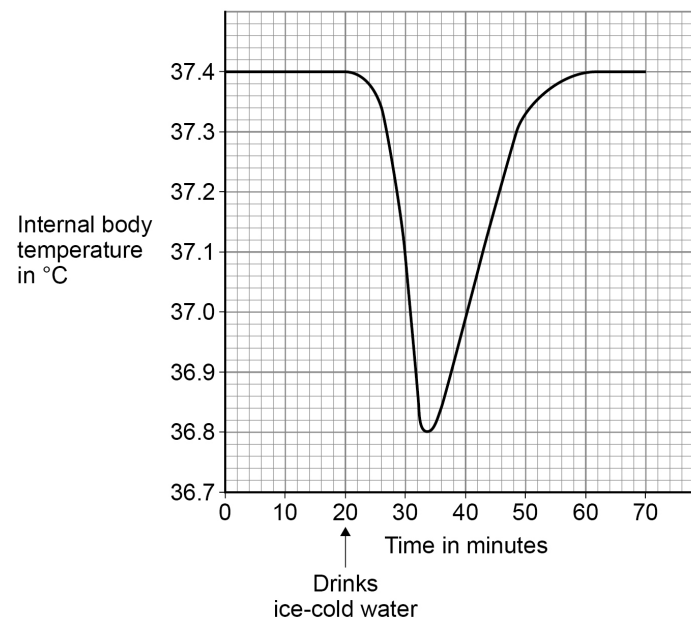
Treatment choices. Spectacles or contact lenses change the rays before they enter the eye. Laser surgery changes the cornea's shape; a replacement lens changes focusing inside the eye. Suitability depends on the defect and the individual. Use supplied evidence to compare benefits, risks, care requirements and reversibility; no treatment is best for everyone.

■ Control of body temperature

The **thermoregulatory centre** in the brain monitors blood temperature. Skin temperature receptors send nervous impulses to it. It coordinates responses by muscles and sweat glands.

Condition	Response	Effect (HT explanation)
Too hot	skin arterioles dilate	more blood near surface
Too hot	more sweat	evaporation transfers energy away
Too cold	skin arterioles constrict	less blood near surface
Too cold	less sweating	less evaporative cooling
Too cold	shivering	more energy from respiration

Vasodilation and **vasoconstriction** change blood flow through skin capillaries; capillaries themselves do not actively widen and narrow. When the surroundings are cooler than the skin, more surface blood flow increases energy transfer to the surroundings; reduced flow reduces this transfer. Sweating cools when **sweat** evaporates, not merely when it is secreted. Shivering is involuntary skeletal-muscle contraction; increased respiration transfers energy that warms the body. These responses oppose the initial change: negative feedback.

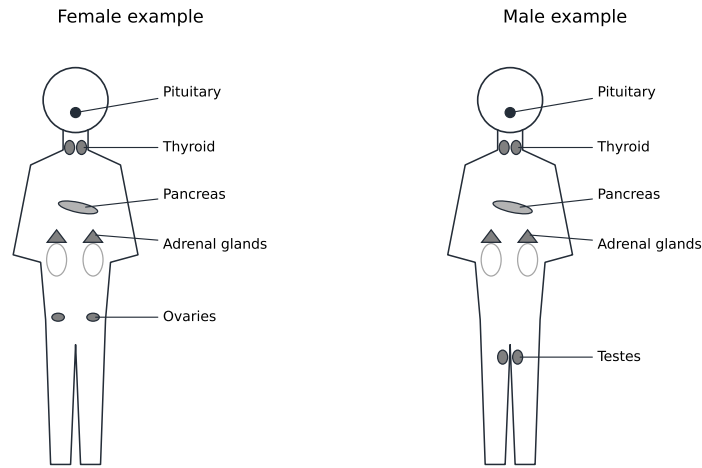


Worked evidence (HT). AQA 8461/2H 2021 Q03 uses a person drinking ice-cold water after 20 minutes. Its graph gives this person's initial temperature as **37.4 °C**: read the graph rather than automatically writing 37 °C. Cooled blood travels from the mouth/stomach to the brain. Nervous impulses coordinate a reduction in sweating. Less sweat evaporates, so less energy is transferred away; this helps restore temperature. The 24–36 minute interval shows **less sweating**, not no sweating. Holding the person still controls extra energy release from movement. This explains supplied evidence; it is not a classroom instruction to administer ice-cold water.

Hormonal coordination in humans (4.5.3)

■ Glands, hormones and target organs

The **endocrine system** contains glands that release **hormones** directly into the blood. Blood transports them to **target organs**, where they produce an effect. Compared with nervous signalling, hormonal responses are usually slower and last longer. This is a general comparison, not a claim that every hormone acts slowly.



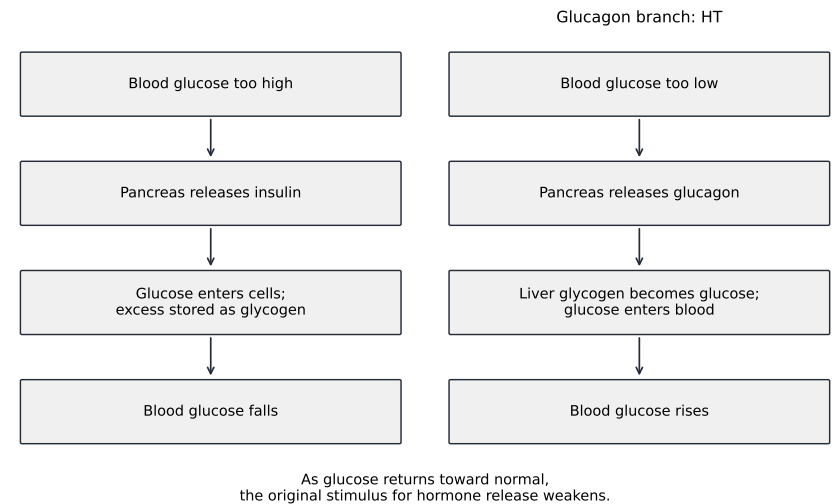
Schematic positions; the two gonad arrangements are alternatives

Identify the **pituitary gland** at the base of the brain, **thyroid** in the neck, **adrenal glands** above the kidneys, **pancreas** in the upper abdomen, **ovaries** in the female pelvis and **testes** in the scrotum. The pituitary releases several hormones that influence other glands; this is why it is called a 'master gland'. It does not directly control every endocrine response: the pancreas itself monitors blood glucose.

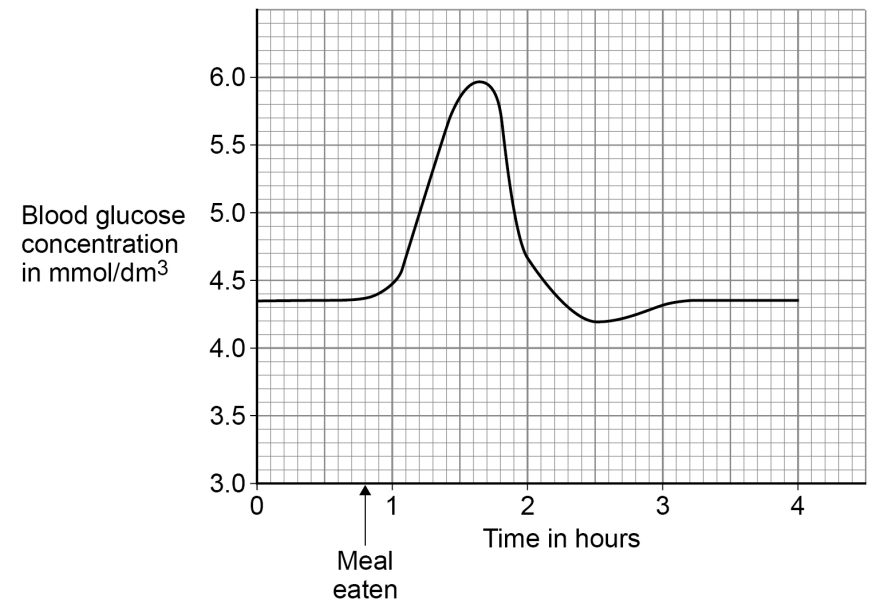
■ Blood glucose and negative feedback

The pancreas monitors blood glucose. When it rises too high, the pancreas releases **insulin**. Glucose moves from the blood into cells, where it can be used in respiration. Excess glucose is converted to **glycogen** for storage in the liver and muscles; blood glucose falls.

(HT) When blood glucose is too low, the pancreas releases **glucagon**. In the **liver**, stored glycogen is converted to glucose and released into the blood; blood glucose rises. Insulin and glucagon oppose changes away from the normal range. As the original stimulus decreases, the drive to release the responding hormone decreases. This is **negative feedback**; it does not mean both hormones are permanently switched off or glucose stays at an exactly constant value.



Worked graph reading. AQA June 2022 8461/2H Q03.1 asks when insulin would be high. Read the time axis and the high-glucose part of the curve. **1.5 hours** is a valid answer; the official accepted range is 1.1–2.0 hours. This is a glucose graph, not a measured insulin graph: insulin release is inferred from the control mechanism. For Q03.2, explain that insulin lowers blood glucose by glucose uptake/use or conversion to glycogen in cells, liver or muscles.

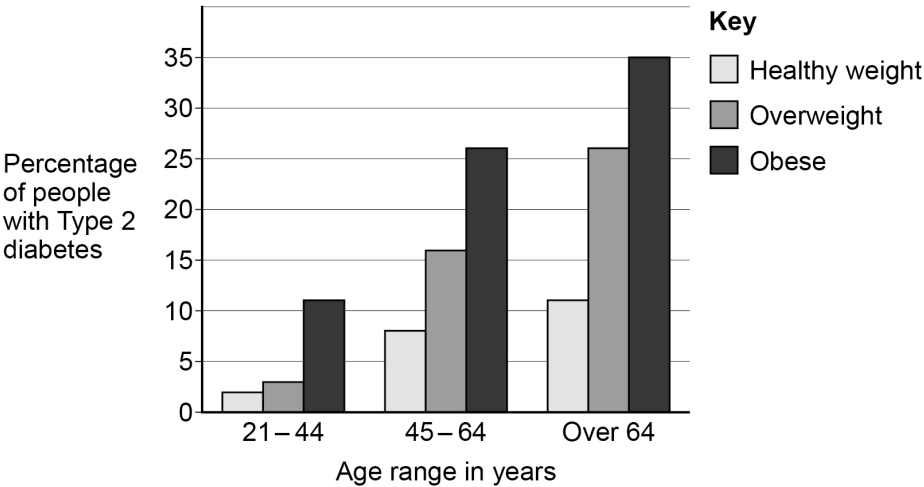


■ **Diabetes: compare the mechanisms and the evidence**

Type 1 diabetes: the pancreas does not produce sufficient insulin; blood glucose can remain too high. Insulin injections are a usual treatment. **Type 2 diabetes:** body cells have a reduced response to insulin; insulin may still be present at high levels. A carbohydrate-controlled diet and exercise are common treatments; medicines are also used, as the 2025 paper illustrates. Obesity is a risk factor, not a guarantee that an individual has Type 2 diabetes.

Worked comparison, AQA 2022 Q03.5. Person C has blood glucose **9.56 mmol/dm³**, compared with **4.51 mmol/dm³** for the mean without diabetes. Insulin is **24.32 arbitrary units**, compared with **14.83**. Both are higher: state the comparison, not just two isolated values. High insulin alongside high glucose is consistent with reduced cellular response. These supplied results support “might have Type 2 diabetes”; they do not establish a diagnosis by themselves. The scheme rejects higher cholesterol as one of the two requested indicators.

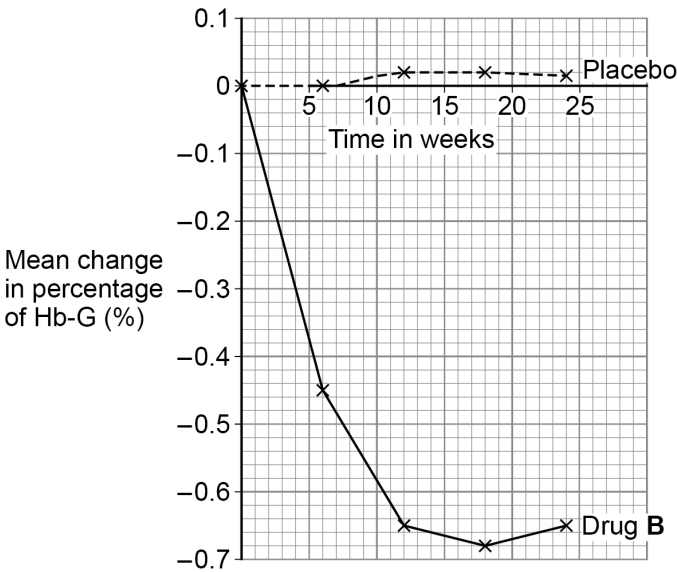
Population evidence, AQA 2025 Q09.1. Compare age groups within the same weight category, and weight categories within the same age group. The percentage with Type 2 diabetes increases with age and with heavier weight category in these results. A group-level association does not show that every person will develop the condition or prove a single cause.



Reading a treatment graph, AQA 2025 Q09.2–Q09.3. Hb-G is the percentage of haemoglobin with glucose attached; the question uses it as an indicator of longer-term blood-glucose control. Figure 11 plots the **change**, not the final Hb-G percentage. Drug B starts at 8.3%; at 12 weeks the change is -0.65 percentage points.

$$H_{12} = H_0 + \Delta H$$
$$H_{12} = 8.3\% + (-0.65\%) = 7.65\%$$

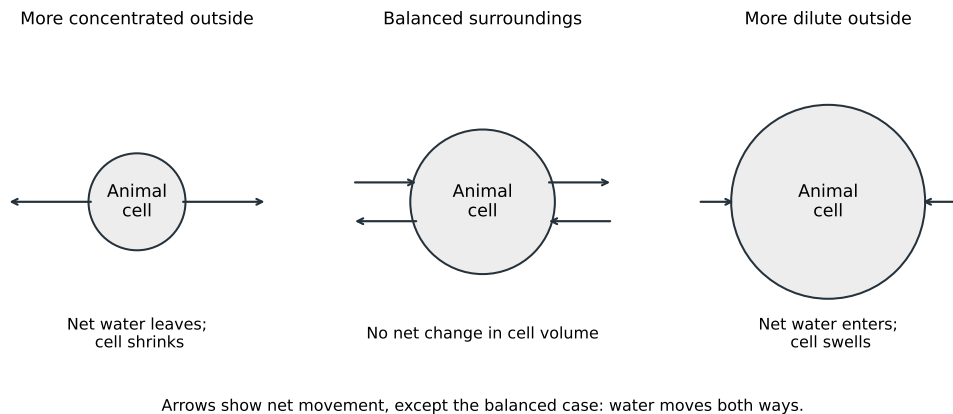
The result is not 0.65%, and the graph is not an instantaneous glucose concentration in mmol/dm³.



Evaluate the two trials. Drug A: 175 patients, daily injection, 12 weeks, Hb-G 9.2%→7.6%. Drug B: 631 patients, daily tablet, 24 weeks; 630 placebo patients; readings every 6 weeks; initial Hb-G 8.3%. Both treatments lower Hb-G, but neither reaches the question’s acceptable value of **less than 7%**. Drug A has the larger observed decrease (1.6 percentage points versus 0.65 at 12 weeks), but unequal starting levels, sample sizes, durations and methods prevent a secure “A is the better drug” conclusion. The placebo and repeated measurements strengthen interpretation of trial B. Side effects and doses are not supplied. Do not invent randomisation or double-blinding. Give a judgment linked to both the methods and the outcomes, as the six-mark scheme requires.

■ **Water and nitrogen balance – biology only**

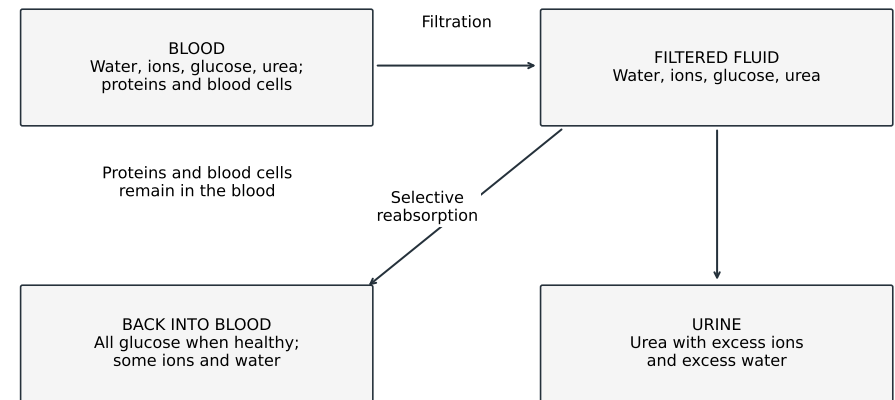
Why water balance matters. Water moves by osmosis through cell membranes from a more dilute solution towards a more concentrated solution. In more concentrated body fluid, animal cells lose water and shrink; in more dilute fluid they gain water and swell. Too much change prevents efficient cell function. In balanced surroundings water still moves both ways, with no net change in cell volume. Compare the fluid outside the cell with the fluid inside it.



Different exit routes. Water leaves in exhaled air; sweat loses water, ions and some urea. Kidneys cannot recover material already lost through skin or lungs; they adjust urine to maintain balance. Sweating is still controlled for temperature regulation. Urine removes excess water and ions with urea. **Excretion** removes metabolic waste; it is not the same as passing undigested food out of the gut.

(HT) Where urea comes from. Digestion releases amino acids from proteins. Excess amino acids are deaminated in the **liver**: the amino group is removed, forming toxic ammonia, which is immediately converted to less toxic **urea**. Blood carries urea to the kidneys for excretion. Do not say that kidneys make urea or that all amino acids are waste: many are used to build proteins.

Filtration and selective reabsorption are different steps. Small substances leave the blood during filtration. Useful substances are then taken back into the blood by selective reabsorption. In healthy kidneys, all filtered glucose is reabsorbed; some ions and water are reabsorbed according to need. Large proteins and blood cells stay in the blood. Urea is filtered and mostly remains in the fluid that becomes urine. This is a functional account; kidney and nephron anatomy are not required here.



Functional process, not anatomy.

Worked explanation, AQA 2024 Q08.2 [4]. Glucose and urea are filtered out of the blood (1); protein is not filtered out (1); all glucose is reabsorbed into the blood in healthy kidneys (1); urea is mostly not reabsorbed and passes out in urine (1). "Glucose is useful" alone does not describe its journey. Filtration is not selective reabsorption, and filtered fluid is not yet the final urine.

(HT) ADH controls water reabsorption. When blood becomes too concentrated, the **pituitary releases ADH** into blood. ADH makes kidney tubules more permeable to water. More water returns to blood, leaving a smaller volume of more concentrated urine. As blood concentration returns towards normal, the original stimulus for ADH release weakens: negative feedback. With less ADH, tubules are less permeable, less water is reabsorbed, and a larger volume of more dilute urine is produced. ADH changes water movement; it does not add urea to urine.

Worked response, sheet 5.3 Q3.3 [4]. Dehydration makes blood more concentrated and receptors detect the change (1); the pituitary releases more ADH (1); tubules become more permeable and more water is reabsorbed into blood (1); less, more concentrated urine is produced (1). AQA 2024 Q08.3 instead starts with ADH: name permeability/reabsorption, the tubules, increased urine concentration and decreased urine volume. Match the starting point of the question.

Table 2

Concentration of ADH in the blood in nanograms/dm ³	Concentration of dissolved substances in urine in arbitrary units	Rate of urine production in cm ³ /minute
0.0	50	20.0
1.25	700	8.8
2.50	980	3.9
3.75	1110	1.8
5.00	1170	0.9

Worked data explanation, AQA 2023 Q05.3 [4]. ADH falls from 3.75 to 1.25 nanograms/dm³. Tubules become less permeable to water (1), so less water is reabsorbed into blood (1). More water remains in urine, increasing production from 1.8 to 8.8 cm³/minute (1) and diluting dissolved substances from 1110 to 700 arbitrary units (1). Values support the answer; they do not replace the causal explanation. A production rate is volume per time, not a total collected volume.

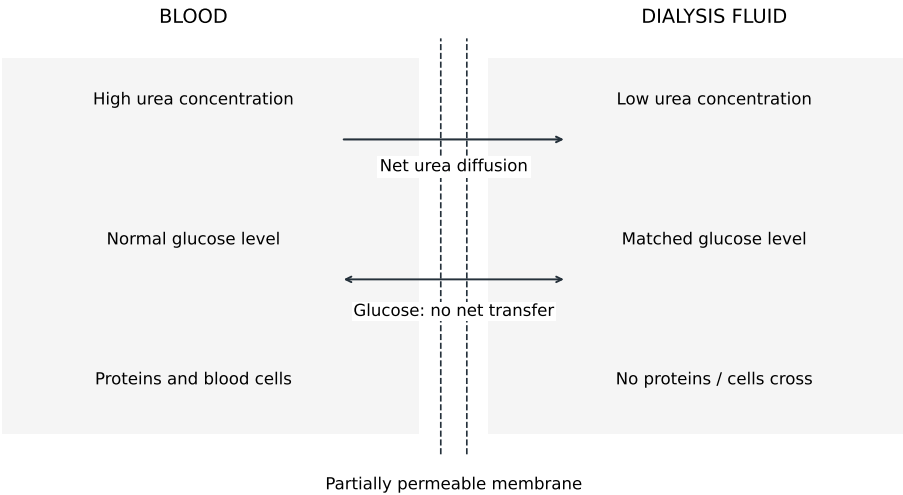
Teacher-written extension using those rates. If the rate remains 8.8 cm³/minute for 10 minutes, find the volume collected. Known: rate and duration; use volume = rate × time because rate is volume per minute.

$$V = rt$$

$$V = (8.8 \text{ cm}^3/\text{min}) \times (10 \text{ min}) = 88 \text{ cm}^3$$

The time assumption is supplied by this extension, not by the original paper. For the same 10 minutes at 1.8 cm³/minute, $V = rt = (1.8 \text{ cm}^3/\text{min}) \times (10 \text{ min}) = 18 \text{ cm}^3$.

Kidney failure: explain dialysis using a gradient. In **dialysis**, blood and dialysis fluid are separated by a partially permeable membrane. Urea can cross and diffuses from its higher concentration in blood towards the initially low concentration in the fluid. Replacing the fluid maintains that gradient. Dialysis fluid has a suitable glucose concentration matched to normal blood, so there is no net glucose loss when concentrations match. Proteins and blood cells are too large to cross. Glucose molecules can cross; no net loss is explained by concentration, not by an impermeable glucose barrier.



Evaluate dialysis and transplant. Dialysis can treat someone while a suitable donor is unavailable and avoids transplant surgery; repeated lengthy sessions restrict daily life and diet/fluid intake may need control. A successful **transplant** can give continuous kidney function and greater freedom, but requires a suitable donor and surgery. Rejection is a risk; immunosuppressant medicines reduce rejection risk but increase susceptibility to infection. Neither option is a guaranteed cure for every patient.

Teacher-written judgment. A patient has no suitable donor now and needs waste removal. Dialysis is a practical current treatment. If a suitable donor becomes available, transplant may reduce the burden of repeated sessions, but donor compatibility, surgery, rejection and infection risks must be weighed. State a decision linked to the supplied circumstances; a list of advantages alone is not an evaluation.

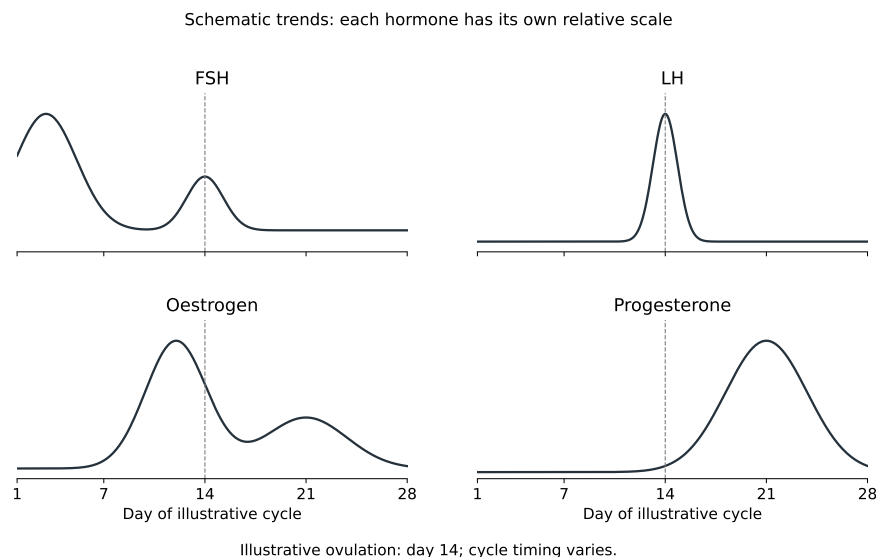
■ **Hormones in human reproduction**

Puberty and reproductive hormones. **Oestrogen** is produced by the ovaries and helps female secondary sexual characteristics develop; **testosterone** is produced by the testes and stimulates sperm production. Eggs begin to mature at puberty. **Ovulation** is release of an egg from an ovary, not fertilisation by a sperm. A cycle of about 28 days is an illustrative pattern; timing varies.

The basic roles are common-tier. Explaining interactions and interpreting hormone graphs are HT.

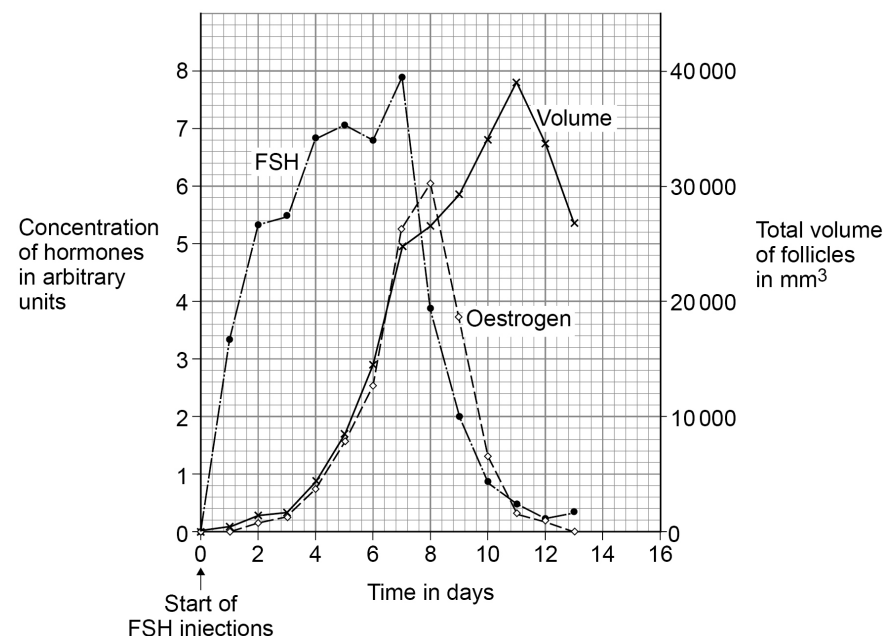
Hormone	Source	Basic role
FSH	pituitary	causes an egg to mature in an ovarian follicle
LH	pituitary	stimulates ovulation
Oestrogen	ovary	helps build and maintain the uterus lining
Progesterone	ovary	maintains the uterus lining

(HT) **Link the stages.** FSH stimulates follicle development and oestrogen production. Oestrogen inhibits FSH; high oestrogen near ovulation promotes an LH surge. LH stimulates egg release. Progesterone then maintains the uterus lining and inhibits FSH and LH. If pregnancy does not occur, progesterone falls, the lining breaks down and a new cycle begins. Do not say that LH fertilises the egg or that menstruation is egg release.



Read the schematic honestly. Use the order of events: oestrogen rises before the LH surge, then progesterone rises after ovulation. Each panel has its own relative scale; it does not compare absolute concentrations of different hormones. The curves are an author-drawn teaching model, not patient measurements or diagnostic cut-offs.

Actual treatment evidence, AQA 2023 Q07.1–Q07.3. A woman with no detectable FSH received daily FSH injections for seven days. Figure12 shows hormone concentration on the **left axis** in arbitrary units and total follicle volume on the **right axis** in mm³. Use the axis for the quantity being read. The original graph below retains its data, labels, units and injection-start marker.



Worked evidence, Q07.1 [1]. For roughly the first seven or eight days, increasing follicle volume is associated with increasing oestrogen concentration. This supports follicles releasing oestrogen. The relationship does not continue throughout the whole graph, and association alone does not prove that oestrogen causes follicle growth. The official scheme rejects that reversed causal claim.

Worked calculation, Q07.2 [5]. The mean follicle diameter on day11 is 22mm. Assume spherical follicles, using the supplied $\pi = 3.14$. First find radius, because the sphere formula uses radius rather than diameter:

$$r = \frac{d}{2}$$

$$r = \frac{22 \text{ mm}}{2} = 11 \text{ mm}$$

For one follicle:

$$V_{\text{one}} = \frac{4}{3}\pi r^3$$

$$V_{\text{one}} = \frac{4}{3} \times 3.14 \times (11 \text{ mm})^3 = 5572.45 \text{ mm}^3$$

Read the **total** follicle volume at day11 from the right axis: $V_{\text{total}} = 39000 \text{ mm}^3$. The number is total volume divided by the modelled volume of one follicle:

$$N = \frac{V_{\text{total}}}{V_{\text{one}}}$$

$$N = \frac{39000 \text{ mm}^3}{5572.45 \text{ mm}^3} = 6.9987 \dots \approx 7$$

Answer **7 follicles**, to the nearest whole number, not 7.0. Keep extra digits until the final division. The calculation uses the paper's common-size/sphere approximation, not a claim that all real follicles are identical.

Worked mechanism, Q07.3 [2]. Lack of FSH means little follicle development/oestrogen production (1); development of female secondary sexual characteristics depends on oestrogen (1). FSH acts through the ovary; do not replace that link with "FSH directly causes breast growth". The inheritance questions later in this paper belong to the genetics topic.

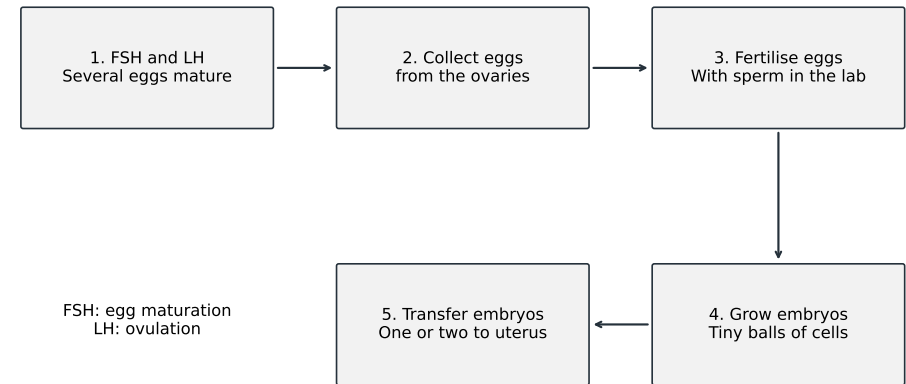
■ Controlling fertility: reduce or increase the chance of pregnancy

Hormonal contraception. In the GCSE model, contraceptive hormones inhibit FSH so an egg does not mature; inhibition of LH prevents ovulation. Without a released egg there is no egg for sperm to fertilise. Giving contraceptive hormones is therefore different from giving FSH/LH to stimulate fertility. Examples include oral pills and hormonal injections, implants and patches. The hormones and duration depend on the method: a combined patch releases oestrogen and progesterone (a progesterone-like hormone), so do not describe every method as progesterone-only or as lasting years.

Non-hormonal methods and devices. Condoms and diaphragms form barriers preventing sperm reaching an egg. Spermicides kill or disable sperm. Avoiding intercourse when an egg may be present depends on estimating timing; the illustrative day14 is not a guaranteed safe/unsafe timetable. Sterilisation surgically prevents sperm and egg meeting and is intended to be permanent. Intrauterine devices act within the uterus: copper IUDs primarily prevent fertilisation; hormonal intrauterine systems release progesterone. Do not assume every coil releases a hormone. **Implantation** is an embryo attaching to the uterus lining, a different event from fertilisation.

Evaluate using a supplied case. Compare effectiveness evidence, correct use, reversibility, hormone use, duration, practical access and the person's stated preferences. A teacher-written case asks for a reversible method without hormones and accepts use at each intercourse: a barrier method meets those conditions, whereas sterilisation conflicts with reversibility. Science can explain mechanisms and provide evidence, but personal, social and ethical values also affect a choice. No single method is automatically best for every case.

(HT) Fertility drugs and IVF. FSH stimulates eggs to mature; LH stimulates ovulation. Fertility drugs may allow pregnancy through intercourse, without laboratory fertilisation. **IVF** adds collection of eggs, fertilisation with sperm in a laboratory and embryo transfer. Hormone treatment alone is not the whole IVF process.



Fertilisation happens in the laboratory; embryos are transferred.

Worked, sheet5.3 Q3.4 [5]. Give FSH/LH to stimulate several eggs to mature (1); collect eggs and fertilise with sperm in the laboratory (1); let embryos develop into tiny balls of cells, then transfer one or two to the uterus (1). Concerns include emotional/physical stress (1), limited success and risk of multiple births to mother/babies (1). Do not transfer unfertilised eggs and call them embryos. Chance of success is not a promise of pregnancy.

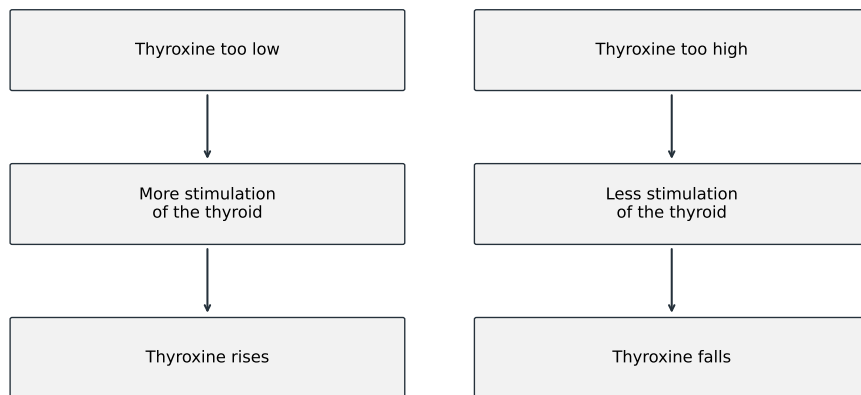
Capstone, AQA 2024 Q05.6 [6]. Explain **both** uses of hormones. For contraception, link contraceptive hormones → inhibited FSH/LH → reduced egg maturation/ovulation → no egg to fertilise. For infertility, link FSH → egg maturation and LH → ovulation, then explain collection, laboratory fertilisation and embryo transfer if using IVF. Progesterone may support the uterus lining. The top level requires detailed causal links and both contraception and infertility treatment; listing six hormone names does not earn six marks.

■ Adrenaline, thyroxine and negative feedback (HT)

Adrenaline is released by the adrenal glands in fear or stress. Heart rate rises, increasing delivery of oxygen and glucose to brain and muscles for respiration and action. AQA 2024 Q05.5 [2] accepts two distinct effects, for example increased heart rate and increased oxygen delivery. "Fight or flight" names the overall response but does not replace two specified effects. Hormones are carried in blood; adrenaline can act rapidly, so "hormones always act slowly" is not a rule.

Thyroxine from the thyroid increases the **basal metabolic rate**, and is important in growth and development. **Worked, AQA 2023 Q05.2 [2].** In the given cold-body context, increased thyroxine increases metabolic rate/respiration (1); respiration releases energy, including thermal energy (1), increasing body temperature. Energy is released, not created. This is distinct from the earlier nervous control of skin blood

flow, sweating and shivering.



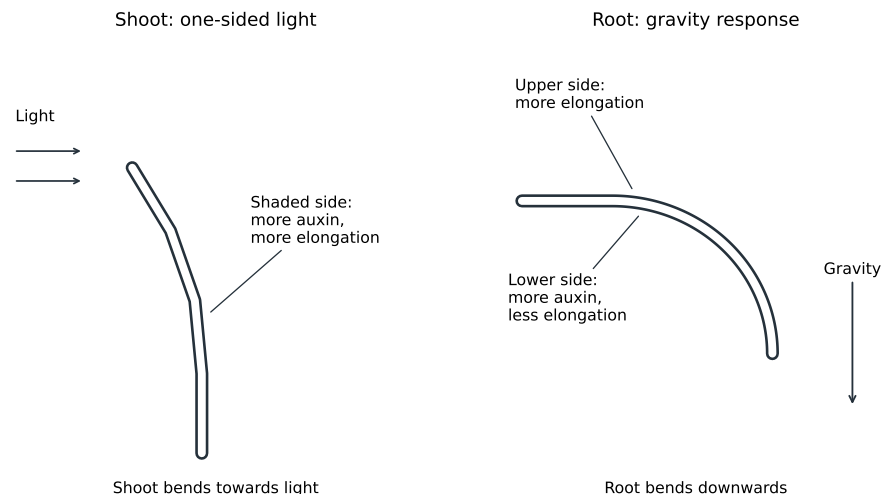
Responses oppose the change and move the level towards normal.

Read negative feedback in either direction. When thyroxine is below normal, increased stimulation of the thyroid helps raise it; when it is above normal, reduced stimulation helps lower it. As levels return towards normal, the original stimulus weakens. Negative feedback means opposing the original deviation, not always reducing every hormone. The model describes function; naming additional signalling hormones is unnecessary here.

Plant hormones – biology only (4.5.4)

Tropisms are growth responses to the direction of a stimulus. **Phototropism** responds to light; **gravitropism** (geotropism) responds to gravity. A positive response is towards the stimulus, a negative response away from it. Shoots commonly grow towards light and against gravity; roots grow with gravity. AQA 2025 Q03.1 [2] requires both **growth response** and **gravity**, not just “downwards”. A plant does not move its whole body like a walking animal.

Unequal auxin distribution produces unequal growth. In a shoot receiving one-sided light, more **auxin** accumulates on the shaded side. Those cells elongate more, so the shoot bends towards the light. Do not teach that light simply destroys auxin. In a horizontal root, more auxin accumulates on the lower side, where it inhibits elongation; the upper side grows more and the root bends down. The effect depends on the organ and conditions: do not apply a shoot’s elongation rule to a root.

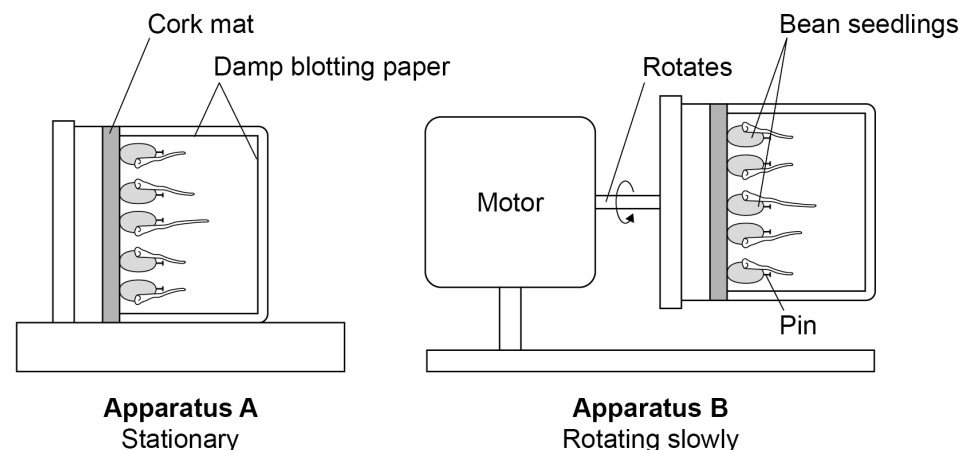


Worked, sheet 5.4 Q3.1 [3]. More auxin on the shaded side (1) → greater elongation there than on the lit side (1) → shoot bends towards light (1). **Worked, AQA 2024 Q04.6 [2].** Uneven auxin distribution, with more on the lower side (1) → upper-side root growth exceeds lower-side growth (1), causing a downward bend. Explain the comparison between sides, not just “auxin makes it grow”.

■ RP8: investigate direction and growth

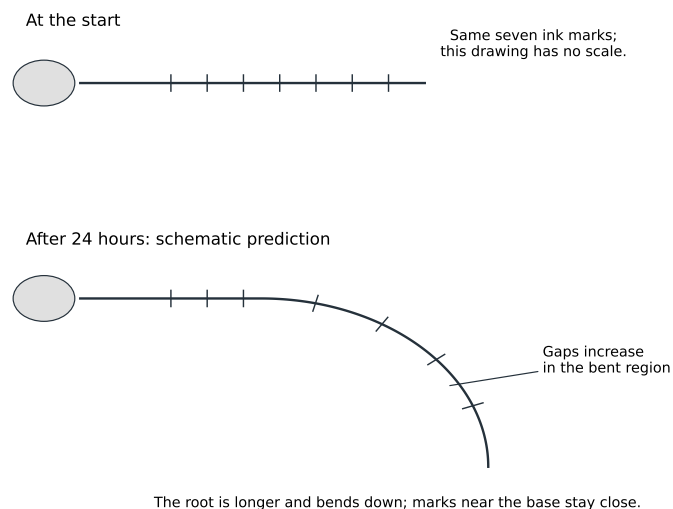
Original gravity experiment, AQA 2024 Q04.1–Q04.6. Apparatus A is stationary; apparatus B rotates slowly. Both are left in darkness for 24 hours and surrounded with damp blotting paper. The original apparatus drawing is reproduced below.

Figure 6



Explain each control. Darkness prevents directional light affecting the root response (Q04.1 [1]). Damp paper supplies water for growth and reduces an unequal water supply influencing direction (Q04.2 [2]); it is not primarily a source of mineral ions. The rotating apparatus provides comparison and prevents gravity acting consistently on the same side of the root (Q04.3 [2]). Rotation does **not** remove gravity. In B, the root grows approximately straight/horizontally, unlike the downward bend in A (Q04.5 [1]).

Predict the drawing, Q04.4 [3]. The stationary root becomes longer (1), bends down (1), and the ink marks become further apart in the bent growth region (1). Do not spread the marks equally along the old base: that does not show the location of elongation. The author-drawn example below preserves seven marks and illustrates the pattern; it is not measured experimental data or an original exam answer image.



Plan light-direction RP8, AQA 2025 Q03.2 [6]. Use newly germinated seedlings of the same species and age with similar starting lengths. Compare light entering through a slit on one side with all-round light; keep temperature, water, growth medium and duration alike, and use comparable light intensity where possible. Darkness is another allowed exam comparison, but changes light availability as well as its direction. Record initial and final shoot lengths over the same interval. A curved shoot needs non-stretch thread laid along its curve then measured against a ruler; vertical height alone is not its length. Use several seedlings per condition, calculate mean growth and compare directions as well as lengths. Record careful **labelled biological drawings** of the results; a photo alone does not satisfy the specified drawing record.

Teacher-written measurement example. Three shoots in one condition start at 20 mm and finish at 32, 34 and 33 mm. Use final minus initial for each shoot, then calculate the mean increase. These are illustrative classroom values, not results from

the 2025 paper.

$$\Delta L = L_{\text{final}} - L_{\text{initial}}$$

$$\Delta L_1 = 32 \text{ mm} - 20 \text{ mm} = 12 \text{ mm}$$

$$\Delta L_2 = 34 \text{ mm} - 20 \text{ mm} = 14 \text{ mm}$$

$$\Delta L_3 = 33 \text{ mm} - 20 \text{ mm} = 13 \text{ mm}$$

$$\overline{\Delta L} = \frac{\sum \Delta L}{n}$$

$$\overline{\Delta L} = \frac{12 + 14 + 13}{3} \text{ mm} = 13 \text{ mm}$$

Compare that mean with the other condition and examine the recorded bends. One condition alone cannot establish the effect of light direction. A mean does not replace repeat measurements or drawings.

■ Applying plant hormones (HT)

Auxins are used in rooting powders, to promote growth in tissue culture, and as weed killers. Rooting powder stimulates root formation at the cut end so a cutting can establish and grow as a clone; this is not a claim that more auxin always speeds elongation in existing roots. Some auxin-like weed killers disrupt growth of susceptible plants. Not every herbicide is an auxin-like hormone. Killing non-target plants can reduce plant diversity and food/habitat for other organisms, so weigh the agricultural benefit against biodiversity effects.

Ethene controls cell division and fruit ripening; it is used to control ripening during storage and transport. **Gibberellins** initiate germination and are used to end seed dormancy, promote flowering and increase fruit size. Their biochemical mechanisms are not required.

Worked applications, AQA 2024 Q04.7–Q04.8 [2+2]. Two distinct auxin uses could be rooting powders and growth in tissue culture. For a sprayed apple tree, promoting flowering and increasing fruit size are relevant gibberellin uses. Ending seed dormancy is a valid general use but does not answer why an already-growing apple tree was sprayed. Select the application for the object and context in the question.

Checklist before you call this topic done

- Define homeostasis; receptor–coordination centre–effector said in order; reflex arc drawn with synapse.
- Eye parts and accommodation table cold; myopia vs hyperopia with corrections.
- Temperature: vasodilation/sweat vs vasoconstriction/shivering, in context (HT).
- Insulin and (HT) glucagon with negative feedback; Type 1 vs Type 2 treatments.
- (Bio) kidney filtration + selective reabsorption; (HT) ADH; dialysis vs transplant.
- Reproductive hormone roles and contraception; (HT) cycle interactions/graphs, IVF, adrenaline and thyroxine.
- (Bio) tropisms with auxin; RP8; (HT) the three hormone uses.