

Science 9–10

Chapter 8 — Biological sciences B: coordination, homeostasis and disease

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The nervous and endocrine systems: coordinating responses to internal and external stimuli

Chapter 8 — Biological sciences B: coordination, homeostasis and disease (Science, Levels 9 and 10)

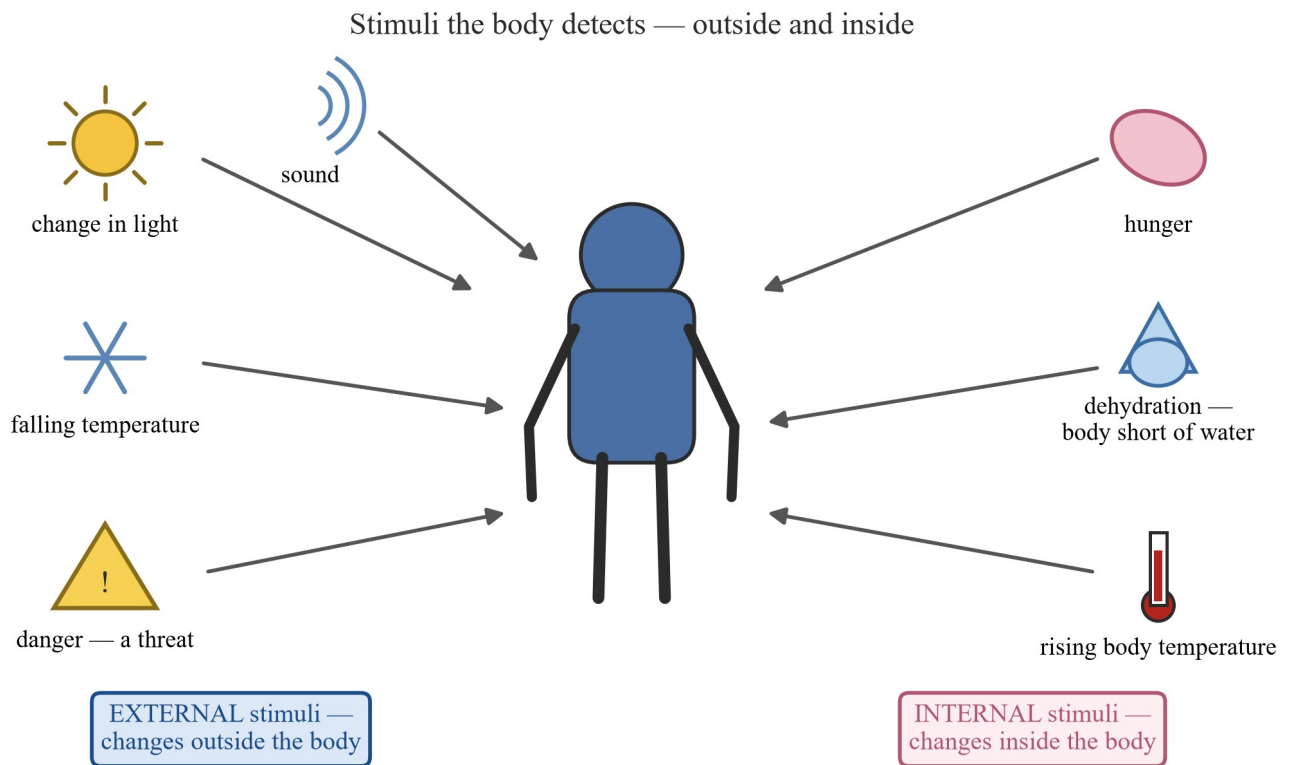
Subtopic 8A · VC2 Science Understanding — Biological sciences

CD code: VC2S10U02 (split delivery †; this subtopic is the accountable owner) **Content description (verbatim):** “the nervous and endocrine systems work together to regulate and coordinate the body’s response to stimuli, ensuring homeostasis, including through negative feedback mechanisms” **This subtopic’s limb (TOC §4 clause split):** the nervous and endocrine systems coordinating responses to stimuli. The partner subtopic 8B delivers the other limb: homeostasis and negative feedback. **Elaboration ids drawn on:** VC2S10U02.E01 · VC2S10U02.E02 · VC2S10U02.E03 (ids VC2S10U02.E04–VC2S10U02.E06 are drawn on by Subtopic 8B; no elaboration of this CD is withheld under the TOC’s D10 ICIP decision) **Achievement standard (extract served):** “They explain how the nervous and endocrine systems use negative feedback to support homeostasis in the body’s internal environment.” This subtopic builds the first half of that sentence — how the two systems carry and coordinate the body’s responses; Subtopic 8B builds the negative-feedback half.

Theory

A body that answers back. Every day, things change around you and inside you: a light switches on, the air turns cold, a dog runs towards you, your stomach empties hours after breakfast. Each change is a **stimulus** — a change in a condition that the body can detect (the plural is **stimuli**). And in every case your body answers with a **response** — an action that follows the stimulus, such as a muscle contracting or a gland releasing a chemical. The body never leaves these responses to chance: they are organised by two systems, the **nervous system** and the **endocrine system**, working together. That teamwork is what this subtopic is about.

Stimuli come from two directions. **External stimuli** are changes outside the body — light, sound, temperature, danger. **Internal stimuli** are changes inside the body — hunger, thirst, a rising body temperature. The figure below shows examples of each.



A person in the centre receiving arrows from external stimuli on the left (a change in light shown as a sun, sound shown as wave arcs, falling temperature shown as a snowflake, danger shown as a warning triangle) and internal stimuli on the right (hunger shown as a stomach, dehydration shown as a water droplet, rising body temperature shown as a thermometer), with boxes defining external and internal stimuli.

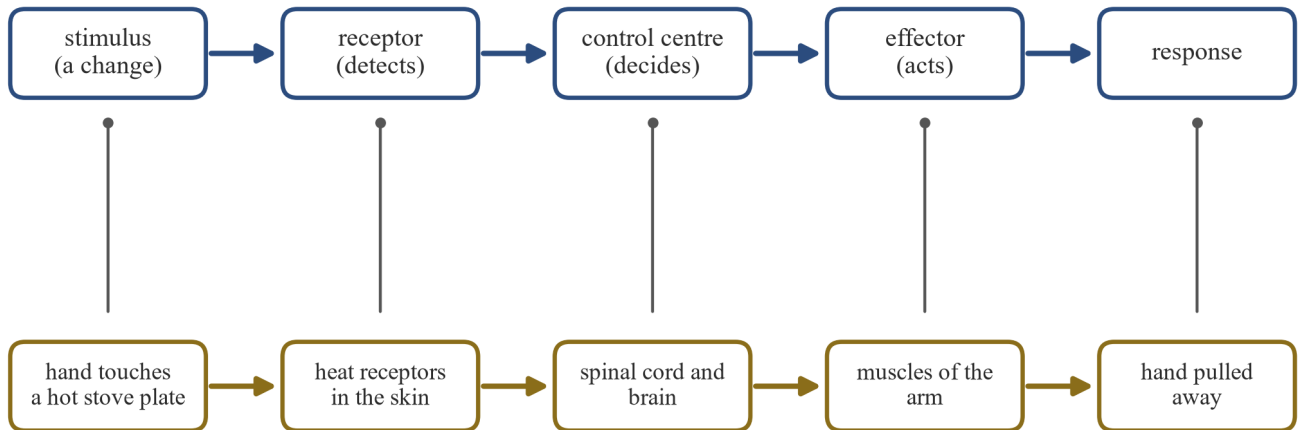
Every stimulus is detected by a **receptor** — a structure that detects one kind of change and turns it into a message the body can act on. The message is then carried to the part that decides what to do, and from there a command goes to the part that acts — a muscle or a gland, called an **effector**.

The pathway every coordinated response follows (elaboration VC2S10U02 . E02). However different the stimulus and the response look, every coordinated response follows the same five-part pathway:

stimulus → receptor → control centre → effector → response

The **control centre** is the part that receives the message, decides what is needed, and sends the command. In the body the control centre is usually the brain or the spinal cord (or, in some loops, a gland). (VCAA's elaboration VC2S10U02 . E04 calls this part the *command centre*; the two names mean the same thing, and this book uses *control centre* throughout.) The lower row of the figure below reads one worked example — the hot stove plate — under the same pathway.

Every coordinated response follows the same pathway



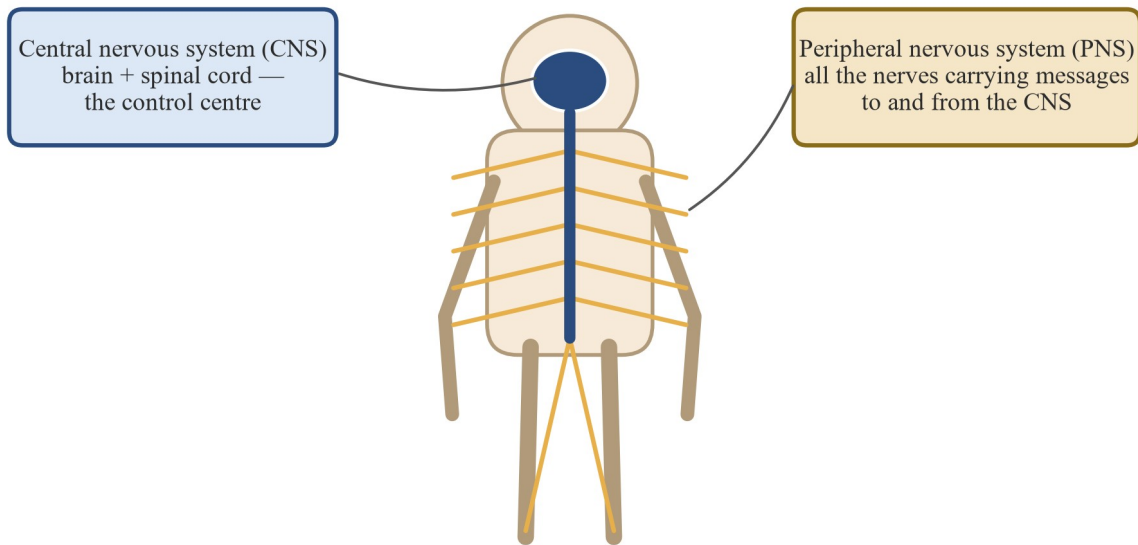
A worked example — read each column of the lower row under the matching part of the pathway.

Flow diagram of the pathway: stimulus (a change), receptor (detects), control centre (decides), effector (acts), response; below it the same pathway filled in for one example: hand touches a hot stove plate, heat receptors in the skin, spinal cord and brain, muscles of the arm, hand pulled away.

Two systems carry the messages of this pathway. The rest of this subtopic looks at each system in turn, then at how the two compare and work together.

The nervous system — two parts working as one. The nervous system is made of two parts. The **central nervous system (CNS)** is the brain and the spinal cord — the control centre that receives messages and decides the response. The **peripheral nervous system (PNS)** is all the nerves that carry messages to and from the CNS: sensory messages in, command messages out to muscles and glands.

The nervous system — two parts working as one

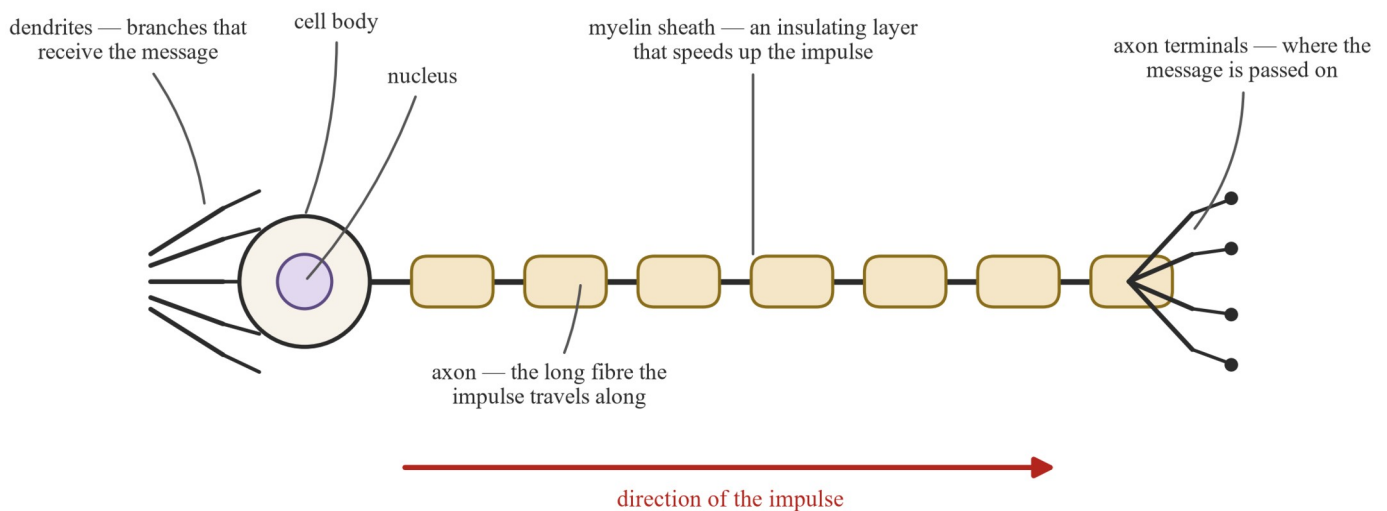


Sensory messages travel IN to the CNS; command messages travel OUT to muscles and glands.

Outline of a body showing the brain and spinal cord labelled as the central nervous system (CNS), the control centre, and the nerves to the limbs labelled as the peripheral nervous system (PNS), carrying messages to and from the CNS.

Nerves are made of cells called **neurons**, each one built to carry a message. The message a neuron carries is an **impulse** — a fast electrical signal that travels along the cell. The parts of a neuron each do one job: **dendrites** are branches that receive the message; the **cell body** (with its **nucleus**) keeps the cell alive; the **axon** is the long fibre the impulse travels along; the **myelin sheath** is an insulating layer over the axon that speeds the impulse up; and the **axon terminals** are where the message is passed on to the next cell. Some motor neurons are over a metre long — from the spinal cord to the muscles of the foot.

A motor neuron — one cell built to carry a message

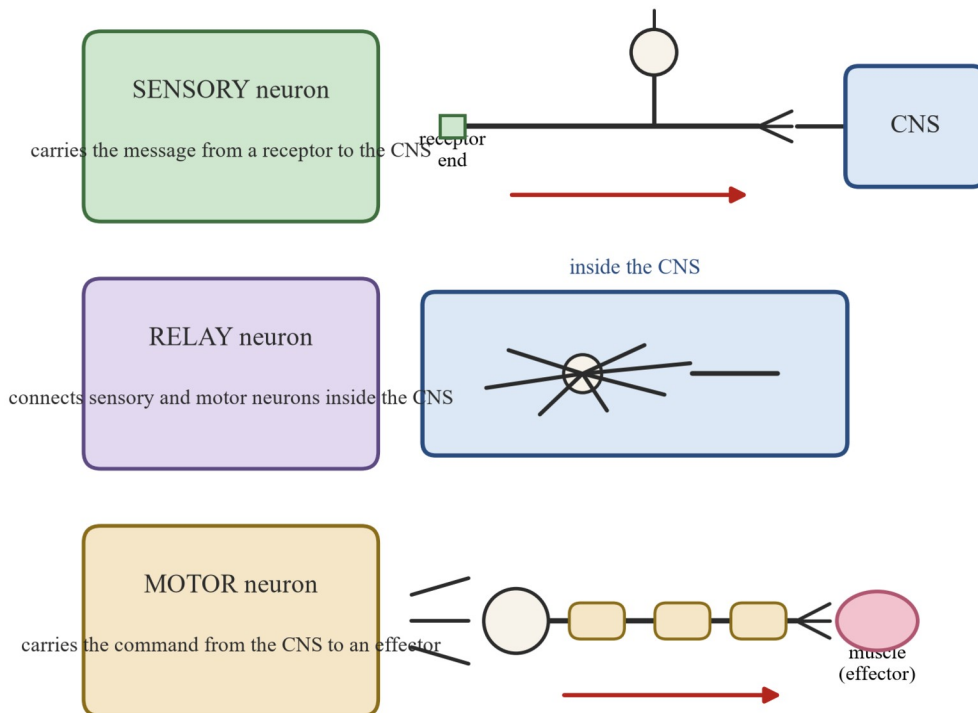


Some motor neurons are over a metre long — from the spinal cord to the muscles of the foot.

Labelled diagram of a motor neuron: dendrites as branches that receive the message, the cell body with its nucleus, the long axon covered by a myelin sheath that speeds up the impulse, and axon terminals where the message is passed on, with an arrow marking the direction of the impulse.

Three kinds of neuron carry the message in turn. A pathway uses three kinds of neuron in the same order every time: a **sensory neuron** carries the message from a receptor to the CNS; a **relay neuron** connects sensory and motor neurons inside the CNS; and a **motor neuron** carries the command from the CNS to an effector. *Sensory in, relay between, motor out.*

Three kinds of neuron carry the message in turn

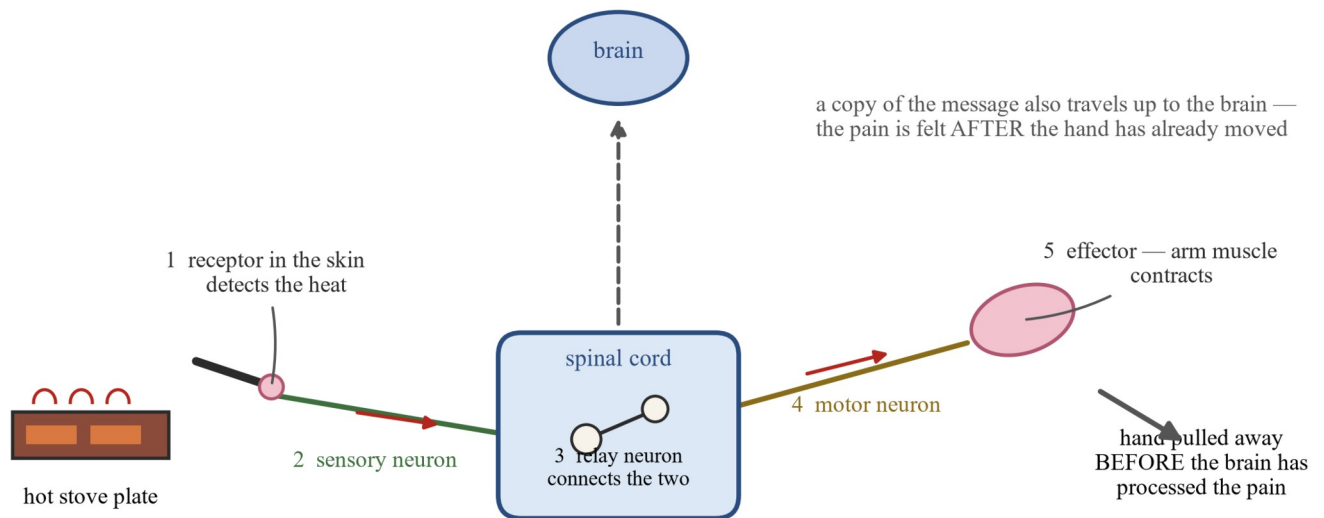


Sensory in, relay between, motor out — the same order in almost every pathway you will trace.

Three rows, each with a name box and a diagram: a sensory neuron carrying the message from a receptor to the CNS, a relay neuron connecting sensory and motor neurons inside the CNS, and a motor neuron carrying the command from the CNS to a muscle effector, each with a red arrow showing the direction of the impulse.

Reflex arcs — fast, automatic responses (elaboration VC2S10U02 . E02). Touch a hot stove plate and your hand is pulled away before you have thought about it. This fast, automatic response to a stimulus is a **reflex**, and the pathway that produces it is a **reflex arc**: receptor → sensory neuron → relay neuron in the **spinal cord** → motor neuron → effector. The decision is made in the spinal cord, not in the thinking part of the brain, and that is why a reflex is so fast. A copy of the message still travels up to the brain — which is why the pain is felt *after* the hand has already moved.

A reflex arc — the hot stove plate



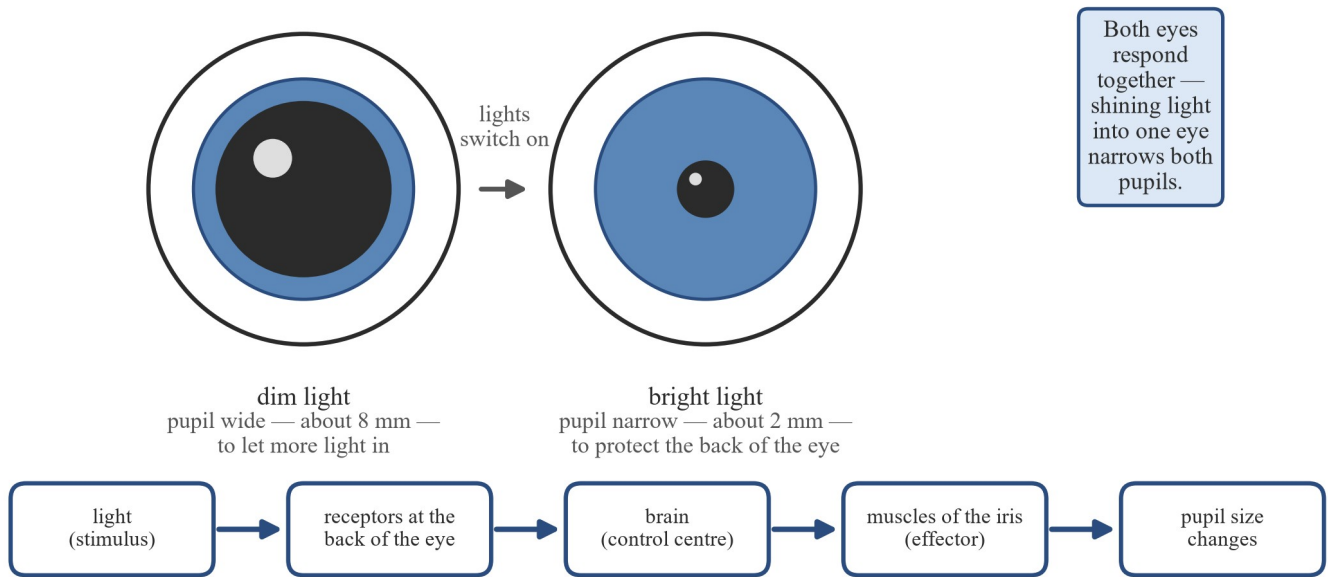
A reflex is fast and automatic because the decision is made in the spinal cord, not in the thinking part of the brain.

Reflex arc for the hot stove plate, numbered 1 to 5: receptor in the skin detects the heat, sensory neuron, relay neuron inside the spinal cord connecting the two, motor neuron, and effector (arm muscle contracts) pulling the hand away; a dashed arrow shows a copy of the message travelling up to the brain, so the pain is felt after the hand has already moved.

Reflexes like this are protective: the body moves away from harm a fraction of a second sooner than it could if the brain had to think first. The pupil reflex below is another example of the same idea.

The pupil reflex — the eye's response to light. The **pupil** is the dark hole at the front of the eye that lets light in. In dim light the pupil is wide — about 8 mm — to let more light in; in bright light it narrows to about 2 mm to protect the back of the eye. The change is a reflex: the stimulus (a change in light) is detected by receptors at the back of the eye, the brain acts as the control centre, and the effectors are the muscles of the **iris** — the coloured ring that sets the pupil's size. Shine a light into one eye and *both* pupils narrow, because the control centre commands both eyes together.

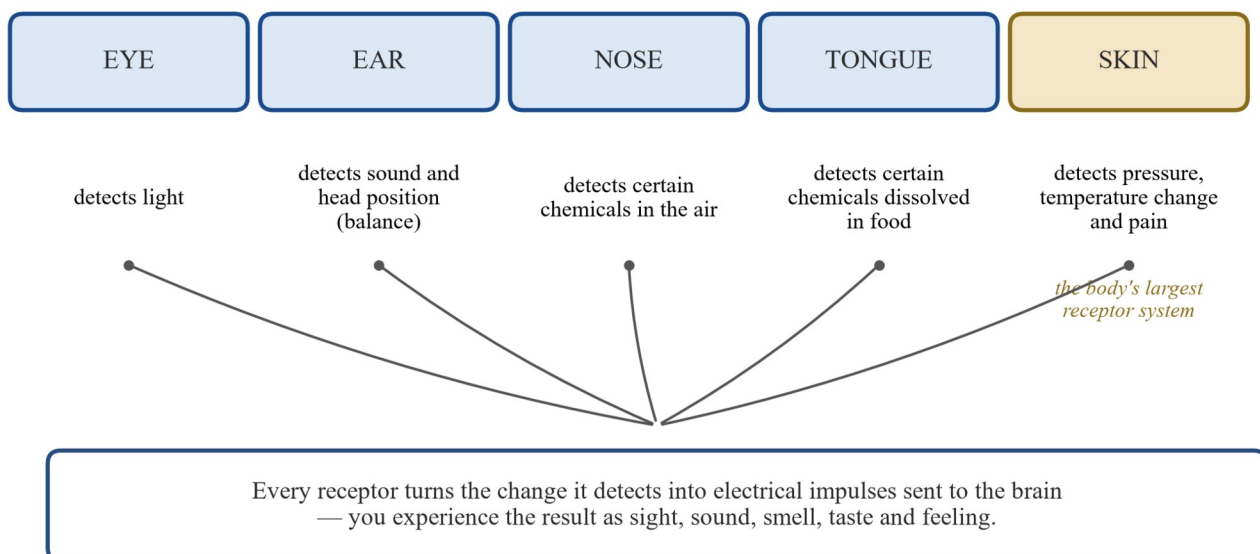
The pupil reflex — the eye's response to light



Two eyes side by side: in dim light the pupil is wide, about 8 millimetres, to let more light in; in bright light the pupil is narrow, about 2 millimetres, to protect the back of the eye; below, the pathway in five boxes: light (stimulus), receptors at the back of the eye, brain (control centre), muscles of the iris (effector), pupil size changes.

Receptors — each detects one kind of stimulus. The body has a receptor system for each kind of stimulus it can detect: the **eye** detects light; the **ear** detects sound and head position (balance); the **nose** detects certain chemicals in the air; the **tongue** detects certain chemicals dissolved in food; and the **skin** — the body's largest receptor system — detects pressure, temperature change and pain. Every receptor does the same job in the end: it turns the change it detects into electrical impulses sent to the brain, and you experience the result as sight, sound, smell, taste and feeling.

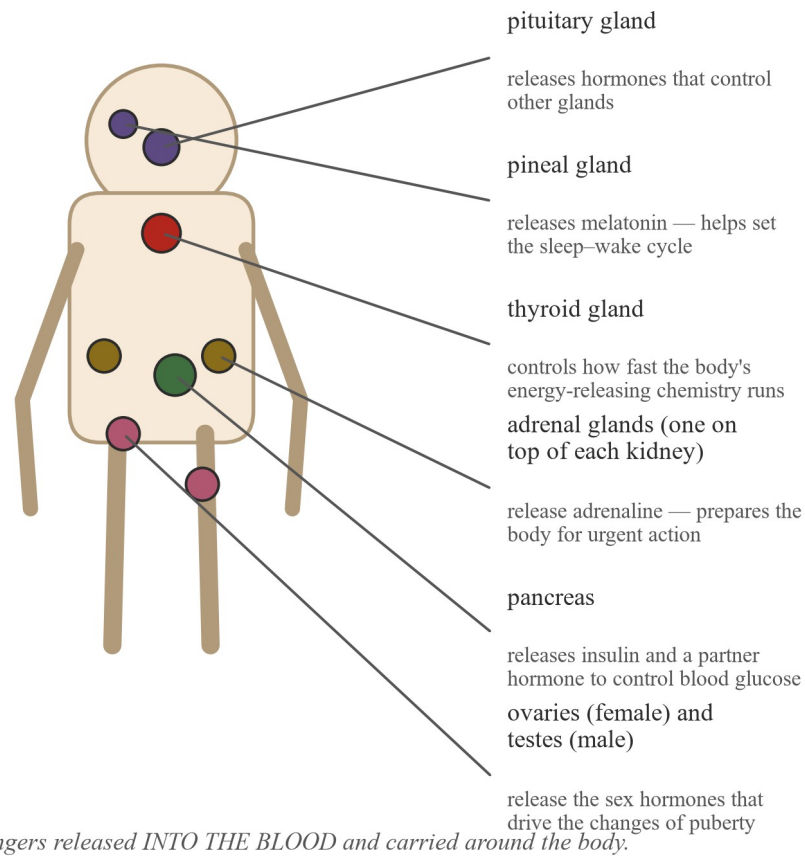
Receptor systems — each detects one kind of stimulus



Five receptor systems in boxes with what each detects: eye detects light, ear detects sound and head position, nose detects certain chemicals in the air, tongue detects certain chemicals dissolved in food, skin detects pressure, temperature change and pain; a note that every receptor turns the change it detects into electrical impulses sent to the brain.

The endocrine system — glands and hormones. The second system is the **endocrine system**: a set of **glands** — organs that release chemical messengers called **hormones** straight into the blood. A hormone travels around the body in the blood and changes the activity of the organs that can detect it. The map below shows the main glands and what each one does.

The endocrine system — glands that release hormones

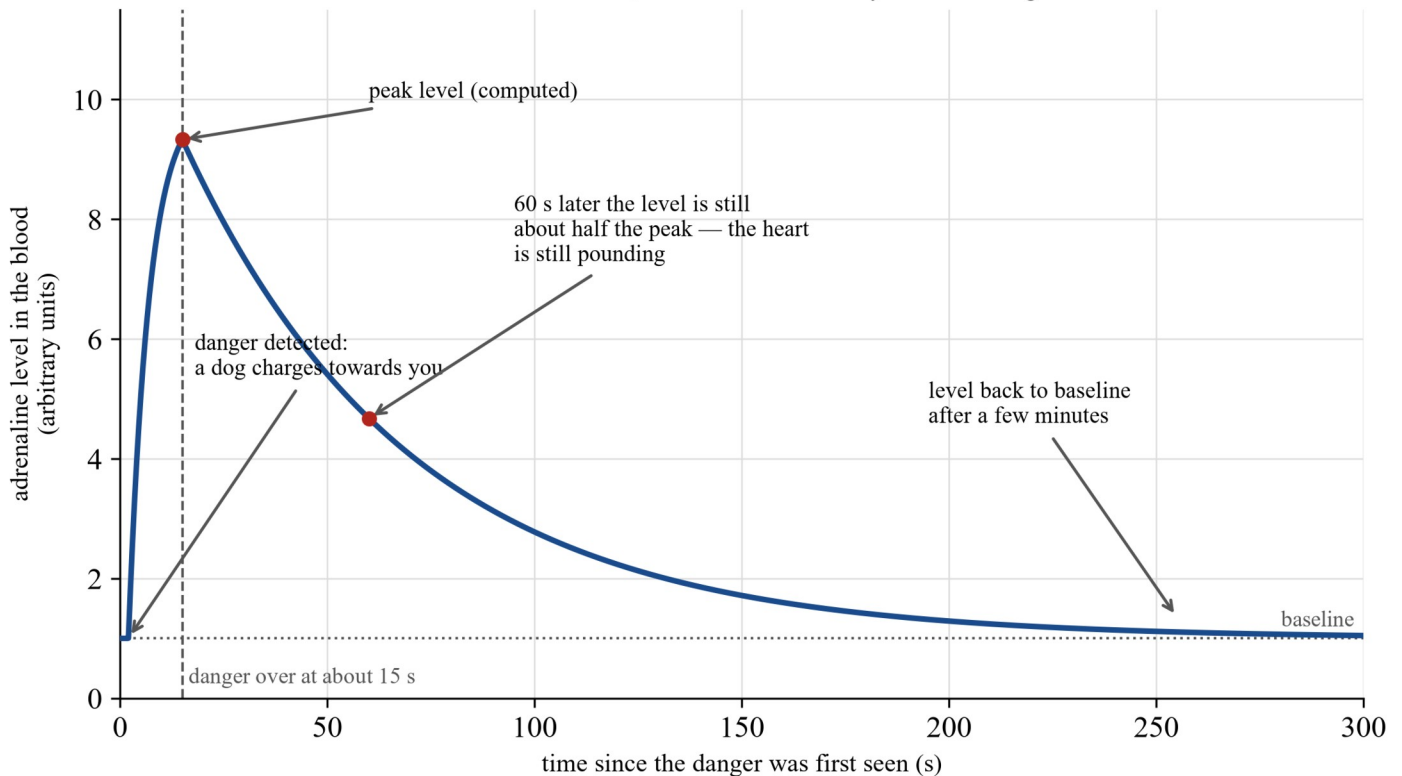


Outline of a body with the endocrine glands marked and labelled with their jobs: pituitary gland releases hormones that control other glands; pineal gland releases melatonin, which helps set the sleep–wake cycle; thyroid gland controls how fast the body's energy-releasing chemistry runs; adrenal glands release adrenaline, which prepares the body for urgent action; pancreas releases insulin and a partner hormone to control blood glucose; ovaries and testes release the sex hormones that drive the changes of puberty.

Read the map carefully: some glands act on other glands (the pituitary), some set the body's pace (the thyroid), some prepare the body for urgent action (the adrenals), and some drive the changes of puberty (the ovaries and testes). The **pancreas** releases **insulin** and a partner hormone to control blood glucose; the loop that keeps blood glucose steady is examined in full in Subtopic 8B.

Adrenaline — a hormone for urgent action. When a danger is detected, the brain acts on the adrenal glands at once, and they release **adrenaline** into the blood: the heart beats faster and harder, breathing speeds up, and extra fuel is released into the blood — the body is prepared for urgent action. The curve below is a stylised teaching curve: the level rises within seconds of the danger being seen, and — here is the point — it is slow to clear. The danger in the example is over at about 15 s, yet 60 s later the level is still about half of the peak. That is why your heart keeps pounding for minutes after the scare has passed: the hormone is still in the blood.

Adrenaline: fast to rise, slow to clear — a stylised teaching curve



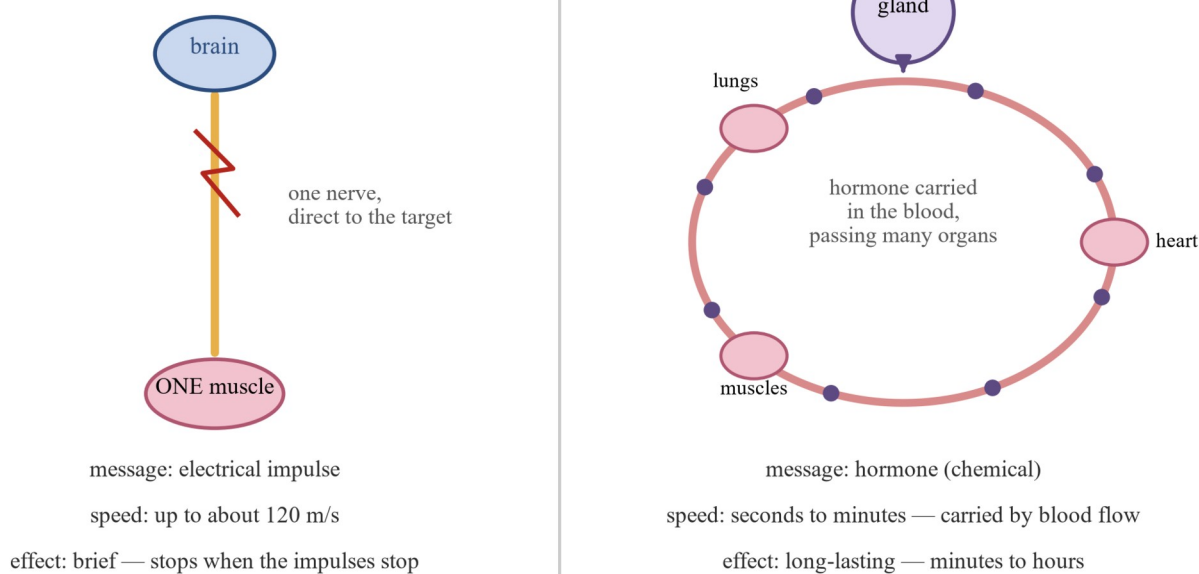
Stylised line graph of adrenaline level in the blood in arbitrary units against time in seconds: the level rises quickly after danger is detected at about 2 seconds, peaks near 15 seconds when the danger is over, is still about half of the peak 60 seconds later, and returns to the starting level after a few minutes.

Two routes for one job (elaboration VC2S10U02 . E03). The two systems solve the same problem — carrying a message from where a change is detected to where something must be done — in different ways. The nervous route sends an electrical impulse along one nerve, direct to one exact target, at up to about 120 m/s; the effect is brief and stops when the impulses stop. The endocrine route releases a hormone into the blood, where it is carried past many organs; it arrives in seconds to minutes, and its effect lasts minutes to hours.

Two routes for carrying a message through the body

THE NERVOUS ROUTE

THE ENDOCRINE ROUTE



Two panels comparing the routes: the nervous route shows the brain connected by one nerve direct to one muscle, message an electrical impulse, speed up to about 120 metres per second, effect brief; the endocrine route shows a gland releasing hormone into a blood loop that passes the heart, lungs and muscles, message a hormone, speed seconds to minutes, effect long-lasting.

	Nervous route	Endocrine route
message	electrical impulse	hormone (a chemical)
carried by	one nerve, direct to the target	the blood, passing many organs
speed	up to about 120 m/s — arrives in under a second	seconds to minutes — carried by blood flow
effect	brief — stops when the impulses stop	long-lasting — minutes to hours
best for	quick, exact actions, like pulling a hand away or moving one muscle	responses that must be kept going, like the changes of puberty or the hours-long control of blood glucose

Neither route is better; they suit different jobs. A response that must be instant and exact needs a nerve. A response that must last, or act on several organs at once, needs a hormone.

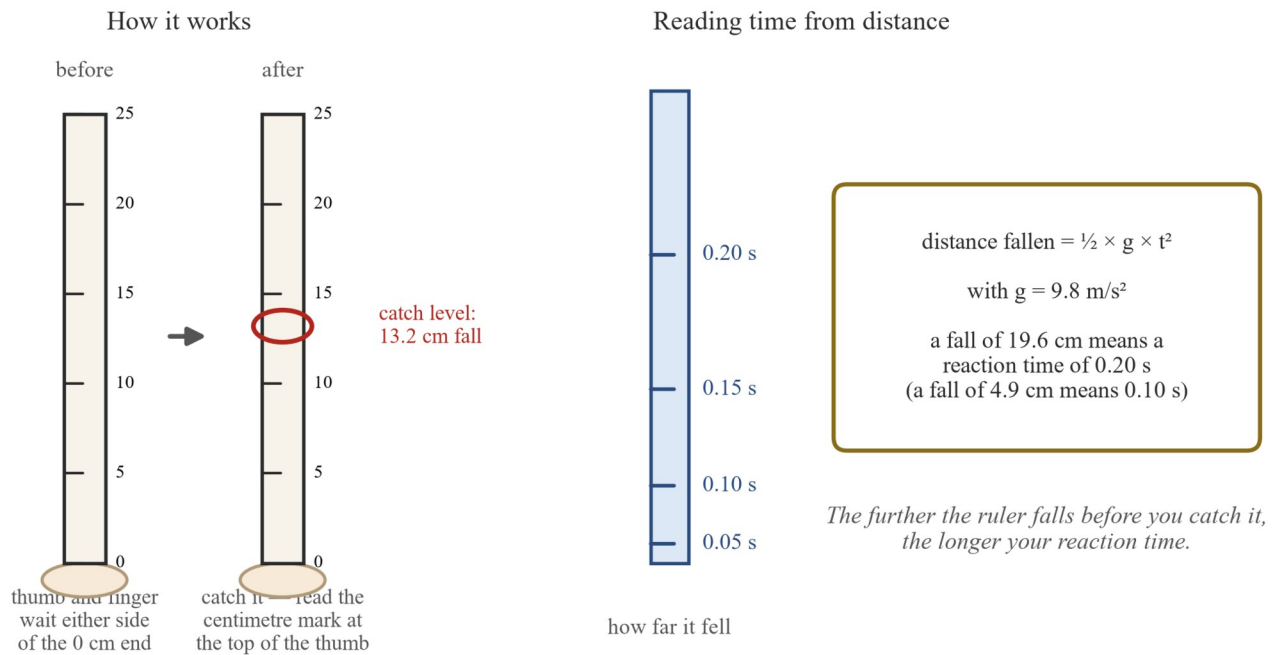
The two systems work together. Most real responses use both routes at once. See a dog running towards you and the nervous system acts first — eyes and ears send impulses to the brain, and commands fly out to the leg muscles that start you moving. At the same moment the brain switches on the adrenal glands, and the adrenaline they release keeps the heart and lungs working hard for minutes afterwards. One stimulus, two routes, one coordinated response — which is exactly what the content description for this subtopic says: the nervous and endocrine systems *work together* to regulate and coordinate the body’s response to stimuli.

Keeping the body’s internal conditions steady with these loops — **homeostasis**, including the negative-feedback loops that reverse a change — is the limb of this content description delivered by Subtopic 8B, which builds directly on the two systems you have just met.

Activities

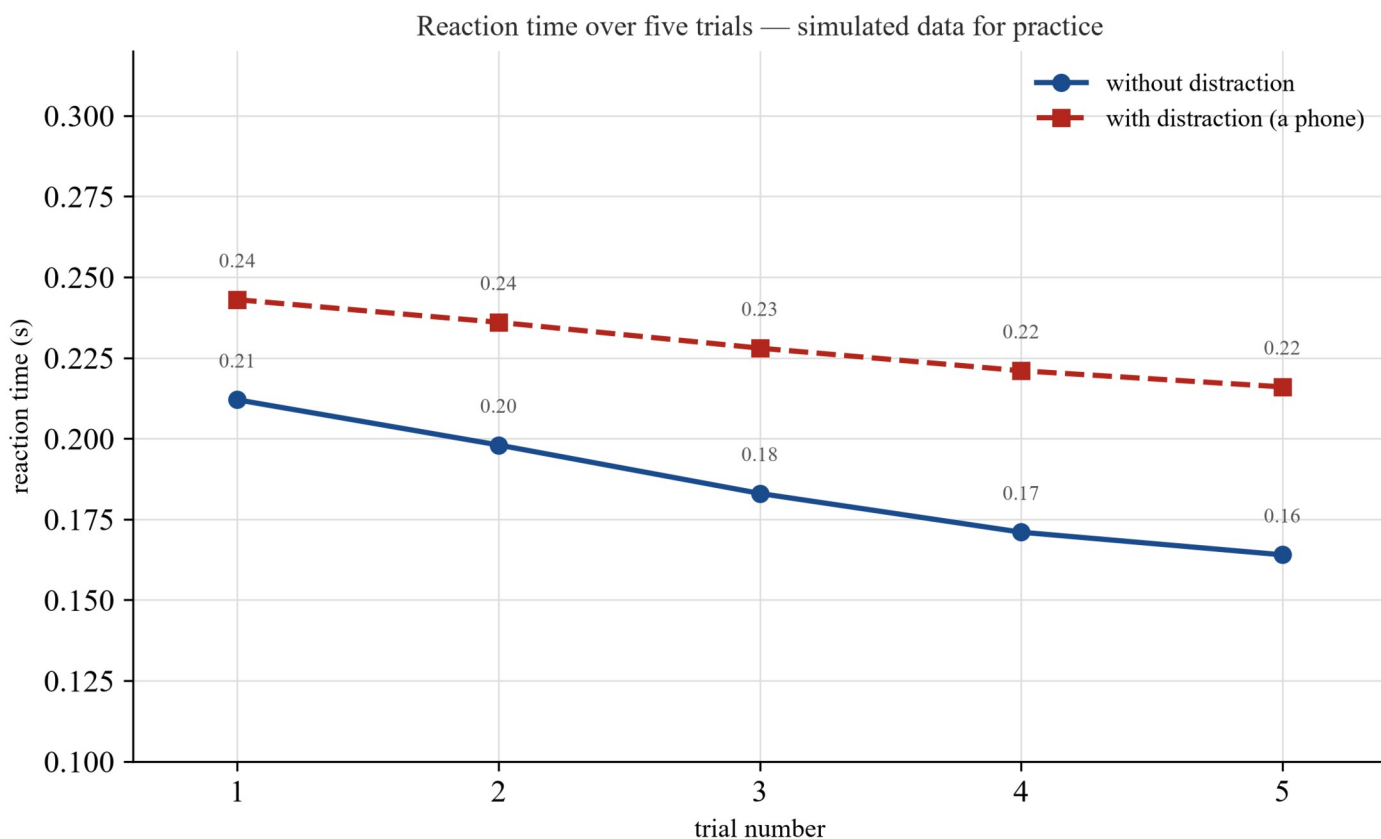
Activity 1 — Measure reaction time with the ruler-drop test (elaboration VC2S10U02 .E02). Work in pairs. Your partner holds a 30 cm ruler vertically so that the 0 cm end hangs between your thumb and first finger, which wait either side of it without touching (see the figure below). Without warning, your partner lets go; catch the ruler as quickly as you can and read the centimetre mark at the top of your thumb — that is the distance the ruler fell. Repeat for five trials, then swap roles. Record your results in a table (skills from Subtopic 4A). Convert each distance to a reaction time using the scale and formula in the figure (distance fallen = $\frac{1}{2} \times g \times t^2$, with $g = 9.8 \text{ m/s}^2$). Then: (i) name the stimulus, the receptor, the control centre and the effector in this response; (ii) explain why this response is *not* a reflex; (iii) suggest one change to the method that would test whether distraction slows the pathway, and say which variables you would keep the same (skills from Subtopic 2A).

Measuring reaction time — the ruler-drop test



Two diagrams of the ruler-drop test: before, with the thumb and finger waiting either side of the 0 cm end of a vertical ruler, and after, with the ruler caught at a 13.2 cm fall; beside them a scale converting the distance fallen to a reaction time, and a box giving distance fallen equals one half times g times t squared with $g = 9.8$ metres per second squared, a fall of 19.6 cm meaning 0.20 s and a fall of 4.9 cm meaning 0.10 s.

Activity 2 — Reading reaction-time data (elaboration VC2S10U02 .E02). The graph below is **simulated data for practice** — not measurements of a real person. It shows reaction time, in seconds, over five trials of a ruler-drop test, with and without a distraction (a phone).



Line graph of simulated reaction time in seconds against trial number 1 to 5: without distraction the time falls from about 0.21 s to about 0.16 s; with distraction (a phone) it falls from about 0.24 s to about 0.22 s; the distraction curve lies above the other at every trial.

- (i) Describe each curve, using the words *level* and *change* carefully. (ii) State the effect of practice on reaction time, and the effect of the distraction. (iii) Predict the reaction time for a sixth trial in each case, and explain your predictions. (iv) The distraction slows the control centre, not the eye or the muscle: explain which result in the graph supports that claim.

Activity 3 — Observe the pupil reflex (elaboration VC2S10U02 .E01). In pairs, in a dimmed room, sit facing your partner and observe the size of their pupils. Then, with your teacher's supervision, shine a small torch briefly from the side towards — never straight into — their eyes, and observe what happens to both pupils; let the eyes rest in the dim light again between repeats. Record the stimulus and the response you observed, and say which part of the pathway each of the following is: the light, the receptors at the back of the eye, the brain, the iris muscles. Explain why this response counts as a reflex, and why it is protective.

Worked examples

Example 1 — scaffolded

A student rests their hand near a bench and touches a hot stove plate by accident. Their hand is pulled away before they feel the pain. (a) Name the stimulus and the receptor in this reflex arc. (b) Put the following in the order the message travels: *motor neuron*, *receptor*, *relay neuron*, *sensory neuron*, *effector*. (c) State where the decision to move the hand is made, and explain why the pain is felt only after the hand has moved.

Working	Comment
Stimulus: the heat of the stove plate; receptor: heat receptors in the skin of the hand	The stimulus is the change; the receptor is the structure that detects it.
Order: receptor → sensory neuron → relay neuron → motor neuron → effector	Sensory in, relay between, motor out — the same order in almost every pathway.
Effector: the muscles of the arm, which contract and pull the hand away	An effector is the muscle or gland that carries out the response.

Working	Comment
The decision is made in the spinal cord, not the thinking part of the brain	That is what makes it a reflex: fast and automatic.
A copy of the message travels up to the brain after the reflex has happened, so the pain is felt after the hand has already moved	The brain finds out about the stimulus a moment too late — by design.

Example 2 — scaffolded

In a ruler-drop test, a student catches the ruler at a fall of 4.9 cm on their best trial and 19.6 cm on their worst trial. The distance fallen is related to the reaction time by distance fallen = $\frac{1}{2} \times g \times t^2$, with $g = 9.8 \text{ m/s}^2$. (a) Show that a fall of 4.9 cm means a reaction time of 0.10 s. (b) Calculate the reaction time for the 19.6 cm fall. (c) The worst fall is 4 times the best fall, but the worst time is not 4 times the best time. Explain why, and say what this means for reading the ruler.

Working	Comment
4.9 cm = 0.049 m; $0.049 = \frac{1}{2} \times 9.8 \times t^2$, so $t^2 = 0.049 \div 4.9 = 0.01$, and $t = 0.10 \text{ s}$	Convert cm to m first; the formula uses metres.
19.6 cm = 0.196 m; $t^2 = 0.196 \div 4.9 = 0.04$, so $t = 0.20 \text{ s}$	The same three steps: convert, divide, square-root.
Distance grows with t^2 , so 4 times the distance means only 2 times the time ($2 \times 2 = 4$)	Squaring and square-rooting undo each other: double the time, quadruple the fall.
The ruler's scale is therefore not evenly spaced in time — equal time steps need bigger and bigger distance steps	This is why the time marks on the ruler-drop figure crowd together towards the bottom.

Example 3 — unscaffolded

A student hears a loud bang, jumps instantly, and then notices their heart is still pounding a minute later, long after they have worked out the bang was only a dropped tray. Explain which system produces the instant jump and which keeps the heart pounding, using the message, the speed and the duration of each route.

The instant jump is the **nervous system**. The sound is detected by receptors in the ear, impulses race to the brain at up to about 120 m/s, and commands fly straight out to the muscles — one nerve, direct to the target, effect within a fraction of a second. The pounding heart a minute later is the **endocrine system**: at the same moment, the brain switched on the adrenal glands, which released **adrenaline** into the blood. The hormone took seconds to arrive, carried by blood flow, and it is slow to clear — the level is still about half of the peak 60 s later — so the heart and lungs keep working hard long after the danger is over. One stimulus, two routes: the nerve gives the instant, brief action; the hormone gives the slower, longer-lasting one.

Example 4 — unscaffolded

A rare condition damages the **sensory neurons** carrying messages from the skin of the hand, while the receptors, the spinal cord and the motor neurons all work normally. Predict what happens if this person's hand touches a hot stove plate, and explain your prediction by tracing the reflex arc link by link.

The hand would **not be pulled away, and no pain would be felt**. Trace the arc: the heat receptors detect the stimulus and start the message as normal, but the damaged sensory neurons cannot carry it to the spinal cord. With that link broken, the relay neuron never receives the message, so no command goes out along the motor neurons, and the effector — the arm muscles — never contracts. The same broken link also means no copy of the message ever reaches the brain, so there is no feeling of heat or pain from the hand. The person is in real danger for exactly this reason: with a working reflex the hand would have been moved before any thought was needed, and here that protection is gone even though the muscles themselves are perfectly able to move. (The person can still move the hand on purpose, because voluntary commands start in the brain and use the motor neurons, which are unharmed.)

Practice questions

Scaffolded questions

Question 1 The vocabulary of coordination. Define each of the following: (a) stimulus; (b) response; (c) receptor; (d) effector; (e) hormone; (f) reflex.

Question 2 Sort these stimuli into two lists — *external* and *internal*: bright sunlight; hunger; the sound of thunder; cold wind on the skin; dehydration (the body short of water); the smell of food.

Question 3 Copy and complete the pathway for catching a dropped ruler, putting these parts in order: *brain and spinal cord decide, eye detects the ruler falling, hand muscles close, message carried in along a sensory neuron, command carried out along a motor neuron*.

Question 4 Three kinds of neuron. (a) Which kind of neuron carries the message from a receptor to the CNS? (b) Which kind carries the command from the CNS to an effector? (c) Which kind connects the other two inside the CNS?

Question 5 Reading the ruler. A student's two catches are a fall of 4.9 cm and a fall of 19.6 cm. (a) Use the ruler-drop figure to state the reaction time for each catch. (b) State which catch was the faster response, and by how much. (c) Name the formula that links the fall to the time.

Question 6 Reflex or not? Sort these into *reflex* and *voluntary*: pulling your hand away from something hot; deciding to pick up a school bag; your pupils narrowing in bright light; blinking when something moves quickly towards your eye; running to catch a bus. Then state the feature that all the reflexes share.

Un scaffolded questions

Question 7 Explain why reflex arcs are protective, referring to where the decision is made and to the time it saves.

Question 8 Walking from a dark cinema foyer out into bright sunlight, your pupils narrow within a second. (a) Identify the stimulus, the receptor, the control centre and the effector in this reflex. (b) Explain why both pupils respond even if the light mainly strikes one eye.

Question 9 The adrenaline curve in the figure shows the danger over at about 15 s. (a) State roughly how long after the danger was detected the level peaks. (b) State roughly what the level is at 60 s, compared with the peak. (c) Explain why the heart is still pounding a minute after the danger has gone.

Question 10 Copy and complete the table comparing the two routes: for each of *message, carried by, speed, effect*, write the nervous route and the endocrine route.

Question 11 The reaction-time graph in Activity 2 shows two curves. (a) Describe each curve using *level* and *change* carefully. (b) State the effect of practice and the effect of distraction. (c) Predict both reaction times for a sixth trial and explain your predictions.

Question 12 A loud bang makes a student jump instantly and then feel their heart race for minutes. Explain which system produces each part of the response, using the message, speed and duration of each route.

Question 13 As evening light fades, the pineal gland releases more **melatonin**, the hormone that helps set the sleep–wake cycle. (a) Is the stimulus here external or internal, and which receptor system detects it? (b) Explain why this response suits the endocrine route rather than the nervous route. (c) Explain how this response shows the two systems working together.

Question 14 A rare condition damages the sensory neurons from the skin of the hand; the receptors, spinal cord and motor neurons all work normally. Predict what happens if this person touches a hot stove plate, and explain your prediction by tracing the reflex arc link by link.

Question 15 A nerve connects the brain to one exact muscle; a hormone is carried past every organ in the blood. Explain why the nerve suits a quick, brief, exact action while the hormone suits a slower, longer-lasting, widespread one.

Question 16 A company claims its new drink contains a hormone-like chemical that “speeds up your reaction time within one second of swallowing it”. Use what you know about the two routes to evaluate this claim. State what would have to be true for the claim to work, and why you would be cautious about it.

Answers

Question 1 (a) a change in a condition that the body can detect; (b) the action that follows a stimulus; (c) the structure that detects a stimulus and turns it into a message; (d) a muscle or gland that carries out the response; (e) a chemical messenger released by a gland into the blood; (f) a fast, automatic response to a stimulus. **Question 2** external: bright sunlight, the sound of thunder, cold wind on the skin, the smell of food; internal: hunger, dehydration. **Question 3** eye detects the ruler falling → message carried in along a sensory neuron → brain and spinal cord decide → command carried out along a motor neuron → hand muscles close. **Question 4** (a) sensory neuron; (b) motor neuron; (c) relay neuron. **Question 5** (a) 0.10 s and 0.20 s; (b) the 4.9 cm catch, faster by 0.10 s; (c) distance fallen = $\frac{1}{2} \times g \times t^2$, with $g = 9.8 \text{ m/s}^2$. **Question 6** reflex: pulling the hand away, pupils narrowing, blinking; voluntary: picking up the bag, running for the bus; shared feature — see solution. **Question 7** see solution — the decision is made in the spinal cord, saving the time a brain decision would take. **Question 8** (a) see solution; (b) the control centre commands both eyes together. **Question 9** (a) about 15 s; (b) about half the peak; (c) see solution. **Question 10** see solution (the comparison table from the theory). **Question 11** (a)–(c) see solution. **Question 12** see solution. **Question 13** (a) external — the eye; (b)–(c) see solution. **Question 14** see solution. **Question 15** see solution. **Question 16** see solution.

Fully-worked solutions

Question 1 (a) A **stimulus** is a change in a condition that the body can detect. (b) A **response** is the action that follows a stimulus. (c) A **receptor** is a structure that detects one kind of stimulus and turns it into a message the body can act on. (d) An **effector** is a muscle or gland that carries out the response. (e) A **hormone** is a chemical messenger released by a gland straight into the blood, which changes the activity of the organs that can detect it. (f) A **reflex** is a fast, automatic response to a stimulus, produced by a reflex arc.

Question 2 External stimuli — changes outside the body: bright sunlight; the sound of thunder; cold wind on the skin; the smell of food. **Internal stimuli** — changes inside the body: hunger; dehydration.

Question 3 The order is: **eye detects the ruler falling** (receptor) → **message carried in along a sensory neuron** → **brain and spinal cord decide** (control centre) → **command carried out along a motor neuron** → **hand muscles close** (effector and response). Sensory in, relay between, motor out.

Question 4 (a) The **sensory neuron**. (b) The **motor neuron**. (c) The **relay neuron**.

Question 5 (a) A fall of 4.9 cm means **0.10 s**; a fall of 19.6 cm means **0.20 s** (both are marked on the ruler-drop figure, and both follow from distance fallen = $\frac{1}{2} \times g \times t^2$). (b) The **4.9 cm catch** was the faster response, by **0.10 s**. (c) **distance fallen** = $\frac{1}{2} \times g \times t^2$, with $g = 9.8 \text{ m/s}^2$.

Question 6 Reflex: pulling your hand away from something hot; your pupils narrowing in bright light; blinking when something moves quickly towards your eye. **Voluntary:** deciding to pick up a school bag; running to catch a bus. All the reflexes share the same feature: they are **fast and automatic**, with the decision made in the spinal cord (or a low part of the brain) rather than by a conscious choice — you cannot decide not to have them happen.

Question 7 In a reflex arc the decision is made in the **spinal cord**, not in the thinking part of the brain. The message therefore travels a much shorter loop — receptor, sensory neuron, relay neuron, motor neuron, effector — and the response begins a fraction of a second sooner than it could if the brain had to receive the message, think about it, and decide. That saved time is the protection: the hand is already moving away from the hot stove plate before the pain is even felt.

Question 8 (a) Stimulus: the **sudden increase in light**. Receptor: the **light receptors at the back of the eye**. Control centre: the **brain**. Effector: the **muscles of the iris**, which narrow the pupil. (b) Because the control centre — the brain — receives the message from both eyes and commands **both** irises together, shining light into one eye narrows both pupils.

Question 9 (a) The level peaks at about **15 s** — roughly when the danger is over. (b) At 60 s the level is still **about half of the peak**. (c) Adrenaline is carried **in the blood** and is slow to clear: the hormone released in the first seconds is still circulating, so the heart and lungs keep working hard until it falls back to the starting level, which takes a few minutes. The endocrine route's long-lasting effect outlives the stimulus that started it.

Question 10

	Nervous route	Endocrine route
message	electrical impulse	hormone (a chemical)
carried by	one nerve, direct to the target	the blood, passing many organs
speed	up to about 120 m/s — arrives in under a second	seconds to minutes — carried by blood flow
effect	brief — stops when the impulses stop	long-lasting — minutes to hours

Question 11 (a) Without distraction the reaction time **falls from about 0.21 s at trial 1 to about 0.16 s at trial 5** — the level drops as the trials go on. With distraction it falls from about **0.24 s to about 0.22 s**. At every trial the distracted level is **above** the undistracted one. (b) **Practice** shortens the reaction time (the change across trials); **distraction** lengthens it (the gap between the curves). (c) Any prediction near **0.16 s or just below** without distraction and **0.22 s or just below** with distraction, with the reason that both curves are levelling out — the change from trial to trial is getting smaller, so a sixth trial should be much like the fifth.

Question 12 The instant jump is the **nervous route**: receptors in the ear detect the sound, impulses travel to the brain at up to about 120 m/s, and commands go direct to the muscles — a response within a fraction of a second, over quickly. The racing heart for minutes afterwards is the **endocrine route**: the brain switched on the adrenal glands, whose adrenaline travels in the blood, arrives in seconds, and clears only slowly, keeping the heart and lungs working hard long after the bang. The nerve is fast and brief; the hormone is slower and long-lasting — one stimulus, two routes.

Question 13 (a) The stimulus is **external** — the fading light — detected by the **eye**, the light receptor system. (b) The response must be **kept going for hours** while you sleep, and it acts on the whole body's rhythm rather than one quick muscle action — exactly the job the endocrine route is built for: a hormone carried in the blood with a long-lasting effect. (c) The two systems work **together**: the nervous system (the eye and the brain) detects the external change, and it is the brain's command to the pineal **gland** that starts the endocrine response — a nervous detection followed by a hormonal action.

Question 14 The hand would **not be pulled away and no pain would be felt**. The receptors detect the heat and start the message, but the damaged **sensory neurons** cannot carry it to the spinal cord; the relay neuron therefore receives nothing, sends nothing to the motor neurons, and the arm muscles never contract — the effector link is intact but never receives its command. No copy of the message reaches the brain either, so there is no pain. The protection a reflex normally gives is lost even though the muscles can still move the hand on purpose, because voluntary commands start in the brain and use the unharmed motor neurons.

Question 15 A nerve is a **single, direct line** to one exact target, carrying electrical impulses at up to about 120 m/s, so the action begins in under a second — and when the impulses stop, the effect stops: brief and exact. A hormone is released **into the blood**, so it reaches every organ the blood passes, taking seconds to minutes to arrive; any organ that can detect it may respond, so the effect is widespread — and because the hormone clears slowly, the effect lasts minutes to hours. Each route therefore suits the kind of job described: quick-exact-brief for the nerve, slow-widespread-lasting for the hormone.

Question 16 You should be **cautious**. Reaction time is a **nervous** response — eye or ear to brain to muscle, in under a second. A chemical taken by mouth must first be **absorbed through the gut into the blood**, and a hormone-like chemical then travels the endocrine route: seconds to minutes to arrive, with a long-lasting rather than instant effect. For the claim to be true, the chemical would have to reach the blood and act on the nervous system within one second of swallowing — far faster than the endocrine route works and faster than absorption through the gut normally allows. That contradicts the well-understood speeds of the two routes, so the claim would need strong published evidence before it could be believed.

Where this leads: the pathway and two-route model taught here is the picture VCE Biology Unit 1, Area of Study 2 (“How do plant and animal systems function?”) formalises, and VCE Psychology builds on it further, adding the

chemistry of how neurons pass messages on and how pathways change with experience — extensions that are VCE-only and are not taught here (TOC D9), reference-only for this book. Subtopic 8B takes up the other limb of VC2S10U02 — homeostasis and the negative-feedback loops that keep the body's internal conditions steady, including the blood-glucose loop the pancreas runs — and Subtopics 8C and 8D take up disease and how its spread is controlled.

Homeostasis and negative feedback — receptor, control centre, effector

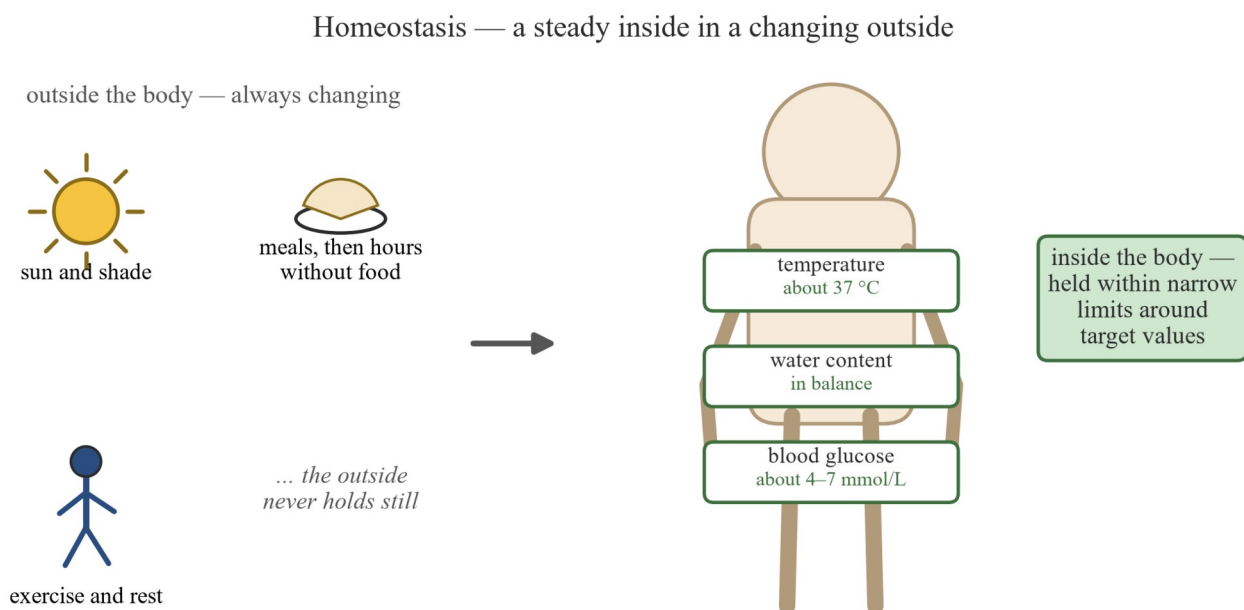
Chapter 8 — Biological sciences B: coordination, homeostasis and disease (Science, Levels 9 and 10)

Subtopic 8B · VC2 Science Understanding — Biological sciences

CD code: VC2S10U02 (split delivery †; this subtopic is the partner, not the accountable owner) **Content description (verbatim):** “the nervous and endocrine systems work together to regulate and coordinate the body’s response to stimuli, ensuring homeostasis, including through negative feedback mechanisms” **This subtopic’s limb (TOC §4 clause split):** homeostasis and negative feedback. The accountable owner 8A delivers the other limb: the nervous and endocrine systems coordinating responses to stimuli. **Elaboration ids drawn on:** VC2S10U02.E04 · VC2S10U02.E05 · VC2S10U02.E06 (ids VC2S10U02.E01–VC2S10U02.E03 are drawn on by Subtopic 8A; no elaboration of this CD is withheld under the TOC’s D10 ICIP decision) **Achievement standard (extract served):** “They explain how the nervous and endocrine systems use negative feedback to support homeostasis in the body’s internal environment.”

Theory

A steady inside in a changing outside. Your body is made of trillions of cells, and every one of them is carrying on the chemistry of life: taking in glucose and oxygen, releasing energy, and producing waste. Those cells work best only within narrow limits of temperature, water content and food supply. The world outside those cells is anything but steady — you move between sun and shade, you eat meals and then go hours without food, you exercise and then rest. The body’s answer is to keep conditions on the *inside* steady no matter what is happening outside. This steady internal environment is called **homeostasis**. In this book, *homeostasis* means the body’s keeping of its internal conditions — such as temperature, water content and blood sugar — within narrow limits around a target value, even while conditions outside the body change. (The Victorian Curriculum uses the term without a single fixed wording, so this subtopic works to that definition, and every question here can be answered from it.)

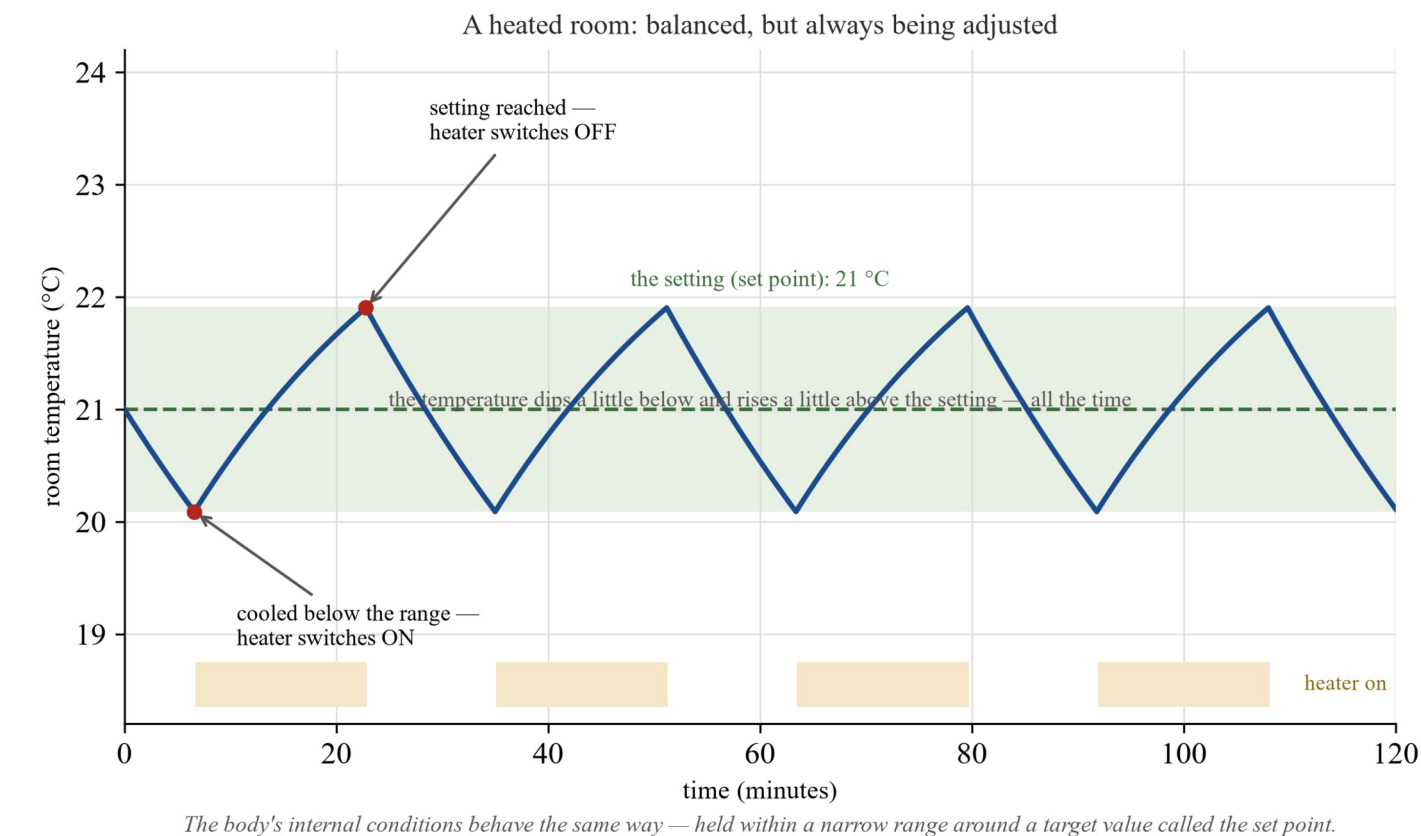


The body keeps its internal conditions steady no matter what is happening outside — that steady internal environment is homeostasis.

Diagram of homeostasis. On the left, the outside of the body is always changing: sun and shade, meals then hours without food, exercise and rest. On the right, a body holds its inside steady: temperature about 37 degrees Celsius, water content in balance, and blood glucose about 4 to 7 mmol/L, each held within narrow limits around a target value.

Homeostasis does not mean that internal conditions are frozen at one exact value. Each condition is held within a **narrow range** around a target value called the **set point**, dipping a little below it and rising a little above it all the

time. Think of the temperature of a heated room: the heater does not hold the room at exactly one temperature; it keeps the temperature within a degree or two of the setting on the thermostat. The body’s internal conditions behave the same way — they are **balanced, but always being adjusted**.



Line graph of the temperature of a heated room over two hours. The room temperature dips to about 20 degrees Celsius, where the heater switches on, and rises to about 22 degrees, where the setting is reached and the heater switches off, so the temperature keeps moving in a narrow band around the set point of 21 degrees; shaded bars along the bottom show when the heater is on.

Some of the conditions the body keeps steady are:

Condition	Typical set-point value	Why cells need it steady
Core body temperature	about 37 °C	the chemistry of cells slows right down if it falls, and key cell parts are damaged if it rises much above it
Blood glucose	roughly 4–7 mmol/L through the day	glucose is the fuel cells use to release energy; too little and cells run short, too much and it damages blood vessels over time
Water content of body fluids	no single number — a balance between water taken in and water lost	cells must not swell with too much water or shrink with too little

Other conditions kept steady include the amount of iron carried in the blood and the acidity (measured on the pH scale) of the body’s fluids (elaboration VC2S10U02 . E05). You do not need to learn the details of every loop in this subtopic — what matters is that **every one of them is run by the same three-part system** you are about to meet.

A note on units. Blood glucose in Australia is reported in **mmol/L** (millimoles per litre), a measure of concentration. You do not need to do calculations with this unit here — just read the numbers as “how much glucose is in each litre of blood”.

The three parts of every feedback loop (elaboration VC2S10U02 . E04). Every homeostasis loop in the body has the same three parts, joined in a circle.

1. **Receptor** — the part that **detects** a change. A receptor is a structure that watches one condition and sends information about it to the control centre. Temperature receptors in your skin detect the cold of a winter morning; receptors inside your body detect that your blood glucose has risen after a meal. The change that a receptor detects is called a **stimulus** (the plural is **stimuli**).
2. **Control centre** — the part that **decides**. The control centre receives the information, compares it with the set point, and works out what response is needed. In the body the control centre is usually the brain or a gland. (VCAA's elaboration VC2S10U02.E04 calls this part the *command centre*. The two names mean the same thing; this book uses *control centre* throughout.)
3. **Effector** — the part that **acts**. An effector is a muscle or a gland that carries out the response the control centre orders. Sweat glands, muscles and the liver are all effectors.

The three parts are joined by messages, and the messages travel along one of the two systems you met in Subtopic 8A:

- the **nervous system** carries fast electrical impulses along nerves — suited to quick, short-lived responses such as pulling away from heat or starting to shiver;
- the **endocrine system** carries chemical messengers called **hormones** in the blood — slower to arrive, but suited to responses that must be kept going for minutes or hours, such as bringing blood glucose back down after a meal.

The two systems often work on the same loop together. That is the heart of the content description for this subtopic: the nervous and endocrine systems working together to keep the body's internal conditions steady.

You can read any feedback loop as one chain of cause and effect:

stimulus (a change is detected) → **receptor** → **control centre** → **effector** → **response** → the change is corrected

Reading this chain — and predicting what happens when one link of it breaks — is the main skill of this subtopic.

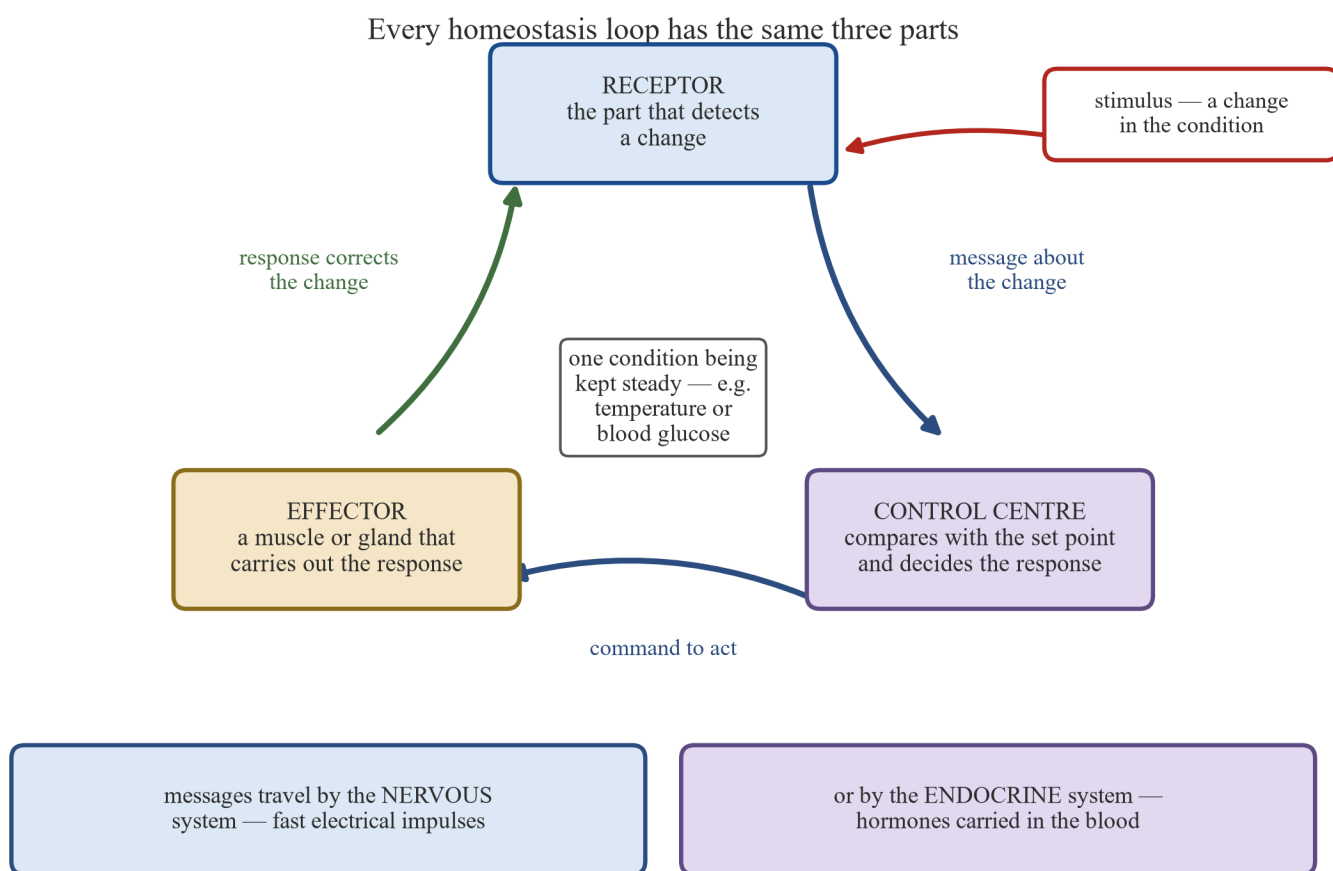


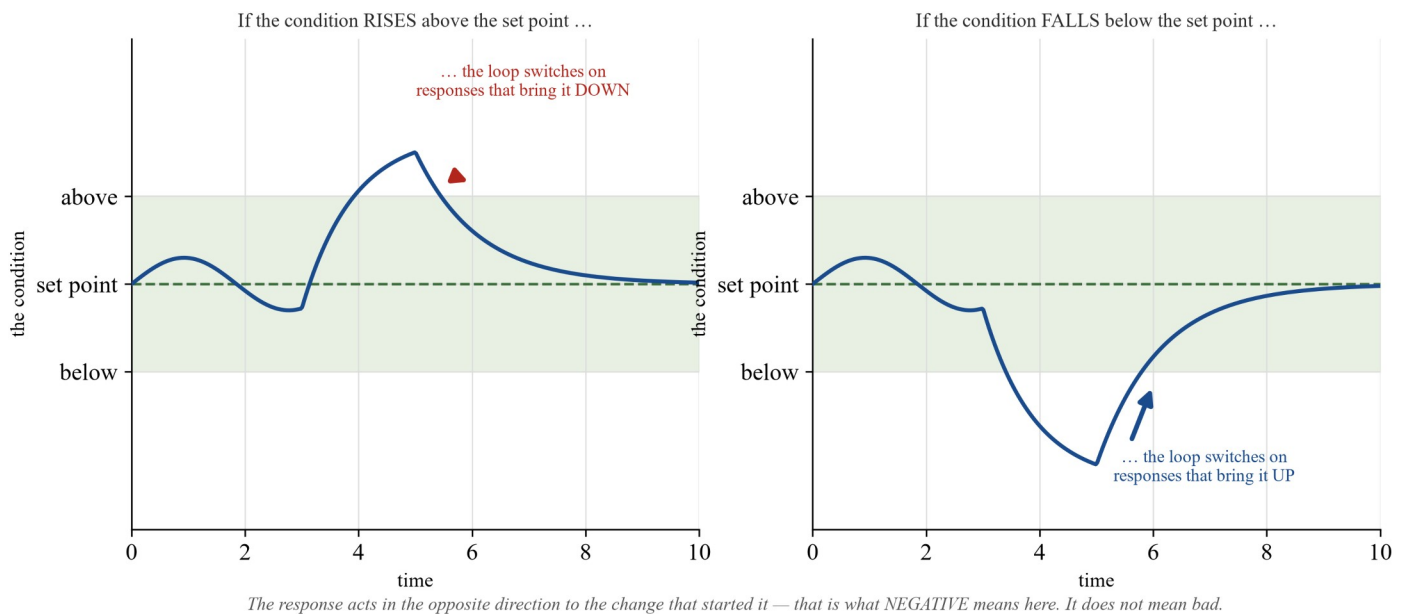
Diagram of the three parts of every feedback loop joined in a circle: the receptor detects the change, the control centre compares it with the set point and decides, and the effector carries out the response, which corrects the change.

Two boxes below show the two routes the messages can travel by: the nervous system, fast electrical impulses, or the endocrine system, hormones carried in the blood.

Negative feedback: the response reverses the change (elaboration VC2S10U02 .E05). The loops that keep the body steady are called **negative feedback loops**. The word *negative* here does not mean “bad”. It means that **the response acts in the opposite direction to the change that started it**:

- if a condition rises **above** its set point, the loop switches on responses that bring it **down**;
- if a condition falls **below** its set point, the loop switches on responses that bring it **up**.

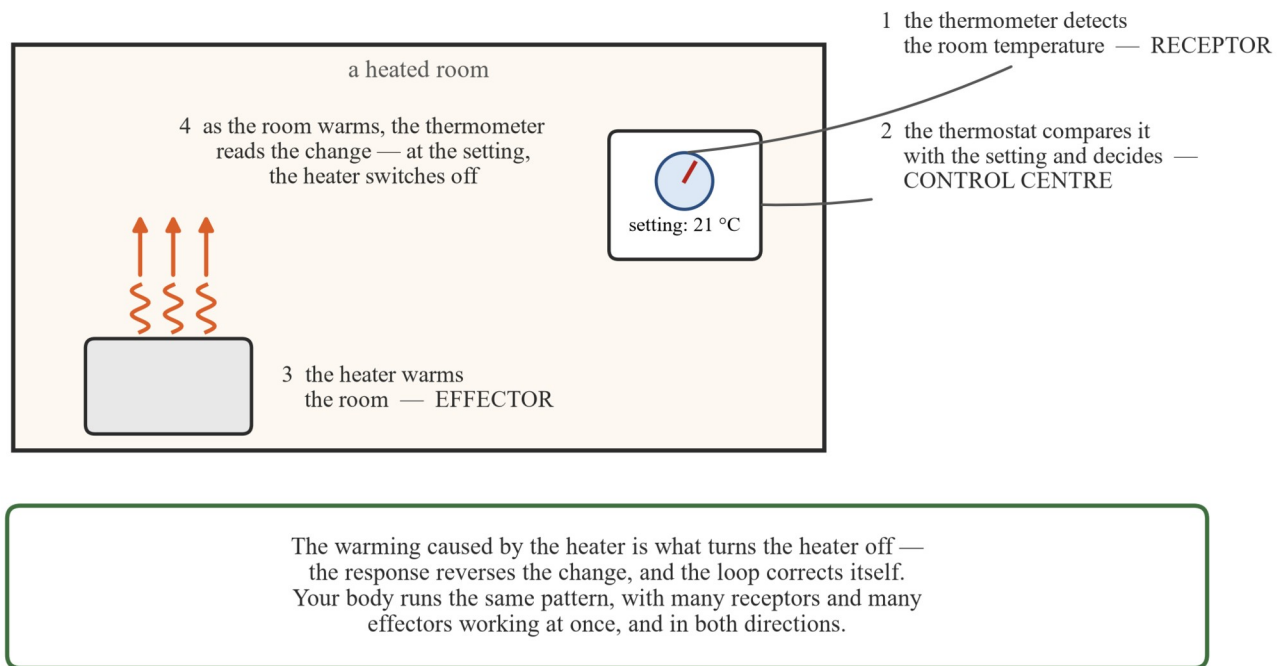
The response therefore *reverses* the change, and once the condition is back near the set point the loop quiets down again. The loop is **self-correcting**: it is kept going only while there is something to correct.



Two graphs side by side. Left: a condition rises above its set point, and the loop switches on responses that bring it back down. Right: a condition falls below its set point, and the loop switches on responses that bring it back up. In both graphs the response acts in the opposite direction to the change that started it, returning the condition toward the set point.

A home heating system shows the same pattern, and it is worth spelling out because you know it from daily life. The thermometer in the thermostat **detects** the room temperature (receptor). The thermostat **compares** it with the setting you chose and decides whether the heater should switch on (control centre). The heater **warms** the room (effector). As the room warms, the thermometer reads the change, and when the setting is reached the heater switches off — the warming caused by the heater is what turns the heater off. The response (warming) reverses the change (cold), and the loop corrects itself. Your body runs the same pattern, with many receptors and many effectors working at once, and in both directions.

A home heating system runs the same loop



Labelled sketch of a home heating loop in four steps: 1, the thermometer detects the room temperature (receptor); 2, the thermostat compares it with the setting and decides (control centre); 3, the heater warms the room (effector); 4, as the room warms, the thermometer reads the change and, at the setting, the heater switches off. The warming caused by the heater is what turns the heater off, so the response reverses the change and the loop corrects itself.

Worked loop 1 — body temperature. Your core body temperature is held close to 37 °C by a loop called **temperature regulation**. The control centre is a small region deep in the brain called the **hypothalamus**, which acts like the body's thermostat. Temperature receptors in the skin and inside the body report to it. When the reported temperature moves away from 37 °C, the hypothalamus sends commands to effectors. Here is what happens in each direction.

When the body is too hot:

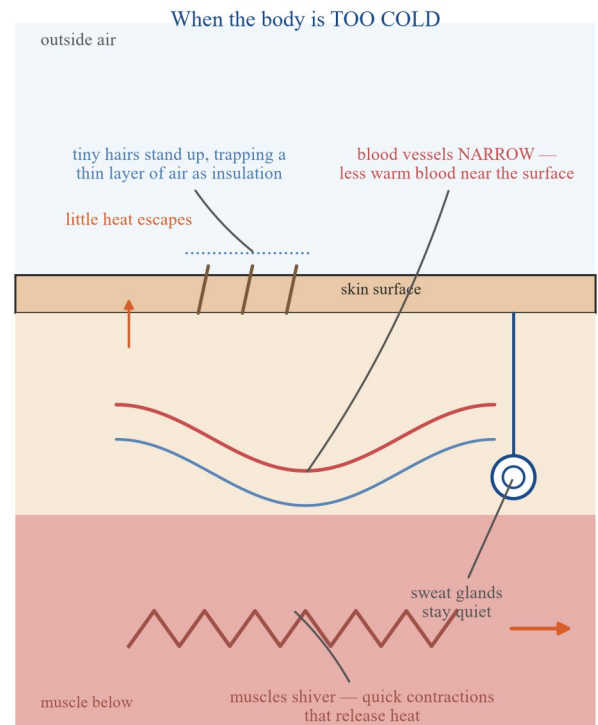
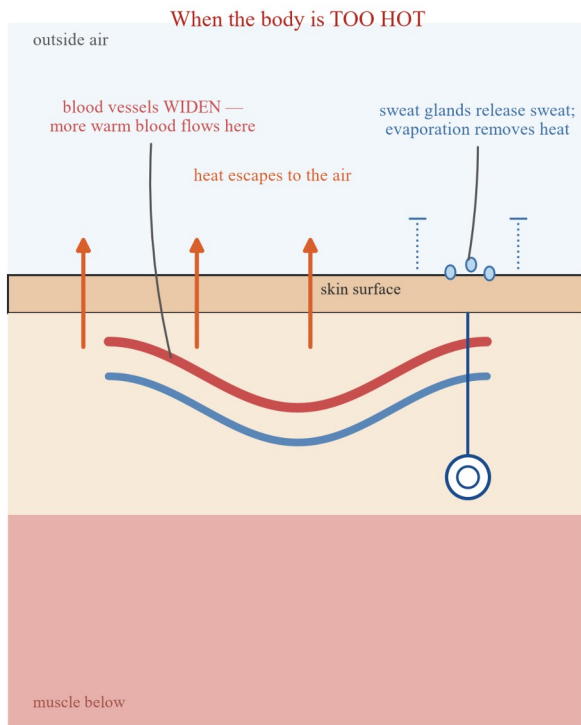
Effector / response	How it brings temperature back down
Sweat glands release sweat onto the skin	as the sweat evaporates, it removes heat from the skin and cools the blood below it
Blood vessels near the skin surface widen	more warm blood flows near the surface, so more heat escapes from the blood to the air
Behaviour: move into shade, take off a layer of clothing, drink cool water	voluntary actions that reduce heat gain or add heat loss

When the body is too cold:

Effector / response	How it brings temperature back up
Muscles shiver — quick, small contractions you do not choose	the contractions release heat, warming the blood nearby
Blood vessels near the skin surface narrow	less warm blood flows near the surface, so less heat escapes to the air
Tiny hairs on the skin stand up, trapping a thin layer of air	the trapped air acts as insulation (this works far better in furry animals than in humans)
The body speeds up its energy-releasing chemistry	more of that energy comes out as heat

Behaviour: put on a jumper, keep moving, get out of the wind

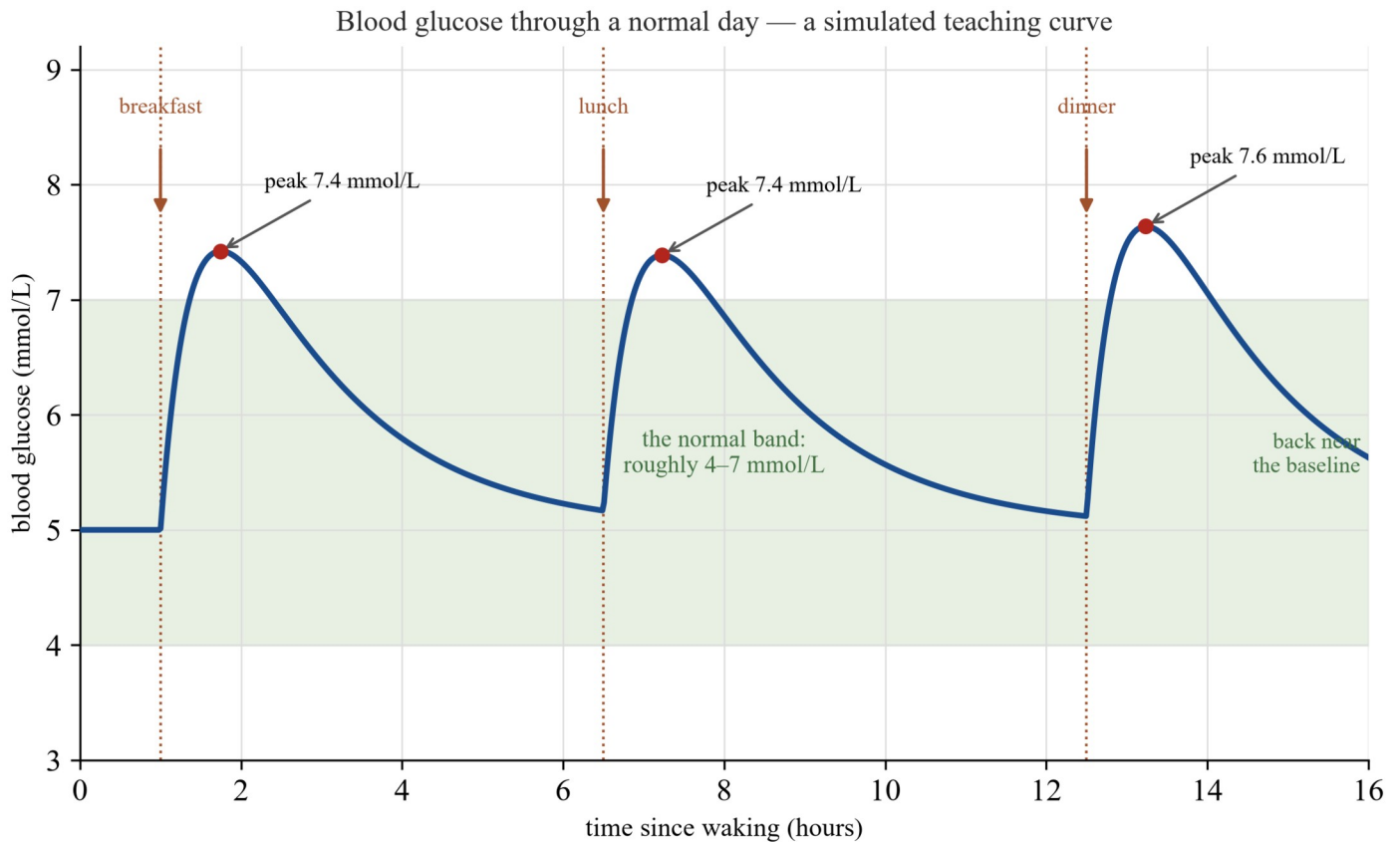
voluntary actions that reduce heat loss or add heat



Two labelled cross-sections of skin side by side. On a hot day, sweat glands release sweat and evaporation removes heat, and blood vessels near the surface widen so more warm blood flows there and heat escapes to the air. On a cold day, blood vessels near the surface narrow so less warm blood flows there, and tiny hairs stand up, trapping a thin layer of air as insulation.

One detail makes the first row of the “too hot” table worth a second look: sweat only cools you when it **evaporates**. On a humid day the air already holds a lot of water, so sweat evaporates slowly and stays on the skin — which is why a humid 34 °C day feels harder to cope with than a dry one. Evaporation, not the sweat itself, is what removes the heat.

Worked loop 2 — blood glucose. Glucose is the sugar your cells use as fuel. It enters the blood when carbohydrate food is digested, so blood glucose **rises** after a meal. Between meals, cells keep drawing glucose out of the blood to release energy, so blood glucose **falls**. Through a normal day the level is held within a narrow band — roughly 4 to 7 mmol/L — by a hormone loop.



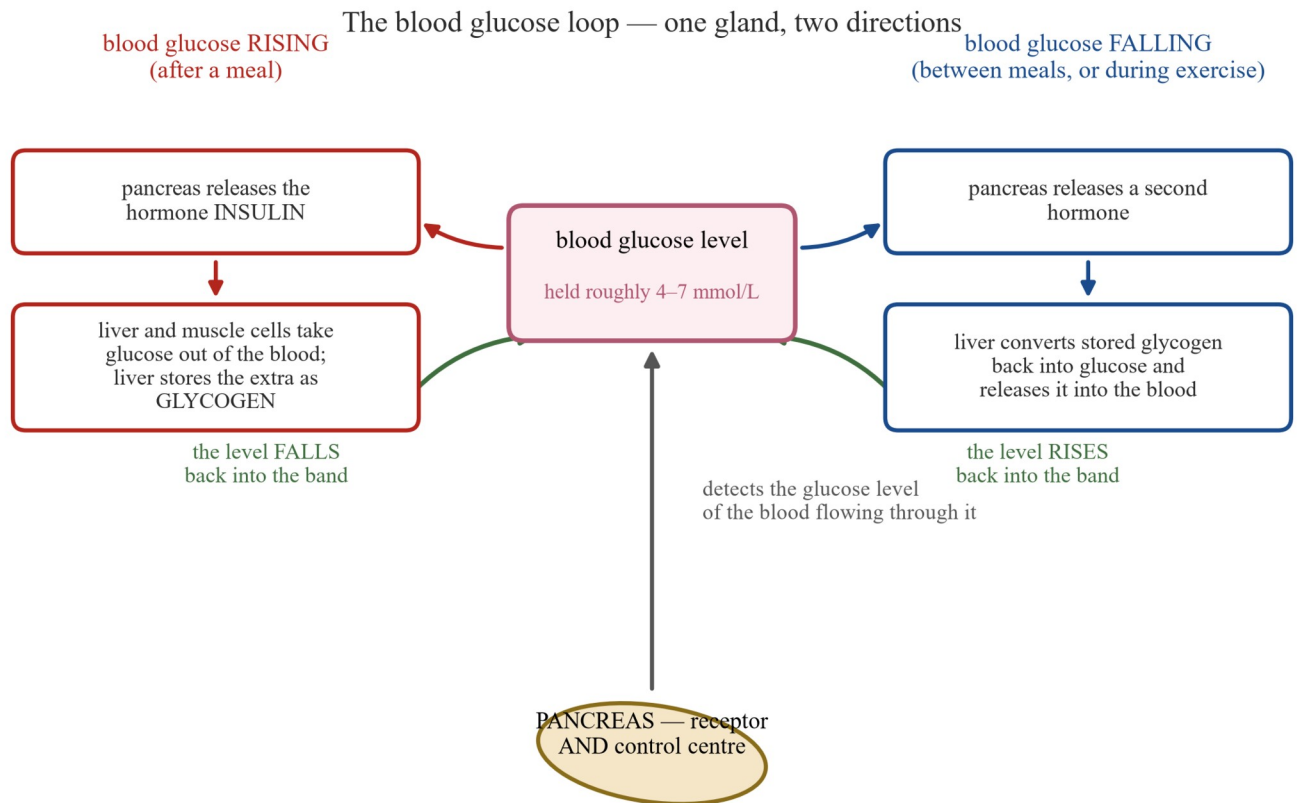
Each meal makes the level rise; the loop brings it back into the band within a few hours.

Line graph of blood glucose through a normal day (a simulated teaching curve). After each meal, breakfast, lunch and dinner, the level rises to a peak of about 7.4 to 7.6 mmol/L, then falls back into the normal band of roughly 4 to 7 mmol/L within a few hours, returning near the baseline before the next meal.

This loop's receptor and control centre sit in one organ: the **pancreas**, a gland that releases hormones into the blood. The pancreas detects the glucose level of the blood flowing through it and responds in opposite ways on the two sides of the set point:

- **Blood glucose rising (after a meal).** The pancreas releases the hormone **insulin**. Insulin tells body cells — especially liver and muscle cells — to take glucose out of the blood. The liver stores the extra glucose as a substance called **glycogen**. Blood glucose falls back into the band.
- **Blood glucose falling (between meals, or during exercise).** The pancreas releases a second hormone, which tells the liver to convert some of its stored glycogen back into glucose and release it into the blood. Blood glucose rises back into the band. (The name of this second hormone is given in VCE Biology; it is not needed here.)

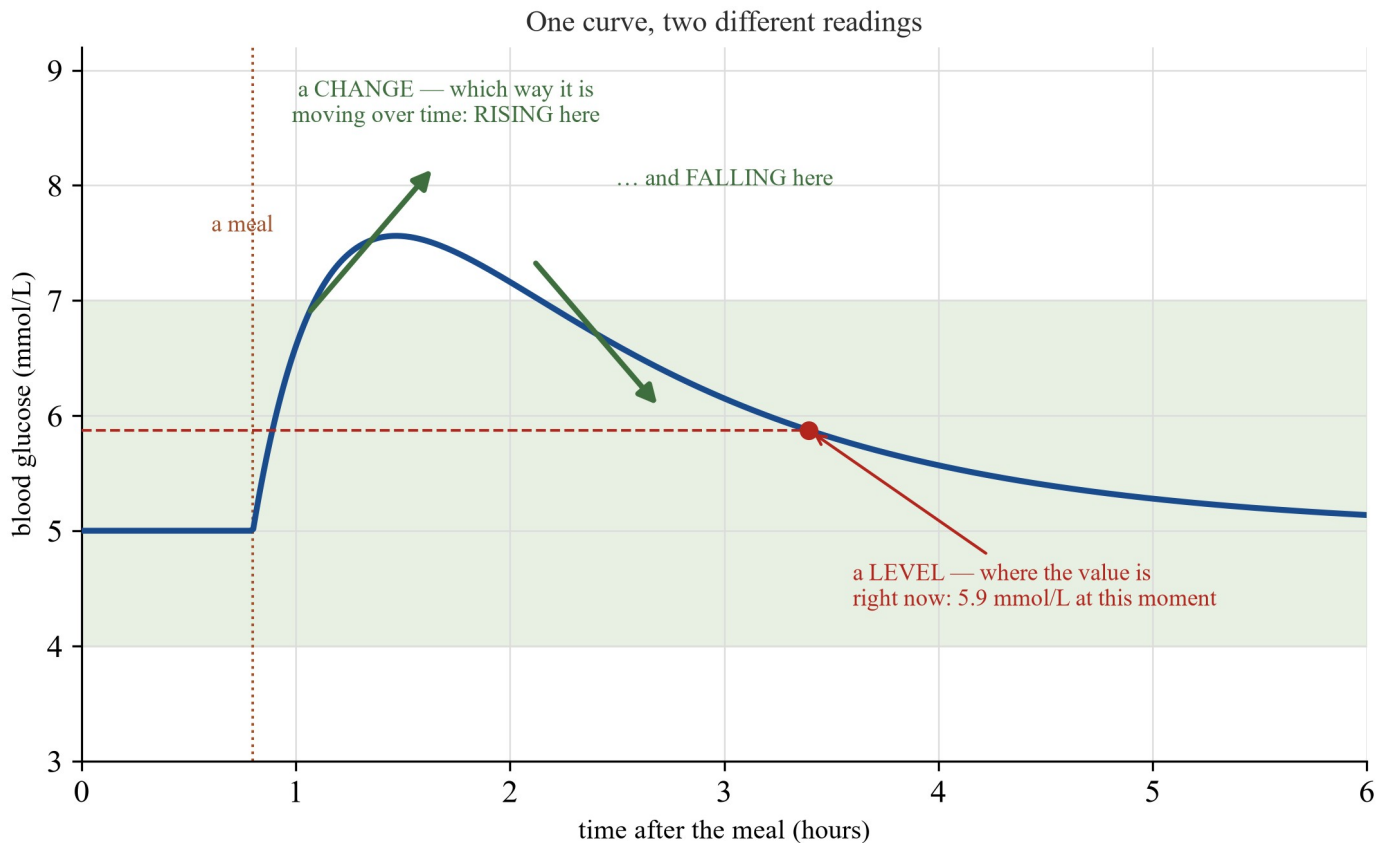
The effectors of this loop are the liver and the muscles, and the messages travel by the endocrine route — hormones carried in the blood. That route takes longer than a nerve impulse, which suits the job: a meal raises blood glucose over tens of minutes, and the correction can take its time too.



The messages travel the endocrine route — hormones carried in the blood — which suits a correction that takes tens of minutes.

Flow diagram of the blood glucose loop, with the pancreas as both receptor and control centre. Left side, when blood glucose is rising after a meal: the pancreas releases the hormone insulin, liver and muscle cells take glucose out of the blood, the liver stores the extra as glycogen, and the level falls back into the band. Right side, when blood glucose is falling between meals or during exercise: the pancreas releases a second hormone, the liver converts stored glycogen back into glucose and releases it, and the level rises back into the band.

Words matter: a level is not a change. Look carefully at the two sentences “*blood glucose is high*” and “*blood glucose is rising*”. The first describes a **level** (where the value is right now); the second describes a **change** (which way it is moving over time). A person’s blood glucose can be high while falling, or normal while rising. When you describe a feedback loop or read a graph of one, say which you mean — the loop responds to the level, but your explanation is marked on precise words.

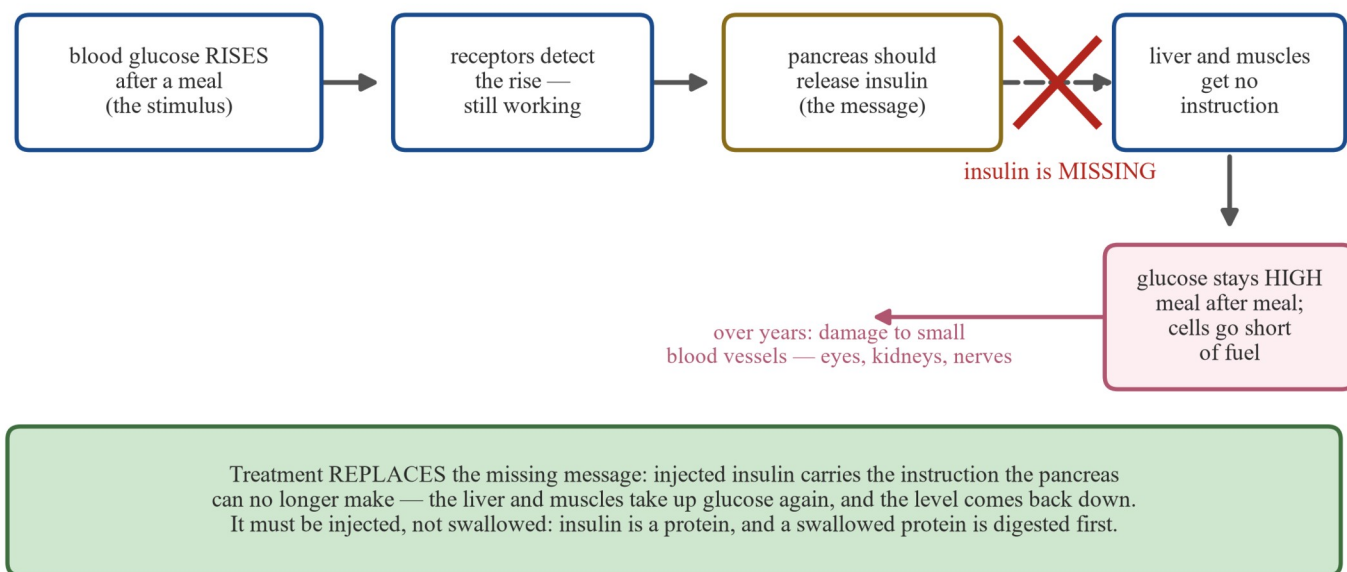


The loop responds to the level — but your explanation is marked on saying level and change apart.

Line graph of blood glucose after a meal, with two different readings marked on the one curve: a level, where the value is right now, shown as a point at 5.9 mmol/L at that moment, and a change, which way the value is moving over time, shown by arrows rising on the way up after the meal and falling on the way down.

When a link in the loop breaks: type 1 diabetes (elaborations VC2S10U02.E05, VC2S10U02.E06). A feedback loop only works while every part of it works. In **type 1 diabetes**, the pancreas stops producing enough insulin. Follow the chain: blood glucose rises after a meal (the stimulus), and the receptors still detect it — but the message that should follow, insulin, is missing. The liver and muscles get no instruction to take glucose out of the blood, so blood glucose stays high meal after meal, while the cells go short of the fuel they need. The person feels tired and thirsty and loses weight. Over years, persistently high blood glucose damages small blood vessels; in the eyes this can lead to vision loss and even blindness, and the kidneys and nerves can be damaged too.

Type 1 diabetes — the insulin link of the loop breaks



Understanding the loop is exactly what made the treatment possible.

Flow diagram of the broken loop in type 1 diabetes: after a meal, blood glucose rises and the pancreas still detects it, but the insulin message is missing, so the liver and muscles get no instruction to take glucose out of the blood and the level stays high meal after meal while cells go short of fuel; over years, the high level damages small blood vessels in the eyes, kidneys and nerves. A box notes that treatment replaces the missing message with injected insulin.

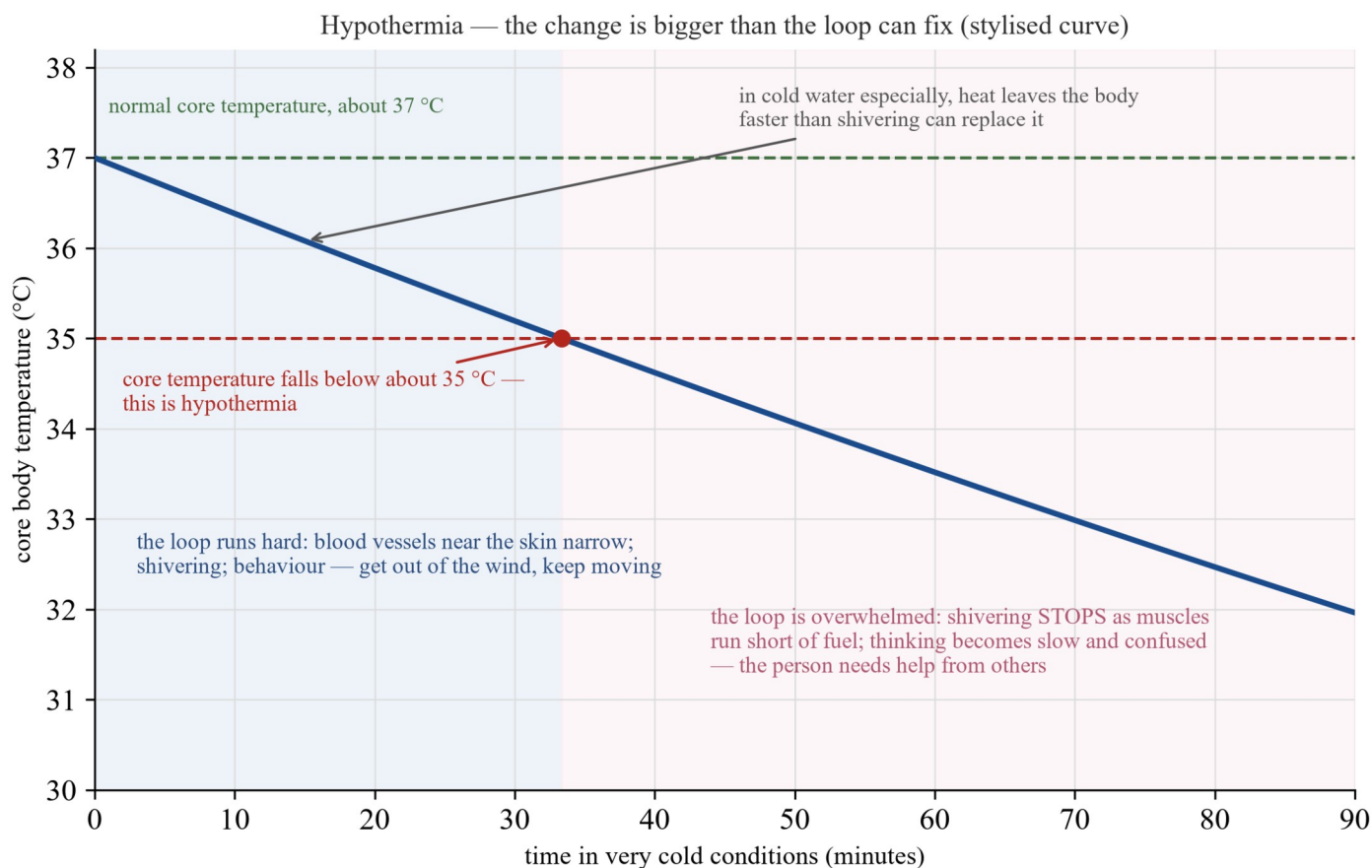
Understanding the feedback loop is exactly what made a treatment possible: the missing message can be replaced. Insulin was first used to treat a person with diabetes in 1922, after Frederick Banting, Charles Best, James Collip and John Macleod isolated it at the University of Toronto, and people with type 1 diabetes today inject insulin to replace what their pancreas no longer makes. Two points about that treatment follow straight from the biology:

- **It must be injected, not swallowed.** Insulin is a protein, and a swallowed protein is digested in the gut and broken down before it can reach the blood — it would never arrive intact to carry its message.
- **The dose must be matched to food and activity.** A person with type 1 diabetes monitors their blood glucose (with a finger-prick test or a wearable sensor) and adjusts the insulin to what they have eaten and how much they are moving, doing by hand what the pancreas normally does by negative feedback.

(In the much more common type 2 diabetes, the pancreas still makes insulin but the body's cells do not respond to it well. It is managed with food choices, exercise and medicines, and sometimes insulin too.)

When the loop is overwhelmed: hypothermia (elaboration VC2S10U02 .E06). A feedback loop can only correct a change while its effectors can keep up with it. If the change is too big or too fast, the loop is overwhelmed. That is what happens in **hypothermia**, the condition in which core body temperature falls below about 35 °C.

At first, the usual loop runs hard: blood vessels near the skin narrow, the person shivers, and behaviour kicks in — get out of the wind, put on dry layers, keep moving. But in very cold air, and especially in cold water, heat leaves the body faster than shivering can replace it. Water carries heat away from the body far faster than air does, so even water that feels only “chilly” can become dangerous within an hour. As hypothermia deepens, shivering stops — the muscles have run short of the fuel they need to keep contracting — and thinking becomes slow and confused. That last point is what makes hypothermia so dangerous: the very behaviour that would save the person (getting to shelter, changing out of wet clothes) becomes harder to organise just when it is needed most. Someone with deepening hypothermia needs help from others: get them dry, warm and sheltered, and seek urgent medical care.



Line graph of core body temperature falling over time when heat leaves the body faster than it is replaced, from 37 degrees Celsius toward the temperature of the surroundings. A shaded zone marks the point where the core temperature falls below about 35 degrees Celsius, which is hypothermia. Labels show the loop running hard at first, narrowing blood vessels, shivering and behaviour, and then being overwhelmed, as shivering stops and thinking becomes slow and confused.

Hypothermia teaches the same lesson as diabetes, from a different direction. In diabetes, one link of the loop breaks and the loop cannot correct the change. In hypothermia, the loop is working but the change is bigger than the loop can fix. Either way, the steady state is lost.

Other loops, and products built on feedback (elaboration VC2S10U02 . E05). Temperature and glucose are the two loops this subtopic works through in detail, but the body runs many more with the same three-part layout. The water content of body fluids is kept steady by a loop in which the brain detects how concentrated the blood is and sends a hormone message to the **kidneys**, which adjust how much water leaves the body in urine. The amount of iron carried in the blood, and the acidity of body fluids, are held steady by loops of the same shape.

Understanding feedback has also been put to work in products, not just treatments (elaboration VC2S10U02 . E05). Insulin for type 1 diabetes is the clearest example: a medicine that replaces the missing message of a broken loop. Another is **electrolyte solutions** — drinks that replace the water and mineral salts lost in sweat during long, hard exercise. Sweat takes salt as well as water out of the body, and for prolonged sweating the salts matter as much as the water. (For ordinary day-to-day activity and short exercise, plain water is all most people need.)

Putting the two systems back together. Look back over the two worked loops and the way each message travels. The temperature loop leans on the nervous system — fast impulses to muscles, glands and blood vessels, with behaviour joining in. The glucose loop leans on the endocrine system — hormones carried in the blood over minutes and hours. Most real situations use a mix of both, and that is the content description of this subtopic in one sentence: the nervous and endocrine systems working together, through negative feedback, to keep the body's internal environment steady.

Activities

Activity 1 — Build and break a feedback loop (elaboration VC2S10U02 .E04). In small groups, make a set of six cards labelled: *stimulus (a change) · receptor · control centre · effector · response · condition back toward the set point*. Shuffle the cards and arrange them into a loop that tells the story of (i) stepping outside on a cold morning, and then (ii) eating a meal rich in carbohydrate. For each arrangement, point to each card in turn and say the sentence it stands for out loud. Then **break the loop**: remove one card of your choice and predict, in one sentence, what would happen to the body's condition — this is the same move as Question 8 and Worked Example 3. Record which card you removed and what your group predicted, and compare predictions with another group's.

Activity 2 — Reading blood glucose data (elaboration VC2S10U02 .E05). The table below is **simulated data for practice** — not measurements of any real person. It shows blood glucose, in mmol/L, for two people before and after a meal eaten at time zero.

Time after the meal (min)	Person A (mmol/L)	Person B (mmol/L)
0	4.8	4.9
30	7.2	8.6
60	7.8	11.2
90	6.4	12.4
120	5.2	12.1
180	4.9	11.8

Plot both sets of data on one graph with time on the horizontal axis (graph choice and axis labels are skills from Subtopic 4A). Then: (i) describe the trend for each person, using the words *level* and *change* carefully; (ii) say which person's feedback loop is working, and which link of the loop you think is not working in the other; (iii) predict what Person B's curve would do if they injected insulin at 120 minutes, and sketch it on your graph.

Activity 3 — Modelling heat loss and insulation (links to elaboration VC2S10U02 .E06). This activity models why insulation — fat, fur, clothing — slows heat loss, the same physics the body's cold responses rely on. Fill two identical small containers with the same volume of warm water (warm from the tap is enough — not boiling; a teacher should supervise) and record each temperature. Wrap one container in a layer of fabric or bubble wrap to model an insulating layer, and leave the other bare. Record both temperatures every two minutes for twenty minutes. Identify the independent, dependent and controlled variables (skills from Subtopic 2A), tabulate your results (Subtopic 4A), and describe which container cooled faster and why. Then connect your result to the body: name the response of the cold body that works the same way as your fabric layer.

Worked examples

Example 1 — scaffolded

A student plays football on a 34 °C afternoon. Their body temperature begins to rise above 37 °C. (a) Identify the stimulus, the receptor, the control centre and one effector in the loop that follows. (b) Give two responses of the body and explain how each helps. (c) Explain why this loop is an example of negative feedback.

Working	Comment
Stimulus: body temperature rising above the set point of about 37 °C	The stimulus is the change the loop corrects.
Receptor: temperature receptors in the skin and inside the body	Receptors detect the change and report it.
Control centre: the hypothalamus in the brain	It compares the reported temperature with the set point and decides the response.
Effector (any one): sweat glands; blood vessels in the skin; the muscles	Effectors carry out the response.
Responses: sweating, and widening of blood vessels	Name the response, then say how it corrects the change.

Working	Comment
near the skin surface	
Sweat evaporating removes heat; wider skin blood vessels let more heat escape from the blood to the air	Each response must be linked to heat loss, not just named.
The response (heat loss) acts in the opposite direction to the change (rising temperature), bringing temperature back toward the set point	“Negative” means the response reverses the change — this sentence is the whole mark.

Example 2 — scaffolded

The table shows **simulated data for practice** — a person’s blood glucose, measured in mmol/L, before and after a meal.

Time	Blood glucose (mmol/L)
Before the meal	5.0
Just after the meal	7.5
Two hours after the meal	5.2

- Describe the change in blood glucose over the three hours, using *level* and *change* carefully.
- Name the organ that acts as the receptor and control centre of this loop, and the hormone it releases after the meal.
- Explain what happens to bring the glucose level back down.

Working	Comment
Blood glucose rises from 5.0 to 7.5 mmol/L after the meal, then falls to 5.2 mmol/L two hours later — back near its starting level	Describe the change (rising, then falling) and the levels (from and to which values).
Organ: the pancreas; hormone: insulin	The pancreas detects the level and releases the hormone.
Insulin tells liver and muscle cells to take glucose out of the blood; the liver stores the extra glucose as glycogen	Name what the hormone instructs, and where the glucose goes.
As glucose leaves the blood, the level falls back toward the set point — the response reverses the rise, so the loop is negative feedback	Close by tying the fall back to the rise.

Example 3 — unscaffolded

A person has type 1 diabetes, in which the pancreas produces little or no insulin. Predict what happens to their blood glucose after a meal, explain the prediction in terms of the feedback loop, and explain why their insulin treatment is given by injection rather than as a tablet to swallow.

After the meal, blood glucose **rises and stays high** for much longer than usual. The stimulus is detected as normal — receptors report the rising level — but the message that should follow is missing: the pancreas releases little or no **insulin**, so the liver and muscles receive no instruction to take glucose out of the blood, and the level does not fall back toward the set point. In loop terms, the link between the control centre and the effectors is broken. The treatment replaces the missing message: injected insulin tells the liver and muscles to take up glucose, so the level comes back down. It must be **injected, not swallowed**, because insulin is a **protein**: swallowed, it would be digested in the gut and broken down before it could reach the blood to carry its message.

Example 4 — unscaffolded

A person falls into cold water while walking near the coast in winter. Explain the body’s first responses, why those responses eventually fail to keep body temperature steady, and why the person’s companions must act even if the person says they feel fine.

At first the temperature loop runs hard: blood vessels near the skin **narrow** to reduce heat loss, the muscles **shiver** to release heat, and the person tries to get out of the water. These responses fail because **water carries heat away from the body far faster than air**, so heat leaves faster than shivering can replace it and core temperature keeps falling. As

it falls below about 35 °C, shivering stops — the muscles run short of the fuel they need — and thinking becomes slow and confused. The companions must act because a person with deepening hypothermia can no longer judge their own state or organise their own rescue; feeling “fine” is itself a sign the condition is worsening. The person needs to be got dry, warm and sheltered, and needs urgent medical care.

Practice questions

Scaffolded questions

Question 1 The vocabulary of homeostasis. Define each of the following: (a) homeostasis; (b) stimulus; (c) receptor; (d) control centre; (e) effector; (f) negative feedback.

Question 2 A home heating system keeps a room’s temperature within a degree or two of the setting on the thermostat. (a) Match each part of the heating system — thermometer, thermostat setting and switch, heater — to the matching part of a body feedback loop. (b) State one way the body’s temperature loop is more than this simple heating system.

Question 3 Body temperature is held close to 37 °C. Copy and complete the table: for each condition, give one response of the body and explain how the response corrects the change. (a) Body temperature rising above 37 °C. (b) Body temperature falling below 37 °C.

Question 4 Blood glucose is held within a narrow band. (a) State where the glucose in the blood comes from. (b) Name the gland that detects the blood glucose level and releases hormones. (c) Name the hormone released when blood glucose rises, and state what it instructs the liver to do. (d) State the form in which the liver stores extra glucose.

Question 5 Water balance. The water content of the body is kept steady by a loop involving the brain and the kidneys. (a) State what the brain detects in this loop. (b) State what the kidneys adjust. (c) State the type of message that carries the instruction from the brain to the kidneys.

Question 6 Words matter. Consider the two sentences: (i) “Her blood glucose is high.” (ii) “Her blood glucose is rising.” (a) State which sentence describes a level and which describes a change. (b) Explain why it matters which one you use when describing a feedback graph.

Unscaffolded questions

Question 7 Explain why the body’s temperature and glucose loops are called *negative* feedback loops, and state clearly what the word *negative* does not mean here.

Question 8 A rare condition stops a person’s sweat glands from working. Predict what would happen to this person’s body temperature during hard exercise on a hot day, and explain your prediction using the parts of the feedback loop.

Question 9 Person B in Activity 2 has untreated type 1 diabetes. Use the loop to explain why their blood glucose keeps rising after a meal instead of returning to the band, and predict how the curve would change after an insulin injection.

Question 10 Cold water. (a) Explain why falling into cold water is more dangerous than standing in air of the same temperature. (b) Explain why shivering eventually stops in deepening hypothermia. (c) Explain why companions must act even if the person insists they are fine.

Question 11 You are asked to find out whether a fabric layer slows the cooling of warm water, as a model of body insulation. (a) Write an investigable question for this task. (b) Identify the independent variable, the dependent variable, and two variables that must be kept the same. (c) State what you would measure, and how often.

Question 12 Describe the two curves in Activity 2’s table. For each person, describe the trend over the three hours using *level* and *change* carefully, identify which person’s loop is working, and name the part of the loop you think is failing in the other.

Question 13 Electrolyte solutions replace water and mineral salts lost in sweat. (a) State what sweat contains besides water. (b) Explain why replacing only water is not enough after long, hard exercise. (c) Connect your answer to the idea of homeostasis.

Question 14 Sort these responses into two lists — *automatic responses of the body* and *voluntary behaviour*: shivering; moving into shade; sweating; putting on a jumper; blood vessels near the skin narrowing; drinking cool water. Then explain why behaviour alone is not enough to keep body temperature steady.

Question 15 The chemistry of cells works best within narrow limits. Explain why homeostasis matters to the cells of the body, and predict what would happen to a person's cells if their core temperature rose several degrees above 37 °C for a long time.

Question 16 A company claims it has developed a new medicine for type 1 diabetes: a protein that acts like insulin, taken as a tablet to be swallowed. Use your understanding of digestion and of how insulin works to evaluate this claim. State what would have to be true for the claim to work, and why you would be cautious about it.

Answers

Question 1 (a) the keeping of the body's internal conditions within narrow limits; (b) a change that a receptor detects; (c) the part that detects a change; (d) the part that compares the detected level with the set point and decides the response; (e) a muscle or gland that carries out the response; (f) a loop in which the response reverses the change that started it. **Question 2** (a) thermometer = receptor; thermostat setting and switch = control centre; heater = effector; (b) see solution. **Question 3** (a) sweating — evaporation removes heat; (b) shivering — contractions release heat. See solution for fuller answers. **Question 4** (a) digested carbohydrate food; (b) the pancreas; (c) insulin — it tells the liver (and muscles) to take glucose out of the blood; (d) glycogen. **Question 5** (a) how concentrated the blood is (its water content); (b) how much water leaves the body in urine; (c) a hormone (chemical message in the blood). **Question 6** (a) (i) a level, (ii) a change; (b) see solution. **Question 7** see solution — the response reverses the change; “negative” does not mean bad. **Question 8** see solution — temperature rises because one effector link is missing. **Question 9** see solution — the insulin message is missing; the curve would fall back toward the band after an injection. **Question 10** see solution. **Question 11** (a)–(c) see solution. **Question 12** see solution. **Question 13** (a) mineral salts; (b)–(c) see solution. **Question 14** automatic: shivering, sweating, blood vessels narrowing; voluntary: moving into shade, putting on a jumper, drinking cool water; explanation — see solution. **Question 15** see solution. **Question 16** see solution.

Fully-worked solutions

Question 1 (a) **Homeostasis** is the body's keeping of its internal conditions — such as temperature, water content and blood sugar — within narrow limits around a target value, even while conditions outside the body change. (b) A **stimulus** is a change in a condition that a receptor detects. (c) A **receptor** is the part of a feedback loop that detects a change and reports it to the control centre. (d) The **control centre** is the part that receives the report, compares it with the set point and decides what response is needed. (e) An **effector** is a muscle or gland that carries out the response the control centre orders. (f) **Negative feedback** is a control loop in which the response acts in the opposite direction to the change that started it, reversing the change and returning the condition toward the set point.

Question 2 (a) The **thermometer** matches the **receptor** (it detects the temperature). The **thermostat's setting and switch** match the **control centre** (they compare the reading with the target and decide). The **heater** matches the **effector** (it acts to warm the room). (b) Any one clear point. For example: the body loop works in **both directions** — it can warm the body *and* cool it, while the simple heater only warms. Or: the body has **many receptors and many effectors** working at once, and adds **voluntary behaviour** (seeking shade, putting on clothing) on top of the automatic responses.

Question 3 (a) Rising above 37 °C: **sweat glands release sweat**, and as it evaporates it removes heat from the skin, cooling the blood; **blood vessels near the skin widen**, so more warm blood flows near the surface and more heat escapes to the air. Either response earns the mark if the correction is explained. (b) Falling below 37 °C: **muscles shiver**, and the quick contractions release heat that warms the blood; **blood vessels near the skin narrow**, so less warm blood flows near the surface and less heat escapes. Again, the correction must be explained, not just named.

Question 4 (a) Glucose enters the blood when **carbohydrate food is digested**. (b) The **pancreas**. (c) **Insulin**. It tells the liver and muscles to **take glucose out of the blood**; the liver stores the extra as glycogen. (d) **Glycogen**.

Question 5 (a) The brain detects **how concentrated the blood is** — that is, its water content. (b) The kidneys adjust **how much water leaves the body in urine**. (c) A **hormone** — a chemical message carried in the blood (the endocrine route).

Question 6 (a) (i) describes a **level** — where the value is right now. (ii) describes a **change** — the direction the value is moving over time. (b) A value can be high while falling, or normal while rising, so the two sentences can be true of different moments — or both true at once. The loop responds to the level, and an explanation or graph description is judged on precise words, so saying which you mean keeps your answer correct.

Question 7 The loops are called **negative** feedback loops because the response acts in the **opposite direction to the change** that started it: a rise is met with responses that bring the condition down, and a fall with responses that bring it up. The response therefore reverses the change and returns the condition toward the set point. The word *negative* does **not** mean “bad” or “harmful” — it refers to this reversing action, which is exactly what keeps the body's conditions steady.

Question 8 Their body temperature would **rise and could become dangerous**. The loop still detects the change — temperature receptors report the rising temperature and the brain's control centre still orders cooling — but one of the main effectors, the **sweat glands**, cannot respond, so the body loses much less heat by evaporation than it needs to during hard exercise on a hot day. With the effector link broken, heat produced by the working muscles builds up faster than the remaining responses can remove it, and the temperature climbs instead of staying near the set point.

Question 9 After the meal, Person B's blood glucose **rises** as the food is digested, and receptors detect the rise as normal. But their pancreas produces little or no **insulin**, so the message that should follow is missing: the liver and muscles get no instruction to take glucose out of the blood, and glucose is not stored as glycogen. The level therefore **keeps rising and stays high** instead of returning to the band — the link between the control centre and the effectors is broken. After an **insulin injection**, the missing message is replaced: the liver and muscles take glucose out of the blood, and the curve would **fall back toward the normal band**.

Question 10 (a) **Water carries heat away from the body far faster than air**, so in water of a given temperature the body loses heat much faster than it would in air at that same temperature, and the loop cannot keep up. (b) Shivering needs the muscles to keep contracting, and that needs fuel. In deepening hypothermia the muscles **run short of the fuel they need**, and the body also conserves what it has, so shivering stops — a sign the condition is getting worse, not better. (c) As hypothermia deepens, **thinking becomes slow and confused**, so the person can no longer judge their own state or organise their own rescue; feeling fine is itself a sign of worsening. The companions must get the person dry, warm and sheltered and seek urgent medical care.

Question 11 (a) For example: *Does wrapping a container in a fabric layer slow the cooling of warm water?* The question names the variable being changed and the effect being measured. (b) Independent variable: **whether the container is wrapped or bare**. Dependent variable: **the temperature of the water (and how fast it falls)**. Variables kept the same (any two): volume of water, starting temperature, size and type of container, room conditions, and how often temperature is read. (c) Measure the **temperature of each container every two minutes** for a set time (say twenty minutes), and record both in a table.

Question 12 **Person A:** the level **rises** from 4.8 to a peak of 7.8 mmol/L in the first hour (change), then **falls** over the next two hours back to 4.9 mmol/L — near where it started. This is a working loop: the rise is reversed and the level returns to the band. **Person B:** the level **rises** from 4.9 mmol/L and **keeps rising** to 12.4 mmol/L at 90 minutes, then stays high (it has only fallen slightly to 11.8 by 180 minutes). The loop is not correcting the change. The failing part is the **message from the control centre** — the pancreas releases little or no insulin, as in type 1 diabetes, so the effectors (liver and muscles) are never told to take glucose out of the blood.

Question 13 (a) Sweat contains **mineral salts** as well as water. (b) Long, hard exercise loses **both** water and salts in sweat. Replacing only the water leaves the body's fluids short of salts, so the balance the body is trying to keep is still disturbed. (c) Homeostasis is the keeping of internal conditions — including water and salt — within narrow limits. An electrolyte solution replaces the two things sweat removes, so it helps restore the balance the loop is working to hold.

Question 14 **Automatic responses of the body:** shivering; sweating; blood vessels near the skin narrowing. **Voluntary behaviour:** moving into shade; putting on a jumper; drinking cool water. Behaviour alone is not enough because it needs a person to be **aware and awake** — during sleep, or when a change happens too fast to notice, only the automatic responses are working. The automatic loop is also always on, adjusting moment by moment, while behaviour happens only from time to time.

Question 15 Homeostasis matters because the chemistry of cells — the reactions that release energy and keep cells alive — works only within **narrow limits** of temperature, water and fuel. If core temperature rose several degrees above 37 °C for a long time, those reactions would be disrupted: cells could not release energy properly, and key cell parts would be damaged, which is why a very high body temperature is a medical emergency.

Question 16 You should be **cautious**. Insulin and medicines that act like it are **proteins**, and a swallowed protein is **digested in the gut and broken down** before it can reach the blood — so a tablet “that acts like insulin” would normally be destroyed before it could carry its message, which is exactly why real insulin is injected. For the claim to be true, the tablet would have to protect the protein through digestion and get it into the blood intact — a genuine scientific challenge, not an ordinary one. The claim is not impossible in principle, but it contradicts the well-

understood reason insulin is given by injection, so it would need strong published evidence before it could be believed.

Where this leads: the receptor–control centre–effector loop taught here is the model VCE Biology Unit 1, Area of Study 2 (“How do plant and animal systems function?”) formalises for temperature, glucose and water balance, reference-only for this book. VCE adds the name of the second hormone of the glucose loop, the hormones of water balance, and more detail of how the control centres work; those extensions are VCE-only and are not taught here (TOC D9). VCE Psychology also builds on the nervous-system picture of this chapter. Subtopic 8A delivers the other limb of VC2S10U02 — how the nervous and endocrine systems coordinate responses to stimuli — and Subtopics 8C and 8D take up disease and how its spread is controlled.

Infectious and non-infectious disease: pathogens, agents and causes

Chapter 8 — Biological sciences B: coordination, homeostasis and disease (Science, Levels 9 and 10)

Subtopic 8C · VC2 Science Understanding — Biological sciences

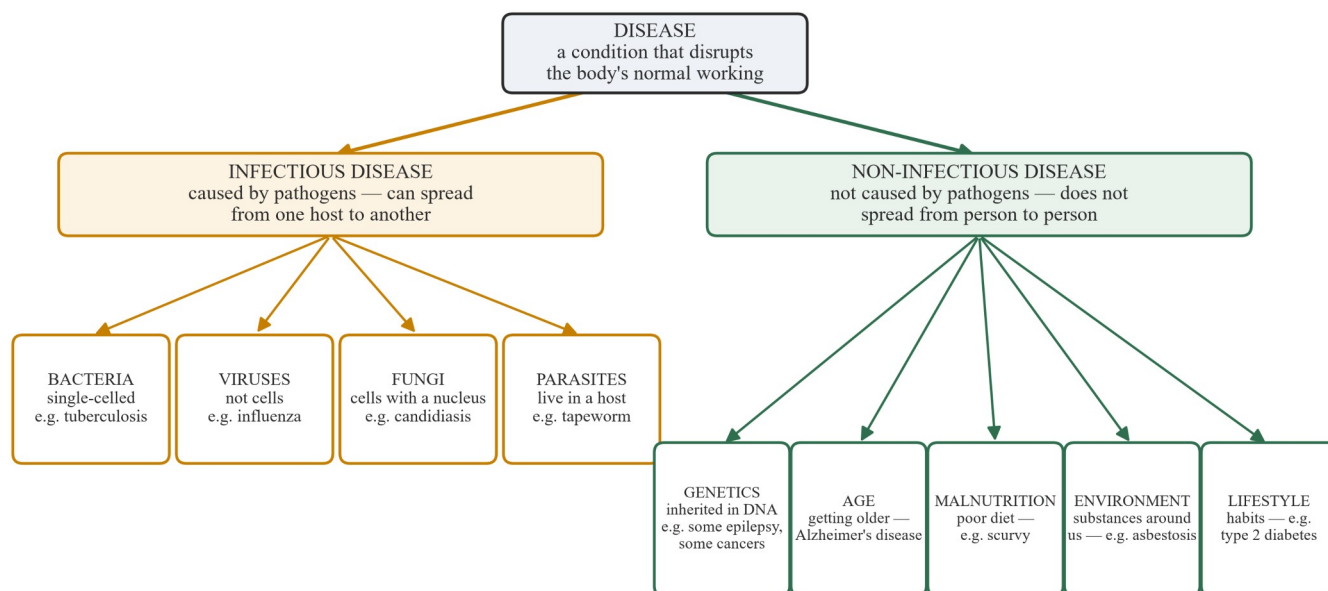
CD code: VC2S10U03 (split delivery †; this subtopic is the accountable owner) **Content description (verbatim):** “infectious and non-infectious diseases are caused by different organisms and agents; measures to control the transmission of infectious diseases include personal hygiene, quarantine protocols, medical treatment and public education programs” **This subtopic’s limb (TOC §4 clause split):** causes — infectious and non-infectious diseases are caused by different organisms and agents. The partner 8D delivers the other limb: measures to control the transmission of infectious diseases. **Elaboration ids drawn on:** VC2S10U03.E01 · VC2S10U03.E03 · VC2S10U03.E05 · VC2S10U03.E07 (ids VC2S10U03.E02 and VC2S10U03.E04 are drawn on by Subtopic 8D; id VC2S10U03.E06 is reserved under the TOC’s D10 decision and is not taught in this book) **Achievement standard (extract served):** “They distinguish between infectious and non-infectious disease” (the comparison clause of the standard’s sentence is served by Subtopic 8D).

Theory

Two families of disease. Your body is a working system — Subtopic 8B showed how it keeps its internal conditions steady, and Subtopic 8A showed how its parts are coordinated. A **disease** is a condition that disrupts the normal working of the body. The Victorian Curriculum uses the term without a single fixed wording, so this subtopic works to that definition, and every question here can be answered from it. The most useful first question to ask about any disease is not “how bad is it?” but “**what causes it?**” — because the cause decides whether the disease can spread from one person to another, and that in turn decides how it is treated and controlled.

Every disease sits in one of two families, split by its cause:

- an **infectious disease** is caused by a **pathogen** — an organism or agent that causes disease — and because pathogens can move from one host to another, infectious diseases can **spread**;
- a **non-infectious disease** is not caused by a pathogen; its cause lies in the person’s genes, age, diet, surroundings or habits, and it **cannot spread** from person to person.



Many real diseases have more than one contributing factor — the split is about the cause.

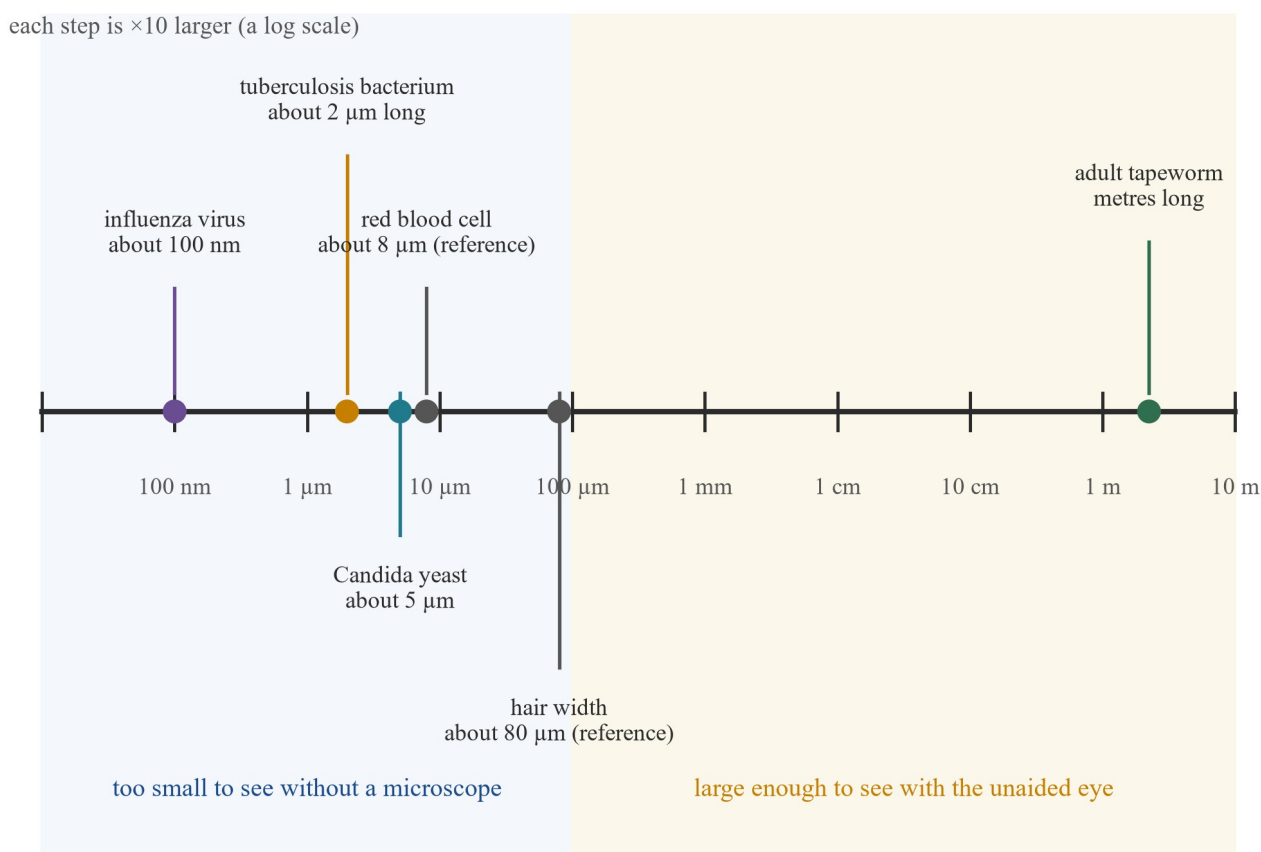
Classification tree: disease splits into infectious disease, caused by the four pathogen types (bacteria, viruses, fungi, parasites), and non-infectious disease, caused by genetics, age, malnutrition, environment and lifestyle, with an example disease under each branch

Pathogens — the four types (elaboration VC2S10U03 .E01). A **pathogen** is an organism, or agent, that causes disease. The **host** is the living thing a pathogen lives in or on. Elaboration VC2S10U03 .E01 names the four types of pathogen, each with a different kind of body and a different example disease:

Type of pathogen	What it is	Example disease it causes
Bacterium (plural: bacteria)	a single-celled organism whose cell has no nucleus	tuberculosis (TB), a disease of the lungs
Virus	not a cell — genetic material in a protein coat; can only multiply inside a living cell	influenza (the flu), a disease of the airways
Fungus (plural: fungi)	a cell with a nucleus ; some fungi are single-celled yeasts	candidiasis, a yeast infection caused by <i>Candida</i>
Parasite	an organism that lives on or in a host and takes what it needs from it	a tapeworm infection of the gut

Most bacteria and fungi do **not** cause disease — many are harmless, and some are useful to you. Only a small share of all microbes are pathogens. What matters for this subtopic is that the four types are genuinely different kinds of thing, as their sizes and structures show.

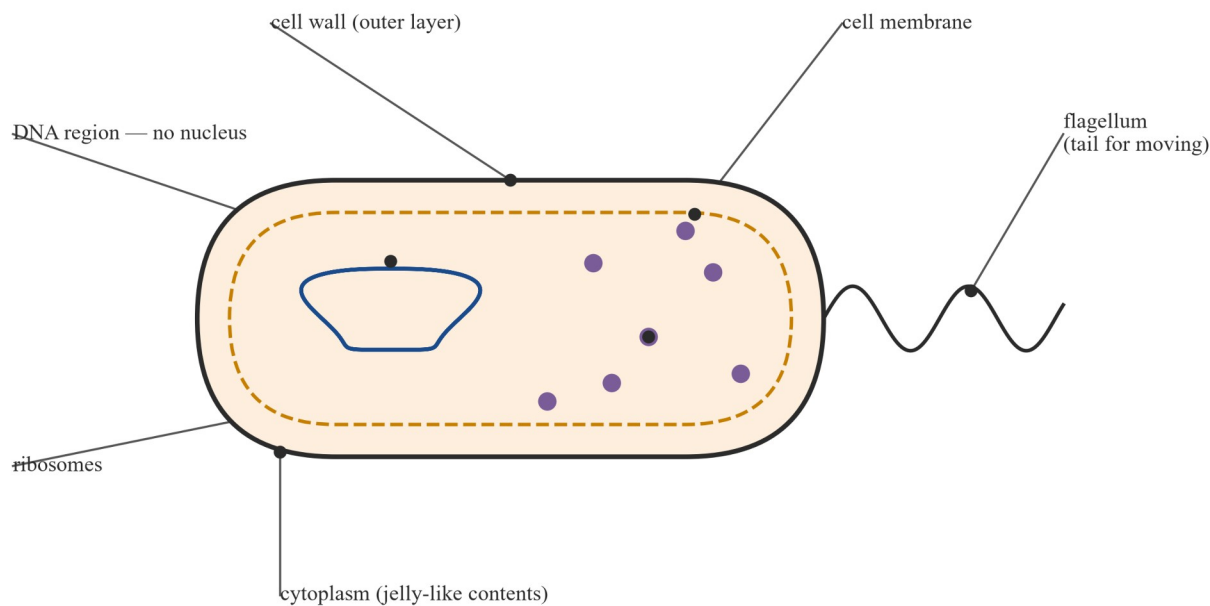
How small is small? A note on units. Pathogens are measured in micrometres and nanometres. One **micrometre (µm)** is a thousandth of a millimetre; one **nanometre (nm)** is a thousandth of a micrometre. A human hair is about 80 µm wide, near the smallest thing the eye can see on its own, and a red blood cell is about 8 µm across — both are shown on the scale below only for reference.



Size scale from 100 nm to 10 m on a log axis: influenza virus about 100 nm, tuberculosis bacterium about 2 µm, Candida yeast about 5 µm, red blood cell about 8 µm and hair width about 80 µm as references, adult tapeworm metres long; the left zone is too small to see without a microscope

Each step along that scale is ×10 larger. The influenza virus, the TB bacterium and the *Candida* yeast all sit in the zone that is **too small to see without a microscope**; the adult tapeworm is the odd one out — a parasite you can see very easily, because it grows to metres long inside the gut.

Meet the four pathogens. The four structure diagrams below show what each type of pathogen looks like, drawn much larger than life and labelled.

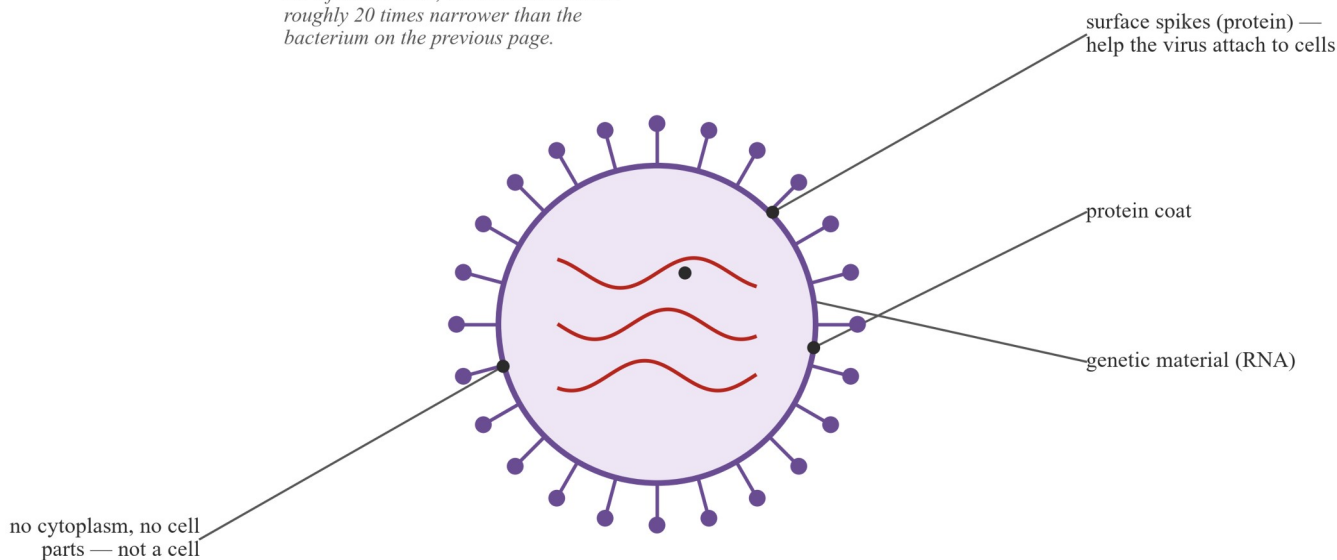


A typical rod-shaped bacterium, about 1–5 μm long. Many bacteria have no flagellum.

A rod-shaped bacterium with cell wall, cell membrane, cytoplasm, ribosomes, a DNA region with no nucleus, and a flagellum tail for moving

A **bacterium** is a complete single cell, about 1–5 μm long. It has a cell wall, cytoplasm, ribosomes and a DNA region — but **no nucleus** holding the DNA. Many bacteria move using a tail called a flagellum. A bacterium is a living organism in its own right: it can grow and multiply on its own wherever conditions suit it.

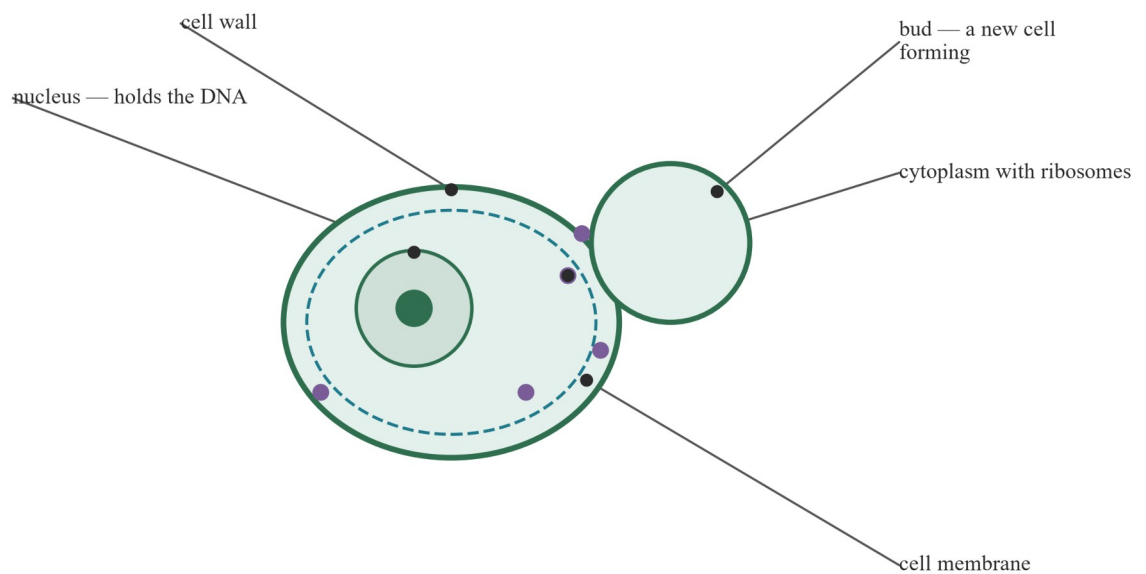
An influenza virus, about 100 nm across — roughly 20 times narrower than the bacterium on the previous page.



A virus is genetic material in a protein coat. It can only multiply inside a living cell.

An influenza virus about 100 nm across: genetic material (RNA) inside a protein coat with surface spikes, and no cell parts

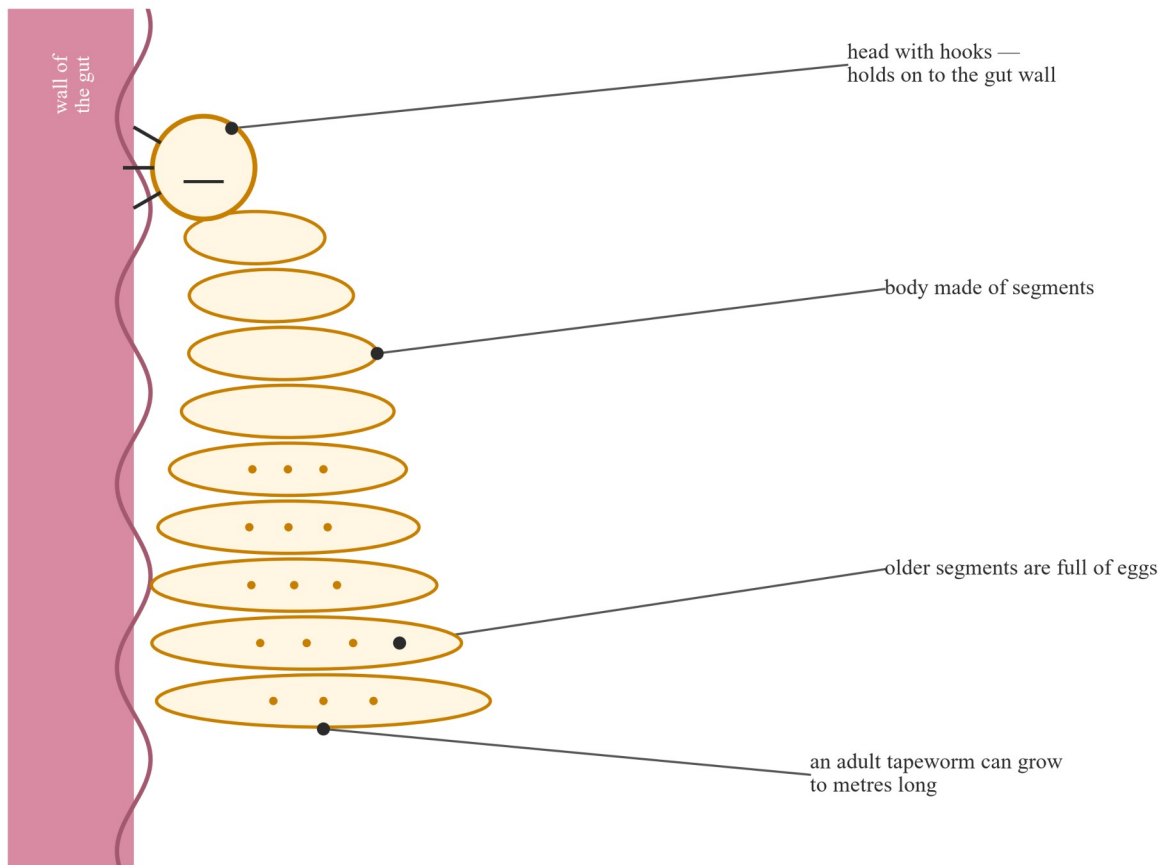
A **virus** is about 100 nm across — roughly 20 times narrower than the TB bacterium. It is **not a cell**: no cytoplasm, no cell parts, nothing that can grow or release energy on its own. It is genetic material wrapped in a protein coat, with spikes that help it attach to a cell. A virus can only multiply **inside a living cell**, by taking over the cell's own machinery. That is why a virus is described as an agent rather than a fully living organism.



A single-celled fungus (a yeast, like Candida), about 5 μm across. Fungal cells have a nucleus; bacterial cells do not.

A single-celled yeast such as Candida, about 5 μm across, with a cell wall, a nucleus, cytoplasm with ribosomes, and a bud forming as a new cell

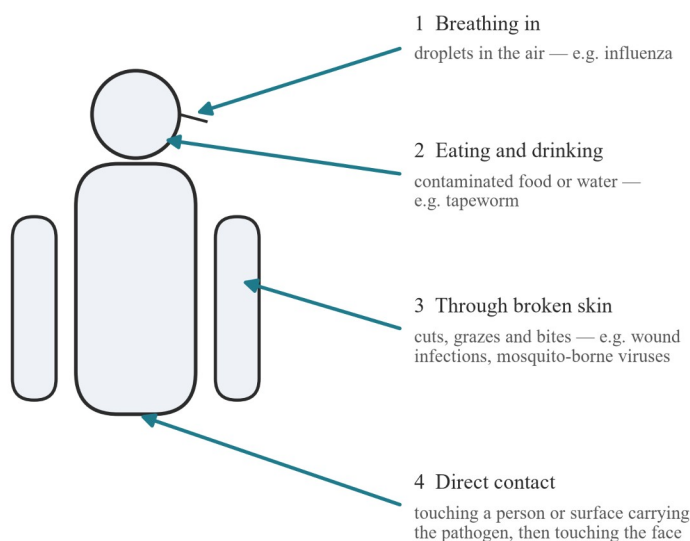
A **fungus** such as the yeast *Candida* is a single cell about 5 μm across. Like your own cells, it has a **nucleus** holding its DNA — the feature bacteria lack. Yeasts reproduce by **budding**: a small new cell forms on the side of the parent and pinches off. *Candida* lives harmlessly on many people's skin and in their mouths; it causes candidiasis when it multiplies more than it should, for example after the microbes that normally keep it in check are removed.



A tapeworm in the gut: a head with hooks anchored to the gut wall, and a body made of a chain of segments, older segments full of eggs

A **parasite** such as a tapeworm is a many-celled organism, far larger than any microbe — an adult grows to metres long. Its head carries hooks that anchor it to the wall of the host's gut, and its body is a chain of segments; the older segments become full of eggs. It takes in food the host has already digested, so the host loses nutrition to it.

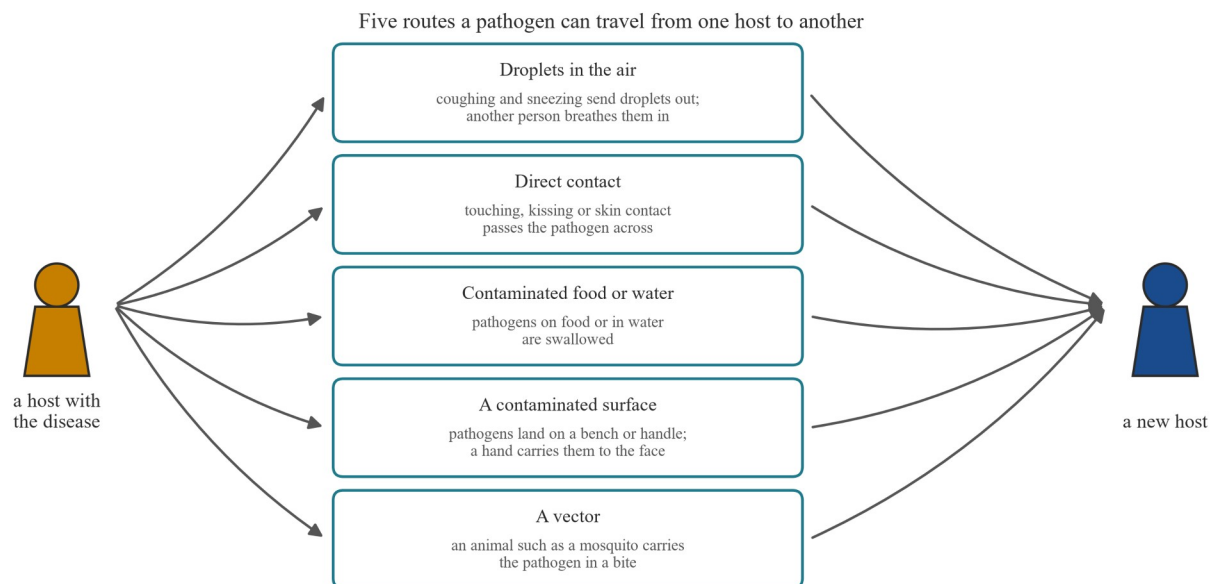
How pathogens enter and move. For an infectious disease to spread, a pathogen must get from one host into another. The ways in are few and predictable:



Four common ways pathogens enter the body

A person with four labelled arrows showing routes of entry: breathing in droplets, eating and drinking contaminated food or water, entry through broken skin such as cuts and bites, and direct contact with a person or surface carrying the pathogen

Once in, the pathogen multiplies, and the host can pass it on. The routes out and across mirror the routes in:

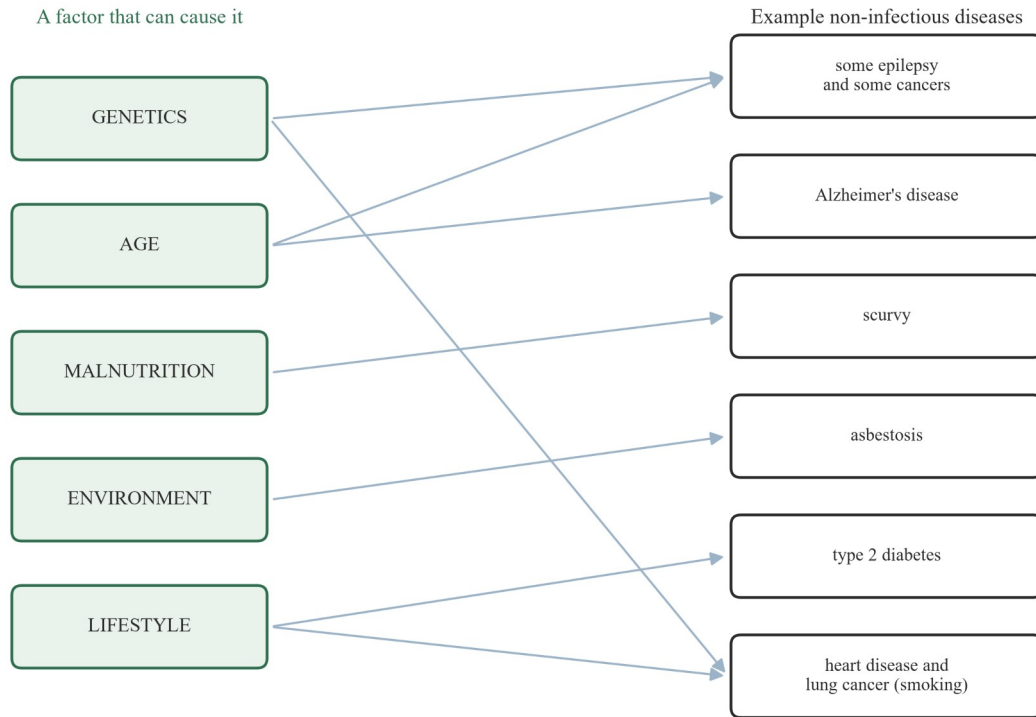


Five transmission routes from a host with the disease to a new host: droplets in the air, direct contact, contaminated food or water, a contaminated surface, and a vector such as a mosquito

A **vector** is an animal that carries a pathogen from one host to another, as a mosquito carries certain viruses in its bite. Notice the single idea behind all five routes: **a pathogen physically moves from one host to the next**. That movement is exactly what a non-infectious disease can never do. (The measures that block these routes — personal hygiene, quarantine, medical treatment and public education — are the other limb of this content description, taught in Subtopic 8D.) Knowing the **type** of pathogen also matters, because a medicine that kills a bacterium does nothing to a virus: the cause decides the treatment.

Non-infectious disease: five factors (elaboration VC2S10U03.E05). A non-infectious disease has no pathogen in its cause. Elaboration VC2S10U03.E05 names five factors that can cause or contribute to non-infectious diseases, each with example diseases:

- **Genetics** — some diseases run in families because they are inherited in DNA, for example some forms of epilepsy and some cancers.
- **Age** — the risk of some diseases rises as the body gets older; Alzheimer’s disease, a form of dementia, is far more common in older age.
- **Malnutrition** — disease caused by a diet that is missing what the body needs, or badly out of balance; **scurvy**, caused by a diet lacking vitamin C, is the classic example.
- **Environment** — substances in the surroundings, for example asbestos fibres in the air of some old workplaces; breathing them for years causes **asbestosis**, a scarring of the lungs.
- **Lifestyle** — day-to-day habits, for example a diet high in sugar with little exercise raising the risk of type 2 diabetes (the disease met in Subtopic 8B), and smoking raising the risk of heart disease and lung cancer.

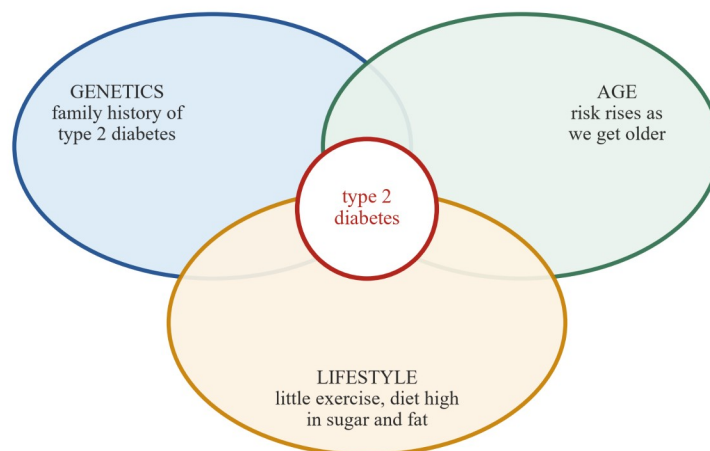


Link map from the five causal factors to example non-infectious diseases: genetics to some epilepsy and some cancers and to heart disease; age to Alzheimer's disease and some epilepsy; malnutrition to scurvy; environment to asbestosis; lifestyle to type 2 diabetes and to heart disease and lung cancer from smoking

You cannot catch any of these diseases. Sitting next to a person with scurvy changes nothing about your diet; working beside a person with asbestosis does not put asbestos fibres in your lungs. That is the practical meaning of *non-infectious*.

Risk factors: raising the chance, not guaranteeing. Most non-infectious diseases have **more than one** contributing factor, and a factor raises the *chance* of the disease rather than guaranteeing it. A factor that raises the chance of a disease is called a **risk factor**.

Three factors overlapping on one disease — none of them alone guarantees it

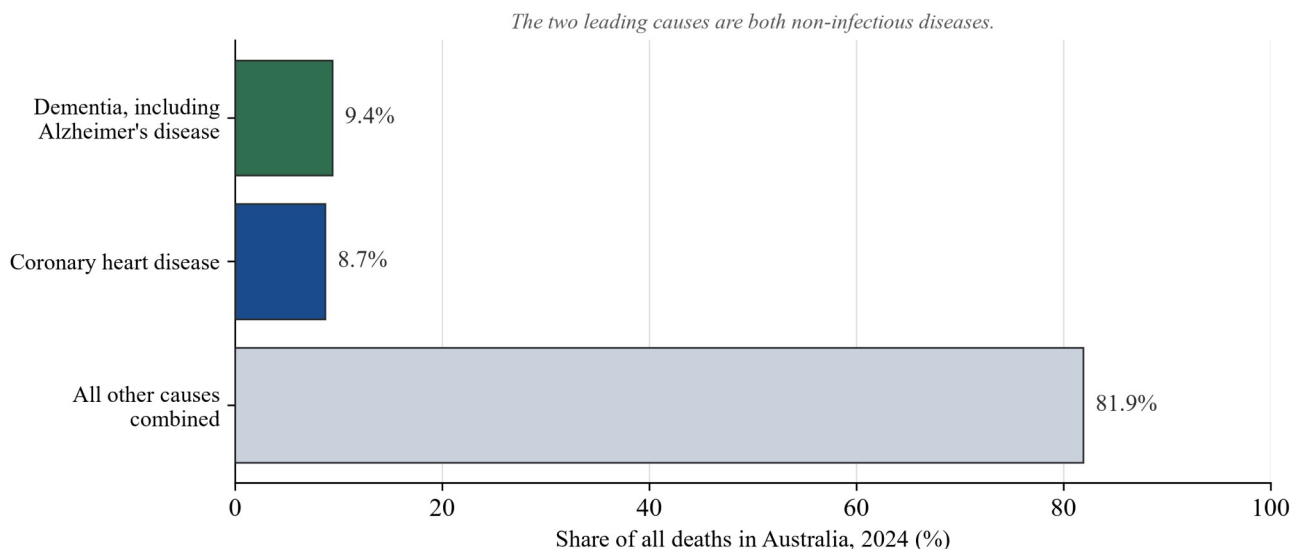


A person can carry one factor and stay well; another person with several factors is at higher risk — that is what 'risk factor' means.

Three overlapping circles labelled genetics (family history of type 2 diabetes), age (risk rises as we get older) and lifestyle (little exercise, diet high in sugar and fat), overlapping on a small circle labelled type 2 diabetes

A person can carry one of these factors and never develop type 2 diabetes; a person carrying several is at higher risk. That is what *risk* means in science — a raised chance, not a promise — and it is why two people with the same factor can end up with different outcomes.

The picture in Australia. The distinction is not just academic. The two leading single causes of death in Australia are both non-infectious diseases:



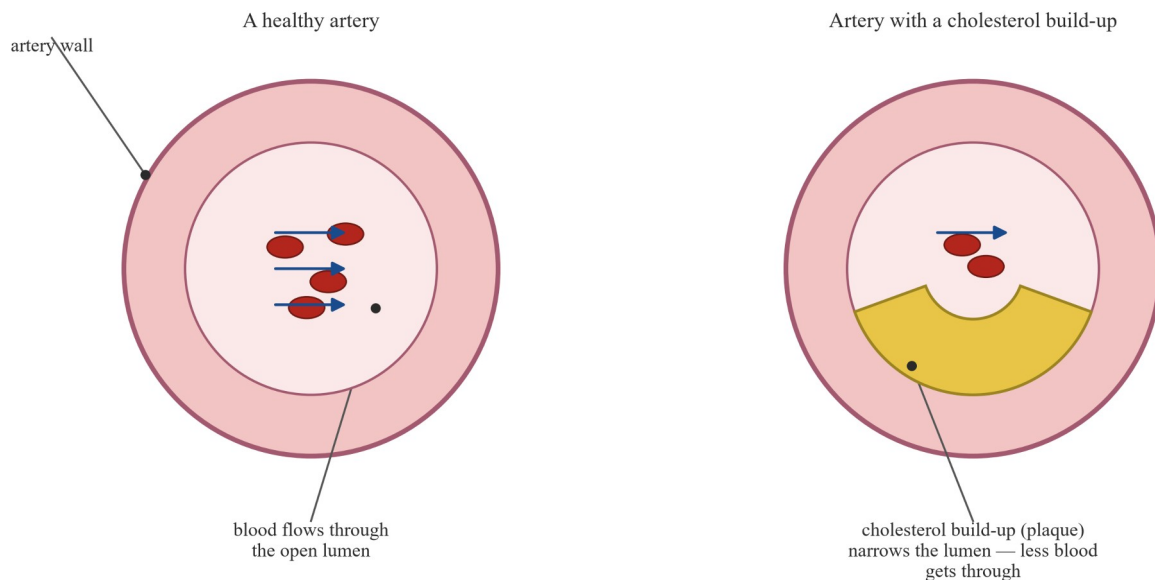
Total: 187 268 deaths registered. AIHW, Deaths in Australia (2026), 2024 data.

Bar chart of the share of all deaths in Australia in 2024: dementia including Alzheimer's disease 9.4%, coronary heart disease 8.7%, all other causes combined 81.9%

Australian Institute of Health and Welfare, "Deaths in Australia", 2026. <https://www.aihw.gov.au/reports/life-expectancy-deaths/deaths-in-australia/contents/summary> — retrieved 2026-08-21.

Of the 187 268 deaths registered in Australia in 2024, dementia (including Alzheimer's disease) accounted for 9.4% and coronary heart disease for 8.7% — the two largest single causes, and both non-infectious. Infectious disease still matters, in bad influenza seasons and in the parts of the world where pathogens spread more easily; but in Australia today, the biggest killers are conditions no one can catch.

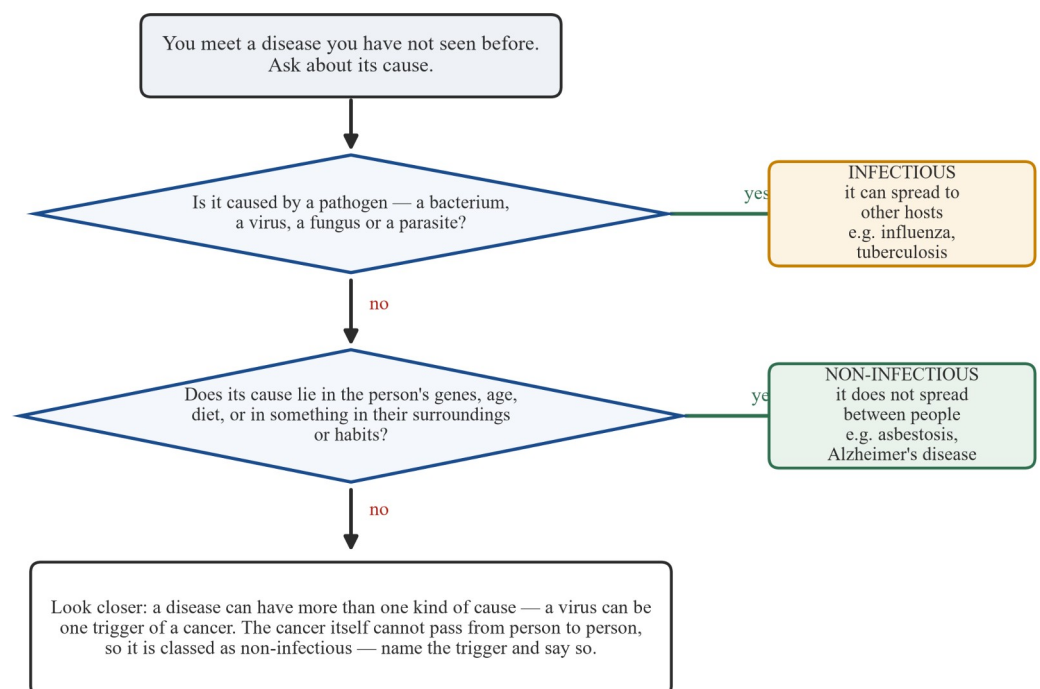
Model: how cholesterol narrows an artery (elaboration VC2S10U03.E03). Coronary heart disease — the second-largest cause above — is a good example of a non-infectious disease with several factors. Elaboration VC2S10U03.E03 suggests modelling how a build-up of **cholesterol**, a fatty substance, narrows an artery over time. Cholesterol is made by the body and also arrives in some foods; when too much of it settles in the artery wall it forms a build-up called a **plaque**.



Cross-sections of two arteries: a healthy artery with a wide open channel and blood flowing freely, and an artery with a cholesterol build-up (plaque) narrowing the channel so less blood gets through

The artery on the right carries less blood because its channel is narrower. The heart muscle itself is fed by these coronary arteries, so when they narrow, the heart muscle gets less oxygen than it needs — especially in exercise, when it needs more. Diet (a lifestyle factor), age and genetics all raise the chance of the build-up, which is why coronary heart disease sits where the factor circles overlap. **Activity 1** builds this model with everyday materials.

Deciding the split: a key you can use. Put the whole subtopic into a method. When you meet a disease you have not seen before, ask about its cause:



Decision key: if the disease is caused by a pathogen (a bacterium, virus, fungus or parasite) it is infectious and can spread to other hosts, for example influenza and tuberculosis; if its cause lies in genes, age, diet, surroundings or habits it is non-infectious and does not spread between people, for example asbestosis and Alzheimer's disease; a final box notes that a disease can have more than one kind of cause and a virus-triggered cancer is still classed non-infectious because the cancer cannot pass between people

One caution finishes the method. A disease can have **more than one kind of cause**: certain viruses are one trigger of certain cancers. The cancer itself still cannot pass from person to person, so it is classed as **non-infectious** — name the viral trigger and say so when you classify. Classifying by cause, and stating the cause you classified by, is the skill this subtopic builds.

Activities

Activity 1 — Modelling a narrowed artery (elaboration VC2S10U03.E03). In pairs, model why a cholesterol build-up reduces blood flow. You will need two identical straws, sticky tape, a jug of water, two identical cups, a sink or tray, and a watch with a second hand. Wrap tape around the middle of one straw from the outside so the hole through it is about half as wide as before — this models the plaque. Hold each straw over a cup and, with a partner pouring steadily from the same height, time how much water each straw passes in ten seconds (pour from the same jug, at the same speed, for the same time — these are your controlled variables; the width of the channel is the independent variable; the water passed is the dependent variable, skills from Subtopic 2A). Record both volumes, repeat once, and describe the difference. Then connect the model to the body: (i) what does the narrowed straw stand for, and what does the water passed stand for? (ii) During hard exercise the heart muscle needs **more** blood — predict, using your result, what a narrowed coronary artery does to a person who exercises hard. (iii) Name two factors that raise the chance of the build-up forming.

Activity 2 — Storyboard a social-media clip (elaboration VC2S10U03.E07). Plan a 45–60 second social-media clip that teaches a Year 7 audience the difference between infectious and non-infectious disease. On paper or slides, draw **six to eight panels**; for each panel give a simple sketch (stick figures are fine) and the caption or spoken line that goes with it. Your storyboard must include: the difference stated in one clear sentence; one infectious example naming its type of pathogen; one non-infectious example naming its factor; and one myth corrected (for example, “you can catch scurvy from someone who has it” — no, and your clip should say *why*). You are assessed on the storyboard, not on filming: clarity of the science and of the cause-first message is the mark. Swap storyboards with another pair and check each other’s science against the decision key in this subtopic.

Activity 3 — Sort the diseases with the key. Make a card for each of these ten diseases, with the cause clue written on it: influenza (a virus of the airways); tuberculosis (a bacterium of the lungs); candidiasis (a yeast multiplying on skin or in the mouth); a tapeworm infection (a many-celled organism in the gut); scurvy (a diet lacking vitamin C); asbestosis (breathing asbestos fibres); Alzheimer’s disease (risk rising with age); type 2 diabetes (diet, exercise and family history); some epilepsy (inherited in DNA); and a cancer with a viral trigger. Shuffle the cards and sort them, using the decision key, into *infectious* and *non-infectious*, saying the key’s question out loud for each card. The last card is the test of the caution in the Theory: write two sentences for it — one naming the trigger, one saying why the disease still sorts where it does. Check your sort against the answer to Question 14.

Worked examples

Example 1 — scaffolded

Four diseases are described by their cause. Copy and complete the table, classifying each disease and stating the kind of cause. (i) Tuberculosis — a bacterium destroys lung tissue over several months. (ii) Scurvy — a diet lacking vitamin C weakens the body’s tissues. (iii) Asbestosis — years of breathing asbestos fibres scar the lungs. (iv) Influenza — a virus enters through the airways and multiplies in the cells there.

Working	Comment
(i) Cause: a bacterium — a pathogen → infectious	A pathogen as the cause is the test for infectious disease.
(ii) Cause: a diet lacking a nutrient (malnutrition) → non-infectious	No pathogen is involved, so nothing can spread.
(iii) Cause: a substance in the surroundings (environment) → non-infectious	The fibres are not alive and are not a pathogen.
(iv) Cause: a virus — a pathogen → infectious	A virus counts as a pathogen even though it is not a cell.
Check: (i) and (iv) can pass from host to host; (ii) and	The spread test should always agree with the cause test.

(iii) cannot

Example 2 — scaffolded

The influenza virus is about 100 nm across. The tuberculosis bacterium is about 2 μm long. (a) Express the length of the TB bacterium in nanometres. (b) How many times longer is the TB bacterium than the influenza virus is wide? (c) Using the size scale in this subtopic, state whether either can be seen without a microscope, and name the reference object that sets the eye's limit.

Working

Comment

(a) $1\ \mu\text{m} = 1000\ \text{nm}$, so $2\ \mu\text{m} = 2 \times 1000 = 2000\ \text{nm}$

Convert to the same unit before comparing.

(b) $2000\ \text{nm} \div 100\ \text{nm} = 20$ — the bacterium is about 20 times longer

A ratio needs both lengths in the same unit.

(c) Neither can be seen without a microscope; both sit in the “too small” zone of the scale. A hair's width (about $80\ \mu\text{m} = 80\ 000\ \text{nm}$) is near the smallest thing the eye sees on its own

Read the zones, then use the reference objects shown for the eye's limit.

Example 3 — unscaffolded

A student says: “Type 2 diabetes runs in my family, and the flu runs in my family too — so both diseases must be infectious, because both spread through a household.” Explain the confusion in this argument, and classify each disease correctly by its cause.

The two diseases “run in families” for **different reasons**. Influenza clusters in a household because a **pathogen** — the influenza virus — physically passes from one person to the next in droplets and on hands; each sick person caught it *from* another person. That is what *spreading* means, and it makes influenza **infectious**. Type 2 diabetes clusters in families for two other reasons: relatives **share genes** that raise the risk, and households **share habits** — the kind of food eaten and the amount of exercise taken. Nothing alive passes between the people; a relative's diabetes cannot enter your body in a droplet or on a handle. Its causes are genetics and lifestyle, so type 2 diabetes is **non-infectious**. The argument's confusion is treating “appearing in several members of a family” as the same thing as “spreading”; the cause test separates them.

Example 4 — unscaffolded

Person X has a parent with type 2 diabetes, but exercises most days and eats a balanced diet. Person Y has no family history of the disease, takes little exercise, and eats a diet high in sugar and fat. Use the idea of overlapping risk factors to compare the two people's risk, and state what can and cannot be concluded about each of them.

Person X carries **one** risk factor (genetics — the family history). Person Y carries **two** (lifestyle: little exercise, and a diet high in sugar and fat). Because risk factors add, Person Y is at **higher risk** than a person with no factors, and probably higher than Person X, whose other factors are protective habits. But that is all the comparison can say. A risk factor raises a **chance**; it does not guarantee the disease. Person X may never develop type 2 diabetes despite the family history, and Person Y may never develop it despite the habits — the overlap diagram shows factors combining as chances, not as certainties. So the correct conclusion is a statement about risk (“Person Y carries more of the known risk factors, so their chance is higher”), never a prediction of who will certainly get the disease.

Practice questions

Scaffolded questions

Question 1 The vocabulary of disease. Define each of the following: (a) disease; (b) pathogen; (c) host; (d) infectious disease; (e) non-infectious disease; (f) risk factor.

Question 2 The four pathogens. Copy and complete the table with one missing entry per row: (a) the type of pathogen that causes tuberculosis; (b) what a virus is, in one phrase; (c) the example disease caused by the yeast *Candida*; (d) the type of pathogen a tapeworm is.

Type of pathogen	What it is	Example disease
(a)	a single-celled organism with no nucleus	tuberculosis
virus	(b)	influenza
fungus	a cell with a nucleus	(c)
(d)	lives on or in a host and takes what it needs from it	a tapeworm infection

Question 3 Reading the size scale. Using the size scale in this subtopic: (a) state the size of the influenza virus; (b) state the length of the tuberculosis bacterium; (c) say which is smaller, a *Candida* yeast cell or a red blood cell; (d) name the only organism on the scale that can be seen with the eye on its own.

Question 4 First sort. Sort these four diseases into two lists — *infectious* and *non-infectious* — and give the cause of each in one phrase: influenza; scurvy; tuberculosis; asbestosis.

Question 5 Routes of entry. Match each event to the route of entry it shows: (a) a person with a cold sneezes across a room and you breathe in; (b) you eat food carrying a tapeworm's eggs; (c) a mosquito bites you; (d) you shake hands with someone and then rub your eyes.

Question 6 Factors and diseases. Match each factor to the example disease from this subtopic that it causes or contributes to: (a) genetics; (b) age; (c) malnutrition; (d) environment; (e) lifestyle.

Unscaffolded questions

Question 7 Explain why influenza can sweep through a classroom in a week, while type 2 diabetes cannot — even though both diseases are named in the same households.

Question 8 A student writes: “A virus is a very tiny cell.” Use the structure of the influenza virus to explain why that statement is wrong, and state what a virus needs in order to multiply.

Question 9 Explain why a tapeworm is classed as a parasite, and state where in the body it lives and what it takes from the host.

Question 10 A human hair is about 80 μm wide, near the smallest thing the eye can see on its own. The tuberculosis bacterium is about 2 μm long. Use these numbers to explain why a doctor cannot see TB bacteria without a microscope.

Question 11 Using the artery model in this subtopic, explain how a cholesterol build-up harms the heart muscle, and name two factors that raise the chance of the build-up forming.

Question 12 “A risk factor raises the chance of a disease; it does not guarantee it.” Explain this sentence using type 2 diabetes and two named factors.

Question 13 Certain viruses are one trigger of certain cancers. Explain why such a cancer is still classed as non-infectious, and state what you should say when you classify it.

Question 14 Apply the decision key, in full sentences, to (a) asbestosis and (b) candidiasis. For each, state the cause, the kind of cause it is, and the family the disease belongs to.

Question 15 Reading the Australian data. Using the bar chart of deaths in Australia in 2024: (a) state the share of deaths caused by dementia including Alzheimer's disease; (b) say which of the two leading causes accounted for more deaths; (c) state whether these two leading causes are infectious or non-infectious; (d) explain why the chart cannot tell you how many people died of influenza that year.

Question 16 A social-media post claims: “Heart disease must be infectious — it kills more Australians than anything else, so it must spread between people.” Evaluate the claim using the cause test from this subtopic.

Answers

Question 1 (a) a condition that disrupts the normal working of the body; (b) an organism or agent that causes disease; (c) the living thing a pathogen lives in or on; (d) a disease caused by a pathogen, which can spread from host to host; (e) a disease not caused by a pathogen, which cannot spread between people; (f) a factor that raises the chance of a disease. **Question 2** (a) bacterium; (b) genetic material in a protein coat, not a cell; (c) candidiasis; (d) parasite. **Question 3** (a) about 100 nm; (b) about 2 μm ; (c) the *Candida* yeast cell (about 5 μm against about 8 μm); (d) the adult tapeworm. **Question 4** infectious: influenza (virus), tuberculosis (bacterium); non-infectious: scurvy (diet lacking vitamin C), asbestosis (asbestos fibres in the air). **Question 5** (a) breathing in; (b) eating and drinking; (c) through broken skin; (d) direct contact. **Question 6** (a) some epilepsy and some cancers; (b) Alzheimer's disease; (c) scurvy; (d) asbestosis; (e) type 2 diabetes (and heart disease, lung cancer from smoking). **Question 7** see solution — a pathogen moves between hosts for influenza; no pathogen is involved in type 2 diabetes. **Question 8** see solution — a virus has no cytoplasm and no cell parts; it needs a living cell to multiply in. **Question 9** see solution. **Question 10** see solution — $80\text{ }\mu\text{m} \div 2\text{ }\mu\text{m} = 40$, so the bacterium is 40 times narrower than the eye's limit. **Question 11** see solution. **Question 12** see solution. **Question 13** see solution — the cancer cannot pass from person to person. **Question 14** see solution. **Question 15** (a) 9.4%; (b) dementia including Alzheimer's disease; (c) both non-infectious; (d) see solution. **Question 16** see solution.

Fully-worked solutions

Question 1 (a) A **disease** is a condition that disrupts the normal working of the body. (b) A **pathogen** is an organism, or agent, that causes disease — a bacterium, virus, fungus or parasite. (c) A **host** is the living thing a pathogen lives in or on. (d) An **infectious disease** is caused by a pathogen and can spread from one host to another. (e) A **non-infectious disease** is not caused by a pathogen; its cause lies in genes, age, diet, surroundings or habits, and it cannot spread between people. (f) A **risk factor** is a factor that raises the chance of a disease without guaranteeing it.

Question 2 (a) A **bacterium** — its cell has no nucleus. (b) A virus is **genetic material in a protein coat — not a cell**. (c) The fungus *Candida* causes **candidiasis**, a yeast infection. (d) A tapeworm is a **parasite**.

Question 3 (a) The influenza virus is about **100 nm** across. (b) The TB bacterium is about **2 μm** long. (c) The ***Candida* yeast cell** is smaller — about 5 μm against the red blood cell's 8 μm . (d) The **adult tapeworm**, which grows to metres long, is the only organism on the scale the eye can see on its own.

Question 4 Infectious: influenza, caused by a virus; tuberculosis, caused by a bacterium. **Non-infectious:** scurvy, caused by a diet lacking vitamin C (malnutrition); asbestosis, caused by breathing asbestos fibres (environment). The first two have pathogens as their cause and can spread; the second two have no pathogen and cannot.

Question 5 (a) **Breathing in** — droplets in the air. (b) **Eating and drinking** — contaminated food or water. (c) **Through broken skin** — the bite breaks the skin. (d) **Direct contact** — touching a surface or person carrying the pathogen, then touching the face.

Question 6 (a) Genetics → some epilepsy and some cancers. (b) Age → Alzheimer's disease. (c) Malnutrition → scurvy. (d) Environment → asbestosis. (e) Lifestyle → type 2 diabetes, and heart disease and lung cancer from smoking.

Question 7 Influenza is caused by a **pathogen** that physically moves from one host to the next — in droplets when a person coughs or sneezes, and on hands and surfaces — so each sick student can pass the virus to several more, and the disease **spreads** through the room. Type 2 diabetes has **no pathogen** in its cause: its risk factors are genetics and lifestyle. Nothing alive moves from a person with diabetes to anyone else, so the disease cannot spread at all. Households share genes and habits, which is why the disease appears in several members of a family — but appearing in a family is not spreading.

Question 8 A cell has cytoplasm and cell parts, and can grow and multiply on its own. A virus has **none of these**: it is genetic material in a protein coat, with no cytoplasm and no cell parts, which is why it is described as not a cell. To multiply, a virus must get **inside a living cell** and take over that cell's machinery — outside a living cell it can do nothing. So “a very tiny cell” is wrong in the part that matters: a virus is not a cell at any size.

Question 9 A tapeworm is classed as a **parasite** because it **lives inside a host and takes what it needs from it**, to the host's harm. It lives in the **gut**, anchored to the gut wall by the hooks on its head, and it takes in **food the host has already digested**, so the host loses nutrition. Its many-celled, segmented body — metres long in an adult — also marks it out from the single-celled and non-cell pathogens.

Question 10 The eye on its own can see down to about a hair's width, **80 µm**. The TB bacterium is **2 µm** long, and $80 \div 2 = 40$, so the bacterium is about **40 times narrower** than the smallest thing the eye can see on its own — deep in the “too small” zone of the size scale. No amount of careful looking will reach it; it can only be seen with a **microscope**, which is why TB is diagnosed with lab tests rather than with the eye.

Question 11 A build-up of cholesterol (a plaque) in the artery wall **narrows the channel** through the artery, so **less blood gets through** — exactly what the narrowed-straw model in Activity 1 shows. Because the coronary arteries feed the heart muscle itself, the muscle then receives less oxygen than it needs, especially in exercise when it needs more; that is coronary heart disease. Two factors that raise the chance of the build-up: a **diet high in fat and sugar** (a lifestyle factor) and **age** (or **genetics** / a family history). Any two earn the mark.

Question 12 Take **genetics** (a family history of type 2 diabetes) and **lifestyle** (little exercise, a diet high in sugar and fat). A person carrying both has a **higher chance** of developing the disease than a person carrying neither — the factors add. But either person may still stay well: the factors raise the *probability*, they do not decide it, which is what the overlap diagram shows. So the sentence means: the chance goes up, the certainty never arrives — and that is why “has the risk factor” and “has the disease” are different statements.

Question 13 The split between the two families is about whether **the disease itself** can pass from person to person. A cancer cannot: no cancer moves between people in droplets, food, contact or bites. Where a virus is one trigger, it is one of **several** causes acting on the person, and the disease that results still does not spread. The cancer is therefore classed as **non-infectious**. When classifying it, you should **name the viral trigger and say so** — state that a pathogen is one contributing cause while the disease itself remains non-infectious.

Question 14 (a) Asbestosis is caused by **breathing asbestos fibres** over years. The fibres are a substance in the surroundings — an **environment** factor — and not a pathogen (they are not alive). The disease therefore belongs to the **non-infectious** family, and it cannot spread between people. (b) Candidiasis is caused by the yeast **Candida** multiplying on the skin or in the mouth. A yeast is a **fungus** — **a pathogen**, so the disease belongs to the **infectious** family; it can pass between hosts, which is why the cause test puts it there even though it is usually a person's own *Candida* that multiplies.

Question 15 (a) Dementia including Alzheimer's disease caused **9.4%** of all deaths. (b) It also accounted for more deaths than the other leading cause: 9.4% against coronary heart disease's 8.7%. (c) Both leading causes are **non-infectious** diseases. (d) The chart shows only the two leading single causes and one combined bar; deaths from influenza are counted inside **“all other causes combined” (81.9%)**, so the chart alone cannot separate them out.

Question 16 The claim is **wrong**, and it makes a category error the cause test exposes. How often a disease kills says nothing about whether it spreads; the families are split by **cause**, not by death toll. Coronary heart disease is caused by a cholesterol build-up narrowing the coronary arteries, with genetics, age and lifestyle as its risk factors — **no pathogen is involved**, and nothing passes from one person to another. The post argues from the size of the death toll to “must spread”, which is exactly the inference the cause test forbids. The correct statement is: heart disease is the second-largest single cause of death in Australia and is non-infectious.

Where this leads: the pathogen classification built here — bacterium, virus, fungus, parasite, and the infectious/non-infectious split by cause — is the prerequisite for VCE Biology Unit 4, Area of Study 1 (“How do organisms respond to pathogens?”), which formalises the body's defences against each pathogen type; that immunity material is reference-only for this book and is **not** pre-taught here (TOC D9). VCE Biology Unit 1, Area of Study 2 also assumes the risk-factor and lifestyle picture of this subtopic for heart disease and diabetes. Subtopic 8D, the partner limb of VC2S10U03, takes up the measures that block the transmission routes met here — personal hygiene, quarantine, medical treatment and public education programs — and compares how well they work.

Controlling transmission: hygiene, quarantine, medical treatment and public education

Chapter 8 — Biological sciences B: coordination, homeostasis and disease (Science, Levels 9 and 10)

Subtopic 8D · VC2 Science Understanding — Biological sciences

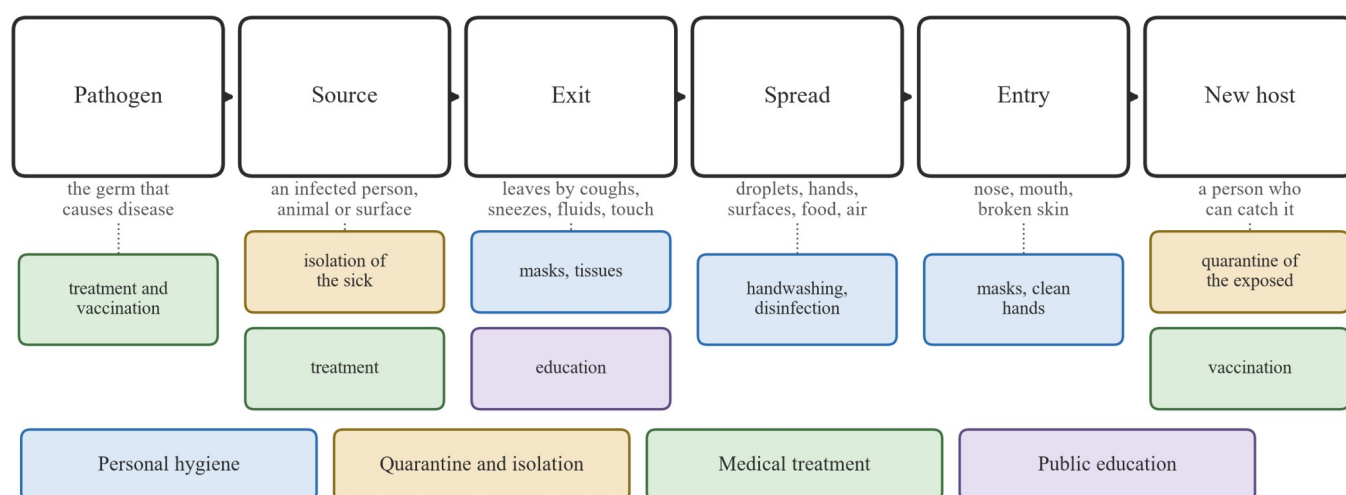
CD code: VC2S10U03 (split delivery †; this subtopic is the partner, not the accountable owner) **Content description (verbatim):** “infectious and non-infectious diseases are caused by different organisms and agents; measures to control the transmission of infectious diseases include personal hygiene, quarantine protocols, medical treatment and public education programs” **This subtopic’s limb (TOC §4 clause split):** measures to control the transmission of infectious diseases — personal hygiene, quarantine protocols, medical treatment and public education programs. The accountable owner 8C delivers the other limb: infectious and non-infectious diseases and the different organisms and agents that cause them. **Elaboration ids drawn on:** VC2S10U03.E02 · VC2S10U03.E03 · VC2S10U03.E04 (ids VC2S10U03.E01, VC2S10U03.E05 and VC2S10U03.E07 are drawn on by Subtopic 8C, the accountable owner; VC2S10U03.E06 is withheld under the TOC’s D10 ICIP decision and is not authored) **Achievement standard (extract served):** “They distinguish between infectious and non-infectious disease, and compare different infectious disease control measures.” (8D serves the second clause — comparing control measures; the first clause is served and assessed by 8C.)

Theory

From cause to control. Subtopic 8C established what causes infectious disease: a **pathogen** — an organism or agent that causes disease, such as a bacterium, a virus, a fungus or another parasite like tapeworm. (The pathogen groups themselves belong to 8C; this subtopic refers to them rather than re-teaching them.) It also separated infectious disease, which can pass from one host to another, from non-infectious disease, which cannot. This subtopic asks the next question: **if a disease can spread, what stops it spreading?** The content description names four families of answers — **personal hygiene, quarantine protocols, medical treatment and public education programs** — and the skill of this subtopic is to **compare** them: where each one acts, who it protects, and what it cannot do on its own.

The chain of infection — the model that organises everything here. A pathogen reaches a new host only by completing a chain of links. Every control measure works by breaking one of those links, and a measure can be understood by naming the link it breaks.

The chain of infection — a measure only works if it breaks a link



If any one link is broken, the chain stops — which is why measures are combined, not used one at a time.

A horizontal chain of six labelled links — pathogen, source, exit, spread, entry, new host — with a short description under each link, and coloured chips below showing which family of control measures breaks which link: treatment and vaccination under pathogen; isolation of the sick and treatment under source; masks, tissues and education under exit; handwashing, disinfection under spread; masks and clean hands under entry; quarantine of the exposed and vaccination under new host; a four-colour legend names the families personal hygiene, quarantine and isolation, medical treatment, and public education.

Read the chain from left to right: the **pathogen** lives in a **source** (an infected person, animal or contaminated material), **exits** the source (in coughs, sneezes, body fluids or by touch), **spreads** (through droplets, hands, surfaces, food, water or air), **enters** a new host (through the nose, mouth or broken skin), and meets a **new host** who can catch it. If **any one** link is broken, the chain stops — which is why control measures are combined rather than used one at a time. The four families each specialise in different links, as the chips below the chain show.

The four families at a glance. Before comparing the families in detail, here is the full picture of what each one does.

Controlling transmission — four families of measures (content description, VC2S10U03)

Personal hygiene

- handwashing with soap and water
- cough or sneeze into your elbow
- wear a mask when you are sick
- clean surfaces; prepare food safely

Quarantine and isolation

- isolate people who are sick
- quarantine people who were exposed
- border checks on people, food, goods
- exclusion zones keep pests out

Medical treatment

- antibiotics treat bacterial infections
- antivirals treat some viral infections
- antifungals treat fungal infections
- vaccination programs protect populations

Public education

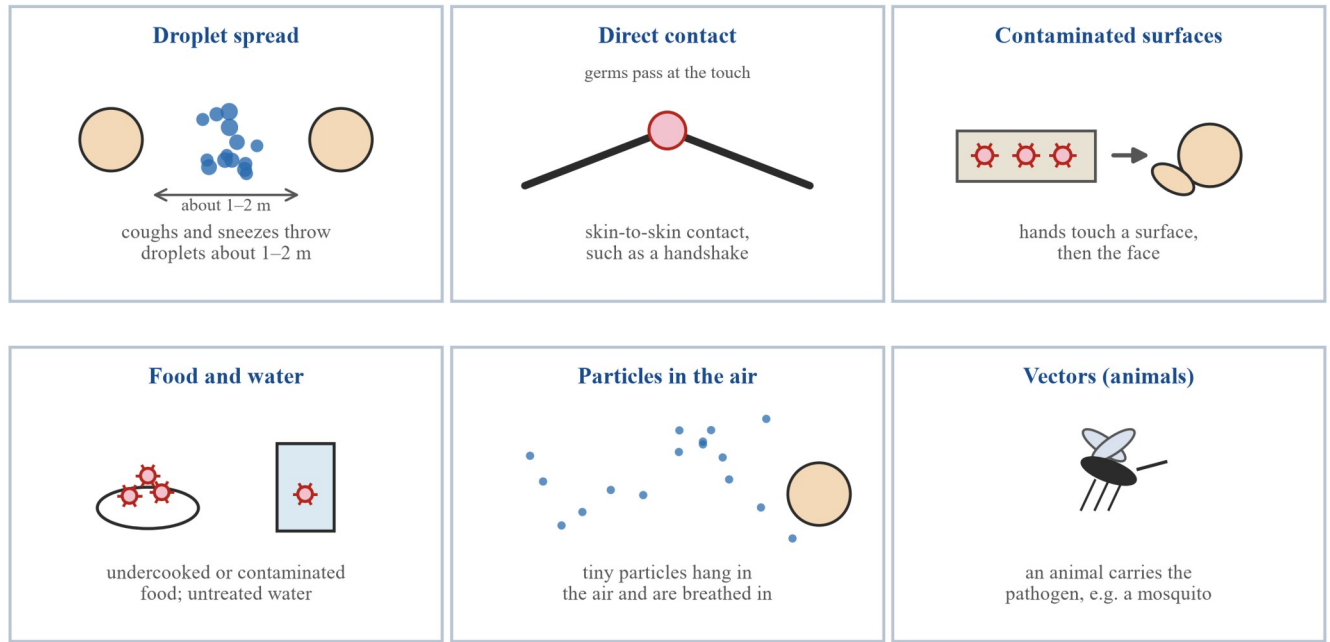
- campaigns that change behaviour
- a clear action and a reason
- aimed at the right audience
- delivered by a trusted source

Each family acts on a different part of the chain of infection — see Figure: The chain of infection.

A two-by-two overview of the four families of control measures. Personal hygiene: handwashing with soap and water; cough or sneeze into your elbow; wear a mask when you are sick; clean surfaces and prepare food safely. Quarantine and isolation: isolate people who are sick; quarantine people who were exposed; border checks on people, food and goods; exclusion zones keep pests out. Medical treatment: antibiotics treat bacterial infections; antivirals treat some viral infections; antifungals treat fungal infections; vaccination programs protect populations. Public education: campaigns that change behaviour; a clear action and a reason; aimed at the right audience; delivered by a trusted source.

Routes of transmission — how the spread link actually works. To break the spread link you need to know how the pathogen travels. The main routes are shown below; a single disease can travel by more than one route, and each route has a measure that blocks it.

Routes of transmission — how a pathogen travels to a new host



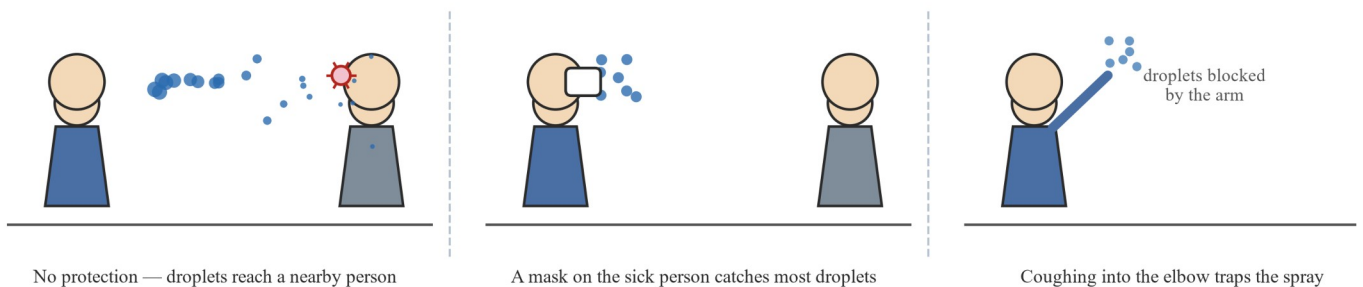
A three-by-two grid of six route vignettes. *Droplet spread: coughs and sneezes throw droplets about 1–2 metres. Direct contact: skin-to-skin contact such as a handshake. Contaminated surfaces: hands touch a surface, then the face. Food and water: undercooked or contaminated food and untreated water. Particles in the air: tiny particles hang in the air and are breathed in. Vectors: an animal carries the pathogen, for example a mosquito.*

Notice that most routes pass through things we touch, share or breathe. That is exactly why so many control measures target **hands, droplets and surfaces** — they sit on the busiest routes.

Family 1 — Personal hygiene: blocking the pathogen at exits and on the spread link.

Droplets first. Most droplets thrown out by a cough or sneeze fall to the ground within about 1–2 m of the person. That short range is the whole rationale for three everyday measures: coughing into the **elbow** (not the hand, which then touches everything), using a **tissue** and binning it, and wearing a **mask** when sick so droplets are caught at the source.

Most droplets from a cough or sneeze fall within about 1–2 metres — blocking them at the source works

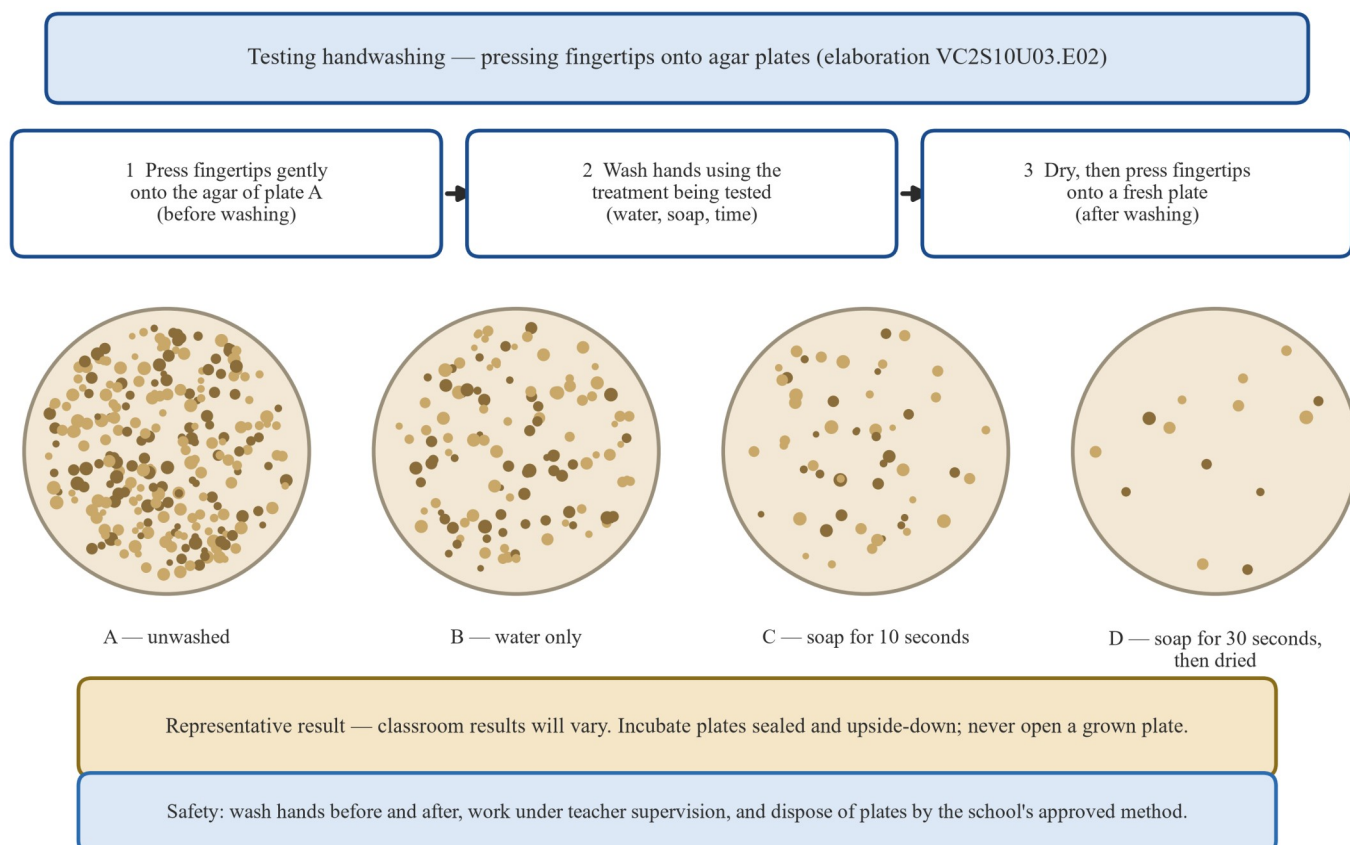


Three side-by-side scenes of a person coughing near another person. Left: no protection — droplets travel across the gap and reach the nearby person. Middle: a mask on the sick person catches most droplets, with only a few small droplets escaping close to the mask. Right: coughing into the elbow traps the spray, with droplets blocked by the arm.

Hands second. Hands are the great taxi service of pathogens: they touch surfaces, then touch the face, completing the contaminated-surface route. **Washing with soap and water for at least 20 seconds** lifts microbes off the skin so the water rinses them away; drying matters too, because damp hands transfer microbes more easily than dry ones. The real-world evidence is strong: reviews of community studies find that regular handwashing cuts diarrhoeal illness by about a third and also reduces respiratory infections such as colds (Wikipedia, “Hand washing”, retrieved 2026-08-21).

Surfaces and food third. Cleaning and **disinfection** (destroying pathogens on surfaces with cleaning agents) break the surface route, and safe food handling — cooking food properly, keeping raw and cooked food apart, using clean water — breaks the food-and-water route.

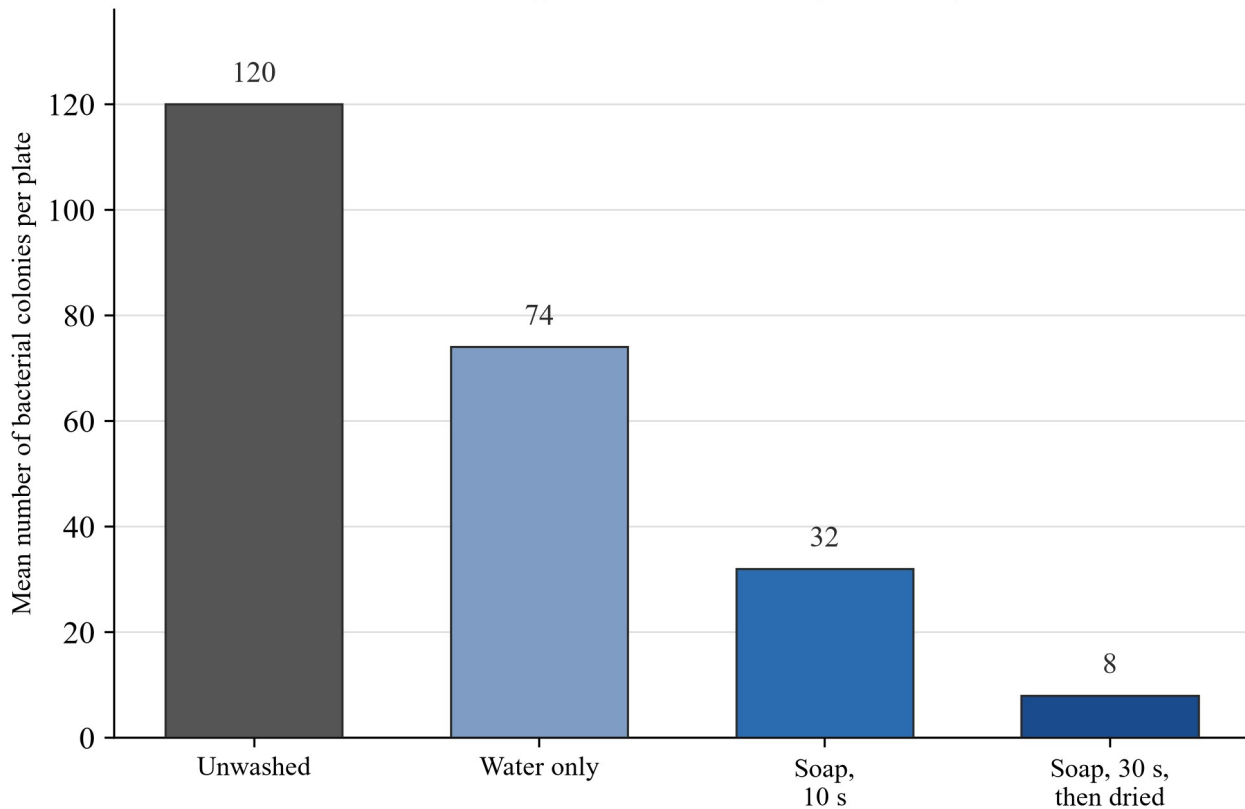
The classic way to *see* why handwashing works is the agar-plate investigation of elaboration VC2S10U03.E02: press fingertips onto nutrient agar before and after washing, incubate the sealed plates, and compare the number of bacterial **colonies** — visible clusters of bacteria, each grown from microbes left by the fingertips — that grow on each plate.



The method and a representative result of the handwashing agar-plate investigation. Three method steps: press fingertips gently onto the agar of plate A before washing; wash hands using the treatment being tested; dry, then press fingertips onto a fresh plate. Four plates are shown with dots representing bacterial colonies: plate A, unwashed, heavily dotted; plate B, water only, moderately dotted; plate C, soap for 10 seconds, lightly dotted; plate D, soap for 30 seconds then dried, almost clear. A banner reads: representative result — classroom results will vary; incubate plates sealed and upside-down and never open a grown plate; a safety banner adds wash hands before and after, work under teacher supervision, and dispose of plates by the school's approved method.

Activity 1 walks you through planning that investigation. A simulated data set for practice with the same shape as real results is shown next — it is used in Worked example 1.

Simulated data for practice — handwashing and colony counts

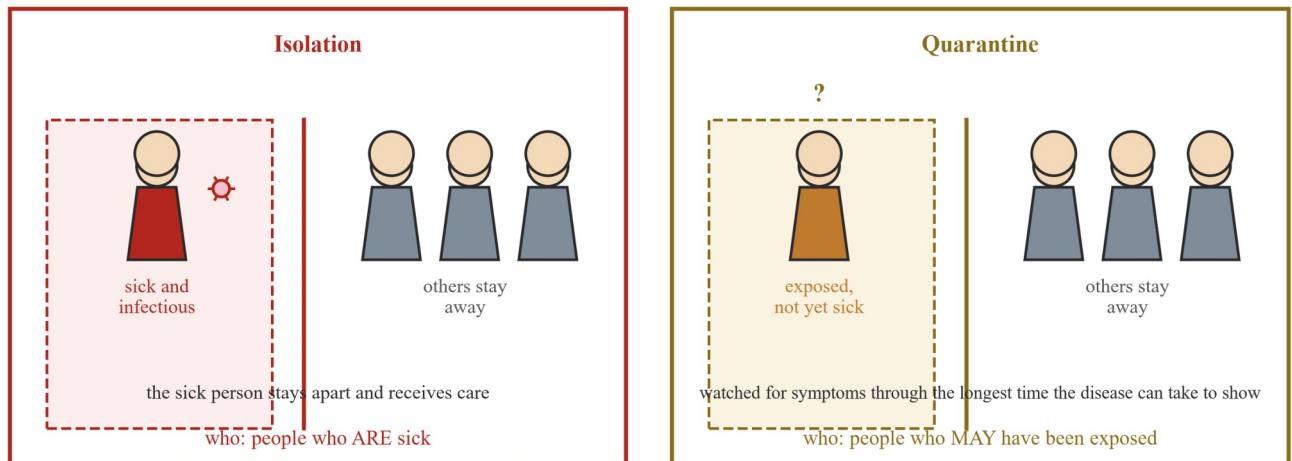


A bar chart labelled simulated data for practice showing mean number of bacterial colonies per plate for four handwashing treatments: unwashed, 120 colonies; water only, 74 colonies; soap for 10 seconds, 32 colonies; soap for 30 seconds then dried, 8 colonies. The bars step down steeply from left to right.

Family 2 — Quarantine protocols: separating people and goods to break the chain at the source.

Two words are often confused, and the difference matters. **Isolation** separates people who **are** sick and infectious, so they cannot pass the pathogen on. **Quarantine** separates people (or animals, or goods) who **may have been exposed** but are not yet showing symptoms, and watches them for the longest time the disease can take to show — so that, if they do become infectious, they are already apart.

Isolation and quarantine both separate people — they target different groups



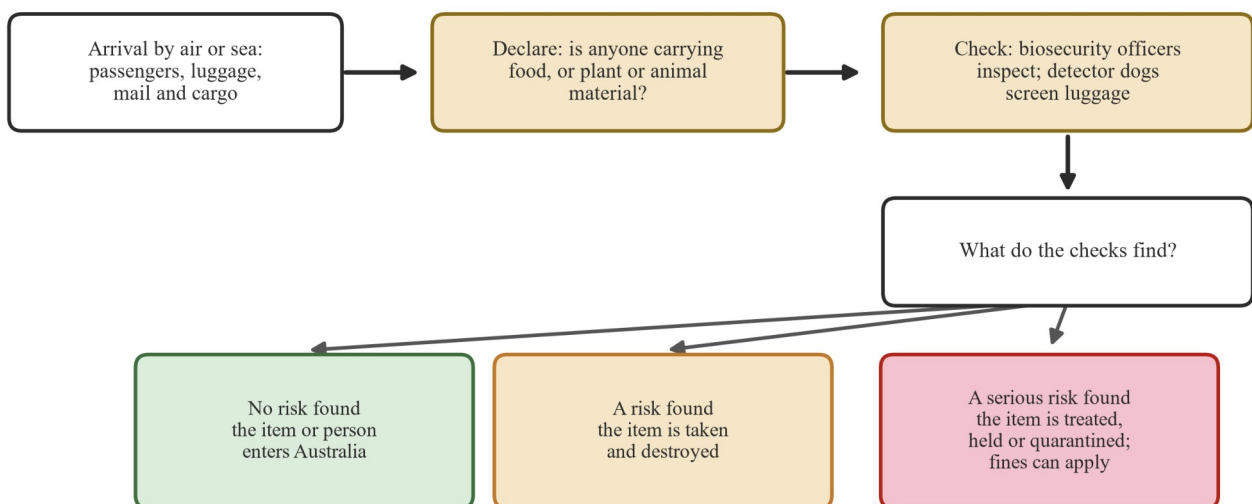
Both break the chain at the source link — before a pathogen can reach a new host.

Two side-by-side panels. *Isolation*: a sick, infectious person is held in a dashed red zone apart from others, labelled *who: people who ARE sick*; the sick person stays apart and receives care. *Quarantine*: a person who was exposed but is not yet sick, marked with a question mark, is held in a dashed amber zone apart from others, labelled *who: people who MAY have been exposed*; they are watched for symptoms through the longest time the disease can take to show.

Both measures break the chain at the **source** link — before the pathogen ever reaches the spread routes — which is what makes them so powerful.

Quarantine at the border. Australia applies the same idea to its borders. Under the **Biosecurity Act 2015 (Cth)** — the Commonwealth law that replaced most of the old Quarantine Act 1908 — arrivals by air and sea, their luggage, mail and cargo, must be declared and can be checked: biosecurity officers inspect, and detector dogs screen luggage for food and plant or animal material that could carry disease or pests.

Quarantine at the border — what happens to arrivals under the Biosecurity Act 2015 (Cth)



The same idea protects farms and native wildlife: fruit-fly exclusion zones restrict moving fruit into pest-free growing regions, and one infested fruit can start an outbreak.

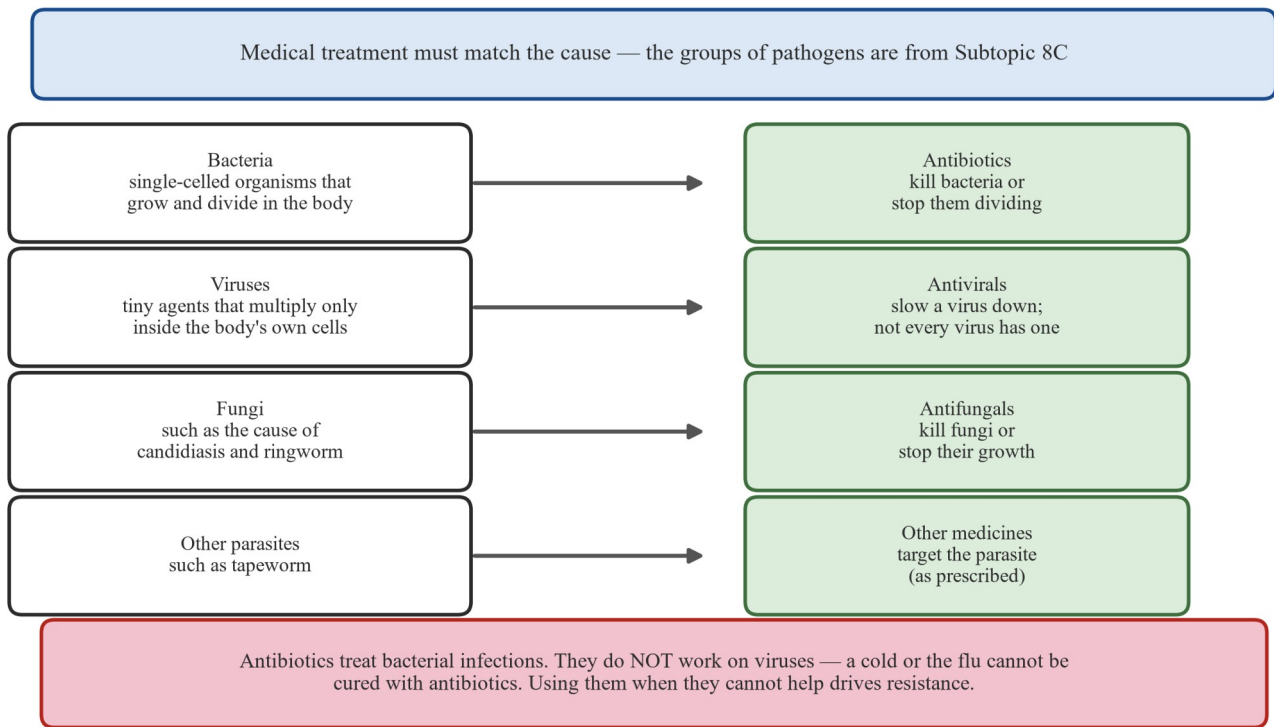
A decision flow for border quarantine under the Biosecurity Act 2015 (Cth). Arrival by air or sea leads to declare (is anyone carrying food, or plant or animal material?), then to check (biosecurity officers inspect; detector dogs screen

luggage), then to the question what do the checks find? Three outcomes branch below: no risk found — the item or person enters Australia; a risk found — the item is taken and destroyed; a serious risk found — the item is treated, held or quarantined, and fines can apply. A footnote adds that the same idea protects farms and native wildlife: fruit-fly exclusion zones restrict moving fruit into pest-free growing regions, and one infested fruit can start an outbreak.

Australia has long used quarantine this way. The Point Nepean Quarantine Station, at the head of Port Phillip Bay, opened in 1852 and operated until 1980, receiving ships’ passengers who showed signs of infectious disease (Wikipedia, “Point Nepean Quarantine Station”, retrieved 2026-08-21). Its finest hour came with the 1918–19 influenza pandemic: strict maritime quarantine kept the virus out of Australia through 1918, and when it finally entered in January 1919, quarantine between the states slowed its spread, so that Queensland, Western Australia and Tasmania were infected months later than the eastern seaboard (Wikipedia, “1918 flu pandemic”, retrieved 2026-08-21). The same logic protects farms and native wildlife today: **exclusion zones** around pest-free growing regions make it illegal to carry fruit into them, because a single infested fruit can start an outbreak — the Queensland fruit fly costs Australian horticulture about \$28.5 million a year and can destroy up to a whole exposed crop (Wikipedia, “Bactrocera tryoni”, retrieved 2026-08-21).

Family 3 — Medical treatment: matching the medicine to the cause, and protecting populations.

Treatment must match the pathogen. The pathogen groups of Subtopic 8C each have their own kind of medicine, and using the wrong one does nothing.

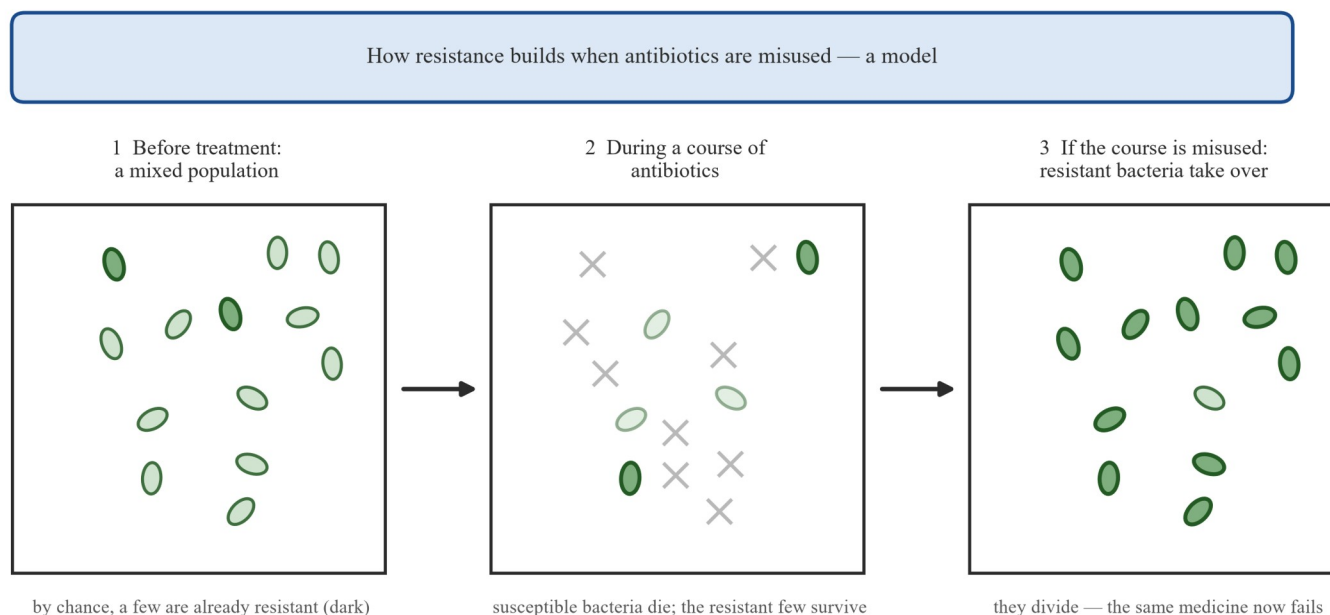


A matching table of pathogen group to treatment. Bacteria (single-celled organisms that grow and divide in the body) are treated with antibiotics, which kill bacteria or stop them dividing. Viruses (tiny agents that multiply only inside the body’s own cells) are treated with antivirals, which slow a virus down; not every virus has one. Fungi (such as the cause of candidiasis — a fungal infection — and ringworm) are treated with antifungals, which kill fungi or stop their growth. Other parasites (such as tapeworm) are treated with other medicines that target the parasite as prescribed. A red banner below reads: antibiotics treat bacterial infections; they do NOT work on viruses — a cold or the flu cannot be cured with antibiotics; using them when they cannot help drives resistance.

The banner carries one of the most important public-health messages there is: **antibiotics treat bacterial infections and do not work on viruses**. A cold or the flu cannot be cured with antibiotics, and every unnecessary use is a chance for **resistance** to build.

How resistance builds — a model. Within any population of bacteria, a few individuals are resistant to a given antibiotic by chance. A proper course of antibiotics kills the susceptible bacteria and is continued long enough to

finish the job. A **misused** course — stopped early, or taken for a viral illness it cannot treat — kills only the susceptible bacteria and leaves the resistant ones alive to divide and take over. The next infection, even in another person, may then resist the same medicine.

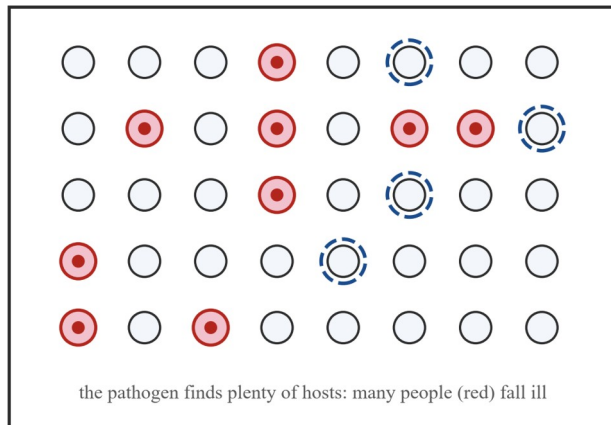


A three-panel model of how antibiotic resistance builds. Panel 1, before treatment: a mixed population of bacteria, mostly light susceptible cells with a few dark resistant cells by chance. Panel 2, during a course of antibiotics: susceptible bacteria die (shown as grey cross marks) while the resistant few survive. Panel 3, if the course is misused: resistant bacteria take over and divide, so the same medicine now fails.

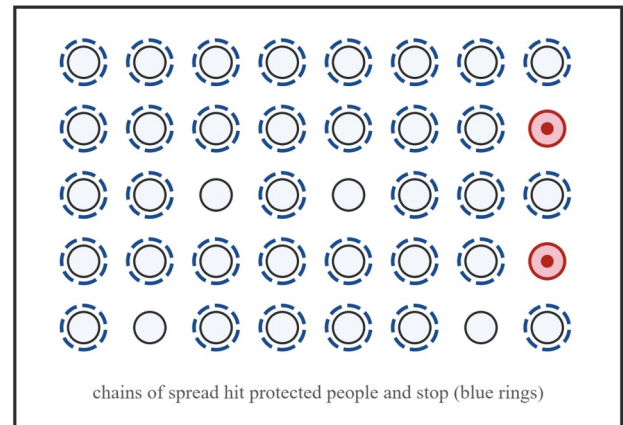
This is why finishing a prescribed course matters, and why misuse and overuse of antibiotics are the main drivers of resistance. The stakes are global: a major international study published in *The Lancet* in 2022 found that in 2019 about 1.27 million deaths worldwide were directly attributable to bacterial antimicrobial resistance (Wikipedia, “Antimicrobial resistance”, retrieved 2026-08-21).

Vaccination protects populations. The fourth medical measure works at the scale of a whole community rather than one patient. A vaccine prepares the body to fight one specific disease; **how** the body builds that protection — the cells and molecules involved — is VCE Biology and is not taught here (TOC D9). What matters at this level is the population picture: when most people in a community are vaccinated, chains of spread keep hitting protected people and stop, so the outbreak stays small — and people who **cannot** be vaccinated, such as newborns and people with some medical conditions, are shielded too.

Low uptake — few people vaccinated



High uptake — most people vaccinated

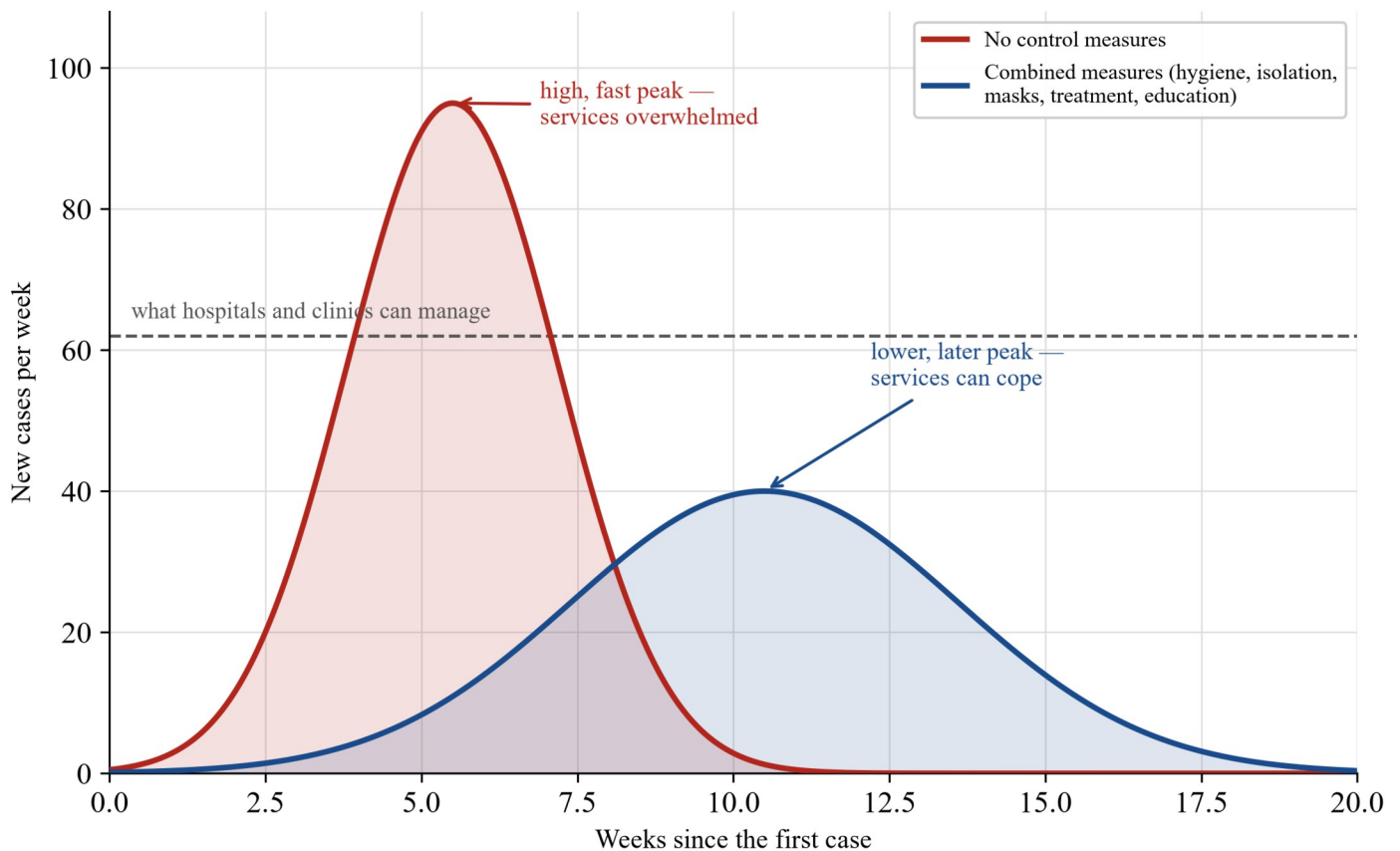


High uptake also shields people who cannot be vaccinated — newborns, and people with some medical conditions.

A model of two outbreaks in two communities. Low uptake: few people are vaccinated (blue dashed rings) and the pathogen finds plenty of hosts, so many people (red) fall ill. High uptake: most people are vaccinated, chains of spread hit protected people and stop, and only two people fall ill. A note below adds that high uptake also shields people who cannot be vaccinated — newborns, and people with some medical conditions.

Putting the measures together — a model epidemic curve. When hygiene, isolation, masks, treatment and education act together, the shape of an outbreak changes. The model below shows two epidemic curves for the same disease: with no control measures, cases rise to a high, fast peak that overwhelms hospitals and clinics; with combined measures, the peak is lower and later, and stays within what health services can manage.

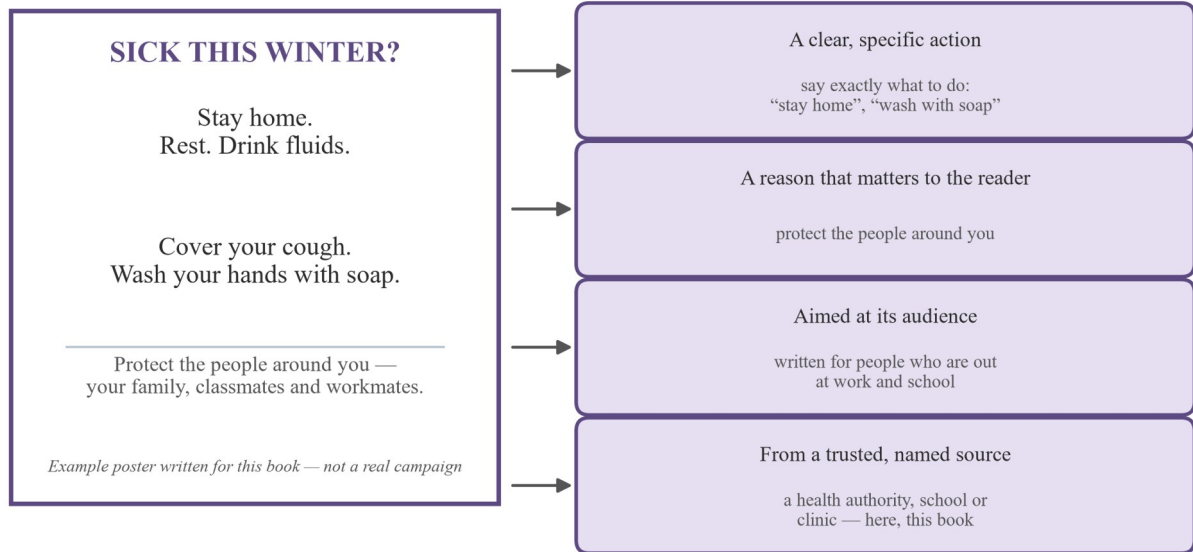
A model for classroom discussion — not data from a real outbreak



A model graph of new cases per week against weeks since the first case, labelled a model for classroom discussion and not data from a real outbreak. The red curve with no control measures rises to a high, fast peak of about 95 cases per week around week 5–6, above a dashed line marking what hospitals and clinics can manage. The blue curve with combined measures (hygiene, isolation, masks, treatment, education) rises more slowly to a lower, later peak of about 40 cases per week around week 10–11, below the dashed line, so services can cope.

Family 4 — Public education programs: changing behaviour at scale.

Every measure above only works if people actually do it — wash their hands, cough into their elbows, stay home when sick, declare food at the border, finish their antibiotic course, get vaccinated. That is the job of **public education**: campaigns that change the behaviour of thousands of people at once. A message that works has a recognisable anatomy, shown below against an example poster written for this book.



Education works by changing behaviour at scale — each message must earn attention and be easy to act on.

An example public education poster on the left — headline SICK THIS WINTER?; body Stay home. Rest. Drink fluids. Cover your cough. Wash your hands with soap.; reason line Protect the people around you — your family, classmates and workmates; small italic note Example poster written for this book — not a real campaign — and, on the right, four labelled boxes naming what makes the message work: a clear, specific action (say exactly what to do: stay home, wash with soap); a reason that matters to the reader (protect the people around you); aimed at its audience (written for people who are out at work and school); from a trusted, named source (a health authority, school or clinic — here, this book).

Education is the quiet multiplier of the other three families: it is how handwashing becomes a habit, quarantine becomes accepted, and antibiotics are used properly. Evaluating health claims and misinformation is the work of Chapter 16; here the point is simpler — **a control measure that people do not follow is a link left unbroken.**

Comparing the four families. The achievement standard for this content description asks you to *compare* control measures. The table below is the comparison this subtopic has been building.

Family	Example measures	Chain link mainly broken	Who it protects	One limitation
Personal hygiene	handwashing with soap; coughing into the elbow; masks when sick; disinfection	exit and spread	the person and everyone they touch	depends on every person, every time
Quarantine protocols	isolation of the sick; quarantine of the exposed; border checks; exclusion zones	source (and entry of new diseases)	the whole community	needs checking and cooperation; separates people
Medical treatment	antibiotics, antivirals, antifungals; vaccination programs	pathogen and new host	the treated person; vaccination protects the population	each medicine matches only one pathogen group; misuse drives resistance
Public education	campaigns with a	every link, by	the whole	behaviour change is

Family	Example measures	Chain link mainly broken	Who it protects	One limitation
	clear action, a reason, a trusted source	changing behaviour	community	slow and must be maintained

No family does everything — which is the chain model's final lesson, and the reason public health always **combines** measures.

Activities

Activity 1 — Planning the handwashing agar-plate investigation (elaboration VC2S10U03 .E02). In small groups, plan the investigation shown in the handwashing figure: pressing fingertips onto agar plates before and after different handwashing treatments, then comparing colony counts after incubation. (a) Write a hypothesis comparing **water only** with **soap for 30 seconds, then drying**. (b) List three things you would keep the same across all plates so the comparison is fair. (c) Plate A (fingertips before washing) is the starting point for the comparison. Explain why including it matters. (d) The plates are incubated **sealed and upside-down, and are never opened once grown**. Give one reason for each of these two safety rules.

Activity 2 — Reading the simulated handwashing data (elaboration VC2S10U03 .E04). Use the simulated bar chart of handwashing and colony counts. (a) Describe the trend in colony counts across the four treatments, using the words *level* and *change* carefully. (b) Which treatment removes the most microbes? Quote two values from the chart in your answer. (c) The chart is labelled **simulated data for practice**. Explain what a class would need to do in Activity 1 to turn its own plate counts into evidence of the same kind (think about repeats and averages).

Activity 3 — Two models of protection (elaboration VC2S10U03 .E03). Models let us visualise processes we cannot watch directly. Use the vaccination community model and the epidemic-curve model. (a) In the vaccination model, explain in one or two sentences why the high-uptake community has fewer sick people even though both communities started with the same disease. (b) In the curve model, read off the approximate peak (height and week) of each curve, and state which curve stays below the line for what hospitals and clinics can manage. (c) Both figures are labelled as models, not real data. State one way a model like these can mislead if it is read as if it were measured data.

Worked examples

Example 1 — scaffolded (percentage reduction from simulated data)

The simulated handwashing chart shows mean colony counts per plate: unwashed 120; water only 74; soap for 10 s 32; soap for 30 s then dried 8. For each washing treatment, calculate the percentage reduction in colonies compared with the unwashed plate, and write a one-sentence conclusion.

Working	Comment
Water only: reduction = $120 - 74 = 46$ colonies; $46 \div 120 = 0.383 \rightarrow$ 38 % fewer colonies than unwashed	Percentage reduction = (reduction $\div$ starting value) $\times$ 100. Always reduce against the <i>unwashed</i> value, 120.
Soap, 10 s: reduction = $120 - 32 = 88$; $88 \div 120 = 0.733 \rightarrow$ 73 % fewer	Same starting value; the soap-and-time treatment removes far more than water alone.
Soap, 30 s, dried: reduction = $120 - 8 = 112$; $112 \div 120 = 0.933 \rightarrow$ 93 % fewer	The longest, complete treatment leaves the fewest colonies.
Conclusion: water alone helps (38 % fewer), but soap, time and drying together remove far more (93 % fewer)	A conclusion compares the treatments and answers the question the data was collected to answer.

Example 2 — scaffolded (tracing the chain and breaking it)

A student has a cold. During the morning they cough into their hand at assembly, then share a water bottle with a friend at lunch. The friend catches the cold a few days later. (a) Trace this story through the six links of the chain of infection. (b) Name one measure that would have broken the chain, and state the link it breaks.

Working	Comment
(a) Pathogen: the cold virus. Source: the sick student.	One clear sentence per link earns the trace. The story

Working	Comment
Exit: coughing carries it out in droplets and onto the hand. Spread: droplets in the air at assembly, and the shared bottle carrying the virus from hand to mouth. Entry: the friend's mouth. New host: the friend, who catches it.	supplies every link — the task is to place them.
(b) Any one, with its link. Coughing into the elbow breaks exit (droplets and hand contamination are blocked at the source). Not sharing the bottle breaks spread (the surface route is removed). The sick student staying home breaks source (isolation).	The measure must be matched to a named link — that matching is the skill.

Example 3 — unscaffolded (comparing two measures for droplet spread)

Compare a **mask worn by a sick person** with **isolation of the sick person** as responses to a droplet-spread disease. For each, state the chain link it mainly breaks, one strength and one limitation, and say which is more certain to stop spread and why.

Both measures act early in the chain. A **mask on the sick person** breaks the **exit** link: it catches most droplets at the source, and its strength is that the person can keep going about their day while still protecting others; its limitation is that it catches *most* droplets, not all, and it only works while it is worn correctly. **Isolation** breaks the **source** link: the sick person stays apart until they are no longer infectious, and its strength is that, while it lasts, it removes nearly every route of spread at once; its limitation is its cost — the person cannot attend work or school, and the community must support them while they stay home. Isolation is the **more certain** of the two: a mask reduces the droplets that escape, whereas isolation removes the opportunity for spread altogether for as long as it is kept. That is exactly why public health adds measures together — a mask when isolation is impossible, isolation when the disease is serious.

Example 4 — unscaffolded (reading the epidemic-curve model)

Use the model epidemic curves. (a) State the approximate peak height and peak week of each curve. (b) The dashed line marks what hospitals and clinics can manage, at about 62 new cases per week. For how long does each curve sit above that line? (c) Explain in chain-of-infection terms why the combined-measures curve is lower and later.

- (a) With no control measures the curve peaks at about **95 new cases per week, around week 5–6**; with combined measures it peaks at about **40 new cases per week, around week 10–11**.
- (b) The no-measures curve sits above the 62-case line for roughly **weeks 4 to 7** — several weeks in which services are overwhelmed. The combined-measures curve **never crosses** the line: its peak of about 40 stays below 62 the whole time. (c) Each measure in the combined set breaks a link of the chain — hygiene breaks spread, isolation and quarantine break source, masks break exit and entry, treatment shortens the time a person is infectious, and education keeps all of these in practice. With links broken, one sick person passes the disease to fewer people, and each of those cases arises later — so the same outbreak arrives **slower, lower and later**, inside the capacity of the health services that treat it.

Practice questions

Scaffolded questions

Question 1 The vocabulary of control. Define each of the following as used in this subtopic: (a) pathogen; (b) isolation; (c) quarantine; (d) disinfection; (e) a bacterial colony (on an agar plate).

Question 2 Match the measure to the link. Copy the table and, for each measure, write the chain link it **mainly** breaks: (a) coughing into the elbow; (b) quarantine of people who were exposed on a flight with a sick passenger; (c) washing hands with soap for at least 20 s before eating; (d) antibiotics for a bacterial chest infection; (e) a mask worn by a sick person.

Question 3 Isolation or quarantine? Sort these four situations into two lists — *isolation* and *quarantine* — using the definitions in this subtopic: (i) a confirmed case of an infectious disease is moved to a separate room with its own care; (ii) people who sat near a sick passenger stay home and watch for symptoms for the disease's longest hidden

period; (iii) a sick student is sent home from school; (iv) a household contact of a case, not yet sick, is asked to stay apart for a set period.

Question 4 One more percentage. Using the simulated handwashing chart: calculate the percentage reduction in colonies of the **soap for 10 s** treatment (32) compared with **water only** (74), to the nearest whole percent. Show the reduction, the division and the result.

Question 5 The anatomy of a message. The campaign figure names four features of a public education message that works. List them, and for each one quote the words of the example poster that show it.

Question 6 Routes and blockers. Name the route of transmission for each situation, then one measure that blocks that route: (a) a person shakes the hand of someone with a cold, then rubs their eye; (b) a person drinks untreated stream water on a hike; (c) a person breathes in tiny particles from a sick workmate across a small office; (d) a mosquito bites an infected person, then bites a healthy one.

Unscaffolded questions

Question 7 Explain, using the chain of infection, why public health responses combine several measures instead of relying on one.

Question 8 Compare isolation and quarantine. State who each measure separates, when each is used, and the one thing both measures achieve for the chain of infection.

Question 9 Quarantine in Australian history. Australia’s maritime quarantine kept the 1918–19 influenza virus out through 1918, and interstate quarantine slowed its spread once it entered in January 1919. (a) Which link of the chain does border quarantine mainly break? (b) Explain why Queensland, Western Australia and Tasmania were infected later than the eastern seaboard.

Question 10 Why misuse matters. Use the resistance model to explain why (a) stopping an antibiotic course early, and (b) taking antibiotics for a viral illness such as the flu, can both leave a population of bacteria more resistant than before.

Question 11 Vaccination at the population level. (a) In the vaccination community model, explain why high uptake leads to a small outbreak. (b) Explain how high uptake protects people who cannot be vaccinated. (c) This subtopic describes vaccination at the **population** level only. State what it does not explain, and where that explanation belongs.

Question 12 At the border. Under the Biosecurity Act 2015 (Cth), name two kinds of material a person must declare on arrival, and state the three possible outcomes when a check finds a risk.

Question 13 Quarantine for pests. Fruit-fly exclusion zones make it illegal to carry fruit into pest-free growing regions. (a) Explain how an exclusion zone applies the idea of quarantine to a pest rather than a human disease. (b) Why is **one** infested fruit enough to justify the rule?

Question 14 Reading the curves. A classmate says: “the combined-measures curve in the model proves that the measures saved lives.” Using the figure’s own labels, explain what the model can support and what the word *proves* gets wrong.

Question 15 Designing the investigation. For the agar-plate handwashing investigation of Activity 1: (a) write an investigable question; (b) identify the independent and dependent variables; (c) give two variables to keep the same; (d) state one safety rule and the reason for it.

Question 16 Evaluate a claim. A social media post claims: “vitamin drops kill viruses, so you don’t need a flu vaccine — and antibiotics work too, just in case.” Evaluate both halves of the claim using this subtopic. State what would make a health claim trustworthy (think of the message-anatomy figure and Chapter 16).

Answers

Question 1 (a) an organism or agent that causes disease (bacterium, virus, fungus, other parasite); (b) separating people who **are** sick and infectious; (c) separating and watching people or goods that **may have been exposed** but are not yet sick; (d) destroying pathogens on surfaces with cleaning agents; (e) a visible cluster of bacteria grown on agar from one or more microbes. **Question 2** (a) exit; (b) source (and entry of the disease into a new community); (c) spread; (d) pathogen; (e) exit. **Question 3** Isolation: (i), (iii). Quarantine: (ii), (iv). **Question 4** reduction $74 - 32 = 42$; $42 \div 74 = 0.568 \rightarrow 57\%$. **Question 5** The four features and matching poster words — see solution. **Question 6** (a) direct contact / contaminated hands — handwashing; (b) food and water — treat or boil water; (c) particles in the air — ventilation, masks, distance; (d) vector — prevent bites (nets, repellent) and control the animal. See solution. **Question 7** see solution — one broken link stops the chain, but no single measure breaks every link every time. **Question 8** see solution — who is separated differs; both break the chain at the source link. **Question 9** (a) the source/entry link — the infected never meet the new community; (b) see solution. **Question 10** see solution — both misuses kill the susceptible bacteria and leave the resistant few to divide. **Question 11** (a) chains of spread hit protected people and stop; (b) see solution; (c) the body's own mechanism of protection — VCE Biology (TOC D9). **Question 12** declare: food, and plant or animal material (any two named); outcomes for a risk: the item is taken and destroyed, or treated/held/quarantined, and fines can apply. **Question 13** see solution. **Question 14** see solution — a labelled model supports comparison and discussion, not *proof*. **Question 15** see solution. **Question 16** see solution — both halves fail; trustworthy claims come from named, trusted sources with evidence.

Fully-worked solutions

Question 1 (a) A **pathogen** is an organism or agent that causes disease — the bacteria, viruses, fungi and other parasites (such as tapeworm) of Subtopic 8C. (b) **Isolation** is the separating of people who **are** sick and infectious, so they cannot pass the pathogen on. (c) **Quarantine** is the separating and watching of people, animals or goods that **may have been exposed** but are not yet showing symptoms, for the longest time the disease can take to show. (d) **Disinfection** is the destroying of pathogens on surfaces using cleaning agents. (e) A **colony** is a visible cluster of bacteria on an agar plate, grown from microbes left on the agar — in the handwashing investigation, by fingertips.

Question 2 (a) Coughing into the elbow — **exit**: droplets are blocked at the source. (b) Quarantine of exposed people — **source** (it also stops **entry** of the disease into a community): people who may carry it are kept apart before symptoms appear. (c) Handwashing before eating — **spread**: microbes are rinsed off the hands before they can complete the surface-to-face route. (d) Antibiotics for a bacterial infection — **pathogen**: the medicine kills the bacteria or stops them dividing. (e) A mask on the sick person — **exit**: droplets are caught as they leave.

Question 3 **Isolation**: (i) the confirmed case in a separate room, and (iii) the sick student sent home — both separate people who **are** sick. **Quarantine**: (ii) the exposed people watching for symptoms, and (iv) the household contact not yet sick — both separate people who **may have been exposed**, for the disease's longest hidden period. The sorting test is one question: *is this person already sick (isolation), or possibly exposed but not yet sick (quarantine)?*

Question 4 Reduction = $74 - 32 = 42$ colonies. Percentage reduction = $42 \div 74 = 0.5676 \rightarrow 57\%$ (to the nearest whole percent). Note the starting value here is the *water-only* count, because the comparison asked for is soap against water — always divide by the value you are comparing against.

Question 5 (1) A **clear, specific action** — “Stay home. Rest. Drink fluids. Cover your cough. Wash your hands with soap.” (2) A **reason that matters to the reader** — “Protect the people around you — your family, classmates and workmates.” (3) **Aimed at its audience** — the poster speaks to people who are out at work and school (“classmates and workmates”). (4) **From a trusted, named source** — in a real campaign a health authority, school or clinic; on the example poster, this book, labelled as such.

Question 6 (a) **Direct contact / contaminated hands** (the handshake, then the eye) — blocked by **handwashing with soap** before touching the face. (b) **Food and water** — blocked by **treating or boiling drinking water** (or drinking bottled water). (c) **Particles in the air** — reduced by **ventilation, distance and masks**, which remove or catch the particles. (d) **Vector** — blocked by **preventing bites** (repellent, nets, covering skin) and by controlling the animal that carries the pathogen.

Question 7 A pathogen completes its chain only if **every** link holds; breaking any one link stops that chain. But no single measure breaks every link on every occasion: a mask catches most droplets, not all; handwashing misses the airborne route; isolation ends when the person returns; education fades if campaigns stop. Each measure also fails sometimes — worn badly, skipped, forgotten. Combining measures means the links a first measure misses are covered by another, so the chance of the chain completing falls again and again. The chain model makes this precise: measures multiply their protection because they act on **different links**.

Question 8 **Isolation** separates people who **are** sick and infectious; it is used once illness is confirmed or obvious. **Quarantine** separates people (or animals or goods) who **may have been exposed** but are not yet sick; it is used after a known exposure, and lasts through the longest time the disease can take to show. The one thing both achieve: they break the chain at the **source** link — the sick or possibly-sick are apart before the pathogen can reach a new host.

Question 9 (a) Border quarantine mainly breaks the chain between **source and new host** — infected arrivals are kept apart (or the virus is kept out entirely), so the spread link into the community never forms. (b) With the virus already in the eastern states, interstate quarantine made movement between states a checked, slowed route: fewer infectious people arrived, and those who did were caught early. Queensland, Western Australia and Tasmania therefore received the virus later, and their epidemics peaked later — quarantine did not always stop the disease, but it **bought time** for each region.

Question 10 (a) A full course continues long enough to kill the last of the susceptible bacteria, including the hardest to reach. **Stopping early** kills only the most susceptible and leaves the partly resistant ones alive; these divide, and the population that remains is, on average, more resistant than the one the course began with. (b) Antibiotics act on **bacteria**, not viruses, so during a viral illness they have nothing to treat — but they still kill susceptible bacteria living harmlessly in the body, leaving the resistant few to multiply. In both cases the model’s middle panel runs without its final step: susceptible bacteria die, the resistant few survive, and — if the misuse repeats — the resistant take over.

Question 11 (a) In the high-uptake community, most people are protected, so a chain of spread keeps meeting protected people in whom the disease cannot establish and pass on; chains stop after one or two steps and the outbreak stays small (two sick people in the model, against nine in the low-uptake community). (b) People who cannot be vaccinated — newborns, and people with some medical conditions — are shielded because the chains that would have reached them stop at the protected people around them. Their safety comes from the community’s uptake, not from anything their own bodies do. (c) The subtopic does not explain, by design, **how the body itself builds protection after a vaccine** — the cells and molecules involved. That mechanism is VCE Biology (Unit 4, Area of Study 1, “How do organisms respond to pathogens?”), reference-only for this book (TOC D9).

Question 12 Anyone arriving must declare **food, and plant or animal material** (for example fruit, vegetables, seeds, meat or wooden goods). When checks find a risk, the outcomes are: the item is **taken and destroyed**; for a serious risk, the item is **treated, held or quarantined**; and **fines can apply**. Where no risk is found, the item or person enters Australia.

Question 13 (a) Quarantine’s idea is: keep the possibly-carrying material apart from the vulnerable population until it is checked. An exclusion zone applies this to a pest: fruit that **could** carry fruit-fly eggs or larvae must not enter a pest-free region, just as exposed people or goods must not enter a disease-free community unchecked. The “possibly exposed” group is the fruit; the “new hosts” are the orchards. (b) A single infested fruit can carry eggs that hatch into breeding adults; one mated female can start a population, and an established pest costs Australian horticulture about \$28.5 million a year and can destroy up to a whole exposed crop. The rule is strict because the consequence of one lapse is an outbreak, not an individual illness.

Question 14 The figure is labelled “**a model for classroom discussion — not data from a real outbreak**”, so it can support claims about *shape and comparison*: combined measures give a lower, later peak that stays within service capacity, while no measures give a high, fast peak that overwhelms it. That supports reasoning such as “the measures would reduce the peak below what services can manage”. It cannot **prove** that lives were saved in any real event, because no real event was measured: the curves are smooth, idealised shapes chosen to show a mechanism, and a real outbreak has noise, behaviour change and luck. *Proves* also overstates what any single representation can do — evidence accumulates from real data (as in the handwashing evidence of Family 1), and models are for understanding and discussion.

Question 15 (a) For example: *Does washing hands with soap for 30 s (then drying) leave fewer bacterial colonies on agar than washing with water only?* (b) Independent variable: **the handwashing treatment** (water only / soap and time / none). Dependent variable: **the number of bacterial colonies** counted on each plate after incubation. (c) Keep the same (any two): the person pressing their fingertips; the pressure and area of the fingertip press; the incubation time and temperature; the type of agar and plates; when in the day the presses happen. (d) Safety rule and reason (any one): incubate plates **sealed and upside-down** so condensation and colonies cannot fall out or leak; **never open a grown plate** so grown microbes are not released or touched; **wash hands before and after** so the investigation does not itself spread microbes; dispose of plates by the school's approved method.

Question 16 The first half — “vitamin drops kill viruses, so you don’t need a flu vaccine” — fails every test this subtopic teaches: it offers no **trusted, named source** and no evidence, it contradicts the population-level evidence behind vaccination programs, and it asks the reader to drop a proven measure on a promise. The second half — “and antibiotics work too, just in case” — is wrong on the science: antibiotics treat **bacterial** infections and do nothing against viruses, so taking them “just in case” for a viral illness cannot help and actively harms by driving resistance (Family 3). A health claim becomes trustworthy when it comes **from a named, trusted source** (a health authority or clinic), says **clearly what to do**, gives a **reason that matters**, and rests on published evidence — the anatomy of the campaign figure, plus the claim-evaluation work of Chapter 16. This claim has none of these, so both halves should be rejected.

Where this leads: the control-measures picture taught here sits beside Subtopic 8C’s account of pathogens and causes; together they deliver VC2S10U03. The one stop in this subtopic is the body’s own defence: **how a vaccinated or infected body recognises and fights a pathogen — antibodies, lymphocytes and the immune response — is VCE Biology Unit 4, Area of Study 1 (“How do organisms respond to pathogens?”)**, reference-only for this book, and is not taught here (TOC D9). Resistance, treated here as a population model, is explained by natural selection in Chapter 9; the evaluation of health claims and misinformation continues in Chapter 16.

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