

Coordination and response revision notes

Organisms detect changes in their surroundings and respond to them. This topic covers how the nervous system carries electrical impulses, how the eye detects light and how hormones and the chemical control of plant growth coordinate responses. It also covers homeostasis, the maintenance of a constant internal environment.

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). **Supplement** is Extended content, only examined on Papers 2 and 4.

1 Nervous control Spec 14.1

The nervous system and neurones Spec 14.1.1, 14.1.2, 14.1.3, 14.1.4

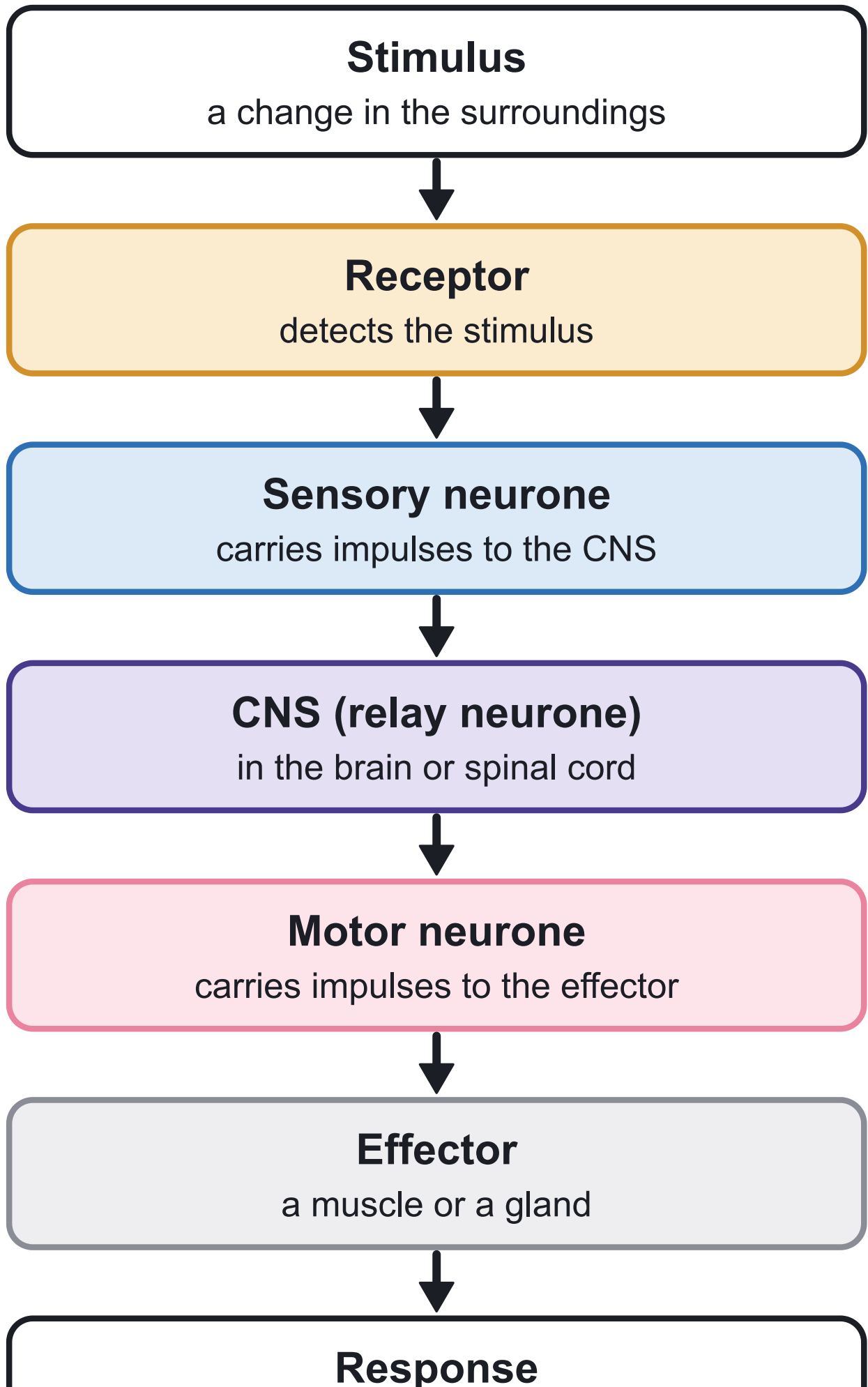
Electrical impulses travel along cells called **neurones**. Neurones carry information quickly between the parts of the body.

The mammalian nervous system has two parts.

- The **central nervous system (CNS)** consists of the **brain and the spinal cord**.
- The **peripheral nervous system (PNS)** consists of the **nerves outside of the brain and spinal cord**.

The role of the nervous system is the **coordination and regulation of body functions**. Receptors detect a change (a stimulus), impulses pass along neurones to the CNS, and the CNS sends impulses to effectors (muscles and glands), which produce a response.

1. Stimulus (a change in the surroundings)
2. Receptor detects the stimulus
3. Impulses travel along a sensory neurone to the CNS
4. The CNS coordinates the response
5. Impulses travel along a motor neurone to an effector
6. Effector (muscle or gland) produces the response

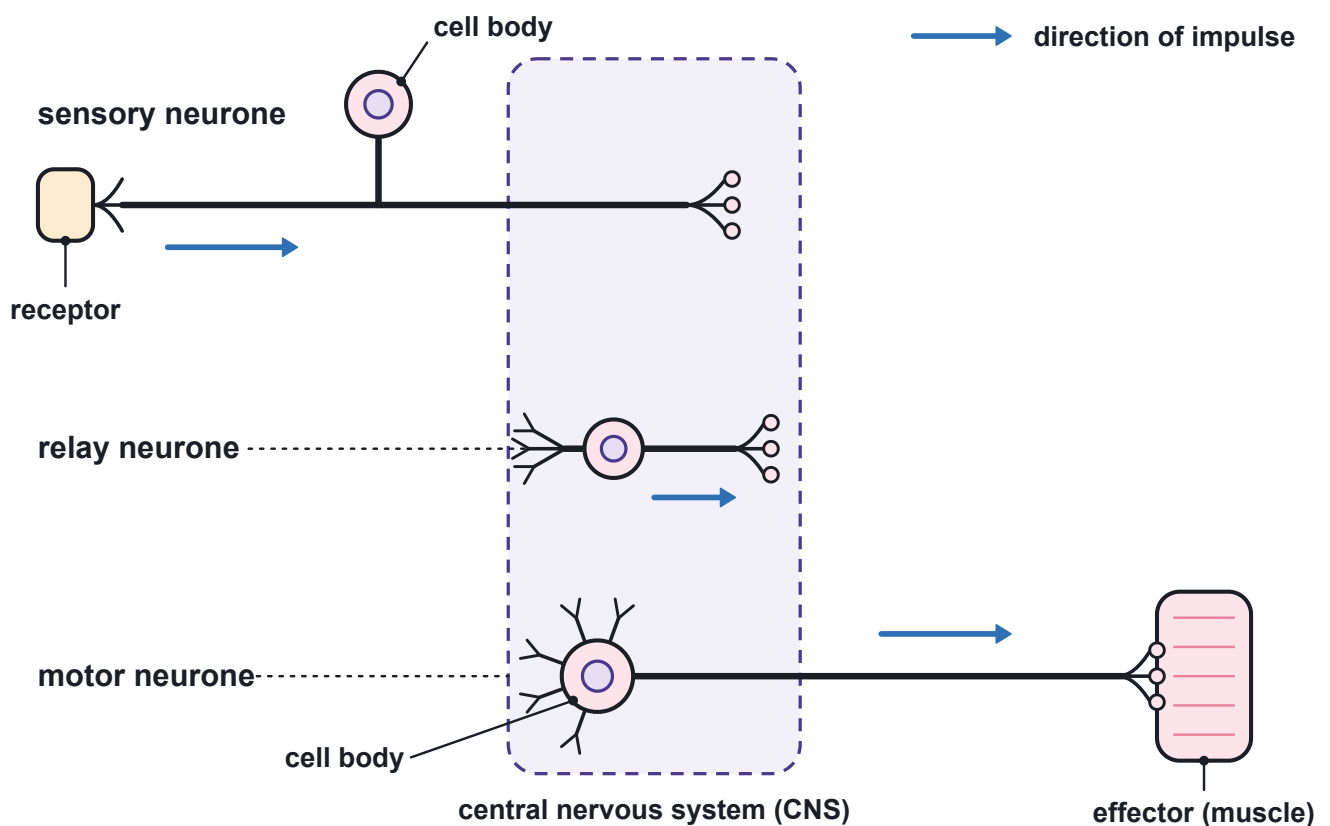


e.g. a muscle contracts

The pathway from **stimulus** to **response**.

Three types of neurone

Sensory, relay and motor neurones		
Neurone	Where it carries impulses	How to identify it in a diagram
Sensory neurone	From a receptor to the CNS	Receptor at one end; the cell body is off to the side of the long fibre; the fibre enters the CNS
Relay neurone	Within the CNS, from the sensory neurone to the motor neurone	Short; found entirely inside the CNS; connects the other two types
Motor neurone	From the CNS to an effector (a muscle or a gland)	Cell body inside the CNS at one end; long fibre leaving the CNS to the effector



The three types of neurone. Only the **relay neurone** lies wholly inside the CNS.

Exam tip: To identify a neurone, ask where it is and which way the impulse goes. Only the relay neurone sits wholly inside the CNS. Remember the PNS is the nerves, not the brain or spinal cord.

Reflex actions and reflex arcs Spec 14.1.5, 14.1.6

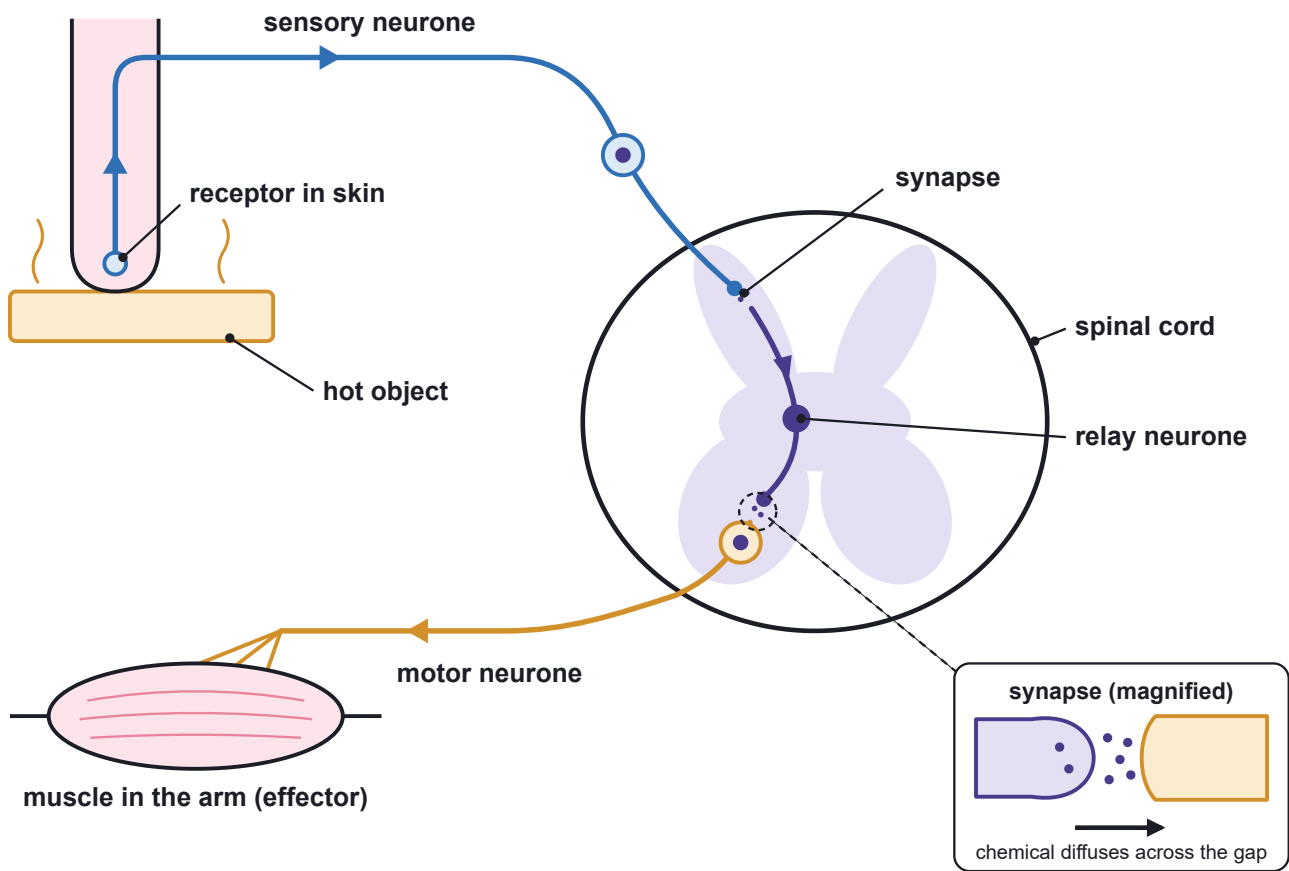
Reflex action

A means of automatically and rapidly integrating and coordinating stimuli with the responses of effectors (muscles and glands).

A reflex action is **automatic** and **rapid**. You do not have to think about it first. Reflexes protect the body from harm, for example pulling your hand away from something hot.

A **simple reflex arc** is the pathway that the impulses follow. It has five parts: **receptor**, **sensory neurone**, **relay neurone**, **motor neurone** and **effector**.

Parts of a simple reflex arc	
Part	Function
Receptor	Detects the stimulus and starts an impulse
Sensory neurone	Carries impulses from the receptor to the CNS
Relay neurone	Carries impulses within the CNS from the sensory neurone to the motor neurone
Motor neurone	Carries impulses from the CNS to the effector
Effector	A muscle (contracts) or a gland (secretes) that produces the response



A reflex arc. The impulse goes **receptor** → **sensory neurone** → **relay neurone** → **motor neurone** → **effector**.

Exam tip: Describe the pathway in order and name each part. If asked why a reflex is useful, use the words 'rapid', 'automatic' and 'protects the body from harm'.

Synapses Spec 14.1.7, 14.1.8, 14.1.9, 14.1.10

Synapse	A junction between two neurones.
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There is a tiny gap between one neurone and the next. The electrical impulse cannot cross this gap, so a chemical is used instead.

Supplement

Structure of a synapse

Supplement

- Vesicles in the first neurone contain neurotransmitter molecules.
- The synaptic gap separates the two neurones.
- The membrane of the next neurone has receptor proteins.

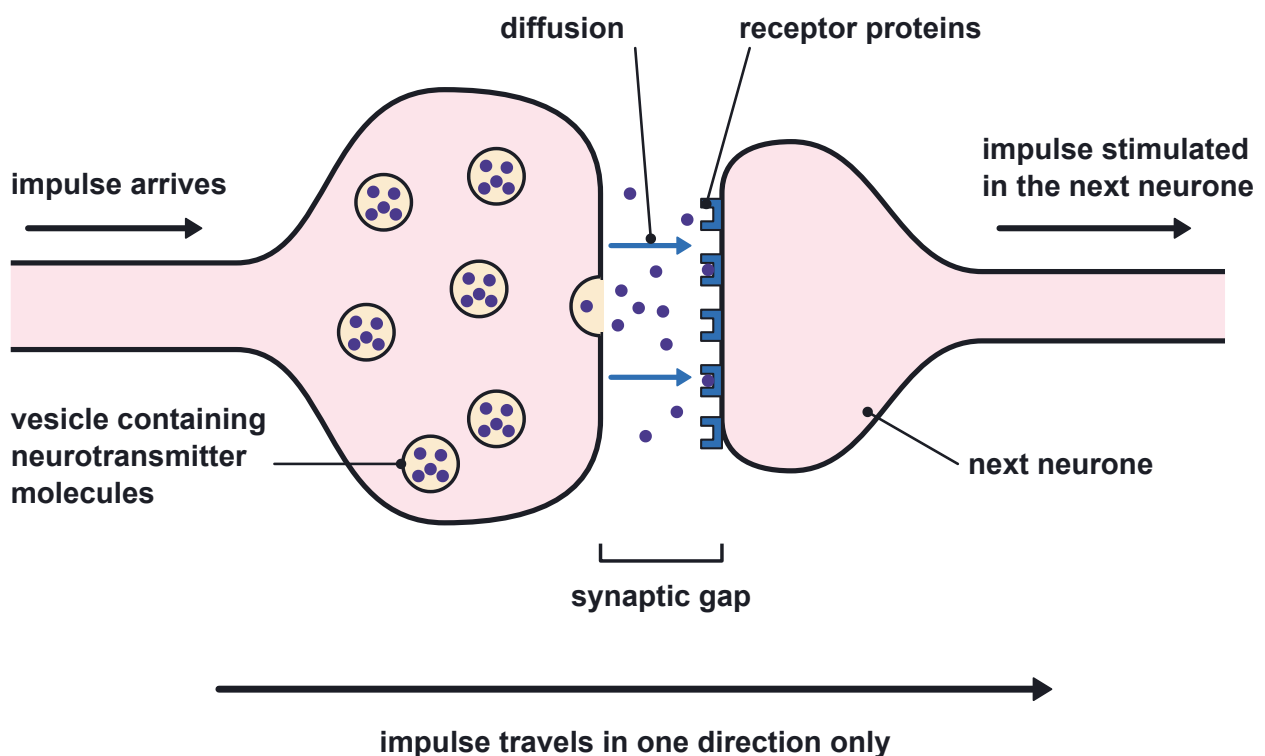
Supplement

Events at a synapse

Supplement

1. An impulse arriving at the end of the first neurone stimulates the release of neurotransmitter molecules from vesicles into the synaptic gap.
2. The neurotransmitter molecules diffuse across the gap.
3. The neurotransmitter molecules bind with receptor proteins on the next neurone.
4. An impulse is then stimulated in the next neurone.

Supplement



At a synapse, neurotransmitter molecules diffuse across the synaptic gap and bind to receptor proteins on the next neurone.

Supplement

Synapses ensure that **impulses travel in one direction only**. Neurotransmitter is released from only one side of the gap, and the receptor proteins are only on the next neurone.

Supplement

Common mistake: The impulse itself does not cross the gap. The neurotransmitter diffuses across and starts a new impulse in the next neurone.

Quick check

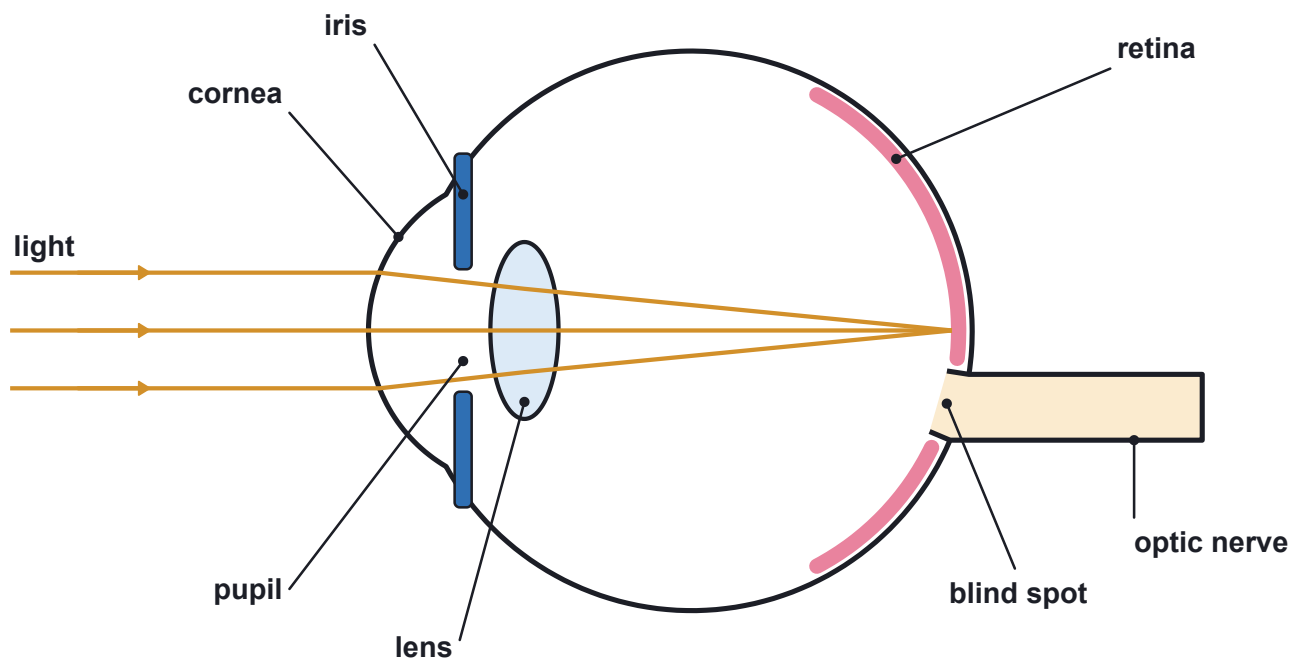
1. What does the central nervous system consist of?
2. Which neurone is found entirely within the CNS?
3. Name the five parts of a simple reflex arc in order.
4. What is a synapse?
5. **Supplement** What diffuses across the synaptic gap?

2 Sense organs Spec 14.2

Sense organs and the eye Spec 14.2.1, 14.2.2, 14.2.3

Sense organs are groups of **receptor cells** responding to **specific stimuli**: light, sound, touch, temperature and chemicals. The eye is a sense organ that responds to light.

Structures of the eye	
Structure	Function
Cornea	Refracts (bends) light as it enters the eye
Iris	Controls how much light enters the pupil
Pupil	The hole in the centre of the iris through which light enters
Lens	Focuses light on to the retina
Retina	Contains light receptors, some sensitive to light of different colours
Optic nerve	Carries impulses to the brain
Blind spot	The place where the optic nerve leaves the eye. It has no receptors, so it is not sensitive to light



Structures of the eye. The **blind spot** is where the optic nerve leaves the eye.

*Exam tip: Give the job of each structure with the exact verb: the cornea **refracts** light, the lens **focuses** light, the iris **controls how much light enters**. The optic nerve carries impulses, not images, to the brain.*

The pupil reflex Spec 14.2.4, 14.2.5

The **pupil reflex** changes the diameter of the pupil when the light intensity changes. It is an automatic response, which protects the retina and lets enough light in to see.

The pupil reflex

	Bright light	Dim light
Pupil diameter	Gets smaller (constricts)	Gets larger (dilates)
Amount of light entering the eye	Less	More
Effect	Protects the retina from damage	Allows more light to reach the retina so you can see better

Supplement

Antagonistic muscles in the iris

Supplement

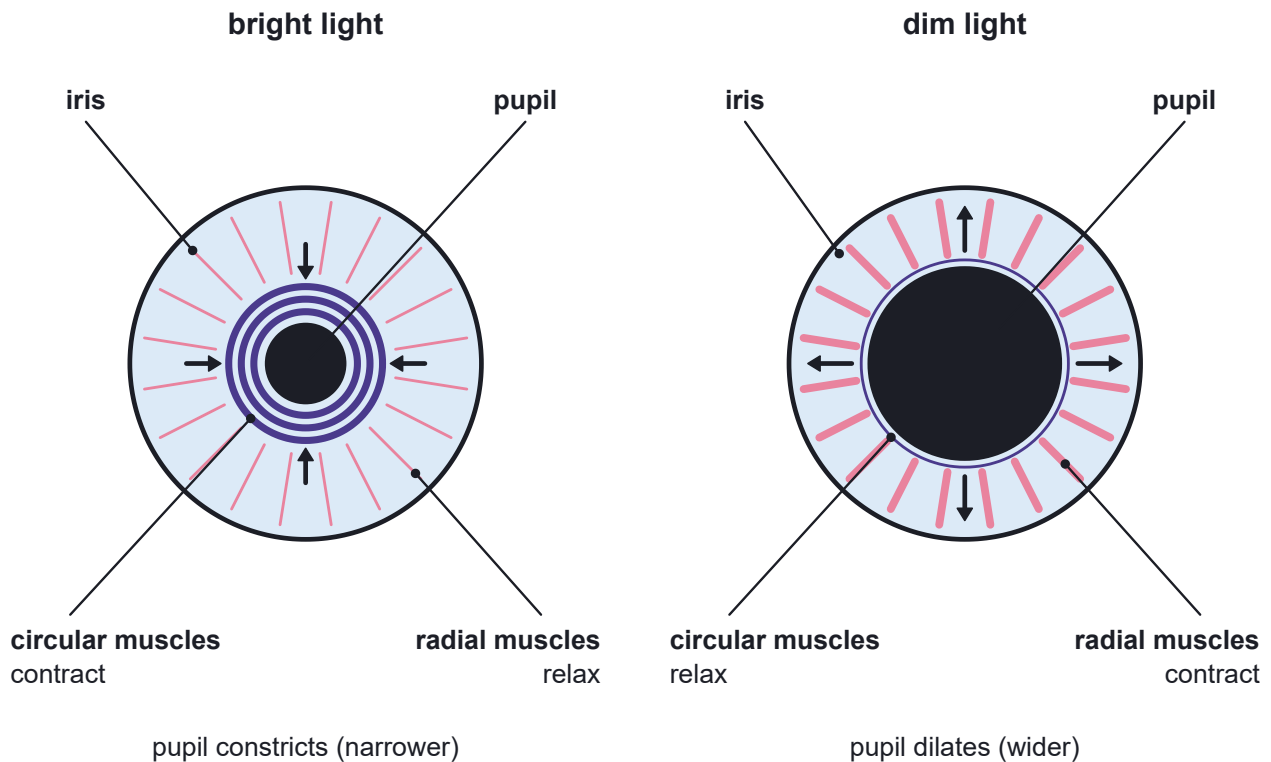
The iris contains two sets of muscles that work against each other. These are **antagonistic** muscles. **Circular muscles** form rings around the pupil. **Radial muscles** run outwards like the spokes of a wheel.

Supplement

Antagonistic action of the iris muscles

	Bright light	Dim light
Circular muscles	Contract	Relax
Radial muscles	Relax	Contract
Pupil	Constricts (narrower)	Dilates (wider)

Supplement



The pupil reflex. Bright light: **circular muscles contract**. Dim light: **radial muscles contract**.

Supplement

Common mistake: Radial muscles contract to make the pupil wider. Circular muscles contract to make it narrower. Always say which set contracts and which relaxes.

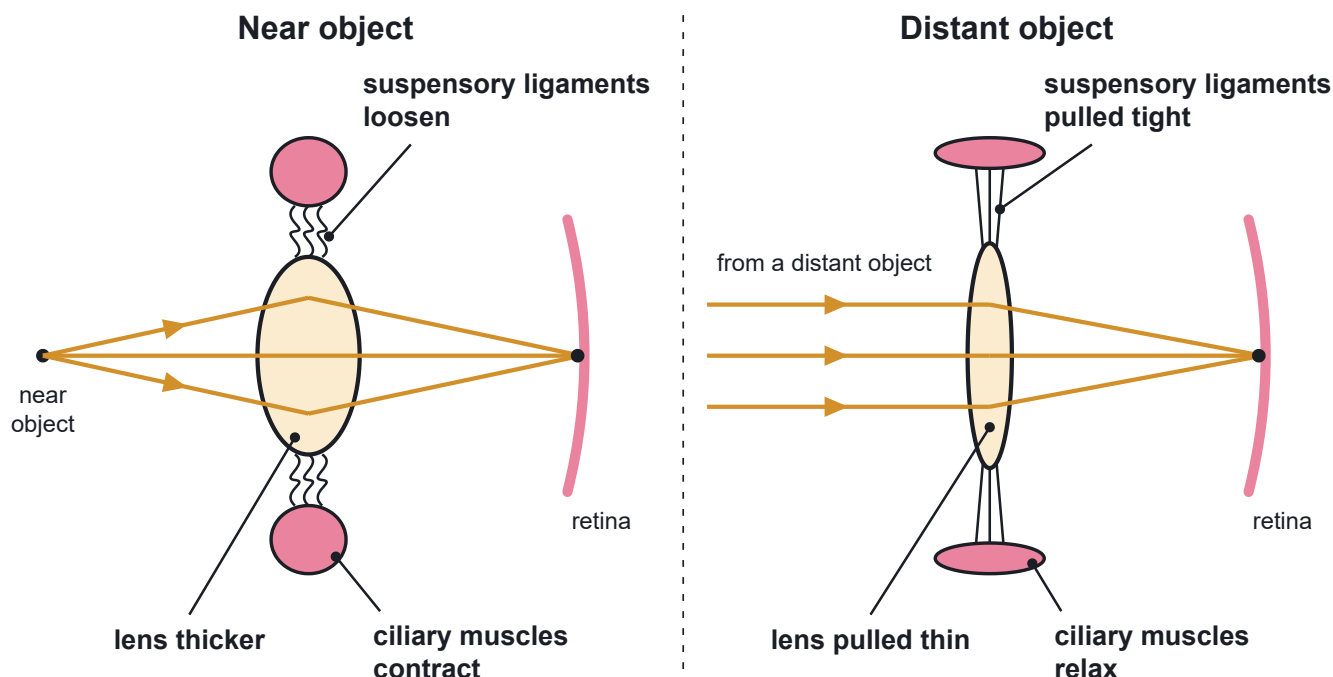
Accommodation Spec 14.2.6 Supplement

Accommodation Changing the shape of the lens to focus on near or distant objects.

The **ciliary muscles** form a ring around the lens. The lens is held in place by the **suspensory ligaments**, which join it to the ciliary muscles. When the ciliary muscles contract or relax, the tension in the suspensory ligaments changes. This changes the shape of the lens, so it **refracts** light by a different amount.

Focusing on near and distant objects

	Near object	Distant object
Ciliary muscles	Contract	Relax
Tension in suspensory ligaments	Decreases (ligaments slack)	Increases (ligaments pulled tight)
Shape of lens	Thicker (more curved)	Thinner (flatter)
Refraction of light	Light is refracted more	Light is refracted less



Accommodation. Near object: muscles contract, ligaments loosen, lens thicker. Distant object: muscles relax, ligaments tight, lens thin.

Common mistake: For a near object the ciliary muscles contract and the ligaments go slack. Many students reverse this. Remember: contracted muscle, slack ligaments, fat lens.

Rods, cones and the fovea

Spec 14.2.7, 14.2.8, 14.2.9

Supplement

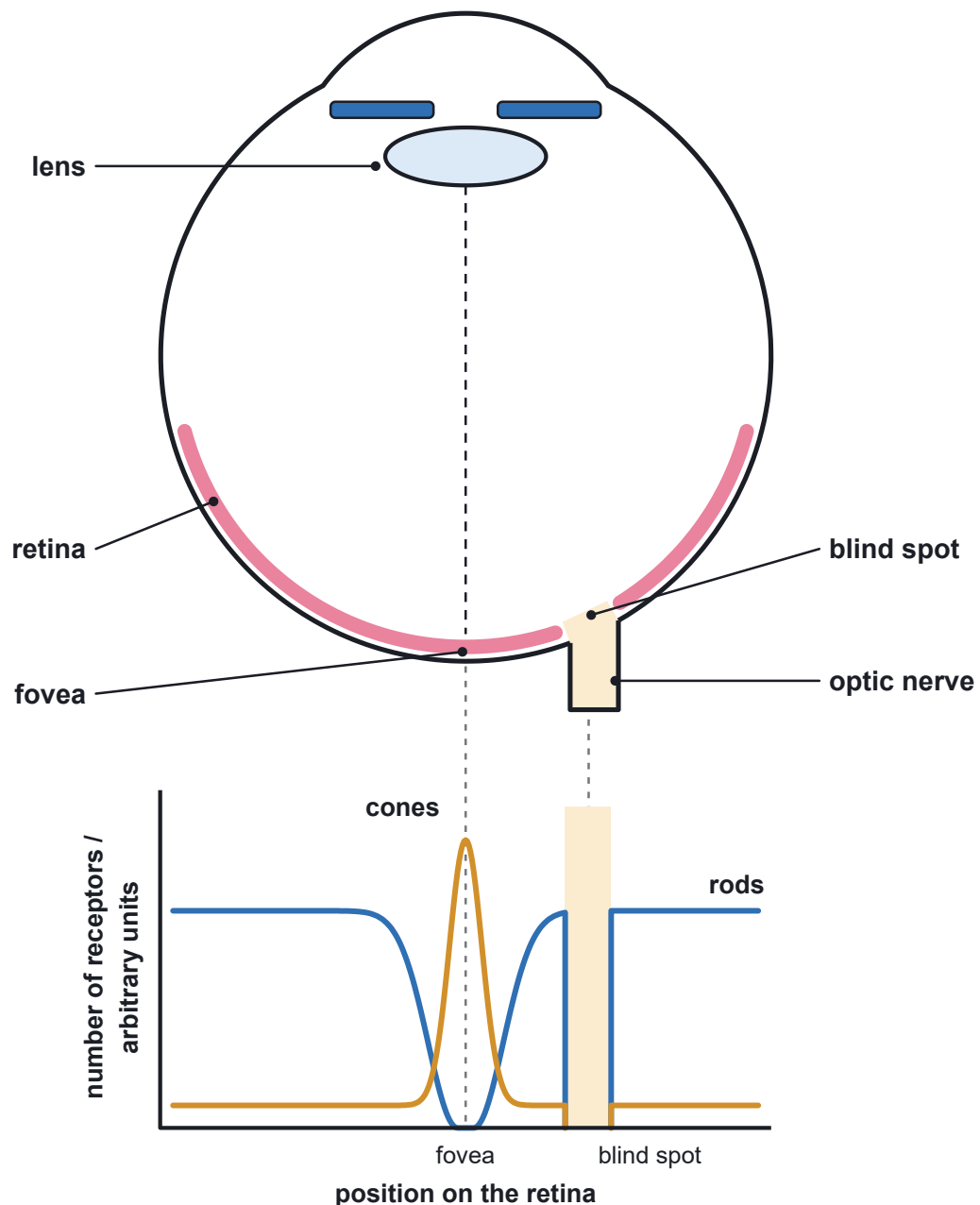
The retina contains two types of light receptor, rods and cones.

Rods and cones		
	Rods	Cones
Distribution in the human retina	Spread over the retina, more towards the edges; none in the fovea	Packed closely in the fovea, with fewer over the rest of the retina
Function	Greater sensitivity to light, so used for night vision (dim light)	Colour vision, in bright light
Types	One type	Three different kinds, absorbing light of different colours

The three kinds of cone absorb red, green and blue light. The brain combines the signals from the three kinds to give colour vision.

The fovea

The fovea is a small area of the retina directly behind the lens. Its function is to give the sharpest vision (the greatest detail) because it has a very high density of cones. When you look straight at an object, its image falls on the fovea.



Cones are packed into the **fovea**; rods are absent there and more common towards the edges. The **blind spot** has no receptors.

Exam tip: Link the receptor to the light level: rods for dim light (night vision) and cones for bright light and colour. Say the fovea has the highest density of cones and no rods, so it gives the sharpest vision.

Quick check

1. Which structure of the eye refracts light as it enters?
2. What is the blind spot?
3. What happens to the pupil in bright light?
4. **Supplement** Which muscles of the iris contract to widen the pupil?
5. **Supplement** What is the function of the fovea?

3 Hormones Spec 14.3

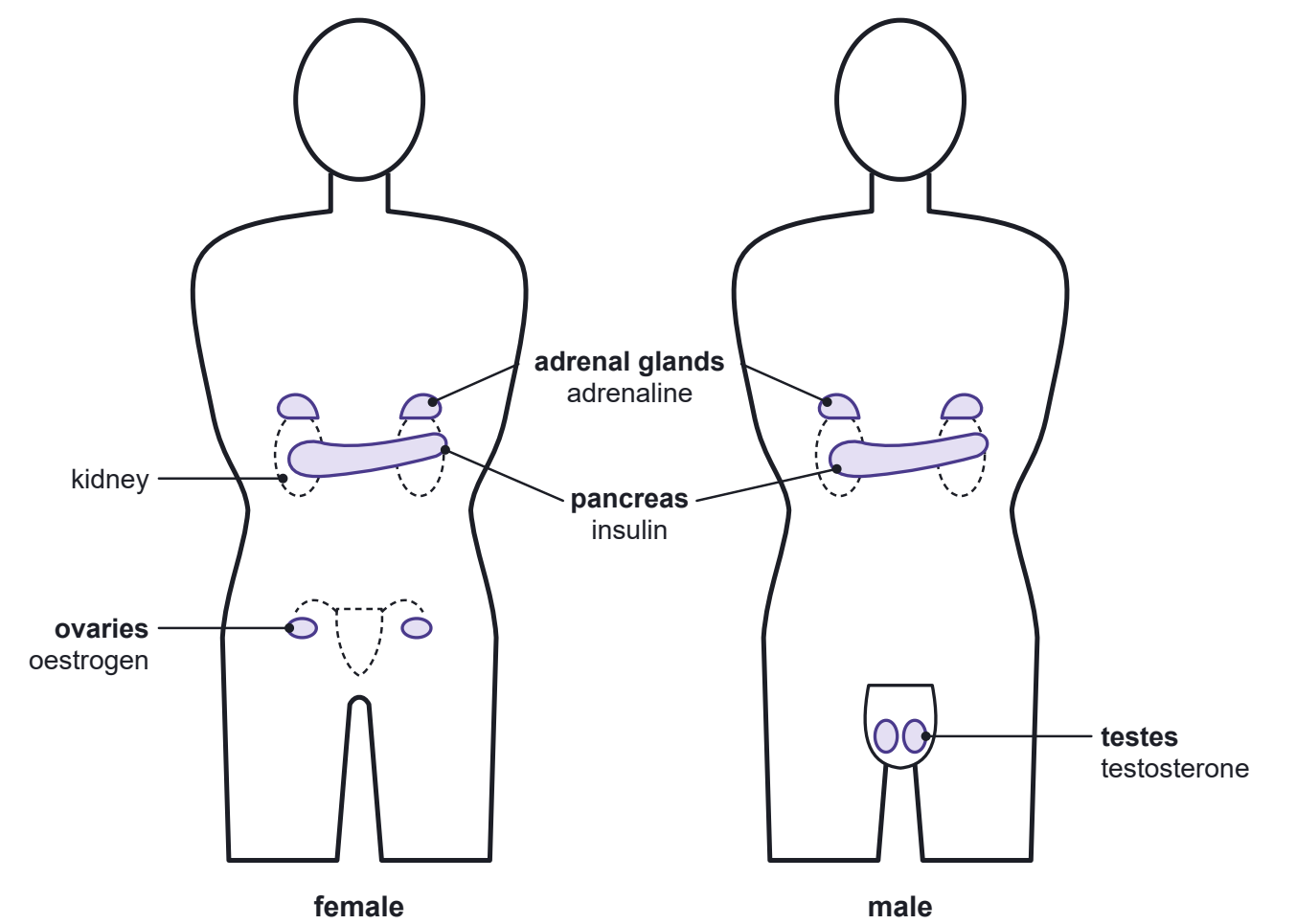
Hormones and endocrine glands Spec 14.3.1, 14.3.2, 14.3.4

A **hormone** is a chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs.

Hormone

A chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs.

The glands that make hormones are called **endocrine glands**. They release hormones straight into the blood. The blood carries the hormone around the whole body, but it only affects its target organs.



The endocrine glands and the hormones they secrete.

Endocrine glands and the hormones they secrete	
Gland	Hormone secreted
Adrenal glands	Adrenaline
Pancreas	Insulin
Testes	Testosterone
Ovaries	Oestrogen

Nervous control and hormonal control

Comparing nervous and hormonal control

	Nervous control	Hormonal control
Speed of action	Very fast: impulses travel quickly along neurones	Slower: hormones travel in the blood
Duration of effect	Short: the effect stops soon after the impulse stops	Longer: the effect can last minutes, hours or longer

Exam tip: In a comparison, always give both sides. Say 'nervous is fast and hormonal is slower', not just 'hormones are slow'.

Adrenaline Spec 14.3.3, 14.3.6

Adrenaline is the hormone secreted by the adrenal glands in 'fight or flight' situations. These are moments of danger or stress when the body must get ready to fight or run away.

- Increased breathing rate
- Increased heart rate
- Increased pupil diameter

These changes get more oxygen and glucose to the muscles quickly, and let more light into the eyes so the person can see the danger better.

Supplement

Adrenaline and metabolic activity

Supplement

Adrenaline also controls metabolic activity. It **increases the blood glucose concentration** and **increases heart rate**.

Supplement

- Adrenaline increases the blood glucose concentration, so more glucose is available to the muscles.
- Adrenaline increases heart rate, so this glucose, and oxygen, reach the muscles more quickly.
- The muscle cells use the glucose in respiration to release energy for movement.

Common mistake: Adrenaline is spelt with an e at the end. Do not write that it 'gives you energy'. It raises blood glucose so cells can release energy by respiration.

Quick check

1. Which gland secretes insulin?
2. Name the hormone made by the testes.
3. Which type of control has the longer-lasting effect, nervous or hormonal?
4. **Supplement** State two ways adrenaline affects the metabolic activity of the body.

4 Homeostasis Spec 14.4

Homeostasis and negative feedback Spec 14.4.1, 14.4.3

Homeostasis is the maintenance of a constant internal environment. Cells only work well when conditions around them stay steady. Two things the body keeps steady are the **body temperature** and the **blood glucose concentration**.

Homeostasis

The maintenance of a constant internal environment.

Supplement

Negative feedback

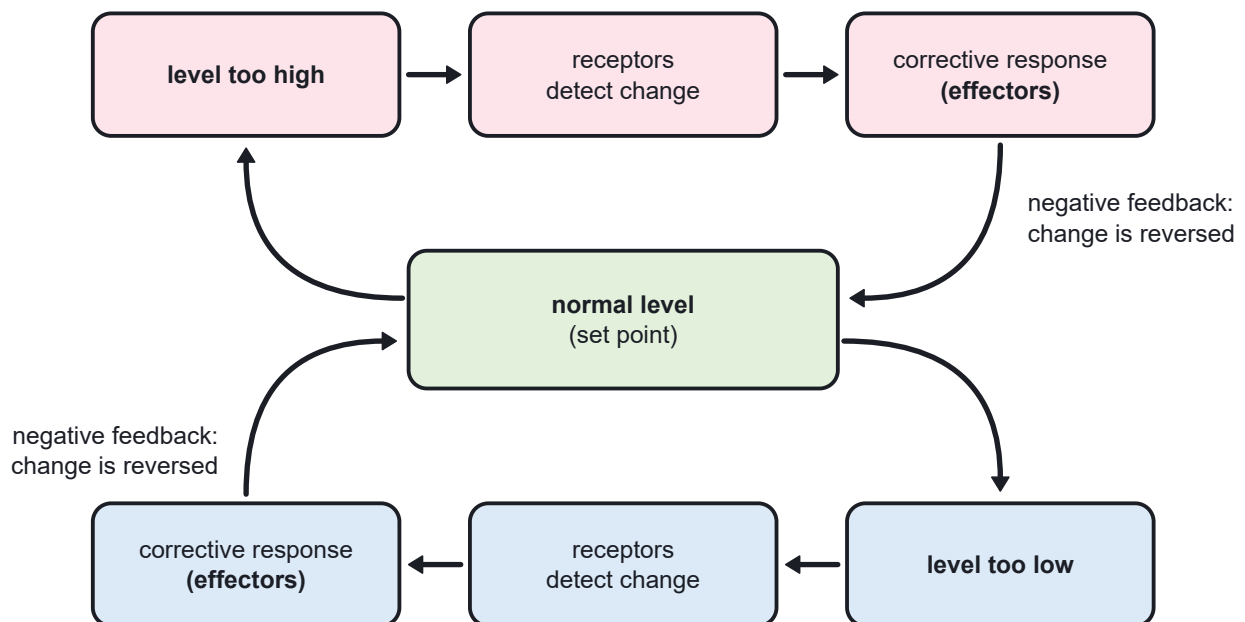
Supplement

Homeostatic control works by **negative feedback**. The body has a **set point**, which is the normal level for the factor being controlled. If the level moves away from the set point, the body responds so that the level changes back towards the set point.

Supplement

1. The level of a factor (for example blood glucose) changes away from the set point.
2. Receptors detect the change.
3. A control system (for example the brain or the pancreas) coordinates a response.
4. Effectors act to reverse the change, so the level returns towards the set point.
5. When the level is back at the set point, the response is reduced or stops.

Supplement



Negative feedback: any change away from the set point is reversed.

Supplement

Exam tip: Negative feedback does not keep a level exactly fixed. The level goes slightly above and below the set point, and the response brings it back each time.

Controlling blood glucose Spec 14.3.5, 14.4.2, 14.4.4

The pancreas secretes the hormone **insulin**. Insulin decreases blood glucose concentration.

Supplement

Insulin is secreted when the blood glucose concentration is too high, for example after a meal containing carbohydrate. The pancreas also secretes a second hormone, **glucagon**, when the blood glucose concentration is too low.

Supplement

The role of the liver

Supplement

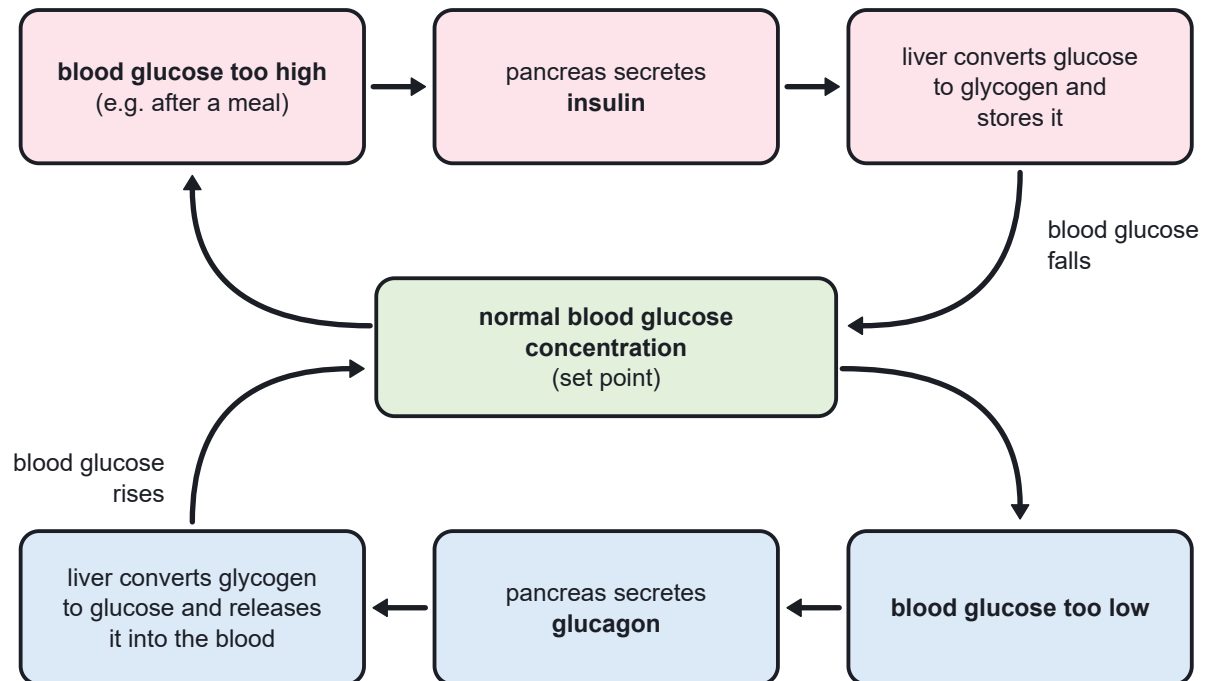
The **liver** controls blood glucose concentration by storing and releasing glucose. It stores glucose as **glycogen**. Insulin and glucagon both act on the liver.

Supplement

Control of blood glucose concentration

	Blood glucose too high	Blood glucose too low
Hormone secreted by the pancreas	Insulin	Glucagon
Response of the liver	Converts glucose to glycogen, which it stores	Converts glycogen to glucose and releases it into the blood
Effect on blood glucose	Decreases	Increases

Supplement



Control of blood glucose. **Insulin** lowers it and **glucagon** raises it, both acting on the **liver**.

Supplement

Common mistake: Insulin and glucagon are hormones. Glycogen is the storage carbohydrate. Do not mix up the three names.

Type 1 diabetes Spec 14.4.5 Supplement

In **Type 1 diabetes**, the pancreas produces little or no insulin. After a meal the blood glucose concentration rises and stays too high, because it is not brought back down.

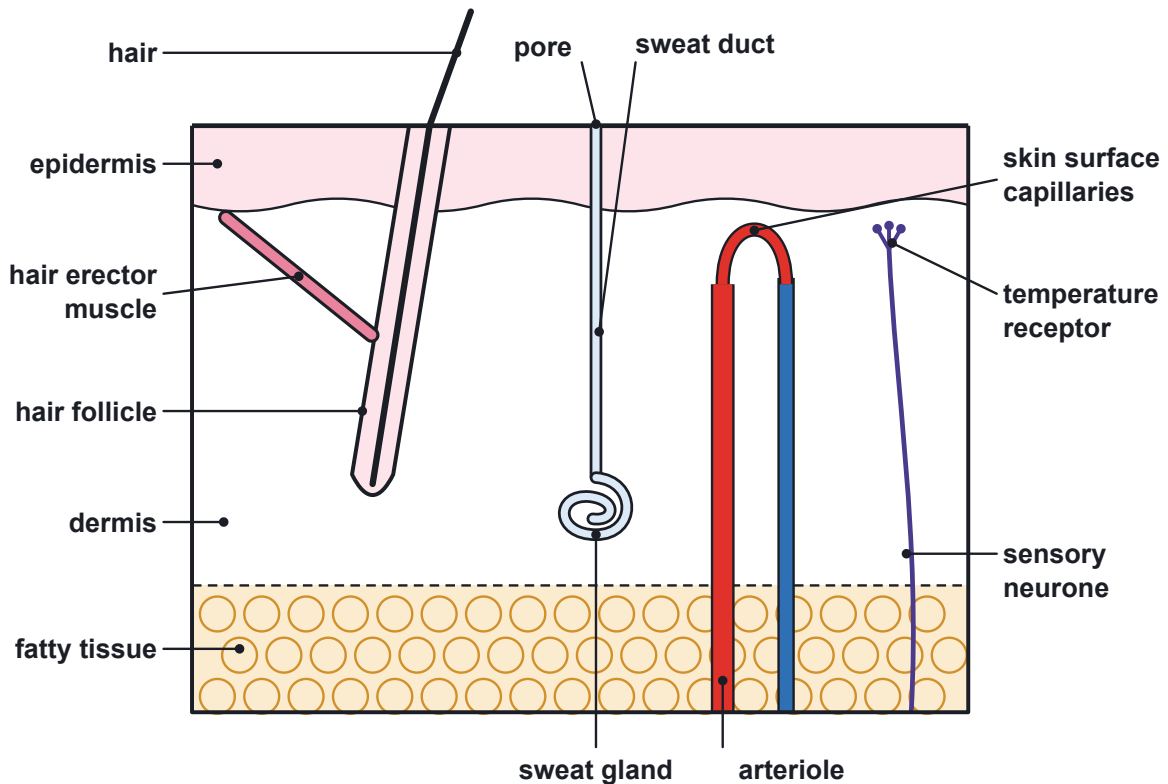
Treatment of Type 1 diabetes has three main parts.

- **Insulin injections**, usually at mealtimes, to lower the blood glucose concentration.
- **Monitoring** the blood glucose concentration, so the right dose of insulin can be given.
- Managing the **diet**, especially the amount of carbohydrate eaten, to avoid large rises in blood glucose.

Exam tip: Insulin is a protein, so it is injected. If it were swallowed it would be digested in the gut.

The skin and temperature control Spec 14.4.6, 14.4.7, 14.4.8 Supplement

Mammals keep their internal body temperature constant (about 37 °C in humans). Temperature receptors in the skin send impulses along sensory neurones to the brain, and the brain also detects the temperature of the blood. The **brain** compares the body temperature with the set point and coordinates the responses of the effectors: sweat glands, muscles, hair erector muscles and arterioles.



Structures in the skin used in temperature control.

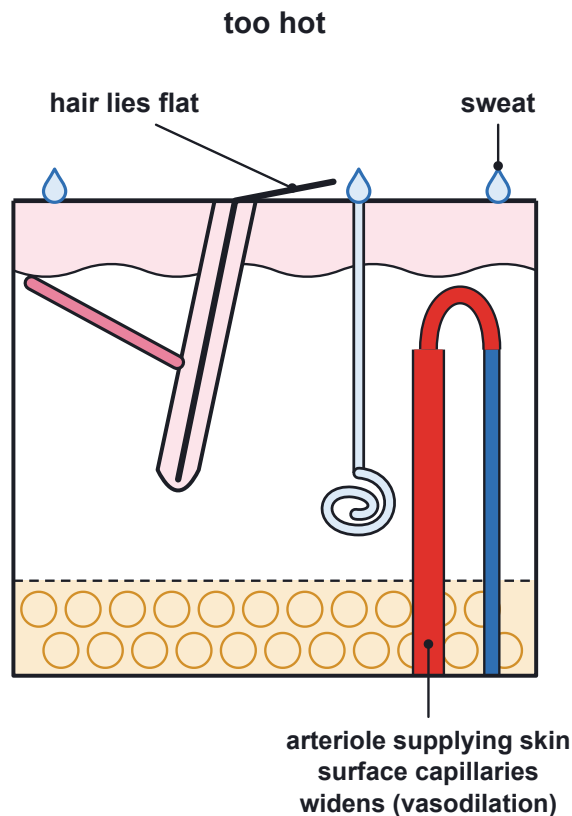
Structures of the skin	
Structure	Role in temperature control
Hairs	Raised in the cold to trap a layer of air (insulation)
Hair erector muscles	Contract to raise the hairs; relax to lower them
Sweat glands	Release sweat onto the skin surface
Receptors	Detect temperature changes
Sensory neurones	Carry impulses from the receptors to the brain
Blood vessels	Arterioles supplying skin surface capillaries change in width
Fatty tissue	Insulation: reduces heat loss

When the body is too hot

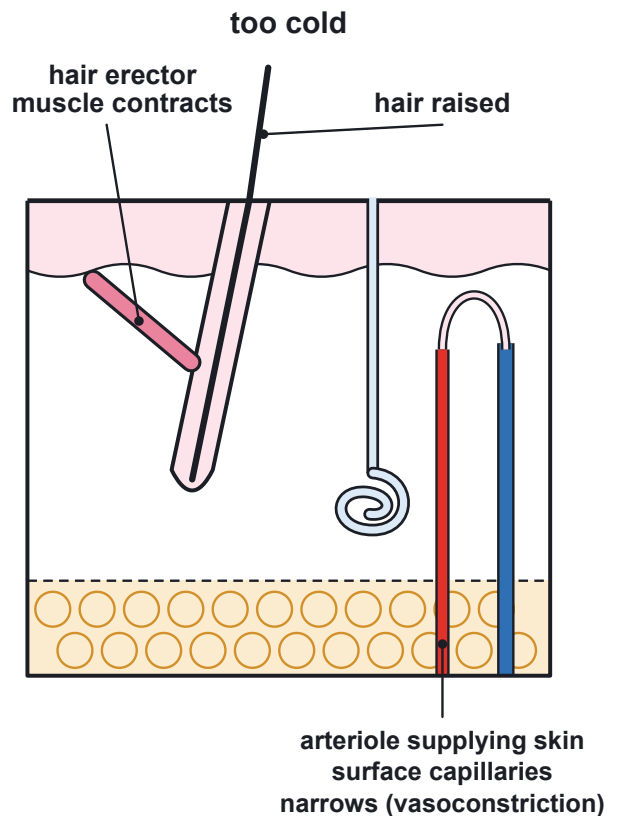
- **Sweating**: sweat evaporates from the skin and takes heat from the body.
- **Vasodilation**: the arterioles supplying the skin surface capillaries widen, so more blood flows through the capillaries and more heat is lost.

When the body is too cold

- **Shivering**: muscles contract rapidly, and respiration in them releases heat.
- **Vasoconstriction**: the arterioles supplying the skin surface capillaries narrow, so less blood flows near the surface and less heat is lost.
- **Insulation**: hairs are raised by the hair erector muscles to trap air, and fatty tissue under the skin reduces heat loss.



more blood flows through the capillaries



less blood flows through the capillaries

Vasodilation when too hot; **vasoconstriction** when too cold. The arterioles change width; they do not move.

Supplement

Common mistake: Blood vessels do not move up and down towards the skin surface. The arterioles get wider (vasodilation) or narrower (vasoconstriction).

Quick check

1. What is homeostasis?
2. What does insulin do to blood glucose concentration?
3. **Supplement** What is a set point?
4. **Supplement** What does the liver do with glucose when insulin is secreted?
5. **Supplement** What happens to the arterioles supplying the skin surface capillaries when the body is too cold?

5 Tropic responses Spec 14.5

Phototropism, gravitropism and auxin Spec 14.5.1, 14.5.2, 14.5.4, 14.5.5

Gravitropism is a response in which parts of a plant grow towards or away from gravity.

Phototropism is a response in which parts of a plant grow towards or away from the direction of the light source.

Gravitropism	A response in which parts of a plant grow towards or away from gravity.
Phototropism	A response in which parts of a plant grow towards or away from the direction of the light source.

Tropisms in shoots and roots

Plant part	Response to light	Response to gravity
Shoot	Grows towards light	Grows away from gravity (upwards)
Root	Grows away from light	Grows towards gravity (downwards)

Supplement

Chemical control of plant growth

Supplement

Phototropism and gravitropism of a shoot are examples of the **chemical control of plant growth**. The chemical is a plant hormone called **auxin**.

Supplement

- Auxin is made in the shoot tip.
- Auxin diffuses through the plant from the shoot tip.
- Auxin is unequally distributed in response to light and gravity.
- Auxin stimulates cell elongation.

Supplement

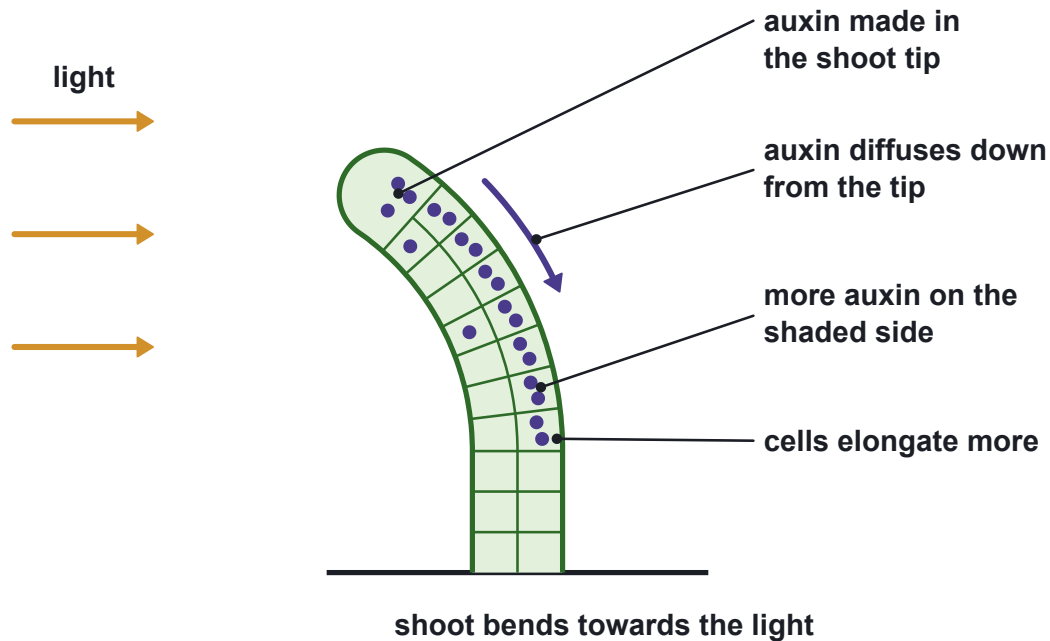
Phototropism of a shoot: when light shines from one side, auxin builds up on the shaded side. Cells on the shaded side elongate more than cells on the lit side, so the shoot bends towards the light.

Supplement

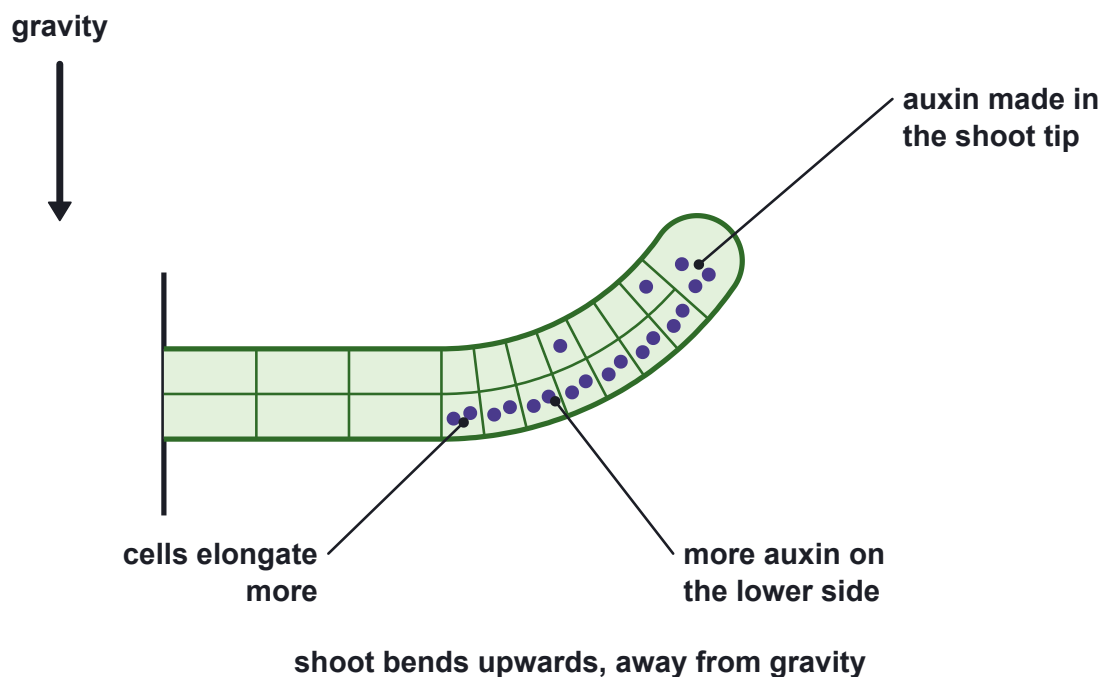
Gravitropism of a shoot: when a shoot is on its side, auxin builds up on the lower side. Cells on the lower side elongate more, so the shoot bends upwards, away from gravity.

Supplement

Phototropism of a shoot



Gravitropism of a shoot



Auxin in shoots: more auxin on one side makes the cells on that side elongate more.

Supplement

Exam tip: Always say auxin is unequally distributed, and that it makes cells elongate. Do not say auxin makes cells 'divide' or that the shoot 'grows towards' without saying which side has more auxin.

Investigating tropisms Spec 14.5.3

You can investigate **gravitropism** and **phototropism** in the shoots and roots of young seedlings, such as cress or bean seedlings. Grow them on damp cotton wool or filter paper in clear dishes so the roots can be seen.

Phototropism

1. Grow seedlings of the same species and age in identical clear dishes on damp cotton wool or filter paper, with equal water.
2. Put one set in a box with a slit or hole so light reaches them from one side only.
3. Put a control set in the same conditions but with light from all sides, or in the dark.
4. Leave for several days, then record the direction of growth of the shoots and roots, with a sketch or by measuring the angle.

Gravitropism

1. Place germinating seeds on damp cotton wool or paper in a dish, and fix the dish upright so the seeds are held in place.
2. Keep one dish upright and turn another on its side. Keep both in the dark so light does not affect the result.
3. Leave for several days, then record the direction of growth of the shoots and roots.

Typical results		
Plant part	Light from one side	Dish turned on its side (dark)
Shoot	Bends towards the light	Bends upwards
Root	Bends away from the light	Bends downwards

Practical skill: Change only one variable. For gravitropism keep the seedlings in the dark, and for phototropism keep their position fixed. Keep temperature and water the same, and use several seedlings so one odd result does not mislead you.

Quick check

1. Define phototropism.
2. In which direction does a root grow in response to gravity?
3. **Supplement** Where is auxin made in a shoot?
4. **Supplement** What does auxin do to shoot cells?

Quick check answers

Nervous control

1. The brain and the spinal cord.
2. The relay neurone.
3. Receptor, sensory neurone, relay neurone, motor neurone, effector.
4. A junction between two neurones.
5. Neurotransmitter molecules.

Sense organs

1. The cornea.
2. The place where the optic nerve leaves the eye. It has no receptors.
3. It gets smaller, so less light enters the eye.
4. The radial muscles.
5. It gives the sharpest vision because it has a high density of cones.

Hormones

1. The pancreas.
2. Testosterone.
3. Hormonal.
4. It increases blood glucose concentration and increases heart rate.

Homeostasis

1. The maintenance of a constant internal environment.
2. It decreases it.
3. The normal level of a factor that the body keeps steady by negative feedback.
4. Converts it to glycogen for storage.
5. They narrow (vasoconstriction).

Tropic responses

1. A response in which parts of a plant grow towards or away from the direction of the light source.
2. Towards gravity (downwards).
3. In the shoot tip.
4. It stimulates cell elongation.