

Cambridge IGCSE · Biology 0610 · Notes

The nervous system and sense organs

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Read first: [Movement into and out of cells](#)

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What you need to know

This topic is on nearly every paper. Papers 1 and 2 ask one-mark multiple choice about reflex arcs, the eye, synapses and the pupil; Papers 3 and 4 build longer questions round a diagram of a reflex arc, an eye or a synapse. Outcomes marked **Extended only** are tested on Papers 2 and 4 only. By the end of this topic you should be able to:

Core: the nervous system

1. **State that electrical impulses travel along neurones** (nerve cells).
2. **Describe how the mammalian nervous system is organised:** the **central nervous system (CNS)** is the brain and spinal cord; the **peripheral nervous system (PNS)** is the nerves outside the brain and spinal cord.
3. **Describe the role of the nervous system:** coordinating and regulating the body's functions.
4. **Identify sensory, relay and motor neurones** in diagrams and pictures.
5. **Describe a simple reflex arc:** receptor → sensory neurone → relay neurone → motor neurone → effector.
6. **Describe a reflex action:** an automatic, rapid response that links a stimulus to the response of an effector (a muscle or a gland).
7. **Describe a synapse** as a junction between two neurones.

Extended only: synapses

8. **Describe the structure of a synapse:** vesicles containing neurotransmitter molecules, the synaptic gap and receptor proteins.
9. **Describe the events at a synapse** in order: the impulse makes vesicles release neurotransmitter into the gap; it diffuses across; it binds to receptor proteins on the next neurone; an impulse starts in the next neurone.
10. **State that synapses make impulses travel in one direction only.**

Core: sense organs and the eye

11. **Describe sense organs** as groups of receptor cells that respond to specific stimuli: light, sound, touch, temperature and chemicals.
12. **Identify the parts of the eye:** cornea, iris, pupil, lens, retina, optic nerve and blind spot.

13. **Describe the function of each part:** the cornea refracts light; the iris controls how much light enters the pupil; the lens focuses light on to the retina; the retina contains the light receptors, some sensitive to different colours; the optic nerve carries impulses to the brain.
14. **Explain the pupil reflex** in terms of light intensity and pupil diameter.

Extended only: more on the eye

15. **Explain the pupil reflex** in terms of the antagonistic action of the **circular** and **radial** muscles of the iris.
16. **Explain accommodation** for near and distant objects: the ciliary muscles contracting or relaxing, the tension in the suspensory ligaments, the shape of the lens and how much it refracts light.
17. **Describe where rods and cones are** in the human retina.
18. **Outline what rods and cones do:** rods are more sensitive and give night vision; three kinds of cone absorb different colours of light and give colour vision.
19. **Identify the fovea** and state its function.

Diffusion comes from Movement into and out of cells. Comparing nervous and hormonal control is an outcome of Hormones and homeostasis, but some questions here ask it, so a short version is in "How to do it".

Understand it

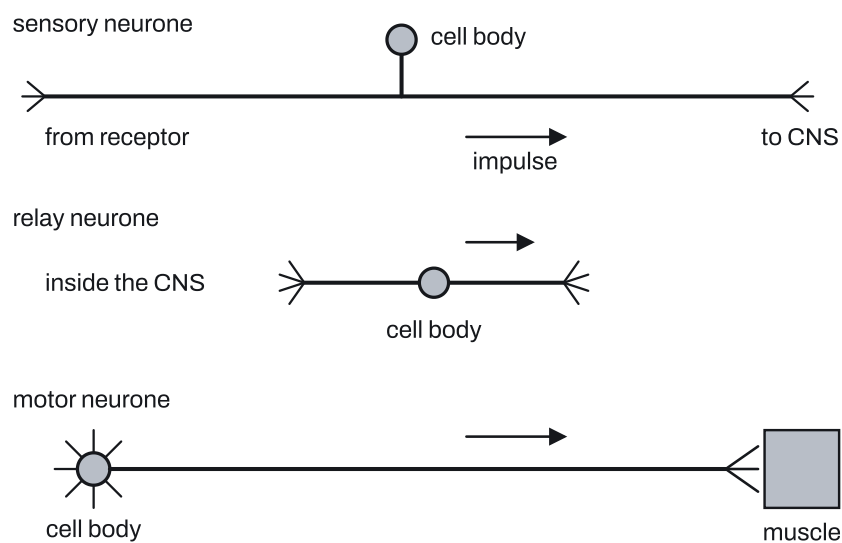
What the nervous system does

Your body has to react to changes, inside and outside it, fast and in the right place. The **nervous system** does this: it **coordinates and regulates body functions**. Its messages are **electrical impulses** that travel along nerve cells called **neurones**.

- The **central nervous system (CNS)** is the **brain** and the **spinal cord**. It receives impulses, links them together and sends impulses out.
- The **peripheral nervous system (PNS)** is all the **nerves** outside the brain and spinal cord. A nerve is a bundle of many neurones. The PNS carries impulses between the CNS and the rest of the body.

Every response follows the same chain: a **stimulus** (a change, such as heat or light) is detected by a **receptor**, impulses travel through the nervous system, and an **effector** (a **muscle** or a **gland**) makes the **response**.

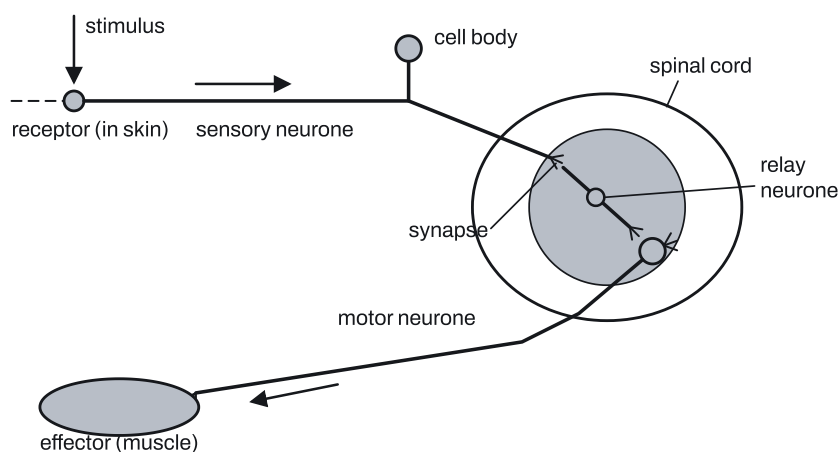
Three kinds of neurone



Neurone	Carries impulses	How to recognise it
Sensory	from a receptor to the CNS	long; cell body on a side branch part-way along
Relay	within the CNS , from sensory to motor neurones	short , lots of branches, found inside the brain or spinal cord
Motor	from the CNS to an effector (muscle or gland)	cell body at one end with many short branches, inside the CNS; long fibre to the muscle

Neurones are long so that one cell can carry an impulse a long way: the longest run from the spinal cord to the toes, over a metre.

The reflex arc



A **reflex action** is an **automatic** (involuntary: you don't decide to do it) and **rapid** response to a stimulus. It links the stimulus straight to the response of an **effector** (muscle or gland), without waiting for you to think. The same stimulus gives the same response each time. Reflexes protect you: pulling your hand off a hot pan,

blinking when something flies at your eye, sneezing, the pupil shrinking in bright light, the knee jerk.

The pathway, the **reflex arc**, is:

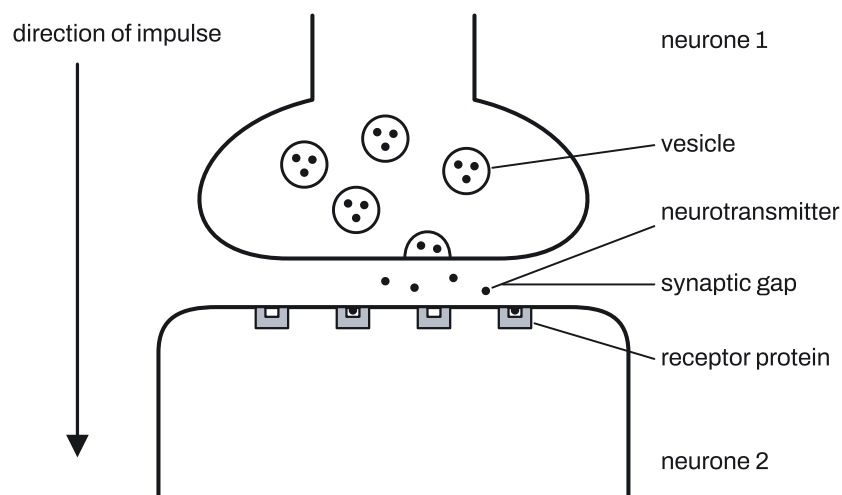
stimulus → **receptor** → **sensory neurone** → **relay neurone (in the spinal cord)** → **motor neurone** → **effector** → **response**

Touching a hot pan: the **stimulus** is the heat (temperature) of the pan; the **receptor** is in the skin of the finger; the **effector** is a **muscle** in the arm, which **contracts** and pulls the hand away. In a knee jerk, a tap below the knee stretches a muscle; the effector is the thigh muscle, which contracts and straightens the leg.

The **junctions between neurones** are **synapses**. A reflex arc through the spinal cord has two: sensory → relay and relay → motor.

A **voluntary** action, such as raising your hand to answer a question, is one you decide to make; it starts in the brain and is slower.

Extended: the synapse



Neurones don't touch: there is a tiny **synaptic gap** between them. An electrical impulse can't jump it, so a **chemical** carries the message across.

1. An **impulse** arrives at the end of the first neurone and **stimulates the release of neurotransmitter molecules from vesicles** into the synaptic gap.
2. The neurotransmitter molecules **diffuse** across the gap (from a high concentration to a low one, by the random movement of molecules).
3. They **bind with receptor proteins** on the membrane of the next neurone. The receptor's shape fits (is complementary to) the neurotransmitter.
4. This **stimulates an impulse** in the next neurone.

Why impulses go one way only: the vesicles of neurotransmitter are only in the neurone **before** the gap, and the receptor proteins are only on the neurone **after** it. So a synapse can only pass an impulse forwards. This keeps impulses in a reflex arc going from receptor to effector.

Anything that blocks the receptor proteins stops the message. A poison with the same shape as the neurotransmitter can sit in the receptors, so the real neurotransmitter can't bind; no impulse starts in the next neurone, and a muscle it controls can't contract.

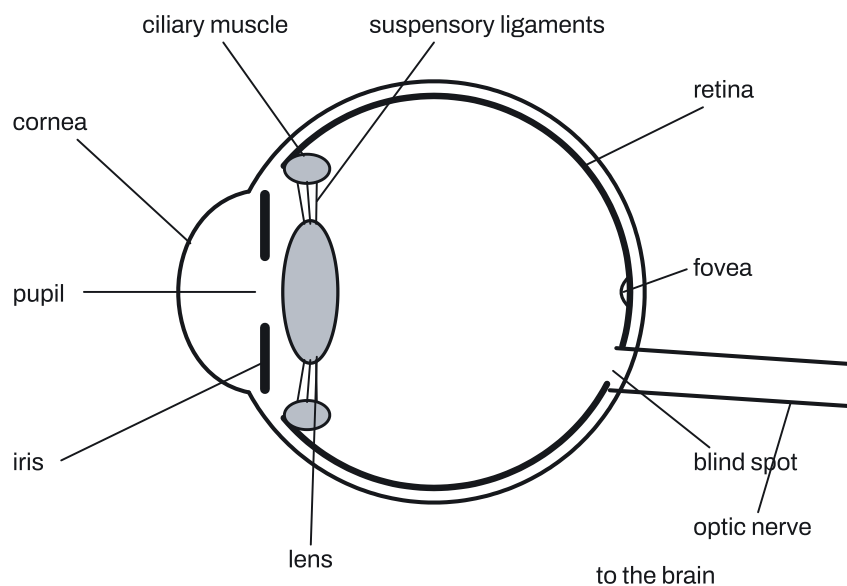
Sense organs

A **sense organ** is a **group of receptor cells** that respond to **specific stimuli**. The five kinds of stimulus are **light, sound, touch, temperature and chemicals**.

Sense organ	Stimuli
Eye	light
Ear	sound
Skin	touch (pressure), temperature, pain
Tongue and nose	chemicals

Note the difference: "light" is a **stimulus**; "eye" is a **sense organ**.

The eye



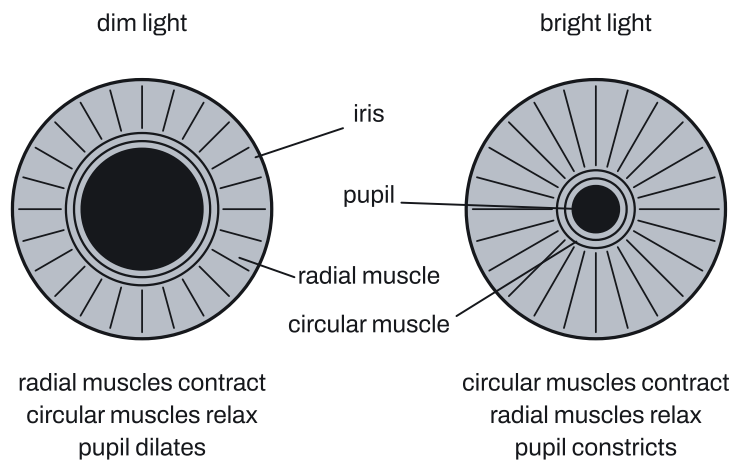
Part	Function
Cornea	the clear, curved front: refracts (bends) light as it enters the eye; it does most of the refracting
Iris	the coloured ring of muscle: controls how much light enters the pupil
Pupil	the hole in the middle of the iris that light passes through (it is a gap, not a structure that does anything itself)

Part	Function
Lens	focuses light on to the retina ; it changes shape to focus near or distant objects
Retina	the inner layer at the back: contains the light receptors (rods and cones), some sensitive to light of different colours
Optic nerve	carries impulses to the brain
Blind spot	where the optic nerve leaves the retina: no receptors , so light falling here is not detected
Fovea (Extended)	a small pit in the retina straight behind the lens, packed with cones : gives the sharpest, most detailed colour vision
Ciliary muscle and suspensory ligaments (Extended)	a ring of muscle attached to the lens by the ligaments: change the shape of the lens

Light passes: **cornea** → **pupil** → **lens** → **retina**. The receptors send impulses along the **optic nerve** to the brain.

The pupil reflex

In **bright light** the pupil gets **smaller** (constricts). This lets **less light** in and stops too much light **damaging the retina**. In **dim light** the pupil gets **larger** (dilates), letting **more light** in so that you can still see. This happens automatically, so it is a **reflex**: the **pupil reflex**. The iris muscles are the **effectors**.



Extended only: the iris has two sets of muscle.

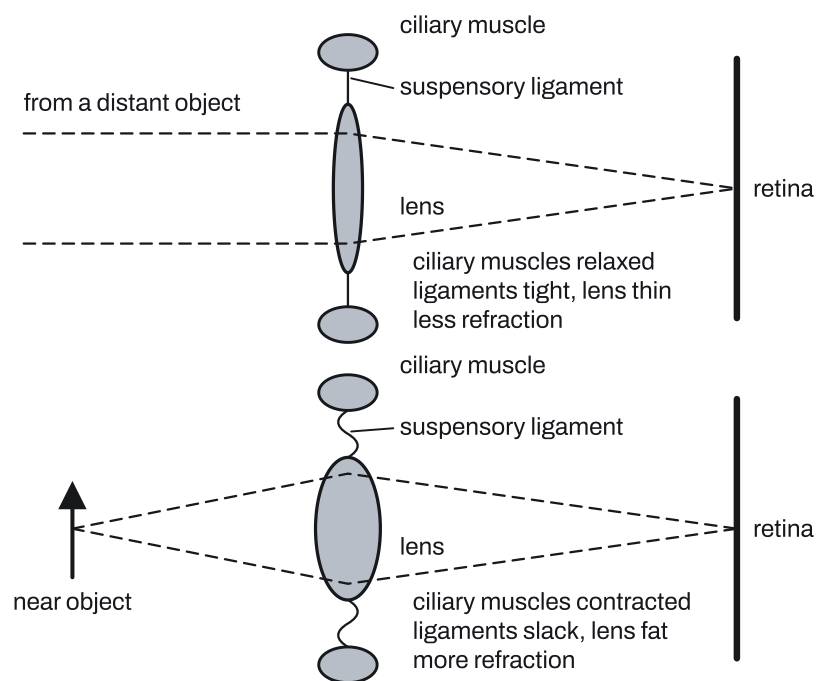
- **Circular muscles** form rings round the pupil. When they **contract**, the rings get smaller and the pupil **constricts**.
- **Radial muscles** run outwards like the spokes of a wheel. When they **contract**, they pull the edge of the pupil outwards and the pupil **dilates**.

Light	Circular muscles	Radial muscles	Pupil
Bright	contract	relax	constricts (smaller)
Dim	relax	contract	dilates (larger)

When one set contracts the other relaxes, so they work in opposite directions: this is **antagonistic** action (like the biceps and triceps).

Extended: accommodation

Accommodation is changing the shape of the lens to focus on objects at different distances. Light from a **distant** object arrives almost parallel and needs little bending; light from a **near** object is spreading out and needs to be bent (refracted) **more** to meet on the retina. A **fatter** lens refracts light more.



Object	Ciliary muscles	Suspensory ligaments	Lens	Refraction
Near	contract	slacken (less tension)	fatter (thicker, more rounded)	more
Distant	relax	tighten (pulled tight)	thinner (pulled flat)	less

How it works: the ciliary muscle is a **ring**. When it **contracts**, the ring gets smaller, so it moves closer to the lens and the ligaments are **no longer pulled tight**. The lens is elastic, so it springs back into a **fatter** shape. When the ciliary muscle **relaxes**, the ring is wider, the ligaments are **pulled tight**, and they pull the lens **thin**.

Only the ciliary muscle contracts and relaxes. The **ligaments** don't contract; they only become **tight or slack**.

Predicting from a fault:

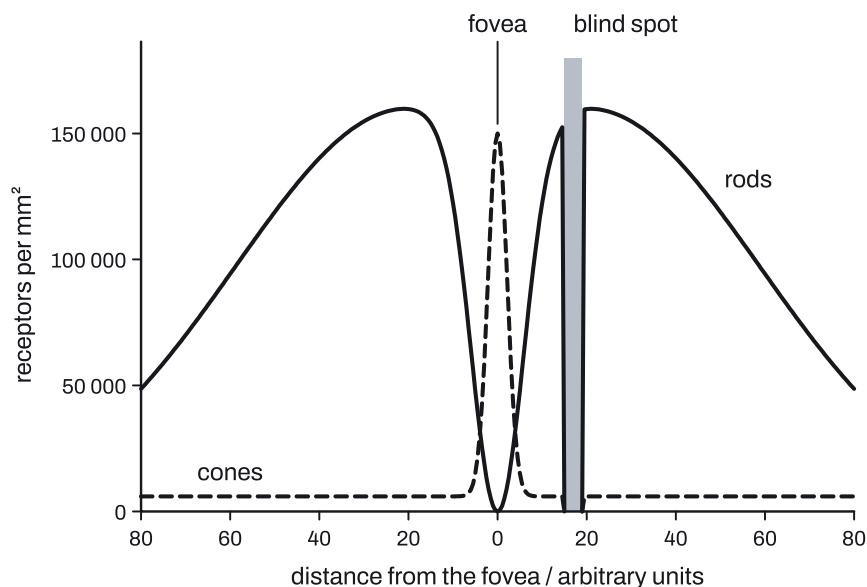
- **Ciliary muscles stuck contracted:** the lens stays fat, so near objects are in focus but **distant objects can't be**.

- **Suspensory ligaments overstretched:** they can't pull tight enough to make the lens thin, so light from **distant objects** is refracted too much and **can't be focused** on the retina.

Extended: rods and cones

The retina has two kinds of receptor cell.

- **Rods** are **more sensitive** to light: they work in **dim light** and give **night vision**, but only in black and white.
- **Cones** need **brighter** light. There are **three kinds of cone**, each absorbing light of a **different colour** (red, green or blue), and together they give **colour vision**. (Say "three **types** of cone", not "three cones".)



Where they are:

- **Cones** are packed most densely at the **fovea** (here 150 000 per mm²) and are **few** everywhere else (here about 6 000 per mm²).
- There are **no rods at the fovea**. Rods are **most numerous just either side** of it (here about 160 000 per mm², about 20 units away) and are found across the rest of the retina.
- Overall there are **many more rods than cones**.
- The **blind spot** has **neither** rods nor cones.

So you see fine detail and colour best when you look straight at something (its image falls on the fovea). At night you see a dim star better if you look slightly to one side of it, so that its light falls on the rods.

An animal active at night (nocturnal) has **more rods** (and fewer cones) than a daytime animal, because it needs sensitive vision in low light, and colour vision matters less in the dark.

Key facts and formulas

There is no formula list in the IGCSE Biology exam. Everything below must be learnt.

Formula	Status
CNS = brain + spinal cord; PNS = nerves outside them	Learn it
Reflex arc: stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response	Learn it
Effector = muscle or gland	Learn it
Reflex action: automatic (involuntary) and rapid	Learn it
Synapse = junction between two neurones	Learn it
Extended: synapse: vesicles → neurotransmitter released → diffuses across the gap → binds to receptor proteins → impulse in the next neurone	Learn it
Extended: synapses make impulses travel in one direction only	Learn it
Sense organ = group of receptor cells responding to specific stimuli (light, sound, touch, temperature, chemicals)	Learn it
Cornea refracts; iris controls light entering the pupil; lens focuses; retina has receptors; optic nerve carries impulses to the brain	Learn it
Bright light: pupil constricts; dim light: pupil dilates	Learn it
Extended: bright light: circular muscles contract, radial relax (antagonistic)	Learn it
Extended: near object: ciliary muscles contract, ligaments slack, lens fatter, more refraction	Learn it
Extended: rods: night vision; three types of cone: colour vision; cones packed at the fovea; no receptors at the blind spot	Learn it
Percentage change = $(\text{new} - \text{original}) \div \text{original} \times 100$	Learn it

How to do it

We tagged 108 questions for this topic (2021–2025, Papers 1–4; some multiple-choice questions appear on more than one paper). 25 of them mix types, so the counts add up to 160.

Question type	Questions
Name and order the parts of a reflex arc	39

Question type	Questions
Name eye structures and state their functions	26
Label a synapse and describe how an impulse crosses it	22
Describe the pupil reflex	21
Nervous system organisation, sense organs and stimuli	19
Describe accommodation (Extended)	12
Rods and cones: function and distribution (Extended)	10
Features and examples of reflex actions	5
Compare nervous and hormonal control	4
Calculate from nervous-system data	2

1. Name and order the parts of a reflex arc (39 questions)

1. **Find the receptor** (where the stimulus is detected, often in the skin) and the **effector** (the **muscle** that moves; or a gland).
2. **Find the spinal cord.** The neurone inside it that joins two others is the **relay** neurone.
3. The neurone coming **from the receptor into** the spinal cord is the **sensory** neurone (cell body on a side branch). The neurone going **out to the muscle** is the **motor** neurone.
4. Write the order: receptor → sensory → relay → motor → effector.

Variations you will meet:

- **Letters on a diagram** ("which is the motor neurone?"): follow the arrows from the stimulus. The motor neurone is the one that **ends at the muscle**; many candidates pick the sensory neurone by mistake.
- **A flow diagram with blanks**, such as "stimulus → V → W → relay neurone → X → Y → response": V receptor, W sensory neurone, X motor neurone, Y effector.
- **A table of function** → **name**: "carries impulses to the CNS" = sensory; "carries impulses only within the CNS" = relay; "carries impulses to an effector" = motor.
- **Name the stimulus and effector in a story**: stepping on a pin (stimulus: pressure or pain from the pin; effector: leg muscle); a hot pan (stimulus: heat; effector: arm muscle); a knee tap (effector: thigh muscle, which straightens the leg).
- **Which part is only in the CNS?** The **relay** neurone.
- **Fill-in sentences**: "The impulse passes along a **sensory** neurone to the spinal cord, then to a **relay** neurone and out along a **motor** neurone to the **effector**."
- **"Which structures are connected directly to a motor neurone?"** In a reflex arc the motor neurone connects to the **relay neurone** and to the **effector** (muscle); the receptor connects to the sensory neurone.
- **Parts of the PNS on a diagram**: the sensory and motor neurones outside the spinal cord (and the receptor's nerve); the spinal cord and relay neurone are CNS.

- **Older papers (2021–2022)** asked how a neurone is adapted to carry impulses (a long fibre, many branched endings to connect with other cells). If a current question gives such details, use them.

2. Name eye structures and state their functions (26 questions)

1. Find the **cornea** first: the clear bulge at the front. The **iris** is the pair of short bars behind it; the gap between them is the **pupil**. Behind that is the **lens**.
2. The layer lining the back is the **retina**; the thick cable leaving the back is the **optic nerve**; where it leaves is the **blind spot**.
3. Match functions with the exact words: cornea **refracts**, iris **controls how much light enters**, lens **focuses light on the retina** (by changing shape), retina **contains light receptors**, optic nerve **carries impulses to the brain**.

Variations you will meet:

- **"Which part refracts light as it enters the eye?"** The **cornea**, not the lens or pupil. "Bends light" is too vague in a written answer: say **"refracts"**.
- **"Which part focuses light on the retina?"** The **lens**.
- **"Which part contains light receptors / detects red light?"** The **retina** (its cones).
- **Draw an X on the blind spot:** exactly where the optic nerve joins the back of the eye, not on the fovea or lens.
- **A damaged iris:** the person can't control how much light enters the eye.
- **Unfamiliar eyes** (an octopus, a frog photograph): use the same shapes; the lens is the round body behind the pupil, the retina lines the back.
- **"State the tissue in the eye that detects light":** the **retina**.

3. Label a synapse and describe how an impulse crosses it (22 questions)

1. **Core:** the junction between two neurones is a **synapse** (spell it exactly; "synapsis" isn't accepted).
2. **Extended labels:** round sacs in the first neurone = **vesicles**; small dots = **neurotransmitter**; the space = **synaptic gap**; sites on the second neurone's membrane = **receptor proteins**.
3. **Extended events**, in order: impulse arrives → vesicles release neurotransmitter into the gap → it **diffuses** across → **binds to receptor proteins** → impulse **stimulated in the next neurone**.

Variations you will meet:

- **Order four numbered events** in multiple choice: release → diffuse → bind → new impulse.
- **"Which process moves neurotransmitter across the gap?"** **Diffusion** (not active transport or osmosis). For 2 marks: diffusion, from a high concentration to a low concentration by random movement.
- **"Which structures contain neurotransmitter?"** **Vesicles**.
- **"What is a function of a synapse?"** To make impulses travel in **one direction** only.
- **"Explain why impulses pass in one direction only":** neurotransmitter is released only from the neurone **before** the gap (only it has vesicles); receptor proteins are only on the neurone **after** it.

- **Which way does the neurotransmitter go?** From the neurone with vesicles to the one with receptors; in a reflex arc, from sensory to relay and from relay to motor.
- **A toxin shaped like the neurotransmitter** blocks the receptor proteins, so the neurotransmitter can't bind, no impulse starts in the next neurone and the muscle doesn't contract.
- **Too little neurotransmitter, or fewer receptors:** fewer impulses start in the next neurone, so control of movement is poorer.

4. Describe the pupil reflex (21 questions)

1. **Bright light** → **pupil smaller** (constricts): less light enters, **protecting the retina** from damage.
2. **Dim light** → **pupil larger** (dilates): more light enters, so you can **see**.
3. **Extended:** bright light → **circular** muscles **contract**, **radial** muscles **relax**; dim light is the reverse. The muscles are the **effectors** and act **antagonistically**.

Variations you will meet:

- **"Describe and explain the change shown"** (before and after pictures): say what happened to the pupil's **diameter**, then why (more or less light, to see in dim light or protect the retina).
- **Draw the pupil in bright light:** a **smaller** black circle, same centre.
- **Name the response:** "**pupil reflex**" ("iris reflex" or just "reflex action" isn't accepted when the name is asked).
- **Name an effector:** a muscle of the **iris** (Extended: circular or radial muscle). Don't write "ciliary muscle"; that is for focusing.
- **Moving from bright to dim:** circular muscles relax, radial muscles contract, pupil dilates.
- **Combined with accommodation** (Extended): "dark, distant → bright, near" means radial muscles relax, pupil constricts, **and** ciliary muscles contract, lens gets thicker. Work out each half separately.
- **Pupil data:** percentage change = $(\text{new} - \text{original}) \div \text{original} \times 100$. A pupil shrinking from 8 mm to 2 mm is a 75% decrease, caused by an **increase** in light.

5. Nervous system organisation, sense organs and stimuli (19 questions)

1. **CNS** = **brain** and **spinal cord**; **PNS** = the nerves outside them.
2. **Role of the nervous system:** **coordination and regulation** of body functions.
3. **Sense organ** = a **group of receptor cells** responding to **specific stimuli**.
4. **Stimuli:** light, sound, touch, temperature, chemicals.

Variations you will meet:

- **"Define the term sense organ":** you need **receptor cells** and **specific stimuli**. Naming examples (eye, ear) or just "an organ that senses" scores nothing.
- **"State three other stimuli"** besides light: sound, touch, temperature, chemicals. Write stimuli, **not** sense organs (not "ear").
- **"Two stimuli the skin detects":** touch (pressure), temperature, pain.

- **"Why is the eye a sense organ?"** It contains a group of receptor cells (rods and cones) that respond to a specific stimulus, light.
- **Fill in:** "The **central** nervous system consists of the brain and spinal cord and the **peripheral** nervous system consists of the nerves outside them."
- **Pick numbered parts** of a diagram that form the CNS: the brain and the spinal cord.

6. Describe accommodation (12 questions, Extended)

1. **Near object:** ciliary muscles **contract** → suspensory ligaments **slacken** → lens becomes **fatter** → **more** refraction.
2. **Distant object:** ciliary muscles **relax** → suspensory ligaments **tighten** → lens is pulled **thinner** → **less** refraction.
3. In a written answer, give each link in order and finish with "so the light is focused on the retina".

Variations you will meet:

- **Table multiple choice** (ciliary muscles / ligaments / lens): check each column against the table in "Understand it". "Contracted, slack" goes with near; "relaxed, tense" with distant.
- **"Describe and explain accommodation for a near object, using letters from the diagram":** name the letter each time ("the ciliary muscle, **P**, contracts ...").
- **Faults:** ciliary muscles stuck contracted, or ligaments overstretched, mean **distant** objects can't be focused.
- **Refraction** is the key word: a fatter lens refracts light **more**.

7. Rods and cones: function and distribution (10 questions, Extended)

1. **Function:** rods → **night vision** (more sensitive, work in dim light); cones → **colour vision** (three types, each absorbing a different colour).
2. **Distribution:** cones **concentrated at the fovea**; **no rods at the fovea**; rods across the rest of the retina, **most just either side** of the fovea; **more rods than cones** overall; **neither at the blind spot**.

Variations you will meet:

- **Describe a graph** of rods and cones (4 marks): one point per sentence, using the fovea and distances. For example: more rods than cones overall; cones peak at the fovea (0); no rods at the fovea; rods peak either side of the fovea; cones few and fairly constant away from the fovea; neither at the blind spot. Quote numbers from the axes.
- **Mark the fovea on a graph:** where cones peak and rods are zero. The **blind spot** is where **both** are zero.
- **Fill a table with many / few / none:** fovea: cones many, rods none; rest of the retina: rods many, cones few; blind spot: none of either.
- **"How many types of cone?"** Three.
- **Nocturnal animals: more rods** (fewer cones), because rods are more sensitive, giving vision in low light; colour vision is less important.

8. Features and examples of reflex actions (5 questions)

1. **Features:** **automatic** (involuntary), **rapid**, the same response to the same stimulus, often **protective**.
2. **Examples:** pulling the hand from a hot object, blinking, sneezing, the knee jerk, the pupil reflex.

Variations you will meet:

- **"Which is a voluntary action?"** One you choose, such as raising your hand to answer a question. Blinking and a racing heart in danger are involuntary.
- **"State two features of reflex actions":** give features (fast, automatic), not examples.
- **"State the type of action"** (sneezing, blinking): a **reflex** (involuntary) action.

9. Compare nervous and hormonal control (4 questions)

This comes from Hormones and homeostasis; it is often asked alongside reflexes.

	Nervous control	Hormonal control
Speed of action	fast	slower
Duration of effect	short	longer
How the message travels	electrical impulses along neurones	chemicals (hormones) carried in the blood

A "describe two differences" question wants both halves of each comparison, such as "nervous control is faster, hormonal control is slower".

10. Calculate from nervous-system data (2 questions)

1. **Put both values in the same units first.** 1 m = 1000 mm.
2. **"How many times longer":** divide the larger by the smaller. A 0.9 m neurone compared with a 0.0003 mm one: 0.9 m = 900 mm, and $900 \div 0.0003 = 3\,000\,000$ times.
3. **Speed of an impulse** = distance $\div$ time, in metres per second.
4. **Percentage change:** (new – original) $\div$ original $\times$ 100, and say whether it is an increase or a decrease.

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

Core. A person picks up a very hot plate and immediately drops it.

- (a) State the stimulus in this reflex action. **[1]**
 - (b) Put these parts of the reflex arc in the order the impulse passes through them: motor neurone, receptor, relay neurone, effector, sensory neurone. **[2]**
 - (c) State the name of the effector and where the relay neurone is found. **[2]**
 - (d) Explain why dropping the plate is described as a reflex action and not a voluntary action. **[2]**
 - (e) In this reflex the impulse travels a total distance of 1.2 m, from the fingertip to the spinal cord and back to the arm muscle, in 0.024 seconds. Calculate the average speed of the impulse in metres per second. **[2]**
- (a) Heat (a high temperature) from the plate **B1**.
- (b) Receptor → sensory neurone → relay neurone → motor neurone → effector. **B2** (one mark lost for one pair out of order).
- (c) A muscle (in the arm or hand) **B1**; in the spinal cord (the CNS) **B1**.
- (d) It happens automatically, without the person deciding to do it **B1**, and very rapidly, before the brain is involved **B1**.
- (e) speed = distance ÷ time = $1.2 \div 0.024$ **M1** = 50 m per second **A1**.

Example 2

Core and Extended. A student measured the diameter of her pupil in a dim room and then in bright sunlight. It was 7.5 mm in the dim room and 3.0 mm in sunlight.

- (a) Calculate the percentage change in pupil diameter. **[2]**
 - (b) Explain why this change is useful. **[2]**
 - (c) **Extended:** Explain how the muscles of the iris bring about this change. **[3]**
 - (d) **Extended:** State the term for the way these two muscles work together. **[1]**
- (a) $\frac{3.0 - 7.5}{7.5} \times 100$ **M1** = -60% , a 60% decrease **A1**.
- (b) The smaller pupil lets less light into the eye **B1**, which protects the retina from damage by too much light **B1**.
- (c) The circular muscles contract **B1**; the radial muscles relax **B1**; so the pupil constricts (gets smaller) **B1**.
- (d) Antagonistic **B1**.

Example 3

Extended. A drug is found to make the neurotransmitter stay in the synaptic gap for longer than usual.

(a) Describe how an impulse passes from one neurone to the next across a synapse. [4]

(b) Explain why impulses can only cross a synapse in one direction. [2]

(c) Suggest how the drug would affect the next neurone. [1]

(a) The impulse causes vesicles to release neurotransmitter molecules into the synaptic gap **B1**. The neurotransmitter diffuses across the gap **B1** and binds with receptor proteins on the membrane of the next neurone **B1**. This stimulates an impulse in the next neurone **B1**.

(b) Vesicles containing neurotransmitter are only in the neurone before the gap **B1**; receptor proteins are only on the neurone after the gap **B1**.

(c) The neurotransmitter keeps binding with the receptors, so impulses keep being stimulated in the next neurone (for longer) **B1**.

Example 4

Extended. A student reading a book looks up at a bird far away.

(a) Describe and explain the changes in the eye that let her focus on the bird. [4]

(b) Her image of the bird falls on the fovea. Explain why she can see the bird's colours clearly. [2]

(c) Later, at dusk, she sees a faint star best by looking slightly to one side of it. Explain why. [2]

(a) The ciliary muscles relax **B1**, so the suspensory ligaments are pulled tight **B1**. This pulls the lens thinner **B1**, so it refracts the light less and the light from the distant bird is focused on the retina **B1**.

(b) The fovea has the most cones **B1**; there are three types of cone, which absorb different colours of light, giving colour vision **B1**.

(c) There are no rods at the fovea; rods are found away from it **B1**. Rods are more sensitive to light, so they detect dim light (night vision) **B1**.

Common mistakes

- **Defining a sense organ with examples.** "Eyes and ears" earns nothing. Say "a group of **receptor cells** responding to **specific stimuli**". Examiners saw this often.
- **Naming sense organs when asked for stimuli.** "Ear" is an organ; the stimulus is **sound**.
- **Saying the effector is a nerve or the brain.** In a reflex arc the effector is a **muscle** (or gland). Examiners said many missed this in the knee jerk.

- **Misidentifying the motor neurone.** It is the one that **ends at the muscle**; many chose the sensory neurone. The relay neurone is the short one inside the spinal cord.
- **Saying the cornea "focuses" or "bends" light.** It **refracts** light. Many candidates didn't know the cornea is the part that refracts.
- **Saying the pupil focuses light.** The **lens** focuses; the pupil is just a hole.
- **Putting the blind spot X in the wrong place** (on the fovea or lens). It is where the **optic nerve** leaves.
- **Mixing up ciliary and circular muscles.** Circular (and radial) muscles are in the **iris** and change the **pupil**; ciliary muscles change the **lens**. "Ciliated" is a different word altogether.
- **Saying the suspensory ligaments contract.** Ligaments only go **tight or slack**; only the ciliary muscle contracts.
- **Mixing up the pupil reflex and accommodation.** Light intensity → pupil; distance of the object → lens.
- **Writing "there are three cones".** There are **three types** of cone, and millions of cones.
- **Swapping the functions of rods and cones.** Rods: dim light, night vision. Cones: colour.
- **Misspelling synapse** as "synapsis", which isn't accepted.
- **Saying neurotransmitter crosses by active transport or osmosis.** It **diffuses**.
- **Giving examples when features of a reflex are asked.** Features: automatic, rapid.

How to get the marks

- **"State" or "name":** one term (synapse, cornea, relay neurone, pupil reflex). Give one answer: a wrong extra answer cancels a right one.
- **Use the exact functions** the mark schemes reward: cornea **refracts**; iris **controls how much light enters**; lens **focuses light on the retina**; retina **contains light receptors**; optic nerve **carries impulses to the brain**.
- **"Describe" a reflex arc:** name each part in order (receptor, sensory, relay, motor, effector) and say the impulse is **electrical**.
- **"Describe and explain" the pupil or accommodation:** say what changes (pupil diameter; muscles, ligaments, lens) **and** why (amount of light; refraction to focus on the retina). Each link is a mark.
- **Synapse answers** (Extended): vesicles, neurotransmitter, synaptic gap, diffuses, receptor proteins, impulse in the next neurone. Use all six words.
- **Graph descriptions:** one feature per point, with the fovea or blind spot named and numbers read from the axes.
- **Labelling:** draw label lines that touch the right structure, and draw an **X** exactly where asked.
- **Calculations:** convert to the same units, show the working, and state increase or decrease for a percentage change.
- **Spelling:** synapse, neurone, neurotransmitter, suspensory, ciliary, accommodation, antagonistic. Misspellings that could mean another word lose the mark.

Quick check

1. State the two parts of the central nervous system.
2. Which neurone carries impulses from the CNS to an effector, and which lies entirely inside the CNS?
3. State the function of (a) the iris and (b) the optic nerve.
4. **Extended:** A person walks from a bright street into a dark cinema. Describe what happens to the iris muscles and the pupil.
5. A pupil's diameter changed from 2.5 mm to 6.0 mm. Calculate the percentage change, and suggest what change in light caused it.
6. **Extended:** Describe the changes in the eye when someone looks from a distant hill to a map in their hands.

Answers

1. The brain and the spinal cord.
2. The motor neurone carries impulses to an effector; the relay neurone lies entirely inside the CNS.
3. (a) It controls how much light enters the pupil. (b) It carries impulses from the retina to the brain.
4. The radial muscles contract and the circular muscles relax, so the pupil dilates and more light enters the eye.
5. $\frac{6.0 - 2.5}{2.5} \times 100 = 140\%$, an increase. The light got dimmer (a lower light intensity), so the pupil dilated to let more light in.
6. The ciliary muscles contract, the suspensory ligaments slacken, and the lens becomes fatter, so it refracts light more and focuses the near map on the retina.

Past questions to try

- **0610/41/O/N/24 Q4**: CNS and PNS, ordering a reflex arc, stimuli detected by skin, an effector of the pupil reflex and one-way transmission at a synapse (Extended).
- **0610/42/F/M/23 Q5**: why the eye is a sense organ, the blind spot, eye functions, the pupil reflex muscles and overstretched suspensory ligaments (Extended).
- **0610/31/M/J/23 Q8**: a knee-jerk reflex arc, features of reflexes and a neurone-length calculation (Core).
- **0610/42/M/J/22 Q3**: refraction, accommodation from far to near and the distribution of rods and cones (Extended).