The human nervous system

4.5.2 · Biology · revision notes

How the nervous system carries information as electrical impulses, how a reflex arc works, and the required practical on reaction time. Expect ordering and labelling questions, 'explain why reflexes are useful', synapse explanations and data questions from the reaction time practical.

Key facts

- CNS = brain + spinal cord
- Effectors: muscles contract, glands secrete hormones
- Reflex = automatic and rapid; does not involve the conscious part of the brain
- Reaction time practical: shorter catch distance = faster reaction
- Neurones carry electrical impulses
- Reflex arc: receptor → sensory neurone → relay neurone → motor neurone → effector
- Synapse: a chemical is released, diffuses across the gap and binds to receptors on the next neurone

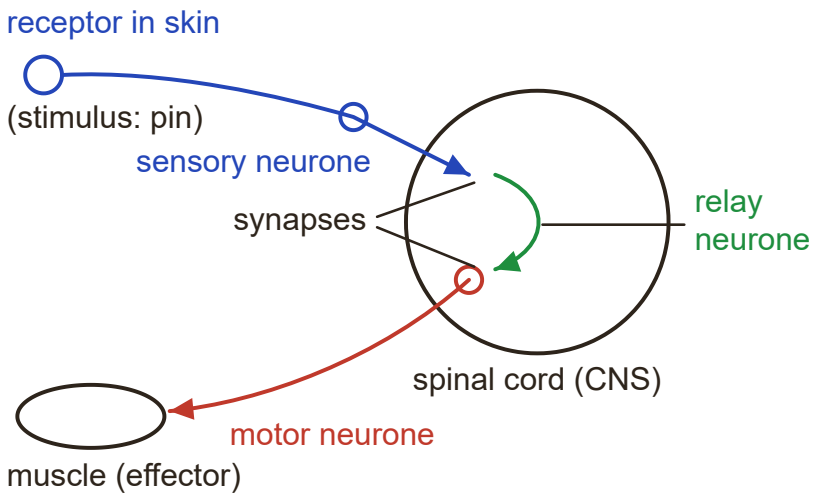
Notes

How the nervous system works

- The nervous system lets you **react to your surroundings** and **coordinate your behaviour**.
- Receptors detect a stimulus. Information passes along nerve cells (**neurones**) as **electrical impulses** to the **central nervous system (CNS)**: the **brain and spinal cord**.
- The CNS coordinates the response of **effectors**: muscles contract or glands secrete hormones.
- Stimulus → receptor → coordinator (CNS) → effector → response.

Reflex arcs

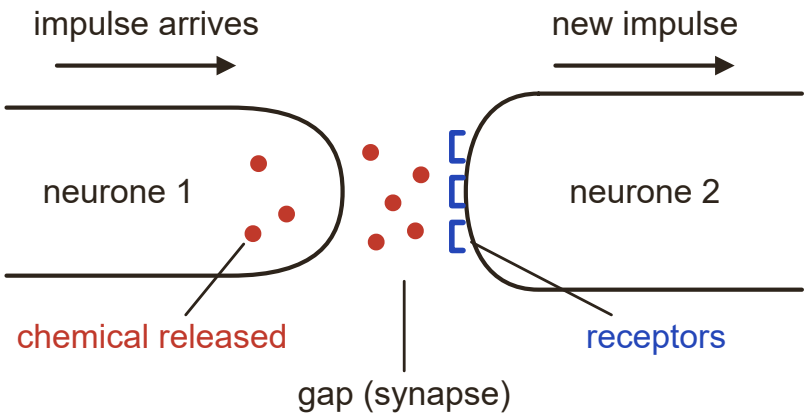
- **Reflex actions** are **automatic and rapid**. They do not involve the conscious part of the brain, so no time is spent deciding what to do.
- Reflexes protect you from harm, e.g. pulling your hand away from a hot pan or blinking when something flies towards your eye.
- Path: stimulus → receptor → **sensory neurone** → **relay neurone** (in the spinal cord or brain) → **motor neurone** → effector → response.
- Sensory neurones carry impulses from receptors to the CNS. Relay neurones link sensory and motor neurones inside the CNS. Motor neurones carry impulses from the CNS to effectors.



Reflex arc: receptor → sensory neurone → relay neurone (in spinal cord) → motor neurone → effector. The arrows show the direction of the impulse.

Synapses and adaptations

- A **synapse** is the tiny gap where two neurones meet.
- When an impulse reaches the end of a neurone, a **chemical** is released. It **diffuses** across the gap and binds to **receptors** on the next neurone, which triggers a new electrical impulse.



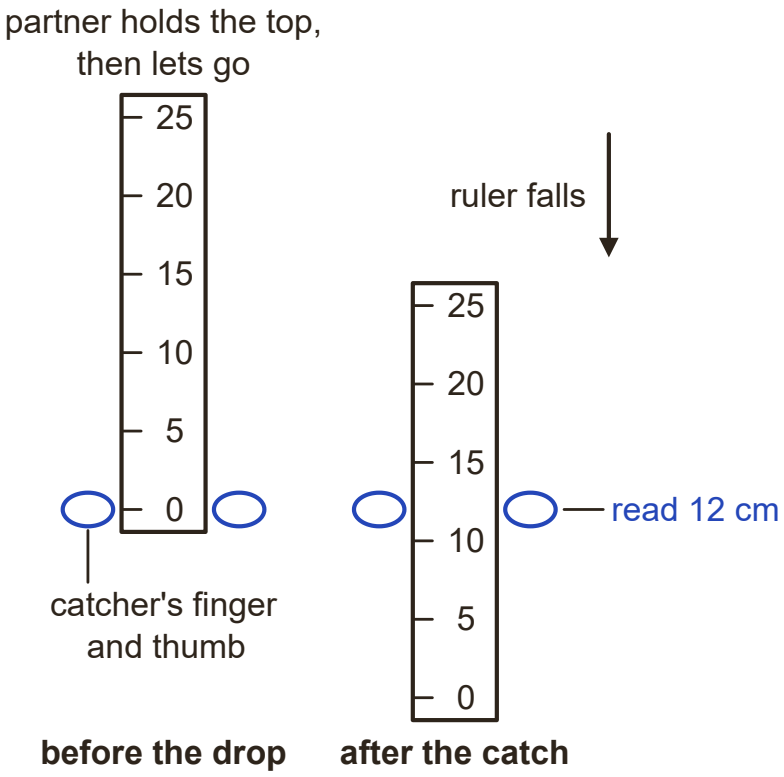
At a synapse the chemical diffuses across the gap and binds to receptors on the next neurone.

- Neurones have a **long axon** to carry impulses over long distances, **branched endings** to connect with many other neurones, and a **fatty (myelin) sheath** that insulates the axon and speeds up impulses.

Grade 6+ only

Required practical: reaction time

- Your partner holds a ruler vertically with the zero mark between your thumb and first finger. They drop it without warning and you catch it as quickly as you can.



Reaction time: the further the ruler falls before you catch it, the longer your reaction time.

- Record the distance the ruler fell. A **shorter distance** means a **shorter reaction time**. Convert distances to times using a conversion table or the equation given in the question (1 s = 1000 ms).
- Repeat at least three times, leave out any anomalous result and calculate a mean.
- Change one factor (the independent variable), e.g. caffeine, practice, tiredness or distraction, and measure the reaction time again (the dependent variable). Test several people.
- Control variables: same person dropping the ruler, same hand catching, same ruler, same starting gap between finger and thumb, arm resting on the table edge.

How to answer each type of question

Describe the pathway of a reflex arc

3 to 4 marks | Grade 5

1. Start at the receptor and finish at the effector.
2. Name the three neurones in order: sensory, relay, motor.
3. Say where the relay neurone is (the spinal cord) and what the effector does.

Example. A person touches a sharp pin and immediately pulls their hand away.
Describe the pathway taken by the nerve impulses in this reflex action.

Model answer. Receptors in the skin detect the stimulus (1). Impulses travel along a sensory neurone to the spinal cord (1). They pass to a relay neurone in the spinal cord and then to a motor neurone (1). The motor neurone carries impulses to a muscle (the effector), which contracts to pull the hand away (1).

Explain how an impulse crosses a synapse

3 marks | Grade 5

1. The impulse arrives at the end of the first neurone.
2. A chemical is released and diffuses across the gap.
3. The chemical binds to receptors on the next neurone, starting a new electrical impulse.

Example. Describe how a nerve impulse passes from a sensory neurone to a relay neurone.

Model answer. The impulse reaching the end of the sensory neurone causes a chemical to be released (1). The chemical diffuses across the synapse / gap (1). It binds to receptors on the relay neurone, triggering a new electrical impulse (1).

Explain why a reflex is an advantage

2 marks | Grade 5

1. Say that reflexes are automatic and fast because the conscious brain is not involved.
2. Say how this protects the body in the context given.

Example. Blinking when an object comes towards your eye is a reflex action.
Explain why it is an advantage for this response to be a reflex.

Model answer. Reflexes are automatic / do not involve the conscious part of the brain, so they are very fast (1). The eye closes before the object hits it, so the eye is protected from damage (1).

Required practical: reaction time data

3 to 5 marks **Grade 5**

1. Spot any anomalous result and leave it out of the mean.
2. Add the remaining values and divide by how many there are.
3. Name specific control variables, not just 'keep it fair'.

Example. A student caught a dropped ruler five times. The table shows the distance the ruler fell each time.

Attempt	1	2	3	4	5
Distance (cm)	14	12	13	25	11

(a) Identify the anomalous result.
(b) Calculate the mean distance, not including the anomalous result.
(c) Give two variables the student should control.

Model answer.

(a) 25 cm (1)

(b) (14 + 12 + 13 + 11) ÷ 4 = 50 ÷ 4 (1) = 12.5 cm (1)

(c) Any two from: same person dropping the ruler; same hand used to catch; same starting gap between thumb and finger; same ruler (2)

Don’t lose marks

- Saying the electrical impulse 'jumps' across the synapse. A chemical diffuses across the gap.
- Saying the brain decides what to do in a reflex. Reflexes do not involve the conscious part of the brain.
- Missing out the relay neurone, or putting the three neurones in the wrong order.
- Including an anomalous result when calculating a mean.
- Writing 'keep it a fair test' instead of naming a specific control variable.

More tips

Memory tricks

- Sensory neurones Send information in to the CNS; Motor neurones make things Move.
- Relay neurones relay the impulse across the CNS, like passing the baton in a relay race.
- Ruler drop: short distance = short time = quick reactions.
- Synapse in three words: chemical, diffuses, receptors.

Exam technique

- Use the exact names: receptor, sensory neurone, relay neurone, motor neurone, effector.
- For effectors, give the action in context, e.g. 'a muscle in the arm contracts', not just 'the arm moves'.
- In reaction time questions, look at the units and give the mean to a sensible number of decimal places.
- If asked why a result is anomalous, say it does not fit the pattern of the other results.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **State what the nervous system does**
It lets you react to your surroundings and coordinates your behaviour.

Grade 4 — **Name the parts of the CNS**
The central nervous system (CNS) is the brain and spinal cord.

Grade 4 — **Put the reflex arc in order**
Stimulus → receptor → sensory neurone → relay neurone → motor neurone → effector → response.

Grade 5 — **Explain why reflex actions are fast**
They are automatic and do not involve the conscious part of the brain.

Grade 5 — **Describe the ruler-drop reaction time practical**
Catch a dropped ruler, record the distance it fell and convert it to a reaction time.

Grade 5 — **Explain how impulses cross a synapse**
A chemical is released, diffuses across the gap and binds to receptors on the next neurone, starting a new impulse.

Grade 5 — **Explain how neurones are adapted**
Long axons carry impulses a long way, branched endings connect to many neurones, and a fatty sheath speeds impulses up.

Grade 5 — **Analyse and evaluate reaction time data**
Calculate means, spot anomalies, judge conclusions and suggest control variables.

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