A-LEVEL BIOLOGY • EXERCISE SHEET

15.1 Control and coordination in mammals

Name: _____ Class: _____ Date: _____ **Total: 35 marks**

KEY WORDS neurone 神经元 • synapse 突触 • sensory neurone 感觉神经元 • action potential 动作电位 • endocrine 内分泌

Objective

Build the skills to answer exam questions on **control and coordination in mammals** — the **nervous** 神经 and **endocrine** 内分泌 systems, **neurones** 神经元, the **action potential** 动作电位, **saltatory conduction** 跳跃式传导, and the **synapse** 突触.

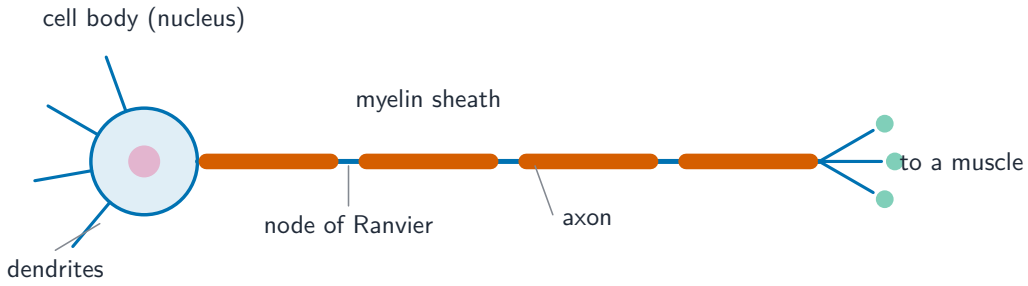
You must be able to:

- compare the nervous and endocrine systems and describe sensory and motor neurones
- describe the events of an action potential and how the resting potential is restored
- explain saltatory conduction and transmission across a cholinergic synapse

1 Worked examples

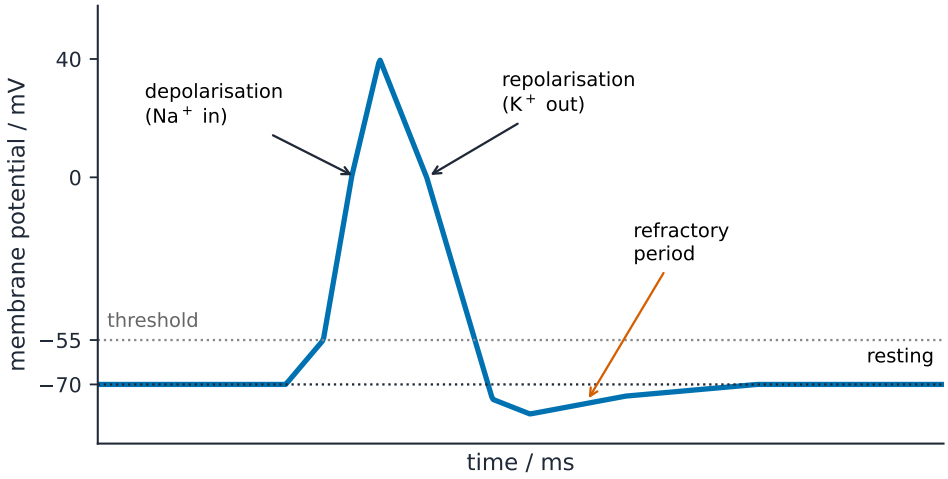
Nervous vs endocrine, and neurones

The **nervous system** sends fast, short-lived electrical **impulses** 冲动 along neurones; the **endocrine system** sends slower, longer-lasting **hormones** 激素 in the blood.



A motor neurone carries impulses to an effector; a sensory neurone carries them from a receptor

The action potential

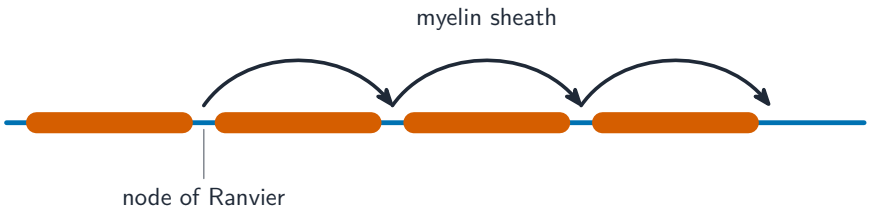


all-or-nothing: once threshold is reached, a full spike fires (no partial APs)

Sodium in → depolarisation; potassium out → repolarisation; then a refractory period

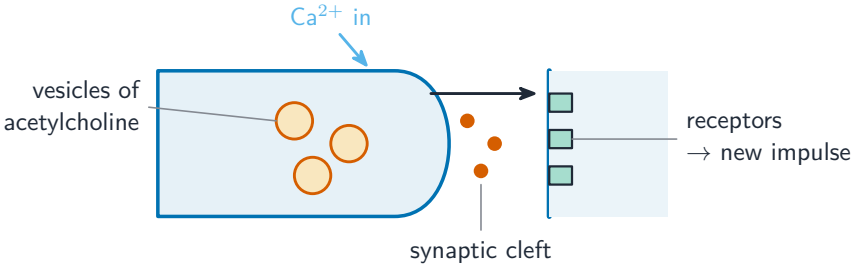
- **resting potential** 静息电位 (−70 mV): a pump moves Na^+ out and K^+ in; the membrane is more permeable to K^+.
- **depolarisation**: a stimulus opens Na^+ channels; Na^+ rushes in; inside becomes positive.
- **repolarisation**: K^+ channels open; K^+ leaves; the potential returns to negative.
- **refractory period** 不应期: Na^+ channels cannot reopen for a moment, limiting impulse frequency.

Saltatory conduction and the synapse



the impulse jumps from node to node (saltatory conduction) → faster

The impulse jumps between nodes (saltatory conduction), so a myelinated neurone conducts much faster



At a cholinergic synapse, acetylcholine diffuses across the cleft and binds receptors to start a new impulse

The action potential, and why it travels one way

Resting potential 静息电位, about −70 mV: the **sodium–potassium pump** actively moves 3 Na^+ out for every 2 K^+ in, and the membrane is far more permeable to K^+ than to Na^+, so the inside is negative relative to the outside.

The action potential, in the order the marks are awarded:

1. A stimulus opens some **voltage-gated Na^+ channels**; Na^+ enters and the membrane **depolarises**.
2. If the **threshold** (about −55 mV) is reached, all the voltage-gated Na^+ channels open — positive feedback — and the potential rises to about +40 mV.
3. Na^+ channels close and **voltage-gated K^+ channels open**; K^+ leaves and the membrane **repolarises**.
4. K^+ channels are slow to close, so the potential briefly overshoots: **hyperpolarisation**.
5. The sodium–potassium pump restores the resting potential.

All-or-nothing. Below threshold there is no impulse at all; at or above it the action potential is always the same size. A stronger stimulus is therefore coded by a **higher frequency** of impulses, not a bigger one.

The refractory period 不应期 is the short time after an action potential during which the Na^+ channels cannot reopen. It does three things the exam asks for: it makes impulses **discrete** and separated, it **limits the frequency** of impulses, and — because the region behind is still refractory — it ensures the impulse travels in **one direction only**.

Myelination. In a myelinated axon the sheath insulates the membrane, so depolarisation can only occur at the **nodes of Ranvier**. The impulse therefore jumps node to node — **saltatory conduction** 跳跃式传导 — which is much faster than the continuous conduction of an unmyelinated axon. A larger axon diameter and a higher temperature also increase conduction speed.

Nervous or endocrine? Nervous: electrical along neurones, very fast, short-lived, and targeted at specific effectors. Endocrine: chemical in the blood, slower to act, longer-lasting, and reaching all cells with the right receptor.

2 Practice

2.1 State **two** differences between the nervous and the endocrine systems. [2]

2.2 Name the ion that (a) rushes in during depolarisation and (b) leaves during repolarisation. [2]

2.3 State the value of the resting potential and explain how the sodium–potassium pump helps establish it. [3]

2.4 Explain what is meant by the all-or-nothing principle, and state how a stronger stimulus is represented. [3]

2.5 Name the gaps in the myelin sheath and state the term for the conduction they allow. [2]

3 Exam-style questions

3.1 During the refractory period, a neurone cannot send another impulse because: [1]

A	B
C	D

A there is no stimulus
B the sodium channels cannot reopen for a short time
C the myelin sheath blocks it
D acetylcholine is not made

3.2 Why does a myelinated neurone conduct impulses faster than an unmyelinated one? [1]

A	B
C	D

A it has a larger cell body
B the impulse jumps between nodes of Ranvier
C it has more synapses
D it uses hormones

3.3 (a) Describe how the resting potential is maintained in a neurone. [2]

(b) Describe how an action potential is produced when the neurone is stimulated. [3]

3.4 An impulse travels along an axon a distance of 0.60 m in 0.012 s. Calculate the speed of conduction, in m s^{-1}. [2]

3.5 The graph of an action potential shows the potential difference across an axon membrane rising from −70 mV to +40 mV and back.

(a) Explain the events that produce the rise from −70 mV to +40 mV. [3]

(b) Explain the events that return the membrane to its resting potential, including the brief undershoot below −70 mV. [3]

(c) Explain two consequences of the refractory period. [2]

(d) A myelinated axon conducts at 100 m s^{-1} and an unmyelinated axon of the same diameter at 1 m s^{-1}. Explain this difference. [3]

(e) Compare nervous and hormonal coordination, giving three differences. [3]