Week 42

A-Level Biology

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

Topic 15 quiz 2

Exercise sheet 15.1 5

Past-paper questions 15.1 12

Exercise sheet 15.2 20

Past-paper questions 15.2 24

15. Control and coordination

Starter Quiz · 课前小测

A-Level Biology Name: _____ Score: _____

1. A neurone that carries impulses from a receptor to the CNS is a:

   ☐ sensory neurone

   ☐ motor neurone

   ☐ relay neurone

   ☐ effector

2. The brief reversal of charge across a neurone membrane is an action _____.

   _____

3. Neurotransmitters carry the signal across the synaptic gap from one neurone to the next.

   ☐ True ☐ False

4. A sarcomere is:

   ☐ the repeating unit of a muscle fibre, containing thick myosin and thin actin filaments

   ☐ a type of neurone

   ☐ a hormone

   ☐ the gap between two neurones

5. A directional plant growth response to a stimulus (such as light) is called a _____.

   _____

6. Compared with the endocrine system, the nervous system is:

   ☐ faster, using electrical impulses that last a short time

   ☐ slower, using hormones

   ☐ carried only in the blood

   ☐ longer-lasting

7. At the resting potential, the inside of the neurone is:

   ☐ negative compared with the outside

   ☐ positive compared with the outside

   ☐ the same as the outside

   ☐ full of sodium ions

8. The tiny gap between two neurones at a synapse is the synaptic _____.

   _____

9. The calcium ions for contraction are stored in, and released from, the _____ reticulum.

   _____

10. Plants can use fast electrical signals as well as slower hormones to coordinate responses.

    ☐ True ☐ False

A-Level Biology

1. **sensory neurone**

   Sensory neurones carry signals into the CNS.

2. **potential**

   It travels along the axon as the nerve impulse.

3. **True**

   They diffuse across the cleft because the electrical impulse cannot jump the gap directly.

4. **the repeating unit of a muscle fibre, containing thick myosin and thin actin filaments**

   Muscle fibres are divided into sarcomeres, each holding thick (myosin) and thin (actin) filaments.

5. **tropism**

   e.g. phototropism is growth towards light; gravitropism is growth in response to gravity.

6. **faster, using electrical impulses that last a short time**

   Nervous signals are fast electrical impulses with short-lived effects; hormones are slower and longer-lasting.

7. **negative compared with the outside**

   The resting potential keeps the inside negative, maintained by the Na^+/K^+ pump and K^+ permeability.

8. **cleft**

   The neurotransmitter diffuses across the synaptic cleft to the next neurone.

9. **sarcoplasmic**

   When the impulse arrives, the sarcoplasmic reticulum releases Ca^{2+} to trigger contraction.

10. **True**

    The Venus fly trap shows plants use fast electrical signals; hormones like auxin and gibberellin act more slowly.

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.

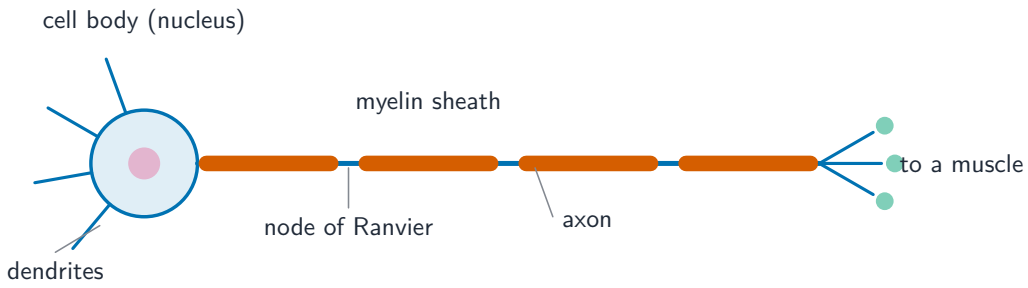
You must be able to:

- 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

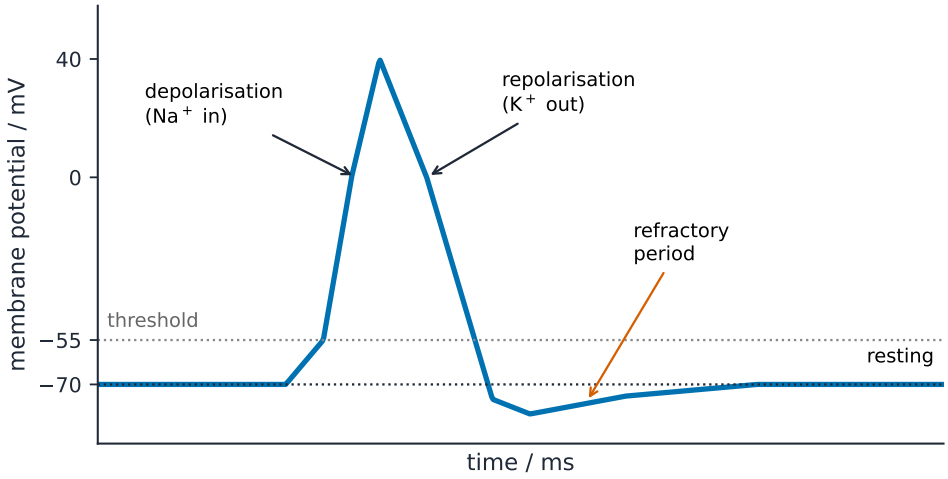
Nervous vs endocrine, and neurones

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

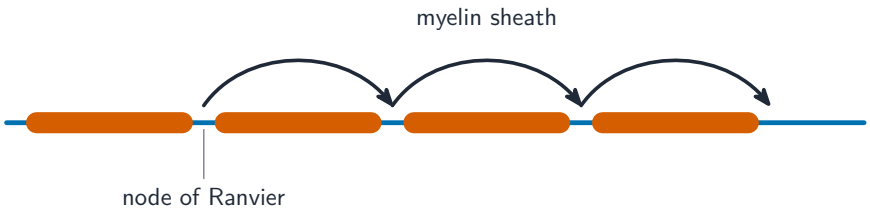


all-or-nothing: once threshold is reached, a full spike fires (no partial APs)

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

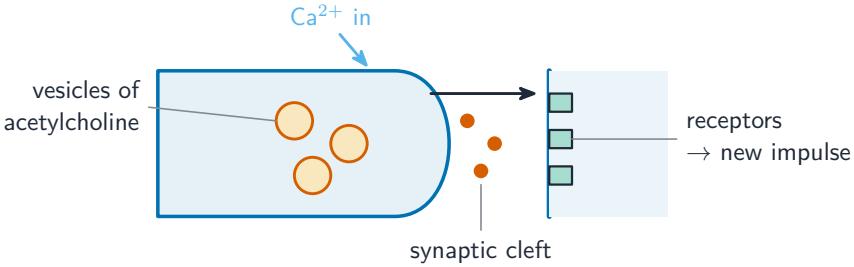
- **resting potential** 静息电位 (−70 mV): a pump moves Na^+ out and K^+ in; the membrane is more permeable to K^+.
- **depolarisation**: a stimulus opens Na^+ channels; Na^+ rushes in; inside becomes positive.
- **repolarisation**: K^+ channels open; K^+ leaves; the potential returns to negative.
- **refractory 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** 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** 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]

Solutions

2.1 any two: nervous uses electrical impulses vs hormones; along neurones vs in the blood; fast vs slow; short-lived vs longer-lasting.

2.2 (a) sodium (Na^+); (b) potassium (K^+).

2.3 About −70 mV; the pump actively transports 3 Na^+ out for every 2 K^+ in, so more positive ions leave than enter and the inside becomes negative relative to the outside.

2.4 Below the threshold potential no action potential is produced at all; at or above it the action potential is always the same size, however strong the stimulus; a stronger stimulus is represented by a higher frequency of impulses.

2.5 The nodes of Ranvier; saltatory conduction.

3.1 B. The sodium channels are temporarily unable to reopen.

3.2 B. The impulse jumps between nodes of Ranvier (saltatory conduction).

3.3 (a) a pump moves sodium ions out and potassium ions in; the membrane is more permeable to potassium, so the inside is negative.
(b) sodium channels open and Na^+ rushes in, depolarising the membrane to about +40 mV; then K^+ channels open and K^+ leaves, repolarising it.

3.4 speed $= \dfrac{0.60}{0.012} = 50$ m s^{-1}.

3.5 (a) The stimulus opens voltage-gated sodium channels and Na^+ enters, depolarising the membrane; once the threshold of about −55 mV is reached, all the voltage-gated Na^+ channels open; the rapid influx of Na^+ raises the potential to about +40 mV.
(b) The Na^+ channels close and voltage-gated K^+ channels open; K^+ leaves the axon, repolarising the membrane; the K^+ channels are slow to close, so the potential briefly falls below the resting value — hyperpolarisation — before the sodium–potassium pump restores it.
(c) Any two of: impulses are kept discrete and separate; the maximum frequency of impulses is limited; the impulse can only travel in one direction, because the region behind is still refractory.
(d) The myelin sheath insulates the axon, so depolarisation can only occur at the nodes of Ranvier; the impulse jumps from node to node, which is saltatory conduction; this is much faster than the continuous depolarisation of the whole membrane in an unmyelinated axon.
(e) Any three of: nervous is electrical along neurones, hormonal is chemical in the blood; nervous is very fast, hormonal slower; nervous effects are short-lived, hormonal longer-lasting; nervous is targeted at specific effectors, hormonal reaches all cells with the right receptor.

5 The endocrine system and the nervous system both coordinate responses in mammals.

(a) Complete Table 5.1 to show the features of three cell-signalling molecules of the endocrine system: antidiuretic hormone (ADH), glucagon and insulin.

Use a tick (✓) if the molecule has the feature and a cross (✗) if the molecule does **not** have the feature.

Put a tick (✓) or a cross (✗) in every box.

Table 5.1

feature	ADH	glucagon	insulin
binds to receptors on cell surface membranes			
results in molecules moving from cells into the blood			
is secreted as a result of detection by osmoreceptors			

[3]

(b) The endocrine system has a slower transmission speed than the nervous system.

Describe **other** ways in which the endocrine system and the nervous system differ.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) The endocrine system and the nervous system can affect muscle function.

Fig. 5.1 shows a transmission electron micrograph of a longitudinal section of striated muscle tissue that is in a relaxed state.

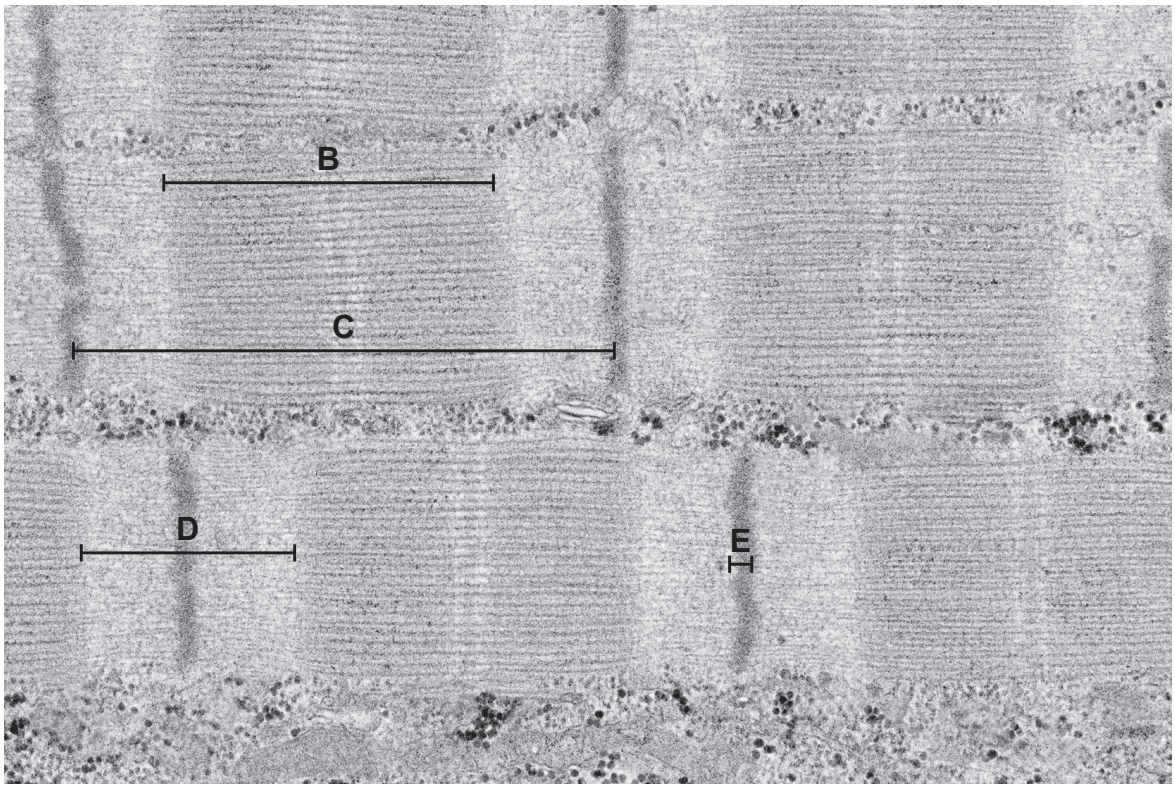


Fig. 5.1

(i) State the letter on Fig. 5.1 that indicates the length of a sarcomere.

..... [1]

(ii) State the letter on Fig. 5.1 that indicates a region where actin and myosin overlap.

..... [1]

(iii) Describe **and** explain how the region labelled **D** on Fig. 5.1 changes during muscle contraction.

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

10 **(a)** Nerve impulses can be transmitted along a myelinated motor neurone to a neuromuscular junction at fast speeds of up to $100\,m\,s^{-1}$.

Outline how a transmission speed of $100\,m\,s^{-1}$ is achieved by the neurone.

.....

.....

.....

.....

.....

.....

..... [3]

(b) When a nerve impulse reaches the neuromuscular junction, acetylcholine is released and diffuses to the sarcolemma.

Describe how the release of acetylcholine can result in the binding of calcium ions to troponin in the sarcomere.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Muscle contraction can be affected by a low blood glucose concentration.

Suggest how a low blood glucose concentration would affect the functioning of the sarcomere.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

1 **(a)** Fig. 1.1 is a diagram of a sensory neurone.

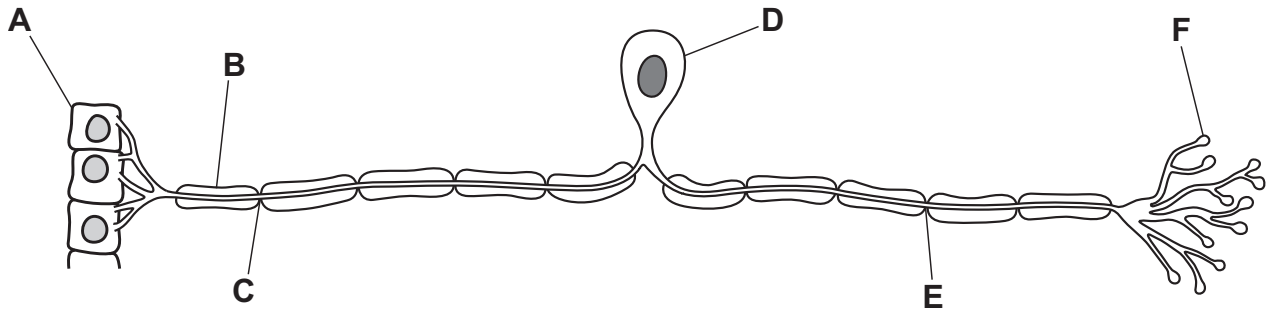


Fig. 1.1

Use the letters **A**–**F** in Fig. 1.1 to identify:

a receptor cell .....

an area where dendron membrane depolarisation occurs .....

a structure that forms a synapse with an intermediate neurone .....

a structure that allows rapid transmission of impulses .....

[4]

(b) Opioid drugs can bind to opioid receptors in the presynaptic membrane of a cholinergic synapse.

Fig. 1.2 is a diagram of a presynaptic membrane with an opioid receptor.

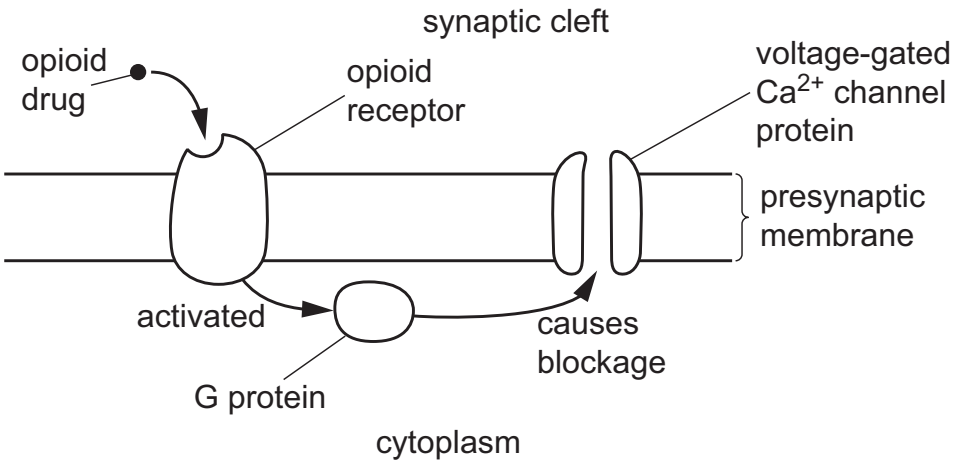


Fig. 1.2

Opioid drugs have an effect on the normal events that occur at a cholinergic synapse.

Suggest **and** explain the effect that an opioid drug will have on the normal events that occur at a cholinergic synapse.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 8]

10 During the course of an action potential, the potential difference across a neurone membrane changes.

Table 10.1 shows the potential difference across the neurone membrane at three sequential time points, **X**, **Y** and **Z**, just before and during an action potential.

Table 10.1

time point	**potential difference / mV**
X	–70
Y	+40
Z	–90

(a) Describe the events that cause each of the potential differences at points **X**, **Y** and **Z**.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [7]

(b) Suggest how one action potential causes an action potential in an adjacent section of the axon of an unmyelinated neurone.

.....

.....

.....

..... [2]

(c) Vertebrate animals generally have a myelin sheath around the axons of motor neurones.

Explain why the presence of a myelin sheath around a motor neurone axon is an advantage.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

A-LEVEL BIOLOGY • EXERCISE SHEET

15.2 Control and coordination in plants

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS gibberellin 赤霉素 • venus fly trap 捕蝇草 • auxin 生长素 • proton 质子 • germination 萌发

Objective

Build the skills to answer exam questions on **control and coordination in plants** — the **Venus fly trap** 捕蝇草, **auxin** 生长素 in elongation growth, and **gibberellin** 赤霉素 in germination.

You must be able to:

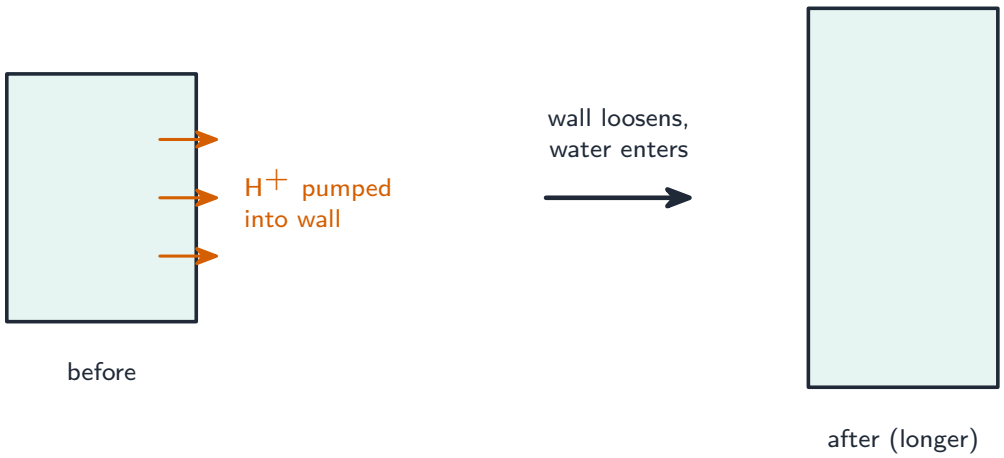
- describe the rapid response of the Venus fly trap and how the trap closes
- explain how auxin causes elongation growth by acidifying the cell wall
- describe the role of gibberellin in the germination of barley

1 Worked examples

■ The Venus fly trap

Touching the trigger hairs starts a fast electrical signal; cells rapidly lose water and change shape, so the trap snaps shut to catch the insect.

■ Auxin and elongation growth



Auxin's "acid growth": H^+ pumped into the wall loosens it, so the cell stretches as water enters

Auxin makes the cell pump **protons** 质子 (H^+) into the **cell wall** 细胞壁; this **acidifies** 酸化 and loosens the wall, so the cell can stretch as water enters — **elongation** 伸长 growth.

Gibberellin and germination

In germinating **barley** 大麦, gibberellin switches on the genes that make **amylase** 淀粉酶, which breaks down stored starch into sugars to feed the growing seedling.

2 Practice

2.1 Name the plant hormone responsible for elongation growth. [1]

2.2 State what gibberellin causes to be made during the germination of barley. [1]

3 Exam-style questions

3.1 How does auxin loosen a plant cell wall? [1]

- **A** by pumping protons (H^+) into the wall, acidifying it
- **B** by removing water from the cell
- **C** by adding cellulose to the wall
- **D** by closing the stomata

3.2 In germinating barley, gibberellin switches on the gene for: [1]

- **A** amylase
- **B** auxin
- **C** chlorophyll
- **D** rubisco

3.3 Explain how auxin causes a plant cell to grow longer. [3]

3.4 A seedling is given gibberellin and grows much taller than an untreated one.

(a) Suggest why the untreated seedling grew less. [2]

(b) Suggest **one** control the experimenter should include. [1]

Solutions

2.1 auxin.

2.2 amylase.

3.1 A. Auxin pumps H^+ into the wall, acidifying and loosening it.

3.2 A. Gibberellin switches on the amylase gene.

3.3 auxin makes the cell pump protons (H^+) into the cell wall; the acidified wall is loosened; so the cell stretches/elongates as water enters by osmosis.

3.4 (a) the untreated seedling may make less gibberellin itself, so less starch is broken down / less elongation occurs.
(b) e.g. treat with water only / same conditions otherwise.

1 Juglone is a chemical produced by plants in the genus *Juglans*, which includes different species of walnut tree.

Fig. 1.1 shows a black walnut tree.

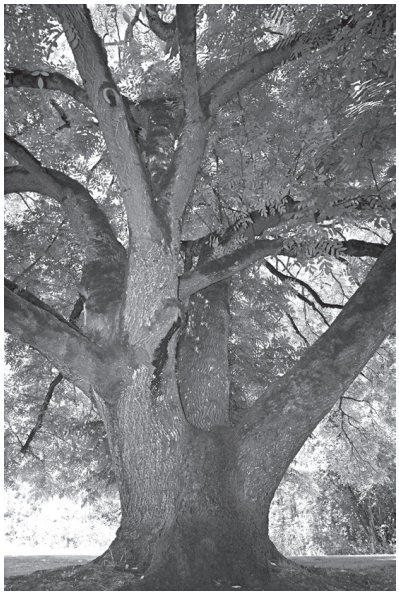


Fig. 1.1

Juglone produced by a black walnut tree can diffuse into the soil surrounding the tree.

Groups of scientists have observed that juglone affects different species of plant growing close to black walnut trees.

Juglone can reduce the percentage of seeds that germinate, delay the start of germination or reduce growth. In some studies, juglone has no effect on germination or growth.

A student planned to investigate the effect of juglone on the cucumber plant, *Cucumis sativus*.

In the investigation, the student:

- placed some damp soil containing juglone in a tray
- added some cucumber seeds to the soil
- placed the container in a suitable environment for germination and growth.

Fig. 1.2 shows cucumber seedlings (young plants) a few days after germination.

Fig. 1.2

The student planned to compare the effect of exposing cucumber seeds to:

- juglone solution with a concentration of 1.0×10^{-3} mol dm^{-3}, which is a concentration that has been measured in soils surrounding black walnut trees
- a control treatment.

The student planned to determine:

- the percentage of cucumber seeds that germinated in soil
- the growth of each cucumber seedling 10 days after the appearance of the seedling above the soil.

(a) Identify the independent variable in this investigation.

..... [1]

(b) Juglone solutions are prepared using a mixture of solvents.

The student was provided with:

- a juglone solution with a concentration of 0.1 mol dm^{-3}
- the mixture of solvents.

Using the solution provided, the student prepared a juglone solution with a volume of 500 cm^3 and a concentration of 1.0×10^{-3} mol dm^{-3}.

The student carried out 1 dilution to prepare the 1.0×10^{-3} mol dm^{-3} solution using measuring cylinders.

(i) State the volumes that the student used to carry out the dilution to produce 500 cm^3 of 1.0×10^{-3} mol dm^{-3} juglone solution.

.....

..... [2]

(ii) Outline **one** improvement the student could make to reduce the percentage error while carrying out the dilution.

.....

.....

..... [1]

(c) **(i)** State a suitable control that the student could use, **and** explain why the student decided to include a control in the investigation.

control .....

.....

explanation .....

.....

.....

[2]

(ii) Describe a method the student could use to investigate the effect of juglone on:

- the percentage of cucumber seeds that germinate
- the growth of each cucumber seedling 10 days after the appearance of the seedling above the soil.

The description of your method should be set out in a logical way and be detailed enough for another person to follow.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

(d) Another student investigated the effect of juglone on a different species of plant called crimson clover, *Trifolium incarnatum*.

The student recorded the number of days required for germination of:

- 10 seeds treated with a juglone solution with a concentration of 1.0×10^{-3} mol dm^{-3}
- 10 seeds not treated with a juglone solution.

(i) The student used the *t*-test to analyse the results. The *t*-test is appropriate for the number of seeds that were used.

Suggest **two other** reasons why the *t*-test is an appropriate statistical test to use for this investigation.

.....

.....

.....

..... [2]

(ii) The null hypothesis for this *t*-test was:

There is no difference between the time taken for seeds to germinate when treated with juglone and the time taken for seeds to germinate when not treated with juglone.

The calculated value of *t* was **2.090**.

The student compared **2.090** to the values in Table 1.1.

Table 1.1

degrees of freedom	probability level (*p*)			
	0.10	**0.05**	**0.01**	**0.001**
17	1.740	2.110	2.898	3.965
18	1.734	2.101	2.878	3.922
19	1.729	2.093	2.861	3.883
20	1.725	2.086	2.845	3.850
21	1.721	2.080	2.831	3.819

Using Table 1.1 and the calculated value of *t* of **2.090**, state **and** explain what the student can conclude about the results.

.....

.....

.....

.....

.....

..... [3]

[Total: 18]

3 Seeds of the common stork's-bill, *Erodium cicutarium*, are shown in Fig. 3.1.

The awn is an extension on the *E. cicutarium* seed. The seed uses the awn to push the seed head into the soil to allow the seed to germinate. The awn changes shape when the humidity changes.

Humidity is the concentration of water vapour in the air. The higher the humidity, the higher the concentration of water vapour in the air.

Fig. 3.1

A student investigated the effect of humidity on the appearance of the awn.

The student set up the apparatus as shown in Fig. 3.2.

Water can be added to the filter paper to change the humidity in the beaker surrounding the seed. Increasing the volume of water added to the filter paper increases the humidity.

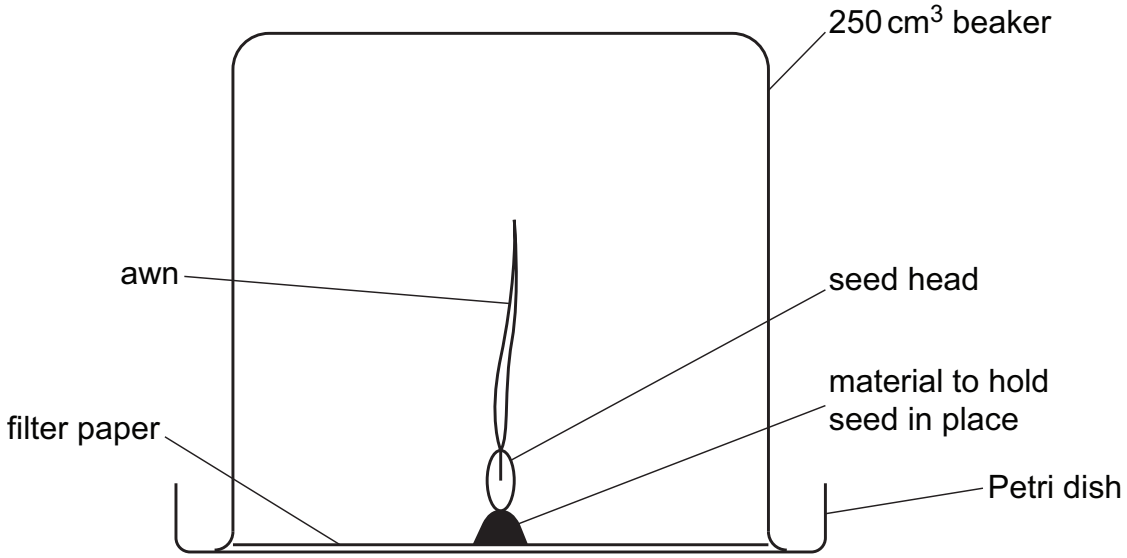


Fig. 3.2

(a) State **two** variables the student would need to standardise for the investigation using the apparatus shown in Fig. 3.2.

.....

.....

.....

.....

..... [2]

(b) Outline a method the student could use to measure the effect of different levels of humidity on the appearance of the awn, using the apparatus in Fig. 3.2.

Do **not** include standardised variables from **(a)** or a risk assessment.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 5]