Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U30-1

S25-A400U30-1

WEDNESDAY, 18 JUNE 2025 – MORNING

BIOLOGY – A level component 3

Requirements for Life

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**10**	
	2.	**12**	
	3.	**20**	
	4.	**14**	
	5.	**15**	
	6.	**9**	
Section B	**Option**	**20**	
	Total	**100**	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B**.

Section **A**: 80 marks. Answer **all** questions. You are advised to spend about 1 hour 35 minutes on this section.

Section **B**: Options; 20 marks. Answer **one option only**. You are advised to spend about 25 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

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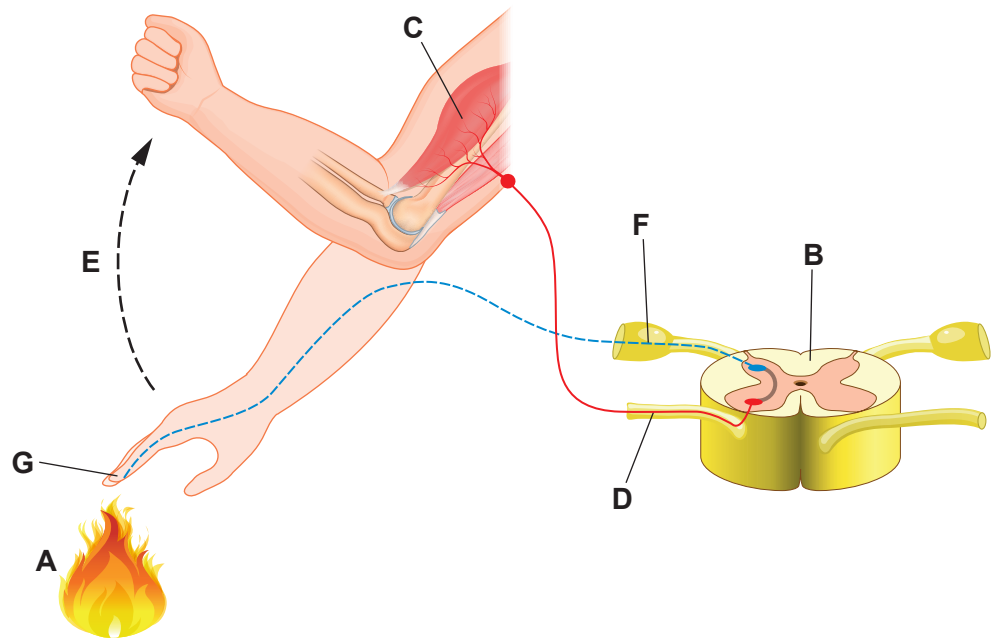
Answer **all** questions.

1. The mammalian reflex arc consists of several components for sensing and responding to the environment. **Image 1.1** shows the reflex arc involved when a heat source is touched by a finger.

Image 1.1



(a) Use letters **A** to **G** from **Image 1.1** to complete the table. [2]

Component of reflex arc	Letter
Coordinator (spinal cord)	B
Effector	.....
Motor neurone	.....
Receptor	.....
Response	E
Sensory neurone	.....
Stimulus	A

Examiner only

(b) Impulses are transferred along both sensory and motor neurones as a wave of action potentials.
Describe how the movement of ions generates an action potential. [3]

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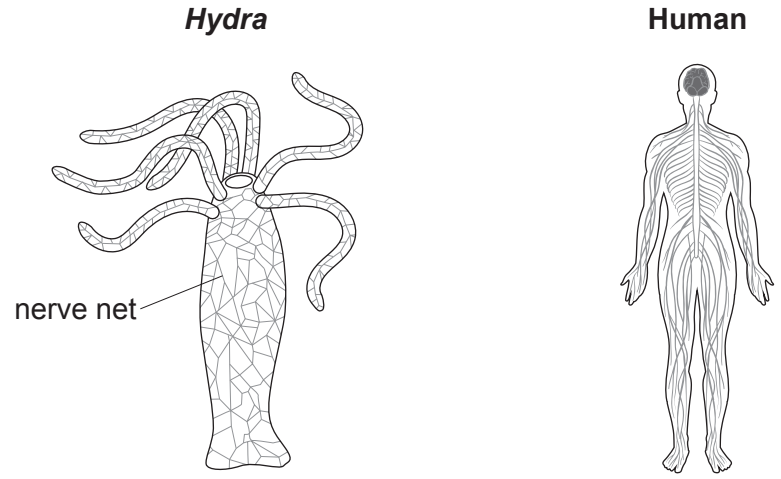
(c) Nerve nets are found in cnidarians (for example, *Hydra*) and are different from the nervous systems of vertebrates. **Image 1.2** shows a nerve net in *Hydra* and the nervous system of a human.

Image 1.2



(i) Use your own knowledge and the information provided in **Image 1.2** to give **three** differences between the nerve net of *Hydra* and the nervous system in a human. [3]

Hydra	Human
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....	....
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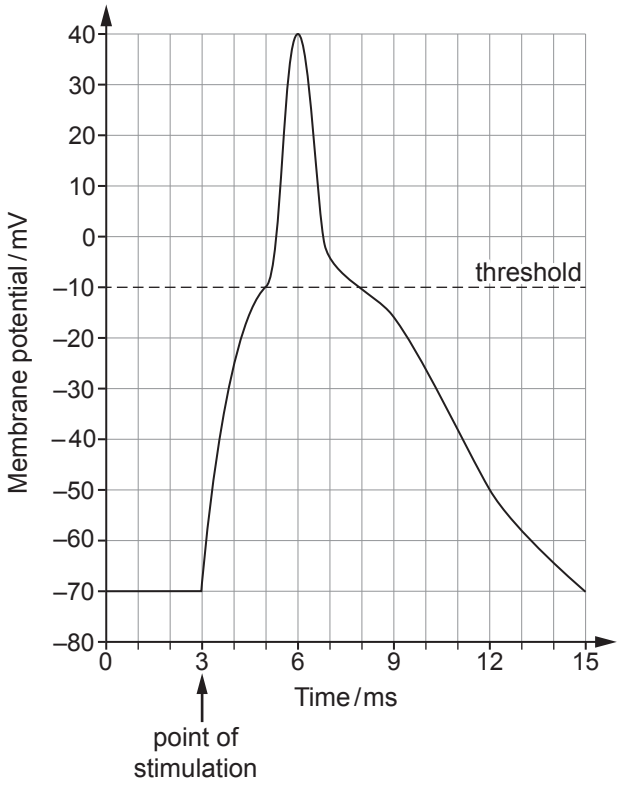
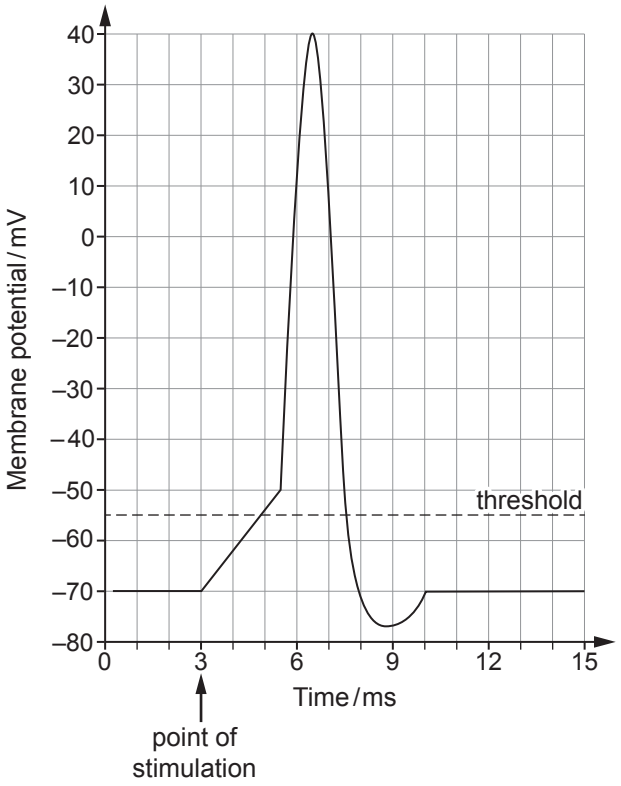
Both *Hydra* and humans generate action potentials in their neurones.
Graphs 1.3A and 1.3B show a trace from each organism.

Graph 1.3A – *Hydra*



Graph 1.3B – Human



(ii) Describe **two** ways in which the *Hydra* trace differs from that of the human. [2]

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II. .....

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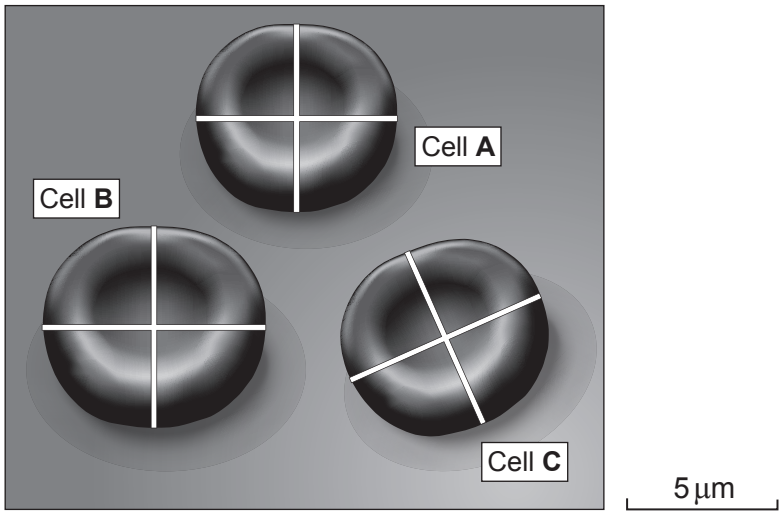
2. (a) **Image 2.1** shows three human erythrocytes.

Image 2.1



(i) Human erythrocytes are biconcave in shape.
Explain how this increases the efficiency of gas exchange by these cells. [1]

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Examiner only

Two diameters of cells **A**, **B** and **C** have been marked on **Image 2.1**. The length of the diameters for the cells were measured from the image and are shown in **Table 2.2**.

Table 2.2

Cell	Diameter 1 / mm	Diameter 2 / mm
A	28	23
B	30	28
C	27	25

(ii) I. Use all the data in **Table 2.2** to calculate the mean diameter of the human erythrocytes in **Image 2.1**. [1]

Mean diameter of human erythrocytes in **Image 2.1** = ... mm

II. **Use the scale bar** in **Image 2.1** and your answer to (ii)I. to calculate the mean **actual** diameter of a human erythrocyte. **Give your answer in μm.** [2]

Mean **actual** diameter of a human erythrocyte = ... μm

III. Use **Image 2.1** to suggest **one** reason why the erythrocytes have different measured diameters in **Table 2.2**. [1]

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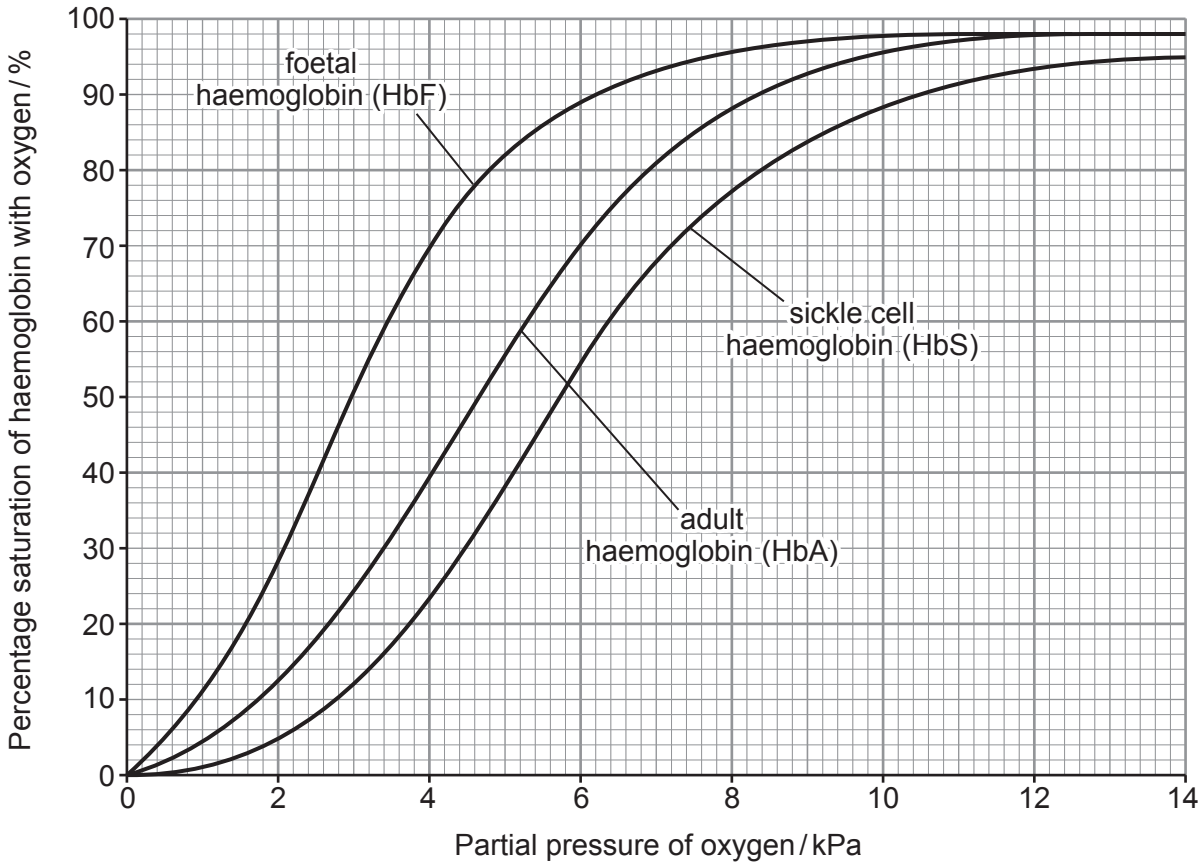
(b) In the uterus, a developing foetus gains oxygen from maternal blood via the placenta. The foetal erythrocytes contain foetal haemoglobin (HbF) rather than adult haemoglobin (HbA).
People with sickle cell anaemia have a gene mutation resulting in the production of sickle cell haemoglobin (HbS).

Graph 2.3 shows the oxygen dissociation curves for HbF, HbA and HbS

Graph 2.3



(i) Use data from **Graph 2.3** to explain the advantage to a foetus of having HbF rather than HbA. [3]

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Examiner only

(ii) Use **Graph 2.3** to explain how the positions of the curves for HbA and HbS affect oxygen saturation. [2]

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(iii) Use all the information provided to explain the effect of HbS on a person with sickle cell anaemia. [2]

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3. Sucrose and other carbohydrates, such as raffinose, are transported from mesophyll cells in leaves to other parts of a plant through the phloem.

(a) Sucrose is a disaccharide. Raffinose is a trisaccharide made up of galactose, glucose and fructose. Both sucrose and raffinose contain glycosidic bonds.

Raffinose is a non-reducing sugar.
Describe how you would show that raffinose is a **non-reducing sugar** and not a reducing sugar. [4]

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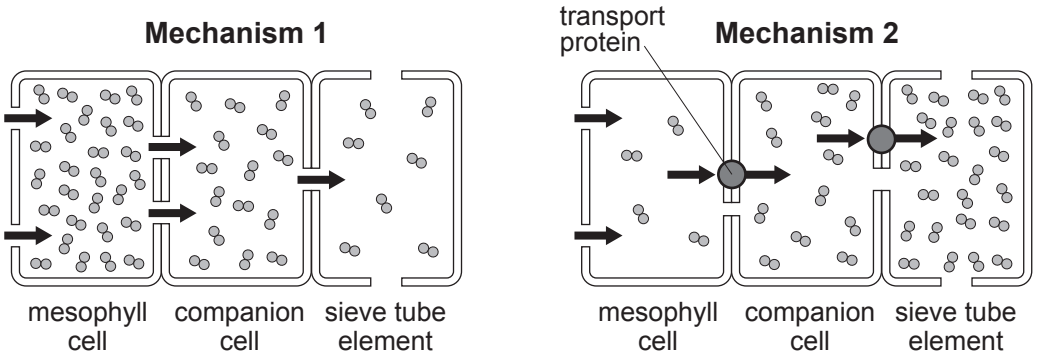
(b) Carbohydrates move from leaf mesophyll cells into the sieve tube elements of plants via companion cells. There are several possible mechanisms involved. **Image 3.1** shows two of these mechanisms.

Image 3.1



(i) Identify how sucrose is transported **from mesophyll to companion cells** in each mechanism shown in **Image 3.1**. Explain the reason for your answer. [4]

Mechanism	Mode of transport	Explanation
1	....	....
2	....	....

Examiner only

(ii) A third mechanism involves sucrose being hydrolysed into its monosaccharides and used to synthesise raffinose in the companion cell.

Suggest how this increases the rate of movement of sucrose from mesophyll into the companion cells. [2]

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(c) The mass flow hypothesis of movement of sugars in the phloem suggests there is a pressure gradient from source to sink.
Explain how high pressure is generated in the phloem near the source cells. [4]

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(d) The transport of sucrose in the phloem was investigated using radioactive carbon dioxide and ringing of the stem.

- All leaves were removed apart from one midway down the stem.
- Radioactive carbon dioxide $^{14}CO_2$ was added to a chamber surrounding the leaf.
- The level of ^{14}C was then measured at the top of the stem, in the leaf and in the root.
- The experiment was then repeated on three more plants but with the stem being ringed to remove the phloem in a combination of locations. **Image 3.2** shows the setup up of the apparatus.

Image 3.2

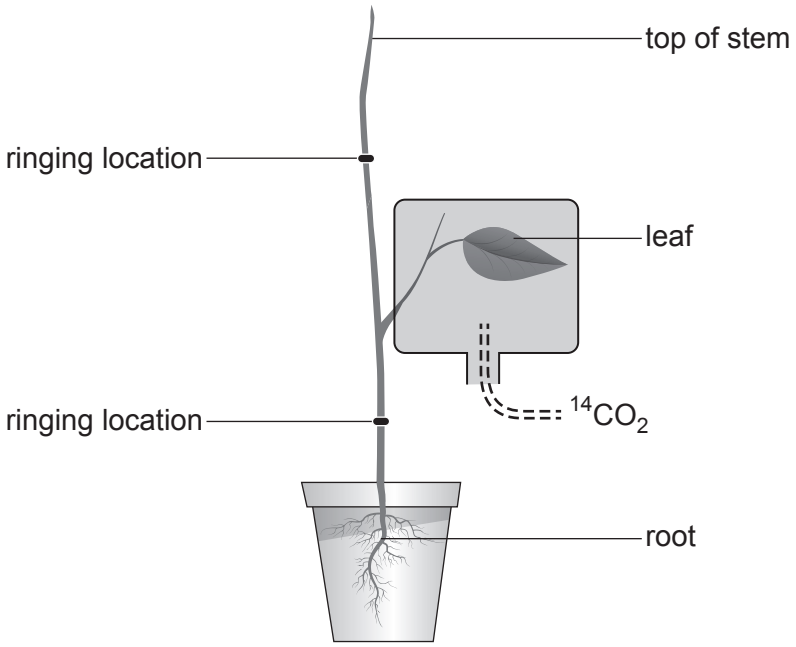

Table 3.3 shows the results of the investigation.

Table 3.3

Plant	Ringing location in relation to leaf	Level of ^{14}C / au		
		Leaf	Top of stem	Root
A	none	2.5	3.3	0.9
B	above	2.3	0.0	1.7
C	below	2.1	4.1	0.0
D	above and below	2.1	0.0	0.0

Examiner only

(i) Suggest and explain the purpose of plant **A**. [2]

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(ii) Use the information from **Image 3.2** and **Table 3.3** to make **two** conclusions about the transport of sucrose in plants. Justify each conclusion. [4]

Conclusion 1

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Conclusion 2

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Turn over.

Examiner only

4. Parasites are organisms which obtain nourishment at the expense of the host. Parasites of humans include *Taenia solium* (pork tapeworm) and *Pediculus capitus* (headlouse). These are shown in **Image 4.1**.

Image 4.1

Taenia

Pediculus

(a) *Taenia* is an endoparasite and *Pediculus* is an ectoparasite. Define each of these terms. [1]

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(b) Explain why *Taenia* does not have a digestive system but *Pediculus* does have a digestive system. [4]

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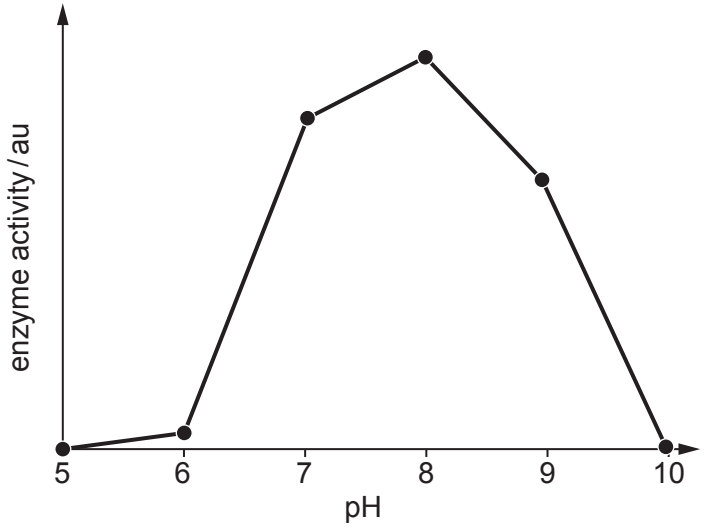
Examiner only

(c) Trypsin is an enzyme which digests proteins in the small intestine of humans.
Graph 4.2 shows how trypsin is affected by pH.

Graph 4.2



(i) Describe the evidence in **Graph 4.2** that suggests that trypsin is released into the duodenum. [1]

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(ii) Trypsin is released in an inactive form called trypsinogen.
Name the molecule that activates trypsinogen. [1]

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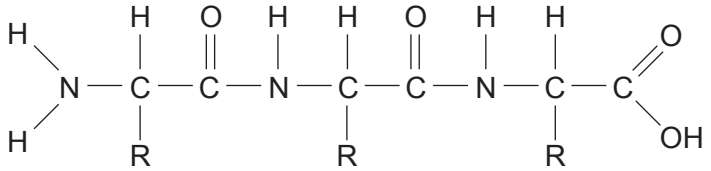
Image 4.3 shows a polypeptide containing three amino acids.

Image 4.3



(iii) Trypsin hydrolyses peptide bonds within polypeptides.
Draw an arrow on Image 4.3 to identify **one** peptide bond. [1]

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(d) *Taenia* is able to change the pH of its environment.

An investigation was carried out to determine the effect of *Taenia* on the pH of its environment.

- Different saline (salt) solutions were prepared, each with a different initial pH (between 5.5 and 10.0).
- One *Taenia* was added to each solution.
- Each solution was incubated for two hours at 37 °C.
- The pH of the solutions was measured after incubation.

(i) Suggest why the *Taenia* were placed in saline solution rather than distilled water. [1]

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(ii) The results of the experiment showed that the pH of **all** the saline solutions at the end of the two-hour period was pH 5.0.
With reference to **Graph 4.2**, explain why it is of benefit to *Taenia* to reduce the pH of its environment. [3]

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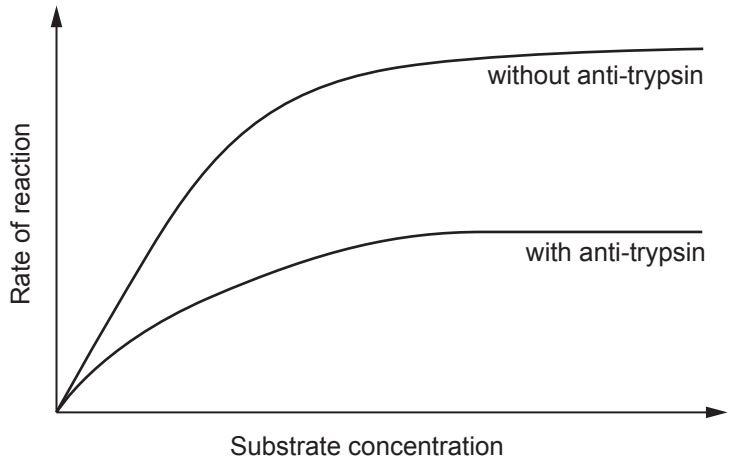
Taenia also secretes a molecule called anti-trypsin which acts as an inhibitor of trypsin. **Graph 4.4** shows the rates of reaction of trypsin with and without the anti-trypsin.

Graph 4.4



(iii) Use **Graph 4.4** to identify which type of inhibition is shown by antitrypsin. Explain your answer. [2]

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5. Bony fish have a specialised gas exchange surface. Smaller organisms, like the flatworm, do not need specialised surfaces for gas exchange.

(a) Explain why larger organisms require specialised gas exchange surfaces. [2]

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(b) Nitrogenous waste, in the form of ammonia, is released by the gills of bony fish directly into the water. Other organisms release different forms of nitrogenous waste.

(i) State the main form of nitrogenous waste excreted by: [1]

Mammals .....

Birds .....

Mammals have kidneys which can change the concentration of their urine. Urine concentration is measured in $mOsm\,dm^{-3}$ and represents the number of particles dissolved in a dm^3 of solvent. **Table 5.1** shows the water availability and the urine concentration of a range of organisms.

Table 5.1

Organism	Water availability	Urine concentration / $mOsm\,dm^{-3}$
domestic cat	medium	3100
kangaroo rat	low	5500
beaver	high	520
human	medium	1400
camel	low	2800

(ii) I. Use the information in **Table 5.1** to describe the relationship between the availability of water and the concentration of urine produced by different mammals. [1]

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II. Explain the advantage of this relationship to the kangaroo rat. [1]

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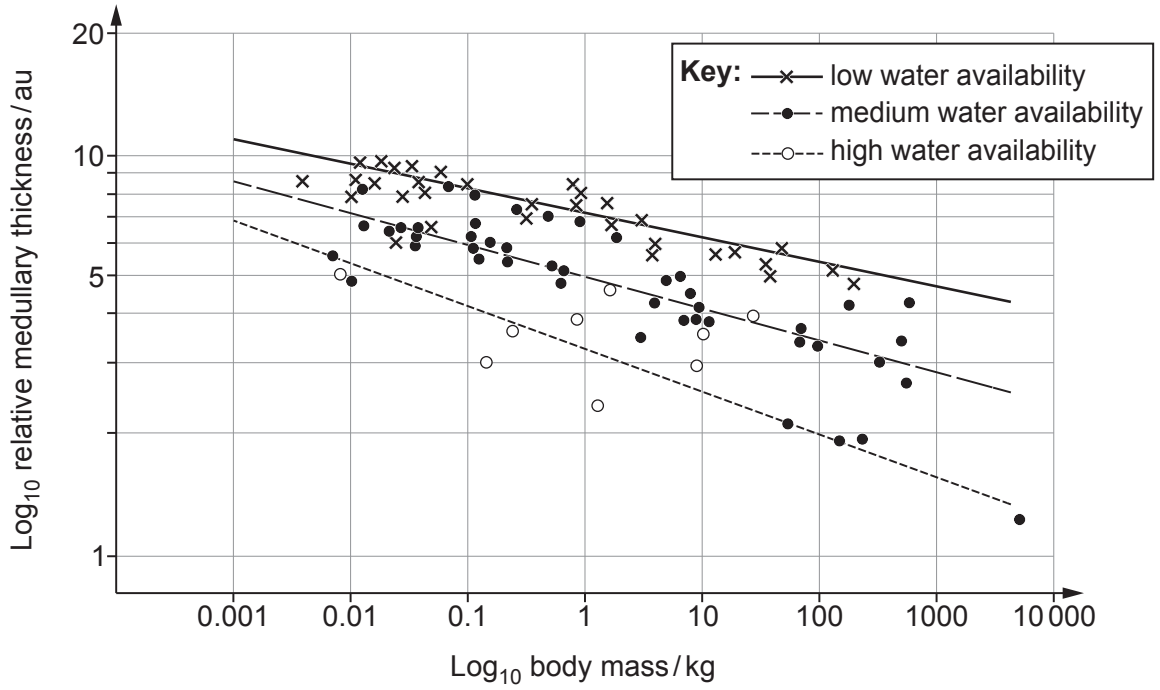
The medulla of the kidney contains the loop of Henle and the collecting ducts. **Graph 5.2** shows the relative medullary thickness in a range of organisms from habitat types with different levels of water availability.

Graph 5.2



(iii) Explain why **Graph 5.2** uses a log scale for body mass. [1]

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Examiner only

(iv) Use **Graph 5.2** and your own knowledge to suggest how mammals living in habitats with a low water availability produce more concentrated urine. No details of ADH are required. [4]

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Turn over.

Examiner only

(c) (i) Toxic particles from plasma can be removed from the body in urine. Renal clearance is a measure of the volume of plasma that can be cleared of a particle by the kidneys per unit time.

Renal clearance can be calculated using the following equation:

$$CL_x = \frac{U_x \times V}{P_x}$$

Where

CL_x = renal clearance of particle **X**
U_x = urine concentration of particle **X**
P_x = plasma concentration of particle **X**
V = urine flow rate

Use the equation and the values below to calculate the renal clearance for particle **X** for a human. **Give your answer to the nearest whole number.** [3]

$U_x = 3.3\,\text{mg}\,\text{cm}^{-3}$
$P_x = 0.24\,\text{mg}\,\text{cm}^{-3}$
$V = 7\,\text{cm}^3\,\text{min}^{-1}$

CL_x = ... $\text{cm}^3\,\text{min}^{-1}$

(ii) If a human was dehydrated their urine flow rate would decrease.
Suggest how this would affect renal clearance of particle X and the consequences of this to the person. [2]

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6. Mollusca is a phylum of invertebrate animals that have evolved different types of vascular systems. **Images 6.1** and **6.2** show the generalised circulatory systems of an aquatic snail and a squid (also aquatic). The circulatory system of aquatic snails includes a haemocoel. This is the main body cavity containing circulatory fluid which surrounds the internal organs.

Image 6.1: circulatory system of an aquatic snail

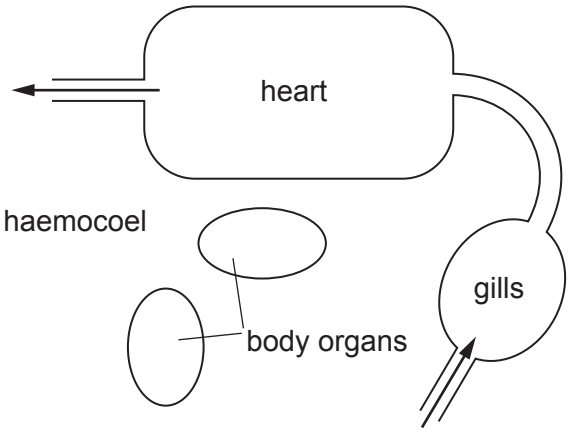
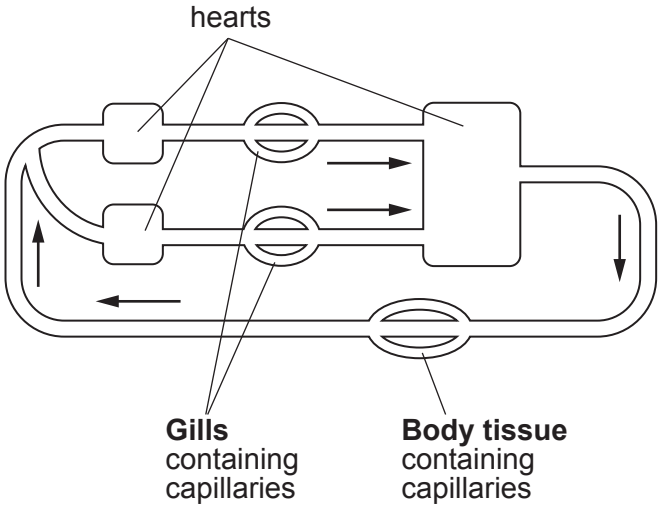


Image 6.2: circulatory system of a squid



Snails are slow-moving animals which feed mainly by grazing on algae and plants.

Squid are fast-moving predatory animals feeding on a wide variety of marine animals.

Describe the key features of the open circulatory system found in aquatic snails (**Image 6.1**) and the closed circulatory system found in squid (**Image 6.2**).
Explain how the circulatory systems of these organisms reflect their lifestyles. [9 QER]

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Examiner only

Examiner only

Examiner only

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Examiner only

SECTION B: OPTIONAL TOPICS

Option A: **Immunology and Disease** ☐

Option B: **Human Musculoskeletal Anatomy** ☐

Option C: **Neurobiology and Behaviour** ☐

Answer the question on **one topic only**.

Place a tick **(✓)** in **one** of the boxes above, to show which topic you are answering.

You are advised to spend about 25 minutes on this section.

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Option A: Immunology and Disease

7. Scarlet fever is an infectious disease of young children. The characteristic symptoms are sore throat, fever, and a red rash. The disease is caused by the bacterium *Streptococcus pyogenes* which produces a toxin that causes the symptoms. Diagnosis of scarlet fever may be confirmed by a test that detects antigens of *S. pyogenes*.

(a) Define the following terms: [2]

Infectious disease;

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Toxin;

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Antigen.

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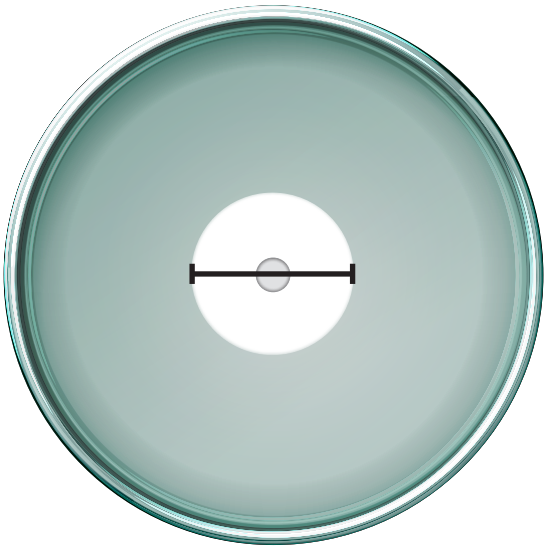
(b) **Image 7.1** shows the results of an experiment into the effect of an antibiotic on *S. pyogenes*. This involved placing a disc soaked in the antibiotic on an agar plate spread with a culture of *S. pyogenes*. The antibiotic diffuses through the agar and a clear zone is produced around the disc where bacterial growth has been inhibited.

Image 7.1



Magnification = × 0.6

Examiner only

(i) Use the line on **Image 7.1** to calculate the actual diameter of the clear zone. [2]

Actual diameter = ... mm

The experiment was then carried out for a range of antibiotics. The mean results are shown in **Table 7.2**.

Table 7.2

Antibiotic	Mean diameter of clear zone / mm	Standard deviation / ±
Penicillin G	30.4	2.7
Amoxycillin	27.8	2.9
Tetracycline	9.5	2.4
Control	0.0	0.0

(ii) It was concluded that Penicillin G was the most effective antibiotic against *S. pyogenes*.
Use the data in **Table 7.2** to evaluate this conclusion. [2]

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(iii) In this investigation, identical agar plates and discs were used for all antibiotics and the concentration of each of the antibiotics was kept the same.
State **two** other variables which would need to be controlled during the investigation. [2]

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Examiner only

(c) Tetracycline is a broad-spectrum antibiotic. Some strains of *S. pyogenes* have become resistant to this antibiotic.

(i) Explain why tetracycline is effective against a wide range of bacterial species. [1]

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(ii) *S. pyogenes* is a Gram positive bacterium. Resistant strains of *S. pyogenes* survive due to one of two different mechanisms:

- A transmembrane protein which pumps tetracycline out of the cell as fast as it enters.
- A protein that protects the ribosome from the effects of tetracycline.

Use the information given to explain why *S. pyogenes* which are resistant to tetracycline can still be killed by penicillin. [3]

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(iii) Scientists have concluded that resistance of *S. pyogenes* to tetracycline has become a problem due to the extensive use of this antibiotic.

Explain how the extensive use of this antibiotic might lead to an increased number of resistant strains of *S. pyogenes*. [3]

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Examiner only

(d) Following infection by *S. pyogenes*, the patient develops immunity to the bacterium. This immunity can last for several years.

(i) Describe how infection can lead to the development of a primary immune response against *S. pyogenes*. [3]

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(ii) Scarlet fever caused by *S. pyogenes* is very uncommon in children under 6 months old who are breastfed.

State the type of immunity present in these children and suggest how this occurs. [2]

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Examiner only

Option B: Human Musculoskeletal Anatomy

8. (a) The axial skeleton includes the vertebral column and rib cage.

(i) State **one** function of the axial skeleton. [1]

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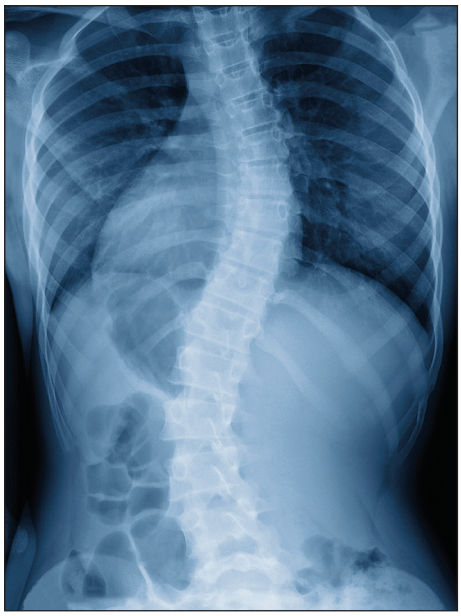
Image 8.1 shows an X-ray of part of the axial skeleton of a patient with a postural deformity.

Image 8.1



(ii) Name the type of deformity shown in **Image 8.1** and identify the region of the spine which is most affected in this patient. [2]

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(iii) In addition to surgery, identify **one** type of treatment which might be used to correct the deformity shown in **Image 8.1**. [1]

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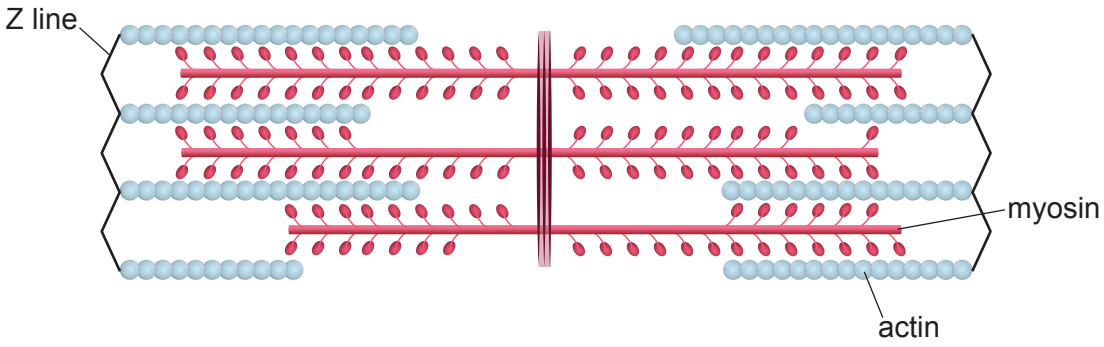
Examiner only

(b) Muscle wasting involves both the breakdown of muscle tissue and increased muscle fatigue. This can occur as part of the aging process, prolonged inactivity or disease. **Image 8.2** shows the appearance of a sarcomere in a person with wasted muscles.

Image 8.2



(i) Use your own knowledge of the sliding filament theory to describe the damage seen to the sarcomere in **Image 8.2**. Explain how this can lead to muscle weakness. [3]

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(ii) Enzymes in lysosomes of muscle cells can lead to the breakdown of mitochondria in a process called autophagy.

Suggest how autophagy might affect muscle contraction. [2]

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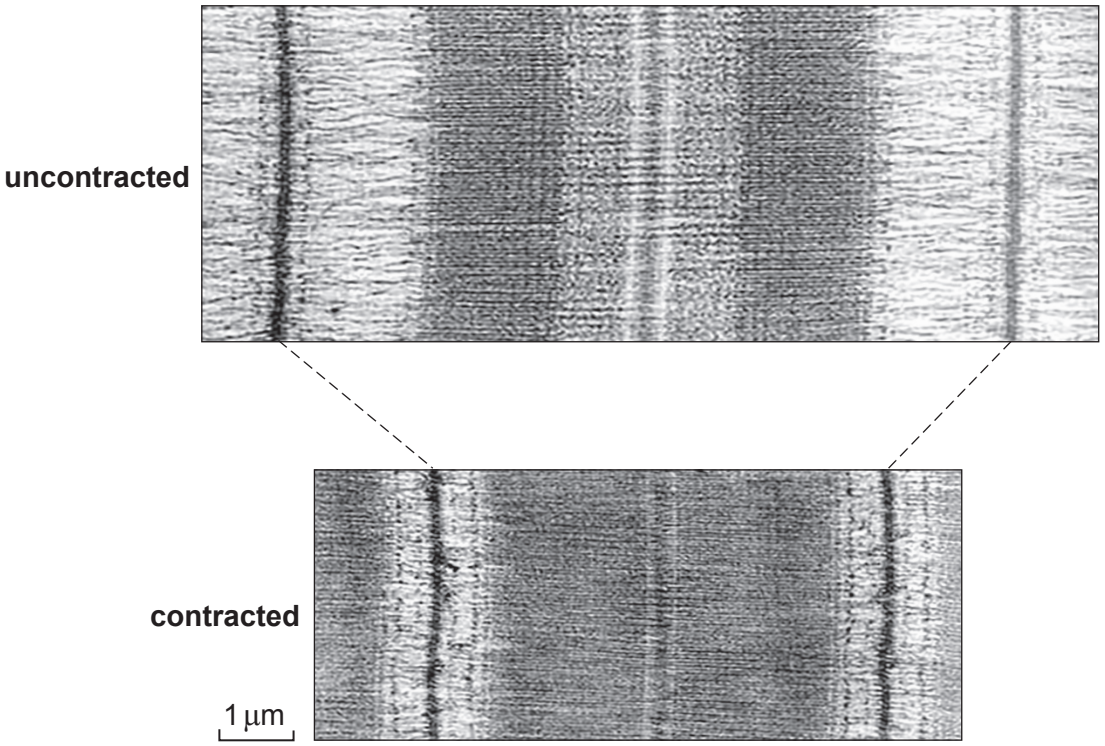
Image 8.3 shows the changes that occur in a sarcomere when skeletal muscle contracts, as seen through an electron microscope.

Image 8.3



(iii) Use the scale bar to determine the actual length of the **contracted** sarcomere in **Image 8.3**. [2]

Actual length = ... μm

Examiner only

(c) **Table 8.4** shows data on the percentage of slow twitch (ST) and fast twitch (FT) muscle fibres from groups of athletes and non-athletes. It also shows the ratio of slow twitch to fast twitch muscles in each group of athletes.

Table 8.4

Group	Proportion of slow twitch and fast twitch muscle fibres		
	Slow Twitch / %	Fast Twitch / %	Ratio ST : FT
marathon runners	82	18	4.6 : 1
swimmers	75	25	3.0 : 1
non-athlete	45	55	0.8 : 1
sprinters	37	63	0.6 : 1

(i) The ratio of ST : FT muscle fibres in marathon runners was 4.6 : 1.
Explain the advantage of this ratio to marathon runners. [1]

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(ii) The samples analysed were all obtained from the same muscle in all individuals in the study.

Explain why it is important to obtain the samples from the same muscle in each individual. [2]

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(iii) State **two** factors that should have been controlled within each group to improve confidence in the conclusions. [2]

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(d) **Image 8.5** shows an X-ray of a patient who was suffering from osteoarthritis of the knee.

Image 8.5

FRONT VIEW

(i) Describe the evidence from **Image 8.5** that this patient had osteoarthritis. [1]

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(ii) The patient above was advised that they would be a suitable candidate for knee replacement surgery.
State **three disadvantages** of this treatment. [3]

I. .....

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II. .....

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III. .....

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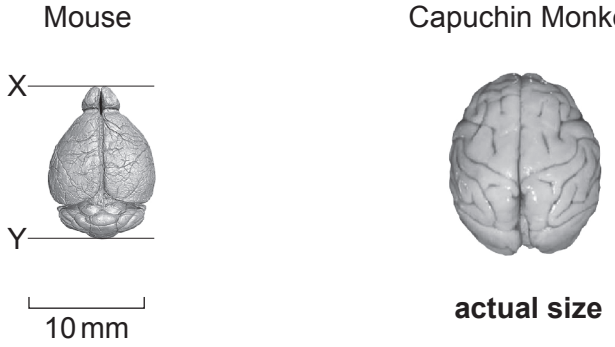
Option C: Neurobiology and Behaviour

9. (a) **Image 9.1** shows the brains of a mouse and a capuchin monkey.

Image 9.1



(i) The mouse brain in **Image 9.1** has been magnified to allow comparison with the monkey brain.
Use the scale bar to calculate the actual length of the mouse brain. **Give your answer to the nearest mm.** [2]

Actual length = ... mm

(ii) The monkey has a larger brain than the mouse and is considered to be a more intelligent animal.
Use **Image 9.1** to identify **one** other difference between the two brains that might account for this. [1]

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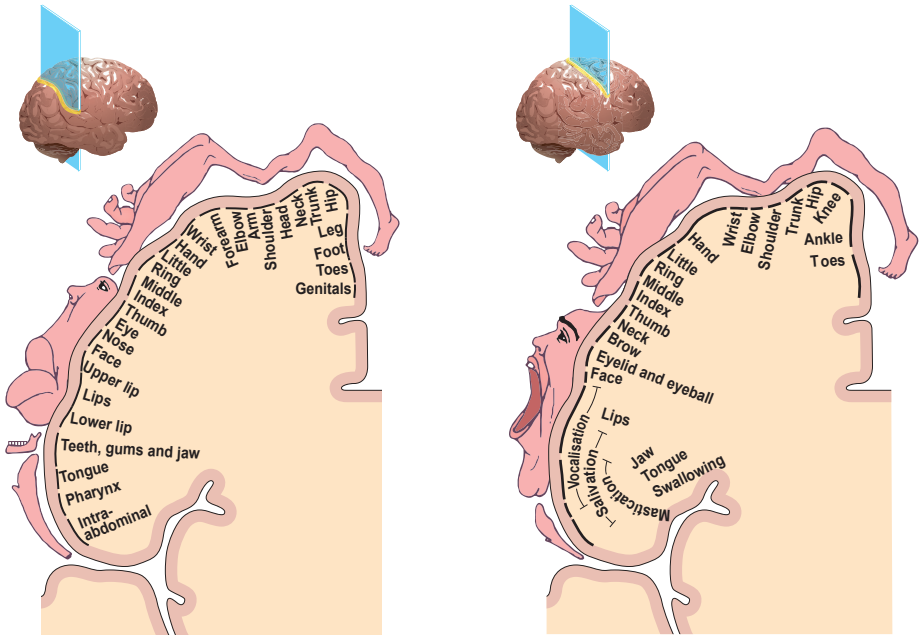
Homunculi are used to represent the sizes of the relevant parts of the cerebrum associated with receiving sensory information from different parts of the body and their motor control. **Image 9.2** shows sensory and motor homunculi.

Image 9.2



Sensory cortex in right cerebrum

Motor cortex in right cerebrum

(iii) I. Describe the relationship between the size of the body parts shown in **Image 9.2** and the degree of innervation of the cerebrum. [1]

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II. Explain why the size of the fingers in both the sensory and motor homunculi are similar. [2]

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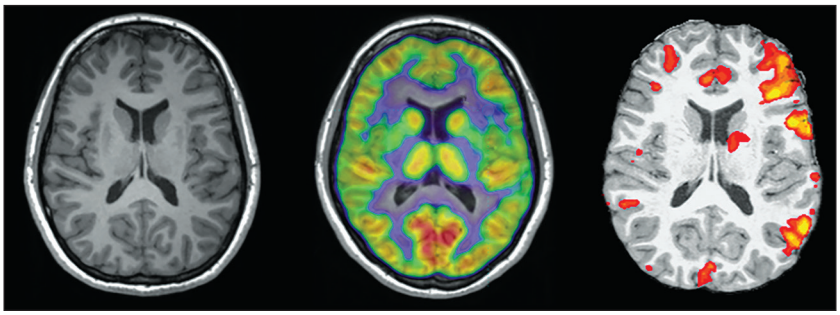
(b) **Image 9.3** shows three types of scan which are used to visualise the brain.

Image 9.3



CAT/CT Scan PET Scan fMRI Scan

(i) Describe **two** advantages of using scans to visualise the brain. [2]

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(ii) fMRI scanning is considered the best method for monitoring brain activity.
State the full name for this scanning method. [1]

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(iii) The coloured areas on the fMRI scan correspond to increased flow of oxygenated blood in that region.
Explain how this can be used to monitor brain activity. [2]

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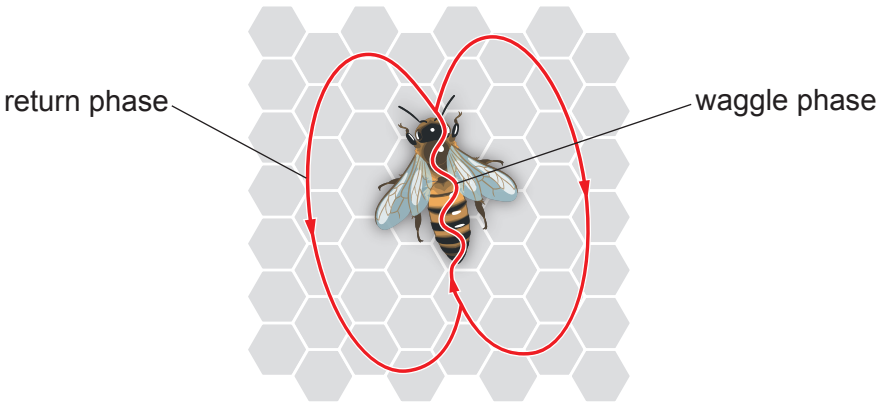
Examiner only

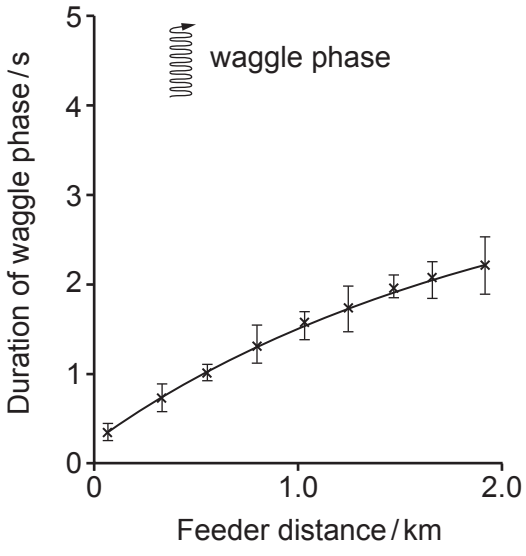
(c) Honeybees live in dense groups called colonies. The bees display a range of innate behaviour patterns which help them to communicate within the colony. On returning to their colonies, worker honeybees perform a waggle dance many times to communicate to other bees the distance and direction of a food source from the hive. The dance is made up of two phases, the waggle phase and the return phase. This is shown in **Image 9.4**.

Image 9.4

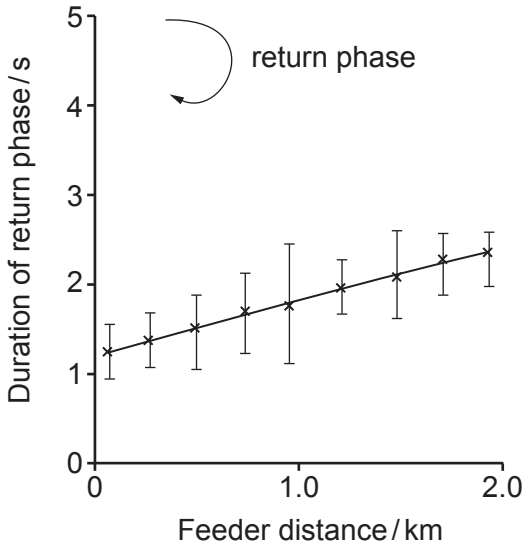


A group of researchers studied the relationship between the duration of the two phases of the waggle dance to the distance of artificial feeders from the hive. The artificial feeders contained a sugar solution and were all the same colour. The results they obtained are shown in **Graph 9.5A** and **Graph 9.5B**.

Graph 9.5A



Graph 9.5B



(i) Suggest **two** factors that could be controlled by using an artificial feeder for this experiment rather than relying on naturally occurring flowers. [2]

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(ii) Identify which of **Graphs 9.5A** and **B** has the more reliable data. Explain your choice. [1]

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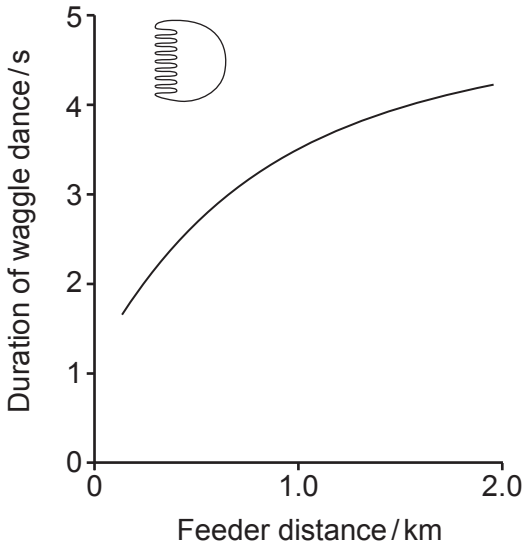
Graph 9.6 shows data from **Graphs 9.5A** and **B** combined.

Graph 9.6



(iii) State the general relationship shown in **Graph 9.6** and suggest the benefit of this relationship to the bee colony. [3]

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(iv) The bee waggle dance is an example of innate behaviour in a social insect. Primates also live in close social groups and display both innate and learned behaviour within the social group.

I. Distinguish between innate and learned behaviour. [1]

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II. Give **one** example of each type of behaviour in primates. [2]

Innate

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Learned

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