Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U30-1

S24-A400U30-1

WEDNESDAY, 19 JUNE 2024 – MORNING

BIOLOGY – A level component 3
Requirements for Life

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**11**	
	2.	**16**	
	3.	**22**	
	4.	**10**	
	5.	**12**	
	6.	**9**	
Section B	**Option**	**20**	
	Total	**100**	

A400U301
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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.

You may use a pencil for graphs and diagrams only.

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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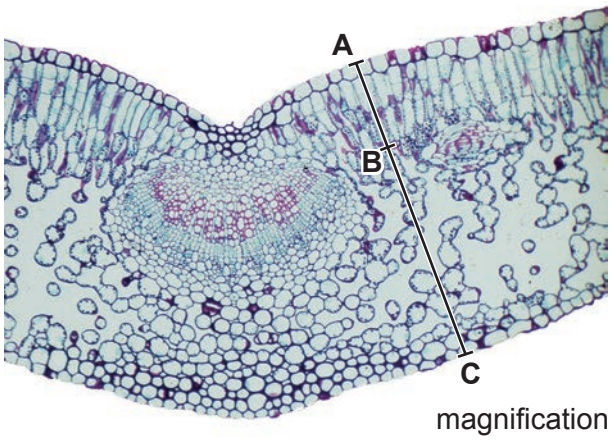
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SECTION A

Answer **all** questions.

1. (a) **Image 1.1** is a photomicrograph of part of a transverse section of a privet (*Ligustrum*) leaf.

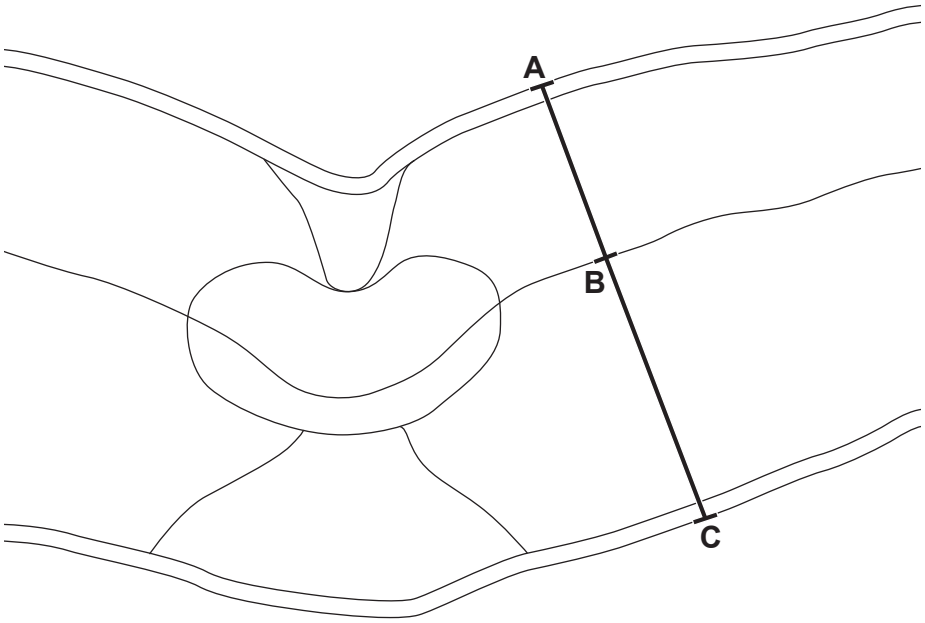
Image 1.1



magnification × 60

A student drew a low power plan of **Image 1.1** as shown in **Image 1.2**.

Image 1.2



(i) **Add labels** to **Image 1.2** to identify **three** tissue layers that contain **photosynthesising cells**. [3]

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(ii) The proportions of (A–C : A–B) in **Image 1.1** have a ratio of **3.5 : 1**.

I. Calculate the ratio of (A–C : A–B) in **Image 1.2**. [1]

Ratio = ... : 1

II. **Image 1.2** has not been drawn in the correct proportions.
Tissue layer A–B has been drawn too thick.
Calculate how thick tissue A–B should have been drawn in **Image 1.2** to make the proportion of the plan correct. [2]

Thickness = ... mm

A400U301
03

(b) To photosynthesise effectively, a leaf is adapted for the absorption of light energy and for diffusion of gases.

State **two** adaptations of a leaf for the absorption of light and **two** adaptations for the efficient diffusion of gases. [4]

Adaptations for the absorption of light.

1. .....

2. .....

Adaptations for the efficient diffusion of gases.

1. .....

2. .....

(c) The vascular bundles in a leaf form a highly branched network. Two functions of the vascular bundles are transport of:

- water and mineral ions in the xylem
- sugars and other organic materials in the phloem.

State **one** other function of the vascular bundles. [1]

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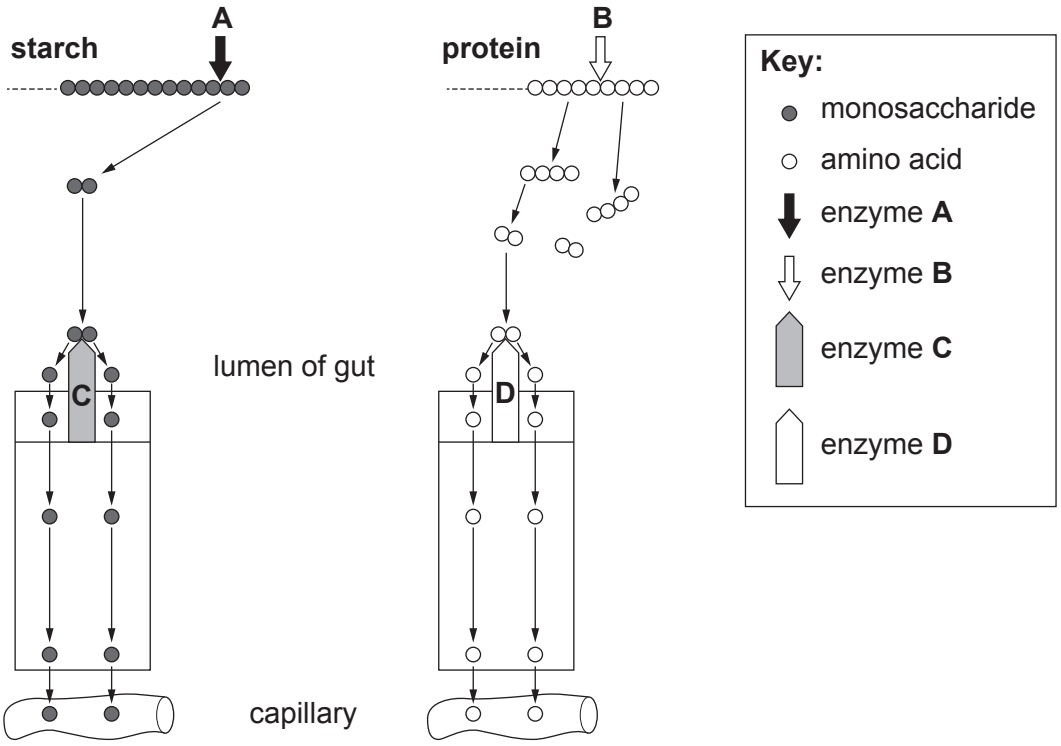
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2. The efficient digestion of molecules in food substances requires many different enzymes and different conditions. **Image 2.1** is a schematic diagram representing the breakdown and absorption of starch and protein.

Image 2.1



(a) (i) I. Use **Image 2.1** to complete **Table 2.2**. [3]

Table 2.2

Label	Enzyme name	Product
A	.....	.....
B	.....	.....
C	.....	.....

II. Name the bond hydrolysed by enzyme **D**. [1]

.....

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(ii) Many digestive enzymes are secreted into the lumen of the gut. Describe the exact position of enzymes **C** and **D** in **Image 2.1** and suggest the advantage of the position of these enzymes. [2]

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(b) When vinegar (ethanoic acid) is added to potato chips, enzyme **A** (produced in the mouth) is unable to break down the starch they contain. Suggest the reason for this. [1]

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QUESTION CONTINUED OVERLEAF

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(c) The structure of the gut of a cow, horse and dog is shown in **Image 2.3** (not drawn to scale). Cows and horses are herbivores and dogs are carnivores.

Image 2.3

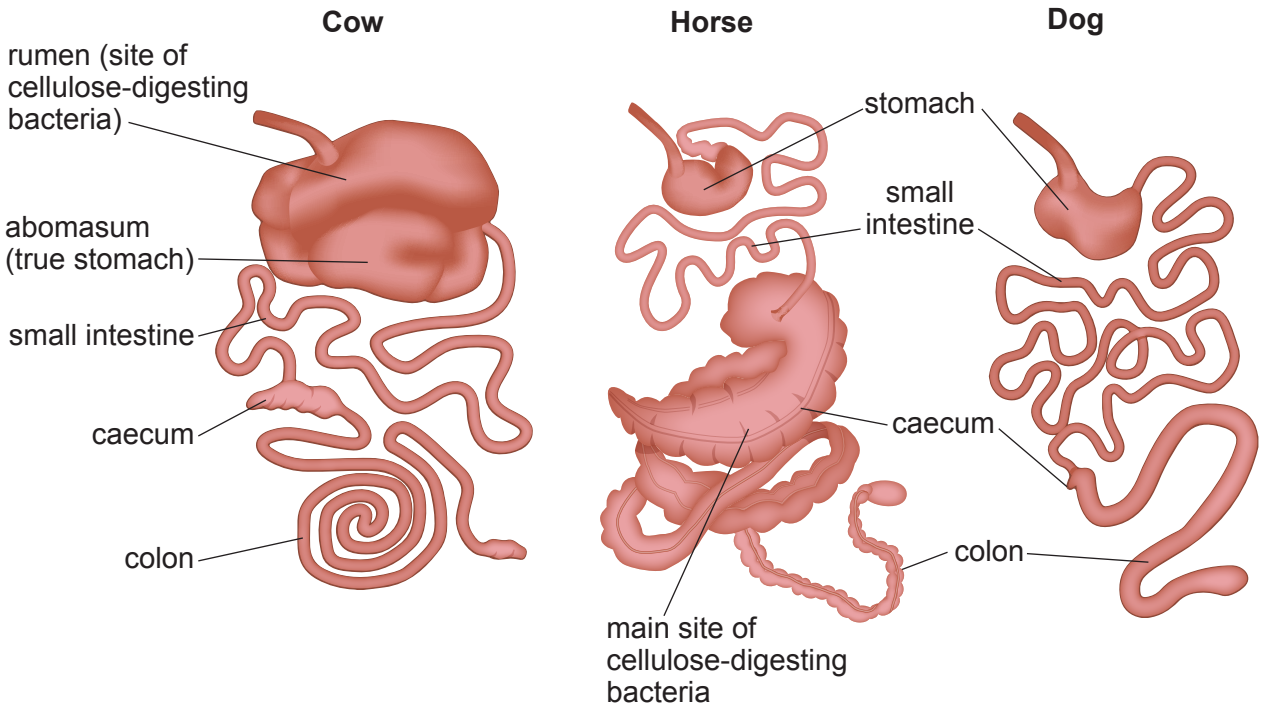


Table 2.4

	Relative volume of entire gut / %		
Part of gut	Cow	Horse	Dog
rumen	62.8	–	–
stomach	8	8.5	62.3
small intestine	18.5	30.2	23.3
caecum	2.8	15.9	1.3
colon	7.9	45.4	13.1

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(i) Use **Table 2.4** to give **two** differences in the relative volume of the structures in the gut of a **cow** and the gut of a **dog** and conclude how these differences reflect their respective diets. [4]

Difference in relative volume	How this reflects their diet
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....
.....	.....

(ii) Cows are classified as mammals and so their young feed on milk.
With reference to their diet, explain why the abomasum of a newborn calf is proportionally larger at birth than in an adult cow. [2]

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(iii) Explain the advantage of 'chewing the cud' in ruminants such as cows. [1]

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(iv) Horse manure is a better source of plant nutrients than cow manure. With reference to **Image 2.3**, suggest why. [2]

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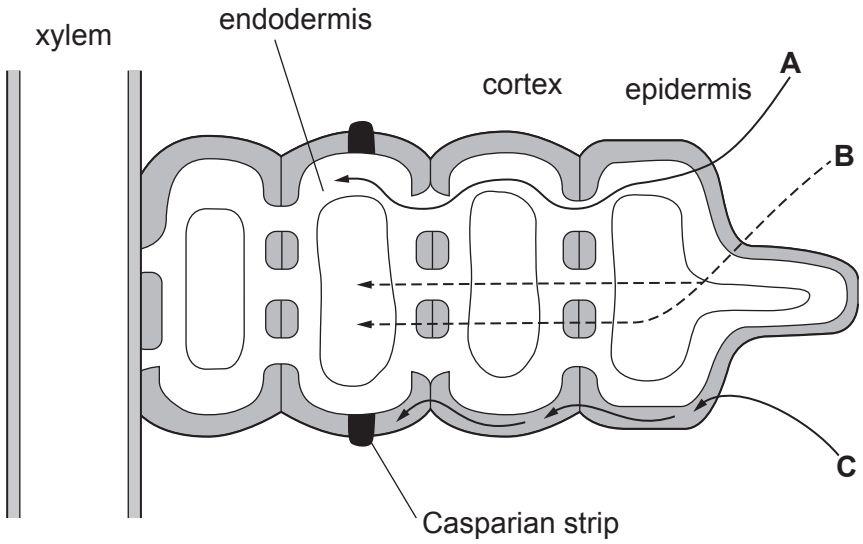
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3. Water lost by transpiration from the leaves of plants results in a flow of water across the roots, as shown in **Image 3.1**.

Image 3.1



(a) (i) Use the information in **Image 3.1** to name the **three** pathways **A**, **B** and **C** by which water moves from the soil to the endodermis. [2]

A .....

B .....

C .....

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(ii) Complete the table below to describe **three** differences between pathways **A** and **B** in **Image 3.1**. [3]

Pathway **A**	Pathway **B**
....	....
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....	....

(iii) State the function of the Casparian strip. [2]

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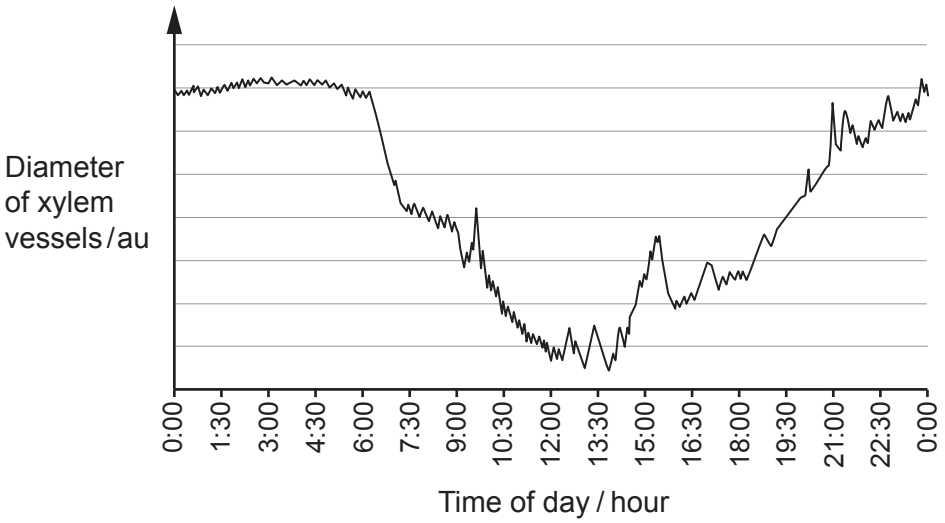
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(b) Water molecules in the xylem are attracted to each other by cohesion and to the inside of the xylem vessels by adhesion. The rate of water movement affects the diameter of the xylem vessels.
The variation in the diameter of xylem vessels over a 24-hour period is shown in **Graph 3.2**.

Graph 3.2



(i) The diameter of a tree trunk was measured over a 24-hour period.
Use the information above to predict and explain what would happen to the trunk diameter between 6:00 hours and 12:00 hours. [5]

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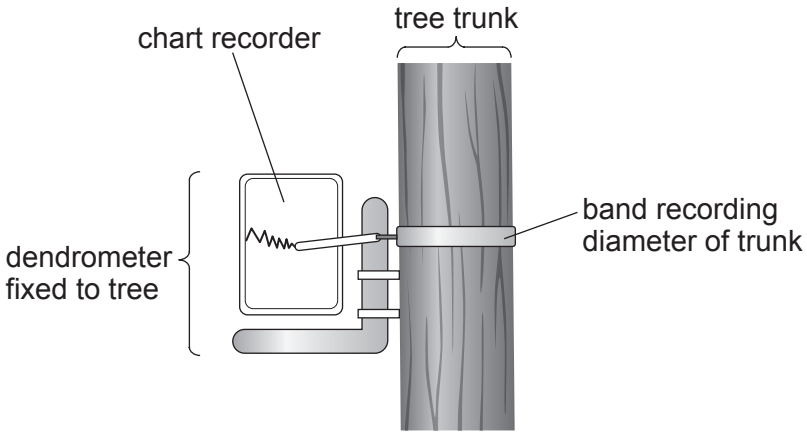
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The diameter of the trunk was measured using a dendrometer. This is shown in **Image 3.3**. The band detects changes in the diameter of the trunk. This is then recorded on a chart on a rotating drum.

Image 3.3



(ii) To increase confidence in results, the diameter of ten different tree trunks in one area of woodland was measured over the same time period.

Suggest **three other** factors that would need to be controlled when obtaining these readings using the dendrometer. [3]

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(c) Maize is an agricultural crop which is grown throughout the world. **Table 3.4** shows data relating to the growing of maize.

Table 3.4

Volume of water lost by one maize plant in a growing season.	200 dm^3
Length of growing season	80 days
Density of maize plants	30 000 $acre^{-1}$

1 acre = 4047 m^2

(i) Use the information given in **Table 3.4** to calculate the volume of water lost through transpiration by 1 m^2 of maize per day during the growing season. [3]

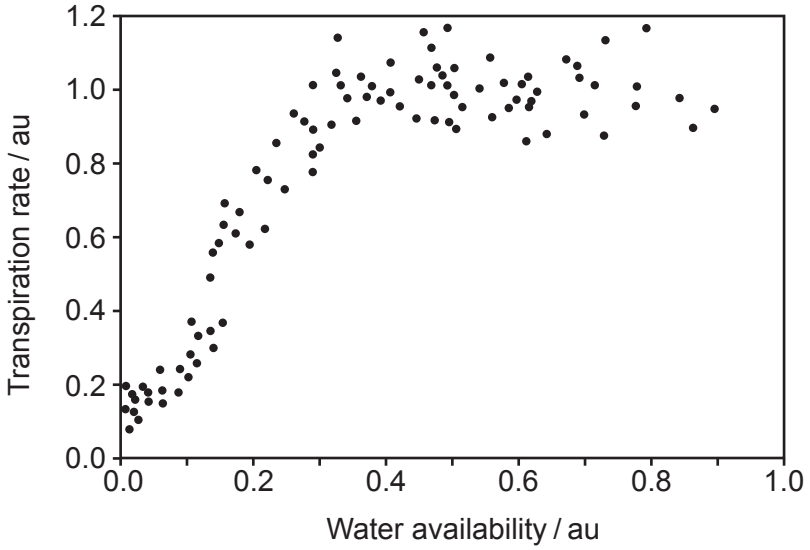
Volume of water lost = ... $dm^3m^{-2}\ day^{-1}$

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The effect of soil water availability on the transpiration rate of five plants of the same species is shown in **Graph 3.5**.

Graph 3.5



(ii) Describe the relationship shown in **Graph 3.5** between transpiration rate and availability of water in the soil. [2]

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(iii) Draw **one** conclusion about the confidence in the data shown in **Graph 3.5** at lower water availability. Explain your answer. [2]

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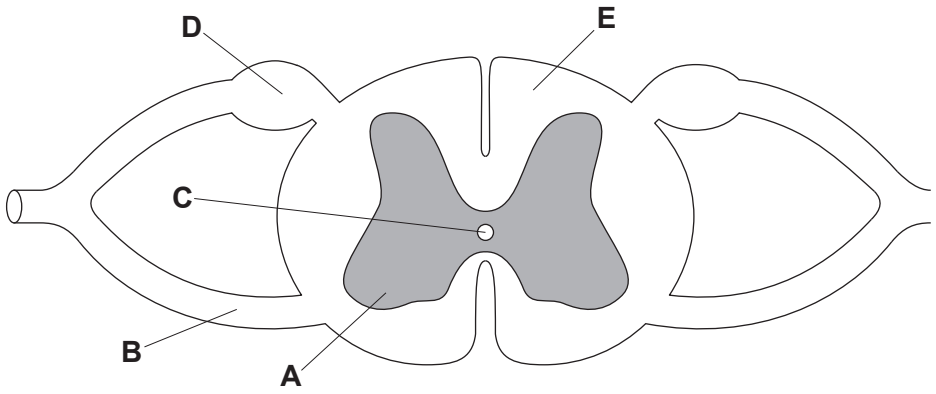
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4. **Image 4.1** shows a transverse section through the spinal cord.

Image 4.1



(a) Name the labelled structures **A–E** shown in **Image 4.1**. [3]

A .....

B .....

C .....

D .....

E .....

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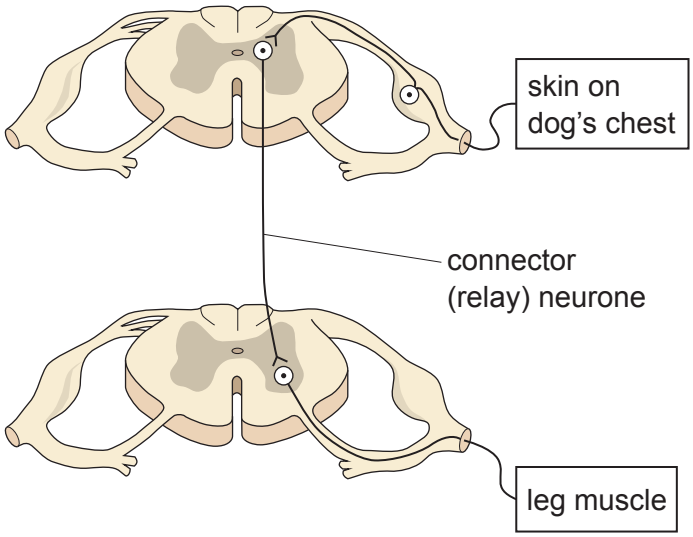
(b) If sensory neurones in the skin of the chest of dogs are stimulated, the nearby hind limb reaches toward the area and scratches it. This is called the dog scratch reflex, shown in **Image 4.2**.

Sections through the spinal cord at the level of stimulation and at the level of the hind leg are shown in **Image 4.3**.

Image 4.2



Image 4.3



(i) Complete **Image 4.3** to **label** the **sensory** and **motor** neurones involved in the dog scratch reflex.
Draw arrows on all the neurones involved to show the direction of the impulse. [3]

(ii) Use the information in **Images 4.2** and **4.3** to explain why the axon of the connector (relay) neurone is so long in this reflex arc. [2]

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(c) In a dog, the nerve impulse takes 6 milliseconds to travel 0.3 m.
Calculate the rate of transmission of the nerve impulse.
Give your answer in metres per second. [2]

Rate = ... ms^{-1}

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15

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5. The kidneys play an important role in homeostasis through osmoregulation and the excretion of urine.

The volume of urine produced can be affected by both the glomerular filtration rate and the reabsorption of filtrate.

(a) To control the glomerular filtration rate, a protein is released by the body which causes vasoconstriction of the afferent arterioles. This protein functions as both an enzyme and a hormone.

(i) Describe what is meant by the term enzyme and explain why the tertiary structure of the enzyme is important to the function of the enzyme. [2]

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(ii) Describe what is meant by the term hormone and explain why the tertiary structure of this protein is important in its function as a hormone. [2]

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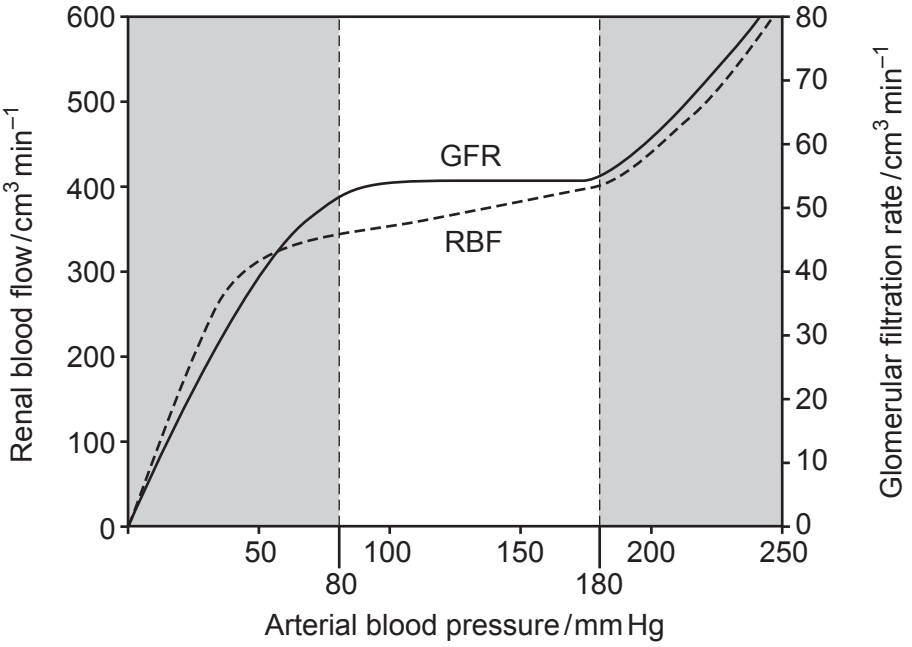
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(b) The relationship between arterial blood pressure, renal blood flow (RBF) (volume of blood entering kidney) and the glomerular filtration rate (GFR) is shown in **Graph 5**.

Graph 5



RBF = renal blood flow per minute in cm^3
GFR = Volume of glomerular filtrate produced per minute in cm^3

The normal range of arterial blood pressure in a healthy human adult is between 80 mm Hg at rest to 180 mm Hg during exercise.

Use **Graph 5** and the information given to answer the following questions:

(i) Explain how increasing RBF results in an increase in GFR as arterial blood pressure increases from 0 to 80 mm Hg. [1]

.....

.....

(ii) Use your knowledge of vasoconstriction in the afferent arterioles to describe and explain the GFR between 80 and 180 mm Hg. [2]

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(iii) Above 180 mm Hg GFR increases dramatically.
Suggest how the increase in GFR demonstrates that the kidneys are acting homeostatically to reduce blood pressure. [1]

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(c) Antidiuretic hormone (ADH) is a hormone that affects the volume of urine produced.
Describe and explain the effect on the kidneys of a high concentration of antidiuretic hormone (ADH) in the blood. [4]

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A400U301
19

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6. Multicellular animals have evolved different ways of ventilating their gas exchange surfaces. **Image 6.1** shows the thorax of a human (a mammal), **Image 6.2** shows a cross section through part of the head of a bony fish and **Image 6.3** shows the tracheal system in an insect.

Image 6.1

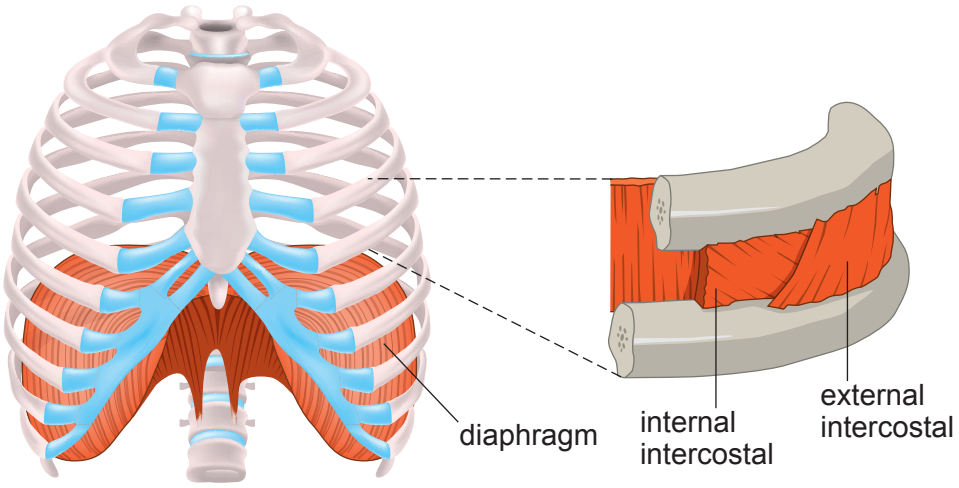


Image 6.2

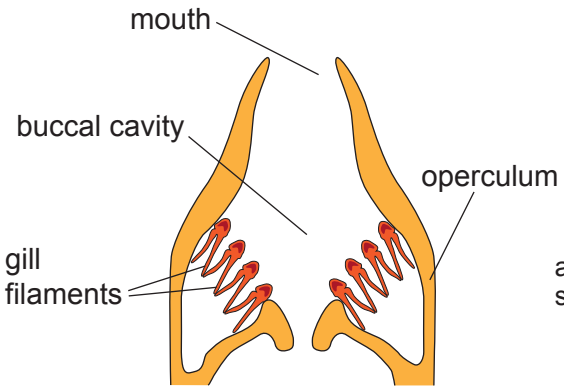
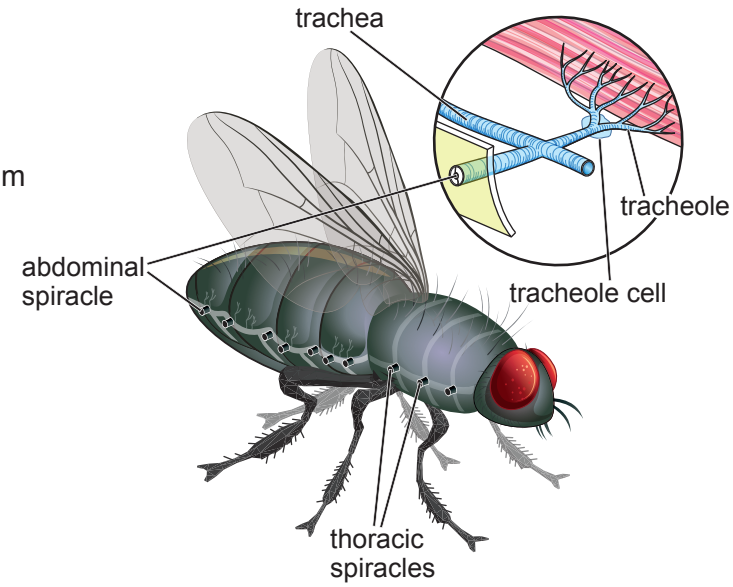


Image 6.3



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Use the information shown in **Images 6.1 and 6.2** to describe and explain ventilation of the lungs in a human and ventilation of the gills in a bony fish.
Describe the advantages and disadvantages of the insect tracheal system when compared to the gas exchange system of humans. [9 QER]

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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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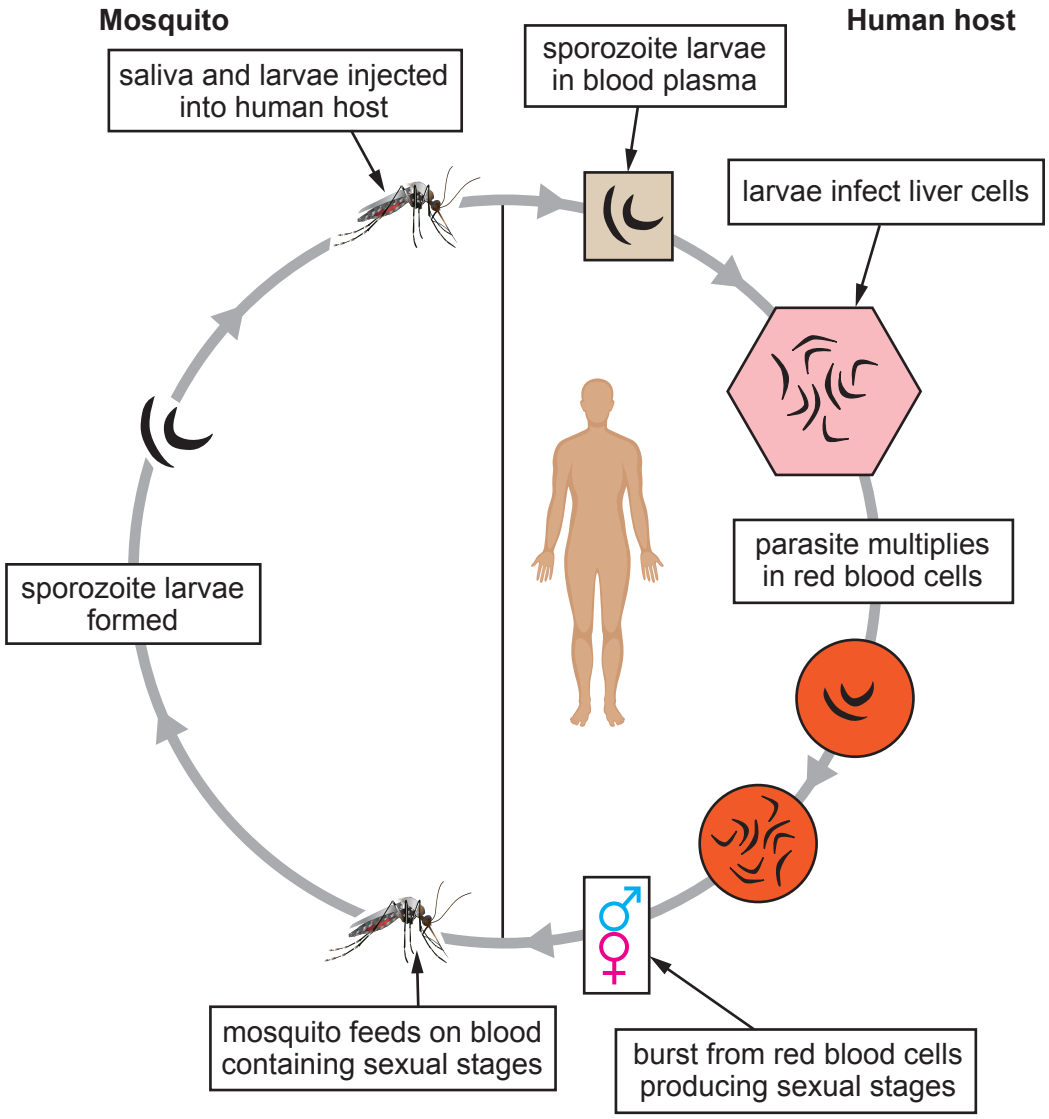
Option A: Immunology and Disease

7. (a) Malaria is a disease caused by a protoctistan parasite belonging to the genus *Plasmodium*. The disease is caused mainly by two species of *Plasmodium* (*P. vivax* and *P. falciparum*) of which there are many antigenic types.

The life cycle of malaria consists of multiple stages within two host organisms; humans and the *Anopheles* mosquito. Some of these stages are free-swimming (for example, sporozoites) while other stages happen within human liver cells and red blood cells.

Image 7.1 shows the generalised life cycle of the malaria parasite.

Image 7.1



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(i) State the role of the mosquito in the life cycle of *Plasmodium*. [1]

.....

(ii) Explain why multiplying within liver cells and red blood cells helps the parasite to evade the host's immune system. [2]

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(iii) The sexual stage involving meiosis helps to increase **genetic variation** within parasite populations.
Explain why this means that a person may develop symptoms of malaria following re-infection. [3]

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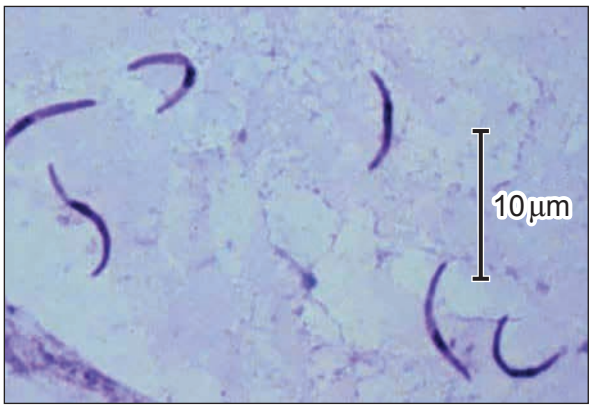
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(b) There is great interest in the development of a vaccine to prevent malarial infection. One of the most promising candidates for a vaccine uses whole, live sporozoites which have been exposed to ionising radiation. Irradiating the sporozoites prevents them from replicating but does not affect the antigens they produce.

Image 7.2 shows a photomicrograph of *Plasmodium* sporozoites

Image 7.2



(i) **Use only the scale bar** to calculate the magnification of **Image 7.2**. [2]

Magnification = × .....

(ii) Use the information given about the life cycle of malaria and your own knowledge of the specific immune response to suggest why sporozoites are the life cycle stage chosen for the vaccine. [2]

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(iii) Explain why live irradiated sporozoites are used. [1]

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(iv) *Plasmodium* sporozoites can be cultured in human cells in the laboratory under very specific conditions:

- 37 °C
- low oxygen concentrations.

Use information from **Image 7.1** to suggest why *Plasmodium* sporozoites can only be cultured under these conditions. [3]

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(v) Explain how vaccination can give long-term protection against disease. [2]

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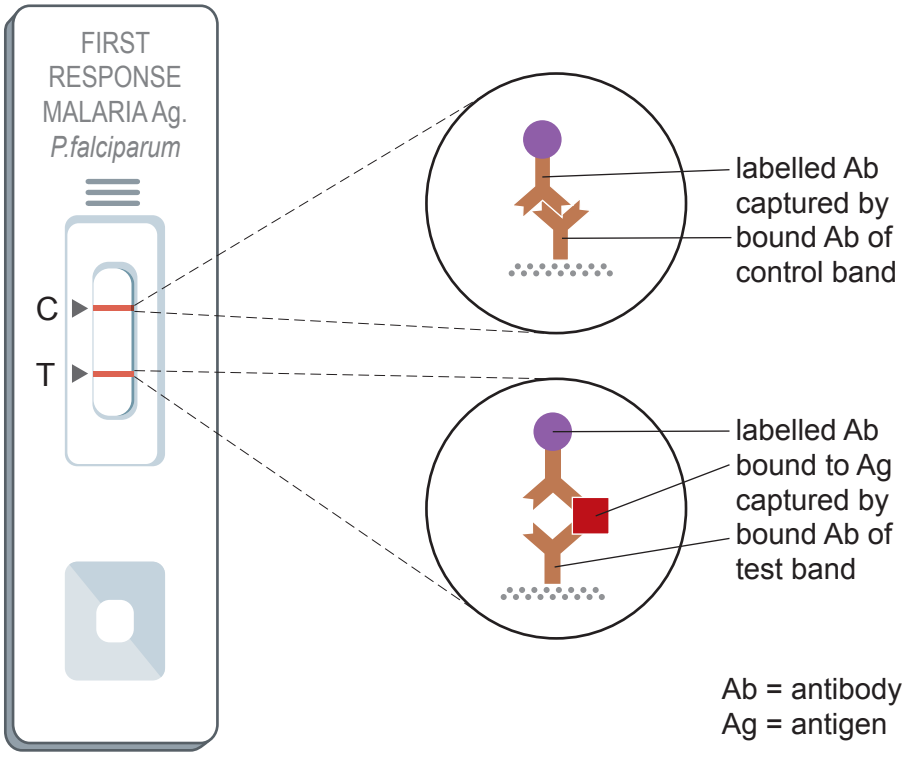
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(c) An antigen test for malaria caused by *P. falciparum* is shown in **Image 7.3**. This type of test uses labelled antibodies specific to antigens found on the infecting parasite. These antigens will be present in a blood sample from an infected person.

Image 7.3



(i) Explain what the test shown in **Image 7.3** would look like if the blood sample was from someone infected with *P. vivax*. [3]

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(ii) Explain why penicillin would not be effective against malaria. [1]

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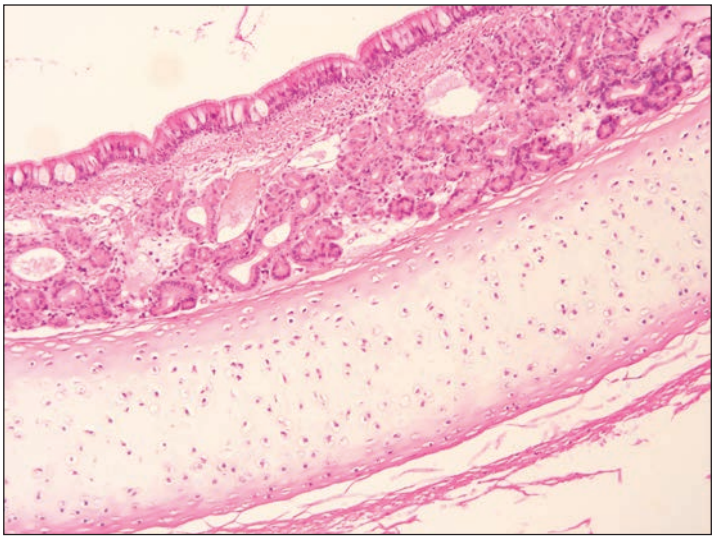
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Option B: Human Musculoskeletal Anatomy

8. **Image 8.1** shows a photomicrograph of a section taken from the trachea.

Image 8.1



(a) (i) Identify the cells present in the hyaline cartilage shown in **Image 8.1** and explain how nutrients and oxygen are supplied to these cells. [2]

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(ii) Describe the role of hyaline cartilage in the trachea. [1]

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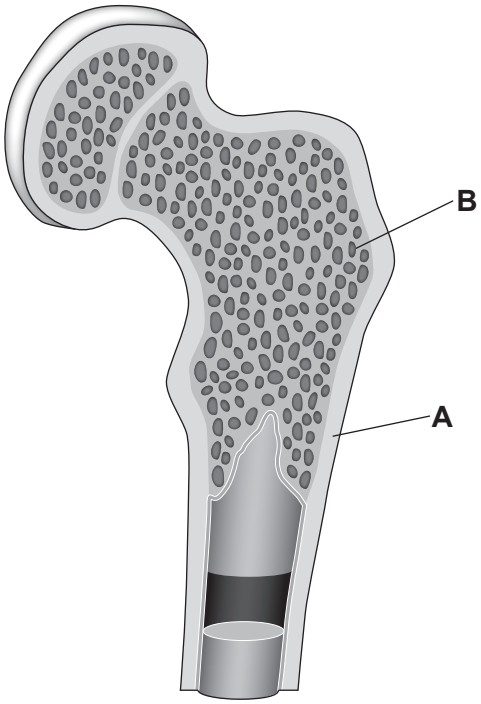
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(b) **Image 8.2** shows a longitudinal section through the head of a femur.

Image 8.2



(i) Identify the type of bone labelled **A** on **Image 8.2**. [1]

.....

(ii) The tissue at **B** is known as cancellous spongy bone. It has many spaces known as trabeculae. This tissue is not as strong as the bone tissue at **A**. Cancellous bone comprises around 20% of the volume of long bones such as the femur.

Suggest the benefit of this type of bone tissue in the human skeleton. Explain your answer. [2]

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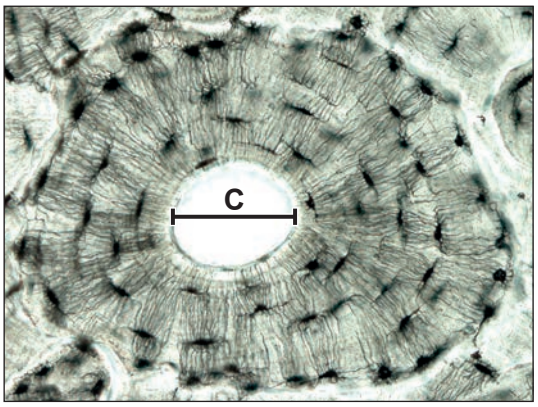
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Image 8.3 shows a highly magnified section of tissue **A**.

Image 8.3



magnification × 200

(iii) Use line **C** to calculate the width of the Haversian canal from **Image 8.3**.
State your answer in μm. [2]

Width = ... μm

(iv) Describe the role of the Haversian canal in bone. [1]

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(c) **Images 8.4A** and **8.4B** show two X-ray images of the knee joint.

Image 8.4A

Knee of patient



Image 8.4B

Healthy knee



(i) State the type of synovial joint shown in **Image 8.4B**. [1]

.....

(ii) I. **Image 8.4A** shows the knee joint of a patient who was otherwise generally healthy.
Suggest how **Image 8.4A** shows arthritis. [1]

.....

.....

II. The patient was 27 years old. Their weight was within normal range but they had low levels of physical activity. The patient's knee was swollen and warm to the touch. The patient was in a great deal of pain and had difficulty walking.

Use all the information provided to suggest why a diagnosis of rheumatoid arthritis was made rather than osteoarthritis. [2]

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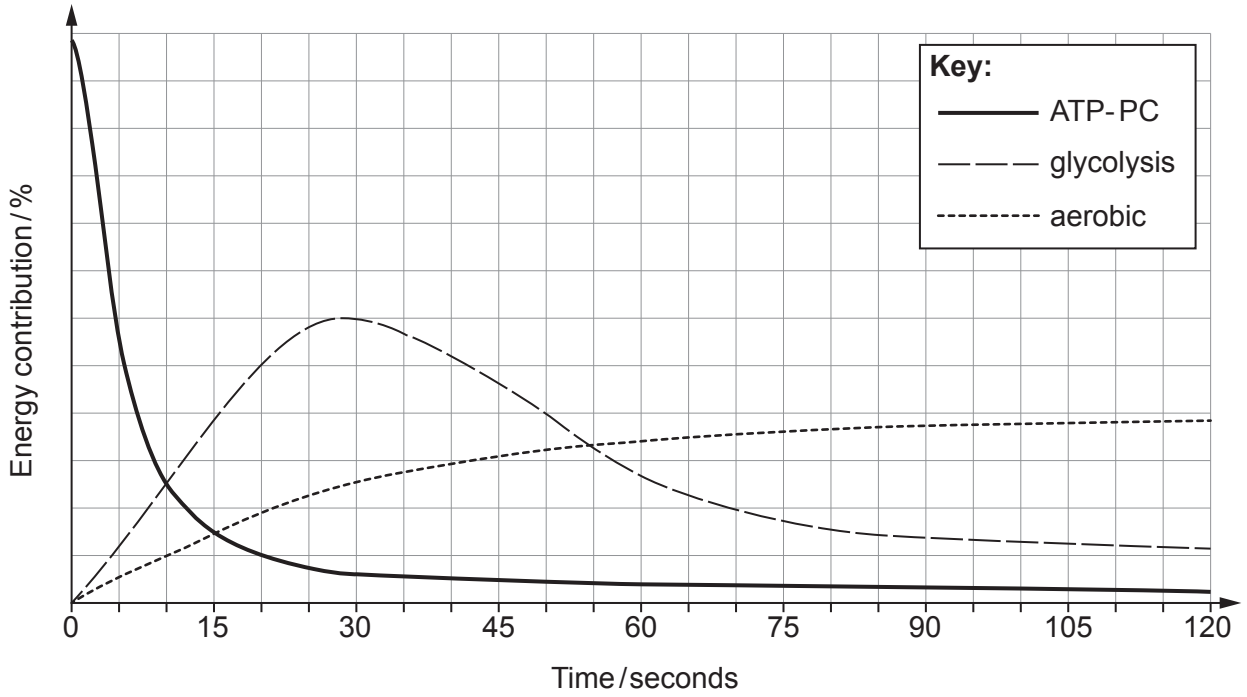
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(d) The energy for muscle contraction may be obtained from one of three different energy systems as shown on **Graph 8.5**.

Graph 8.5



(i) With reference to **Graph 8.5**, suggest which of the three systems would provide the greatest percentage energy contribution in athletes performing each of the following activities. Explain your answers.

I. a 100-metre sprint; [2]

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II. a 5-kilometre race. [2]

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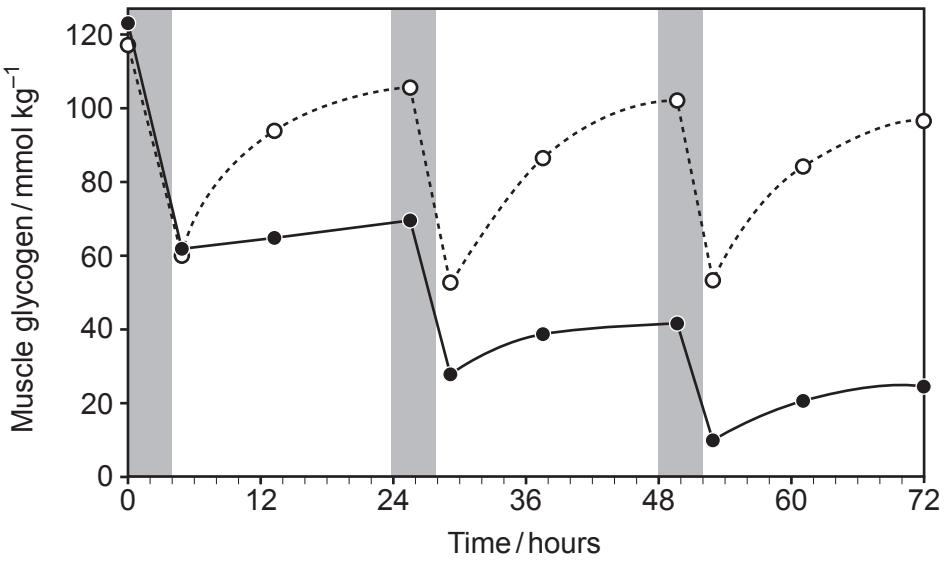
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Glycogen is the main carbohydrate storage compound in muscle cells.
Graph 8.6 shows the results of an experiment where two athletes were given standard daily training bouts and their muscle glycogen levels were then measured regularly over 72 hours. One athlete was given a carbohydrate loading diet while the other was given a normal diet with no carbohydrate loading.

Graph 8.6



Key: ------- carbohydrate loading diet ——— normal diet ▒ training bout (4 hours)

(ii) Explain why the intensity and duration of training bouts were controlled in this experiment. [1]

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(iii) With reference to **Graph 8.6** explain how carbohydrate loading might improve an athlete's performance. [2]

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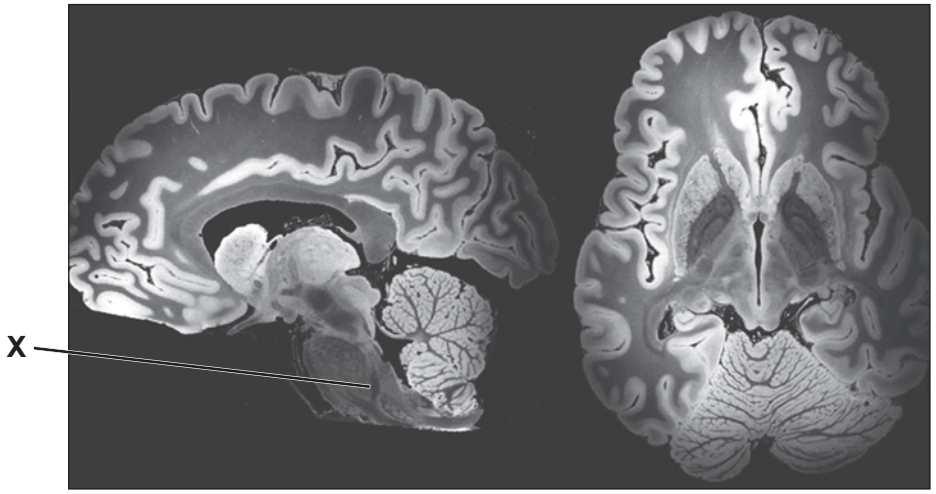
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Option C: Neurobiology and Behaviour

9. **Image 9.1** shows two computerised tomography (CT) scans of the same brain.

Image 9.1



(a) (i) Account for the different appearance of the brain in the two scans. [1]

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(ii) Identify structure **X** on **Image 9.1**. [1]

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(iii) Structure **X** is part of the autonomic nervous system.

Describe the function of the autonomic nervous system. [1]

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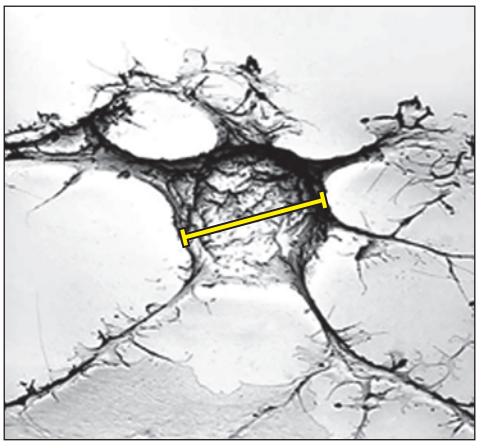
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Image 9.2 shows an electron micrograph of a single neurone from a human brain showing many connections to other neurones.

Image 9.2



magnification × 1800

(iv) Calculate the actual diameter of the cell body of the neurone in **Image 9.2** along the line shown. **State your answer in µm.** [2]

Diameter = ... µm

(v) Following damage to the brain, there can be changes in neural pathways by establishing new connections between neurones.
State the term used to describe these changes. [1]

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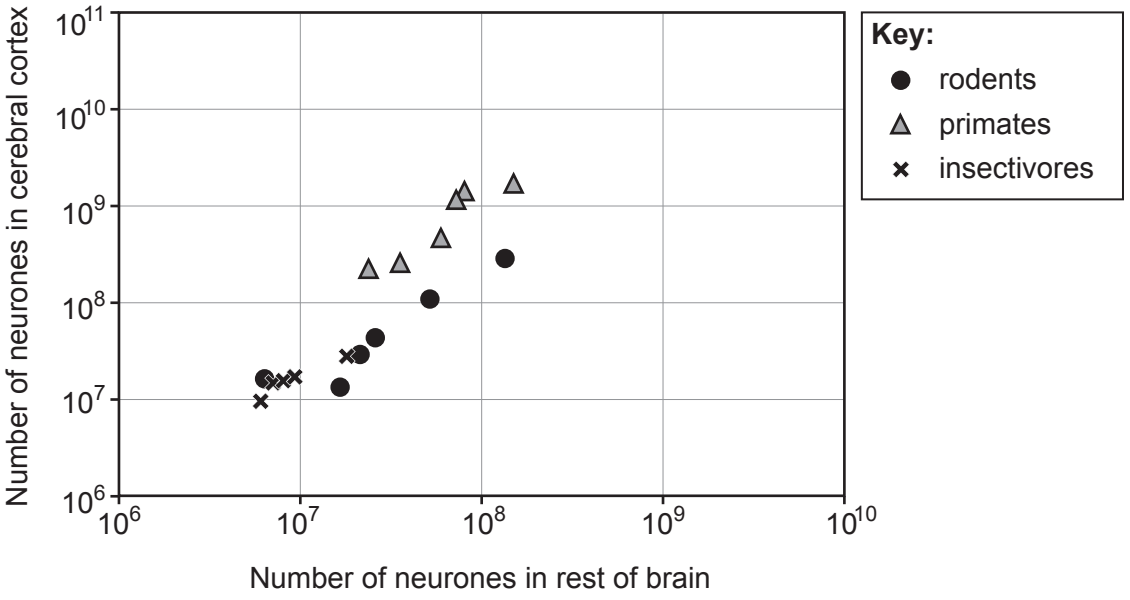
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(b) An investigation was carried out into the relationship between the number of neurones in the cerebral cortex compared to the rest of the brain in different mammals. Researchers examined the brains of six species of primate (including apes and monkeys), six species of rodent (including rats and mice) and five species of insectivore (including shrews, moles and hedgehogs).

Graph 9.3 shows the relationship between the number of neurones in the cerebral cortex compared to the rest of the brain in the three different groups of mammals.

Graph 9.3



(i) Describe the general trend for the mammals shown in **Graph 9.3**. [1]

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(ii) Primates generally exhibit complex social behaviours such as imitation and insight. They are capable of higher levels of cognitive functioning than the other groups of mammals in this study.

The researchers concluded that these behaviours are linked to the relative number of neurones in the cerebral cortex. Explain how the data supports their conclusion. [3]

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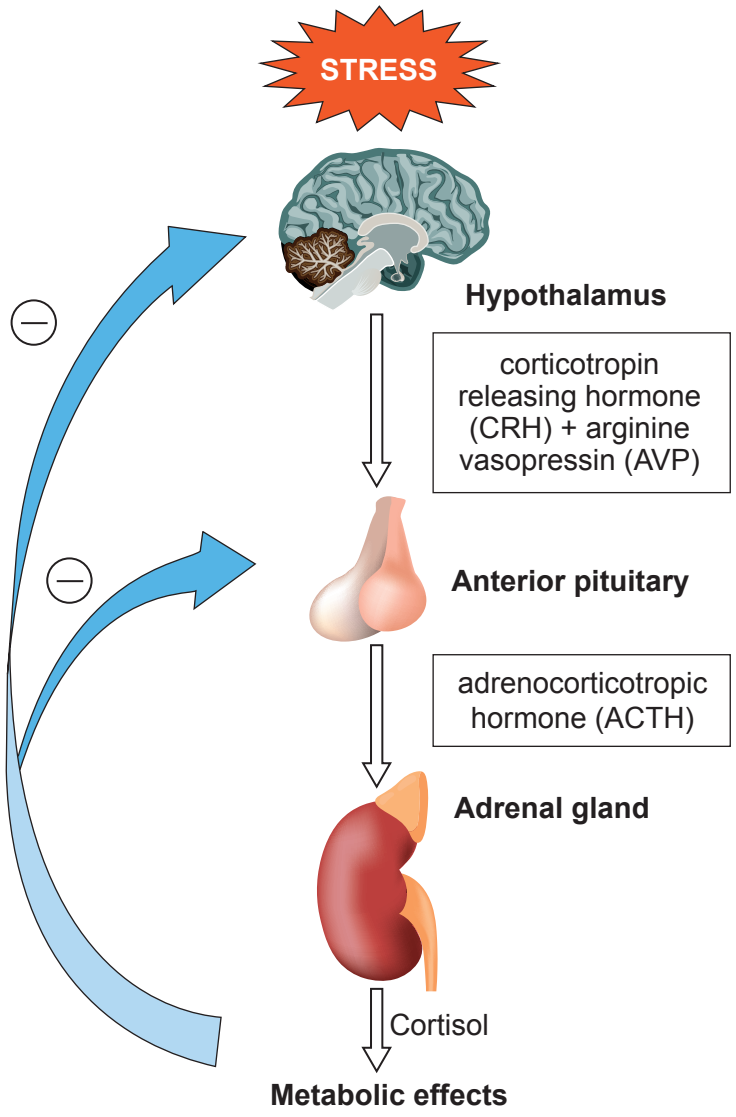
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(c) Cortisol is produced by the adrenal glands in response to stress via the pathway shown in **Image 9.4**.

Image 9.4



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(i) Use **Image 9.4** and your knowledge of cortisol production to describe and explain the effect on this pathway of increasing cortisol concentrations in the blood. [3]

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(ii) Suggest the benefit of the response described in **Image 9.4**. [1]

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(iii) Some individuals have an unusually high concentration of corticotropin releasing hormone in their bloodstreams.
Suggest a possible life event that may have caused such raised levels and explain how these raised levels would affect the way such individuals respond to stressful situations. [2]

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(d) Black grouse are ground nesting birds found on moorland. Incubation of the eggs and care of the young is carried out by the female. Several black grouse males perform elaborate displays before groups of females in a ritual known as a lek. The male birds compete for the attention of the female birds.

Image 9.5 shows a female (left) and male (right) black grouse.

Image 9.5



(i) Use evidence from **Image 9.5** to explain how this species shows sexual dimorphism. [1]

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(ii) Use all the information provided to identify the **two** types of selection that have resulted in sexual dimorphism in black grouse. Explain each answer. [3]

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