Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S25-2400U20-1

2400U20-1

THURSDAY, 22 MAY 2025 – MORNING

BIOLOGY – AS unit 2
Biodiversity and Physiology of Body Systems

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**14**	
3.	**11**	
4.	**17**	
5.	**9**	
6.	**12**	
7.	**9**	
Total	**80**	

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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

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 **7**.

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

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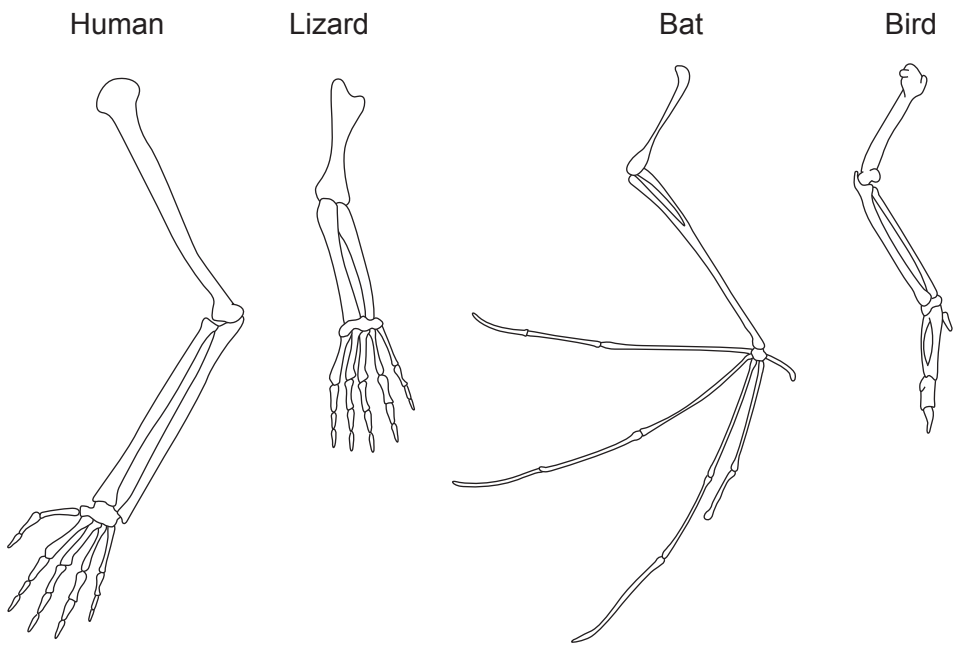
Answer **all** questions

1. Classification places organisms into hierarchical groups based on relatedness. Until recently organisms were classified into five Kingdoms based on morphological features.

(a) The pentadactyl limb demonstrates relatedness between different species as shown in **Image 1.1**.

Image 1.1



(i) State the name given to structures such as the pentadactyl limb, that show relatedness. [1]

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(ii) Explain the limitations of comparing the wings of birds and insects when considering morphological features to establish relatedness. [2]

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(b) Comparison of the amino acid sequence of proteins can provide evidence for evolution. **Image 1.2** shows part of the amino acid sequence of a protein found in all organisms. Each capital letter indicates a different amino acid. The **shaded** amino acids are **the same** in all the organisms.

Image 1.2

Human	D A P G H R D F I K N M I T G T S Q A D C A V L I V
Tomato	D A P G H R D F I K N M I T G T S Q A D C A V L I I
Yeast	D A P G H R D F I K N M I T G T S Q A D C A I L I I
Protoctista	D A P G H R D F V K N M I T G T S Q A D C A I L I I
Archaea	D A P G H R D F V K N M I T G A S Q A D A A I L V V
Eubacteria	D C P G H A D Y V K N M I T G A A Q M D G A I L V V

Table 1.3 shows the number of differences in the amino acid sequence between the organisms shown in **Image 1.2**.

Table 1.3

	Human	Tomato	Yeast	Protoctista	Archaea	Eubacteria
Human						
Tomato	1					
Yeast	2	1				
Protoctista	3	2	1			
Archaea	.....	.....	.....	.....		
Eubacteria	10	11	10	10	6	

(i) Complete **Table 1.3** to indicate the number of differences in the amino acid sequence between the archaea and the other organisms shown in **Image 1.2**. [2]

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(ii) Biochemical analysis has resulted in the classification of organisms into three Domains.
Image 1.4A shows a phylogenetic tree based on five Kingdoms and **Image 1.4B** shows a phylogenetic tree based on three Domains.

Image 1.4A

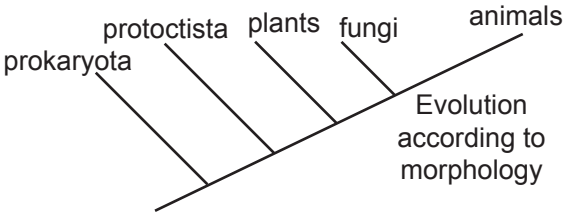
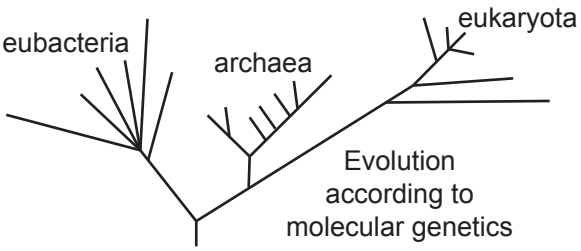


Image 1.4B



Use **Image 1.4A, Image 1.4B** and the number of differences in **Table 1.3** to explain why **Image 1.4B**, which shows three Domains, is likely to be more accurate than **Image 1.4A** which shows five Kingdoms. [3]

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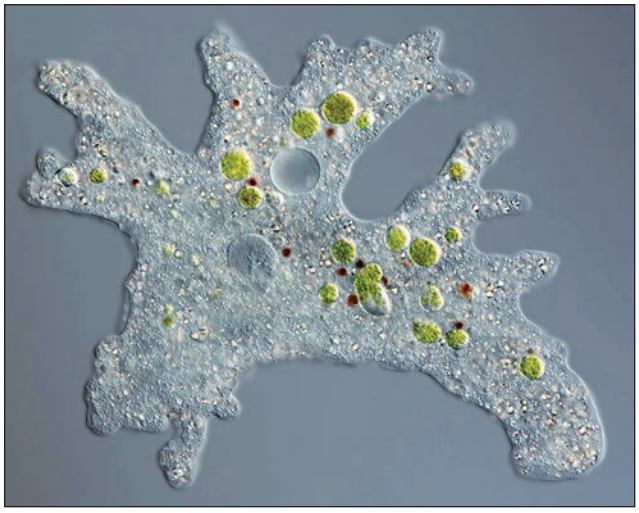
2. **Image 2.1** shows an amoeba, a single-celled eukaryotic organism that lives in an aquatic habitat.

Image 2.1



1 mm

(a) Explain how an amoeba carries out gas exchange. [2]

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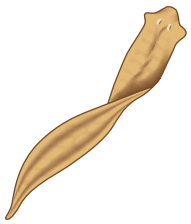
(b) **Image 2.2** shows a flatworm and an earthworm.

Image 2.2

Flatworm



100 µm

Habitat: freshwater

Earthworm

20 mm

Habitat: garden soil

Table 2.3 shows some data on the surface area and volume of a flatworm and an earthworm.

Table 2.3

Organism	Surface area / mm^2	Volume / mm^3	Surface area : Volume ratio
Flatworm	0.15	0.003	..... : 1
Earthworm	.....	500	0.5 : 1

(i) Use the data provided to calculate the **two** missing values.
Write your answers in Table 2.3. [2]

Space for working

(ii) Explain why the body surface of both the flatworm and the earthworm is:

I. thin; [1]

.....

II. moist. [1]

.....

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(iii) Lugworms spend most of their lives in U-shaped burrows in tidal areas. Some species of lugworm can reach 25 cm in length. **Image 2.4A** shows a lugworm in its burrow. **Image 2.4B** shows its external gills and the direction of flow of blood and of water.

Image 2.4A

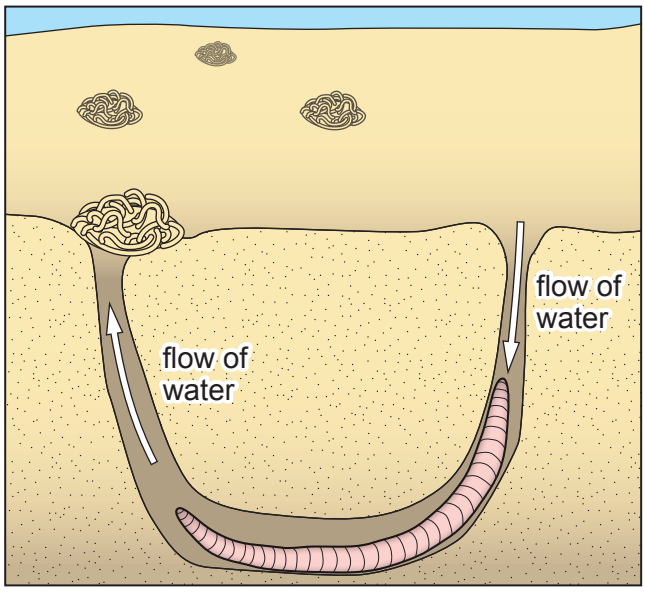
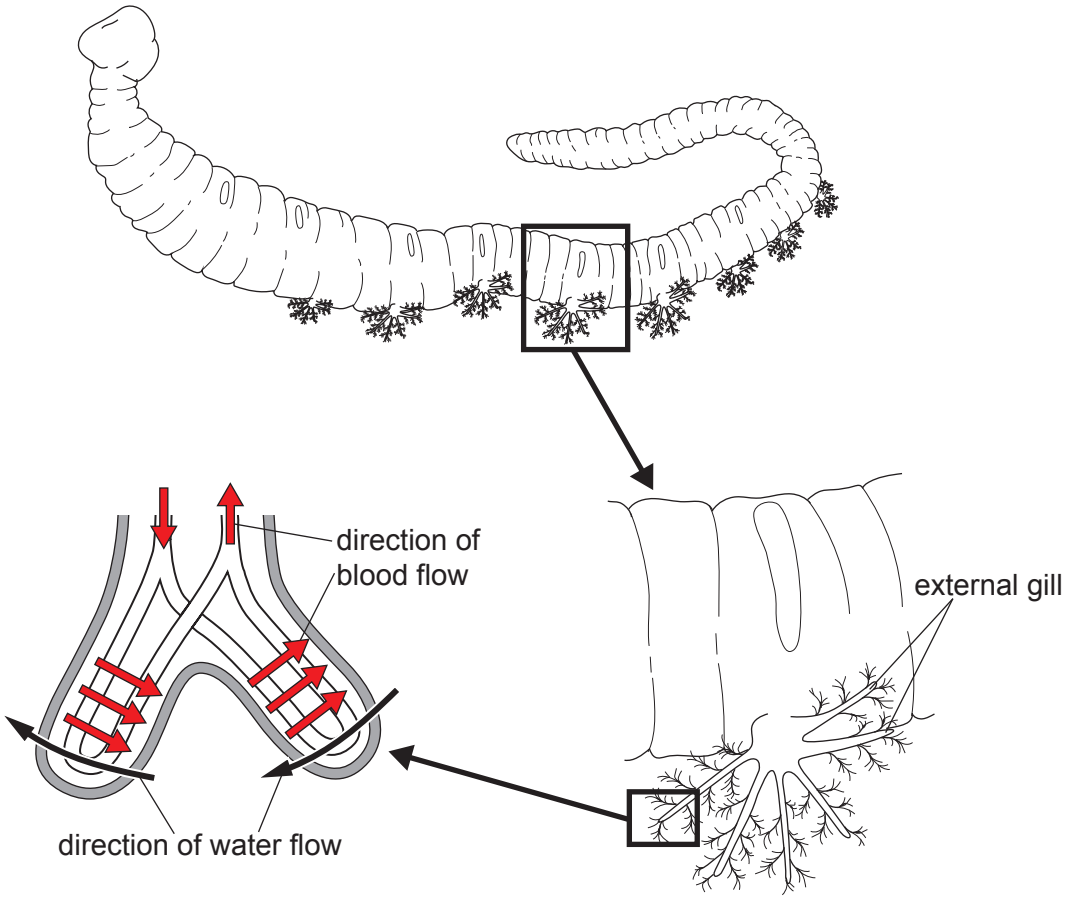


Image 2.4B



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The gas exchange surface of the lugworm is also thin and surrounded by water. Use **Images 2.4A and B** to explain **three** other adaptations that enable the lugworm to carry out efficient gas exchange. [3]

I. .....

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II. .....

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III. .....

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Question continued overleaf

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(c) Insects have a tracheal system to deliver oxygen to respiring tissues. **Image 2.5** shows this system in an insect.

Image 2.5

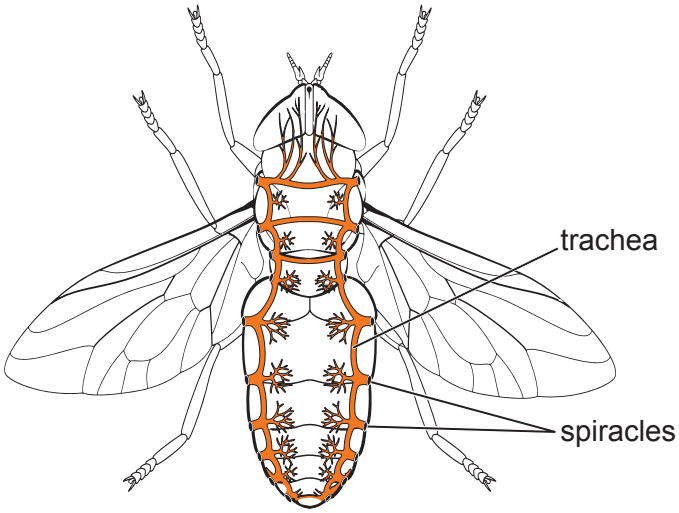
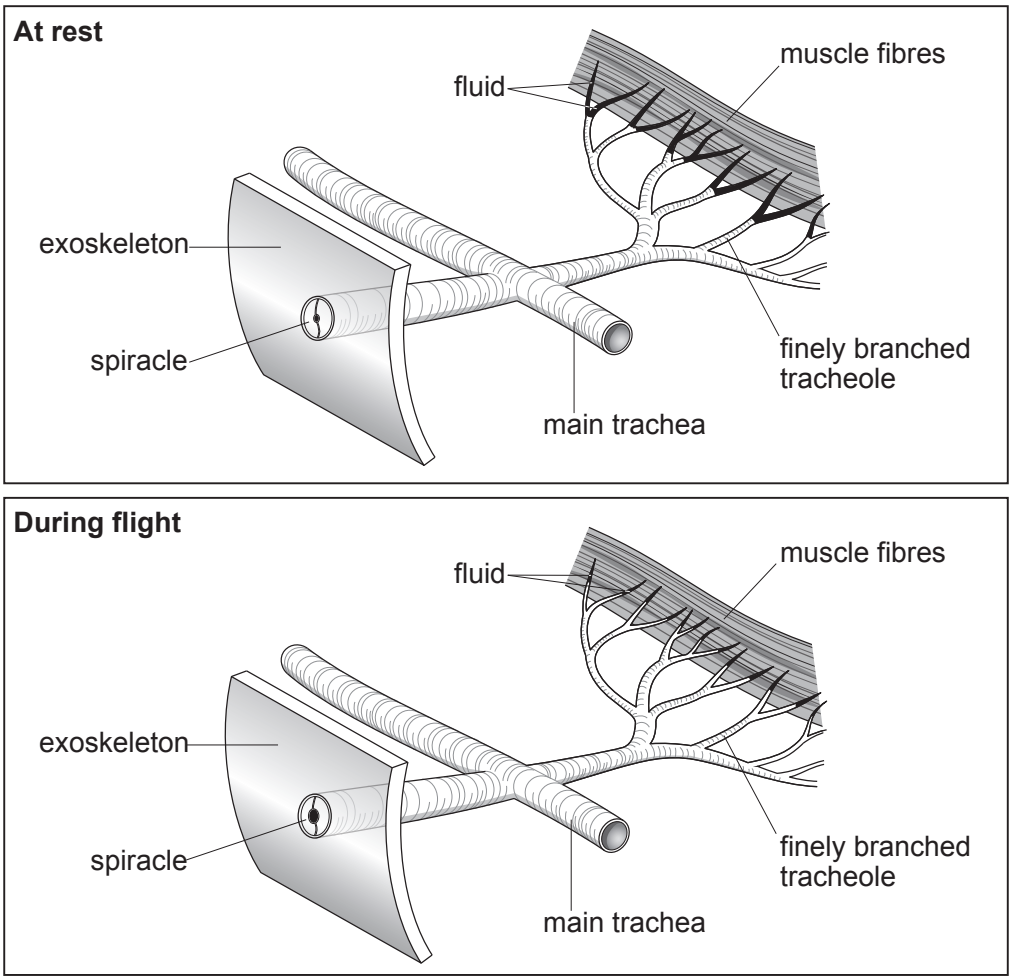


Image 2.6 shows insect tracheoles supplying the muscle fibres at rest and during flight.

Image 2.6



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(i) Explain why the insect cannot carry out gas exchange through the body surface and needs a tracheal system to deliver oxygen to respiring tissues. [2]

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(ii) Suggest the role of the rings of chitin in the tracheoles. [1]

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(iii) Use **Image 2.6** to describe the change in fluid levels in the tracheoles during flight.
Explain the advantage of this to the insect. [2]

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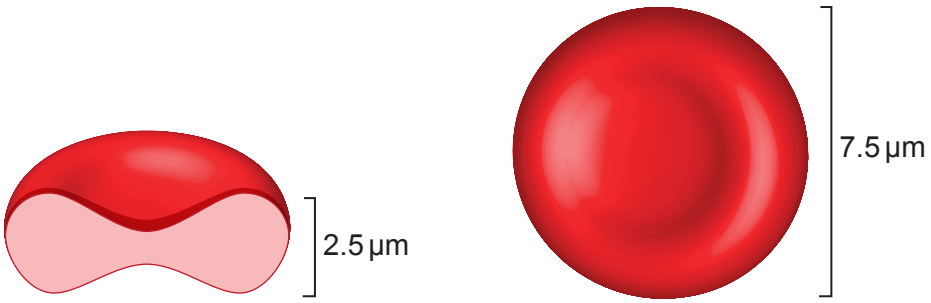
3. Erythrocytes (red blood cells) transport oxygen around the bodies of some animals. **Image 3.1** shows two views of an erythrocyte.

Image 3.1



side view (cut) top view

(a) Explain **two** ways in which the biconcave shape of the erythrocyte is an adaptation to its function. [2]

I. .....

.....

II. .....

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(b) The following is a fact file about blood in the average human.

- 5500 cm^3 of blood in the body
- 5 million erythrocytes per cm^3 of blood
- 2.7×10^8 haemoglobin molecules in one erythrocyte
- 15 g of haemoglobin per 100 cm^3 of blood.

(i) Use the information in the fact file to calculate the following for an average human:

I. The number of haemoglobin molecules in the body.
Express your answer in standard form. [3]

Space for working

Number of haemoglobin molecules in the body = ...

II. The total mass of haemoglobin in the body. [1]

Total mass of haemoglobin in the body = ... g

(ii) Describe how the values calculated in (i) I. and II. would change in an athlete who spends a month training at altitude.
Explain why this change would be of benefit to the athlete. [2]

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(c) (i) The association between haemoglobin and oxygen is reversible, as shown in the equation:

$$Hb + 4O_2 \underset{ppO_2 \text{ in tissues}}{\overset{ppO_2 \text{ in lungs}}{\rightleftharpoons}} HbO_8$$

State why the fact that this association is reversible is important to humans. [2]

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(ii) Myoglobin is a protein found in muscle. It can reach 100% oxygen saturation and has a higher affinity for oxygen than haemoglobin.

Explain why and when this would be beneficial to humans. [1]

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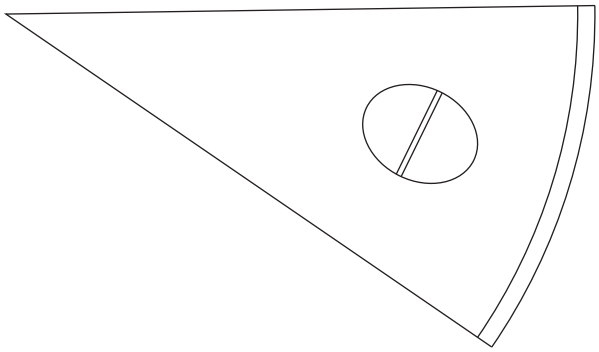
4. The vascular systems of flowering plants transport water, minerals and the products of photosynthesis.

(a) **Image 4.1** shows a low power plan of a sector of a transverse section of a stem.

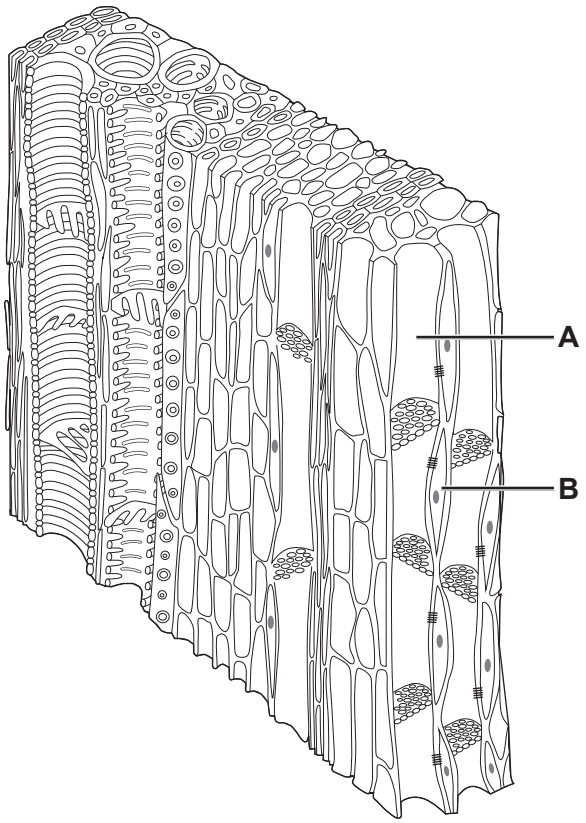
Image 4.1



(i) On **Image 4.1, draw an arrow to label the position of the phloem tissue** in the vascular bundle. [1]

Image 4.2 shows a three-dimensional drawing of part of a vascular bundle.

Image 4.2



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(ii) I. State the names of the cells labelled **A** and **B** in **Image 4.2**. [1]

Cell **A** .....

Cell **B** .....

II. Explain how cell **B** supports the function of cell **A**. [1]

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(b) (i) State the name of the material in the wall of the xylem vessel that provides strength. [1]

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(ii) Describe the movement of water across the root into the xylem. Include the role of the Casparian strip in your description. [4]

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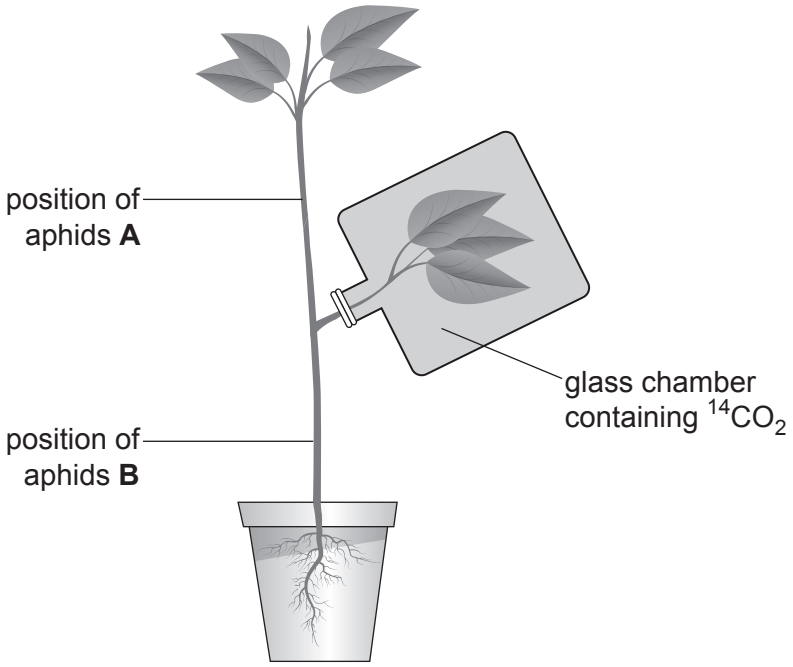
(c) Scientists can investigate the rate of translocation in phloem using aphids. Aphids insert their mouthparts into phloem to feed on the organic molecules. Scientists can remove the bodies of the aphids, leaving the mouthparts in place. Sap will drip from the cut mouthparts and can be collected and analysed.

In the experiment shown in **Image 4.3**, the leaves of a plant were enclosed in a glass chamber containing radioactively labelled carbon dioxide ($^{14}CO_2$). The same number of aphids were placed at two different positions on the stem and the time taken for radioactive carbon compounds to be detected was recorded.

Image 4.3



(i) Name **two** radioactively labelled organic molecules that could be found in the phloem. [1]

..... and .....

(ii) Suggest **two** factors that would need to be controlled throughout the investigation. [2]

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The results of the investigation are shown in **Table 4.4**.

Table 4.4

Position of aphids	Distance of aphids from glass chamber / mm	Time taken for radioactivity to be detected / hours	Rate of phloem transport / mm hr^{-1}
A	15	1.1	13.6
B	15	1.9	.....

(iii) Calculate the rate of phloem transport at position **B**.
Write your answer in Table 4.4. [2]

Space for working

Question continued overleaf

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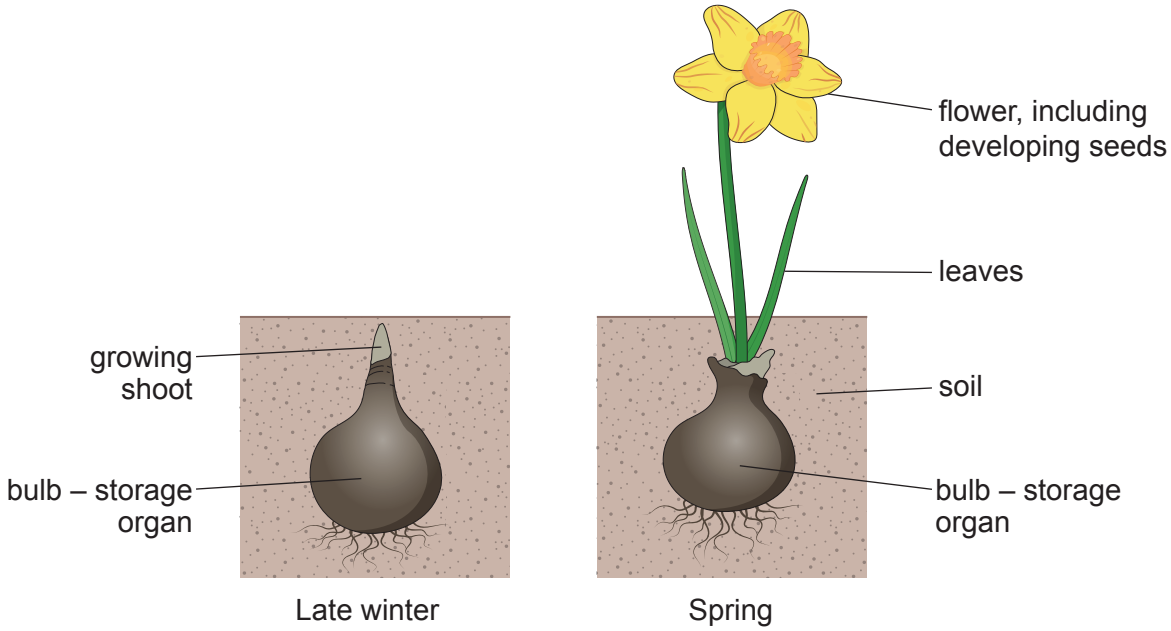
(iv) The rate and direction of phloem transport varies during the year. Daffodils produce leaves and flowers in early spring. They store organic molecules in structures called bulbs which allow them to survive over winter.
Image 4.5 shows a daffodil in late winter and in spring.

Image 4.5



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Use **Image 4.5** and your knowledge of translocation to answer the following questions.

I. Complete the table below to identify the sources and sinks in the daffodil in late winter and spring. [2]

	Source(s)	Sink(s)
Late winter	.....	.....
Spring	.....	.....

II. Explain why phloem transport needs to occur in **both directions** in the same daffodil in **spring**. [2]

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5. Students carried out a study of the biodiversity of invertebrate life in the leaf litter (dead leaves on the woodland floor) of two woodland habitats in Wales:

Habitat **A** was a deciduous woodland. Deciduous trees lose their leaves in the autumn and regrow them in the spring.

Habitat **B** was a fast-growing coniferous woodland. The trees were tall and densely planted. Conifers do not shed all their leaves in autumn but do lose some leaves (needles) which fall to the ground throughout the year.

Both woodlands were approximately 1000 m^2. The students investigated both sites using the following method:

- A 400 m^2 area was marked using two 20 m tape measures.
- Five pairs of co-ordinates within the area were chosen by generating random numbers using 20-sided dice.
- 1 m^2 quadrats were placed at each co-ordinate site and all the leaf litter in the quadrat was collected.
- The leaf litter was examined to find, identify and record the number of individuals of each invertebrate species.

The total number of each invertebrate species found in the leaf litter at each site is shown in **Table 5.1**.

Table 5.1

Species	Number of organisms	
	Habitat **A**	Habitat **B**
Musk beetle	482	0
Shield bug	76	0
Wood ant	573	328
Flat-backed millipede	36	30
Harvestman spider	10	0
Fine-streaked bugkin	14	9

(a) The students concluded that they could be confident in their results because the data they gathered was representative of each woodland.
Evaluate this conclusion. [3]

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(b) The results for Habitat **A**, the deciduous woodland, are shown in **Table 5.2**.

Table 5.2

Species	n	$(n-1)$	$n(n-1)$
Musk beetle	482	481	231 842
Shield bug	76	75	5700
Wood ant	573	572	327 756
Flat-backed millipede	36	35	1260
Harvestman spider	10	9	90
Fine-streaked bugkin	14	13	182
N =	.....	$\sum n(n-1)$ =	.....
$N(N-1)$ =	.....		

(i) Use **Table 5.2** and the equation below to calculate the Simpson's Diversity Index for the deciduous woodland.
Express your answer to two decimal places. [3]

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Where;
n = the number of each organism found
N = the total number of organisms
$\sum$ = sum of

D = ...

(ii) The students calculated the Simpson's Diversity Index for Habitat **B**, the coniferous woodland, as 0.19.
Use the information given to explain **one** reason why Habitat **A** has a higher biodiversity. [3]

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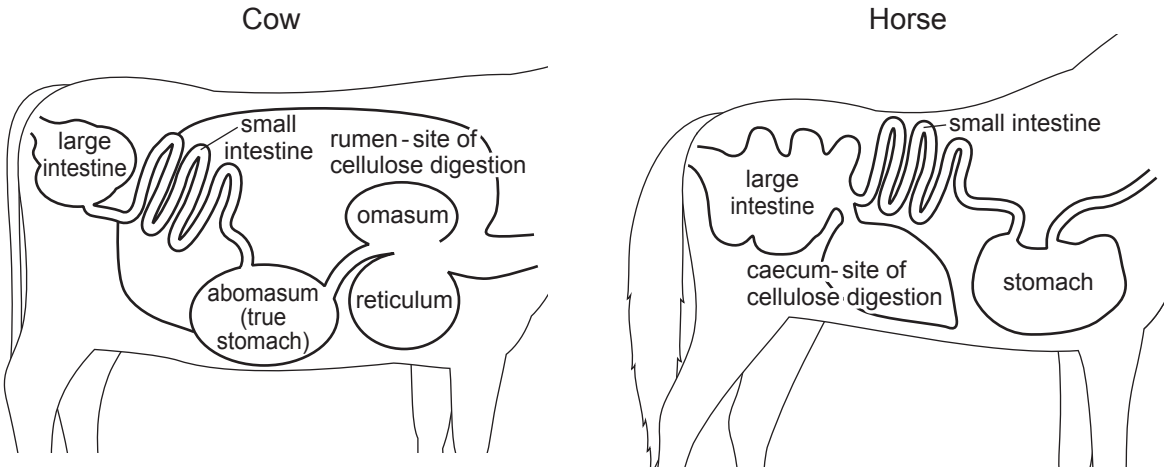
6. Mammalian digestive systems have structural differences based on their diet.
Image 6.1 represents the digestive systems of a cow and a horse. The cow and the horse have similar diets. However, there are differences in the way they digest food.

Image 6.1



(a) (i) Identify the **two** main sites of protein digestion in the digestive system in a mammal. [2]

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(ii) Both horse and cow manure can be used to fertilise land for growing food crops.

Use **Image 6.1** to explain why there are less nitrogen-containing compounds in cow manure compared to horse manure. [4]

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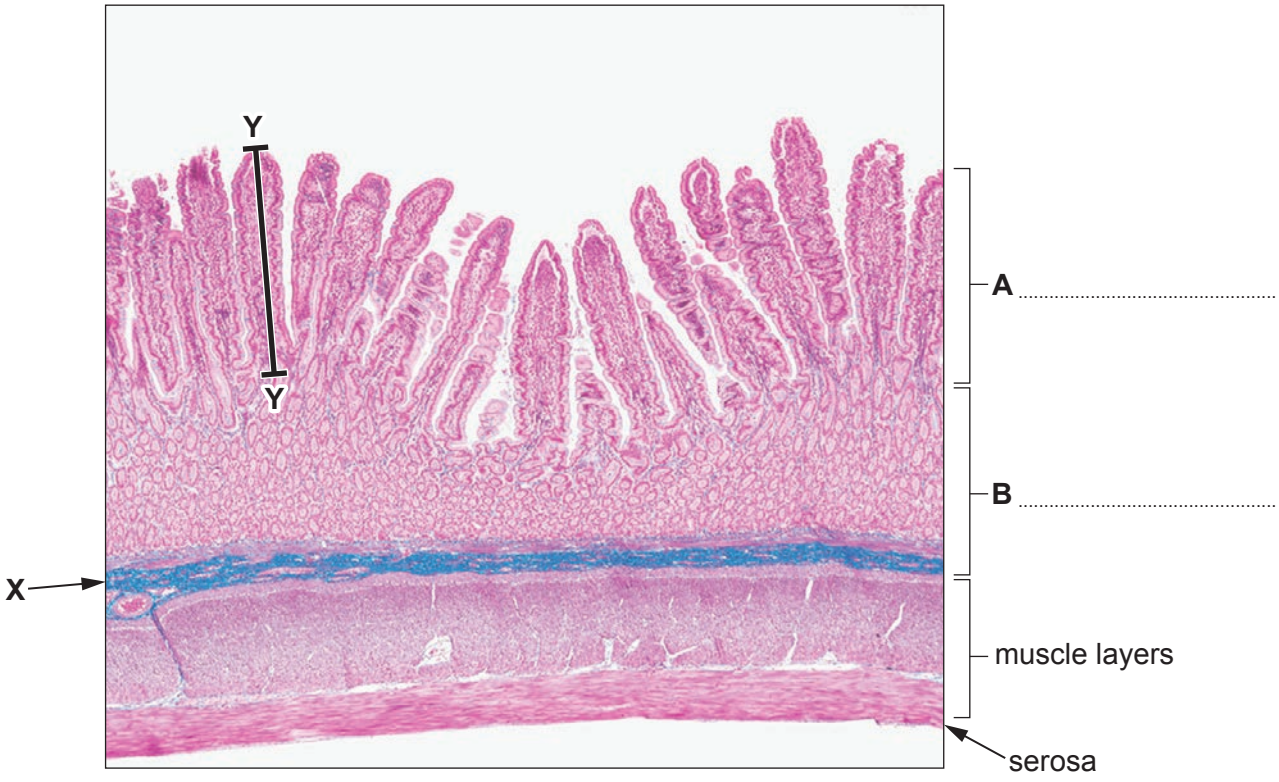
(b) **Image 6.2** is a micrograph of a longitudinal section of the ileum of a mammal.

Image 6.2



(i) Label tissues **A** and **B** on **Image 6.2**. [1]

(ii) The villus indicated with the line **Y–Y** is 750 µm in length.
Calculate the magnification of **Image 6.2**. [2]

Magnification = × .....

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(iii) Nervous tissue at **X** in **Image 6.2** controls the activity of the two muscle layers.

Name and describe the process by which food is moved along the gut and explain why control of this process is necessary. [3]

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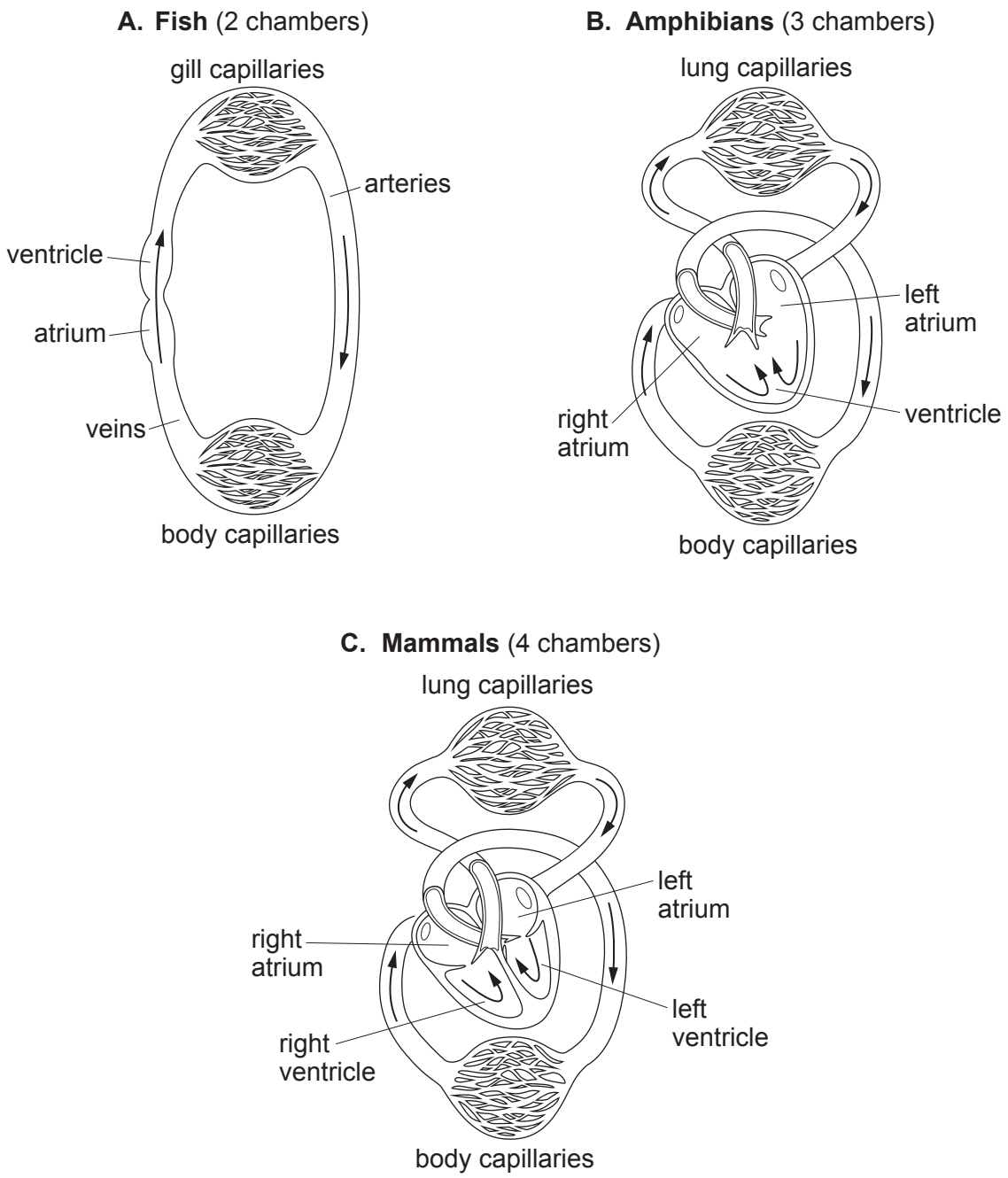
7. Large complex animals require specialised transport systems. Some invertebrates have open circulatory systems whereas all vertebrates have a closed circulatory system with a heart to function as a pump.

Image 7 shows the closed circulatory systems of three different vertebrates.

Image 7



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Use **Image 7** and your own knowledge to compare the features of open and closed circulatory systems.

Explain the benefits of the circulatory system of mammals compared to the circulatory system of fish.

Evaluate the effectiveness of the circulatory system of amphibians compared to fish and mammals. [9 QER]

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.	Examiner only

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