Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B400U20-1

O20-B400U20-1

FRIDAY, 16 OCTOBER 2020 – MORNING

BIOLOGY – AS component 2
Biodiversity and Physiology of Body Systems

1 hour 30 minutes

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Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**16**	
3.	**15**	
4.	**20**	
5.	**9**	
Total	**75**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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 continuation 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 quality of extended response (QER) will take place in question **5**.

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

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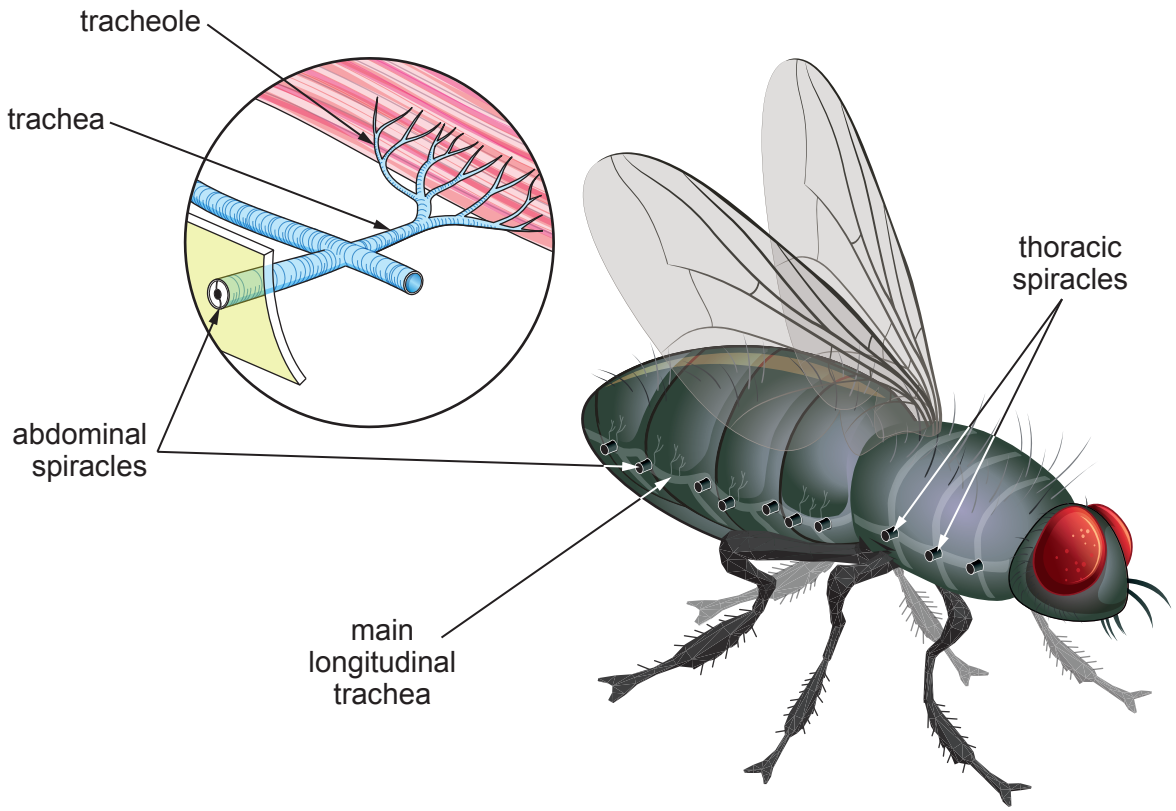
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Answer **all** *questions.*

1. The tracheal system, as shown in **image 1.1**, is the site of gas exchange in insects.

Image 1.1



(a) (i) State precisely where gas exchange takes place in the tracheal system. [1]

At the ends of the tracheoles (at the muscle cells).

(ii) One problem facing terrestrial animals like insects is water loss.
State **two** adaptations of the insect tracheal system to reduce water loss. [2]

Spiracles are small and can close, reducing water loss by evaporation.

The tracheal system is internal, so the moist gas exchange surface is inside the body.

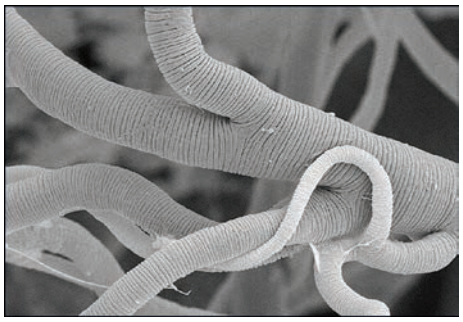
Hairs in the spiracles trap moist air.

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(iii) **Image 1.2** is an electron photomicrograph which shows the detail of the insect tracheae.

Image 1.2



Use the scale bar in **image 1.2** to calculate the magnification of the photomicrograph. [2]

length of scale bar = 12 mm = 12 000 µm

M = image size ÷ actual size = 12 000 ÷ 10

Magnification = × *1200*

(b) In the experiment shown in **image 1.3**, a grasshopper was placed in a gas syringe. Its abdomen was observed and the number of abdominal movements per minute was counted for three consecutive minutes. The student then exhaled one breath gently into the syringe through the plastic tubing and the number of abdominal movements was counted again in the same way. The experiment was repeated using two, three and four exhalations. The results are shown in **table 1.4**.

Image 1.3

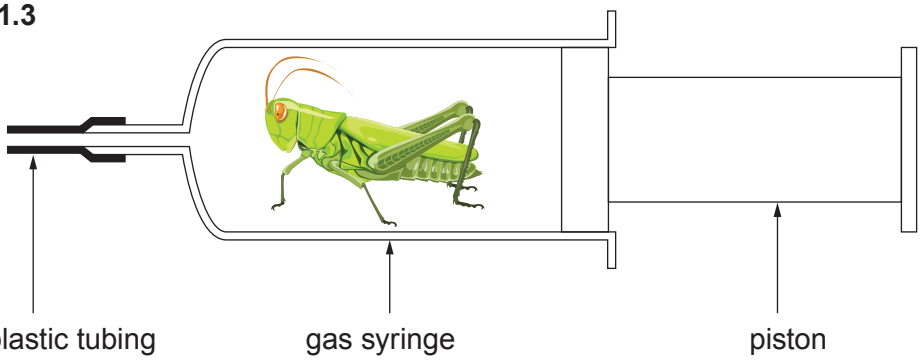


Table 1.4

Number of exhalations	Number of abdomen movements per min			
	Minute 1	Minute 2	Minute 3	Mean
0	47	43	50	47
1	64	66	62	64
2	89	89	91	90
3	103	99	106	103
4	104	106	105	105

(i) State **two** factors that would need to be controlled during the experiment. [2]

Temperature of the surroundings.

The volume of each exhalation into the syringe (same grasshopper).

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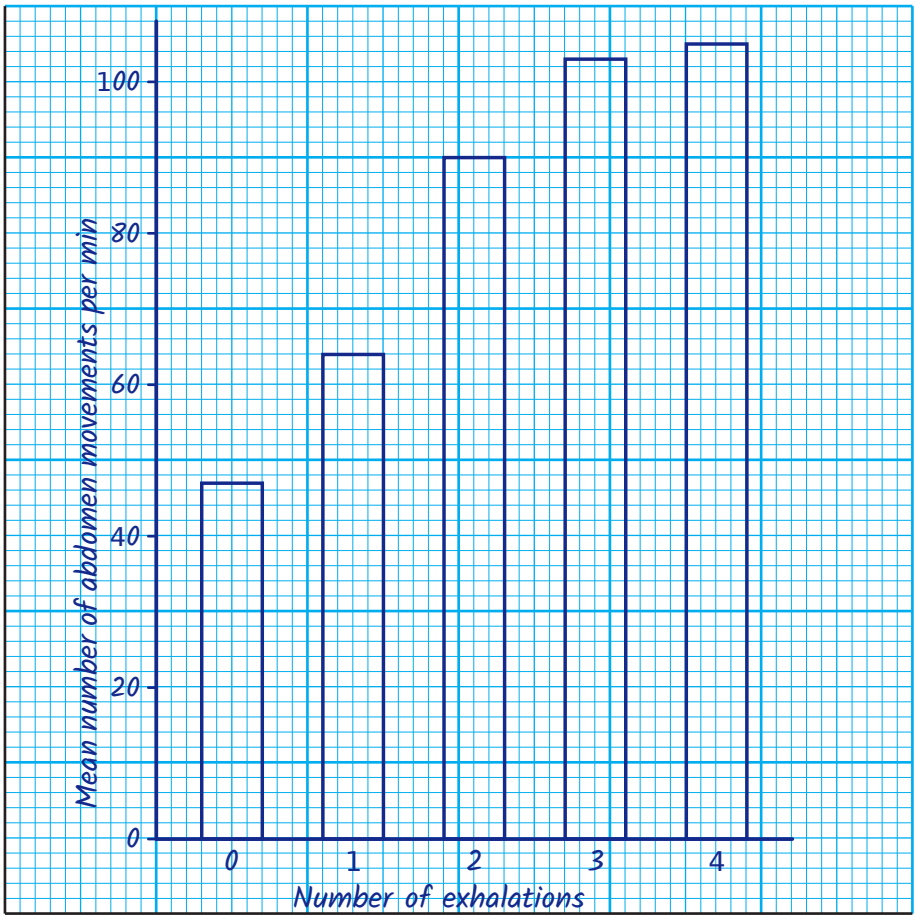
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(ii) Explain how abdominal movements are linked to ventilation in the insect. [2]

Contraction and relaxation of the abdominal muscles changes the volume, and so the pressure, inside the insect's body.

These pressure changes draw air into and force air out of the tracheal system through the spiracles (ventilation).

(iii) Plot the mean data from the experiment as a **bar graph** on the graph paper below [2]



(iv) Describe and explain the trend shown by the data. [4]

As the number of exhalations increases, the mean number of abdomen movements per min increases (47 to 105).

It levels off at 3 to 4 exhalations, as the maximum rate of abdominal movements is reached.

More movements mean increased ventilation (air flow), due to the higher level of CO_2 and lower level of O_2 in the syringe after each exhalation.

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2. Transpiration is the loss of water vapour from the leaves of a plant. This allows water to move through the xylem of the plant.

(a) (i) Explain how the cohesion-tension theory accounts for most of the water movement through the xylem of a plant. [4]

Water is lost by transpiration (evaporation) from the leaves through the stomata, which creates a tension (drop in pressure) at the top of the xylem.

Water molecules are polar and form hydrogen bonds with each other (cohesion), so a continuous column of water is pulled up the xylem as the transpiration stream.

Water molecules are also attracted to the lignin in the xylem walls (adhesion), giving capillarity.

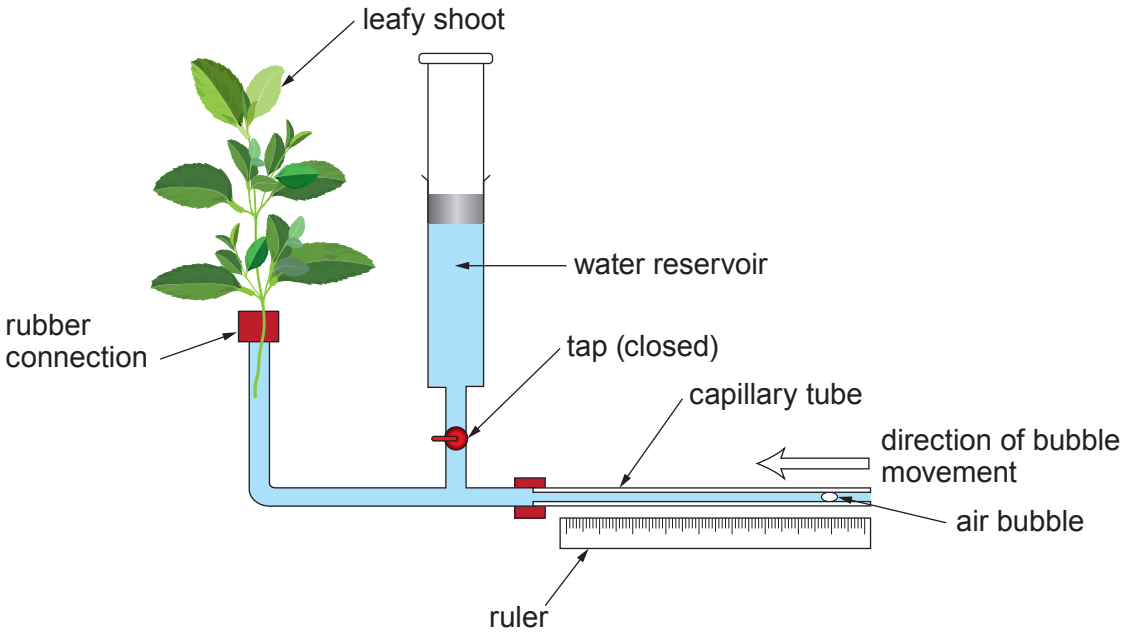
(ii) Explain how water moves by osmosis into the xylem of the root. [2]

Ions are actively transported into the xylem of the root (by the endodermis cells).

This lowers the water potential in the xylem, so water moves into the xylem by osmosis down a water potential gradient.

(b) A potometer was set up, as shown in **image 2.1**, to investigate transpiration in plants. The shoot was exposed to a range of different air speeds using a hairdryer.

Image 2.1



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(i) Using the fast air speed, the air bubble in the capillary tubing moved 47 mm in 12 minutes. The capillary tubing diameter was 1 mm. Calculate the volume of water lost through transpiration from the shoot **per hour** using the formula $\pi r^2 h$. [3]

π = 3.14
h = distance moved

r = 1 ÷ 2 = 0.5 mm, h = 47 mm

volume in 12 min = 3.14 × 0.5^2 × 47 = 36.895 mm^3

volume per hour = 36.895 × (60 ÷ 12)

= 36.895 × 5 = 184.475 mm^3 hr^{-1}

Volume of water lost = *184.5* mm^3 hr^{-1}

(ii) Explain why it would be incorrect to conclude that all the water taken up was lost in transpiration from the shoot. [1]

Some water is used by the plant, e.g. in photosynthesis or to keep cells turgid (support).

(iii) Explain how and why the results obtained would differ if a **xerophytic** plant was used in the same experiment. [3]

The bubble would move a shorter distance, as there would be less transpiration (a lower volume of water lost).

This is because xerophytes have leaf adaptations that reduce water loss, e.g. a thick waxy cuticle reduces evaporation from the leaf surface, and sunken stomata trap moist air, increasing humidity and reducing the water potential gradient.

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(c) **Table 2.2** shows the results of the experiment for three air speeds generated by the hairdryer.

Table 2.2

Air speed setting	Distance moved by the bubble in 12 minutes / mm
slow	28
medium	35
fast	47

A student made the following conclusion from these results: '*Increasing the air speed caused an increase in the distance the bubble moved.*'
Suggest **three** reasons why it would not be possible to be confident in this conclusion.
[3]

Only one reading was taken at each air speed, with no repeats, so a mean cannot be calculated.

The hairdryer also generates heat, so temperature was not controlled.

Only three air speeds were used; more air speeds are needed to show a trend.

Other variables such as light intensity and humidity were not controlled.

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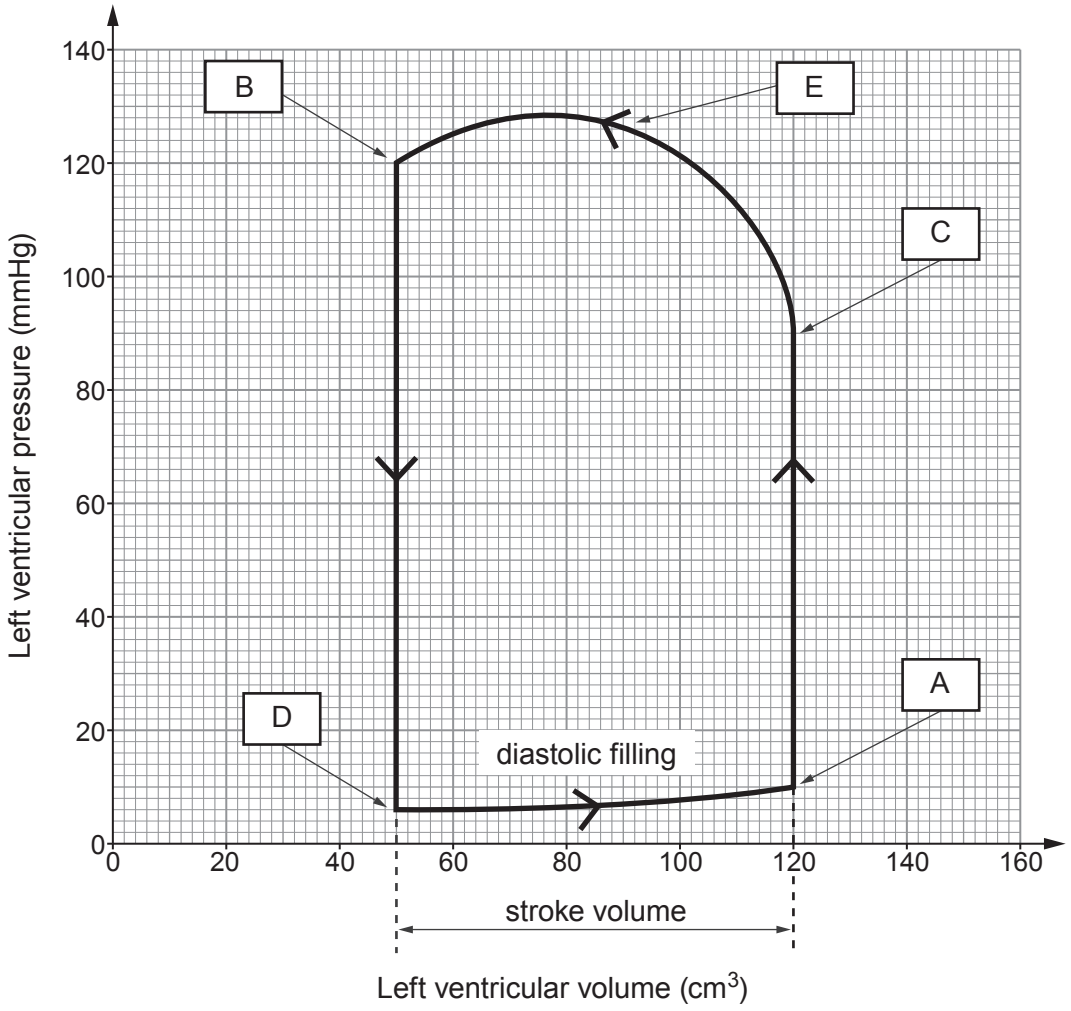
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3. **Graph 3.1** shows how pressure and volume change in the left ventricle during the cardiac cycle in mammals. This is known as a pressure-volume loop. The arrows represent the sequence of these changes during one cardiac cycle. The diagram also shows the stroke volume (SV), which is the volume of blood pumped from the left ventricle during each contraction.

Graph 3.1



(a) (i) Using **graph 3.1**, determine which letter(s) fits the statements in **table 3.2**. The letters can be used, once, more than once or not at all. [4]

Table 3.2

Statement	Letter(s)
Atrio-ventricular valve closes	A
Left ventricle is relaxed	D
Left ventricle pressure is greater than in the aorta	C, E
Semi-lunar valves close	B

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(ii) A patient has a heart rate (HR) of 80 beats per minute. Using the information from **graph 3.1** and the following formula, **calculate their cardiac output in cm^3 min^{-1}**.

Cardiac output (CO) = HR × SV [2]

SV = 120 − 50 = 70 cm^3

CO = 80 × 70

Cardiac output = ...5600.... cm^3 min^{-1}

(b) (i) Name the structures which ensure that the atrio-ventricular valves only open in one direction. [1]

Chordae tendineae (tendinous cords).

(ii) Explain why blood only flows into the aorta and nowhere else when the left ventricle contracts. [3]

When the left ventricle contracts (ventricular systole), the pressure in the ventricle rises above the pressure in the aorta, so the semilunar valves are forced open and blood flows into the aorta.

The ventricle pressure is also greater than in the left atrium, so the atrio-ventricular valve closes and blood cannot flow back into the atrium.

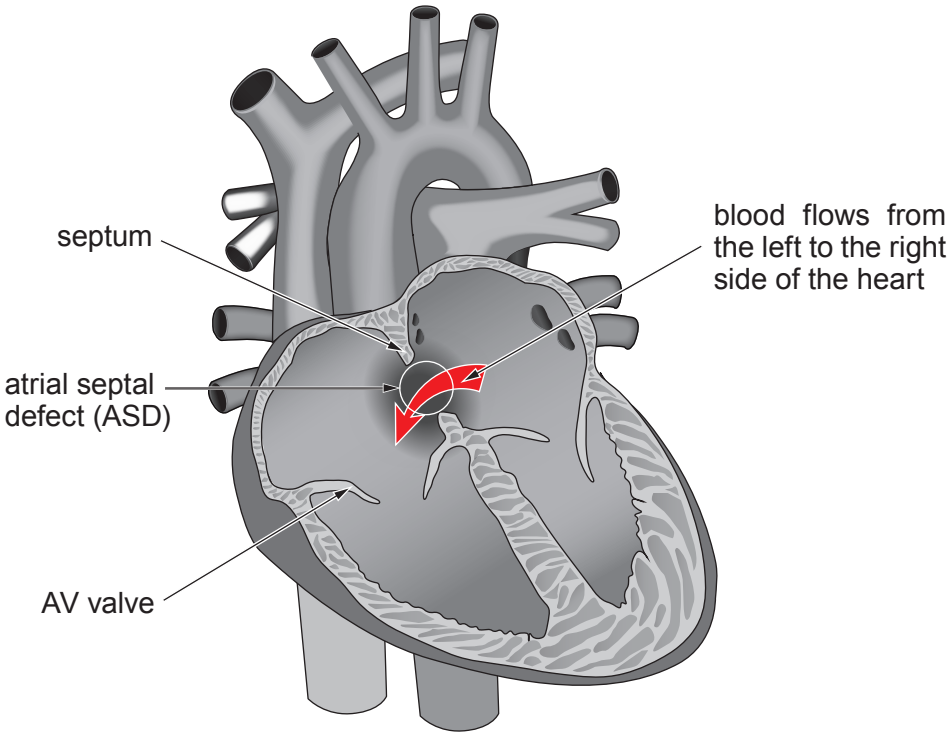
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(c) **Image 3.3** shows a condition called atrial septal defect in the heart of a child. The septum of the atria has a hole which allows blood to flow from the left atrium to the right atrium.

Image 3.3



(i) Using **image 3.3** and your own knowledge of the cardiac cycle, explain how the defect shown could result in tiredness and a lack of energy. [4]

Oxygenated blood flows from the left atrium into the right atrium, mixing with deoxygenated blood, so a smaller volume of blood reaches the left ventricle.

So less oxygenated blood is pumped to the body tissues.

This means less aerobic respiration and less ATP, as the oxygen demand of the cells is not met.

Oxygenated blood is also sent to the lungs, so less oxygen is picked up at the alveoli.

(ii) Suggest why the atrial septal defect could reduce the stroke volume of the child. [1]

Less blood passes into the left ventricle, so less blood passes out of the left ventricle into the aorta with each beat.

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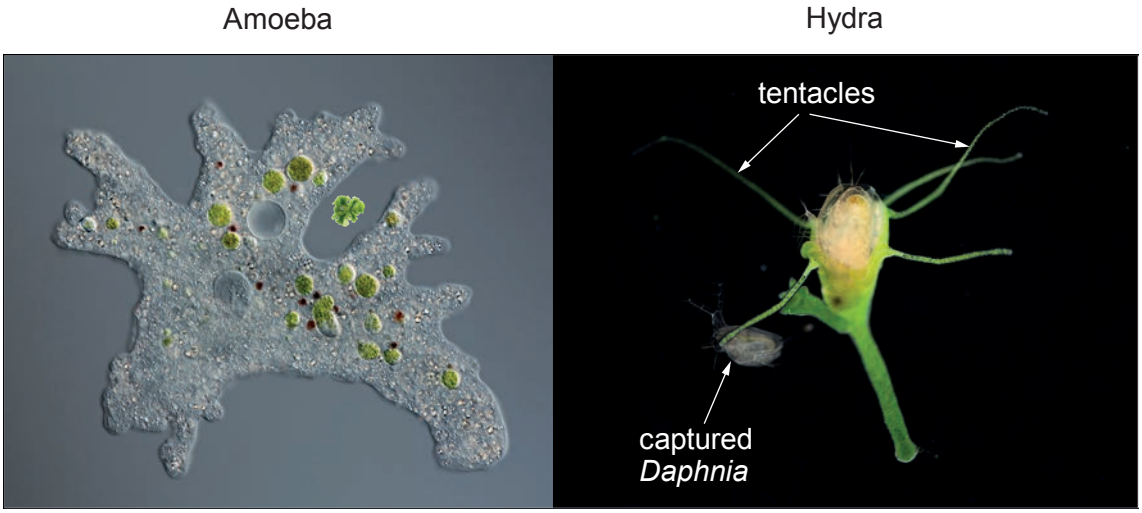
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4. **Image 4.1** shows an amoeba and a hydra feeding. Both organisms are holozoic and heterotrophic.

Image 4.1



(a) Define the following terms: [2]

holozoic; involves ingestion, digestion, absorption, assimilation and egestion (internal digestion of food substances).

heterotrophic. cannot manufacture its own organic molecules from inorganic substances, so eats other organisms to gain organic molecules.

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(b) The giant panda, *Ailuropoda melanoleuca*, is a bear which eats bamboo. It is also holozoic and heterotrophic. The giant panda is classified as a carnivore but eats mainly plants. The ancestors of giant pandas were originally carnivores and began consuming bamboo in their diet around 7 million years ago. It is thought that they then switched to eating mainly bamboo about 2 million years ago.

(i) The binomial naming system uses the genus and species name for the giant panda. State the main reason for using this system of naming organisms. [1]

It is universal: the names are used by biologists worldwide (international), avoiding confusion.

(ii) **Image 4.2** shows the skull of a giant panda.

Image 4.2



Using **image 4.2** and your own knowledge of dentition, state the evidence which supports the classification of giant pandas as carnivores. [3]

Large, pointed canines are present, which are used for killing and holding prey.

Carnassial teeth are present, used for shearing flesh.

There is no diastema.

Small, sharp incisors are present in both jaws (no horny pad) for gripping flesh.

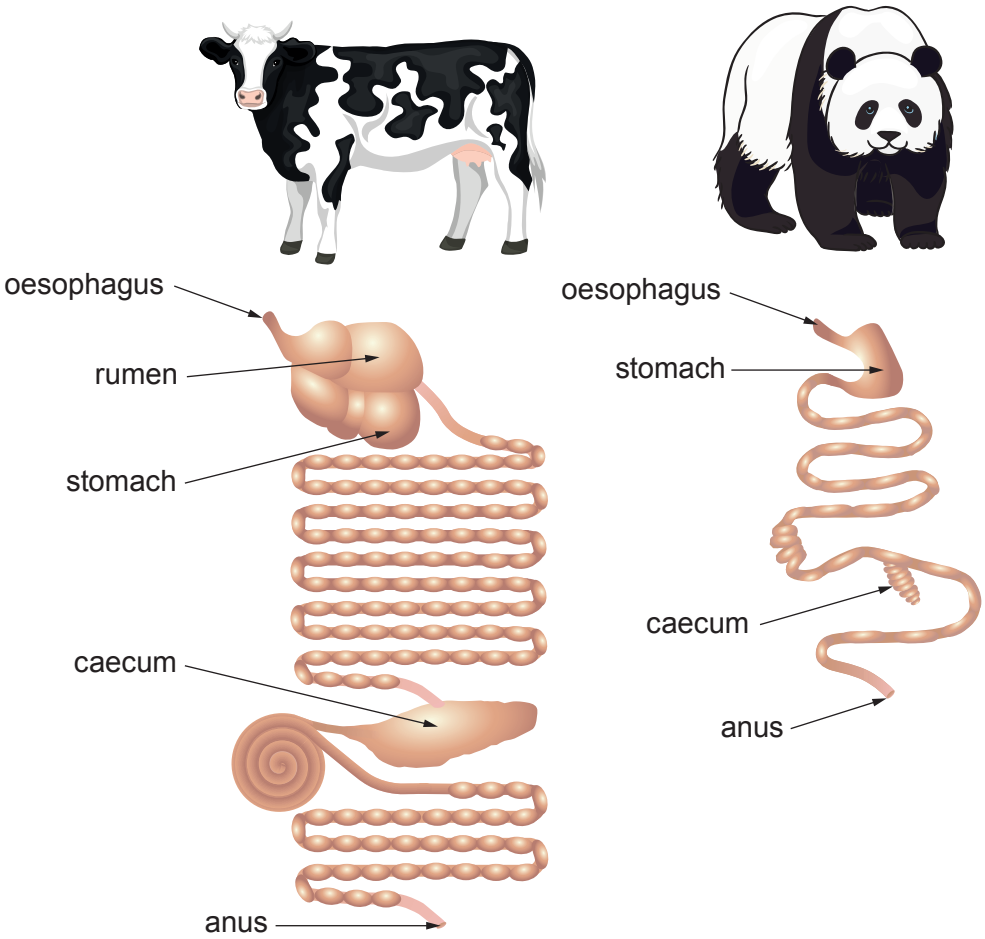
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Image 4.3 shows the digestive tract of a cow and a giant panda.

Image 4.3



(iii) Describe how **and** explain why the gut of the panda differs from the gut of a cow. [4]

The panda has a less complex stomach with no rumen, whereas the cow has a rumen and a four-chambered stomach.

The panda has a much shorter small intestine (shorter gut overall) and a shorter, smaller caecum than the cow.

This is because the panda has the gut of a carnivore: proteins are easier to digest, so less time is needed for digestion,

whereas the long gut of the cow gives a longer time for the digestion of plant material (cellulose).

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(c) Cellulase producing bacteria have been found in the faeces of some giant pandas. Using your knowledge of digestion, suggest where in the gut the bacteria would need to be located to provide the greatest benefit to the panda. Explain your answer. [3]

In the stomach or oesophagus, i.e. before the duodenum.

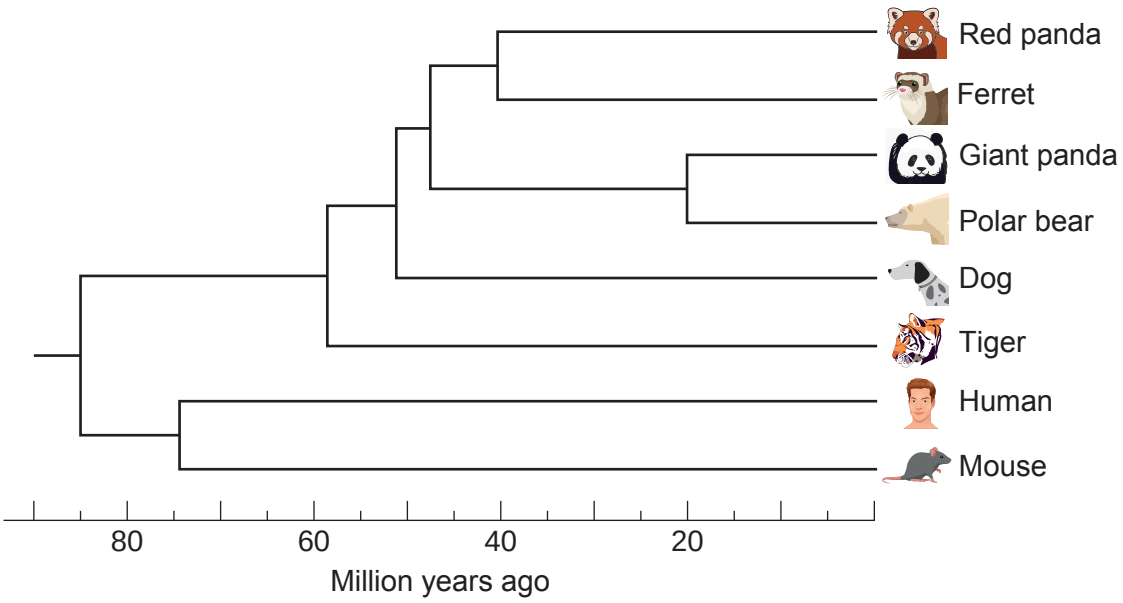
Cellulose would then be digested before the food reaches the duodenum,

so the products (glucose) can be absorbed in the ileum (small intestine),

giving more efficient digestion and absorption.

Image 4.4 shows a phylogenetic tree. The tree was constructed using information gathered after analysis of haemoglobin from a number of species.

Image 4.4



(d) (i) Using **image 4.4**, state how many million years ago the last common ancestor existed between the giant panda and a human. [1]

85 million years ago.

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(ii) State the information that the analysis of the haemoglobin would provide, and how this could have been used to construct the phylogenetic tree shown in **image 4.4**. [4]

It gives the amino acid sequence of haemoglobin in each species.

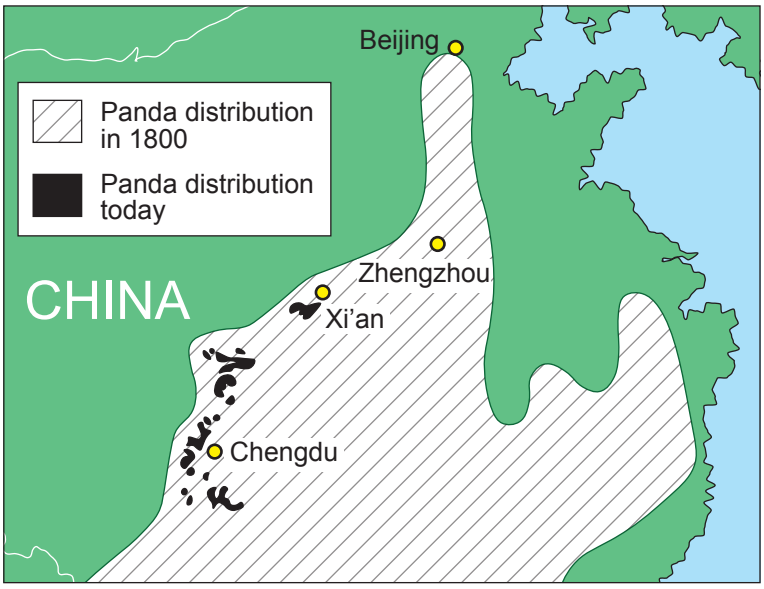
The sequences of different organisms are compared for similarity.

The more similarities, the more closely related the species, so they are placed closer together on the tree.

Mutation rate allows the time since divergence to be calculated, so branch length shows when they diverged.

There are only around 1 000 giant pandas living in the wild. These are split between three areas in China as shown in **image 4.5**.

Image 4.5.



The separation of the populations of giant pandas was thought to have caused a reduction in the biodiversity of the species. Further studies have revealed that the biodiversity is high even though the number of individuals is low. The high biodiversity is caused by a high level of genetic polymorphism.

(e) State what is meant by a '*high level of genetic polymorphism*'. [2]

There are multiple (many different) phenotypes within the population, because there is a high number of different alleles at each locus (for each gene).

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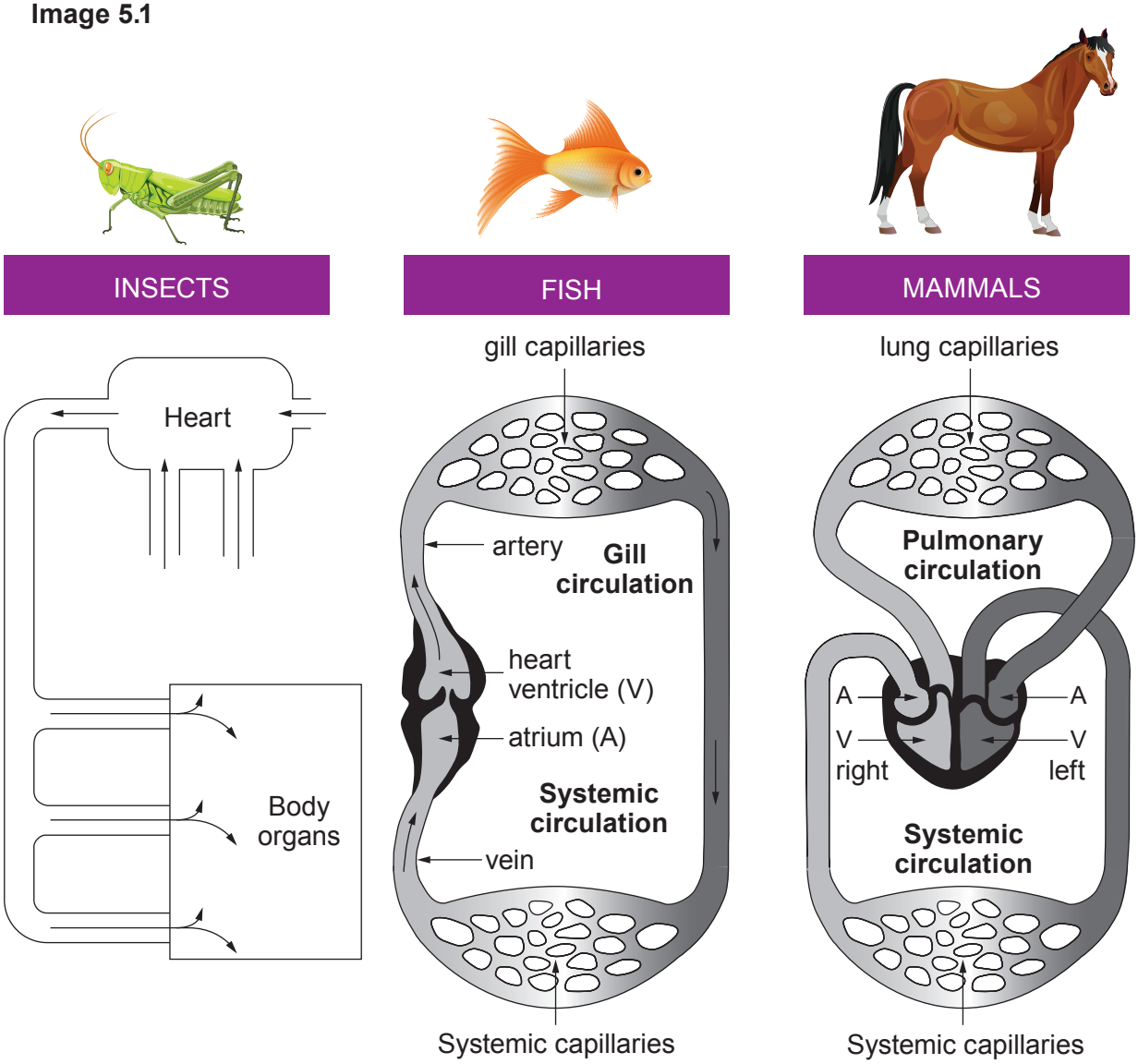
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5. Circulatory systems in animals have evolved in different ways.

Image 5.1 shows organisms which have different arrangements of their circulatory systems.

Image 5.1



Explain the similarities and differences between the circulatory systems shown in the diagrams.

Outline the advantages and disadvantages of the single and double circulatory systems.

[9 QER]

Similarities: all three systems contain blood, a transport medium, and a heart which generates pressure to maintain the flow of blood around the body.

Open vs closed: insects have an open circulation with no blood vessels to carry blood to the tissues. The heart pumps blood into the body cavity, where it

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bathes the organs directly at low pressure; this is sufficient because oxygen is delivered by the tracheal system. Fish and mammals have closed circulations, in which the blood is always enclosed within blood vessels (arteries, capillaries and veins).

Single vs double: in the fish (single circulation) blood passes through the heart once in each complete circulation: heart, gill capillaries, systemic capillaries, back to the heart. In mammals (double circulation) blood passes through the heart twice in each complete circulation: once through the pulmonary circulation to the lungs and once through the systemic circulation to the body. The mammalian heart is more complex, with two atria, two ventricles and a septum, whereas the fish heart has one atrium and one ventricle. Pressure is higher in a double circulation, because blood returns to the heart after the lungs to be pumped again.

Advantages of a single circulation: the heart only has to generate a lower pressure, which suits animals with a low activity level, so less energy is needed to power the heart. In fish, blood is pumped at high pressure directly to the gills for gas exchange.

Advantages of a double circulation: the left ventricle generates a higher pressure to the body cells, giving a higher rate of blood flow, so oxygen and glucose are delivered quickly to support a high metabolic rate. At the same time, the right ventricle sends blood at a lower pressure to the lungs, so the alveoli and capillaries are not damaged and there is more time for gas exchange. Separation of oxygenated and deoxygenated blood by the septum makes oxygen delivery more efficient.

Disadvantages of a single circulation: blood loses pressure as it passes through the gill capillaries, so oxygenated blood travels to the body at a lower pressure, giving a slower rate of blood flow to the body organs; this limits the

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metabolic rate of the animal.

Disadvantages of a double circulation: the greater pressure gives a greater risk of problems, such as damage to the heart and blood vessels. The greater complexity of the heart structure also gives a greater risk of problems, such as septal defects or valve issues.

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