

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names	
Pearson Edexcel		Centre Number	Candidate Number
Level 3 GCE			
Time 1 hour 30 minutes	Paper reference	8BI0/02	
Biology B Advanced Subsidiary PAPER 2: Core Physiology and Ecology			
Candidates may use: Calculator, HB pencil, ruler			Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In question(s) marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Biologists classify organisms based on characteristics and on evolutionary relationships.

(a) (i) Which of these groups contains the greatest variety of organisms? (1)

- ☐ **A** genus
- ☒ **B** kingdom
- ☐ **C** phylum
- ☐ **D** species

(ii) Closely-related genera are grouped together in a (1)

- ☐ **A** class
- ☐ **B** domain
- ☒ **C** family
- ☐ **D** order

(iii) Which of these is a kingdom? (1)

- ☐ **A** Archaea
- ☐ **B** Bacteria
- ☐ **C** Eukarya
- ☒ **D** Protista



- (b) (i) Explain the evidence that led to the three-domain model of classification replacing the five-kingdom model.

(3)

Techniques of molecular phylogeny (biochemistry), such as comparing base sequences of rRNA genes and amino acid sequences of proteins, were used.

These found large differences between archaea and bacteria, which had both been put in the prokaryote kingdom, and showed archaea are more closely related to eukaryotes.

For example, archaea have different membrane lipid structure, different membrane proteins and different ribosomes (RNA polymerase) from bacteria, so they were placed in a separate domain.

- (ii) Give a method that a scientist, with a new theory based upon experimental results, could use to share this with others in the scientific community.

(1)

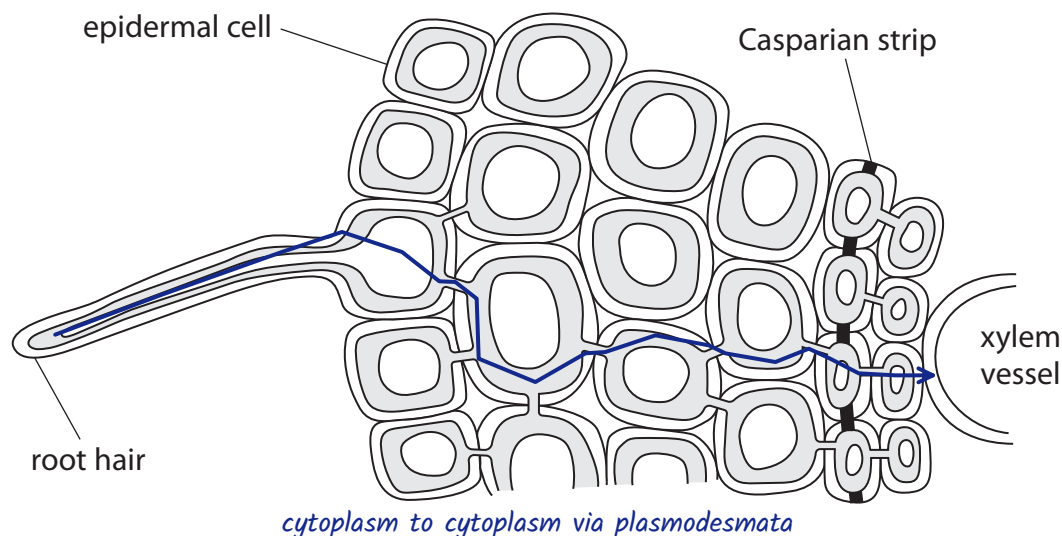
Publish the results in a peer-reviewed scientific journal (or present them at a scientific conference).

(Total for Question 1 = 7 marks)



2 Water can move through plant cells.

(a) The diagram shows the cells in a plant root.



(Source from: https://cronodon.com/BioTech/Plant_Transport.html)

(i) On the diagram, draw the symplastic pathway that water takes from the soil to the xylem vessel.

(2)

(ii) The length of the root hair cell in the diagram is 60 mm.

The magnification of the diagram is $\times 100$.

Calculate the actual length of the root hair cell in micrometres.

(2)

$$\text{length of image} = 60 \text{ mm} \times 1000 = 60\,000 \mu\text{m}$$

$$\text{actual length} = 60\,000 \div 100 = 600 \mu\text{m}$$

Answer 600 μm



(b) Explain how the cohesion-tension model accounts for the transport of water from plant roots to leaves.

(4)

Water is lost by transpiration: it evaporates from the cells inside the leaf and diffuses out through the stomata.

This lowers the water potential of the leaf cells, so water moves into them from the xylem, creating a tension (water potential gradient) that pulls water up the xylem.

Water enters the root hairs down the water potential gradient.

Water molecules are polar and form hydrogen bonds with each other, so cohesion holds them together as a continuous column of water that is pulled up.

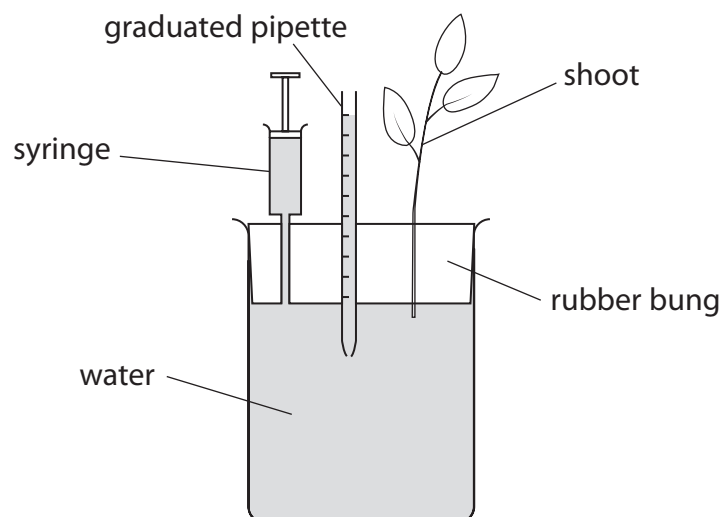
Adhesion of water molecules to the walls of the xylem vessels also helps the water move up.

(Total for Question 2 = 8 marks)



P 6 7 1 4 9 R A 0 5 2 8

3 The diagram shows a type of potometer.



(Source from: Science and Plants for Schools: www.saps.org.uk)

The leaves of the shoot must be kept dry when assembling the potometer under water in a sink.

The syringe plunger is pushed down until the water level is raised to zero in the graduated pipette.

The water level in the graduated pipette is used to measure water uptake by the shoot.

(a) (i) Explain why the apparatus should be assembled under water.

(2)

So that no air bubbles enter the apparatus and it is air-tight.

This keeps a continuous column of water connecting the water in the potometer to the leaves (an air bubble would break the column and stop water uptake).

(ii) Explain why the leaves must be kept dry whilst assembling the apparatus.

(2)

Water on the leaves would cover (block) the stomata.

There would be no water vapour (concentration) gradient, so water would not diffuse and evaporate from the leaves, which prevents transpiration.



- (b) (i) Explain how this potometer can be used to investigate the effect of light intensity on the rate of water uptake by this shoot.

(4)

Vary light intensity by placing a lamp at 5 different distances from the shoot (e.g. 10, 20, 30, 40 and 50 cm), or by using a light dimmer (rheostat).

At each light intensity leave the shoot to acclimatise, then measure how far the water level falls in the graduated pipette in a stated time, e.g. 5 minutes.

Reset the water level to zero using the syringe between readings.

Take several (at least 3) readings at each light intensity and calculate a mean rate of water uptake.

Control other abiotic variables such as temperature (use a heat filter or water screen), humidity and air movement (wind), and use the same shoot.

- (ii) This potometer measures the uptake of water by a plant shoot.

Give **two** reasons why the water lost by transpiration is less than the water taken up by the plant shoot.

(2)

Some of the water taken up is used in photosynthesis.

Some water is kept in the cells to maintain turgor (support).

(Total for Question 3 = 10 marks)



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4 Substances move into cells by several processes.

(a) (i) Which of these processes requires energy from respiration?

(1)

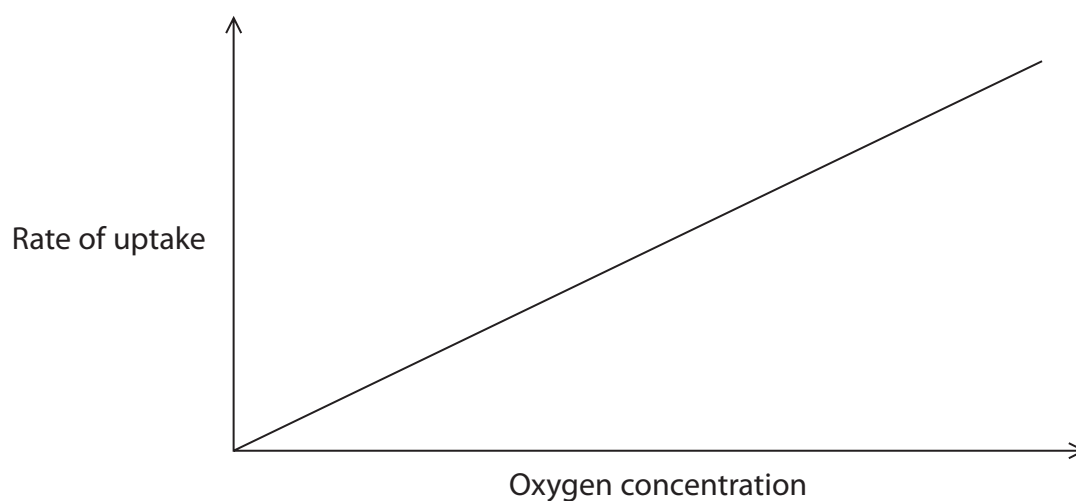
- ☐ A diffusion
- ☒ B endocytosis
- ☐ C facilitated diffusion
- ☐ D osmosis

(ii) Which of these processes can occur against a concentration gradient?

(1)

- ☒ A active transport
- ☐ B diffusion
- ☐ C facilitated diffusion
- ☐ D osmosis

(iii) The graph shows the effect of increasing oxygen concentration on the rate of uptake of a substance **other** than oxygen.



Which of these processes is shown by the graph?

(1)

- ☒ A active transport
- ☐ B diffusion
- ☐ C facilitated diffusion
- ☐ D osmosis



(iv) Which substance can enter a cell by diffusion?

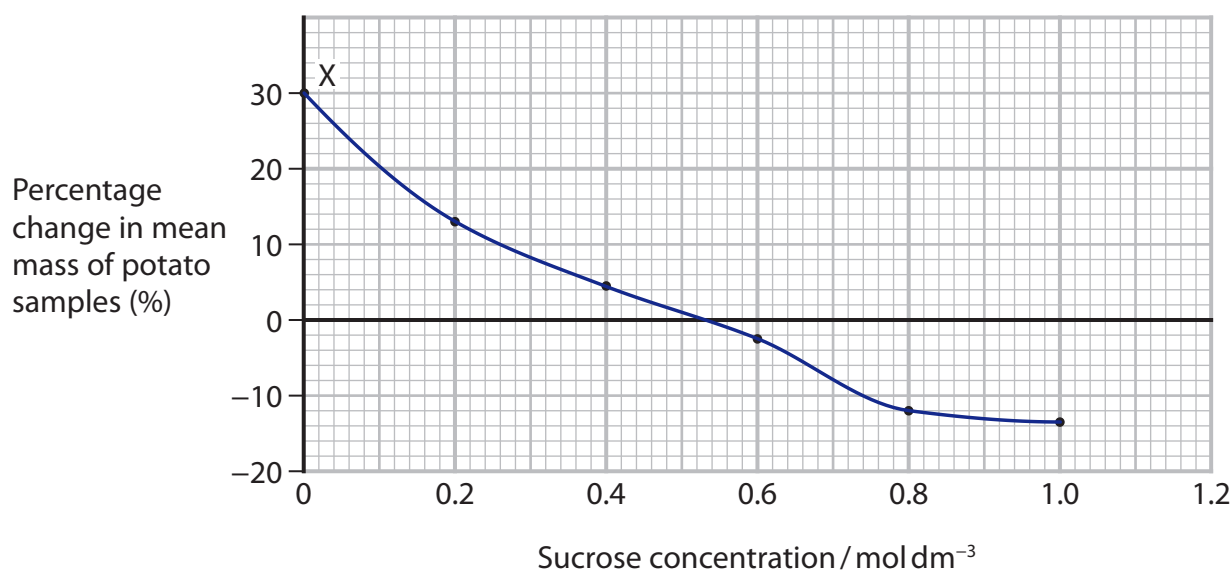
(1)

- ☐ A amino acid
- ☒ B carbon dioxide
- ☐ C glucose
- ☐ D protein

(b) When plant cells absorb water, the water potential of the cells changes.

The water potential of potato cells was investigated.

The graph shows the percentage change in mean mass of potato samples after immersion in sucrose solutions of different concentrations.



(i) Draw a suitable line on this graph.

(1)

(ii) Give the sucrose concentration that has the same water potential as the cells in these potato samples.

(1)

Answer 0.54 mol dm⁻³



(iii) The water potential (ψ) of plant cells can be calculated using the equation:

$$\psi = P + \pi$$

Explain the changes in the water potential of cell (ψ), turgor pressure (P) and osmotic potential (π), at point X on the graph.

(4)

At point X the sucrose solution has a higher water potential than the cells, so water enters the cells by osmosis down the water potential gradient.

As water enters, the cell (protoplast) pushes against the cell wall, so the turgor pressure (P) increases.

The osmotic potential (π) changes very little (becomes slightly less negative as the cell contents are diluted), so the water potential of the cell (ψ) increases (becomes less negative) towards 0.

Water enters until the turgor pressure is equal and opposite to the osmotic potential, so $\psi = 0$; the cell wall prevents further entry of water and the cell is fully turgid.

(iv) Explain why it is more difficult to determine the osmotic potential (π) than the water potential (ψ) of plant cells.

(2)

Osmotic potential cannot be measured directly, because the water potential of a cell includes both the osmotic potential (π) and the turgor pressure (P).

It can only be found by the method of incipient plasmolysis, when $P = 0$, so $\psi = \pi$.

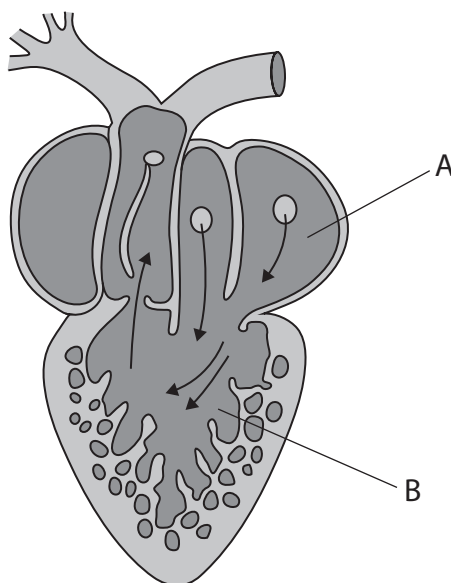
(Total for Question 4 = 12 marks)



5 The structure of a frog heart is different from those of mammals and fish.

The diagram shows the structure of a frog heart.

The arrows show the direction of blood flow.



(a) (i) Name the parts of the heart labelled A and B.

(2)

A atrium

B ventricle

(ii) Compare and contrast the structure of the frog heart with the structure of the mammalian heart.

(3)

Similarities: both hearts have two atria (upper chambers) above the ventricle(s) and both have atrioventricular valves.

Differences: the frog heart has only one ventricle, which is undivided, whereas the mammalian heart has two ventricles separated by a septum.

So the frog heart has three chambers, whereas the mammalian heart has four. The frog has no (semilunar) valves in its arteries.

(b) Amphibians, such as the frog:

- absorb oxygen through their lungs and through their moist skin
- have a lower metabolic rate than mammals
- have a double circulation system.

(i) State one difference between the double circulation system of the frog and that of the mammal.

(1)

In the frog, blood from the single ventricle goes to both the lungs and the body, so the systemic circulation contains oxygenated blood from both the lungs and the skin.

(ii) Explain how the circulatory system of the frog is adapted for the metabolism and gas exchange of the frog.

(4)

The frog has a low metabolic rate, so it requires less oxygen for respiration.

So mixing of oxygenated and deoxygenated blood in the single ventricle is not limiting.

However, blood has to go to two gas exchange surfaces, the lungs and the skin, so the double circulation sends blood to both.

The moist skin allows oxygen to dissolve and provides a large surface area for gas exchange, with a good blood supply, while the lungs allow the frog to be more active on land.



- (c) Describe the sequence of stimulation that occurs in a mammalian heart in one cardiac cycle.

(4)

The sinoatrial node (SAN) in the right atrium acts as the pacemaker and initiates a wave of depolarisation (impulse).

The impulse spreads through the heart muscle of the atria, causing atrial contraction (atrial systole).

The atrioventricular node (AVN) delays transmission of the impulse, so the ventricles contract after the atria.

The impulse then passes down the bundle of His and spreads through the Purkinje (Purkyne) fibres.

So the ventricles contract from the apex upwards, pushing blood into the arteries.

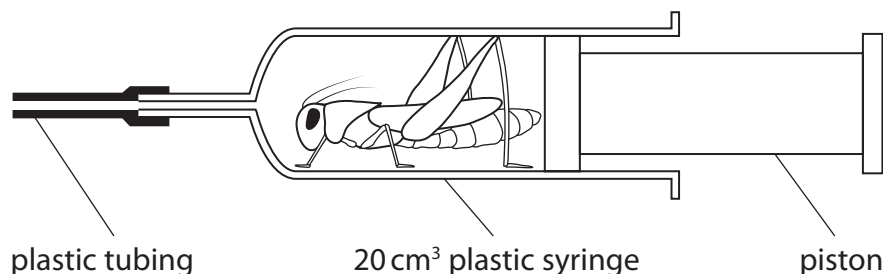
(Total for Question 5 = 14 marks)



6 The effect of gas composition on the breathing rate of locusts was investigated.

The method used was:

Step 1 A locust was placed in a 20 cm³ clear plastic syringe, as shown in the diagram. The piston was inserted so it gently held the locust in place so that the locust had no room to move.



Step 2 The number of pumping movements of the abdomen which occurred in 30 seconds was counted. This was repeated three more times.

Step 3 Gases of different compositions were added to the syringe through the plastic tubing.

Step 4 For each different composition of gases, the number of pumping movements of the abdomen which occurred in 30 seconds was counted.

Step 5 Between each composition of gases used, the piston was moved in and out ten times to replace the exhaled air with laboratory air.

Step 6 The locust was then left for 5 minutes before the next composition of gases was added.

(a) (i) State the purpose of **Step 5**.

(1)

To flush out (remove) the gases from the previous trial, so the locust breathes normal air before the next composition of gases is added.

(ii) State the purpose of **Step 6**.

(1)

To allow the breathing rate of the locust to recover (return to its normal resting value in air) before the next test.



(b) The table shows the results of the investigation.

Gas composition (%)		Number of movements in 30 seconds				Mean	Range	SD
oxygen	carbon dioxide							
21	0.1	26	22	31	29	27	9	3.9
16	4.1	41	44	46	49	45	8	3.4
100	0.0	5	12	6	8	8	7	3.1
94	6.0	48	42	46	49	46	7	3.1
88	12.0	44	46	50	53	48	9	4.04
83	17.0	54	51	53	49	52	5	2.2

- (i) Calculate the standard deviation for the number of movements in 30 seconds when the gas has a composition of 88% oxygen and 12% carbon dioxide.

Use the formula

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad (3)$$

$$\text{mean} = 48$$

$$\sum (x - \text{mean})^2 = (44 - 48)^2 + (46 - 48)^2 + (50 - 48)^2 + (53 - 48)^2$$

$$= 16 + 4 + 4 + 25 = 49$$

$$s = \sqrt{(49 \div (4 - 1))} = \sqrt{16.33}$$

$$= 4.04$$

Answer 4.04



(ii) Explain the relationship between the range and the standard deviation.

(2)

As the range gets higher, so does the standard deviation (positive correlation).

This is because both the range and the standard deviation measure the dispersal (spread) of the data.

(c) Analyse the data to comment on the effect gas composition has on the breathing rate of this locust.

(4)

As the oxygen concentration increases the breathing rate fluctuates, so there is no clear relationship with oxygen; e.g. 27 movements at 21% oxygen but 45 at 16% oxygen.

The lowest breathing rate is at 100% oxygen (0.0% carbon dioxide), a mean of only 8 movements in 30 seconds.

As the carbon dioxide concentration increases, the breathing rate increases: the highest carbon dioxide (17.0%) gives the highest breathing rate, a mean of 52.

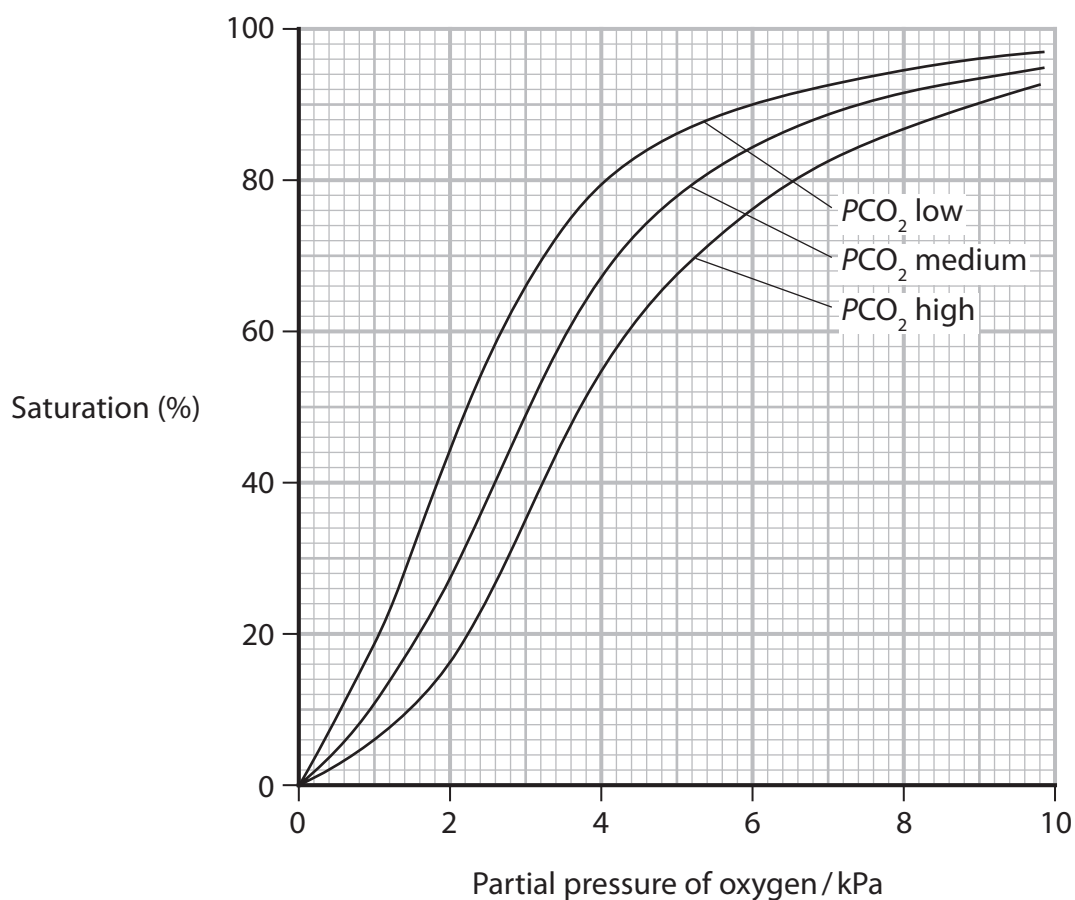
So carbon dioxide has a greater effect on the breathing rate than oxygen. However, only one locust was used, so the results may not be representative.

(Total for Question 6 = 11 marks)



7 Haemoglobin transports oxygen within the blood.

The graph shows the relationship between the partial pressure of oxygen and the saturation of haemoglobin with oxygen at three partial pressures of carbon dioxide.



(a) (i) The curve moves to the right when more carbon dioxide is present.

This move to the right is due to the

(1)

- ☒ **A** Bohr effect
- ☐ **B** chloride shift
- ☐ **C** dissociation curve
- ☐ **D** oxygen debt



(ii) Explain why the curves are S-shaped.

(2)

The binding of the first oxygen molecule to haemoglobin changes the shape (tertiary and quaternary structure) of the haemoglobin molecule.

This makes it easier for further oxygen molecules to bind (cooperative binding), so the curve rises steeply.

(iii) Calculate the difference between the percentage change in saturation of haemoglobin with oxygen as the partial pressure of oxygen changes from 8 kPa to 2 kPa for low carbon dioxide compared with high carbon dioxide.

(2)

low CO₂: 95 - 44 = 51%

high CO₂: 87 - 16 = 71%

difference = 71 - 51 = 20

Difference 20 %

(iv) Analyse the data to explain the advantage to the mammal of the curve moving to the right.

(3)

Respiring cells (tissues) release carbon dioxide, so the partial pressure of carbon dioxide is high in the tissues.

This lowers the affinity of haemoglobin for oxygen, so haemoglobin is less saturated at the same partial pressure of oxygen, e.g. at 4 kPa it is about 80% saturated at low CO₂ but only about 55% at high CO₂.

So haemoglobin unloads (dissociates from) its oxygen more readily, at a higher partial pressure of oxygen.

Thus more oxygen is released to the respiring cells to be used in aerobic respiration.



- (b) Mammals that live at high altitudes are in an environment with a lower partial pressure of oxygen.

Explain the position of the haemoglobin dissociation curve for mammals that live at high altitude.

(2)

The dissociation curve lies to the left of the curve for mammals living at sea level.

So the haemoglobin has a higher affinity for oxygen and is more saturated at lower partial pressures of oxygen, so enough oxygen can be loaded in the lungs.

(Total for Question 7 = 10 marks)



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8 The photograph shows a fruit fly, *Drosophila*.

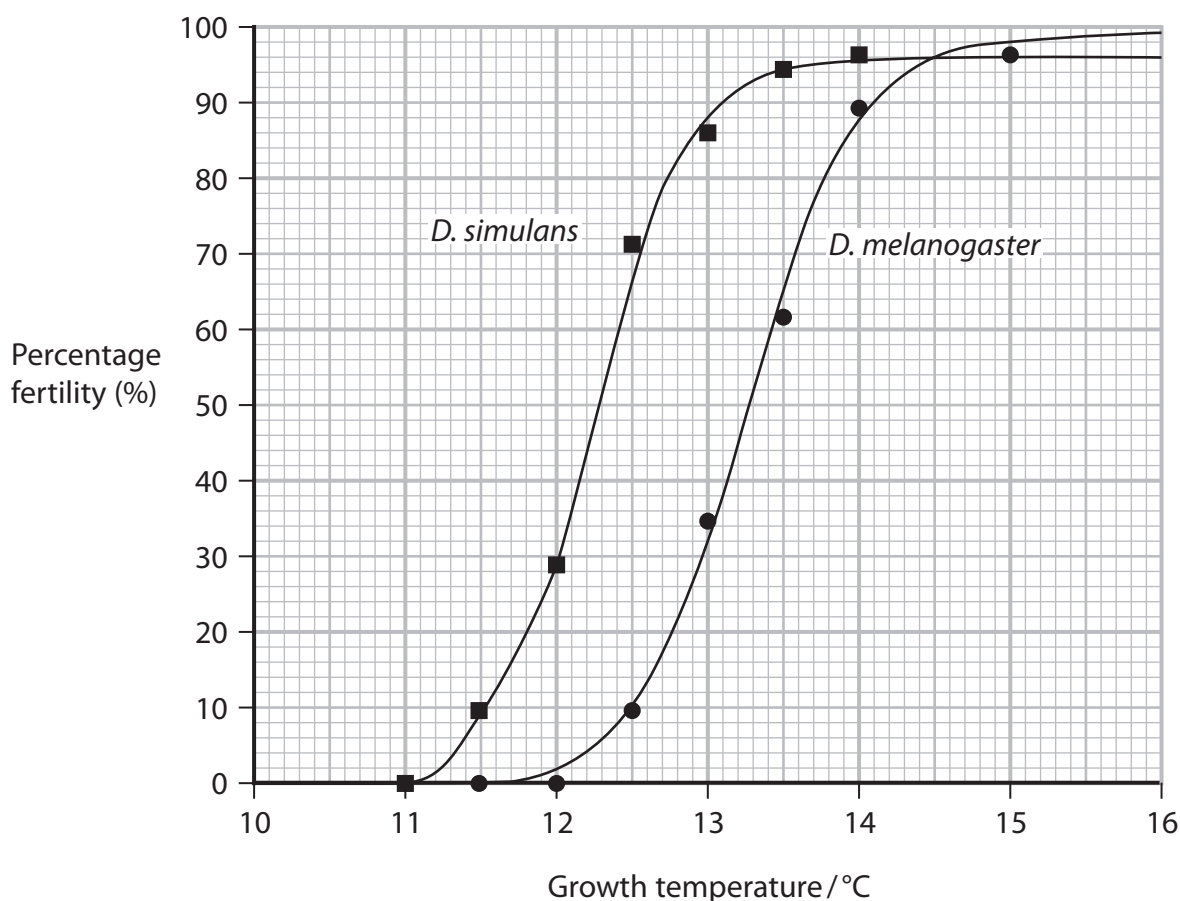


(Source: © Roblan/Shutterstock)

Species of *Drosophila* live in a range of habitats in different parts of the world.

The geographic distribution of these species ranges from regions with low temperatures to regions with high temperatures.

The graph shows the effect of temperature on the percentage fertility of male flies of two species of *Drosophila*, *D. simulans* and *D. melanogaster*.



- (a) The effect of low temperature on fertility is often compared using the temperature that results in 50% fertility.

Determine the difference in these temperatures for the two species.

(1)

D. melanogaster 13.25 °C, *D. simulans* 12.30 °C

$$13.25 - 12.30 = 0.95$$

Temperature difference 0.95 °C

- (b) Scientists also collected data from the two species about the effect of both high and low temperature on the viability of eggs and fertility of male flies.

An egg is viable if it develops into an adult.

The table shows the effects of temperature on the viability of eggs and fertility of males, for the two species of *Drosophila*.

Species	Lowest temperature / °C		Highest temperature / °C	
	at which eggs are viable	at which males are fertile	at which eggs are viable	at which males are fertile
<i>D. melanogaster</i>	10	12	32	30
<i>D. simulans</i>	10	11	31	28

- (i) Give the relationship between temperature and the viability of eggs and fertility of males.

(1)

Eggs are viable and males are fertile over a similar temperature range; at very low and very high temperatures eggs are not viable and males are infertile.



- *(ii) Another group of scientists recorded the courtship song of male *D. melanogaster* and male *D. simulans*.

The male flies vibrate their wings producing a courtship song to attract females.

The courtship song is produced in pulses.

The interval between pulses and the duration of each pulse are shown in the table.

Species	Mean interval between pulses / ms	Duration of pulse / s
<i>D. melanogaster</i>	34.1	1.6
<i>D. simulans</i>	48.9	3.4

Discuss how the data provides evidence for the geographical distribution and type of speciation of the two species of *Drosophila*.

Use the data from tables for temperature and for courtship song.

(6)

Temperature: for both species, the temperatures at which eggs are viable are always more extreme than those at which males are fertile (e.g. *D. simulans* eggs viable at 10 °C but males fertile only from 11 °C), because flies can survive at a temperature but not be able to breed.

Neither species can survive below 10 °C. *D. melanogaster* cannot breed below 12 °C and *D. simulans* cannot breed below 11 °C. At high temperature *D. melanogaster* cannot survive above 32 °C or breed above 30 °C, and *D. simulans* cannot survive above 31 °C or breed above 28 °C.

So the two species have very similar temperature ranges for breeding (*D. melanogaster* 12 to 30 °C, *D. simulans* 11 to 28 °C), so we would expect to find them in similar locations (the same geographical areas).

Courtship song: *D. melanogaster* has a shorter mean interval between pulses (34.1 ms) than *D. simulans* (48.9 ms), and a shorter pulse duration (1.6 s compared with 3.4 s, less than half as long).

These species differences in the courtship song mean that females only respond to the song of males of their own species, so they only mate with their own species.



This is behavioural isolation, which causes reproductive isolation, so there is no gene flow between them.

As the species live in the same area and are not geographically isolated, the speciation is sympatric speciation.

(Total for Question 8 = 8 marks)

TOTAL FOR PAPER = 80 MARKS



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