Surname	Centre Number	Candidate Number
Other Names		2

GCE AS – NEW AS

B400U20-1

S16-B400U20-1

BIOLOGY – Component 2
Biodiversity and Physiology of Body Systems

P.M. TUESDAY, 7 June 2016

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**7**	
2.	**13**	
3.	**12**	
4.	**12**	
5.	**10**	
6.	**12**	
7.	**9**	
Total	**75**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

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

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

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation pages 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 repsonse (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. Athletes carry out aerobic training in order to improve the efficiency with which their cardiovascular systems deliver oxygen to their muscles. The body responds by producing more blood cells.

(a) (i) Describe **one** adaptation of red blood cells for transport of oxygen. [1]

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(ii) Explain how training at altitude can help improve an athlete's performance when subsequently competing at sea level. [1]

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(b) (i) The physiology of delivering oxygen to muscles during exercise is linked to the removal of carbon dioxide which is mainly transported in the form of hydrogen carbonate ions. Explain how carbon dioxide in the plasma becomes hydrogen carbonate ions inside red blood cells. [3]

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(ii) Describe how the production of hydrogen carbonate ions accounts for the Bohr Effect. [2]

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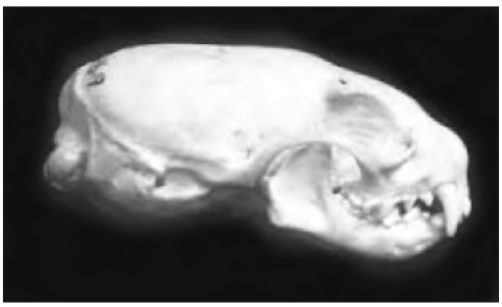
2. Classification has traditionally been based on morphology, size, shape and structure, because such features can be seen. Modern classification is phylogenetic, which means it attempts to show the evolutionary relatedness of organisms. At the taxonomic level of Orders, feeding methods may be used to determine phylogeny. Dentition may be used to determine the feeding method of an animal.

dormouse, *Muscardinus avellanarius*

pipistrelle bat, *Pipistrellus pipistrellus*



polecat, *Mustela putorius*

(a) Use the photographs to determine which **two** animals would be classified in the same Order. Explain the evidence you used to make your choice. [3]

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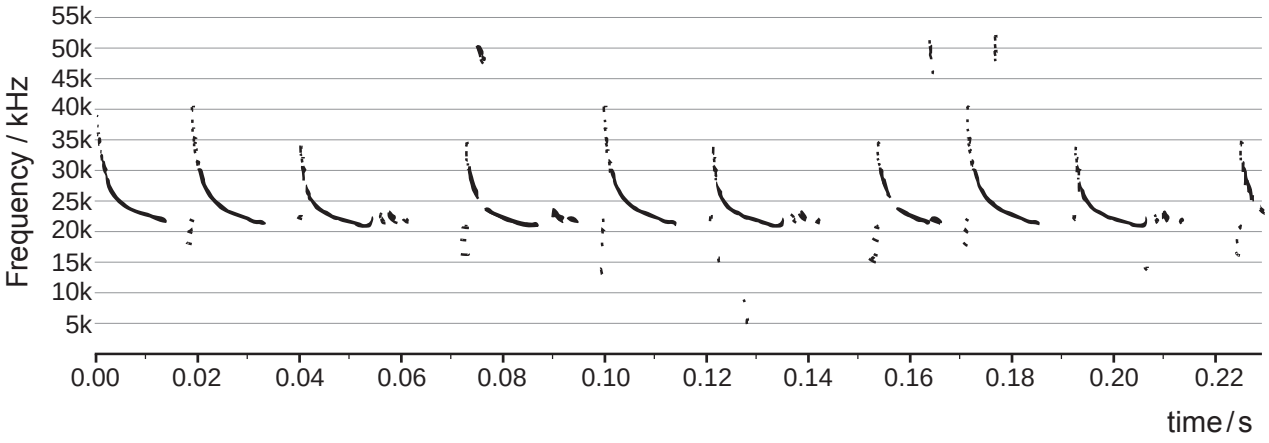
(b) At the taxonomic level of Species, many different features may be used to classify organisms. Individual bat species make high frequency sounds within specific ranges that suit their environment and prey types. This means that we can identify many bats simply by listening to their calls with bat detectors.

The table below shows the properties of the sounds bat species use for echolocation.

Species of bat	Frequency range kHz
Soprano pipistrelle	55.1 - 79.6
Common pipistrelle	41.9 - 68.8
Noctule	18.3 - 37.9
Lesser horseshoe	83.4 - 114

The trace below is a recording (sonogram) of a bat call.



(i) Using information from the table and the sonogram, identify the bat species in the recording. [1]

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(ii) Assuming each mark (small curve) on the sonogram is a single sound pulse, calculate the number of pulses per second from the sonogram. Show your working. [2]

Number of pulses per second = ...

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(c) Cytochrome oxidase is an enzyme found in mitochondria. It has a quaternary structure. The gene for one polypeptide chain in cytochrome oxidase has 1542 nucleotides. State how many amino acids make up that chain in one molecule of cytochrome oxidase, explaining how you reached your answer. [2]

Number of amino acids = ...

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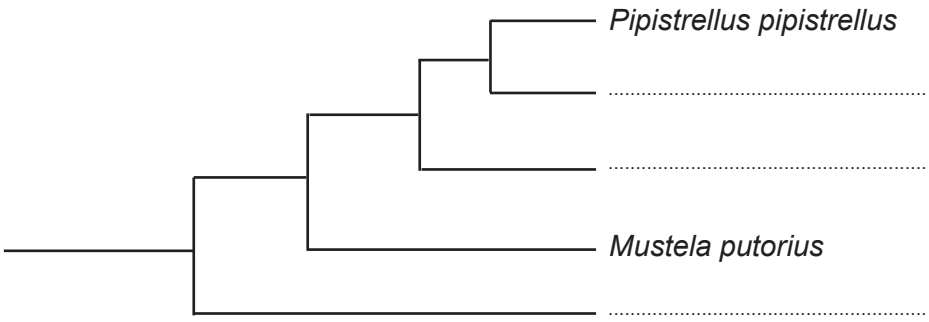
(d) Biochemical techniques are used in modern phylogenetics. Scientists have worked out the nucleotide sequences for the gene for the enzyme cytochrome oxidase in the species shown as well as in the Soprano Pipistrelle, *Pipistrellus pygmeaus* and the brown long-eared bat, *Plecotus auritus*. To investigate how closely the species are related the nucleotide base sequences were compared. The table shows what percentage of the nucleotide sequence is identical to the sequence found in *Pipistrellus pipistrellus*.

Species of bat	**Percentage of nucleotide sequence which is identical to the sequence found in *Pipistrellus pipistrellus* (%)**
Pipistrellus pygmeaus	93
Muscardinus avellanarius	79
Plecotus auritus	85
Mustela putorius	.....

(i) Use information from the table above to **complete the phylogenetic tree below**. [3]



(ii) Suggest the value for *Mustela putorius* and **write your answer in the table above**. [1]

(iii) **Mark with an X** the position on the phylogenetic tree where *Pipistrellus pipistrellus* and *Mustela putorius* most recently shared a common ancestor. [1]

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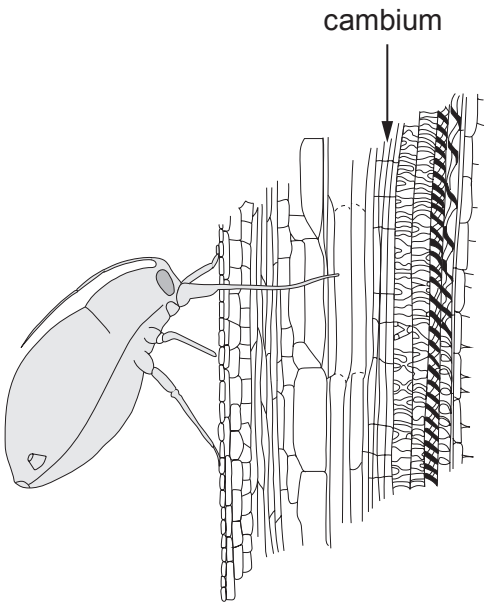
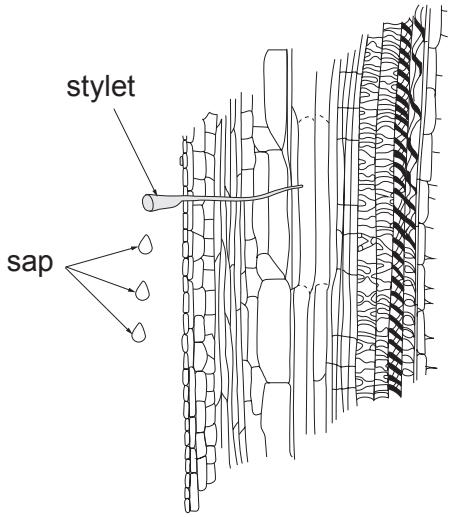
3. The drawing below shows an aphid feeding on the stem of a bean plant.



After anaesthetising an aphid its body may be cut from its stylet (stylectomy). The stylet remains in place and can be used to sample sap from a single tube inside the stem, as shown below.



(a) **Mark on the drawing**, using arrows and clear labels, the positions of

(i) a phloem sieve tube,

(ii) a xylem vessel. [2]

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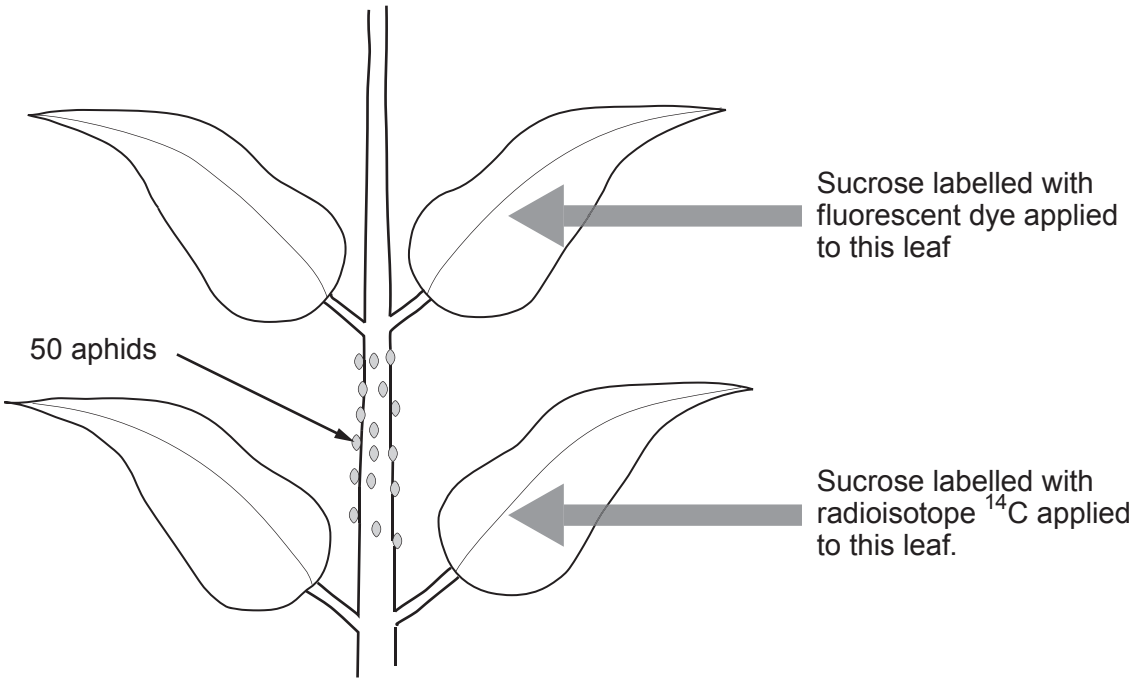
In this way aphids can be used to sample sap from the stems of plants. By applying substances to leaves scientists are able to track what is being transported in single tubes. One such experiment to compare downward and upward transport is shown below:



Young bean plant

Fifty aphids were feeding between two successive layers of leaves. Sucrose labelled with fluorescent dye was applied to an upper leaf and radioactive sucrose was applied to the corresponding lower leaf. The aphids were removed from their stylets as shown opposite, sap was then collected at **20 minute** intervals and tested for radioactivity and fluorescence.

Radioactivity and fluorescence were both detected in the sap from each individual aphid.

(b) Explain why this observation **does not** support the mass flow hypothesis and name an alternative hypothesis which could account for the observation. [3]

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(c) The time taken for radioactivity and fluorescence to reach their maximum values in the sap sample was recorded for 20 plants treated in this way. The means and standard deviations of the results are given below:

	mean time taken to reach maximum value / min	**standard deviation**
radioactivity	80	± 43.5
fluorescence	120	± 20.1

(i) What evidence is there in the table that sucrose is transported upwards more quickly than it is transported downwards? [1]

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(ii) Compare the consistency of the results for radioactivity and the results for fluorescence. [2]

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(iii) Describe **two** limitations of the method used in this investigation. [2]

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(d) Aphid stylectomy can also be used to estimate rates of translocation. In the experiment above over a six hour period, a total of 0.015 mm^3 of sap was collected from all 50 aphid stylets.

Calculate the rate at which sap flows out of a single stylet per hour. Express your answer in standard form. [2]

Rate = ... mm^3 per hour

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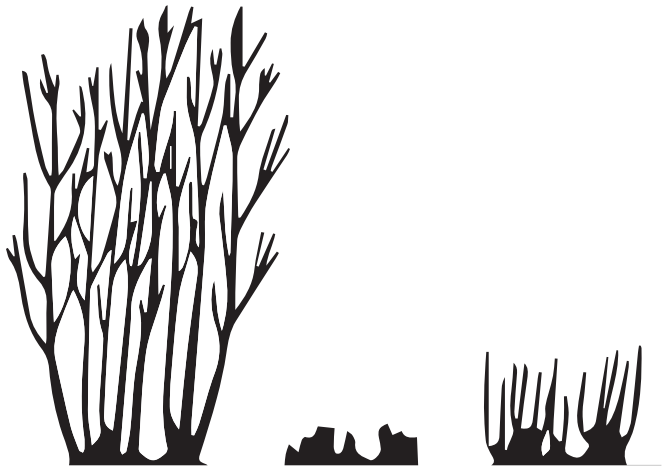
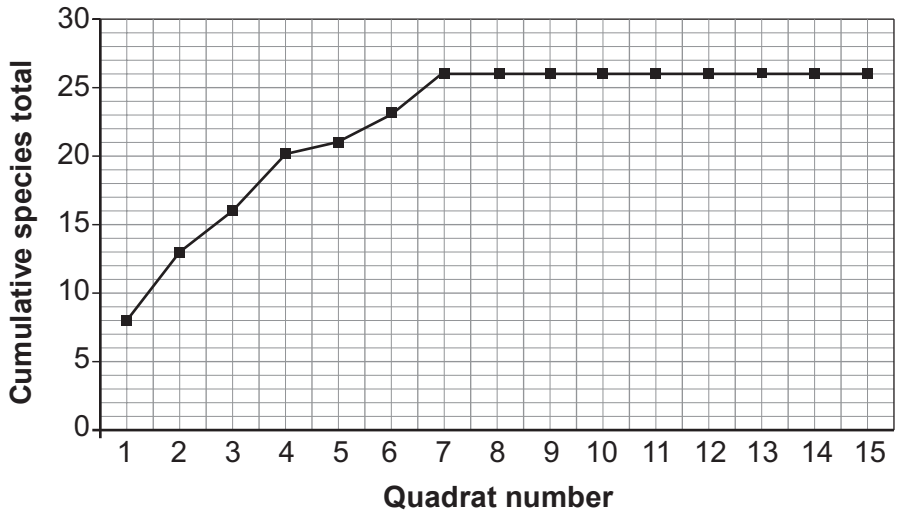
4. Coppicing is a method of woodland management in which trees are cut close to the ground and allowed to regrow from the cut stumps, as shown in the diagram below.



A conservation group used Simpson's Diversity Index (D) to monitor the impact of coppicing on their local wood.

They used a 1 m^2 quadrat to identify and count plant species on the floor of the wood. Preliminary work to decide how many times to use the quadrat produced the following results.



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(a) (i) With reference to these results suggest the number of quadrats the group **should use** in their actual investigation, giving reasons for your choice of sample size. [3]

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(ii) Describe a method the group could use to randomise the positions of the quadrats. [2]

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(b) The group surveyed an un-coppiced area and an area where all the Hazel trees had been coppiced three years earlier. They calculated Simpson's Diversity Index using the formula:

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

where;
n = the number of individuals of each species
N = the total number of individuals of all species
$\sum$ = sum of.

The results for the un-coppiced area are shown below:

Species	**n**	**(n – 1)**	**n(n – 1)**
Bramble	2	1	2
Yellow Archangel	0	–1	0
Wood Sorrel	2	1	2
Foxglove	0	–1	0
Wood Anemone	0	–1	0
Dog's Mercury	6	5	30
TOTAL	N = 10		$\sum n(n-1) = 34$
	$N(N-1) = 90$		

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

= 0.62

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The results for the coppiced area are given below.

(i) Using the table and the formula, calculate Simpson's Diversity Index, to two decimal places, for the coppiced area. [3]

Species	n	(n – 1)	n(n – 1)
Bramble	2		
Yellow Archangel	3		
Wood Sorrel	4		
Foxglove	2		
Wood Anemone	3		
Dog's Mercury	0		
	N = ...		∑n(n – 1) = ...
	N(N – 1) = ...		

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

= .....

(ii) Using the Diversity Index values for un-coppiced and coppiced areas, draw a conclusion about the general effect of coppicing. [1]

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(c) Different plants are affected differently by coppicing.

Describe the effect coppicing has had on Dog's Mercury and suggest an explanation for how coppicing might have caused this effect. [3]

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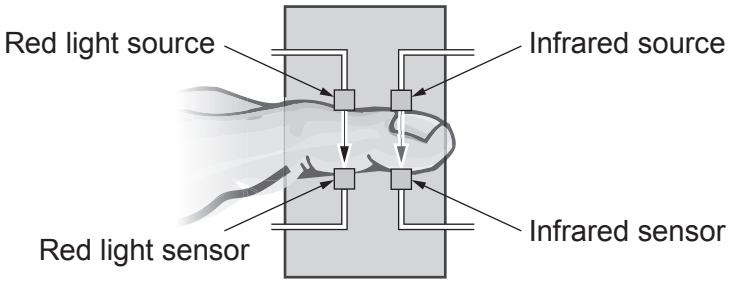
5. Pulse oximeters are simple, relatively cheap and non-invasive devices to monitor oxygenation of the blood. They measure the percentage saturation of haemoglobin with oxygen.

(a) Oximeters work by the principles of spectrophotometry:

The sensor unit contains two light sources and two light sensors, arranged as shown:



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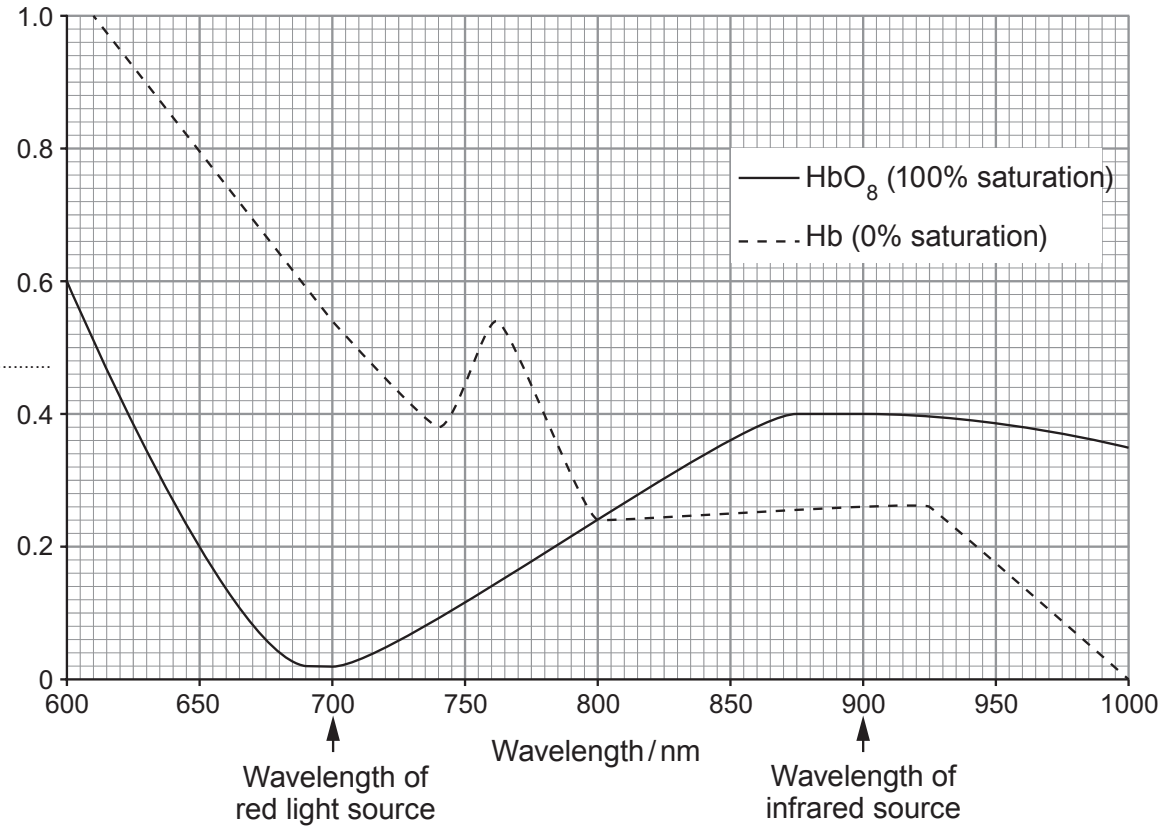
The graphs below show characteristic spectra for haemoglobin (Hb) and oxyhaemoglobin (HbO_8).



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(i) Deoxygenated blood absorbs more red light but transmits more infrared whilst oxygenated blood absorbs more infrared but transmits more red light. Using information from the description above, **write a suitable label** for the vertical axis. [1]

(ii) The microprocessor takes readings from each of the sensors and converts the values into a value for percentage saturation of haemoglobin.

Complete the table below to show the readings which the sensors would give. [1]

Percentage saturation of Haemoglobin (%)	Reading from red sensor	Reading from infrared sensor
0	0.54	.....
100	.....	0.4

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(iii) Explain why an oximeter would be useful for monitoring the condition of a patient suffering from a chronic lung disease. [1]

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(b) A double circulatory system is found in mammals whereas a single system is found in fish. Describe the difference between the systems and explain why a double system is more efficient. [2]

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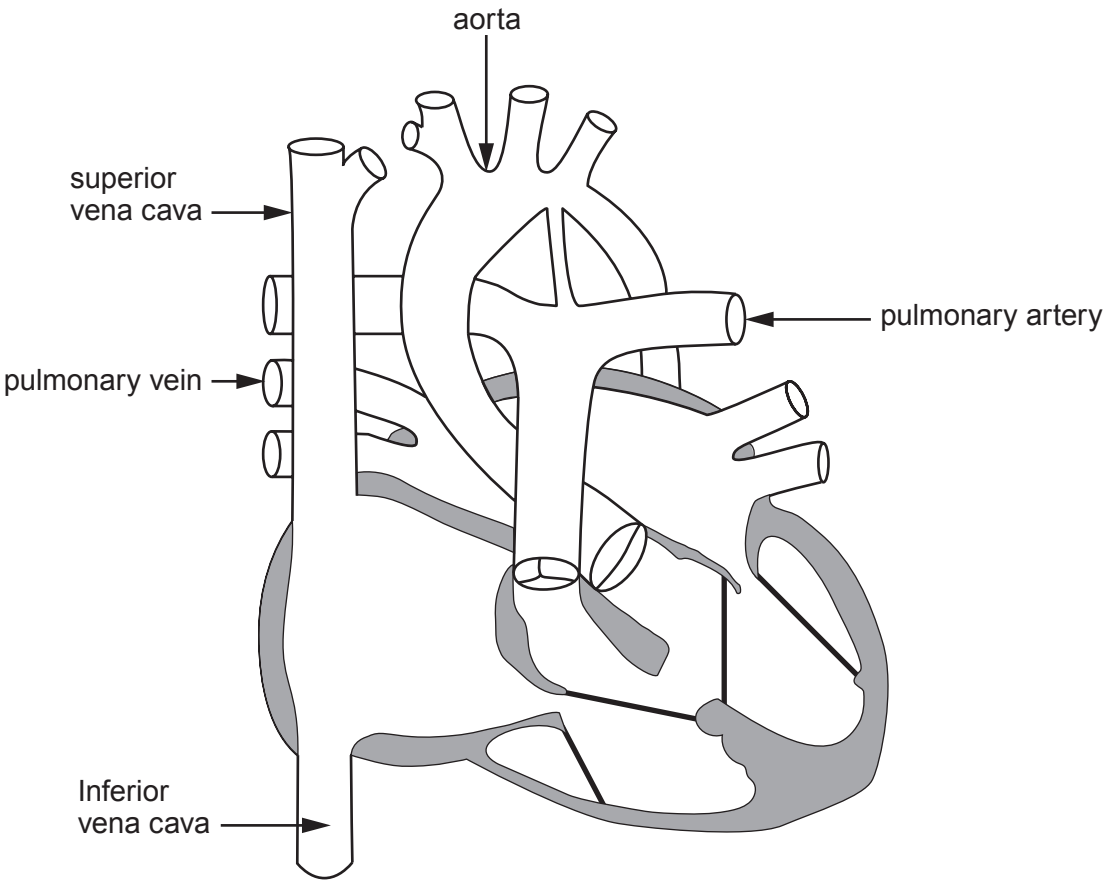
(c) The drawing below shows a human heart with its associated main blood vessels. Two defects are shown in the drawing.



(i) Use **two** arrows, labelled **A** and **B**, to show the positions of the **two** defects shown in the drawing. [2]

(ii) Suggest the consequences of the defects on the circulation of blood and explain the reasons why the oximeter readings would be different from a person without such defects. [3]

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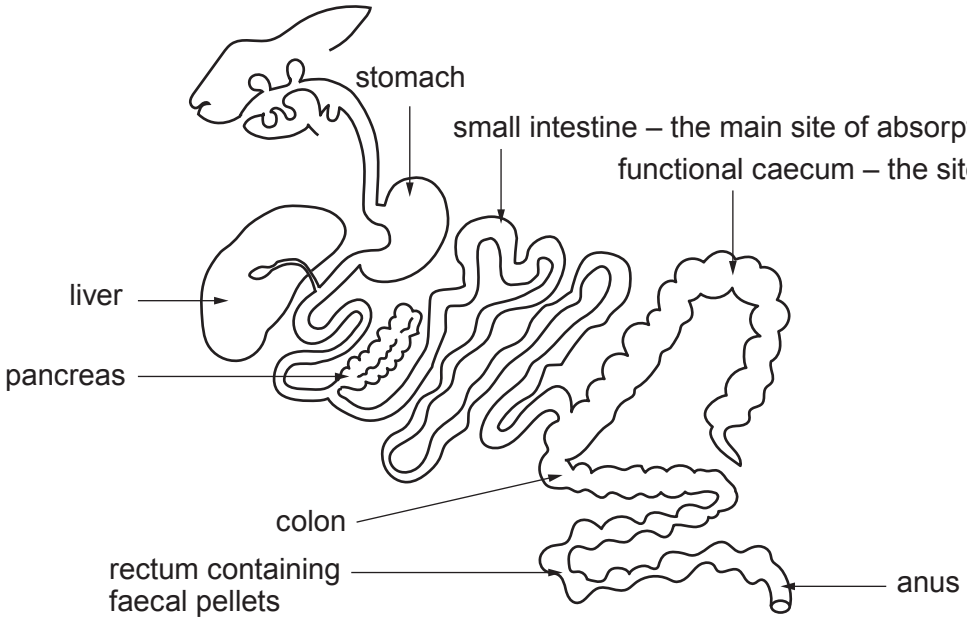
6. The diagram below shows the digestive system of a rabbit, which is adapted to its high cellulose diet, as a non-ruminant herbivore.



(a) Rabbit cells can produce α amylase to digest starch, but cannot produce an enzyme to digest cellulose.

(i) With reference to the structure of starch and cellulose molecules, explain why α amylase is unable to digest cellulose even though starch and cellulose are both polymers of glucose. [3]

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(ii) Explain how rabbits are able to digest cellulose without their cells being able to produce the necessary enzyme. [1]

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Coprophagy is the term applied to the practice of eating faeces. In rabbits this is a natural part of digesting their high cellulose diet. It is noticeable that rabbits produce two distinct types of faeces, soft and hard faeces.

soft faeces hard faeces

Furthermore, they are more frequently seen eating the soft faeces than the hard faeces. For this reason it has been suggested that the soft faeces may be more nutritious.

(b) Some students decided to test this hypothesis by analysing samples of the two types of faeces for the presence of the main food substances.

(i) Complete the table by giving the names of the reagents they should have used. [2]

Food substance	Reagent
starch	
reducing sugar	

The results they obtained for **reducing sugars** are shown below;

Type of faeces	Colour at end of test
soft	orange
hard	green

(ii) What conclusion could the students have drawn from these results? [1]

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(iii) Explain how rabbits would be able to detect this nutritional difference between the types of faeces. [1]

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(c) With reference to the relative positions of the main organs of the digestive system, shown on the diagram on page 18 and using all the information given then on page 19, explain the reasons for the nutritional difference between the two types of faeces. [4]

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7. Axolotls are slow moving animals that live under water. They are sometimes called Mexican Walking Fish, but they are not fish they are amphibians.

Axolotls have external gills which are similar in structure to the internal gills found in bony fish such as goldfish.

Describe how the gills of both bony fish and axolotls are adapted to increase the efficiency of gas exchange and explain how structures in the heads of bony fish enable them to be highly active even when oxygen levels are relatively low but axolotls are slower moving under these conditions. [9 QER]

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