Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
January 2004
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

BIOLOGY (SPECIFICATION B) BYB4
Unit 4 Energy, Control and Continuity

Thursday 22 January 2004 Morning Session

In addition to this paper you will require:
- a ruler with millimetre measurements.

You may use a calculator.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 81.
- Mark allocations are shown in brackets.
- Answers for **Section A** are expected to be short and precise.
- Questions in **Section B** should be answered in continuous prose where appropriate. Quality of Written Communication will be assessed in these answers.
- In addition to the mark allocations indicated within **Section B**, you will be awarded up to 1 mark for your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate. The legibility of your handwriting and the accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
8			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

Answer **all** questions in the spaces provided.

1 **Figure 1** shows a diagram of part of a muscle myofibril.

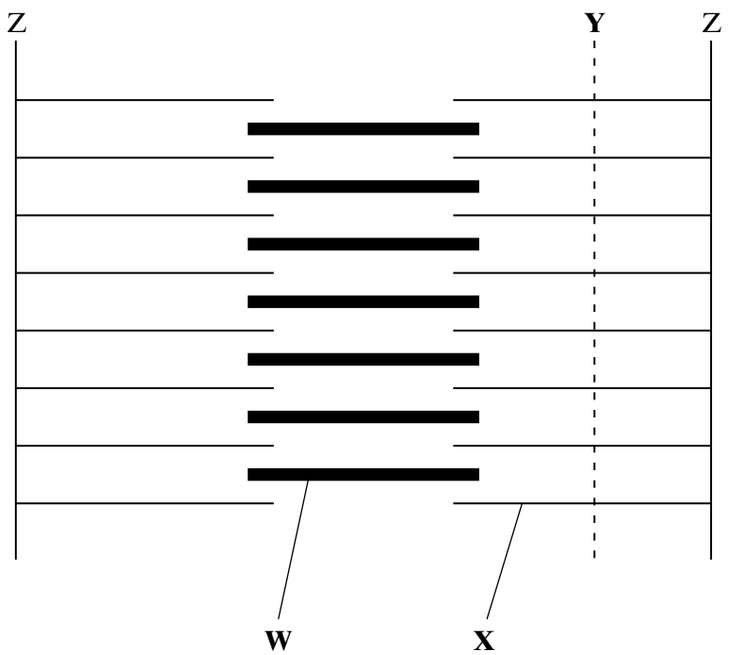

Figure 1

(a) Name the protein present in the filaments labelled **W** and **X**.

W .....

X .....

(1 mark)

(b) **Figure 2** shows the cut ends of the protein filaments when the myofibril was cut at position **Y**. **Figure 3** shows the protein filaments when the myofibril was cut at the same distance from a Z line at a different stage of contraction.

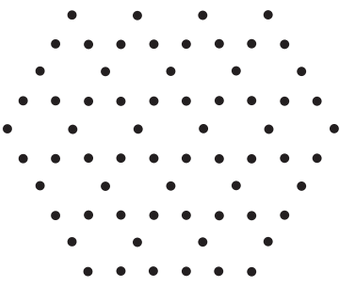

Figure 2

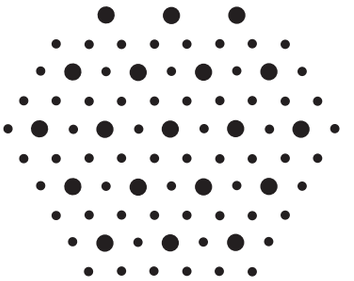

Figure 3

Explain why the pattern of protein filaments differs in **Figure 2** and **Figure 3**.

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(2 marks)

(c) Describe the role of calcium ions in the contraction of a sarcomere.

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(4 marks)

7

2 **Figure 4** and **Figure 5** show the chromosomes from a single cell at different stages of meiosis.

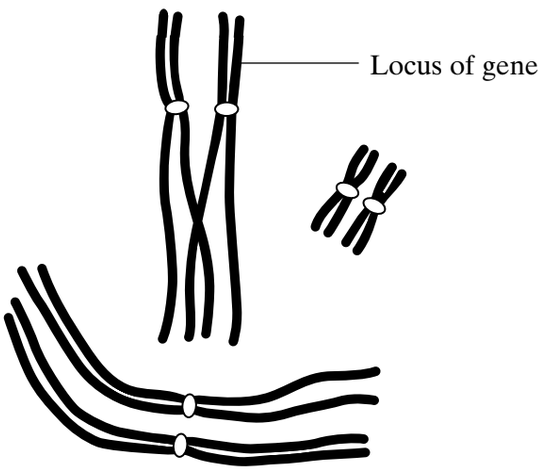

Figure 4

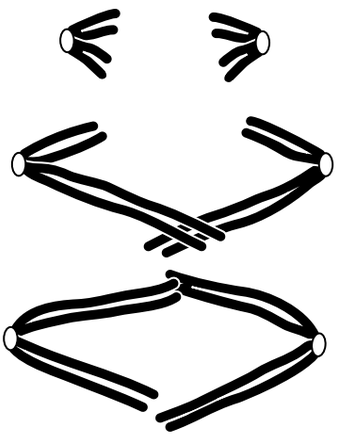

Figure 5

(a) What is the diploid number of chromosomes in the organism from which this cell was taken?

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(1 mark)

(b) Describe what is happening to the chromosomes at the stage shown in

(i) **Figure 4**;

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(2 marks)

(ii) **Figure 5**.

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(2 marks)

(c) (i) The genotype of this organism is **Bb**. The locus of this pair of alleles is shown in **Figure 4**.

Label **two** chromosomes on **Figure 5** to show the location of the **B** allele and the location of the **b** allele.

(1 mark)

(ii) How many genetically different gametes can be produced by meiosis from a cell with the genotype, **Bb Cc Dd**? Assume these genes are located on different pairs of homologous chromosomes. Show your working.

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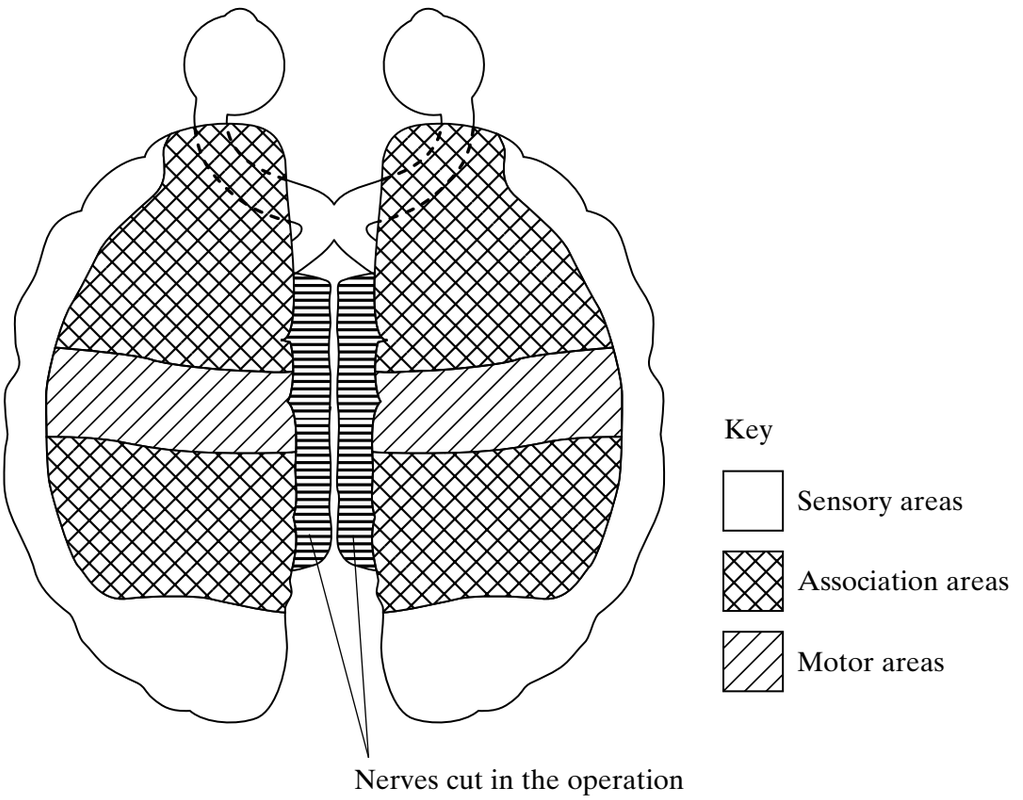
(2 marks)

8

TURN OVER FOR THE NEXT QUESTION

3 The diagram shows the cerebral hemispheres of a human brain and their nervous connections with the eyes when viewed from above.



(a) A small electric shock was used to stimulate part of the brain. This caused a muscle in the left leg to contract.

Label the diagram with a letter **X** to show the part that would cause the muscle to contract when stimulated.

(2 marks)

(b) A person looks at a familiar object. Use information given in the diagram to explain how this object can be recognised.

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(3 marks)

(c) During a surgical operation the nerves connecting the two hemispheres were cut. As a result, the two hemispheres were unable to communicate with each other. No other nerve connections were affected.

After the operation the person was blindfolded and a toothbrush was placed in his left hand. The person knew what he was holding but could not say that it was a toothbrush, even though he was able to speak. Explain why.

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(3 marks)

8

4 (a) Describe how insulin reduces the concentration of glucose in the blood.

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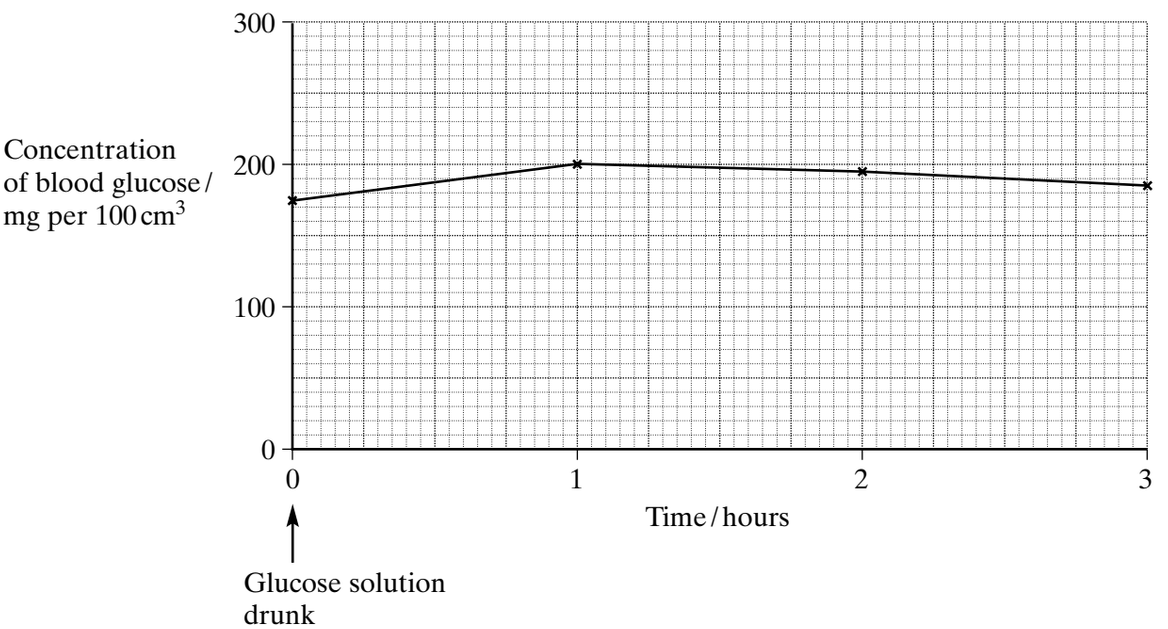
(3 marks)

Some people produce no insulin. As a result they have a condition called diabetes. In an investigation, a man with diabetes drank a glucose solution. The concentration of glucose in his blood was measured at regular intervals. The results are shown in the graph.



(b) Suggest **two** reasons why the concentration of glucose decreased after 1 hour even though this man's blood contained no insulin.

1 .....

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2 .....

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(2 marks)

(c) The investigation was repeated on a man who did not have diabetes. The concentration of glucose in his blood before drinking the glucose solution was 80 mg per 100 cm^3. Sketch a curve on the graph to show the results you would expect.

(1 mark)

(d) The diabetic man adopted a daily routine to stabilise his blood glucose concentration within narrow limits. He ate three meals a day: breakfast, a midday meal and an evening meal. He injected insulin once before breakfast and once before the evening meal.

The injection he used before breakfast was a mixture of two types of insulin. The mixture contained slow-acting insulin and fast-acting insulin.

(i) Explain the advantage of injecting both types of insulin before breakfast.

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(2 marks)

(ii) One day, the man did not eat a midday meal. Suggest **one** reason why his blood glucose concentration did not fall dangerously low even though he had injected himself with the mixture of insulin before breakfast.

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(1 mark)

9

TURN OVER FOR THE NEXT QUESTION

5 A sex-linked gene controls fur colour in cats. Ginger-coloured fur is controlled by the allele **G**, and black-coloured fur is controlled by the allele **g**. Some female cats have ginger and black patches of fur. They are described as tortoiseshell. Male cats cannot be tortoiseshell.

(a) What is meant by a *sex-linked* gene?

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.....

(1 mark)

(b) A male cat with the genotype $\mathbf{X^g Y}$ mates with a tortoiseshell female.

(i) Give the phenotype of the male.

.....

(1 mark)

(ii) Give the genotype of the tortoiseshell female.

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(1 mark)

(iii) Complete the genetic diagram to show the genotypes and the ratio of phenotypes expected in the offspring of this cross.

Parents	Male	Tortoiseshell female
Parental genotypes	$\mathbf{X^g Y}$	……
Parental gametes		
Offspring genotypes		
Offspring phenotypes		
Ratio		

(3 marks)

(c) The effect of the **G** and **g** alleles is modified by another gene. This gene is not sex-linked and it has two alleles. The allele **d** changes the ginger colour to cream and the black colour to grey. The dominant allele **D** does not modify the effect of **G** or **g**.

A cream-coloured male cat mated with a black female whose genotype was $\mathbf{X^gX^g}$ **Dd**. Male kittens of two different colours were produced. Complete the genetic diagram.

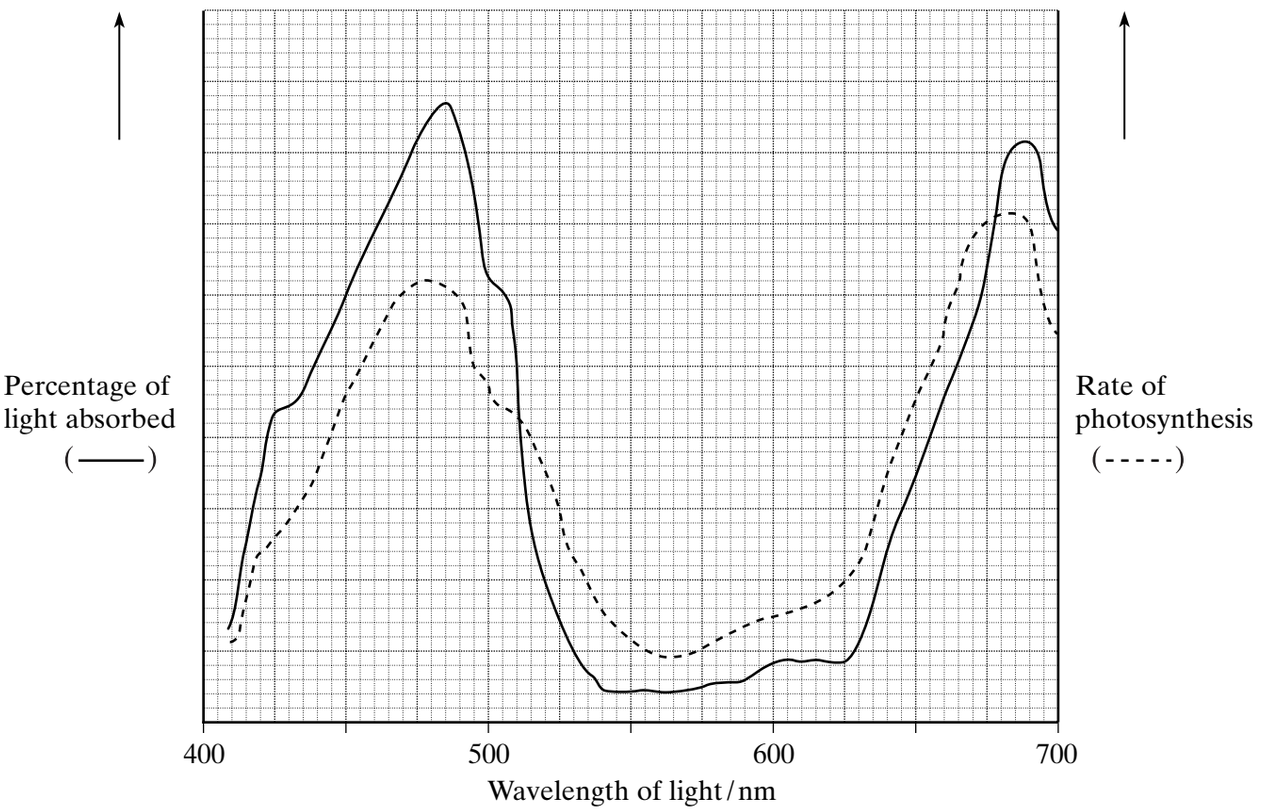
Parental phenotypes	Cream-coloured male	Black female
Parental genotypes	.....	$\mathbf{X^gX^g}$ **Dd**
Parental gametes		
Male kitten genotypes		
Male kitten colours		

(3 marks)

9

TURN OVER FOR THE NEXT QUESTION

6 The percentage of light absorbed by an aquatic plant was measured when it was exposed to different wavelengths. The rate of photosynthesis was also measured at each wavelength of light. The results are shown in the graph.



(a) Describe and explain the relationship between light absorption and the rate of photosynthesis for the wavelengths of light between 410 nm and 500 nm.

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(2 marks)

(b) Give **one** dependent variable you could measure in order to determine the rate of photosynthesis in an aquatic plant.

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(1 mark)

(c) Use the graph to identify the range of wavelengths of light that would be green in colour. Give a reason for your answer.

Wavelengths ..... to ..... nm

Reason .....

.....

(2 marks)

(d) A suspension of chloroplasts was isolated from an aquatic plant and a reagent was added. The reagent is blue when oxidised and is colourless when reduced.

(i) The suspension of chloroplasts in blue reagent was exposed to sunlight. The blue colour disappeared. Use your knowledge of the light-dependent reactions of photosynthesis to explain why.

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(2 marks)

(ii) Another suspension of chloroplasts was set up as before. Small quantities of ADP and phosphate ions were added and then the tube was exposed to light. The blue colour disappeared more quickly. Explain why.

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(2 marks)

9

SECTION B

Answer **all** questions in the spaces provided.

Questions should be written in continuous prose, where appropriate.
Quality of Written Communication will be assessed in these answers.

7 (a) Explain how a resting potential is maintained in a neurone.

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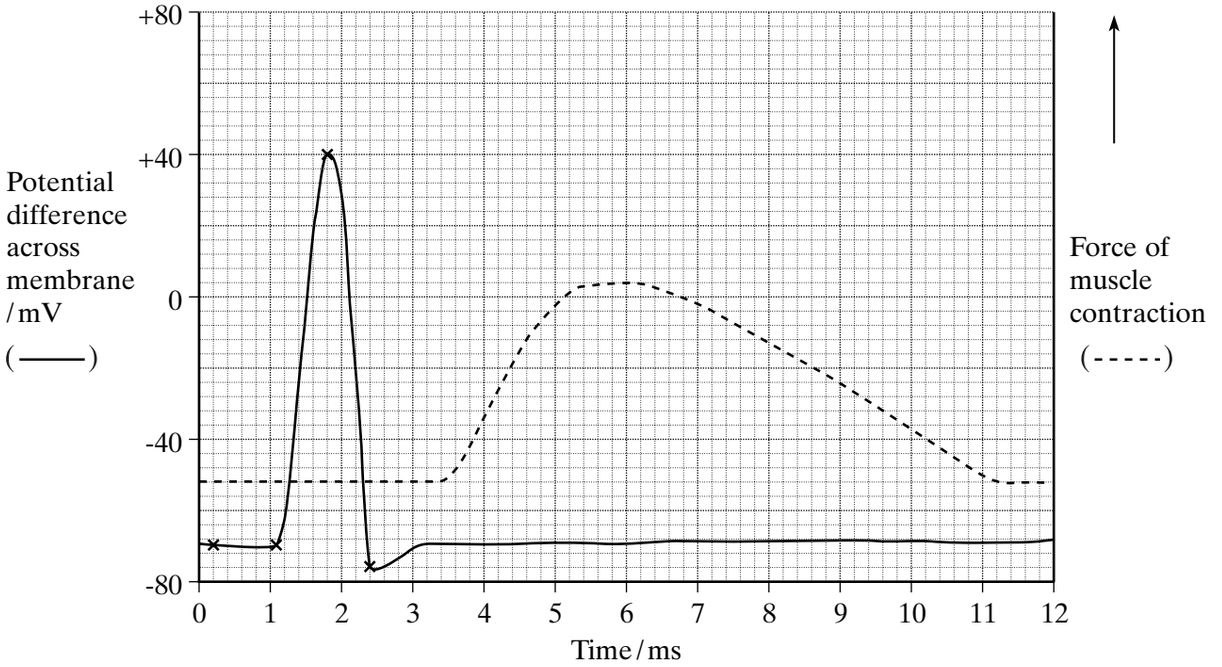
(4 marks)

(b) In an investigation, an impulse was generated in a neurone using electrodes. During transmission along the neurone, an action potential was recorded at one point on the neurone. When the impulse reached the neuromuscular junction, it stimulated a muscle cell to contract. The force generated by the contraction was measured. The results are shown in the graph.

The distance between the point on the neurone where the action potential was measured and the neuromuscular junction was exactly 18 mm.



(i) Use the graph to estimate the time between the maximum depolarisation and the start of contraction by the muscle cell.

Time ..... ms
(1 mark)

(ii) Use your answer to part (i) to calculate the speed of transmission along this neurone to the muscle cell. Give your answer in mm per second.
Show your working.

Speed ..... $mm\,s^{-1}$
(2 marks)

(iii) Give **one** reason why the value calculated in part (ii) would be an underestimate of the speed of transmission of an impulse along a neurone.

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(1 mark)

QUESTION 7 CONTINUES ON THE NEXT PAGE

Turn over ▶

Acetylcholine is the neurotransmitter at neuromuscular junctions.

(c) Describe how the release of acetylcholine into a neuromuscular junction causes the cell membrane of a muscle fibre to depolarise.

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(3 marks)

(d) Use your knowledge of the processes occurring at a neuromuscular junction to explain each of the following.

(i) The cobra is a very poisonous snake. The molecular structure of cobra toxin is similar to the molecular structure of acetylcholine. The toxin permanently prevents muscle contraction.

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(2 marks)

(ii) The insecticide DFP combines with the active site of the enzyme acetylcholinesterase. The muscles stay contracted until the insecticide is lost from the neuromuscular junction.

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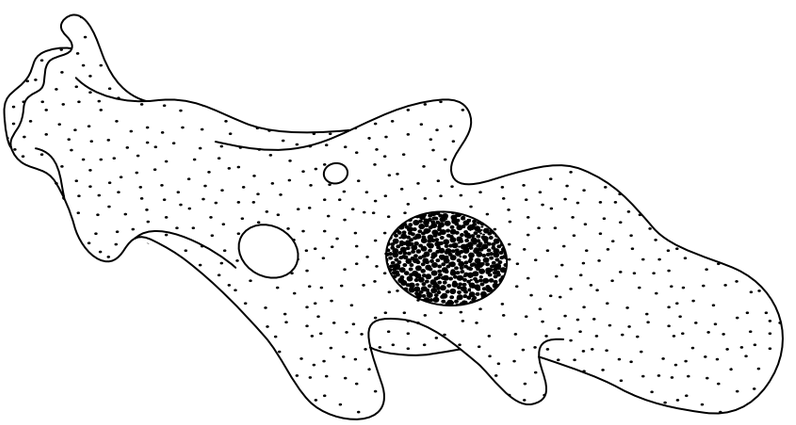
(2 marks)

8 (a) Use your knowledge of classification to arrange *class*, *phylum*, *genus* and *family* in order of decreasing number of species.

largest number of species			smallest number of species
.....	.....	.....	.....

(1 mark)

(b) The diagram shows an amoeba. This is a single-celled organism.



Amoeba is classified as a protoctist. Giving a different answer in each case, explain why it is **not**

(i) a prokaryote;

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.....

(ii) a fungus.

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(2 marks)

QUESTION 8 CONTINUES ON THE NEXT PAGE

(c) Cytochrome c is a protein involved in one of the reactions of aerobic respiration in a mitochondrion. The molecular structure of cytochrome c from different species has been analysed. More similarities are present in the structure of cytochrome c in closely related species than in distantly related species.

(i) Explain what is meant when two species are described as being *closely related*.

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(1 mark)

(ii) A difference in the molecular structure of cytochrome c may arise in a small population that becomes geographically isolated. Explain how the difference may arise and how it may spread in the population.

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(4 marks)

(d) Explain how the amount of ATP is increased by reactions occurring inside a mitochondrion.

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(7 marks)

15

END OF QUESTIONS

QWC

1