

BIOLOGY

6811

Monday 27 June 2005 9.00 am to 12 noon

In addition to this paper you will require:

- a 16-page answer book.
- You may use a calculator.

Time allowed: 3 hours

Instructions

- Use blue or black ink or ball-point pen.
- Write the information required on the front of your answer book. The *Examining Body* for this paper is AQA. The *Paper Reference* is 6811.
- Answer **four** questions.
- This paper is divided into four Sections, A, B, C and D. Answer **all** parts of the questions in Sections A and B. Answer **one** question from each of Sections C and D.
- Do all rough work in the answer book. Cross through any work you do not want marked.

Information

- The maximum mark for this paper is 100.
- Each question carries 25 marks. Mark allocations for part-questions are shown in brackets.
- Quality of Written Communication will be assessed in your answers to Sections C and D. You will be assessed on 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.
- Answers may be illustrated with diagrams provided that the diagrams explain or add to the written information.
- Graph paper is available on request.
- You are expected to use a calculator where appropriate.

Advice

- You are advised to spend about 45 minutes on each question.
- You may answer the questions in any order.
- Read each question carefully in Sections C and D before making your choice. Before beginning your answers, plan out roughly what you intend to write.

SECTION A

Answer **all** parts of the question.

1**Total for this question: 25 marks**

Read the following passage.

Three-toed sloths are herbivorous mammals. They inhabit the forests of Central and South America. They have a number of unusual adaptations, some of which are thought to be associated with poor nutrient availability from their diet of leaves. These adaptations range from a low metabolic rate to the extraordinary ability to urinate and defaecate no more than once a week.

- 5 The core body temperature of a sloth is about 33 °C but varies according to the environmental temperature, which itself may vary considerably. A core body temperature as low as 28.4 °C has been recorded. The low core body temperature may link to the relatively small muscle mass of sloths. The variability may result from the limited amount of insulation that sloths possess. Their fur does provide some protection from the effects of cooling but fat would be rather better as an insulator. However, perhaps not surprisingly, subcutaneous fat is almost entirely absent in sloths. One feature that sloths do have, and which helps them to conserve heat, is the arrangement of arteries and veins in their limbs. These vessels lie side by side so that blood taken to the extremities is very close to that returning to the body.

- 15 Sloths are characteristically slow-moving. The maximum rate of movement in a three-toed sloth is only about 300 metres per hour. In most mammals, two types of skeletal muscle are present. Red muscle is associated with slow, sustained contraction and depends largely on aerobic respiration. White muscle produces rapid, powerful contractions and much of its ATP supply comes from anaerobic respiration. All muscle in a sloth is red muscle. When compared with similar red muscle in a cat, that of a sloth contracts at a slower rate. When a correction for temperature is made, the contraction rate in a sloth is slower by a factor of three. One possible explanation for this slow rate of contraction lies in the length of the Schwann cells around the axons supplying these muscles.

- 25 Low body temperature and slow movement are associated with a relatively low metabolic rate. Low metabolic rate is, in turn, linked to low cardiac output. Sloths appear at first sight to have a small relative heart mass. However, when a correction is applied for the mass of body waste, the figure of 2.7 g per kg body mass is comparable to that for many other mammals. Early investigators of gas exchange in sloths commented on the relatively low partial pressure of carbon dioxide in expired air. Although this can be attributed to the structure of the lungs, the explanation is now thought to be largely due to the long trachea of the sloth.



Three-toed sloth

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- (a) Suggest why a diet of leaves is likely to be associated with poor nutrient availability (lines 2 - 3). *(3 marks)*
- (b) (i) Explain the link between muscle mass and the low core body temperature (lines 7 - 8). *(1 mark)*
- (ii) Explain why “perhaps not surprisingly, subcutaneous fat is almost entirely absent in sloths” (line 10). *(2 marks)*
- (iii) Explain the advantage for sloths of having arteries and veins lying side by side in their limbs (lines 11 - 12). *(4 marks)*
- (c) Seals are aquatic mammals that have both fur and subcutaneous fat for insulation. Species of seal which stay near the surface rely mainly on their fur for insulation. They have little subcutaneous fat. Species which hunt in deep water rely on a thick layer of subcutaneous fat. Suggest why fur is not an effective insulator at depth. *(3 marks)*
- (d) (i) Measurements made on red muscle, such as that from a sloth, show that it has a low concentration of glycogen. White muscle has a higher glycogen concentration. Suggest the advantage of white muscle having a higher glycogen concentration. *(2 marks)*
- (ii) Explain why it is necessary to make a correction for temperature when comparing the rate of red muscle contraction in a sloth with that of a cat. *(3 marks)*
- (e) Explain how the speed at which a nerve impulse is conducted is related to the length of the Schwann cells which wrap around the axons. *(2 marks)*
- (f) (i) Explain why a correction needs to be made in comparing relative heart mass in a sloth with that in other mammals (lines 24 - 26). *(2 marks)*
- (ii) Would you expect the low cardiac output of a sloth, when compared with other mammals, to be due to differences in heart rate or in the volume of blood pumped out each time the ventricles contract? Give the reason for your answer. *(1 mark)*
- (g) Explain how the relatively low partial pressure of carbon dioxide in the air expired by a sloth can be explained by the animal’s long trachea (lines 27 - 29). *(2 marks)*

Turn over ►

SECTION B

Answer **all** parts of the question.

2**Total for this question: 25 marks**

When a boat is on the sea, marine organisms grow on its hull. These organisms slow the boat down as it moves through the water. They were prevented from growing by using paint containing the substance TBT. However, research has shown that TBT affected other marine organisms living in coastal habitats.

Mussels are molluscs found on rocky shores. They feed on plankton which they filter from the water. The effect of TBT on the growth of mussels was investigated. Simple measurements of growth, such as mass, were found to be unreliable, the main reason for this being that mussels produce large quantities of gametes.

- (a) Explain why the production of large quantities of gametes might make measurements of growth based only on mass unreliable. *(2 marks)*

Because of this unreliability, 'scope for growth' was measured. Scope for growth (Q_G) is the difference between the energy content of food consumed and all energy uses and losses apart from growth and gamete production. It can be expressed as

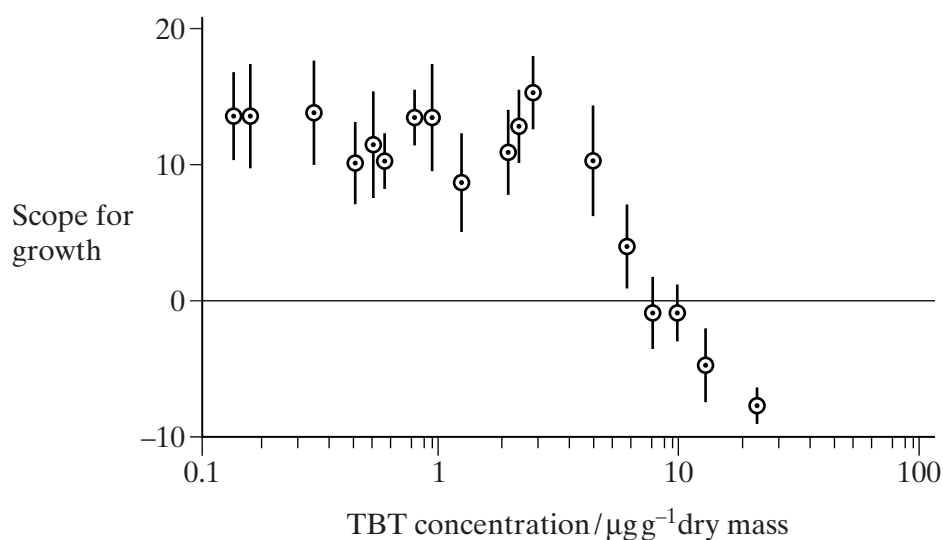
$$Q_G = Q_A - Q_B - Q_C$$

- (b) Q_B is the energy released in respiration. What is represented by
- (i) Q_A ; *(1 mark)*
 - (ii) Q_C ? *(1 mark)*

In the investigation, groups of 16 mussels were kept in separate tanks. Each group was exposed to a different concentration of TBT for a period of four days. The TBT/seawater mixture was replaced four times each day.

- (c) (i) Explain why it was necessary to replace the seawater in which the mussels were kept. *(1 mark)*
- (ii) The research team related scope for growth to the concentration of TBT in the tissues of the mussels rather than to its concentration in the seawater. Explain why. *(1 mark)*

The results of this investigation are shown in the graph. The plotted points show the means and the bars represent standard deviation.



- (d) (i) Suggest suitable units for scope for growth. (2 marks)
- (ii) Describe what the graph shows about the effect of TBT concentration on the mussels. (3 marks)
- (iii) Use the equation for scope for growth to suggest a possible explanation for its values above a TBT concentration of $10 \mu\text{g g}^{-1}$ dry mass. (2 marks)

Dogwhelks are also molluscs. In dogwhelks, exposure to TBT causes a condition called imposex. Imposex is the irreversible development of male characteristics in females. **Table 1** shows the effects of different concentrations of TBT on female dogwhelks.

Concentration of TBT in water/ ng dm^{-3}	Effect on female dogwhelk
3	Initiates development of a penis and its duct, the vas deferens. Breeding unaffected.
5	Produces greater development of penis and vas deferens. The vas deferens blocks the oviduct so egg capsules cannot be released.
10	Depresses egg production in ovary.
25	Changes ovary into a testis which produces sperms.

Table 1

- (e) (i) It has been suggested that TBT affects the enzyme which converts testosterone to oestrogen. How might this explain the effects described in **Table 1**? (3 marks)
- (ii) How would you expect the ages and sexes of individuals in a population of dogwhelks exposed to concentrations of TBT above 25ng dm^{-3} to differ from a population from an unaffected site? Explain your answer. (2 marks)

QUESTION 2 CONTINUES ON THE NEXT PAGE

Turn over ►

As a result of exposure to high concentrations of TBT in their natural environment, most dogwhelk populations around the Kent coast have become extinct. However, remnant populations at Dumpton Gap and at Oldstairs Bay have survived. Samples of female dogwhelks from these two populations were investigated. The results are shown in **Table 2**.

Location	Condition of female dogwhelk		
	Unaffected	Possesses vas deferens but no penis	Possesses vas deferens and penis
Dumpton Gap	42	54	191
Oldstairs Bay	1	2	35

Table 2

- (f) (i) Briefly describe how you would investigate whether the difference in the response of the Dumpton Gap and Oldstairs Bay dogwhelks to TBT was likely to be due to genetic rather than environmental differences. *(3 marks)*
- (ii) The population of dogwhelks at Dumpton Gap is at present fairly small. It has been suggested that this population is likely to increase in size. Explain how the response to TBT shown by the Dumpton Gap population could lead to its recovery. *(2 marks)*
- (iii) The resistance to TBT shown by the Dumpton Gap population is rare in dogwhelk populations which have not been exposed to TBT. Suggest why. *(2 marks)*

SECTION C

Answer **one** question from this section.

Each question carries 25 marks.

In addition to the biological content of your answer, marks will be awarded for your ability to:

- select appropriate and relevant material from different areas of your biological knowledge and apply this to the topic concerned;
 - organise and present information clearly and logically, using appropriate scientific terminology.
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- 3 Write an essay about **either** mitochondria **or** chloroplasts.
 - 4 The variety of alleles in populations on small islands differs from the variety of alleles in populations on nearby continental land masses. Discuss the causes and consequences of this.
 - 5 Using specific examples to illustrate your answer, discuss the ways in which insect pests may be controlled.
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SECTION D

Answer **one** question from this section.

Each question carries 25 marks.

In addition to the biological content of your answer, marks will be awarded for your ability to:

- develop and support a general argument with appropriate biological information;
 - organise and present information clearly and logically, using appropriate scientific terminology.
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- 6 What is wrong with eating 'junk food'?
- 7 Discuss the ways in which biodiversity may be affected by human activities.
- 8 Are drug trials on animals other than humans justified?

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE

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Question 1 Illustration: F A Reid *Field Guide to the mammals of Central America and Southeast Mexico* Oxford University Press 1997

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APW/0205/6811