General Certificate of Education
June 2004
Advanced Extension Award

BIOLOGY 6811

Monday 28 June 2004 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.

Selenium is a chemical element very similar in many of its properties to sulphur. Because of this it substitutes for sulphur in some biochemical reactions.

In most soils, selenium is bound to soil particles and cannot be taken up by plants. There are parts of the world, however, where there are high concentrations of soluble selenium compounds in the soil. In these areas some plants are able to survive by accumulating selenium in their cells. These plants are called selenium accumulators. Their ability to take up the element is remarkable. Cells of the species *Astragalus bisulcatus*, for example, may contain as much as 5000 ppm of selenium. The dangerous nature of these selenium accumulators can be appreciated from experiments which have shown that grazing animals may show signs of selenium poisoning when on a diet containing as little as 1 ppm.

How do selenium accumulators survive such high concentrations without damage? The answer is that sulphur and selenium follow different biochemical pathways once they have entered these accumulators. Instead of being incorporated into the amino acids cysteine and methionine, as is sulphur, selenium is channelled into synthesis of amino acid homologues. These homologues differ structurally from the sulphur-containing amino acids. They are not, therefore, incorporated into proteins but are normally stored in the vacuoles of leaf cells.

In contrast, in non-adapted plants selenium follows the same pathway as sulphur, and the amino acids selenocysteine and selenomethionine are synthesised. Selenium toxicity may be due largely to these amino acids being incorporated into enzymes where they form Se - Se bridges which are considerably less stable than disulphide bridges.

Selenium can also be a persistent toxin in aquatic ecosystems as has been shown in a study of Belews Lake in the USA. This artificial lake was contaminated with selenium from a power station. Ten years after the power station stopped discharging contaminated waste into the lake, research workers found that bioaccumulation in food chains was still causing otherwise harmless concentrations of selenium to reach toxic levels.

Despite its toxic nature, recent evidence suggests that selenium may help to reduce the risk of prostate cancer. A large trial is being carried out in the USA to find out if selenium, vitamin E or a combination of both can lower the risk of prostate cancer. This trial is using doses of 200 µg of selenium and 400 mg of vitamin E per day and involves 32 000 men.

(a) Describe precisely how a molecule of cysteine differs from a molecule of selenocysteine. *(1 mark)*

(b) Selenocysteine and selenomethionine are incorporated into proteins but the amino acid homologues are not. Explain why. *(4 marks)*

(c) By what means would you expect the amino acid homologues to enter the vacuole of a leaf cell (line 16)? Give an explanation for your answer. *(3 marks)*

(d) Explain how selenium toxicity may be due largely to selenium-containing amino acids being incorporated into enzymes (lines 18-19). *(3 marks)*

(e) An ecological survey found that the species *Astragalus bisulcatus* was present in larger numbers on soils containing high concentrations of selenium than on soils where the concentration was low. Suggest an explanation for this. *(2 marks)*

(f) (i) *Thlaspi caerulescens* is another species of plant. It is a zinc accumulator. It has been used in Europe to remove zinc from contaminated soils. Suggest how *A. bisulcatus* might be used in a similar way to reduce the concentration of selenium in the soil. *(1 mark)*

(ii) Explain **one** problem arising from the method you have described. *(2 marks)*

(g) (i) Draw a diagram to summarise how the element selenium is cycled in a natural ecosystem. *(3 marks)*

(ii) Explain how otherwise harmless concentrations of selenium can reach toxic levels in a food chain (lines 24-25). *(2 marks)*

(h) The 32 000 men in the trial described in the last paragraph were divided into four groups. Explain how the trial described in the last paragraph should be carried out. *(4 marks)*

SECTION B

Answer **all** parts of the question.

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

Adult tigers vary in size. Adult tiger skulls were obtained from specimens in museums. An investigation was carried out into how the length of these tiger skulls varied with latitude. The results are shown in **Figure 1**.

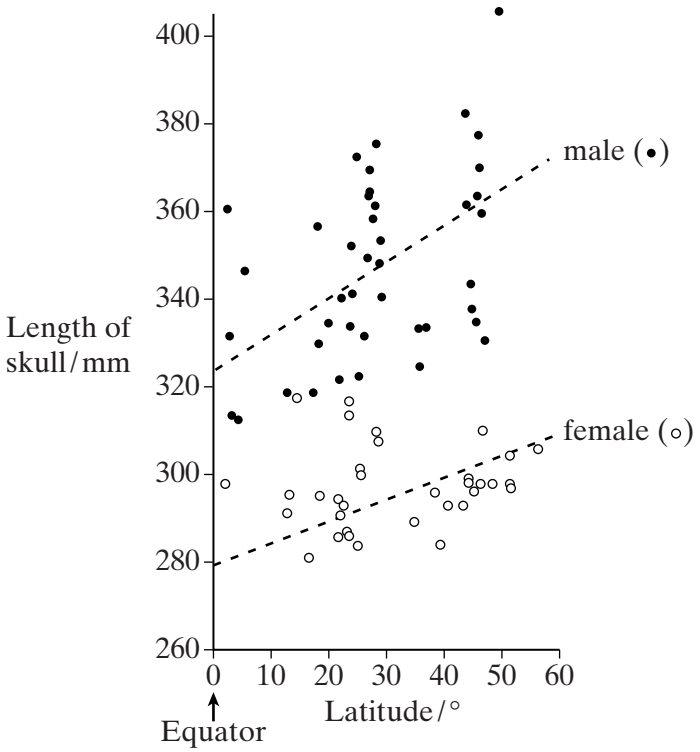

Figure 1

(a) (i) Museum collections contain the skulls and the skins of tigers. What was the advantage of using skull measurements rather than skin measurements in this study?

(1 mark)

(ii) Suggest how a tiger skull could be identified as coming from an adult animal.

(3 marks)

(b) Describe how skull length varies with latitude. *(2 marks)*

(c) Skull length gives an indication of total body size. How can variation in skull length with latitude be explained in terms of mean annual temperature? *(2 marks)*

(d) (i) It has also been suggested that variation in skull length may be explained in terms of prey size. Assuming this explanation is correct, what do the data in **Figure 1** suggest about feeding behaviour in tigers?

(ii) What are the ecological consequences of the differences in feeding behaviour?

(4 marks)

Other studies have been carried out on genetic variation in tigers. Variation in base sequence in mitochondrial DNA (mtDNA) was studied in tigers and other species of cat. Mitochondrial DNA is a circular molecule about 16 500 base pairs long. The genes it contains are very similar in all species. Some of them code for rRNA or tRNA and some of them code for proteins.

(e) Describe how the synthesis of tRNA from information encoded on mitochondrial DNA will differ from the synthesis of a protein. *(2 marks)*

(f) The barchart in **Figure 2** shows some results from this investigation. It shows the variation in the base sequence of mitochondrial DNA coding for a ribosomal RNA molecule in tigers and other species of cat.

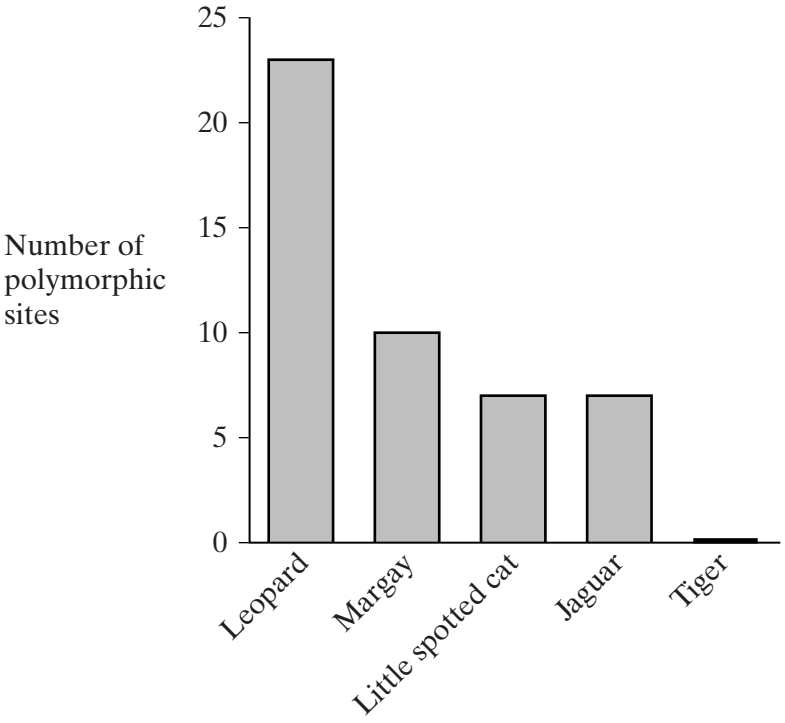

Figure 2

(i) What is meant by a polymorphic site? *(1 mark)*

(ii) It has been suggested that tigers suffered a massive population reduction at some time during the past several thousand years before recovering in numbers. Explain how this is supported by the data in **Figure 2**. *(2 marks)*

(iii) The rate of genetic change in mitochondrial DNA is much faster than the rate of change in nuclear DNA. Suggest the advantage of basing this study on mitochondrial DNA rather than on nuclear DNA. *(1 mark)*

(g) Approximately 31 kinds of tRNA molecules are involved in the translation of mRNA on the rough endoplasmic reticulum of a cell. Mitochondria synthesise all their own tRNA but produce only 22 different kinds of tRNA molecules. Explain what this suggests about the translation of mitochondrial mRNA compared with the translation of cytoplasmic mRNA. *(2 marks)*

QUESTION 2 CONTINUES ON THE NEXT PAGE

Turn over ▶

Variation in tigers is used as a way of estimating the size of tiger populations. Camera traps are set in different parts of the study area. These traps are set at random in the area being studied and automatically photograph all tigers passing the camera. Each tiger has a unique pattern of stripes which enables it to be identified. The table shows some of the results of such a survey of a population of adult tigers in Indonesia.

Animal number	Sex	Number of photographs (P)	Number of locations (L)
1	female	13	2
2	female	15	4
3	female	12	3
4	male	16	9
5	male	18	11

(h) (i) The home range of a tiger is the area over which it hunts. What information do the results in this table give about the home range of these male and female tigers? Give the evidence from the table to support your answer. *(2 marks)*

(ii) Explain how the evidence from camera traps could be used to determine the size of a tiger population in a particular area. *(3 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 Explain how an increase in the concentration of carbon dioxide in the atmosphere might affect crop production.

4 Hydrogen bonds occur within and between biologically important molecules. Explain how hydrogen bonds play an important role in living organisms.

5 Write an essay about the genetic code.

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 Proposals have recently been made to farm marine fish on a very large scale using huge cages on the seabed. What are the possible advantages and disadvantages of such a scheme?

7 Sales of produce labelled "organic" have increased considerably over the last few years. What are the biological arguments for and against so-called "organic" food?

8 Smallpox has now been eradicated. How practicable is it to eradicate other infectious diseases? Illustrate your answer with specific examples where possible.

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE