General Certificate of Education
June 2006
Advanced Extension Award

BIOLOGY **6811**

Tuesday 27 June 2006 9.00 am to 12 noon

For this paper you must have:
- 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.

Mammals such as hedgehogs live in temperate regions and face food shortage in winter. One strategy that has evolved in association with this is hibernation. During hibernation, their body temperature falls and this fall is associated with other physiological changes. Hibernation has been studied extensively in hedgehogs.

Before it hibernates, a hedgehog builds up a large reserve of subcutaneous fat which is used during hibernation to maintain metabolism. During hibernation, metabolic rate falls to as little as 1 – 2% of the rate in an active animal. Low metabolic rate is accompanied by a number of other physiological changes. Some of these are of adaptive significance, while others are merely side effects.

It is difficult to give a precise figure for the heart rate in a hibernating hedgehog as it varies and depends on the method used to measure it. When determined by means of electrodes placed on the skin, the heart rate of a hibernating hedgehog at 4 °C was found to be about 8 beats per minute. When measured by using the fingers to feel the heart beating, the figure rose to around 25 beats per minute. Hedgehog hearts show a number of features associated with maintenance of function during hibernation. There is, for example, a high concentration of glycerophosphate dehydrogenase, an enzyme associated with lipid oxidation. In addition, the composition of the plasma membranes in cardiac muscle changes to include more unsaturated fatty acids. This compensates for cold-induced changes in membrane fluidity, and helps to maintain permeability.

The composition of the blood alters during hibernation. For example, blood glucose concentration falls. Although breathing rate is low and breathing sometimes ceases altogether for short periods, oxygen deficiency is unusual. The reasons for this are complex but it can, in part, be explained by an increase in the affinity of haemoglobin for oxygen.

Arousal from hibernation involves a rapid warming of the body produced by brown fat thermogenesis. Brown fat is a specialised type of adipose tissue and is the only animal tissue with the sole function of heat production. It is distributed around the blood vessels and muscles of the thorax where it forms a vest-like arrangement in close contact with the main arteries and the central nervous system. Brown fat cells are characterised by numerous small lipid droplets and the presence of large numbers of mitochondria. The tissue is also richly supplied with blood vessels.

Activation of brown fat thermogenesis is controlled mainly by hormones. Adrenaline binds to receptors on the plasma membranes and this brings about the synthesis of cyclic AMP. Cyclic AMP activates lipases. As a result, free fatty acids are produced which are then available for oxidation to acetylcoenzyme A, which enters the Krebs cycle. These free fatty acids have a second function. They control the activity of a protein, thermogenin, found only on the inner membranes of brown fat mitochondria. Active thermogenin modifies the membrane by providing channels for hydrogen ions, effectively uncoupling the production of ATP from the electron-transport chain.

(a) Explain the advantage of a low body temperature during hibernation in a mammal such as a hedgehog. *(2 marks)*

(b) Explain the advantages of fat as an energy store during hibernation. *(3 marks)*

(c) Suggest the advantage of a high concentration of glycerophosphate dehydrogenase in the heart muscle of a hibernating hedgehog (lines 15 – 16). *(1 mark)*

(d) (i) Describe and explain how a decrease in temperature would affect the movement of substances through plasma membranes that are not adapted to low temperatures. *(4 marks)*

(ii) Explain how the inclusion of more unsaturated fatty acids compensates for cold-induced changes in membrane fluidity (lines 17 – 19). *(2 marks)*

(e) Explain how an increase in the affinity of haemoglobin for oxygen contributes to oxygen deficiency being unusual in a hibernating hedgehog (lines 22 – 23). *(2 marks)*

(f) Explain the significance of

(i) the distribution of brown fat in a hibernating mammal (lines 26 – 28); *(2 marks)*

(ii) brown fat being richly supplied with blood vessels (lines 29 – 30). *(1 mark)*

(g) (i) Describe the part played by reduced coenzymes, such as NAD, in the production of ATP in mitochondria. *(3 marks)*

(ii) Explain how the activation of thermogenin results in the production of heat in the mitochondria of brown fat cells. *(2 marks)*

(h) Bats also hibernate during the winter months. Disturbance of hibernating bats caused, for example, by handling, reduces the probability of their surviving through the winter. Use information in the passage to explain why. *(3 marks)*

Turn over for the next question

SECTION B

Answer **all** parts of the question.

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

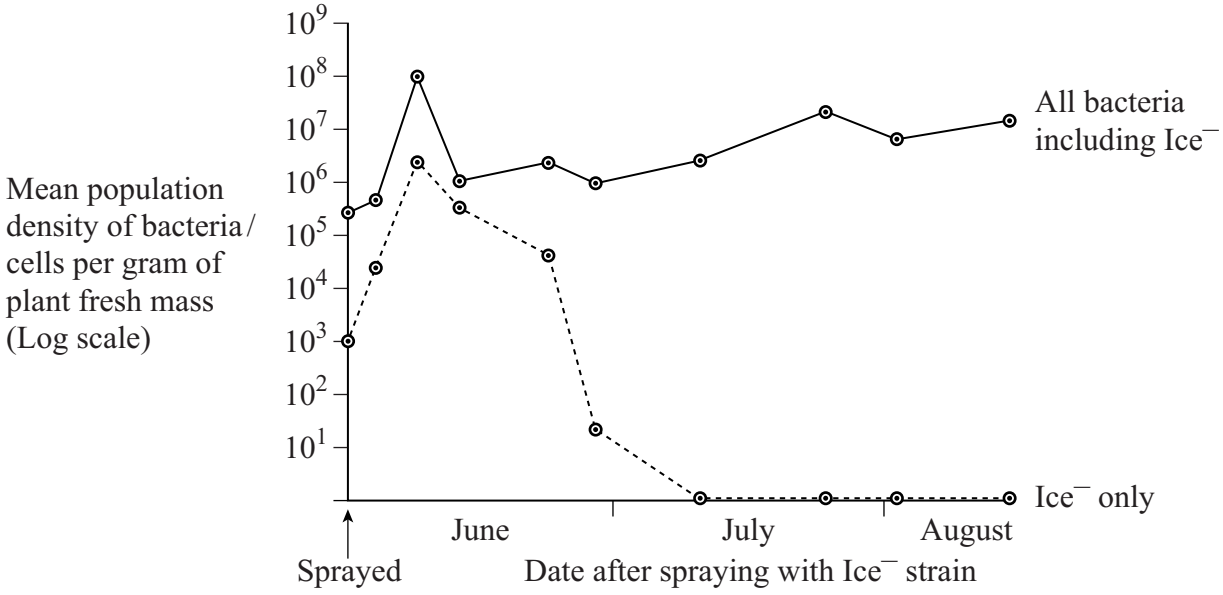
New strains of potentially useful bacteria and plants have been produced by genetic engineering, but there are concerns about releasing these organisms into the environment. Much research has been carried out concerning aspects of safety.

Pseudomonas syringae is a common bacterium which lives on the surface of leaves. A naturally occurring strain is called Ice^+ because, in cold weather, the bacterium promotes the formation of ice crystals and this causes frost damage in crop plants. Deletion of a single gene produces the genetically modified Ice^- strain. This strain does not result in the formation of ice crystals.

(a) (i) It is thought that spraying the Ice^- strain of *P. syringae* on crop plants might reduce frost damage caused to crops by the Ice^+ strain. Explain the ecological assumption on which this idea is based. *(2 marks)*

(ii) The Ice^- strain grows on the surface of the leaves of crop plants. It also grows on the leaves of other plants in the area in which it is released. Suggest how spraying a field with the Ice^- strain may have an adverse effect on the crop yield. *(3 marks)*

An investigation was carried out into the survival of the Ice^- strain under natural conditions. Ice^- bacteria were suspended in a carrier solution and sprayed on the leaves of potato plants. The population densities of the Ice^- strain of *P. syringae* and of all bacteria on the leaves were then monitored. The results are shown in the graph.



(b) (i) Suggest a suitable control to be used in this investigation. *(1 mark)*

(ii) Suggest the advantage in plotting data such as these on a log scale. *(1 mark)*

(iii) From the data collected on population densities, standard deviations were calculated. Explain the link between standard deviation and the reliability of the conclusions that can be drawn from an investigation such as this. *(2 marks)*

(c) Explain whether or not the results of this investigation indicate that the Ice^- strain would be

(i) likely to spread to plants other than the crop plants on which they were sprayed; *(1 mark)*

(ii) effective in reducing ice damage to the crop on which they were sprayed. *(4 marks)*

Plasmids may be used in the genetic modification of bacteria. Plasmids can be transferred naturally between different species of bacteria. Providing that such bacteria are metabolically active, this transfer may occur between bacteria which are not even closely related. A concern with releasing genetically modified bacteria is that artificially created plasmids may be transferred.

Research on soil bacteria has shown that environmental conditions may influence the frequency of plasmid transfer between bacteria. The table shows the frequency of plasmid transfer between two species of *Bacillus, B. cereum* and *B. subtilis,* inoculated into different soils.

Conditions	**Number of plasmid transfers per 10^7 cells**
Unsterilised sandy soil	0.0
Sterilised sandy soil	0.2
Sterilised sandy soil + nutrients*	0.5

*Nutrients included amino acids, mineral ions and a soluble, organic, energy-providing substrate.

Question 2 continues on the next page

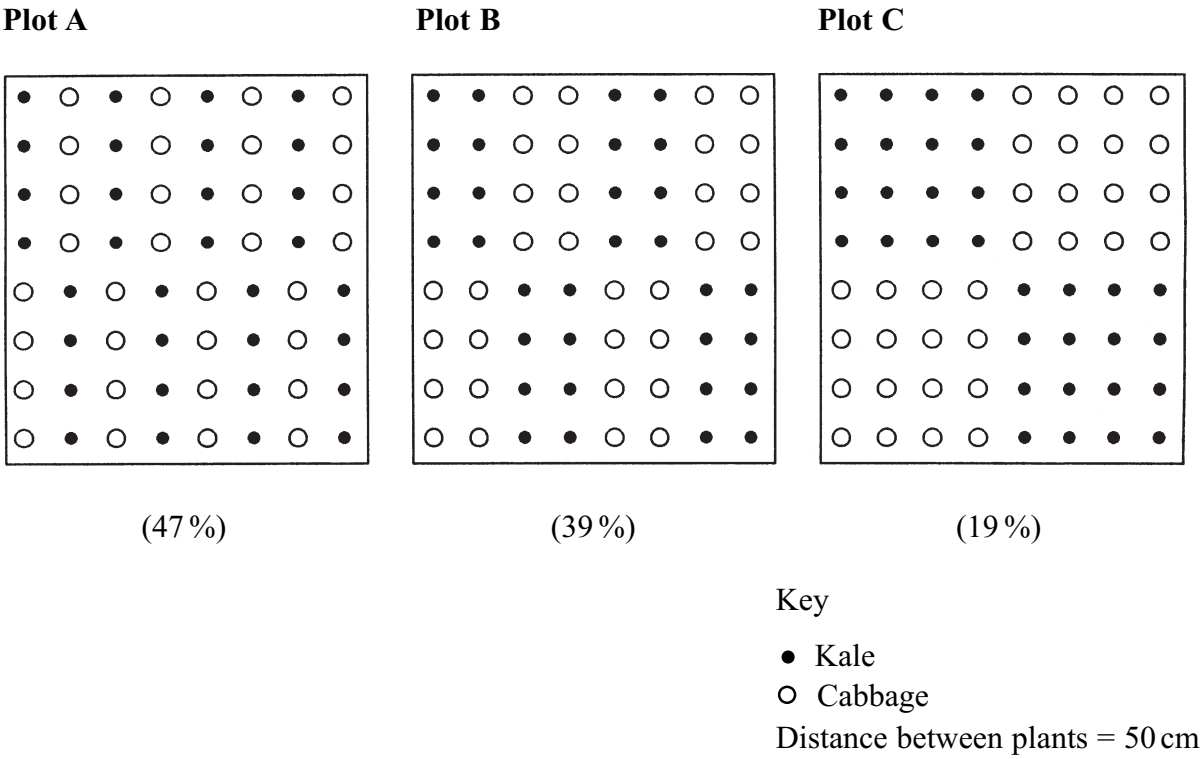
(d) Explain how the addition of nutrients may affect plasmid transfer. *(2 marks)*

(e) Suggest why sterilising the soil before adding *B. cereum* and *B. subtilis* may lead to a greater frequency of plasmid transfer between these two species. *(1 mark)*

(f) Scientists are concerned about the transfer of antibiotic resistance between different species of bacteria in human intestines. Use the information given to help explain why the human intestine is a particularly important site of transfer. *(3 marks)*

Concerns have also been expressed about hybridisation between weeds and crop plants which have been genetically modified so that they are resistant to herbicides.

Cabbage and kale are varieties of the same species of plant. The diagram shows the different arrangements in which cabbage and kale were planted in trial plots. After the plants had produced seeds, samples of the seeds were tested. The percentage of seeds that were hybrids between cabbage and kale was determined. These percentages are shown in brackets.



(g) Explain the different percentages of hybrid seeds produced in these plots. *(1 mark)*

(h) The results of this investigation might be used to support an argument against growing a crop, such as maize, which has been genetically modified to make it resistant to a herbicide. Suggest why care must be taken in using these results to support this argument. *(4 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.

3 Discuss the causes and effects of mutation.

4 Discuss the ways in which human activity may influence nutrient cycles.

5 Explain how surface area to volume ratio affects the biology of cells, organs and organisms.

SECTION D

Answer **one** question from this section.

Each question carries 25 marks.

In addition to the biological content of your essay, 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.

6 "You are what you eat." As a biologist, how far would you agree with this statement?

7 Can zoos play any part in conservation?

8 The pattern of disease in the United Kingdom has changed over the past fifty years. How would you expect it to change over the next fifty years?

END OF QUESTIONS

There are no questions printed on this page