General Certificate of Education
June 2007
Advanced Extension Award

BIOLOGY **6811**

Tuesday 26 June 2007 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 to be marked.

Information
- The maximum mark for this paper is 100.
- There are 25 marks for each question. The marks for part-questions are shown in brackets.
- Sections C and D should be answered in continuous prose. In these sections you will be marked on your ability to use good English, to organise information clearly 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.

Deserts are areas where limited availability of resources results in very few living organisms. Until the mid-1970s, the sea below a depth of 1500 metres was thought to be a desert. There are some animals living in these deep waters, however, and many have remarkable adaptations. Almost all the fish have huge mouths and enormous stomachs. Their skeletons show reduced calcification and their tissues have an exceptionally high water content. Reproduction in these deep-sea fish is also modified. In some angler fish, a newly hatched male attaches itself to the body of a female. In time, the male and female bodies fuse and their blood systems become continuous. Eventually, the tiny parasitic male supplies the sperms necessary for fertilisation of the female's eggs.

In 1977, exploration of the sea bed by a submarine upset the widely held view of the deep sea as a marine desert. The expedition discovered a densely packed mass of animal life clustered round a volcanic vent 2600 metres below the surface. This discovery was all the more remarkable because the hot water coming from the vent contained a high concentration of hydrogen sulphide (H_2S), a substance toxic to most organisms.

One of the commonest organisms round the vent was a metre-long tubeworm. It is an unusual animal consisting of a closed body sac with neither mouth nor digestive system. At the anterior end, a cluster of bright red structures forms the site where hydrogen sulphide and respiratory gases are exchanged between blood and water. Within the body sac is a large organ called a trophosome. Examination of the cells of this trophosome show them to be packed with sulphur bacteria. Sulphur bacteria are similar to green plants in being producers, fixing carbon dioxide in the Calvin cycle. They differ, however, in that they use the oxidation of hydrogen sulphide to drive this cycle. There is clearly a mutualistic relationship since both tubeworms and bacteria benefit nutritionally.

The ability of tubeworms to absorb and transport hydrogen sulphide without being poisoned presented a puzzle. Hydrogen sulphide inhibits respiration in two ways. It blocks the oxygen-carrying site on a haemoglobin molecule and it inhibits cytochrome oxidase, the terminal carrier in the chain of reactions associated with oxidative phosphorylation. It was first suggested that the tubeworm might have a form of cytochrome oxidase insensitive to hydrogen sulphide but a series of experiments showed that the sensitivity of cytochrome oxidase depended on the degree to which it had been purified. As the investigators went through successive purification steps, they observed a decrease in the bright red colour of the preparation together with an increase in sensitivity of cytochrome oxidase to the toxic effects of hydrogen sulphide.

The tubeworm haemoglobin proved to be very different from human haemoglobin. It is a very large molecule with a relative molecular mass of approximately two million. It also has an unusually high affinity for oxygen, as well as a high carrying capacity. It is thus well suited for extracting oxygen from the water around the vent.

Use information from the passage and your own knowledge to answer the questions.

(a) The deep-sea fish referred to in line 4 ultimately depend on solar energy. Explain how. *(3 marks)*

(b) Deep-sea fish have many adaptations. Explain how the following are adaptations to the deep-sea environment

(i) a huge mouth and enormous stomach (lines 4 –5) *(2 marks)*

(ii) males which are parasitic and small in size (line 9). *(3 marks)*

(c) The cluster of bright red structures at the anterior end of the tubeworm forms the site where gases are exchanged (lines 18–19). Describe **three** ways in which these structures might be adapted and explain how each would ensure efficient gas exchange. *(3 marks)*

(d) Explain how oxidation of hydrogen sulphide drives the Calvin cycle (lines 23–24). *(3 marks)*

(e) Explain why the relationship between tubeworms and bacteria is described as mutualistic (line 24). *(2 marks)*

(f) In tubeworms, cytochrome oxidase is not inhibited by hydrogen sulphide. Use evidence from the passage to explain this. *(2 marks)*

(g) Tubeworm haemoglobin is found free in the plasma; it is not contained in red blood cells. Why would it be disadvantageous for humans to transport their haemoglobin free in the plasma? *(4 marks)*

(h) Explain the advantage of tubeworm haemoglobin having an unusually high affinity for oxygen (line 38). *(3 marks)*

Turn over for the next question

SECTION B

Answer **all** parts of the question.

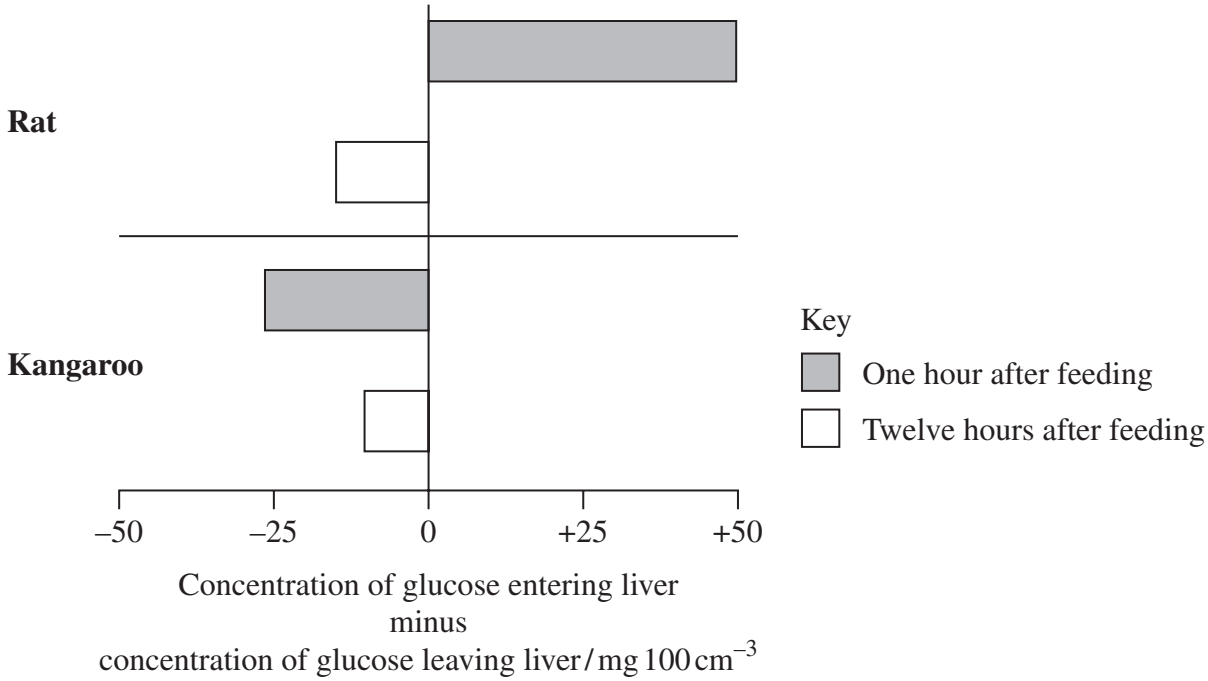
2 **Total for this question: *25 marks***

Kangaroos are mammals. They eat large amounts of plant material that enters a long tubular stomach, which is similar in function to the rumen of a cow. Carbohydrates such as cellulose are fermented by bacteria and protozoa in this stomach. Short-chain fatty acids are a waste product of fermentation and are absorbed and metabolised by the kangaroo. Proteins and other nitrogen-containing compounds are first processed into microbial protein, which is then digested in the kangaroo's intestine.

(a) An industrial fermenter maintains a constant temperature and pH in order to achieve an optimum rate of fermentation. Suggest how a constant temperature and pH are maintained during fermentation in the kangaroo stomach. *(4 marks)*

Figure 1 shows the difference in the concentration of glucose in the blood entering and leaving the liver in a rat and in a kangaroo.

Figure 1



(b) (i) Explain the difference between the concentration of glucose entering the liver of the rat and the concentration leaving one hour after feeding. *(2 marks)*

(ii) What does **Figure 1** suggest about the role of the liver in glucose metabolism in the kangaroo? Explain your answer. *(3 marks)*

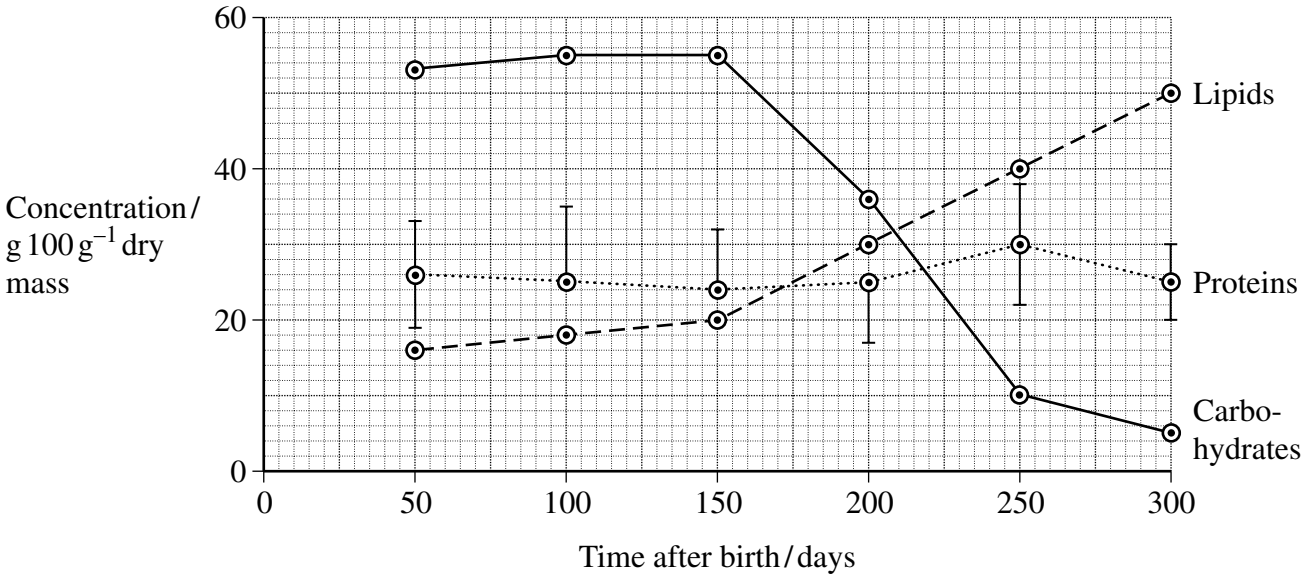
(c) Under some conditions, urea is reabsorbed into the blood in the kidneys. It is transported to the salivary glands where it is secreted in saliva. Explain how this is an advantage to kangaroos during periods of hot and dry weather when food is scarce. *(3 marks)*

Kangaroos are marsupials. A kangaroo weighs approximately 1 g at birth and is relatively undeveloped. It crawls into its mother's pouch and attaches itself to a nipple on one of the mammary glands. It feeds only from this gland throughout its long period of growth and development.

Figure 2 shows the composition of kangaroo milk during this period. The bars show standard deviations. Some bars have been removed for clarity.

The table shows the body mass of the young kangaroo from birth.

Figure 2



Time after birth / days	0	50	100	150	200	250
Body mass of young kangaroo / g	1	42	238	790	2250	6230

(d) Describe what happens to the protein concentration during the period shown in **Figure 2**. *(2 marks)*

(e) Suggest the advantages to the young kangaroo and its mother of the changes in carbohydrate and lipid concentration in the milk. *(3 marks)*

Question 2 continues on the next page

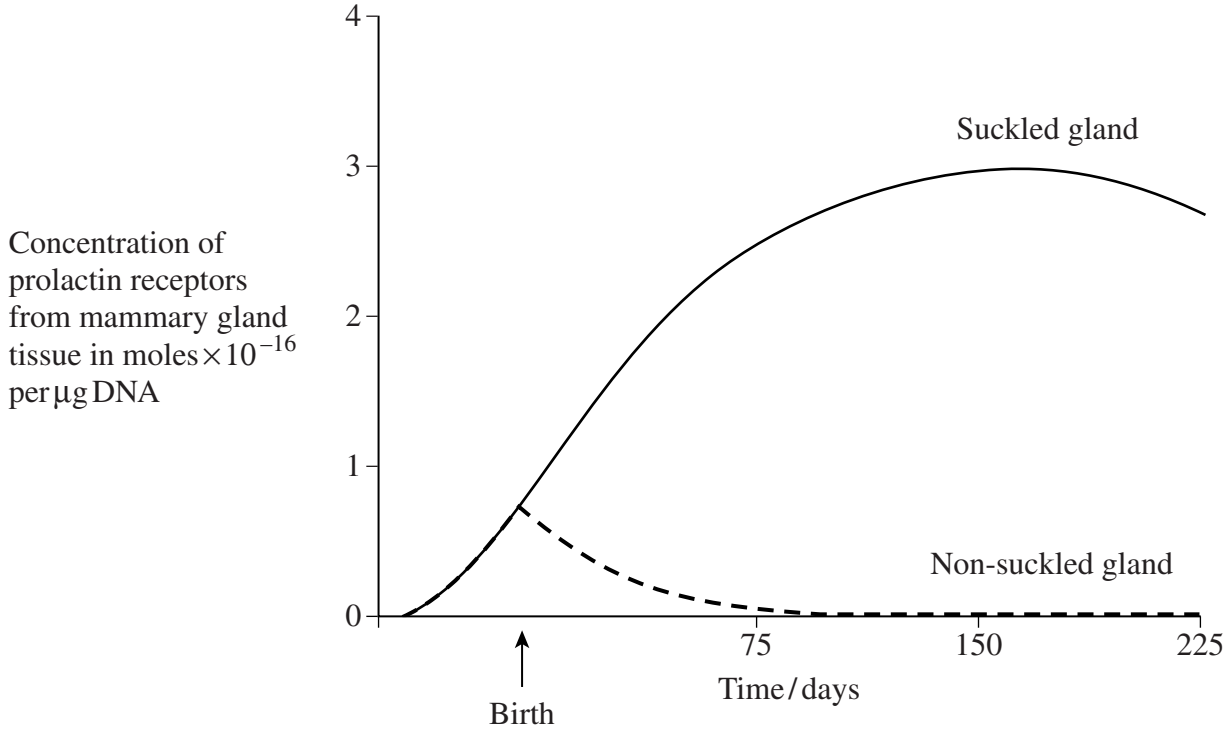
Female kangaroos frequently suckle two young at the same time. One will be newborn, the other will have left the pouch. Each suckles from a different mammary gland.

(f) Prolactin is a hormone secreted by the pituitary gland. It has a role in lactation in all mammals. In mammals other than marsupials, it is known that milk composition is controlled by the concentration of prolactin. When biologists first investigated the hormonal control of milk composition in kangaroos, they experienced difficulties in explaining it in terms of the concentration of prolactin. Explain why.

(3 marks)

Figure 3 shows some of the results obtained when biologists investigated the role of prolactin in kangaroos. It shows the concentration of prolactin receptors in suckled and non-suckled mammary glands.

Figure 3



(g) In **Figure 3**, the concentration of prolactin receptors is given per µg of DNA in the mammary gland tissue. Suggest why. *(2 marks)*

(h) Use information in **Figure 3** to suggest how prolactin controls the milk production and its composition in the mammary glands of kangaroos. *(3 marks)*

SECTION C

Answer **one** question from this section.

There are 25 marks for this question.

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 Membranes are found surrounding cells and within them. Discuss the functions of these cell membranes.

4 Give a critical account of the ways in which the sizes of animal populations may be estimated.

5 How are genes transferred from one organism to another?

SECTION D

Answer **one** question from this section.

There are 25 marks for this question.

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 Are viruses living?

7 Can biology be applied to combat global warming?

8 What is biodiversity and why should we care about it?

END OF QUESTIONS

There are no questions printed on this page