OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

BIOLOGY

Applications of Genetics

FRIDAY 22 JUNE 2007

2805/02

Afternoon

Time: 1 hour 30 minutes

Additional materials: Electronic calculator
Ruler (cm/mm)

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	15	
2	15	
3	15	
4	15	
5	15	
6	15	
TOTAL	90	

This document consists of **14** printed pages and **2** blank pages.

[Turn over

Answer **all** the questions.

1 **(a)** Explain the meaning of the terms *linkage* and *crossing over*.

linkage .....

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crossing over .....

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..... [3]

(b) In an investigation into the genes on chromosome 2 of the tomato genome, pollen from a pure-bred plant with green leaves and smooth-surfaced fruit was transferred to flowers of a plant with mottled green and yellow leaves and hairy (so-called 'peach') fruit. All the F_1 generation had green leaves and smooth fruit.

Describe briefly how a plant breeder ensures that the offspring produced are **only** from the desired cross.

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(c) Four different test crosses, **A** to **D**, were then made between F_1 plants and pure-bred plants with mottled leaves and 'peach' fruit. The phenotypes of 50 offspring of each of the crosses were recorded and are shown in Table 1.1.

Table 1.1

	phenotypes of offspring of test crosses			
cross	green leaves and smooth fruit	green leaves and 'peach' fruit	mottled leaves and smooth fruit	mottled leaves and 'peach' fruit
A	23	4	3	20
B	21	3	3	23
C	16	4	5	25
D	22	6	4	18
total	82	17	15	86

(i) Suggest **one** reason why, in Table 1.1, the numbers of plants with green leaves and smooth fruit is not the same in each of the crosses **A** to **D**.

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(ii) The percentage cross over value is calculated as

$$\frac{\text{number of recombinant offspring}}{\text{total number of offspring}} \times 100$$

Using the information in Table 1.1, calculate the percentage cross over value between the loci for leaf colour and fruit surface texture. Show your working.

Answer = ... % [2]

(iii) Use annotated diagrams of tomato chromosome 2 to explain the results of the test crosses shown in Table 1.1.

Use the symbols **A**/**a** for the leaf colour alleles and **B**/**b** for the fruit surface texture alleles.

[6]

[Total: 15]

2 **(a)** **(i)** Outline the principle of selective breeding.

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(ii) Explain the use of progeny testing in selective breeding.

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(b) In this question, one mark is available for the quality of spelling, punctuation and grammar.

In 1959, a breeding colony of 100 female and 30 male Siberian foxes was established in Russia. For the next 45 years, they were selectively bred for **one** trait only: that of lack of aggression to humans (tameness).

By the end of 2004, the behaviour and appearance of the selectively bred foxes differed from wild foxes in the following ways:

- their fur had white patches
- their muzzles were shorter
- some had floppy ears and curly tails
- they whimpered to attract human attention, wagged their tails and licked the human's hand.

Describe how selective breeding of animals is carried out **and** explain how selectively breeding for **one** trait may result in many differences between selectively bred and wild animals.

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[8]

Quality of Written Communication [1]

[Total: 15]

3 (a) The Endangered Wildlife Trust in South Africa uses a cloning technique to help conserve endangered species of mammal such as the darted buffalo.

A cell from an adult darted buffalo was fused with egg cells from domesticated cows, using the procedure outlined in Fig. 3.1.

A diagram has been removed due to third party copyright restrictions

Details: A diagram of a procedured used to fuse a cell from an adult darted buffalo with an egg cell from a cow. In step 1, two cow egg cells are cut in half, the cell halves containing the nuclei are disgarded, in step 2, a cell from an adult darted buffalo is fused with cow cytoplast, in step 3, an embryo is fused with the second cow cytoplast to increase cell volume to that of the original egg cell and in step 4, the cloned darted buffalo embryo implanted into a hormonally treated surrogate mother

Fig. 3.1

With reference to Fig. 3.1, explain

(i) how a supply of cow egg cells is obtained for step 1 ;

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(ii) why the cloned darted buffalo embryo produced in **steps 2** and **3** does **not** have exactly the same DNA as the adult darted buffalo from which a cell was taken;

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(iii) why it is necessary to treat the surrogate mother with hormones in **step 4**.

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(b) Explain how a procedure such as that shown in Fig. 3.1 can help save an endangered species of mammal.

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(c) State **three** ways of setting up a gene bank for the darted buffalo.

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[Total: 15]

4 **(a)** The DNA target sites of four restriction enzymes are shown in Table 4.1. The points at which the strands of DNA are cut are shown by arrows and lines.

Table 4.1

restriction enzyme	target site
Sau3AI	↓ G – A – T – C – – C – T – A – G ↑
BamHI	– G ↓ G – A – T – C – C – – C – C – T – A – G ↑ G –
HinfI	– G ↓ A – N – T – C – – C – T – N – A ↑ G – 'N/N' may be any complementary base pair

With reference to the information in Table 4.1,

(i) describe the characteristics of a restriction enzyme's target site;

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(ii) explain whether or not a piece of DNA cut by **Sau3AI** could join with one cut by **BamHI**;

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(iii) show on Fig. 4.1 the result of exposing this piece of DNA to **HinfI**.

– G – A – T – T – C – A – G – A – A – T – T – T – C – G – A – A – T – C –
– C – T – A – A – G – T – C – T – T – A – A – A – G – C – T – T – A – G –

Fig. 4.1 [1]

(b) In this question, one mark is available for the quality of use and organisation of scientific terms.

Describe the roles of restriction enzymes and other enzymes in genetic engineering.

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Quality of Written Communication [1]

[Total: 15]

5 **(a)** The malarial parasite, *Plasmodium*, and its vector, the mosquito, are both eukaryotes.

The treatment and control of malaria is difficult because *Plasmodium* rapidly develops resistance to most anti-malarial drugs as do mosquitoes to insecticides. Also, vaccine production has proved to be very difficult. The B-cell responses induced by experimental vaccines are not yet very effective.

Explain

(i) the genetic basis of resistance in eukaryotes;

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(ii) why producing an effective vaccine against *Plasmodium* has proved to be so difficult.

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(b) A gene has been identified in several species of *Plasmodium* which codes for a small transmembrane protein.

A mutant form of *P. berghei* exists in which this protein is **not** produced. *P. berghei* infects mice. The mutants:

- develop normally in a mosquito and infect the salivary glands in numbers comparable to wild type parasites
- infect mouse liver cells but do not multiply
- do not infect red blood cells.

(i) Describe **one** mutation of this gene that could have occurred in *P. berghei* so that the encoded protein is **not** produced.

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(ii) Suggest **one** reason why mutant *P. berghei* **do not** infect red blood cells.

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(c) It has been suggested that *Plasmodium* with this mutation could be used as a 'whole organism' vaccine against malaria.

Mice were inoculated with different numbers of mutant *Plasmodium* and then given one or two 'booster' inoculations. Their protection against infection by wild-type *Plasmodium* was compared with that of mice that had not been inoculated. The results of the investigation are shown in Table 5.1.

Table 5.1

number of mutant *Plasmodium*			percentage of mice resistant to infection by wild-type *Plasmodium*
in initial inoculation	in first booster inoculation	in second booster inoculation	
50 000	25 000	25 000	100
10 000	10 000	10 000	100
10 000	10 000	0	70
0	0	0	0

With reference to the information in Table 5.1 and in **(b)**, comment on the use of this mutant *Plasmodium* as a 'whole organism' vaccine.

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[Total: 15]

6 **(a)** Transplants of cells from the islets of Langerhans can be given to patients with insulin-dependent diabetes. Islet cells are isolated from donors whose HLA alleles match those of the recipient. The cells are injected into the hepatic portal vein and become lodged in the liver, where they function in the same way as in a normal pancreas.

Explain

(i) the importance of matching the HLA alleles of donor and recipient;

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(ii) why it is difficult to find a donor of islet cells whose HLA alleles match those of the recipient.

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(b) In an experimental gene therapy for insulin-dependent diabetes, the insulin gene was combined with a glucose-sensitive promoter and inserted into liver cells of diabetic rats.

The mean concentration of insulin was then measured at three different concentrations of blood glucose. The results are shown in Table 6.1.

Table 6.1

concentration of blood glucose / mg dm^{-3}	mean concentration of insulin / ng cm^{-3}
100	0.3
300	5.0
500	7.0

With reference to Table 6.1, explain the role of the glucose-sensitive promoter in this gene therapy.

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(c) Treated rats were given a glucose meal and the concentration of blood glucose measured immediately and at intervals for eight hours. The results of this investigation are shown in Fig. 6.1.

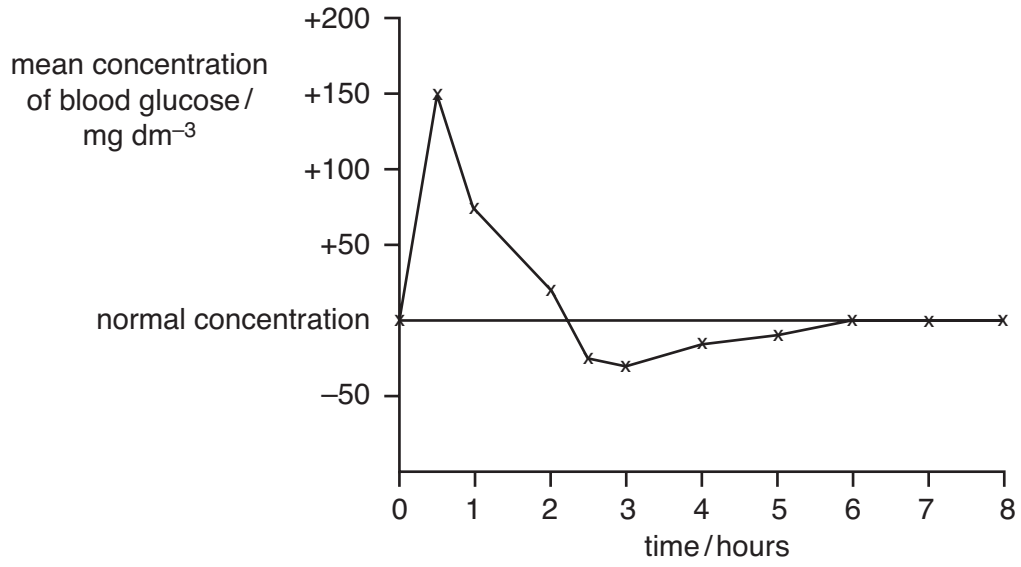

Fig. 6.1

With reference to Fig. 6.1, discuss the possible **benefits** and **problems** of using this gene therapy in the treatment of diabetes in humans, rather than taking insulin.

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[Total: 15]

END OF QUESTION PAPER

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