OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2805/02

Applications of Genetics

Thursday **29 JANUARY 2004** Afternoon 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Read each question carefully before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks 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 question paper consists of 15 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 Pollen from a pure-bred maize plant with dark green leaves and the ability to produce kernels with yellow endosperm was transferred to a pure-bred maize plant with pale green leaves and white endosperms.

All the F_1 generation had dark green leaves and yellow endosperms.

In a test cross, pollen from an F_1 plant was transferred to a pure-bred plant with pale green leaves and white endosperms.

The ratio of phenotypes **expected** in a dihybrid test cross (backcross) such as this is 1:1:1:1.

(a) Using the symbols **A/a** for leaf colour and **B/b** for the colour of the endosperm, draw a genetic diagram of the **test cross** to show that the ratio is 1:1:1:1.

[4]

[Turn over

(b) Seeds from the test cross were collected and grown, giving plants with the following phenotypes:

- dark green leaves and yellow endosperms 82
- dark green leaves and white endosperms 18
- pale green leaves and yellow endosperms 22
- pale green leaves and white endosperms 78

200

A chi-squared (χ^2) test can be carried out to check whether or not the number of each phenotype of offspring resulting from the test cross is in agreement with a 1:1:1:1 ratio. Part of the calculation is shown in Table 1.1.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

Σ = sum of
O = observed value
E = expected value
degrees of freedom = number of classes – 1

Table 1.1

phenotypes	dark green leaves yellow endosperms	dark green leaves white endosperms	pale green leaves yellow endosperms	pale green leaves white endosperms
observed number (O)	82	18	22	78
expected ratio	1	1	1	1
expected number (E)	50	50	50	50
O – E	32			28
$(O - E)^2$	1024			784
$\frac{(O - E)^2}{E}$	20.48			15.68

$\chi^2 = \Sigma \frac{(O - E)^2}{E}$	

(i) Complete the shaded boxes in Table 1.1 to calculate χ^2 for these results. [3]

(ii) Use the calculated value of χ^2 and the table of probabilities provided in Table 1.2 to find the probability of the results of the test cross departing significantly by chance from the expected ratio.

probability (p) ..... [1]

Table 1.2

Distribution of χ^2 values

degrees of freedom	probability, p				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

(iii) State what conclusion may be drawn from the probability calculated in **(b)(ii)** about the difference between the observed and expected results.

.....

.....

..... [2]

(c) Explain the discrepancy between the actual and expected results of the test cross.

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 15]

2 **(a)** Describe briefly how a seed bank is maintained.

.....

.....

.....

.....

..... [3]

(b) Seeds of coconut cannot be stored in a seed bank and are described as recalcitrant. In 1984, in Sri Lanka, where coconut is the most widely grown plantation crop, a systematic collection of coconut phenotypes was made and two field gene banks established in different ecological conditions.

Explain the importance of maintaining gene banks.

.....

.....

.....

..... [3]

(c) Heritability has been calculated for a number of phenotypic characteristics in coconuts, some of which are shown in Table 2.1.

Table 2.1

phenotypic characteristic	heritability
flowering period	0.23
number of coconuts per palm tree	0.48
mass of husked coconut	0.45
mass of copra per coconut	0.67

(i) Explain briefly the importance of heritability in selective breeding.

.....

.....

.....

..... [3]

(ii) With reference to Table 2.1, comment on the likely success of improving these traits in a selective breeding programme.

.....

.....

.....

..... [3]

(d) State **three** ways in which selective breeding **differs** from the evolutionary process.

1 .....

.....

2 .....

.....

3 .....

..... [3]

[Total: 15]

3 **(a)** The cypress tree, *Cupressus dupreziana*, which is native to the Algerian desert, is one of the world's most endangered trees. In 2001 only 231 trees remained. *C. dupreziana* is a natural outbreeder.

Describe the **genetic** effects of inbreeding in a small population of a naturally outbreeding plant species.

.....

.....

.....

..... [3]

(b) In this question, one mark is available for the quality of written communication.

Outline how genetic fingerprinting is carried out **and** explain its theoretical basis.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [8]

Quality of Written Communication [1]

(c) Pollen from one *C. dupreziana* tree was transferred to trees of a related species, *C. sempervirens*. All the resulting offspring appeared to be identical, in all the phenotypic characteristics that were measured, to the male parent, *C. dupreziana*.

The process of genetic fingerprinting was carried out to compare the offspring with their parents.

The genetic fingerprints of the male parent, *C. dupreziana*, a female parent, *C. sempervirens*, and three of the offspring are shown in Fig. 3.1.

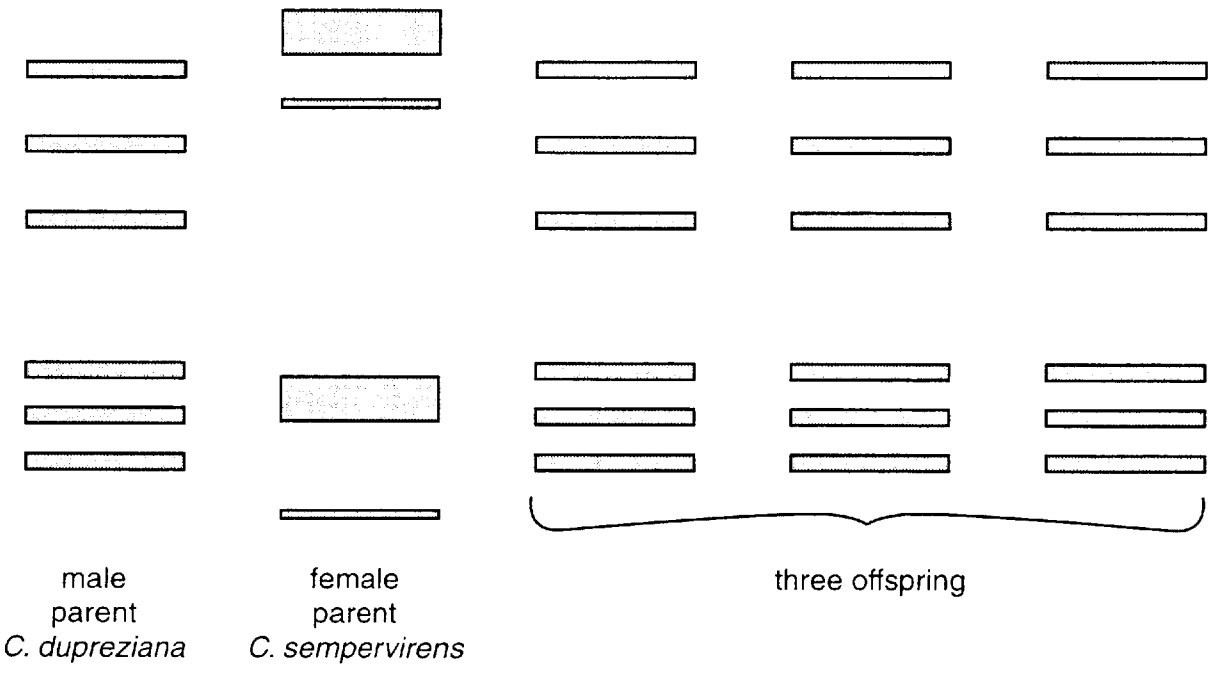

Fig. 3.1

State what conclusions may be drawn from the genetic fingerprints shown in Fig. 3.1.

.....

.....

.....

.....

..... [3]

[Total: 15]

4 A 10 year study was carried out into the possibility of transgenic crops persisting in the wild, in the event of their 'escaping' from cultivation. Four different transgenic crops and their non-transgenic counterparts were grown in 12 different natural habitats.

The four transgenic crops were:

- oilseed rape tolerant of herbicide
- maize tolerant of herbicide
- sugar beet tolerant of herbicide
- potato expressing an insecticide.

(a) Explain briefly the advantages of growing **one** of the transgenic crops listed above.

crop .....

advantages .....

.....

.....

.....

..... [4]

(b) The survival of the transgenic and non-transgenic crop plants in natural habitats was calculated as the percentage of seeds sown or tubers planted that produced mature plants. The mean percentage survival of the plants in all 12 habitats at the end of the first growing season is shown in Fig. 4.1.

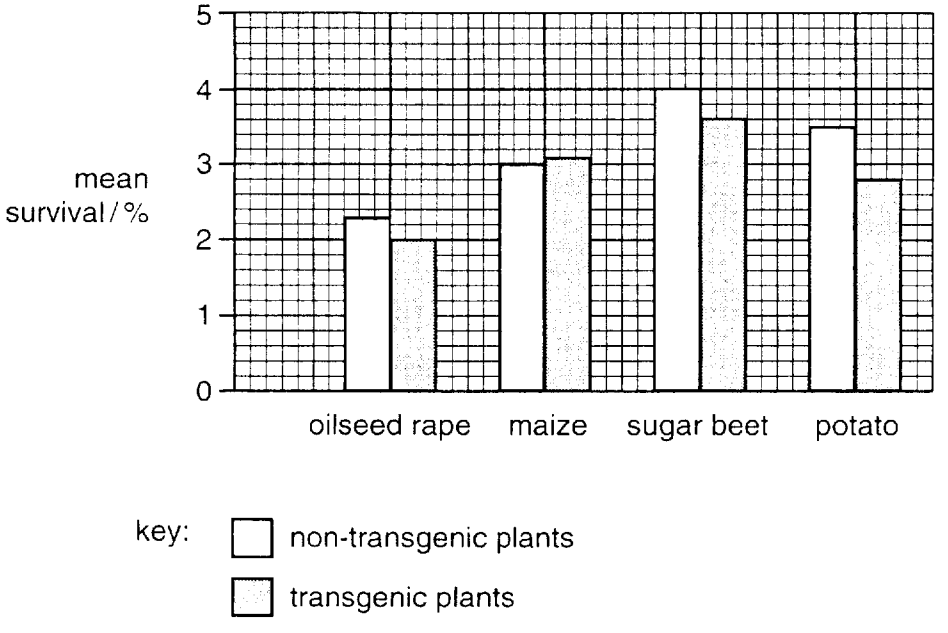

Fig. 4.1

Using the data in Fig. 4.1, compare the mean percentage survival in natural habitats of transgenic and non-transgenic crop plants at the end of the first growing season.

.....

.....

.....

.....

.....

..... [4]

(c) Population sizes of all crops declined after the first year and in no case did the transgenic plants survive significantly longer than their non-transgenic counterparts.

All populations of oilseed rape, maize and sugar beet were extinct at all sites within four years. Non-transgenic potatoes survived in one habitat for longer than 10 years.

Assess the potential danger to natural habitats of these transgenic crops **and** discuss the ethical implications of genetic engineering in agriculture.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [7]

[Total: 15]

5 Restriction enzymes cut DNA molecules only at specific target sites with particular base sequences.

The target sites for the enzymes **HaeIII**, **HpaII** and **SmaI** are shown in Table 5.1. The line drawn across each sequence shows where the enzyme cuts the DNA molecule.

Table 5.1

restriction enzyme	specific target base sequence of DNA
HaeIII	-G-G | C-C- -C-C | G-G-
HpaII	-C|C-G-G- -G-G-C|C-
SmaI	-C-C-C | G-G-G- -G-G-G | C-C-C-

(a) The plasmid (loop of DNA) shown in Fig. 5.1 includes the target site for the enzyme **SmaI**.

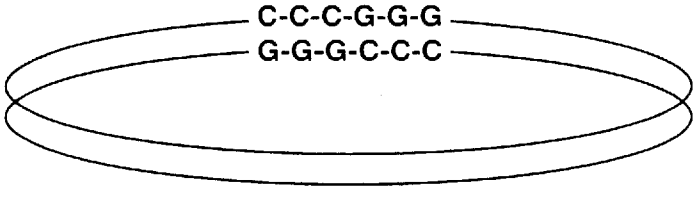

Fig. 5.1

Explain whether or not this sequence can also be cut by the enzymes **HaeIII** and **HpaII**.

HaeIII .....

.....

.....

HpaII .....

.....

..... [3]

(b) A genetic engineer cuts a plasmid with **HpaII** in order to insert a human gene.

(i) Describe the steps that must then be carried out in order to insert the human gene into the plasmid.

.....

.....

.....

.....

.....

..... [4]

(ii) Describe any **differences** in procedure that would be needed if the plasmid had been cut with **SmaI**.

.....

.....

.....

.....

..... [3]

(c) The human gene inserted into the plasmid codes for a protein growth factor which stimulates the growth of blood vessels. The plasmids are used as a form of gene therapy and are injected into the heart to encourage blood vessel growth in diseased heart muscle with a poor blood supply.

(i) Explain briefly what is meant by *gene therapy*.

.....

.....

.....

..... [3]

(ii) Suggest **one** benefit and **one** potential hazard of the gene therapy described above.

benefit .....

.....

.....

hazard .....

.....

..... [2]

[Total: 15]

For Examiner's Use

6 (a) In this question, one mark is available for the quality of written communication.

Explain how Down's syndrome may be inherited.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [8]

Quality of Written Communication [1]

Question 6 continues on page 16

(b) State **two** methods of obtaining fetal cells for testing for Down's syndrome.

1 .....

.....

2 .....

..... [2]

(c) The number of cases of Down's syndrome occurring during a six year period at a maternity hospital was recorded. Table 6.1 shows the number of cases of Down's syndrome occurring in babies with younger and older mothers.

Table 6.1

	number of babies with Down's syndrome	
	mothers younger than 35 years	mothers aged 35 years or older
not tested before birth	1	7
tested but not detected before birth	7	2
tested and detected before birth	9	27
total	17	36

Using the information in Table 6.1,

(i) calculate the percentage of cases of Down's syndrome that were detected before birth;

Answer ..... % [1]

(ii) suggest an explanation for the differing number of cases of Down's syndrome in babies of older and younger mothers.

.....

.....

.....

.....

..... [3]

[Total: 15]