OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2805/02

Applications of Genetics

Tuesday **29 JANUARY 2002** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator

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 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	14	
2	14	
3	18	
4	16	
5	14	
6	14	
TOTAL	90	

This question paper consists of 14 printed pages and 2 blank pages.

Registered Charity Number: 1066969
[Turn over

1 An inbred variety of maize, variety **A**, with finely striped leaves was found to be resistant to the fungus that causes the disease corn leaf blight.

Plants of variety **A** were crossed with another inbred variety of maize, variety **B**, with entirely green leaves and low resistance to the fungus. The F_1 generation all had entirely green leaves and low resistance.

(a) Describe the interaction of the alleles

(i) at the locus **F/f**, controlling finely striped or entirely green leaves;

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(ii) at the locus **H/h**, controlling resistance.

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(b) Using the symbols given in **(a)**, state the genotype of variety **A**.

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In an attempt to produce plants with entirely green leaves and resistance to the fungus, plants from the F_1 generation were back crossed to variety **A**, giving the following results:

finely striped leaves and resistance	80
finely striped leaves and low resistance	20
entirely green leaves and resistance	22
entirely green leaves and low resistance	78

The ratio of phenotypes **expected** from this cross was 1 : 1 : 1 : 1.

The χ^2 (chi-squared) test was performed on these data giving a calculated value for χ^2 of 67.36.

Table 1.1

distribution of χ^2

	probability, p				
degrees of freedom	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

(c) **(i)** State the number of degrees of freedom applicable to these data.

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(ii) Use the calculated value of χ^2 and the table of probabilities provided in Table 1.1 to find the probability of the results of the cross departing significantly by chance from the expected ratio.

probability ..... [1]

(iii) State what conclusions may be drawn from the probability found in **(c)(ii)**.

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(iv) Explain the discrepancy between the actual results and those expected.

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(v) State whether the 22 plants with entirely green leaves and resistance to the fungus would breed true if interbred. Explain your answer.

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[Total : 14]

[Turn over

2 Phenotypic variation may be continuous or discontinuous.

(a) State **one** example of

(i) continuous variation;

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(ii) discontinuous variation.

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(b) Describe the differences between continuous and discontinuous variation of the **phenotype** and explain the **genetic basis** of these differences. (*In this question, 1 mark is available for the quality of written communication.*)

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For Examiner's Use

The six loci of the major histocompatibility (HLA) system each have many alleles.

(c) Explain briefly the significance of this for transplant surgery.

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[Total : 14]

3 **(a)** Explain briefly the importance of *heritability* in selective breeding.

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Estimates of heritability have been made for various traits in cattle. They are given in Table 3.1.

Table 3.1

trait	*heritability*
white spotting of coat	0.95
birth mass	0.49
milk yield	0.43
gestation length	0.35
calving interval	0.04

(b) With reference to Table 3.1, comment on the likely success of improving these traits in a selective breeding programme.

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(c) Explain how a breeder might measure the ability of a bull to sire (father) daughters with a good milk yield.

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For Examiner's Use

(d) Describe ways in which selective breeding of cattle is helped by artificial insemination and transplanting embryos into surrogates.

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[Total : 18]

[Turn over

4 A strain of the bacterium, *Streptococcus pneumoniae*, has been found which does not grow in the presence of the antibiotic vancomycin, but does not die. This vancomycin tolerance is caused by a mutation of a gene coding for an enzyme, **E**.

(a) Explain briefly how a mutation of a gene coding for an enzyme

(i) may still result in the production of a functioning enzyme;

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(ii) may result in an enzyme with reduced activity.

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(b) Explain how a mutation giving tolerance to vancomycin may spread amongst bacteria of the same and of different species.

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In 'wild type' *S. pneumoniae*, the presence of vancomycin triggers enzyme **E** to alter the shape of a gene regulator protein, **R**. This protein controls the expression of a gene coding for an enzyme which digests the bacterial cell wall. The sequence is shown in Fig. 4.1.

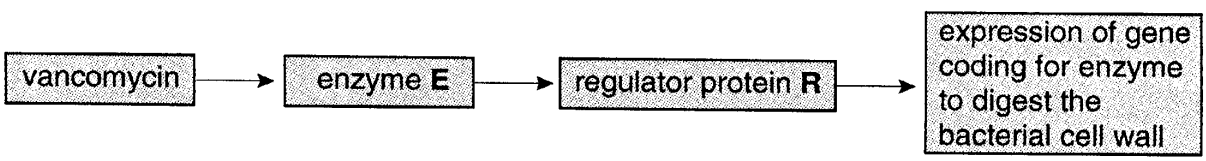

Fig. 4.1

Two mutant strains of *S. pneumoniae* were produced from the 'wild type' strain by genetic engineering:

- strain **minus E** with loss of function of enzyme **E**;
- strain **minus R** with loss of function of gene regulator protein **R**.

The 'wild type' bacteria and both mutant strains were cultured separately, treated with vancomycin and the number of living cells in each culture counted at hourly intervals after the addition of vancomycin for six hours. The results are shown in Fig. 4.2.

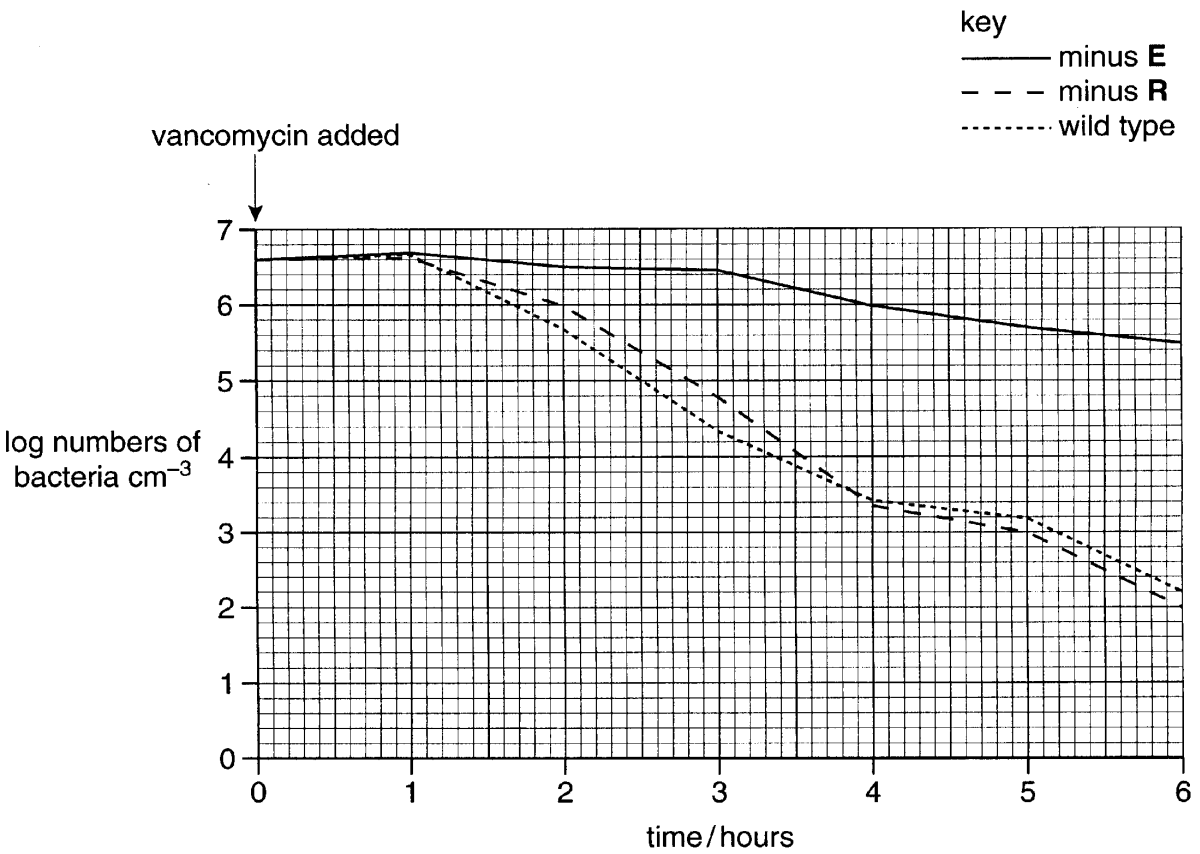

Fig. 4.2

(c) With reference to Fig. 4.2, describe the effect of vancomycin on the three strains of bacteria.

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..... [4]

Regulator protein **R** in 'wild type' bacteria inactivates the expression of the gene it controls in the **absence** of vancomycin.

(d) With reference to Fig. 4.1 and Fig. 4.2, explain how it is possible to justify this statement.

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[Total : 16]

[Turn over

5 The DNA target sites of two restriction enzymes (restriction endonucleases) are shown in Table 5.1. The point at which each enzyme cuts the DNA is shown by a vertical bar.

Table 5.1

restriction enzyme	*target site*
HaeIII	–G–G | C–C– –C–C | G–G–
HpaI	–G–T–T | A–A–C– –C–A–A | T–T–G–

(a) With reference to Table 5.1, describe the characteristics of the target sites of restriction enzymes.

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A short length of DNA is treated first with *HaeIII* and then with *HpaI*. The DNA has the following base sequence:

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

(b) State how many fragments of DNA will be present after treatment with

(i) *HaeIII*;

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(ii) *HaeIII* and *HpaI*.

..... [1]

(c) Explain why restriction enzymes act only at certain target sites in a DNA molecule.

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For Examiner's Use

(d) Outline the ways in which restriction enzymes are used in genetic engineering. (*In this question, 1 mark is available for the quality of written communication.*)

[7]

[Total : 14]

[Turn over

6 The black truffle, a culinary delicacy, is the reproductive structure of the fungus *Tuber melanosporum*. The fungus is found in Spain, France and Italy and the smell and taste vary considerably in truffles from different sources.

The DNA of truffles from different populations in France and Italy was analysed by gel electrophoresis in a process similar to that used in genetic fingerprinting. The analysis showed almost no genetic variation between the different populations.

(a) Describe briefly

(i) what happens to DNA during electrophoresis;

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(ii) how the position of DNA fragments is revealed after electrophoresis;

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(iii) how such analysis shows genetic variation or lack of variation.

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The genetic uniformity of *T. melanosporum* across its large population range suggests that it is inbred.

(b) Describe the harmful effects of inbreeding.

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(c) Suggest why genetically similar truffles from different populations vary so much in smell and taste.

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[Total : 14]