OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY

2805/02

Applications of Genetics

Friday **25 JUNE 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 18 printed pages and 2 blank pages.

For Examiner's Use

Answer **all** the questions.

1 **(a)** The synthesis of carotenoid pigments in sweet pepper fruits is controlled by two unlinked genes. As a pepper fruit ripens, the dominant allele, **A**, of one gene results in the synthesis of red pigment, whilst the recessive allele, **a**, gives yellow pigment. The recessive allele, **b**, of the second gene reduces the quantity of carotene produced by the gene **A/a** so that potentially red peppers are orange coloured and potentially yellow peppers are a paler, lemon yellow. The dominant allele **B** has no effect on the gene **A/a**.

State the colour of ripe fruit produced by pepper plants with the following genotypes:

AaBb ....

Aabb ....

aaBB ....

aabb .... [4]

(b) Two pepper plants with the genotypes **AABB** and **aabb** were crossed and the resulting F_1 generation interbred to give an F_2 generation.

Draw a genetic diagram of this cross to show:

- the phenotypes of the parent plants
- the gametes
- the genotypes and phenotypes of the F_1 and F_2 generations.

Give the ratio of phenotypes expected in the F_2 generation.

For Examiner's Use

ratio of F_2 phenotypes ....

.... [8]

[Turn over

(c) **(i)** Recessive epistasis usually results in a 9 : 3 : 4 ratio in this type of cross. The colour of these sweet pepper fruits is caused by recessive epistasis.

Suggest why the ratio is **not** 9 : 3 : 4.

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.... [2]

(ii) Suggest how allele **b** interacts with locus **A/a** to cause recessive epistasis.

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.... [1]

[Total: 15]

For Examiner's Use

2 (a) Outline the techniques used in embryo transplantation.

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.... [5]

(b) Human embryos may be frozen and stored before being given to a woman who cannot conceive naturally. Data relating to the transfer of previously frozen embryos during one year in the UK is shown in Table 2.1.

Table 2.1

origin of frozen embryo	number of times frozen embryos transferred	number of successful pregnancies	number of babies born
woman's and partner's own gametes	4533	531	638
woman's own egg and donated sperm	336	52	69
donated egg and partner's sperm	375	49	66
donated embryo	176	35	47
totals	5420	667	820

For Examiner's Use

Using the information in Table 2.1,

(i) calculate the percentage of transfers of frozen embryos that led to successful pregnancies. Show your working.

Answer = ... % [1]

(ii) comment on whether the origin of the embryo affects the success of pregnancy.

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.... [3]

(c) Explain the reasons why

(i) human embryos may be frozen and stored;

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(ii) donated gametes or donated embryos may be used.

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[6]

[Total: 15]

For Examiner's Use

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

Describe how antibiotic resistance arises and spreads in a bacterial population.

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.... [7]

Quality of Written Communication [1]

For Examiner's Use

(b) An investigation was carried out in Australia to see whether the development of antibiotic resistance in bacteria is related to the extent of antibiotic use.

Penicillin belongs to a group of antibiotics called β-lactams. A record was kept of all the β-lactam antibiotics given to 484 young children over a two year period. Nasal swabs were collected from the children at intervals. All bacteria found were tested for resistance to penicillin.

The results of the investigation are shown in Fig. 3.1.

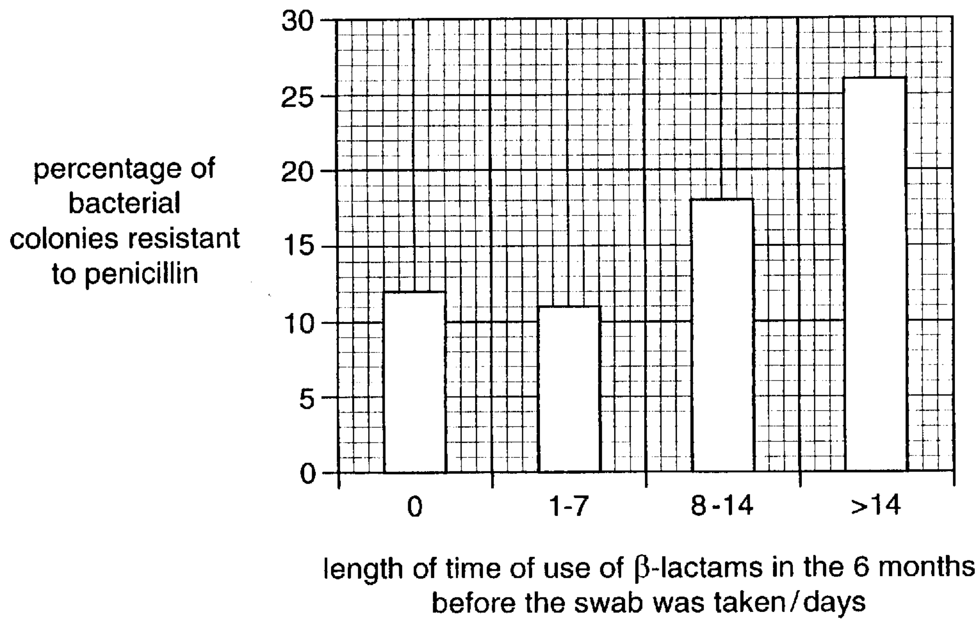

Fig. 3.1

Using the data in Fig. 3.1,

(i) describe the relationship between the length of time the antibiotic was used and the percentage of penicillin-resistant bacterial colonies;

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.... [2]

(ii) explain the presence of penicillin-resistant bacteria in swabs from children that had **not** been treated with β-lactam antibiotics.

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.... [3]

[Turn over

For Examiner's Use

(c) Suggest **two** ways of reducing the numbers of penicillin-resistant bacteria.

1 ....

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2 ....

.... [2]

[Total: 15]

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

Describe **one** use of genetic engineering in agriculture.

.... [8]

Quality of Written Communication [1]

[Turn over

For Examiner's Use

(b) An investigation was performed in 2000 into the possible spread of genetically modified DNA into maize grown in the remote mountains of Southern Mexico. Southern Mexico is the region of origin and the centre of diversity of maize. Mexico has banned the planting of transgenic maize since 1998.

Grains of native landraces of maize grown in two sites were tested for the presence of a DNA promoter sequence derived from cauliflower mosaic virus (CMV). This promoter is commonly used in transgenic maize.

Maize grains from a 30 year old museum collection in Mexico and blue maize from remote mountains in Peru were also tested for the presence of the CMV promoter sequence.

The results of the investigation are shown in Table 4.1.

Table 4.1

type of maize	presence (✓) or absence (✗) of CMV promoter DNA sequence
Mexican native landrace maize - site 1	✓ in 3 - 10% of grains
Mexican native landrace maize - site 2	✓ in 3 - 10% of grains
transgenic maize	✓ in 100% of grains
maize from museum collection in Mexico	✗
blue maize from Peru	✗

Using the information given and the results in Table 4.1, explain

(i) why grains from the museum collection in Mexico and blue maize from Peru were both tested for the presence of CMV promoter DNA;

museum collection ....

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blue maize ....

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.... [2]

For Examiner's Use

(ii) how CMV promoter DNA has been passed to native landrace maize;

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.... [2]

(iii) why the CMV promoter DNA is present in native landrace maize two years after the ban on cultivation of transgenic maize in Mexico.

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.... [2]

[Total: 15]

For Examiner's Use

5 **(a)** Transplantation of cells from the islets of Langerhans is a possible treatment for some forms of diabetes. Its use is limited by a shortage of HLA-compatible donor material.

Explain briefly the significance of the HLA genes in transplant surgery.

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.... [5]

(b) It has been suggested that the HLA allele D4 gives a susceptibility to Type 1 diabetes.

Two groups of people were tested for the presence of HLA D4:

- a group of unrelated people with Type 1 diabetes
- a control group of the same number of unaffected people.

The numbers of people with HLA D4 in the two groups are shown in Table 5.1.

Table 5.1

group	number of people with HLA D4
people with Type 1 diabetes	61
people unaffected by Type 1 diabetes	39

A chi-squared (χ^2) test can be carried out to check whether the numbers of people with HLA D4 is in agreement with an **expected** 50 : 50 distribution.

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

Σ = 'sum of'
O = observed value
E = expected value

For Examiner's Use

(i) Calculate χ^2 for the data given in Table 5.1. Show your working.

χ^2 = ... [5]

(ii) State the number of degrees of freedom applicable to these data.

.... [1]

(iii) Use the calculated value of χ^2 and the table of probabilities provided in Table 5.2 to find the probability of the number of people with and without diabetes who have the HLA D4 allele departing significantly by chance from the expected numbers.

probability (p) .... [1]

Table 5.2

Distribution of χ^2 values

	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

(iv) State what conclusions may be drawn from this probability.

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.... [3]

[Total: 15]

For Examiner's Use

6 **(a)** Describe the **genetic basis** of Huntington's disease (HD).

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.... [4]

(b) Outline the **symptoms** of HD.

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.... [3]

Question 6 continues on page 18

(c) People with HD have abnormal huntingtin protein with a long sequence of glutamine amino acids at one end.

Such people have a normal enzyme, acetyl transferase (AT), which activates gene transcription in the nucleus. Like huntingtin, AT also has a chain of glutamine amino acids. Both huntingtin and AT are found in nerve cells.

A modified form of the gene for AT, which no longer codes for the sequence of glutamines, has been introduced into human brain cells. These cells also contained the abnormal HD allele. Separate cultures were made of:

- cells with normal (unmodified) AT and abnormal huntingtin
- cells with modified AT and abnormal huntingtin.

Observation of the cultures gave the results summarised in Table 6.1.

Table 6.1

cell type	normal AT with glutamine chain abnormal huntingtin with long glutamine chain	modified AT with no glutamine chain abnormal huntingtin with long glutamine chain
observations	AT and huntingtin clump together cell dies	AT does not clump huntingtin clumps cell survives

Suggest an explanation for the results shown in Table 6.1.

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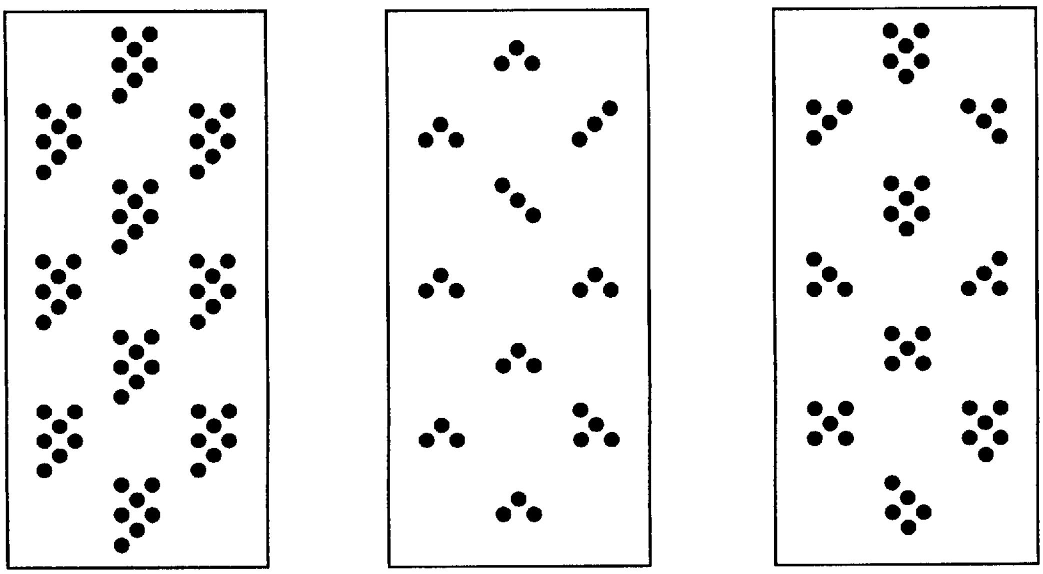
.... [3]

(d) Some *Drosophila* were genetically engineered to develop HD by expressing an HD allele for huntingtin with 93 glutamine repeats. The photoreceptor neurones of the eyes of these flies gradually degenerate. Fig. 6.1 shows drawings of the distribution of photoreceptor neurones in part of the eyes of different flies.

key: ● = one photoreceptor neurone



photoreceptor neurones of eye of normal fly — photoreceptor neurones of eye of fly expressing mutant HD allele — photoreceptor neurones of eye of fly expressing mutant HD allele but treated with chemical which allows transcription to continue

Fig. 6.1

With reference to Fig. 6.1, describe the effect on the fly photoreceptor neurones of

(i) the mutant HD allele;

....

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.... [2]

(ii) the mutant HD allele together with treatment with a chemical which allows transcription to continue.

....

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.... [2]

(e) With reference to Table 6.1 and Fig. 6.1, suggest why HD causes neurones to die.

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.... [1]

[Total: 15]

END OF QUESTION PAPER