OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2805/02

Applications of Genetics

Thursday **30 JANUARY 2003** Afternoon 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	15	
2	15	
3	15	
4	12	
5	16	
6	17	
TOTAL	90	

This question paper consists of 17 printed pages and 3 blank pages.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 Purple buds of the morning glory flower, *Ipomoea*, open into blue flowers. As the flower opens, the pH in the vacuoles of the flower epidermal cells increases.

A mutant purple-flowered morning glory plant carries recessive alleles of a gene, **I/i**, coding for a membrane-bound ion pump, and is unable to increase the pH in the vacuoles.

Both normal blue flowers and mutant purple flowers have the same anthocyanin pigment, coded by the dominant allele of the gene **A/a**. Plants with the genotype **aa** cannot produce anthocyanin and they have white flowers.

The genes **I/i** and **A/a** are **not** linked.

(a) List the genotypes of morning glory plants that result in

(i) blue flowers;

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..... [2]

(ii) purple flowers.

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..... [1]

(b) Morning glory plants with the genotypes **AAII** and **aaii** were crossed and the resulting F_1 generation were interbred to give an F_2 generation.

On the page opposite, 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.

genetic diagram:

ratio of F_2 phenotypes .....

..... [8]

[Turn over

(c) A small part of the DNA coding for the normal allele, **I**, and mutant allele, **i**, of the gene coding for the ion pump that may increase the pH of the vacuoles is shown below.

Normal allele, **I**: —TTA ATC CTG AGA TTT—

Mutant allele, **i**: —TTA ATC CTG CTG AGA TTT—

(i) State the effect of the mutant allele on the structure of the protein that forms the ion pump.

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..... [2]

(ii) Explain the likely effects of the mutant allele on the functioning of the ion pump.

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[Total: 15]

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2 *Oryza longistaminata* is a wild species of rice native to Mali in Africa. It is useless as a crop plant because of poor taste and low yield, but it is resistant to a large number of different strains of the disease known as bacterial blight or Xoo. Xoo is common throughout Asia and Africa and can reduce yields by half.

O. longistaminata was crossed with a popular variety of *Oryza sativa* with no resistance to Xoo. Plants from the interspecific hybrid 1 were selected for their resistance to Xoo and for other desirable traits and backcrossed to *O. sativa*. The process of selection and backcrossing was repeated for five generations, as shown in Fig. 2.1.

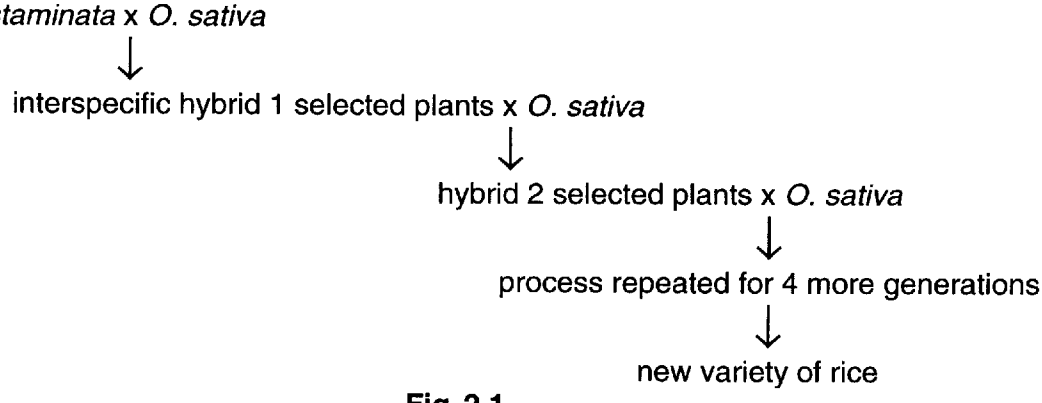

Fig. 2.1

(a) State **two** traits, other than resistance to Xoo, for which each generation of hybrids would be selected.

1. .....

2. ..... [2]

(b) With reference to Fig. 2.1, explain why selected hybrids were repeatedly backcrossed to *O. sativa*.

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(c) Explain why seeds of *O. longistaminata* should be collected and stored in a gene bank.

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(d) It is now known that resistance to Xoo is conferred by a single gene. This gene codes for a protein which spans the plasma membrane of rice cells. The part of the protein outside the cell binds to molecules released by bacteria and the part inside the cell is an enzyme which, when activated, triggers the cell's defence mechanisms.

Suggest how an enzyme can be activated by binding to a molecule released by a bacterium.

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..... [2]

(e) As an alternative to selective breeding, the gene from *O. longistaminata* has been introduced into a popular variety of *O. sativa* by genetic engineering. The resulting transgenic plants are resistant to Xoo.

Describe the advantages of producing Xoo-resistant *O. sativa* by genetic engineering rather than by selective breeding.

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..... [5]

[Total: 15]

3 **(a)** When semen is collected for storage in a sperm bank, the sperm are checked for structural damage and mitochondrial activity.

Describe briefly how sperm are **stored** in a sperm bank.

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..... [3]

(b) Damage and low mitochondrial activity reduce the viability of sperm (the ability to fertilise an egg). One method for evaluating sperm for viability is the use of a triple fluorescent stain.

- A yellow fluorescent probe can enter and stain the acrosome only when the acrosome membrane is damaged.
- A red fluorescent probe can enter and stain sperm only when the plasma membrane is damaged.
- A green probe fluoresces brightly in sperm with active mitochondria.

Fig. 3.1 shows the target sites of each stain.

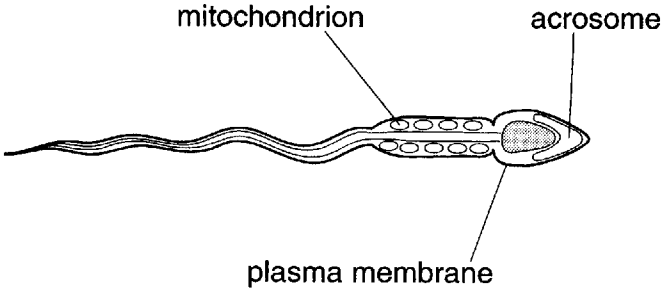

Fig. 3.1

Complete the table below, by placing ticks (✓) in the appropriate boxes to describe the appearance of **viable** sperm after using this triple stain.

	appearance of viable sperm			
target of probe	red	yellow	green	colourless
acrosome				
plasma membrane				
mitochondria				

[3]

For Examiner's Use

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

Discuss the advantages and disadvantages of artificial insemination (AI) in selective breeding of domesticated animals.

[8]

Quality of Written Communication [1]

[Total: 15]

4 *Bt* oilseed rape has been genetically modified to express a gene for a toxin (*Bt* toxin) from the bacterium *Bacillus thuringiensis*. The toxin kills susceptible caterpillars of the Diamondback moth. After the use of sprays containing *Bt* toxin, some caterpillars were found to be resistant to the toxin.

(a) Explain how some caterpillars have become resistant to *Bt* toxin.

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(b) The caterpillars of the Diamondback moth are parasitised by a wasp, which lays its eggs inside them. The developing wasp larvae feed on the tissues of the caterpillars, killing them.

An experiment was set up to see whether planting *Bt* oilseed rape could affect the wasp population.

Groups of *Bt*-susceptible and *Bt*-resistant Diamondback caterpillars were each fed either *Bt* oilseed rape or non-*Bt* oilseed rape leaves. The percentage of parasitised caterpillars from which adult wasps emerged was recorded. The results are shown in Table 4.1.

Table 4.1

type of caterpillar	*Bt*-susceptible		*Bt*-resistant	
type of leaf	*Bt* oilseed rape	non-*Bt* oilseed rape	*Bt* oilseed rape	non-*Bt* oilseed rape
percentage of parasitised caterpillars from which adult wasps emerged	0 (caterpillars died before the wasp larvae completed development)	63	54	56

With reference to Table 4.1, explain whether or not

(i) growing *Bt* oilseed rape instead of non-*Bt* oilseed rape could affect **food chains**;

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(ii) there is any evidence that *Bt* toxin kills wasp larvae.

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(c) State **two** benefits and **two** hazards of genetic engineering in agriculture.

benefit 1 .....

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benefit 2 .....

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hazard 1 .....

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hazard 2 .....

..... [4]

[Total: 12]

5 **(a)** It has recently been discovered that intact fetal cells can be found in the blood plasma of pregnant women and used in the genetic screening of fetuses early in pregnancy.

Explain briefly what is meant by *genetic screening*.

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(b) The fetal cells are treated with fluorescent DNA probes, each specific for a particular chromosome, and then analysed by fluorescence microscopy. A single, bright fluorescent spot can be seen wherever a probe binds to its specific chromosome.

Explain why a DNA probe binds only to a specific chromosome.

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(c) Fetal cells from the plasma of two pregnant women, **A** and **B**, were treated with probes for chromosomes 21 and Y. The results of the microscopical analysis are shown in Table 5.1.

Table 5.1

	number of spots of fluorescence seen	
source of fetal cells	probe specific to chromosome 21	probe specific to Y chromosome
pregnant woman **A**	3	0
pregnant woman **B**	2	1

With reference to Table 5.1, explain the results of the genetic screening of fetal cells from

(i) pregnant woman **A**;

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(ii) pregnant woman **B**.

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(d) Explain the need for genetic counselling before and after such genetic screening.

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..... [6]

[Total: 16]

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6 **(a)** A complete gene map and sequence of the human major histocompatibility (HLA) system on chromosome 6 was published in 1999 as part of the Human Genome Project.

Describe briefly the significance of the Human Genome Project to human health and disease.

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Part of the gene map of chromosome 6 is shown in Fig. 6.1.

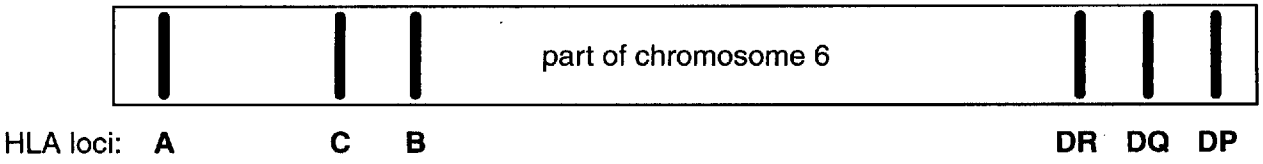

Fig. 6.1

Each of the genes shown in Fig. 6.1 has a large number of alleles and before transplant surgery is performed, the best possible match of the HLA system of donor and recipient has to be assured.

The alleles at **four** of the HLA loci (**A**, **B**, **DR** and **DQ**) of three pairs of potential donors and recipients of transplant tissue are shown in Table 6.1. The alleles at these loci are numbered.

Table 6.1

		HLA alleles	
	HLA locus	potential donor	potential recipient
pair 1	**A**	2, 2	2, 2
	B	13, 44	13, 44
	DR	7, 11	7, 11
	DQ	2, 7	2, 7
pair 2	**A**	11, 24	11, 24
	B	15, 18	15, 18
	DR	2, 2	2, 3
	DQ	1, 1	1, 2
pair 3	**A**	24, 29	24, 30
	B	44, 14	14, 14
	DR	7, 11	1, 1
	DQ	2, 7	1, 7

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

With reference to Table 6.1, explain why, in transplant surgery, it is necessary to match donors and recipients.

Comment on the suitability of the matches shown in Table 6.1.

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Quality of Written Communication [1]

(c) Explain why a suitable donor is more likely to be found within the family of the recipient than outside it.

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[Total: 17]