THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE
BIOLOGY
Applications of Genetics

2805/02

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator
- Ruler (cm/mm)

Wednesday 17 June 2009
Afternoon

Duration: 1 hour 30 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- 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.
- This document consists of **16** pages. Any blank pages are indicated.

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

Turn over

Answer **all** the questions.

1 **(a)** An isolated population of bighorn sheep on Ram Mountain, Alberta, Canada, has been monitored for more than 30 years.

During most summers, the adult sheep have been captured, weighed and the length of their curled horns measured. Mass and horn length of bighorn sheep are both examples of continuous variation of the phenotype.

(i) Describe the differences between continuous and discontinuous variation of the phenotype.

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.... **[3]**

(ii) Explain the genetic basis of **continuous** variation.

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(b) In bighorn sheep, the heritability of mass has been found to be 0.4 and the heritability of horn length, 0.7.

Explain what is meant by *heritability*.

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.... **[3]**

(c) Male bighorn sheep with horns that have reached a minimum size can legally be shot as 'trophy' rams. In 1996, the minimum horn size was increased because of concerns that hunting was altering the gene pool of the isolated population. It had been found that:

- the 'breeding value' for mass and horn length of trophy rams was greater than that of non-trophy rams
- the greater the breeding value for horn length, the younger the ram was when it was shot
- the greater the breeding value for horn length, the fewer offspring the ram sired in a lifetime.

The changes in the mean mass of adult rams in the population and in the mean length of their horns from 1975 to 2000 are shown in Fig. 1.1.

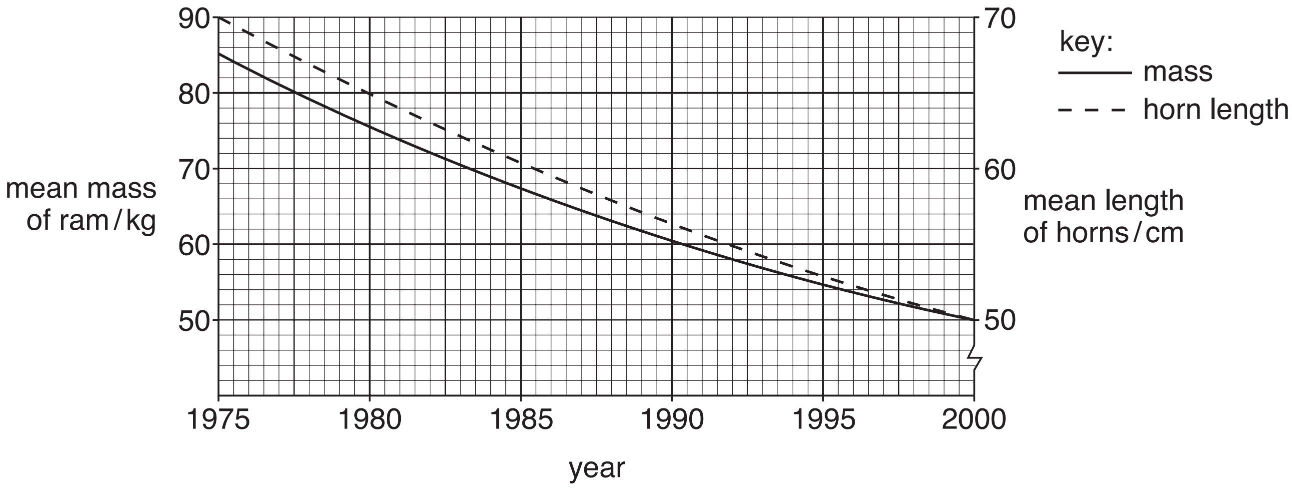

Fig. 1.1

(i) Describe how the 'breeding value' of a ram could be determined.

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(ii) With reference to Fig. 1.1, explain the changes in mean mass and mean horn length of this population of adult rams.

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[Total: 15]

2 **(a)** Wild-type fruit flies, *Drosophila melanogaster*, have red eyes. The red pigment, drosopterin, is derived from the amino acid tryptophan by a series of steps, each controlled by a different gene.

Flies that were each heterozygous for two of the genes, **A**/**a** and **B**/**b**, were mated. The offspring had three different eye colours in a ratio of 9 red-eyed flies : 3 brown-eyed flies : 4 cinnabar-eyed flies. There were approximately equal numbers of male and female flies with each phenotype.

The genotypes associated with each phenotype are shown in the Punnett square of the cross in Table 2.1.

Table 2.1

female parent **AaBb**

		genotypes and phenotypes of offspring			
	gametes	**AB**	**Ab**	**aB**	**ab**
male parent **AaBb**	**AB**	AABB red eyes	AABb red eyes	AaBB red eyes	AaBb red eyes
	Ab	AABb red eyes	AAbb brown eyes	AaBb red eyes	Aabb brown eyes
	aB	AaBB red eyes	AaBb red eyes	aaBB cinnabar eyes	aaBb cinnabar eyes
	ab	AaBb red eyes	Aabb brown eyes	aaBb cinnabar eyes	aabb cinnabar eyes

With reference to Table 2.1 and the information provided,

(i) state precisely the name given to this type of interaction between genes;

.... **[2]**

(ii) describe the effects of the two genes on eye colour in *D. melanogaster*;

*gene **A/a*** ....

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*gene **B/b*** ....

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.... **[4]**

(iii) explain whether or not there is any evidence from the 9 : 3 : 4 ratio of phenotypes that the two genes, **A**/**a** and **B**/**b**, are on the same chromosome;

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(iv) assuming that the two genes code for enzymes involved in drosopterin production, suggest an explanation for the gene interaction in the pathway of drosopterin production.

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(b) The expected results from the Mendelian dihybrid cross described in **(a)** would be **four** different phenotypes in a ratio of 9 : 3 : 3 : 1.

The phenotypes of 160 randomly chosen offspring from this cross were recorded. The expected and actual numbers of flies with each phenotype are shown in Table 2.2.

Table 2.2

	numbers of flies with each phenotype			
phenotypes	red eyes	brown eyes	cinnabar eyes	another colour eyes
expected numbers	90	30	30	10
actual numbers	96	26	38	0

A χ^2 (chi-squared) test was performed on these data to determine whether the results differed significantly from the expected Mendelian ratio.

The probability was found to be less than 0.01.

State what conclusions may be drawn from this probability.

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.... **[3]**

[Total: 15]

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PLEASE DO NOT WRITE ON THIS PAGE

QUESTION 3 STARTS ON PAGE 8

3 (a) It has proved to be very difficult to establish a gene bank for the coconut palm, *Cocos nucifera*, for the following reasons:

- the very large seeds cannot be stored in a conventional seed bank
- *C. nucifera* does not have a natural method of asexual reproduction.

Biologists in Sri Lanka have found that a reliable way to propagate *C. nucifera* by means of tissue culture is to use immature embryos from 7- to 8-month-old coconuts.

Each embryo is dissected and grown into callus, which can then be used to produce many more embryos.

(i) Describe how dissected immature embryos can be grown into callus.

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(ii) Suggest **one other** way, not involving tissue culture, of establishing a gene bank for *C. nucifera*.

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

In 2007, the Norwegian government began work on the Svalbard International Seed Vault. The vault is at the end of a 120-metre tunnel cut into the rock of a mountain on the island of Spitzbergen, within the Arctic circle.

The vault is intended to house duplicate seed samples of the world's crop plants in order to protect them from any disasters that might affect the seed banks that hold the rest of each sample.

The running costs of the vault are met by the Global Crop Diversity Trust, which claims that the vault offers the best conditions for seed storage on Earth. The vault is only opened in winter, when the temperature on Spitzbergen falls to –18 °C.

Critics of the scheme point out that, even with optimal storage conditions, most seeds lose their ability to germinate after about 20 years.

Describe the optimum conditions for storing seeds and explain how the problem of the limited storage life of many seeds is overcome.

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Quality of Written Communication **[1]**

[Total: 15]

4 **(a)** The mating of Antarctic fur seals on a beach on South Georgia was studied. During the main breeding season the males rarely moved from their chosen place on the beach. Females, however, moved around the beach after their arrival.

The percentages of females within particular distances of the nearest male, and of females moving particular distances in order to mate, are shown in Table 4.1.

Table 4.1

distance / m	percentage of females within this distance of nearest male	percentage of females moving this distance to mate
0 – 4	99	53
5 – 9	1	30
10 – 14	–	9
15 – 19	–	3
20 – 24	–	3
25 – 29	–	1
30 – 34	–	1

Explain whether or not the data in Table 4.1 support the suggestion that female fur seals select their mates.

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(b) Tissue samples were taken from each mating pair of fur seals so that their DNA could be analysed by gel electrophoresis to determine whether or not the male and female were related to one another.

(i) Describe how gel electrophoresis can be used to analyse DNA.

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(ii) Explain how such analysis can reveal whether or not a male and female are related.

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(iii) The results showed that those females who do **not** mate with the nearest male tend to mate with unrelated males.

Describe the advantages of female fur seals mating with unrelated males.

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(c) A female fur seal's ability to assess whether or not a male is a close relative may be associated with the major histocompatibility (HLA) system. Although there are a very large number of possible HLA genotypes in a mammalian population, closely related individuals often share HLA genotypes.

Explain,

(i) the existence of a very large number of possible HLA genotypes in a population of mammals;

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.... **[2]**

(ii) why closely related individuals often share HLA genotypes.

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[Total: 15]

5 **(a)** The hormone treatment given to women in preparation for *in vitro* fertilisation (IVF) often results in considerable discomfort.

Suggest why such hormone treatment is a necessary preparation for IVF.

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(b) In the hope of reducing the discomfort of 'standard' IVF treatment, Dutch scientists proposed a so-called 'mild' form of treatment.

Equal numbers of women were given mild or standard treatment, but all patients who were given mild treatment received only **one** embryo, whilst women who were given standard treatment received **two** embryos.

A comparison of the outcomes of the two treatments is shown in Table 5.1.

Table 5.1

treatment	mild treatment	standard treatment
number of embryos received	1	2
percentage of pregnancies resulting in live births	43.4	44.7
percentage of pregnancies resulting in multiple births	0.5	13.1
discomfort	no significant differences	

With reference to the information given,

(i) compare the success of mild and standard treatments;

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(ii) comment on the percentages of pregnancies resulting in multiple births in both treatments.

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

Discuss the social **and** ethical implications of the use of IVF in humans.

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Quality of Written Communication **[1]**

[Total: 15]

6 **(a)** Down's syndrome in humans usually results from acquiring an extra chromosome 21 from the mother.

Explain how the presence of an extra chromosome such as chromosome 21, occurs.

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(b) An inherited form of Down's syndrome results from the translocation of part of chromosome 21 onto another chromosome.

Examination of the chromosomes of a male carrier of the condition showed a translocation of part of a chromosome 21 onto a chromosome 14 (a 14-21 translocation).

These chromosomes in a **diploid** nucleus from a testis cell of the carrier are shown in Fig. 6.1.

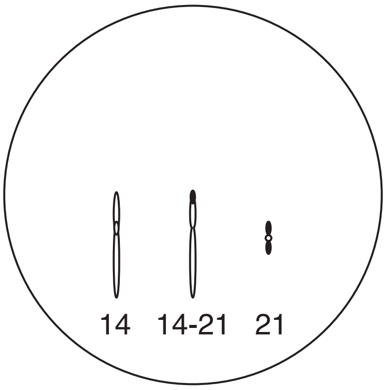

Fig. 6.1

State the chromosome content of spermatozoa, which, when they fertilise normal egg cells result in:

(i) a child with no chromosomal abnormalities;

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.... **[1]**

(ii) a child with Down's syndrome;

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.... **[1]**

(iii) a child who is a carrier of Down's syndrome.

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.... **[1]**

(c) A small section of chromosome 21, the so-called Down's syndrome critical region (DSCR) causes the abnormalities associated with the syndrome.

Precise regulation of gene expression by a particular group of transcription factors is essential for normal development. In inactive cells the transcription factors are found in the cytoplasm, but in active cells they move into the nucleus.

In humans, a gene, **D**, has been identified in the DSCR that affects a transcription factor. Mice that have been genetically engineered to over-express **D** show many of the symptoms of Down's syndrome.

The nuclear / cytoplasmic ratio of the transcription factors and the expression of the genes that they control was measured in the genetically engineered mice and in normal mice. The results are shown in Table 6.1.

Table 6.1

	normal mice	mice genetically engineered to over-express **D**
nuclear / cytoplasmic ratio of transcription factors	2.75	0.75
relative expression of genes controlled by these transcription factors	×12	×1

With reference to the information given in Table 6.1 and above,

(i) describe the effect of the over-expression of the human gene, **D**, in mice;

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(ii) suggest why the genetically engineered mice show many of the symptoms of Down's syndrome.

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(d) Suggest what benefits and hazards arise from genetically engineering mice to express human genes.

benefits ....

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hazards ....

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.... **[4]**

[Total: 15]

END OF QUESTION PAPER