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)

Monday 26 January 2009
Morning

Duration: 1 hour 30 minutes

CUP/T57206

2805502

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 **20** 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**	

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Answer **all** the questions.

1 **(a)** *Miscanthus* is a large, perennial grass which is grown in Europe as a source of solid biofuel. Most of the crops originate from a single clone of a sterile hybrid, **H**, obtained from a cross between *M. sacchariflorus* and *M. sinensis*, as shown in Fig. 1.1.

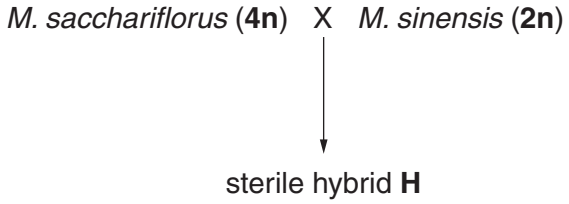

Fig. 1.1

Explain why the hybrid, **H**, shown in Fig. 1.1 is sterile.

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(b) The cost of planting **H** is high, since it must be propagated either by dividing the plants' rhizomes or by producing plantlets from tissue culture.

Outline a suitable procedure for producing plantlets from tissue culture.

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(c) Analysis of six regions of the DNA of 31 different examples of **H** stored in a gene bank showed very little genetic variation.

Explain:

(i) what is meant by a *gene bank*,

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(ii) how the DNA from different examples of **H** can be analysed to show the presence or absence of genetic variation.

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[Total: 15]

2 Many varieties of rice, *Oryza sativa*, die quickly when totally submerged by flood water.

In 2006, a gene, *Sub1A*, on rice chromosome 9 was found to be involved in tolerance of prolonged submergence.

An allele, *Sub1A-1*, was found only in submergence-tolerant rice. Varieties that are submergence-intolerant either have a second allele, *Sub1A-2*, or lack the gene altogether.

(a) *Sub1A-1* codes for a protein that controls the transcription of the gene for alcohol dehydrogenase. This gene is activated when the plant is in anaerobic conditions.

Explain the importance to submerged rice plants of producing alcohol dehydrogenase.

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(b) Alleles *Sub1A-1* and *Sub1A-2* differ by one nucleotide. The amino acid, serine, in the protein produced by submergence-tolerant plants is replaced by proline in submergence-intolerant plants.

Suggest why the protein produced by submergence-intolerant plants is inactive.

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(c) A variety of submergence-intolerant rice, which lacked the gene *Sub1A*, was genetically engineered to express *Sub1A-1*.

Typically, submergence-intolerant plants respond to submergence by elongating rapidly as a result of:

- increased internal concentration of ethene, trapped as bubbles in the plants,
- increased sensitivity to gibberellin.

The mean heights of three types of rice plants were compared before and after 11 days of submergence in water. The types of rice plants were:

- submergence-intolerant plants, **I**
- transgenic submergence-intolerant plants expressing *Sub1A-1*, **I^+**
- submergence-tolerant plants, **T**.

The results are shown in Fig. 2.1.

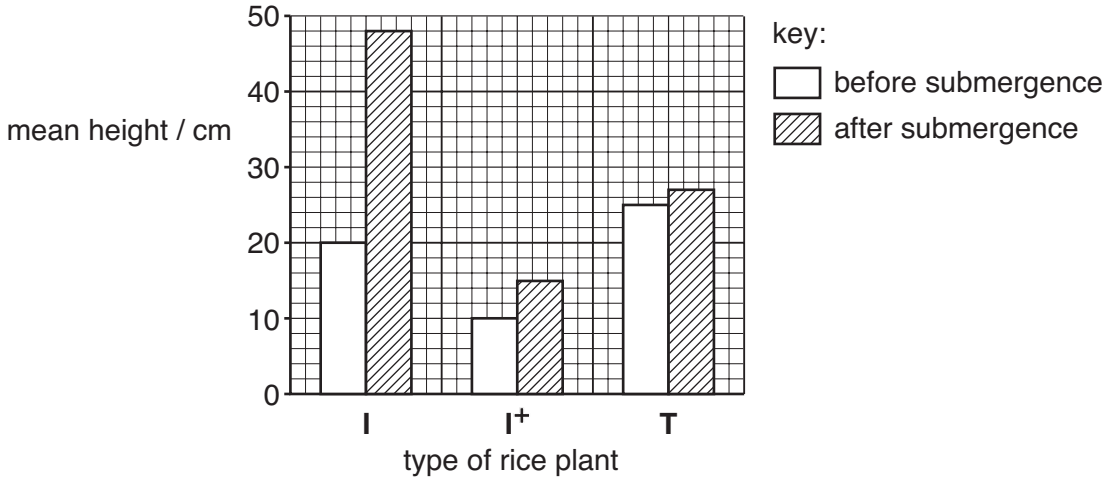

Fig. 2.1

With reference to Fig. 2.1:

(i) describe the effect of submergence on the three types of rice plants,

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(ii) suggest **two** reasons why the response shown by the submergence-intolerant plants, **I**, may lead to their death.

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(d) The allele *Sub1A-1* could be introduced into a high-yielding variety of submergence-intolerant rice either by genetic engineering or by selective breeding.

Describe **three** advantages of using genetic engineering, rather than selective breeding, to introduce the allele.

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[Total: 15]

3 The world's largest lizard, the Komodo dragon, is an endangered species. More than 50 zoos worldwide have been cooperating in a captive breeding programme to increase the number of lizards.

Zoos usually keep more females than males, and these extra females are often isolated from the males to reduce the risk of aggression.

In 2006, the only two sexually mature female Komodo dragons in the UK both produced eggs, despite having been isolated from males.

(a) Genetic fingerprinting showed that the eggs had been produced by asexual reproduction. All the embryos were diploid and were homozygous at **all** loci. However, the offspring of each female were **not** clones.

Explain these findings.

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(b) In lizards, unlike mammals, the female is the heterogametic sex, with dissimilar sex chromosomes, referred to as **W** and **Z**. The male is the homogametic sex, **ZZ**.

The viable embryos produced asexually by an isolated female, **WZ**, were all male.

Explain why.

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

Asexual reproduction of Komodo dragons is an extreme form of inbreeding.

Explain why it may be unwise for those zoos taking part in the captive breeding programme to isolate some female Komodo dragons from males.

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Quality of Written Communication **[1]**

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4 **(a)** Describe how a population of bacteria can become resistant to an antibiotic.

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(b) It is often assumed that bacteria that are resistant to an antibiotic are at a disadvantage compared with antibiotic-sensitive bacteria, when the antibiotic is no longer present in the environment. It is assumed that restricting the use of antibiotics would allow resistant strains to be replaced by sensitive strains.

To test this assumption, antibiotic-sensitive *Escherichia coli* were grown in the presence of the antibiotic streptomycin. This gave rise to a streptomycin-resistant strain, **str**, with a single base substitution in its DNA.

The rates at which the sensitive strain and **str** synthesised a particular protein were measured as an indication of the ability of **str** to compete with the sensitive strain.

The sensitive strain and **str** were then cultured separately in the **absence** of streptomycin for a total of 180 generations.

Bacteria from the final (180th) generation of each strain were tested for streptomycin resistance and the rate of protein synthesis measured again. The mutated DNA triplet code was checked for any change. The results are shown in Table 4.1.

Table 4.1

strain of *E. coli*	generation	DNA sequence of mutated triplet	resistance to streptomycin	rate of protein synthesis / number of amino acids added per second
sensitive	first	TTT	sensitive	18
	final	TTT	sensitive	20
str	first	TTG	resistant	9
	final	TTG	resistant	18

With reference to Table 4.1:

(i) explain whether or not, in the absence of the antibiotic, **str** is at a disadvantage to the sensitive strain in the first and final generations,

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(ii) suggest how the differences between the first and final generations of bacteria may have occurred,

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(iii) comment on the likely success of attempting to counteract the problem of antibiotic-resistance in bacteria by restricting the use of antibiotics.

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5 Embryos produced by *in vitro* fertilisation (IVF) may be screened by means of pre-implantation genetic diagnosis (PGD). PGD can be used to detect the presence of specific mutant alleles or to count the number of chromosomes.

In PGD, one cell is removed from the embryo at the 8-cell stage for testing.

Most chromosome abnormalities of an embryo lead to spontaneous abortion, but some, such as those involving three examples (trisomy) of the X chromosome, or of autosomes 13, 18 or 21, may result in live births showing recognised syndromes.

DNA probes attached to different coloured fluorescent stains are used to identify specific chromosomes. Fig. 5.1 shows the nucleus of an embryonic cell after staining for the X chromosome and for autosomes 13, 18 and 21. The different fluorescent colours are represented by different degrees of shading.

PGD was recommended because the egg used in IVF came from a woman aged 40 years.

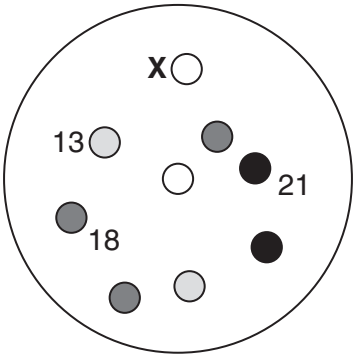

Fig. 5.1

(a) Explain why PGD was recommended for the 40 year-old expectant mother.

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(b) With reference to Fig. 5.1, comment on the results of the test.

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

Describe the techniques used in embryo transplantation in **livestock**.

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Quality of Written Communication **[1]**

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6 **(a)** Cystic fibrosis (CF) is caused by failure of a protein ion channel, the cystic fibrosis transmembrane conductance regulator (CFTR), which spans the plasma (cell surface) membrane.

Describe the inheritance of CF.

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(b) A flow of ions through CFTR channels is needed for normal functioning of epithelia of the lungs and gut.

Explain what happens when the CFTR ion channels fail to work properly or are missing.

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(c) The ion channel is opened when ATP from the cell cytoplasm binds to it. Hydrolysis of the ATP closes the channel again.

Some mutations that give rise to CF result from changing one amino acid in the region of CFTR that is thought to bind ATP.

The effect of different concentrations of ATP on opening two of these altered channels, **A** and **B**, was compared with the effect on normal CFTR. The results are shown in Fig. 6.1.

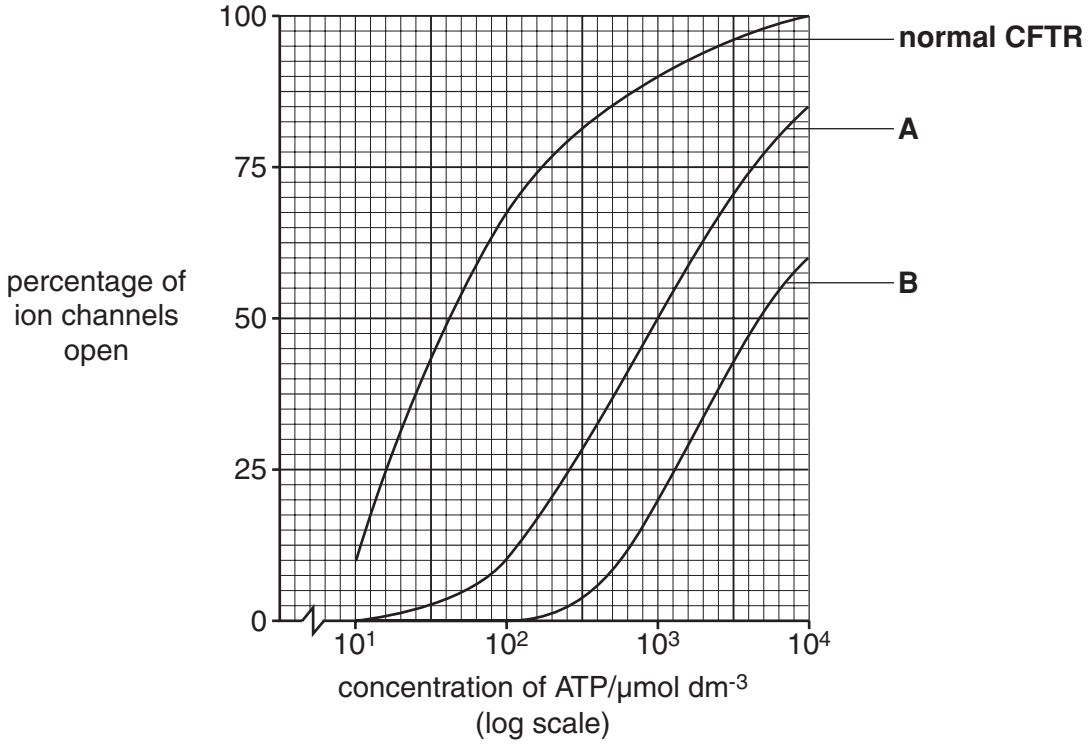

Fig. 6.1

With reference to Fig. 6.1:

(i) compare the effect of increasing ATP concentration on the three different ion channels,

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(ii) explain whether or not the information given supports the suggestion that **A** and **B** each have a different amino acid in the region of the protein that binds ATP, compared with normal CFTR.

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(d) As a result of the most common mutation in the *CFTR* gene, the encoded CFTR does not become part of plasma membranes, and so is non-functional. When put into membranes, experimentally, the ion channel functions almost as well as normal CFTR.

Suggest why this is so.

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[Total: 15]

END OF QUESTION PAPER

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