OCR
RECOGNISING ACHIEVEMENT

**ADVANCED GCE** **2805/02**

**BIOLOGY**

Applications of Genetics

**WEDNESDAY 18 JUNE 2008** Afternoon

Time: 1 hour 30 minutes

Candidates answer on the question paper.
**Additional materials:** Electronic calculator
Ruler (cm/mm)

*CUP/T39888*

| Candidate Forename | | Candidate Surname | |
|---|---|---|---|

| Centre Number | | | | | | Candidate Number | | | | |
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**INSTRUCTIONS TO CANDIDATES**

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or 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.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

**INFORMATION FOR CANDIDATES**

- The number of marks for each question 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.

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

This document consists of **15** printed pages and **1** blank page.



**[Turn over**

Answer **all** the questions.

**1** A pure-breeding variety of tomato plant, variety **A**, produced red fruit which remained green at their bases even when ripe.

Plants of variety **A** were crossed with another pure-breeding variety, **B**, with orange fruit which have no green bases when ripe. The $F_1$ generation plants all had red fruit with green bases.

**(a)** Describe the interaction of the alleles,

**(i)** at the locus **G**/**g**, controlling green-based or not green-based fruit;

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**(ii)** at the locus **R**/**r**, controlling red or orange fruit.

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

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**(c)** Plants from the $F_1$ generation were test crossed (backcrossed) to variety **B**. The ratio of phenotypes expected in a dihybrid test cross such as this is 1 : 1 : 1 : 1.

Using the symbols given in **(a)**, draw a genetic diagram of the test cross to show that the expected ratio of offspring phenotypes is 1 : 1 : 1 : 1.

[4]

**(d)** Two hundred randomly chosen offspring from the test cross described in **(c)** had the following phenotypes:

| | |
|---|---|
| red fruit with green bases | 55 |
| red fruit with no green bases | 45 |
| orange fruit with green bases | 43 |
| orange fruit with no green bases | 57 |

The $\chi^2$ (chi-squared) test was performed on these data, giving a calculated value for $\chi^2$ of 3.2.

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

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**Table 1.1**

Distribution of $\chi^2$ 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 |

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

probability ........................................................................................................ [1]

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

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**(e)** Experiments have shown that loci **G**/**g** and **R**/**r** are on the same chromosome of the tomato plant genome. The two loci are 44 map units apart.

Explain how the results of the test cross shown in **(d)** could occur when the two loci are on the same chromosome.

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[Total: 15]

**2** Bread wheat is a hexaploid (**6n**) plant, with three sets of paired chromosomes. The likely origin of hexaploid bread wheat from diploid wild grasses is shown in Fig. 2.1.

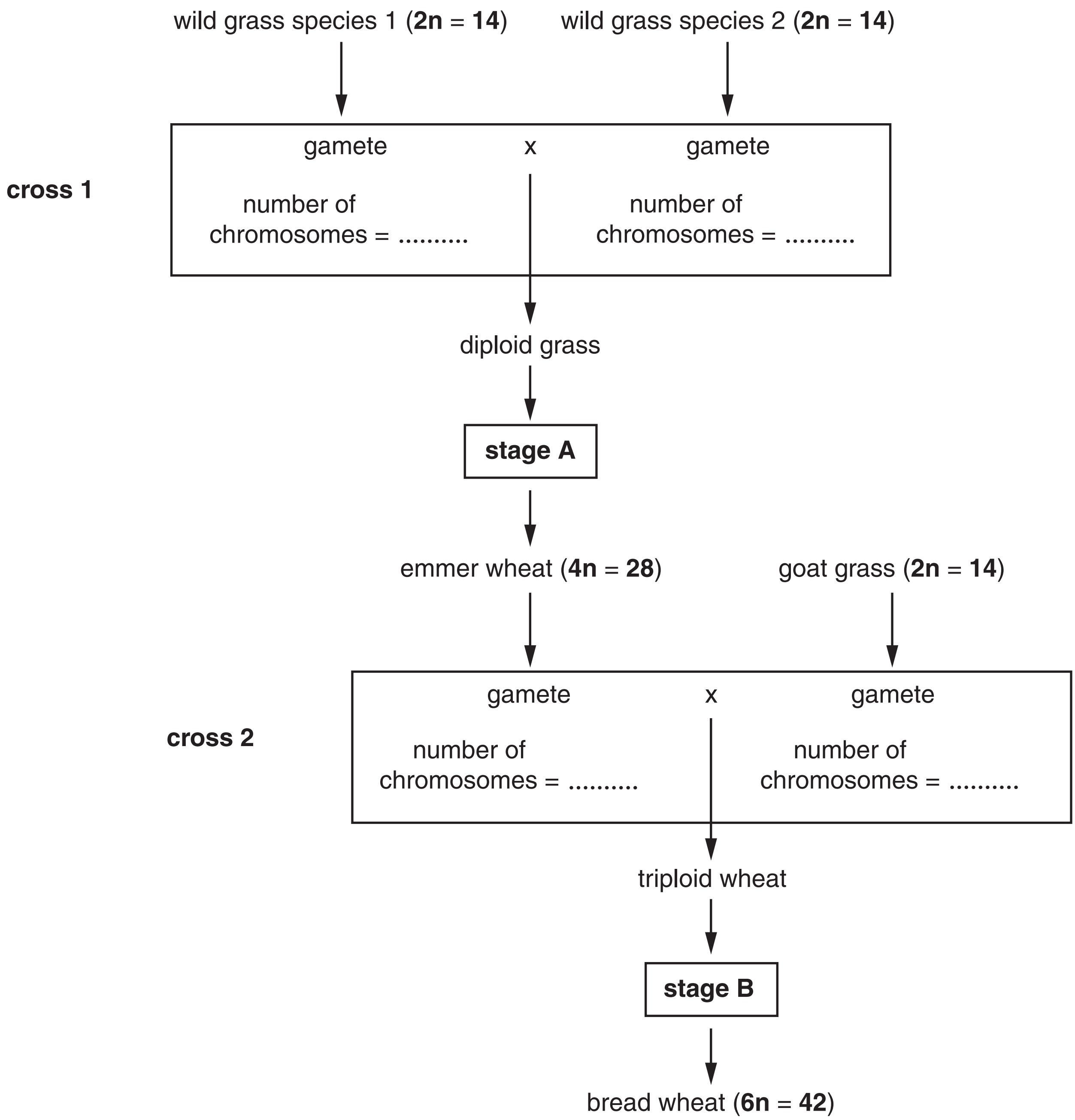


**Fig. 2.1**

**(a)** **(i)** **Write into the spaces in Fig. 2.1** the numbers of chromosomes in the gametes involved in **cross 1** and **cross 2**. [2]

**(ii)** With reference to Fig. 2.1, explain what happened at **stages A** and **B** to give emmer wheat and bread wheat respectively.

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**(b)** For many years, plant breeders have selectively bred wheat varieties with progressively higher yields. However, bread wheat cannot be interbred with diploid species of grass to establish a variety of wheat with new traits.

Explain why bread wheat cannot be interbred with diploid species of grass to establish new varieties of wheat.

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

The International Maize and Wheat Improvement Centre (CIMMYT) in Mexico has re-created **cross 2** and **stage B** of Fig. 2.1 by interbreeding different varieties of wild emmer wheat and goat grass. In this way more than 1000 varieties of hexaploid 'synthetic wheat' have been produced which can then be interbred with bread wheat.

Explain the need for CIMMYT to maintain seed banks of emmer wheat and goat grass.

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Quality of Written Communication [1]

[Total: 15]

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**3** **(a)** Female pseudoscorpions mate with more than one male and carry their mixed brood of offspring before giving birth to the whole brood at one time.

In order to compare the outcomes of inbreeding and outbreeding, virgin females underwent various matings including the following:

**NN** – mated with two males not related to the female or to each other (the usual mating in the wild);

**BB** – mated with two of the female's brothers;

**BN** – mated with a brother and with a non-related male.

The mean number of live offspring produced per female and the percentage of females aborting their brood before birth are shown in Fig. 3.1.

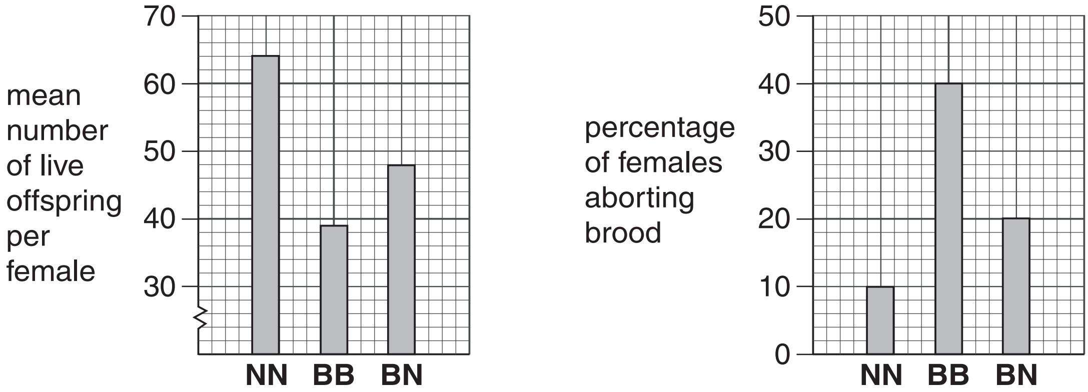


**Fig. 3.1**

With reference to the information in Fig. 3.1, describe the effect of outbreeding on reproductive success in pseudoscorpions.

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**(b)** Explain the effect of outbreeding on reproductive success.

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**(c)** Sometimes, in selective breeding programmes, it is necessary to inbreed organisms.

Describe **one** circumstance in which such inbreeding is necessary.

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**(d)** Sometimes, captive breeding populations of endangered species are established. Individuals, whose relationships are usually unknown, are taken from the wild and bred in captivity. The relationships of these individuals are determined by genetic fingerprinting.

Explain briefly how genetic fingerprinting can be used to keep inbreeding of captive populations to a minimum.

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**(e)** The aims of selective breeding and of maintaining a captive breeding population of an endangered species are very different.

Explain:

**(i)** why selective breeding is carried out;

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**(ii)** in what ways maintaining a captive breeding population of an endangered species differs from that of selective breeding.

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**4** **(a)** Describe the role of a sperm bank in breeding livestock.

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**(b)** The viability of samples of sperm that have been stored in a sperm bank depends on the rates at which they are cooled and thawed.

- Sperm cooled too quickly do not lose water to their surroundings and therefore develop intracellular ice crystals.
- Sperm cooled too slowly dehydrate too much, decreasing their volume below a critical value.
- Rapid thawing ensures that any small ice crystals that are present remain small.

Samples of human sperm were cooled to –196 °C at five different rates and then thawed slowly (1 °C $min^{-1}$) or rapidly (400 °C $min^{-1}$). The mean percentage of sperm with undamaged plasma (cell surface) membranes was then determined. The results are shown in Fig. 4.1. Sperm with damaged plasma membranes cannot fertilise an egg without assistance.

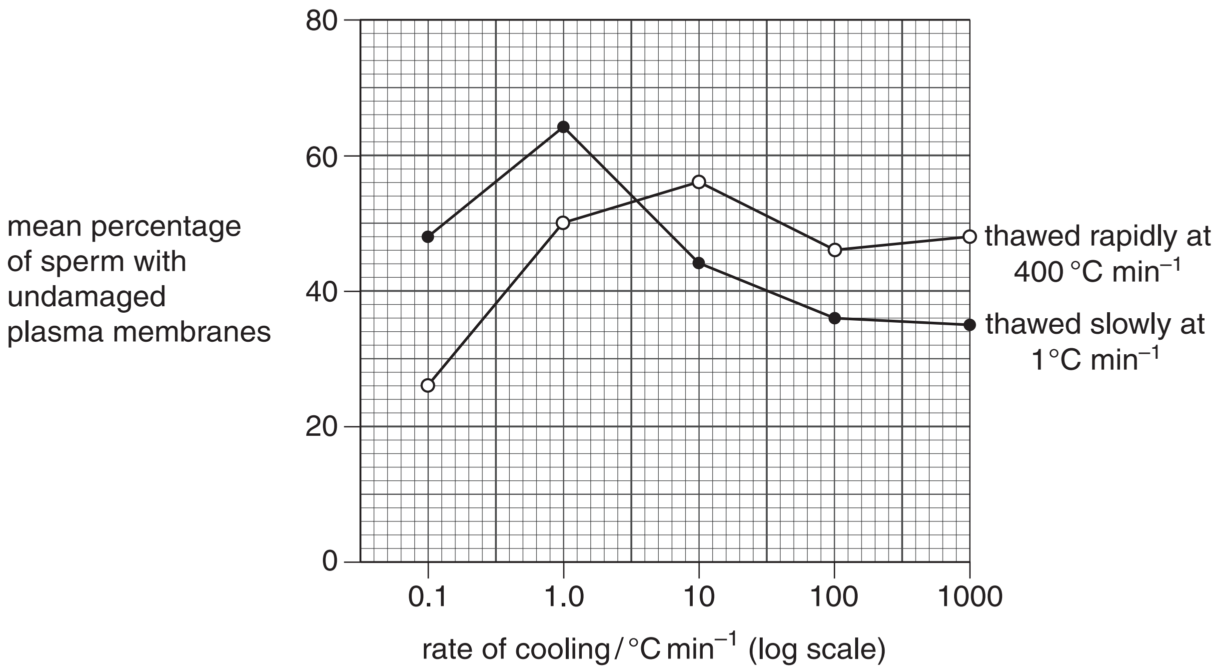


**Fig. 4.1**

With reference to Fig. 4.1 and the information given in the bullet points:

**(i)** state how human sperm should be cooled and thawed to produce least damage to their plasma membranes;

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**(ii)** explain how intracellular ice crystals may damage sperm;

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**(iii)** suggest why slow thawing and rapid thawing of the sperm samples do not give the same results.

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**(c)** Comment on the ethical implications of the use of artificial insemination (AI) in humans.

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**5** **(a)** Halo blight is an economically important disease of common bean plants. It is caused by the bacterium, *Pseudomonas phaseolicola*.

Bacteria carrying the gene *avrPphB* secrete a protein into the bean plant. This may be recognised by a protein encoded by one of the plant's resistance genes. When a bacterial protein is recognised by a plant protein, a so-called hypersensitive resistance reaction is triggered and the plant becomes resistant to the infection.

Suggest how a plant protein might recognise a bacterial protein.

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**(b)** A strain of *P. phaseolicola* expressing *avrPphB* was used to infect leaves from a resistant bean plant. Surviving bacteria were collected and transferred to fresh resistant leaves. This transfer was repeated many times and, each time, the proportions of bacterial colonies able to cause disease and to express *avrPphB* were determined.

The results are shown in Fig. 5.1.

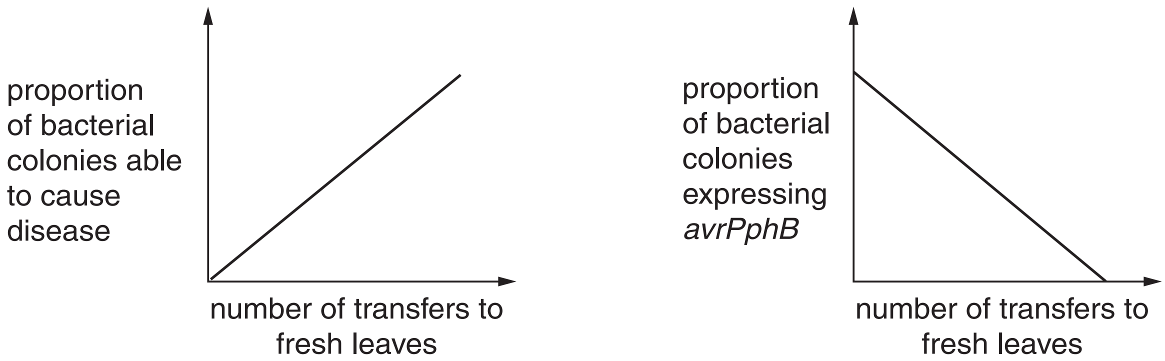


**Fig. 5.1**

With reference to the information in Fig. 5.1, explain why repeated exposure to the resistance mechanisms of the bean plant increases the ability of *P. phaseolicola* to cause disease.

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

Describe ways in which a mutation in *P. phaseolicola* could result in lack of expression of a gene.

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Quality of Written Communication [1]

[Total: 15]

6 **(a)** Outline the **symptoms** of Huntington's disease (HD).

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**(b)** Fig. 6.1 shows a family's history of HD.

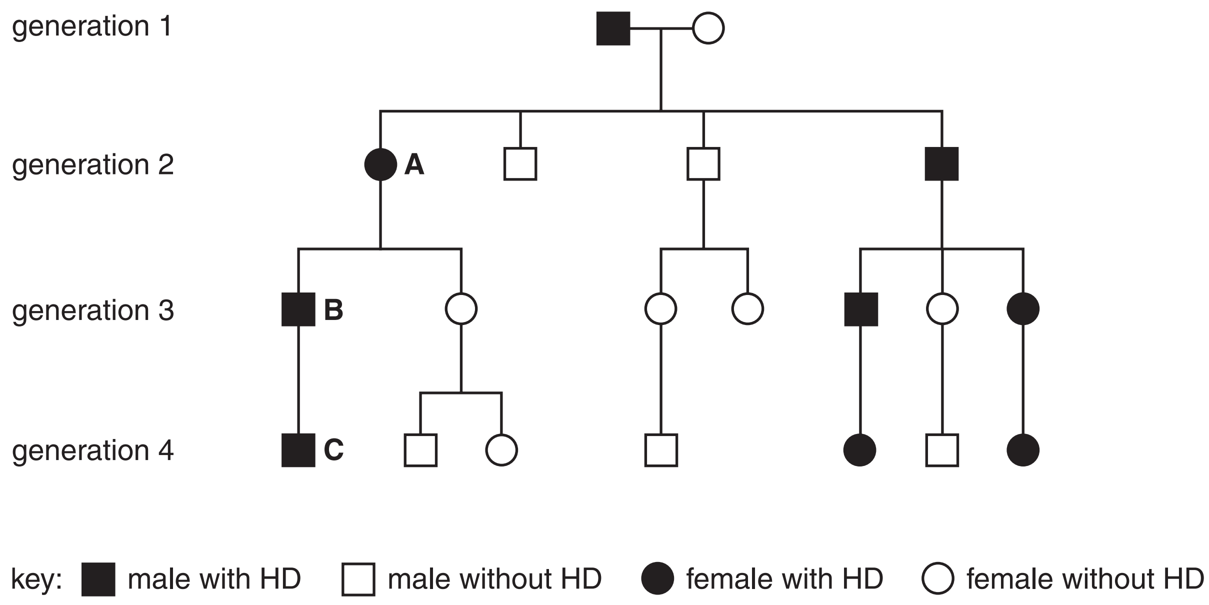


**Fig. 6.1**

Explain how Fig. 6.1 provides evidence that HD results from the inheritance of an autosomal dominant allele.

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**(c)** Genetic screening for HD can be carried out, using a process similar to genetic fingerprinting, to find the length of a repeated triplet, or 'stutter', in an allele.

After treatment with a restriction enzyme, fragments of DNA of different lengths are separated by gel electrophoresis.

**(i)** Describe the role of a restriction enzyme in this technique.

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**(ii)** Explain why fragments of DNA of different lengths can be separated by gel electrophoresis.

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**QUESTION 6 CONTINUES ON THE NEXT PAGE**

**(d)** DNA from individuals **A**, **B** and **C** from the family shown in Fig. 6.1 (on page 14) was analysed. The resulting banding patterns are shown in Fig. 6.2.

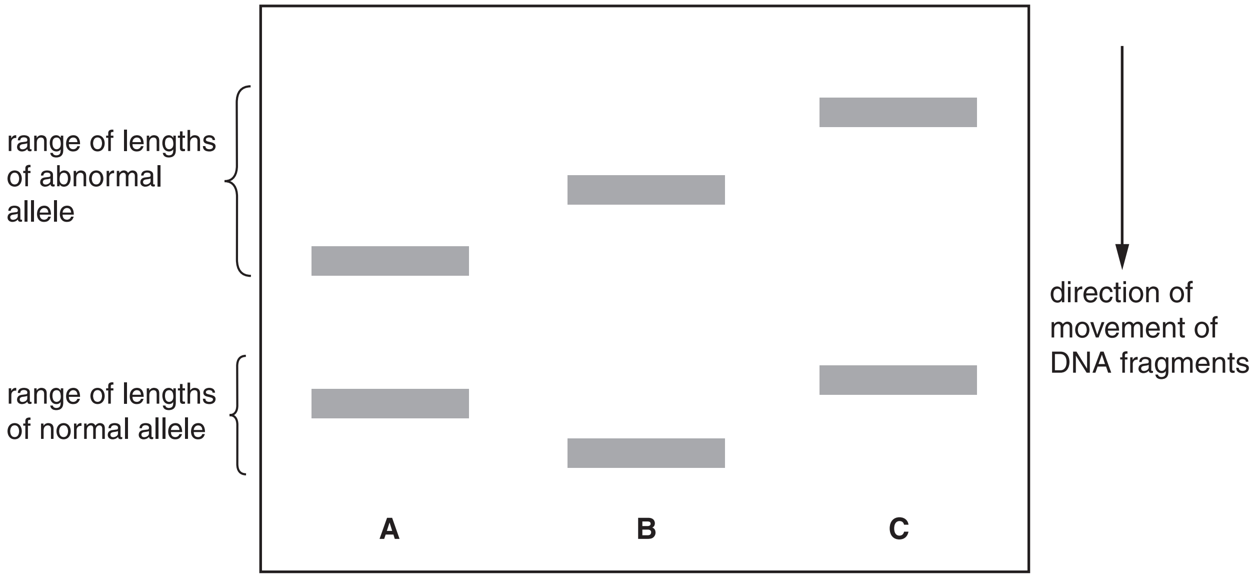


**Fig. 6.2**

Explain why the DNA of the following bands in Fig. 6.2 are **not** the same length:

**(i)** the three normal alleles;

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**(ii)** the three abnormal alleles.

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[Total: 15]

**END OF QUESTION PAPER**