OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

BIOLOGY 2805/02

Applications of Genetics

Tuesday **31 JANUARY 2006** 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.

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Answer **all** the questions.

1 Two species of monkeyflower, *Mimulus*, have pink anthocyanin pigment in their flower petals.

In both species, two alleles of a gene, **A/a**, control the activity of another gene responsible for the production of a second pigment, a carotenoid. The dominant allele, **A**, prevents carotenoid production so that the flowers show only their pink anthocyanin pigment.

Flowers containing both anthocyanin and carotenoid pigments are red in colour.

(a) (i) Describe the interaction between gene **A/a** and the gene responsible for carotenoid production.

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(ii) Explain why flower colour in *Mimulus* is an example of **discontinuous** variation.

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(b) Wild type *M. lewisii* have the genotype **AA** and have pink flowers that are pollinated by bumblebees.

Wild type *M. cardinalis* have the genotype **aa** and have red flowers that are pollinated by hummingbirds.

The two species were interbred to investigate the role of gene **A/a** in attracting pollinators to the flowers. Alleles **A** and **a** were exchanged between the two species in the selective breeding programme shown in Fig. 1.1.

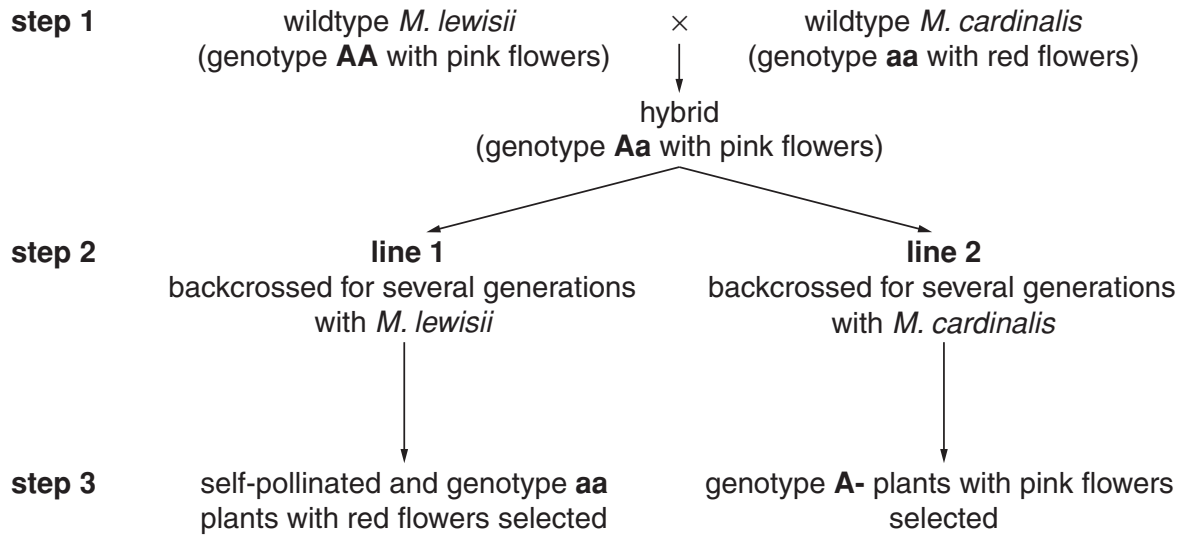

Fig. 1.1

(i) State **two** practical precautions that the plant breeder could take to be sure that the plants produced in **step 1** were hybrids.

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(ii) Explain why, in **step 2**, the hybrids were backcrossed for several generations to one or other of the parent species.

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(iii) State why the plants in **line 1** were self-pollinated in **step 3**.

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(c) The number and type of pollinators visiting different coloured flowers were then recorded. The results are shown in Table 1.1.

Table 1.1

plant species	genotype	flower colour	number of pollinator visits per hour	
			bumblebee	hummingbird
wild type *M. lewisii*	**AA**	pink	15	0
selectively bred *M. lewisii*	**aa**	red	3	2
wild type *M. cardinalis*	**aa**	red	0	190
selectively bred *M. cardinalis*	**Aa**	pink	11	170

Comment on the effect on pollinators of selectively breeding allele **a** into *M. lewisii* and allele **A** into *M. cardinalis*.

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[Total: 15]

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

Over the past 50 years, there has been a strong selective pressure for lean growth (increased muscle mass and low fat content) in the selective breeding of pigs.
The heritability of muscle mass is between 0.15 and 0.3 and that of fat content between 0.1 and 0.2.

Explain the importance of heritability and progeny testing in a selective breeding programme, such as that involving pigs.

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Quality of Written Communication [1]

(b) A gene, Q/q, affecting muscle mass and fat deposition in pigs has been identified in crosses between domesticated pigs and wild boars. Most European domesticated pigs carry the dominant allele, Q, but wild boar populations are homozygous recessive. The Q/q gene codes for a protein growth factor, IGF2.

The transcription of the gene in skeletal and cardiac muscle was measured in piglets with QQ and qq genotypes at three and sixteen weeks after birth. The results are shown in Fig. 2.1.

A graph has been removed due to third party copyright restrictions

Details:

A graph showing the transcription of the gene in skeletal and cardiac muscle at three and sixteen weeks after birth.

Fig. 2.1

Using the information in Fig. 2.1, compare the transcription of the IGF2 gene in piglets with QQ and qq genotypes.

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(c) DNA analysis has shown that alleles **Q** and **q** differ by one base in a triplet in the **non-coding**, regulatory region of the gene:

allele **Q** **- - - - - - T-C-A-C-A-G - - - - - -**

allele **q** **- - - - - - T-C-G-C-A-G - - - - - -**

Suggest how a single base substitution, such as that shown above, results in a different expression of the gene.

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[Total: 15]

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

Britain's only native species of carp, the crucian carp, is very hardy and can live in conditions that would be fatal for most freshwater fish. It can survive in water temperatures from 1 °C to 38 °C and can live in water with a very low oxygen concentration and a low pH.

The crucian carp can interbreed with two other species of carp:

- common carp, a non-native species which was introduced into Britain to increase the stock of fish for freshwater fishing;
- goldfish, which are often illegally released into the wild.

Explain the importance of maintaining a population of crucian carp that has not interbred with other species.

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Quality of Written Communication [1]

(b) Interbreeding between the three species of fish can be detected by genetic fingerprinting.

A repetitive sequence of DNA has been found in all three species. This sequence has been isolated by using a restriction enzyme. The length of the sequence differs in the three species:

- goldfish - 100 base pairs
- common carp - 75 base pairs
- crucian carp - 65 base pairs.

(i) Explain briefly what is meant by a *restriction enzyme*.

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(ii) Fig. 3.1 shows an electrophoresis gel on which bands of DNA produced by genetic fingerprinting have been revealed by staining. **Only** the bands produced from goldfish, common carp and hybrid goldfish × crucian carp are shown.

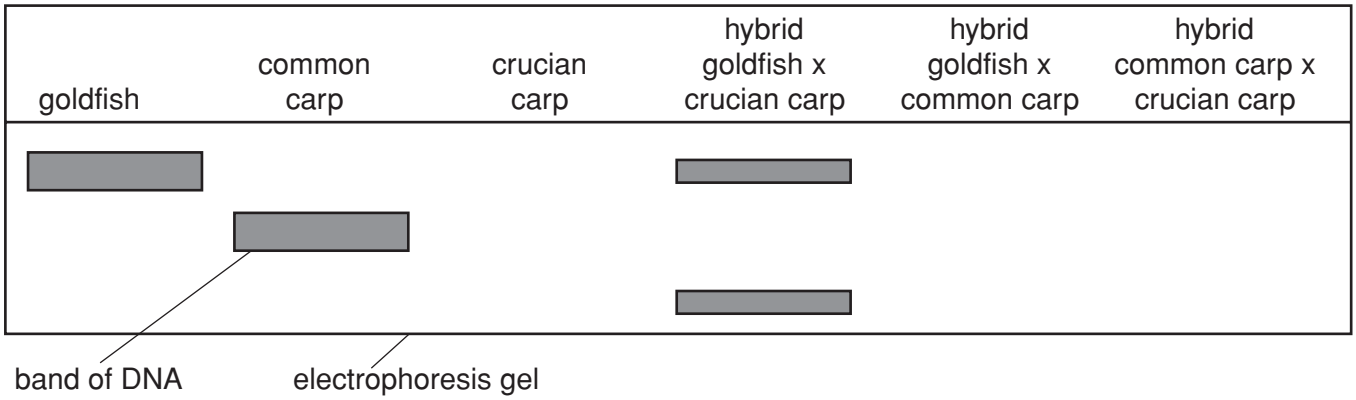

Fig. 3.1

Draw onto Fig. 3.1 the bands expected from:

- crucian carp;
- hybrid goldfish × common carp;
- hybrid common carp × crucian carp.

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4 The synthesis of caffeine in coffee plants involves enzymes which add methyl groups (CH_3) to convert xanthosine to caffeine:

In an attempt to produce caffeine-free coffee, cells of a coffee plant, *Coffea canephora*, were grown in tissue culture and genetically modified to suppress expression of the gene for theobromine synthase.

DNA was constructed to code either for short or for long lengths of RNA with the **complementary** base sequences to parts of the messenger RNA (mRNA) produced by the gene for theobromine synthase.

(a) Explain how lengths of RNA that are complementary to mRNA may suppress the expression of a gene.

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(b) Three types of cell were then cloned in tissue culture into plantlets:

A - unmodified (control) cells
B - genetically modified cells with the DNA code for short lengths of RNA complementary to mRNA for theobromine synthase
C - genetically modified cells with the DNA code for long lengths of RNA complementary to mRNA for theobromine synthase.

Samples of each of the three types of plantlet were analysed to measure their theobromine and caffeine content. The results of the analysis are shown in Fig. 4.1.

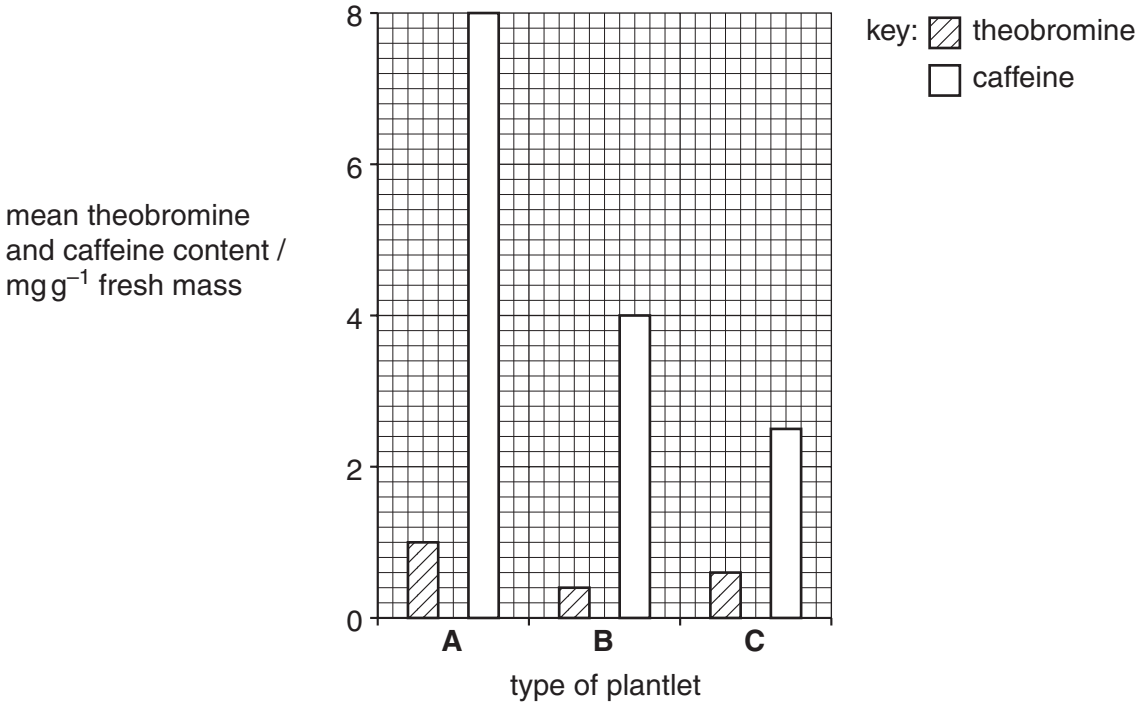

Fig. 4.1

(i) Describe the results shown in Fig. 4.1.

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(ii) Suggest an explanation for the difference in the results of the two experimental treatments, **B** and **C**.

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(iii) Describe briefly how plants are cloned by tissue culture.

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(iv) Explain the advantages of using cloned plants in experiments such as this.

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5 **(a)** An infection by the bacterium, *Pseudomonas aeruginosa*, may be in the form of separate bacterial cells or of a 'biofilm'. A biofilm is a layer of bacteria growing on a surface, attached to one another by polymers of glucose. Infections in the form of biofilms are difficult to control by antibiotics.

Suggest why infections in the form of biofilms are more difficult to control by antibiotics than those caused by separate bacterial cells.

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(b) The sensitivity of two strains of *P. aeruginosa* to three commonly used antibiotics (**A**, **B** and **C**) was measured when the bacteria were grown in suspension and in biofilms. The results are shown in Table 5.1.

Table 5.1

		lowest concentration of antibiotic needed to kill bacteria / μg cm^{-3}		
		A	**B**	**C**
strain 1	bacteria in suspension	8	40	4
strain 1	bacteria in biofilm	400	500	50
strain 2	bacteria in suspension	8	40	4
strain 2	bacteria in biofilm	25	60	6

Compare the sensitivity of bacterial **strains 1** and **2** to the three antibiotics when grown in suspension and in biofilms.

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(c) A gene has been identified in *P. aeruginosa* which is expressed **only** when cells grow in biofilms. The gene codes for an enzyme which is needed for the synthesis of polymers of glucose, called glucans, which are secreted by the bacteria. Strains 1 and 2 have different alleles of this gene.

Explain how the difference in sensitivity to antibiotics of strains 1 and 2 could have arisen.

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(d) Describe briefly how resistance to an antibiotic may be transferred naturally from *P. aeruginosa* to a different species of bacterium.

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6 **(a)** Genes of the major histocompatibility (HLA) system code for glycoproteins. In transplant surgery, a mismatch occurs when a glycoprotein is present in the transplant but **not** in the recipient.

Fig. 6.1 shows the results of a survey of the mean percentage of first transplants surviving the first five years after transplant surgery, with one, three or five mismatches between transplant and recipient.

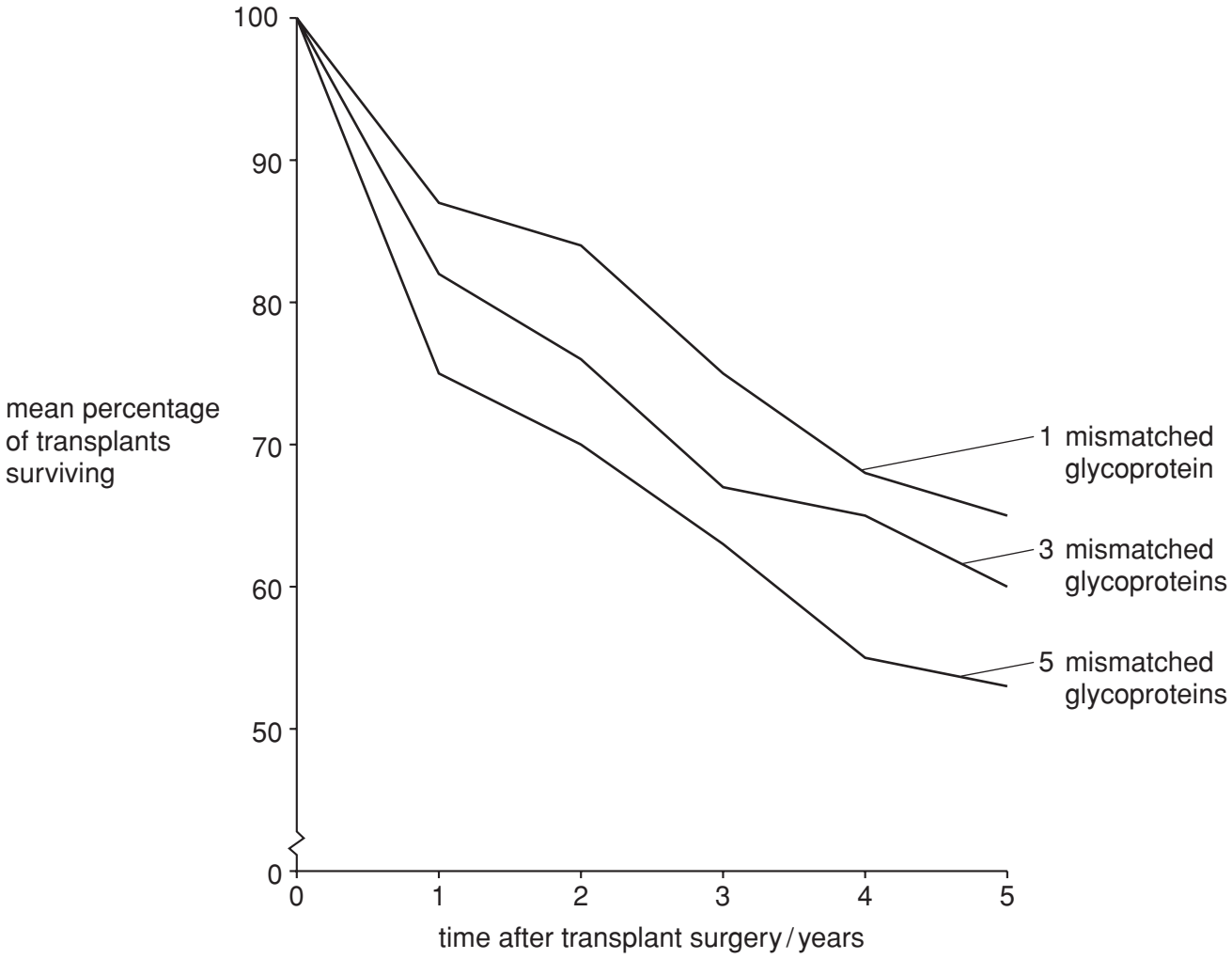

Fig. 6.1

(i) Describe the roles of the glycoproteins coded by the HLA loci.

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(ii) Explain the differences in the percentage survival of transplants shown in Fig. 6.1.

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(iii) Suggest why individuals who had received a second transplant, after the failure of the first, were not included in this survey.

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Question 6 continues on page 18

(b) Fig. 6.2 shows a mother's and father's HLA genotypes at four of the six loci.

Using the lines provided in Fig. 6.2, write in:

(i) the term used for one haploid HLA genotype; [1]

(ii) **one** possible HLA genotype of a child of the couple; [1]

(iii) the probability of a child having the genotype chosen in **(ii)**. [1]

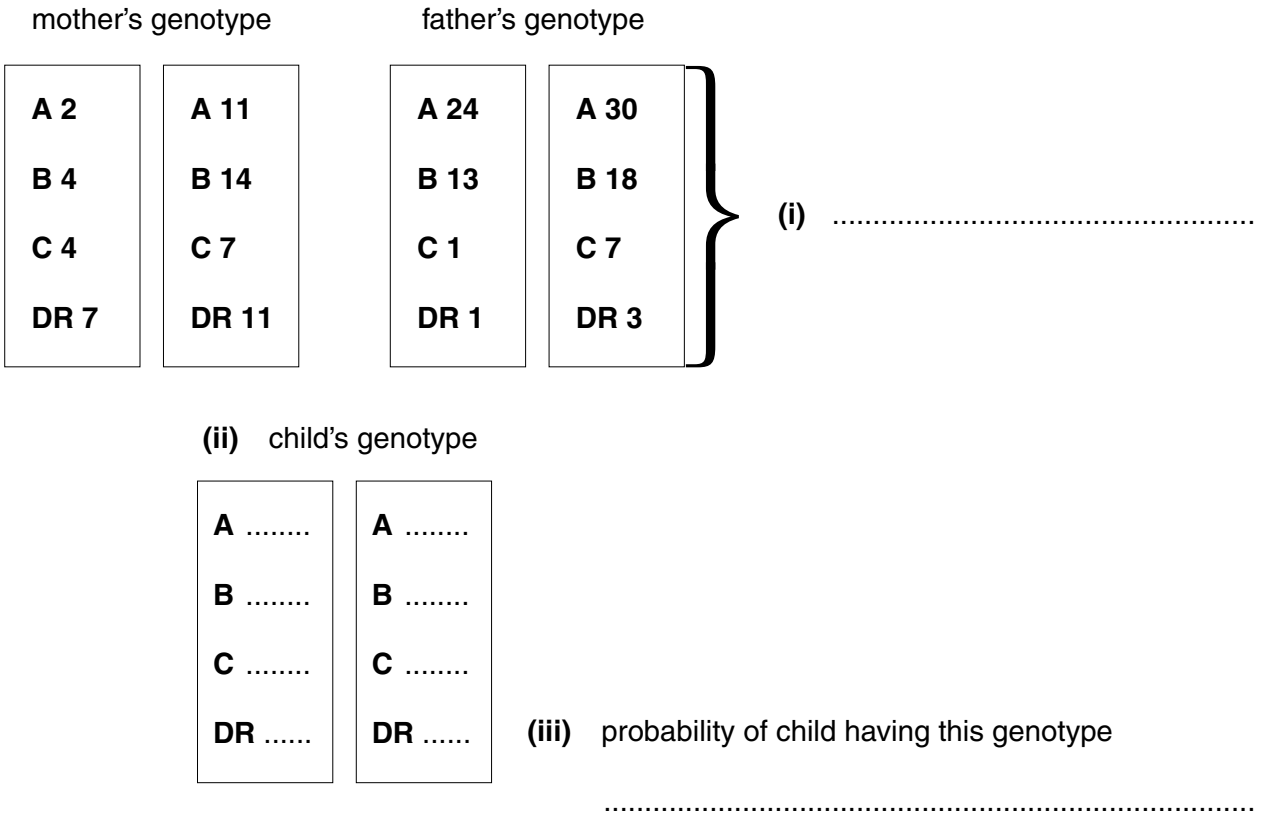

Fig. 6.2

(c) Explain why the number of possible HLA genotypes of the child is very limited.

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[Total: 15]

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