The roles of genes in determining the phenotype

Question Paper 3

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Inherited change
Sub Topic	The roles of genes in determining the phenotype
Booklet	Theory
Paper Type	Question Paper 3

Time Allowed : **66 minutes**

Score : **/ 55**

Percentage : **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Explain what is meant by a **gene** mutation and outline the possible consequences of a gene mutation for an organism. [9]

(b) Explain how faulty CFTR proteins in cell surface membranes can lead to the symptoms of cystic fibrosis. [6]

[Total: 15]

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2 A mutation in a gene in the fruit fly, *Drosophila melanogaster*, gives rise to white-eyed flies instead of the normal red-eyed flies. The allele for red eyes (**R**) is dominant to the allele for white eyes (**r**).

A student crossed a red-eyed fly with a white-eyed fly.

The results are shown in Table 1.1.

Table 1.1

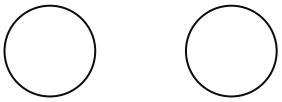
phenotype of fly	number of offspring
red-eyed female	54
red-eyed male	0
white-eyed female	0
white-eyed male	46

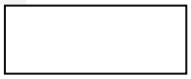
(a) In *Drosophila*, males possess two different sex chromosomes, X and Y, as in humans.

Complete the genetic diagram below to show how the results in Table 1.1 could have been produced.

parental phenotypes red-eyed fly white-eyed fly

parental genotypes  

gametes  

offspring genotypes  

offspring phenotypes red-eyed female white-eyed male [3]

(b) (i) The chi-squared (χ^2) test can be used to analyse the results in Table 1.1.

The expected ratio of red-eyed females to white-eyed males is 1:1.

Complete Table 1.2 and use this to calculate a value for chi-squared (χ^2).

$\chi^2 = \sum \frac{(O-E)^2}{E}$ $\quad\quad\quad\quad$ $v = n-1$

key

Σ = sum of
v = degrees of freedom
n = number of classes
O = observed value
E = expected value

Table 1.2

phenotype of fly	**O**	**E**	**O–E**	**$(O-E)^2$**	**$\frac{(O-E)^2}{E}$**
red-eyed female					
white-eyed male					

χ^2 = ...[3]

(ii) Use your calculated value of χ^2 and the table of probabilities below, to test the significance of the difference between observed and expected results.

degrees of freedom	**probability**			
	0.90	**0.50**	**0.10**	**0.05**
1	0.02	0.45	2.71	3.84
2	0.21	1.39	4.61	5.99

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[Total: 8]

3 Flowers are the organs of sexual reproduction in plants. Before fertilisation and seed development can take place, pollination must occur. This can be either self-pollination or cross-pollination, and can be carried out by insects or by wind.

(a) Explain the meaning of the term *self-pollination*.

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(b) Explain why cross-pollination may be more beneficial to a species than self-pollination.

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(c) In maize, wind pollination occurs. An investigation was carried out to find out how the length of time that maize pollen is in the air affects its ability to bring about fertilisation in a female flower.

- Pollen grains were removed from maize flowers and left exposed to the air for varying times.
- The pollen grains were then placed onto groups of female flowers.
- The groups of fertilised flowers developed into 'ears', each containing many seeds. The number of seeds per ear was counted.

The results are shown in Fig. 5.1.

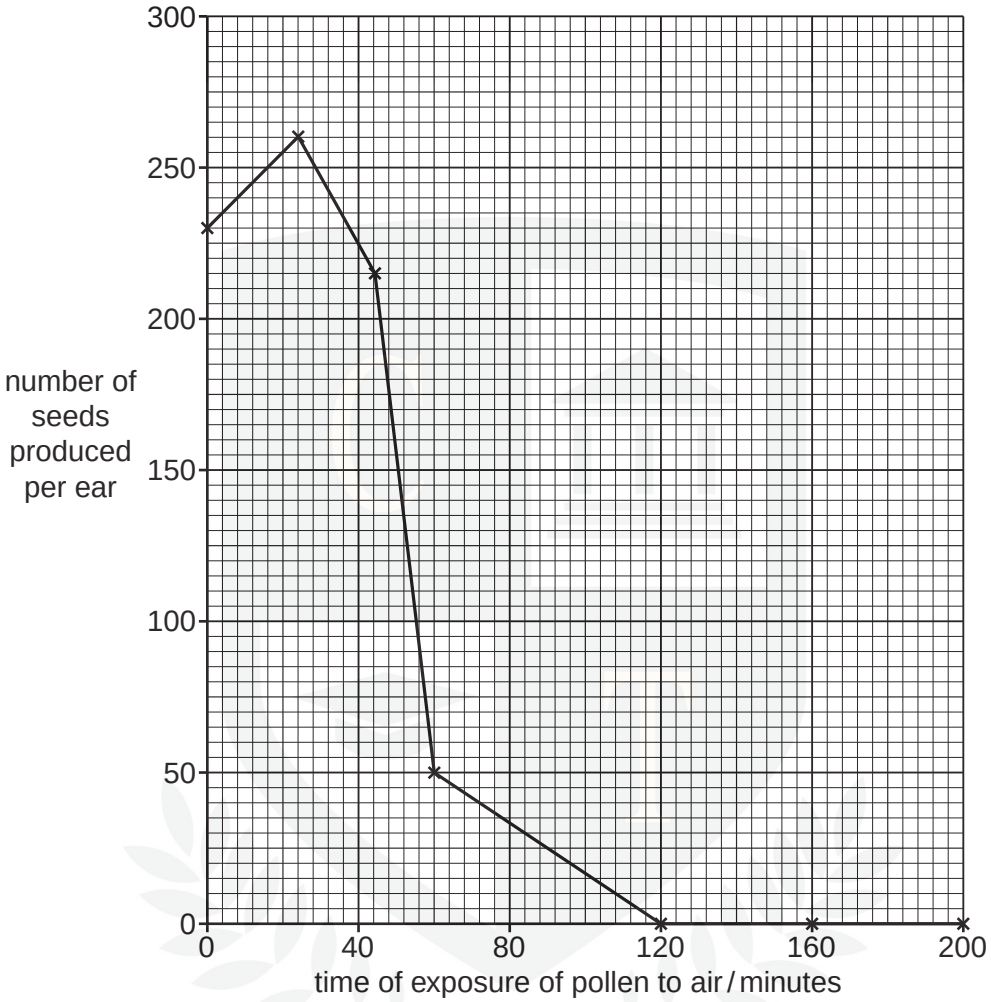

Fig. 5.1

(i) Describe the effect of exposure to the air on maize pollen.

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(ii) A wild relative of maize, called teosinte, grows in Mexico. There are concerns that pollen from genetically-modified maize could pollinate wild teosinte and transfer new genes to it.

Suggest how the results shown in Fig. 5.1 could be used to devise strategies that would reduce the possibility of this happening.

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[Total: 9]

4 **(a)** Describe the **first** division of meiosis (meiosis I) in animal cells. [6]

(b) Discuss the link between the frequency of sickle cell anaemia and the number of cases of malaria. [9]

[Total: 15]

5 In mice, fur colour is controlled by a gene with multiple alleles. These alleles are listed below in no particular order.

black and tan = C^{bt}	yellow = C^{y}
agouti = C^{a}	black = C^{b}

(a) Suggest explanations for the results of the following crosses between mice.

(i) Mice with agouti fur crossed with mice with black fur may produce all agouti offspring **or** some agouti and some black offspring.

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(ii) Crosses between heterozygous parents with the genotype $C^{y}\ C^{b}$ always produce a ratio of two yellow mice to one black mouse.

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(iii) Mice with yellow fur crossed with mice with black fur will produce one of the following outcomes:

- some yellow offspring and some agouti offspring
- some yellow offspring and some black and tan offspring
- some yellow offspring and some black offspring.

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(b) A test cross is used to determine the genotype of an organism.

Describe how you would carry out a test cross to determine the genotype of a black and tan mouse.

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[Total: 8]