16.2 The Roles of Genes in Determining the Phenotype

Question Paper

Course	CIE A Level Biology
Section	16. Inheritance
Topic	16.2 The Roles of Genes in Determining the Phenotype
Difficulty	Hard

Time allowed: 40

Score: /33

Percentage: /100

Question 1a

In fruit flies (*Drosophila melanogaster*) wing length and body colour are each controlled by a single gene with two alleles. Allele **L** for long wings is dominant over allele **l** for vestigial wings, while allele **G** for grey body colour is dominant over allele **g** coding for ebony body colour.

Two homozygous fruit flies were crossed, one had a grey body colour and long wings while the other had an ebony body colour and vestigial wings.

State the number of offspring that would display a grey body colour and vestigial wings if 400 offspring were produced from this cross **and** explain your answer.

[3 marks]

Question 1b

Two fruit flies from the cross in part a) were crossed and 4 800 offspring were produced.

Calculate the expected number of offspring that would display the phenotypes listed in Table 1. Assume that the genes for the body colour and wing length are not linked and show your working.

Table 1

Phenotype	Expected number of offspring
Grey body, long wings	
Grey body, vestigial wings	
Ebony body, long wings	
Ebony body, vestigial wings	

[2 marks]

Question 1c

The results for the cross from part b) were different from what was expected. Scientists decided to perform a chi-squared (χ^2) test to determine if the difference is significant.

The formulae to calculate χ^2 are as follows:

$$^2 = \Sigma \frac{(O - E)^2}{E}$$

Key:

Σ = sum of
O = observed value
E = expected value

Complete Table 2 and use this to calculate the value of χ^2.

Table 2

Phenotype of offspring	Observed (O)	Expected (E)	(O - E)	(O - E)^2	$\frac{(O - E)^2}{E}$
Grey body, long wings	2 580				
Grey body, vestigial wings	900				
Ebony body, long wings	1 010				
Ebony body, vestigial wings	310				

χ^2 = ...

[3 marks]

Question 1d

The scientists calculated the degrees of freedom (v) by using the following formula:

$v = n - 1$

The symbol "n" refers to the number of classes in the data set.

Table 3 shows the values for χ^2 at different levels of probability and for different degrees of freedom.

Table 3

Degrees of freedom	Probability, p				
	0.2	**0.1**	**0.05**	**0.02**	**0.01**
1	1.64	2.71	3.84	5.41	6.64
2	3.22	4.61	5.99	7.82	9.21
3	4.64	6.25	7.82	9.84	11.35
4	5.99	7.78	9.49	11.67	13.28
5	7.29	9.24	11.07	13.39	15.09

State the conclusion the scientists can make about the significance of their results **and** explain your answer.

[3 marks]

Question 2a

In the fruit fly, *Drosophila melanogaster*, two different genes control body colour and eye colour.

- **G/g** are alleles of the body colour gene.
- **G** results in grey body, **g** results in black body.

- **R/r** are alleles of the eye colour gene.
- **R** results in red eyes, **r** results in brown eyes.

Each gene is autosomal.

A dihybrid cross was carried out using a fly with a grey body and red eyes crossed with a fly with a black body and brown eyes. Both parents were homozygous for both genes. The offspring from the F1 generation were crossed to obtain the F2 offspring.

A statistical test showed that the results of the cross were significantly different from those expected.

State the name of the statistical test used **and** state the expected phenotypic ratio for the F2 generation

[2 marks]

Question 2b

A test cross can be carried out in order to identify flies from an F2 generation that are heterozygous for both genes.

Draw a genetic diagram to show how a test cross between a heterozygous grey-bodied, red-eyed F2 fly and a fly with a black body and brown eyes can produce four different offspring phenotypes.

Use the symbols **G/g** and **R/r**.

[4 marks]

Question 2c

The results of the test cross in **(b)** are shown in Table 1. These results are significantly different from the expected results.

Table 1

phenotypes of offspring of test cross	number of individuals
grey body, red eyes	123
grey body, brown eyes	7
black body, red eyes	6
black body, brown eyes	132

Describe how these results are different from the expected results **and** explain why they are different.

[5 marks]

Question 3a

Some neurones in the brain produce a neurotransmitter known as dopamine. Parkinson's disease occurs when the neurones that produce dopamine die. A person with the disease may experience difficulty in coordinating movement, often seen as tremors (shaking) in different parts of the body.

Parkinson's disease typically occurs in people older than 55 years. Younger people with these symptoms are said to have early onset Parkinson's disease (EOPD).

Recessive mutations in a gene known as *PINK1*, located on chromosome 1, an autosome, are believed to be one cause of EOPD. A person with this form of EOPD has a homozygous recessive genotype.

Draw a genetic diagram of a cross between two individuals who are heterozygous at the *PINK1* gene locus.

Include the following:

- key to symbols used for alleles
- parental genotypes
- gametes
- offspring genotypes
- ratio of offspring phenotypes

[4 marks]

Question 3b

PINK1 codes for a protein kinase enzyme that is important in the functioning of mitochondria in neurones.

Most recessive *PINK1* mutations are base substitutions which lead to the production of a non-functioning protein kinase enzyme.

Explain how a base substitution mutation can lead to the production of a non-functioning protein kinase.

[5 marks]

Question 3c

One rare, dominant mutation of the *PINK1* gene codes for a product that inhibits the normal protein kinase.

Explain how this mutation causes EOPD in a heterozygote.

[2 marks]