# Passage of information from parent to offspring

## Question Paper 4

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| **Level** | International A Level |
| **Subject** | Biology |
| **Exam Board** | CIE |
| **Topic** | Inherited change |
| **Sub Topic** | Passage of information from parent to offspring |
| **Booklet** | Theory |
| **Paper Type** | Question Paper 4 |

**Time Allowed :** **64 minutes**

**Score :** **/ 53**

**Percentage :** **/100**

**Grade Boundaries:**

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

**1** 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 ($\chi^2$) 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 ($\chi^2$).

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

key

$\Sigma$ = 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 | | | | | |

$\chi^2$ = ................................................[3]

**(ii)** Use your calculated value of $\chi^2$ 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]

**2** A group of plants, known as Rapid Cycling Brassicas (RCBs), has been developed for use in schools and colleges for genetics experiments.

When RCB seedlings develop they can have either purple stems or non-purple stems. Their seed leaves can be either green or yellow-green.

Purple stems and green seed leaves are controlled by dominant alleles.

The genes for stem colour and seed-leaf colour are located on separate chromosomes.

**(a)** Explain what is meant by a *dominant allele.*

*allele* ..........................................................................................................

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*dominant* ..........................................................................................................

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**(b)** Draw a genetic diagram to show the likely outcome of a cross between two RCB plants which are heterozygous for **both** stem colour and seed-leaf colour.

Use the symbols **A / a** for stem colour and **B / b** for seed leaf colour.

[6]

[Total: 8]

**3** 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]

**4** Tuberous Sclerosis Complex (TSC) is a genetic condition caused by a dominant allele of the *TSC* gene, which leads to abnormal growth of tissue in organs such as the heart, lungs and kidneys.

Children with TSC can, with treatment, lead reasonably normal lives.

About 33% of people with TSC have at least one parent with the condition.

**(a)** Explain the meaning of the terms *dominant* and *gene.*

*dominant* ..........................................................................................................

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*gene* ..........................................................................................................

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**(b)** A couple wish to start a family. The man does not have TSC but the woman does have TSC. The woman's father does not have the condition.

Complete the genetic diagram below to show the probability of the couple's first child having TSC.

*key*
*TSC allele = T*
*normal allele = t*

| | | |
|---|---|---|
| *parental phenotypes* | man without TSC | woman with TSC |
| *parental genotypes* | .......................... | .......................... |
| *gametes* | ...................................... | ...................................... |
| *offspring genotypes* | .................................................................... | |
| *offspring phenotypes* | .................................................................... | |

*probability of first child having TSC* ...................................................... [3]

**(c)** Suggest how a person may develop TSC when there is no family history of the condition.

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[Total: 7]

**5** In sickle cell anaemia the recessive allele $Hb^S$ replaces the normal allele $Hb^A$.

- The frequency of $Hb^S$ is much higher in West Africa than in most parts of the world.
- The frequency of $Hb^S$ corresponds with the distribution of malaria.

**(a)** Explain what is meant by the term *allele.*

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**(b)** State whether the likely life expectancy is high or low in West Africa for individuals with the following genotypes. In each case give a reason for your answer.

$Hb^AHb^A$ ..........................................................................................................

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$Hb^AHb^S$ ..........................................................................................................

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$Hb^SHb^S$ ..........................................................................................................

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**(c)** Explain why populations of West African descent living in the USA have a decreased frequency of the $Hb^S$ allele compared to West African populations.

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[Total: 7]

**6** **(a)** Explain how meiosis and fertilisation may result in genetic variation in offspring. [7]

**(b)** Explain, using examples, how the environment may affect the phenotype of an organism. [8]

[Total: 15]

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