# WJEC (Eduqas) Biology A-level
# Topic 2.5: Inheritance
# Questions by Topic

**1.** The fruit fly Drosophila melanogaster is extensively used to study genetics because it is relatively easy to cause mutations in the flies.

Some mutant flies have very small (vestigial) wings:

normal wings

vestigial wings

Other mutants have very dark (ebony) bodies instead of the normal grey body.

grey body

ebony body

In a dihybrid cross, when flies with normal wings and grey bodies were crossed with flies with vestigial wings and ebony bodies all the offspring had normal wings and grey bodies.

*(a)* The $F_1$ hybrid flies (heterozygous for both traits) were allowed to interbreed freely. The $F_2$ flies were sorted and counted. The results are shown below.

| **Phenotype** | | **Number of flies** |
|---|---|---|
| **Wings** | **Body** | |
| Normal | Grey | 75 |
| Normal | Ebony | 23 |
| Vestigial | Grey | 21 |
| Vestigial | Ebony | 9 |

(i) Draw a genetic diagram, in the space provided below, to show the expected $F_2$ phenotype ratio. [5]
Use the letters given

Allele for normal wings = N    Allele for vestigial wings = n

Allele for grey body = G    Allele for ebony body = g

| | | | |
|---|---|---|---|
| $F_1$ phenotypes | Normal wing, grey body | X | Normal wing, grey body |
| $F_1$ genotypes | ................................................ | X | ................................................ |
| Gametes | ................................................ | X | ................................................ |

$F_2$ phenotype **ratio** ........................................................................................................................

(ii) Using the $F_2$ phenotype ratio from part (i) calculate the **expected** number of each phenotype in the $F_2$ generation from a total of 128 offspring, and enter the values in the table below. [1]

| Phenotype | | Observed number (O) | Expected number (E) | (O – E) | $(O - E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|---|
| Normal wings | Grey body | 75 | | | | |
| Normal wings | Ebony body | 23 | | | | |
| Vestigial wings | Grey body | 21 | | | | |
| Vestigial wings | Ebony body | 9 | | | | |

*(b)* Complete the other columns in the table and carry out a Chi square test, testing the Null Hypothesis – that there is no significant difference between the observed and expected results.

(i) Use the last column in the table to calculate $\chi^2$. [1]

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

$\chi^2 =$ ........................

(ii) Use the 5% probability level and the correct number of degrees of freedom to **circle** the critical value of $\chi^2$ in the table below. [1]

| Degrees of freedom | Probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.9 | 0.8 | 0.7 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 | 0.01 |
| 1 | 0.016 | 0.064 | 0.15 | 0.46 | 1.64 | 2.71 | 3.84 | 5.41 | 6.64 |
| 2 | 0.21 | 0.45 | 0.71 | 1.39 | 3.22 | 4.60 | 5.99 | 7.82 | 9.21 |
| 3 | 0.58 | 1.00 | 1.42 | 2.37 | 4.64 | 6.25 | 7.82 | 9.84 | 11.34 |
| 4 | 1.06 | 1.65 | 2.20 | 3.36 | 5.99 | 7.78 | 9.49 | 11.67 | 13.28 |

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(c) In another cross, flies with ebony bodies and scarlet eyes were crossed with flies homozygous for grey body and red eyes. All the $F_1$ flies had grey bodies and red eyes. When the $F_1$ hybrid flies were crossed the following results were obtained:

| Phenotype | | Number of flies |
|---|---|---|
| **Eyes** | **Body** | |
| Red | Grey | 91 |
| Red | Ebony | 3 |
| Scarlet | Grey | 2 |
| Scarlet | Ebony | 32 |

The table shows that some of the offspring were far more common than expected and some phenotypes were very rare. Explain both of these observations.

[2]

**2.** There are three varieties of Labrador dogs; black, chocolate, and yellow. A student noticed that some yellow Labradors have black noses and some have brown noses. She proposed the hypothesis that the overall appearance is determined by fur colour **and** skin colour, as follows:

| **Variety** | **Fur colour** | **Skin colour** |
|---|---|---|
| black | black | black |
| chocolate | black | brown |
| yellow (black nose) | brown | black |
| yellow (brown nose) | brown | brown |

*(a)* The alleles for black fur (**B**) and black skin (**R**) are both dominant.

(i) Draw a genetic diagram to illustrate a cross between two heterozygous black Labradors. [4]

| | | | |
|---|---|---|---|
| Parental phenotypes | black fur, black skin | X | black fur, black skin |
| Parental genotypes | ........................................ | X | ........................................ |
| Gametes | ........................................................... | X | ........................................................... |

(ii) State the proportion of the offspring which would be, [1]

chocolate ..............................

yellow ..............................

(iii) State the proportion of the yellow offspring which would have brown noses. [1]

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(iv) Suggest what simple observation of the chocolate Labradors could be used to support her hypothesis. [1]

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*(b)* A dog breeder has a chocolate bitch which she would like to use to produce only chocolate pups.

(i) State the genotype of bitch the breeder should use to produce only chocolate pups. [1]

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(ii) Describe the cross the breeder should carry out to test whether the bitch has the correct genotype. [1]

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(iii) Which is the only variety of Labrador, if bred with the same variety, will always produce pups with the same phenotype as both parents? [1]

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**3.** The image below shows sweet peas which can be a number of different colours including white and purple.

Pollen was transferred from the anthers of white flowers onto the stigmas of purple flowers. In the F1, some plants produced purple flowers and some produced white flowers.

Two hypotheses have been suggested to explain this result.

*(a)* The **first hypothesis** is that the purple variety is caused by a dominant allele of a single gene.

(i) Construct a genetic diagram to show the genotypes and phenotypes of the parents of this cross. Use the letters **A** and a to represent the alleles of this gene. [2]

(ii) Based on the first hypothesis, the F1 would be expected to contain equal numbers of plants producing purple flowers compared to white flowers. When the cross was carried out, the resulting seeds were planted and 32 plants produced white flowers and 18 produced purple flowers.

State the null hypothesis and complete the table below. [4]

Null hypothesis

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| Phenotype | Observed numbers *(O)* | Expected numbers *(E)* | $O-E$ | $(O-E)^2$ | $\frac{(O-E)^2}{E}$ |
|---|---|---|---|---|---|
| White | 32 | | | | |
| Purple | 18 | | | | |

Use the formula below to calculate the value of chi-squared ($\chi^2$).

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

$\chi^2$ = ..............................................

(iii) Use the table of chi-squared values below to state whether you would accept or reject the null hypothesis stated in *(a)*(ii). Explain your answer. [4]

| Degrees of freedom | Probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.9 | 0.8 | 0.7 | 0.5 | 0.2 | 0.1 | 0.05 | 0.02 | 0.01 |
| 1 | 0.016 | 0.064 | 0.15 | 0.46 | 1.64 | 2.71 | 3.84 | 5.41 | 6.64 |
| 2 | 0.21 | 0.45 | 0.71 | 1.39 | 3.22 | 4.60 | 5.99 | 7.82 | 9.21 |
| 3 | 0.58 | 1.00 | 1.42 | 2.37 | 4.64 | 6.25 | 7.82 | 9.84 | 11.34 |
| 4 | 1.06 | 1.65 | 2.20 | 3.36 | 5.99 | 7.78 | 9.49 | 11.67 | 13.28 |

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(b) The **second hypothesis** is that the purple variety is produced by an interaction between two unlinked genes **A** and **B**. The presence of at least one dominant allele for both genes results in purple flowers. If the plant is homozygous recessive for either gene, the phenotype will be white.

(i) Complete the Punnett square to determine the phenotype ratios expected on the basis of this second hypothesis, given that the genotype of the purple flower is **AaBb** and the genotype of the white flower is **aaBb**. The gametes for the white flowering plant have been done for you. [3]

| | | | | |
|---|---|---|---|---|
| | | | | |
| aB | | | | |
| ab | | | | |

Phenotype ratio ..............................................................................

(ii) The value of chi-squared for the second hypothesis was calculated as 0.044. Using the data conclude which hypothesis is more likely to be correct, the first or the second. Explain your answer. [1]

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(c) Explain how a cross between two white flowered parents which produced purple flowered offspring would confirm that hypothesis 2 is correct. [1]

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**4.** Haemophilia is caused by a sex linked gene.

(a) (i) What is meant by the term '*sex linkage*'?

[1]

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(ii) Complete the following genetic diagram to show how parents who did not suffer from haemophilia, could have a son with haemophilia but also other children who did not suffer from haemophilia. Use the symbols $\mathbf{X^H}$ for the normal allele and $\mathbf{X^h}$ for the allele which causes haemophilia. [4]

| | | |
|---|---|---|
| Phenotype of parents | Normal male | Normal female |
| Genotype of parents | .......... | .......... |
| Genotype of gametes | .......... .......... | .......... .......... |
| Genotype of offspring | .......... .......... | .......... .......... |
| Phenotype of offspring | .......... .......... | .......... .......... |

(iii) What is the probability of the couple having a daughter with haemophilia?

[1]

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(iv) What is the probability of the couple having another son with haemophilia?

[1]

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*(b)* An organism has two genes A and B which are found on the same chromosome.

Complete the following genetic diagram for a cross between two individuals with genotype Aa Bb but where no crossing over occurs (complete linkage). [3]

Genotype AaBb AaBb

Genotype of gametes ..................... ..................... ..................... .....................

Genotype of offspring ............................ ............................ ............................ ............................

Ratio of Phenotype ..........................................................................................

(c) In another cross between two individuals with the genotype DdEe, where the genes D and E are on the same chromosome, the offspring showed four different types of phenotype.

The phenotype of some of the offspring were far more common than expected and some phenotypes were very rare. Explain these observations.

[2]

**5.** A species of mouse *Peromyscus polionotus* found in Florida, USA, has a number of different coat colours. Coat colour in mice is controlled by several genes. Dark fur is produced when the hair producing cells secrete a pigment called eumelanin. A high level of eumelanin is produced when a transmembrane protein called MC1R is stimulated by a hormone.

(a) The diagram below shows part of the amino acid sequence of MC1R, part of the sequence of nucleotides in the gene for MC1R and how it might change to produce light fur:

**Original**

Amino acid sequence: Ile – Thr – Lys – Asn – Arg – Asn – Leu – His – Ser

Nucleotide sequence (allele R): ATCACCAAAAACCGCAACCTGCACTCG

**Changed to produce light fur**

Amino acid sequence: Ile – Thr – Lys – Asn – Cys – Asn – Leu – His – Ser

Nucleotide sequence (allele C): ATCACCAAAAACTGCAACCTGCACTCG

(i) Describe the change in the gene and the subsequent change in the MC1R molecule. [2]

(ii) Using the information provided, explain how this change results in mice with light fur. [2]

**6.** *(a)* Cattle can have coats which are white, red or an even distribution of white and red hair (Roan). Roan is caused by incomplete dominance between the alleles for red and white hair (heterozygous condition).
Cattle can have horns or be hornless. Horns are a result of a double recessive allele and hornless is caused by a dominant allele.

| **Key:** | |
|---|---|
| WW = white | H = hornless |
| RW = roan | h = horned |
| RR = red | |

The genetic diagram shows the cross between a hornless white animal with a horned red animal.

| | | | |
|---|---|---|---|
| parental phenotype: | hornless white | × | horned red |
| parental genotype: | HH WW | | hh RR |
| genotype gametes: | HW | | h R |
| genotype offspring: | | Hh W R | |
| phenotype offspring: | | hornless roan | |

(i) The offspring were then bred together. Complete the Punnett square to show the possible genotypes of the offspring. [4]

| Gametes | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

(ii) Complete the following table to show the different phenotypes you would expect and the ratio. [6]

| *Phenotype* | *Ratio* |
|---|---|
| | |
| | |
| | |
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| | |

**(Total 10 marks)**