FREE SAMPLE: THE FIRST QUESTION

Question One (21 marks)

(a) In the snapdragon, flower colour is controlled by one gene showing incomplete dominance: red (RR) and white (rr) are the homozygous phenotypes and the heterozygote (Rr) is pink. Use the allele letters R and r.

A snapdragon with genotype Rr is crossed with a snapdragon with genotype Rr.

(i) Complete a Punnett square for this cross.

(ii) State the genotype ratio and the phenotype ratio of the offspring.

(iii) Calculate the probability that two offspring produced by this cross will both have the pink phenotype.

[6 marks]

(b) The ABO blood group in humans is controlled by one gene with three alleles: I^A (A) and I^B (B) are codominant, and both are dominant over i (O).

A man with blood group AB (genotype I^AI^B) and a woman with blood group B (genotype I^Bi) have a child.

(i) Complete a Punnett square for this cross.

(ii) State all the possible blood groups of the child and the probability of each.

(iii) Explain what is meant by ‘codominant’ and why a person with genotype I^AI^B has blood group AB.

[7 marks]

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(c) In the fruit fly, wing length (long dominant over vestigial) and body colour (grey dominant over ebony) are controlled by two genes on different chromosomes. Use the letters V/v for wing length and E/e for body colour.

A fruit fly with genotype VvEe is crossed with a fruit fly with genotype vvee.

(i) Write the genotypes of the gametes produced by each parent, and complete a Punnett square.

(ii) State the phenotype ratio of the offspring.

(iii) 1600 offspring are produced. Calculate the expected number with the phenotype ‘long, grey’.

(iv) Explain why the genes must be on different chromosomes for this ratio to occur.

[8 marks]

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THE WORKED ANSWER TO THAT QUESTION

Question 1 (21 marks) [Inheritance of one and two genes]

(a) In the snapdragon, flower colour is controlled by one gene showing incomplete dominance: red (RR) and white (rr) are the homozygous phenotypes and the heterozygote (Rr) is pink. Use the allele letters R and r. A snapdragon with genotype Rr is crossed with a snapdragon with genotype Rr. (i) Complete a Punnett square for this cross. (ii) State the genotype ratio and the phenotype ratio of the offspring. (iii) Calculate the probability that two offspring produced by this cross will both have the pink phenotype.

(a) Answer: (ii) genotypes 1 : 2 : 1; phenotypes 2 : 1 : 1; (iii) $\frac{1}{4}$

- Evidence level: Merit (list the gametes from each parent, complete the Punnett square, then read off the ratios).
- (i) Gametes: R and r from the first parent and R and r from the second parent. The square shows the offspring genotypes RR, Rr, Rr, rr.
- (ii) Genotype ratio 1 : 2 : 1 (RR : Rr : rr); phenotype ratio 2 : 1 : 1 (pink : red : white).
- (iii) P(one pink offspring) = $\frac{1}{2}$, so P(both) = $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$.

> **KEY TAKEAWAY**
> Crosses: write the gametes, fill the Punnett square, count genotypes then phenotypes; probabilities multiply for independent events and expected numbers = probability × number of offspring.

(b) The ABO blood group in humans is controlled by one gene with three alleles: I^A (A) and I^B (B) are codominant, and both are dominant over i (O). A man with blood group AB (genotype I^AI^B) and a woman with blood group B (genotype I^Bi) have a child. (i) Complete a Punnett square for this cross. (ii) State all the possible blood groups of the child and the probability of each. (iii) Explain what is meant by 'codominant' and why a person with genotype I^AI^B has blood group AB.

(b) Answer: (ii) A $\frac{1}{4}$; AB $\frac{1}{4}$; B $\frac{1}{2}$; (iii) both alleles expressed

- Evidence level: Merit (gametes → Punnett square → genotypes → blood groups (I^A and I^B both dominant to i)).
- (i) Gametes: I^A or I^B from the man and I^B or i from the woman.
- (ii) group A: $\frac{1}{4}$; group AB: $\frac{1}{4}$; group B: $\frac{1}{2}$.
- Achievement: (iii) States that both alleles are expressed.
- Merit: Links to the phenotype: in the heterozygote I^AI^B neither allele masks the other.
- Excellence: Full explanation: codominant alleles are both fully expressed in the heterozygote; I^A codes for the A antigen and I^B for the B antigen, so a person with I^AI^B makes both antigens on their red blood cells and has blood group AB, rather than a blend or only one antigen.

> **KEY TAKEAWAY**
> Blood groups: A and B are codominant and both dominate O; group A can be IAIA or IAi, group O is ii; use the Punnett square to find each probability.

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(c) In the fruit fly, wing length (long dominant over vestigial) and body colour (grey dominant over ebony) are controlled by two genes on different chromosomes. Use the letters V/v for wing length and E/e for body colour. A fruit fly with genotype VvEe is crossed with a fruit fly with genotype vvee. (i) Write the genotypes of the gametes produced by each parent, and complete a Punnett square. (ii) State the phenotype ratio of the offspring. (iii) 1600 offspring are produced. Calculate the expected number with the phenotype ‘long, grey’. (iv) Explain why the genes must be on different chromosomes for this ratio to occur.

(c) Answer: (ii) 1 : 1 : 1 : 1; (iii) 400

- Evidence level: Excellence (gametes (one allele of each gene), Punnett square, phenotype ratio, expected number).
- (i) First parent VvEe gametes: VE, Ve, vE, ve. Second parent vvee gametes: ve.
- (ii) Phenotype ratio 1 : 1 : 1 : 1 (long, grey; long, ebony; vestigial, grey; vestigial, ebony).
- (iii) Probability of ‘long, grey’ = $\frac{1}{4}$, so expected number = $\frac{1}{4}$ × 1600 = 400.
- Achievement: (iv) States that the genes assort independently.
- Merit: Links to meiosis: alleles of different genes are separated independently.
- Excellence: Full explanation: genes on different (non-homologous) chromosomes line up and separate independently during metaphase I and anaphase I of meiosis, so every combination of alleles is equally likely in the gametes (independent assortment); genes close together on the same chromosome are linked and are inherited together, which would change the ratio.

KEY TAKEAWAY

Dihybrid crosses: each gamete takes one allele of each gene; a 4 × 4 square gives 9 : 3 : 3 : 1 for AaBb × AaBb and 1 : 1 : 1 : 1 for a test cross; multiply the probability by the number of offspring.

LOS: Inheritance of one and two genes (91157)

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