



ANSWER BOOK

Two genes at once: 9 : 3 : 3 : 1, the ways it breaks, and the chi-squared test

Inheritance and population genetics · Unit B16

AQA 3.7.1 · OCR A 6.1.2 · Edexcel A Topic 3 (dihybrid crosses only) · CAIE 16.2

6 questions · 21 marks

NAVY EDITION

SECTION A · Short, 1 to 2 marks

A1 **B1** 9 : 3 : 3 : 1 from the cross between two double heterozygotes. **B1** 1 : 1 : 1 : 1 from the dihybrid test cross. [2]

SECTION B · Standard, 3 to 5 marks

B1 **M1** the parts of the ratio add to 16 and $160 \div 16 = 10$, so the expected numbers are 90 black, 30 brown and 40 white, which add back to 160. **M1** each term is the difference squared divided by the expected value: $36 \div 90$, $36 \div 30$ and $0 \div 40$. **A1** the terms are 0.40, 1.20 and 0, so chi-squared = 1.6. **B1** there are three phenotype classes, so the degrees of freedom are $3 - 1 = 2$ and the critical value at $p = 0.05$ is 5.99. **A1** 1.6 is below 5.99, so the difference is not significant, the null hypothesis is accepted and the deviation from 9 : 3 : 4 is attributed to chance. [5]

B2 **B1** a gamete receives one allele of each gene, and because the two genes are on different chromosomes the choice at one locus is independent of the choice at the other. **B1** this is independent assortment at metaphase I, so RrYy produces RY, Ry, rY and ry in equal numbers. **B1** the double recessive parent contributes ry to every offspring, so the offspring phenotypes read out directly the gametes the first parent made. **A1** a large excess of two classes and a shortage of the other two would suggest the genes are autosomally linked, so they cannot assort independently and only crossing over produces the scarce recombinant classes. [4]

B3 **B1** this is complementary gene action, a form of epistasis: a dominant allele is needed at both loci for any pigment to be made. **B1** a plant of genotype A_bb makes the first enzyme but not the second, and a plant of genotype aaB_ makes the second but not the first, so in each the pathway is blocked and the flower stays white. **B1** those two classes, 3 and 3 in sixteenths, join the double recessive class of 1, which makes neither enzyme, giving 7 white in every 16. **A1** only the A_B_ class, 9 in every 16, makes both enzymes and completes the pathway to pigment, so the total is still in sixteenths and the classes have merged rather than changed in proportion. [4]

B4 **M1** the two classes in large excess, 145 and 128, are the parental combinations, so the recombinants are the two scarce classes: $15 + 12 = 27$. **M1** recombination frequency is the number of recombinant offspring divided by the total and multiplied by 100, so $27 \div 300 \times 100$. **A1** 9 per cent, a low value showing the two loci lie close together on the same chromosome. [3]

B5 **B1** linkage arises because the two genes sit on the same chromosome and [3]
cannot assort independently, whereas epistasis arises because one gene affects the
expression of the gene at the other locus, usually through a shared pathway. **B1** linkage
leaves all the phenotype classes present but shifts the proportions heavily in favour of
the parental combinations, whereas epistasis merges classes so fewer phenotypes
appear. **B1** an epistatic ratio still adds to sixteen parts, such as 9 : 3 : 4 or 9 : 7, whereas a
linked test cross departs from 1 : 1 : 1 : 1 by an amount that measures the distance
between the loci.
