

### Chi squared

1. Two pure breeding strains of snapdragon, a garden plant, were obtained. One strain had red flowers and the other had white flowers. The two strains were crossed yielding F<sub>1</sub> plants all with pink flowers. The F<sub>1</sub> were then interbred to produce F<sub>2</sub> plants with the following colours:

<b>red</b>	<b>62</b>
<b>pink</b>	<b>131</b>
<b>white</b>	<b>67</b>

The following hypothesis was proposed:

*Flower colour is controlled by a single gene with two codominant alleles.*

- (b) Complete the genetic diagram to explain this cross. Use the following symbols to represent the alleles:

**C<sup>r</sup> = red, C<sup>w</sup> = white**

Parental phenotypes:	red flowers	x	white flowers
Parental genotypes:	.....		.....
Gametes:	.....		.....

F<sub>1</sub> genotypes: .....

F<sub>1</sub> phenotypes: .....

Gametes: .....

F<sub>2</sub> genotypes: .....

F<sub>2</sub> phenotypes: .....

Expected F<sub>2</sub> phenotypic ratio:.....

- (c) A chi-squared ( $\chi^2$ ) test is carried out on the experimental data to determine whether the hypothesis is supported.

- (i) Complete the table below by calculating the expected numbers.

F <sub>2</sub> phenotype	observed numbers	expected numbers
red	62	
pink	131	
white	67	
total	260	260

[3]

The  $\chi^2$  statistic is calculated in the following way:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} \quad \sum = \text{“sum of ...”}$$

- (ii) Calculate the value of  $\chi^2$  for the above data. Show your working.

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

[2]

- (iii) The critical value of  $\chi^2$  for this type of investigation with two degrees of freedom is 5.991.

Explain whether your answer to **(b) (ii)** supports the hypothesis.

.....

.....

[1]  
Total 12

2. A student carried out a genetic investigation with fruit flies, *Drosophila melanogaster*. Two characteristics were observed, body colour and wing shape. The student had the following information:

- the characteristics were controlled by separate genes carried on separate chromosomes
- grey body colour was dominant to black body colour
- normal wing shape was dominant to bent wing shape.

The student carried out a cross between a fly **heterozygous** for both grey body colour and normal wing shape and a fly with a black body and bent wing. The numbers and phenotypes of the offspring were as follows:

grey body and normal wing	83
black body and normal wing	85
grey body and bent wing	78
black body and bent wing	74

(i) Complete the genetic diagram to explain this cross. Use the following symbols to represent the alleles:

**A = grey body colour, a = black body colour**  
**B = normal wing shape, b = bent wing shape**

Parental phenotypes: grey body / normal wing x black body / bent wing

Parental genotypes: ..... ..

Gametes: ..... ..

Offspring genotypes: .....

Offspring phenotypes: .....

.....

Phenotypic ratio: .....

The student concluded that the results showed that independent assortment had taken place.

To determine whether this conclusion is justified a chi-squared test ( $\chi^2$ ) can be carried out on the experimental data.

- (ii) Complete the table below by calculating the expected numbers.

offspring	observed numbers	expected numbers
grey body / normal wing	83	
black body / normal wing	85	
grey body / bent wing	78	
black body / bent wing	74	
total	320	320

[1]

- (iii) The  $\chi^2$  value is calculated in the following way:

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} \quad \text{where } \sum = \text{'sum of ...'}$$

Calculate the  $\chi^2$  value for the above data. Show your working.

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

[2]

- (iv) The critical value of  $\chi^2$  for this type of investigation with three degrees of freedom is 7.82.

Explain whether your answer to (c) (iii) supports the student's conclusion.

.....  
 .....

[1]

[Total 9 marks]

Answer **all** the questions.

- 1 A pure-breeding variety of tomato plant, variety **A**, produced red fruit which remained green at their bases even when ripe.

Plants of variety **A** were crossed with another pure-breeding variety, **B**, with orange fruit which have no green bases when ripe. The  $F_1$  generation plants all had red fruit with green bases.

(a) Describe the interaction of the alleles,

- (i) at the locus **G/g**, controlling green-based or not green-based fruit;

.....  
 ..... [1]

- (ii) at the locus **R/r**, controlling red or orange fruit.

.....  
 ..... [1]

(b) Using the symbols given in (a), state the genotype of variety **B**.

..... [1]

- (c) Plants from the  $F_1$  generation were test crossed (backcrossed) to variety **B**. The ratio of phenotypes expected in a dihybrid test cross such as this is 1 : 1 : 1 : 1.

Using the symbols given in (a), draw a genetic diagram of the test cross to show that the expected ratio of offspring phenotypes is 1 : 1 : 1 : 1.

[4]

- (d) Two hundred randomly chosen offspring from the test cross described in (c) had the following phenotypes:

red fruit with green bases	55
red fruit with no green bases	45
orange fruit with green bases	43
orange fruit with no green bases	57

The  $\chi^2$  (chi-squared) test was performed on these data, giving a calculated value for  $\chi^2$  of 3.2.

- (i) State the number of degrees of freedom applicable to these data.

..... [1]

**Table 1.1**

Distribution of  $\chi^2$  values

degrees of freedom	probability, $p$				
	0.10	0.05	0.02	0.01	0.001
1	2.71	3.84	5.41	6.64	10.83
2	4.61	5.99	7.82	9.21	13.82
3	6.25	7.82	9.84	11.35	16.27
4	7.78	9.49	11.67	13.28	18.47

- (ii) Use the calculated value of  $\chi^2$  and the table of probabilities provided in Table 1.1 to find the probability of the results of the test cross departing significantly by chance from the expected ratio.

probability ..... [1]

- (iii) State what conclusions may be drawn from the probability found in (d)(ii).

.....  
 .....  
 .....  
 .....  
 ..... [3]

- (e) Experiments have shown that loci **G/g** and **R/r** are on the same chromosome of the tomato plant genome. The two loci are 44 map units apart.

Explain how the results of the test cross shown in (d) could occur when the two loci are on the same chromosome.

.....  
 .....  
 .....  
 .....  
 ..... [3]

[Total: 15]

**[Turn over]**