Snapdragon Flowers

Chi-squared Test

Subject & topics: Biology | Genetics | Inheritance **Stage & difficulty:** A Level P3

In snapdragon plants, flower colour is controlled by a single gene with two alleles, C^R and C^W.

- C^RC^R plants have red flowers
- C^RC^W plants have pink flowers
- C^WC^W plants have white flowers.

Two pink-flowered snapdragon plants were crossed together, producing 108 offspring.

Part A

Expected ratio

Enter the expected ratio of red flowers : pink flowers : white flowers in the offspring.

Give the ratio in its simplest form.

[ ] : [ ] : [ ]

Part B

Calculate χ^2

The table below shows the observed number of offspring with each phenotype.

Fill in the rest of the table to calculate χ^2 using the formula below.

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

Give inexact answers to 4 dp.

Flower colour	Observed number (O)	Expected number (E)	$(\mathrm{O} - \mathrm{E})$	$\frac{(\mathrm{O}-\mathrm{E})^2}{\mathrm{E}}$
Red	31			
Pink	47			
White	30			
			χ^2	

Part C

Chi-squared critical value

Identify the critical value for this chi-squared test at the 5% level of significance.

Part D

Chi-squared test conclusion

The calculated χ^2 value is [ ] the critical value.

Therefore, the probability that the difference between the observed frequencies and expected frequencies occurred by chance is [ ] 5%. In other words, the difference between the observed frequencies and expected frequencies is [ ].

Items:

greater than | less than | equal to | significant | not significant

Monohybrid Cross Phenotype Frequencies

Chi-squared Test

Subject & topics: Biology | Genetics | Inheritance **Stage & difficulty:** A Level C3

In a monohybrid cross between two individuals that showed the same phenotype, 160 offspring were produced. 36 of these offspring showed a different phenotype to both parents for the same characteristic.

The characteristic is controlled by a single gene with one dominant allele and one recessive allele.

Part A

Calculate χ^2

Calculate χ^2 using the formula below. Assume that no mutations occur and that no genotype results in the death of individuals.

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

Give your answer to 3 dp.

Part B

Chi-squared critical value

Identify the critical value for this chi-squared test at the 5% level of significance.

Part C

Chi-squared test conclusion

The calculated χ^2 value is [ ] the critical value.

Therefore, the probability that the difference between the observed frequencies and expected frequencies occurred by chance is [ ] 5%. In other words, the difference between the observed frequencies and expected frequencies is [ ].

Items:

greater than | less than | equal to | significant | not significant

Adapted with permission from NSAA 2021 Section 2 Q59

Question deck:

STEM SMART Biology Week 43 - Chi-squared Tests

Drosophila Dihybrid Cross

Chi-squared Test

Subject & topics: Biology | Genetics | Inheritance **Stage & difficulty:** A Level C3

An experiment was carried out to investigate the inheritance of body colour and wing type in *Drosophila melanogaster* (fruit flies). These characteristics are controlled by two genes.

- Gene **B/b** determines body colour. The allele for yellow-brown colouration is dominant to the allele for black colouration.
- Gene **V/v** determines wing type. The allele for normal wings is dominant to the allele for short wings.

A parent that was homozygous dominant for both genes was crossed with a parent that was homozygous recessive for both genes to produce F1 offspring. Then, two F1 individuals were crossed to produce F2 offspring.

The observed phenotype frequencies in the F2 generation are shown below.

Phenotype	yellow-brown, normal wings	yellow-brown, short wings	black, normal wings	black, short wings
Frequency	68	3	5	20

Part A

Calculate χ^2

Calculate χ^2 using the formula below. Assume that no mutations occur and that no genotype results in the death of individuals.

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

Give your answer to 3 dp.

Part B

Chi-squared critical value

Identify the critical value for this chi-squared test at the 5% level of significance.

Part C

Chi-squared test conclusion

The calculated χ^2 value is [ ] the critical value.

Therefore, the probability that the difference between the observed frequencies and expected frequencies occurred by chance is [ ] 5%. In other words, the difference between the observed frequencies and expected frequencies is [ ].

There [ ] evidence to suggest that this pair of genes does **not** follow the expected inheritance pattern.

Items:

greater than | less than | equal to | significant | not significant | is | is insufficient

Part D

Biological explanation

Which of the following statements could explain why this pair of genes does not follow the expected inheritance pattern? Select all that apply.

- [ ] The two genes are found on the **same** chromosome.
- [ ] The two genes are found on **different** chromosomes.
- [ ] Crossing over of these alleles **never** happens during meiosis.
- [ ] Crossing over of these alleles only **sometimes** happens during meiosis.
- [ ] Crossing over of these alleles **always** happens during meiosis.
- [ ] Independent assortment of the relevant chromosomes **never** occurs during meiosis.

Question deck:

STEM SMART Biology Week 43 - Chi-squared Tests

Grey Seal Diet Composition

Chi-squared Test

Subject & topics: Biology | Maths Skills | Statistical Tests **Stage & difficulty:** A Level P3

A marine biologist carried out an investigation into the diet of grey seals, to investigate whether they prefer to eat certain types of prey over others. By analysing seal scats (faeces), they recorded how many animals of each type (fish, crustaceans, molluscs) were eaten by seals. The relative abundances of these types of animals in this habitat are as follows:

- Fish: 70% of individuals
- Crustaceans: 20% of individuals
- Molluscs: 10% of individuals

To investigate whether grey seals prefer to eat certain types of prey over others, the researcher compared their data to the relative abundances shown above.

Part A

Calculate χ^2

The table below shows the observed number of individuals of each type found in seal scats in this investigation.

Fill in the rest of the table to calculate χ^2 using the formula below.

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

Give your answers as exact decimals.

Prey type	Observed number (O)	Expected number (E)	$(\mathrm{O} - \mathrm{E})$	$\frac{(\mathrm{O}-\mathrm{E})^2}{\mathrm{E}}$
Fish	161			
Crustaceans	24			
Molluscs	15			
			χ^2	

Part B

Chi-squared critical value

Identify the critical value for this chi-squared test at the 5% level of significance.

Part C

Chi-squared test conclusion

The calculated χ^2 value is [ ] the critical value.

Therefore, the probability that the difference between the observed frequencies and expected frequencies occurred by chance is [ ] 5%. In other words, the difference between the observed frequencies and expected frequencies is [ ].

We [ ] the null hypothesis and conclude that there [ ] evidence to suggest that grey seals prefer to eat certain types of prey over others.

Items:

greater than | less than | significant | not significant | reject | do not reject | is | is insufficient

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Question deck:

STEM SMART Biology Week 43 - Chi-squared Tests

Pollinator Preferences

Chi-squared Test

Subject & topics: Biology | Maths Skills | Statistical Tests **Stage & difficulty:** A Level P3

A researcher carried out an investigation into pollination behaviour in bees, to investigate whether bees prefer to visit certain colours of flower over others. The researcher presented bees with snapdragons of various colours (white, yellow, red, purple) and recorded the total number of visits made by bees to each colour of flower. For each colour category, the same number of flowers were present. The results are shown in the table below.

Flower colour	White	Yellow	Red	Purple
Total number of visits made by bees	32	40	18	38

Part A

Type of test

The researcher decided to perform a chi-squared test.

Why did they decide to perform this type of test?

- The chi-squared test is used to determine whether there is a significant correlation between two continuous variables.
- The chi-squared test is used to determine whether a continuous variable shows a significant difference between two categories of a categorical variable.
- The chi-squared test is used to compare observed frequencies to expected frequencies of a categorical variable and determine whether there is a significant difference

Part B

Null and alternative hypotheses

Select the correct null hypothesis (H_0) and the correct alternative hypothesis (H_1) below.

- [ ] null hypothesis: the number of visits to each colour of flower **does** follow the expected ratio of $1:1:1:1$
- [ ] null hypothesis: the number of visits to each colour of flower does **not** follow the expected ratio of $1:1:1:1$
- [ ] alternative hypothesis: the number of visits to each colour of flower **does** follow the expected ratio of $1:1:1:1$
- [ ] alternative hypothesis: the number of visits to each colour of flower does **not** follow the expected ratio of $1:1:1:1$

Part C

Calculate χ^2

Calculate χ^2 using the formula below.

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

Part D

Chi-squared critical value

Identify the critical value for this chi-squared test at the 5% level of significance.

Part E

Chi-squared test conclusion

The calculated χ^2 value is [ ] the critical value.

Therefore, the probability that the difference between the observed frequencies and expected frequencies occurred by chance is [ ] 5%. In other words, the difference between the observed frequencies and expected frequencies is [ ].

We [ ] the null hypothesis and conclude that there [ ] evidence to suggest that bees prefer to visit certain colours of flower over others.

Items:

greater than | less than | significant | not significant | reject | do not reject | is | is insufficient