

Mendelian Genetics

Learning objective 5.3.A Explain the inheritance of traits using Mendel's laws.

Name:

Date:

Period:

Use the tool **Where the Ratio Comes From**. Part 1 uses **Build the square**, Part 2 uses **Two genes at once** and Part 3 uses **Does it fit?**. The tool uses abstract alleles **A/a** and **B/b**; the questions here attach them to Mendel's peas, where **A** = round seed, **a** = wrinkled seed, **B** = yellow seed and **b** = green seed. Never quote a ratio you have not counted.

Part 1 • Build the squares yourself

Open **Build the square**. Draw each square in the space, fill in the four boxes, then set the parents in the tool and check. Predict before you check.

Cross	The four boxes	Genotype ratio (AA:Aa:aa)	Phenotype ratio (round:wrinkled)
Aa × Aa			
AA × aa			
Aa × aa			
AA × aa			
Aa × AA			

1. Explain why the genotype ratio from Aa × Aa is 1:2:1 and not 1:1:1.

2. Two of your rows give the same phenotype ratio from different parents. Identify them and explain why the phenotype cannot distinguish those crosses.

Part 2 · The test cross

A pea plant has round seeds, so it is either **AA** or **Aa** and you cannot tell which by looking. Use the tool to work out which partner to cross it with.

Unknown parent	Crossed with aa	Crossed with AA
AA		
Aa		
Does this cross identify the unknown?		

3. State which partner you would use for a test cross, and explain why the other one is useless.

4. A test cross produces 20 offspring, all with round seeds. State what this suggests about the unknown parent, and explain why it is not proof.

Part 3 • Two genes at once

Switch to **Two genes at once**. Both parents are **AaBb** — round yellow seeds, heterozygous for both. Use the class chips to count each phenotype class, then check it against the multiplication.

Phenotype	Boxes counted	First gene	Second gene	Product
Round, yellow				
Round, green				
Wrinkled, yellow				
Wrinkled, green				

5. Explain why 9:3:3:1 is two 3:1 ratios multiplied rather than a separate rule to learn.

6. Without drawing a square, calculate the probability that an offspring of AaBb × AaBb has round green seeds. Show the multiplication.

Part 4 · Testing the prediction

Switch to **Does it fit?**. Work each dataset through the table yourself before reading the tool's answer. $\chi^2 = \sum (\mathbf{O} - \mathbf{E})^2 / \mathbf{E}$, and degrees of freedom is the number of classes minus one.

Dataset	χ^2	df	Critical value	Reject or not?
A 3:1 cross that fits				
A 3:1 cross that is off but survives				
A 3:1 cross that fails				
A 9:3:3:1 cross that fits				
A dihybrid cross that fails				

7. State the null hypothesis for a chi-square test on a genetic cross.

8. One of your datasets has a chi-square value above the critical value. State what you can conclude and what you cannot.

9. Two datasets have the same degrees of freedom but very different numbers of offspring. Explain why the number of offspring does not affect the degrees of freedom, but does affect the chi-square value.

What the model simplifies

Every cross here assumes complete dominance, two alleles per gene, genes on different chromosomes, and equal survival of all genotypes. Topic 5.4 removes the first two of those assumptions, and linked genes break the third.

The tool uses abstract alleles A/a and B/b ; the handout attaches them to Mendel's pea traits. The counting is identical either way, and the abstraction is deliberate — a ratio derived from letters transfers to any trait.

A Punnett square gives probabilities, not predictions about a particular family. Four offspring from an $Aa \times Aa$ cross are not guaranteed to be three round and one wrinkled, any more than four coin tosses are guaranteed to be two heads and two tails.

The chi-square critical values are those for $p = 0.05$, the threshold the AP course uses. That choice is a convention, not a property of the data: a departure significant at $p = 0.05$ may not be at $p = 0.01$.

Mendel's dihybrid figures (315, 108, 101, 32) are his published counts. The other datasets are constructed so that the arithmetic is checkable and so that a rejected result can be shown as well as an accepted one.