

Halving, crossing and the genotype

60 minutes • D3.2.1 to D3.2.4 • Chapters 1, 2, 3

Meiosis as halving and fertilisation as doubling, how a cross in flowering plants is made and described, and the difference between genotype and phenotype

BY THE END, STUDENTS CAN

- ☐ Explain how meiosis halves the chromosome number to make haploid gametes, and how fusion gives a diploid zygote D3.2.1
- ☐ Describe how a genetic cross is made in flowering plants, using the terms P generation, F1 generation, F2 generation and Punnett grid D3.2.2
- ☐ Define genotype, and use homozygous, heterozygous, gene and allele correctly D3.2.3
- ☐ Explain how phenotype comes from genotype and the environment, with examples of each D3.2.4

TIMING

0-6	6 min	Do now: how many chromosomes?	
6-18	12 min	Halve, then fuse	
18-28	10 min	Halve and fuse: the model	
28-40	12 min	Making a cross	
40-55	15 min	Gene, allele, genotype, phenotype	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

6 min

Do now: how many chromosomes?

Chapter 1's first predict box. Students answer on mini whiteboards before the options appear on the screen: how many chromosomes in a human sperm, and in the zygote? Keep the boards up. Ask what would happen if gametes were made by ordinary division.

ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

01 Halve, then fuse

CHAPTER 01 IN THE SLIDES

Step through the figure (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

- Two parents, each with **diploid** body cells ($2n = 46$). Three of the 23 pairs are drawn.
- Meiosis** makes gametes with one chromosome from each pair: an egg and a sperm, each **haploid** ($n = 23$).
- Fusion** of the two gametes makes a zygote. It is diploid again, with one set from each parent.
- In the zygote, a pair of chromosomes carries the **same gene** twice, one copy from each parent.

Play the animation, Watch it happen: halving, then fusing. It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. A **diploid** cell of a parent. Its chromosomes are in pairs: one of each pair came from its mother (pink), one from its father (green).
2. First the DNA is copied: each chromosome becomes two identical **sister chromatids**, joined at a **centromere**.
3. The nucleus breaks down and each chromosome lies beside its partner: a **homologous pair**, with the same genes in the same order.
4. **Crossing over**: chromatids of a pair swap matching sections, making new mixes of the mother's and the father's alleles.
5. A spindle forms and the pairs line up across the middle. Which way round each pair lies is down to chance: **random orientation**.
6. **Meiosis I**: one chromosome of each pair is pulled to each end, and the cell divides. Each new cell has half the number of chromosomes.
7. **Meiosis II**: in each cell the sister chromatids are pulled apart, and both cells divide again.
8. Four **haploid** gametes, each with one chromosome of every pair, and no two alike.
9. **Fertilisation**: the gamete fuses with one from another parent (yellow). The **zygote** is diploid again, with one of each pair from each parent.

Predict box: A human body cell has 46 chromosomes. How many chromosomes are in a sperm, and how many in the zygote it helps to form? Hands up or mini whiteboards first.

Answer B: 23 in the sperm and 46 in the zygote

02 How to make a cross

CHAPTER 02 IN THE SLIDES

Step through the figure (5 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A pea flower makes both kinds of gamete. **Pollen** forms in the anthers and holds the male gametes. The **ovules** in the ovary hold the female gametes.
2. Left alone, a pea flower **pollinates itself**: its pollen reaches its own stigma.
3. For a **cross**, the anthers are removed from the receiving flower, and pollen is carried from the donor to its stigma.
4. Cross two true-breeding parents (the **P generation**). Every seed of the **F1 generation** has one allele from each parent.
5. Let the F1 plants self-pollinate to make the **F2 generation**. The **Punnett grid** shows every way their gametes can combine: 3 yellow seeds for every 1 green.

Predict box: A student wants to cross a purple-flowered pea plant with a white-flowered one, but forgets to remove the anthers from the white plant. What is likely to happen? Hands up or mini whiteboards first.

Answer A: Some seeds will come from self-fertilisation, so not all will be from the cross

Remember it: Parents First Follows (P generation, F1 generation, F2 generation).

03 Genes, alleles and the traits you see

CHAPTER 03 IN THE SLIDES

Step through the figure (3 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A pair of homologous chromosomes. The **gene** is one place on the chromosome. Each chromosome carries one **allele** of it, here Y and y.
2. The two alleles make the **genotype**. Two the same is **homozygous**. Two different is **heterozygous**.
3. The **phenotype** comes from the genotype, the environment, or both: blood group, a scar and height.

Predict box: Two plants have the same genotype for every gene, but one grows much taller because it was given more water and fertiliser. What does this show? Hands up or mini whiteboards first.

Answer B: The environment affects the phenotype as well as the genotype

THE LESSON

12
min

Halve, then fuse

Chapter 1's film, paused at each stage. Students sketch a cell with two chromosome pairs, then the four gametes it can make, then the zygote. Land on the linking question: what processes involve doubling and halving? Meiosis halves the number, fertilisation doubles it.

10
min

Halve and fuse: the model

The activity below. Each pair makes gametes by flipping a coin for each chromosome pair, then fuses with another pair. Tally the zygotes on the board and ask why two gametes from the same parent are never quite the same.

12
min

Making a cross

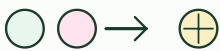
Chapter 2's figure, one step at a time, then its predict box on the forgotten anthers. Students write the words pollen, anther, stigma, ovary, P, F1 and F2 on a flower outline. Turn over the Remember it tiles for the generations.

15
min

Gene, allele, genotype, phenotype

Chapter 3's figure and predict boxes. Then the card sort below: is each trait set by genotype only, environment only, or both? Ask students to defend any card the class splits on. Do not rush the gene against allele distinction: say "versions of a gene".

ACTIVITIES

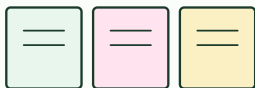


MODEL

Halve and fuse

Each student has two cards for one chromosome pair, one pink (from the mother) and one green (from the father), and a coin. Heads, the pink card goes into the gamete; tails, the green one. Two students then bring their gametes together to make a zygote. Repeat with two pairs, using two coins. Tally on the board how many zygotes have both pink, both green, or one of each. Ask why a parent never passes both cards.

Needs: coins, pink and green cards (two for each pair of chromosomes), a tally table on the board.



CARD SORT

Genes, environment or both?

Twelve trait cards for pairs, sorted into three piles: set by genotype only, by environment only, and by both. Use blood group, a scar, a tattoo, height, the shape of earlobes, a tan, speaking a language, body mass, the colour of eyes and a broken arm, with two of your own. Some cards invite argument; that is the point. For each card in the third pile, name the gene and name the environmental factor. Expect disagreement over height and body mass; both belong in the third pile.

Needs: printed cards, one set per pair.

PLENARY

5
min

Exit

Write a sentence using homozygous and a sentence using heterozygous, each for the pea seed shape gene. Collect on the way out.

WHAT STUDENTS GET WRONG

"Dominant means common or strong." A dominant allele is one that shows in the heterozygote. Many dominant alleles are rare, and some harmful ones are dominant.

Gene and allele are the same. A gene is a stretch of DNA that codes for a polypeptide; alleles are its versions. Ask "which gene, and which allele of it?".

"A Punnett grid predicts exactly." It gives a probability for each child. Four children from Yy by Yy need not include a green one. Use the coins.

STRETCH AND SUPPORT

Support: give each figure's captions as a cut-up storyboard to put in order, and let students tap the dotted words as a glossary.

Stretch: a pea plant has 7 pairs of chromosomes. How many different gametes can one plant make from the way the pairs line up, ignoring crossing over? *2 to the power 7, which is 128.*

IN THE GUIDE

- 1 [Halve, then fuse](#)
- 2 [How to make a cross](#)
- 3 [Genes, alleles and the traits you see](#)
- A11 [The whole guide, with the figures that play](#)
- PPTX [This lesson's slides, in the order of this plan](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on D3.2 at standard level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=D3.2&level=SL&paper=quiz&marks=15&src=ep



PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on D3.2, built from its key terms and ready to print
- A [pub quiz](#) with rounds on D3.2, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on D3.2

ALREADY ON THE SITE FOR D3.2

- Lesson: [Linked Genes & Chi-Squared](#)
- Lesson: [Dihybrid Crosses & Test Crosses](#)
- Lesson: [Inheritance](#)
- Summary doodle: [Inheritance](#)
- Quiz: [Inheritance \(HL\)](#)
- Quiz: [Inheritance](#)
- Revision map: [D3.2 Inheritance](#), to fill in
- Exam questions: [D3.2 in the exam maker](#), a paper with its markscheme

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- [D3.2 Inheritance](#)

How this was made. The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.