

# Two genes at once HL

60 minutes • D3.2.16 and D3.2.17 • Chapter 13

## Segregation and independent assortment of unlinked genes, and the Punnett grid for a dihybrid cross

### BY THE END, STUDENTS CAN

- ☐ Explain segregation and independent assortment of unlinked genes in meiosis D3.2.16
- ☐ Use Punnett grids to predict genotypic and phenotypic ratios in dihybrid crosses of unlinked autosomal genes D3.2.17

### TIMING

|       |        |                        |                        |
|-------|--------|------------------------|------------------------|
| 0-6   | 6 min  | Do now                 | <div><div></div></div> |
| 6-18  | 12 min | Watch the line-up      | <div><div></div></div> |
| 18-30 | 12 min | Gametes with two coins | <div><div></div></div> |
| 30-50 | 20 min | The grid               | <div><div></div></div> |
| 50-60 | 10 min | Exam practice          | <div><div></div></div> |
|       | 60 min | One lesson             |                        |

### STARTER

**6**  
min

#### Do now

A pea plant is heterozygous for seed colour and seed shape. List every kind of gamete it could make. Students get 2 or 4; take a vote and keep it up.

### 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.

## 13 Two genes at once

CHAPTER 13 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.

- In meiosis I each pair of **homologous chromosomes** lines up at the equator, and the partners go to opposite poles.
- The pairs line up either way round, independently. Two equally likely ways give **four kinds of gamete**: YR, yr, Yr and yR.
- A YyRr × YyRr cross: put each parent's four kinds of gamete along the sides of a 4 × 4 grid.
- Fill in the **16 genotypes**, each equally likely.
- Read off the phenotypes: **9 : 3 : 3 : 1**.

**Play the animation, Watch it happen: two genes line up independently.** It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. One cell of an **YyRr** parent, its DNA already copied. Gene Y is on one pair of chromosomes and gene R on another: capitals from its mother (pink), lower case from its father (green).
2. Each chromosome pairs with its homologue, so the two alleles of each gene lie side by side.
3. The pairs line up. In this cell both pink chromosomes face the same end, so Y will go with R, and y with r.
4. **Segregation:** in meiosis I the alleles of each gene separate, Y from y and R from r.
5. Meiosis II separates the sister chromatids, which carry the same alleles.
6. This cell makes two kinds of gamete: YR and yr.
7. In another cell the pairs line up the other way round: now Y goes with r, and y with R.
8. That cell makes Yr and yR gametes.
9. Both line-ups are equally likely, so the four types are made in equal numbers, **1:1:1:1**. This is **independent assortment**.

**Step through the figure** (2 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Each parent makes gametes by meiosis, one allele of each gene in each. The female parent's go down the side of the **Punnett grid**, the male parent's along the top.
2. Each cell joins one gamete from each parent: a possible offspring, every cell as likely as the next. The F1: genotypes all YyRr; phenotypes all yellow round.

**Predict box:** A plant YyRr is crossed with a plant yyrr. What proportion of the offspring are yellow and round?  
Hands up or mini whiteboards first.

**Answer B: One quarter**

## THE LESSON

**12**

min

### Watch the line-up

Chapter 13's meiosis film at higher level. Pause at the line-up and show both ways the pairs can face. Define segregation and independent assortment, and note the nature of science point: the second law holds only for unlinked genes.

**12**

min

### Gametes with two coins

The activity below. Two coins make a gamete from a double heterozygote. Fill in the four gamete types and their frequencies, then the grid.

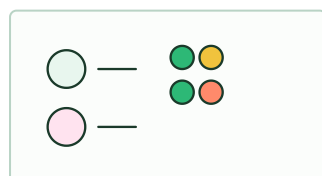
**20**

min

### The grid

Chapter 13's figure and the cross builder in dihybrid mode. Students predict before the grid fills. Then the ratio sort below: match each cross to 9:3:3:1, 1:1:1:1 or all one type.

## ACTIVITIES



### MODEL

#### Gametes with two coins

Each student plays a plant heterozygous for two genes, YyRr. One coin chooses Y or y, the other chooses R or r. Flip both, write the gamete, and make 40 gametes. Tally the four types on the board. Compare with the grid and with a plant of genotype YyRR. Then two students fuse a gamete each, ten times, to make F2 plants, and the class counts the phenotypes. Is it close to 9:3:3:1?

**Needs:** two coins per student, a tally table.

## CARD SORT

## Sort the ratios

Eight cross cards and three ratio cards (9 : 3 : 3 : 1, 1 : 1 : 1 : 1, one type only). Match each cross to its ratio without drawing a grid when you can: YyRr by YyRr, YyRr by yyrr, YYRR by yyrr, YyRr by YyRR and so on. Then draw grids for the two you were least sure of. Ask students to say why a test cross gives the ratio that it does, and what the F2 of a cross between true-breeding parents looks like.

**Needs:** printed cards, one set per pair.

## PLENARY

10

min

## Exam practice

A dihybrid question from the exam maker (in Practise and revise, below). Students write gametes, grid and ratio in 8 minutes and peer-mark against the scheme.

## WHAT STUDENTS GET WRONG

**"Two genes always assort independently."** Only genes on different chromosomes, or far apart on one, do.

## STRETCH AND SUPPORT

**Support:** the four gametes of a double heterozygote written out for the first two examples.

**Stretch:** in an F2 of 9 : 3 : 3 : 1, count seed colour on its own and then seed shape on its own. What ratio does each gene give, and what does that tell you? *Each gives 3 : 1: the genes are sorted independently, so each still behaves as in a one-gene cross.*

## IN THE GUIDE

**13** [Two genes at once](#)

**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 higher 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=HL&paper=quiz&marks=15&src=ep](https://biologybybradford.com/exam-maker/sit?topics=D3.2&level=HL&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.