

# Evolution and speciation

## Four one-hour lesson plans, and one more at higher level

Four one-hour lessons cover the standard level statements, and a fifth adds the higher level ones (the guide gives A4.1 four hours at SL and one more at HL). The plan follows the chapters, so a class can read the guide for homework and use the lesson for the activities. Every figure plays on a projector: step through it with the arrow keys and stop on each caption.

| LESSON                                    | COVERS            | FOCUS                                                                                                          | CHAPTERS  |
|-------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------|-----------|
| <b>1 What evolves, and what DNA shows</b> | A4.1.1, A4.1.2    | Evolution as a change in a population's heritable characteristics, and what base and amino acid sequences show | 1, 2      |
| <b>2 Breeding, bones and wings</b>        | A4.1.3 to A4.1.5  | Selective breeding, the pentadactyl limb, and homologous against analogous structures                          | 3, 4      |
| <b>3 How one species becomes two</b>      | A4.1.6, A4.1.7    | Speciation by splitting: reproductive isolation and differential selection in bonobos and chimpanzees          | 5, 6      |
| <b>4 The island dry lab</b>               | A4.1.6 to A4.1.8  | The finches dry lab: what isolation, gene flow and population size do to two populations                       | 5, 6, 1ab |
| <b>5 Higher level</b> <span>HL</span>     | A4.1.8 to A4.1.11 | Allopatric and sympatric speciation, adaptive radiation, and new plant species by polyploidy                   | 7, 8, 9   |

The guide, for the class to read and play: [biologybybradford.com/guides/ib-biology-a4-1-evolution-and-speciation](https://biologybybradford.com/guides/ib-biology-a4-1-evolution-and-speciation)

# What evolves, and what DNA shows

60 minutes • A4.1.1, A4.1.2 • Chapters 1, 2

Evolution as a change in a population's heritable characteristics, and what base and amino acid sequences show

## BY THE END, STUDENTS CAN

- ☐ Explain why evolution is a change in the heritable characteristics of a population, and why a change gained in one lifetime is not A4.1.1
- ☐ Use differences in base and amino acid sequences to judge which species share the most recent common ancestor A4.1.2

## TIMING

|       |        |                                    |                        |
|-------|--------|------------------------------------|------------------------|
| 0-8   | 8 min  | Do now: two stories of a long neck | <div><div></div></div> |
| 8-20  | 12 min | The drought on Daphne Major        | <div><div></div></div> |
| 20-25 | 5 min  | "Just a theory"?                   | <div><div></div></div> |
| 25-45 | 20 min | Sequence detectives                | <div><div></div></div> |
| 45-55 | 10 min | Evidence organiser, row 1          | <div><div></div></div> |
| 55-60 | 5 min  | Exit: back to the vote             | <div><div></div></div> |
|       | 60 min | One lesson                         |                        |

## STARTER

- 8 min** **Do now: two stories of a long neck**
- On the board: "Giraffes stretched for high leaves and passed longer necks on" against "Giraffes with longer necks happened to feed better and left more young". Students vote, then defend their vote in pairs. Leave the votes up; come back to them at the end.

## 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 Evolution is a change in what a population inherits

CHAPTER 01 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.

- Each dot is one finch. Beak depth **varies**, and the variation is heritable: chicks resemble their parents.
- A drought leaves only big, hard seeds. Most finches with shallow beaks **starve**.
- The survivors breed and pass on their **alleles**, deep-beak alleles included.
- The next generation's beaks are deeper on average: the population has **evolved**. (Numbers simplified from the real study.)
- A beak chipped on a hard seed is not passed on: the chick hatches with a whole beak. An **acquired** change is not evolution.

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

- Birds spot the beetles that stand out. The **best hidden** survive and breed.
- Then soot from a fire darkens the ground. Now the **pale** beetles stand out.
- No beetle ever changed its shell. The **population** changed: that is evolution.

**Predict box:** A gardener clips a hedge into a perfect cube every year for 40 years. Seeds from the hedge are sown. What shape do the seedlings grow into? Hands up or mini whiteboards first.

**Answer C: The usual shape for the species: clipping never touched their alleles**

## 02 Sequences remember common ancestors

CHAPTER 02 IN THE SLIDES

Switch the figure through Bases and Amino acids, and have the class say what will change before each.

**Predict box:** Before you compare: which species' sequence will differ from the human one at the most positions? Hands up or mini whiteboards first.

**Answer D: Frog**

### THE LESSON

12

min

#### The drought on Daphne Major

Play [chapter 1](#)'s figure step by step. At each step students sketch the dot plot and say what changed and what did not: no bird's beak changed, the population did. Write the definition only after the sketches: evolution is a change in the heritable characteristics of a population.

5

min

#### "Just a theory"?

Think, pair, share: why is evolution called a theory when nothing contradicts it? Land on the nature of science point: it explains and predicts a huge range of observations, but no theory can be proved true, only fail to be disproved.

20

min

#### Sequence detectives

Students predict the most different species ([chapter 2](#)'s predict box), then use the sequence figure in pairs: compare each species, record the differences in a table, and watch the tree build. Switch to amino acids and ask why some differences vanish. Then the cytochrome c facts: identical in chimpanzees, one difference in rhesus monkeys, over 40 in yeast.

10

min

#### Evidence organiser, row 1

A grid with a row for each kind of evidence (sequences, selective breeding, homologous structures) and columns for what it is, a sketch, a named example and why it supports evolution. Fill the sequences row now; the others come in lesson 2.

### ACTIVITIES



#### DATA

##### Sequence detectives

Pairs use the sequence figure in [chapter 2](#), or a printed copy of its five sequences. They count differences from the human sequence, put the species in order, and draw the tree. Extension: why are there more differences between base sequences than between amino acid sequences? Teachers who want real data can give the cytochrome c difference counts from a database.

**Needs:** the guide on devices, or printed alignments; squared paper.

### PLENARY

5

min

#### Exit: back to the vote

Which giraffe story was Lamarck's, and why is it wrong? One sentence each, using the word "allele".

#### WHAT STUDENTS GET WRONG

**"Animals evolve to survive."** Individuals do not evolve, and nothing changes because it is needed. Insist on "the population" and "more offspring".

**Acquired changes are inherited.** Use the hedge and the chipped beak: only alleles in gametes are passed on.

**Evolution as a ladder.** Pictures of a line of apes walking into a human are wrong: every living species is the tip of a branch, and humans did not come from chimpanzees.

#### STRETCH AND SUPPORT

**Support:** give the captions of each figure as a cut-up storyboard to put in order, and use the key terms (tap the dotted words) as a glossary.

**Support:** the three mnemonics (Dragons Breathe Heat; Hungry Rats Chew My Pencils; Grumpy Birds Tweet) as a starter on each lesson.

**Stretch:** use a sequence database to compare one real protein across five species and build a tree.

#### IN THE GUIDE

- 1** [Evolution is a change in what a population inherits](#)
- 2** [Sequences remember common ancestors](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

#### PRACTISE AND REVISE

##### BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on A4.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A4.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on A4.1

##### ALREADY ON THE SITE FOR A4.1

- [Quiz: Evolution & Speciation](#)
- Revision map: [A4.1 Evolution and speciation](#), to fill in
- Exam questions: [A4.1 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.

- [A4.1 Evolution and Speciation \(SL\)](#)
- [A4.1 Evolution and Speciation \(HL\)](#)

#### EXAM PRACTICE

##### Check yourself

Set it for homework: a fresh paper of exam-bank questions on A4.1 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=A4.1&level=SL&paper=quiz&marks=15&src=ep](https://biologybybradford.com/exam-maker/sit?topics=A4.1&level=SL&paper=quiz&marks=15&src=ep)



# Breeding, bones and wings

60 minutes • A4.1.3 to A4.1.5 • Chapters 3, 4

## Selective breeding, the pentadactyl limb, and homologous against analogous structures

### BY THE END, STUDENTS CAN

- ☐ Explain how crops and domestic animals show how quickly heritable characteristics can change A4.1.3
- ☐ Name the bones of the pentadactyl limb and tell homologous structures from analogous ones made by convergent evolution A4.1.4, A4.1.5

### TIMING

|       |        |                                     |                        |
|-------|--------|-------------------------------------|------------------------|
| 0-5   | 5 min  | Do now: which are the same species? | <div><div></div></div> |
| 5-20  | 15 min | Six vegetables, one species         | <div><div></div></div> |
| 20-35 | 15 min | One bone plan                       | <div><div></div></div> |
| 35-45 | 10 min | Homologous or analogous?            | <div><div></div></div> |
| 45-55 | 10 min | Evidence organiser, rows 2 and 3    | <div><div></div></div> |
| 55-60 | 5 min  | Exit                                | <div><div></div></div> |
|       | 60 min | One lesson                          |                        |

### STARTER

#### 5 min Do now: which are the same species?

Six vegetables on the front bench (or six pictures): kale, cabbage, Brussels sprouts, kohlrabi, broccoli, cauliflower. How many species? Most students guess four to six. The answer is one.

### ON THE BOARD, FROM THE GUIDE

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#### 03 Six vegetables, one wild weed

CHAPTER 03 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.

- Wild cabbage: **leaves**, buds at the tip and along the stem, and yellow flowers.
- Selected for **leaves**: kale. Selected for a big **terminal bud**: cabbage.
- Selected for **side buds**: Brussels sprouts. Selected for a swollen **stem**: kohlrabi.
- Selected for **flower stalks and buds**: broccoli and cauliflower. All six can still interbreed: **one species**.

**Predict box:** Kohlrabi and Brussels sprouts look nothing alike. A grower lets them cross-pollinate. What happens? Hands up or mini whiteboards first.

**Answer B: Seeds form and grow into fertile plants: one species**

**Remember it:** Darwin's Big Hunch (DNA and protein sequences, Breeding, Homologous structures).

#### 04 Same bones, different jobs, and the reverse

CHAPTER 04 IN THE SLIDES

**Switch the figure** through Homologous and Analogous, and have the class say what will change before each.

**Predict box:** A bat's wing and a bird's wing: homologous or analogous? Hands up or mini whiteboards first.

**Answer C: Both: homologous as forelimbs, analogous as wings for flight**

## THE LESSON

**15**

min

### Six vegetables, one species

The practical below, then [chapter 3](#)'s figure. Ask why this counts as evidence for evolution, and why it is not an example of new species forming.

**15**

min

### One bone plan

[Chapter 4](#)'s figure on the board: tap each bone group across all four limbs. Students colour the same five groups on a blank limb outline, then learn the order with the mnemonic tiles. Ask: why would anyone build a wing, a paddle and a leg from the same parts?

**10**

min

### Homologous or analogous?

The card sort below, in pairs. Take feedback on the two trap cards (the flippers, and the bat and bird wings) before anything else.

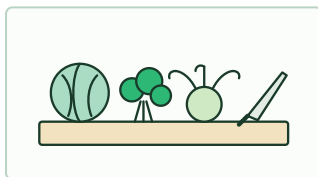
**10**

min

### Evidence organiser, rows 2 and 3

Selective breeding and homologous structures. Students swap with a partner and add one thing to each other's rows.

## ACTIVITIES

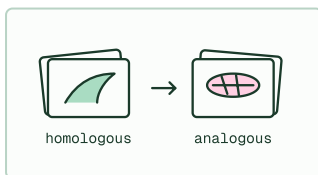


### PRACTICAL

#### Six vegetables, one species

Groups get one of each cultivar of *Brassica oleracea* and a drawing of wild cabbage ([chapter 3](#)'s figure). They cut each vegetable lengthways, find which organ has been enlarged (leaf, terminal bud, side bud, stem, flower stalk, flower buds) and label it on the wild plant. Finish by asking what farmers chose each time, and what that shows about how fast heritable characteristics can change.

**Needs:** kale, cabbage, Brussels sprouts on the stalk if you can get them, kohlrabi, broccoli, cauliflower; knives and boards; hand lenses.



### CARD SORT

#### Homologous or analogous?

Ten pairs of structures, each on a card, to sort into homologous, analogous, or both. Include the bird and bee wing, a human arm and a bat wing, a horse and a cat foreleg, octopus and human eyes, a cactus stem and a euphorbia stem, and two traps: whale and penguin flippers (homologous as forelimbs, analogous only in their flipper shape), and bat and bird wings (homologous as forelimbs, analogous as wings).

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

## PLENARY

**5**

min

### Exit

Name one pair of analogous structures and say why they are not homologous.

#### WHAT STUDENTS GET WRONG

**Looking different means a different species.** Dog breeds and cabbage cultivars are one species each.

**Analogous means "looks similar".** It means same function, different origin; the flippers are the classic trap.

**Pentadactyl means five fingers.** It names the bone plan; a horse has one digit on the same plan.

#### STRETCH AND SUPPORT

**Support:** give the captions of each figure as a cut-up storyboard to put in order, and use the key terms (tap the dotted words) as a glossary.

**Support:** the three mnemonics (Dragons Breathe Heat; Hungry Rats Chew My Pencils; Grumpy Birds Tweet) as a starter on each lesson.

#### IN THE GUIDE

- 3** [Six vegetables, one wild weed](#)
- 4** [Same bones, different jobs, and the reverse](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

#### PRACTISE AND REVISE

##### BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on A4.1, built from its key terms and ready to print
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- An [escape room](#) built from the [question bank](#) on A4.1

##### ALREADY ON THE SITE FOR A4.1

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- Revision map: [A4.1 Evolution and speciation](#), to fill in
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#### EXAM PRACTICE

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# How one species becomes two

60 minutes • A4.1.6, A4.1.7 • Chapters 5, 6

## Speciation by splitting: reproductive isolation and differential selection in bonobos and chimpanzees

### BY THE END, STUDENTS CAN

- ☐ Explain why splitting is the only way new species arise, and why gradual change in one line is not speciation A4.1.6
- ☐ Explain how reproductive isolation and differential selection split bonobos from common chimpanzees A4.1.7

### TIMING

|       |        |                                       |                        |
|-------|--------|---------------------------------------|------------------------|
| 0-5   | 5 min  | Do now                                | <div><div></div></div> |
| 5-15  | 10 min | Splits add, extinctions take away     | <div><div></div></div> |
| 15-25 | 10 min | Storyboard: from one gene pool to two | <div><div></div></div> |
| 25-50 | 25 min | The river case file                   | <div><div></div></div> |
| 50-60 | 10 min | Exam question, timed                  | <div><div></div></div> |
|       | 60 min | One lesson                            |                        |

### STARTER

#### 5 min Do now

"A chihuahua and a grey wolf: one species or two? How would you decide?" Draw out the definition: able to interbreed and have fertile offspring. By that test they are one species: dogs and wolves still interbreed and have fertile pups, and the dog is often classed as a subspecies of the grey wolf.

### ON THE BOARD, FROM THE GUIDE

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#### 05 New species arise only by splitting

CHAPTER 05 IN THE SLIDES

**Step through the figure** (6 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

- One species:** every population can interbreed with every other.
- A barrier divides it into two populations. **Gene flow stops**, but for now they are still one species.
- Each population changes separately until they **cannot interbreed**: two species.
- The lower species changes **gradually** but never splits: still one species, so the count stays at two.
- The upper species **splits** again: three.
- The lower species dies out: **extinction** takes the count back to two.

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

- One population:** any two can meet and mate, so genes flow across the valley.
- Different selection** each side: coats match the ground, displays drift apart.
- Hybrids are rare, weak and often sterile, so the two never merge: **two species**.

**Predict box:** A line of snails changes its shell shape steadily for two million years and never splits. The oldest and newest shells look so different that fossil experts give them different names. How many species has the line added to the Earth? Hands up or mini whiteboards first.

**Answer B: None: at every moment there was still only one species**

**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. Long ago: one population of **ancestral apes**, north of the Congo River.
2. Perhaps in a dry spell, the river runs low and a few apes reach the **south bank**.
3. The water rises. Neither side can cross: **no gene flow** between the populations.
4. Different conditions on each bank: **differential selection** favours different behaviour and bodies.
5. Over about 1 to 2 million years they diverge into **two species**: chimpanzees north, bonobos south.

**Predict box:** Suppose the river had divided the apes but the forests on both banks were identical. What would you expect after a million years? Hands up or mini whiteboards first.

**Answer B: Some differences, from mutation and drift, but less divergence**

## THE LESSON

10

min

### Splits add, extinctions take away

Play [chapter 5](#)'s figure and keep the species counter in view. Stop at step 4 and ask whether the count should go up. Then the snail predict box.

10

min

### Storyboard: from one gene pool to two

Four panels, drawn by each student with no notes: one population; a barrier; each side changing differently; the barrier gone and the two unable to interbreed. A caption under each panel must use one of: gene flow, differential selection, mutation, genetic drift.

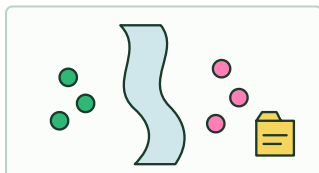
25

min

### The river case file

The activity below: groups build a one-page case file on the bonobos and chimpanzees from evidence cards, including what is still uncertain. Play [chapter 6](#)'s map first.

## ACTIVITIES



### RESEARCH AND WRITING

#### The river case file

Each group gets evidence cards: the map; where gorillas live; food on each bank; group behaviour; body differences; the genetic estimate of 1 to 2 million years; the traces of later crossings. They write a one-page case file under five headings: the barrier, the two populations, what differed on each side, how they diverged, and what is still uncertain. The last heading is the point: good science says how sure it is.

**Needs:** [chapter 6](#) on screen; evidence cards; A3 paper.

## PLENARY

10

min

### Exam question, timed

A written question on speciation from the A4.1 exam maker (in Practise and revise, below), such as the one on bonobos and chimpanzees, in 8 minutes, then peer-marked against the markscheme. Point out that the markscheme has more points than marks. For homework, [the Check step](#): a fresh paper on A4.1 from the exam bank, marked as students go.

#### WHAT STUDENTS GET WRONG

**The barrier causes the change.** It only stops gene flow; selection, mutation and drift do the changing.

**Gradual change is speciation.** Only a split adds a species.

#### STRETCH AND SUPPORT

**Support:** give the captions of each figure as a cut-up storyboard to put in order, and use the key terms (tap the dotted words) as a glossary.

**Support:** for the river case file, give a writing frame with the five headings and a sentence starter for each.

**Support:** the three mnemonics (Dragons Breathe Heat; Hungry Rats Chew My Pencils; Grumpy Birds Tweet) as a starter on each lesson.

**Stretch:** the bonobos and chimpanzees still have traces of later interbreeding in their genomes. Does that change whether they are two species? What does it say about the species concept?

#### IN THE GUIDE

**5** [New species arise only by splitting](#)

**6** [One river, two apes](#)

**A11** [The whole guide, with the figures that play](#)

**PPTX** [This lesson's slides, in the order of this plan](#)

#### EXAM PRACTICE

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#### PRACTISE AND REVISE

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##### CARD SETS ON SPLYCR

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- [A4.1 Evolution and Speciation \(HL\)](#)

# The island dry lab

60 minutes • A4.1.6 to A4.1.8 • Chapters 5, 6 • The dry lab

## The finches dry lab: what isolation, gene flow and population size do to two populations

### BY THE END, STUDENTS CAN

- ☐ Explain why splitting is the only way new species arise, and why gradual change in one line is not speciation A4.1.6
- ☐ Explain how reproductive isolation and differential selection split bonobos from common chimpanzees A4.1.7

### TIMING

|       |        |                               |                        |
|-------|--------|-------------------------------|------------------------|
| 0-5   | 5 min  | The question                  | <div><div></div></div> |
| 5-20  | 15 min | Control against split         | <div><div></div></div> |
| 20-35 | 15 min | How much gene flow undoes it? | <div><div></div></div> |
| 35-45 | 10 min | Small against large           | <div><div></div></div> |
| 45-60 | 15 min | What it shows                 | <div><div></div></div> |
|       | 60 min | One lesson                    |                        |

### STARTER

**5**  
min

#### The question

What does it take to turn one population into two species? Name the independent, dependent and controlled variables together before anyone touches a slider.

### ON THE BOARD, FROM THE GUIDE

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### 05 New species arise only by splitting

CHAPTER 05 IN THE SLIDES

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- Hybrids are rare, weak and often sterile, so the two never merge: **two species**.

**Predict box:** A line of snails changes its shell shape steadily for two million years and never splits. The oldest and newest shells look so different that fossil experts give them different names. How many species has the line added to the Earth? Hands up or mini whiteboards first.

**Answer B: None: at every moment there was still only one species**

**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. Long ago: one population of **ancestral apes**, north of the Congo River.
2. Perhaps in a dry spell, the river runs low and a few apes reach the **south bank**.
3. The water rises. Neither side can cross: **no gene flow** between the populations.
4. Different conditions on each bank: **differential selection** favours different behaviour and bodies.
5. Over about 1 to 2 million years they diverge into **two species**: chimpanzees north, bonobos south.

**Predict box:** Suppose the river had divided the apes but the forests on both banks were identical. What would you expect after a million years? Hands up or mini whiteboards first.

**Answer B: Some differences, from mutation and drift, but less divergence**

## THE LESSON

**15 min** **Control against split**  
Pairs run the control (same food both sides) three times and the split with very different food three times, recording the isolation index each time. Why repeat? Because the runs scatter, as real populations do.

**15 min** **How much gene flow undoes it?**  
Give each pair a different number of birds crossing each generation (0, 1, 2, 4, 8, 15) and the same other settings. Pool the results on the board.

**10 min** **Small against large**  
Run the control with 20 birds and with 300. Which drifts apart more by chance? HL students try one island with two foods and raise mate choice step by step.

## ACTIVITIES

### DRY LAB

#### Finches on islands

The [dry lab](#) above, with the tasks and questions under it. It works on a phone as well as a laptop, and the results table downloads as a CSV for the class's pooled graph.

**Needs:** one device per pair.

## PLENARY

**15 min** **What it shows**  
Plot the class's mean isolation index against birds crossing. Answer the questions under the lab. End on the limits of the model: real species also build up genetic incompatibilities over far more generations.

### STRETCH AND SUPPORT

**Support:** the three mnemonics (Dragons Breathe Heat; Hungry Rats Chew My Pencils; Grumpy Birds Tweet) as a starter on each lesson.

**Stretch:** in [the dry lab](#), find settings that give a split on one island (HL) and explain why mate choice is needed.

#### IN THE GUIDE

- 5** [New species arise only by splitting](#)
- 6** [One river, two apes](#)
- Lab** [Dry lab: Finches on islands](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

#### PRACTISE AND REVISE

##### BUILD FOR YOUR CLASS

- [Tarsia puzzle, dominoes and picture reveal](#) on A4.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A4.1, to present or run with no projector
- An [escape room built from the question bank](#) on A4.1

##### ALREADY ON THE SITE FOR A4.1

- Quiz: [Evolution & Speciation](#)
- Revision map: [A4.1 Evolution and speciation](#), to fill in
- Exam questions: [A4.1 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.

- [A4.1 Evolution and Speciation \(SL\)](#)
- [A4.1 Evolution and Speciation \(HL\)](#)

#### EXAM PRACTICE

### Check yourself

Set it for homework: a fresh paper of exam-bank questions on A4.1 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=A4.1&level=SL&paper=quiz&marks=15&src=ep](https://biologybybradford.com/exam-maker/sit?topics=A4.1&level=SL&paper=quiz&marks=15&src=ep)



# Higher level HL

60 minutes • A4.1.8 to A4.1.11 • Chapters 7, 8, 9

## Allopatric and sympatric speciation, adaptive radiation, and new plant species by polyploidy

### BY THE END, STUDENTS CAN

- ☐ Compare allopatric and sympatric speciation, and explain how adaptive radiation fills vacant niches A4.1.8, A4.1.9
- ☐ Explain why a mule is sterile, and how hybridisation and polyploidy make a new plant species at once A4.1.10, A4.1.11

### TIMING

|       |        |                            |                        |
|-------|--------|----------------------------|------------------------|
| 0–5   | 5 min  | Do now: Grumpy Birds Tweet | <div><div></div></div> |
| 5–15  | 10 min | Apart or together          | <div><div></div></div> |
| 15–30 | 15 min | Beak buffet                | <div><div></div></div> |
| 30–45 | 15 min | Paper chromosomes          | <div><div></div></div> |
| 45–55 | 10 min | Chromosome arithmetic      | <div><div></div></div> |
| 55–60 | 5 min  | Exit                       | <div><div></div></div> |
|       | 60 min | One lesson                 |                        |

### STARTER

5  
min

**Do now: Grumpy Birds Tweet**

Six one-line cases to sort into geographic, behavioural and temporal isolation (the crickets that sing in different seasons, the frogs in March and May, the apes either side of a river, fireflies with different flash codes, and two more of your own).

### 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.

## 07 Apart or together: two routes to a new species

CHAPTER 07 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 populations, each of **one species**: finches on an island, flies on hawthorn trees.
- Left: the sea rises and **splits** the island. Right: apple trees arrive and some flies **switch** to them; no barrier.
- Left: different seeds each side select different beaks. Right: apple flies mate earlier, on apples. **Gene flow stops** in both.
- Both groups diverge. What stopped gene flow differs: **geography**, or **timing and behaviour**.

**Predict box:** Two populations of a cricket share one meadow. One sings and mates in spring, the other in late summer. Which kind of isolation is this, and which route to speciation? Hands up or mini whiteboards first.

**Answer B: Temporal isolation: sympatric speciation**

**Remember it:** Grumpy Birds Tweet (Geographic, Behavioural, Temporal).

## 08 One ancestor, many niches

CHAPTER 08 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 seed-eating finch arrives on islands with **vacant niches**: foods no other small bird is using.
2. The first split: one line takes to eating **insects**, with a thin, pointed beak.
3. The rest split into **ground finches** and **tree finches**.
4. Each line splits again, each species with a beak **suited to its food**.
5. Different foods mean **little competition**: many related species live side by side.

**Predict box:** Suppose the first finches had landed on islands already full of small birds of many kinds. What would you expect? Hands up or mini whiteboards first.

**Answer A: Fewer finch species: most niches would already be filled**

## 09 The mule's dead end, the plant's way out

CHAPTER 09 IN THE SLIDES

**Step through the figure** (6 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A horse gamete (32 chromosomes) and a donkey gamete (31) make a **mule** with 63. A few of each set are drawn.
2. At meiosis, matching chromosomes pair up, but horse and donkey sets differ in **number and arrangement**: some cannot pair.
3. So the gametes get **unbalanced** sets and do not work: the mule is sterile.
4. Two smartweed species make a hybrid with  $11 + 11 = 22$ . No chromosome has a matching partner: **sterile**, like the mule.
5. The chromosome number **doubles** to 44: every chromosome now has an identical partner, so meiosis works.
6. A fertile **polyploid** whose offspring with either parent are sterile: a new species, made in a generation or two.

**Predict box:** Redshank ( $2n = 44$ ) is crossed with one of its parents, pale persicaria ( $2n = 22$ ). How many chromosomes do the offspring have, and are they fertile? Hands up or mini whiteboards first.

**Answer B: 33: three sets that cannot pair evenly, so sterile**

### THE LESSON

**10**  
min

#### Apart or together

Chapter 7's figure, then the apple maggot fly. Students make a Venn diagram of allopatric and sympatric speciation: what is the same (gene flow stops, then divergence) and what differs (how it stops).

**15**  
min

#### Beak buffet

The short version of the practical below, then chapter 8's figure. Link each tool to a finch and each food to a niche, and ask why the species can share an island.

**15**  
min

#### Paper chromosomes

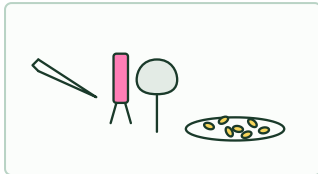
The model below: pair up a mule's chromosomes and fail, then double a smartweed hybrid's and succeed. Chapter 9's figure confirms it.

**10**  
min

#### Chromosome arithmetic

Three quick problems: gamete numbers, hybrid number, doubled number (one with an odd parental number). Then a higher level written question on polyploidy from the A4.1 exam maker, set at HL.

## ACTIVITIES

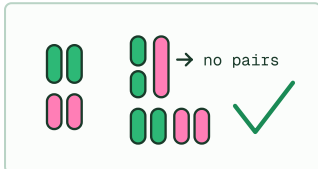


PRACTICAL · HL

### Beak buffet

Each student gets a "beak" (tweezers, clothes peg, pliers, chopsticks, a teaspoon) and 30 seconds per food station: sunflower seeds, rice grains, marbles in a dish, a raisin wedged in foam, water in a test tube. Count items moved to a cup. Pool the class's results in a table: which beak wins where? Then ask what would happen to the tweezers birds if a plier-beaked species already ate every seed.

**Needs:** five kinds of tool, foods, cups, a timer, a results table on the board.



MODEL · HL

### Paper chromosomes

Strips of card in two colours: a horse set (with two short chromosomes) and a donkey set (with one long chromosome matching those two). Students make a mule cell and try to pair every chromosome for meiosis: they cannot. Then a smartweed hybrid with three of each colour, no pairs; photocopy the set (doubling) and pair again: every strip finds its twin.

**Needs:** printed chromosome strips in two colours, scissors, glue.

## PLENARY

5  
min

### Exit

Chapter 9's predict box: a 44-chromosome redshank crossed with a 22-chromosome parent.

#### WHAT STUDENTS GET WRONG

**The hybrid's number is the parents' numbers added.** It is the gametes' numbers added:  $32 + 31 = 63$ , not 126.

#### STRETCH AND SUPPORT

**Support:** give the captions of each figure as a cut-up storyboard to put in order, and use the key terms (tap the dotted words) as a glossary.

**Support:** the three mnemonics (Dragons Breathe Heat; Hungry Rats Chew My Pencils; Grumpy Birds Tweet) as a starter on each lesson.

**Stretch:** why is sympatric speciation commoner in plants than in animals?

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- 8 [One ancestor, many niches](#)
- 9 [The mule's dead end, the plant's way out](#)
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**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.

## EXAM PRACTICE

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