

Natural selection

Three one-hour lesson plans, and three more at higher level

Six one-hour lessons cover D4.1: three for standard level and three more for higher level (the guide gives D4.1 two hours at SL and two 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 and film plays on a projector: step through each figure with the arrow keys and stop on each caption, and pause a film at each of its letters.

LESSON	COVERS	FOCUS	CHAPTERS
1 Variation, pressure and ICE AGE	D4.1.1 to D4.1.4	Natural selection as the mechanism of evolution, and its first three ingredients: variation, overproduction and the pressures that sort the winners	1, 2, 3
2 Fitness, heritability and choosing a mate	D4.1.5 to D4.1.7	Fitness as survival and reproduction, why only heritable traits are selected, and sexual selection as a pressure of its own	4, 5
3 Endler's guppies	D4.1.8	Interpreting data from a controlled experiment on sexual and natural selection, and planning one of your own	6, lab
4 Gene pools and neo-Darwinism HL	D4.1.9 to D4.1.11	Describing a population by its allele frequencies, and defining evolution as a change in them	7, 8
5 Three kinds of selection, and Hardy-Weinberg HL	D4.1.12 to D4.1.14	Directional, stabilising and disruptive selection, and using the Hardy-Weinberg equation and its conditions	9, 10
6 Artificial selection, and putting it together HL	D4.1.15	Artificial selection against natural selection, antibiotic resistance as natural selection, and a consolidation of the whole subtopic	11

The guide, for the class to read and play: biologybybradford.com/guides/ib-biology-d4-1-natural-selection

Variation, pressure and ICE AGE

60 minutes • D4.1.1 to D4.1.4 • Chapters 1, 2, 3

Natural selection as the mechanism of evolution, and its first three ingredients: variation, overproduction and the pressures that sort the winners

BY THE END, STUDENTS CAN

- ☐ Explain natural selection as the mechanism of evolution, and why Darwin's explanation replacing Lamarck's was a paradigm shift D4.1.1
- ☐ Explain how mutation makes new alleles and sexual reproduction makes new combinations of them D4.1.2
- ☐ Explain how overproduction of offspring and competition for limited resources promote natural selection D4.1.3
- ☐ Explain how abiotic factors such as a hard frost act as density-independent selection pressures D4.1.4

TIMING

0-8	8 min	Do now: Who am I?	
8-18	10 min	Four claims	
18-28	10 min	Watch ICE AGE	
28-40	12 min	Where variation comes from	
40-55	15 min	Too many young, and the frost	
55-60	5 min	Exit: ICE AGE on a new case	
	60 min	One lesson	

STARTER

- 8 min** **Do now: Who am I?**
- Each student wears a card with a key word on a headband (variation, mutation, carrying capacity, abiotic factor, paradigm shift, selection pressure, competition, adaptation) and finds out what it is by asking the class yes or no questions. The class may not say the word. Keep the words on the board; students use them all lesson.

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 has a mechanism

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.

- Lamarck's idea: a giraffe stretches for leaves, its **neck lengthens**, and it passes the change on.
- In fact the calf hatches with an ordinary neck: a change gained in life is **not inherited** (chapter 4).
- Darwin's idea starts with **variation**: the necks in a population are not all the same.
- Long necks feed best in the lean season and **leave more young**. The alleles go with them.
- Generations later, long necks are commoner. The explanation was **replaced**: a paradigm shift.

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

1. **Inherited variation.** Jaws differ, set by the two versions of a jaw gene that each beetle carries (the pips): pink large, green slender.
2. **Competition.** Twelve beetles leave thirty-six young, three times as many as the ground can feed.
3. **Environmental pressure.** A drought leaves only tough seeds. Large jaws crack them; slender jaws cannot, and those beetles starve.
4. **Adaptation.** The twelve survivors all have large or medium jaws, the trait that suits a dry year. Every one carries the large-jaw version.
5. **Genotype frequencies change.** Only survivors breed, so the large-jaw version of the gene is more common in generation 2.
6. **Evolution.** The dry years go on. By generation 5 nearly every beetle has large jaws: no beetle changed, the population did.

Predict box: Claim 1: "Natural selection gives organisms what they need to survive." Hands up or mini whiteboards first.

Answer B: False: it favours only variation that already exists, and it cannot know what is needed

Remember it: Icy Cubs Eat Anything Growing Enormous (Inherited variation, Competition, Environmental pressure, Adaptations, Genes (alleles), Evolution).

02 Variation to select from

CHAPTER 02 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.

1. A gene is a sequence of **bases**. This version is one allele of the gene.
2. A copying error changes **one base**. The changed sequence is a **new allele**: mutation makes new alleles.
3. In meiosis, **crossing over** swaps pieces between a pair of chromosomes that carry the alleles A, B and a, b.
4. The gametes carry **combinations** that neither chromosome had before: sexual reproduction makes new combinations of alleles.

Predict box: Where does the very first copy of a new allele come from? Hands up or mini whiteboards first.

Answer B: A mutation in the DNA of a cell that goes on to make gametes

03 More offspring than the world can feed

CHAPTER 03 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 habitat has **four places** with enough food, and four adults hold them.
2. The adults raise **twelve young**: far more than the places can hold.
3. The young **compete**. Only four find a place; eight find none. The limit is the food, not the number born.
4. A different pressure: two patches of seedlings, one **sparse** and one **crowded**.
5. A cold snap kills half of each. It is **density-independent**: the share lost does not depend on the crowd.

Predict box: A late frost kills 60% of the seedlings in a sparse patch. How will a crowded patch of the same plant fare? Hands up or mini whiteboards first.

Answer C: About the same share will die: the frost does not count heads

THE LESSON

10
min

Four claims

Chapter 1's four predict boxes, in pairs. Students decide true or false and say why before opening each answer. Collect the wording of each slip on the board: "needs", "for the good of the species", "trying to", "strongest". Say once that ICE AGE is a teaching aid, not an IB term.

10

min

Watch ICE AGE

[Chapter 1's](#) ICE AGE film, paused at each of the six letters. Students write one sentence a letter on a six-box strip, using the film's population. Finish by turning over [chapter 1's](#) Remember it tiles. Land on the paradigm shift: Darwin replaced Lamarck's idea because his explained more.

12

min

Where variation comes from

[Chapter 2's](#) figure, step by step, and its predict box. Students sketch the two sources, new allele and new combination, in two boxes. Ask: why does a new allele need a mutation, and why can sexual reproduction not make one?

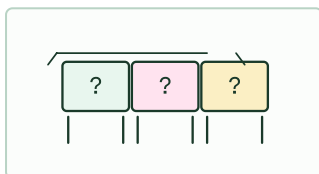
15

min

Too many young, and the frost

[Chapter 3's](#) figure: the four places and twelve young, then the two patches of seedlings. Take the frost predict box before step 5. Then ask for one resource that could limit a population of your choice and one abiotic factor. Link: what mechanisms minimise competition (B4.2).

ACTIVITIES

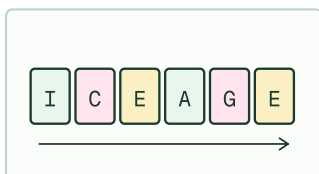


GAME

Who am I?

Each student wears a card with a key word on a headband and finds out what it is by asking the class yes or no questions. Use variation, mutation, carrying capacity, abiotic factor, paradigm shift, selection pressure, competition and adaptation. The class may answer only yes, no or "sort of". Replay with a partner who must give a hint when you are stuck.

Needs: eight headbands or sticky notes, the key words written on cards.



WRITING

ICE AGE on a fresh example

Give a new population, not one from the guide, such as an island population of lizards whose food changes (invent the details, and make clear it is invented). On six strips, pairs write what happens at each of Inherited variation, Competition, Environmental pressure, Adaptations, Genes and Evolution, then order and read them aloud. Check that each strip is about the example, not just the definition, and that "Genes" is about allele frequencies.

Needs: six blank strips per pair, the invented case on a card.

PLENARY

5

min

Exit: ICE AGE on a new case

Give a short invented case (beetles on a dark lava flow, say). Students write one line for I, C and E. Collect on the way out.

WHAT STUDENTS GET WRONG

"Animals adapt because they need to." The variation is already there, produced by chance; the environment sorts it. Make students say "individuals with the allele left more offspring".

"Natural selection is for the good of the species." It favours whatever raises an individual's reproductive success, even if it costs the species later.

"Individuals evolve." A population evolves across generations. Ask "what changed, and in whom?".

Mutations happen because they are needed. They are chance changes in the base sequence; the environment only decides whether they help.

"Natural selection makes perfect organisms." It sorts what variation exists, under current conditions, so every organism is a compromise.

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 ICE AGE tiles (Icy Cubs Eat Anything, Growing Enormous) on the board for every lesson.

Stretch: why can natural selection not make a trait the population has no allele for, and what would have to happen first?

IN THE GUIDE

- 1 [Evolution has a mechanism](#)
- 2 [Variation to select from](#)
- 3 [More offspring than the world can feed](#)
- 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 D4.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on D4.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on D4.1

ALREADY ON THE SITE FOR D4.1

- Lesson: [Hardy-Weinberg & Chi-Squared](#)
- Quiz: [Natural Selection \(HL\)](#)
- Quiz: [Natural Selection](#)
- Revision map: [D4.1 Natural selection](#), to fill in
- Exam questions: [D4.1 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.

- [D4.1 Natural Selection](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on D4.1 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=D4.1&level=SL&paper=quiz&marks=15&src=ep



Fitness, heritability and choosing a mate

60 minutes • D4.1.5 to D4.1.7 • Chapters 4, 5

Fitness as survival and reproduction, why only heritable traits are selected, and sexual selection as a pressure of its own

BY THE END, STUDENTS CAN

- ☐ Use fitness, adaptation, survival and reproduction to explain why some individuals leave more offspring than others D4.1.5
- ☐ Explain why only heritable traits can be selected, and why traits acquired in a lifetime cannot D4.1.6
- ☐ Explain how competing for mates and being chosen drive the evolution of traits such as the plumage of birds of paradise D4.1.7

TIMING

0-5	5 min	Do now	
5-13	8 min	Fitness is offspring	
13-28	15 min	Chopsticks	
28-38	10 min	Run a population	
38-53	15 min	Compete or choose?	
53-60	7 min	Exit	
	60 min	One lesson	

STARTER

- 5 min Do now**
- Chapter 4's first predict box: the cat that lived 15 years with no surviving kittens, against the cat that lived 6 years with eight. Vote, then defend the vote. Leave the votes up until the figure.

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.

04 Who survives, who breeds

CHAPTER 04 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.

- Three birds, and how many years each **lived**.
- And how many young each raised that reached **breeding age**.
- The bird that lived least has the **highest fitness**. Survival matters only because it lets an animal reproduce.
- A parent grew large on extra food. Its DNA bases are the same as before: the size was **acquired**.
- The chick inherits the same bases and hatches a normal size: an acquired trait is **not heritable**.

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.

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. Generation 1: the beetles' jaws vary, slender to large, and each carries two copies of the jaw gene (the pips: pink for large, green for slender). Which letter is this?
2. A drought leaves only tough seeds: who cracks them, and who starves? Predict before you run it.
3. Three dry years on. What has happened to the population, and to any one beetle?

Predict box: A cat lives 15 years but raises no surviving kittens. A second cat lives 6 years and raises 8 kittens that all breed. Which has the higher fitness? Hands up or mini whiteboards first.

Answer A: The second, because it left more offspring that went on to breed

05 Choosing a mate

CHAPTER 05 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.

1. Four males of one species, with **plumes** of different lengths.
2. A female looks them over, and **chooses** the longest plume.
3. The male she chooses sires the **most young**, and they inherit his alleles for a long plume.
4. But a long plume has a **cost**: it spreads only while the extra young outweigh the extra risk.

Predict box: A male's bright tail makes him easier for predators to catch. How can the trait still spread through the population? Hands up or mini whiteboards first.

Answer B: Only if the extra matings it brings outweigh the extra risk of being caught

THE LESSON

8 min Fitness is offspring

Chapter 4's figure, steps 1 to 3, then the acquired steps 4 and 5 with the weight-lifter predict box. Write the definition of fitness only after the figure. Ask: why is an acquired trait not heritable? (not encoded in the base sequence of the gametes' genes).

15 min Chopsticks

The practical below: students are birds with a utensil for a beak, and the food is something small and slippery. Three rounds, with the successful utensils becoming commoner each round. Then tie it to ICE AGE on the board.

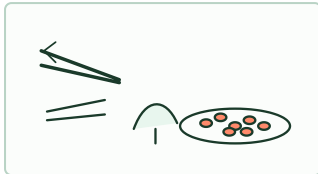
10 min Run a population

The ICE AGE game, in pairs, rounds on the letters and on the heritable case. Take notes on any round where pairs disagree and discuss it in the plenary. The peppered moth game is the alternative for classes that know the story.

15 min Compete or choose?

Chapter 5's figure and predict box, then the card sort below: intrasexual (compete) or intersexual (choose). Press on the costs: what is the price of a long tail, and when is it worth paying? Birds of paradise are the example to name in an answer.

ACTIVITIES

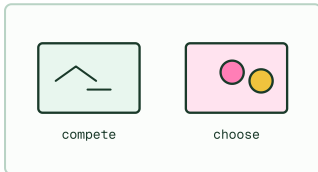


PRACTICAL

Chopsticks

Students are birds with a utensil for a beak: chopsticks, tweezers, a spoon, a clothes peg. A dish of small slippery food is the island. Each bird has 20 seconds to move as much food as it can into a cup. Birds that move less than a set number do not breed; the rest each "have chicks" that use the same utensil. Run three rounds with the new generation and tally the utensils. Which beak is commoner each round, and why? Then name each letter of ICE AGE in the activity.

Needs: five kinds of utensil, enough for every student to have one; a dish of dried beans or rice; cups; a timer; a tally table on the board.



CARD SORT

Compete or choose?

Eight cards for pairs: stags clashing antlers, a peahen picking between displaying males, frogs calling, males defending a territory, females comparing song, males wrestling over a nest, birds of paradise dancing for visiting females, and males displaying at one another. Sort into intrasexual (members of one sex compete) and intersexual (one sex chooses), and add a cost for each.

Needs: printed cards, one set per pair.

PLENARY

7
min

Exit

Two sentences: one that explains why the male with the largest antlers may not be the one with the highest fitness, and one that uses the word "heritable".

WHAT STUDENTS GET WRONG

"Fittest means strongest." It means most offspring that survive to breed. The small, plain animal with six young is fitter than the powerful one with none.

Acquired traits are inherited. Muscles, scars and the effects of extra food are not encoded in the base sequence of the genes in the gametes.

Sexual selection is "survival of the fittest". It can lower survival. What it raises is mating success.

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 ICE AGE tiles (Icy Cubs Eat Anything, Growing Enormous) on the board for every lesson.

Stretch: a costly display can be an honest sign of health because it is hard to fake. What would stop a weak male from faking it?

IN THE GUIDE

- 4** [Who survives, who breeds](#)
- 5** [Choosing a mate](#)
- 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 D4.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on D4.1, to present or run with no projector
- An [escape room built from the question bank](#) on D4.1

ALREADY ON THE SITE FOR D4.1

- Lesson: [Hardy-Weinberg & Chi-Squared](#)
- Quiz: [Natural Selection \(HL\)](#)
- Quiz: [Natural Selection](#)
- Revision map: [D4.1 Natural selection](#), to fill in
- Exam questions: [D4.1 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.

- [D4.1 Natural Selection](#)

EXAM PRACTICE

Check yourself

Set it for homework: a fresh paper of exam-bank questions on D4.1 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=D4.1&level=SL&paper=quiz&marks=15&src=ep



Endler's guppies

60 minutes • D4.1.8 • Chapter 6 • The dry lab

Interpreting data from a controlled experiment on sexual and natural selection, and planning one of your own

BY THE END, STUDENTS CAN

- ☐ Interpret data from Endler's guppy experiments, and explain how controlling the predator separates sexual from natural selection D4.1.8

TIMING

0-6	6 min	Do now: predict the ponds	
6-18	12 min	The experiment	
18-28	10 min	Reading the data	
28-53	25 min	The dry lab	
53-60	7 min	Plenary: what does it model?	
	60 min	One lesson	

STARTER

- 6 min** **Do now: predict the ponds**
- On a mini whiteboard, sketch a graph of the males' mean spots against generations for three ponds: no predator, a weak predator and a dangerous one. No numbers. Hold them up. Keep them for the end of the lesson.

ON THE BOARD, FROM THE GUIDE

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06 Two pressures, tested

CHAPTER 06 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.

- In the wild, males in streams with **fierce predators** are duller than males in streams with few.
- Endler set up **three ponds** with the same starting guppies: no predator, a weak predator and a dangerous one.
- He changed **one thing**, the predator, measured the males' spots, and kept everything else the same.
- After the generations: more colour with no or a weak predator, **less colour** with the dangerous one.

Predict box: In the pond with the dangerous predator, males end up with fewer spots. What is the best explanation? Hands up or mini whiteboards first.

Answer A: Males that show a lot of colour are caught more often, so duller males leave more offspring

THE LESSON

12 min The experiment

Chapter 6's figure. Students name the independent variable (the predator), the dependent variable (spots on the males), and what is kept the same, before step 3 shows it. Ask: why is the pond with no predator needed, and why start with the same fish in each?

10

min

Reading the data

The four questions in [chapter 6](#) ("Reading data like this"): the start, the direction, the separation and the control. Apply them to the class's whiteboards first, then to a real graph from [the dry lab](#).

25

min

The dry lab

[The dry lab](#), in pairs. Run the no-predator pond (A), the strong predator pond (C) and the control (D) three times each, then change the strength of mate choice. Students record every run and bring the class's results together on the board. Point out the IA coach under the bench: the structure of a good investigation is variables, repeats and uncertainty.

ACTIVITIES

DRY LAB

Endler's guppy ponds

[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. The IA coach under the bench takes students through variables, repeats and uncertainty.

Needs: one device per pair.

PLENARY

7

min

Plenary: what does it model?

Back to the whiteboards. What did the experiment model, and what did it leave out? (Real streams have many other pressures; ponds are small.) Link to the nature of science: experiments control one factor to test a cause.

WHAT STUDENTS GET WRONG

Individual guppies lose their spots. The change is in the population across generations.

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: give a writing frame for the plenary: "The experiment modelled... It left out..."

Stretch: what extra control pond or measurement would show whether spots are heritable, and not just something the ponds caused?

IN THE GUIDE

- 6** [Two pressures, tested](#)
- Lab** [Dry lab: Endler's guppy ponds](#)
- All** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

PRACTISE AND REVISE

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- [D4.1 Natural Selection](#)

EXAM PRACTICE

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Gene pools and neo-Darwinism HL

60 minutes • D4.1.9 to D4.1.11 • Chapters 7, 8

Describing a population by its allele frequencies, and defining evolution as a change in them

BY THE END, STUDENTS CAN

- ☐ Describe a gene pool, and calculate and compare allele frequencies in a population, using a database for a human example D4.1.9, D4.1.10
- ☐ Explain neo-Darwinism: how selection between individuals changes allele frequencies in the gene pool D4.1.11

TIMING

0-6	6 min	Do now: marbles in a bag	
6-16	10 min	The gene pool	
16-34	18 min	Search a database	
34-48	14 min	Selection by hand	
48-55	7 min	Watch ICE AGE again	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

6
min

Do now: marbles in a bag

Pairs get a bag of 20 coloured marbles for one gene. Count the alleles of each colour and write the frequency of each as a decimal. Do the two frequencies add to 1? Compare bags across the room.

ON THE BOARD, FROM THE GUIDE

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07 The gene pool

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.

- Ten individuals, each carrying **two alleles** of one gene: allele A in green, allele a in pink.
- Tip every allele into one jar: the **gene pool**, 20 alleles, 14 of them A and 6 of them a.
- The **allele frequency** of A is 14 out of 20, which is 0.7. The frequencies of A and a add to 1.
- A second population, cut off from the first, has **different** frequencies: 0.4 and 0.6.

Predict box: A population of 50 diploid individuals has 30 copies of allele B in its gene pool. What is the frequency of B? Hands up or mini whiteboards first.

Answer B: 0.30, because there are 100 alleles in the pool and 30 are B

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

1. Twenty beetles, each with two alleles of a jaw gene. Across the population, J and j are equally common: **p = 0.5**.
2. A drought leaves only tough seeds. The four **jj** beetles cannot feed and do not breed.
3. Count the alleles of the 16 survivors: 20 J and 12 j. The frequency of J is now **0.625**.
4. The survivors breed, so their gene pool is the next generation's. **The allele frequency has changed: evolution.**

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

1. **Inherited variation.** Jaws differ, set by the two alleles of a jaw gene that each beetle carries (the pips): pink J large, green j slender.
2. **Competition.** Twelve beetles leave thirty-six young, three times as many as the ground can feed.
3. **Environmental pressure.** A drought leaves only tough seeds. Large jaws crack them; slender jaws cannot, and those beetles starve.
4. **Adaptation.** The twelve survivors all have large or medium jaws, the trait that suits a dry year. Every one carries J.
5. **Genotype frequencies change.** Only survivors breed, so the allele frequency of J rises in generation 2.
6. **Evolution.** The dry years go on. By generation 5 nearly every beetle has large jaws: no beetle changed, the population did.

Predict box: In the beetle example, the J share of the gene pool was 0.5 before the drought and 20 of the 32 alleles of the survivors. What is it among the survivors? Hands up or mini whiteboards first.

Answer A: 0.625, because 20 of the 32 surviving alleles are J

THE LESSON

10 min **The gene pool**

Chapter 7's figure and its predict box (count alleles, not individuals). Define gene pool and allele frequency, and note the isolated populations in the last step.

18 min **Search a database**

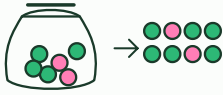
The database task below: students find one allele in two populations from different regions, write down both frequencies and suggest a reason for the difference. A fixed table is on the card if the database is not available.

14 min **Selection by hand**

Chapter 8's figure, with the marbles: pairs lay out the twenty beetles as 40 marbles, take out every jj pair, then recount the survivors' alleles. Check the frequency of J against the figure's 0.625. Define neo-Darwinism: Darwin plus genetics.

7 min **Watch ICE AGE again**

The higher level ICE AGE film in chapter 8. Where is the allele frequency in each letter? Ask: why did no individual evolve?



MODEL · HL

Marbles in a bag

Part 1 (the Do now): pairs share a bag of 20 marbles for one gene, green allele A and pink allele a. They count the alleles, write each frequency as a decimal and check that the two add to 1. Part 2 (lesson step three): pairs lay out [chapter 8](#)'s population with 40 marbles, 20 green J and 20 pink j, in twenty pairs (4 JJ, 12 Jj, 4 jj). They take out every jj pair, recount the survivors' alleles and find the new frequency of J. Ask what happened to the individuals, and what to the gene pool.

Needs: coloured beads or marbles in two colours, small bags, a table for the counts.

place	allele	freq.

DATA TASK · HL

Search a database

Students open a human allele frequency database your school can reach and find one allele (the sickle-cell allele of the beta haemoglobin gene is a good one) in two populations from different regions. They write both frequencies, say which is higher, and suggest a reason (malaria is the usual one for the sickle allele). If the database is not available, give the table in [chapter 7](#) and ask the same questions.

Needs: devices with internet access, a recording sheet with space for two populations and the source.

PLENARY

5
min

Exit

Write a definition of evolution in terms of allele frequency, and an example from today in one sentence.

WHAT STUDENTS GET WRONG

Counting individuals instead of alleles. 50 diploid individuals hold 100 alleles of a gene, not 50.

STRETCH AND SUPPORT

Support: a worked example of allele counting for a population of five individuals on the board.

Stretch: the sickle allele is common where malaria is common. Why does the heterozygote's advantage stop it from being removed?

IN THE GUIDE

- 7** [The gene pool](#)
- 8** [Selection shifts allele frequencies](#)
- 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 D4.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on D4.1, to present or run with no projector
- An [escape room built from the question bank](#) on D4.1

ALREADY ON THE SITE FOR D4.1

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- Quiz: [Natural Selection \(HL\)](#)
- Quiz: [Natural Selection](#)
- Revision map: [D4.1 Natural selection](#), to fill in
- Exam questions: [D4.1 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.

- [D4.1 Natural Selection](#)

EXAM PRACTICE

Check yourself

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biologybybradford.com/exam-maker/sit?topics=D4.1&level=HL&paper=quiz&marks=15&src=ep



Three kinds of selection, and Hardy-Weinberg HL

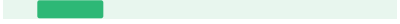
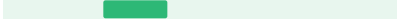
60 minutes • D4.1.12 to D4.1.14 • Chapters 9, 10

Directional, stabilising and disruptive selection, and using the Hardy-Weinberg equation and its conditions

BY THE END, STUDENTS CAN

- ☐ Distinguish directional, stabilising and disruptive selection, and explain why all three change allele frequencies
D4.1.12
- ☐ Use the Hardy-Weinberg equation to calculate allele and genotype frequencies, and say what its five conditions tell you
D4.1.13, D4.1.14

TIMING

0-5	5 min	Do now	
5-15	10 min	Three curves	
15-25	10 min	The square	
25-45	20 min	Problem set	
45-55	10 min	Switch off a condition	
55-60	5 min	Exit	
60 min One lesson			

STARTER

- 5 min Do now**
- Draw a bell curve for beak depth. Shade the part that a pressure removes and redraw the population after, for the pressure the teacher names: a sudden cold snap that only kills small birds. Which kind of selection is it?

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.

09 Three ways selection can act

CHAPTER 09 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. Directional:** one tail of the curve is removed, and the whole curve shifts. Alleles for large beaks become commoner.
- 2. Stabilising:** both tails are removed and the curve narrows. Alleles for the extremes become rarer.
- 3. Disruptive:** the middle is removed and the curve splits in two. Alleles for both extremes become commoner.

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

- One population of 150 finches: how deep each beak is. One gene adds about 1.6 mm for each **D** allele; other genes and food add the rest. **D** is 30% of the alleles.
- The survivors breed. Their mean moves deeper, and **D** rises from 30% to 61% of the alleles they pass on.
- The spread narrows. **D** still shifts, 30% to 35%: the favoured middle is mostly Dd, so more D is kept than before.
- Two peaks are left. The middle was mostly Dd, so **D** falls, 30% to 24%. All three kinds change allele frequency.

Predict box: Babies of very low and very high birth weight are less likely to survive than babies of average weight. Which kind of selection is this? Hands up or mini whiteboards first.

Answer C: Stabilising selection, because both extremes are removed

Remember it: Drive Squeeze Divide (Directional, Stabilising, Disruptive).

10 What a population would be like if it were not evolving

CHAPTER 10 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.

1. Egg and sperm alleles meet at random. If the frequency of A is $p = 0.6$ and of a is $q = 0.4$, each edge of the square is split in those proportions.
2. The four areas are the four ways eggs and sperm can combine: p^2 , pq , pq and q^2 .
3. AA is $p^2 = 0.36$, Aa is $2pq = 0.48$ and aa is $q^2 = 0.16$. Together they make 1.
4. Working back: if 16% show the recessive trait, $q^2 = 0.16$, so $q = 0.4$ and $p = 0.6$.

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. One gene, two alleles: p is the frequency of A, q of a, and $p + q = 1$. Here $p = 0.60$.
2. Hardy-Weinberg predicts the genotypes from p and q : $p^2 + 2pq + q^2 = 1$. When every condition is met, the counts fit.
3. It works backwards too. From the aa frequency, 1 in 2500: $q = 0.02$, $p = 0.98$, and **carriers** $2pq = 0.0392$, about 1 in 26.

Predict box: A recessive condition affects 1 person in 2500. Roughly how many people in the population are carriers (heterozygous)? Hands up or mini whiteboards first.

Answer A: About 1 in 25, since $2pq$ is about 0.04

Remember it: Large Rats Make Most Spaghetti (Large population, Random mating, Migration: none, Mutation: none, Selection: none).

THE LESSON

10
min

Three curves

Chapter 9's figure and the film, one kind at a time. Students use the Remember it tiles (Drive, Squeeze, Divide) and write one new example of each (the funnier the better) on the card below. Then the predict box on birth weight.

10
min

The square

Chapter 10's figure: why $p^2 + 2pq + q^2 = 1$. Students redraw the square for $p = 0.7$, then use it to find the genotype frequencies.

20
min

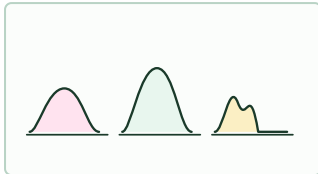
Problem set

The Hardy-Weinberg set below, in pairs, in order. Walk round for the common slip: q^2 is the frequency of the recessive genotype, not of the allele. Take the last problem as a class.

10
min

Switch off a condition

The Hardy-Weinberg tool in [chapter 10](#): turn off one condition at a time and describe what it does to the population against the prediction. Match each to a real case (a small island, inbreeding, a new mutation, a predator that takes one genotype, a new arrival).

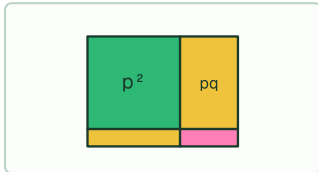


WRITING · HL

Three kinds of selection

Pairs invent one new example (funny is allowed, impossible is not) for each of directional, stabilising and disruptive selection, with a sketch of the curve before and after and a line saying which alleles become more common. Swap and check: does each example remove the right part of the curve?

Needs: mini whiteboards or squared paper.



PROBLEM SET · HL

Hardy-Weinberg problems

Six problems, in order. (1) A recessive trait with $q^2 = 0.25$: find q , p and the carriers. $q = 0.5$, $p = 0.5$, $Aa = 0.5$. (2) $p = 0.8$: genotype frequencies, and how many of 500 are Aa . 0.64 , 0.32 , 0.04 ; 160. (3) Of 1000 beetles, 360 are recessive: how many are AA and how many Aa ? $q = 0.6$, $p = 0.4$: AA 160, Aa 480. (4) Counts of 90 AA , 60 Aa and 50 aa : find the allele frequencies and say whether the population is in equilibrium. $A = 0.6$, $a = 0.4$; *expected 0.36, 0.48, 0.16, observed 0.45, 0.30, 0.25, so no: too few heterozygotes*. (5) A recessive condition affects 1 person in 10 000: roughly how many carry it? $q = 0.01$, $2pq = 0.0198$, *about 1 in 50*. (6) A gene at equilibrium has 0.32 heterozygotes: what are p and q ? 0.8 and 0.2 , or 0.2 and 0.8 : *you cannot tell which allele is which without one more genotype frequency*.

Needs: printed problems, calculators, a copy of [chapter 10](#)'s figure.

PLENARY

5
min

Exit

The five conditions from memory (the Remember it tiles), and which one is broken when the genotypes do not fit.

WHAT STUDENTS GET WRONG

Stabilising selection is no selection. It removes both extremes, so it still changes allele frequencies; only the average stays the same.

q^2 is the allele frequency. It is the frequency of the recessive genotype; q is the allele.

Recessive alleles disappear when they are harmful. Most copies are hidden in heterozygotes.

STRETCH AND SUPPORT

Support: the square for $p = 0.6$ pre-drawn, to colour in.

Stretch: in problem 6, what single extra fact would settle which allele is which?

IN THE GUIDE

- 9** [Three ways selection can act](#)
- 10** [What a population would be like if it were not evolving](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

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biologybybradford.com/exam-maker/sit?topics=D4.1&level=HL&paper=quiz&marks=15&src=ep



Artificial selection, and putting it together HL

60 minutes • D4.1.15 • Chapter 11

Artificial selection against natural selection, antibiotic resistance as natural selection, and a consolidation of the whole subtopic

BY THE END, STUDENTS CAN

☐ Distinguish artificial selection from natural selection, and explain antibiotic resistance as natural selection D4.1.15

TIMING

0-5	5 min	Do now	
5-15	10 min	Choose the parents	
15-25	10 min	Natural or artificial?	
25-45	20 min	ICE AGE on a fresh case	
45-55	10 min	Exam practice	
55-60	5 min	Exit	
	60 min	One lesson	

STARTER

5
min

Do now

Vote: antibiotic resistance in bacteria is artificial selection or natural selection? Keep the votes up.

ON THE BOARD, FROM THE GUIDE

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11 Artificial selection and its side effects

CHAPTER 11 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 crop varies in the size of its cobs. Each plant's size is partly **heritable**.
2. The breeder picks the **largest** and lets only those breed.
3. Repeat for a few generations: the cobs get steadily **bigger**, as the alleles for size become commoner.
4. A dish of bacteria with **one** resistant cell among many susceptible ones.
5. Add an antibiotic: the susceptible cells die, the resistant one multiplies. **Nobody chose it**, so this is natural selection.

Predict box: Farmers spray a crop with an insecticide. After some years most of the pests resist it. Which kind of selection has taken place? Hands up or mini whiteboards first.

Answer B: Natural selection, because the insecticide killed some pests and spared others

THE LESSON

10
min

Choose the parents

The dice model below, three rounds. Plot the class mean each round on the board. What happened to the variation as the breeder chose?

10

min

Natural or artificial?

Chapter 11's figure, then the card sort below. Go back to the vote: the antibiotic was a pressure nobody meant to apply with those consequences, so it is natural selection.

20

min

ICE AGE on a fresh case

The activity below: a new example, and students put the six letters onto it with their own words. Pairs swap and mark each other's against the list of letters. Then link the six letters to the Hardy-Weinberg conditions: which does selection break?

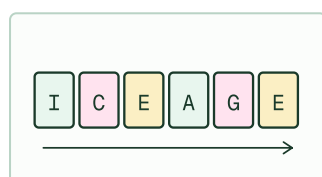
10

min

Exam practice

A written question on D4.1 from the exam maker (in Practise and revise, below), set at HL, in 8 minutes, then peer-marked against the markscheme. For homework, the Check step: a fresh paper on D4.1, marked as students go.

ACTIVITIES



WRITING

ICE AGE on a fresh example

Give a new population, not one from the guide, such as an island population of lizards whose food changes (invent the details, and make clear it is invented). On six strips, pairs write what happens at each of Inherited variation, Competition, Environmental pressure, Adaptations, Genes and Evolution, then order and read them aloud. Check that each strip is about the example, not just the definition, and that "Genes" is about allele frequencies.

Needs: six blank strips per pair, the invented case on a card.

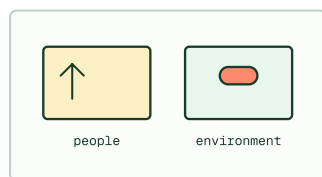


MODEL · HL

Choose the parents

Each group gets ten cards, each with a number from 1 to 10 for a trait (the size of a cob). They pick the two highest as parents. Offspring values are the parents' mean plus the roll of two dice (first die minus second), and the teacher deals the next ten cards that way. After three rounds, they plot the class mean each round. What happened to the mean, and to the spread?

Needs: ten cards per group, two dice, a results grid.



CARD SORT · HL

Natural or artificial?

Eight cards: farmers breeding the heaviest dairy cows; antibiotic resistance in a hospital ward; a breeder keeping only the gentlest puppies; insecticide resistance in a pest; bigger maize cobs over centuries; a dry year in which tough-seeded plants spread; a greenhouse grower choosing the tallest seedlings; resistant weeds after a herbicide. Sort into artificial selection (a person chooses the parents) and natural selection, then argue about any card where the line is unclear.

Needs: printed cards, one set per pair.

PLENARY

5

min

Exit

Linking question, in one sentence each: how do intraspecific and interspecific interactions differ, and what is one way competition is reduced?

WHAT STUDENTS GET WRONG

"Natural selection makes perfect organisms." It sorts what variation exists, under current conditions, so every organism is a compromise.

"The antibiotic caused the resistance." The mutation was already there, or arose by chance; the antibiotic only changed who survived.

STRETCH AND SUPPORT

Stretch: breeders choose for one trait. Why do other traits sometimes change at the same time?

IN THE GUIDE

- 11** [Artificial selection and its side effects](#)
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- [D4.1 Natural Selection](#)

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.