

Diversity of organisms

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

Three one-hour lessons cover the standard level statements, and two more add the higher level ones (the guide gives A3.1 three 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 plays on a projector: step through it with the arrow keys and stop on each caption. Useful pages to have open: [the A3.1 exam questions](#) and [the A3.1 revision map](#).

LESSON	COVERS	FOCUS	CHAPTERS
1 Variation, species and names	A3.1.1 to A3.1.5	Variation, the morphological and biological species concepts, and binomial names	1, 2, 3
2 Counting and pairing chromosomes	A3.1.6, A3.1.7	Chromosome numbers, karyograms, and testing the hypothesis that human chromosome 2 is a fusion	4, 5
3 Genomes and genome size	A3.1.8 to A3.1.11	What a genome is, SNPs, why genome size is not complexity, and whole genome sequencing	6, 7, 8, 1a
4 When the species rule breaks HL	A3.1.12, A3.1.13	Asexual species, horizontal gene transfer, and why different chromosome numbers make hybrids infertile	9, 10
5 Keys and barcodes HL	A3.1.14, A3.1.15	Building and testing a dichotomous key, and identifying species from environmental DNA	11, 12

The guide, for the class to read and play: biologybybradford.com/guides/ib-biology-a3-1-diversity-of-organisms

Variation, species and names

60 minutes • A3.1.1 to A3.1.5 • Chapters 1, 2, 3

Variation, the morphological and biological species concepts, and binomial names

BY THE END, STUDENTS CAN

- ☐ Explain why variation between organisms is a defining feature of life, and how Linnaeus used shared traits to define a species A3.1.1, A3.1.2
- ☐ Name an organism with a binomial name written to the rules, and say what two species of one genus share A3.1.3
- ☐ State the biological species concept, give challenges to it, and explain why gradual speciation makes the line between populations and species arbitrary A3.1.4, A3.1.5

TIMING

0-8	8 min	Do now: sort the cards your own way	
8-20	12 min	No two alike	
20-32	12 min	A name with two parts	
32-52	20 min	Can they breed?	
52-60	8 min	Exit: two tests for a species	
	60 min	One lesson	

STARTER

8
min

Do now: sort the cards your own way

Give each pair the eight beetle cards from [chapter 1](#)'s figure, printed and cut up. They sort them into groups however they like, then write one yes or no question that splits their cards into two groups. Pairs compare with the pair beside them: did anyone sort the same way? Leave the groups on the desks and come back to them in a few minutes.

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 No two beetles are alike, and we sort them anyway

CHAPTER 01 IN THE SLIDES

Switch the figure through Shuffled, By colour and By body shape, and have the class say what will change before each.

Predict box: Identical twins share all their DNA. Are they identical in every trait? Hands up or mini whiteboards first.
Answer B: No: fingerprints, scars and tans differ even so

02 A name with two parts

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 **binomial** name has two words, written in italics.
2. The first word is the **genus**, with a capital letter. The second names the **species**, in lower case.
3. Species in one genus have **similar traits**: lion, tiger and leopard share the genus *Panthera*.
4. After the first full use you may shorten the genus to its **initial**: *P. leo*.

Predict box: Two animals are named *Panthera tigris* and *Panthera onca*. What can you say about them? Hands up or mini whiteboards first.

Answer C: Two species in one genus, so they share similar traits

Remember it: Green Sloths Inch Along (Genus first, Species second, Italics, Abbreviate).

03 Can they breed?

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.

1. A breeding test: two beetles from the **same group**, and a pair with **one from each** (imagined beetles).
2. Both pairs have **young**. Mating alone does not decide it.
3. Only the first pair's young are **fertile**. The mixed pair's young cannot have young of their own.
4. By the biological species concept, A and B are **separate species**.

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).

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

Predict box: Two kinds of snail live on islands 500 km apart, and none has ever crossed the sea. Can the biological species concept say whether they are one species? Hands up or mini whiteboards first.

Answer C: Not directly: they have never met, so other evidence is needed

THE LESSON

12

min

No two alike

Chapter 1's figure on the board: shuffle, then sort by colour, then by body shape. Ask which sort puts like with like, and why. Take chapter 1's predict box on identical twins before the answer opens. Land on two ideas: no two individuals are identical, and Linnaeus sorted by the traits a group shares. A species concept is a working definition, not a fact of nature.

12

min

A name with two parts

Chapter 2's figure, one step at a time. Students write six names on mini whiteboards from your spoken descriptions (the human, the lion, the common chimpanzee, then two shortened ones) and show them at once. Turn over chapter 2's Remember it tiles. Then chapter 2's predict box on *Panthera tigris* and *Panthera onca*.

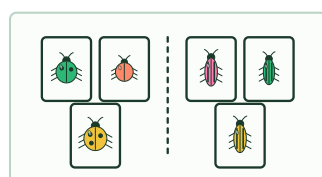
20

min

Can they breed?

Chapter 3's figure on the board, then the species concept clinic below: groups rule on six case cards. Take chapter 3's two predict boxes, the islands and the million years. Run the splitting film once and ask on which day one species became two: the answer is none, so where the line falls is a judgement.

ACTIVITIES



CARD SORT

Sort the cards your own way

Pairs sort eight beetle cards into groups of their own choosing, then split them with one yes or no question each time. They compare groupings with another pair: different people choose different traits, and some traits keep the cards of one kind together while others do not. The lesson takes the point from there.

Needs: chapter 1's figure printed and cut into eight cards per pair; scrap paper.



CARD SORT

The species concept clinic

Six case cards, one per group: a horse and a donkey; two populations on mountains far apart; a fossil species; two oak species that make fertile hybrids where they overlap; a chain of populations in which neighbours breed but the two ends do not; a very large and a very small dog breed that could not physically mate. For each card the group decides whether the biological test gives a clear answer, and if not, what evidence they would use instead.

Needs: six case cards per group; A3 paper.

PLENARY

8

min

Exit: two tests for a species

Two sentences on a slip: say how the morphological and the biological species concepts each decide whether two organisms are one species, and give one problem with the biological one. Collect them on the way out.

WHAT STUDENTS GET WRONG

Species members are identical. They are similar, never identical. Variation within a species is normal and is what natural selection acts on.

Binomial names written any which way. Genus with a capital, species in lower case, both in italics or underlined. The species name never stands alone.

The biological test is whether they do breed. It is whether they *could* produce fertile offspring. Never having met does not make two populations separate species.

A species concept is a fact about nature. It is a working definition, and a different one suits different organisms. That is why the guide says "competing definitions exist".

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 Remember it sets (Green Sloths Inch Along; Five Apes Hug Grumpy Aunts Happily; Cats Eat Any Sausage, Mostly) as a starter or an exit.

Support: for the species concept clinic, give a frame: "The biological test says... but the problem is... so I would use..."

Stretch: is there a species concept that works for both horses and bacteria? What would it have to ignore?

IN THE GUIDE

- 1 [No two beetles are alike, and we sort them anyway](#)
- 2 [A name with two parts](#)
- 3 [Can they breed?](#)
- 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 A3.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A3.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on A3.1

ALREADY ON THE SITE FOR A3.1

- Quiz: [Diversity of Organisms](#)
- Revision map: [A3.1 Diversity of organisms](#), to fill in
- Exam questions: [A3.1 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.
- [A3.1 Diversity of Organisms](#)

EXAM PRACTICE

Check yourself

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biologybybradford.com/exam-maker/sit?topics=A3.1&level=SL&paper=quiz&marks=15&src=ep



Counting and pairing chromosomes

60 minutes • A3.1.6, A3.1.7 • Chapters 4, 5

Chromosome numbers, karyograms, and testing the hypothesis that human chromosome 2 is a fusion

BY THE END, STUDENTS CAN

- ☐ Say that species differ in chromosome number, using humans (46) and chimpanzees (48), and why diploid numbers are even A3.1.6
- ☐ Classify chromosomes in a karyogram by banding, length and centromere position, and evaluate the evidence that human chromosome 2 arose from a fusion A3.1.7

TIMING

0-6	6 min	Do now: guess the count	
6-16	10 min	Counting chromosomes	
16-36	20 min	Build a karyogram	
36-52	16 min	Chromosome 2 on trial	
52-60	8 min	Testable or not?	
60 min		One lesson	

STARTER

- 6 min** **Do now: guess the count**
- On mini whiteboards, students guess the number of chromosomes in a body cell of a fruit fly, a human, a chimpanzee and a dog. Reveal the four (8, 46, 48, 78) and ask what every number has in common. Hold the answer for [chapter 4](#)'s predict box.

ON THE BOARD, FROM THE GUIDE

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04 Every species has its own count

CHAPTER 04 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 fruit fly has 8 chromosomes in its body cells: **4 pairs**. A garden pea has 14: 7 pairs. Different species, different numbers.
2. A human has **46**: 23 pairs.
3. A chimpanzee has **48**: 24 pairs, one more pair than a human.
4. A dog has 78. More chromosomes does **not** mean a bigger or more complex animal. Every number is **even**, because chromosomes come in pairs.

Predict box: Why does a diploid cell always have an even number of chromosomes? Hands up or mini whiteboards first.

Answer A: One of each pair comes from each parent, so the total is even

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 cell is stopped part-way through **dividing**, when its chromosomes are short and thick.
2. The chromosomes are **stained**, so dark bands show, and **photographed**.
3. Each is cut out and matched with its partner by **length, banding pattern** and **centromere position**.
4. The pairs are lined up with the centromeres in a row and numbered from the **longest**: a karyogram. (Simplified: six pairs.)

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. Chromosomes from one cell, condensed and doubled. Pair them by **length, centromere position** and **bands**.
2. A pair matches on all three. A karyogram puts the pairs in order, **longest first**.
3. Human **chromosome 2** beside two chimpanzee chromosomes, 2A and 2B. Do they fit together?

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

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Predict box: If two chromosomes had fused end to end, what would you expect in the middle of the new, longer chromosome? Hands up or mini whiteboards first.

Answer C: Telomere DNA, normally found only at a chromosome's end

THE LESSON

10
min

Counting chromosomes

Chapter 4's figure, then its predict box. Stress that 46 and 48 are the only numbers to learn, and that a bigger number does not mean a more complex animal. Define diploid, haploid and homologous chromosomes with the figure's pairs.

20
min

Build a karyogram

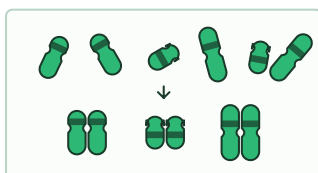
Four minutes on [chapter 5's](#) first figure, stopping on each caption. Then pairs pair up the paper chromosomes below by length, banding and centromere position, and line them up longest first. Check against [chapter 5's](#) pairing tool, which tells them what matched.

16
min

Chromosome 2 on trial

Chapter 5's chromosome 2 tool on the board. Groups complete the evidence cards below: for each of the three pieces of evidence, say what it shows and how strongly it supports the fusion. Then take [chapter 5's](#) predict box on what to expect in the middle of a fused chromosome.

ACTIVITIES

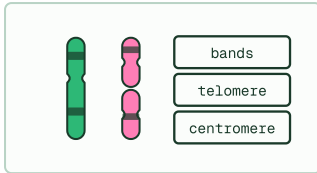


CARD SORT

Pair the paper chromosomes

Teacher-made sets of twelve paper chromosomes, six matching pairs that differ in length, centromere position and the bands drawn on them with a marker. Students match them, line them up longest first, and say which of the three clues settled each pair. They then check their karyogram with the pairing tool.

Needs: twelve paper chromosomes per pair (cut from card, bands in marker); the tool on a device.

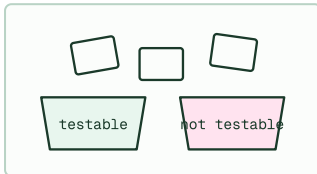


EVIDENCE

Chromosome 2 on trial

Evidence cards from the chromosome 2 tool: the banding of human chromosome 2 against two ape chromosomes, the telomere DNA in its middle, the remains of a second centromere, and the numbers, 46 against 48. For each card, students write what it shows, how strongly it supports the fusion, and one more piece of evidence they would want. A last line says what would make the hypothesis fail.

Needs: evidence cards; the chromosome 2 tool.



NATURE OF SCIENCE

Testable or not?

Students write six statements about chromosome 2, apes or anything in the lesson, three they believe are testable and three that are not, shuffle them and swap. The partner sorts them into two bins and explains each choice, saying what evidence would count against the testable ones.

Needs: six blank slips per student; two labelled bins.

PLENARY

8

min

Testable or not?

Chapter 5's testable or not drill, then students write one testable and one non-testable hypothesis on any topic they like, and swap with a partner to sort. Exit: why is testability what makes a hypothesis scientific?

WHAT STUDENTS GET WRONG

More chromosomes means a more complex organism.

A dog has 78 and a human 46. Number says nothing about complexity.

A karyogram shows the genes. It shows chromosomes only: their number, size, banding and centromere. The genes are in the DNA along them.

Evidence for chromosome 2 means we came from chimpanzees. Humans and chimpanzees share an ancestor that was neither. The fusion happened in the line that led to us.

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 the first three pairs of paper chromosomes already matched, and ask students to explain why before they match the rest.

Stretch: predict what a karyogram of an orangutan would look like beside a human's, and which chromosomes you would compare first.

IN THE GUIDE

- 4** [Every species has its own count](#)
- 5** [Laying out the chromosomes](#)
- 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 A3.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A3.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on A3.1

ALREADY ON THE SITE FOR A3.1

- [Quiz: Diversity of Organisms](#)
- Revision map: [A3.1 Diversity of organisms](#), to fill in
- Exam questions: [A3.1 in the exam maker](#), a paper with its markscheme

CARD SETS ON SPLYCR

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- [A3.1 Diversity of Organisms](#)

EXAM PRACTICE

Check yourself

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biologybybradford.com/exam-maker/sit?topics=A3.1&level=SL&paper=quiz&marks=15&src=ep



Genomes and genome size

60 minutes • A3.1.8 to A3.1.11 • Chapters 6, 7, 8 • The dry lab

What a genome is, SNPs, why genome size is not complexity, and whole genome sequencing

BY THE END, STUDENTS CAN

- ☐ Describe a genome, how SNPs give diversity within a species, and why variation between species is much larger
A3.1.8, A3.1.9
- ☐ Compare genome sizes of different groups from a database and judge whether size measures complexity A3.1.10
- ☐ Describe how whole genome sequencing has become faster and cheaper, and give current and future uses A3.1.11

TIMING

0-6	6 min	Do now: how different are we?	
6-18	12 min	One genome, many versions	
18-40	22 min	Order the genomes	
40-52	12 min	Reading a whole genome	
52-60	8 min	Exit: size and complexity	
	60 min	One lesson	

STARTER

- 6 min** **Do now: how different are we?**
- Students write a guess, as a percentage, for how much of two unrelated people's DNA is the same. Collect the guesses on the board without comment. Return to them after [chapter 6's](#) predict box.

ON THE BOARD, FROM THE GUIDE

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06 One genome, many versions

CHAPTER 06 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.

- One short stretch of the genome in three people. Bases that differ from person 1 are **pink**: very few.
- A difference at a single base is a **single nucleotide polymorphism**, or SNP. Together, SNPs make each person's genome their own.
- The same stretch in another species: **far more** differences. (Simplified: real differences are much rarer in both cases, but the pattern holds.)

Predict box: Two unrelated people have their whole genomes read and compared. About how different are they? Hands up or mini whiteboards first.

Answer B: One base in a thousand differs: they share about 99.9%

07 Big genome, small organism

CHAPTER 07 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 bacterium's genome is millions of base pairs. A human's is about **three billion**. (Mb is millions, Gb billions of base pairs.)
2. The Australian lungfish's genome is more than **ten times** a human's.
3. The flowering plant *Paris japonica* has one of the biggest genomes known. Size is **not** a measure of how complex an organism is.

Show the figure: The same four genes can sit in a small genome or a large one. The difference is mostly DNA that does not code for a protein.

Predict box: A student says: "The organism with the biggest genome must be the most complex." Which fact shows this is wrong? Hands up or mini whiteboards first.

Answer A: A fish and a flowering plant have genomes bigger than ours

08 Reading a whole genome

CHAPTER 08 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. The first human genome was a huge international effort: **years** of work and **billions** of dollars.
2. Sequencing machines improved, and the cost and the time **fell steeply**. (The shape is drawn to show the trend, not exact values.)
3. Cheap, fast genomes bring uses within reach: **comparing species** now, and **personalised medicine** in the future.

Predict box: How has the cost of sequencing a human genome changed since the first one was done? Hands up or mini whiteboards first.

Answer C: It has fallen steeply, and sequencing has become far faster

THE LESSON

12

min

One genome, many versions

Chapter 6's figure, step by step: first within a species, then between two species. Define genome and SNP. Ask where the pink cells would be if the second species were the chimpanzee, and whether there would be more or fewer. Then [chapter 6's](#) predict box.

22

min

Order the genomes

Eight minutes on the genome-size order activity below, then reveal with [chapter 7's](#) figure. Fourteen minutes in [the dry lab](#): students look up ten organisms, plot genome size against group, switch to gene count, and judge the four statements. [Chapter 7's](#) predict box comes after.

12

min

Reading a whole genome

Chapter 8's figure: the falling cost and the two uses. Then a two-minute talk with a partner: who should be allowed to see your genome, and why? Collect three views. Land on the guide's uses: evolutionary relationships now, personalised medicine in the future.

ACTIVITIES



DATA

Order the genomes

Cards of eight organisms (a bacterium, baker's yeast, a nematode worm, a human, an onion, the Australian lungfish, *Paris japonica* and thale cress). Pairs put them in the order they predict, smallest genome to largest, and say why. Then [the dry lab](#) reveals the sizes. Which prediction was furthest out, and what made it wrong?

Needs: eight organism cards per pair; [the dry lab](#) on a device.

Genome size explorer

The [dry lab](#) above, with the tasks and questions under it. Students look up organisms from a table the way a scientist uses a genome database, plot what they find, and judge four statements. It works on a phone as well as a laptop, and the look-ups download as a CSV.

Needs: one device per pair.

PLENARY

8 min Exit: size and complexity

Using two organisms from [the dry lab](#) as evidence, explain in two sentences why genome size is not a measure of complexity. Check [chapter 7](#)'s second figure for the reason: non-coding and repeated DNA.

WHAT STUDENTS GET WRONG

A genome is just the genes. It is all the genetic information: genes, the DNA between them and the DNA in organelles. Most of a large genome is not genes.

A bigger genome means a more complex organism. The largest genomes in the lab belong to a plant and a fish. Size counts DNA, not complexity or genes.

A SNP is a disease mutation. A SNP is a one-base difference found in many people. Most have no known effect.

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.

Stretch: use a public genome database to look up three organisms of your own choice and add them to the class graph, with the source.

Support: give a sentence frame for the exit: "Organism A has a bigger genome than organism B, but...."

IN THE GUIDE

- 6** [One genome, many versions](#)
- 7** [Big genome, small organism](#)
- 8** [Reading a whole genome](#)
- Lab** [Dry lab: Genome size explorer](#)
- A11** [The whole guide, with the figures that play](#)
- PPTX** [This lesson's slides, in the order of this plan](#)

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EXAM PRACTICE

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When the species rule breaks HL

60 minutes • A3.1.12, A3.1.13 • Chapters 9, 10

Asexual species, horizontal gene transfer, and why different chromosome numbers make hybrids infertile

BY THE END, STUDENTS CAN

- ☐ Explain why the biological species concept fails for asexual species and for bacteria that pass genes sideways
A3.1.12
- ☐ Explain why parents with different chromosome numbers are unlikely to have fertile offspring A3.1.13

TIMING

0-6	6 min	Do now: can a bacterium be a species?	
6-20	14 min	Copying and sideways	
20-30	10 min	Where the species concept struggles	
30-50	20 min	Paper chromosomes	
50-60	10 min	Exam question and exit	
	60 min	One lesson	

STARTER

6
min

Do now: can a bacterium be a species?

Ask: "Can you test two bacteria for fertile offspring?" Pairs write what stops them. Take answers, and keep the words partner, clone and plasmid on the board for the next step.

ON THE BOARD, FROM THE GUIDE

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09 When the species rule breaks

CHAPTER 09 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 bacterium reproduces by **copying itself**: two identical cells, with no partner and nothing to test.
2. Two bacteria of **different species**. One carries a **plasmid**, a small ring of DNA, with a gene on it.
3. The cells touch and a bridge forms. A **copy** of the plasmid passes across.
4. The second species now has the gene. No new cell was made: the gene moved **sideways**.

Predict box: A bacterium carries a plasmid with an antibiotic-resistance gene. It touches a bacterium of a different species. What can happen? Hands up or mini whiteboards first.

Answer B: A copy of the plasmid can pass across with no cell dividing

Remember it: Five Apes Hug Grumpy Aunts Happily (Fossils, Apart, Hybrids, Gradual, Asexual, Horizontal transfer).

10 The number that has to match

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. Two **imagined** species. Q has one long chromosome where P has two short ones, so they have different chromosome numbers.
2. A hybrid gets **both sets**: five chromosomes, an odd number. One cannot have an equal partner.
3. At meiosis each chromosome looks for its match. Two pair neatly, but the long one is left matching **two** at once.
4. Some ways of sharing them out give complete sets. Others give a gamete with part of the genome **twice** and part **missing**. With many such mismatches, most gametes fail.

Predict box: A hybrid cell has 63 chromosomes. Could every one of them have an equal partner at meiosis? Hands up or mini whiteboards first.

Answer A: No: with an odd number, at least one has no partner

THE LESSON

14 Copying and sideways

Chapter 9's figure, step by step: binary fission, then conjugation. Run the pass the plasmid role play below for six minutes. Then [chapter 9's](#) predict box. Land on horizontal gene transfer as a way for genes to cross a species line without any offspring.

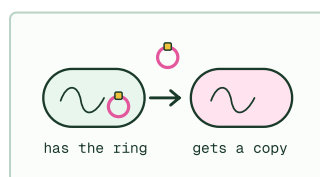
10 Where the species concept struggles

Turn over [chapter 9's](#) Remember it tiles. In groups, students give one example for each of the six: fossils, populations apart, hybrids, gradual change, asexual species, horizontal transfer. Take the HL half (asexual and horizontal) first.

20 Paper chromosomes

Four minutes on [chapter 10's](#) figure. Then the paper chromosomes model below, with a coin to share out the chain: 16 minutes, ten tosses a pair, tally the complete and unbalanced sets. Connect it to the mule from A4.1.

ACTIVITIES

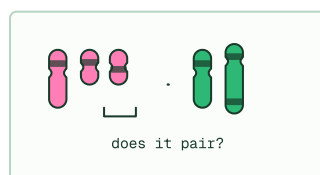


ROLE PLAY · HL

Pass the plasmid

Six students are bacteria. Each holds a card for its species. One holds a paper ring with a coloured sticker (a plasmid with a resistance gene). Cells that touch can pass a copy of the ring by making a second ring on the spot. After two rounds, count the cells holding the ring and ask which species they belong to. Then ask how the species concept would classify them.

Needs: six species cards, paper rings, stickers, sticky tape.



MODEL · HL

Paper chromosomes: a fusion

Strips of card in two colours: species P has three (one long, two short) and species Q has two (one long, one as long as the two short ones together). Students make the hybrid's five strips, pair them, and find the long Q strip matches both short P strips. They share the chain out by tossing a coin ten times and tally complete against unbalanced sets. It is a toy model, since real ratios differ, but many such mismatches multiply the chance of failure.

Needs: two colours of card strips, scissors, a coin, a tally table.

10

min

Exam question and exit

A higher level written question on the species concept or chromosome number from the A3.1 exam maker (in Practise and revise, below), set at HL, then peer-marked. Exit: [chapter 10's](#) predict box on a 63-chromosome hybrid. For homework, [the Check step](#), set at HL.

WHAT STUDENTS GET WRONG

Horizontal gene transfer is bacterial reproduction. Reproduction makes a new cell. Horizontal transfer moves genes between living cells, even of different species.

The hybrid has its parents' chromosome numbers added. It has the two gametes' numbers added: $32 + 31 = 63$ for the mule, not $64 + 62$.

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 Remember it sets (Green Sloths Inch Along; Five Apes Hug Grumpy Aunts Happily; Cats Eat Any Sausage, Mostly) as a starter or an exit.

Stretch: why is a change in chromosome number a more usual way to make a new species in plants than in animals? Link it to polyploidy in A4.1.

IN THE GUIDE

- 9** [When the species rule breaks](#)
- 10** [The number that has to match](#)
- 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 A3.1 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=A3.1&level=HL&paper=quiz&marks=15&src=ep

**PRACTISE AND REVISE****BUILD FOR YOUR CLASS**

- [Tarsia puzzle](#), [dominoes](#) and [picture reveal](#) on A3.1, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A3.1, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on A3.1

ALREADY ON THE SITE FOR A3.1

- Quiz: [Diversity of Organisms](#)
- Revision map: [A3.1 Diversity of organisms](#), to fill in
- Exam questions: [A3.1 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.
- [A3.1 Diversity of Organisms](#)

Keys and barcodes HL

60 minutes • A3.1.14, A3.1.15 • Chapters 11, 12

Building and testing a dichotomous key, and identifying species from environmental DNA

BY THE END, STUDENTS CAN

- ☐ Build and test a dichotomous key for local organisms A3.1.14
- ☐ Explain how DNA barcodes and environmental DNA identify the species in a habitat rapidly A3.1.15

TIMING

0–8	8 min	Do now: a key to the pencil case	
8–20	12 min	What makes a good key	
20–42	22 min	The local key	
42–54	12 min	Barcodes from a sample	
54–60	6 min	Exit: limits of eDNA	
	60 min	One lesson	

STARTER

8 min Do now: a key to the pencil case

Each pair empties a pencil case and writes a yes or no key that names six of the items. Swap with another pair and test it: does every item end at its own name? Note what went wrong, for the next step.

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.

11 Building a key

CHAPTER 11 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.

- Every step is a question with **two** answers. A leaf made of leaflets leads to one more question, and then to horse chestnut or ash.
- A leaf in one piece leads to the next question. **Deep lobes:** oak.
- Each remaining question uses an **edge** that is easy to see: spiny, toothed, or neither. Every leaf reaches exactly one name.
- Check a key by following one leaf through it: holly is **no** to leaflets, **no** to deep lobes and **yes** to a spiny edge.

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

- Eight animals from leaf litter and soil. A **dichotomous key** tells them apart with questions that each have two answers.
- Each question **splits** the group in two; the next question splits each part again, until each animal is alone with its name.

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

- Eight animals from leaf litter and soil. A **dichotomous key** tells them apart with questions that each have two answers.
- Each question **splits** the group in two; the next question splits each part again, until each animal is alone with its name.

Predict box: Which feature is best for a key that tells the leaves of different trees apart? Hands up or mini whiteboards first.

Answer C: Whether the edge is toothed or smooth

12 Barcodes from the soil

CHAPTER 12 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 barcode is a short stretch of DNA with **two ends the same in every species** and a **middle that differs** between species.
2. Because the ends match everywhere, one pair of **primers** can copy the barcode from any species in a mixed sample.
3. Each species in the reference library has its own barcode. Pink marks where a barcode differs from species A. (Letters invented.)
4. A barcode read from a sample is **matched** against the library. Here it is identical to one species' barcode.

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

1. Collect a sample: a bottle of pond water. The DNA in it is **environmental DNA** (eDNA).
2. Push the water through a fine filter. Cells and DNA from every species are caught on it.
3. **Extract** the DNA from the filter: a mixture from every species living there.
4. **PCR** copies one short stretch, the **barcode**, from every species at once. The primers fit ends that all of them share; the barcode between them differs.
5. **Sequence** the copies: each read is one barcode's base sequence.
6. **Match** each read to a reference library of barcodes from identified species.
7. A list of the species present, from one bottle of water, much faster than searching and trapping. One of them nobody saw.

Predict box: A water sample from a pond is barcoded and matched. What can the result tell you? Hands up or mini whiteboards first.

Answer B: Which listed species have left DNA in the water

Remember it: Cats Eat Any Sausage Mostly (Collect, Extract, Amplify, Sequence, Match).

THE LESSON

12 **What makes a good key**

Chapter 11's figure, step by step, then trace the holly through it. Take chapter 11's predict box. Build a class list of good and poor features, sorted by whether they change with age or season. Students fix their pencil case keys.

22 **The local key**

The local key activity below: collect or photograph six to eight local organisms, write a key, swap and test it. In wet weather use the two key tools under chapter 11's figure instead, with the leaves of trees or the garden animals.

12 **Barcodes from a sample**

Chapter 12's film, then its figure on the board. Students put the five step cards of the sample to species activity in order and say what each step needs. Turn over chapter 12's Remember it tiles.

ACTIVITIES

STARTER · HL

A key to the pencil case

Pairs write a yes or no key for six items from a pencil case and swap with another pair to test it. Common faults appear at once: a question with more than two answers, a feature that two items share, and an item that reaches two names. Keep the faults on the board for the lesson.

Needs: a pencil case per pair; scrap paper.

PRACTICAL · HL

The local key

Groups collect or photograph six to eight local plants or animals from the school grounds, a hedge or a park. They list the features that tell them apart, build a key, swap with another group and test each other's. Take only a leaf from a plant that has many, never tear a plant up, and put every animal back where you found it. In wet weather use photographs or leaves brought in.

Needs: hand lenses, clipboards, phones for photographs, a field guide if you have one; permission for the site.

CARD SORT · HL

From sample to species

Five step cards (collect a sample, extract the DNA, amplify the barcode region, sequence it, match it to a reference library) and five cards saying what each step produces or needs. Pairs put both sets in order and pair them up. A last card asks what would go wrong if the library lacked the species in the sample.

Needs: ten cards per pair.

PLENARY

6
min

Exit: limits of eDNA

Chapter 12's predict box. Then one sentence: give two things an eDNA barcode survey cannot tell you.

WHAT STUDENTS GET WRONG

Colour and size make good key features. They change with age and season. Use features that are easy to see and do not change.

eDNA tells you how many. It tells you which species in the library left DNA there, not how many or whether they are still there.

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 Remember it sets (Green Sloths Inch Along; Five Apes Hug Grumpy Aunts Happily; Cats Eat Any Sausage, Mostly) as a starter or an exit.

Stretch: design an eDNA survey for the school pond: what would you collect, what could contaminate it, and what could it never tell you?

Support: give the key for the local organisms with two steps missing and ask students to complete it.

IN THE GUIDE

- 11** [Building a key](#)
- 12** [Barcodes from the soil](#)
- A11** [The whole guide, with the figures that play](#)
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- [A3.1 Diversity of Organisms](#)

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.

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