

Clades, and a clock made of DNA HL

60 minutes • A3.2.4, A3.2.5 • Chapters 4, 5

What a clade is, why sequences are the most objective evidence, and how the molecular clock estimates divergence times

BY THE END, STUDENTS CAN

- ☐ Define a clade, and say what evidence best places organisms in one A3.2.4
- ☐ Explain how the molecular clock estimates when clades diverged, and why it only gives estimates A3.2.5

TIMING

0-6	6 min	Do now: clade or not?	
6-20	14 min	Ring the clades	
20-30	10 min	Which evidence would you trust?	
30-46	16 min	Plot the clock	
46-54	8 min	Why only an estimate?	
54-60	6 min	Exit	
60 min		One lesson	

STARTER

- 6 min** **Do now: clade or not?**
- On the board: an ancestor X with four descendants P, Q, R and S, and the group P, Q, R. Is it a clade?
- Students vote, then defend their vote in pairs. Do not reveal the answer: [chapter 4's](#) predict box does that.

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 A clade is an ancestor and all its descendants

CHAPTER 04 IN THE SLIDES

Tap the parts of the figure in turn: Node E, the root, Node D, Node C, Node B, Node A and The old reptiles.

Predict box: A tree shows an ancestor X with four descendants, P, Q, R and S. Someone proposes the group P, Q and R. Is it a clade? Hands up or mini whiteboards first.

Answer A: No, because S also descends from X and is left out

05 Differences that count the years

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.

- Two pairs of species whose split is **dated from fossils**: 5 differences at 10 million years and 15 at 30 million (made-up numbers).
- The differences grow steadily with time, so a straight line through the points is the **molecular clock**.
- A pair with **no fossil date** differs at 6 places. Read across to the clock, then down: about 12 million years.
- If this pair's lines collected changes **twice as fast**, the same 6 differences would mean about 6 million years. The clock gives an estimate, not a date.

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

1. One ancestor species, and one of its genes: a stretch of 30 bases, drawn as boxes.
2. Its descendants split into new species. In every line, mutations build up in the gene at a fairly steady rate: **the ticks of a clock**.
3. Today there are four species, A to D. Each gene now differs from the ancestor's, in its own places.
4. A dated fossil shows that A and B split **30 million years** ago. Their genes differ at **15** bases.
5. So this clock runs at $15 \div 30 = \mathbf{0.5 \text{ differences per million years}}$.
6. C and D differ at **6** bases: $6 \div 0.5 = \text{about } \mathbf{12 \text{ million years}}$ since they split.
7. Only an **estimate**: generation time, population size and selection all change how fast differences build up. Try the settings.

Predict box: A clock is calibrated on mammals that breed every few years. It is then used to date a split between two lines of insects that breed several times a year. What will the estimate probably be? Hands up or mini whiteboards first.

Answer C: Too old, because the insects probably collected changes faster each year

Remember it: Gerbils Play Sports (Generation time, Population size, Selection pressure).

THE LESSON

14

min

Ring the clades

Chapter 4's figure: tap each lettered node and say the clade it rings, then tap the old reptiles and say why the ring is not a clade. Students write the two-question test for a clade. Then the predict box.

10

min

Which evidence would you trust?

The clade or not card sort below. Pairs decide for each card which evidence would place the organism, and where morphology could mislead. Land on: base and amino acid sequences are the most objective evidence, and morphological traits can also be used.

16

min

Plot the clock

The data task below on graph paper: plot the fossil-dated pairs, draw the clock, and read the undated pair. Then chapter 5's figure and its last step on a faster clock, and the film for the changes building up along two lines.

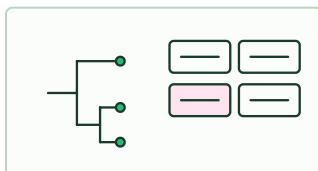
8

min

Why only an estimate?

Students link each of the three factors (generation time, population size, selection pressure) to what it does to the number of changes, using the mnemonic tiles. Then the chapter's predict box on calibrating a clock on mammals and using it on insects.

ACTIVITIES

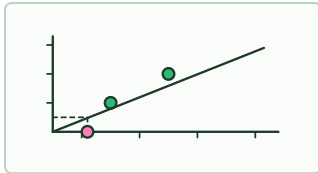


CARD SORT

Clade or not?

A printed tree of six or seven organisms and a set of cards, each naming a group of tips. Pairs sort the cards into "a clade" and "not a clade", and for each one that is not, name the descendant that is missing or the member that does not belong. Include the old reptiles. Then say for each clade which evidence (sequences or structure) you would use to check it.

Needs: the tree from chapter 4 printed, one per pair; cards cut from a sheet.



DATA TASK

Plot the clock

Students plot three pairs of species with fossil-dated splits against the number of differences in one gene (the teacher gives made-up numbers that fall on a straight line, such as 5, 10 and 15 differences at 10, 20 and 30 million years), draw the line through the origin, then read off the age of an undated pair. A second part gives one line a faster rate and asks how the answer changes. Ask what the gradient measures.

Needs: graph paper, rulers, a table of made-up data on the board or printed.

PLENARY

6

min

Exit

Two sentences: what a molecular clock measures, and one reason its estimate could be wrong.

WHAT STUDENTS GET WRONG

"Any group of relatives is a clade." A clade is an ancestor and all its descendants. Leave one out, as the old reptiles do with birds, and it is not a clade.

"The molecular clock gives dates." It gives estimates, calibrated from fossils, which shift with generation time, population size and selection pressure.

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: why might the same gene tick at different rates in different lines? Give an example for each of the three factors.

IN THE GUIDE

- 4** [A clade is an ancestor and all its descendants](#)
- 5** [Differences that count the years](#)
- 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 A3.2 at higher level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=A3.2&level=HL&paper=quiz&marks=15&src=ep



PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- [Tarsia puzzle](#), [dominoes](#) and [picture reveal](#) on A3.2, built from its key terms and ready to print
- A [pub quiz](#) with rounds on A3.2, to present or run with no projector
- An [escape room](#) built from the [question bank](#) on A3.2

ALREADY ON THE SITE FOR A3.2

- [Quiz: Cladistics \(HL\)](#)
- Revision map: [A3.2 Classification and cladistics](#), to fill in
- Exam questions: [A3.2 in the exam maker](#), a paper with its markscheme

CARD SETS ON SPLYCR

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

- [A3.2 Classification and Cladistics \(HL\)](#)

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.