

AP BIOLOGY · UNIT 7 · TOPIC 7.6

Evidence of Evolution

Learning objective 7.6.A Describe the types of data that provide evidence for evolution, and 7.6.B explain how morphological, biochemical, and geological data provide evidence that organisms have changed over time.

Name:Date:Period:

Use the tool **Four Kinds of Evidence, One Answer**. Parts 1 and 2 use **Dating a fossil**, Part 3 uses **Reading a protein**, and Parts 4 and 5 use **Same bones, different jobs**. The case for evolution does not rest on any single line of evidence, and this handout is built so that you can see why. Each part uses a method that has **nothing in common** with the others — measuring radioactive decay, counting differences between protein sequences, comparing skeletons. The last part asks whether they agree.

Part 1 · Dating something with carbon-14

Carbon-14 has a half-life of **5,730 years**: half of whatever is present decays in that time, whatever else is happening. Fill the first two columns from the graph before you use the buttons.

Half-lives elapsed	Years	Carbon-14 remaining
0		
1		
2		
3		
4		
5		

1. Explain how a radioactive isotope can be used to date a fossil.

2. The tool computes an age from the carbon-14 remaining, then runs the decay law forward from that age to see whether it returns the fraction it started with. Explain why that round trip is worth doing.

Part 2 · Where the method stops working

Use the four specimen buttons, then the isotope table on the second panel. Note what each isotope is actually used to date.

Specimen	C-14 left	Age	Isotope	Half-life	What it dates
Charred wood from a hearth			Carbon-14		
Bone from a burial site			Uranium-235		
Plant material in a peat bog			Potassium-40		
Charcoal beneath a volcanic ash layer			Uranium-238		

3. Explain why a dinosaur fossil cannot be dated using carbon-14, and describe how it is dated instead.

4. Name four different kinds of data that provide evidence for evolution.

Part 3 · Counting differences in a protein

Go to **Reading a protein**. Cytochrome c is present in every aerobic eukaryote. The tool compares each species' sequence with the human one, position by position, and counts the mismatches. It does not know anything about evolutionary relationships — it counts letters.

Organism	Differences from human	Positions compared	Identity
Chimpanzee			
Rhesus monkey			
Horse			
Chicken			
Rattlesnake			
Tuna			
Yeast			

5. Explain how comparing protein or DNA sequences between species provides evidence for evolution.

6. Human and chimpanzee cytochrome c are identical at every position compared. Explain why that is evidence, and what the alternative explanation would have to claim.

Part 4 · The molecular clock, and where it strains

Open the panel headed **A molecular clock, calibrated on one point**. A single divergence date — Chicken, 320 million years ago — sets the rate, and every other date is then predicted from sequence differences alone.

Organism	Divergence	Clock estimate (My)	Fossil date (My)	Ratio
Rhesus monkey				
Horse				
Chicken				
Rattlesnake				
Tuna				
Yeast				

7. Chicken and Rattlesnake both separated from the human lineage at the same time, yet their cytochrome c differs from ours by different amounts. Explain what this shows about molecular clocks.

8. The clock ranks every organism in the same order as the fossil record but gets some of the dates wrong by a factor of two or more. Explain why that pattern is more convincing evidence than a perfect match would be.

Part 5 · Same bones, different jobs — and four methods agreeing

Go to **Same bones, different jobs**. Then read the homologous-or-analogous table and the whale panel beneath it.

Pair of structures	Homologous or analogous?	How you can tell
Bat wing and insect wing		
Whale flipper and fish fin		
Whale flipper and bat wing		
Human arm and cat foreleg		

9. Define homologous structures and analogous structures, and explain how to tell them apart.

10. Explain why vestigial structures are evidence of common ancestry.

11. Explain why the strength of the evidence for evolution comes from independent lines agreeing rather than from any one line on its own. Use the whale as your example.

What the model simplifies

The cytochrome c sequences are a 104-position fragment aligned without gaps except at the very end, and the comparison is a plain count of differing positions. Real molecular phylogenetics uses full sequences, many genes, an explicit model of which substitutions are likely, and a correction for the same site changing twice — which is one reason the clock estimates here are rough.

The molecular clock is calibrated on a single point and applied to every other comparison. Real clocks are calibrated on several fossil dates at once and allow the rate to differ between lineages, precisely because it does — as the chicken and rattlesnake rows show.

Carbon-14 ages are computed from a clean exponential with no correction for the fact that atmospheric carbon-14 has varied over time. Real dates are calibrated against tree rings and other records, which shifts them by up to a few per cent.

The forelimb diagram shows 6 bone groups; a real forelimb has many individual carpals and phalanges whose numbers differ between species, and those differences are themselves evidence.

The divergence dates used to check the clock are approximate figures from the fossil record and the rocks around it, and different sources give somewhat different values. They are used here as an independent comparison, not as exact truth.