Year 13 Science: The evidence for evolution: fossils, anatomy, DNA and Gondwana

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. A bone has 25% of its original carbon-14. Using a half-life of 5730 years, find its age.

2. Explain why carbon-14 cannot date a 2–million-year-old fossil.

3. Are a bat's wing and a human arm homologous or analogous?

4. Are a butterfly's wing and a bird's wing homologous or analogous?

5. Two species differ at 12 of 400 bases in a gene that changes by 1.0% per million years. Find the percentage difference and the time since they split.

Exam-style question: where did kiwi come from?

Zealandia began separating from Gondwana about 80 million years ago. Kiwi and moa were long thought to descend from flightless birds that were on the land when it split. A 2014 study of ancient DNA found that the closest relatives of kiwi are the extinct elephant birds of Madagascar, and that moa are most closely related to tinamous, South American birds that can fly. A small fossil kiwi relative from St Bathans in Central Otago, about 19 to 16 million years old, may have been able to fly.

6. Describe what biogeographic and molecular evidence are.

7. Explain the vicariance hypothesis for the origin of kiwi and moa.

8. Explain how the DNA results challenge that hypothesis.

9. Discuss how the fossil, molecular and biogeographic evidence together support a different origin for kiwi, and one limitation of the evidence.

Fix the mistake

10. Correct this statement: "Carbon-14 dating showed the dinosaur bones were 70 million years old."

11. Correct this statement: "After two half-lives all of the isotope has decayed."

12. Correct this statement: "Bird wings and insect wings are homologous because both are used for flying."

13. Correct this statement: "New Zealand's plants and animals are all here because they rode Zealandia away from Gondwana."

Answer key (for parents and tutors)

1. A bone has 25% of its original carbon-14. Using a half-life of 5730 years, find its age.
   100% → 50% → 25% is 2 half-lives, so 2 × 5730 = 11 460 years.
2. Explain why carbon-14 cannot date a 2-million-year-old fossil.
   After about 50 000 years (nearly 9 half-lives) too little carbon-14 is left to measure, so far older fossils need a long half-life isotope such as potassium-40 in nearby volcanic rock.
3. Are a bat's wing and a human arm homologous or analogous?
   Homologous: the same bones from a common ancestor, used for different jobs.
4. Are a butterfly's wing and a bird's wing homologous or analogous?
   Analogous: same job, different structure and origin.
5. Two species differ at 12 of 400 bases in a gene that changes by 1.0% per million years. Find the percentage difference and the time since they split.
   12 ÷ 400 × 100 = 3.0%, so 3.0 ÷ 1.0 = 3.0 million years.
6. Describe what biogeographic and molecular evidence are.
   Biogeographic evidence is the pattern of where species and their relatives are found; molecular evidence compares DNA or protein sequences, where fewer differences mean a more recent common ancestor (Achieved).
7. Explain the vicariance hypothesis for the origin of kiwi and moa.
   Vicariance says the ancestors of kiwi and moa lived on Gondwana and were carried away on Zealandia when it split off about 80 million years ago, so they evolved in isolation from flightless ancestors already there (Merit).
8. Explain how the DNA results challenge that hypothesis.
   If kiwi had been isolated since the split, their closest relatives should be other ancient New Zealand birds such as moa, but DNA shows kiwi are closest to elephant birds of Madagascar and moa to flying tinamous, so the two New Zealand groups are not each other's relatives, and flightlessness evolved separately in each (Merit).
9. Discuss how the fossil, molecular and biogeographic evidence together support a different origin for kiwi, and one limitation of the evidence.
   Madagascar separated from the other land long before kiwi and elephant birds split, so the shared ancestor most likely flew to both places, and flight was lost later in each by convergent evolution; the St Bathans fossil fits this, as a kiwi relative that may still have flown. The tinamou link shows the same for moa ancestors. Together the evidence supports dispersal by flight after Zealandia separated, rather than vicariance. A limitation is that molecular clock dates depend on assumed rates and fossil calibration, and the St Bathans fossil is known from only a few bones, so whether it flew is uncertain (Excellence: links all three lines of evidence and evaluates them).
10. Correct this statement: "Carbon-14 dating showed the dinosaur bones were 70 million years old."
    Carbon-14 is gone after about 50 000 years; old fossils are dated from volcanic layers using isotopes such as potassium-40.
11. Correct this statement: "After two half-lives all of the isotope has decayed."
    Each half-life halves what is left: after two half-lives a quarter (25%) remains.
12. Correct this statement: "Bird wings and insect wings are homologous because both are used for flying."
    They are analogous: same job, different structure and origin, produced by convergent evolution.
13. Correct this statement: "New Zealand's plants and animals are all here because they rode Zealandia away from Gondwana."
    Some groups are Gondwanan, but DNA shows many arrived later across the sea, after much of Zealandia had been under water.