

9.2 How New Species Form

5. What is a species?

6. What is the difference between a prezygotic reproductive barrier and a postzygotic reproductive barrier? Give an example of each.

7. Explain the difference between allopatric speciation and sympatric speciation. Which is more common?

8. What is an adaptive radiation?

9.3 Evidence of Evolution: Natural Selection in Action

9. What is artificial selection? Why does artificial selection provide evidence for evolution?

9.4 Evidence of Evolution: Fossils

10. How do fossils provide evidence for evolution?



11. Explain how the fossil whales that have been discovered support Darwin's theory of evolution.

12. What does the fossil *Archaeopteryx* tell us about bird evolution?

9.5 Evidence of Evolution: Body Structures and Genetics

13. Why does the similarity of the mammalian limb in all different species of mammals provide evidence for evolution?

9.6 Evidence of Evolution: Biogeography

14. How does biogeography provide evidence for evolution?

9.7 The Evolution of Humans

15. What important feature of modern humans can already be seen in 4-million-year-old *Australopithecus* fossils?

16. What was the first species of hominid to leave Africa and spread into Europe and Asia?

17. How old is our species, the modern humans known as *Homo sapiens*?

(CLICK TO CHECK YOUR ANSWERS)



Challenging Review Questions

9.1 Mechanisms of Evolution

18. Can chance cause a population to evolve?

19. You are studying a population of beetles that includes some red individuals and some yellow individuals. You know that color is an inherited trait in the population. By counting the number of red and yellow beetles over a period of 5 years, you notice that the proportion of red individuals is increasing over time while the proportion of yellow individuals is decreasing over time. How could you determine whether this is a result of natural selection? Are there other potential explanations?

20. In a population of mice that you are studying, tail length appears to be increasing over time. However, you find no evidence that natural selection is acting on tail length. What are two alternative explanations for your observation?

9.2 How New Species Form

21. Why is speciation often associated with the introduction of a geographic barrier?

22. Individuals of two different fish species sometimes mate, but their offspring die soon after hatching. Is this an example of a prezygotic or postzygotic reproductive barrier?



23. Finches on two closely situated islands look different; on one island, they have brown tail feathers, and on the other island, they have black tail feathers. Can you conclude that these are two different species? How could you determine whether they are in fact distinct species?

24. At your field site, there are butterflies with yellow wings and butterflies with orange wings. After observing them carefully, you notice that the yellow butterflies always mate in shady areas under trees, whereas the orange butterflies always mate in sunny meadows. Can you conclude that they are different species?

9.3 Evidence of Evolution: Natural Selection in Action

25. What are some examples of artificial selection?

26. How are artificial selection and natural selection similar? How are they different?

9.4 Evidence of Evolution: Fossils

27. Why do fossil whales have legs?



28. This photo shows the leg bone of a fossil horse (left) next to the leg bone of a modern horse (right). What do these fossils tell us about horse evolution?



29. Scientists have found a number of fossil turtles. One early fossil turtle did not have a “shell” but did have wide, expanded ribs along its back (“top”) side and expanded belly coverings on the belly (“bottom”) side. A second, more recent turtle fossil had a full bottom shell. Although this second fossil turtle did not have a full top shell, it did have a partial shell extending from its backbone as well as wide, expanded ribs. What do these two fossils tell us about turtle evolution? Does it support the hypothesis that turtles evolved in water rather than on land? (Hint: If the bottom shell evolved first, what kinds of predators did it help defend turtles from?) Explain your answer.

9.5 Evidence of Evolution: Body Structures and Genetics

30. Many dogs have a dewclaw, a toenail located on the inside of the leg. Although some dogs can use their dewclaws to help grip objects, in many it serves no purpose. In fact, if the nail is not trimmed, it can become overgrown and cause issues for the dog. Is the dewclaw a vestigial organ? How does a dog’s dewclaw provide evidence for evolution?



31. How do the bones of the human hand provide evidence for evolution?

9.6 Evidence of Evolution: Biogeography

32. Islands tend to have fewer species than the nearby mainland. Furthermore, island species often include many flying organisms and few terrestrial ones. Do these biogeographic patterns support evolution? Why?

33. Many of the living organisms in Hawaii are found nowhere else on Earth. Hawaii has numerous unique species of plants, birds, insects, mammals, mushrooms, and other living things. What is the best explanation for this?

9.7 The Evolution of Humans

34. Can *Homo sapiens* and Neanderthals (*Homo neanderthalensis*) be classified as different species if genetic evidence shows they interbred in the past?

35. Laura says she doesn't believe that humans were at one time chimpanzees or gorillas. Jeff says he doesn't believe it either. Explain why biologists also don't believe that humans are descended from chimps or gorillas.



36. In one of the most spectacular archaeological finds in centuries, skeletons of a tiny human relative were discovered on a remote Indonesian island in 2004. Nicknamed "hobbits," *Homo floresiensis* adults had skulls the size of grapefruits and were no bigger than 3-year-old modern children. *Homo floresiensis* lived alongside pygmy elephants, giant rodents, and Komodo dragons. Why might *Homo floresiensis* have evolved to have very small size in its environment?

(CLICK TO CHECK YOUR ANSWERS)

Apply & Discuss Questions

37. A population of beetles that includes both sandy and green individuals is introduced into a grassy environment. How do you expect the population to evolve due to natural selection? Now suppose that another beetle population lives in a nearby sandbank. Most of the individuals in this population are sandy colored. If beetles regularly migrate from one population to the other, what will be the effect on each population? Does gene flow make it easier or harder for these beetle populations to adapt to their environments?

38. Islands tend to have fewer species than an area of equal size on the mainland. Is this consistent with the idea that species were spread around Earth purposefully? Is it consistent with evolution?

39. Scientific theories must be falsifiable. Is evolution falsifiable? For example, can you imagine some biogeographic evidence that would not be consistent with evolution? Has any evidence of this sort been found?



40. Scientists who are searching for new fossils of early hominids usually look in Africa. Does this make sense, or should they expand their search?

(CLICK TO CHECK YOUR ANSWERS)



End of Chapter Solutions

Simple Review Solutions

1. Natural selection acts on an organism's phenotype (traits), not on its genotype (genes).
3. Gene flow describes changes in allele frequencies resulting from a net movement of alleles into or out of a population. For example, a half-polluted town may be next to a clean woodland that is home to a population of light moths. If a few of these light moths migrated from the woodland into town, the frequency of the light allele in the town would increase.
5. A species is a group of organisms whose members can breed with one another, but not with members of other species.
7. In allopatric speciation, new species are formed after a geographic barrier divides a single population into two isolated populations. Sympatric speciation occurs without geographic isolation. Sympatric speciation is less common than allopatric speciation.
9. Artificial selection is the selective breeding of organisms with desirable traits in order to obtain organisms with similar traits. In artificial selection, humans control the reproductive success of different organisms and bring about distinct evolutionary changes in populations over time.
11. Fossil whales not only show that whales are descended from hooved mammals but also tell us how many key whale traits evolved. Whale fossils show how over time, whale nostrils moved from the front of the skull to the top, forming a blowhole. Whale fossils also show how whales gradually lost their hind legs as they became more and more adapted to an aquatic existence.
13. If each of these animals had originated independently, we would expect their limbs to look completely different. Each limb would have been designed from scratch to best perform its function. But, despite the different functions of human hands, cat legs, whale flippers, and bat wings, all these limbs show the same arrangement of bones. This suggests that the limbs were inherited from a common ancestor and then modified through natural selection for different functions.
15. The bones of Lucy's pelvis make it clear that she walked upright on two legs. In fact, older *Australopithecus* fossils show that an upright posture dates to at least 4 million years ago.
17. The earliest fossils of modern humans, *Homo sapiens*, were found in Ethiopia and are 195,000 years old.

Challenging Review Solutions

19. To determine whether natural selection is responsible for the shift, you could compare the fitness (number of offspring left) of red individuals versus yellow individuals. If this turned out to be difficult, you could also compare their survival or ability to acquire mates in an attempt to identify other potential causes of fitness differences. If it's not natural selection, evolution in the population could also be due to genetic drift, migration into or out of the population, or mutation pressure.
21. A geographic barrier causes the two separated populations to evolve in isolation, making it more likely a reproductive barrier will evolve.



23. No, you cannot conclude they are distinct species merely because they are distinguishable. You can determine whether they are distinct species by figuring out whether they interbreed.
25. We saw artificial selection in the breeding of dogs as well as in the breeding of corn from teosinte. There are numerous other examples of domesticated animals and crops that humans have bred through artificial selection, including most of the food we eat and most of the animals we regularly keep as pets or livestock.
27. Because whales are descended from animals that had legs. Some fossil whales show an intermediate state where legs were present, but no longer fully functional.
29. These fossils suggest that the turtle's bottom shell evolved before the top shell. This sequence does support the hypothesis that turtles evolved in water rather than on land. A bottom shell is more likely to protect you from predators attacking from below – something that could happen in water but not on land.
31. The pattern of bones in the human hand is similar to that found in other mammals. If each mammal had originated independently, we would expect their limbs to look completely different. Each limb would have been designed from scratch to best perform its function. But, despite the different functions of human hands, cat legs, whale flippers, and bat wings, all these limbs show the same arrangement of bones. This suggests that the limbs were inherited from a common ancestor and then modified through natural selection for different functions.
33. Hawaii is extremely isolated from all mainlands, so organisms that arrived there then had plenty of time to evolve in isolation and speciate from mainland species.
35. Humans are primates. We belong to a group of mammals that also includes monkeys and apes. This doesn't mean we're descended from any existing species of monkey or ape. It just means we're more closely related to monkeys and apes than we are to other living things, such as dogs, lizards, or plants.

Apply & Discuss Solutions

37. In the grassy environment, the green individuals are likely to have higher fitness because they are better camouflaged. The population is likely to evolve to have more green individuals. Because of migration, sandy genes will constantly enter the grassy population, and green genes will constantly enter the sandy population. Migration and gene flow make it harder for each population to adapt to its local environment.
39. Evolution is falsifiable. In the specific case of biogeography, it is possible to imagine a situation where 1.) the same species is found in many different isolated places on Earth, 2.) islands have more biodiversity than mainlands, 3.) islands are full of terrestrial animals that would have had trouble crossing over from the mainland, 4.) closely related species are scattered over the Earth, etc. However, few or no examples of these can be found, whereas there is abundant evidence of the opposite.

