Biochemical evidence for evolution packet answers

A Horse Is a Horse, of Course, of Course This drawing was created in 1848, but it's likely that you recognize the animal it depicts as a horse. Although horses haven't changed that much since this drawing was made, they have a long evolutionary history during which they changed significantly. How do we know? The answer lies in the fossil record. Figure \(\PageIndex{1}\): Horse Figure \(\PageIndex{2}\): Evolution of the Horse. The fossil record reveals how horses evolved. The lineage that led to modern horses (Equus) grew taller over time (from the 0.4 m Hyracotherium in early Eocene to the 1.6 m Equus). This lineage also developed longer molar teeth and the degeneration of the outer phalanges on the feet. Fossils are a window into the past. They provide clear evidence that evolution has occurred. Scientists who find and study fossils are called paleontologists. How do they use fossils to understand the past? Consider the example of the horse, outlined in figure \(\PageIndex{2}\). Fossils spanning a period of more than 50 million years show how the horse evolved. The oldest horse fossils show what the earliest horses were like. They were only 0.4 m tall, or about the size of a fox, and they had four long toes. Other evidence shows they lived in wooded marshlands, where they probably ate soft leaves. Over time, the climate became drier, and grasslands slowly replaced the marshes. Later fossils show that horses changed as well. They became taller, which would help them see predators while they fed in tall grasses. Eventually, they reached a height of about 1.6 m. They evolved a single large toe that eventually became a hoof. This would help them run swiftly and escape predators. Their molars (back teeth) became longer and covered with hard cement. This would allow them to grind tough grasses and grass seeds without wearing out their teeth. Scientists can learn a great deal about evolution by studying living species. They can compare the anatomy, embryos, and DNA of modern organisms to help understand how they evolved. Figure \(\PageIndex{3}\): Mammals (such as cats and whales) have homologous limb structures - with a different overall look but the same bones. Insects (such as praying mantis and water boatman) also have homologous limbs. Cat legs and praying mantis legs are analogous - looking similar but from different evolutionary lineages. Comparative anatomy is the study of the similarities and differences in the structures of different species. Similar body parts may be homologous structures or analogous structures. Both provide evidence for evolution. Homologous structures are structures that are similar in related organisms because they were inherited from a common ancestor. These structures may or may not have the same function in the descendants. Figure \(\PageIndex{3}\) shows the upper appendages of several different mammals. They all have the same basic pattern of bones, although they now have different functions. All of these mammals inherited this basic bone pattern from a common ancestor. Analogous structures are structures that are similar in unrelated organisms. The structures are similar because they evolved to do the same job, not because they were inherited from a common ancestor. For example, the wings of bats and birds, shown in the figure that follows, look similar on the outside and have the same function. However, wings evolved independently in the two groups of animals. This is apparent when you compare the pattern of bones inside the wings. Comparative embryology is the study of the similarities and differences in the embryos of different species. Similarities in embryos are likely to be evidence of common ancestry. All vertebrate embryos, for example, have gill slits and tails. All of the embryos in Figure \(\PageIndex{4}\), except for fish, lose their gill slits by adulthood, and some of them also lose their tail. In humans, the tail is reduced to the tail bone. Thus, similarities organisms share as embryos may no longer be present by adulthood. This is why it is valuable to compare organisms in the embryonic stage. Figure \(\PageIndex{4}\): Embryos of different vertebrates look much more similar than the animals do at later stages of life. Rows I, II, and III illustrate the development of the embryos of fish on the far left, salamander, tortoise, chick, hog, calf, rabbit, and human on the far right, from the earliest to the latest stages. Structures like the human tail bone are called vestigial structures. Evolution has reduced their size because the structures are no longer used. The human appendix is another example of a vestigial structure. It is a tiny remnant of a once-larger organ. In a distant ancestor, it was needed to digest food, but it serves no purpose in the human body today. Why do you think structures that are no longer used shrink in size? Why might a full-sized, unused structure reduce an organism's fitness? Darwin could compare only the anatomy and embryos of living things. Today, scientists can compare their DNA. Similar DNA sequences are the strongest evidence for evolution from a common ancestor. Look at the diagram in Figure \(\PageIndex{5}\). The diagram is a cladogram, a branching diagram showing related organisms. Each branch represents the emergence of new traits that separate one group of organisms from the rest. The cladogram in the figure shows how humans and apes are related based on their DNA sequences. Figure \(\PageIndex{1}\): Figure \(\PageIndex{5}\): Cladogram of Humans and Apes. This cladogram is based on DNA comparisons. It shows how humans are related to apes by descent from common ancestors. Humans are most closely related to chimpanzees and Bonobo (our common ancestor existed most recently). We are less closely related to gorillas, and even less closely related to Orangutan. Biogeography is the study of how and why organisms live where they do. It provides more evidence for evolution. Let's consider the camel family as an example. Today, the camel family includes different types of camels (Figure \(\PageIndex{6}\)). All of today's camels are descended from the same camel ancestors. These ancestors lived in North America about a million years ago. Early North American camels migrated to other places. Some went to East Asia via a land bridge during the last ice age. A few of them made it all the way to Africa. Others went to South America by crossing the Isthmus of Panama. Once camels reached these different places, they evolved independently. They evolved adaptations that suited them for the particular environment where they lived. Through natural selection, descendants of the original camel ancestors evolved the diversity they have today. Figure \(\PageIndex{6}\). Camel Migrations and Present-Day Variation. Members of the camel family now live in different parts of the world. Dromedary camels are found in Africa, Bactrian camels in Asia, and Llamas in South America. They differ from one another in a number of traits. However, they share basic similarities. This is because they all evolved from a common ancestor. What differences and similarities do you see? The biogeography of islands yields some of the best evidence for evolution. Consider the birds called finches that Darwin studied on the Galápagos Islands (Figure \(\PageIndex{7}\))). All of the finches probably descended from one bird that arrived on the islands from South America. Until the first bird arrived, there had never been birds on the islands. The first bird was a seed eater. It evolved into many finch species, each adapted for a different type of food. This is an example of adaptive radiation. This is the process by which a single species evolves into many new species to fill available ecological niches. Figure \(\PageIndex{7}\): Galápagos finches differ in beak size and shape, depending on the type of food they eat. Those eating buds and fruits have the largest beaks. Insect and grub eaters have narrower beaks Eyewitnesses to Evolution In the 1970s, biologists Peter and Rosemary Grant went to the Galápagos Islands to re-study Darwin's finches. They spent more than 30 years on the project, but their efforts paid off. They were able to observe evolution by natural selection actually taking place. While the Grants were on the Galápagos, a drought occurred, so fewer seeds were available for finches to eat. Birds with smaller beaks could crack open and eat only the smaller seeds. Birds with bigger beaks could crack open and eat seeds of all sizes. As a result, many of the smaller-beaked birds died in the drought, whereas birds with bigger beaks survived and reproduced. As shown in Figure \(\PageIndex{8}\), within 2 years, the average beak size in the finch population increased. In other words, evolution by natural selection had occurred. Figure \(\PageIndex{8}\). Evolution of Beak Size in Galápagos Finches. The left graph shows the beak sizes of the entire finch population studied by the Grants in 1976. The right graph shows the beak sizes of the survivors in 1978. In just 2 years, the mean beak size increased from about 9 mm to just above 10 mm. How do paleontologists learn about evolution? Describe what fossils reveal about the evolution of the horse. What are vestigial structures? Give an example. Define biogeography. Describe an example of island biogeography that provides evidence of evolution. Humans and apes have five fingers they can use to grasp objects. Are these analogous or homologous structures? Explain. Compare and contrast homologous and analogous structures. What do they reveal about evolution? Why does comparative embryology show similarities between organisms that do not appear to be similar as adults? What does a cladogram show? Explain how DNA is useful in the study of evolution. A bat wing is more similar in anatomical structure to a cat forelimb than to a bird wing. Answer the following questions about these structures. Which pairs are homologous structures? Which pairs are analogous structures? Based on this, do you think a bat is more closely related to a cat or to a bird? Explain your answer. If you wanted to test the answer you gave to part c, what is a different type of evidence you could obtain that might help answer the question? True or False. Fossils are the only type of evidence that supports the theory of evolution. True or False. Adaptive radiation is a type of evolution that produces new species. The Galapagos finches remain one of our world's greatest examples of adaptive radiation. Watch as these evolutionary biologists detail their 40-year project to document the evolution of these famous finches: If you're seeing this message, it means we're having trouble loading external resources on our website. If you're behind a web filter, please make sure that the domains *.kastatic.org and *.kasandbox.org are unblocked. Darwin proposed that evolution could be explained by the differential survival of organisms following their naturally occurring variation--a process he termed "natural selection." According to this view, the offspring of organisms differ from one another and from their parents in ways that are heritable--that is, they can pass on the differences genetically to their own offspring. Furthermore, organisms in nature typically produce more offspring than can survive and reproduce given the constraints of food, space, and other environmental resources. If a particular off spring has traits that give it an advantage in a particular environment, that organism will be more likely to survive and pass on those traits. As differences accumulate over generations, populations of organisms diverge from their ancestors. Darwin's original hypothesis has undergone extensive modification and expansion, but the central concepts stand firm. Studies in genetics and molecular biology--fields unknown in Darwin's time--have explained the occurrence of the hereditary variations that are essential to natural selection. Genetic variations result from changes, or mutations, in the nucleotide sequence of DNA, the molecule that genes are made from. Such changes in DNA now can be detected and described with great precision. Genetic mutations arise by chance. They may or may not equip the organism with better means for surviving in its environment. But if a gene variant improves adaptation to the environment (for example, by allowing an organism to make better use of an available nutrient, or to escape predators more effectively--such as through stronger legs or disguising coloration), the organisms carrying that gene are more likely to survive and reproduce than those without it. Over time, their descendants will tend to increase, changing the average characteristics of the population. Although the genetic variation on which natural selection works is based on random or chance elements, natural selection itself produces "adaptive" change--the very opposite of chance. Scientists also have gained an understanding of the processes by which new species originate. A new species is one in which the individuals cannot mate and produce viable descendants with individuals of a preexisting species. The split of one species into two often starts because a group of individuals becomes geographically separated from the rest. This is particularly apparent in distant remote islands, such as the Galápagos and the Hawaiian archipelago, whose great distance from the Americas and Asia means that arriving colonizers will have little or no opportunity to mate with individuals remaining on those continents. Mountains, rivers, lakes, and other natural barriers also account for geographic separation between populations that once belonged to the same species. Once isolated, geographically separated groups of individuals become genetically differentiated as a consequence of mutation and other processes, including natural selection. The origin of a species is often a gradual process, so that at first the reproductive isolation between separated groups of organisms is only partial, but it eventually becomes complete. Scientists pay special attention to these intermediate situations, because they help to reconstruct the details of the process and to identify particular genes or sets of genes that account for the reproductive isolation between species. Genes, Peoples and Languages In this book, the author explains the historical spread of genes, peoples, cultures, and languages through Europe in the past 5,000 years, based on genetic, anthropological, and biogeographic evidence. By Luigi Luca Cavalli-Sforza [Translated by Mark Seielstad. New York: North Point Press, 2000]. Other ResourcesPrint Evidence for Evolution Page 2Darwin, Wallace and the other 19th century naturalists who traveled widely were fascinated by the distribution of animals and plants in their habitats around the world. Why do the Galapagos Islands of South America and the Cape Verde Islands off Africa have strikingly different fauna and flora, despite having similar environments? Why does the Arctic have polar bears and Antarctica penguins? These patterns impressed Darwin deeply. To him, they argued that species arose in single centers by descent with modification from existing species, and that their geographic range was limited by their ability to migrate to other suitable environments. The distribution of flora and fauna of the oceanic islands provided Darwin with some of his strongest arguments. The islands contain a small number of species because immigration from the mainland was difficult, he said. Some categories of life are absent altogether, such as batrachians -- frogs, toads, and newts -- even though they would seem to be adapted for such habitats. The reason? They are killed by saltwater, so could not reach the islands by migration. Terrestrial mammals aren't found on oceanic islands more than 300 miles from the mainland. But bats, with their long-distance flying ability, are plentiful. Another point: Most of the species on islands, while distinct from other species, are most closely related to species on the nearest mainland. Therefore, Darwin said, the island inhabitants must have migrated from the original, mainland area where the species originated. That explains why the species on the Galapagos Islands most closely resemble those on the nearby South American mainland, and those in the Cape Verdes resemble those of west Africa. Aside from the islands, Darwin was intrigued by unusual distributions of animals and plants across the continents. He concluded that changes in locations of climatic zones over time -- the advance and retreat of glaciers, for example -- could explain some of the patterns in animals' habitats. Just as intriguing to Darwin, and even more apparent now, is the fact that fossils of possible ancestors of living species are often found in the same parts of the globe where their descendants live today. Darwin observed this in the South American fossils he collected, relatives of today's capybaras and armadillos. Apes today live only in Africa and Asia, and that is where the fossils most resembling modern apes are also found. There are no apes, fossil or living, known from anywhere in the Americas. These same patterns are just as impressive today. And since Darwin's day, advances in scientific understanding have shown how accurate his conclusions were. For example, plate tectonics, undreamed of when Darwin was forming his ideas, fits elegantly into Darwin's theory as another major influence on dispersal, helping to produce the patterns in the distribution of both fossils and living organisms seen around the world in modern times. Page 3Biogeography: Polar Bears and Penguins